# GoPxL for Gocator Confocal Profilers

USER MANUAL

Gocator 4000 & 5500 Series

Firmware version: 1.3.x.x

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# Introduction

This documentation describes how to connect, configure, and use a Gocator 4000 or Gocator 5500 series line confocal sensor ("G4 sensor" or "G5 sensor" for short) using the GoPxL software. Although you can run the software on-sensor, LMI strongly recommends running these sensors through a PC instance of GoPxL. (For more information, see *Running GoPxL on a Windows PC* on page 814.)

Before using a sensor, you should familiarize yourself with sensor safety and maintenance. For more information, see *Safety and Maintenance* on page 14.

For a breakdown of this documentation, see *Using the Manual* on page 16.

The documentation applies to the following:

- Gocator 4000 series
- Gocator 5500 series
- GoMax NX / ORIN / ORIN+
- X64-based PC (Intel/AMD) running Windows 10 (for running GoPxL on a PC)

GoPxL only supports GoMax NX, ORIN, and ORIN+. It does not support the pre-NX version.

If you need to use the Anomaly Detector tool in GoPxL on PC, you must download the "GoPxL Pro Utilities" package (14658-x.x.x.x_SOFTWARE_GoPxL_Pro_Utilities.exe), which contains this tool.

**Notational Conventions**

This documentation uses the following notational conventions:

Follow these safety guidelines to avoid potential injury or property damage.

Consider this information in order to make best use of the product.

# Safety and Maintenance

The following sections describe the safe use and maintenance of Gocator sensors.

## Electrical Safety

⚠ Failure to follow the guidelines described in this section may result in electrical shock or equipment damage.

**Sensors should be connected to earth ground**
All sensors should be connected to earth ground through their housing. All sensors should be mounted on an earth grounded frame using electrically conductive hardware to ensure the housing of the sensor is connected to earth ground. Use a multi-meter to check the continuity between the sensor connector and earth ground to ensure a proper connection.

**Minimize voltage potential between system ground and sensor ground**
Care should be taken to minimize the voltage potential between system ground (ground reference for I/O signals) and sensor ground. This voltage potential can be determined by measuring the voltage between Analog_out- and system ground. The maximum permissible voltage potential is 12 V but should be kept below 10 V to avoid damage to the serial and encoder connections.

**Use a suitable power supply**
The power supply used with sensors should be an isolated supply with inrush current protection or be able to handle a high capacitive load. Verify the voltage input requirements for your sensor in the sensor's specifications; for specifications, see *Sensors* on page 956.

**Use care when handling powered devices**
Wires connecting to the sensor should not be handled while the sensor is powered. Doing so may cause electrical shock to the user or damage to the equipment.

## Handling, Cleaning, and Maintenance

Dirty or damaged sensor windows (emitter or camera) can affect accuracy. Use caution when handling the sensor or cleaning the sensor's windows.

**Devices are heavy**
Due to the weight of Gocator line confocal sensors, LMI recommends that two people mount the devices.

**Keep sensor windows clean**
Use dry, clean air to remove dust or other dirt particles. If dirt remains, clean the windows carefully with a soft, lint-free cloth and non-streaking glass cleaner or isopropyl alcohol. Ensure that no residue is left on the windows after cleaning.

**Avoid excessive modifications to files stored on the sensor**
Sensor settings are stored in flash memory inside the sensor. Flash memory has an expected lifetime of 100,000 writes. To maximize lifetime, avoid frequent or unnecessary file save operations.

# Environment and Lighting

**Avoid strong ambient light sources**
The imager used in this product is highly sensitive to ambient light. Do not operate this device near windows or lighting fixtures that could influence measurement or data acquisition.If the unit must be installed in an environment with high ambient light levels, a lighting shield or similar device may need to be installed to prevent light from affecting measurement.

**Avoid installing sensors in hazardous environments**
To ensure reliable operation and to prevent damage to sensors, avoid installing the sensor in locations

- that are humid, dusty, or poorly ventilated;
- with a high temperature, such as places exposed to direct sunlight;
- where there are flammable or corrosive gases;
- where the unit may be directly subjected to harsh vibration or impact;
- where water, oil, or chemicals may splash onto the unit;
- where static electricity is easily generated.

**Ensure that ambient conditions are within specifications**
Keep ambient temperatures below 40 °C.

The sensor operating temperature range is 15 to 35 °C. When operating a Gocator 4000 sensor with an ambient temperature from 30 to 35 °C, the sensor's duty cycle should not exceed 50%.

⚠ The sensor is partly cooled through the mounting frame. Therefore, the sensor must be mounted to a solid aluminum plate. All applications should be validated by monitoring the internal temperature reported by the "External thermistor temp" indicator on the **Monitor** > **Health** page. This indicator must remain below 50 °C.

For all sensors, the storage temperature is -30 to 70 °C.

For all sensors, relative humidity (non-condensing) is 25% to 85%.

The Master network controllers are similarly rated for operation between 0 and 50 °C.

⚠ Sensors are high-accuracy devices, and the temperature of all of its components must therefore be in equilibrium. The recommended sensor warm-up time is 30 minutes with a 50% duty cycle (for more information, see *Warm-up Procedure* on page 35).

**Protect Master network controllers from dusty environments**

⚠ If you are installing a Master 810 or 2410 in a dusty environment, LMI strongly recommends installing the device in a vented cabinet or enclosure to avoid contamination.

# Using the Manual

Use the following to help decide which part of this manual you need.

The tool topics from this manual are available in GoPxL, in the **Tool Help** panel at the bottom of the interface.

*Manual breakdown*

| Category | Description |
|---|---|
| Safety and Maintenance | Important safety and maintenance information (see *Manage - Sensor Management and Maintenance* on page 801). |
| Getting Started / Installation | Hardware overview and installation information (see *Quick Start - Installation, Network & Sensor Setup* on page 27). |
| Key Concepts | Fundamental Gocator sensor concepts (see *Key Concepts* on page 39). |
| User Interface Overview | General overview of the GoPxL user interface (see *User Interface Overview* on page 54). |
| File Formats | Lists the formats used in GoPxL (see *File Formats* on page 62). |
| Working with Scan Data | Describes how to record scan data and how to play back recordings (see *Recording and Working with Scan Data* on page 87). |
| Creating, Saving and Loading Jobs | Describes how to work with jobs (see *Creating, Saving and Loading Jobs* on page 91). |
| Configuring Systems | Contains subsections describing how to do the following:<br>• Perform general sensor maintenance<br>• Create a sensor system<br>• Align sensors<br>• Configure acquisition<br>• Configure inspection and processing tools<br>• Configure control (including protocol and GoHMI)<br>• Configure reporting<br>For more information, see *Configuring GoPxL* on page 92. |
| Using a PC Instance of GoPxL | Describes how to start and use a PC instance of GoPxL, as well as GoPxL Manager. You use a PC instance of GoPxL to accelerate a sensor and to examine scan data offline.<br>For more information, see *Running GoPxL on a Windows PC* on page 814. |
| Development Kits and API | Provides an overview of the GoPxL SDK and the REST API and describes installation of the SDK (see *GoPxL SDK and REST API* on page 863). |
| GoHMI | Describes how to configure GoHMI in a PC instance of GoPxL. Also describes the GoHMI Designer (see *GoHMI and GoHMI Designer* on page 833). |
| Integrations | Describes the industrial protocols you can use in GoPxL (see See *Integrations* on |

| Category | Description |
| --- | --- |
| | page 886). |
| Specifications | Provides sensor specifications and drawings (see *Specifications* on page 955). |

# Installation, Setup & Hardware Overview

The following sections provide hardware and system overviews and describe installation and initial networking setup procedures.

# Gocator Overview

Gocator 4000 and 5500 series sensors (G4 and G5 sensors for short) are 3D smart line confocal imaging (LCI) sensors. These sensors simultaneously produce 3D topography, 3D tomography, and 2D intensity data. The sensors can scan a wide variety of material types, including multi-layered, transparent/translucent, curved edge, shiny/specular, high-contrast textured, or mixed materials. G4 sensors use a coaxial optical design to produce scans without shadowing effects for improved data quality and more accurate measurement results on steep-angled features, as well as greater angular range for excellent performance on highly curved surfaces. G5 sensors uses a dual-axis optical system that improves noise immunity and provides higher signal quality. This makes it possible to scan difficult surfaces and very fine features.

G4 and G5 sensors simultaneously generate 3D topography for each layer of a material, making it possible to measure the thickness of individual layers or detect defects on secondary layers.

Sensors are configured through an easy-to-use web-based interface called GoPxL, which provides built-in measurement tools, I/O connectivity, and multi-layer profiling support. Although GoPxL can run on-sensor, with G4 and G5 sensors the frequency is limited. Therefore, in most applications, you will configure and run sensors through the PC-based version of GoPxL.

Before using sensors, see *Safety and Maintenance* on page 14.

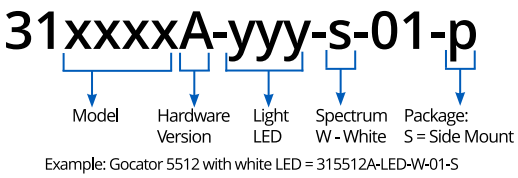
For information on the physical installation and mounting of sensors, as well as a general hardware overview, see *Installation, Setup & Hardware Overview* on page 18.

For key concepts on how sensors acquire data and perform measurements, see *Key Concepts* on page 39.

For information on using the PC-based interface (and the differences between running GoPxL on-sensor and on a PC), see *Running GoPxL on a Windows PC* on page 814.

## Sensor Part Numbers

Use the following to understand sensor part numbers:




Example: Gocator 5512 with white LED = 315512A-LED-W-01-S

# Hardware Overview

The following sections describe Gocator and its associated hardware.

## Gocator Cordsets

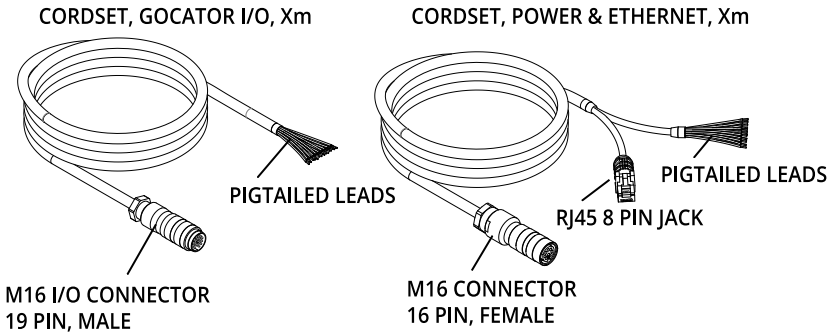
Gocator sensors use two types of cordsets: the Power & Ethernet cordset and the I/O cordset.

> When connecting cordsets to the sensor's connectors, hand-tighten only and do not exceed a torque of 2 N· m (18 in-lbs). Ensure that you properly secure the cordset cabling to avoid stress loading on the sensor connectors.

The Power & Ethernet cordset provides power and Ethernet sensor communication via 1000 Mbit/s Ethernet with a standard RJ45 connector.

Note that Gocator 4000 and 5500 Line Confocal Sensors use a series-specific Power & Ethernet cordset (the High Power & Ethernet cordset). Cordsets with part numbers 301237-5m and 301238-5m are *48-volt only*.

The I/O cordset provides digital input and output connections, an encoder interface, and RS-485 serial connection.

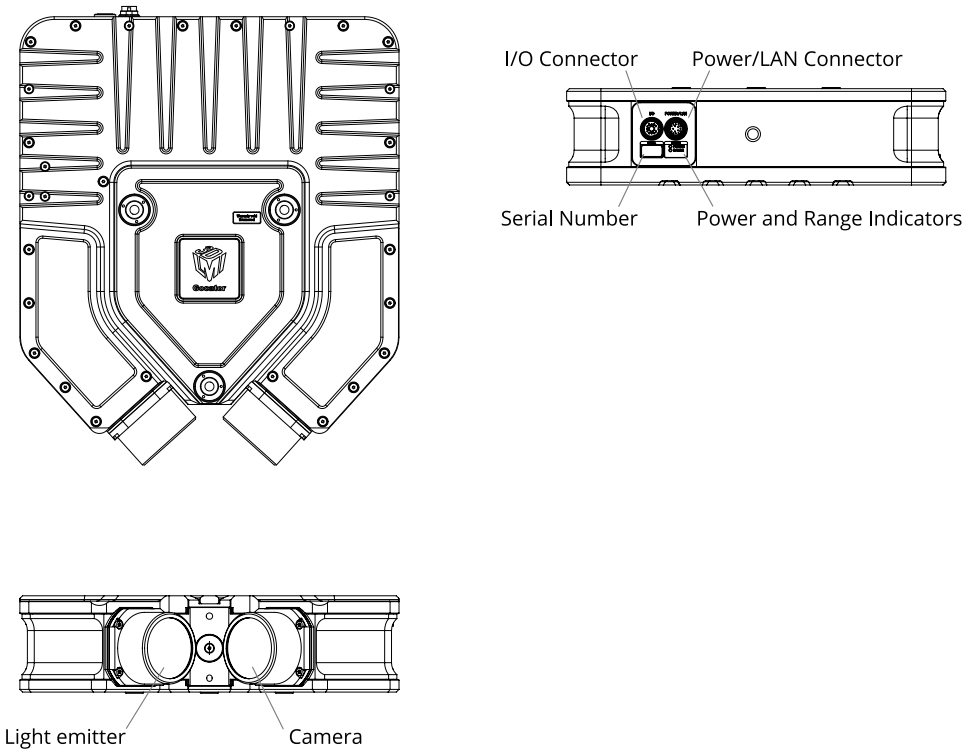



The maximum cordset length is 60 m.

For information on the I/O cordset's pinout, see *Gocator I/O Connector* on page 977.

For information on the High Power & Ethernet cordset, see *Gocator Power/LAN Connector* on page 975.

## Gocator Sensor

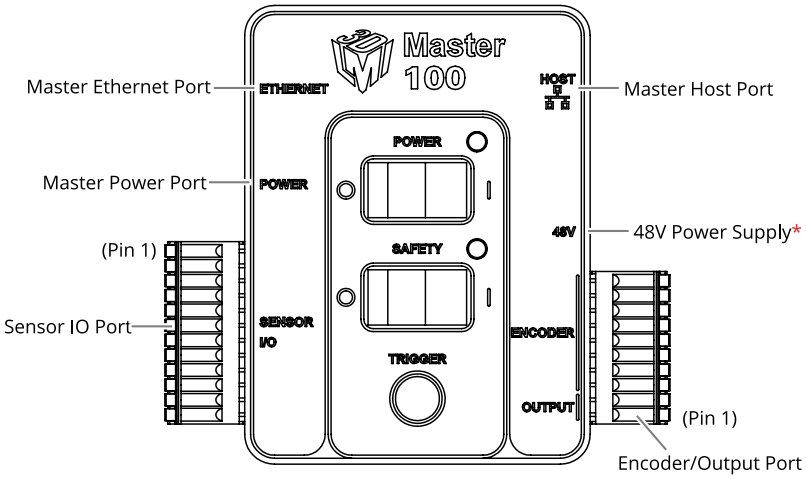



*Gocator 5512*

| Item | Description |
|---|---|
| Light Emitter | Emits light for profiling. |
| Camera | The camera observe the light reflected from target surfaces. |
| I/O Connector | Accepts input and output signals.<br>For more information on cordsets, see *Gocator Cordsets* on the previous page.<br>For information on the connector's pinout, see *Gocator I/O Connector* on page 977. |
| Power / LAN Connector | Accepts power and connects to 1000 Mbit/s Ethernet network.<br>For more information on cordsets, see *Gocator Cordsets* on the previous page.<br>For information on the connector's pinout, see *Gocator Power/LAN Connector* on page 975. |
| Power Indicator | Illuminates when power is applied (blue). |
| Range Indicator | Illuminates when camera detects light as the target is within the sensor's measurement range (green).. |
| Serial Number | Unique sensor serial number. |

## Master 100

The Master 100 is used by sensors for standalone system setup (that is, a single sensor).




| Item | Description |
|---|---|
| Master Ethernet Port | Connects to the RJ45 connector labeled Ethernet on the Power/LAN to Master cordset. |
| Master Power Port | Connects to the RJ45 connector labeled Power/Sync on the Power/LAN to Master cordset. |
| Sensor I/O Port | Connects to the I/O cordset. |
| Master Host Port | Connects to the host PC's Ethernet port. |
| Power | Accepts power (+48 V). |
| Power Switch | Toggles sensor power. |
| Safety Switch | Toggles safety signal provided to the sensors [O= off, I= on]. |
| Trigger | Signals a digital input trigger to the sensor. |
| Encoder | Accepts encoder A, B and Z signals. |
| Digital Output | Provides digital output. |

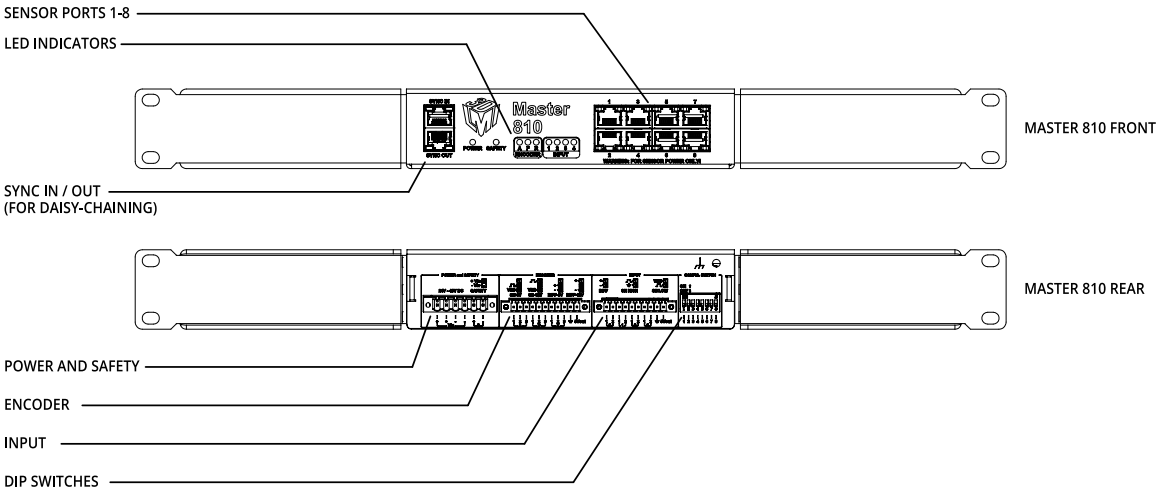
See *Master 100* on page 982 for pinout details.

## Master 810 / 2410

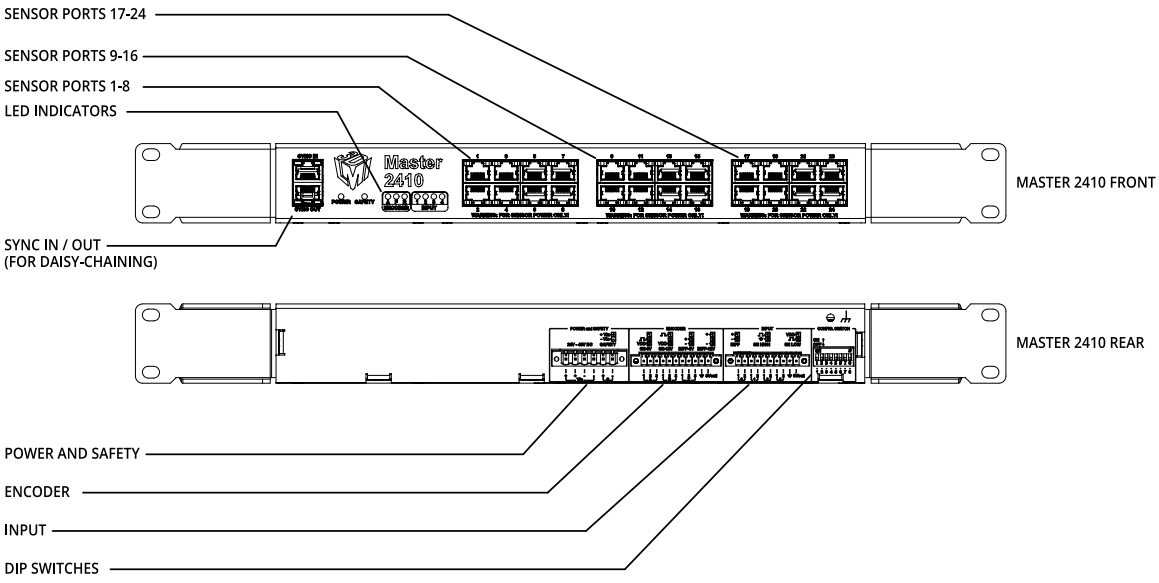
The Master 810 and 2410 network controllers let you connect multiple sensors to create a multi-sensor system:

- Master 810 accepts up to eight sensors
- Master 2410 accepts up to twenty-four sensors

Both models let you divide the quadrature frequency of a connected encoder to make the frequency compatible with the Master, and also set the debounce period to accommodate faster encoders. For more information, see *Configuring Master 810* on page 31. (Earlier revisions of these models lack the DIP switches.)




*Master 810*




*Master 2410*

| Item | Description |
|---|---|
| Sensor Ports | Master connection for sensors (no specific order required). |
| Power and Safety | Power and safety connections. |
| Encoder | Accepts encoder signal. |
| Input | Accepts digital input. |
| DIP Switches | Configures the Master (for example, allowing the device to work with faster encoders). For information on configuring Master 810 and 2410 using the DIP switches, see *Configuring Master 810* on page 31. |
| LED Indicators | For more information, see *Master 810/2410* on page 984. |

For pinout details, see *Master 810/2410* on page 984.

# System Overview

## Standalone System

Standalone systems include only a single sensor. Gocator 4000 and 5500 series sensors are typically only used in a standalone system, mounted above a stage. However, dual-sensor systems are possible. The sensor is typically connected to a computer's Ethernet port for initial setup and during acquisition and inspection.

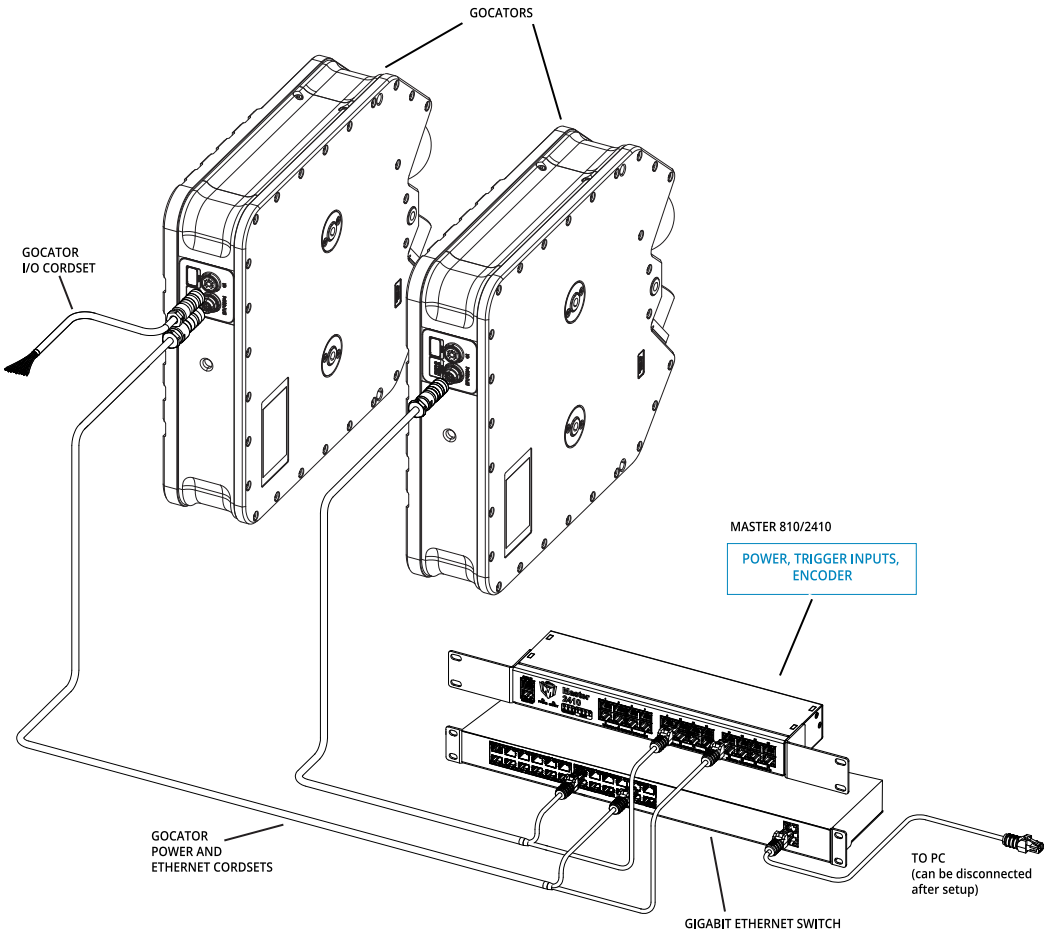
For information on physical installation, see *Quick Start - Installation, Network & Sensor Setup* on page 27.

## Dual-Sensor System

In a dual-sensor system, two sensors work together to perform data acquisition and output the combined results.

> Dual-sensor Gocator confocal sensor systems are limited to Top/Bottom layouts.

A Master network controller (excluding Master 100) must be used to connect two sensors in a dual-sensor system. Power and Ethernet to Master cordsets are used to connect sensors to the Master.



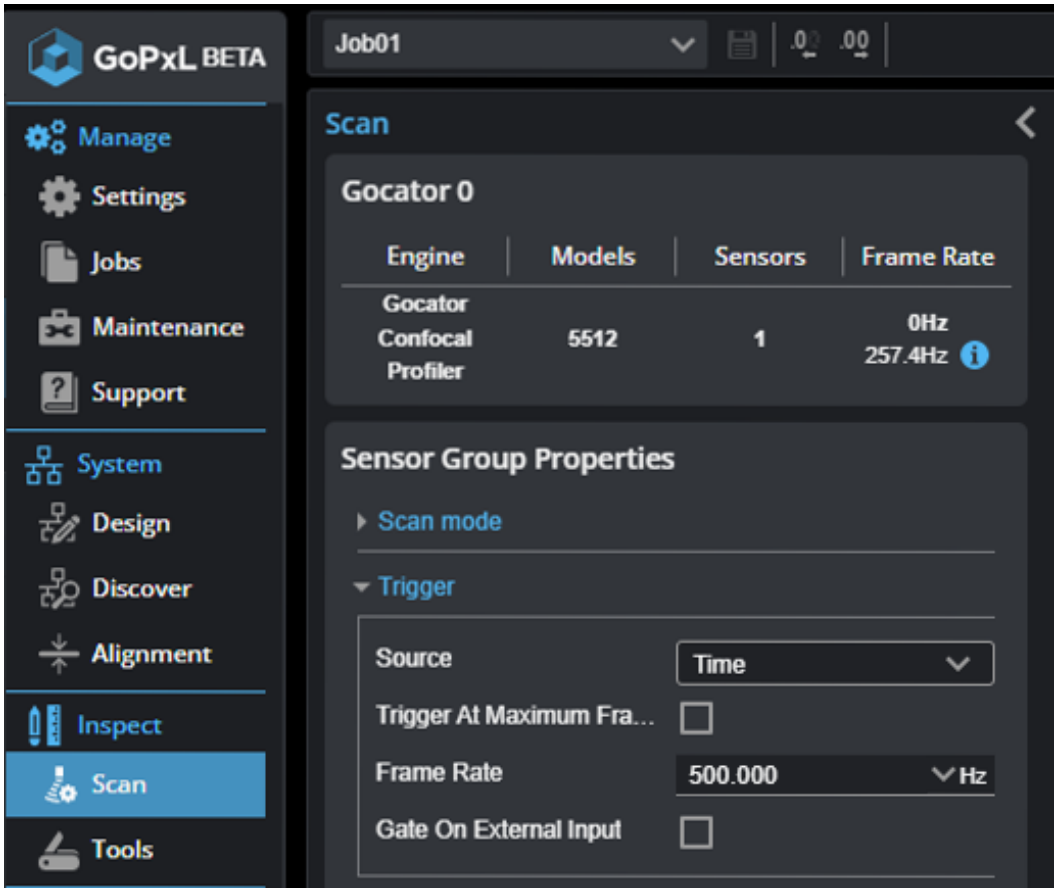
# Warm-up Procedure

LMI recommends warming up the sensor before acquiring data to stabilize the sensor's capability to measure absolute Z coordinates. During the sensor's warm-up procedure, there is a small variation on the absolute Z height on which the sensor sees the target surface.

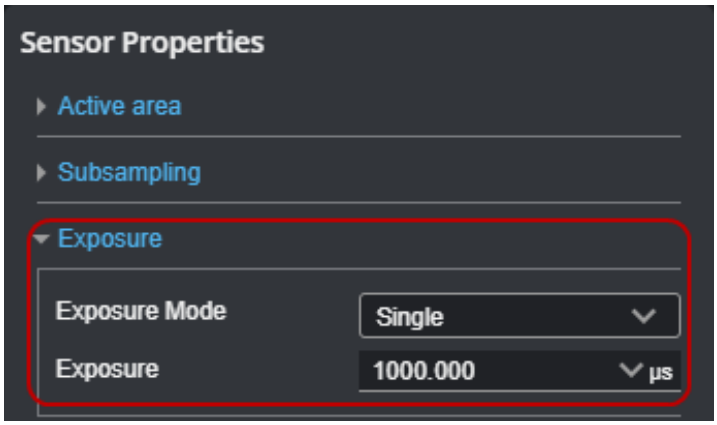
The recommended sensor warm-up time is 30 minutes with a 50% duty cycle.

*To perform sensor warm-up*

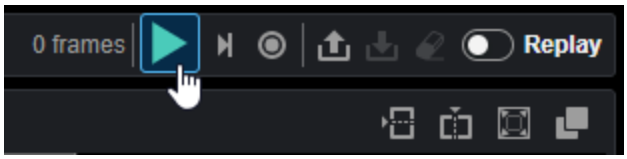
1. Under **Acquire** > **Scan**, expand **Trigger**, set **Source** to Time, and set **Frame Rate** to 500 Hz.



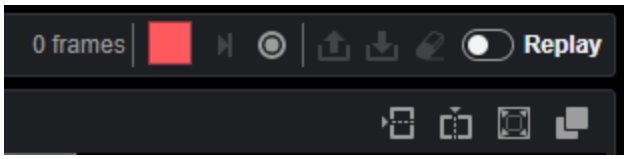

2. Under **Sensor Properties**, expand **Exposure** and set **Exposure mode** to Single and **Exposure** to 1000 µs.




3. Start the sensor.




The sensor starts running.




In general, it is recommended to use relative Z coordinate for measuring rather than absolute. In relative measuring the used Z height value is the difference to the reference, not an absolute Z value. This way the set up is less sensitive to any variation over time like vibration or ambient condition changes.

# Quick Start - Installation, Network & Sensor Setup

## Mounting

Sensors should be mounted using a model-dependent number of screws. Some models also provide the option to mount using bolts in through-body holes.

> ⚠ When mounting a sensor, ensure that the internal threads are not damaged from cross-threading, improper insertion of screws, or excessive torque. For the appropriate screw diameter and bolt hole diameter, pitch, and length, as well as recommended torque, see the sensor dimension drawings in *Specifications* on page 955.

Sensors should not be installed near objects that might occlude a camera's view of the projected light.

> ⚠ The sensor must be heat sunk through the frame it is mounted to. When a sensor is properly heat sunk, the difference between ambient temperature and the temperature reported in the sensor's health channel is less than 15° C.

> ⚠ Gocator sensors are high-accuracy devices. The temperature of all of its components must be in equilibrium. When the sensor is powered up, a warm-up time of at least one hour is required to reach a consistent spread of temperature within the sensor.

For more information on heat considerations, see *Environment and Lighting* on page 15.

## Grounding

Components of a sensor system should be properly grounded.

### Gocator

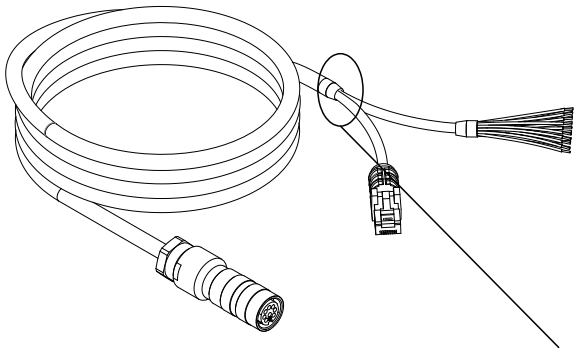
Gocator sensors should be grounded to the earth/chassis through their housings and through the grounding shield of the Power I/O cordset. Sensors have been designed to provide adequate grounding through their mounting screws. Always check grounding with a multi-meter to ensure electrical continuity between the mounting frame and the sensor's connectors.

> ☐ The frame or electrical cabinet that the sensor is mounted to must be connected to earth ground.

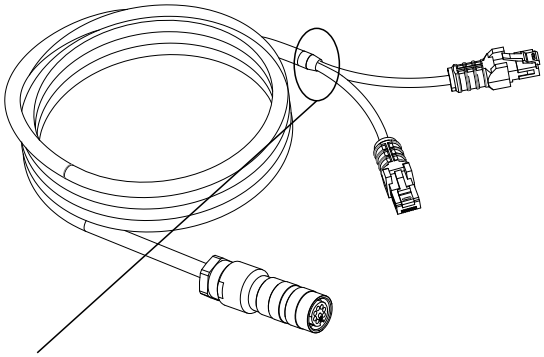
### Recommended Practices for Cordsets

If you need to minimize interference with other equipment, you can ground the Power & Ethernet or the Power & Ethernet to Master cordset (depending on which cordset you are using) by terminating the shield of the cordset before the split. The most effective grounding method is to use a 360-degree clamp.

CORDSET, POWER & ETHERNET, Xm



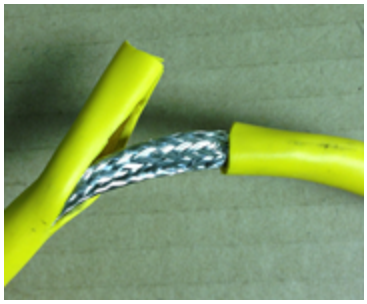
CORDSET, GOCATOR POWER & ETHERNET TO MASTER, Xm



Attach the 360-degree clamp before the split

*To terminate the cordset's shield:*

1. Expose the cordset's braided shield by cutting the plastic jacket before the point where the cordset splits.



2. Install a 360-degree ground clamp.

## Master Network Controllers

The rack mount brackets provided with all Masters are designed to provide adequate grounding through the use of star washers. Always check grounding with a multi-meter by ensuring electrical continuity between the mounting frame and RJ45 connectors on the front.

When using the rack mount brackets, you *must* connect the frame or electrical cabinet to which the Master is mounted to earth ground.

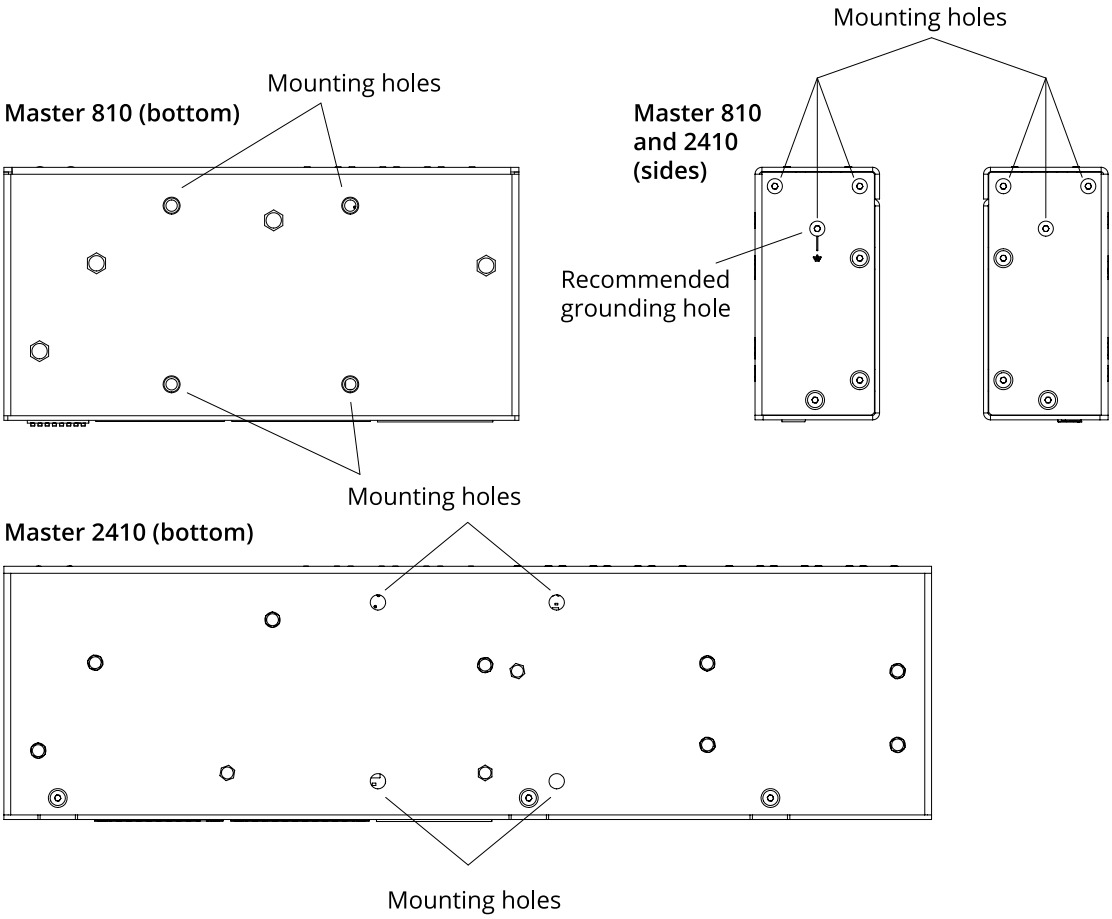
You *must* check electrical continuity between the mounting frame and RJ45 connectors on the front using a multi-meter.

If you are mounting Master 810 or 2410 using the provided DIN rail mount adapters, you must ground the Master directly; for more information, see *Grounding When Using a DIN Rail (Master 810/2410)* on the next page.

### Grounding When Using a DIN Rail (Master 810/2410)

If you are using DIN rail adapters instead of the rack mount brackets, you must ensure that the Master is properly grounded by connecting a ground cable to one of the holes indicated below. The holes on the bottom of the unit accept M4 screws. The holes on the sides of the unit accept M3 screws.

> You can use any of the holes shown below. However, LMI recommends using the holes indicated on the housing by a ground symbol.




An additional ground hole is provided on the rear of Master 810 and 2410 network controllers, indicated by a ground symbol.

## Additional Grounding Schemes

Potential differences and noise in a system caused by grounding issues can sometimes cause sensors to reset or otherwise behave erratically. If you experience such issues, see the *Gocator Grounding Guide* (https://downloads.lmi3d.com/gocator-grounding-guide) in the Download center for additional grounding schemes.

# Installing DIN Rail Clips: Master 810 or 2410

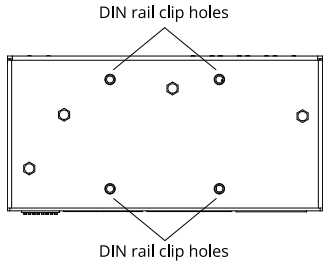
You can mount the Master 810 and 2410 using the included DIN rail mounting clips with M4x8 flat socket cap screws. The following DIN rail clips (DINM12-RC) are included:

Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

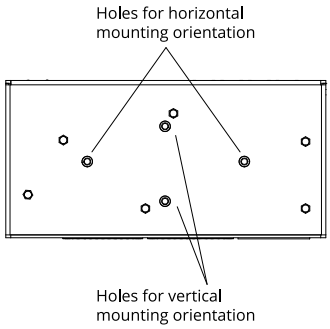
*To install the DIN rail clips:*

1. Remove the 1U rack mount brackets.
2. Locate the DIN rail mounting holes on the back of the Master (see below).

   Master 810:

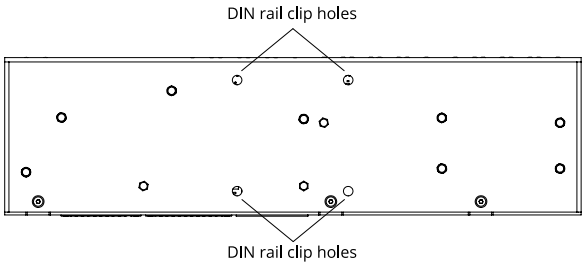



*Current revision*

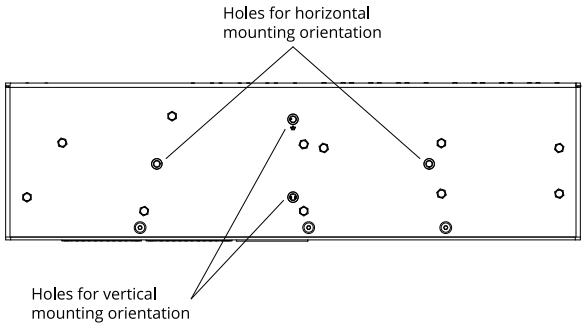



*Older revision*

   Master 2410:



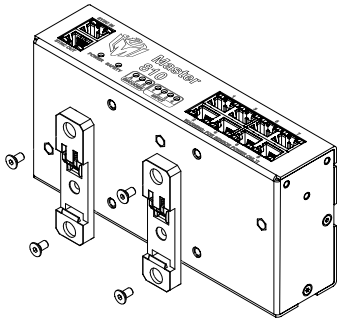

*Current revision*




*Older revision*

3. Attach the two DIN rail mount clips to the back of the Master using two M4x8 flat socket cap screws for each one.

   The following illustration shows the installation of clips on a Master 810 (current revision) for horizontal mounting:



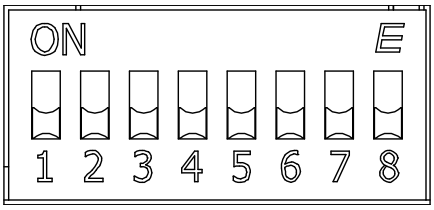
| | |
|---|---|
| | Ensure that there is enough clearance around the Master for cabling. |

# Configuring Master 810

If you are using Master 810 with an encoder that runs at a quadrature frequency higher than 300 kHz, you must use the device's divider DIP switches to limit the incoming frequency to 300 kHz.

| | |
|---|---|
| | Master 810 supports up to a maximum incoming encoder quadrature frequency of 6.5 MHz. |

The DIP switches are located on the rear of the device.




Switches 5 to 8 are reserved for future use.

This section describes how to set the DIP switches on Master 810 to do the following:

- Set the divider so that the quadrature frequency of the connected encoder is compatible with the Master.
- Set the debounce period to accommodate faster encoders.

## Setting the Divider

To set the divider, you use switches 1 to 3. To determine which divider to use, use the following formula:

*Output Quadrature Frequency = Input Quadrature Frequency / Divider*

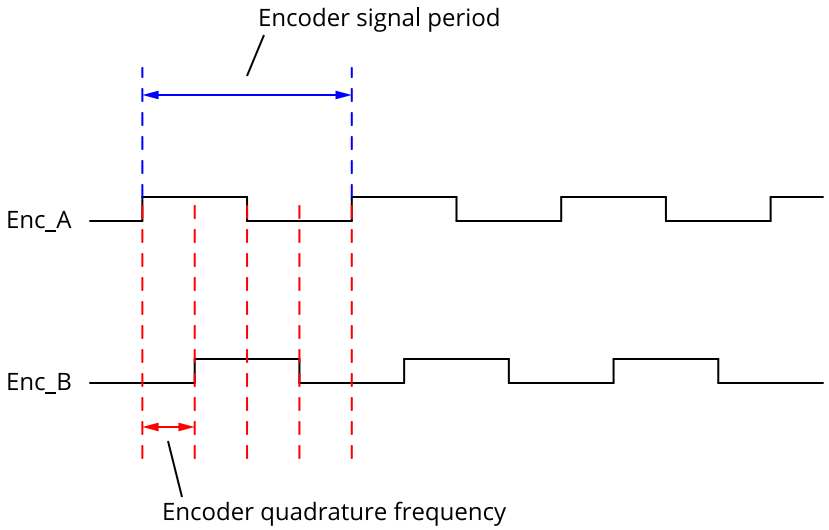
In the formula, use the *quadrature frequency* of the encoder (for more information, see *Encoder Quadrature Frequency* below) and a divider from the following table so that the Output Quadrature Frequency is no more than 300 kHz.

| Divider | Switch 1 | Switch 2 | Switch 3 |
|---|---|---|---|
| 1 | OFF | OFF | OFF |
| 2 | ON | OFF | OFF |
| 4 | OFF | ON | OFF |
| 8 | ON | ON | OFF |
| 16 | OFF | OFF | ON |
| 32 | ON | OFF | ON |
| 64 | OFF | ON | ON |
| 128 | ON | ON | ON |

The divider works on debounced encoder signals. For more information, see *Setting the Debounce Period* on the next page.

### Encoder Quadrature Frequency

Encoder quadrature frequency is defined as illustrated in the following diagram. It is the frequency of encoder ticks. This may also be referred as the native encoder rate.




You must use a quadrature frequency when determining which divider to use (see *Setting the Divider* on the previous page). Consult the datasheet of the encoder you are using to determine its quadrature frequency.

> Some encoders may be specified in terms of encoder signal frequency (or period). In this case, convert the signal frequency to quadrature frequency by multiplying the signal frequency by 4.

### Setting the Debounce Period

If the quadrature frequency of the encoder you are using is greater than 3 MHz, you must set the debounce period to “short.” Otherwise, set the debounce period to “long.”

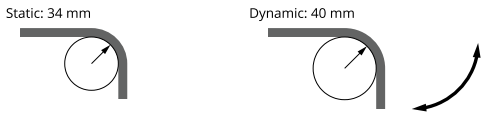
You use switch 4 to set the debounce period.

| Debounce period | Switch 4 |
|---|---|
| short debounce | ON |
| long debounce | OFF |

## Cordset Bend Radius Limits

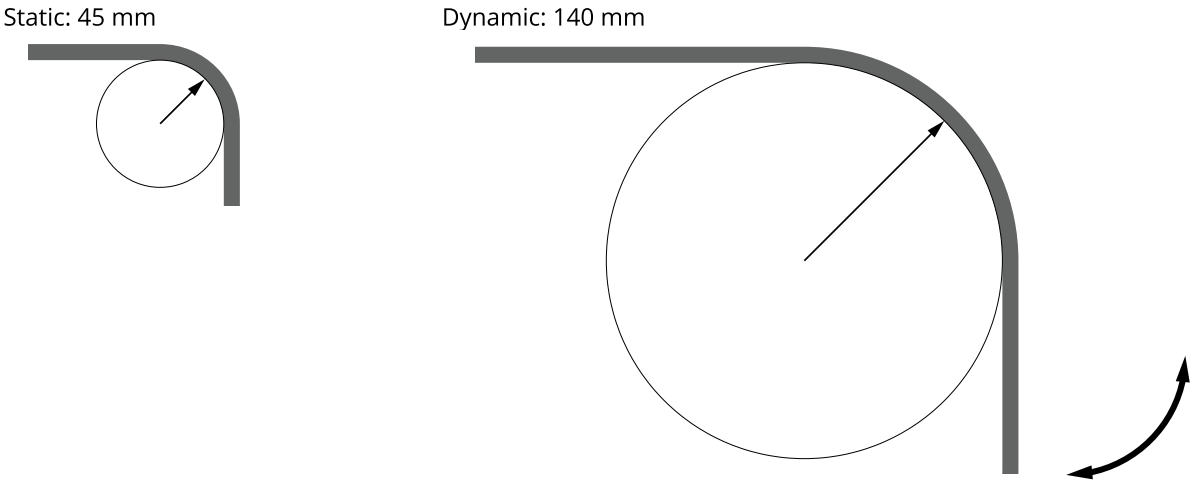
With high flex cordsets of lengths 25 meters and lower, limit bends as follows:

- In installations where a cordset does not bend continuously, limit bending to the static bend radius of 34 mm.
- In installations where a cordset bends continuously, limit bending to the dynamic bend radius of 40 mm.



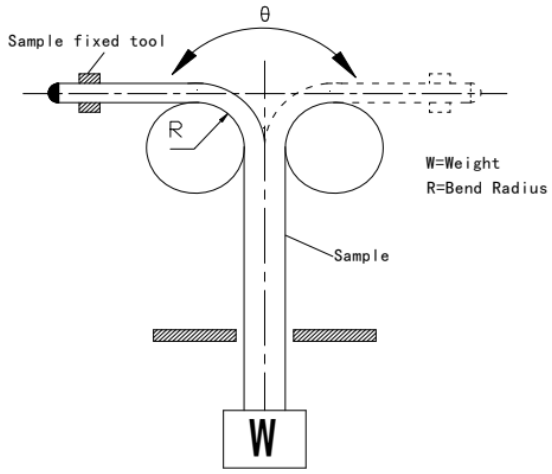

*High flex cordset bend radius limits*

Custom cordsets between 25 and 60 meters (the maximum length available) have a static bend radius limit of 45 mm and a dynamic limit of 140 mm.

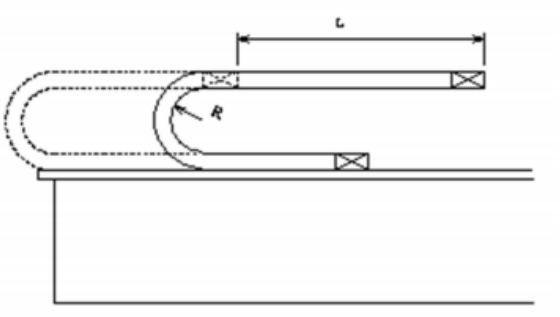



*Standard cordset bend radius limits*

High flex cordsets are rated for a minimum of 2 million 90° Tick Tock bends and 7 million U-shaped bends, both at the dynamic bend radius limit of 40 mm. The following illustrations show the test setups used to determine the number of bends in high flex cordsets.




*Tick-tock test setup (θ = 180°)*




*U-shape test setup (L = 500 mm).*

For cordset part numbers, see *Accessories* on page 995.

| | |
|---|---|
| | Standard (non high flex) cordsets, which are no longer available, have a static bend radius limit of 45 mm and a dynamic limit of 140 mm. Standard cordsets are rated for a minimum of 2 million 90° Tick Tock bends. |

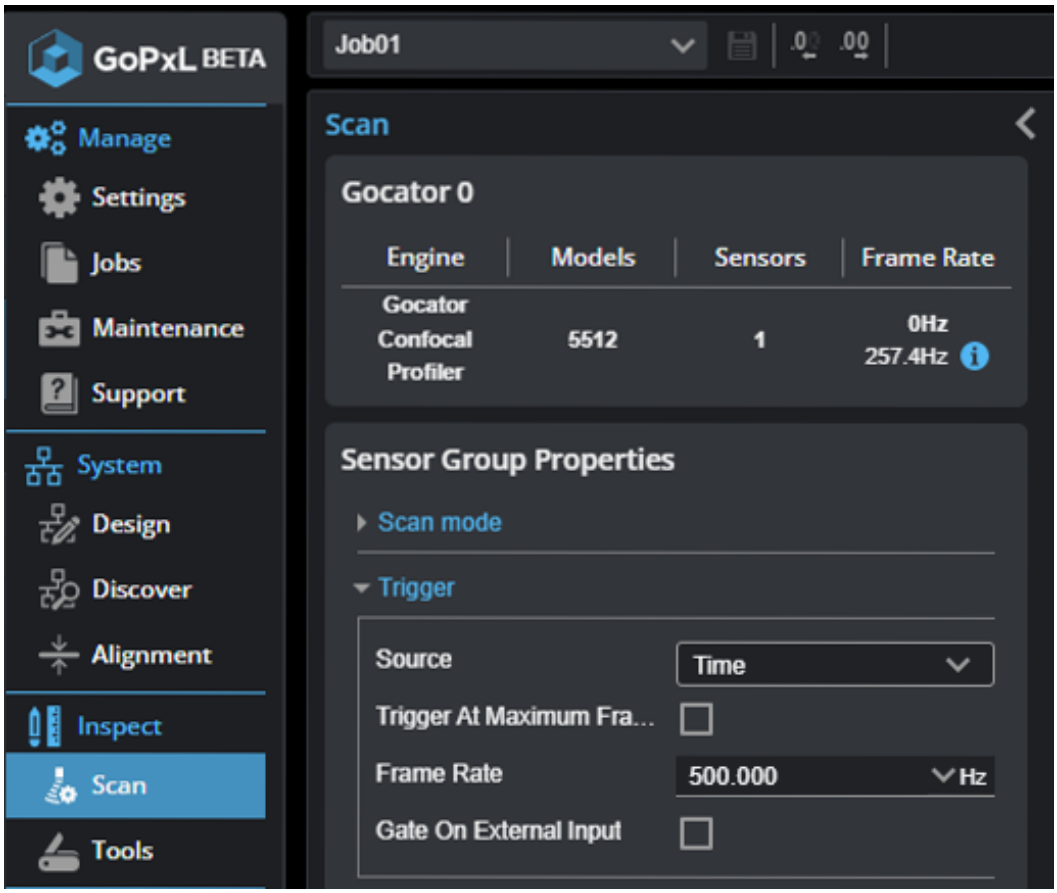
# Warm-up Procedure

LMI recommends warming up the sensor before acquiring data to stabilize the sensor's capability to measure absolute Z coordinates. During the sensor's warm-up procedure, there is a small variation on the absolute Z height on which the sensor sees the target surface.

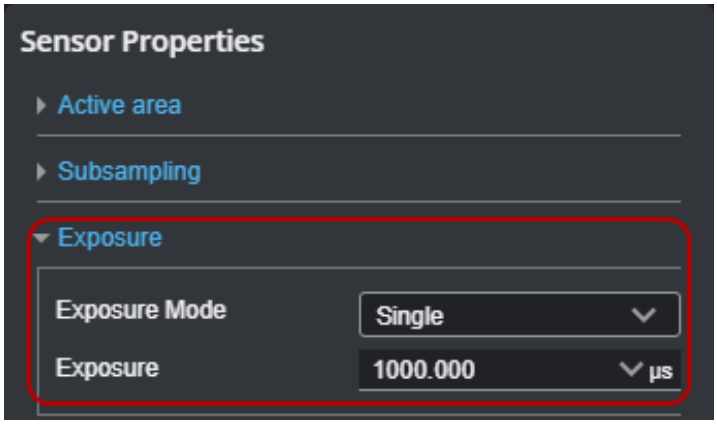
The recommended sensor warm-up time is 30 minutes with a 50% duty cycle.

*To perform sensor warm-up*

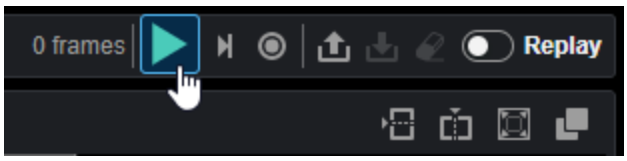
1. Under **Acquire** > **Scan**, expand **Trigger**, set **Source** to Time, and set **Frame Rate** to 500 Hz.



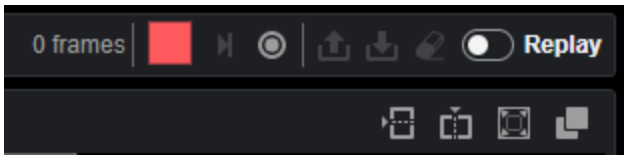

2. Under **Sensor Properties**, expand **Exposure** and set **Exposure mode** to Single and **Exposure** to 1000 µs.




3. Start the sensor.




The sensor starts running.




In general, it is recommended to use relative Z coordinate for measuring rather than absolute. In relative measuring the used Z height value is the difference to the reference, not an absolute Z value. This way the set up is less sensitive to any variation over time like vibration or ambient condition changes.

## Required Ports

The table below lists the ports used by the following:

- sensors
- the Ethernet-based protocols
- the SDK and the REST API
- PC instances of GoPxL

Use this information to decide whether you or your network administrator needs to open network ports and to understand the traffic that a sensor system will produce over a network.

*Ports used by GoPxL*

| Port | Data Packet Protocol | Description |
|---|---|---|
| 80 | TCP | GoPxL web port for GoPxL GUI.<br>**Sensors and GoMax NX**: All devices use this port.<br>**For GoPxL running on a PC**: Use port 8100; for more information, see below. |
| 502 | TCP | Used by the GoPxL Modbus protocol as the listener port. |
| 2222 | UDP | Used by the EtherNet/IP protocol for implicit messaging. |
| 3192 | TCP | FireSync physical sensor upgrade port. |
| 3194 | TCP | FireSync physical sensor health port. |
| 3320 | UDP | GoPxL discovery protocol server listener port |
| 3500 | UDP | GoPxL Remote Procedure Call port. |
| 3600 | TCP | GoPxL control port.<br>**Physical sensors and GoMax NX**: All devices use this port.<br>**GoPxL running on a PC**: By default, the first PC instance starts at this port number, and subsequent instances are offset (for example, 3600, 3620, and so on). You can set custom values in GoPxL Manager. For more information, see *Running GoPxL on a Windows PC* on page 814. |
| 3601 | TCP | Gocator Data Protocol (GDP) port.<br>**Physical sensors and GoMax NX**: All devices use this port.<br>**GoPxL running on a PC**: This port is offset from the control port by |

| Port | Data Packet Protocol | Description |
|---|---|---|
| | | +1 (for example, 3601, 3621, and so on). |
| 8080 | TCP | Default accelerated sensor web server port number. |
| 8100 | | GoPxL web port for GoPxL GUI for PC instances of GoPxL. (Sensors and GoMax NX units use port 80.)<br>By default, the first PC instance starts at this port number, and subsequent instances are offset (for example, 8100, 8120, and so on). You can set custom values in GoPxL Manager. For more information, see *Running GoPxL on a Windows PC* on page 814. |
| 8190 | TCP | Used by GoPxL Ethernet for default ASCII control, data, and health port. Actual ports can be configured by the user. |
| 44818 | TCP and UDP | Used by the GoPxL EtherNet/IP protocol as a UDP and TCP listener port for explicit messaging. |

# Key Concepts

The following sections provide an overview of how devices acquire and produce data, detect and measure parts, and control devices such as PLCs. Some of these concepts are important for understanding how you should mount sensors and configure settings such as active area.

> You can use the PC-based version of GoPxL to speed up the processing of data.

## Sensors, Sensor Groups, and Systems

In GoPxL, the term *sensor* refers to a single device. A *sensor group* contains two or more sensors of the same model. The term "system" refers to the sensor or sensor groups as a whole. Currently GoPxL only supports a single sensor group in a system.

> In this document, we will use the term multi-sensor to describe systems with *two* or more sensors.

In a multi-sensor system, one sensor controls the other sensors, and combines the scan data of the individual sensors. So for example, in a multi-sensor G2 system, the profiles from the individual sensors are combined into a single, wider profile.

> In Gocator Classic, we use the terms "buddy" or "buddying" to refer to the controlled sensors in a sensor group.

Sensors and sensor groups also have an associated "scan engine." For example, when designing a sensor system containing one or more Gocator 5500 series sensors, the associated scan engine is "Gocator Confocal Profiler," with acquisition settings specific to that family of sensors.

> You may still see the term "scanner" in the GoPxL UI, SDK, and REST API. "Scanner" is equivalent to "sensor group."

## 3D Acquisition

After a sensor system has been set up and is running, it is ready to start capturing 3D data.

> Gocator sensors are always pre-calibrated to deliver 3D data in engineering units (mm) throughout their measurement range.

## Multilayer Output

Confocal profile sensors can produce multilayer data when scanning transparent or translucent targets such as glass or plastic. Multi-layer output is only supported if you have enabled uniform spacing (for more information, see *Uniform Data and Point Cloud Data* on page 42). Layers can be Profile or Surface data. You can choose to generate up to eight layers. To perform measurements on

the layers, you use the Array Index tool to select which layer's profile to extract, and then use those extracted profiles as inputs in other measurement tools. For example, to measure the thickness of two layers in scan data, after extracting the layer profiles, you could use the Profile Thickness tool to measure the thickness that those layers represent.

For more information on Array tools, see *Array Tools* on page 671.

For more information on the Profile Thickness tool, see *Profile Thickness* on page 343.

# Profile Output

Gocator sensors represent a profile as a series of ranges, with each range representing the distance from the origin. Each range contains a height (on the Z axis) and a position (on the X axis) in the sensor's field of view.

## Coordinate Systems

Data points are reported in one of two coordinate systems, which depends on the alignment state of the sensor.

- **Unaligned (sensor) coordinates**: Used on unaligned sensors.
- **Aligned (system) coordinates**: Used on aligned sensors.

Understanding coordinate systems is an important part of understanding measurement results. These coordinate systems are described below. For information describing the orientation of the axes used by your sensor, see *Sensors* on page 956.

### Unaligned Coordinates

Unaligned sensors use *sensor* coordinates, that is, the coordinate system is relative to the sensor itself. The measurement range (MR) is along the Z axis. The sensor’s field of view (FOV) is along the X axis. Most importantly, the origin is at the *center* of the measurement range and field of view, in other words, the center of the scan area.

The Y axis represents the relative position of the target part in the direction of travel. Y position increases as the target moves forward (increasing encoder position). Typically, the direction of travel of the target is opposite the sensor's positive Y axis. If it isn't (due to the orientation of the sensor's mounting), you need to configure the sensor's orientation to be "reversed." For more information, see *Connect - Creating a System & Networking* on page 92.

### Aligned Coordinates

Understanding aligned coordinates is important for two reasons. First, they are the direct result of performing the built-in alignment procedure. Second, they change how scan data is represented and how measurement results should be interpreted. For more information on aligning sensors, see *Aligning Sensors* on page 98.

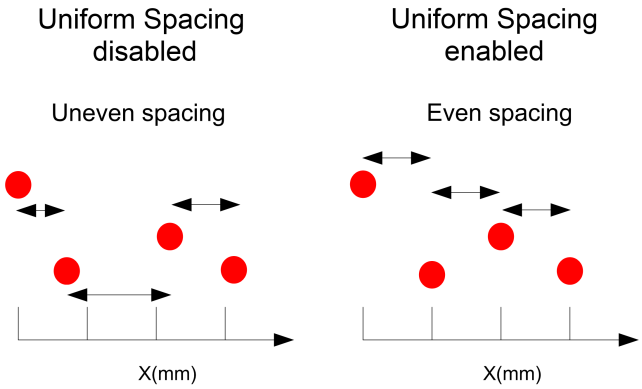
The adjustments resulting from alignment are called *transformations* (offsets along the axes and rotations around the axes). Transformations are displayed on the **Acquire** page, in the **Sensor Properties** section, under **Transform**. Note that currently, you can ignore Sensor Group Transforms, which represent the transformations between *groups* of sensors; support for this will be available in future versions of the sensor software.  For more information on transformations in the web interface, see *Transformations* on page 109.

In aligned coordinates, the X axis is parallel to the alignment target surface. The system Z origin is set to the base of the alignment target object. In both cases, alignment determines the offsets in X and Z.

### Uniform Data and Point Cloud Data

The data that a sensor produces in Profile mode is available in two formats: as uniform (resampled) data and as point cloud data (previously called "raw"). The sensor produces uniform data when the **Enable uniform spacing** option is enabled. The sensor produces point cloud data when the option is disabled. The setting is available in **Scan Mode**, on the **Acquire** page.

When **Enable uniform spacing**is enabled, the ranges that make up a profile are resampled so that the spacing is uniform along the X axis. The resampling divides the X axis into fixed size "bins." Profile points that fall into the same bin are combined into a single range value (Z). You can set the size of the spacing interval.




Resampling to uniform spacing reduces the complexity for downstream algorithms to process the profile data from the sensor, but places a higher processing load on the sensor's CPU.

When uniform spacing is not enabled, no processing is required on the sensor. This frees up processing resources in the sensor, but usually requires more complicated processing on the client side. Ranges in this case are reported in (X, Z) coordinate pairs.

A drawback of uniform spacing is that if sensors are angled to scan the sides of a target, data on the "verticals" is lost because points falling in the same "bin" are combined. When **Enable uniform spacing** is disabled, however, all points are preserved on the sides. In this case, the data can be processed by the subset of tools that work on profiles without uniform spacing. Alternatively, the data can be processed externally using the SDK.

For information on enabling uniform spacing, see *Scan Modes and Intensity* on page 111.

## Data Generation and Processing

After scanning a target, a sensor can process the scan data to allow the use of more sophisticated measurement tools. This section describes the following concepts:

- Surface generation
- Part detection
- Sectioning

## Surface Generation

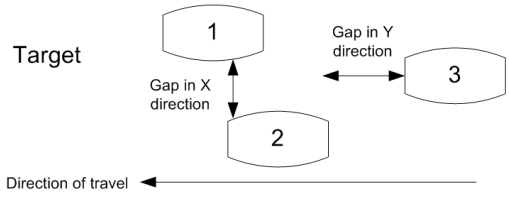
Profile sensors create a single profile with each exposure. GoPxL can combine the series of profiles gathered as a target moves under the sensor to generate Surface data of the entire target.

For more information, see *Surface Generation* on page 113.

## Part Detection

After a sensor has generated surface data by combining single exposures, GoPxL can isolate discrete parts on the generated surface into separate scans representing parts using the Profile Part Detection tool. For more information, see Continuous in *Surface Generation* on page 113.

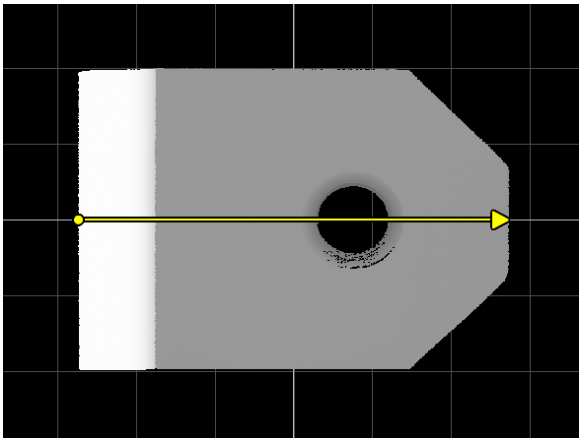
Gocator can then perform measurements on these isolated parts.




Part detection is useful when measurements on individual parts are needed and for robotic pick and place applications.

## Sectioning

In Surface mode, the sensor can also extract a profile from a surface or part using a line you define on that surface or part. The resulting profile is called a “section.” A section can have any orientation on the surface, but its profile is parallel to the Z axis.



You can use most of Gocator's profile measurement tools on a section, letting you perform measurements that are not possible with surface measurement tools.

For more information on sections, see *Surface Section* on page 562.

# Part Matching

The sensor can match scanned parts to the edges of a model based on a previously scanned part using the Surface Pattern Matching tool (for more information, see *Surface Pattern Matching* on

page 533) or to the dimensions of a fitted bounding box that encapsulates the part data (for more information see *Surface Bounding Box* on page 410). When parts match, the sensor can rotate scans so that they are all oriented in the same way, using Surface Transform (for more information, see *Surface Transform* on page 606). This allows measurement tools to be applied consistently to parts, regardless of the orientation of the part you are trying to match.

## Measurement and Anchoring

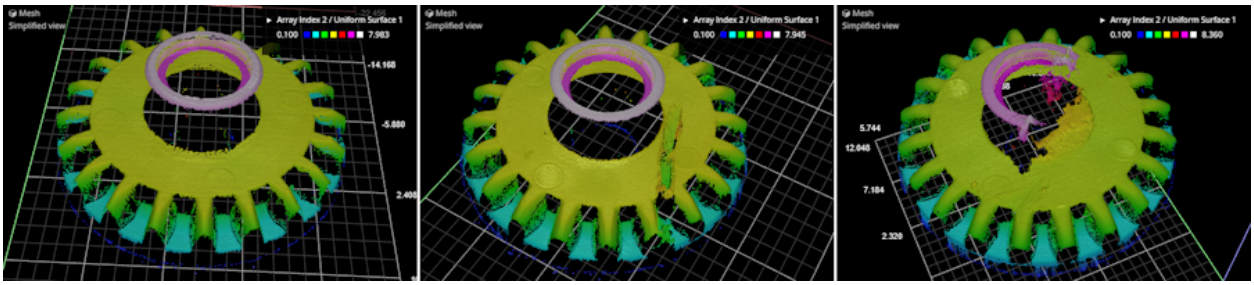
After GoPxL scans a target and, optionally, further processes the data, the sensor is ready to take measurements on the scan data.

GoPxL provides dozens of measurement tools, each of which provides a set of individual measurements, giving you dozens of measurements ideal for a wide variety of applications to choose from. The configured measurements start returning pass/fail decisions, as well as the actual measured values, which are then sent over the enabled outputs to control devices such as PLCs, which can in turn control ejection or sorting mechanisms. (For more information on measurements and configuring measurements, see *Inspect - Measurement and Processing* on page 147.

A part's position can vary on a transport system. To compensate for this variation, Gocator can anchor a measurement to the positional measurement (X, Y, or Z) or Z angle of an easily detectable feature, such as the edge of a part. The calculated offset between the two ensures that the anchored measurement will always be properly positioned on different parts. For more information, see *Measurement Anchoring* on page 193.

## Complex Defect Detection

Many applications rely on more easily quantified differences part to part, such as a simple pass / fail of the height of a feature on a part. In other cases, flaws or defects are much more random and difficult to characterize so simply: a part or material can be damaged or malformed anywhere on its surface. For example, the following images show scan data of a good part, and two defective parts:



GoPxL Anomaly Detector, an AI-based toolset, lets you train a model on representative good ("OK") and bad ("NG") frames of acquired data. After, when the device scans parts in production, the tool uses the trained model in its inference engine to classify the new scan data as either OK or NG, resulting in flexible defect detection. It is also possible to refine the model with other representative frames later on, and even produce simulated variations and flaws / defects to further improve the model's accuracy. For more information, see *Surface Anomaly Detector* on page 354.

# Tool Chaining

GoPxL's measurement and processing tools can be linked together: one tool uses another tool's output as input. This gives you a great deal of control and flexibility when it comes to implementing your application.

The following sections describe the types of output and how you use them as input.

## Tool Data

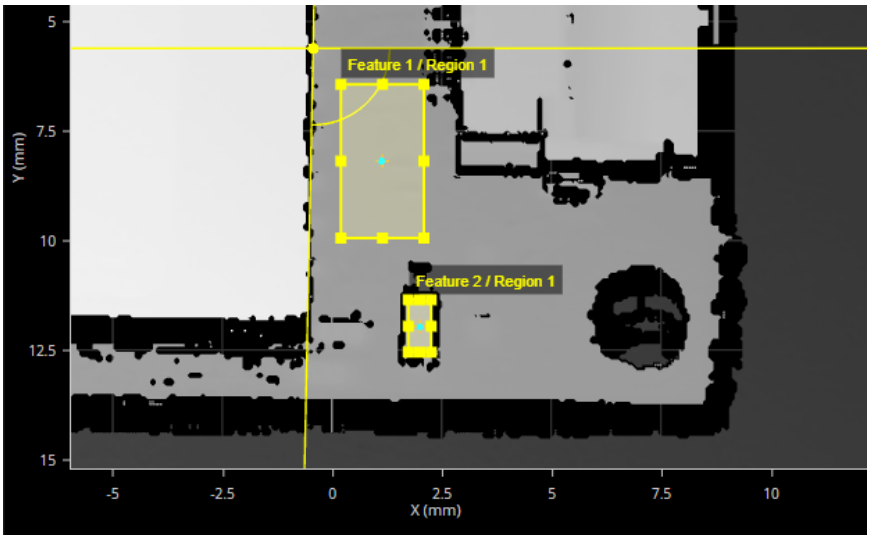
Most measurement and processing tools can output Profile or Surface data, which can be used as input by other tools or SDK applications.

Profile and Surface data produced by a tool is identical in nature to the data produced by a sensor scan, except that they are the processed result from a tool. This kind of data can be used as input in compatible tools. Examples of this kind of this kind of data are the Stitched Surface output from the Surface Stitch tool, or the Filtered Surface output from the Surface Filter tool. Another important kind of data is the Transformed Surface produced by the Surface Transform tool, which transforms (shifting or rotating on the X, Y, and Z axes) the sensor's scan data; the Surface Transform tool supports a full 6 degrees of freedom. For more information, see *Surface Transform* on page 606.

## Anchoring Measurements

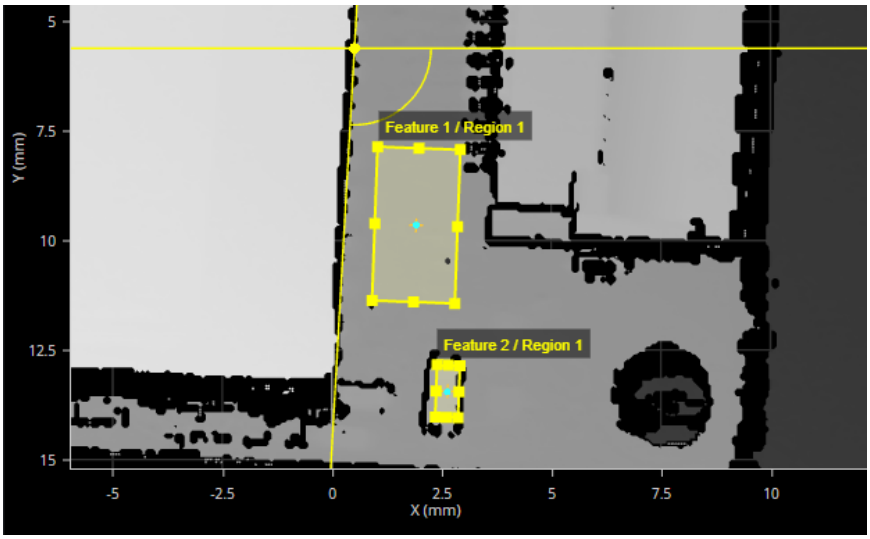
Tools can use the positional measurements (X, Y, or Z) of other tools as anchors to compensate for minor shifts of parts: anchored tools are "locked" to the positional measurements of the anchoring tool's measurements. Some tools can also use a Z Angle measurement as an anchor. Typically, you will use measurements from more easily found features on a target—such as an edge or a hole—as anchors to accurately place other positional and dimensional measurements. This can help improve repeatability and accuracy in the anchored tools. Note that anchoring measurements are used to calculate the offsets of the anchored tools: the results from these measurements are not used as part of the anchored tool's measurements.

Anchoring measurements are rendered as overlays on a tool's input data.

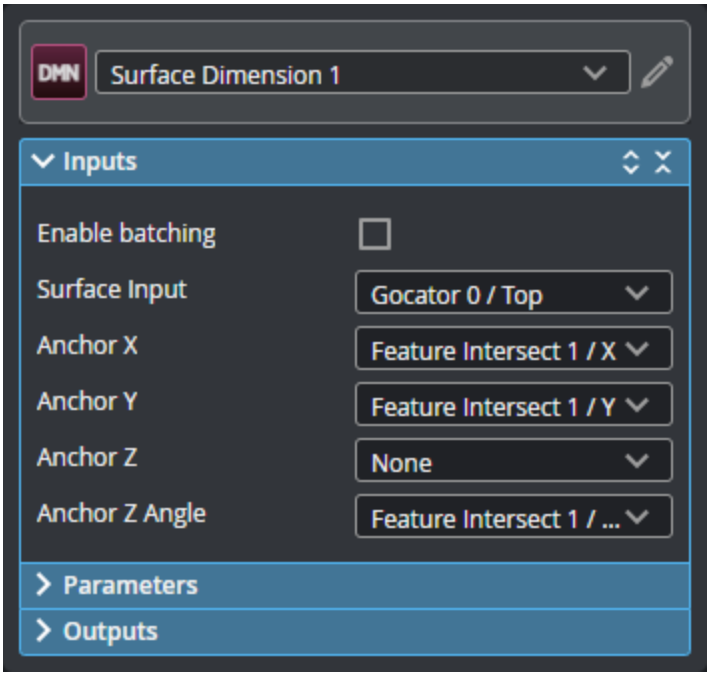



*The height of a small PCB component (Feature 2) relative to nearby surface (Feature 1), anchored to positional (X and Y) measurements of the hole (lower right) and to the Z angle of the edge of a larger component to the left.*

In the following, the part has rotated, but the tool's measurement regions follow the features, ensuring correct measurement.



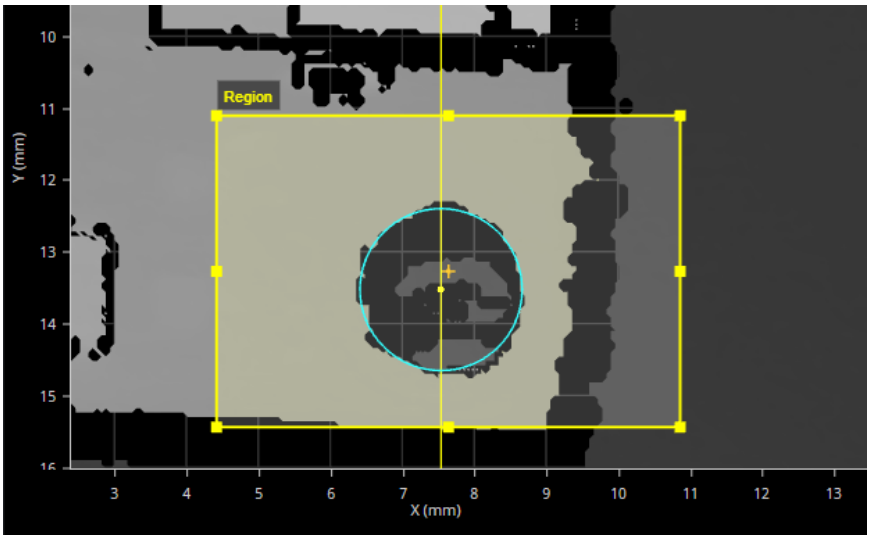

You enable anchoring in the expandable **Inputs** section of a tool:




## Geometric Features

Many of GoPxL's measurement tools can output data structures such as points, lines, planes, and circles. These structures are called geometric features and contain the components you would expect: a point geometric feature contains X, Y, and Z components (representing the location of the point in 3D space). Examples of point geometric features output by Gocator's measurement tools are hole center points, the tip and base of studs, or a position on a surface.

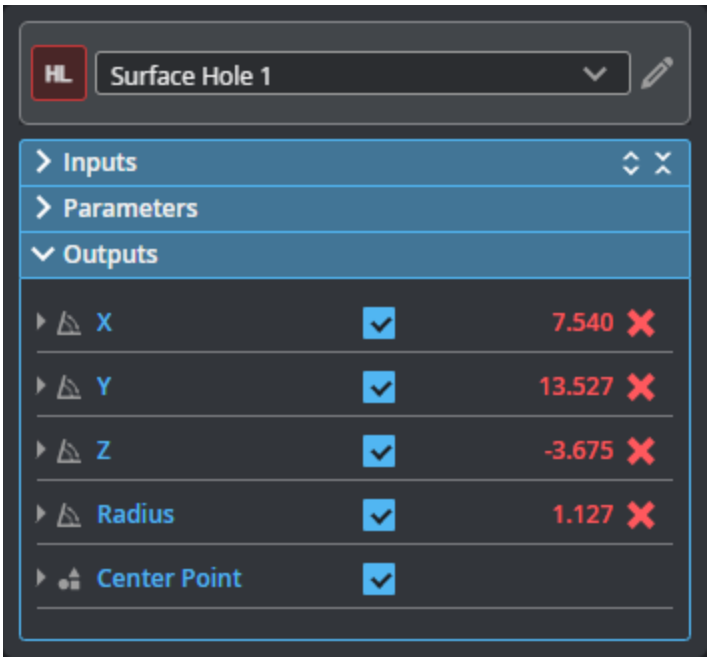
Geometric features are rendered as overlays on a tool's input data.



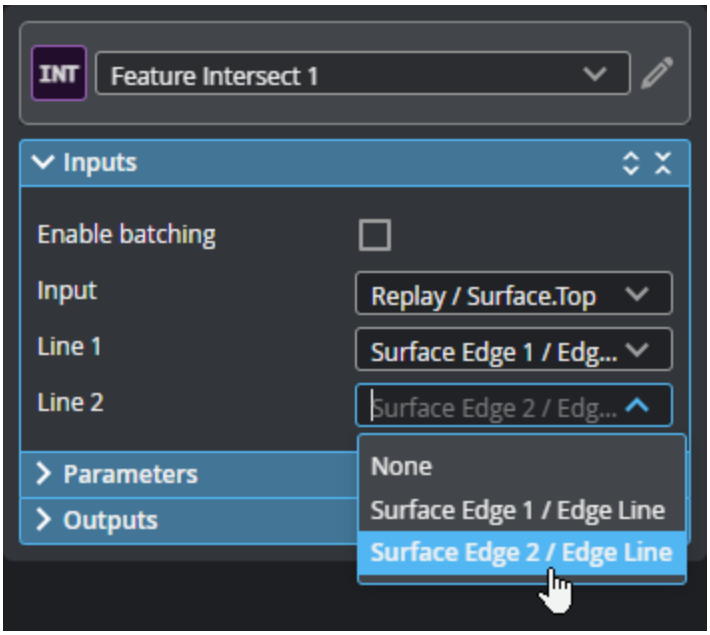

*Point geometric feature (a hole's Center Point) rendered on a tool's input as a small yellow circle*

Gocator's "Feature" tools (such as Feature Dimension and Feature Intersect) use geometric features as inputs. For example, because the point geometric feature representing the center of a hole has X, Y, and Z components, you can perform dimensional measurements between it and another geometric feature, such as another hole or an edge. The Feature Create tool takes one or more geometric features as input and generates *new* geometric features (for example, creating a line from two point geometric features). You can then perform measurements on those features directly in the tool or in other Feature measurement tools. You can also use angle measurements on the newly created features for anchoring. For more information on Feature tools, see *Feature Measurement* on page 626.

You enable geometric feature *outputs* in a tool's expandable **Outputs** section:

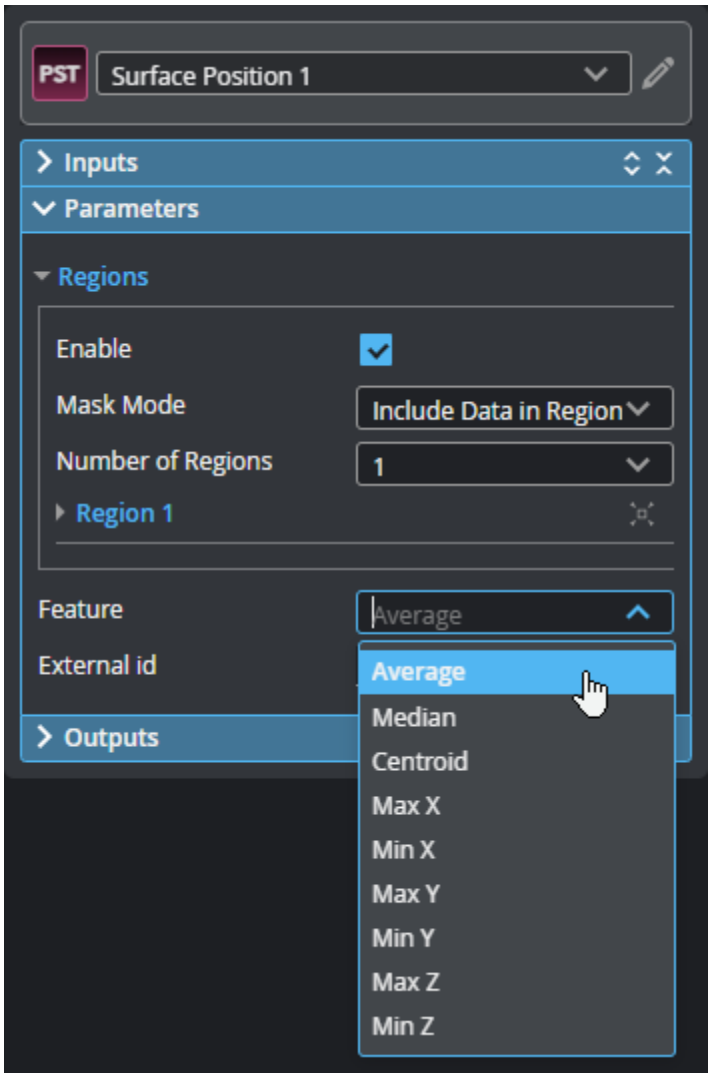



You enable geometric feature *inputs* in a tool's expandable **Inputs** section:




*Setting the Line inputs to two different lines to compute their intersection*

Geometric features are distinct from the “feature points” used by certain tools to determine which data point in a region should be used in a measurement, for example, the maximum versus the minimum on the Z axis of a data point in a region of interest:



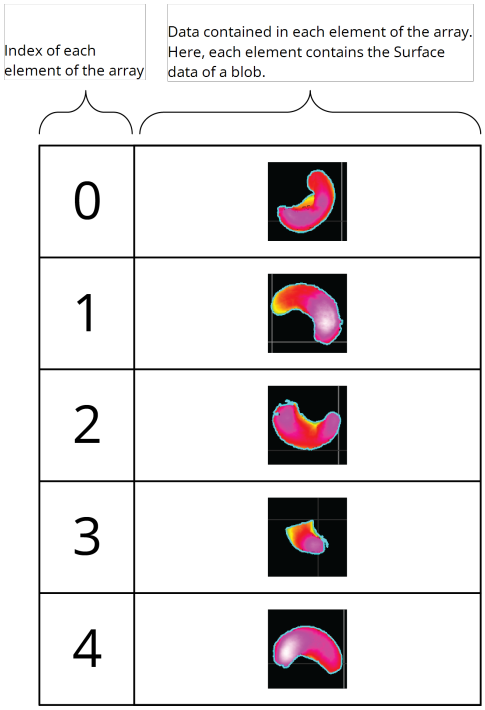

For more information on feature points, see *Feature Points* on page 188.

## Arrays, Batching, and Aggregation

GoPxL supports data structures called arrays to help simplify otherwise complicated applications.

An array is a group of data items bundled into a single structure, such as multiple profiles or surfaces, multiple measurements, or multiple features.

For example, the individual parts in a frame of scan data can be isolated and stored in an array. Each part's scan data occupies on element of the array. Note that arrays start at 0. That is, they use zero-based indexing.




Each item, or element, in the array can be processed by other tools in one of two ways:

- Batching: Tools in batching mode process each array element in an array input separately.
- Aggregating: Aggregating tools combine each element in an array output and process it as a single piece of data.

For more information, see *Arrays, Batching, and Aggregation* on page 171.

## Output and Control

After the sensor has scanned and measured parts, the last step in the operation flow is to output the results.

One of the main functions of GoPxL is to produce pass/fail decisions, and then control something based on that decision. Typically, this involves rejecting a part through an eject gate, but it can also involve making decisions on good, but different, parts. Currently, GoPxL can communicate using the following over Ethernet:

- With PLCs (programmable logic controllers) using industry-standard protocols (EtherNet/IP, Modbus, PROFINET, and ASCII)
- With digital devices (such as ejector chutes or stack lights)
- With the GoPxL SDK and REST API, using the Gocator Communication Protocol

An important concept is digital output tracking. Production lines can place an ejection or sorting mechanism at different distances from where the sensor scans the target. For this reason, GoPxL lets you schedule a delayed decision over the digital interfaces. Because the conveyor system on a typical production line will use an encoder or have a known, constant speed, targets can effectively be “tracked” or "tagged." The sensor will know when a defective part has traveled far enough and trigger a PLC, for example, to activate an ejection/sorting mechanism at the correct moment.

For more information on configuring control, see *Communicate - PLC, Digital, GDP, HMI* on page 732.

For more information on the GoPxL SDK and REST API, see *GoPxL SDK and REST API* on page 863.

# Accelerating Sensors

For performance-critical applications, you can run a sensor through a PC instance of GoPxL or through a GoMax NX, ORIN, or ORIN+ device. LMI *STRONGLY* recommends running confocal sensors through a PC or GoMax NX. Note that for confocal sensors, LMI has only tested single-layer scanning with GoMax NX. For more information on running GoPxL through a PC, see *Running GoPxL on a Windows PC* on page 814.

# User Interface Overview

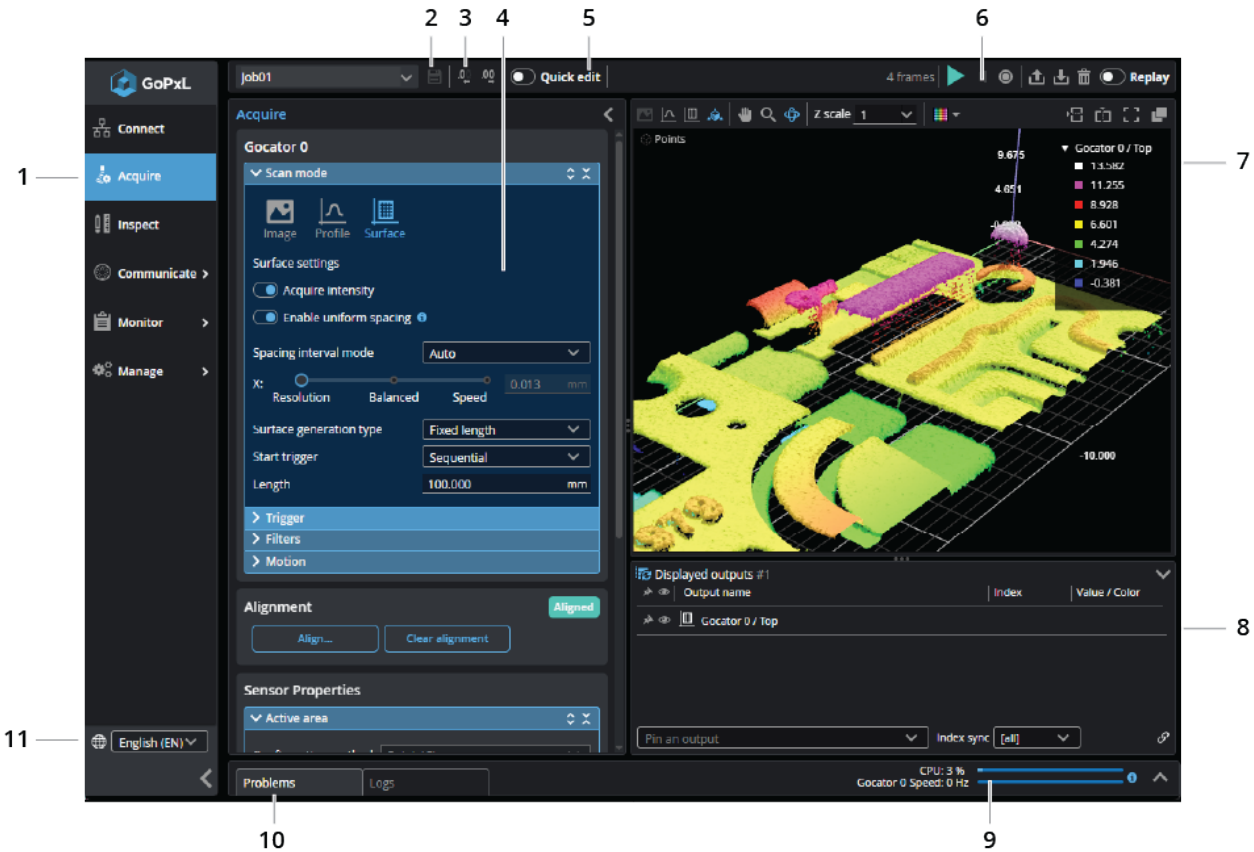
You configure sensors using GoPxL by connecting to an IP address with a web browser.

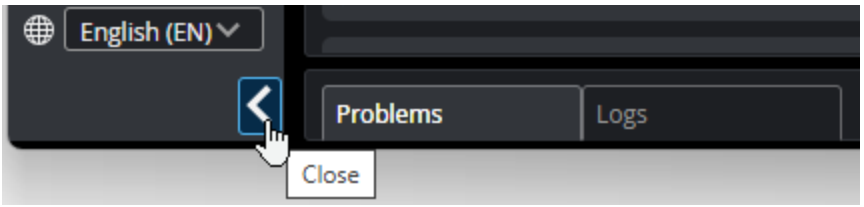
If you are running GoPxL on-sensor, in the browser, you connect to the IP address of the sensor. By default, the IP address of Gocator sensors is 192.168.1.10.

If you are running the Windows-based GoPxL application (to accelerate the sensor on a PC or view previously recorded scans), in the browser, by default you connect to the localhost address (127.0.0.1). For more information on running GoPxL on a PC, see *Running GoPxL on a Windows PC* on page 814.

GoPxL provides categories in a vertical navigation bar on the left of the interface that group similar functions together in pages. Each page contains one or more panels that further categorize functionality. Generally speaking, the order of the categories and the pages reflects the workflow involved in configuring systems for an application for the first time, from the top down.

> Some UI screenshots in this manual may not depict the latest version of GoPxL. These screenshots will be updated soon.



| | Element | Description |
|---|---|---|
| 1 | Navigation bar | The navigation bar (sometimes called the "nav" bar) along the far left of the user interface displays categories (for example, from the top, **Connect**, **Acquire**, **Inspect**, and so on) that contain related settings. Some categories contain sub-pages (for example, the **Manage** category contains the **Settings** and **Jobs** pages, among others). Each page contains one or more panels. The category and page currently selected in the navigation bar are highlighted.<br>By default, the navigation bar is open and shows the category, as well as the page names and icons. To close the navigation bar, click the Close button at the lower left of the interface.<br>  <br>For information on the categories and what you can do with the pages they contain, see *What you can do in the categories* on the next page. |
| 2 | Job-related functions | These controls let you work with jobs, for example, creating and saving jobs. For more information on jobs, see *Jobs* on page 805. |
| 3 | Decimal places | Use the decimal places buttons to control how values are displayed throughout the interface. The values displayed in the interface are rounded to the chosen number of data places, but internally all decimal places are used.<br>Click to decrease the number of decimal places, down to zero decimal places.<br>Click to increase precision, up to six decimal places. |
| 4 | Configuration area | This area contains the configurations of the selected page and panel. When configuring tools, an additional **Tools Configuration** panel lets you configure a tool's parameters. |
| 5 | Quick Edit | When working with a very large number of measurement tools (for example, a few dozen) or a very complex tool (built-in or user-created GDK tool), you can enable Quick Edit mode to make configuration faster, as the data viewer is not refreshed after each setting change. You should enable this setting if changing parameters feels sluggish. It is important to disable this mode after you have finished making parameter changes to save the changes. |
| 6 | Global controls | These controls let you start and stop acquisition, and also work with replay data.<br>For information on starting and stopping acquisition, see *Starting, Stopping, and Recording* on page 88.<br>For information on working with replay data, including adding and removing frames of replay data, see *Playing Back Recorded Data* on page 90. |
| 7 | Data viewer | The data viewer (sometimes called the data visualizer) displays scan data, |

| | Element | Description |
|---|---|---|
| | | providing several tools in its toolbar to control how data is visualized (such as top view, front view, or perspective view). The data viewer is available on all pages. You can split it horizontally and vertically, and create pop-out windows. When GoPxL is in Replay mode, a blue border is displayed around the data viewer.<br>For more information, see *Data Viewer* on page 64. |
| 8 | Displayed outputs pane | This area lets you show, hide, and pin outputs such as measurements. You can also control how outputs are displayed. For more information, see *Displaying and Pinning Outputs* on page 79. |
| 9 | Metrics area | This area provides CPU usage and frame rate, including the calculated maximum frame rate. For more information, see *Metrics Area* on the next page. |
| 10 | System messages | This area provides log messages, error alerts and warnings. For more information, see *System Messages* on the next page. |
| 11 | Interface language | Lets you change the language of the GoPxL interface. To apply the change, GoPxL must restart.<br>For GoPxL on PC, after changing the interface language, you must open GoPxL Manager, select the instance, and then stop and start it manually; for more information, see *Running GoPxL on a Windows PC* on page 814. |

The following lists the categories available in GoPxL and where you can learn how to work with them.

*What you can do in the categories*

| Category | Description |
|---|---|
| Connect | Lets you choose layout options and create multi-sensor systems. Also lets you configure network settings.<br>For more information, see *Connect - Creating a System & Networking* on page 92. |
| Acquire | Lets you configure acquisition. Also lets you perform alignment. For more information, see *Acquire - Alignment and Acquisition* on page 96. |
| Inspect | Lets you add and configure measurement and processing tools. For more information on tools, see *Inspect - Measurement and Processing* on page 147. |
| Communicate | Lets you enable and configure the GoPxL Data Protocol and industrial protocols.<br>For more information, see *Communicate - PLC, Digital, GDP, HMI* on page 732. |
| Monitor | Lets you monitor measurements, as well as sensor health and performance. For more information, see *Monitor - Measurement Stats, Health & Performance* on page 795. |
| Manage | Lets you manage jobs, upgrade sensors, perform a factory restore, and so on. For more information, see *Manage - Sensor Management and Maintenance* on page 801. |

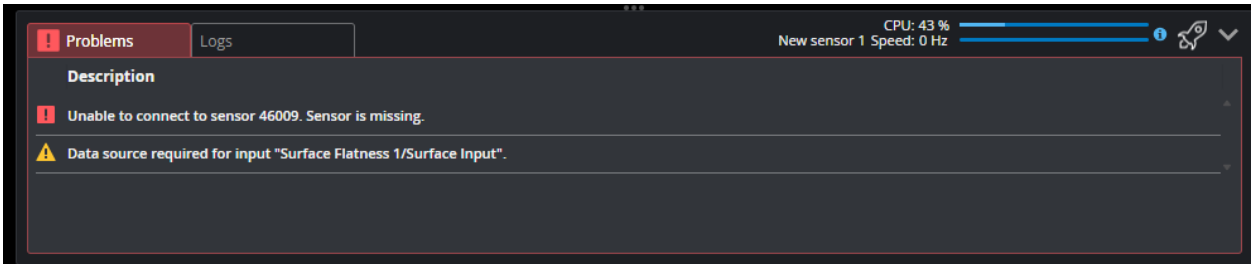
# Status Bar

The status bar lets you do the following:

- Access system messages in the in the **System Messages** panel. For details, see *System Messages* below.
- See important system metrics. For details, see *Metrics Area* below.

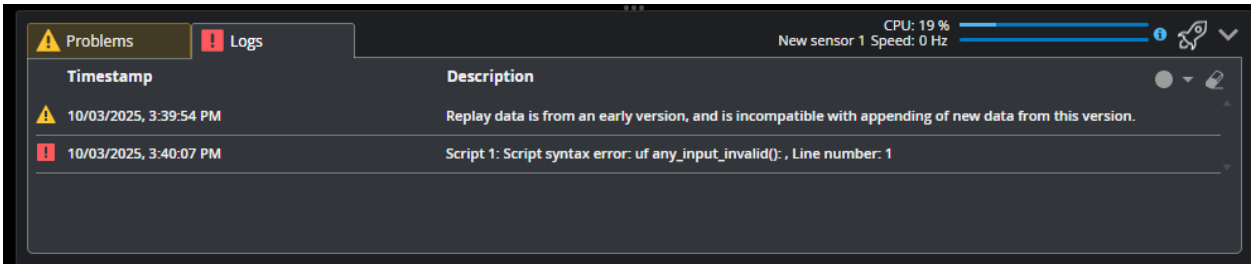
## System Messages

GoPxL displays current problems and a system log containing errors, warnings, and general information, in two tabs at the bottom of the user interface. The **Problems** tab lists the *current* problem. Once you fix a problem, it is removed from the **Problems** tab.

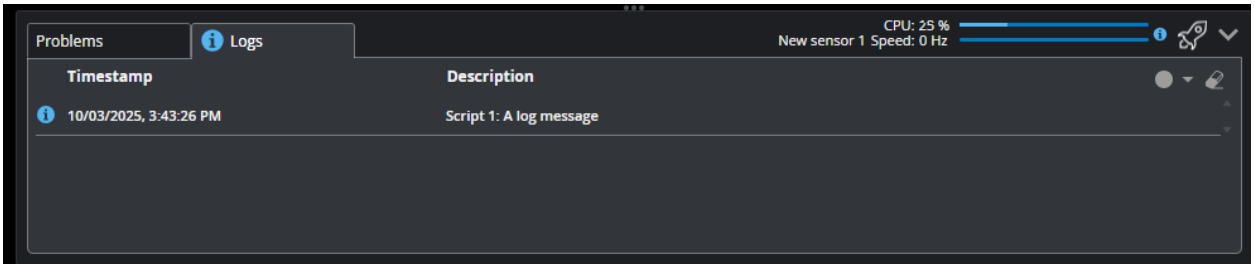



*Problems tab showing a current problem with the system. The number of problems is indicated in parentheses.*

The **Logs** tab displays a complete list of system-level messages. You can filter the log entry types using the filter drop-down to the right of the **Logs** tab, and clear the entries using the eraser button.




Problems that prevent the system from running (they are blocking problems) are indicated with a square red icon ( ). Problems that are less serious (they are potential problems) are indicated with a yellow triangle icon ( ). Informational messages are displayed with a blue circle icon ( ).



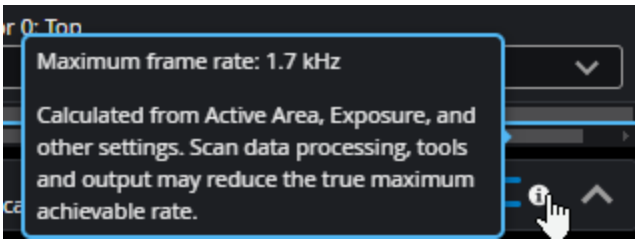

## Metrics Area

The Metrics area on the right side of the status bar displays two important performance metrics: CPU load and sensor speed (current frame rate).

The **CPU** bar in the Metrics area displays how much of the CPU is being used.

The **Speed** bar displays the frame rate of the sensor.

You can see the maximum calculated frame rate by clicking the info icon to the right of the metrics area.



# Keyboard and Mouse Shortcuts

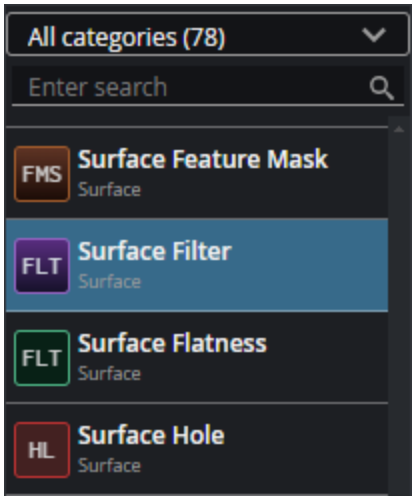
GoPxL supports various keyboard and mouse shortcuts.

*Multiple tools are selected in the Tool Diagram panel (2); to the left is the Tool List (1).*

Left-clicking a block in the Tool Diagram panel selects that tool. You can also select multiple tool blocks to perform operations on all of the selected tools. GoPxL supports the following shortcuts for selecting tools and performing operations on them:

*Tool list shortcuts*

| Keyboard / mouse shortcut | Description |
|---|---|
| Drag and drop | Moves the selected blocks to a new position. |
| Shift + mouse click | Clicking a tool block and then pressing Shift while clicking a second block selects a range of blocks. |
| Ctrl + mouse click | Clicking a tool block while pressing Ctrl adds that tool to the selection; you can select multiple tools this way, including non-contiguously. |
| Ctrl + A | Selects all tool blocks (except for the sensor block). |
| Delete (keyboard) | Removes the selected blocks. |
| Up or Down arrow | In the Tool Diagram, using these moves the selected tool blocks up or down in the tool list. |

| Keyboard / mouse shortcut | Description |
|---|---|
| D key<br>Duplicate (UI context menu) | Duplicates the currently selected tools. |
| Tab key | When a tool is selected in the Tool List, pressing Tab moves the focus to the next tool down. At the bottom of the list, the focus switches to the first tool in the Tool Diagram. Additional tabbing switches the focus to the next added tool. When focus reaches the bottom of the Tool Diagram, the tool selector drop-down in the **Tool Configuration** panel gets focus.<br>  |
| Enter | **Tool List**<br>Adds the tool to the Tool Diagram. Focus switches to the next tool in the Tool List.<br><br>**Tool Diagram**<br>Expands or collapses the tool that has focus.<br><br>**Tool Configuration**<br>Expands or collapses the selected sub-section, such as a measurement under **Outputs**. You must click on the sub-section first. After that, toggling works. |
| Double-click | **Tool List**<br>Adds the selected tool to the Tool Diagram.<br><br>**Tool Diagram**<br>Expands or collapses the tool that has focus. |

Note that the last selected tool gets focus (its configuration is displayed in the **Tool Configuration** panel and its outputs are displayed in the data viewer). Selected tool blocks are outlined in blue; the last selected tool is highlighted with a darker background.

In the data viewer, GoPxL supports the following shortcuts:

*Data Viewer shortcuts*

| Name | Keyboard / mouse shortcut | Description |
|---|---|---|
| Force pan mode | Shift + Mouse drag | When the data viewer is in orbit or zoom mode, holding Shift and dragging scan data in the data viewer with the mouse switches the data viewer to pan mode.<br>This shortcut is only active when the mouse pointer is over the data viewer window. |
| Ignore regions | Alt + Mouse drag | Causes the mouse pointer to ignore regions so that you can pan or orbit over a region.<br>This shortcut is only active when the mouse pointer is over the data viewer window. |
| Temporary pan | Middle mouse button | When the data viewer is in Zoom mode, holding the middle mouse button while moving the mouse temporarily switches to Pan mode. |
| Center camera on clicked point | Double click surface in Perspective view | Double-clicking on a point in Perspective view centers that point in the data viewer. (Click above the data viewer to choose Perspective view.) |
| Z scale | Shift + mouse wheel | Modifies the Z scale value. For more information on Z scaling, see *Data Viewer* on page 64. |
| Toggle demo mode | Alt + Shift + D | Toggles demo mode (automatic camera orbiting) on or off when the data viewer is in Perspective mode. |
| Increase demo speed | Alt + Shift + "+" or<br>Alt + Shift + "=" | Increases the demo speed. |
| Decrease demo speed | Alt + Shift + "-" or<br>Alt + Shift + "_" | Decreases the demo speed. |
| Undo region modification | Ctrl + Z | Undoes changes to the last modified region (size or location). |
| Redo region modification | Ctrl + Shift + Z<br>Ctrl + Y | Redoes a change to the last modified region (size or location). |

# File Formats

The following formats are used with GoPxL, or can be converted using the replay utility tool.

*File formats*

| Format | GoPxL extension | Gocator firmware 6.x and earlier | Content | Description |
|---|---|---|---|---|
| Job | .gpjob | .job | • Scan settings<br>• Tool settings<br>• Control and output settings | Quickly change a set of settings by switching from one job to another.<br>For more information, see *Jobs* on page 805. |
| Recording | .gprec | .rec | • Current job settings[1]<br>• Recorded scan data<br>Note that sensor settings are not necessarily visible after loading a recording. | Quickly save and load recorded data for development and diagnostic purposes.<br>For more information on recording and on loading recorded data, see *Recording and Working with Scan Data* on page 87.<br>You can use the Replay Utils tool, provided in the utilities package, to convert .gprec files to and from various formats. For more information, see *Replay Utility Tool* on page 920. |
| Backup | .gpbak | .bak | • All jobs<br>• Current job settings[1]<br>• Sensor system layout and transformations<br>• Files generated by tools such as Surface Pattern Matching<br>• Global settings | Allows restoring a sensor to a previous state in case undesired changes were made.<br>You back up and restore sensors on the **Maintenance** page. For more information, see *Backup and Restore* on page 809. |
| Support | .gpsup | .gs | • Everything the backup file contains<br>• Additional diagnostic information | For supporting development and diagnosing issues.<br>You download and upload support files on the **Support** page. For more information, see *Support* on page 811. |

1. See Job format details above. This also includes unsaved changes.

The following formats can be converted using the Replay Utils tool. For more information, see *Replay Utility Tool* on page 920.

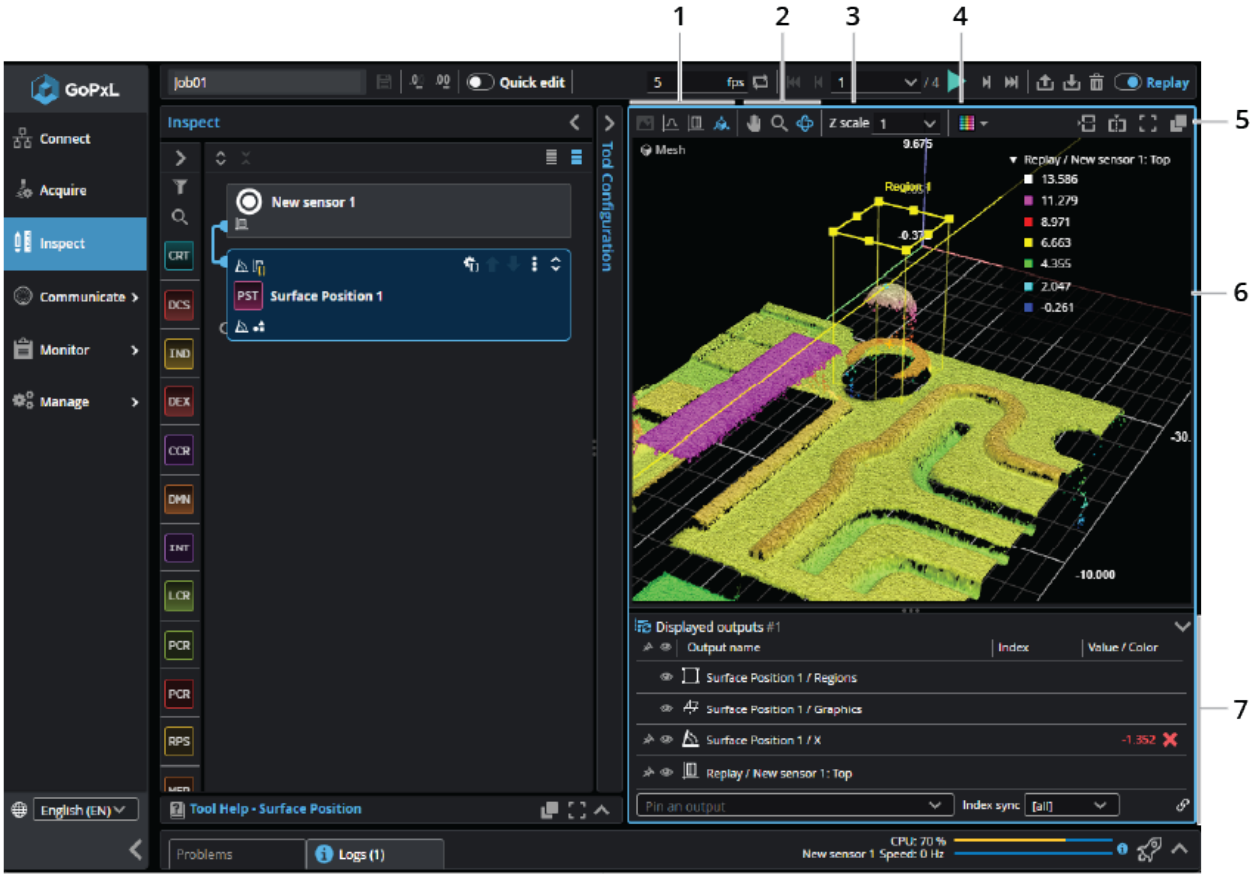
*File formats*

| Format | GoPxL extension | Gocator firmware 6.x and earlier | Content | Description |
|---|---|---|---|---|
| CSV | n/a | .csv | Scan data in CSV format | First download replay data (.gprec) in GoPxL, and then use the Replay Utils tool to convert to the CSV format, for use with third-party tools. |
| .pcd / .sur / .srf / .pro | n/a | n/a | Scan data in various formats | First download replay data in GoPxL, and then use the Replay Utils tool to convert to the desired format, for use with third-party tools. |

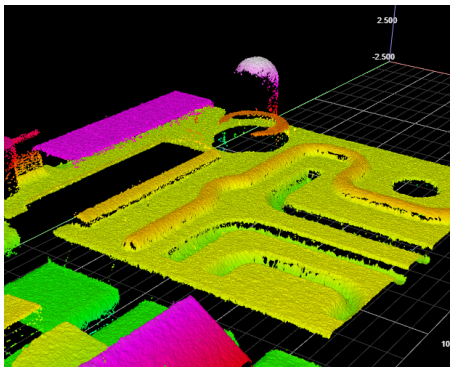
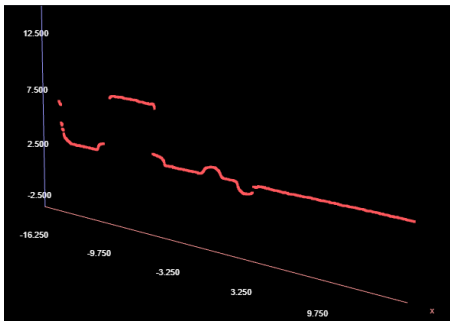
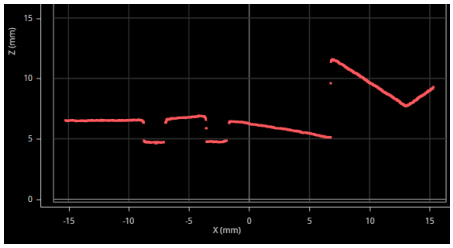
You can also use the Data Export tool to export scan data in various formats. For more information, see *Data Export* on page 666.

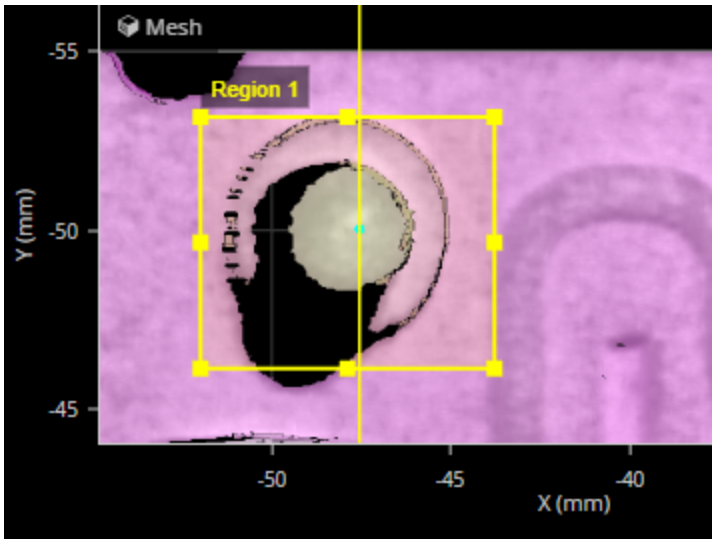
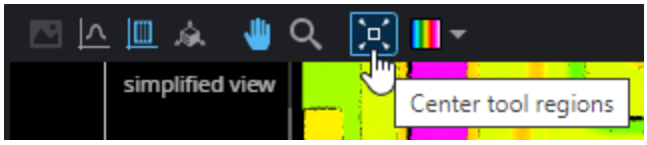
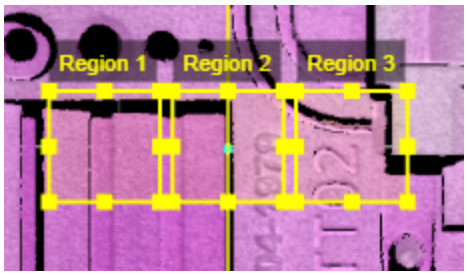
# Data Viewer

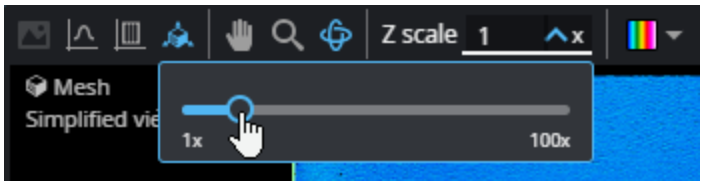
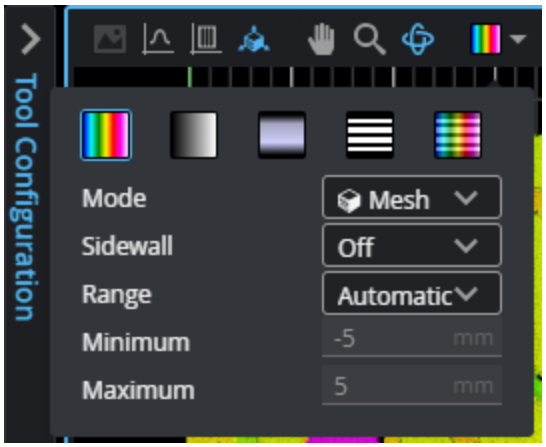
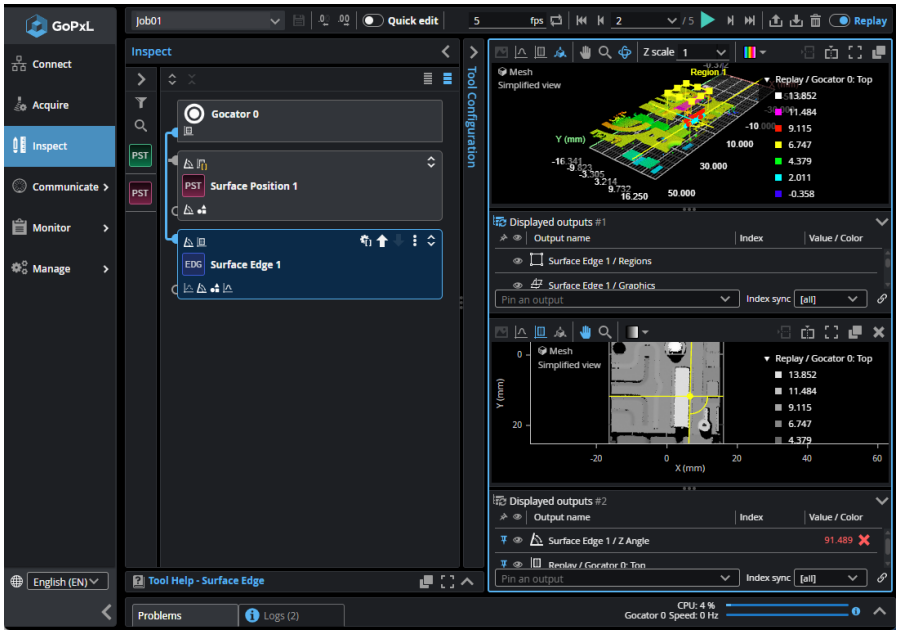
You use a data viewer to observe scan data (such as Profile and Surface data), as well as video images and intensity images. You can also use it to configure measurement tools (see *Inspect - Measurement and Processing* on page 147) and a sensor's active area (see *Active Area* on page 129). GoPxL supports multiple data viewers (via both splitting and pop-out buttons).




| | Element | Description |
|---|---|---|
| 1 | Display modes | Use these to change the data viewer's display mode. One of the following:<br><br>**Image**<br>Image mode ( ) lets you view pixel data that the system has acquired in Image mode. You should use Image mode to adjust exposure as an initial step and for diagnostics. For more information, see *Image Mode* on page 68. |

| Element | Description |
| --- | --- |
| | **Perspective**<br>Perspective mode ( ) lets you view data in a 3D perspective representation. You can move and turn the data using a mouse and the pan, orbit, and zoom buttons ( ). When in orbit mode, hold Shift to temporarily switch to pan mode. The data viewer can display both Surface and Profile data in Perspective display mode. For information on controlling how the data viewer displays Surface data in Perspective mode, see *Surface and Perspective Display Options* on page 73.<br>  <br><br>  <br><br>**Profile / Front**<br>Profile / Front mode ( ) displays profiles in a 2D representation when Profile data is available.<br>  <br><br>**Surface / Top**<br>Surface / Top mode ( ) lets you display surface data in a 2D representation when Surface data is available. For information on controlling how the data |

| | Element | Description |
|---|---|---|
| | | viewer displays Surface data in Perspective mode, see *Surface and Perspective Display Options* on page 73.<br>  <br>Note that In Surface / Top display mode (and in Profile / Front mode), a "Center tool regions" button is available at the top of the data viewer when a tool is selected in the Tool Diagram panel.<br>  <br>Clicking this centers all regions in the middle of the data viewer, resizing them to fit. This can be useful when you have zoomed the data viewer in a lot, and need to quickly bring the regions into view.<br>  <br>For more information on regions, see *Regions* on page 181. |
| 2 | Pan, zoom, and orbit | Use these buttons ( ) to move scan data in the data viewer with your mouse. (Orbit is only available in the perspective view mode; see above.)<br>Various shortcuts are available to make working with the data viewer easier. For more information, see *Keyboard and Mouse Shortcuts* on page 59. |
| 3 | Z scale | When the data viewer is displaying Surface data (in perspective view only) or Profile data, you can adjust the Z scaling to make it easier to distinguish minor height variations in the scan data. |

| | Element | Description |
|---|---|---|
| | |  |
| 4 | Surface display options | Lets you control how scan data is displayed, such as whether Surface scan data is displayed using a color heightmap or a grayscale heightmap overlay. For information on changing how the data viewer displays Surface data, see *Surface and Perspective Display Options* on page 73. For information on how the data viewer displays Profile data, see *Profile Mode* on page 71.<br>  |
| 5 | Split, zoom, and pop-out | Use the split buttons ( and ) to create additional data viewers. You can create as many as four data viewers in the main browser window. To close a split window, click its Close icon ( ).<br>  |

| | Element | Description |
|---|---|---|
| | | Use the Pop-out button ( ) to create a new window with a single data viewer. For more information, see *Using Multiple Data Viewers* on page 84.<br>Use the Zoom to fit button ( ) to zoom the scan data so that it fits in the data viewer window. |
| 6 | Data viewer window | This is the main window in the GoPxL interface that shows scan data. When you configure tools or set the active area, you can graphically configure the regions in the data viewer window.<br>When the view is zoomed out, to reduce processing, the number of data points that are displayed is reduced, as indicated by "simplified view" in the data viewer. When you zoom in enough, the actual data points are all displayed.<br>The legend at the upper right is collapsible.<br> |
| 7 | Displayed Outputs pane | Lets you pin and show / hide outputs. When working with arrays, you can also select an array element (or all of the elements) across all arrayed tool outputs. For more information, see *Displaying and Pinning Outputs* on page 79.<br>Use the link icon ( ) in the lower right of the Displayed Outputs pane to copy the path to the data viewer for use in GoHMI Designer to display a data viewer in your HMI. For more information, see *Using a Data Viewer in an HMI* on page 857. |

# Image Mode

In Image mode, the data viewer displays images directly from a sensor's camera or cameras, as well as other information.

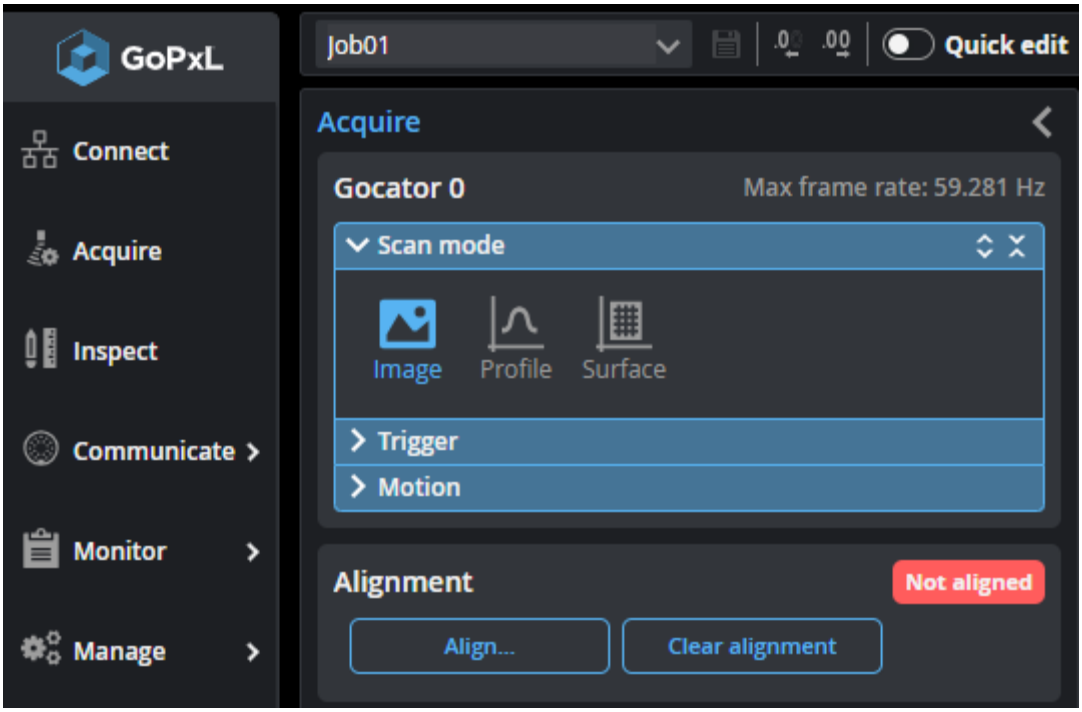
In this mode, depending on your sensor model, you can use the data viewer to display profile exposure information (see *Exposure Information* on page 70) and spot and dropout information (see *Spots and Dropouts* on page 70) that can be useful in properly setting system exposure for scanning, and for troubleshooting stray light or ambient light problems.

Gocator sensors can't generate 3D points in over-saturated areas (indicated with red) or in under-exposed areas (indicated with blue). If it's not possible to set a single exposure to capture the entire object target with minimal red or blue areas appearing in Image mode, you can try enabling the **Multiple** exposure feature; the sensor will then combine the exposures to get the best scan data possible. Choose the exposure you want to examine in the Displayed Outputs panel to view each exposure and tune one high exposure for dark areas on the target and one low exposure for bright areas on the target. Note that multiple exposures reduce the maximum speed the sensor can run at.

Not all sensor models indicate over-exposed areas (red).

The correct tuning of exposure depends on the reflective properties of the target material and on the requirements of the application. You should carefully evaluate the exposure settings for each application.

To view Image data, you must set the system to Image mode before scanning, in the **Acquire** > **Scan mode** section.



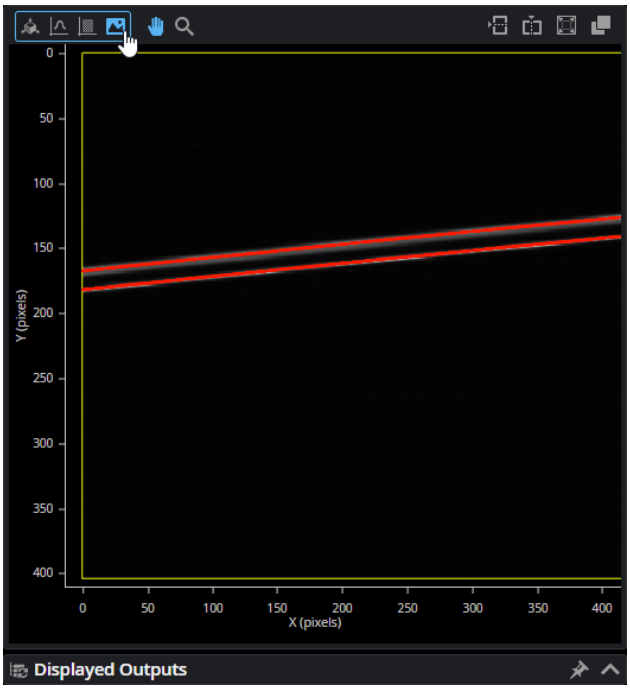



*Image data. Red dots are the "spots" found by the sensor, which become the data points in scan data. The grayscale squares represent the intensity value of a camera pixel. Blue squares (pixels) are underexposed. On some sensors, red squares represent pixels that are overexposed. Yellow dots along the top represent spots. The yellow outline indicates the boundaries of the sensor camera.*

## Exposure Information

In Image mode, you can display exposure-related information. This information can help you correctly adjust the exposure. (For information on setting exposure, see *Exposure and Light Intensity* on page 132.)

To display exposure information in the data viewer, click the Exposure button ( ) at the upper left of the data viewer.

Exposure information is listed in the **Displayed Outputs** panel at the bottom of the data viewer. If you have set the sensor's exposure to **Multiple** on the **Acquire** page, and have set more than one exposure, each exposure is listed individually (G2) or as an element available in a drop-down (other sensors). Exposure information is displayed in Image ( ) outputs.

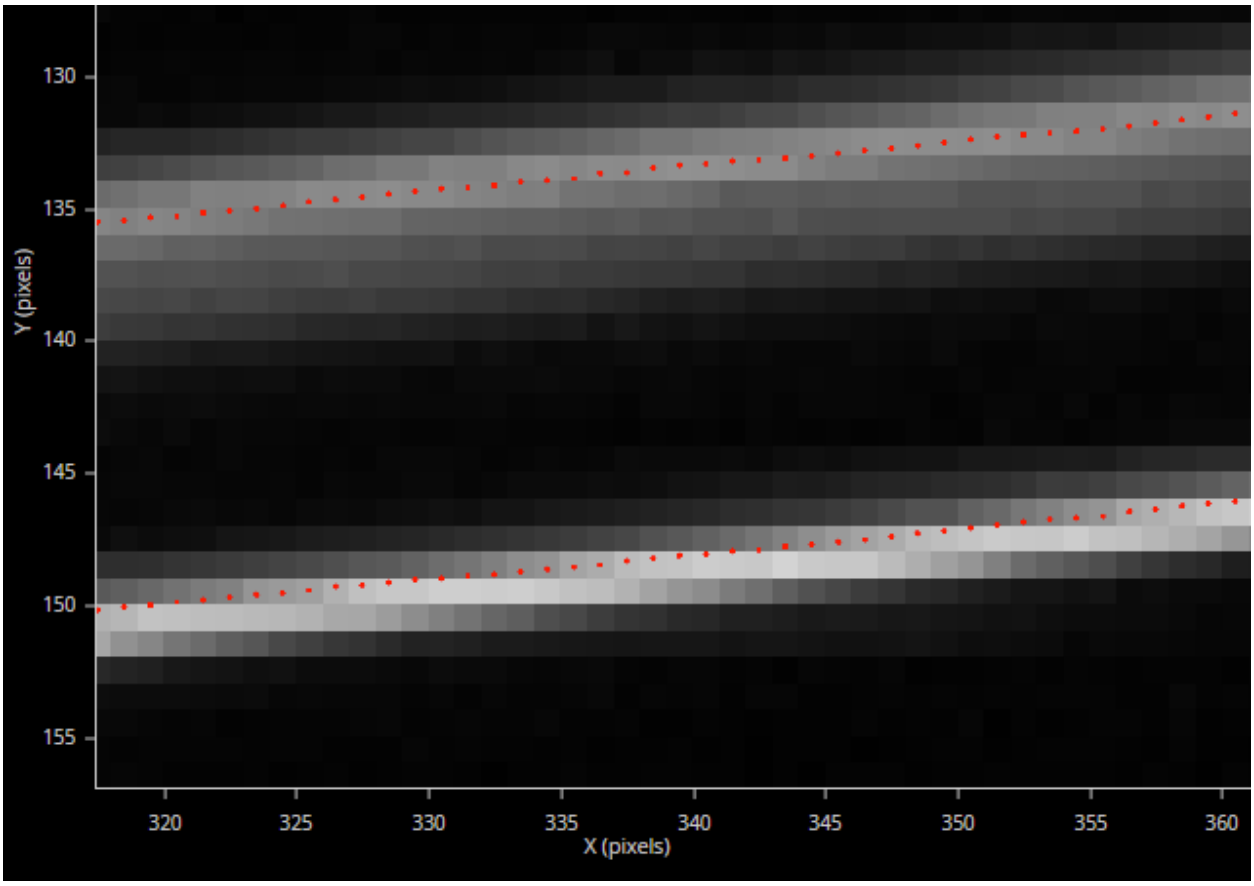
To display this information, the output must be set to visible. That is, the "eye" icon must be enabled ( ) instead of disabled ( ). Note that if you have multiple exposures, only the "top" one is displayed in the data viewer. For example, to see the exposure information for Exposure 3, below, you must hide the Image outputs of Exposure 1 and 2.

## Spots and Dropouts

Various settings related to material types (under **Scan** > **Advanced**, with **Material type** set to Custom) and exposure can interact. In Image mode, you can examine how these settings affect. To

do this, in Image mode, check the **Show Spots** option at the top of the data viewer to overlay a representation of the spots in the data viewer.

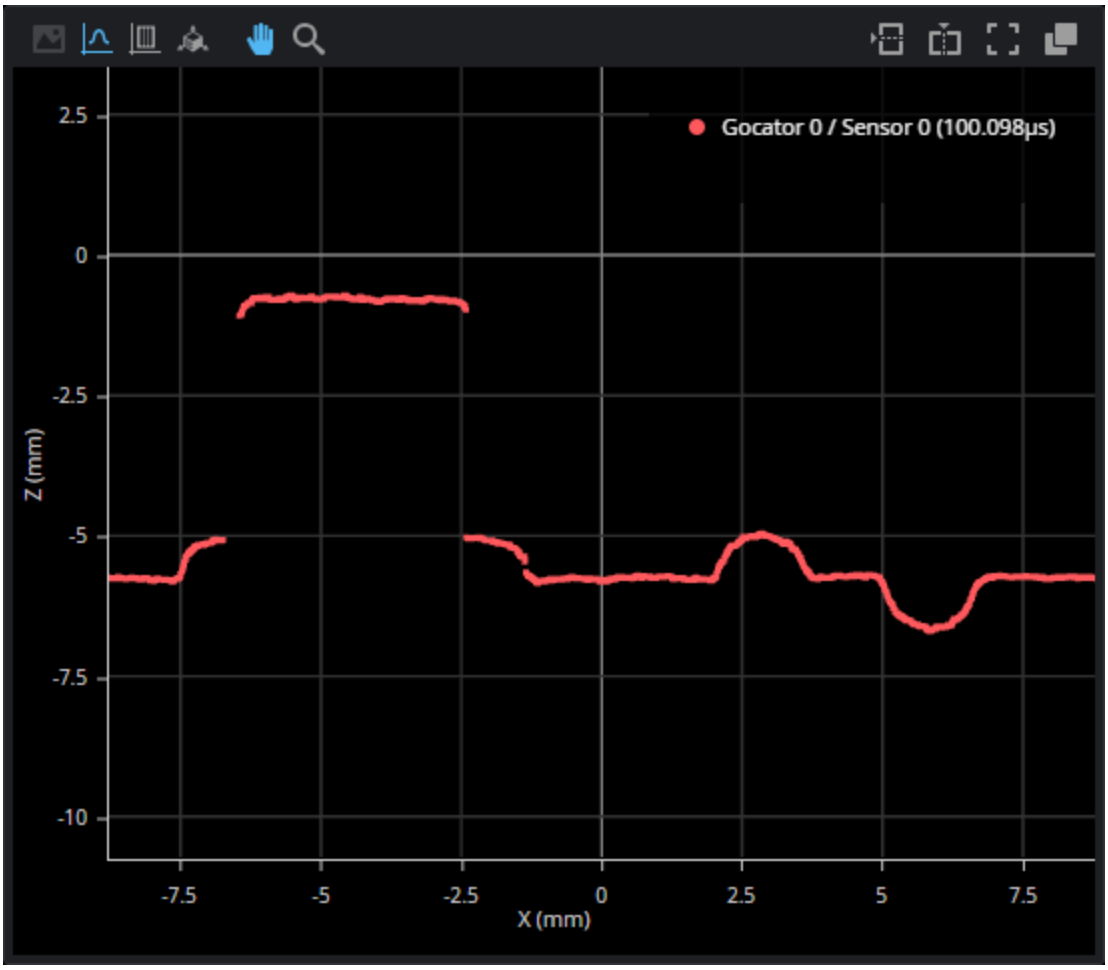
In the image below, the white and gray squares represent the light as it appears on the camera sensor. Spots that GoPxL selects (which roughly represent the center of the line of light on the camera sensor for each column) are displayed as red dots. GoPxL uses these spots to determine where data points in the scan data a sensor produces will be.



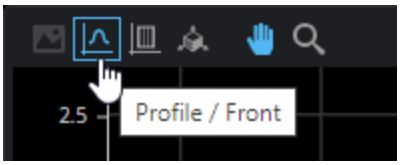

Dropouts (where no spot is detected on the camera sensor in a given column) are depicted at the upper edge of the data viewer as yellow dots.

## Profile Mode

When Profile data is available, either because GoPxL is in Profile scan mode or because a Profile output of a tool like Surface Section is providing Profile data, the data viewer can displays profile plots.



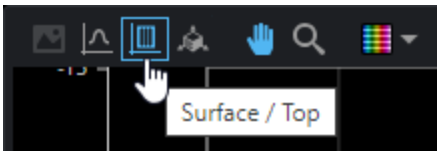

To set the data viewer to Profile mode, click the Profile mode button above the data viewer window:




## Surface Mode

When the data viewer is in Surface / Top mode and Surface data is available, the data viewer can display Surface data.

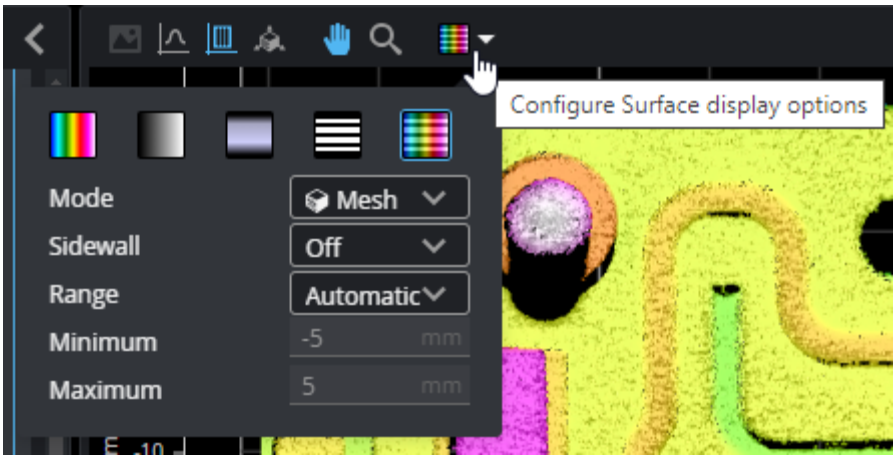
To set the data viewer to Surface / Top mode, click the mode button above the data viewer window:




GoPxL provides several ways of controlling how Surface data is displayed. For more information, see *Surface and Perspective Display Options* below.

## Surface and Perspective Display Options

You control how Surface data displays when the data viewer is in Surface or Perspective mode using the display options available in the Surface display options drop-down at the top-left of the data viewer.




*Surface display options.*

*Display options*

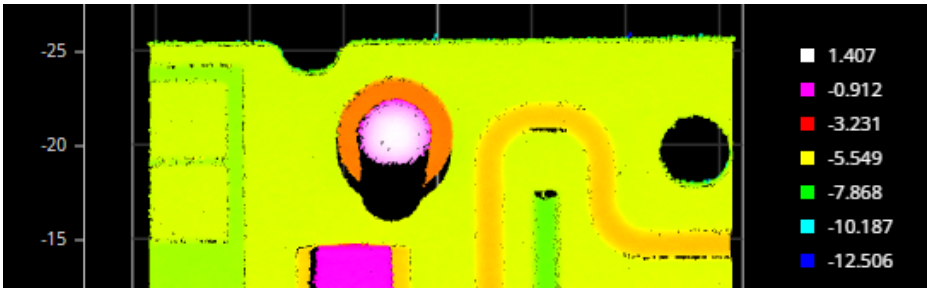
| Option | Description |
|---|---|
| Display options | The output display modes let you choose how GoPxL shades the Surface data when the data viewer is in Surface mode or in Perspective mode. |

For Heightmap, Grayscale, and Heightmap + Intensity settings, you can set the range values that map to the heightmap colors (using the **Range** drop-down and the related settings) to make features easier to see.

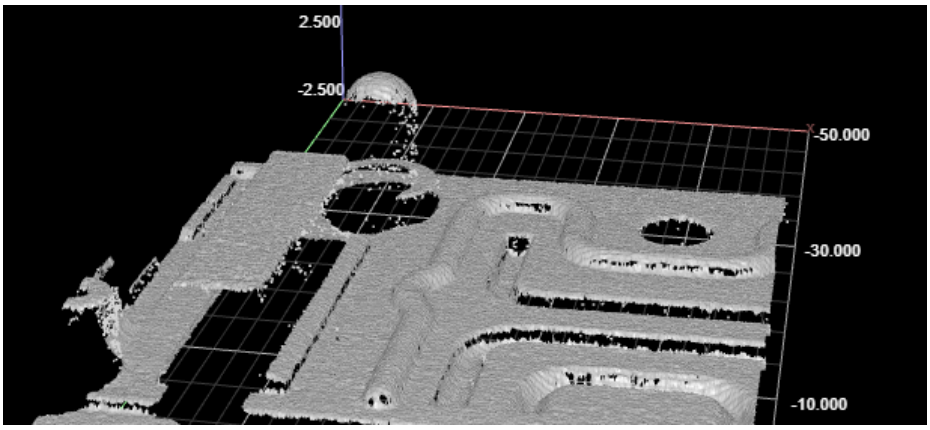
The following output display modes are available:

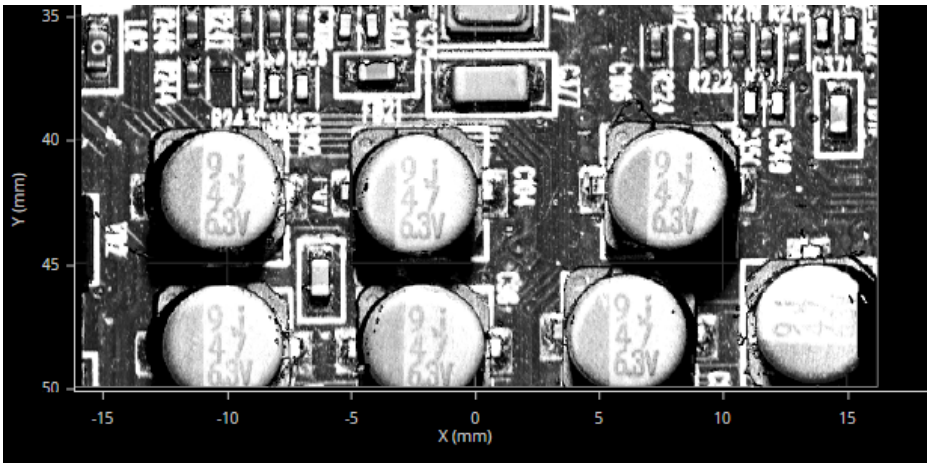
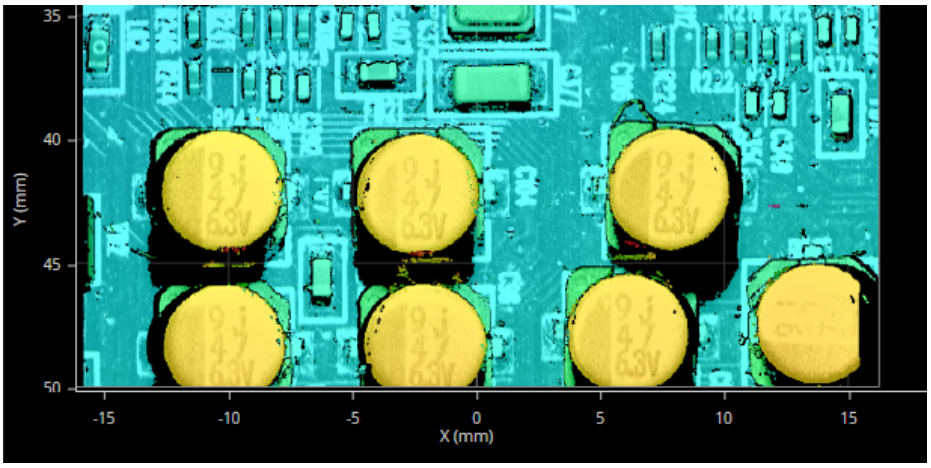
**Heightmap**

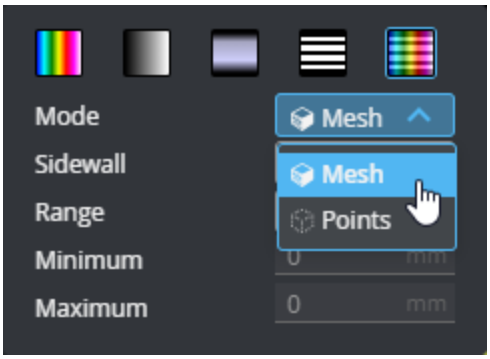
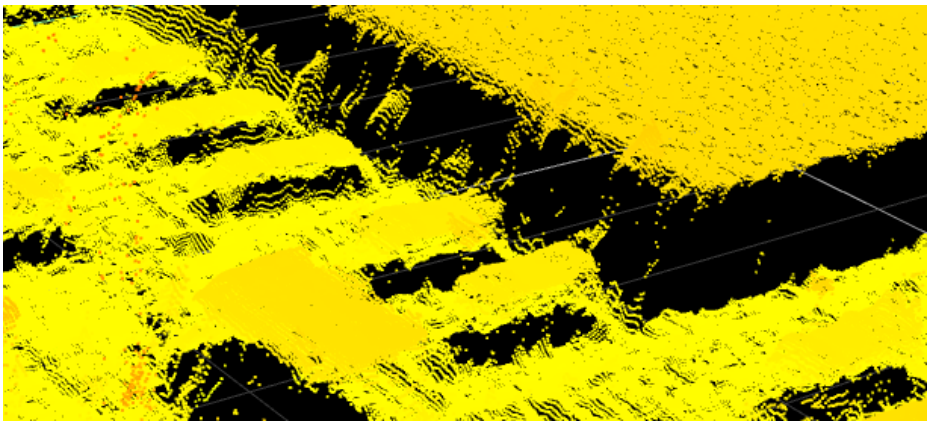
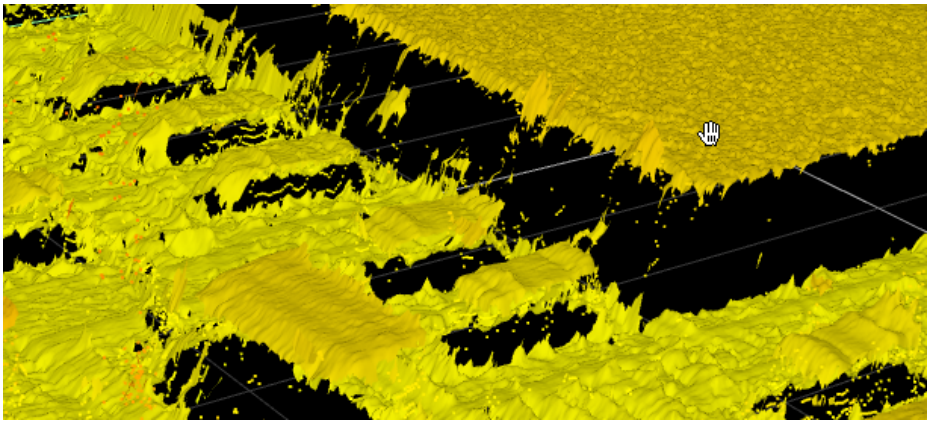
Heightmap mode ( ) displays a pseudo-color heightmap over the Surface data. A heightmap legend is displayed in the data viewer.

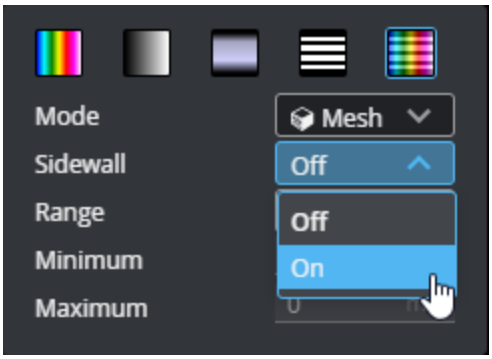
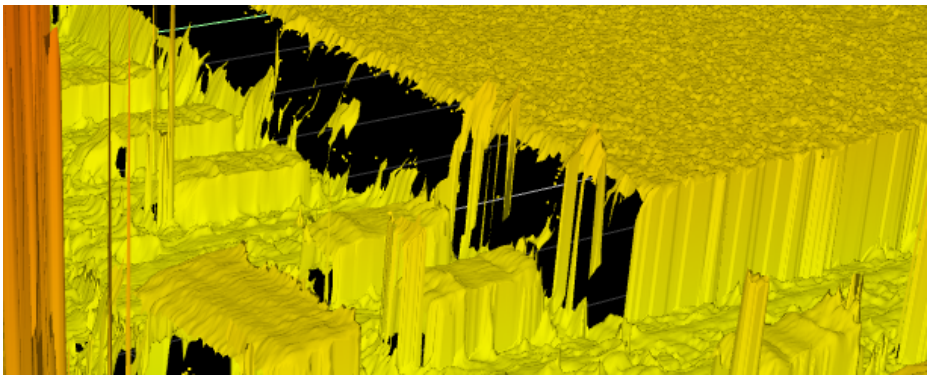
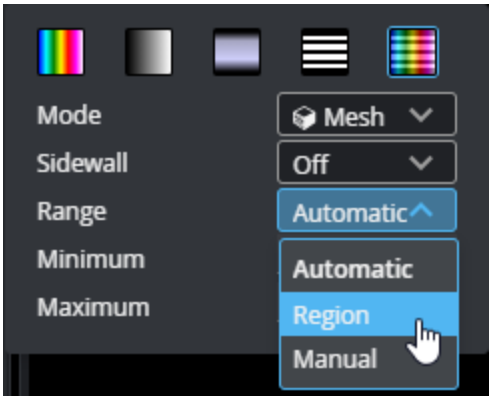



**Grayscale**

| Option | Description |
| --- | --- |
| | Grayscale mode ( ) displays a grayscale heightmap over the Surface data. Working in grayscale mode can make it easier to distinguish the scan data from tool visualizations. A heightmap legend is displayed in the data viewer.<br> <br><br>**Uniform**<br>Uniform mode ( ) displays a uniform gray color over the Surface data. This mode is mostly useful when you want to focus on shape or geometry.<br>  <br><br>You will typically need to set **Mode** to Mesh in the Surface display options drop-down to use this display option.<br>**Intensity**<br>Intensity mode ( ) displays intensity data over the Surface data if it is available.<br>When intensity data is enabled in the **Acquire** page > **Scan mode** section, sensors produce intensity images that measure the amount of light reflected by an object. An 8-bit intensity value is output for each data point in the scan data, where a darker shade represents a smaller value and lighter shade represents a larger value. The sensor applies the same coordinate system and resampling logic as the ranges to the intensity values. For more information, see *Scan Modes and Intensity* on page 111. |

| Option | Description |
| --- | --- |
| |  <br>**Heightmap + Intensity**<br>Heightmap + Intensity mode ( ) displays a color heightmap combined with intensity data on the Surface data. You must enable intensity data before scanning for this mode to be available. For more information, see *Scan Modes and Intensity* on page 111.<br>  |
| Mesh and Points modes | You can choose whether the data viewer displays Surface data as a mesh or points. Note that the data viewer Mesh mode is unrelated to the Mesh data type. (For information on the Mesh data type, see *Mesh Measurement* on page 680.) |

| Option | Description |
| --- | --- |
| |  <br>Points mode displays the data as discrete data points. This mode is useful in scan data that contains noise around edges, and can show hidden structure.<br>  <br>Mesh mode displays Surface data by connecting the data points with polygons.<br>  |
| Sidewall mode | You can toggle the data viewer between hiding and showing polygons which are vertical or nearly vertically oriented. This can produce a more realistic-looking part for demonstrations. |

| Option | Description |
| --- | --- |
| |  <br>For example, in the following, the sidewalls are enabled, resulting in the lines shown at the edges of the PCB components.<br>  <br>Note that this setting only affects the *appearance* of scan data in the data viewer. It does not change the scan data and therefore does not affect measurements. |
| Heightmap range scaling | The data viewer displays heightmap information in pseudo-color or grayscale. The height axis (Z) is color-coded in the legend to the right in the data viewer. You can adjust the scaling of the height map using **Range** and its related settings.<br>  <br>Do one of the following:<br>• To automatically set the scale, choose **Automatic** in the **Range** drop-down.<br>• To automatically set the scale based on sub-region you select on the heightmap, |

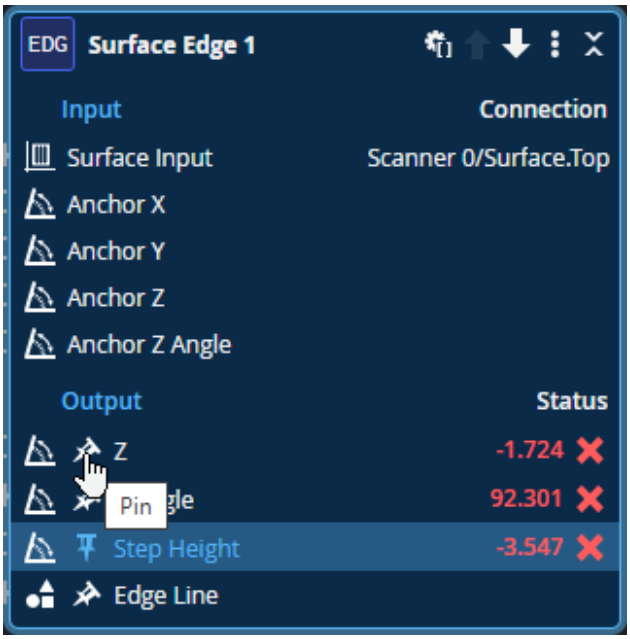
| Option | Description |
| --- | --- |
| | choose **Region** in the **Range** drop-down and adjust the yellow region box in the data viewer to the desired location and size.<br>• To manually set the scale, choose the **Manual** in the **Range** drop-down and enter the minimum and maximum height to which the colors will be mapped. |

## Displaying and Pinning Outputs

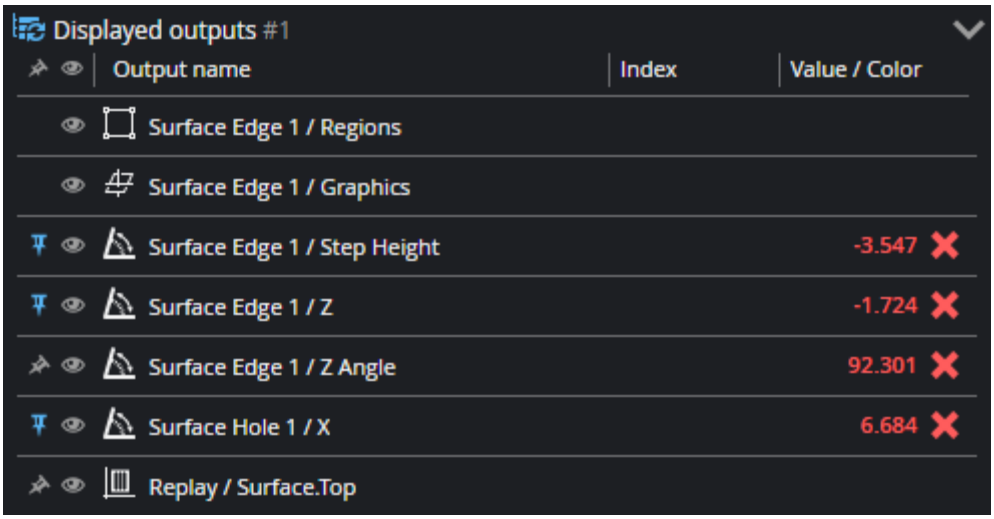
You can interact with the inputs, outputs, and other elements listed in the **Displayed Outputs** panel to control what you see in the data viewer window, by pinning or hiding outputs. This makes it easier to configure and monitor your application. When you select a block (a tool or the sensor, device, or source at the top) in the Tool Diagram panel, the **Displayed outputs** panel lists items related to the currently selected tool. By default, the panel lists *all* of the selected tool's inputs, the currently selected output of that tool, any pinned outputs, and tool-related graphics. In addition to selectively pinning or hiding outputs, you can right-click on an output in the panel to access "show / hide all" options.

You can “pin” items in the **Displayed Outputs** panel so that it they are always displayed, even if you select a different tool, or another input or output in a tool block. Pinning items is useful for example if you want to monitor multiple, independent measurements while GoPxL is running in production. Pinning is also useful when setting up tools: you can change the parameters of a tool (such as a filter) earlier in a tool chain and immediately see the impact that change has on another tool (whose output is pinned) later in the chain. This minimizes toggling and clicking between tools and measurements.

You pin items in the **Displayed Outputs** panel, in the tool's block in the Tool Diagram, or in the tool's Outputs section in the **Tool Configuration** panel. Pinned outputs are identified in GoPxL by a vertical blue "thumbtack" icon. Unpinned outputs are identified by a grey thumbtack icon. (See below.)

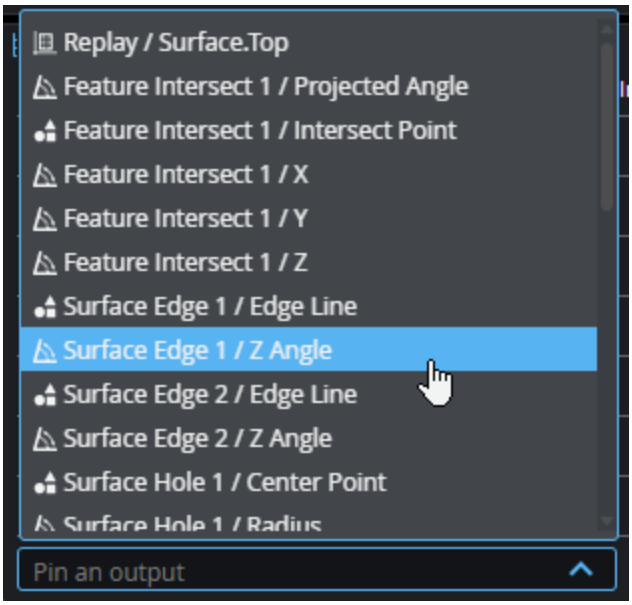



*Pinning an output in the Tool Diagram.*




*Pinning an output in the Displayed Outputs panel.*

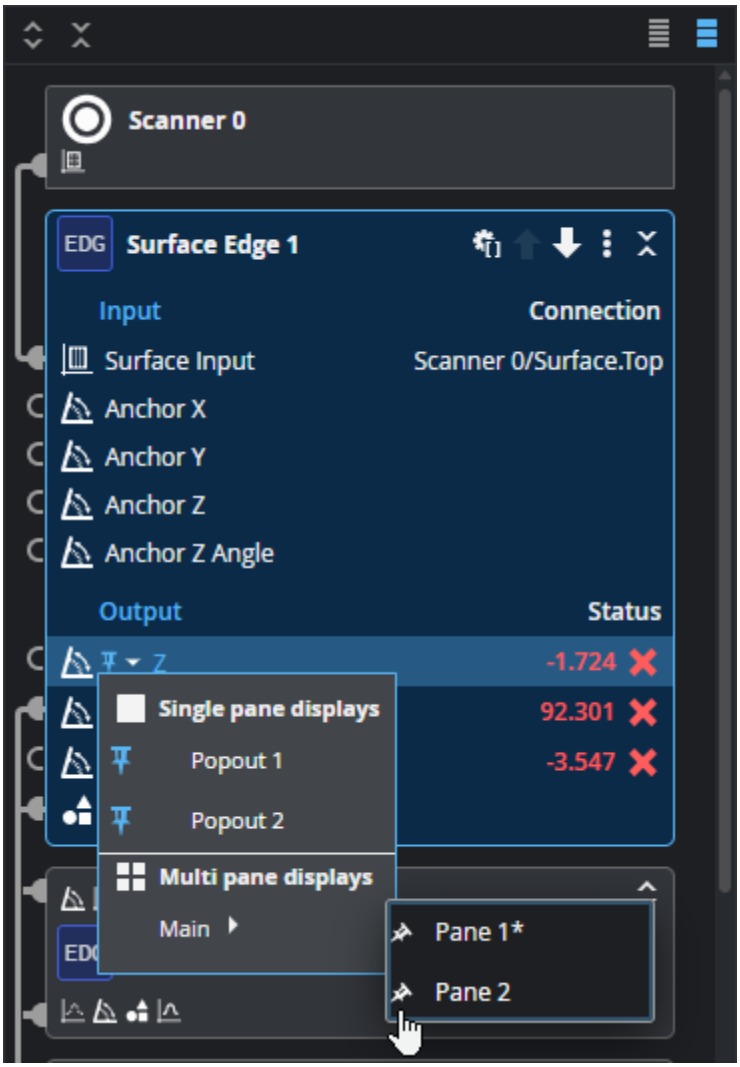
You can also choose an item from the "Pin an output" menu at the bottom of the panel.




If you have created additional data viewers, either by splitting a data viewer in the main browser window, or by popping out a data viewer in a new window, you can choose which data viewer to pin an output to in the Tool Diagram panel. (For information on creating and using new data viewers, see *Using Multiple Data Viewers* on page 84.)

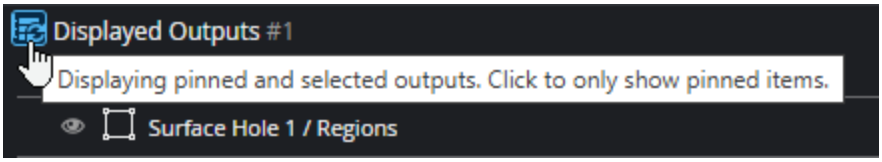
"Single pane displays" are data viewers you've created using the "Pop out" button ( ), which display in a new browser window.

"Multi pane displays" are data viewers you've created using one of the "split" buttons ( or ). In the popped-out data viewer, The pane identified by an asterisk is the original data viewer, the one from which you created others.




In both cases, the input of the currently selected tool and the currently selected tool output are added to the new data viewer and are pinned. You can add more outputs from the "Pin an output" menu.

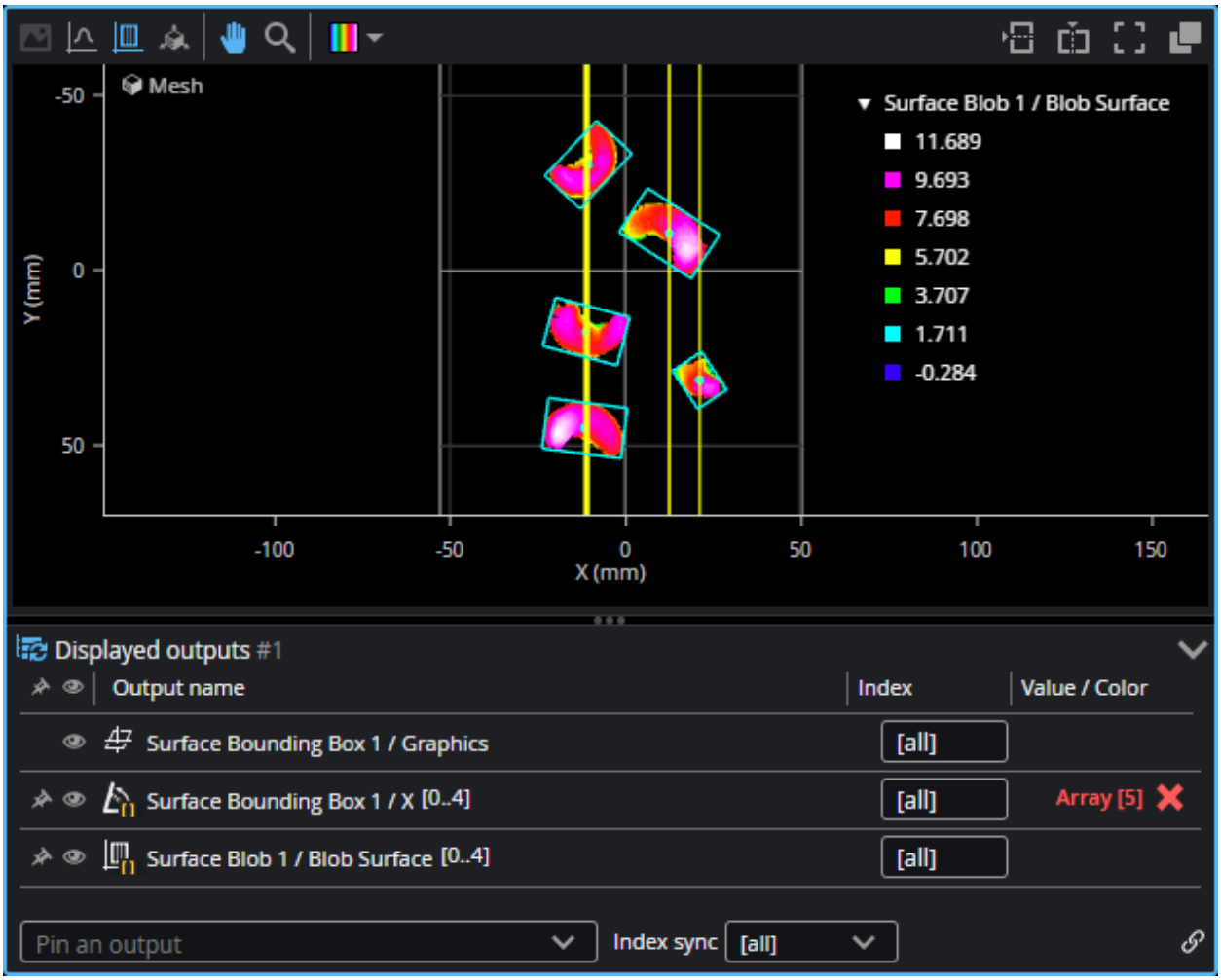
You can control whether a data viewer displays both pinned and selected inputs / outputs, or instead *only* pinned outputs. Displaying only pinned outputs lets you focus on those inputs and outputs in the data viewer while configuring or monitoring your application. You toggle between these modes by clicking the Synchronize pane button ( ) at the top of the **Displayed Outputs** panel.



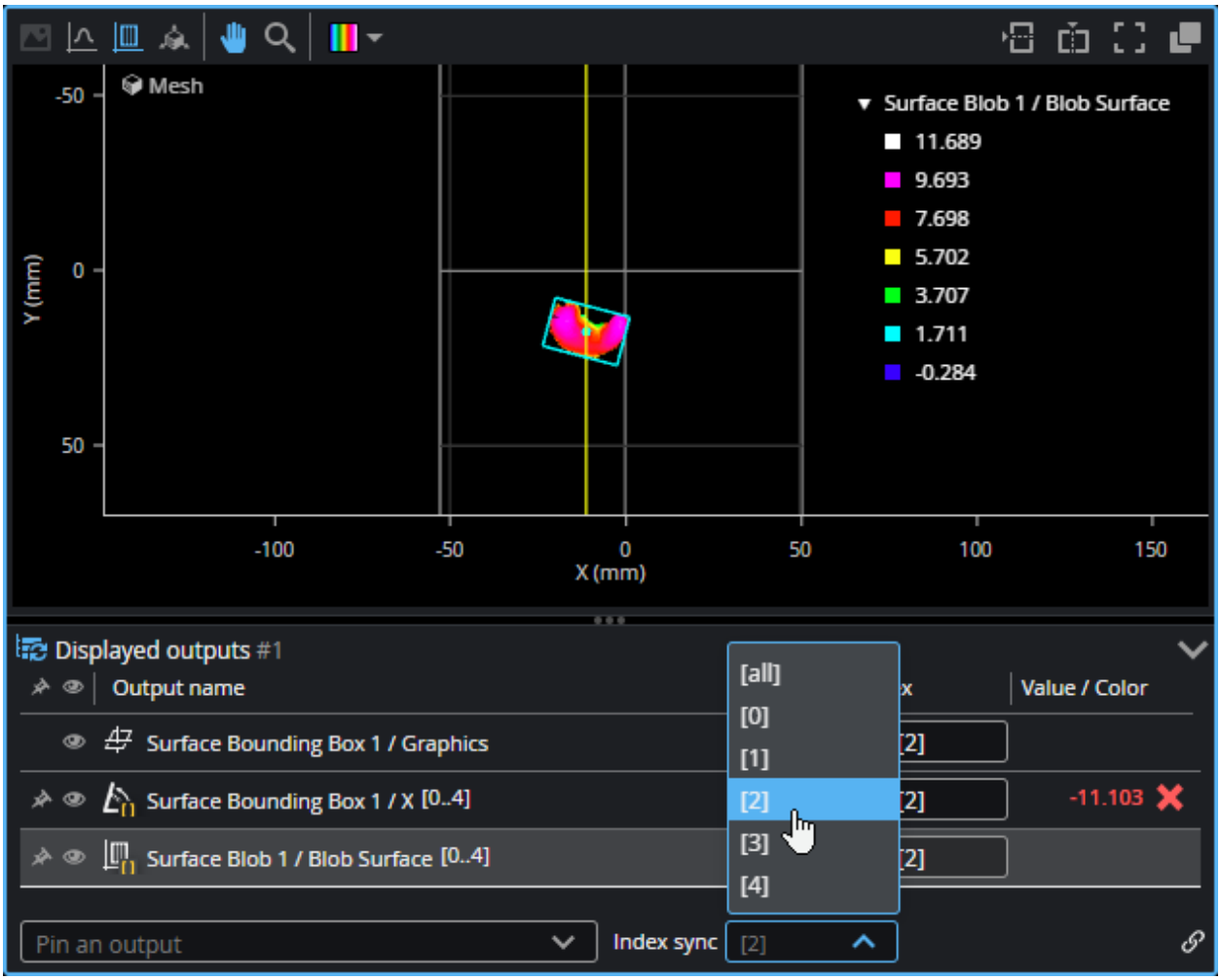

By default, this is enabled in the main data viewer, and disabled in any pop-out or split data viewers you create. Note that if there are no pinned outputs in any of the tools in your job, and you disable

pane synchronization, the **Displayed Outputs** panel will be empty and nothing will be displayed in the data viewer.

When you are working with arrayed outputs, you can select an array element for display across all arrayed outputs listed in the **Displayed Outputs** panel. For example, in the following, we see all five objects in an arrayed output displayed. For *each* element, Bounding Box tool graphics and X and Y measurements, as well as the Surface Blob output.



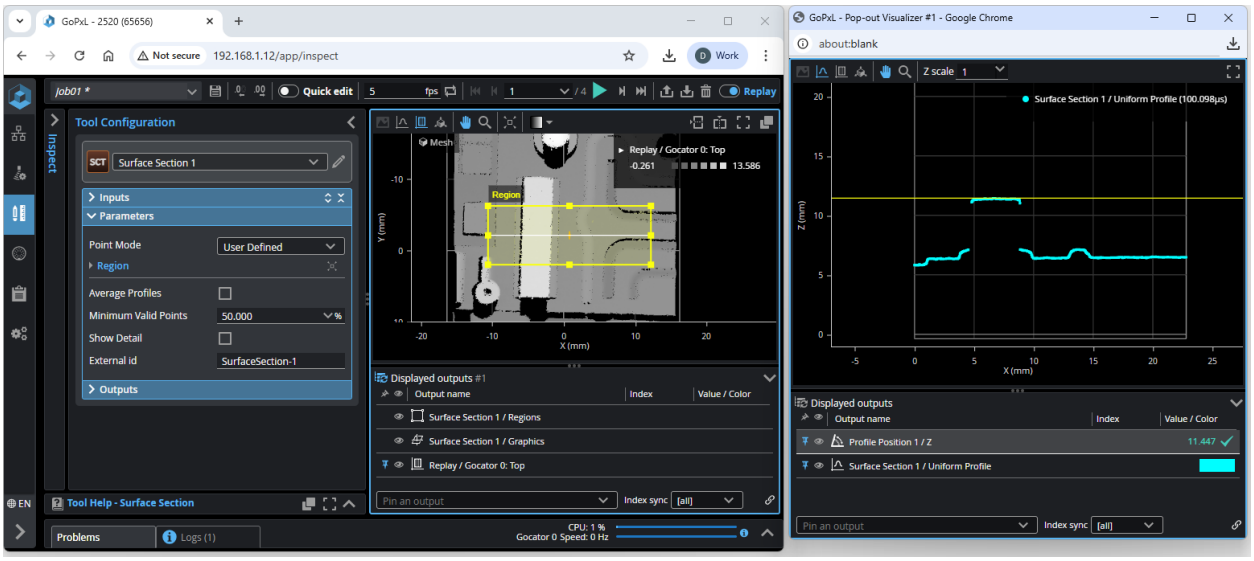

If you want to focus on a single element, you can choose that element in the **Index sync** drop-down.




Note that the default is to display all elements.

## Using Multiple Data Viewers

You can more easily monitor or set up complex applications by popping out multiple data viewers outside of the main browser window, or by splitting a data viewer into two data viewers in the same browser window. You can configure each data viewer to different views, different display modes, and different sets of pinned outputs. This gives you complete flexibility.



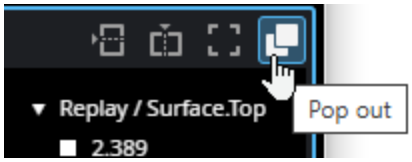

*Main view in original browser window showing surface data and a defined section, and a second window showing a Profile tool running on the section.*

External data viewer windows provide the same functions as the main data viewer via the toolbar above the viewer (except for the ability to open a new window). External windows also include a Displayed Outputs panel at the bottom and support the pinning of outputs; pinning in external windows is independent from the main view data viewer and other external windows. For more information on pinning outputs, see *Displaying and Pinning Outputs* on page 79.

*To create a new data viewer window*

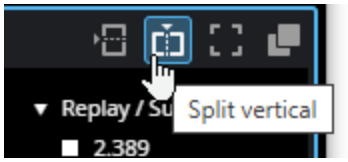
Do one of the following:

- In the toolbar of the main view data viewer, click the Pop out button ( ).




A new browser window opens containing a separate data viewer.

- In the toolbar of any data viewer, click one of the "split" buttons ( or ).




A new data viewer appears in the same browser window.

Use the tool bar at the top of the new data viewer to choose and modify the view. For more information, see *Data Viewer* on page 64.

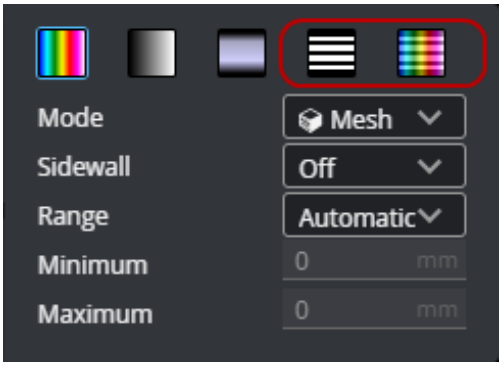
Pin outputs to the new data viewer as in the main view data viewer. For more information, see Displaying Multiple Measurements and Geometric Features (Pinning). Any outputs pinned in the

main view when you open a new data viewer window appear already pinned in the new window, but pinning in data viewers is otherwise independent.

## Intensity Output

Sensors can produce intensity images that measure the amount of light reflected by an object. An 8-bit intensity value is output for each data point in the scan data. GoPxL uses the same coordinate system as the data points.

To display intensity data, choose either of the last two display options in the data viewer display options. If intensity data is not available, the icons are grayed out. Intensity data can only be shown with Surface data.




*Intensity-only, and Surface with intensity buttons*

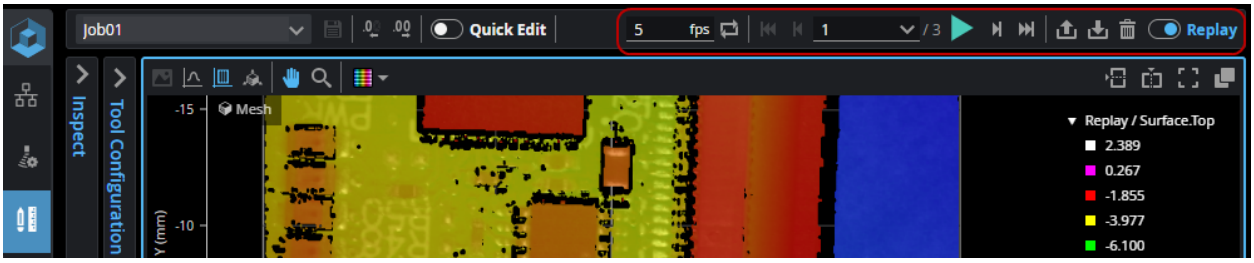
> To be able to display intensity data, you must enable **Acquire Intensity** in the **Scan Mode** panel before scanning. For more information, see *Scan Modes and Intensity* on page 111.

# Recording and Working with Scan Data

You use the buttons in the right half of the global toolbar, at the top of the interface, to do the following:

- start and stop acquisition
- record replay data
- enable replay mode and play back replay data
- upload, download, and clear replay data
- use the Replay Editor

> When switching between scan modes, if you have previously recorded data, you must clear it before recording replay data of a different type.

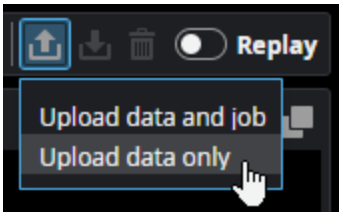



Depending on whether Replay mode (4, below) is disabled or enabled, the control buttons (2, below) change. When Replay is off, the controls let you start and stop data acquisition. When Replay is on, the controls let you play back recorded data.

*The global toolbar with Replay disabled (top) and enabled (bottom)*

Note that when GoPxL is in Replay mode, the data viewer is displayed with a blue border to help

| | Element | Description |
|---|---|---|
| 1 | Frames per second and Repeat frames (looping) | These controls let you set the number of frames per second (fps) during playback, and also whether GoPxL repeats frames, by toggling the Repeat frames button ( ). For more information, see *Playing Back Recorded Data* on page 90. |
| 2 | Data playback and | These controls let you start and stop scanning, start recording and also play |

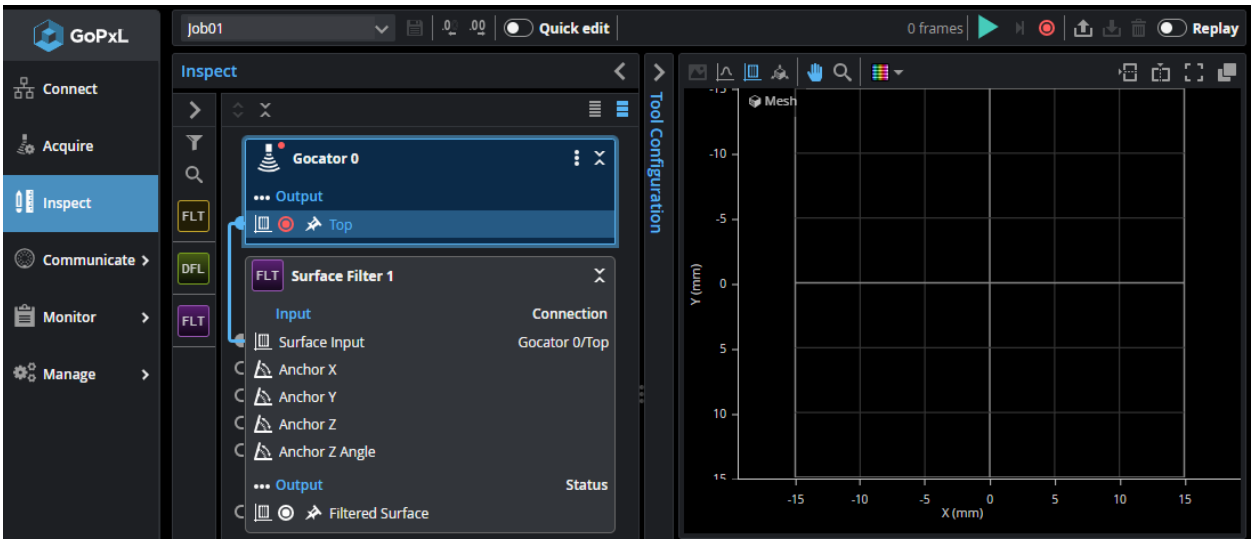
| | Element | Description |
|---|---|---|
| | recording controls | back replay data. The number of frames is also indicated. The controls that are available depends on whether Replay mode is disabled or enabled.<br>For information on starting and stopping scans, see *Starting, Stopping, and Recording* below.<br>For information on data playback, see *Playing Back Recorded Data* on page 90. |
| 3 | Replay actions | Lets you upload, download, and clear recorded data.<br>When uploading data, you can decide whether to only upload data, or to upload both scan data and the associated configuration (tools and other GoPxL settings).<br>  <br>The file type of replay data is .gprec. |
| 4 | Replay toggle | Toggles between data acquisition (toggle is to the left) and data playback (toggle is to the right). |

# Starting, Stopping, and Recording

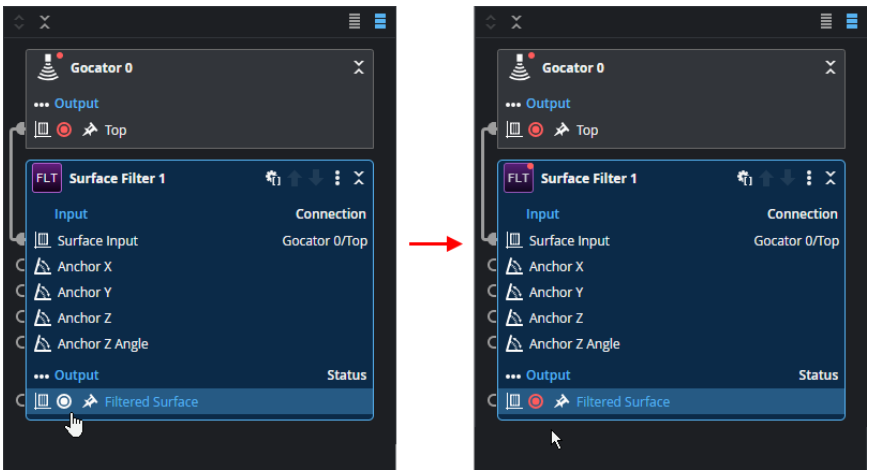
You start and stop data acquisition (and toggle recording) using the data control buttons when Replay is disabled.

| | Element | Description |
|---|---|---|
| 1 | Start or stop scanning | The sensor starts scanning continually when you click the Start button ( ), and stops when you click the Stop button ( ). |
| 2 | Single frame (Snapshot) | The sensor acquires a single frame of data. For line profile sensors, you can't acquire a single frame of data if the sensor is in Surface mode, only in Profile or Image mode. |
| 3 | Record data | Toggles recording scan data as it is acquired. The number of frames recorded is displayed next to the Start button. When recording is enabled, the Record data button turns red ( ). |

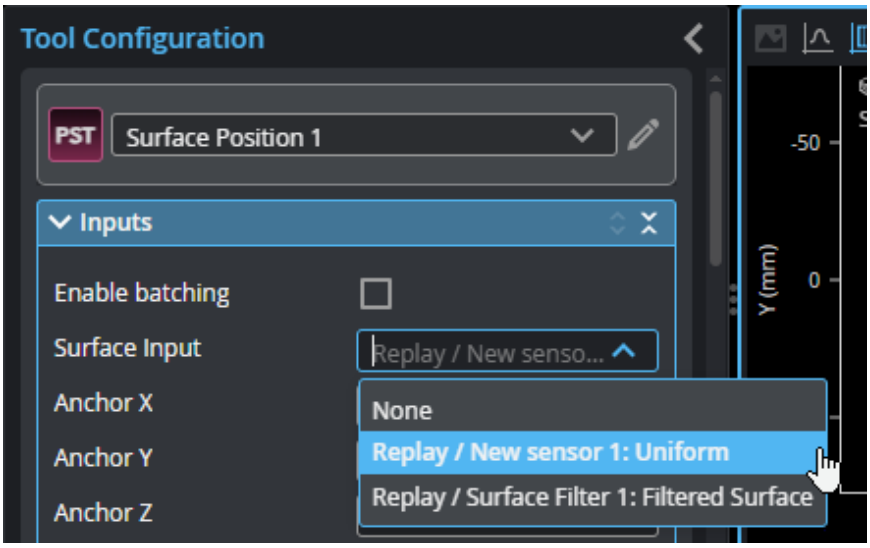
Normally, when you have enabled recording using the Record data button above the data viewer, GoPxL records scan data coming directly from the sensor or group of sensors (in the Tool Diagram, this is called the "sensor block").




You can also record a tool's output. An example of this is recording the Filtered Surface output of a Surface Filter tool. To do this, first enable recording above the data viewer as you would normally do. Then, expand a tool in the Tool Diagram, and click the white Record button next to an output.



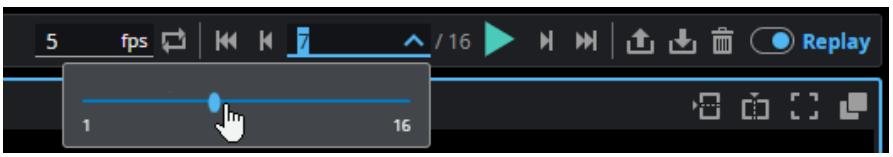

When you record data with output recording enabled for any of the tool's outputs, the resulting replay data will contain the scan data coming from the sensors, but also the tool's output data. Once you've downloaded this replay data and uploaded it to a sensor or PC instance of GoPxL, both sources are available in a tool's input.




You can choose to disable recording of the data coming from the sensor block to only record a tool's output. This can be useful when you have a long chain of pre-processing tools that performs filtering, transformations, or masking to isolate scan data, and so on. By recording the output of the last tool in the pre-processing chain, uploading that to a PC instance of GoPxL, you can then develop the decision-making part of your application separately, without the overhead of the pre-processing tool chain.

## Playing Back Recorded Data

When Replay mode is enabled, you play recorded data back using the data control buttons.

| | Element | Description |
|---|---|---|
| 1 | Playback rate and repeating frames | When "Repeat frames" ( ) is enabled, scan data is played back in a loop. This is useful when inspecting data or configuring tools using recorded data, and also for demos. |
| 2 | Go to previous / first frame | Displays the previous frame or jumps to the first frame of the recorded data and displays it. |
| 3 | Frame position | Lets you go to a specific frame, either by entering a value in the field, or by using a slider.   |
| 4 | Start playback | Starts playing back frames of the recorded data, at the specified number of frames per second. |
| 5 | Go to next / last frame | Displays the next frame or jumps to the last frame of the recorded data. |

# Creating, Saving and Loading Jobs

Jobs contain sensor, tool, and control configurations for a particular inspection or quality control application. (For more information, see *Configuring GoPxL* on page 92.)

A sensor can store many jobs, subject to sensor storage limitations. Running GoPxL on a PC or using GoMax NX provides more storage. Being able to switch between jobs is useful when a sensor is used with different constraints during separate production runs. For example, width decision minimum and maximum values might allow greater variation during one production run of a part, but might allow less variation during another production run, depending on the desired grade of the part.

Most of the settings that you can change in GoPxL's web interface are temporary until saved in a job file. If there is a job file that is set as the default, it will be loaded automatically when GoPxL starts.

GoPxL lets you perform several job-related operations from the global toolbar at the top of the interface:

Other operations are available on the **Manage** > **Jobs** page. For more information on jobs and working with them, see *Jobs* on page 805.

# Configuring GoPxL

The following sections describe how to configure GoPxL using its web interface.

GoPxL can run on a sensor, or you can run GoPxL on a Windows PC and connect to a sensor running GoPxL from the application (in order to increase performance, for example). When GoPxL runs on a PC, we call this a local or PC instance of GoPxL. For applications where performance is critical, you should use the PC version of GoPxL to improve sensor performance. With some sensor models, such as Gocator 4000 and Gocator 5500 series sensors, LMI *strongly* recommends using the PC version of GoPxL (or a GoMax NX accelerator).

To configure GoPxL when it is running on-sensor, you connect directly to the sensor's IP address (by default, 192.168.1.10). To configure GoPxL when it is running on a PC, you connect to the IP address of the PC instance. If you can't connect to GoPxL, use the GoPxL Discovery tool to find it and launch the GoPxL interface (for more information, see *GoPxL Discovery Tool* on page 917).

The interface of the sensor and the PC versions of GoPxL are nearly identical. For this reason, you can use this section to configure sensors whether you are using GoPxL on a sensor or on a PC. If you need to run the PC version of GoPxL, see *Running GoPxL on a Windows PC* on page 814 first.

For information on configuring GoPxL programmatically, see *GoPxL SDK and REST API* on page 863.

## Connect - Creating a System & Networking

You use the **Connect** page to see available devices, create a sensor system containing two or more sensors, and also configure network settings. You can also identify devices that are unavailable (either because of a GoPxL version mismatch, or because a sensor is already running through another PC instance of GoPxL). For information on running a sensor through a PC instance of GoPxL, see *Running GoPxL on a Windows PC* on page 814.

GoPxL does not currently support mixed-model multi-sensor systems.

### Adding Sensors and Configuring Multi-sensor Systems

GoPxL lets you create a dual-sensor system, which combines the scan data from individual sensors into a single frame, on which you can run measurement tools. In these systems, one sensor (or a GoMax Smart Vision accelerator or a PC instance of GoPxL) is the "host" of GoPxL, which is indicated in the Status column in GoPxL, and controls the other sensors. Another way of thinking of this is to say that other sensors are "grouped" with the controlling device, creating a "sensor group."

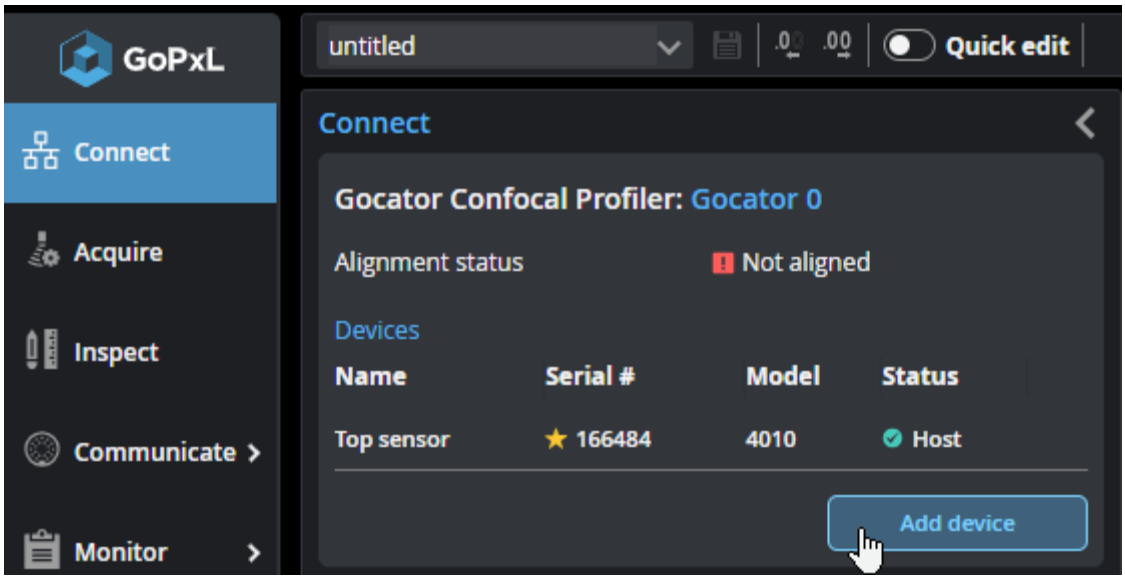
*To create a dual-sensor system*

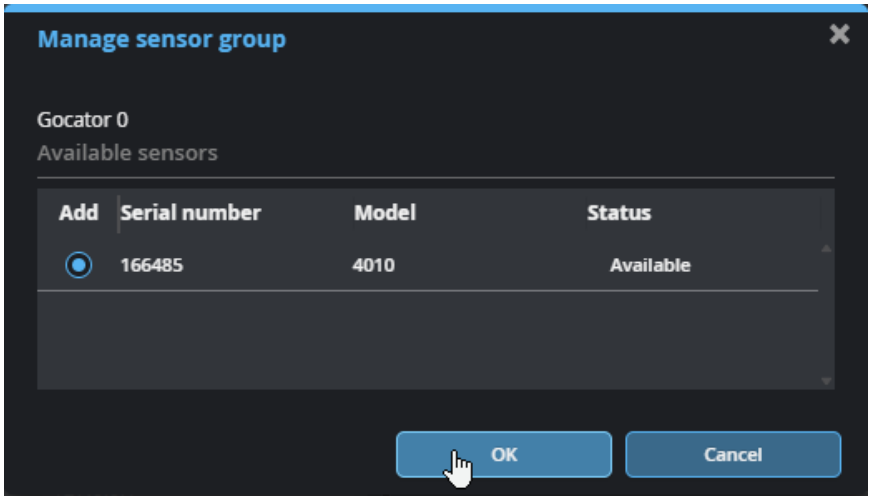
1. In a web browser, connect to the device or PC instance of GoPxL that will control the other devices.

   The default Gocator sensor IP address is 192.168.1.10. If you don't see your sensor in the browser, see *GoPxL Discovery Tool* on page 917.

It may be useful to connect to the leftmost sensor first.

2. In the GoPxL interface, go to the **Connect** page and click **Add device**.

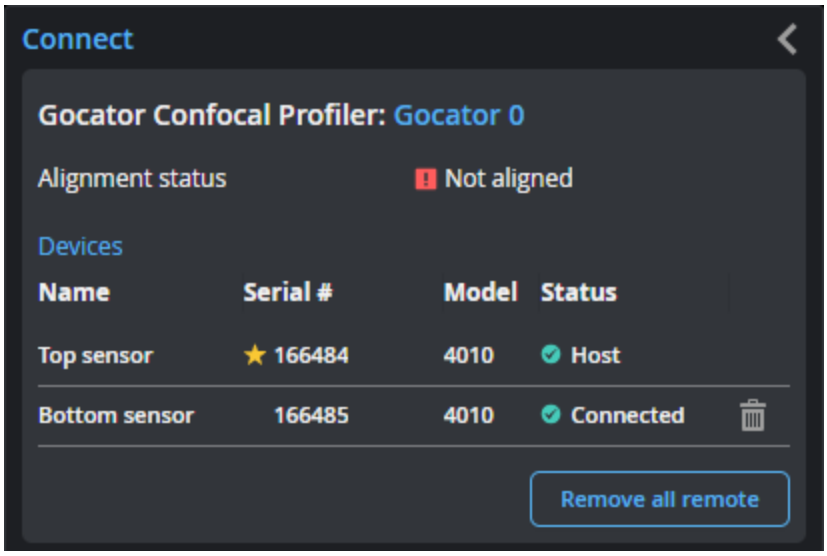


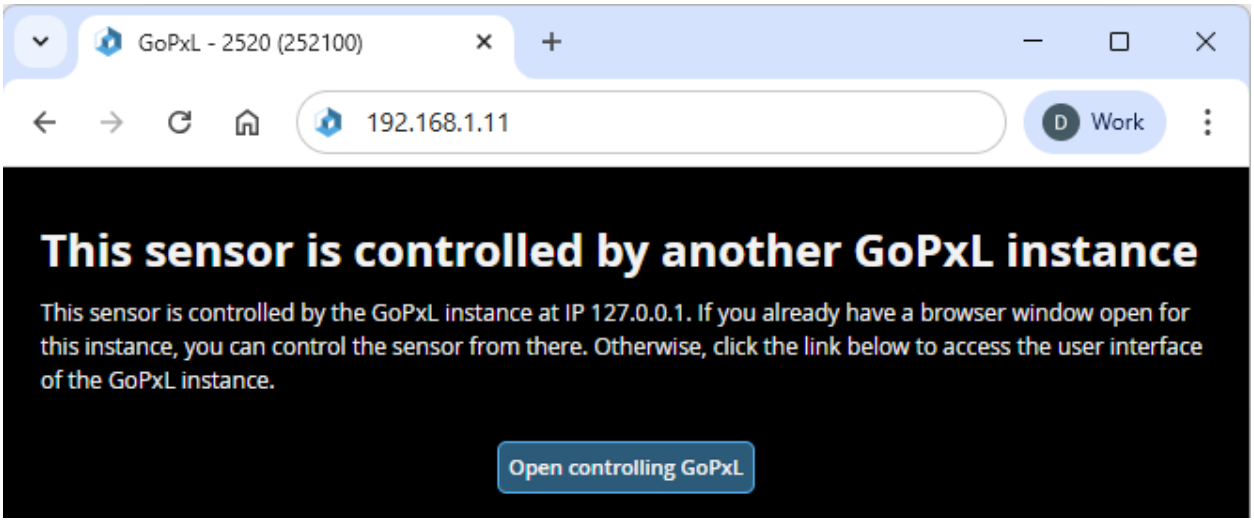

If you don't see sensors you expect to see in the table at the top, close the dialog (Close icon ✖ or **Done**) and observe which sensors are listed in **Visible sensors**. These are the sensors that have been detected on the network. If you still don't see the sensors you expect, use the Discovery tool (for more information, see *GoPxL Discovery Tool* on page 917).

3. In the dialog, select the sensor you want to add to the sensor group and click **OK**.

   The sensor is added to the sensor group.

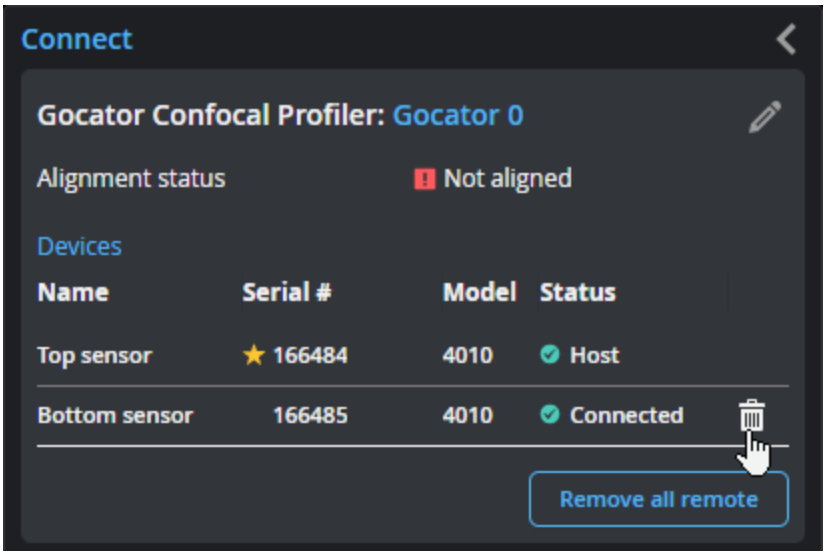



After you have grouped a sensor with another sensor, the web interface of the grouped sensor (also known as a "remote sensor") will show that it's currently being controlled by another GoPxL instance, namely, GoPxL running on the sensor on which you configured the system.




## Removing a Sensor from a System

To remove a sensor from a dual-sensor system, click the trashcan icon in its row, or click **Remove all remote**.




## Resetting the Layout

In some situations, you may need to reset the layout. Clicking **Reset Layout** moves all added sensors to the top row and sets their orientation to Normal.

## Network Settings

*To configure the network settings:*

1. Go to the **Connect** page.
2. Specify the type (Manual or DHCP), IP, subnet mask, and gateway settings.
   The sensor can be configured to use DHCP or assigned a static IP address by selecting the appropriate option in the **Type** drop-down.
3. Click **Save Changes...**.
   You will be prompted to confirm your selection.
   The sensor restarts, using the *new* IP address. It may take several seconds for the sensor to become available.

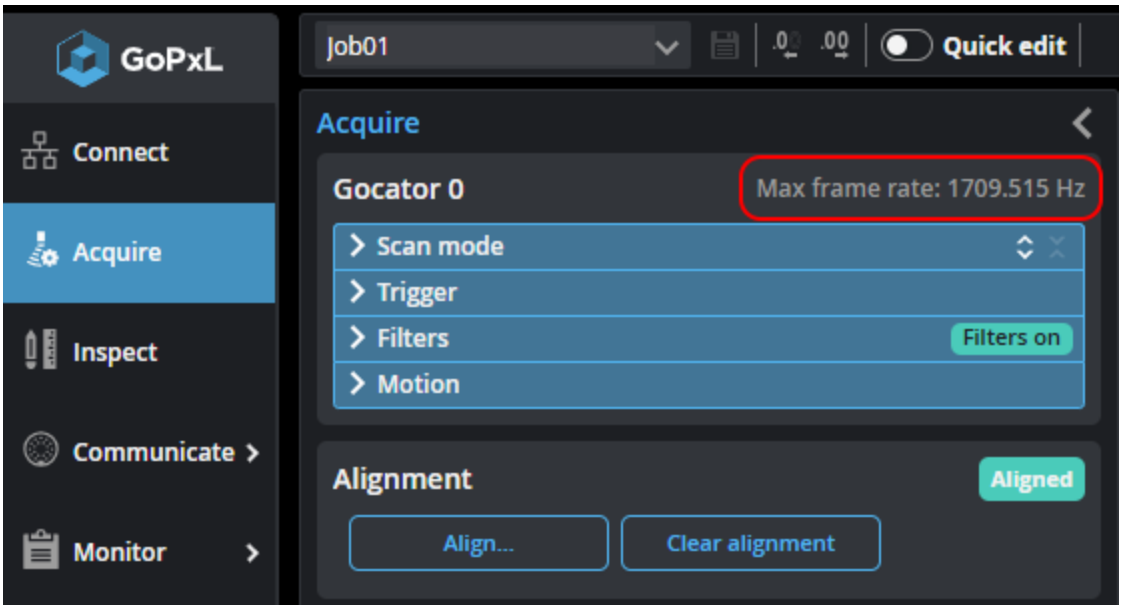
# Acquire - Alignment and Acquisition

You configure acquisition and align sensors on the **Acquire** page.

Scan settings are displayed in two sections: the top section, by default called **Gocator 0**, and the **Sensor Properties** section.

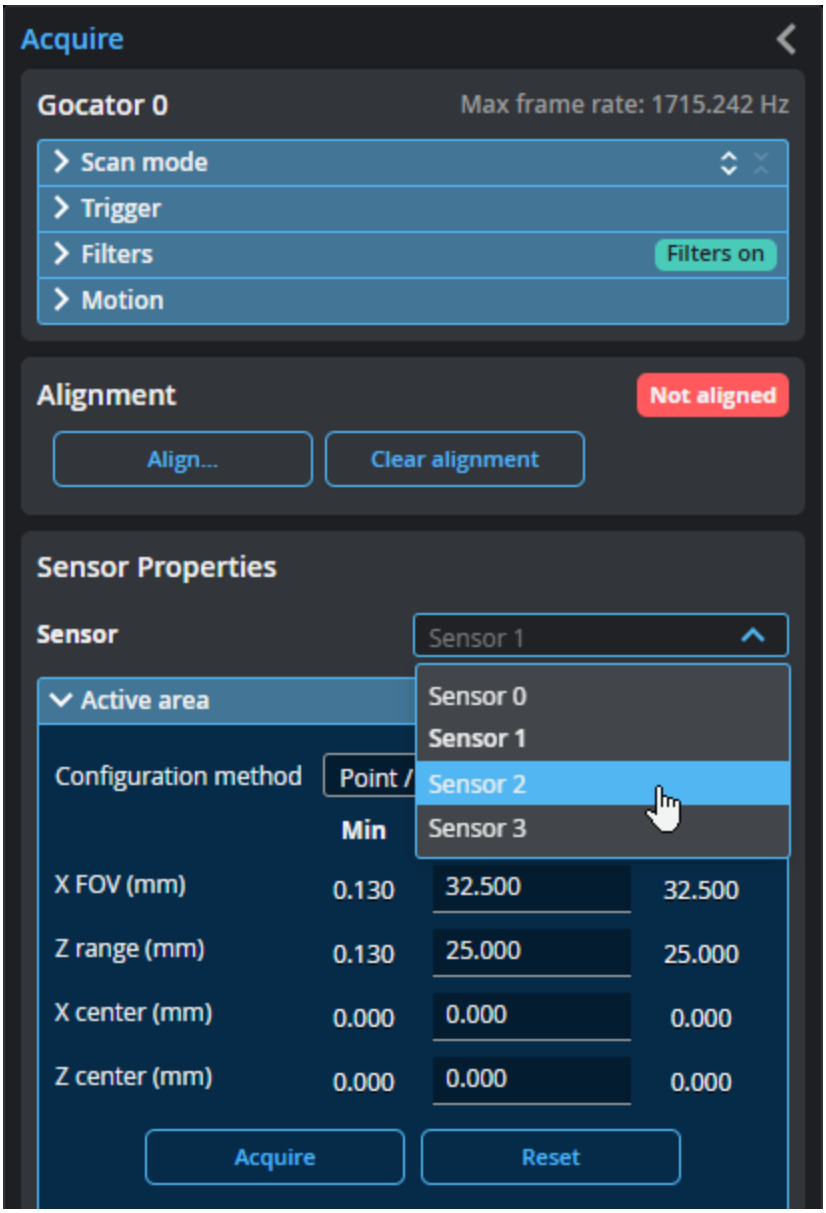
Settings such as the scan mode, X spacing intervals, and triggering, which must apply to *all* sensors in a multi-sensor system (that is, as a sensor group), are in the top section. For consistency, in single-sensor systems and with models such as Gocator 3x00 that don't support multi-sensor grouping, these settings are separated from the others in this section.

Note that the sensor system's maximum possible frame rate is displayed at the top of this section. This value changes depending on some of the settings in the **Sensor Properties** section (see below).




Other settings, such as active area, exposure, and sub-sampling, apply to individual sensors in a sensor group. These settings are in the **Sensor Properties** section.

To configure the per-sensor settings in a multi-sensor system, you select a sensor using the **Sensor** drop-down menu.




Note that with line profile sensors, the type of data displayed in the data viewer changes depending on which of these sections you interacted with last (to change a setting, and so on). With live scan data (what the sensor is actively scanning), interacting with the sensor settings results in Profile data being displayed. Interacting with the sensor group settings results in Surface data being displayed. If you are seeing profiles when you expect to see Surface data, click somewhere in the **Sensor group properties** section. With replay data, after clicking in the appropriate section, you may additionally need to change the display mode by clicking the Profile or Surface button above the data viewer.

The section you last interacted with is highlighted in blue.

## Aligning Sensors

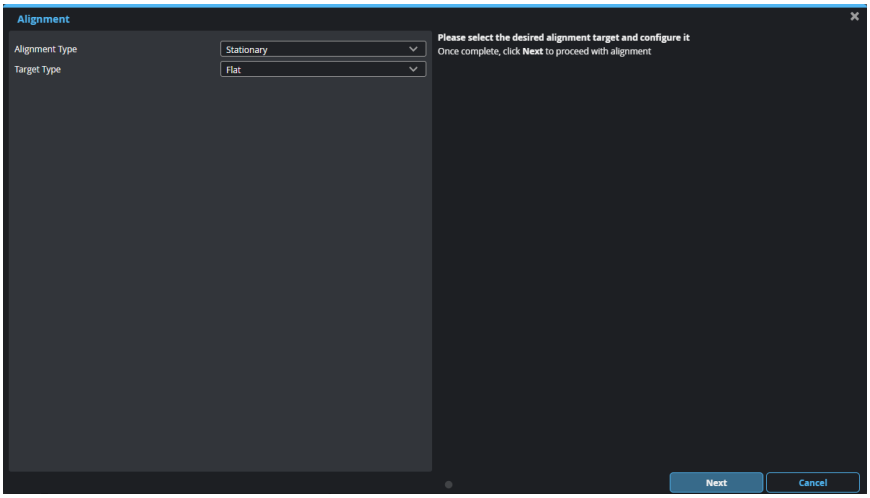
| | |
|---|---|
| | Alignment is rarely used on confocal sensors. |

Alignment is the process you use to automatically calculate transformations (rotations and translations / offsets) that are applied to a sensor's scan data while it is scanning targets. If you do not correct for these rotations, scan data may be too distorted for your application, and your measurements may therefore be inaccurate. Alignment is often required for various reasons:

- To compensate for sensor mounting inaccuracies relative to the intended scanning surface.
- To set a Z (height) reference plane, using a sample target.

In single-sensor G4 or G5 applications, you don't typically need to align the sensor. For dual-sensor applications, however, you need to perform an alignment. You should use the alignment procedure the **Acquire** page, in the Alignment section, by clicking the **Align...**.

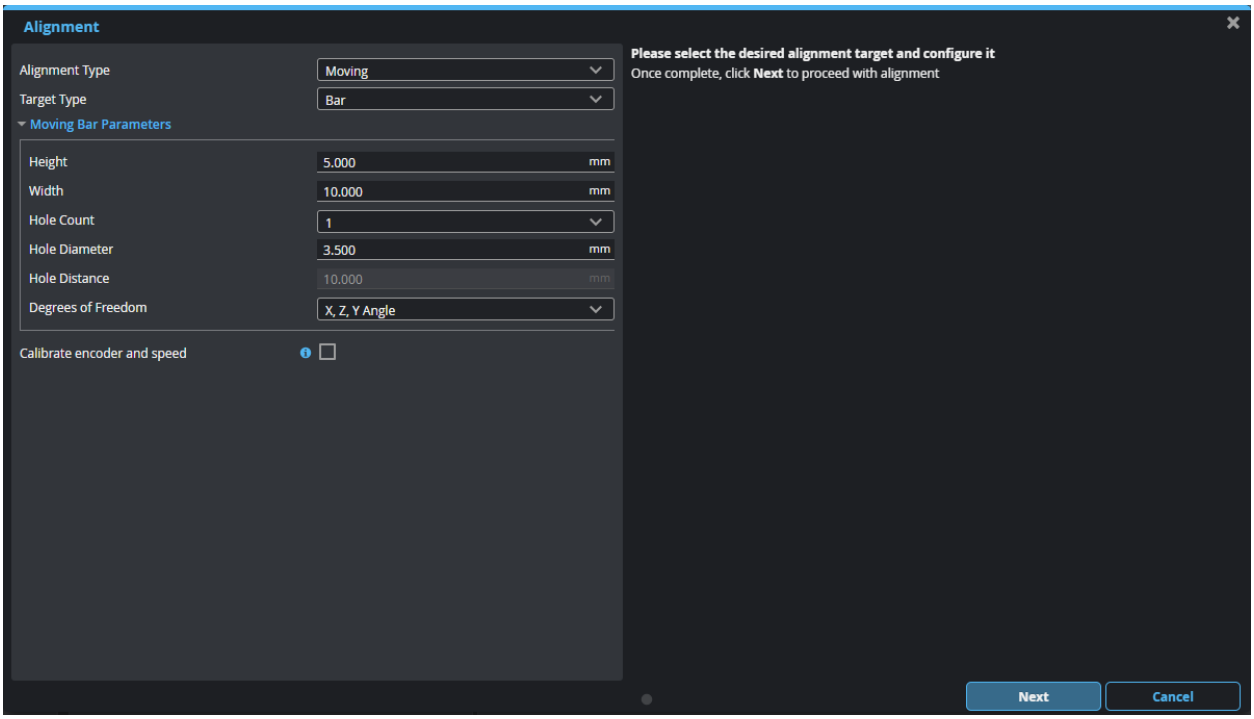
Once you click the **Align...** button, an alignment "wizard" goes through the steps required.




| | |
|---|---|
| | Sensors are pre-calibrated and ready to deliver data in engineering units (mm) out of the box. Alignment procedures do not affect sensor calibration. |

### Aligning Sensors with up to 5 Degrees of Freedom

For information on coordinate systems, see *Coordinate Systems* on page 41.




*Alignment routine when Moving Bar type is selected*

A sensor can be in one of two alignment states: Unaligned and Aligned. An indicator on the **Alignment** panel displays UNALIGNED or ALIGNED, depending on the sensor's state. A sensor's alignment state determines its coordinate system; for more information on coordinate systems, see *Coordinate Systems* on page 41.

> If you perform a high-accuracy tool-based sensor alignment, the **Alignment** panel will still display UNALIGNED. *This is normal.*

*Alignment State*

| State | Explanation |
|---|---|
| Unaligned | The sensor or sensor system is not aligned. Data points are reported in sensor coordinates. |
| Aligned | The sensor is aligned using the alignment procedure (described below) or by manually modifying the values under **Transform** on the **Acquire** page (for more information, see *Transformations* on page 109). Data points are reported in system coordinates. |

Once you have performed the alignment procedure on the **Acquire** page, the calculated transformation values are displayed under **Transform** on the **Acquire** page. For more information on transformations, see *Transformations* on page 109.

With certain types of alignment, a **Degrees of Freedom** setting lets you choose the axes on which offsets and rotations are calculated. If the setting is not available, only X and Z offsets, and Y angle rotation, are calculated. That is, alignment is only performed within the profile plane. When the **Degrees of Freedom** setting is available, it generally provides options that let you perform alignment outside the profile plane.

*To prepare for alignment*

1. For dual- or multi-sensor systems, make sure you have done the following:

   On the **Connect** page, add sensors to the system. For information, see *Adding Sensors and Configuring Multi-sensor Systems* on page 92.

   Configure the system's layout, if necessary. For more information, see *Connect - Creating a System & Networking* on page 92 and *Connect - Creating a System & Networking* on page 92.

   If the profiling lines of the sensors overlap, make sure to check the **Exposure Multiplexing** option. Otherwise, the profiling line from one sensor will be detected by other sensors and cause the alignment procedure to fail or be inaccurate; for more information, see *Connect - Creating a System & Networking* on page 92.

2. Go to the **Acquire**.
3. Ensure that all sensors will have a clear view of the alignment target surface.
4. Perform a preliminary scan of the alignment target to evaluate the quality of the scan data.

   Doing this will help ensure that the alignment process succeeds. In the next step, adjust the settings based on the scan data of the alignment target.

5. If necessary, adjust the settings on the **Acquire** page to get the best data possible from the scans of the alignment target.

   Some examples of the settings you may need to adjust are:

   - Exposure duration (to make sure the target is clearly represented in the scan data). Typically, only a single exposure is needed. For more information, see *Single Exposure* on page 133.
   - Active area. For more information, see *Active Area* on page 129.
   - Spacing: For more information, see *Uniform Spacing* on page 112.

   Because the alignment procedure automatically uses Time triggering, regardless of the settings in the **Trigger** panel, you can leave these settings as is and configure them later. For information on triggering, see *Triggers* on page 120.

6. Do one of the following:
   - If you need to perform a stationary alignment, see *Performing Stationary Alignment* below.
   - If you need to perform a moving alignment, see *Performing Moving Alignment* on page 103.

## Performing Stationary Alignment

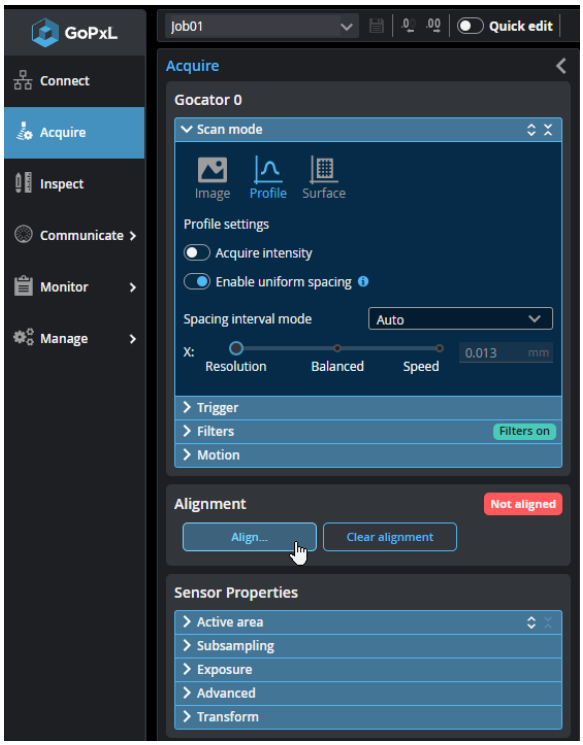
*To perform stationary alignment*

1. Make sure that the alignment surface (whether it's the surface of a conveyor or of an alignment target) is within the sensor's measurement range.

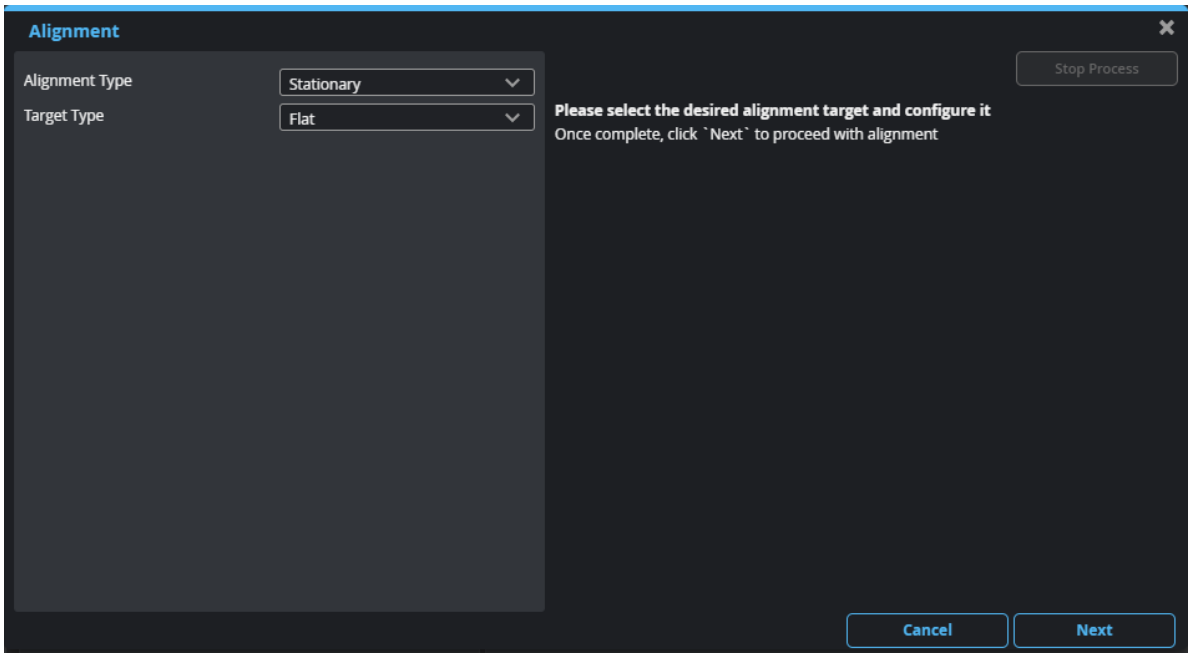
   To determine this, in the sensor's web interface, click **Start** and observe whether the Range LED on the sensor is illuminated. If you have set the trigger source to Encoder under **Acquire** > **Trigger**, temporarily set it to Time for this. Be sure to stop the sensor after confirming the target is in range by clicking the **Stop** button.

   Alternatively, you can determine the correct distance to the scan surface by consulting the sensor's measurement range specifications (see *Sensors* on page 956), and measuring the physical distance between the scan surface and the sensor.

2. Go to the **Acquire** page.
3. (Optional) If a previous alignment is present, click the **Clear Alignment** button.
4. If you are using an alignment target, place it below the sensor or sensors.
5. Click **Align Sensors**.




   The Alignment dialog appears.



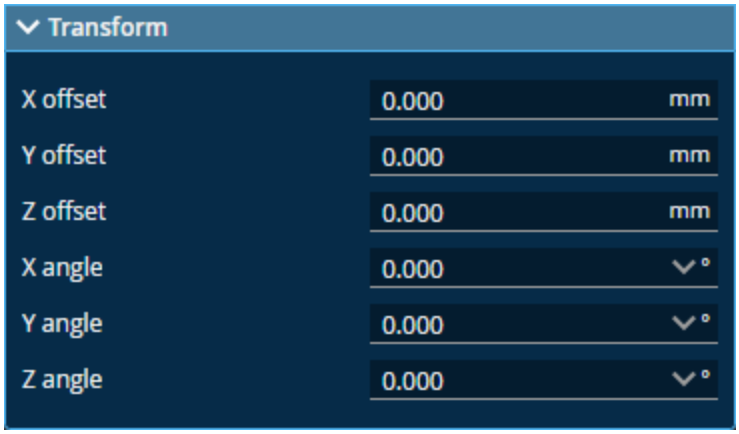

6. Set **Alignment type** to Stationary.
7. Choose an alignment type in **Alignment type**.
   - **Flat Surface**: For more information, see *Stationary Flat Surface* on the next page.
   - **Bar**: Use this to align to a bar alignment target. For information on alignment target requirements, bar-specific settings, and general setup tips, see *Aligning Sensors with up to 5 Degrees of Freedom* on page 98.
8. Click the **Next** button.

   The alignment process starts. Alignment is performed simultaneously for all sensors.

   If the alignment fails, check the settings described in *To prepare for alignment* on page 100 and repeat the steps described here.
9. Inspect alignment results.

   Data points from all sensors should now be aligned to the alignment target surface.

   Check the alignment results under **Transform**.



For information on how alignment affects the coordinate system used by sensors, see *Coordinate Systems* on page 41.

**Performing Moving Alignment**

*To perform moving alignment*

1. Go to the **Acquire** page.
2. (Optional) If a previous alignment is present, click the **Clear Alignment** button.
3. Place the target under the sensor.
4. Make sure that the surface of the alignment target is within the sensor's measurement range.

   You can determine the correct distance to the scan surface by consulting the sensor's measurement range specifications (see *Sensors* on page 956), and measuring the physical distance between the scan surface and the sensor.
5. Set **Alignment Type** to Moving.

   G4 and G5 sensors only support Bar as the target type with moving alignment.
6. (Optional) If you need to calibrate the transport system, check the **Calibrate encoder and speed** checkbox.

   The automatic encoder and speed calibration functionality is less accurate than manually specifying the transport system's encoder resolution or travel speed. You should only use this option if you have no other way of getting these values.

   If you do not use the built-in encoder or speed calibration functionality, make sure you have done one of the following:

   - If the transport system includes an encoder, make sure you have configured the encoder resolution.
   - If the transport system does *not* use an encoder (it is a time-based system), make sure you have configured travel speed.

   For more information on configuring motion settings, see *Motion* on page 128
7. Click the **Next** button.
8. Start the transport system.

   The sensors will start and then wait for the alignment target to pass through the laser plane or light plane. Alignment is performed simultaneously for all sensors. Alignment may take a minute or more.
9. Inspect alignment results.

   If the alignment fails, check the settings described in *To prepare for alignment* on page 100 and repeat the steps described here.

   Check the alignment results under **Transform** on the **Acquire** page.

   For information on how alignment affects the coordinate system used by sensors, see *Coordinate Systems* on page 41.

**Stationary Flat Surface**

No additional settings are required for this alignment method. Note however that this type of alignment expects to receive flat scan data. Therefore, if the surface is curved, the alignment will be inaccurate. The surface should also be clear of debris and damage.

| | |
|---|---|
| | On sensors aligned using Z angle (or sensors with a manually set X angle), and to a lesser extent Y offset, CPU usage increases when scanning, which reduces the maximum scan speed. |

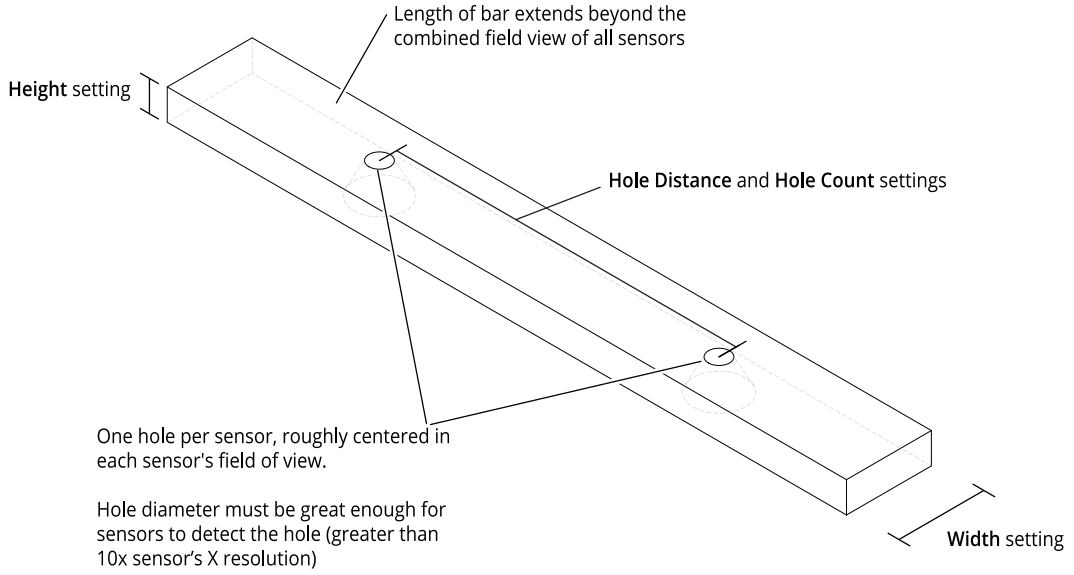
| | |
|---|---|
| | Artifacts may appear in scan data on sensors aligned using Z angle or X angle if encoder trigger spacing is set too high (resulting in a low sampling rate). For more information, see *Trigger Settings* on page 123. |

#### Bar Specifications and Procedural Requirements

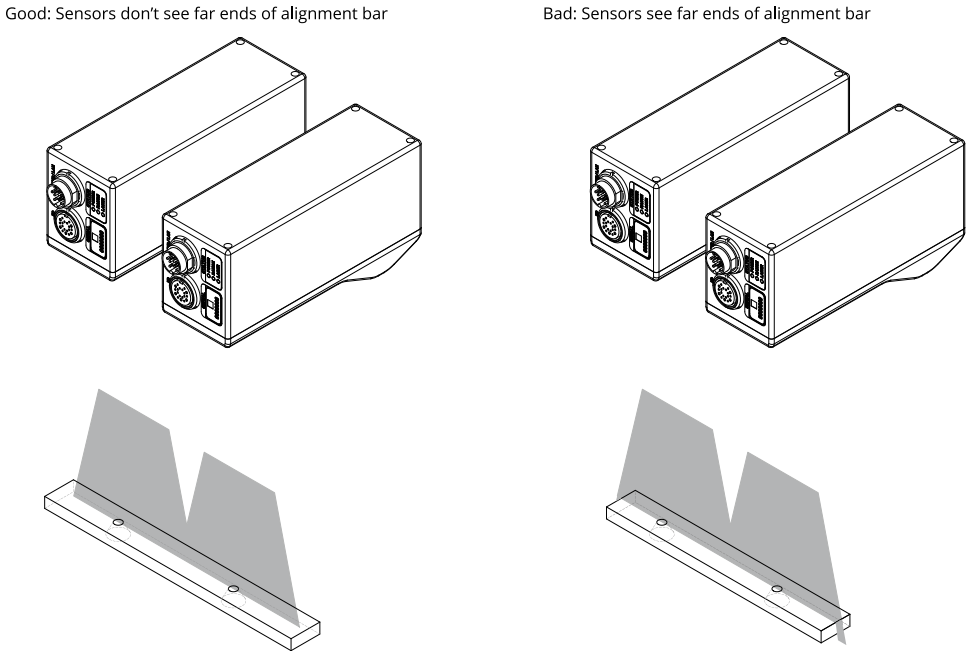
See the following sections for bar specifications and procedural requirements (stationary or moving alignment).

### Bar Specifications

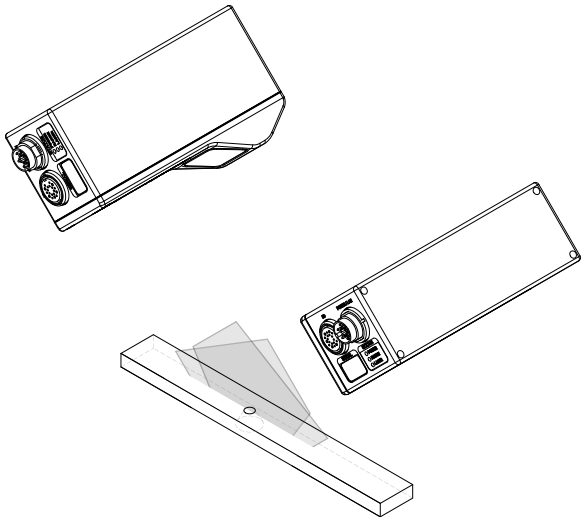
Ensure the following:



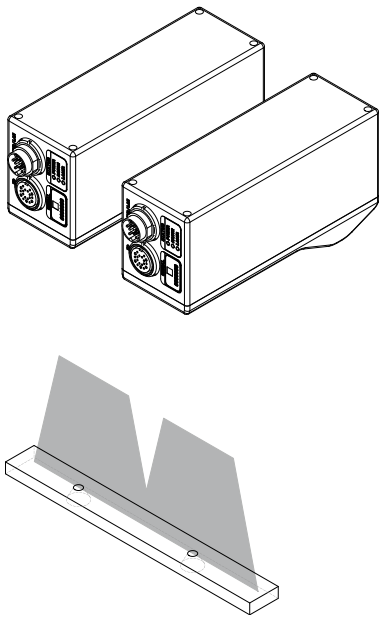

- The bar must extend beyond the outer ends of any profiling line: sensors must not "see" the left or right end of the bar (relative to the direction of travel of the transport system). Alternatively, you can set the active area of sensors that can "see" the ends of the bar to exclude the ends from the scan data; for more information, see *Active Area* on page 129. Otherwise, although the alignment should succeed, it will not be accurate: it may result in unwanted offsets or angles in the transformations.




- If the sensor system contains two or more sensors side by side that are *not* intentionally angled toward each other around the Y axis (for example, to reduce occlusions), the bar should have one hole per sensor. Hole spacing should roughly correspond to the distance between the center of the FOVs of the mounted sensors, and holes should be equidistant. Although alignment can be performed if a sensor sees more than one hole (for example, if the profiling lines overlap enough), only the hole nearest to the center of a sensor's FOV is used for that sensor's alignment.
- If the sensor system contains two or more sensors side by side that *are* angled toward each other around the Y axis, a single hole should be used.



- Holes and bar edges must be as sharp as possible: avoid bevels.
- The size of the holes should be more than 10 times the X resolution of the sensor; for the X resolution of your sensor, see specifications of the sensor in *Sensors* on page 956.



- Sensors must capture as little data from the inside of a hole as possible. Either countersink holes from the opposite side of the bar (if no sensors are positioned on the opposite side of the hole in a "Bottom" position), or paint the insides of the holes with a flat black paint. Otherwise, although the alignment should succeed, it will not be as accurate: it may result in unwanted offsets or angles in the transformations.
- The recommended flatness of bar targets for accurate Y angle is roughly the Z resolution rating of the sensor. If the bar target is curved, it will introduce an apparent Y angle in the sensor alignment. For sensor Z resolution, see the specifications for your sensor in *Sensors* on page 956.
- It is not necessary to machine the bar height to a high tolerance. Bar height can instead be controlled during measuring rather than at manufacture. Only flatness and parallelism are important. If the zero level is not critical for the measurement, then standard machining tolerances can be used. Alternatively you can machine to a low tolerance and measure the value to a high precision to save cost.
- Bar width (the dimension along Y, that is, the direction of travel) is used to calibrate the encoder resolution or the travel speed, and is unrelated to Y offset in dual- or multi-sensor systems.
- Bars should be painted with flat light grey or white paint to improve data capture (by reducing the possibility of reflections and improving profile data of the bar surface). Doing this also allows you to reduce the exposure to further reduce the possibility of sensors seeing the interior of a hole. Note that when performing alignment, typically, sensors only need a Single exposure, regardless of whether sensors are going to be configured to use Dynamic or Multiple exposure when scanning in production. For more information on exposure, see *Exposure and Light Intensity* on page 132.

**Stationary Bar: Visibility of holes and bar**

The hole closest to the center of each sensor's field of view is used for the alignment procedure.

Each profiling line must cross the center of a hole.

*To do this:*

1. Advance or back up the transport system until the sensor profiling line falls on the center of the hole.
2. Continue with step 1 in *To perform stationary alignment* on page 101.

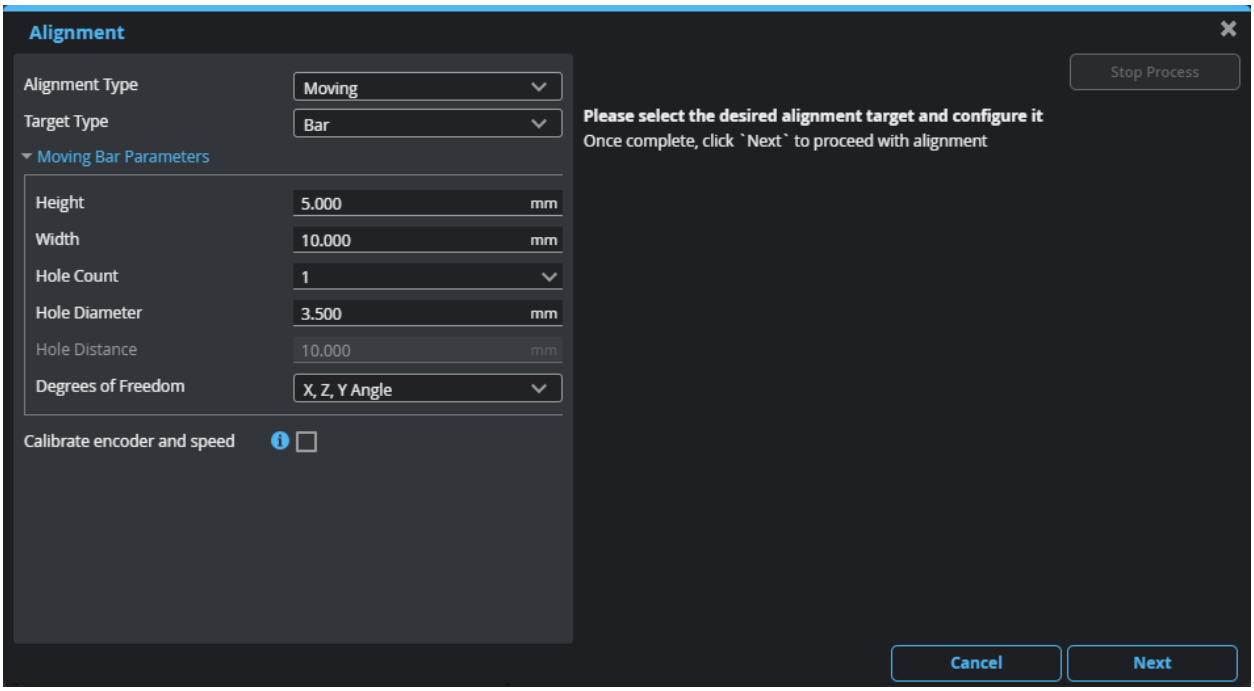
### Moving Bar: Visibility of holes and bar

No other edges than the long edges of the bar should be visible during the alignment procedure: if sensors capture data from a conveyor or other structural component, or even debris, edges from these items may be misinterpreted as bar edges, and alignment will result in a false Y offset. Adjust the active area of sensors that see any of these items to prevent them from affecting the alignment; for more information, see *Active Area* on page 129.

Sensors may either see both the bar surface and the surface the bar is on, or only the bar surface (that is, if the supporting surface is beyond the sensor's measurement range): this has no impact on the alignment procedure.

#### Configuring GoPxL for Bar Alignment

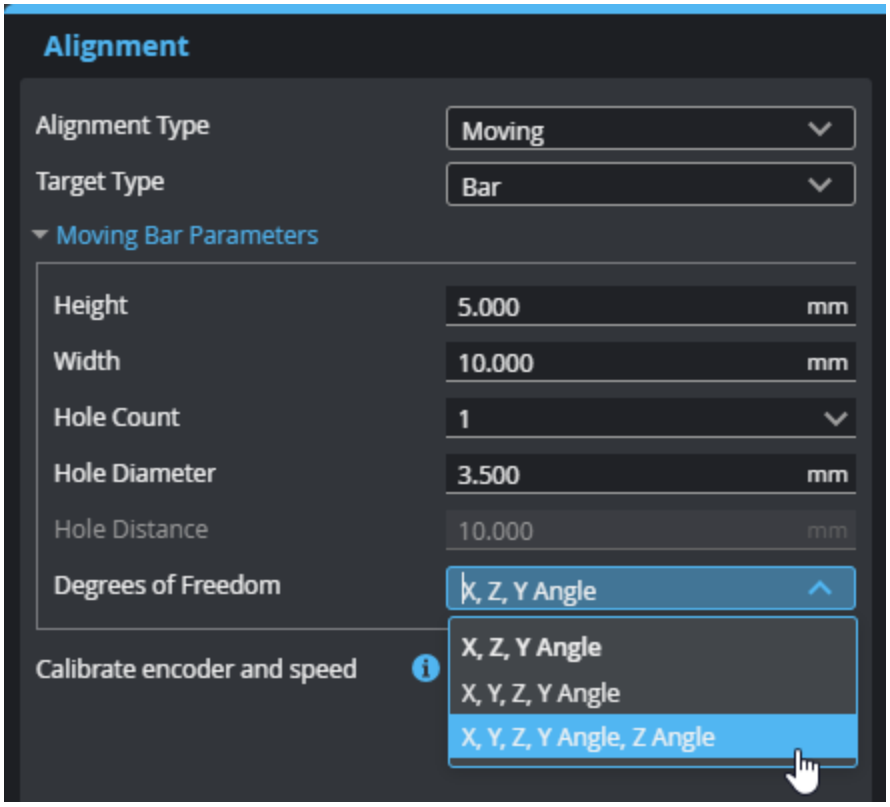
Configure the characteristics of the target (bar dimensions and reference hole layout); for more information on these settings, see below.




For an illustration of the various settings, see *Bar Specifications and Procedural Requirements* on page 104.

- **Height**: The alignment procedure determines the average Z height of the alignment bar's top surface and uses the value specified in **Height** to offset the coordinate system from that average Z height. In effect, the bottom of the alignment target becomes the Z origin (the zero reference level).

- **Width**: Only displayed if you choose a Moving Bar alignment. Sets the width of the bar in the Y direction. The bar width is only used to calibrate encoder resolution and travel speed in conjunction with the **Encoder or Speed Calibration** setting; the width is unrelated to any Y offset between sensors in dual- or multi-sensor system (for more information, see *Encoder Calibration* below). A width of 100 mm is typical.
- **Hole Count**: The number of holes in the bar. For important information on the number of holes you should choose, see *Bar Specifications and Procedural Requirements* on page 104.
- **Hole Diameter**: The diameter of the holes.
- **Hole Distance**: The distance between the centers of the holes. This measurement is critical: you should measure this distance to within the sensor's X resolution. If your bar only has two holes, you can machine the bar to a lower tolerance, measure the true spacing, and use this value for the parameter. But if your bar has more than two holes, you must machine the holes accurately to ensure that the spacing between the holes is the same.
- Under **Degrees of Freedom**, different combinations of offsets (X, Y, and Z) and rotations (Y Angle and Z Angle) are available.




**Encoder Calibration**

For systems that use an encoder, encoder calibration can be performed while aligning sensors. The table below summarizes the differences between performing alignment with and without encoder calibration.

The automatic encoder and speed calibration functionality is less accurate than manually specifying the transport system's encoder resolution or travel speed. You should only use this option if you have no other way of getting these values.

| | With encoder calibration | Without encoder calibration |
|---|---|---|
| **Target Type** | Calibration bar | Flat surface or calibration bar |
| **Target/Sensor Motion** | Linear motion | Stationary |
| **Calibrates Z axis Offset** | Yes | Yes |
| **Calibrates Encoder** | Yes | No |
| **Calibrates Travel Speed** | Yes | No |

See *Coordinate Systems* on page 41 for definitions of coordinate axes. For descriptions of disks and bars, as well as alignment procedures, see the appropriate sections in *Aligning Sensors with up to 5 Degrees of Freedom* on page 98.

After alignment, the coordinate system for will change from sensor coordinates to system coordinates.

### Clearing Alignment

Alignment can be cleared to revert the sensor to sensor coordinates.

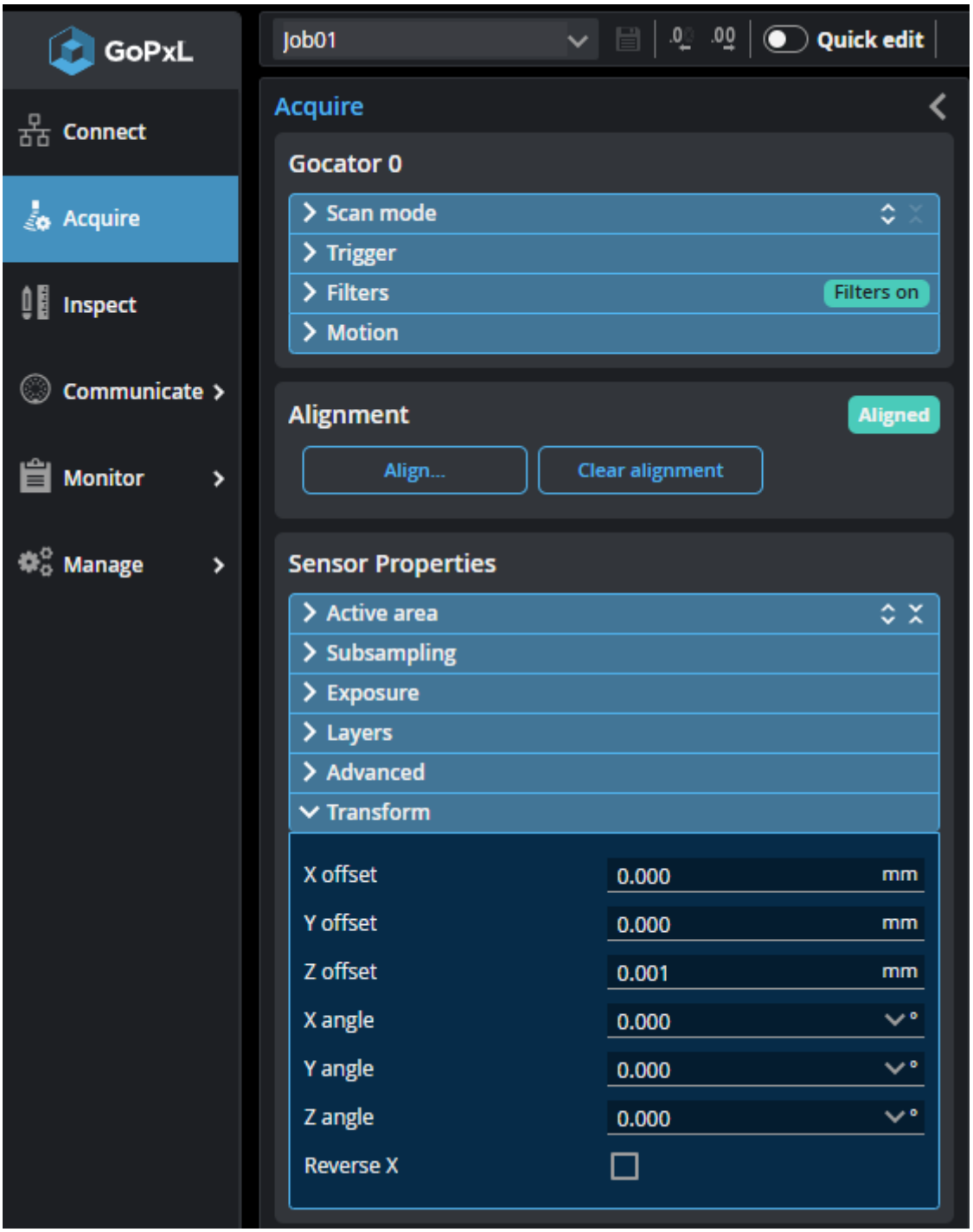
*To clear alignment:*

1. Go to the **Acquire** page.
2. In the **Alignment** section, click **Clear alignment**.

   GoPxL clears the alignment. Sensors revert to using sensor coordinates instead of aligned system coordinates.

### Transformations

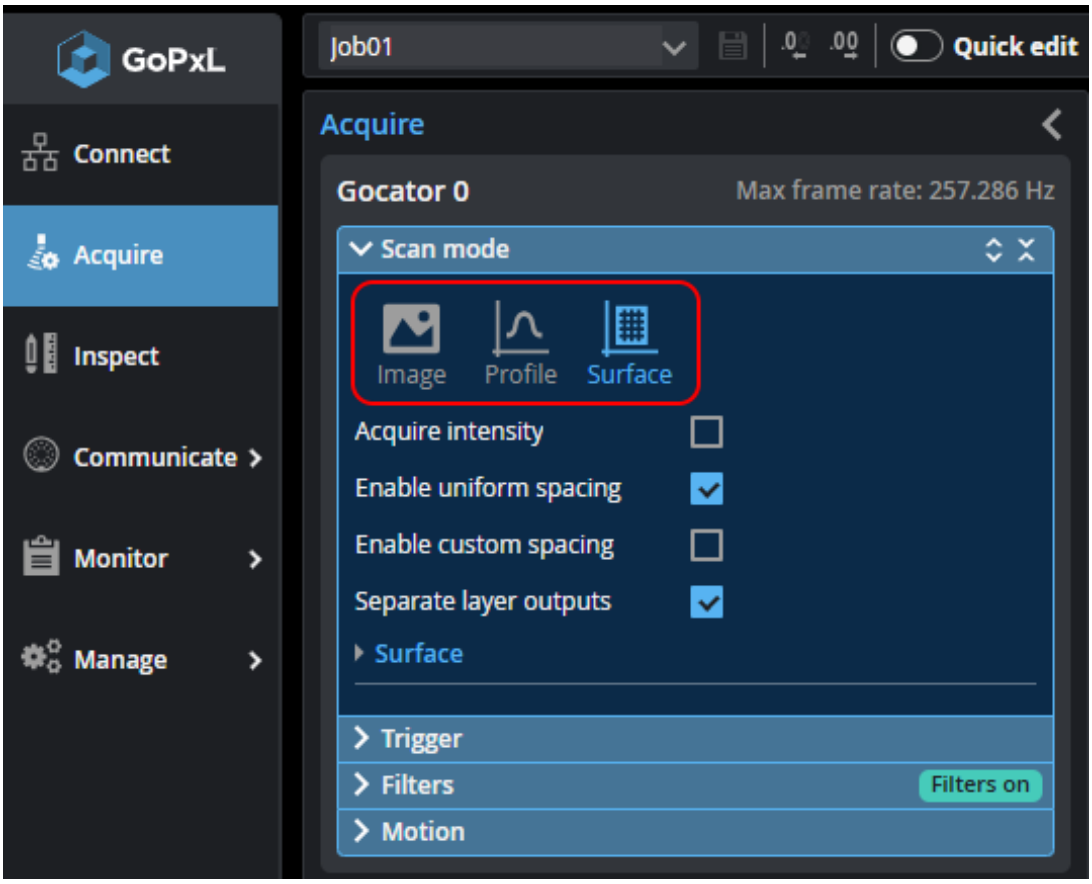
The transformation values determine how data is converted from unaligned coordinates to aligned coordinates (for an overview on coordinate systems, see *Coordinate Systems* on page 41). Transformation values are set automatically when you align a sensor using an alignment routine on the **Acquire** page. The resulting transformations are displayed in the expandable **Transform** section on that page.




| Parameter | Description |
|---|---|
| X Offset | Specifies the shift along the X axis. |
| Z Offset | Specifies the shift along the Z axis. A positive value shifts the data toward the sensor. |
| Y Angle | Specifies the tilt around the Y axis. |

## Scan Modes and Intensity

Sensors supports one or more data acquisition modes, in addition to an image mode. You choose the scan mode in the **Acquire** page > **Scan Mode** section.




If you have previously recorded scan data and have configured the input of measurement tools, changing the scan mode will display an error, saying the tools inputs are no longer available. For example, if you have scanned and recorded some Surface data, and added and configured a Surface Position measurement tool, but then switch to the Image scan mode to diagnose exposure issues, GoPxL warns you that the measurement tool's input (its data source) is missing.

| Scan Mode | Description |
|---|---|
| Image | Outputs video images from the sensor. This mode is useful for configuring exposure time and troubleshooting stray light or ambient light problems. |
| Profile | Outputs profiles.<br>Video images are processed internally to produce profiles and cross-sectional measurements. |
| Surface | Outputs Surface data. |
| Enable uniform spacing | When this option is enabled, data points are resampled to a uniform spacing . |

| Scan Mode | Description |
|---|---|
| | Set the size of the spacing with the Uniform spacing interval settings; for more information, see *Uniform Spacing* below.<br>Disable this option to get data from the sensor at the highest possible rate. |
| Acquire Intensity | When this option is enabled, an intensity value is produced for each data point. For more information on intensity, see *Intensity Output* on page 86. |

## Uniform Spacing

When **Uniform Spacing Enabled** is checked, data points are resampled to a uniform spacing. Set the size of the spacing by checking **Enable Custom Spacing** and setting **Custom Spacing Interval** to the desired value (see below).

> On confocal profile sensors, when **Uniform Spacing Enabled** is unchecked, multilayer data is *not* available. If you need multilayer data, you must check this setting.

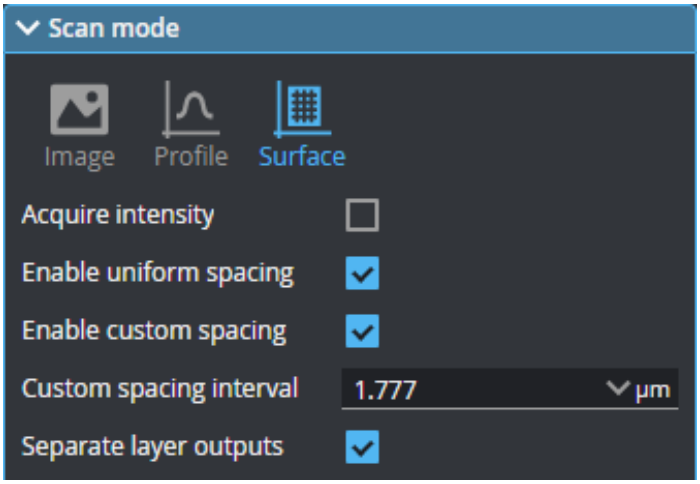
For more information on uniform spacing, see *Uniform Data and Point Cloud Data* on page 42.

When uniform spacing is disabled, the sensor outputs unprocessed data. The sensor reports data points in (x, z) coordinate pairs.

Disable uniform spacing to get data from the sensor at the highest possible rate.

The spacing interval is the user-configured spacing between data points in uniform data. A larger interval also reduces the data output rate.

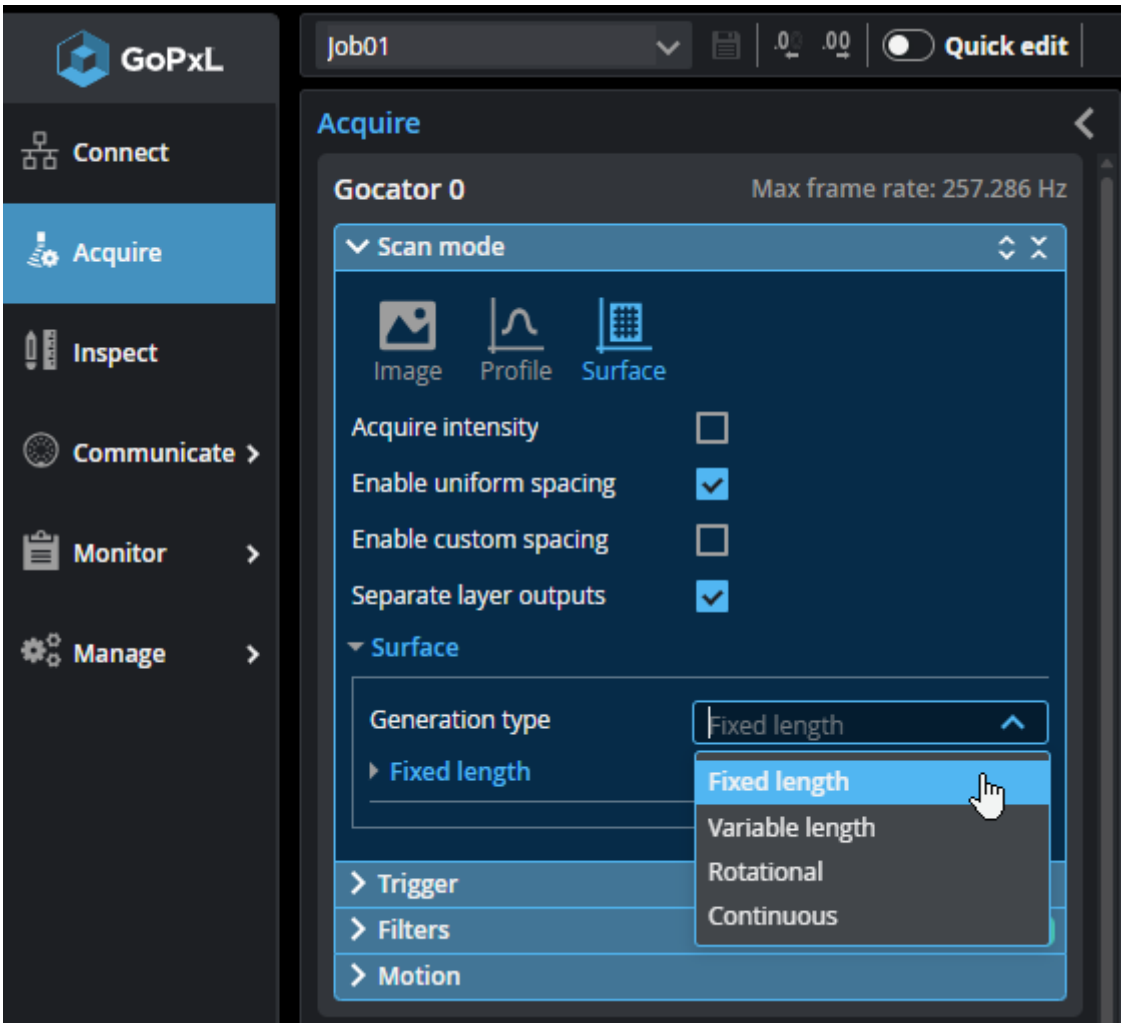
You can set the spacing interval to a custom value if you check **Enable custom spacing** and set the value.



## Surface Generation

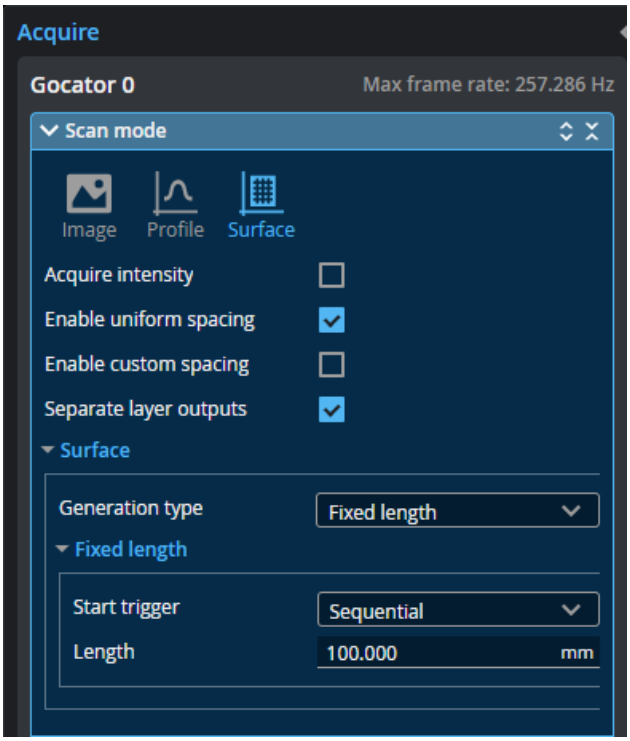
GoPxL provides different ways to generate Surface data, depending on the needs of your application. You configure these Surface generation methods in the **Scan Mode** section on the **Acquire** page. Four Surface generation modes are available:

- Fixed Length
- Variable Length
- Rotational
- Continuous




### Fixed Length

The sensor generates surfaces of a user-configurable fixed length. You must set the length and the start trigger the sensor uses to produce Surface data.




When you set the Surface generation type to **Fixed Length**, the sensor generates surfaces of a user-configurable fixed length. Fixed Length mode is used when material (or parts) continuously pass under the sensor, typically on a conveyor, but do not have distinguishable start and stop edge.

**Start Trigger**

The following types of start triggers are available:

- **Sequential**: Continuously generates back-to-back fixed length surfaces.
- **External Input**: A pulse on the digital input triggers the generation of a single surface of fixed length. For more information on connecting external input to a sensor, see *Digital Input* on page 978.
- **Software Trigger**: Allows starting fixed length surfaces on command from a PC or a PLC.

**Length**

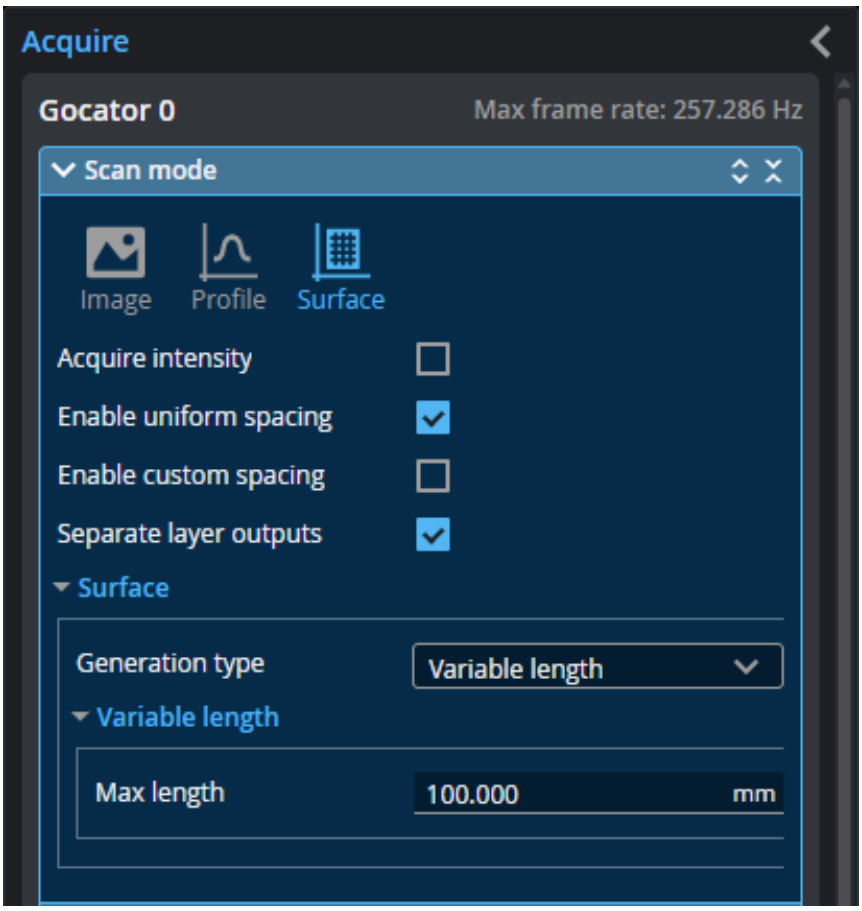
The fixed length of surface to generate.

Note that when encoder triggering is set to bi-directional mode, surface generation is aborted when the encoder direction reverses and the travel distance in the reverse direction is longer than the value of Reversal Distance. Resuming the original direction and travelling the full fixed length will not output a surface. For more information, see *Triggers* on page 120 and *Triggers* on page 120.

### Variable Length

The sensor generates surfaces of variable length. Profiles collected while the external digital input is held high are combined to form a surface. If the value of the **Max Length** setting is reached while

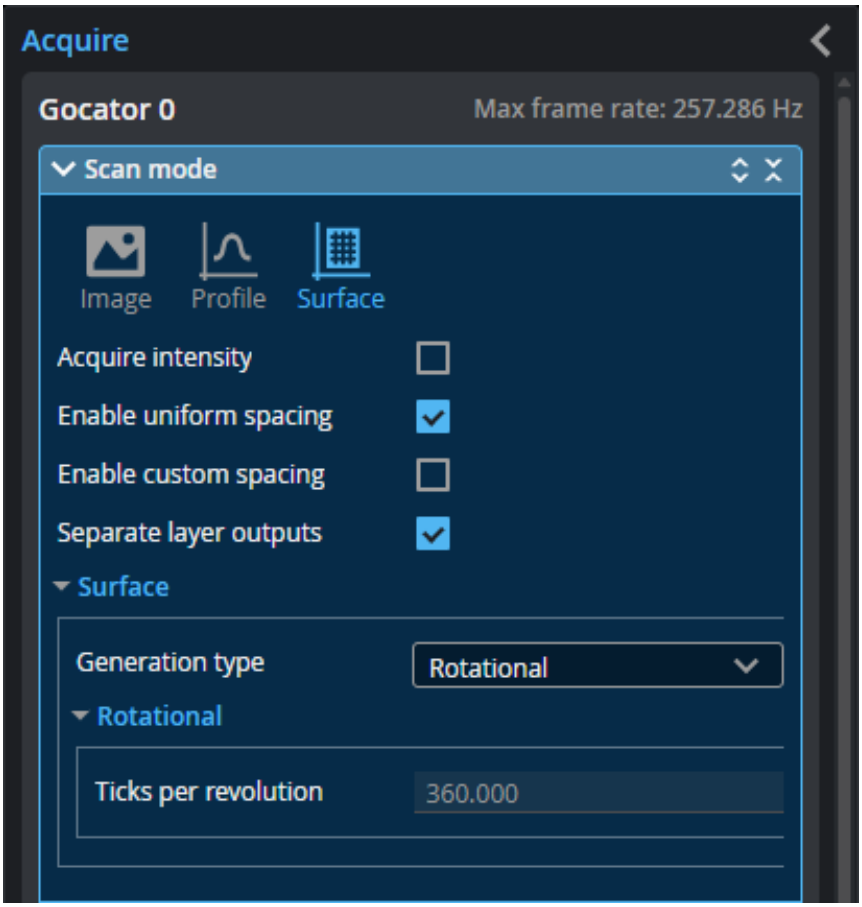
external input is still high, the next surface starts immediately with the next profile. This mode is typically used in robot-mounted applications, for example, measuring the dimensions of different parts on an engine block.




For correct length measurement, you should ensure that motion is calibrated (that is, encoder resolution for encoder triggers or travel speed for time triggers).

### Rotational

The sensor reorders profiles within a surface to be aligned with the encoder's index pulse. That is, regardless of the radial position the sensor is started at, the generated surface always starts at the position of the index pulse. If the index pulse is not detected and the rotation circumference is met, the surface is dropped and the Encoder Index Drop indicator will be incremented. This mode is typically used in applications where measurements of circular objects or shafts need to be taken, such as tire tread inspection, or label positioning on bottles.

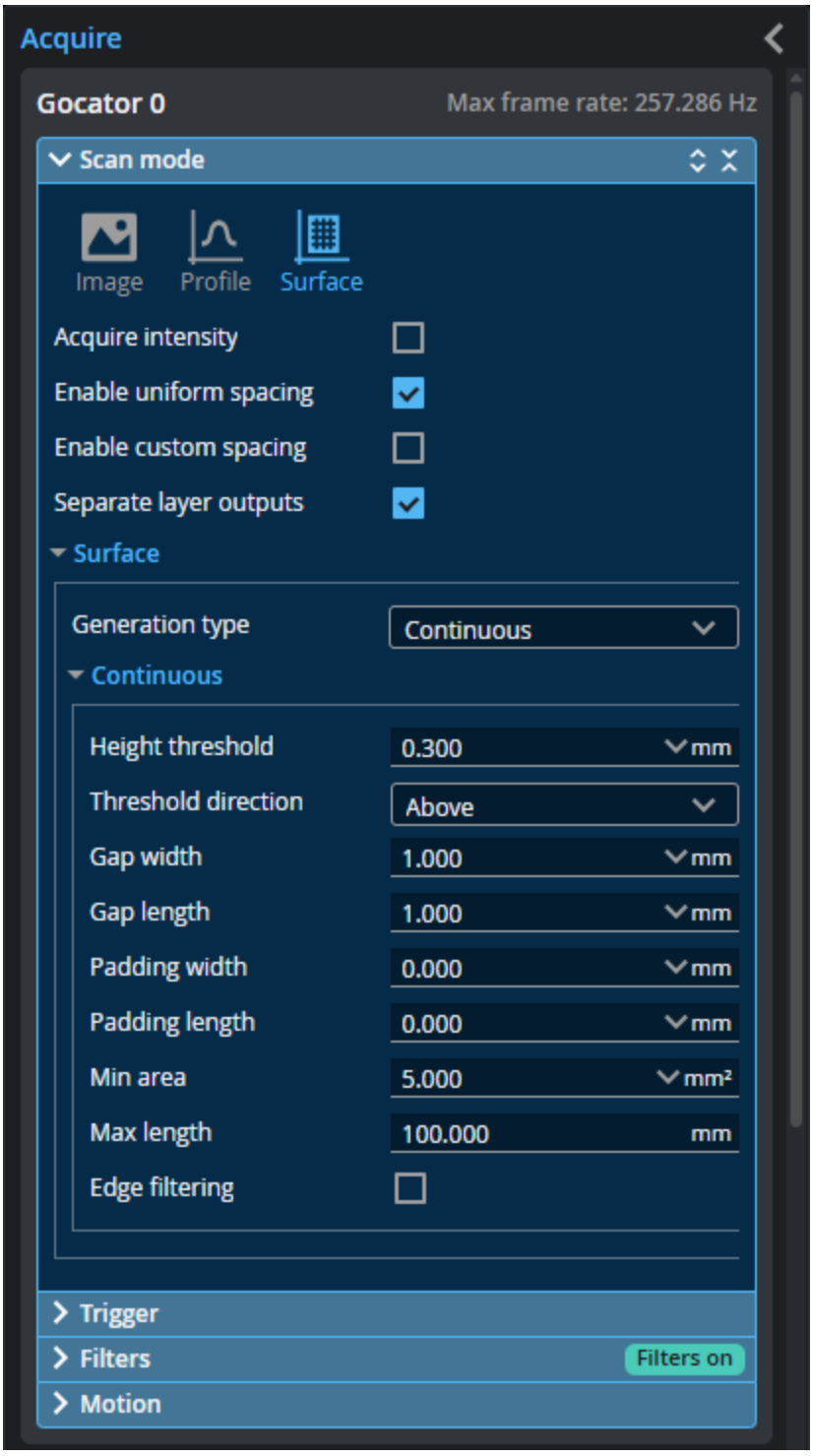



## Continuous Surface Generation and Part Detection

Use this method of surface generation with a transport system such as a conveyor that continuously feeds parts or material under a sensor. The parts or material must have a distinguishable start and stop edge. The sensor continuously generates surfaces of parts that are detected under the sensor. When a sensor is set to continuous Surface generation, you must configure parameters related to part detection.

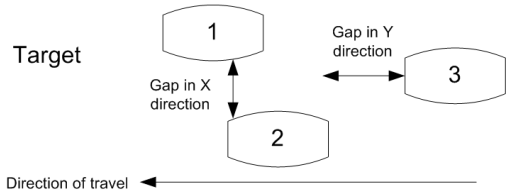
| | |
|---|---|
| | On G4 and G5 sensors, continuous surface generation is not currently supported in dual-sensor top-bottom layouts. |

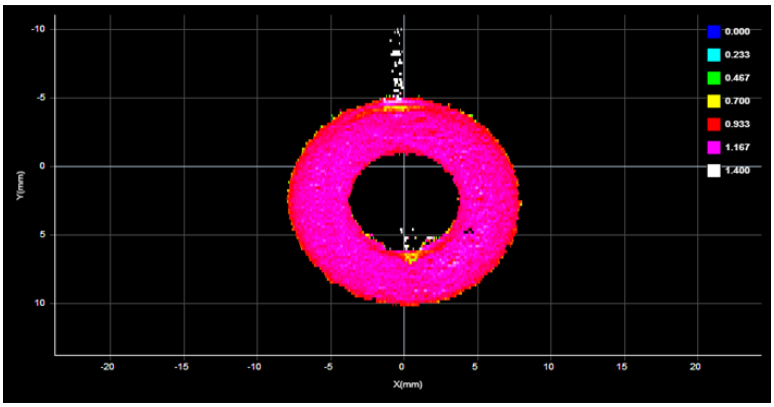
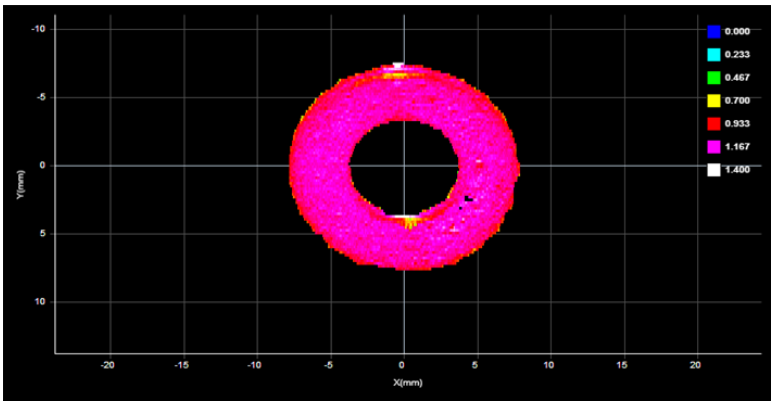
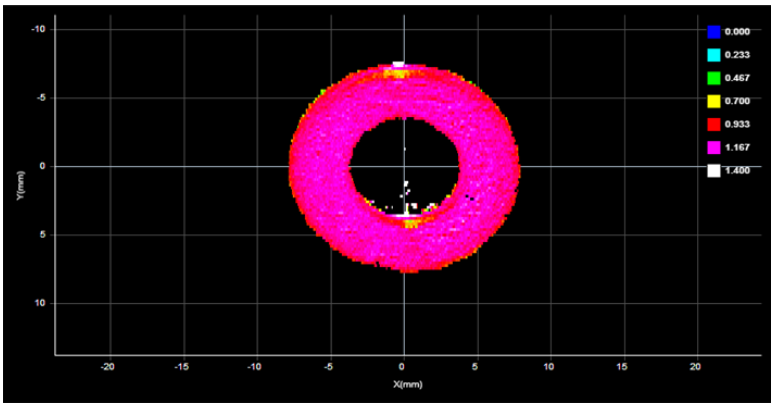
| | |
|---|---|
| | GoPxL also provides part detection through the Profile Part Detection tool. The tool uses the same parameters available with continuous generation Surface mode, but also provides diagnostics that can be useful for troubleshooting. After troubleshooting part detection using this tool, you can copy the settings from the tool to the **Inspect** page. The diagnostics are output as measurements by the tool.<br>Note that the Profile Part Detection has a **Frame of Reference** parameter not available when using continuous Surface generation. |




*Parameters*

| Parameter | Description |
|---|---|
| Height Threshold | Determines the height threshold for part detection. The setting for **Threshold Type** (see above) determines if parts should be detected above or below the value |

| Parameter | Description |
|---|---|
| | in **Threshold**. Above is typically used to prevent the belt surface from being detected as a part when scanning objects on a conveyor. |
| Threshold Type | Determines if parts should be detected above or below the height threshold. |
| Gap Width<br>Gap Length | **Gap Width** and **Gap Length** determine the minimum separation between objects on the X and the Y axis, respectively. If parts are closer than the gap interval, they will be merged into a single Surface output.<br>  |
| Padding Length | These parameters are useful when processing part data with third-party software such as HexSight, Halcon, etc.<br>**Padding Width** and **Padding Length** control the amount of additional scan data output in the X and Y directions, respectively. The padding can contain data points that were outside the height threshold and excluded from the initial part detection. |
| Min Area | Determines the minimum area for a detected part. Set this value to a reasonable minimum in order to filter out small objects or noise. |
| Max Length | Determines the maximum length of the part object. When the object exceeds the maximum length, it is automatically separated into two parts. This is useful to break a long object into multiple sections and perform measurements on each section. |
| Edge Filtering | When **Edge Filtering** is enabled, additional parameters are displayed. These settings are described below.<br>Part scans sometimes contain noise around the edges of the target. This noise is usually caused by the sensor's light being reflected off almost vertical sides, rounded corners, etc. Edge filtering helps reduce edge noise in order to produce more accurate and repeatable volume and area measurements, as well as to improve positioning of relative measurement regions.<br>(The following screenshots are from a G2 sensor.) |

| Parameter | Description |
| --- | --- |
| |  <br>*Edge filtering disabled (scan shows reflection noise)*<br>  <br>*Edge filtering enabled (reflection noise eliminated or reduced)*<br>  <br>*Edge filtering enabled, Keep Interior enabled* |
| Keep Interior | The **Keep Interior** setting limits filtering to the outside edges of the target. Only displayed if **Edge filtering** is enabled. |
| Edge Width<br>Edge Length | The **Edge Width** and **Edge Length** settings represent the size of the filter on the X axis and the Y axis, respectively. Only displayed if **Edge filtering** is enabled. |

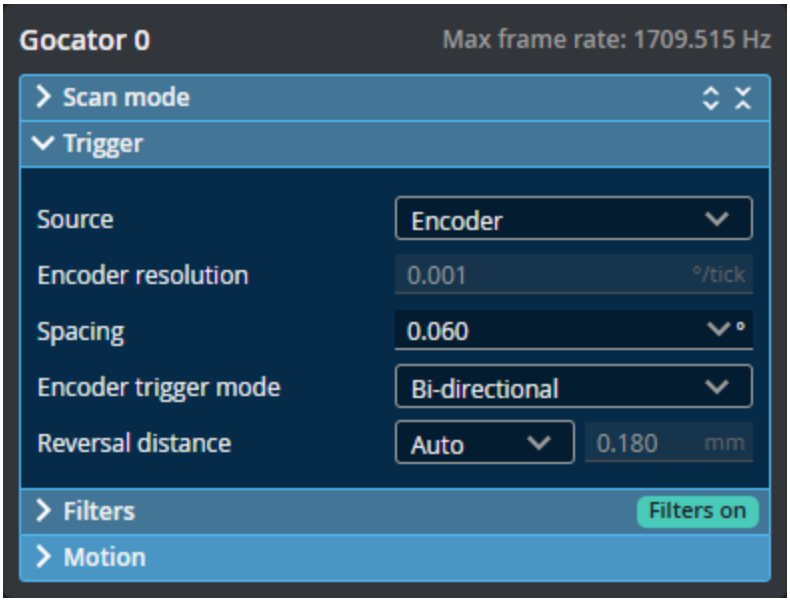
## Triggers

A trigger is an event that causes a sensor to acquire a single frame or image. On line profilers set to Surface mode, this refers to the profiles the device captures, whether you are using Profile mode or Surface mode (which is a concatenation of profiles). You configure triggers on the **Acquire** > page, in the **Trigger** panel.

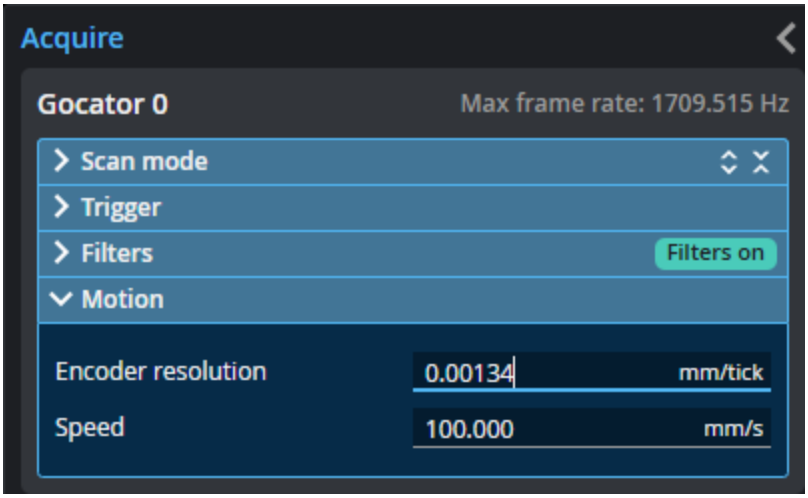
When a trigger is processed, the sensor's laser or LED light strobes and the camera exposes to produce an image. The resulting image is processed inside the sensor to yield scan data. The data can then be used for measurement.

The sensor can be triggered by one of the sources described below.

When using encoder triggering (available with line profilers), the current encoder resolution is displayed under the **Source** drop-down as a reference when setting trigger spacing.

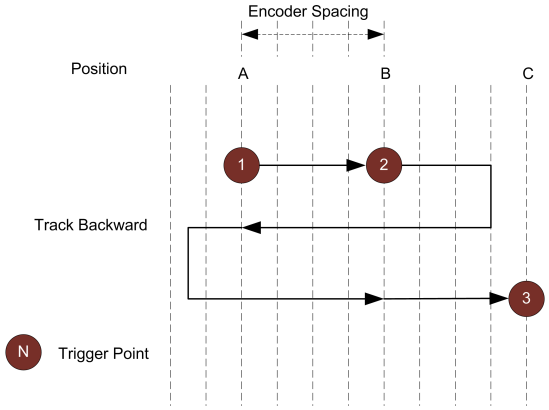
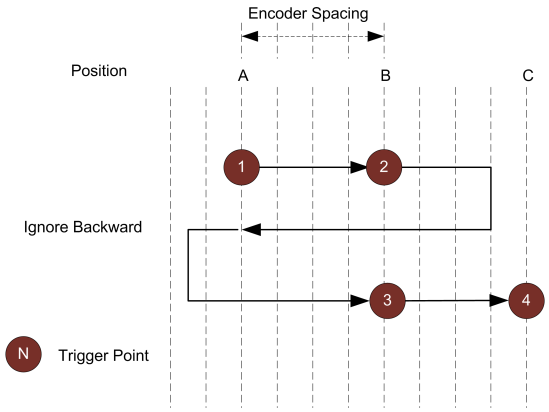


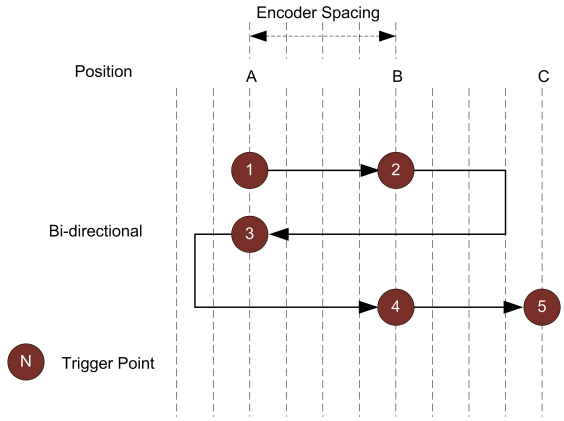

To set the encoder resolution, expand the **Motion** section and set the value in **Encoder Resolution**.



*Trigger source descriptions*

| Trigger Source | Description |
|---|---|
| Time | Sensors have an internal clock that can be used to generate fixed-frequency triggers. The external input can be used to enable or disable the time triggers. |

| Trigger Source | Description |
| --- | --- |
| Encoder | An encoder can be connected to provide triggers in response to motion. Three encoder triggering behaviors are supported. These behaviors are set using the **Behavior** setting. Note that trigger points are indicated by a circle containing a number in the illustrations below.<br>**Track Backward**<br>A scan is triggered when the target object moves forward. If the target object moves backward, it must move forward by at least the distance that the target traveled backward (this distance backward is "tracked"), plus one encoder spacing, to trigger the next scan.<br>  <br><br>**Ignore Backward**<br>A scan is triggered only when the target object moves forward. If the target object moves backward, it must move forward by at least the distance of one encoder spacing to trigger the next scan.<br>  <br><br>**Bi-directional**<br>A scan is triggered when the target object moves forward or backward. |

| Trigger Source | Description |
|---|---|
| |  <br>When triggers are received at a frequency higher than the maximum frame rate, some triggers may not be accepted. Use the **Trigger Drops** indicator in the **Health** panel on the **Reports** page to check for this condition; for more information, see *Monitor - Measurement Stats, Health & Performance* on page 795.<br>The external input can be used to enable or disable the encoder triggers.<br>For information on the maximum encoder rate, see *Maximum Encoder Rate* on page 125.<br>To verify that the sensor is receiving encoder signals, check whether the **Encoder Value** indicator is changing in the **Health** panel on the **Reports** page (for more information, see *Monitor - Measurement Stats, Health & Performance* on page 795). |
| External Input | A digital input can provide triggers in response to external events (for example, a photocell). The external input triggers on the rising edge of the signal.<br>When triggers are received at a frequency higher than the maximum frame rate, some triggers may not be accepted. Use the **Trigger Drops** indicator in the **Health** panel on the **Reports** page to check for this condition; for more information, see *Monitor - Measurement Stats, Health & Performance* on page 795. |
| Software | A network command can be used to send a software trigger. For more information, *Protocols (PLCs and other hardware)* on page 886. |

Depending on the setup and measurement tools used, the CPU utilization may exceed 100%, which reduces the overall acquisition speed.

## Trigger Settings

After you choose the trigger source, configure the other parameters in **Acquire** page > **Trigger** section.

| Parameter | Trigger Source | Description |
|---|---|---|
| Source | n/a | Selects the trigger source (Time, Encoder, External Input, or Software). |
| Trigger at maximum frame | Time | When this is enabled, the frame rate locks to the maximum |

| Parameter | Trigger Source | Description |
|---|---|---|
| rate | | frame rate. |
| Frame Rate | Time | Controls the frame rate. Fractional values are supported. For example, 0.1 can be entered to run at 1 frame every 10 seconds. |
| Spacing | Encoder | Specifies the distance, along the Y axis, between triggers. Internally the sensor rounds the spacing to a multiple of the encoder resolution. |
| Encoder trigger mode | Encoder | Specifies how the sensor is triggered when the target moves. Can be Track Backward, Ignore Backward, or Bi-Directional. For more information, see Encoder in *Trigger source descriptions* on page 121. |
| Enable auto reversal distance | Encoder | When enabled, sets the reversal distance automatically to 3 times the value in **Spacing**. |
| Reversal Distance | Encoder | When encoder triggering is set to **Bi-Directional**, use this setting to ignore jitter or vibrations in the transport system.<br>When **Enable auto reversal distance** is enabled, the distance is automatically set by multiplying the value in **Spacing** by 3.<br>When **Enable auto reversal distance** is disabled, set the desired value in **Reversal Distance** in millimeters. Various functions in the sensor depend on this value to explicitly determine the point where direction change is triggered. Set this value larger than the maximum vibrations you see in your transport system. |
| Gate on External Input | Time, Encoder, Software | You can use external input to enable or disable data acquisition in a sensor. When this option is enabled, the sensor will respond to time, encoder, or software triggers *only* when the external input is asserted.<br>This setting is only displayed when the sensor is in Profile mode.<br>See *Digital Input* on page 978 for more information on connecting external input to sensors. |
| Units | External Input | Specifies the unit. |
| Trigger Delay | External Input | Specifies the amount of time or the distance the sensor waits before producing a frame after the external input is activated. This is used to compensate for the positional difference between the source of the external input trigger (for example, a photocell) and the sensor. |

## Maximum Input Trigger Rate

The maximum external input trigger rate in a system including Master 810 or 2410 is 20 kHz.

When using a standalone sensor or a sensor connected to a Master 100, the maximum trigger rate is 32 kHz. This rate is limited by the fall time of the signal, which depends on the Vin and duty cycles. To achieve the maximum trigger rate, the Vin and duty cycles must be adjusted as follows:

| Maximum Speed | Vin | Maximum Duty Cycle |
|---|---|---|
| 32 kHz | 3.3 V | 88% |
| 32 kHz | 5 V | 56% |
| 32 kHz | 7 V | 44% |
| 32 kHz | 10 V | 34% |

At 50% duty cycle, the maximum trigger rates are as follows:

| Vin | Maximum Speed |
|---|---|
| 3.3 V | 34 kHz |
| 5 V | 34 kHz |
| 10 V | 22 kHz |

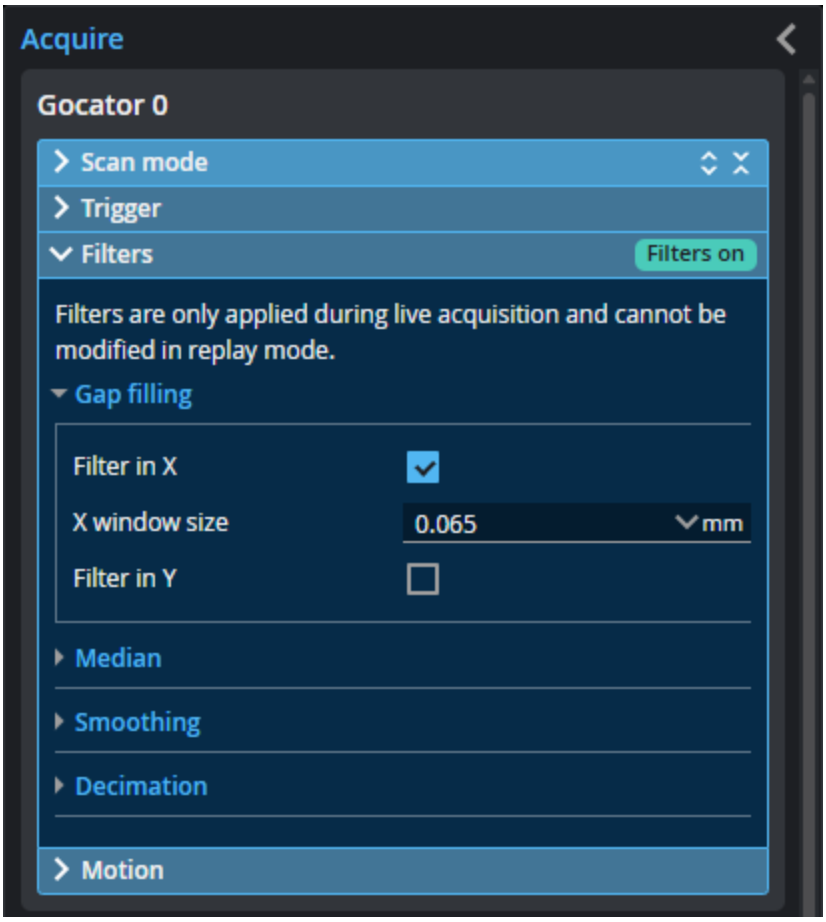
### Maximum Encoder Rate

On a standalone sensor, with the encoder directly wired into the I/O port or through a Master 100, the maximum encoder rate is about 1 MHz.

For sensors connected through a Master 810 or higher, with the encoder signal supplied to the Master, the maximum rate is about 300 kHz.

## Filters

The filters in the **Filters** panel are used to process scan data along the X or Y axis to remove noise or clean it up *before* it is used by measurement tools or is output. Using the filters can help you get more repeatable measurements. The filters are only available when uniform spacing is enabled. They are only applied during data acquisition; modifying these filters when GoPxL is in replay mode has no effect.




The following filters are available in the Filter panel.

*Filters*

| Name | Description |
|---|---|
| Gap Filling | Fills in missing data using information from the nearest neighbor data points, for example, when data is missing due to occlusions. Gap filling also fills gaps where no data is detected, which can be due to low surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The values in **Filter in X** and **Filter in Y** represent the maximum gaps the sensor will fill. Wider gaps are not filled.<br>Gap filling works by filling in missing data points using either the lowest values from the nearest neighbors or linear interpolation between neighboring values (depending on the Z difference between neighboring values), in the specified window. The sensor can fill gaps along both the X axis and the Y axis.<br>In Profile mode, gap filling is limited to the X axis. |
| Median | Substitutes the value of a data point with the median calculated within the window or windows set in **X Window Size** or **Y Window Size** around the data point. If the number of valid (non-null) data points in the window is even, the average of the two values in the center is used. If the number of valid points is odd, the value in |

| Name | Description |
|---|---|
| | the center of the sorted list of values is used.<br>Missing data points will not be filled with the median value calculated from data points in the neighborhood.<br>With an odd-numbered window size, the output is at the center of the window. With an even window size, the output is 0.5 pixels to the right of the center (that is, using window / 2-1 values from the left, and window / 2 from the right. |
| Smoothing | Substitutes a data point value with the mean value of that data point and its nearest neighbors within the window or windows set in **X Window Size** or **Y Window Size**. X smoothing works by calculating a moving average across samples within the same profile. Y smoothing works by calculating a moving average in the direction of travel at each X location.<br>If both X and Y smoothing are enabled, the data is smoothed along X axis first, then along the Y axis.<br>Missing data points will not be filled with the mean value calculated from data points in the neighborhood. |
| Decimation | Decimation reduces the number of data points along the X or Y axis by choosing data points at the end of a specified window around the data point. For example, by setting **X Window Size** to 0.2, only points every 0.2 millimeters will be used. The filter generates points starting from the leftmost edge of the scan data, stepping in equal steps away from that side. |

Tool-based filtering is also available on the **Tools** page. The filters described here and in the filter tool topics use the same algorithms.

Using tool-based filtering provides various advantages:

- Additional filters not available in the **Filters** panel. (This mostly applies to Surface filters.)
- Choosing which tools used in a job take filtered data as input. That is, you can decide to have some tools running on unfiltered data and other tools on filtered data.

For more information on tool-based filters, see *Surface Filter* on page 494 (Surface-based) and *Profile Filter* on page 245 (Profile-based).

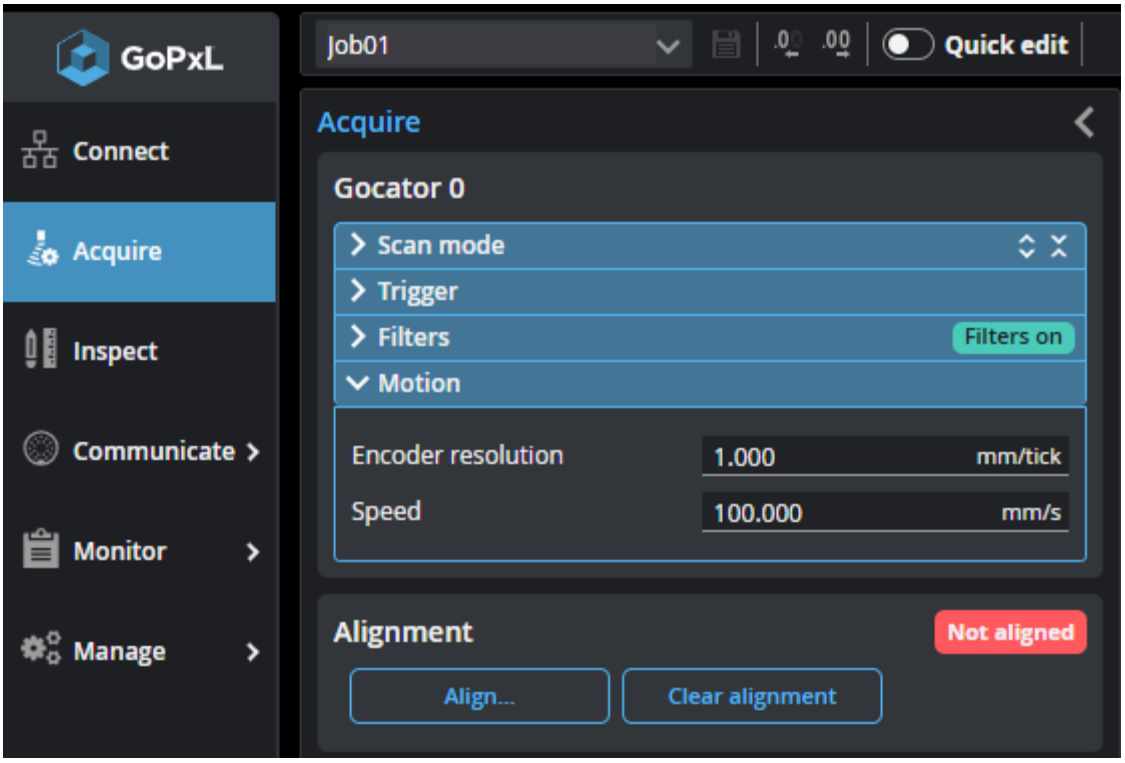
The filter window sizes are specified in millimeters (and additionally, in the tools, in data points). To calculate the number of data points that a window covers when the units are millimeters, use the following calculation:

- User-specified window size divided by the X spacing interval (that is, the number of millimeters per point) on the **Spacing** tab in the **Sensor** panel. (For more information on spacing intervals, see *Uniform Spacing* on page 112.)
- *With the exception of the gap filling filter*, round the result of the division to the nearest integer value. With the gap filling filter, filling is performed within the provided window size.

For example, if you set the size of the filter's window to a value between 1.5 mm and 2.49 mm (inclusively), and the X spacing interval is set to 1 mm, the filter covers 2 data points. A filter window size from 2.5 mm to 3.49 mm results in a filter covering 3 data points.

## Motion

If your sensor system includes a transport system such as a conveyor, to produce accurate scans, you should configure the settings in the **Motion** section on the **Acquire** page. Although GoPxL lets you automatically configure motion settings during the sensor alignment routine available in the **Alignment** section on the same page (for more information, see *Aligning Sensors* on page 98), it's more accurate to manually enter the encoder resolution or travel speed values provided by the manufacturer of your transport system or its components.




If your transport system includes an encoder, you should configure **Encoder Resolution**. If your transport system does not include an encoder (or if it does and you need to temporarily use time-based triggering for testing purposes), you should configure **Speed**.

### Setting Encoder Resolution

Encoder resolution is expressed in millimeters per tick, where one tick corresponds to *one* of the four encoder quadrature signals (A+ / A- / B+ / B-).

| | |
|---|---|
| | Encoders are normally specified in *pulses* per revolution, where each pulse is made up of the four quadrature *signals* (A+ / A- / B+ / B-). Because the sensor reads each of the four quadrature signals, you should choose an encoder accordingly, given the resolution required for your application. |

### Setting Travel Speed

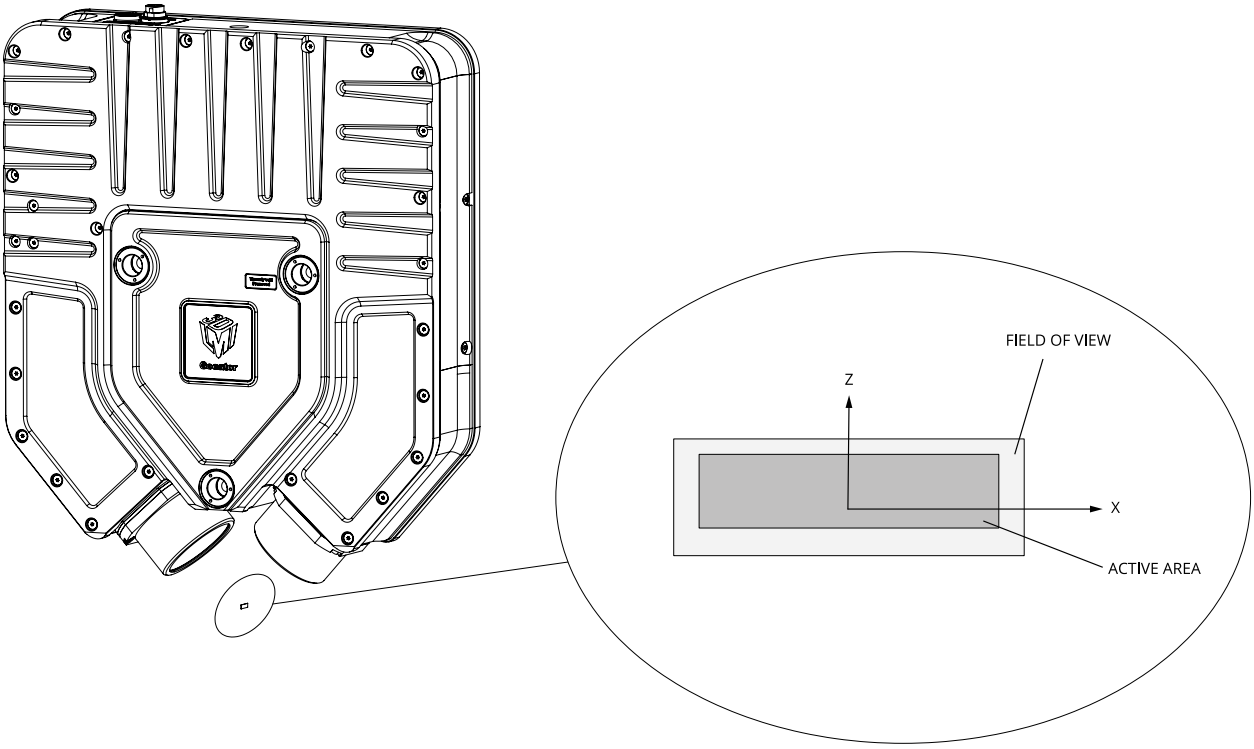
Set the value of the **Speed** setting to correctly scale scans in the direction of travel in systems that lack an encoder but have a conveyor system that is controlled to move at constant speed. Travel speed is expressed in millimeters per second.

## Active Area

Active area refers to the region within the sensor's maximum field of view that is used for data acquisition.

By default, the active area covers the sensor's entire scan area. By reducing the active area, the sensor can operate at higher frame rates. You can also reduce the active area to exclude areas that are affected by ambient light, or to avoid supports or parts of a transport system (such as a conveyor). For confocal sensors, with transparent materials, reducing the active area's Z range to exclude the layers or surface beyond the region of interest is an effective way to improve the scan result.

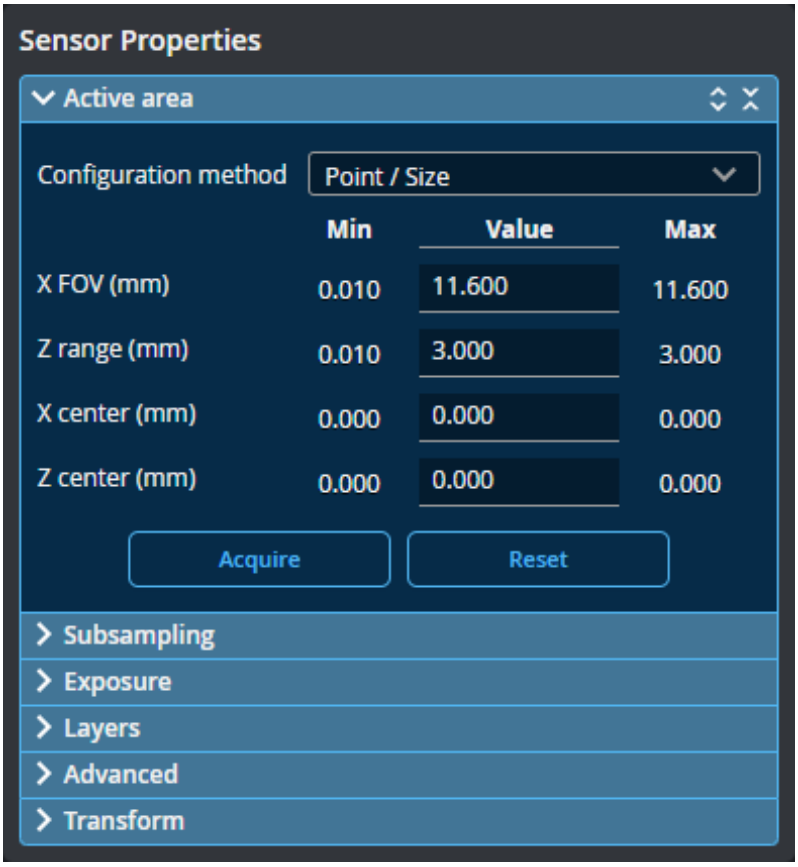
Active area is specified in sensor coordinates, rather than in system coordinates. As a result, if the sensor is already alignment calibrated, press the **Acquire** button to display uncalibrated data before configuring the active area.See *Coordinate Systems* on page 41 for more information on sensor and system coordinates.




*Active area, set to smaller than the maximum FOV.*

You set the active area in the **Acquire** page, in the **Active area** section under **Sensor Properties**. In multi-sensor systems, you set active area for each sensor individually.

Two active area configuration methods are available in the **Configuration Method** parameter: Maximum / Minimum and Point / Size (for the parameters related to each method, see the tables below). For instructions on setting active area, see *To set a sensor's active area* below.




*To set a sensor's active area*

1. Go to the **Acquire** page.
2. (Optional) If you are configuring the active area of a sensor in a multi-sensor system, select the correct sensor.
3. (Optional) Place a sample target in the sensor's scan area, and in the **Active Area** section, click the **Acquire** button to get some scan data.

   Getting a scan while setting the active area can help you determine the necessary size and position of the active area.
4. Choose the active area configuration method in **Configuration Method**.
   One of the following: Point / Size and Minimum / Maximum.
5. Set the active area.
   Adjust the active area graphically in the data viewer using your mouse or enter the values manually in the fields.

   Point / Size: For parameter descriptions, see *Active area parameters - Point / Size method* on the next page.

Minimum / Maximum: For parameter descriptions, see *Active area parameters - Maximum / Minimum method* below.

6. Save the changes in the job file.

*To reset the active area*

- Click the **Reset** button.

*Active area parameters - Point / Size method*

| Name | Description |
|---|---|
| X FOV (mm) | The width of the active area along the X axis. This sets the effective field of view of the sensor. |
| Z range (mm) | The height of the active area along the Z axis. This sets the effective measurement range of the sensor. |
| X center (mm)<br>Z center (mm) | The X and Z position in the entire sensor field of view of the *center* of the active area. |

*Active area parameters - Maximum / Minimum method*

| Name | Description |
|---|---|
| Min X<br>Max X | The minimum and maximum X values. |
| Min Z<br>Max Z | The minimum and maximum Z values. |

## Subsampling

Subsampling reduces the number of camera columns or rows used for data acquisition to increase speed or reduce CPU usage, while maintaining the sensor's field of view and measurement range. You can set sub-sampling independently for the X axis and Z axis. You set subsampling on the **Acquire** page, in the **Sensor Properties** section.

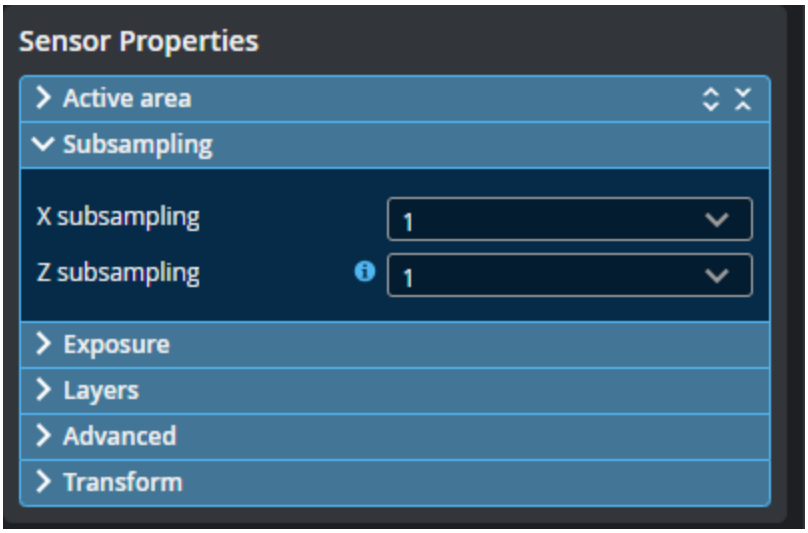
When set to a value of less than 1, the **X** subsampling setting decreases the profile's X resolution to lower sensor CPU usage.

When set to a value of less than 1, the **Z** subsampling setting decreases the profile's Z resolution, which increases speed. The **Z** setting works by reducing the number of image rows used for profiling.

> Because Z subsampling reduces vertical image resolution, you may need to adjust spot detection parameters when it is enabled.

Subsampling values are expressed as fractions in the GoPxL interface. For example, an X subsampling value of 1/2 means that every second camera column will be used for profiling. When the parameter is set to 1, no subsampling occurs.

Sub-sampling is disabled by default on most sensors (set to 1).




The **CPU** load shown at the bottom of the interface displays how much the CPU is being used.

## Exposure and Light Intensity

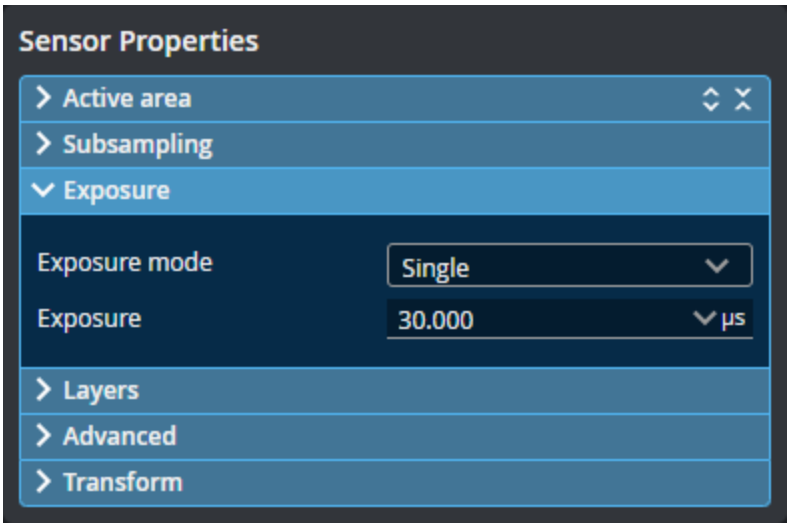
Exposure determines the duration of camera and light-source on-time (or pulse width), given in microseconds (µs). Longer exposures can help detect light on dark or distant surfaces, but increasing exposure time decreases the maximum frame rate. Different target surfaces may require different exposures for optimal results. In general, shiny and mirror-like surfaces require a short pulse width and low-gloss surfaces a high pulse width.

Additionally, G4 and G5 sensors let you set the LED light power (**Light intensity** setting.

Sensors provide two or three exposure modes, depending on the model, for the flexibility needed to scan different types of target surfaces.

To properly set exposure, you can acquire scan data in Image mode and adjust the exposure as needed. Set the scan mode to Image, capture some scan data, and hover the pointer on top of the profile to see the intensity value. Check the whole profile length of interest. It is very important that in the active measurement area the image is not saturated. Intensity value range is from 0 to 255, it is recommended to keep the maximum intensity below 240.

You configure exposure in **Exposure** on the **Acquire** page, in the **Sensor Properties** section.

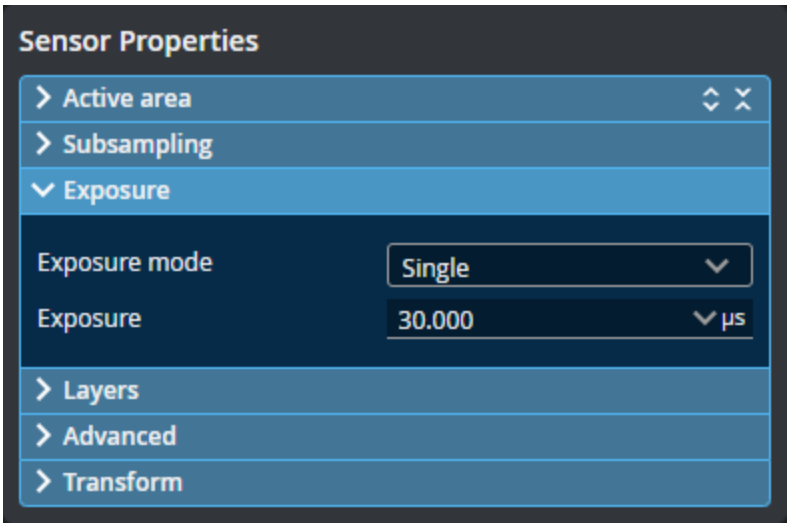



When exposure is set to Dynamic or Multiple, additional parameters are displayed.

| Exposure Mode | Description |
|---|---|
| Single | Uses a single exposure duration for each frame. Use this when the surface is roughly uniform and is the same for all targets. For more information, see *Single Exposure* below. |
| Multiple | Uses multiple exposures to create a single profile. Used when the target surface has a varying reflectance within a single profile. For more information, see *Multiple Exposure* on the next page. |
| Dynamic | Automatically adjusts the exposure after each profile based on an analysis of the preceding frame. Used when the target surface varies between scans. For more information, see *Dynamic Exposure* on page 136. |

## Single Exposure

The sensor uses a fixed exposure in every scan. Single exposure is used when the target surface is uniform and is the same for all targets.



| Setting | Description |
|---|---|
| Exposure Mode | Set to Single. |
| Exposure | The length of the light emitter's on-time, in microseconds. |
| Light Intensity | To display this setting, check **Enable high power** mode on the **Acquire** page, in the **Advanced** section.<br>This lets you adjust the LED current. Typically adjusting is not needed.<br>If the frame rate allows, lowering the light intensity might be useful when scanning a very shiny surface requiring very low exposure. Lower light intensity enables using longer exposure and so the setup will be less sensitive to gloss variation.<br>A light intensity higher than 100% might be useful to reduce the exposure time to enable a higher frame rate. Frame rate becomes limited if the light intensity is set much higher than 100%.<br>Note that updating light intensity can take a few seconds to apply. |

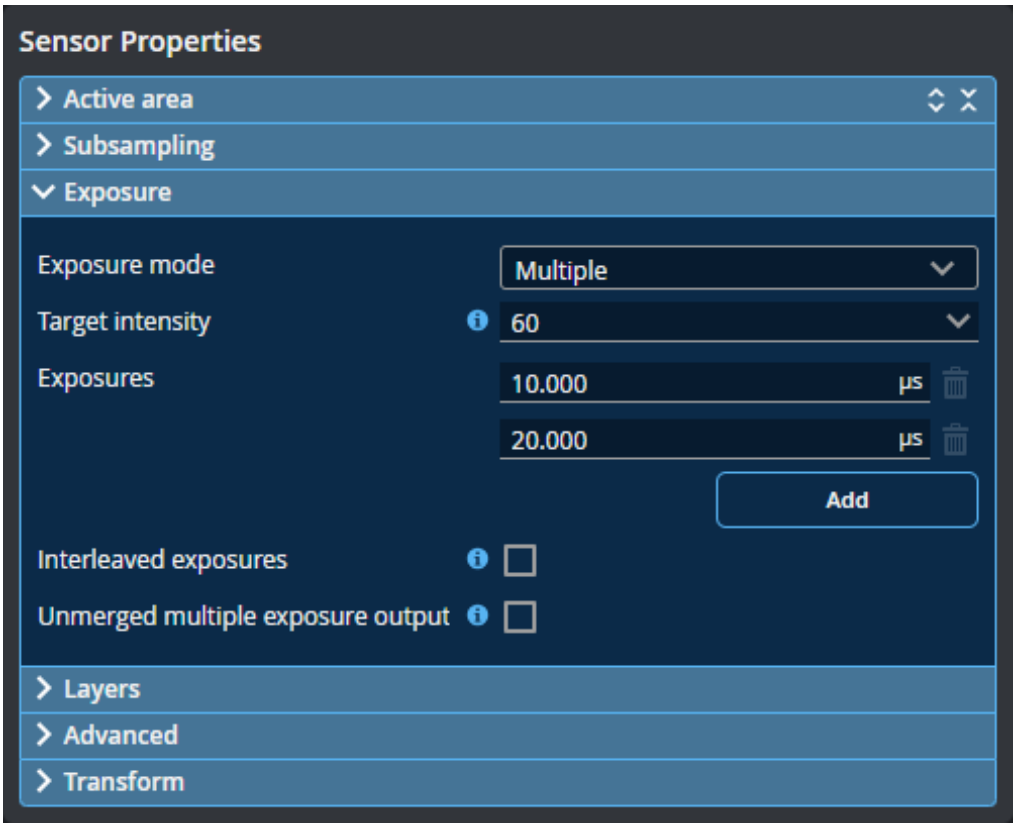
## Multiple Exposure

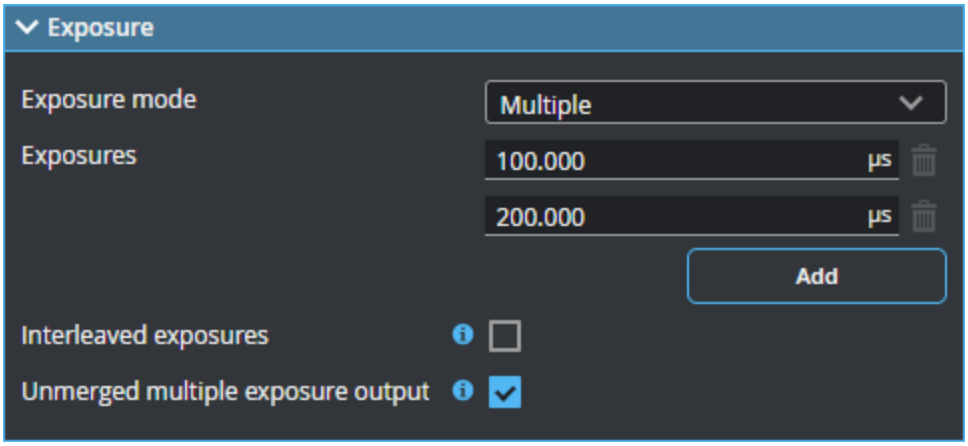
The sensor can combine data from multiple exposures to create a single profile (G2, G4, and G5) or 3D scan (all families). Multiple exposures can be used to increase the ability to detect light and dark materials that are in the field of view simultaneously. Note that you can optionally output the scan data for the different exposures as separate profiles or surfaces, but only if uniform spacing is disabled.

You can define up to five exposures (three for G3 sensors), with each set to a different exposure level. You add exposures using the **Add** button, and remove them using the trashcan icon.

For each exposure, the sensor will perform a complete scan at the current frame rate making the effective frame rate slower. For example, if two exposures are selected, then the speed will be half of the single exposure frame rate. The sensor will perform a complete multi-exposure scan for each external input or encoder trigger.

The resulting scan data is a composite created by combing data collected with different exposures.



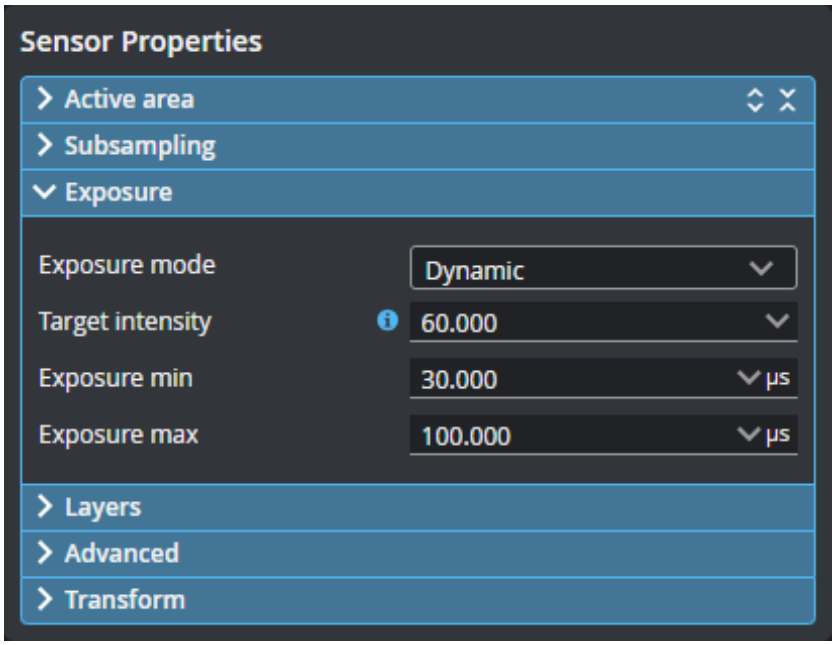

| Setting | Description |
|---|---|
| Exposure Mode | Single, Multiple, or Dynamic. Set to Multiple. |
| Unmerged Multiple Exposure Output | This setting is only available when uniform spacing is disabled (for more information, see *Uniform Spacing* on page 112) and in Profile mode (see *Scan Modes and Intensity* on page 111).   |
| Target Intensity | With multiple exposures, multiple spots can be detected at the same location. The spots closest in intensity to the provided intensity value are selected. |
| Light Intensity | To display this setting, check **Enable high power** mode on the **Acquire** page, in the **Advanced** section.<br>This lets you adjust the LED current. Typically adjusting is not needed. |

| Setting | Description |
|---|---|
| | If the frame rate allows, lowering the light intensity might be useful when scanning a very shiny surface requiring very low exposure. Lower light intensity enables using longer exposure and so the setup will be less sensitive to gloss variation.<br>A light intensity higher than 100% might be useful to reduce the exposure time to enable a higher frame rate. Frame rate becomes limited if the light intensity is set much higher than 100%.<br>Note that updating light intensity can take a few seconds to apply. |

## Dynamic Exposure

When **Exposure mode** is set to Dynamic, the sensor automatically uses previous frames of Profile scan data to adjust the exposure for subsequent exposures to yield the best data. Use this mode when the target surface changes from exposure to exposure.

> You can tune settings that control the exposure that is chosen by dynamic exposure in the Material tab.

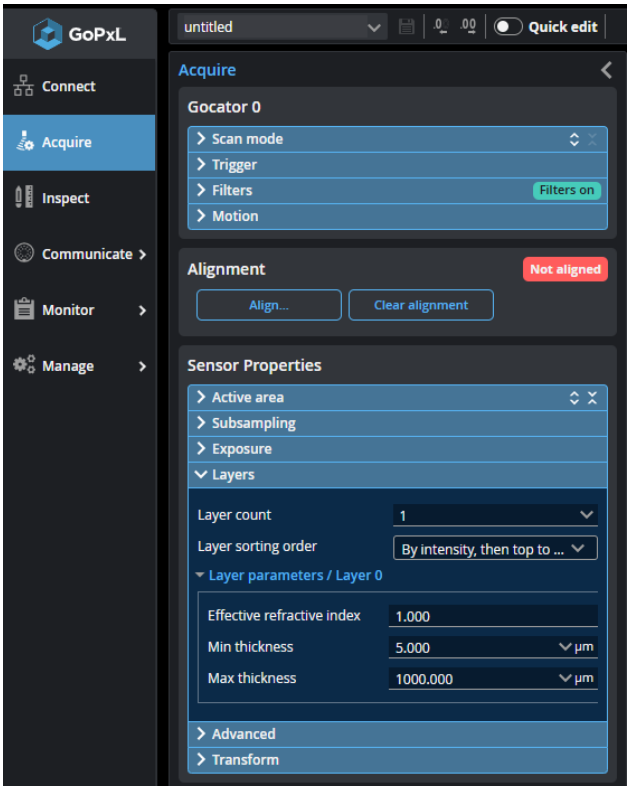



| Setting | Description |
|---|---|
| Exposure Mode | Set to Dynamic. |
| Exposure min<br>Exposure max | Limits the sensor's exposure values to the provided minimum and maximum. |
| Target Intensity | Exposure is continually adjusted so that the average intensity of the brightest profile layer matches the provided target intensity. |
| Light Intensity | To display this setting, check **Enable high power** mode on the **Acquire** page, in the **Advanced** section.<br>This lets you adjust the LED current. Typically adjusting is not needed. |

| Setting | Description |
|---|---|
| | If the frame rate allows, lowering the light intensity might be useful when scanning a very shiny surface requiring very low exposure. Lower light intensity enables using longer exposure and so the setup will be less sensitive to gloss variation.<br>A light intensity higher than 100% might be useful to reduce the exposure time to enable a higher frame rate. Frame rate becomes limited if the light intensity is set much higher than 100%.<br>Note that updating light intensity can take a few seconds to apply. |

## Layer Settings

You configure layers on the **Inspect** > **Scan** page.

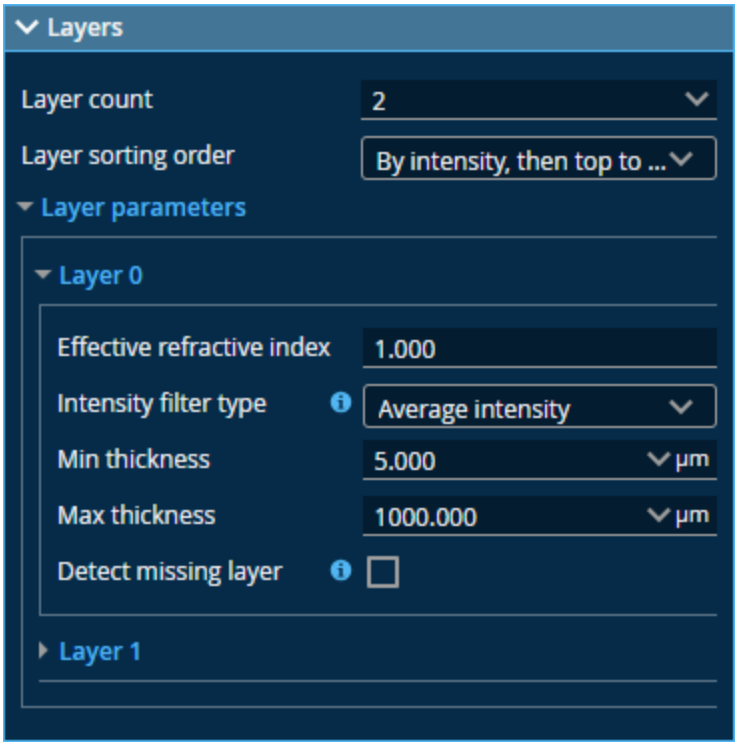



*Parameters*

| Name | Description |
|---|---|
| Layer count | Determines the maximum number of layers the sensor should detect. For each layer, a **Layer {n}** in the **Layer parameters** section is displayed. For information on the parameter-specific parameters, see *Layer-specific parameters (Layer {n})* on the next page. |
| Layer sorting order | The order in which layer profiles are sorted in the output. One of the following:<br>• By Intensity, then top to bottom<br>• Top to Bottom<br>• By Intensity, then bottom to top |

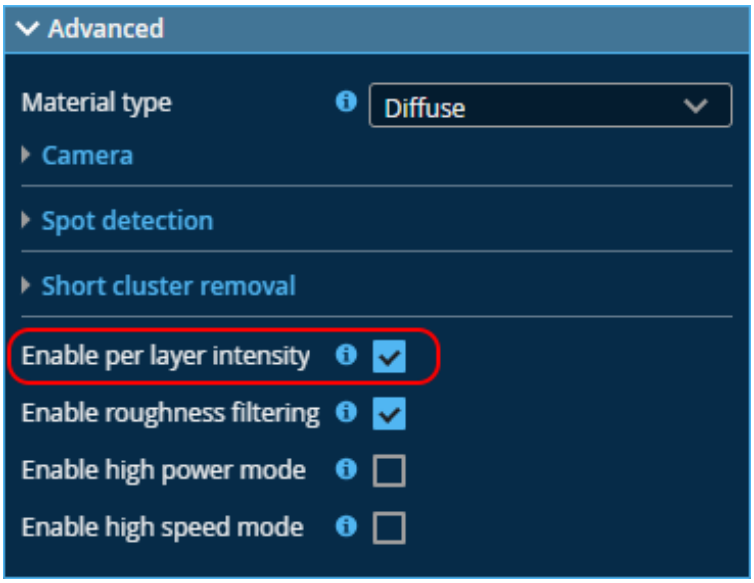
| Name | Description |
|---|---|
| | • Bottom to Top |
| Layer parameters | An expandable section containing the parameters for each layer (see *Layer-specific parameters (Layer {n})* below). |

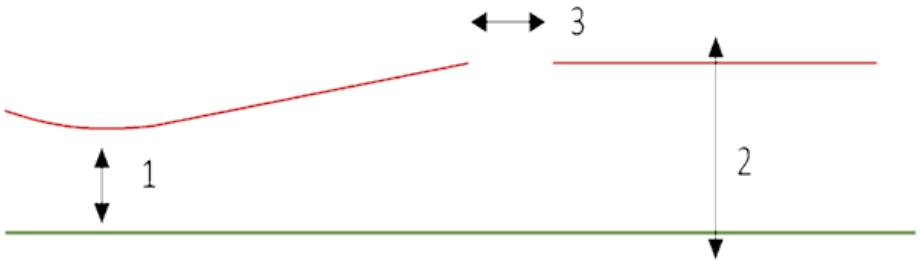
The table below describes the layer-specific parameters available in the expandable **Layer {n}** sections. Note that **Detect missing layer** is only displayed for the first layer (layer 0).




*Layer-specific parameters (Layer {n})*

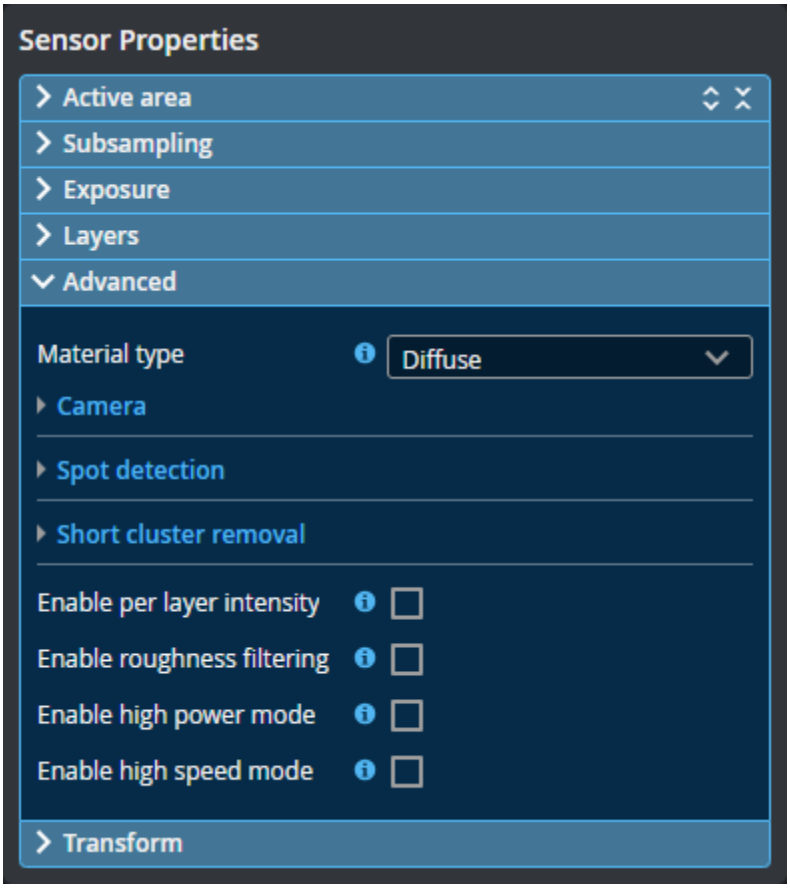
| Name | Description |
|---|---|
| Effective refractive index | The effective refractive index of the material of layer {n}. |
| Intensity filter type | The intensity filter type for layer {n}. Only displayed if you have enabled **Acquire intensity** in the **Scan mode** section (see *Scan Modes and Intensity* on page 111).<br>One of the following:<br>• Average Intensity<br>• Signal Detection<br>To set this to Signal Detection, you must enable **Enable per layer intensity** in the **Advanced** section. Otherwise, average intensity is applied on all layers. |

| Name | Description |
|---|---|
| |  |
| Min thickness<br>Max thickness | These define the minimum and maximum thickness between layer {n} and the layer below it. These have an effect on layer sorting. (When you set **Layer count** to 1, leave these parameters at their default values.)<br>The value of **Min thickness** is used for layer recognition. When the value is smaller than the distance between two layers, both layers are recognized.<br>The value of **Max thickness** is also used for layer recognition. When the value is greater than the distance between two layers, both layers are recognized. If the value is smaller than the distance between two layers, the next is classified as a third layer. |
| Detect missing layer | The setting is only displayed if you have configured more than one layer, and is only displayed in the Layer 0 section, as it only applies to the *first* layer.<br>Points in transparent surfaces are sorted to different layers based on their Z position. But if there are gaps in the *first* layer (and when this parameter is disabled), a data point from *second* layer is considered to be part of the *first* layer.<br>When this parameter is enabled, however, missing points from the first layer are interpreted instead as gaps, and the points in that gap are kept with the second layer.<br>**Detect missing layer** works with the value of **Min thickness** (see above). If **Min thickness** is incorrectly greater than the distance between two layers, the second layer is not detected and the top layer is reported as a second layer.<br>**Maximum gap width** is the maximum width which will be interpreted as missing layer points. Only available when **Detect missing layer is enabled**.<br>The following illustrates how the various settings work together: 1) **Min thickness** for the layer; 2) **Max thickness** for the layer; 3) **Maximum gap width**. |

| Name | Description |
|---|---|
| |  <br>Disable this parameter for maximum performance. |
| Maximum gap width | The maximum gap that will be interpreted as missing layer points. Only available when **Detect missing layer** is enabled. For an illustration of this setting, see *Detect missing layer* on the previous page. |

## Advanced Settings

The settings in **Acquire** page > **Sensor Properties** > **Advanced** section let you configure spot detection (which determines how the sensor handles different material characteristics), camera gain, and other advanced settings.



## Material Type and Spot Detection

You can configure data acquisition to suit different types of target materials. This helps maximize the number of useful profile points produced. For many targets, changing the setting is not necessary, but it can make a great difference with others.

You can select preset material types in the **Material type** setting in the **Advanced** section on the **Acquire** page. The **Diffuse** material option is suitable for most materials.

When **Material type** is set to Diffuse, the sensor uses the following spot detection parameters:

*Diffuse spot detection values*

| Edge window | Average window | Intensity window | Spot threshold |
|---|---|---|---|
| 16 | 16 | 16 | 17 |

When **Material type** is set to **Custom**, you can set camera gain and modify spot detection. Some sensor models support both analog and digital gain, whereas others only support digital gain. For more information, see *Spot Detection* below and *Camera Gain* on page 143.

## Spot Detection

When adjusting the spot detection parameters, it's best to observe how the changes you make to these parameters affect the detected spots in Image mode, and also how that affects the resulting profile in Profile mode.

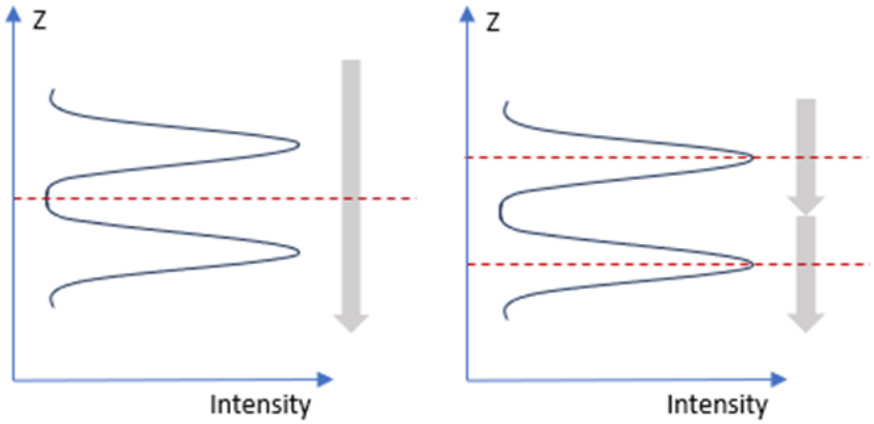
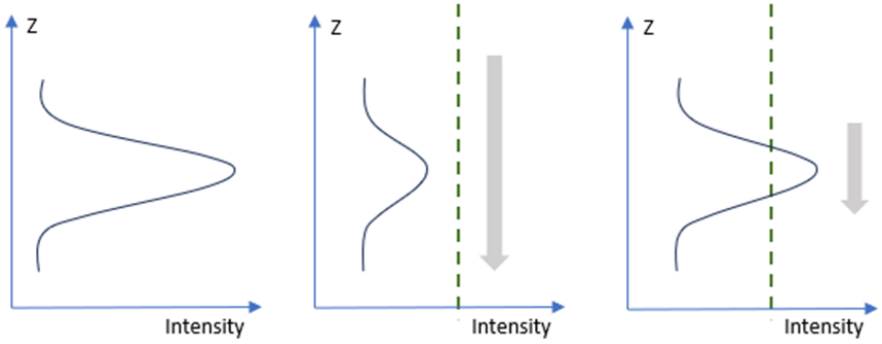
You can only adjust spot detection parameters when **Material type** is set to Custom. Set this to custom if the default values do not provide adequate spot detection.

The windows for spot detection (displayed in Image mode) and intensity (as displayed in Profile or Surface mode when Acquire intensity is enabled) are separate. The **Average window** setting is used in the background for spot detection. The **Intensity window** setting is used to define the intensity displayed in Surface mode.

The effect of the **Intensity window** setting can't be seen in Image mode or Profile mode, only in Surface data or intensity data when **Acquire intensity** is enabled.

*Spot settings*

| Setting | Description |
|---|---|
| Edge window | Sets the height of the window, in pixels, used to calculate the spot's exact peak Z position, using an average of the intensity in the window. The value range is even numbers from 2 to 16.<br>For all non-transparent materials, a value of 16 usually produces the most accurate Z measurement.<br>For thin, transparent materials, a lower value helps to detect all surfaces of the material. In these cases, lower the **Edge window** value until all surfaces are visible.<br>The image below illustrates transparent material with top and bottom layers, and shows the effect of different edge window sizes.<br>Left: A longer edge window moving over Z (the long vertical gray arrow) results in |

| Setting | Description |
| --- | --- |
| | only one maximum intensity peak (the single red dotted line) being detected, and therefore only one layer.<br>Right: A shorter edge window results in both layers being correctly detected.<br>  |
| Average window | Sets the length of the window, in pixels, used to calculate the average intensity for signal detection. The spot is detected if the calculated average intensity is greater than the value in **Spot threshold**. The value range is even numbers from 2 to 16.<br>Note the following:<br>• A high value is useful when the image is noisy, for example, due to strong reflections.<br>• Decreasing the value improves sensitivity to get a signal from low-reflective surfaces.<br>The image below shows the effects of different average window sizes.<br>Left: The raw intensity data is shown.<br>Middle: A longer average window moving over Z (the long vertical gray arrow) results in the averaged intensity staying below the value in **Spot threshold** (green dotted line) and data is not identified as valid for spot detection.<br>Right: With a shorter average window, the averaged peak intensity exceeds the threshold, and the range above the threshold is identified as valid for spot detection.<br>  |

| Setting | Description |
|---|---|
| | The calculated average intensity is not normally reported. To accomplish this, set the layer's **Intensity filter type** parameter to "Signal detection" (for more information, see *Layer-specific parameters (Layer {n})* on page 138). This may be useful in some thin film applications. |
| Intensity window | Sets the length of the window, in pixels, used to define the mean intensity value of the detected spots, which is then reported as the spot's intensity. When the intensity window is long, the reported intensity values are lower due to averaging, and noise is minimized. The value range is even numbers from 2 to 16.<br>Note the following:<br>• Intensity window has no effect in Image view or on spots, only on intensity data in Surface mode. Surface mode intensity values are visible when Acquire intensity is enabled. A default value of 16 is typically good. Use smaller values to avoid cross-talk between layers in thin multilayer measuring. (For more information on Image mode, see *Scan Modes and Intensity* on page 111.)<br>• Only effects the intensity value.<br>• A long intensity window reduces intensity noise.<br>• Use smaller values to avoid cross-talk between layers in thin multilayer measuring.<br>• Do not compensate the intensity window size with a higher exposure. Instead, adjust the exposure in Image mode.<br>• Do not correct a low averaged intensity caused by a long intensity window with a high exposure; instead, adjust the exposure in Image mode.<br>• With dynamic exposure, the intensity window must be short. For information on dynamic exposure, see *Dynamic Exposure* on page 136. |
| Spot Threshold | Sets the minimum intensity for spot detection. The range is from 1 to 150. The spots are detected when the averaged intensity value exceeds the spot threshold value. Note that the value set in **Average window** has an effect on the intensity value.<br>Note the following:<br>• The most commonly used value is about 17.<br>• The value should be as low as possible to maximize the spot detection.<br>• Increasing the value reduces noise.<br>• A high spot threshold introduces a risk of losing data. |

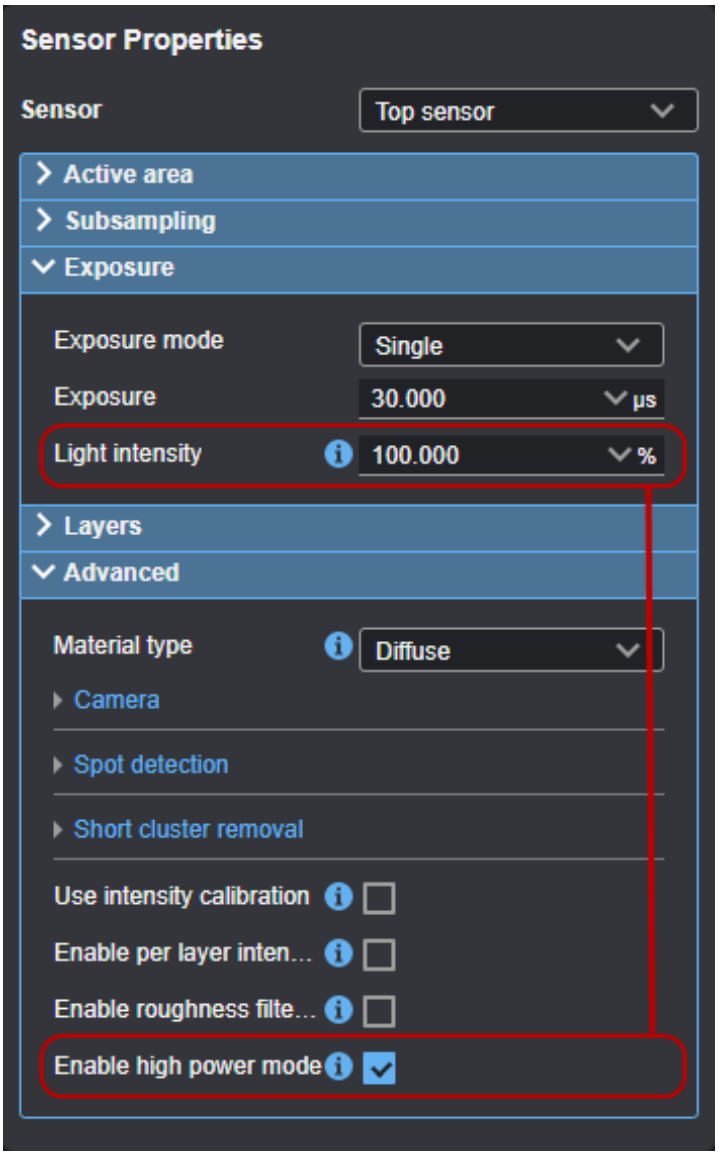
## Camera Gain

| Setting | Description |
|---|---|
| Camera Gain | |

| Setting | Description |
|---|---|
| | **Digital** camera gain can be used when the application is severely exposure limited, yet dynamic range is not a critical factor. Typically a value of 1 is good for most applications. The range is from 0 to 8. Digital gain may be increased to improve the sensitivity when the detection is very low. The disadvantage of increasing the gain is that it also increases the noise. |
| Enhanced Surface Flatness | This setting enables a pre-processing step that reduces spatial noise in video data. This can help the sensor find and measure defects and features more accurately on flat surfaces in scan data. |

## Other Advanced Settings

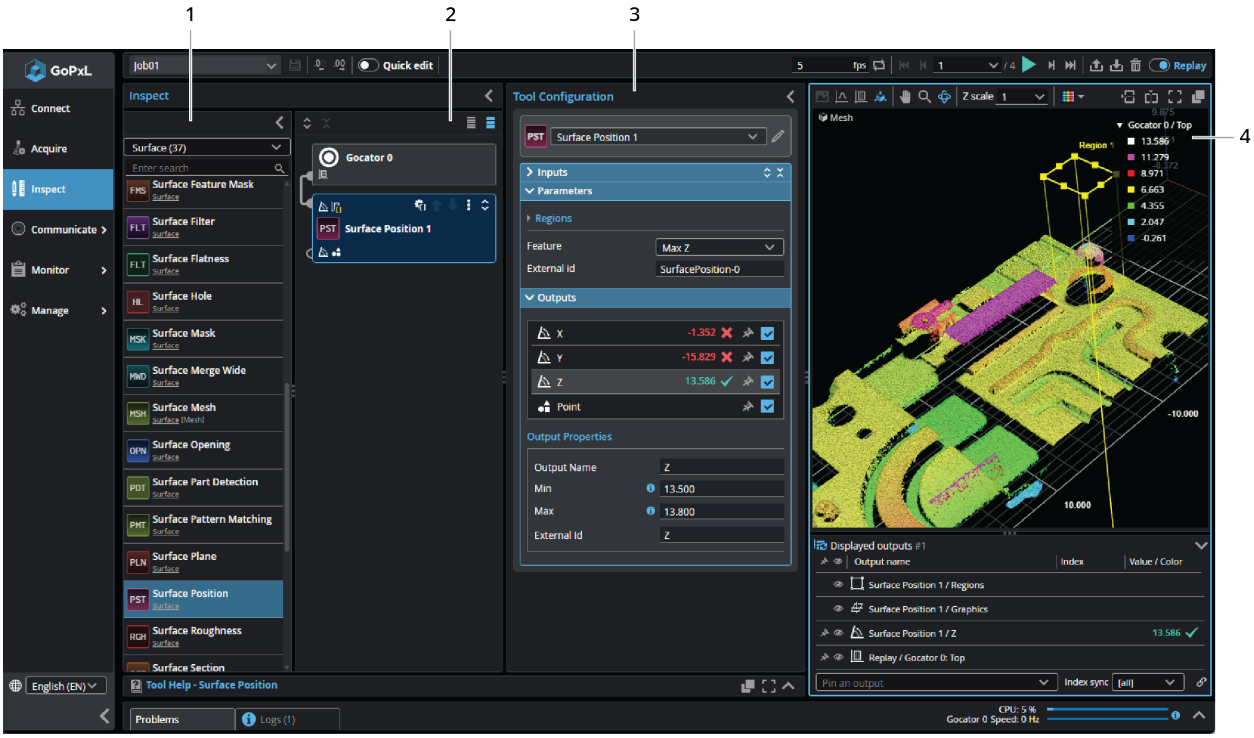
| Setting | Description |
|---|---|
| Short cluster removal | A cluster is a set of points where the neighboring points fall within a specified X and Z window. Cluster removal is done after layer sorting but before detect missing layer.<br><br>The **Clustering X distance** and **Clustering Z distance** parameters connect points to clusters. **Minimum cluster width** removes clusters smaller than the set length. When short cluster removal is enabled, you must set the following parameters.<br><br>**Clustering X distance**<br>Maximum X distance (µm) to the nearest point in a cluster.<br><br>**Clustering Z distance**<br>Maximum Z distance (µm) to the nearest point in a cluster.<br><br>**Minimum cluster width**<br>If a cluster is shorter than **Minimum cluster width** (µm), it will be removed.<br>In the image above, the first three clusters have been recognized using the window of **Clustering X distance** (1) and **Clustering Z distance** (2). (The green lines are together one cluster, because its gaps are shorter than Clustering X distance.) Then the red cluster is removed because it is shorter than **Minimum cluster width** (3).<br>This tool can be useful to remove noise from the first layer, caused by dust, for example. |
| Enable per layer intensity | When this parameter is enabled, you can set the **Intensity filter type** parameter for each layer individually. Otherwise, an "Average intensity" filter is used for all layers.<br>Only available if you have enabled **Acquire intensity** in the **Scan mode** section (see *Scan Modes and Intensity* on page 111). |
| Enable roughness filtering | If enabled, a median Z of 3 pixels is applied to remove the outliers. |

| Setting | Description |
| --- | --- |
| Enable high power mode | If enabled, a **Light intensity** setting is displayed in the **Exposure** section to let you set the LED light intensity to a value greater than 100%.<br>Note that enabling high power mode can limit frame rates. Updating the light intensity can take several seconds to apply. For more information on the **Light intensity** setting, see the topic on the exposure mode you have chosen under *Exposure and Light Intensity* on page 132.<br>  |
| Enable high speed mode | If you enable this mode and enable **X subsampling** (by setting it to a value other than 1), the sensor runs in high speed mode, which results in higher frame rates. Make sure the exposure time is not set to a value that would limit the maximum achievable frame rate. Also, consider reducing active area.<br>The estimated maximum frame rate possible varies by model. Minor differences |

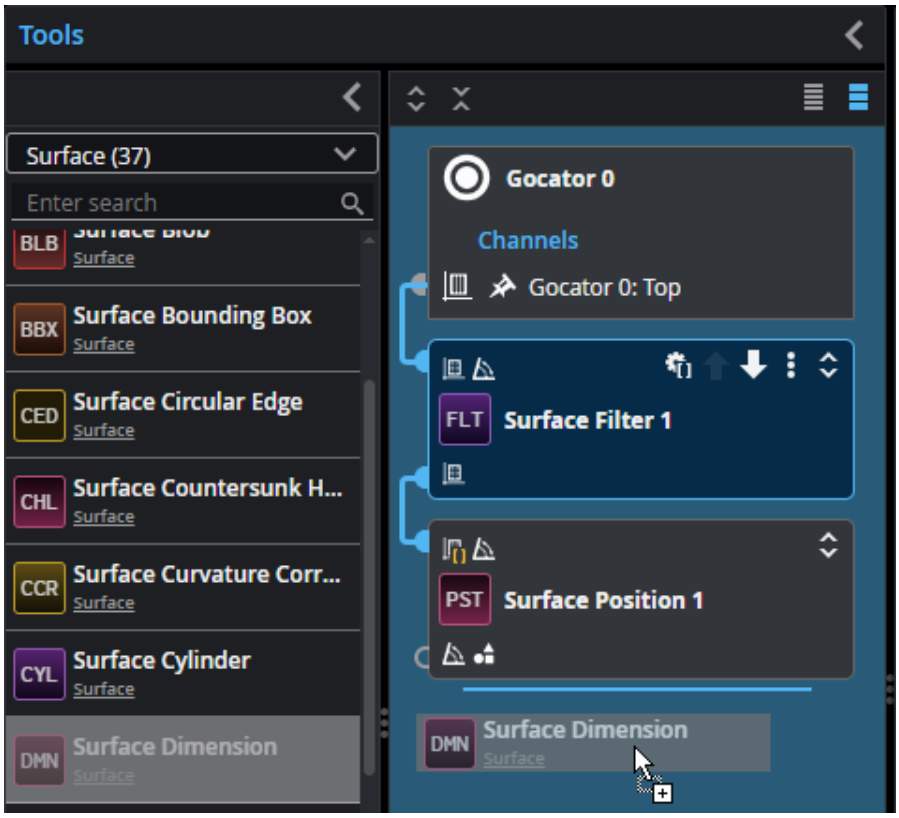
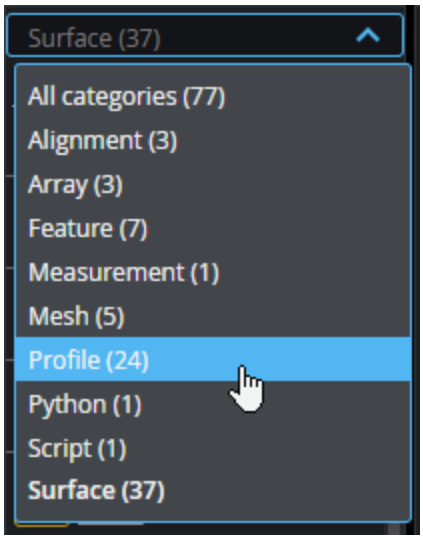
| Setting | Description |
| --- | --- |
| | between sensors may also be present due to variations in the devices' optical paths.<br>LMI has tested the following models, with the active area set to maximum width (except where indicated otherwise) and height reduced to 0.05 mm; for more information on active area, see *Active Area* on page 129. X and Z subsampling were both set to 1/2, and exposure set to 10 µs.<br><br>**Gocator 4010/4011**: 34,700 Hz<br>**Gocator 4020/4021**: 36,500 Hz<br>**Gocator 5504**: 39,000 Hz. To achieve the maximum frame rate, depending on the sensor, you will need to reduce the FOV by up to 0.16 mm if the X center of the FOV is offset to the left or right in the data viewer. If the FOV's X center is not modified, you will need to reduce the FOV by up to 0.32 mm.<br>**Gocator 5512**: 40,000 Hz. To achieve the maximum frame rate, depending on the sensor, you will need to reduce the FOV by up to 0.42 mm if the X center of the FOV is offset to the left or right in the data viewer. If the FOV's X center is not modified, you will need to reduce the FOV by up to 0.84 mm.<br>**Gocator 5516**: 39,000 Hz<br><br>Note that in this mode, computationally intensive operations, such as acquiring intensity or an increased layer count, may result in processing drops. |

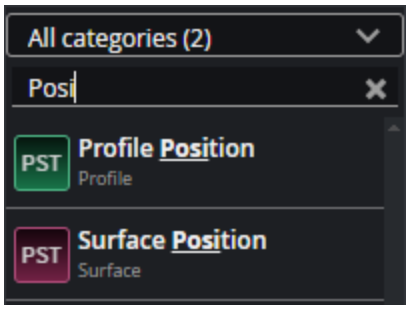
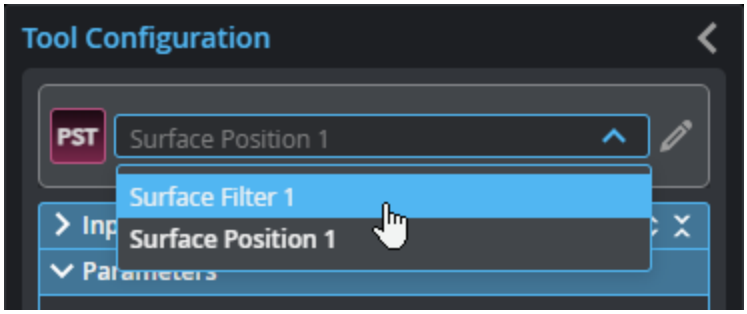
# Inspect - Measurement and Processing

You add and configure measurement and processing tools on the **Inspect** page.




| | Element | Description |
|---|---|---|
| 1 | Tool list | Lists all of the available tools. To add a tool, double-click it or drag and drop it in the Tool Diagram panel to the right of the list. |

| Element | Description |
| --- | --- |
| |  <br>You can filter tools using the filter at the top of the Tool list.<br>  <br>You can also search for tools by typing in the search field. Tools are listed as you type. |

| | Element | Description |
|---|---|---|
| | |  |
| 2 | Tool Diagram | Lists the tools that you have added. The Tool Diagram lets you better visualize the workflow in complex tools chains. For more information, see *Working with Tool Chains* on page 155. |
| 3 | Tool configuration | You configure a tool using the **Inputs**, **Parameters**, and **Outputs** expandable sections in the **Tool Configuration** panel. Typically, you configure tools from top to bottom, that is, by setting and configuring the inputs first, then the parameters, and finally the outputs, all in the order they are presented in these sections.<br>You can select which tool you want to configure from the tool selector drop-down, or by selecting the tool in the Tool Diagram to the left.<br>  <br>For information on parameters common to most tools, see *Tool Configuration* on page 169.<br>For information on the different types of tools, see their topics in the following sections.<br>Profile tools: See *Profile Measurement* on page 199.<br>Surface tools: See *Surface Measurement* on page 351.<br>Feature tools: See *Feature Measurement* on page 626.<br>Mesh tools: See *Mesh Measurement* on page 680.<br>Array tools: See *Array Tools* on page 671.<br>Measurement Formula tool: See *Measurement Formula Tool* on page 700.<br>Script tool: See *Script* on page 703.<br>Data Export tool: *Data Export* on page 666. |
| 4 | Data viewer | When configuring tools, you can graphically configure regions of interest. |

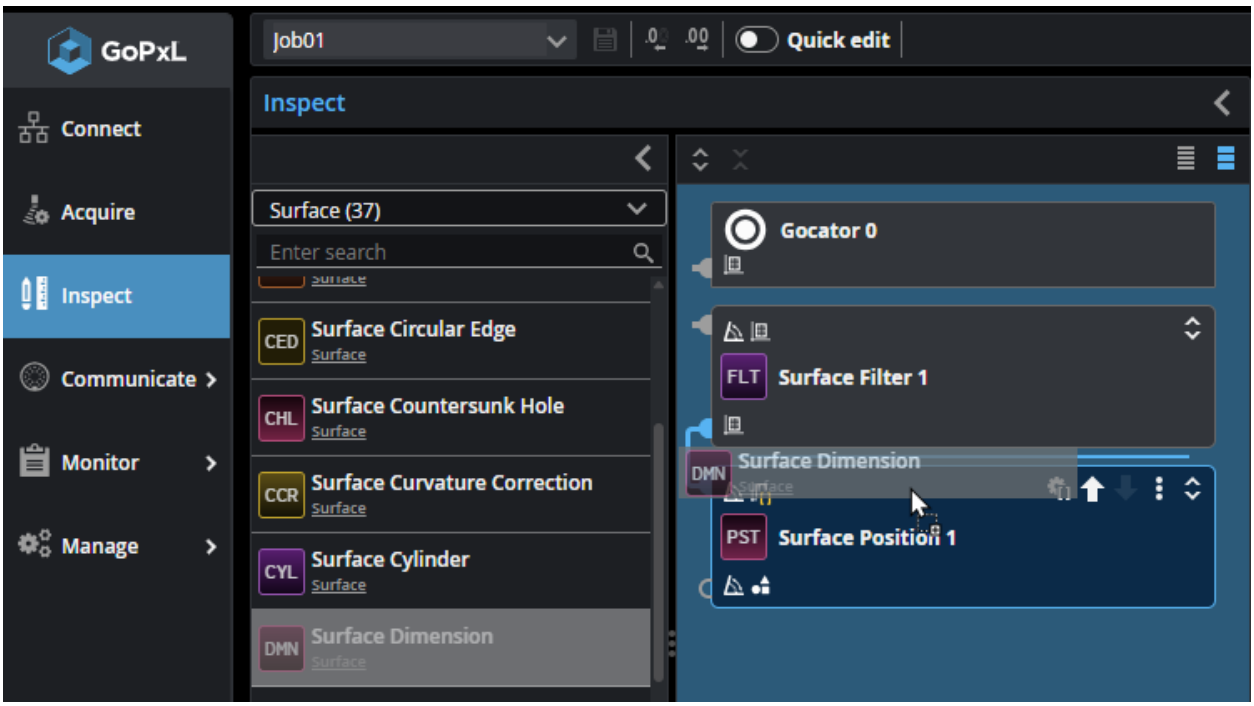
| Element | Description |
|---|---|
| | The data viewer's toolbar lets you change the display mode (for more information, see *Data Viewer* on page 64) and split a data viewer or pop out a data viewer in a new browser window. |

## Adding a Tool

You can add a tool from the tool list in two ways: by dragging and dropping the tool onto the Tool Diagram panel or by double-clicking the tool in the Tool List panel.

GoPxL automatically sets the added tool's input to an appropriate output when possible. The output GoPxL selects is either directly from a sensor or sensor group, or from the output of another tool, depending on various factors (see *Tool Connection Logic* below).

When dragging and dropping a tool, a line in the Tool Diagram shows where the tool will be added when you drop it.

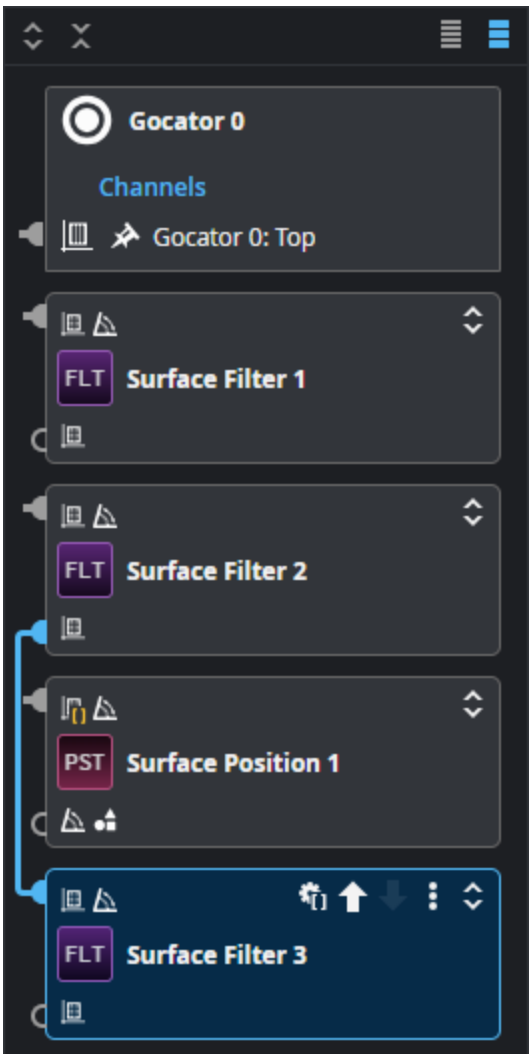



When double-clicking a tool in the tool list, the new tool is added after the currently selected tool in the Tool Diagram.

### Tool Connection Logic

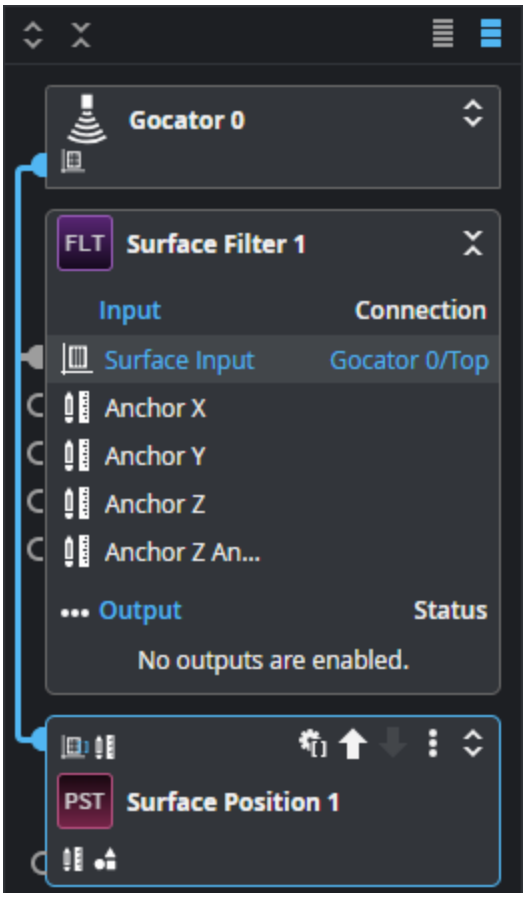
When you add a tool, GoPxL looks for compatible outputs among the other tools to set the added tool's inputs, starting with the tool or sensor directly "above" the added tool in the list of added tools (in the Tool Diagram panel). By "compatible," we mean, for example, data type (Profile vs. Surface, or uniform vs. non-uniform or point cloud data). GoPxL ignores tools "below" the added tool for this initial search. GoPxL checks the compatibility of all the outputs in a tool before moving up to the next tool.

In the following, a Surface Position tool has been added before the third Surface Filter tool. GoPxL will start searching for compatible outputs in Surface Filter 2 and then move to Surface Filter 1. If no compatible outputs are found in the preceding tools, GoPxL will search for compatible outputs in Gocator 0. Surface Filter 3 is ignored for auto-connection.




When a preceding tool has multiple enabled outputs, GoPxL goes through them in the order they are defined in *the tool* (that is, from the top down).

If no outputs from the preceding tools are compatible with the tool's inputs, GoPxL searches through the sensor or sensor group outputs. In the following, the added Surface Position tool "skips" the Surface Filter tool, whose output has been disabled.

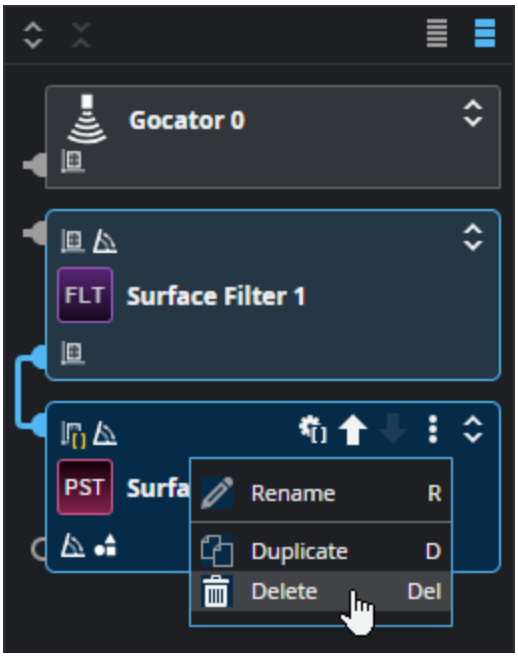



For information on other operations you can perform in the Tool Diagram, see *Working with Tool Chains* on page 155.

## Removing a Tool

If you no longer need a tool, you can remove it in the Tool Diagram. Removing an unused tool can increase performance, as it no longer takes up processing time.

To remove a tool, select it in the Tool Diagram and press Delete on your keyboard. You can also open the tool's Action menu ( ) and choose **Delete**. You can also press the Delete key on your keyboard. If multiple tools are selected, a delete operation will affect all of them.

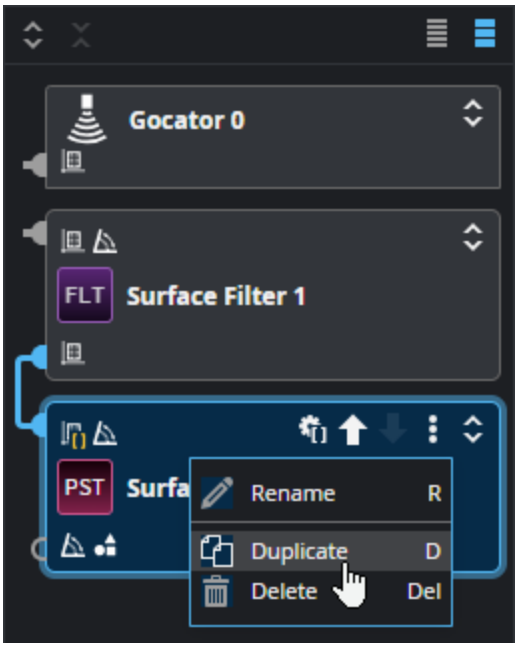



For information on other operations you can perform in the Tool Diagram, see *Working with Tool Chains* on page 155.

## Duplicating a Tool

You can quickly create a copy of a tool you have previously added in GoPxL in the Tool Diagram panel. The tool inputs, parameter settings, and enabled outputs of the original are copied. This is useful, for example, when you need almost identical tools with only minor variations, such as different maximum and minimum decision values, or regions of interest shifted from one component to another.

In the Tool Diagram panel, you duplicate a tool by opening the tool's Action menu ( ) and choosing **Duplicate**. You can also press the D key on your keyboard. If multiple tools are selected, a duplication operation will affect all of them.




For information on other operations you can perform in the Tool Diagram, see *Working with Tool Chains* on the next page.

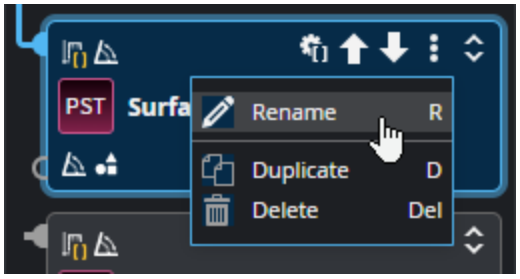
## Renaming a Tool

In the Tool Diagram panel, you rename a tool using the action menu of an individual tool.

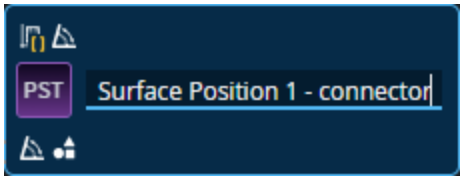
*To rename a tool in the Tool Diagram panel*

1. Click the action menu icon ( ).

   A context menu containing various actions appears.




2. In the context menu, choose **Rename**.
3. In the tool name field, rename to the tool.




4. Press Enter on the keyboard or click outside the text field.

For information on other operations you can perform in the Tool Diagram, see *Working with Tool Chains* below.

## Working with Tool Chains

The Tool Diagram panel between the tool list and Tool Configuration panel provides a visual representation of the data flow in a system (the output from a sensor group, and the input and output of tools). It lets you create and view complex tool chains with drag-and-drop, mouse, and keyboard operations, letting you quickly and easily implement and maintain applications requiring multiple, interconnected tools. Tools are represented by "blocks" in the tool chain.

All data types (if available) and their relationships between tools are displayed:

- Profile data (either directly from a sensor group's output or from tool output)
- Surface data (either directly from a sensor group's output or from tool output)
- Measurements (for use as anchors)
- Geometric features
- Tool data (some data outputs are intended to be consumed only by SDK applications and can't be used as part of a tool chain)

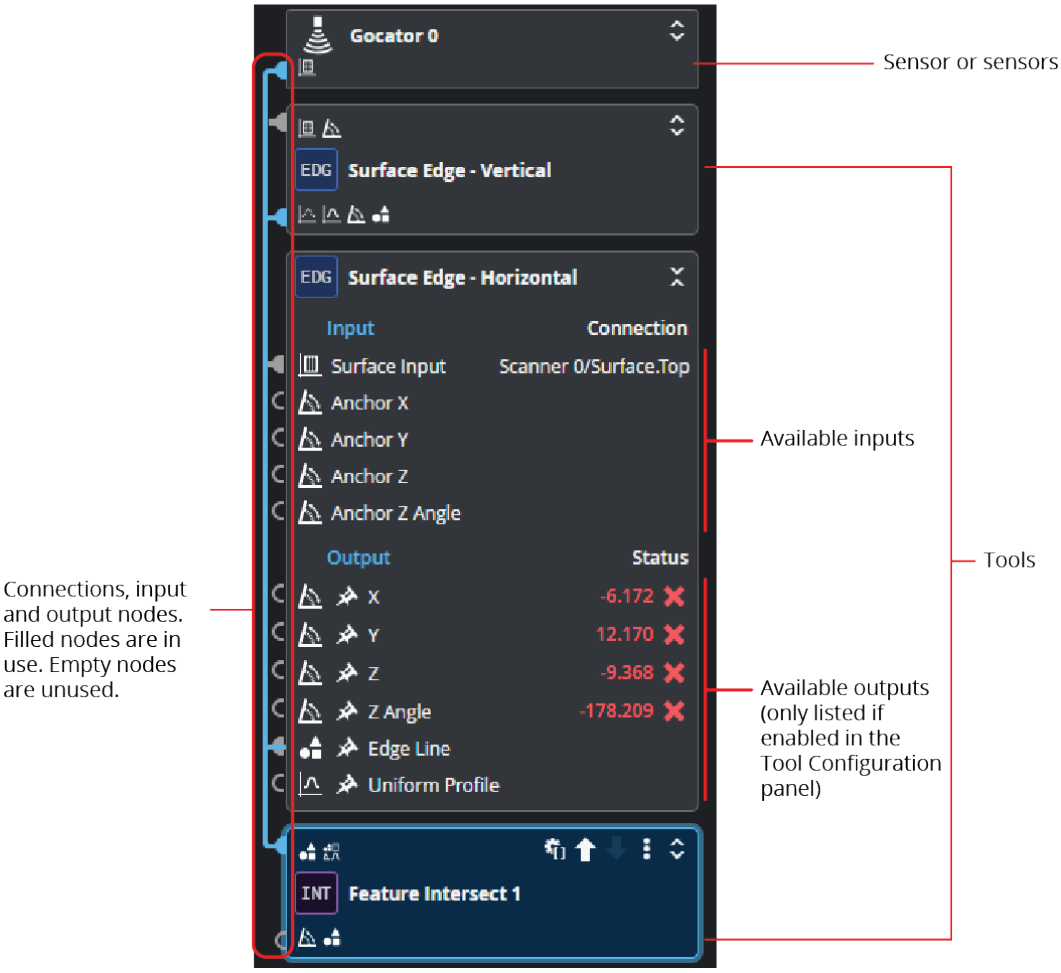
You can perform many operations on multiple tools at once. For more information, see *Keyboard and Mouse Shortcuts* on page 59.

For details on how the Tool Diagram panel displays information, see *Understanding the Data Flow in Tool Chains* on page 160.

For details on how to connect and disconnect, see *Connecting Tools* on page 165 and *Disconnecting Tools* on page 167.

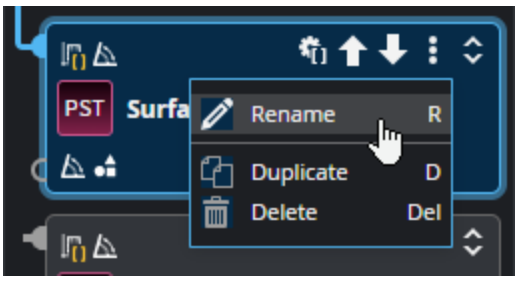
The Tool Diagram panel is open by default. The inputs, parameters, and outputs of the tool selected in the Tool Diagram panel are displayed to the right of the Tool Diagram panel.

The following shows the main features of the Tool Diagram panel.




*Tool Diagram panel showing sensor group, tools, outputs/inputs, and data flow connections.*

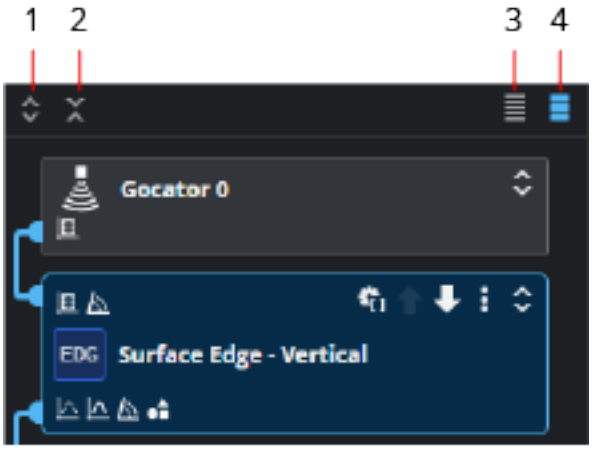
At the top of a tool, an action menu provides functions to rename, duplicate, and delete the current tool.




*Action menu (collapsed tool)*

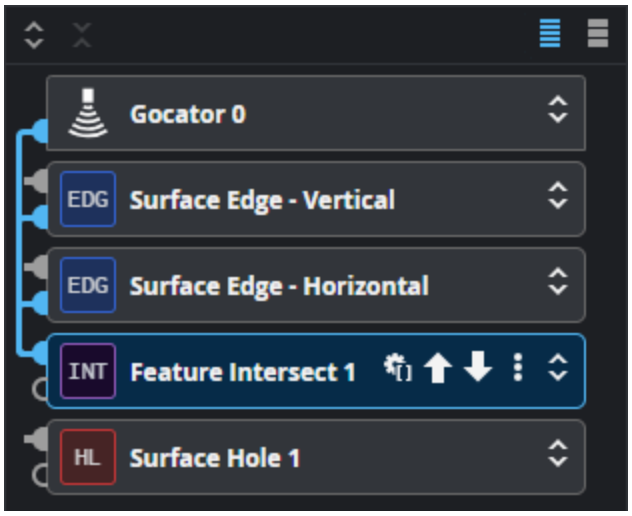
## Changing Tool Display Options

The buttons at the top of the Tool Diagram panel let you control how the panel displays sensor groups, tools, and the data flow (tool chain). Buttons at the top of individual tools let you organize the tools in the list, as well as name, duplicate, and delete them.

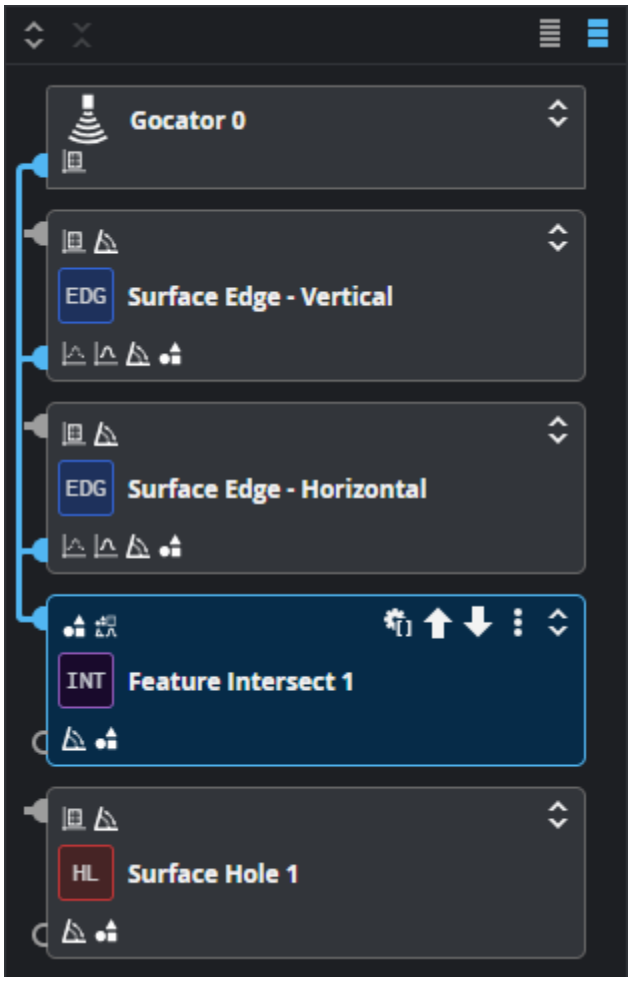



The following describes the toolbar's functions:

1. Open all: Expands the sensor or sensor group block and all tools in the Tool Diagram panel, displaying a list of available inputs and enabled outputs for each one.
2. Close all: Collapses all items in the Tool Diagram panel.
3. Compact view: Hides the list of small input and output icons that indicate the types of the inputs and outputs the sensor or a tool has.



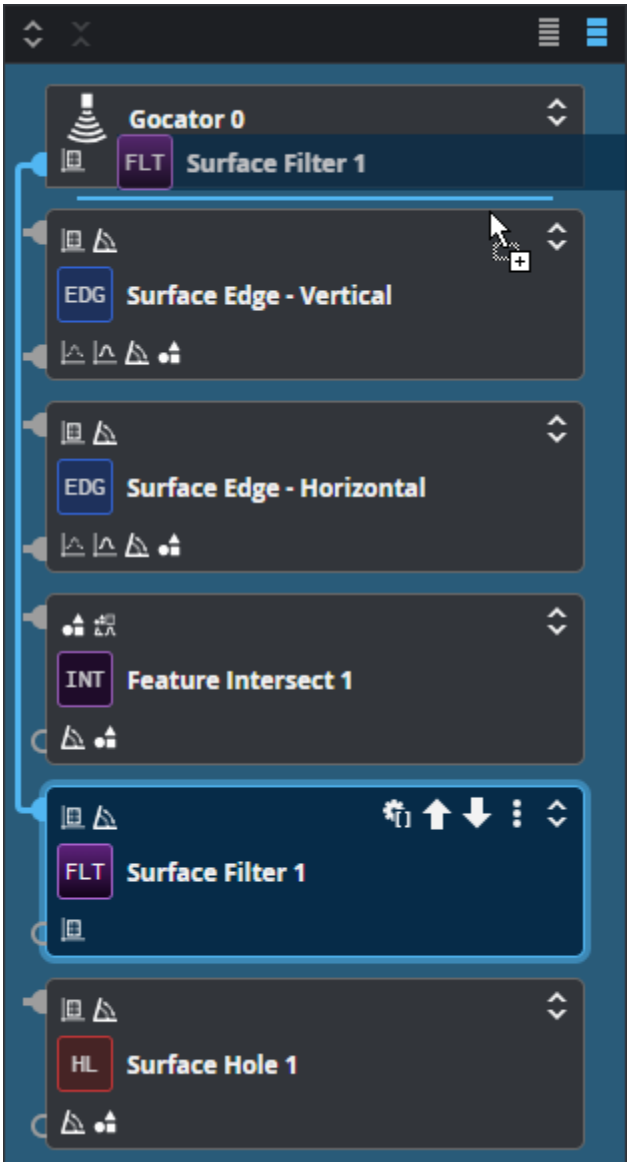
4. Standard view: Shows small icons that indicate the types of the inputs and outputs the sensor group or a tool has. For a list of inputs and outputs, see *Data Types* on the next page.




## Reordering Tools

You can reorder tools in the Tool Diagram to organize them more logically or to better represent the data flow. For example, you could group tools that output geometric features with the tools that use them, or group tools you use as anchors with the tools that use those anchors. Note that the order of tools in the Tool Diagram panel does not affect the flow of data.

You can reorder tools you have added by dragging and dropping them to the position you want in the list of tools. You can also click the up and down arrows in a selected tool block, or a block the mouse is hovering over. You can use your keyboard's up and down arrow keys to move the selected tool up or down in the tool chain. If multiple tools are selected, a move operation will affect all of them.




*Moving the Surface Filter tool to the top of the tool chain.*

## Data Types

GoPxL represents the data types of inputs and outputs with icons. When an input or an output

| Icon | Description |
|---|---|

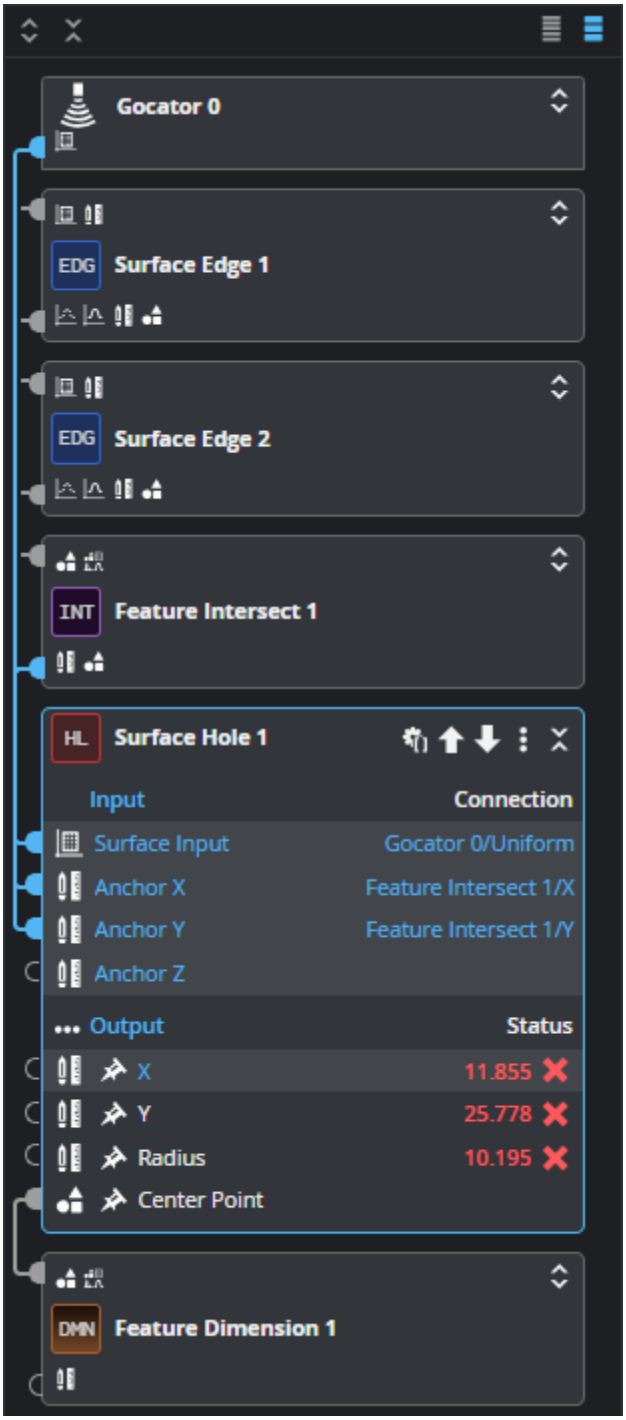
| | |
|---|---|
| | Uniform Surface data |
| | Point Cloud Surface data (non-uniform) |
| | Uniform Profile data |
| | Point Cloud Profile data (non-uniform) |
| | Measurement |
| | Geometric feature |
| | Multiple input types |

Data type icons, as well as tool icons, can be modified with a "[ ]" badge to communicate information related to arrays and batching. For more information, see *Arrays, Batching, and Aggregation* on page 171.

## Understanding the Data Flow in Tool Chains

The rectangular blocks displayed in the Tool Diagram represent a sensor or group of sensors at the top, and any tools you have added below that. Sensor groups display output connection nodes, whereas tools display both input and output connection nodes.

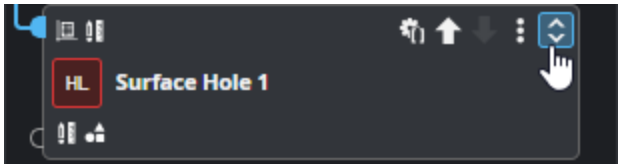
The appearance of nodes changes depending on whether they are connected and whether they are selected. Connections that are used are solid. Connections that are not used are empty. When a sensor or tool is expanded, you can see which specific inputs or outputs are used as part of the tool chain. For example, in the expanded Surface Hole tool below, we can see that the first three inputs (*Surface Input* and the X and Y anchors, receiving their input from the sensor group at the top and from Feature Intersect, respectively) and the Center output are involved in the chain of sensor group and tools.



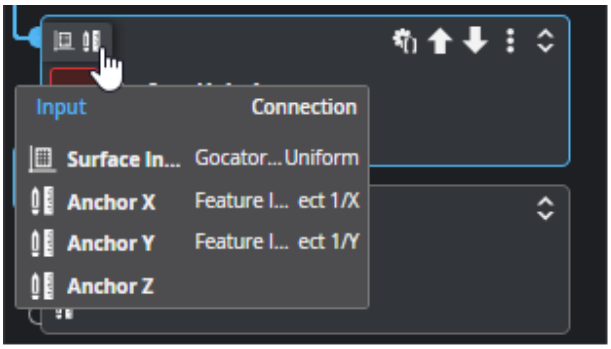
When a tool is collapsed, however, you only know that at least one input or output is used (or none at all). For example, looking at the collapsed Feature Dimension tool at the bottom, we know that at least one input (the connection node at the top) is used, and that none of the tool's outputs are used. Also, we know that inputs and outputs of the three collapsed tools at the top are used, but not exactly which ones.

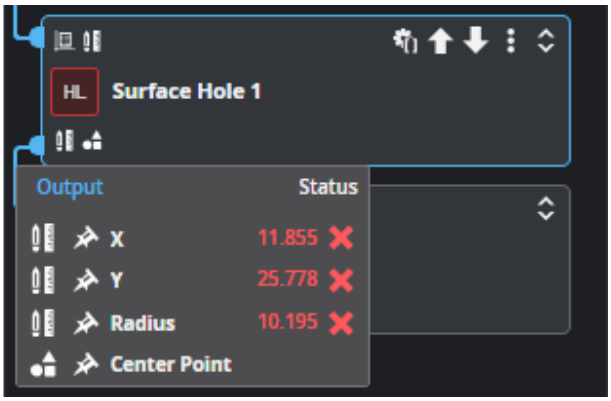
In both cases (collapsed or expanded), the data flow of the selected tool or sensor block is indicated by blue connection lines. For more information, see below.

By default, sensors and tools are collapsed, but you can expand them individually by clicking the expand / collapse button at the top right of a tool to display the complete list of available inputs and outputs. Note that for an output to be listed in the Outputs section, it must be enabled in the tool's configuration: in the tool's Output list, only enabled outputs are listed.

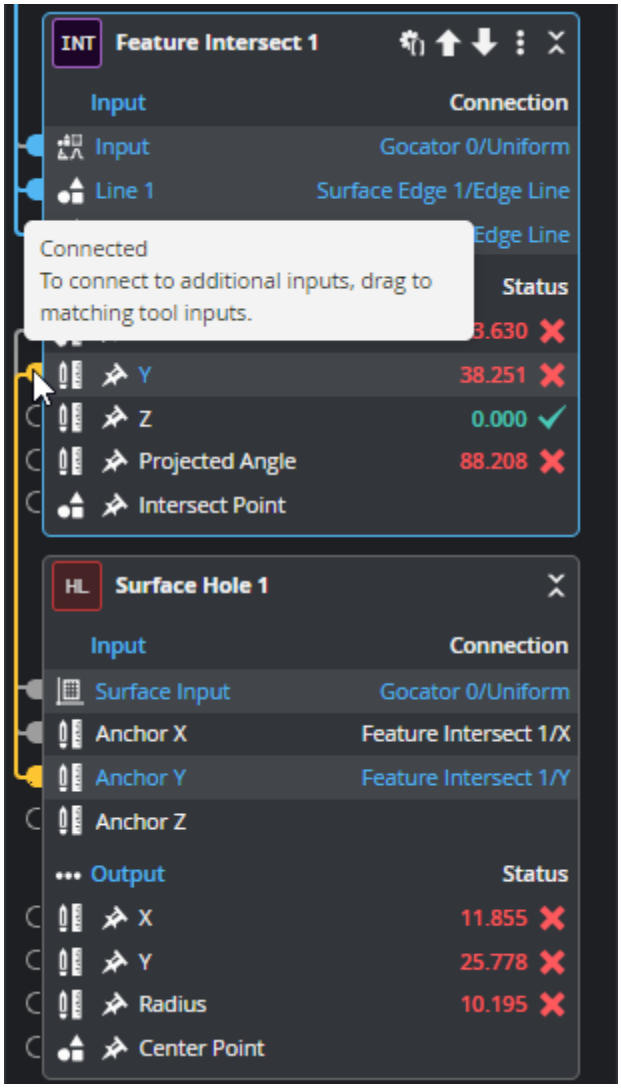



When a tool is collapsed, you can see which inputs are connected and to what source, and also see which outputs are enabled and their values, by clicking one of the rows of small icons at the top or bottom of the block. You can also pin outputs from here; for more information on pinning, see *Displaying and Pinning Outputs* on page 79.

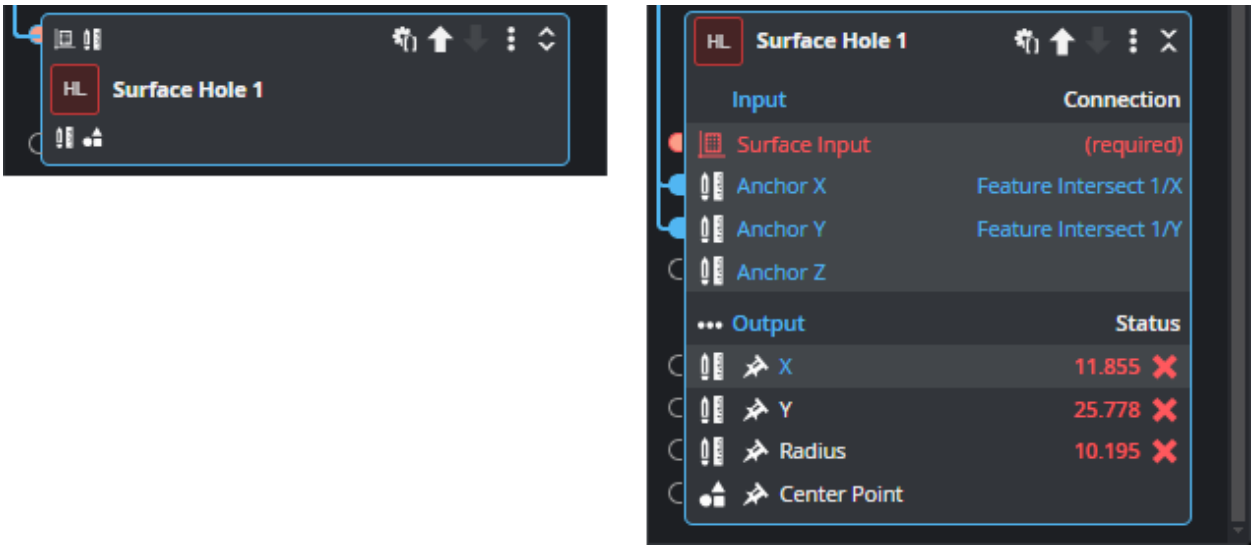


If you hover the mouse pointer over a blue connected node, a part of the blue connection line is highlighted in yellow to indicate what it is connected to. In the image below, you can see that by hovering over an output (the Y measurement of the Feature Intersect tool) it is used as an input (the Y anchor) of the Surface Hole tool at the bottom.

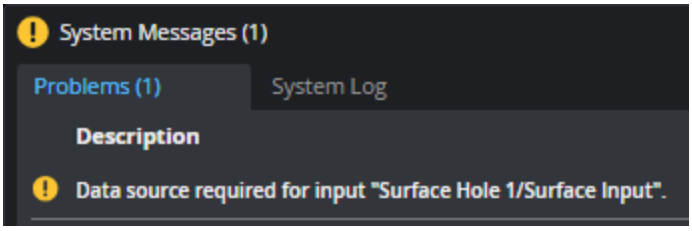


If a tool's input is missing, that input is displayed in red in the Tool Diagram panel to show that you must connect it to something.

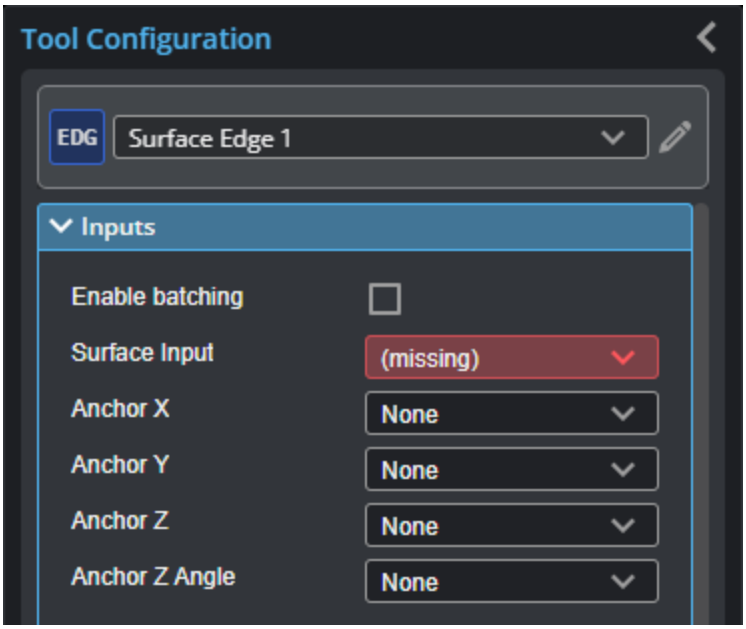



*Collapsed tool and expanded tool with a missing input*

You can also consult the **Problems** tab in the **System Messages** panel at the bottom of the interface to see which tools are missing inputs.




In the Tool Configuration panel, a tool whose input is no longer available (for example, you have removed the preceding tool in the tool chain ) displays "(missing)" in the input parameter.




## Connecting Tools

The Tool Diagram panel lets you quickly connect tools using drag-and-drop operations.

In the following, we connect a measurement output from one tool to an anchor input of another tool. However, the same procedure applies when connecting other kinds of outputs to inputs, such as when connecting a geometric feature output from one tool to the input of another tool, or when connecting Surface output (such as the output from the Surface Filter tool) to the input of another tool.

*To connect a tool's output to another tool's input*

1. Make sure you have added at least two tools and that you have configured the tools higher in the tool chain.

   The output you want to connect must be enabled in the first tool. You can enable a tool's output in the tool's **Outputs** section in the **Tool Configuration** panel, or by using the **Output** menu in the tool's block in the Tool Diagram panel.

   For information on adding tools, see *Understanding the Data Flow in Tool Chains* on page 160.

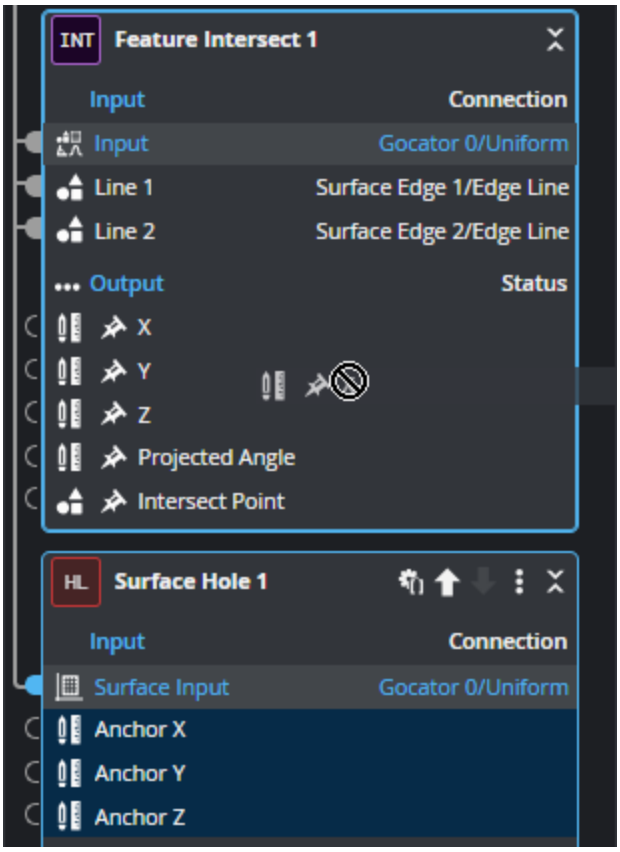
2. Locate the tool whose output you want to use (the "source" tool).

3. Do one of the following:

   From an expanded tool

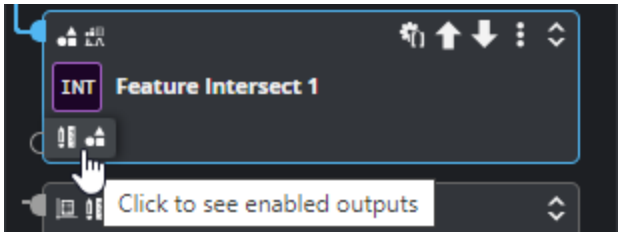
   a. Click and hold the output you want to connect to the other tool's input and drag it to the input.

      Here, we are dragging the X measurement from the Feature Intersect tool. Tools with compatible inputs (here, the anchor inputs of the Surface Hole tool), are highlighted with a dark color.

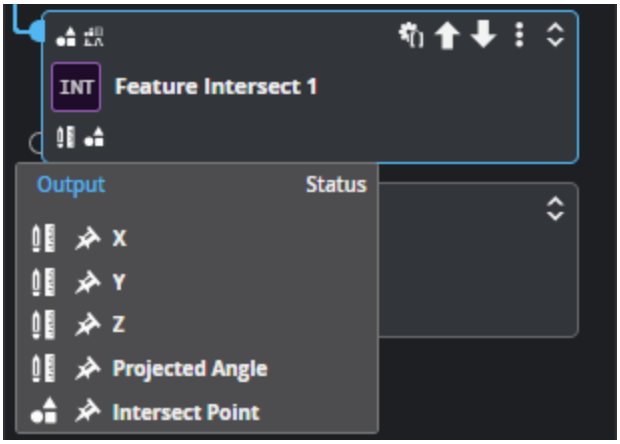



From a collapsed tool

a. Click the small row of icons at the bottom of the tool to expand the list of

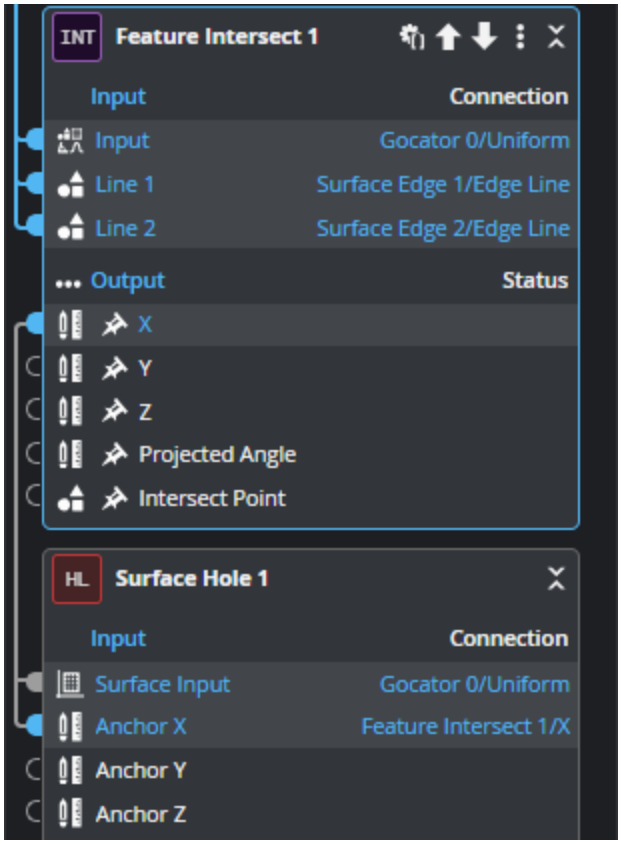



A list of enabled outputs is displayed in a pop-up list.



4. Drop the output on the desired input.

   A new connection appears between the first tool's output and the second tool's input (below, between the Surface Hole tool's Center Point output and the Point input in the Feature Dimension tool).

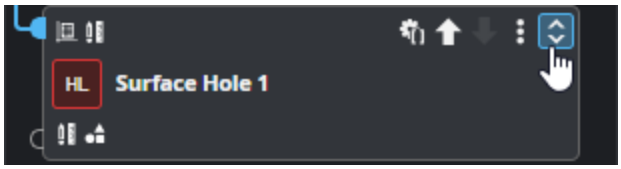



## Disconnecting Tools

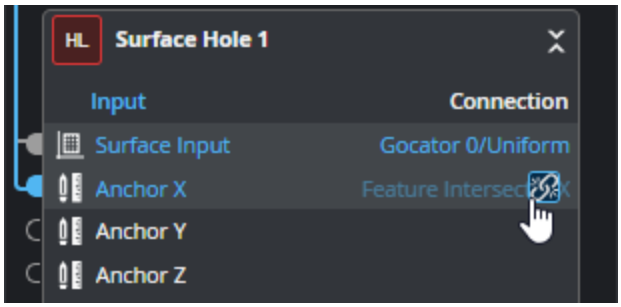
You can quickly disconnect an input in the Tool Diagram panel, but only if the tool containing the input is expanded.

*To disconnect an input in a tool:*

1. If the tool isn't expanded, click the Expand button at the top of the tool.




2. In the expanded tool, move the mouse pointer over the input you want to disconnect and move it to the right until the pointer is over the Disconnect icon.

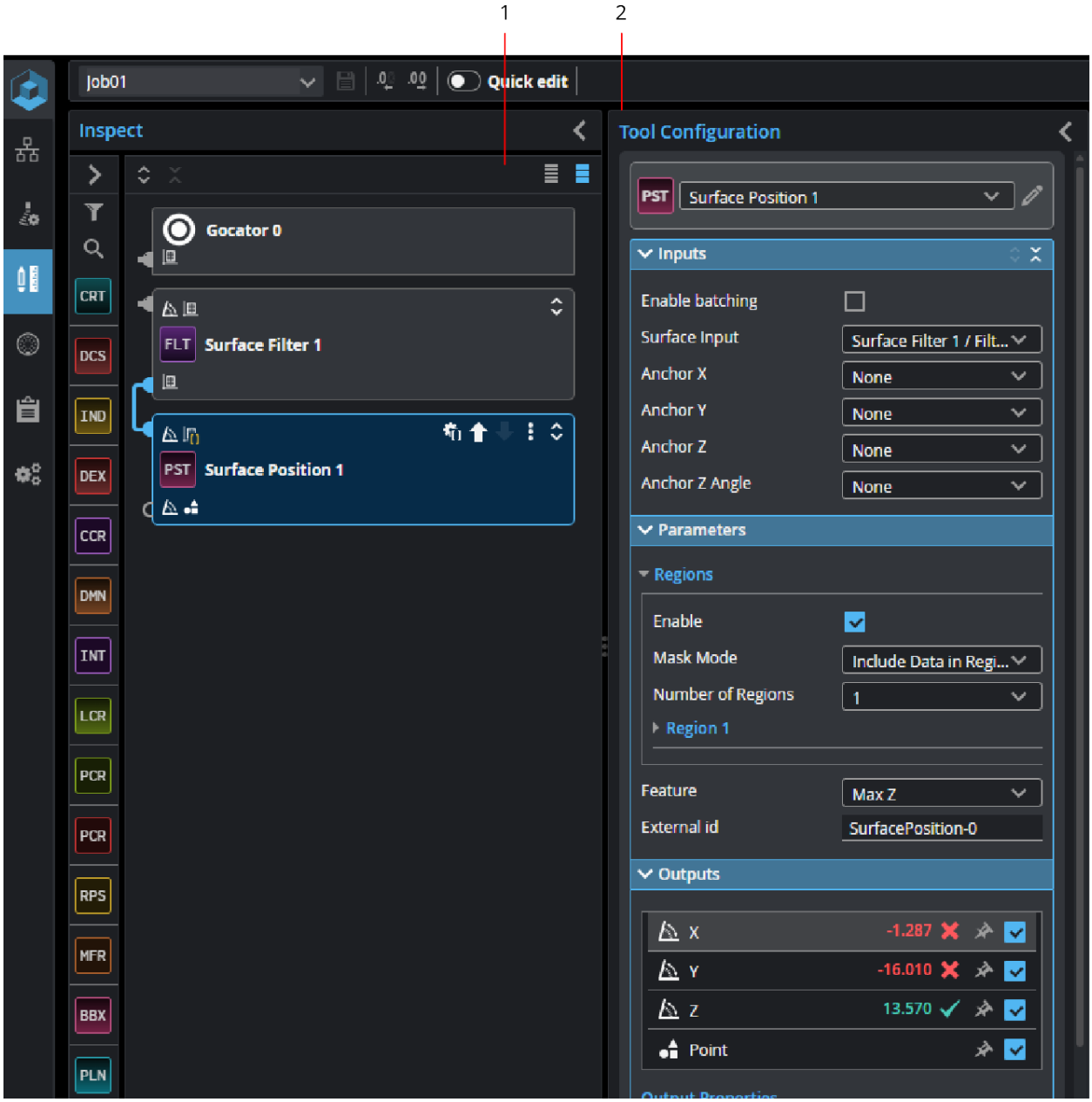



3. Click the Disconnect icon.

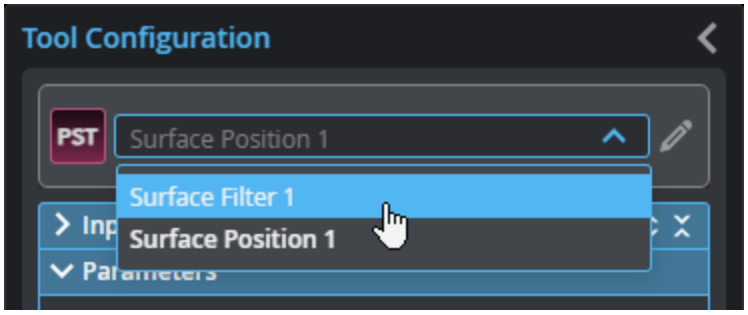
   The input is disconnected from the other tool's output.

## Tool Configuration

You configure a tool's inputs, parameters, and outputs in the tool configuration area to the right of the Tool Diagram.




| | Element | Description |
|---|---|---|
| 1 | Tool Diagram | Lists the tools that you have added. The Tool Diagram lets you better visualize the workflow in complex tools chains. For more information, see *Working with Tool Chains* on page 155. |
| 2 | Tool configuration | Lets you configure the selected tool using the **Inputs**, **Parameters**, and |

| Element | Description |
|---|---|
| | **Outputs** sections in this area.<br>You can select which tool you want to configure from the tool selector drop-down, in addition to selecting the tool in the Tool Diagram.<br>  |

The following sections describe the parameters common to most tools.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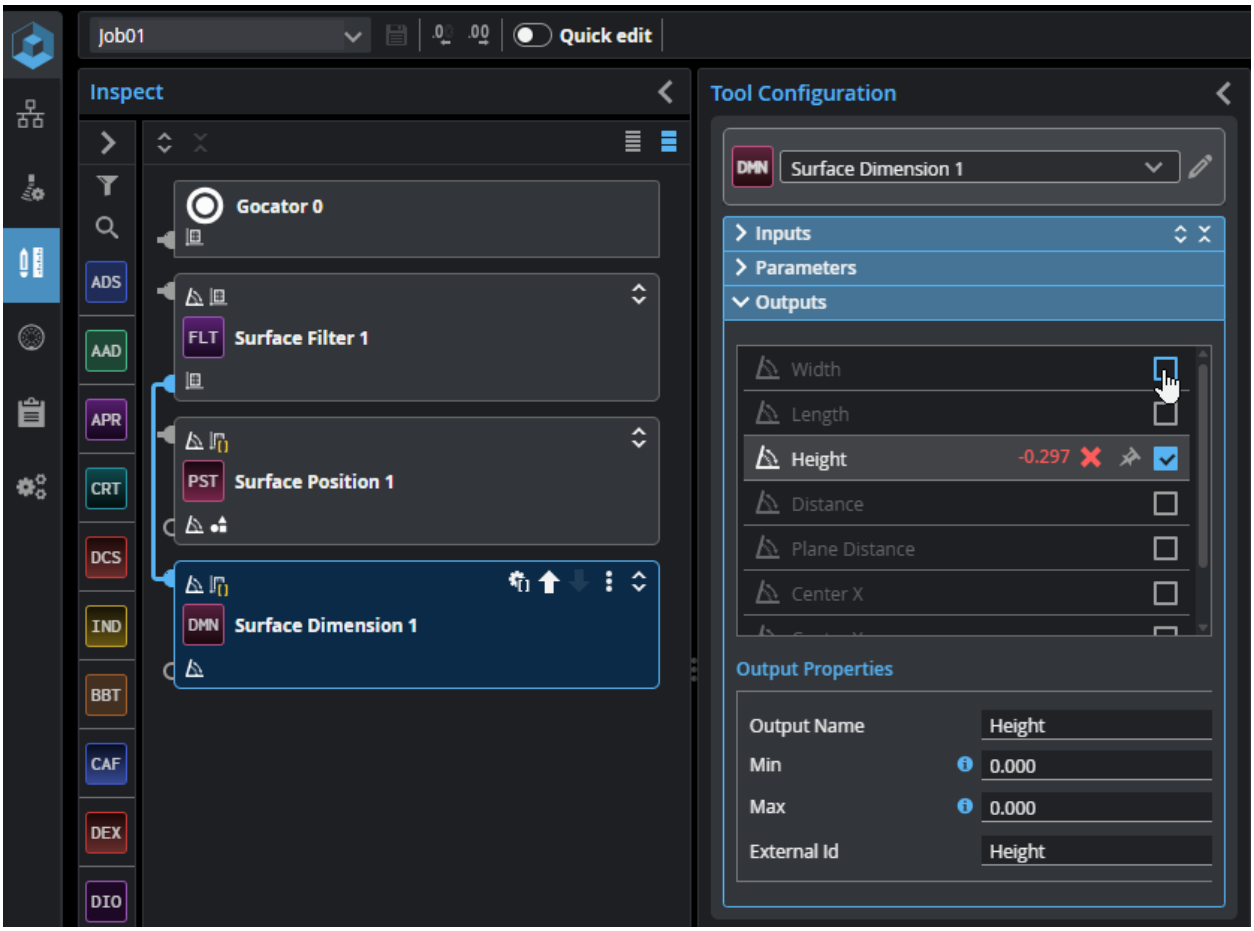
## Inputs and Outputs

All tools take one or more inputs, either directly from a sensor or sensor group, or from another tool. All tools produce output, such as measurements or modified scan data.

The simplest case is a tool taking a single input, such as a profile (line profilers only) or surface data. The tool performs measurements on the input or processes it, and produces outputs.

Most tools can also take "arrays" as inputs. For more information on arrays and how tools work with them, see *Arrays, Batching, and Aggregation* below.

All of the outputs (measurements, features, and scan data such as Surface or Profile data) available in a tool are listed in the **Outputs** section of the tool. To enable an output, check its checkbox in the tool's **Outputs** panel.




*Enabling the Width measurement. Only the Height measurement is currently enabled, which is displayed in the tool's output section in the Tool Diagram.*

## Arrays, Batching, and Aggregation

GoPxL supports data structures called arrays to help simplify otherwise complicated applications.

When working with arrays, you can select an array element (or all of the elements) across all arrayed tool outputs to make it easier to focus on a single array element. For more information, see *Displaying and Pinning Outputs* on page 79.

An array is a group of data items bundled into a single structure, such as multiple profiles or surfaces, multiple measurements, or multiple geometric features.

The items, or elements, in the array can be processed by other tools in one of two ways:

- Batching: Tools in batching mode process each array element *separately*. In other words, the tools "loop" through the elements of the array. Typically, tools in batching mode will output an array of outputs, where each element corresponds to the elements in the input. You enable batching by checking the **Enable batching** parameter in a tool's **Inputs** section. For more information, see *Batching* on page 176.
- Aggregating: Aggregating tools combine each element in the array and process it as a *single* piece of data. For more information, see *Aggregating* on page 178.

Most tools support the batching of array elements. Some tools support both batching and aggregating.

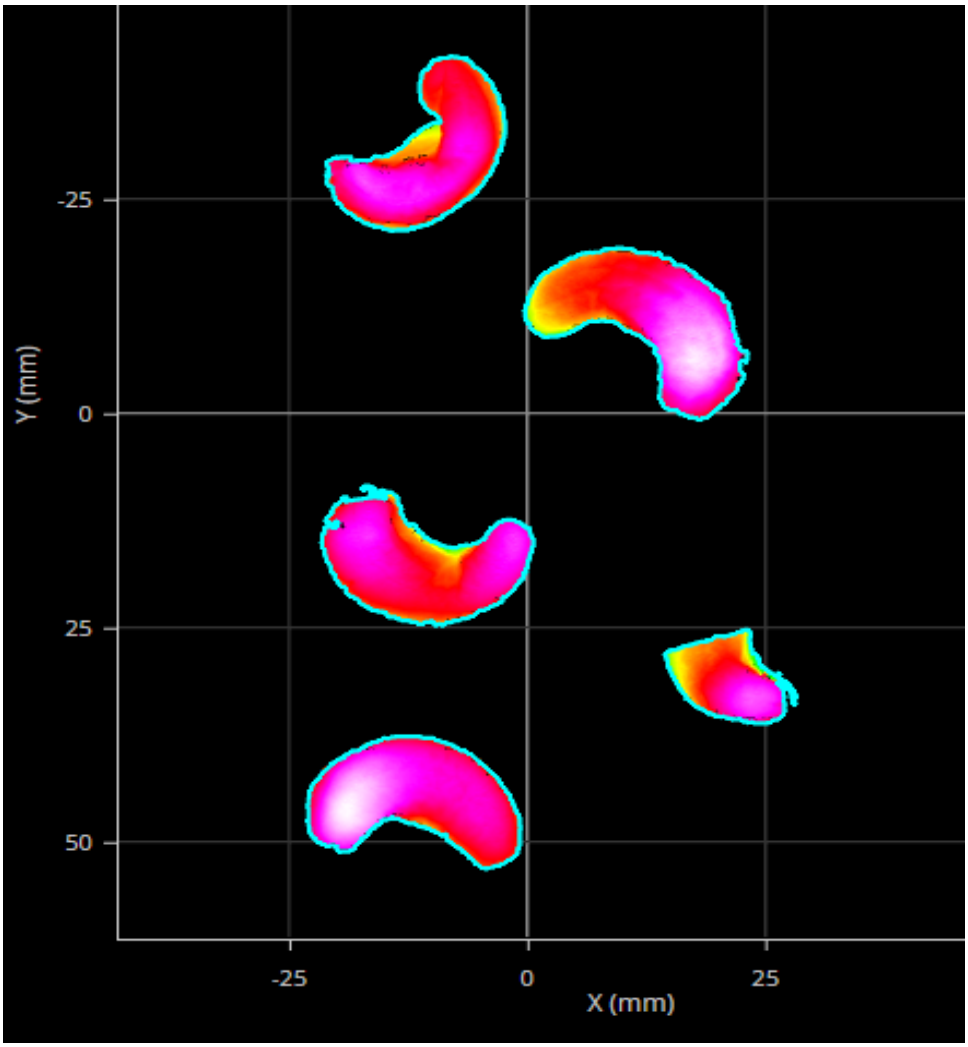
Array data can come from various sources:

- Outputs from tools like Surface Blob, Surface Segmentation, and Surface Pattern Matching. For more information, see *Arrays from Multi-instance Tools* below.
- G4 and G5 (single- and multi-sensor) and multi-layer output. For more information, see *Arrays from Multi-layer Output* on page 174.
- G2 multi-sensor output. For more information, see *G2 Multi-sensor Output* on page 175.
- The Script tool. For more information, see *Script* on page 703.
- The Array Create tool. For more information, see *Array Create* on page 672.

For information on working with arrays in the Displayed Outputs panel, see *Displaying and Pinning Outputs* on page 79.

#### Arrays from Multi-instance Tools

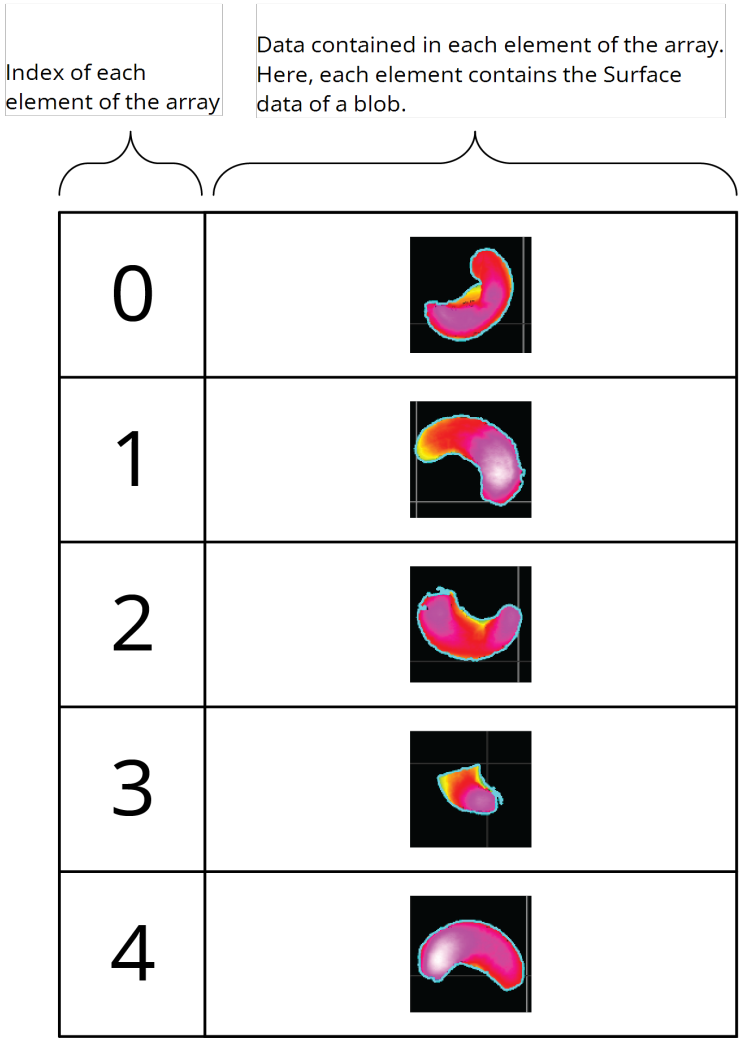
The Surface Blob, Surface Segmentation, and Surface Pattern Matching tools can identify multiple occurrences of features or parts in scan data. When you check **Enable Array Output** in the tool's **Parameters** section, the tool outputs an array containing the occurrences. Otherwise, the tools produce a separate output for each identified feature or part. In the following, a Surface Blob tool has identified five blobs in scan data.




*Surface Blob tool identifying blobs in scan data.*

When the tool's **Enable Array Output** setting is checked, the Surface Blob tool outputs an array containing all of the blobs it identifies.

An array containing objects identified in some scan data could be represented in the following way. (These are "blobs" from the Surface Blob tool.)



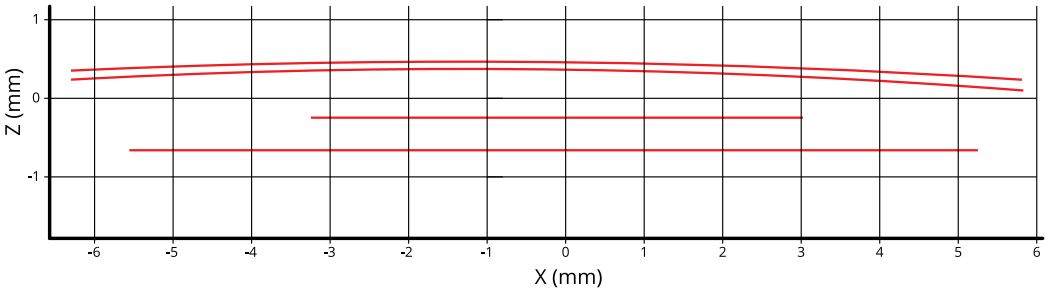

Note that array elements start at 0; that is, arrays are 0-based.

Other tools can then take this array as input. For more information, see *Batching* on page 176 or *Aggregating* on page 178.

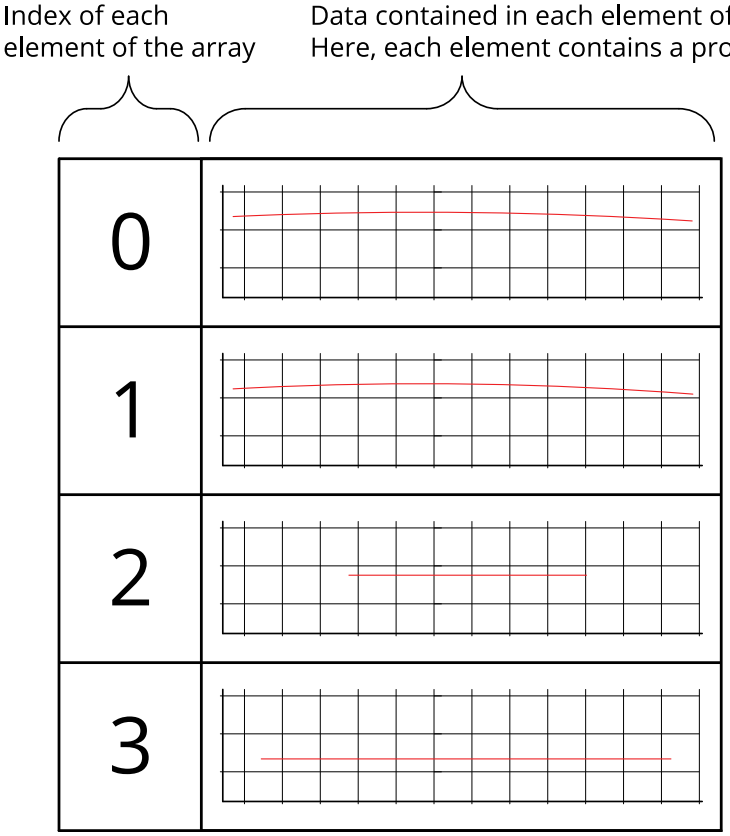
### Arrays from Multi-layer Output

When configured for multi-layer scanning, confocal sensors can scan translucent or transparent targets and return a profile or a surface representing each layer. By default, these profiles are output as an array. (Note that you can optionally have GoPxL output the profiles individually by *enabling* **Separate layer outputs** on the **Scan** page; for more information, see *Scan Modes and Intensity* on page 111.)

The following illustration is a representation of multilayer Profile scan data from a confocal sensor, showing four profiles.




The structure of an array containing these profiles could be represented as follows:




Other tools can then take this array as input. For more information, see *Batching* on the next page or *Aggregating* on page 178.

**G2 Multi-sensor Output**

In G2 multi-sensor systems where sensors are in a top-bottom layout, Profile and Surface data can optionally be output as an array, where top data (from one or more sensors) is one array element, and bottom data (from one or more sensors) is another array element.

Other tools can then take this array as input. For more information, see *Batching* on the next page or *Aggregating* on page 178.

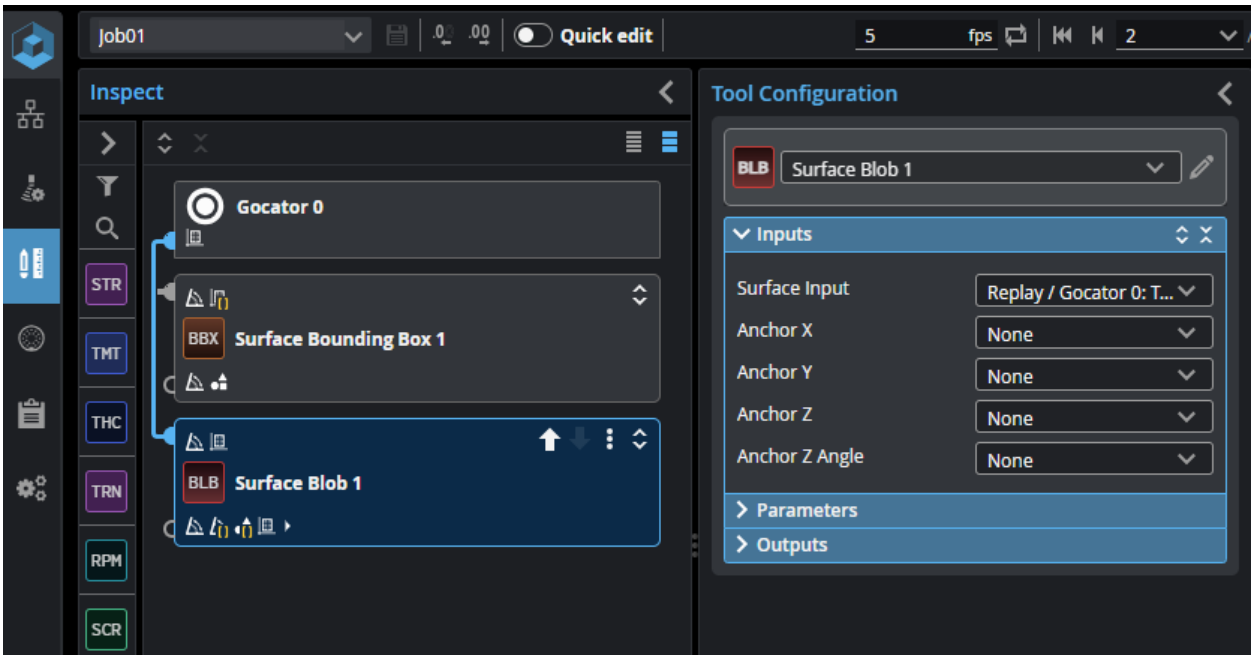
To understand how GoPxL communicates information related to batching and arrays, see *Batch and Array Indicators in GoPxL* on page 179.

### Batching

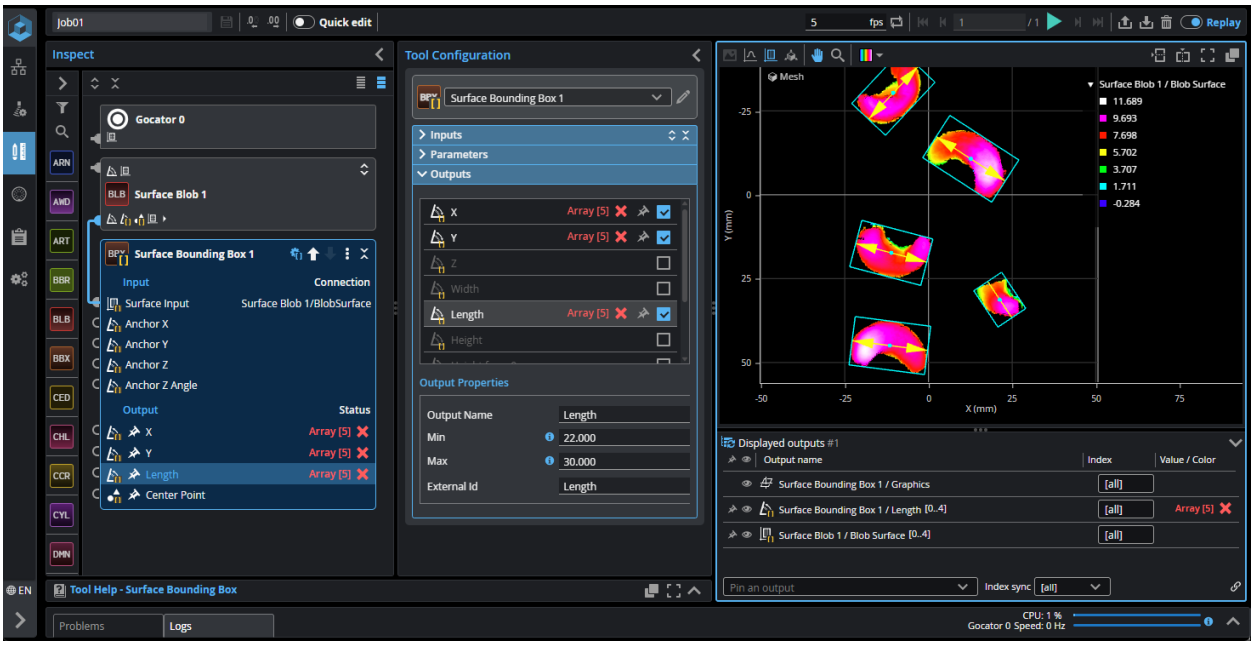
When a tool is in *batching* mode, it processes each item in the input array *individually*. A tool in batching mode also outputs one or more arrays (such as measurements, Profile or Surface data, geometric features, and so on), where each element of the output arrays corresponds to an element in the input array.

When a tool is in batching mode, there is no limit to the number of elements in the input array (other than any CPU limitations).

Batching is enabled in tools by checking **Enable batching**in the tool's **Inputs** section, or by clicking the Batching icon ( ) in a tool's block in the Tool Diagram panel (see below).




The following shows the Surface Bounding Box tool in batching mode (taking the Surface Blob tool's array of outputs as input). The tool calculates the bounding box for each element in the input array, and returns the enabled measurements as arrays. That is, it returns an X, Y, and Z measurement for each object.




Hovering over batched outputs in the Tool Diagram or in the **Tool Configuration** panel displays a list of the elements in the array.

When at least one result in the array is a fail, the output is considered a fail and the "Array[n]" label is red. Otherwise, it's green. Outputs within the pop-up list are displayed in green or red, depending on whether they represent pass or fail. You can copy the values of the measurement into the clipboard by clicking the copy icon ( ). The format of the copied values is as follows:

```
[24.604,22.805,22.018,21.765,13.099]
```

**Aggregating**

Some tools can take arrays as an input and combine (or "aggregate") the data in the array elements and treat it as a single input (see below for an example). These tools are called "aggregating tools"; see *Aggregating Tools* below for a list of the aggregating tools. In order for a tool to aggregate an array input, its **Enable Batching** parameter must be disabled. Otherwise, it will process the array elements individually. Note that aggregating tools also take non-array input (such as a single scan of Profile or Surface data), and simply process the data as usual.

Some aggregating tools are limited to a maximum of a 2-element array in their input. Other tools can accept an arbitrary number. See *Aggregating Tools* below to determine the limits of a tool. Note that when a tool is in *batching* mode, there is no limit to the number of elements in the input array (other than any CPU limitations), regardless of the array size limitations when the tools is aggregating data.

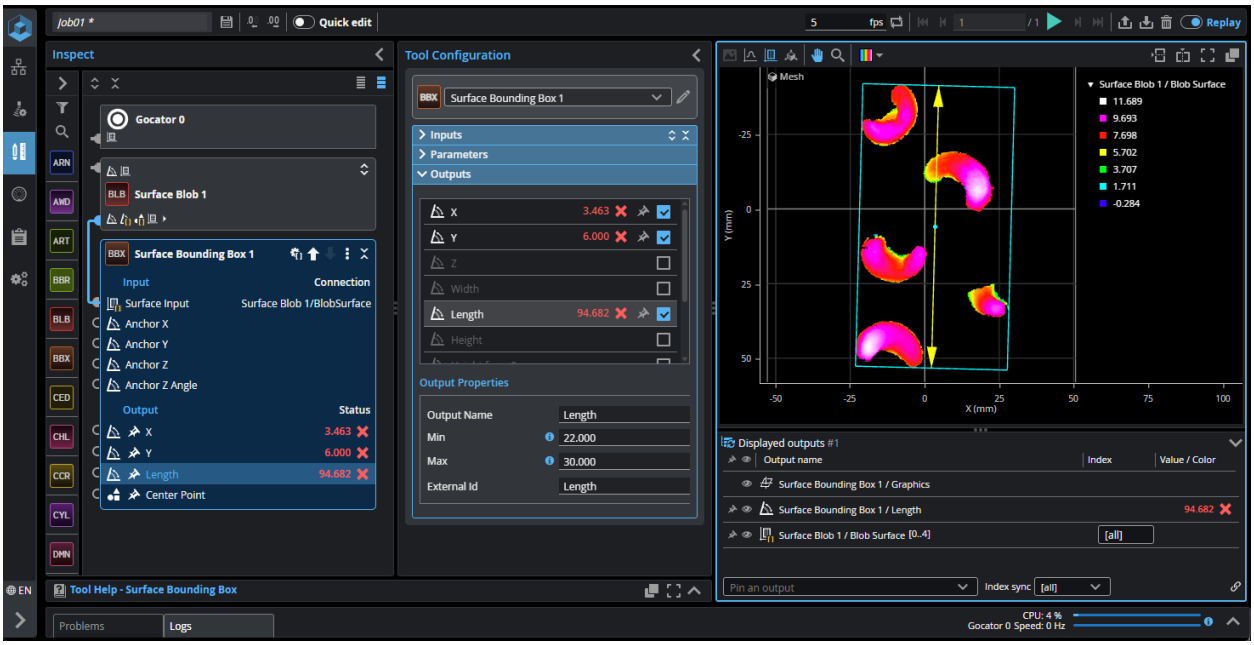
Remember to uncheck **Enable Batching** if you want a tool to aggregate array inputs.

*Aggregating Tools*

| | Number of array elements supported for aggregation | |
|---|---|---|
| **Tool** | **2 elements maximum** | **arbitrary (2 or more elements)** |
| Profile Circle Radii | | ✓ |
| Profile Closed Area | | ✓ |
| Profile Bounding Box | | ✓ |
| Profile Bridge Value | | ✓ |
| Profile Circle | | ✓ |
| Profile Dimension | ✓ | |
| Profile Ellipse | | ✓ |
| Profile Groove | ✓ | |
| Profile Intersect | ✓ | |
| Profile Line | | ✓ |
| Profile Line Intersect | | ✓ |
| Profile Panel | ✓ | |
| Profile Position | ✓ | |
| Profile Round Corner | ✓ | |
| Profile Strip | | ✓ |
| Surface Bounding Box | | ✓ |

| | Number of array elements supported for aggregation |
|---|---|
| Surface Dimension | ✓ |
| Surface Ellipse | ✓ |
| Surface Flatness | ✓ |
| Surface Plane | ✓ |
| Surface Position | ✓ |
| Surface Section | ✓ |
| Surface Sphere | ✓ |
| Surface Stick | ✓ |

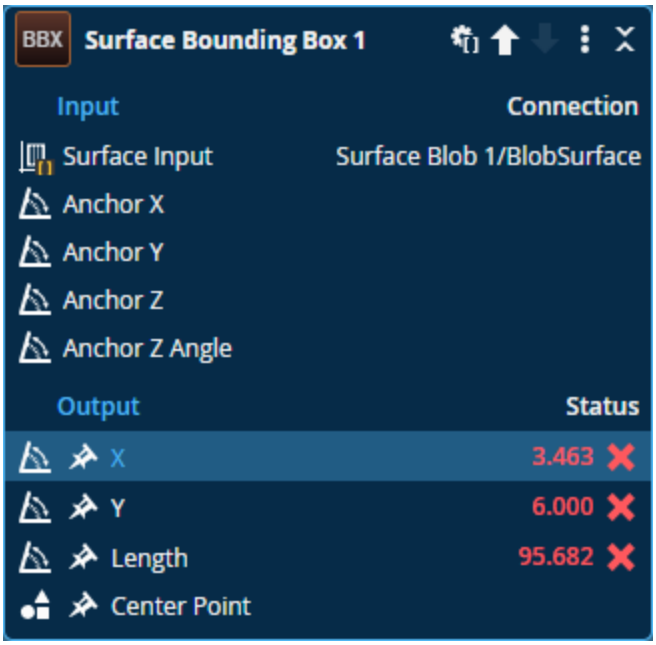
Taking the example from above, if batching in the Surface Bounding Box tool is disabled, it will aggregate the scan data in the input array, and fit the bounding around the scan data of all the elements together.



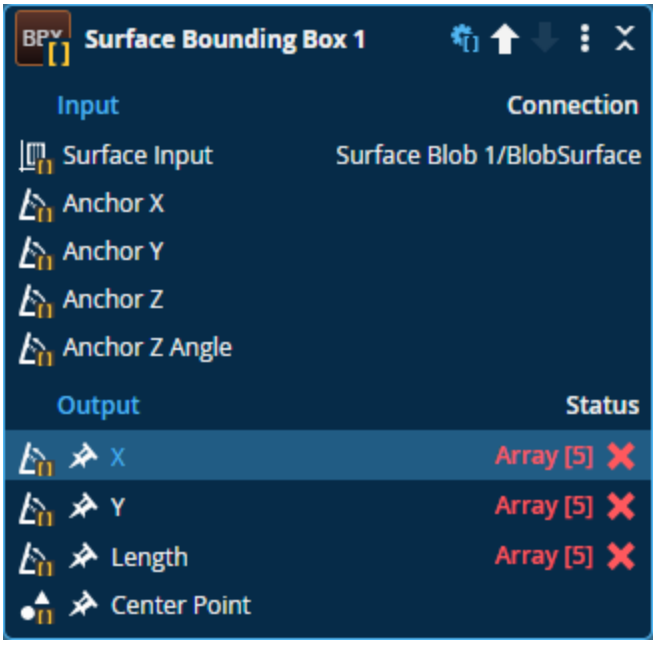

### Batch and Array Indicators in GoPxL

GoPxL communicates information related to batching and arrays by adding a "square bracket" badge ("[ ]") to input, output, and tool icons in the web interface.

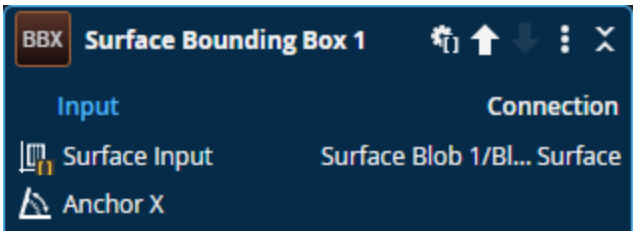
In the Tool Diagram panel, for tools that support batching, a Batching icon ( ) is displayed at the top of the tool block. Use this to toggle batching for that tool. If the tool is not currently selected (that is, you have clicked on it), indicated by a blue border, you must hover the mouse pointer over the top area of the tool block to see whether it supports batching.




When you enable batching on a tool, the Batching toggle icon turns blue, and GoPxL places yellow batching badges on various elements in the web interface. Below, the tool is in batching mode, and its inputs and outputs are therefore all arrays.




For tools that can take array inputs when batching is not enabled, the scan data input (Surface Input) shows a batching badge. Tools like this aggregate array inputs in this state; for more information, see *Aggregating* on page 178.



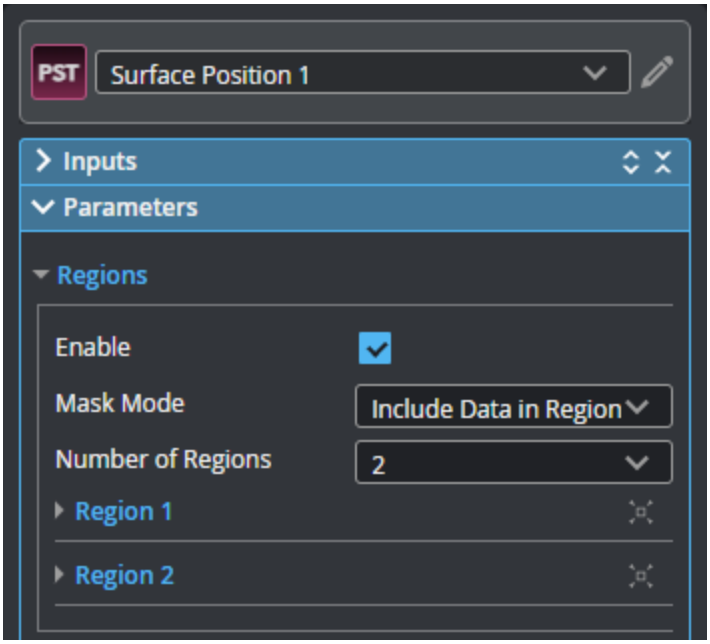

## Regions

Most measurement tools use user-defined regions, or regions of interest, to limit the area in which measurements occur. Unlike reducing the active area, reducing the region of interest does not increase the maximum frame rate of the sensor.

You can use Ctrl-Z and Ctrl-Shift-Z to undo and redo changes to the last changed region's size and position.

When the data viewer is in Surface / Top or Profile / Front mode (not in Perspective mode), you can quickly center all of a tool's regions in the data viewer and reset them to their default size by clicking the "Center tool regions" button ( ) above the data viewer; this is useful if you have zoomed in or out a lot.

You can also center and resize a specific region by clicking its "Center tool region" button in the tool's **Parameters** section, next to the region expander; this also only works .



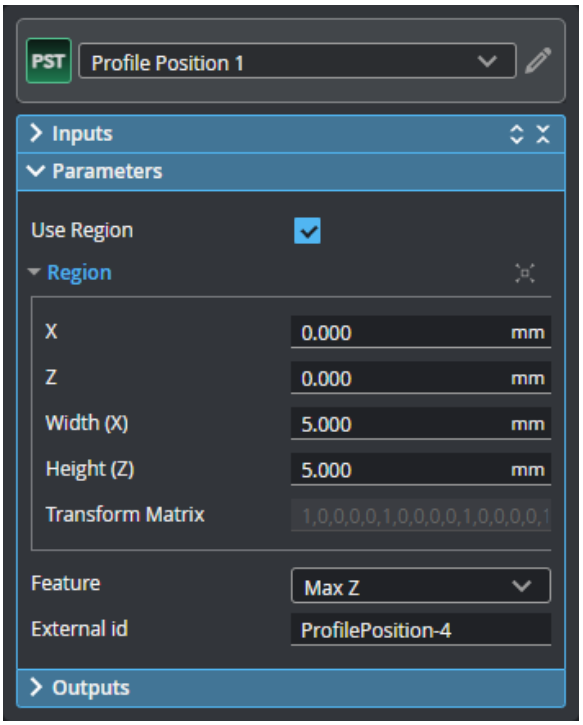

When a tool has multiple regions, the regions are resized and arranged in a row in the center of the data viewer.

Some tools provide "flexible" regions, which in addition to rectangular regions let you create circular and elliptical regions (which can optionally be annular). Some tools also let you use Surface and Surface Intensity data as masks. For information on setting flexible regions, see *Flexible Regions* on the next page.

Other tools are currently limited to standard, rectangular regions.

**Standard Regions**

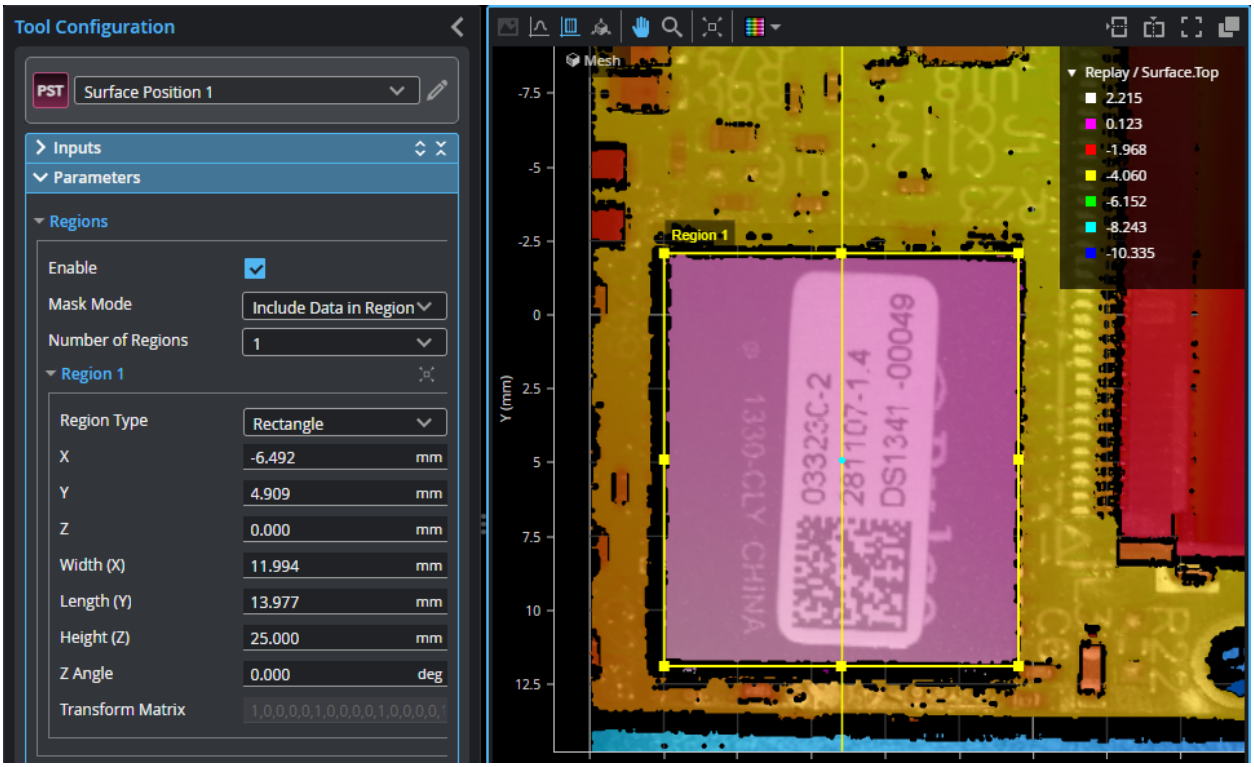
Some tools provide regions limited to boxes/rectangles.




The **Transform Matrix** setting is not currently used.

### Flexible Regions

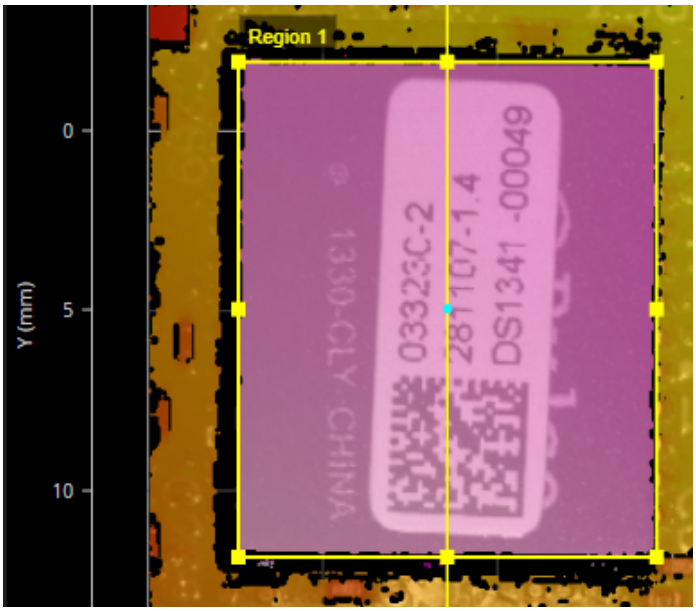
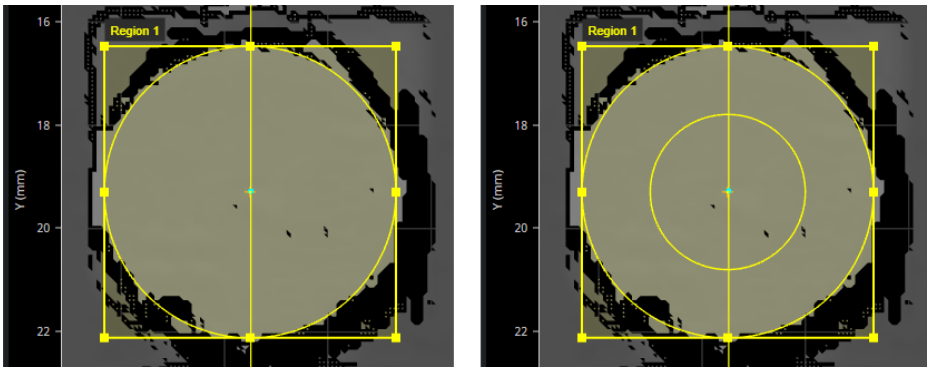
Many tools provide "flexible" regions, which let you choose region types such as circle and ellipse, in addition to rectangle regions. For a complete list and information on the related settings, see *Flexible Region Parameters* below.

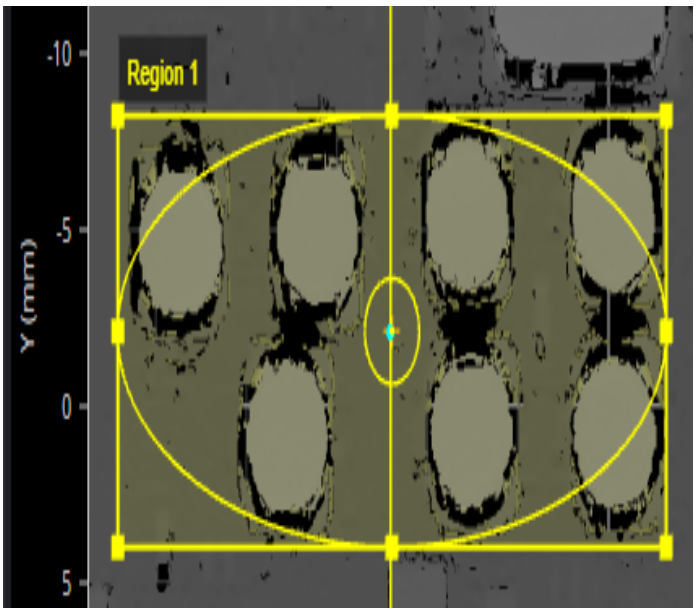


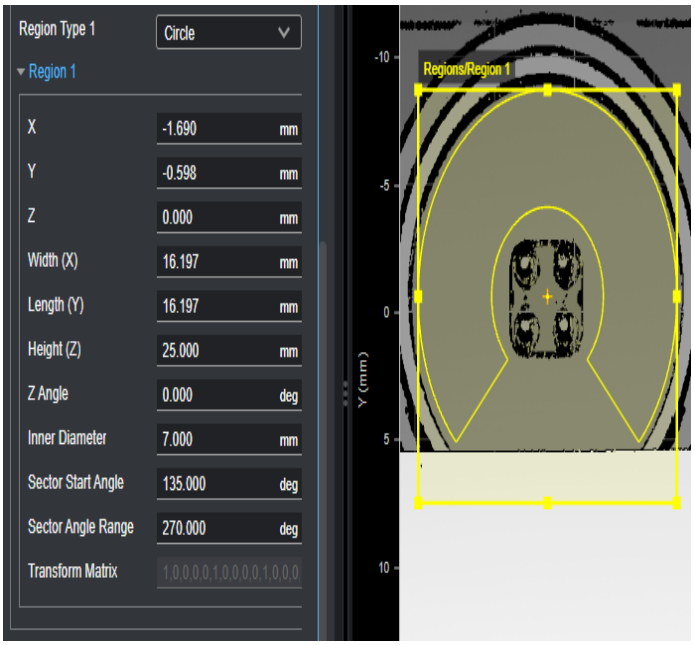

The following parameters are available in tools that support flexible regions.

*Flexible Region Parameters*

| Parameter | Description |
|---|---|
| Mask Mode | One of the following:<br>**Include Data in Region**: The tool uses only the data inside the region or regions.<br>**Exclude Data in Region**: The tool ignores the data inside the region or regions, using only the data outside. |
| Number of Regions | The number of regions or masks the tool uses to extract data. You can define up to 64 regions. This parameter is not available in some tools. To set a number of regions greater than 16, choose "Custom" in this parameter and set **Custom Region Count**.<br>When you specify more than one region, the regions are initially stacked on top of one another, in the same location. |
| Custom Region Count | The number of regions (from 17 to 64) when **Number of Regions** is set to "Custom". |
| Region {n} | An expandable section containing region definitions for each region. |

| Parameter | Description |
| --- | --- |
| Region Type {n} | The type of each region. Regions can overlap.<br>(For more information on the settings you use with the Circle and Ellipse types, see *Working with Circular and Elliptical Regions* on page 186.)<br><br>One of the following:<br><br>**Rectangle**<br>Extracts a rectangular region from the acquired data.<br>  <br><br><br>**Circle**<br>Extracts a circular region from the acquired data, constrained by a square region.<br>Set the region's inner circle using the **Inner Diameter** parameter to 0 to extract circular data. Set it to a non-zero to extract annular data.<br>  <br><br><br>Use the **Sector Start Angle** and **Sector Angle Range** parameters to extract a |

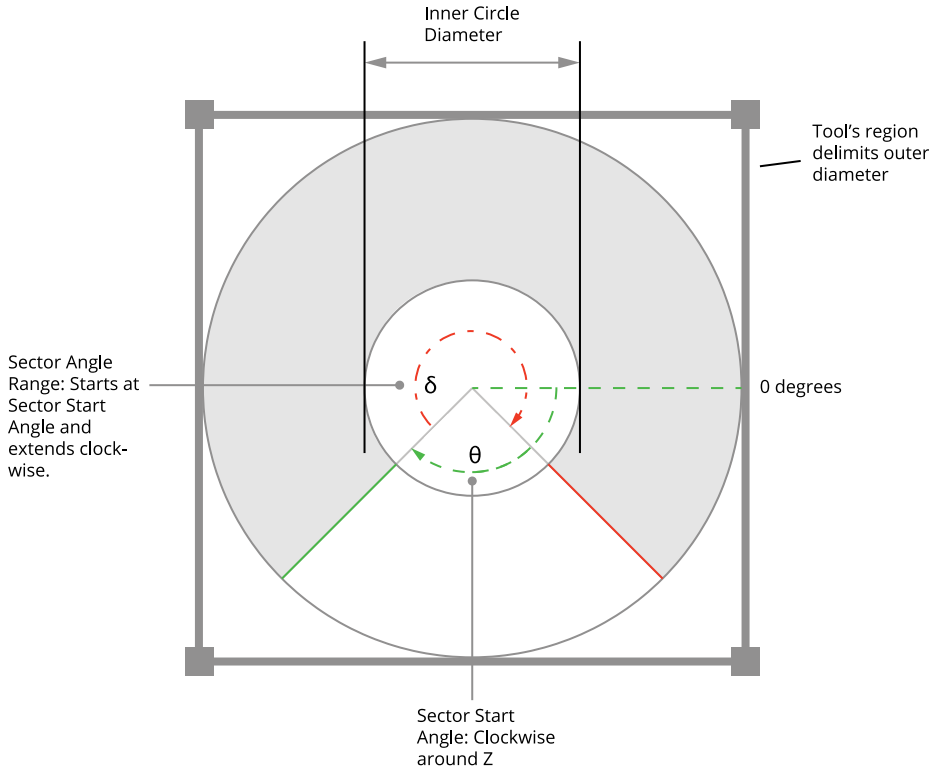
| Parameter | Description |
| --- | --- |
| | partial circular or elliptical region. (See below.)<br><br>**Ellipse**<br>Extracts an elliptical region from the acquired data, constrained by a square or rectangular region.<br>Set the region's inner ellipse (inner cyan ellipse below) using the **Inner Major Axis** and **Inner Minor Axis** parameters to extract annular data.<br>  <br><br>Use the **Sector Start Angle** and **Sector Angle Range** settings to extract a partial circular or elliptical region. (See below.)<br><br>**Surface**<br>Uses the Surface data you select in **Mask Source {n}**, in the **Inputs** panel, to create a mask.<br><br>**Surface Intensity**<br>Uses the intensity data you select in **Mask Source {n}**, in the **Inputs** panel, to create a mask.<br>Set the **Low Threshold** and **High Threshold** parameters as required. |
| X, Y, Z<br>Width (X), Length (Y), Height (Z)<br>Z Angle | These parameters define the size, location (center of the region), and orientation of the region. Not available when **Region Type {n}** is set to the following: **Surface** or **Surface Intensity**. |
| Inner Diameter | Only available when **Region Type {n}** is set to **Circle**.<br>Defines the diameter of the inner circle. |

| Parameter | Description |
|---|---|
| | Set this parameter to a value greater than 0 to extract a ring of data. Set this parameter to 0 to extract a circle of data. |
| Inner Major Axis<br>Inner Minor Axis | Only available when **Region Type {n}** is set to **Ellipse**.<br>These parameters define the major and minor axes of the inner ellipse, respectively<br>Set this parameter to a value greater than 0 to extract a ring of data. Set this parameter to 0 to extract an elliptical disk of data. |
| Sector Start Angle<br>Sector Angle Range | Only available when **Region Type {n}** is set to **Circle** or **Ellipse**<br>Use these parameters together to extract a partial ring of data. **Sector Start Angle** controls the starting angle of the data, whereas **Sector Angle Range** controls the length of the arc.<br>Note that the angles and ranges in these parameters are measured clockwise around Z, where 0 degrees is along the positive X axis.<br>For example, in the first image below, **Sector Start Angle** is set to 135, and **Sector Angle Range** is set to 270. The resulting extracted partial ring (or annular data) is shown below that.<br>  <br>For more information on how these settings work together, see *Working with Circular and Elliptical Regions* below. |
| High Threshold<br>Low Threshold | The high and low thresholds the tool uses in combination with the intensity mask.<br>Only available when **Region Type {n}** is set to the following: **Surface Intensity**. |

### Working with Circular and Elliptical Regions

When you set a region's type to Circle or Ellipse, the tool displays several additional settings that work together to define the region. **Sector Start Angle** and **Sector Angle Range** work together to

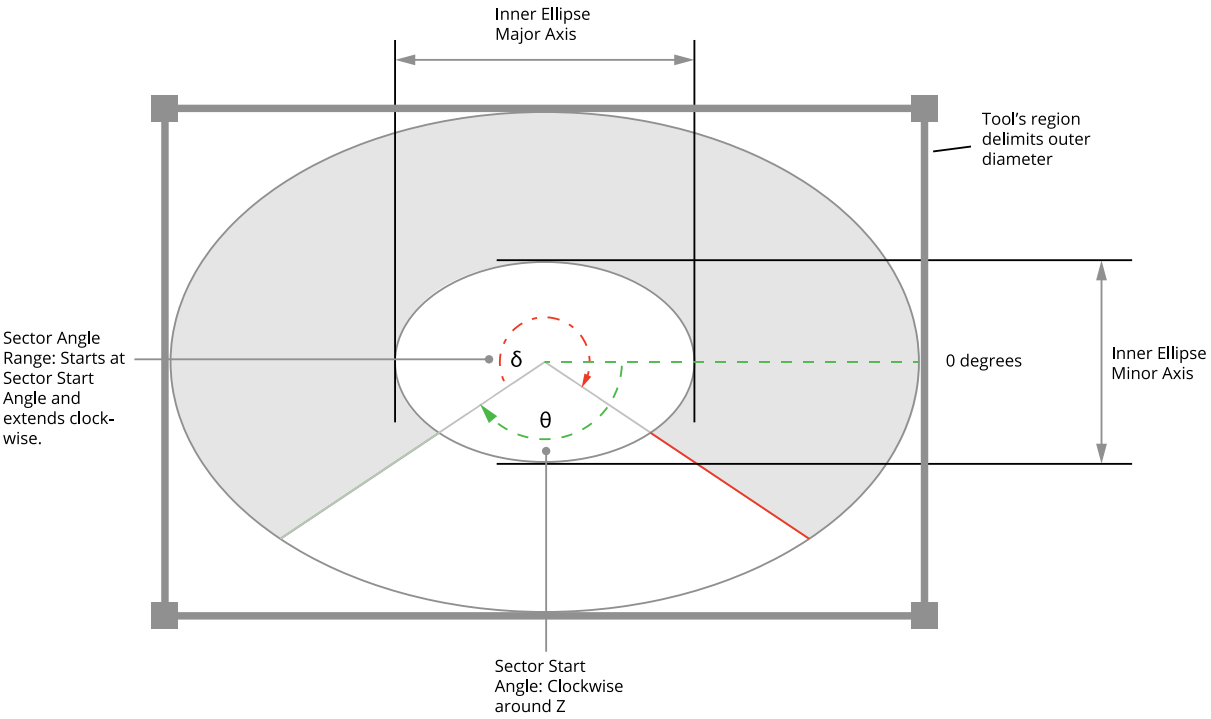
define the start and end of a partial circular/elliptical region (solid or annular). A region will be annular if **Inner Circle Diameter** is non-zero. Note that the "length" of the partial region extends *from* the start angle. In the following illustration, the start angle (θ) is 135 degrees relative to the 0-degree point indicated below, and the region extends 270 degrees (δ) from that, clockwise around Z.




*Sector Start Angle starts at the 0-degree point around Z.*

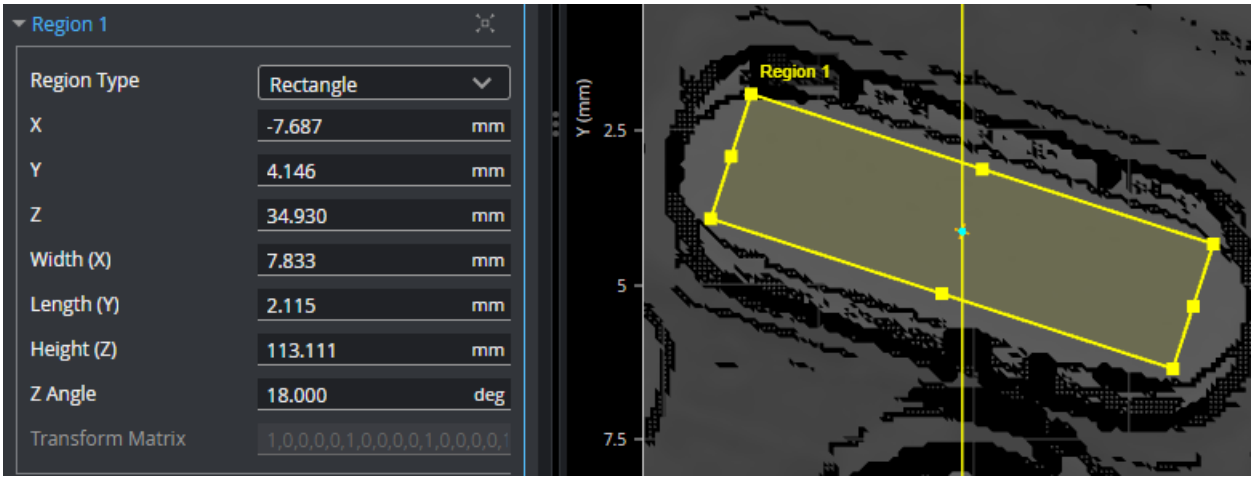
Note that the angles defining a partial circular/elliptical region are relative to the *region*, and not the sensor's coordinate system. So a region rotated 30 degrees using its **Z Angle** setting rotates the start angle and angle range by 30 degrees.

When you set a region type to Ellipse, instead of the inner circle diameter, you must set the major and minor axes of the inner ellipse.



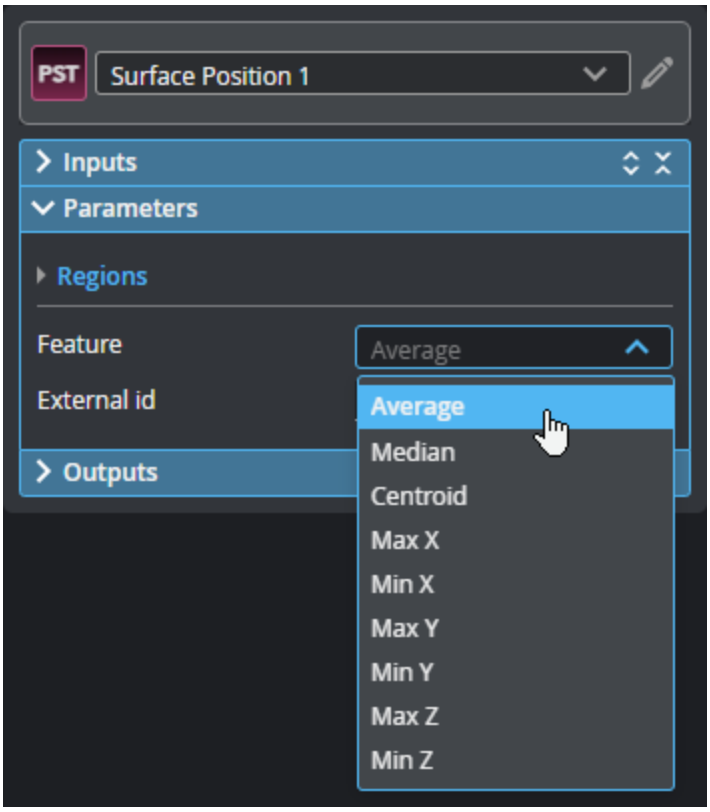

### Region Rotation

The measurement region of some tools can be rotated by setting the region's **Z Angle** (or **Angle** for some models) to better accommodate features that are on an angle on a target. By rotating the measurement region, data not related to the feature can often be excluded, improving accuracy of measurements. You can modify the size and position of a rotated region.




## Feature Points

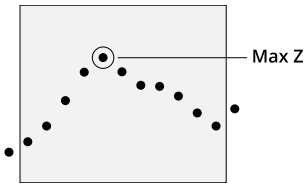
Dimensional and positional measurements detect *feature points* found within the defined region (whether it's a measurement region, feature region, reference region, and so on) and then compare measurement values taken at the selected point with minimum and maximum thresholds to produce a pass / fail decision. Feature points are selected in one or more **Feature** parameters in a tool's **Parameters** section, and are used for all of the tool's measurements.

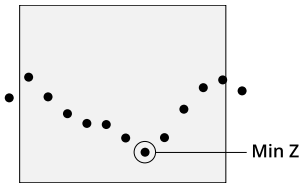
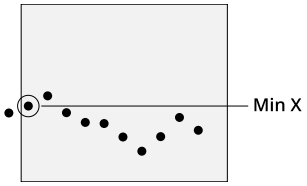
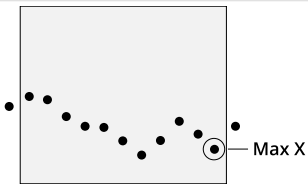
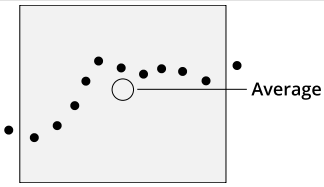
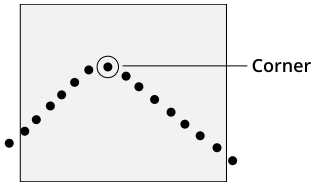
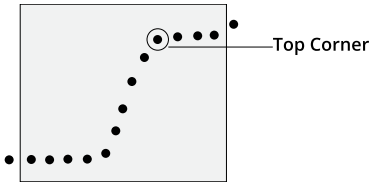
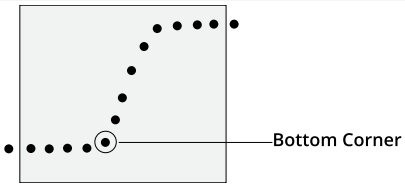


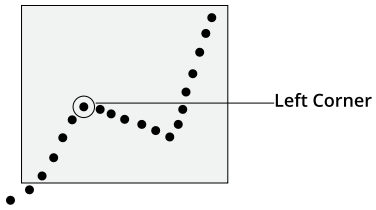
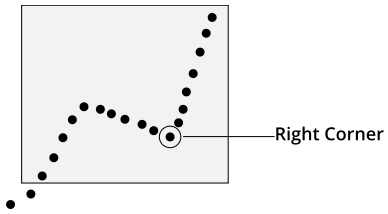
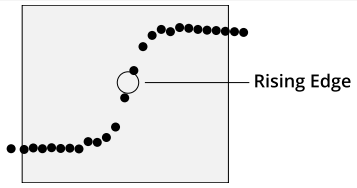
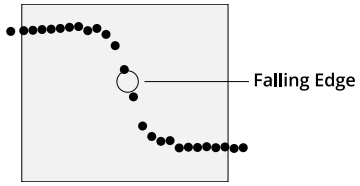
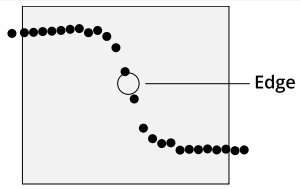
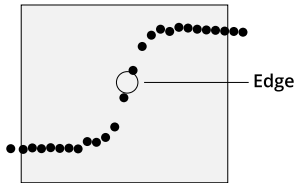
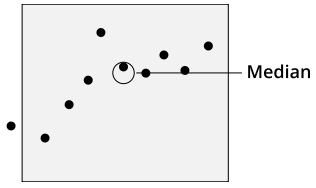

It is important to note that the feature points described here are distinct from the geometric features generated by some tools, and which can be taken as inputs by other tools. Feature points are simply the location in the data at which a measurement tool performs a measurement. So, for example, if you set a Profile Position tool's **Feature** parameter to Max Z, it will return the X and Z positions of the point that is at the highest Z value. Geometric features are a data type produced as output or taken as input by a tool. (For more information on geometric features, see *Geometric Features* on page 191.)

The following types of points can be identified in a measurement region. The availability of a feature point type is tool-dependent.

| | |
|---|---|
| | The following are represented as profiles for clarity. Many Surface tools use feature points. |

| Point Type | Examples |
|---|---|
| **Max Z**<br>Finds the point with the maximum Z value in the region of interest. |  |

| Point Type | Examples |
| --- | --- |
| **Min Z**<br>Finds the point with the minimum Z value in the region of interest. |  |
| **Min X**<br>Finds the point with the minimum X value in the region of interest. |  |
| **Max X**<br>Finds the point with the maximum X value in the region of interest. |  |
| **Average**<br>Determines the average location of points in the region of interest. |  |
| **Corner**<br>Finds a dominant corner in the region of interest, where corner is defined as a change in profile slope. |  |
| **Top Corner**<br>Finds the top-most corner in the region of interest, where corner is defined as a change in profile shape. |  |
| **Bottom Corner**<br>Finds the bottom-most corner in the region of interest, where corner is defined as a change in profile shape. |  |

| Point Type | Examples |
| --- | --- |
| **Left Corner**<br>Finds the left-most corner in the region of interest, where corner is defined as a change in profile shape. |  |
| **Right Corner**<br>Finds the right-most corner in the region of interest, where corner is defined as a change in profile shape. |  |
| **Rising Edge**<br>Finds a rising edge in the region of interest (moving from left to right). |  |
| **Falling Edge**<br>Finds a falling edge in the region of interest (moving from left to right). |  |
| **Any Edge**<br>Finds a rising or falling edge in the region of interest. |  <br>  |
| **Median**<br>Determines the median location of points in the region of interest. |  |

## Geometric Features

Most Surface tools, and many Profile tools, can output features that Feature tools can take as input to produce measurements. These features are called *geometric features*. Feature tools use these

entities to produce measurements based on more complex geometry. (For more information on Feature tools, see *Feature Measurement* on page 626.)

The measurement tools can currently generate the following kinds of geometric features:

**Points**: A 2D or 3D point (device dependent). Can be used for point-to-point or point-to-line measurements.

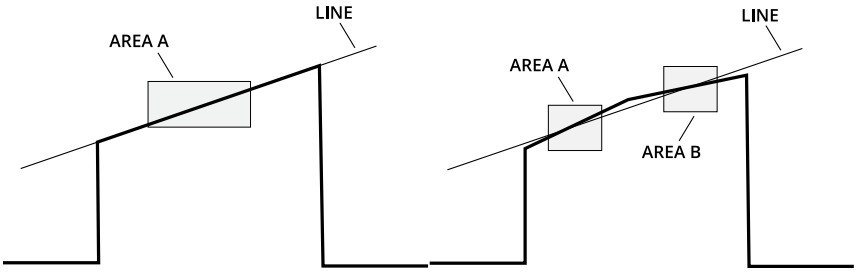
**Lines**: A straight line that is infinitely long. Useful for locating the orientation of an enclosure or part, or to intersect with another line to form a reference point that another tool can take as input.

**Planes**: A plane extracted from a surface. Can be used for point-to-plane distance or line-plane intersection measurements.

**Circles**: A circle extracted from a sphere.

## Fit Lines

Some measurements involve estimating lines in order to measure angles or intersection points. A fit line can be calculated using data from either one or two fit areas.

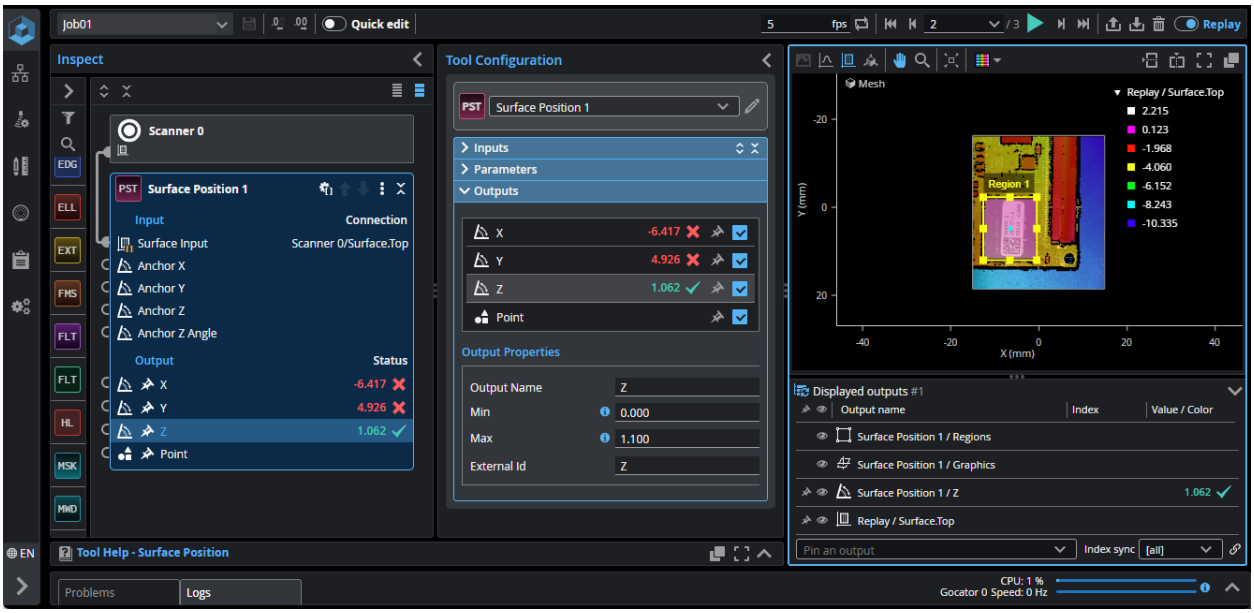



A line can be defined using one or two areas. Two areas can be used to bypass discontinuity in a line segment.

## Decisions

Results from a measurement can be compared against minimum and maximum thresholds you set in a tool's **Outputs** panel under **Output Properties** to generate *pass* / *fail* decisions. The decision state is *pass* if a measurement value is within the minimum / maximum range; the range is inclusive (a measurement value equal to a Min or Max threshold value is a pass). Output values that pass are green in the interface. Output values that fail are red in the interface.

Note that measurement values are output with six decimal places. However, you can configure the GoPxL interface to hide some decimal places, using the "Decrease precision" and "Increase precision" buttons ( and , respectively), from zero to six decimal places. Keep this in mind when configuring thresholds.




*Decision maximum and minimum of Surface Position Z set in the **Tool Configuration** panel (center). Pass values for this measurement are displayed in green. Fail measurements are displayed in red.*

Decisions (and measurements) can be sent to external programs and devices. For more information on sending values and decisions as output, see *Communicate - PLC, Digital, GDP, HMI* on page 732.

## Measurement Anchoring

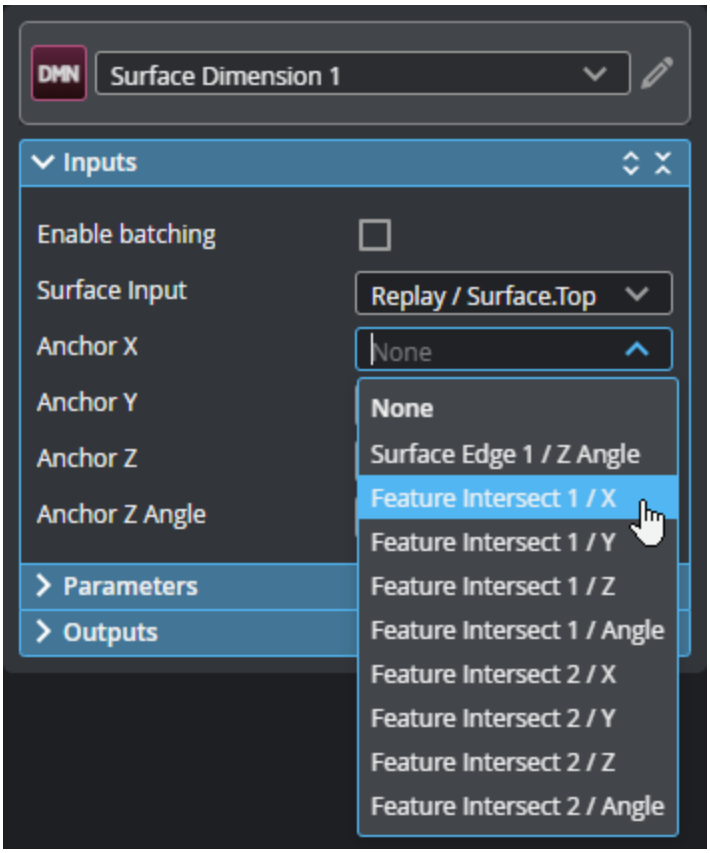
The position of parts moving on a transport mechanism such as a conveyor typically changes from part to part in one or both of the following ways:

- along the X, Y, and Z axes
- around the Z axis (orientation angle)

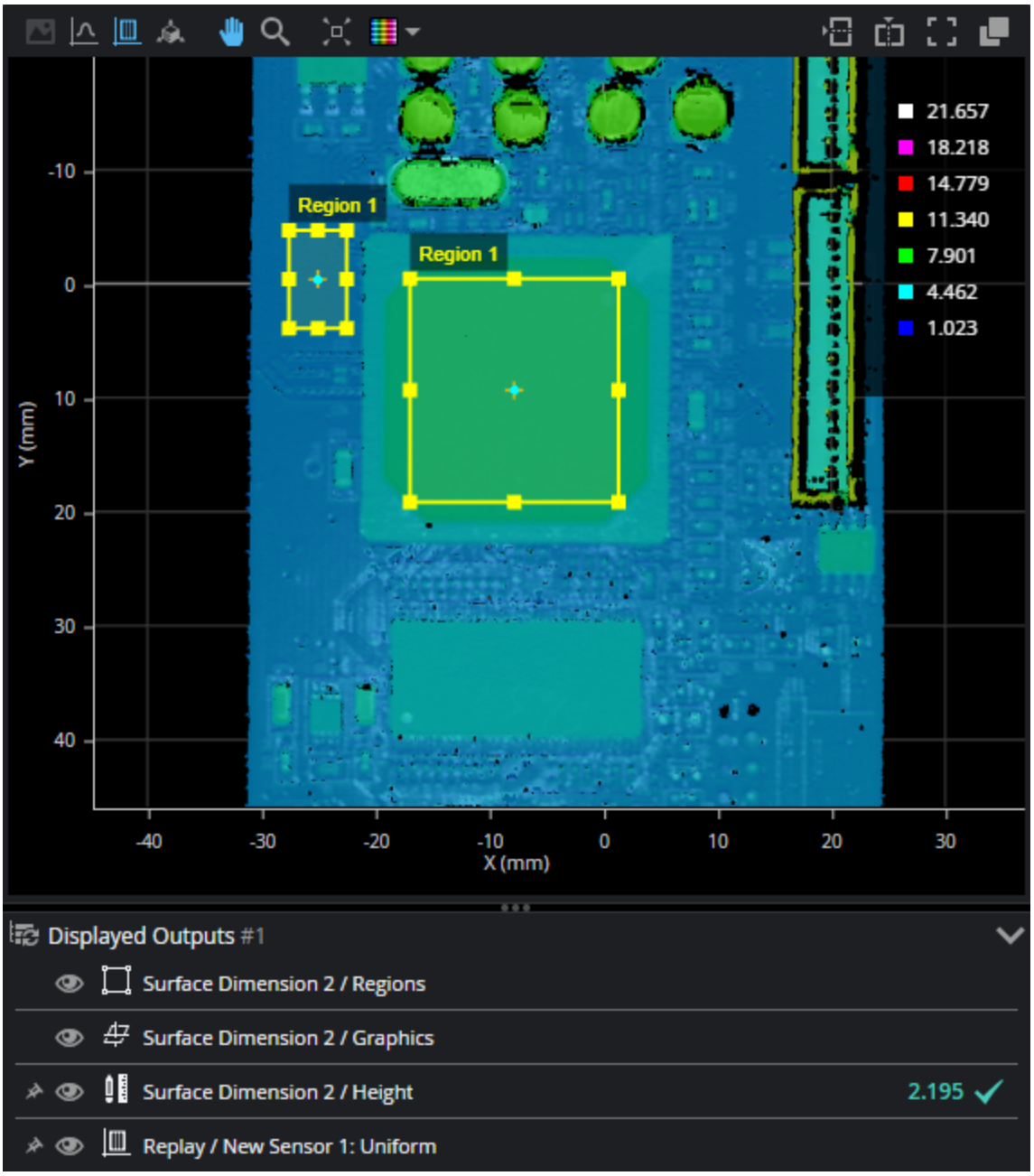
When the position and angle variation between parts is minor—for example, when scanning electronic parts in trays—you can anchor one tool to one or more measurements from one or more other tools to compensate for these minor shifts. As a result, GoPxL can correctly place the anchored tool's measurement regions on each part. This increases the repeatability and accuracy of measurements.

> For cases where movement from part to part is more drastic, you can often use the Surface Pattern Matching tool to compensate. For more information, see *Surface Pattern Matching* on page 533.

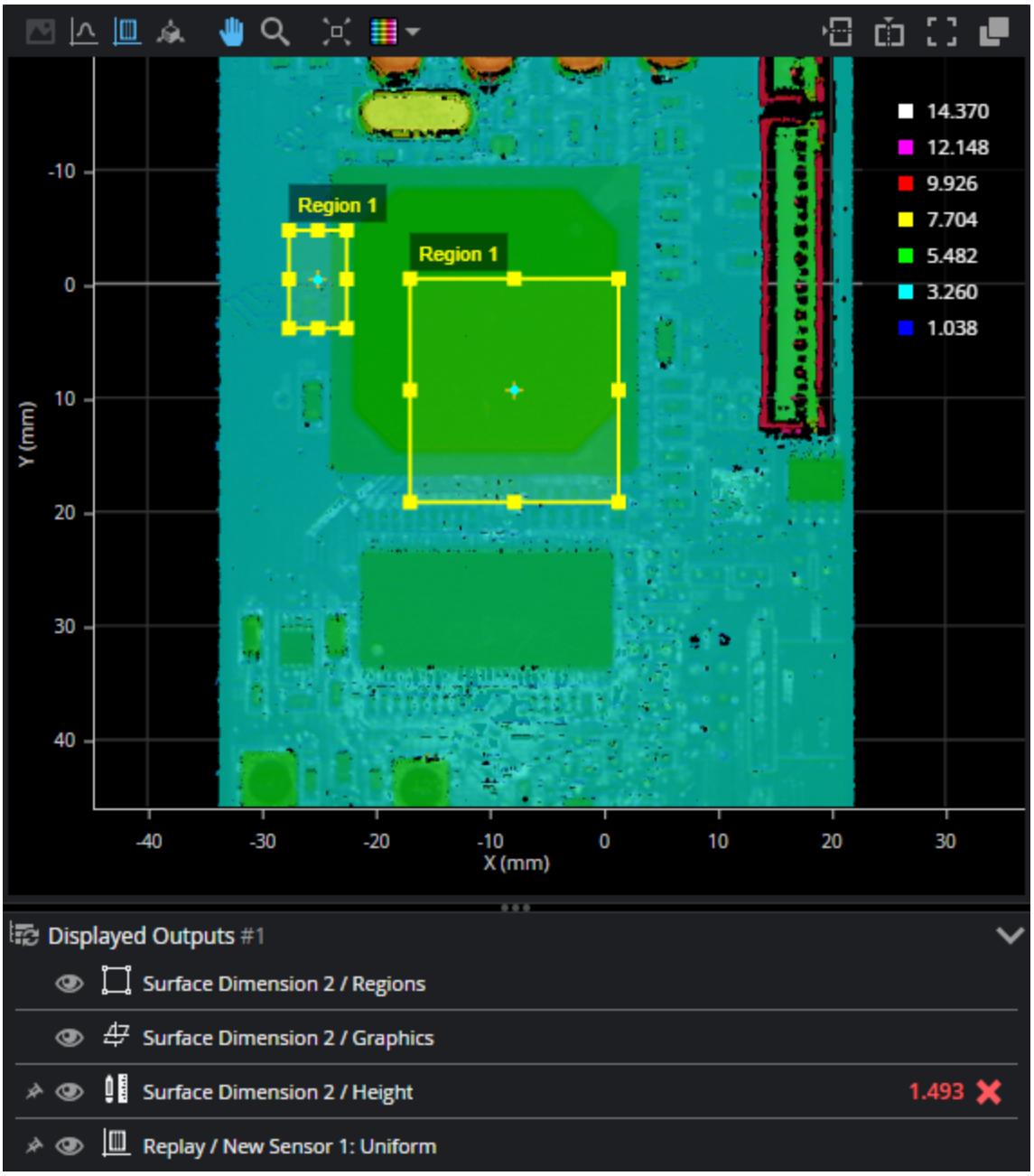
You set a tool's anchors in its **Inputs** section, by setting the desired anchor (such as **Anchor X** or **Anchor Y**) to the appropriate measurement from another tool:




For example, the following shows a surface scan of a PCB. A Surface Dimension height measurement returns the height of a component in the measurement region relative to a nearby reference region; the height is between the measurement's thresholds and is a pass (the green value in the **Displayed Outputs** pane).

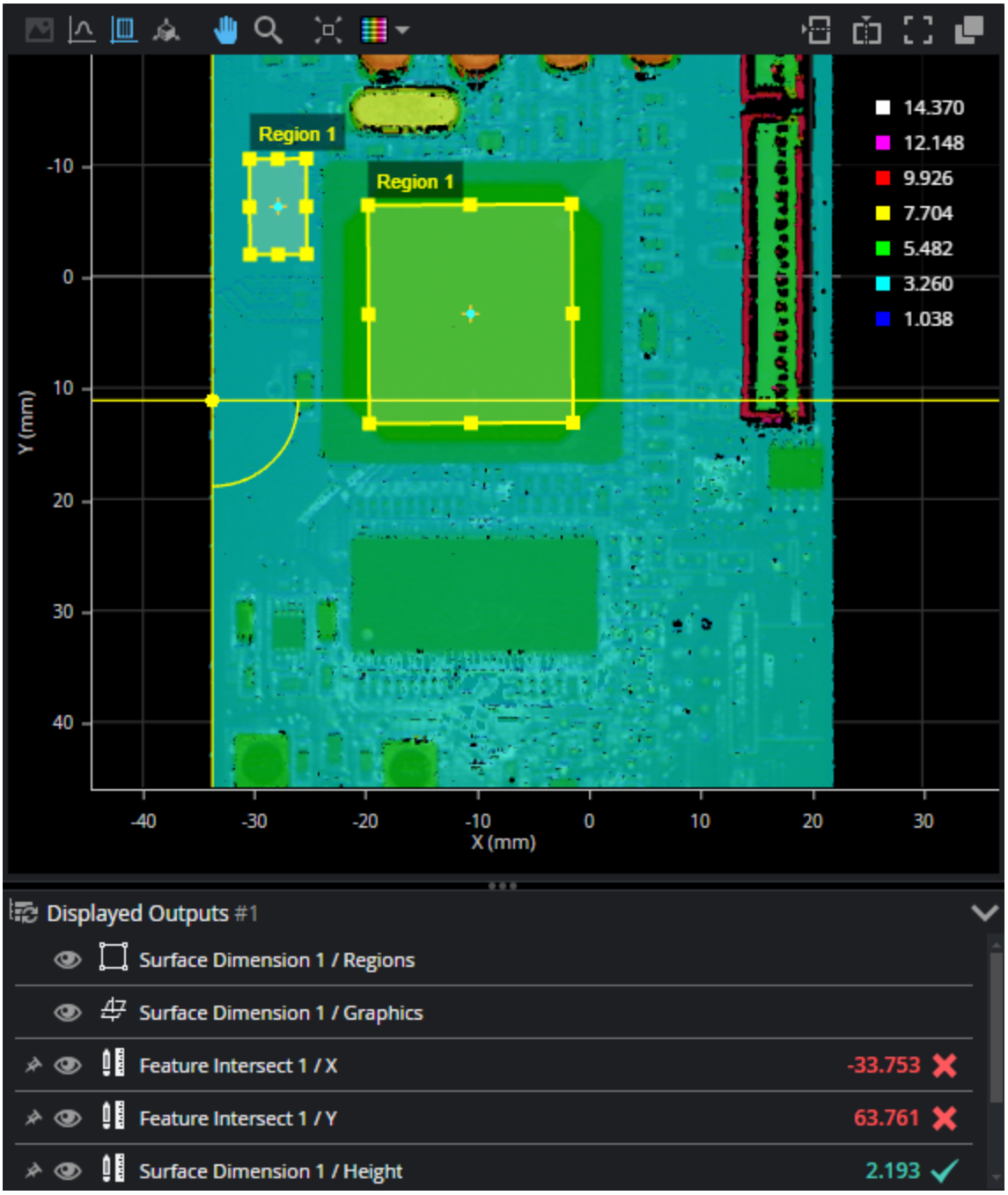



In the following scan, the part has shifted, but the measurement regions remain where they were originally configured, in relation to the sensor or system coordinate system, so the measurement returned is incorrect, and the measurement fails:



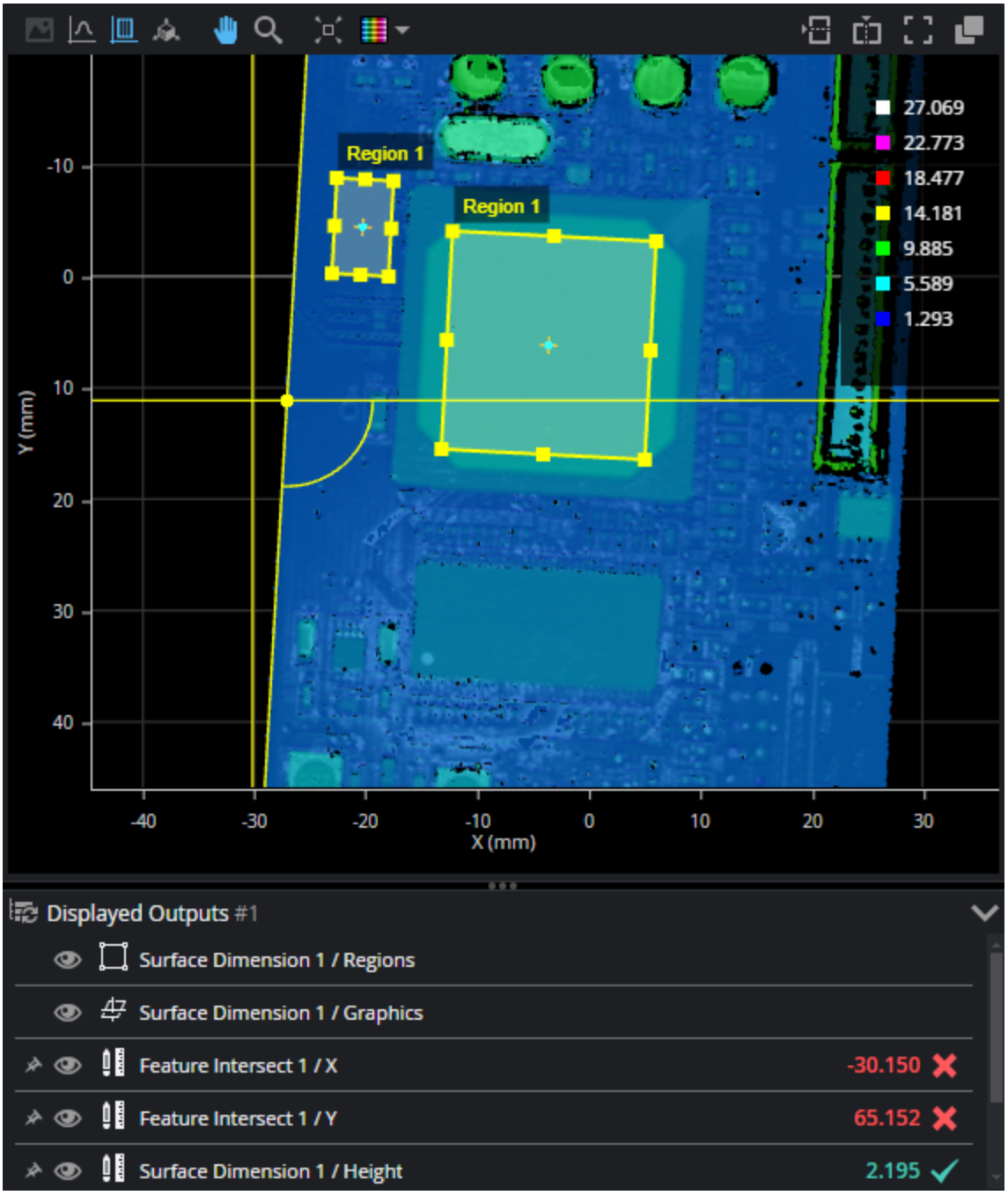

When you set any of a tool's anchor sources, an offset is calculated between the anchored tool and the anchor source. This offset is used for each frame of scanned data: the anchored tool's measurement region is placed in relation to the anchor source, at the calculated offset.

In the following image, after the Surface Dimension tool is anchored to the X and Y measurements from two Surface Edge tools (placed over the left and bottom edges of the PCB), GoPxL compensates for the shift—mostly along the X and the Y axis in this case—and returns a correct measurement, despite the shift.




You can combine the positional anchors with an angle anchor (such as a Z Angle measurement) for optimum measurement placement. For example, in the following scan, the part has not only shifted on the XY plane but also rotated around the Z axis. Anchoring the Surface Dimension tool to the Z

Angle measurement of a Surface Edge tool compensates for the rotation, and the anchored tool returns a correct measurement.




| | |
|---|---|
| | If angle anchoring is used with both X and Y anchoring, the X and Y anchors should come from the same tool. |

| | |
|---|---|
| | If angle anchoring is used without X or Y anchoring, the tool's measurement region rotates around its *center*. If only one of X or Y is used, the region is rotated around its center and then shifted by the X or Y offset. |

## Profile Measurement

This section describes the profile measurement tools available in Gocator sensors.

Profile measurement tools can be used on sections extracted from Surface data. For more information on sections, see *Surface Section* on page 562.

### Profile Advanced Height

The Advanced Height tool provides highly accurate and repeatable master (template) comparison and step height measurements (up to 16 in a tool instance).

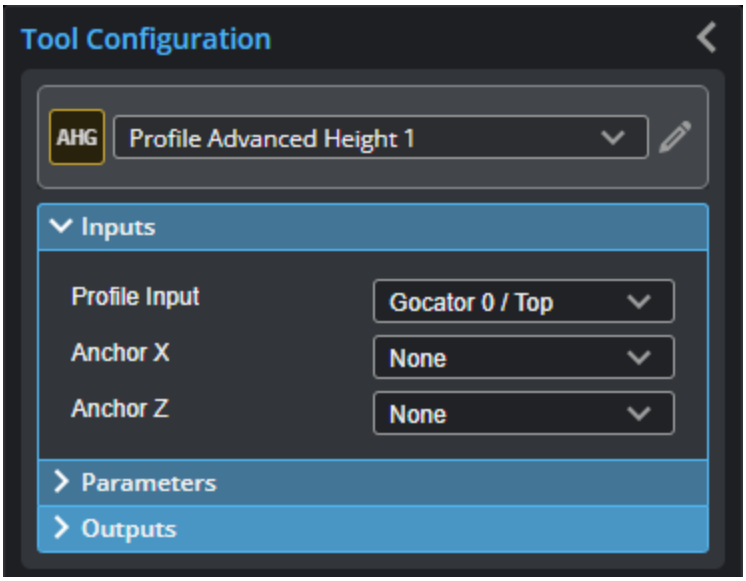
> All instances of the Advanced Height tool share the same template file set in **File**. For this reason, you must be careful when editing or removing template files shared by another instance of the tool.

Height measurements can be made relative to a reference line. Reference line sets the measurement direction (perpendicular to the reference line). A separate base line can also be set so that height measurements are between the base line and a profile feature, rather than the reference line (which in this case is used for angle correction).

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

#### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



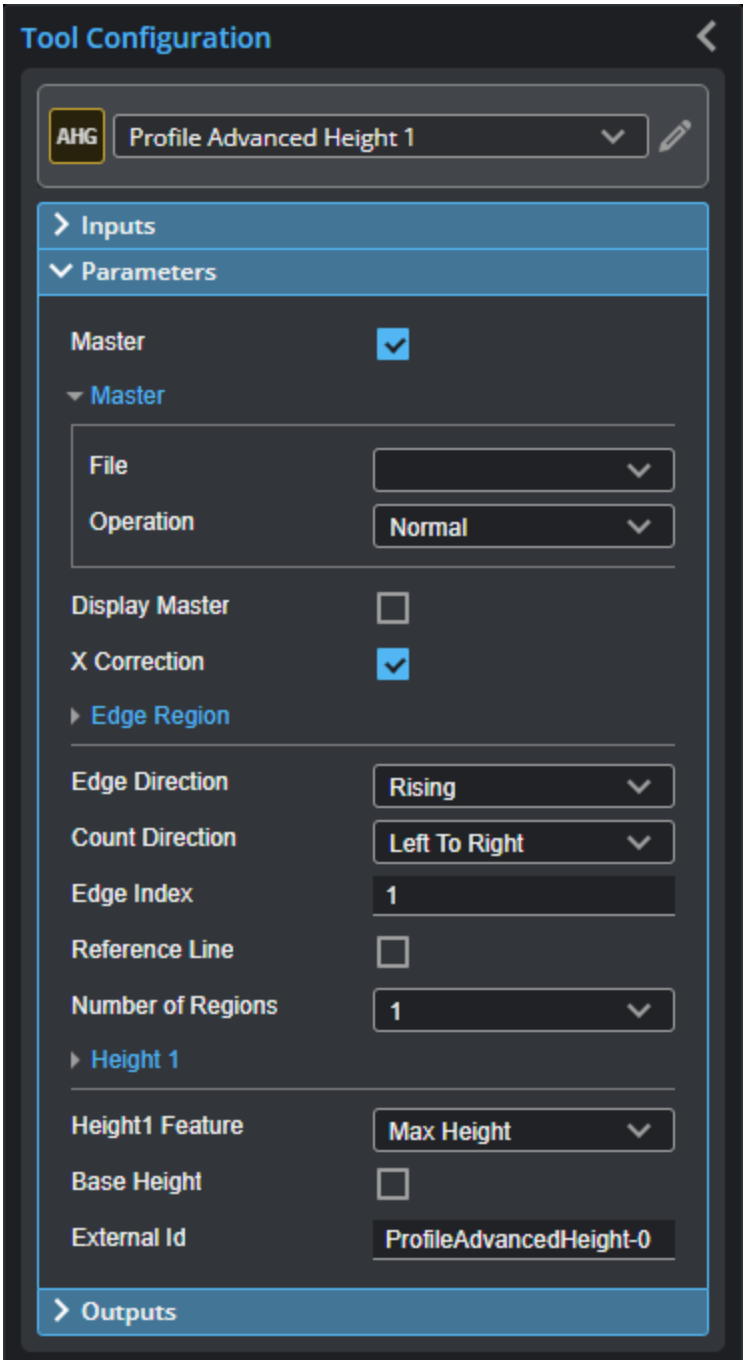

> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

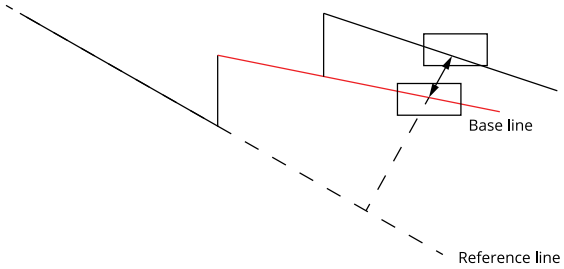
| Name | Description |
|---|---|
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



*Parameters*

| Parameter | Description |
|---|---|
| Master | Toggles a set of settings related to master comparison. For more information, see *Master Comparison* below. |
| Reference Line | Toggles a set of settings related to the reference line. For more information, see *Reference Line* on the next page. |
| Number of Regions | Sets the number of height region measurements the tool returns. For each height region, the tool displays a **Height {n}** section containing the region's position and size. The tool also displays a **Height{n} Feature** drop-down that lets you select the type of feature for that height region. |
| Base Height | Use base height to "set" the Z axis: when enabled, height values are offset from the base. This is useful if you need to measure between two features, rather than between a feature and the reference line.<br>  <br><br>When enabled, the tool displays settings related to the base height: size and position of the base height's region (**Base Height** section) and the base height's feature. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Master Comparison**

When you check the **Master** option, the tool displays several additional settings and disables measurement anchoring from other tools.

The **File** and **Operation** parameters are in an expandable **Master** section.

*Master Parameters*

| Parameter | Description |
|---|---|
| File | The file containing the master (template) profile, created by choosing **Save** from the **Operation** drop-down. |
| Operation | Contains operations related to the master file. One of the following:<br>• **Normal**: Selected by the tool after you perform another file operation.<br>• **Create**: Saves the *current profile* as the master. Use this when the master does not exist.<br>• **Load**: Loads the master file selected in **File**. |

| Parameter | Description |
|---|---|
| | • **Save**: Saves the current profile as the master. If the file already exists, the master is overwritten with the new data.<br>• **Delete**: Deletes the master file selected in **File**.<br>• **Refresh**: Refreshes the list of files in **File**. |
| Display Master | Overlays the master profile, in white, on the current profile. |
| X Correction | Enables settings related to X correction (left or right movement) of the profile compared to the master profile. Only displayed if **Master** is enabled. For more information, see *X Correction* below. |

**X Correction**

When you check the **Master** option and enable **X Correction**, the tool displays several additional settings.

*X Correction Parameters*

| Parameter | Description |
|---|---|
| Edge Region | Lets you set the edge region. You can also edit this region in the data viewer. |
| Edge Direction | Determines the direction of the edge. One of the following: **Falling** or **Rising**. |
| Count Direction | Indicates how edges are counted. One of the following: **Left to Right** or **Right to Left**. |
| Edge Index | Indicates which edge the tool uses. |

**Reference Line**

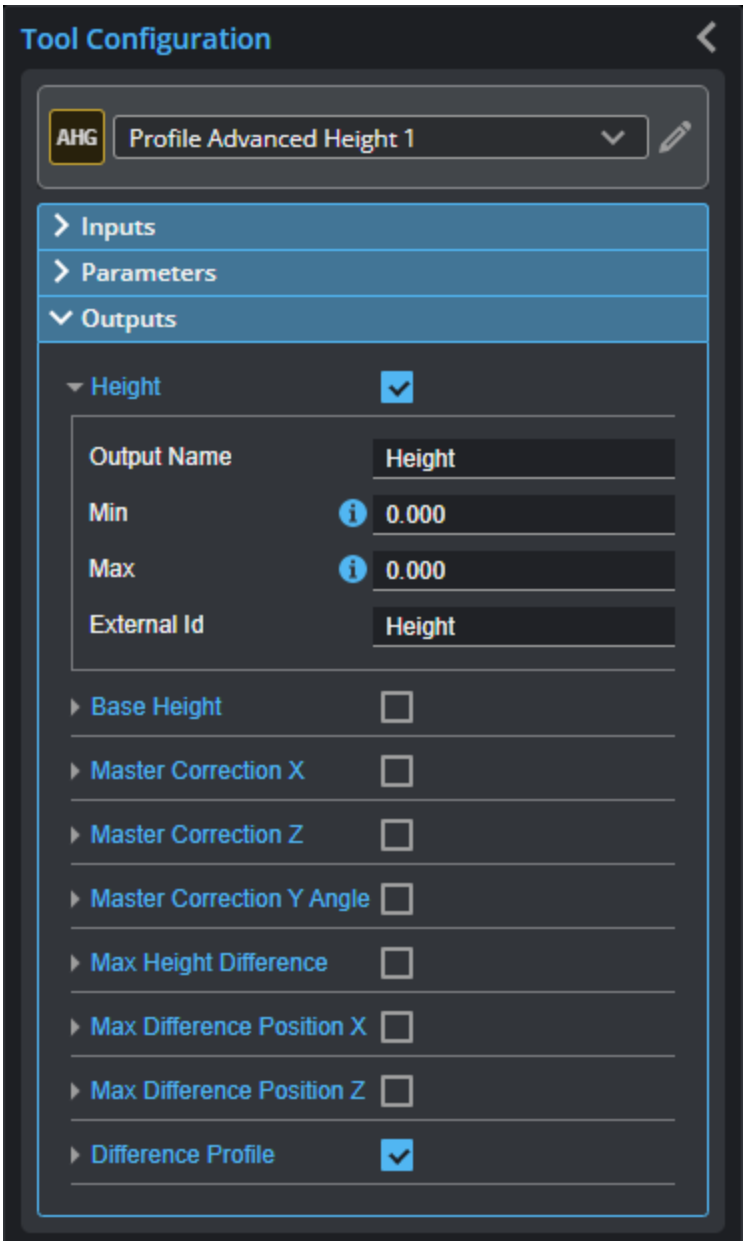
When you enable **Reference Line**, the tool displays several additional settings. The reference line is used to set the measurement direction (perpendicular to the reference line).

*Reference Line Parameters*

| Parameter | Description |
|---|---|
| Line Region | The number of line regions the tool uses. |
| Line {n} | Contains settings that let you edit the size and position of the line's region. You can also edit this region in the data viewer. |
| Fitting Method | Indicates the fitting method the tool uses. One of the following: **Simple** or **Robust**. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
| --- |
| **Height {n}**<br>The height measured in height region {n}. Height is measured perpendicular<br>Will be Invalid if the appropriate number of height regions has not been set in **Height Region**. |

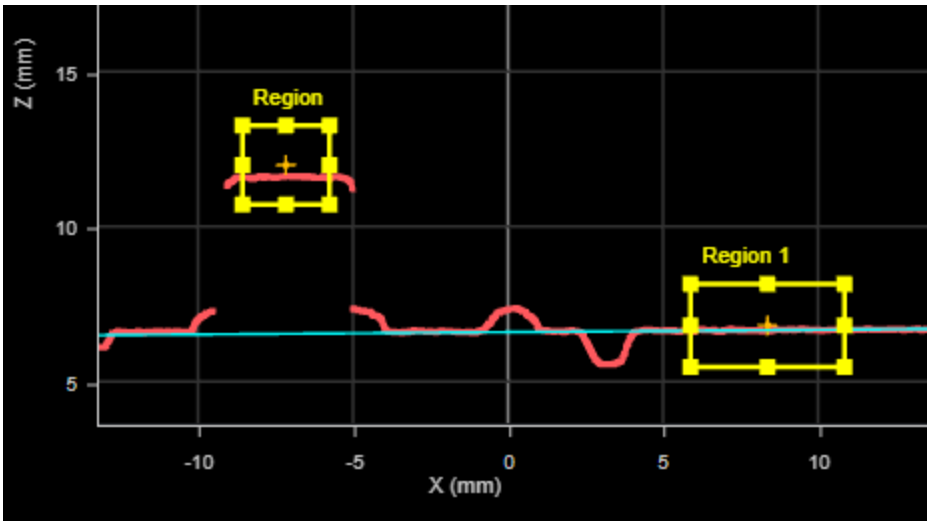
| Measurement |
| --- |
| **Master Correction X** |
| **Master Correction Z** |
| **Master Correction Y Angle** |
| The amount of correction applied to the profile with respect to the master. |
| **Max Height Difference** |
| The maximum height difference. |
| **Max Difference Position X** |
| **Max Difference Position Z** |
| The X and Z positions of the maximum height difference. |

*Data*

| Type | Description |
| --- | --- |
| Difference Profile | A profile representing the difference between the master and the current frame's profile, available for use as input in the **Stream** drop-down in other tools. |

## Profile Area

The Area tool determines the cross-sectional area within a region.

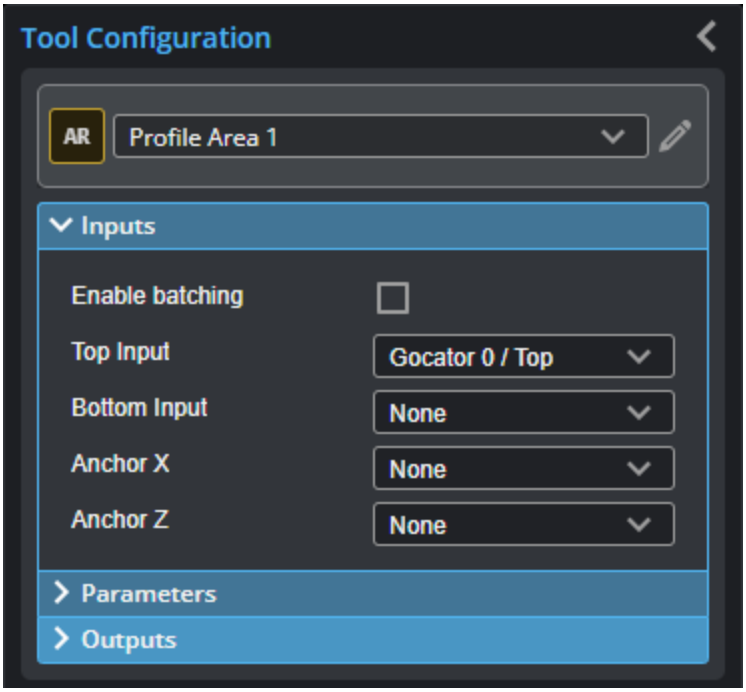



*Profile Area tool with baseline set to the best-fitted line in Region 1*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool

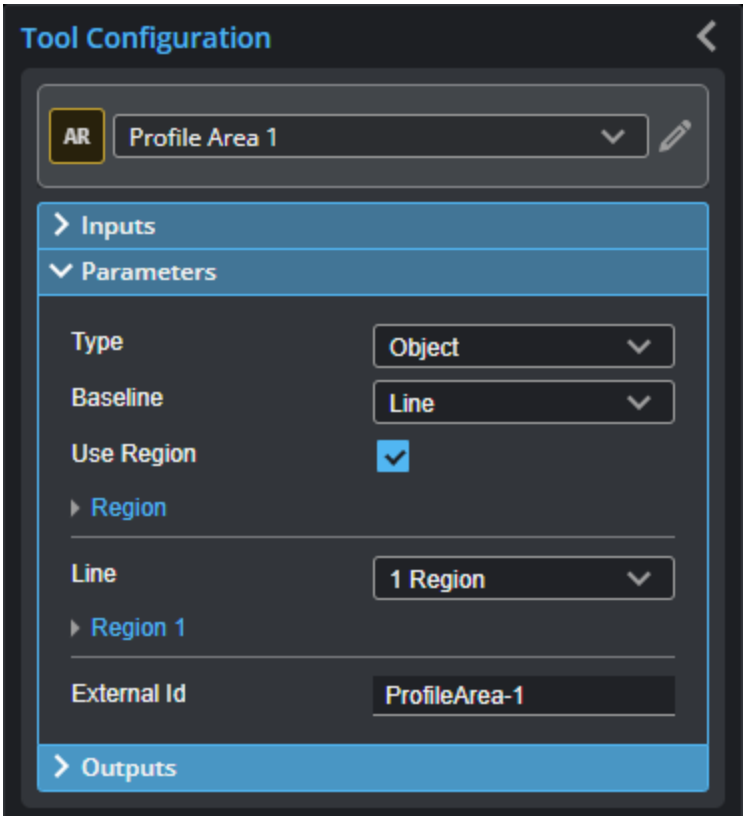
providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Top Input | The data the tool applies measurements to or processes. |
| Bottom Input | This tool can optionally take a second, bottom input. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



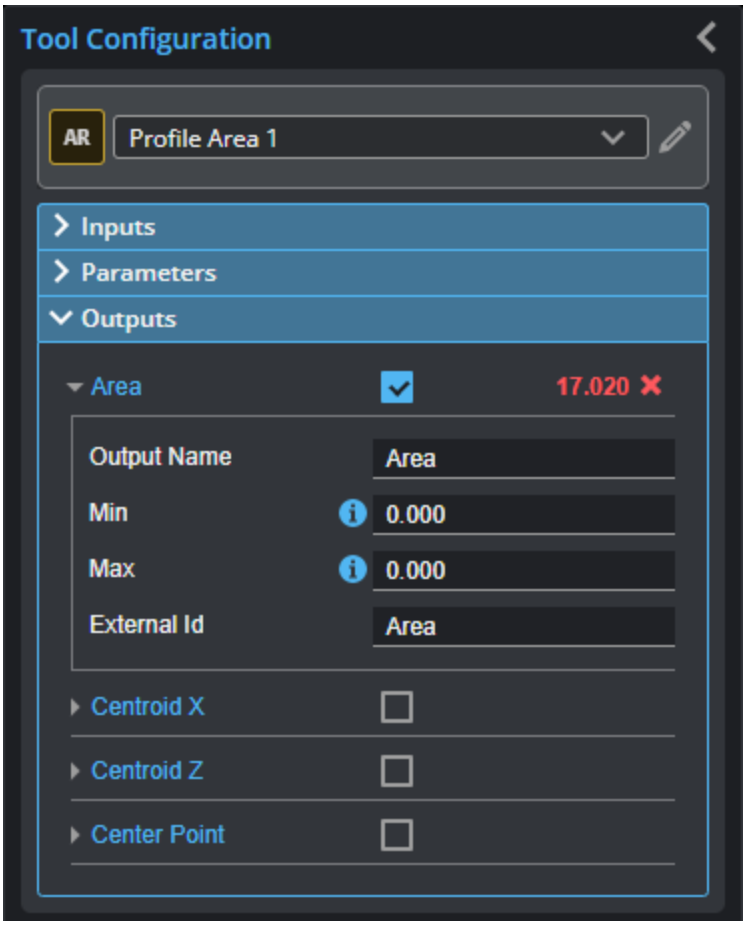

*Parameters*

| Parameter | Description |
|---|---|
| Type | **Object** area type is for convex shapes above the baseline. Regions below the |

| Parameter | Description |
|---|---|
| | baseline are ignored.<br>**Clearance** area type is for concave shapes below the baseline. Regions above the baseline are ignored. |
| Baseline | Baseline is the fit line that represents the line above which (Object clearance type) or below which (Clearance area type) the cross-sectional area is measured.<br>When this parameter is set to **Line**, you must define a line in the Line parameter. See *Fit Lines* on page 192 for more information on fit lines.<br>When this parameter is set to **X-Axis**, the baseline is set to z = 0. |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Line | When **Baseline** (see above) is set to **Line**, set this to one of the following:<br>**1 Region** or **2 Regions**: Lets you set one or two regions. The tool uses the data in those regions to fit a line.<br>**All Data**: The tool uses all of the data in the scan data.<br>For more information on regions, see *Regions* on page 181).<br>For more information on fit lines, see *Fit Lines* on page 192. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

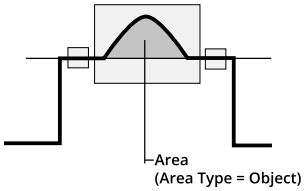
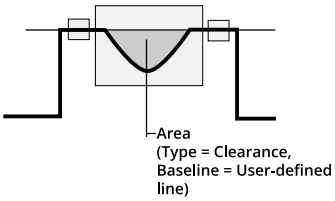
Most tools provide measurements, geometric features, or data as outputs.

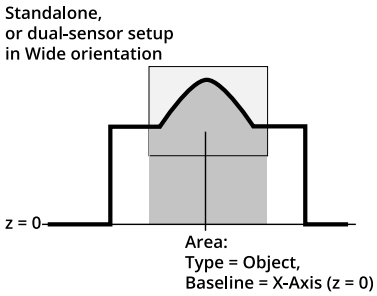
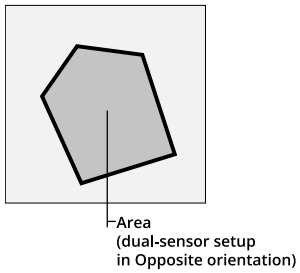
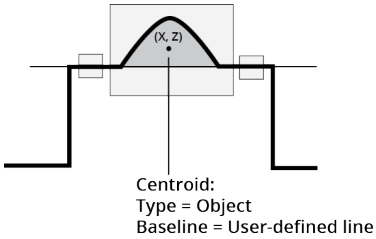



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Area**<br>Measures the cross-sectional area within a region that is above or below a fitted baseline. |  <br>  |

| Measurement | Illustration |
|---|---|
| |  <br>  |
| **Centroid X**<br>Determines the X position of the centroid of the area.<br><br>**Centroid Z**<br>Determines the Z position of the centroid of the area. |  |

*Features*

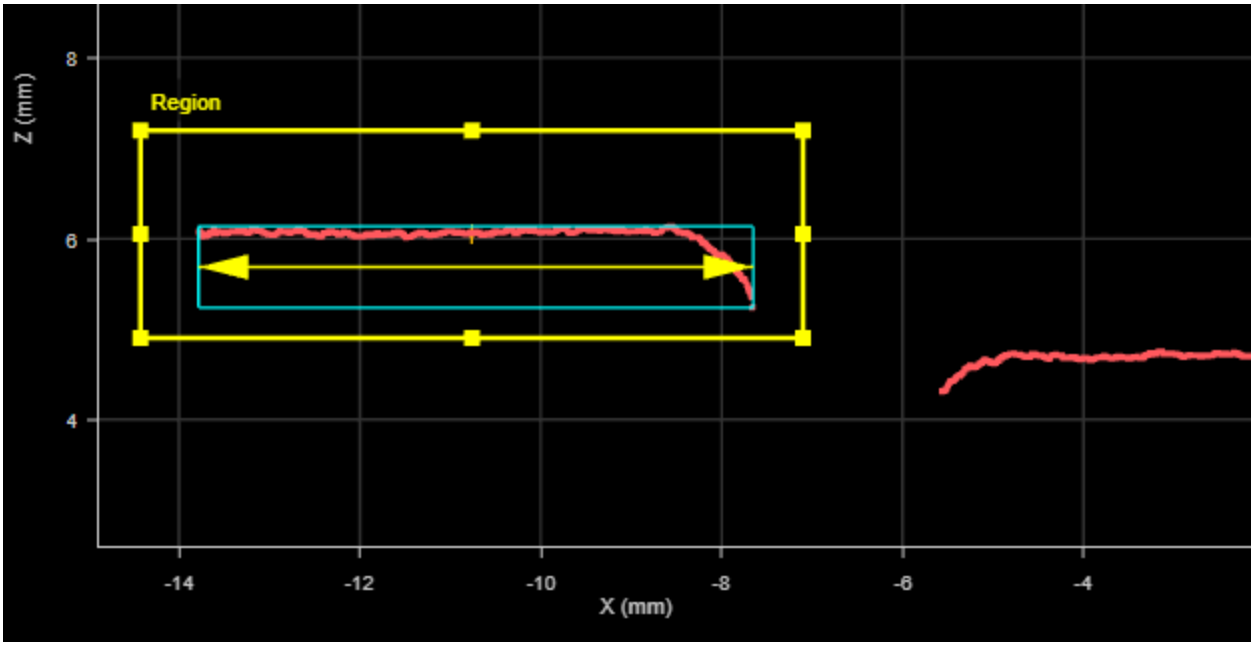
| Type | Description |
|---|---|
| Center Point | The center point of the area. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Bounding Box

The Bounding Box tool provides measurements related to the smallest box that contains the profile (for example, X position, Z position, width, etc.).

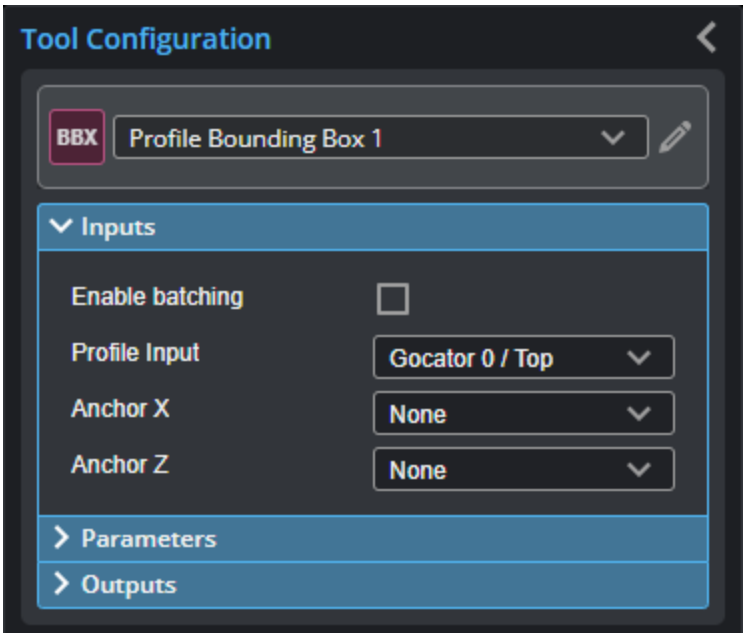
The bounding box provides the absolute position from which the Position centroids tools are referenced.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



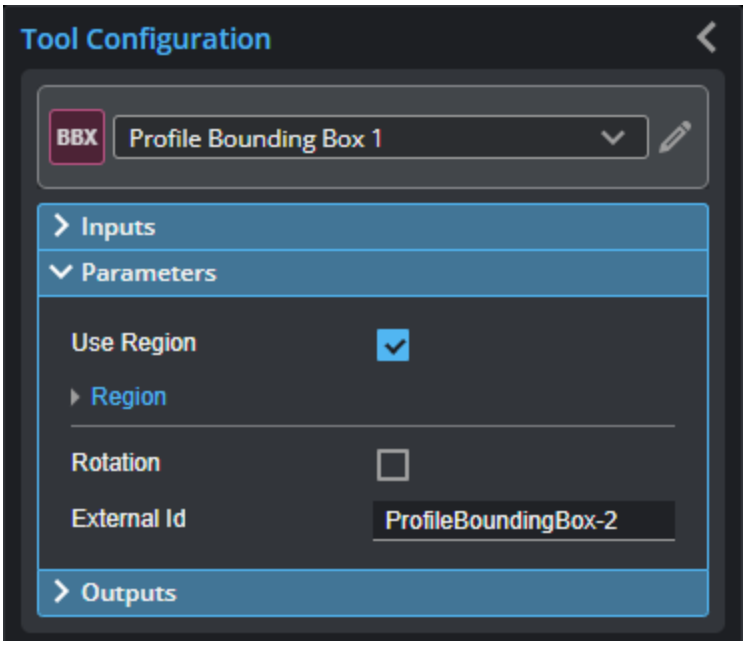

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

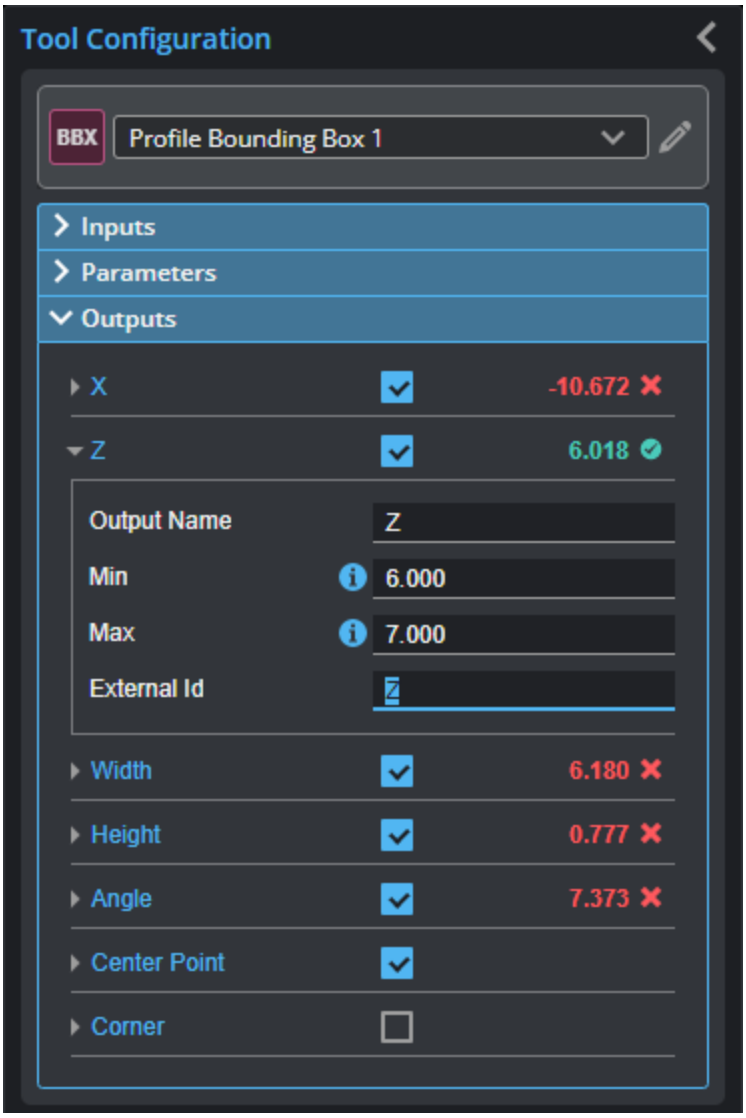



*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Rotation | A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the part's Position centroid measurements are referenced. When enabled, allows rotation of the bounding box.<br>Only displayed if **Use Region** is enabled. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

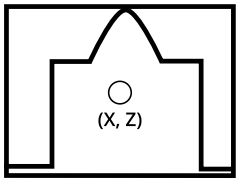
Most tools provide measurements, geometric features, or data as outputs.

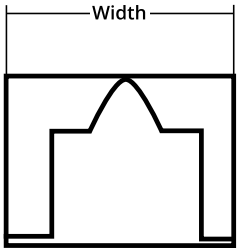
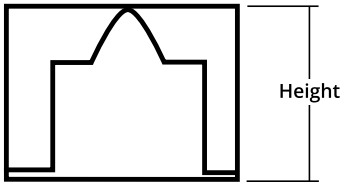



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the center of the bounding box that contains the profile.<br>The value returned is relative to the profile. |  |
| **Z**<br>Determines the Z position of the center of the bounding box that contains the profile. | |

| Measurement | Illustration |
|---|---|
| The value returned is relative to the profile. | |
| **Width**<br>Determines the width of the bounding box that contains the profile. The width reports the dimension of the box in the direction of the minor axis. |  |
| **Height**<br>Determines the height (thickness) of the bounding box that contains the profile. |  |
| **Angle**<br>Determines the angle of the longer side of the bounding box around the Y axis, relative to the X axis.<br>This measurement is only available if the **Rotation** parameter is enabled. | |

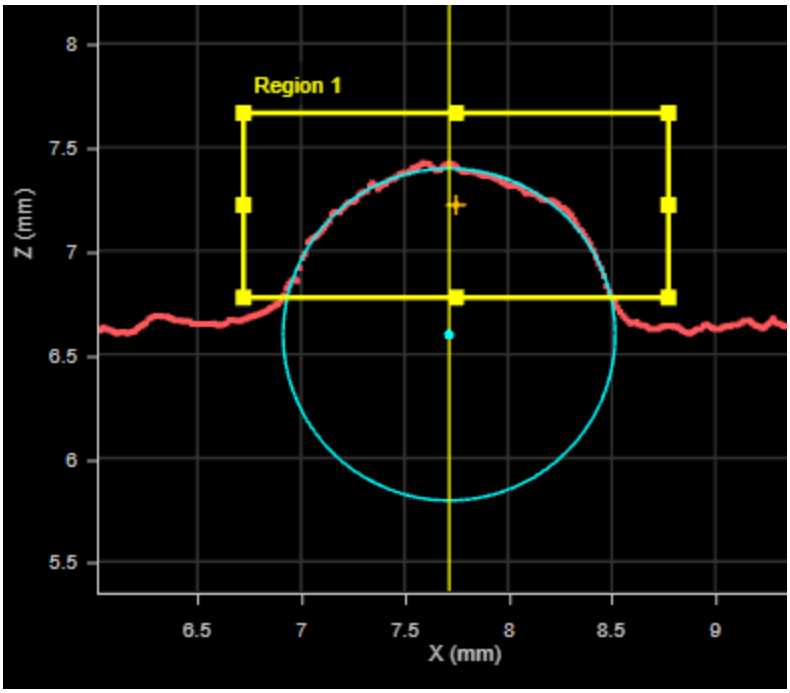
*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the bounding box. |
| Corner Point | The lower left corner of the bounding box. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Circle

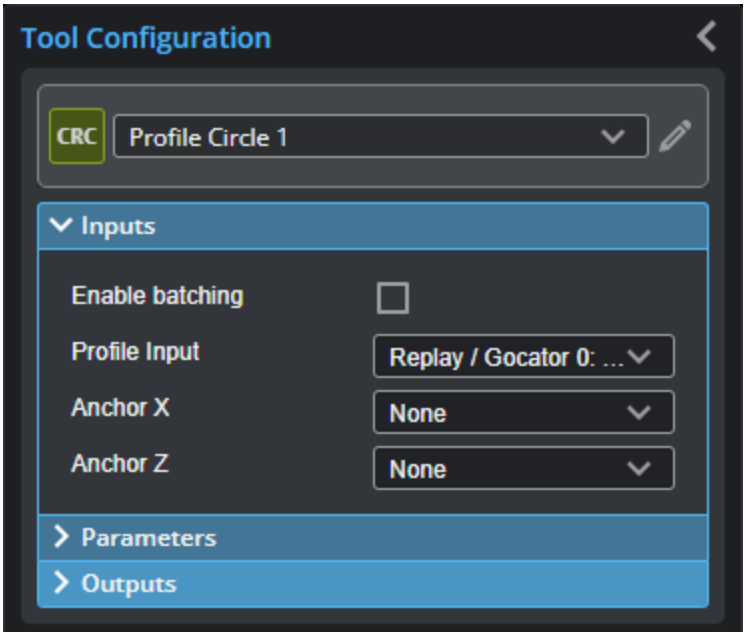
The Circle tool calculates the best-fit circle for a profile and returns measurements of various characteristics of the circle. The tool uses the iterative robust least squares fitting method.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



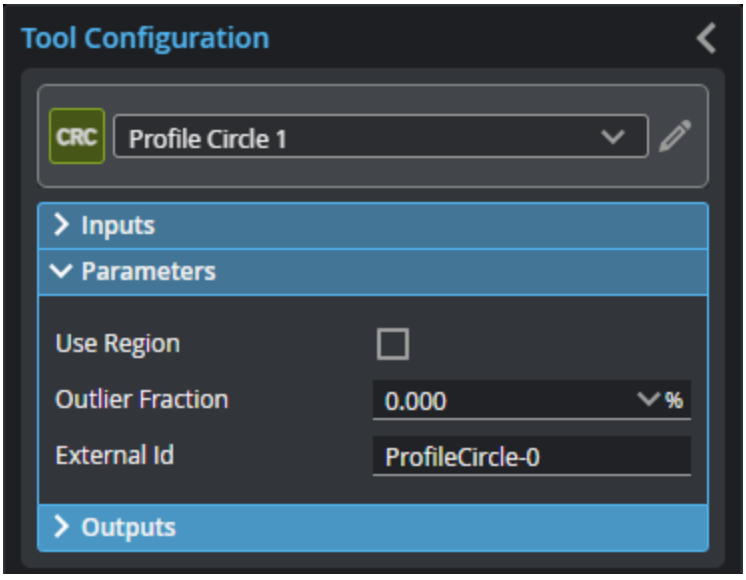
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



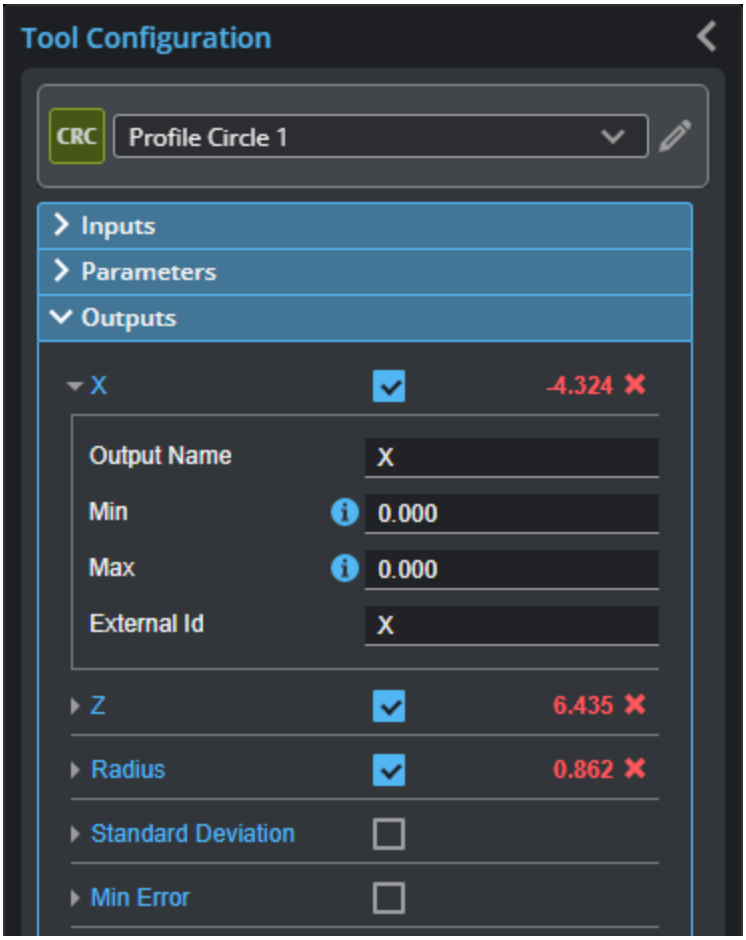

*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |

| Parameter | Description |
|---|---|
| Region {n} | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Outlier Fraction | The percentage of the profile points that are considered noise. A range from 0% to 80%.<br>For example, suppose a profile contains `m` points. If **Outlier Fraction** is not equal to 0, then `Outlier Fraction*m` points will be considered noises and be removed iteratively. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

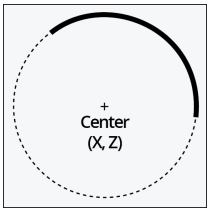
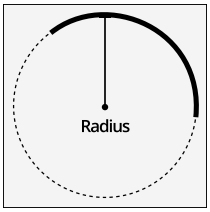
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Finds the circle center position in the X axis. |  |
| **Z**<br>Finds the circle center position in the Z axis. | |
| **Radius**<br>Measures the radius of the circle. |  |
| **Standard Deviation**<br>Returns the standard deviation of the data points with respect to the fitted circle. | |
| **Min Error**<br>**Max Error**<br>The minimum and maximum error among the data points with respect to the fitted circle. | |
| **Min Error X**<br>**Min Error Z**<br>The X and Z position of the minimum error. | |
| **Max Error X**<br>**Max Error Z**<br>The X and Z position of the maximum error. | |

*Features*

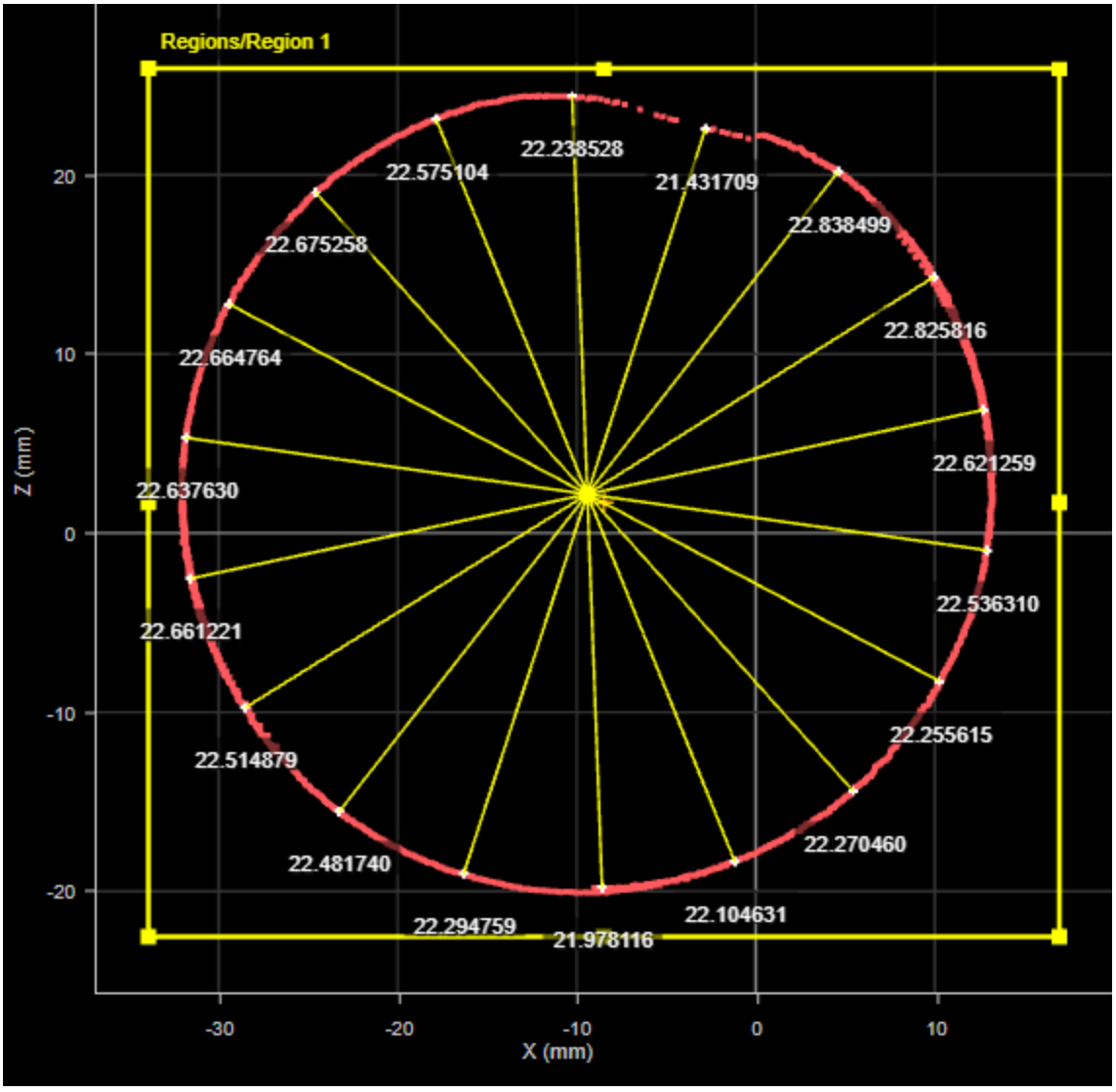
| Type | Description |
|---|---|
| Point | The center point of the fitted circle. |
| Circle | The fitted circle. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Circle Radii

The Profile Circle Radii tool lets you measure radii and diameters at specified angle steps, given a specified center point. The tool draws rays from the center point and returns radii or diameter measurements for each ray. The center point comes from either the center of a bounding box or a point geometric feature from another tool. The tool also provides settings to compensate for missing data and for rough surfaces or noise.

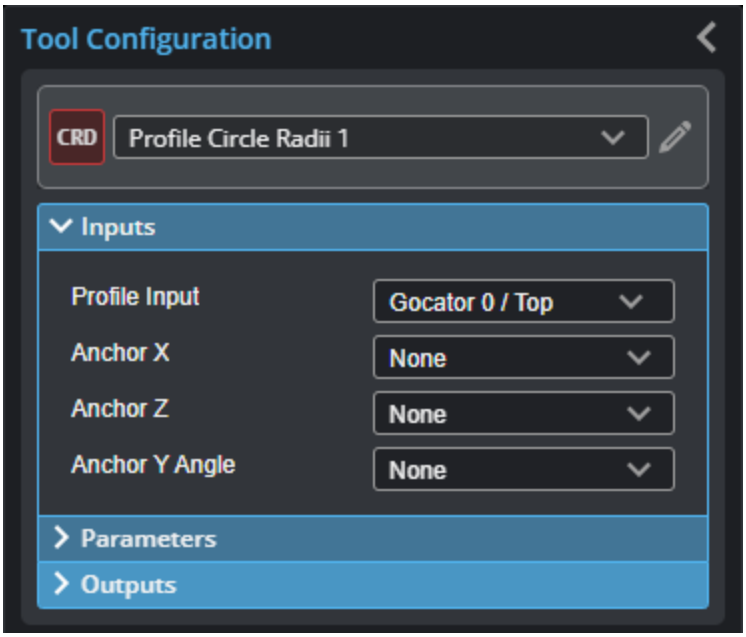
For example, in the following scan of an exhaust pipe by a four-sensor system, the tool is showing a shorter radius measurement at roughly 70 degrees that indicates a dent in the pipe.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



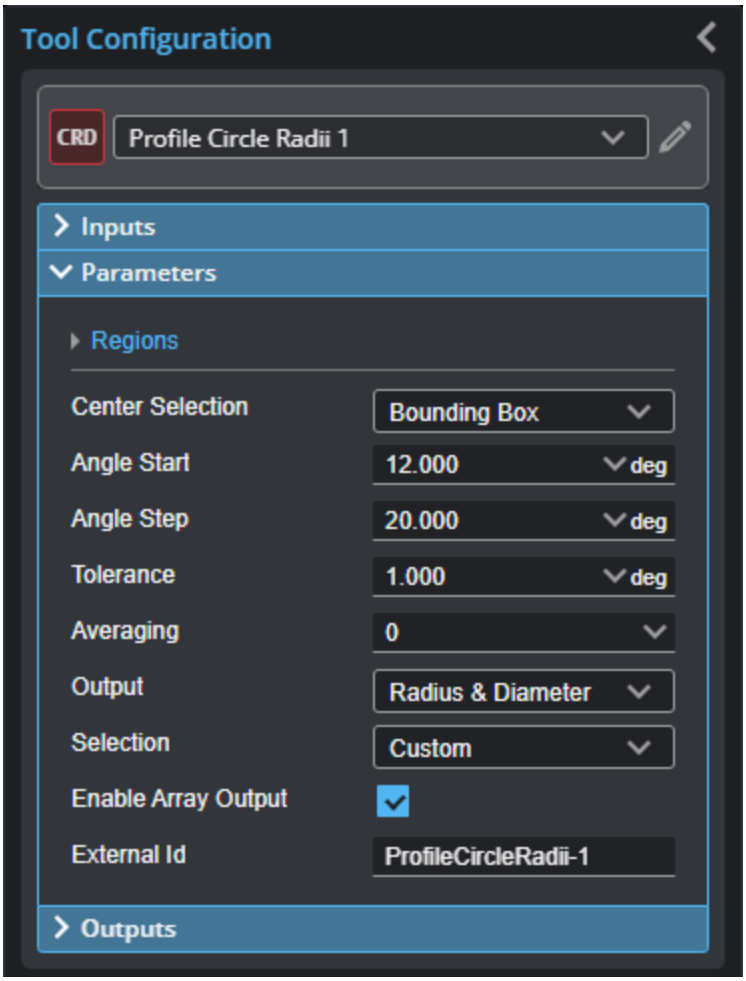

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Y Angle | The Y angle measurement of another tool that this tool uses as a rotational anchor. Rotational anchors are optional. |
| Center | The point geometric feature output by another tool that the Circle Radii tool uses as the center point from which rays are drawn to search for data points. The parameter is only available when **Center Selection** is set to **Feature Input**. |

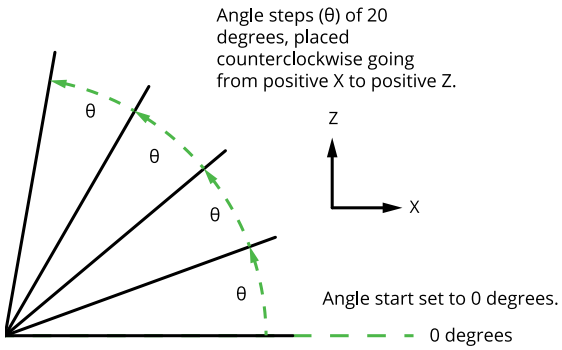
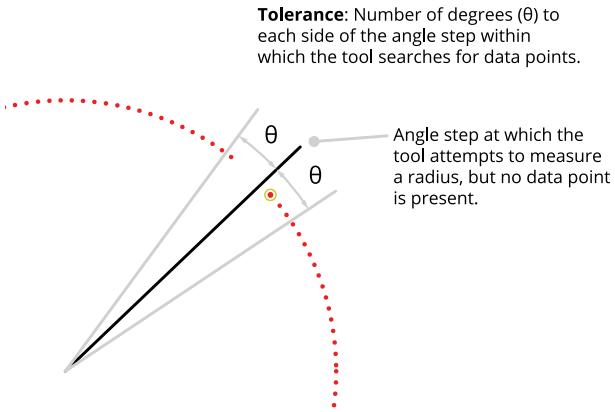
**Parameters**

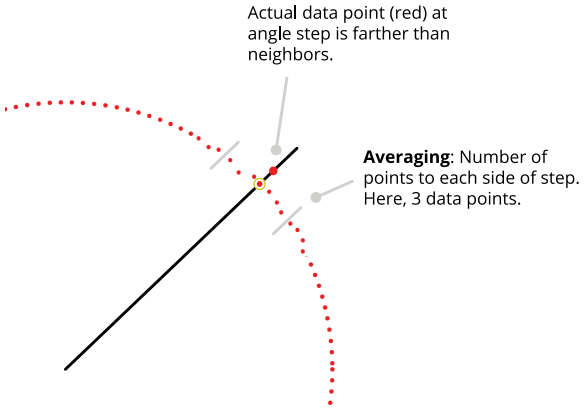
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

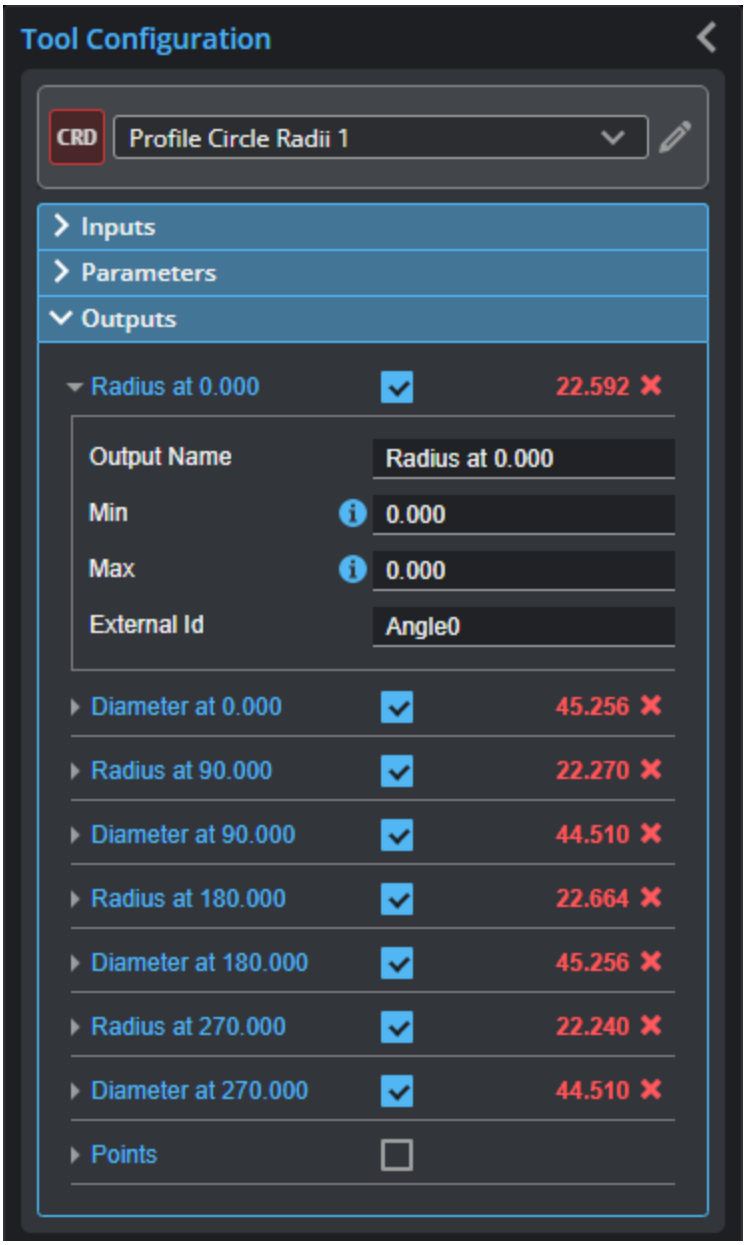
| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Center Selection | The source for the point geometric feature the tool uses as a center point. One of the following:<br>**Bounding Box** – Uses the center of the bounding box that encloses the scan data. If regions are enabled (**Enable** in the **Regions** expander is checked), the tool places a bounding box only around the data in the region. If **Enable** is unchecked, the tool places a bounding box around all scan data; this will include any outliers in the bounding box, which could produce an undesired center point.<br>**Feature Input** – A point geometric feature provided by another tool, such as the |

| Parameter | Description |
|---|---|
| | center point from a Circle tool. |
| Angle Start | **Angle Start**: The angle at which ray steps start. |
| Angle Step | **Angle Step**: The angle step in degrees.<br>The following shows how these settings work together:<br>  <br><br>The tool searches for a data point at each angle step and returns the radius from the center point or the diameter. |
| Tolerance | If no data point is found at the angle step, the tool searches within the specified number of degrees to each side of the step to find a data point. Useful to compensate for gaps in the data.<br>  <br><br>The graphic above shows how the tool searches to each side of the angle step until it finds a data point (circled and in yellow). |
| Averaging | The number of data points to each side of the point the tool uses to average. Use this to compensate for noise or rough surfaces. |

| Parameter | Description |
|---|---|
| |  <br>The graphic above shows how the tool averages the data point at the angle step with the number of data points specified in **Averaging** to each side of the angle step, replacing the original data point with the average (circled and in yellow). |
| Output | Selects whether to output the radius, diameter, or both for each step. |
| Selection | Lets you quickly enable or disable all measurements. |
| Enable Array Output | When this parameter is checked, the tool outputs arrays containing the radius and diameter measurements. If the parameter is disabled, measurements are output for the radius or diameter at each step. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.

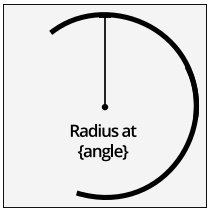
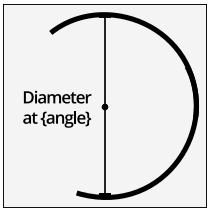



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

| | |
|---|---|
| | If you check **Enable Array Output** in the tool's parameters, the tool outputs radius and diameter measurements in arrays, called Radius and Diameter, respectively. Otherwise, individual measurements are output, such as "Radius at 90.000," "Radius at 180," and so on. |

*Measurements*

| Measurement | Illustration |
|---|---|
| **Radius at {angle}**<br>Returns the radius at {angle}. |  |
| **Diameter at {angle}**<br>Returns the diameter at {angle}. |  |

*Data*

| Type | Description |
|---|---|
| Points | An array of the points at the end of the rays. |

## Profile Closed Area

The Closed Area tool determines the cross-sectional area within a region using point cloud data (that is, with **Enable uniform spacing** disabled in the **Acquire** page > **Scan mode** panel) from a dual- or multi-sensor system.

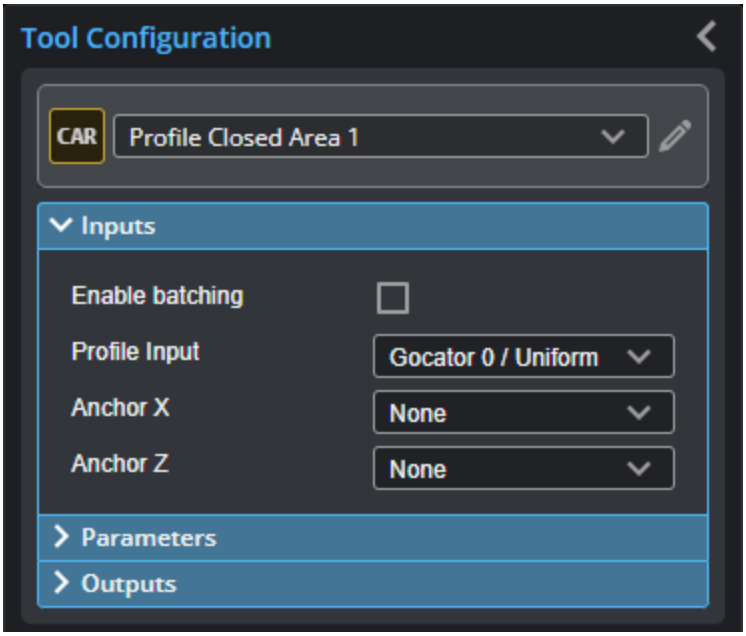
The tool is intended for use with roughly circular shaped profiles, or profiles that do not contain excessive concavity. The tool renders a polygon corresponding to the profile in the data viewer. Use this polygon to decide whether the tool can correctly calculate an acceptable representation of the profile. Minor gaps in the profile are permitted; the size of these gaps is configurable.

Two methods are provided to calculate the area: Sector and Contour. For more information, see *Method* on the next page.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

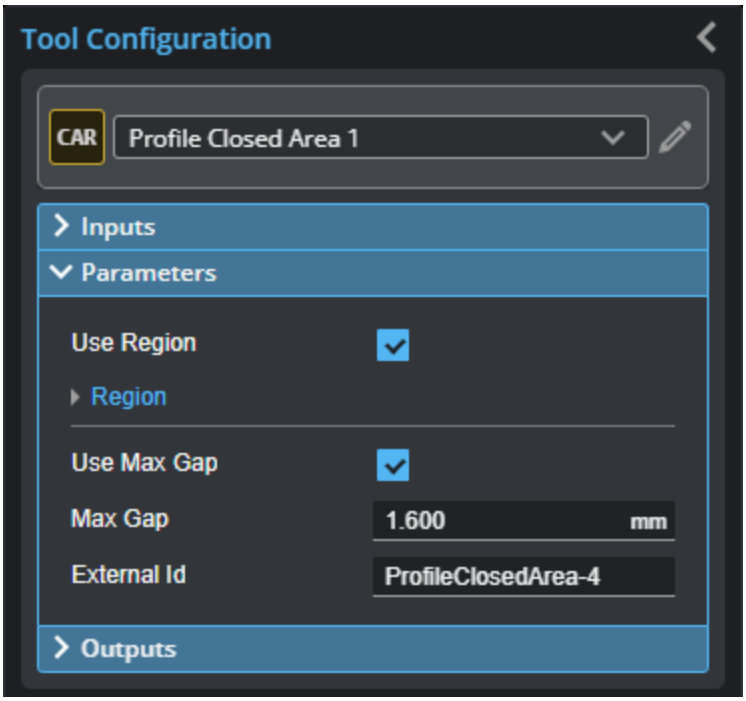
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor. |

| Name | Description |
|---|---|
| | When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

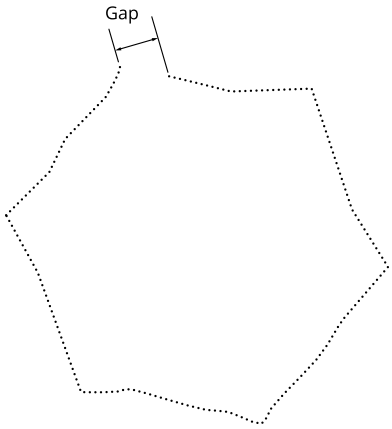
**Parameters**

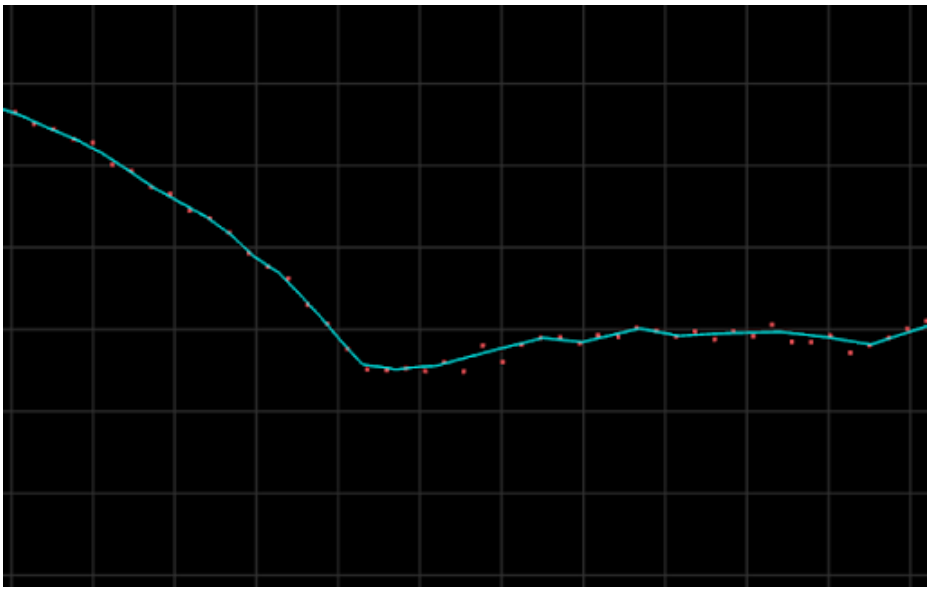
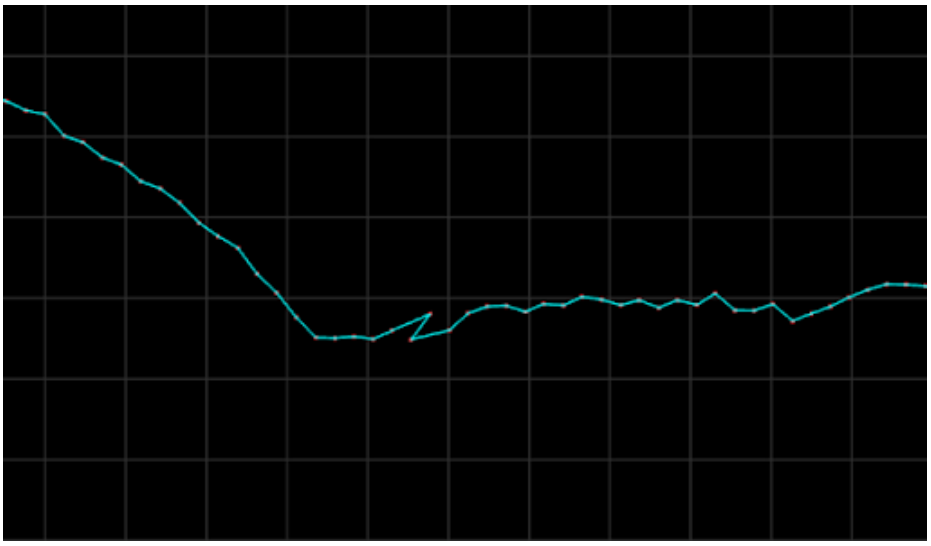
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

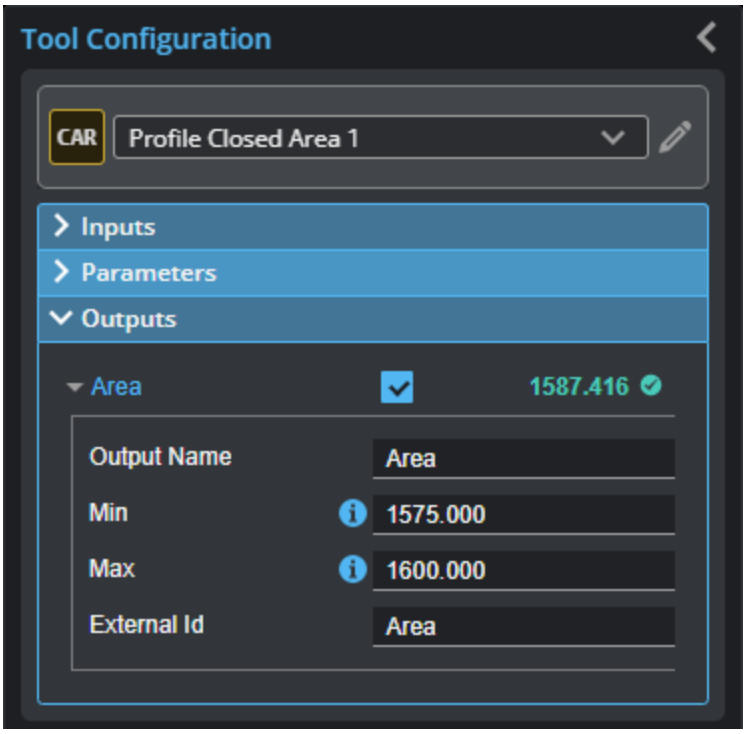
| Parameter | Description |
|---|---|
| Use Region | Indicates whether the tool uses a user-defined region.<br>If this option is not checked, the tool uses data from the entire active area. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Method | One of the following: Sector or Contour. |

| Parameter | Description |
|---|---|
| | **Sector**<br>The closed profile is separated into several sectors. The origin of the rays that produce the polygon is set in **Center Selection**. The output area is equal to the sum of these sector areas.<br><br>**Contour**<br>The closed profile is considered a closed contour, and Green's theorem is used to compute its area. Note that this method only supports uniform profiles (uniform spacing is enabled on the **Acquire** page, in the **Scan mode** section). On non-uniform profiles the tool will return incorrect measurements. |
| Center Selection | The origin of the rays used to create the polygon (which in turn is used to calculate the area). One of the following:<br>**Bounding Box** (default)<br>Sets the center to the center of a bounding box that contains the tool data or the data in the region.<br>**Feature Input**<br>Lets you set the center to a point geometric feature output from another tool. When you choose this option, a **Center** dropdown lets you choose the center point. For more information on geometric features, see *Geometric Features* on page 191. |
| Use Max Gap | Indicates whether the tool uses the **Max Gap** setting (see below). |
| Max Gap | The maximum gap allowed between any two profile points on the contour of the target, in millimeters. In the following illustration of a profile, if the gap were greater than the value set in **Max Gap**, the tool would return an invalid value.<br>  |
| Sample Spacing | The angle interval around the center of the profile the tool uses to calculate area. Enabling this setting and setting a value can increase the tool's performance.<br>In the following image, the spacing is set to 1 degree. The polygon calculated from the profile points, which is then used to calculate the area, is simplified, increasing performance but reducing accuracy. |

| Parameter | Description |
| --- | --- |
| |  <br>In the following image, **Sampling Spacing** is set to 0. Accuracy is increased, but performance is reduced.<br>  <br>If you set the value to 0, the tool uses the smallest angle permitted internally by the sampling engine. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.

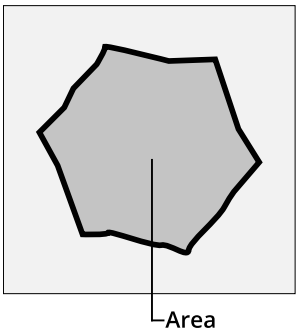



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

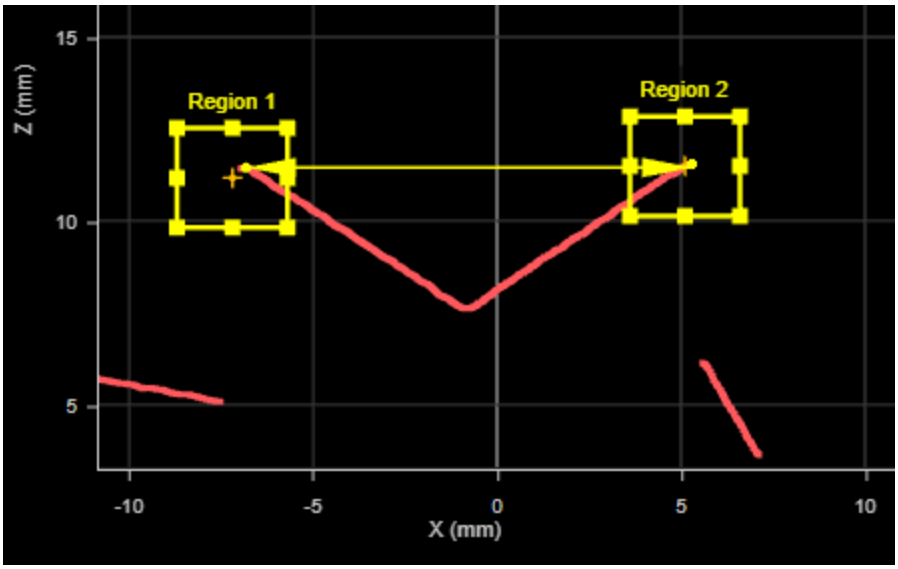
All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Area**<br>Measures the cross-sectional area within a region using data from a dual- or multi-sensor system. |  |

## Profile Dimension

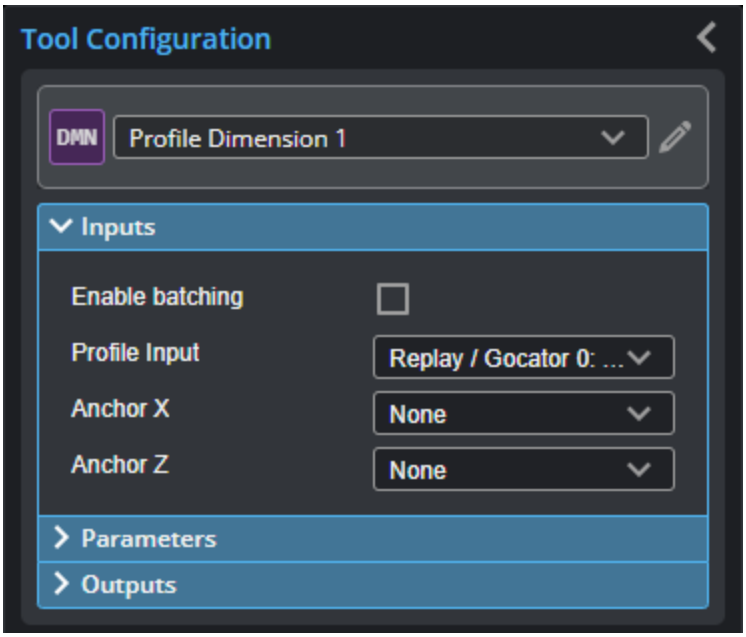
The Dimension tool provides Width, Height, Distance, Center X, and Center Z measurements.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



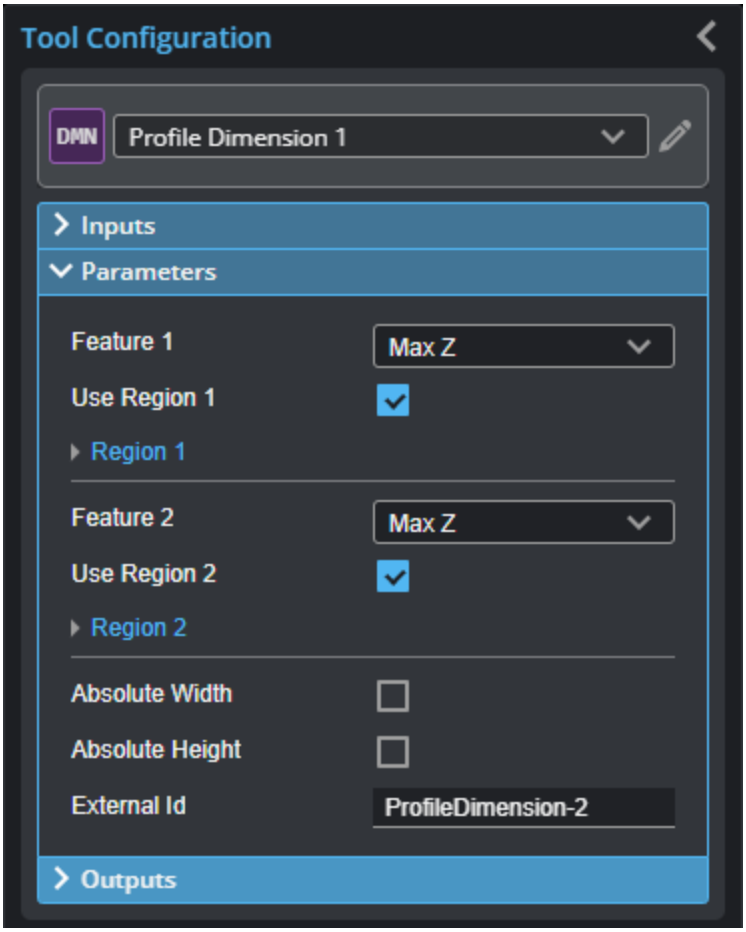

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

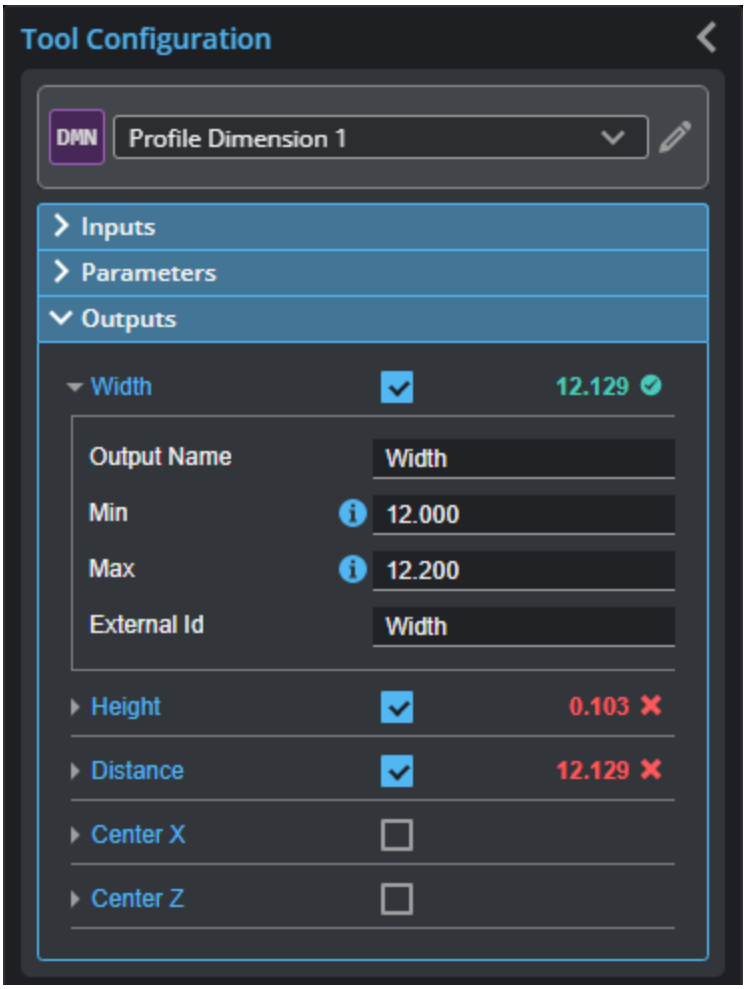


*Parameters*

| Parameter | Description |
|---|---|
| Feature 1<br>Feature 2 | The **Feature 1** and **Feature 2** settings represent the two features the tool uses to perform measurements. For each, one of the following:<br>• Max Z<br>• Min Z<br>• Max X<br>• Min X<br>• Corner<br>• Average<br>• Rising Edge<br>• Falling Edge<br>• Any Edge<br>• Top Corner<br>• Bottom Corner<br>• Left Corner<br>• Right Corner<br>• Median<br>For more information on feature points, see *Feature Points* on page 188. |
| Use Region 1<br>Use Region 2 | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region 1<br>Region 2 | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Absolute Width<br>Absolute Height<br>*(Width and Height measurements only)* | Determines if the result will be expressed as an absolute or a signed value. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

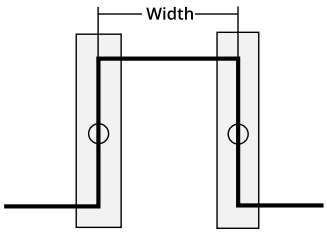
Most tools provide measurements, geometric features, or data as outputs.

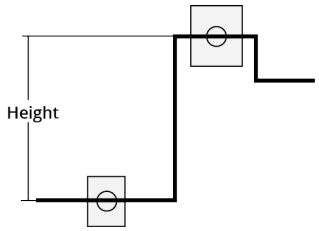
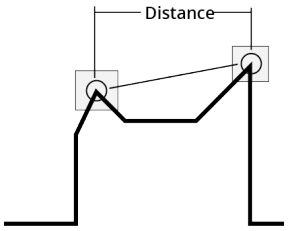
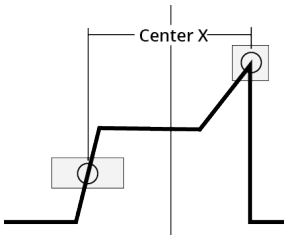
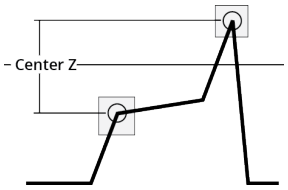



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

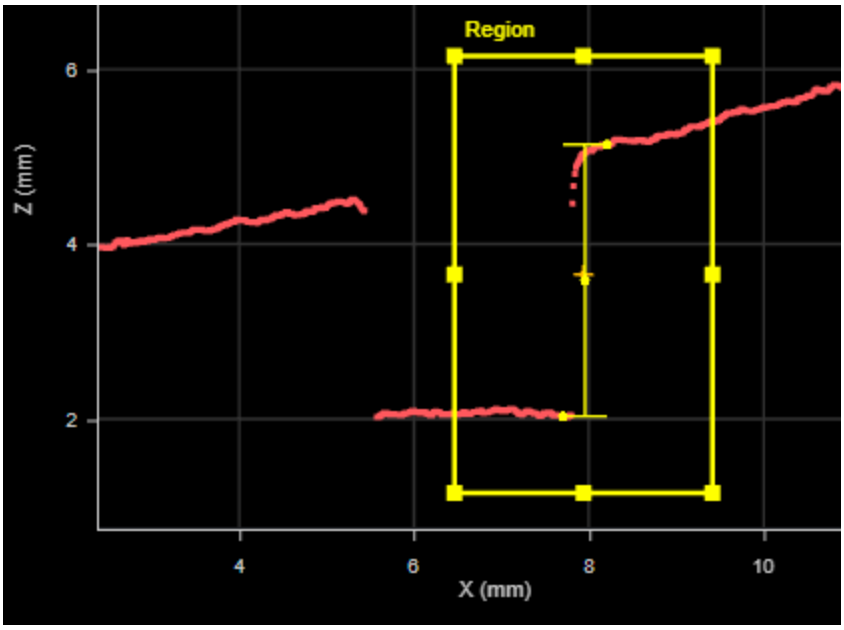
*Measurements*

| Measurement | Illustration |
|---|---|
| **Width**<br>Determines the difference along the X axis between two feature points.<br>The difference can be calculated as an absolute or signed result. The difference is calculated by:<br>$Width = Feature\ 2_{X\ position} - Feature\ 1_{X\ position}$ |  |

| Measurement | Illustration |
| --- | --- |
| **Height**<br>Determines the difference along the Z axis between two feature points.<br>The difference can be expressed as an absolute or signed result. The difference is calculated by:<br>*Height = Feature $2_{Z\ position}$ – Feature $1_{Z\ position}$* |  |
| **Distance**<br>Determines the direct, Euclidean distance between two feature points. |  |
| **Center X**<br>Finds the average location of two features and measures the X axis position of the average location |  |
| **Center Z**<br>Finds the average location of two features and measures the Z axis position of the average location. |  |

## Profile Edge

The Profile Edge tool finds an edge on a profile, searching from left to right. The tool's settings help fit the edge point when multiple potential edges are in the profile. You can configure the tool to locate a step or a corner (that is, for cases where there is no clear step in the profile but instead a smooth slope), as well as rising or falling steps.




*Step height of a step*

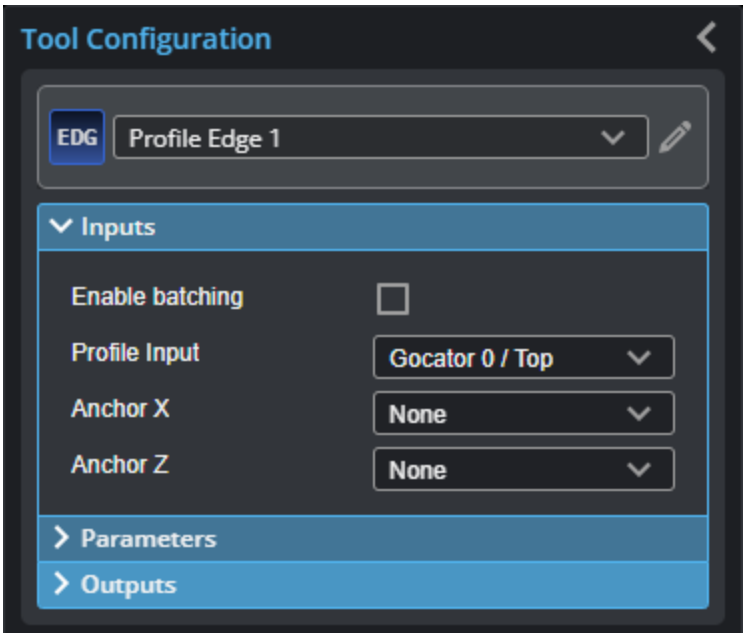
After the tool locates an edge, it returns the position (X and Z) of the edge. For steps, it also returns the step height.

The tool can also generate a point geometric feature corresponding to the center of the step that Feature tools can take as input for measurement. For more information on Feature tools, see *Feature Measurement* on page 626.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



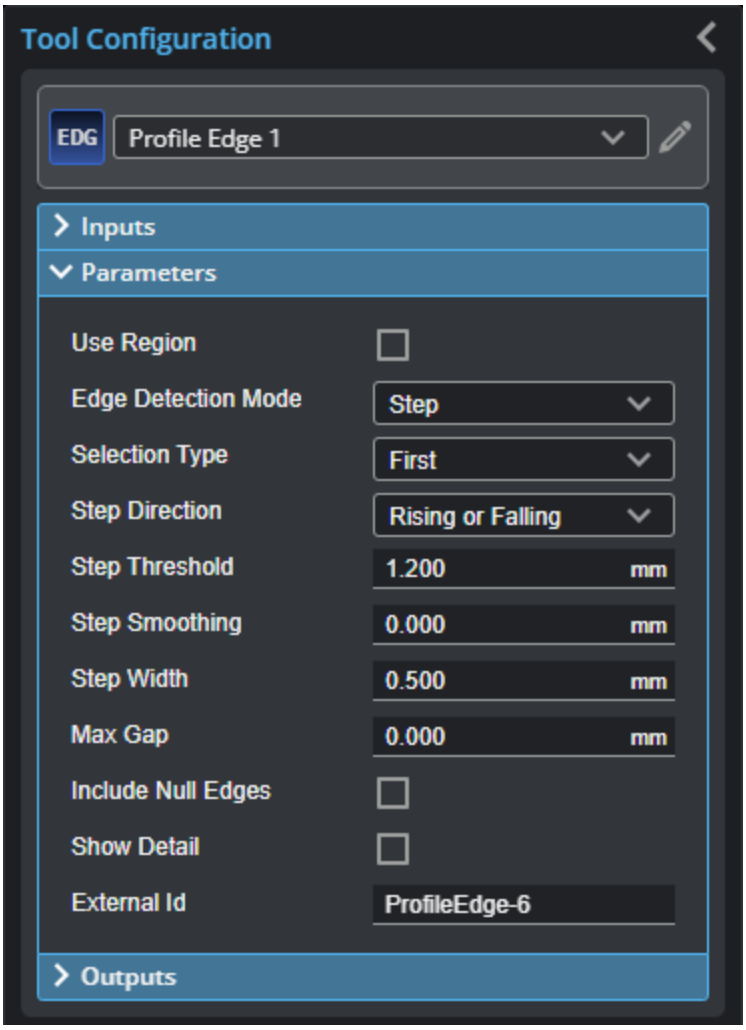

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

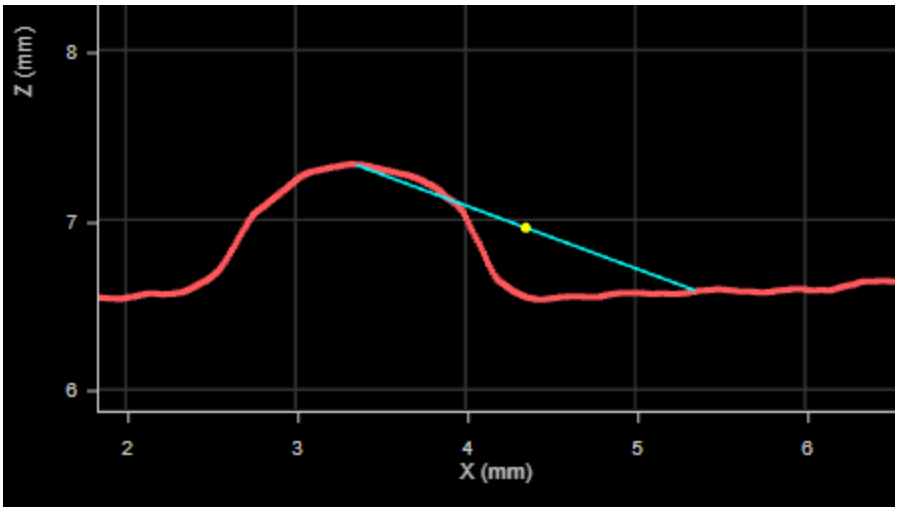
**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



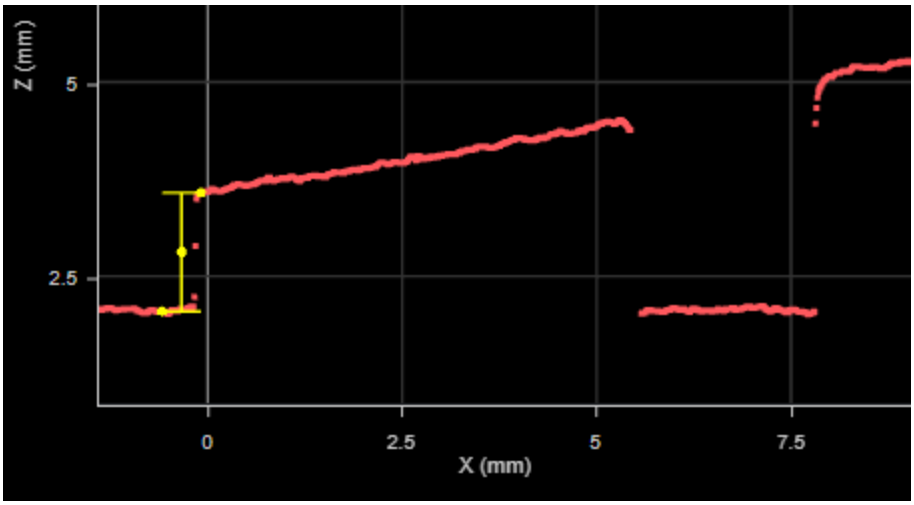
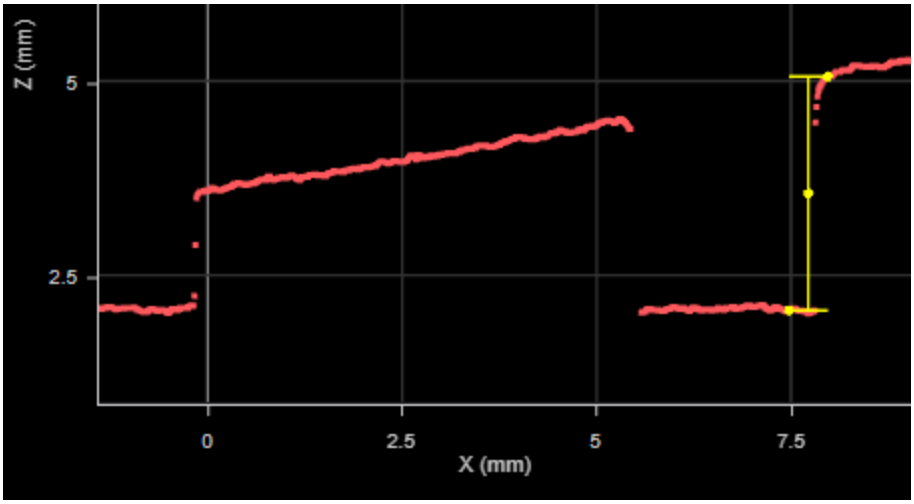

*Parameters*

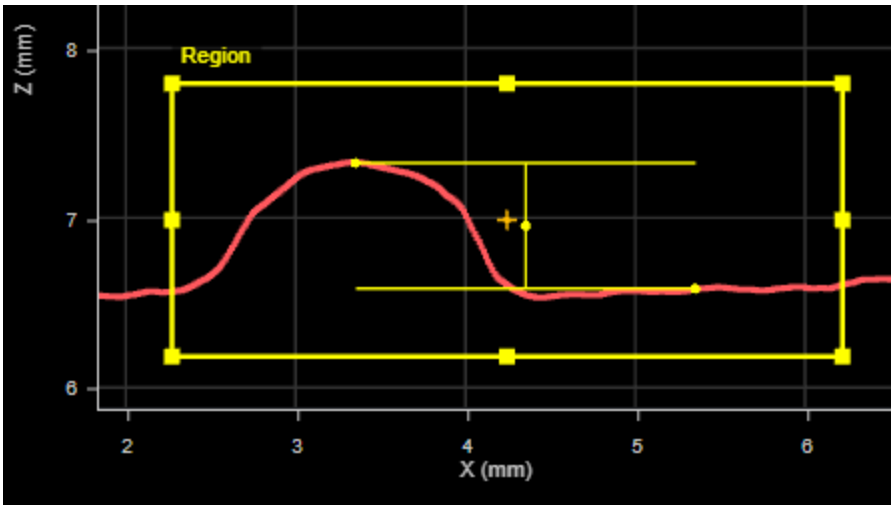
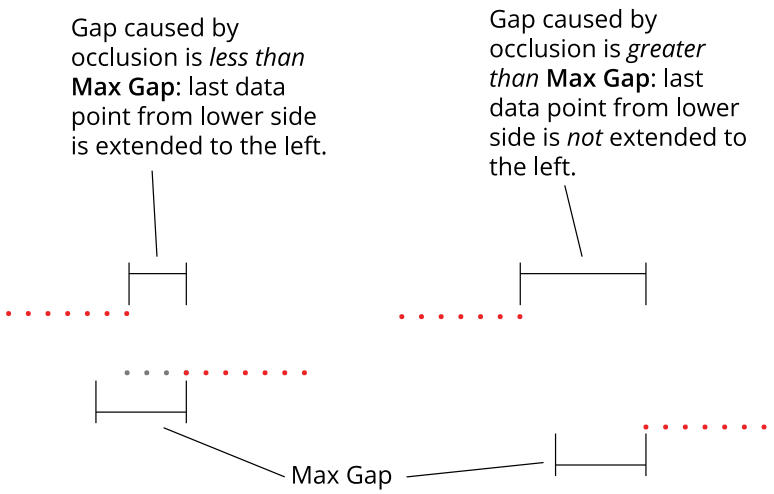
| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Edge Detection Mode | One of the following: Step or Corner.<br>**Step**: Searches for steps on each path profile. When the edge detection mode is set to Step, you must set several additional parameters. For more information, see *Step Edge Detection Mode Parameters* on the next page.<br>**Corner**: Searches for slopes on each path profile. When the edge detection mode is set to Corner, you must set the **Corner Type** parameter. For more information, see *Corner Edge Detection Mode Parameters* on page 242. |
| Show Detail | When the parameter is enable, the tool displays a line joining the points used to calculate the edge. This can be useful when viewing the edge's center point on a |

| Parameter | Description |
|---|---|
| | step. Note that enabling this parameter can have an effect on processing. For high frequency scanning, be sure to disable it.<br>  |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

*Step Edge Detection Mode Parameters*

| Parameter | Description |
|---|---|
| Selection Type | Determines which step the tool uses when there are multiple steps in the profile. An edge point is placed on the chosen step. Steps must satisfy the tool's **Step Threshold** and **Step Direction** settings.<br>**Best**: Selects the greatest step on the profile.<br>**First**: Selects the first step on the profile.<br>**Last**: Selects the last step on the profile. |
| Step Direction | Determines whether the expected step rises or falls, moving from left to right along the profile. Either **Rising**, **Falling**, or **Rising or Falling**. |
| Step Threshold | The minimum step accepted as an edge candidate. Steps on the profile are treated as absolute values when compared to this setting.<br>In the following profile, with **Step Threshold** set to 1.2 (and **Selection Type** set to First), the tool accepts the rising step to the left, with a step of 1.525 mm, because it is the first above the step threshold. |

| Parameter | Description |
| --- | --- |
| |  <br>In the following, when **Step Threshold** is increased to 2.7, the tool excludes the rising step to the left, because it is no longer above the step threshold, and instead uses the step to the right.<br>  |
| Step Smoothing | The size of the (moving) window along the profile used to calculate averages for the data points used to calculate the step. The setting is useful for averaging out noise.<br>If **Step Smoothing** is set to 0, no averaging is performed. |
| Step Width | The distance, along a profile, separating the points the tool uses to find steps on a profile.<br>In the following, a step width of 2 mm causes the tool to consider profile points that distance apart as steps. The curved portion of the profile is not used to measure the step. |

| Parameter | Description |
|---|---|
| |  <br>The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting **Step Width** to a value greater than the width of the slope ensures that the tool measures the height difference between the flat regions on either side of the slope. As a result, the height of the step is accurately measured, and the edge is correctly located.<br>Setting **Step Width** wider than necessary can reduce the accuracy of edge location. |
| Max Gap | Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When **Max Gap** is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in **Max Gap**.<br>  <br>The tool uses data points "filled in" by **Max Gap** before data points filled in by **Null Fill Value** (see below). |
| Include Null Edges | Indicates whether null points (points where no height value is available, due to |

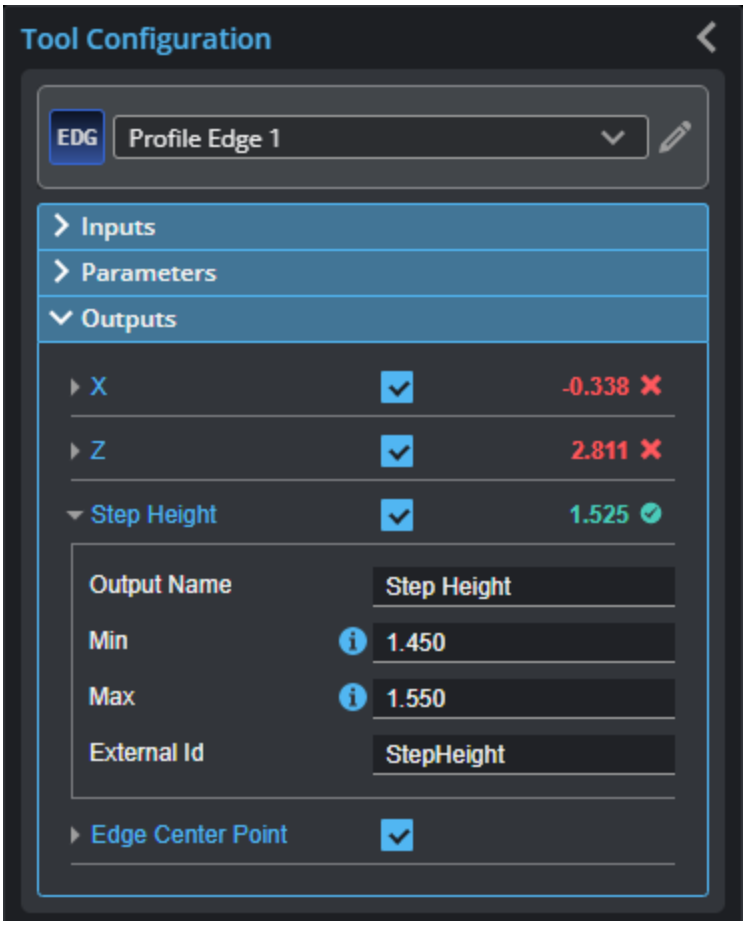
| Parameter | Description |
| --- | --- |
| | dropouts or regions outside of the measurement range) are filled with the value in **Null Fill Value** as a general “background level.” |
| | To find an edges next null points, you must use either this option and an appropriate value in **Null Fill Value** or **Max Gap**. Otherwise, only edges within areas of contiguous data will be detected. |
| Null Fill Value | The height value (in mm) used to replace null points when **Include Null Edges** is enabled.<br>If both **Null Fill Value** and **Max Gap** fill in null points at the same position, the tool uses the value extended by **Max Gap**, regardless of the value of **Null Fill Value**. |

*Corner Edge Detection Mode Parameters*

| Parameter | Description |
| --- | --- |
| Corner Type | Determines the corner type the tool searches for. One of the following:<br>**Best**: Selects the greatest step in the profile data.<br>**Left**: Selects the left-most step in the profile data.<br>**Right**: Selects the right-most step in the profile data.<br>**Top**: Selects the step that is the highest in the profile data.<br>**Bottom**: Selects the step that is lowest in the profile. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
|---|
| **X**<br>**Z**<br>These measurements return the X and Z position of the edge point, respectively. The edge point is located half-way between the upper and lower data points of the step. |
| **Step Height**<br>Returns the height of the step on the profile.<br>Only available if **Edge Detection Mode** is set to Step. |

*Features*

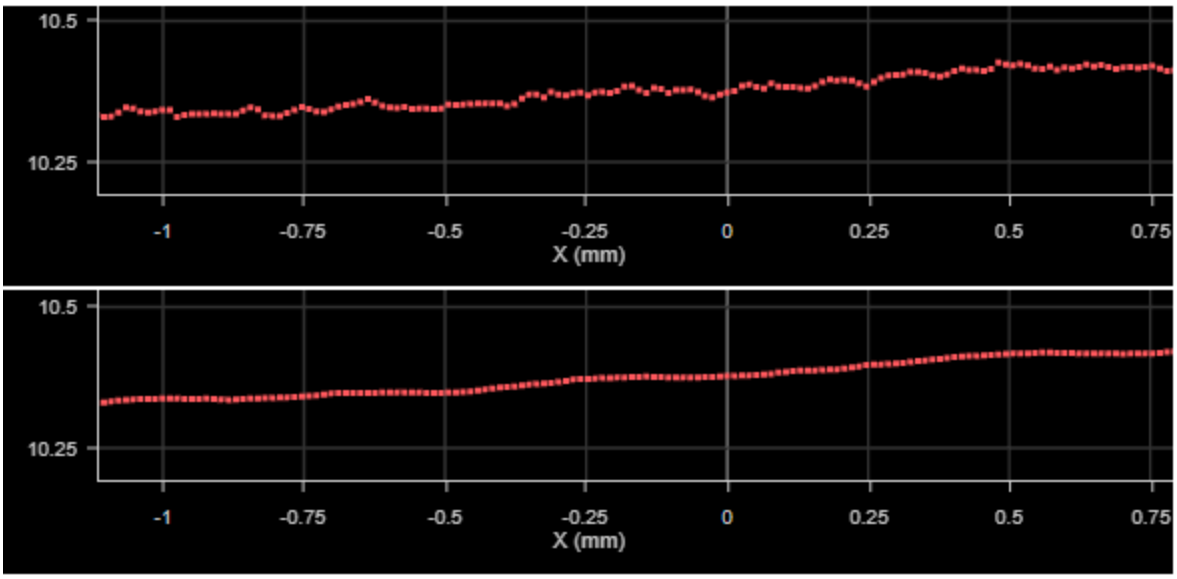
| **Type** | **Description** |
|---|---|
| Edge Center Point | The edge point. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Filter

The Profile Filter tool provides processing filters that you can apply to a uniform profile (not point cloud profiles), letting you process scan data to get more repeatable measurements. You can enable up to seven of the filters at once, in any order. Filters in the tool are chained together. Any Profile tool can use the resulting filtered profile as input.

(The following screenshot is from a G2 sensor.)




*Profile with no filtering (top) and with averaging filter (bottom)*

For a list of the filters, see *Filters* on page 248.

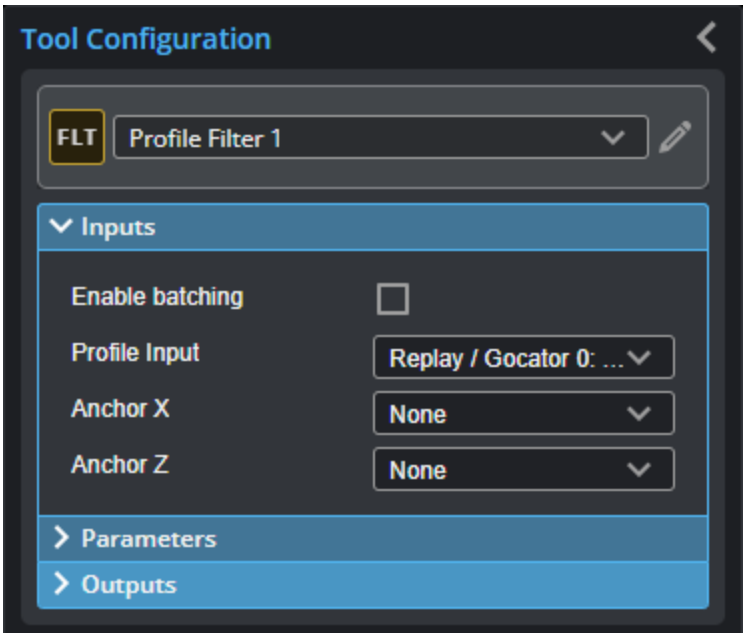
The Filter tool provides no measurements or decisions. It only outputs processed profile data.

> A limited set of filters is also available on the **Acquire** page, in the **Filters** section. These filters let you process scan data without needing to add tools. This can be useful if you are using a sensor mostly as an acquisition device.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



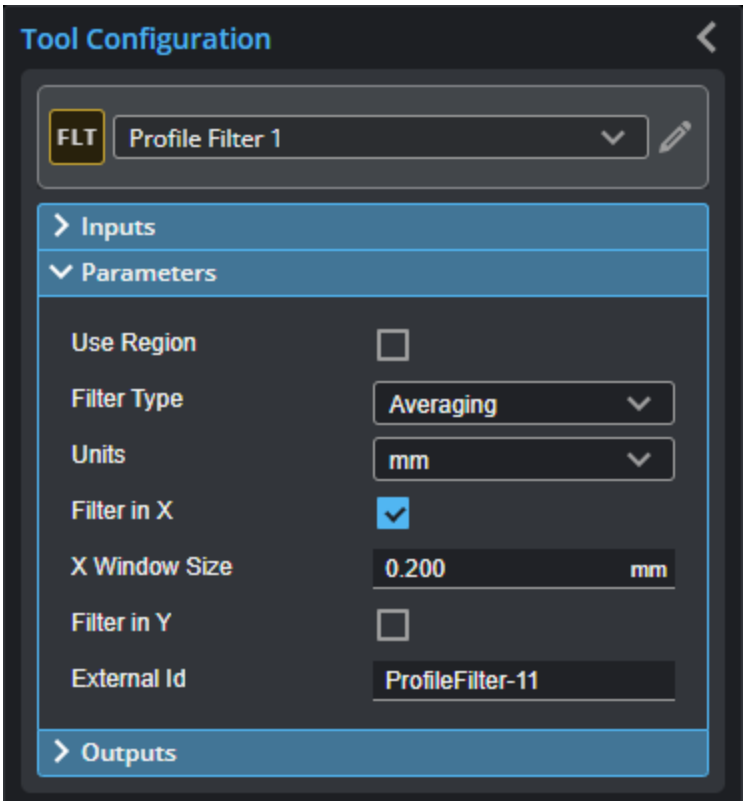

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Number of Regions<br>Region {n} | Lets you set the number of regions, and for each region, the position and dimension.<br>For more information on regions, see *Regions* on page 181. |
| Filter Type | The type of filter. For more information on the available filters, see *Filters* on the next page. |
| Units | The units the filter uses for the window or windows: points or distance (mm). Not available with all filters. This parameter is only displayed after enabling **Filter in X** or **Filter in Y**. |
| Filter in X<br>Filter in Y | When enabled, filters along X and Y, respectively, and displays **X Window Size** or **Y Window Size** parameters you use to set the window size, using the unit set in **Units**. (The gap filling and Gaussian filters only let you filter along the X axis.)<br>The filter window sizes are specified in millimeters (and additionally, in the tools, in data points). To calculate the number of data points that a window covers when the units are millimeters, use the following calculation:<br>• User-specified window size divided by the X spacing interval (that is, the number of millimeters per point) on the **Spacing** tab in the **Sensor** panel. (For more information on spacing intervals, see *Uniform Spacing* on page 112.) |

| Parameter | Description |
|---|---|
| | • *With the exception of the gap filling filter*, round the result of the division to the nearest integer value. With the gap filling filter, filling is performed within the provided window size.<br>For example, if you set the size of the filter's window to a value between 1.5 mm and 2.49 mm (inclusively), and the X spacing interval is set to 1 mm, the filter covers 2 data points. A filter window size from 2.5 mm to 3.49 mm results in a filter covering 3 data points. |
| Sigma | The Gaussian curve's sigma value. (Only displayed with the Gaussian filter and when **Filter in X** is enabled.) |
| Percentile Type | Displayed when **Filter Type** is Percentile. (Be sure to set the **High Percentile** and **Low Percentile** as required.) One of the following:<br>**Point Count**: Removes points based on the count of valid points in the profile.<br>**Point Height Range**: Removes points based on the height range of valid points in the profile. |
| High Percentile<br>Low Percentile | The range for used when you set **Filter Type** to Percentile. You must also set **Percentile Type**. |

The following filters are available in the Profile Filter tool.

*Filters*

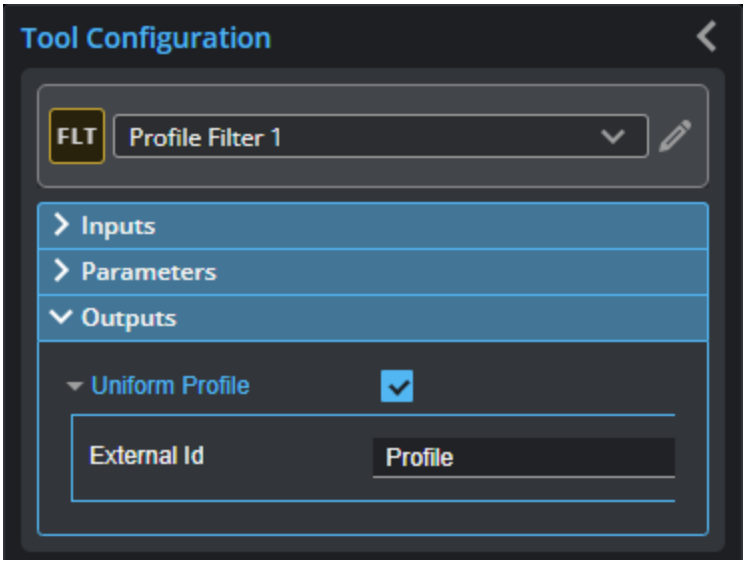
| Name | Description |
|---|---|
| Gap Filling | Fills in missing data using information from the nearest neighbor data points, for example, when data is missing due to occlusions. Gap filling also fills gaps where no data is detected, which can be due to low surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The values in **Filter in X** and **Filter in Y** represent the maximum gaps the sensor will fill. Wider gaps are not filled.<br>Gap filling works by filling in missing data points using either the lowest values from the nearest neighbors or linear interpolation between neighboring values (depending on the Z difference between neighboring values), in the specified window. The sensor can fill gaps along both the X axis and the Y axis.<br>In Profile mode, gap filling is limited to the X axis. |
| Median | Substitutes the value of a data point with the median calculated within the window or windows set in **X Window Size** or **Y Window Size** around the data point. If the number of valid (non-null) data points in the window is even, the average of the two values in the center is used. If the number of valid points is odd, the value in the center of the sorted list of values is used.<br>Missing data points will not be filled with the median value calculated from data points in the neighborhood.<br>With an odd-numbered window size, the output is at the center of the window. With an even window size, the output is 0.5 pixels to the right of the center (that is, using window / 2-1 values from the left, and window / 2 from the right. |

| Name | Description |
|---|---|
| Averaging | Substitutes a data point value with the mean value of that data point and its nearest neighbors within the window or windows set in **X Window Size** or **Y Window Size**. X smoothing works by calculating a moving average across samples within the same profile. Y smoothing works by calculating a moving average in the direction of travel at each X location.<br>If both X and Y smoothing are enabled, the data is smoothed along X axis first, then along the Y axis.<br>Missing data points will not be filled with the mean value calculated from data points in the neighborhood. |
| Decimation | Decimation reduces the number of data points along the X or Y axis by choosing data points at the end of a specified window around the data point. For example, by setting **X Window Size** to 0.2, only points every 0.2 millimeters will be used. The filter generates points starting from the leftmost edge of the scan data, stepping in equal steps away from that side. |
| Gaussian | A Gaussian filter applied over the specified kernel using the provided sigma. Enable **Filter in X** and set the **Sigma** parameter. |
| Percentile | Filters points based on **Percentile Type**, as well as **High Percentile** and **Low Percentile**. |

The filters described here that are available in the Filter panel topic use the same algorithms.

**Outputs**

The tool provides the following output.

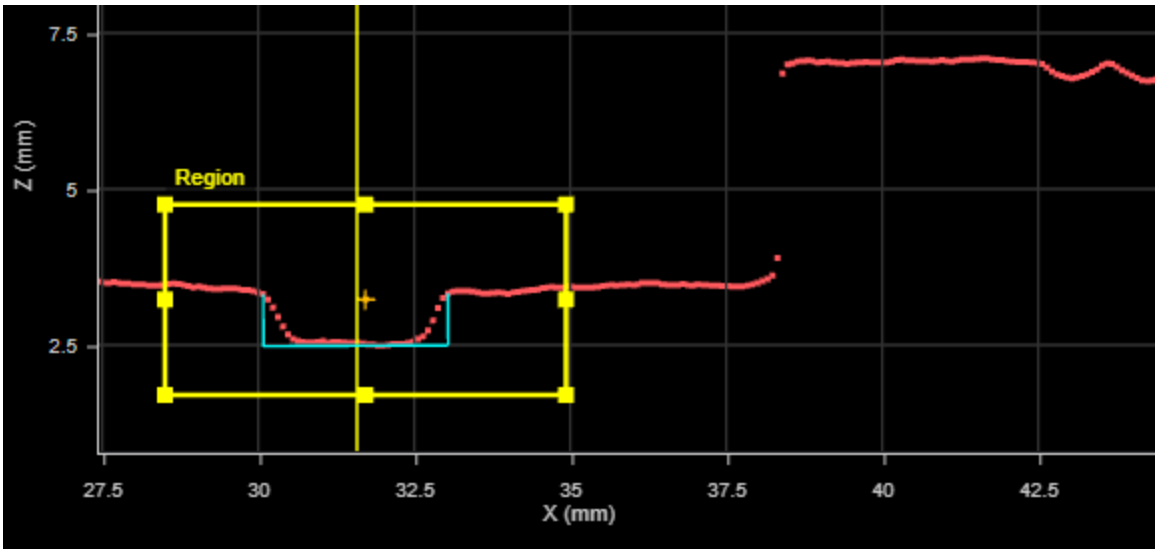



*Data*

| Type | Description |
|---|---|
| Uniform Profile | The filtered uniform profile. |

## Profile Groove

The Groove tool provides measurements of V-shape, U-shape, or open-shape grooves.



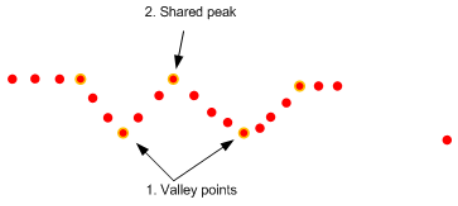

The tool lets you optionally set an index to return the measurements of a specific groove when more than one groove is visible in the region of interest. If you need to return multiple grooves from a profile, add a Profile Groove tool for each groove, configure it to represent the desired groove, and set its **Selection Index** parameter to the desired groove (0-based index).

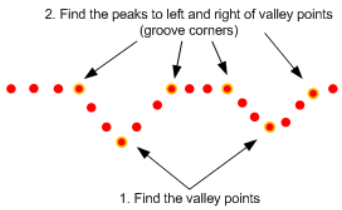
The Groove tool uses a complex feature-locating algorithm to find a groove and then return measurements. For a detailed explanation of the algorithm the tool uses, see *Groove Algorithm* below. The behavior of the algorithm can be adjusted by changing the tool's parameters.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

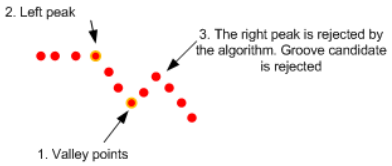
### Groove Algorithm

The Groove measurement tool first locates a valley along the profile line. The bottom point of a valley, the valley point, is the first estimation of the position of the groove bottom. For each valley, the algorithm searches for the corner to the left and to the right to find the groove corners. A groove candidate is found when the groove corners are located on the left and right before the next valley is reached. Two groove candidates may share the same corner as shown in the right image below.

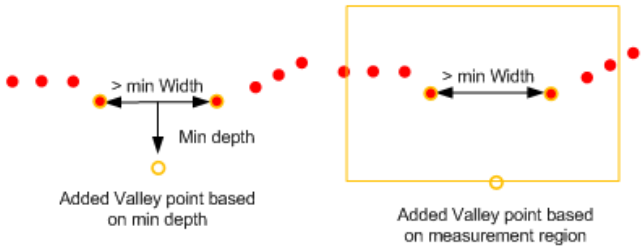


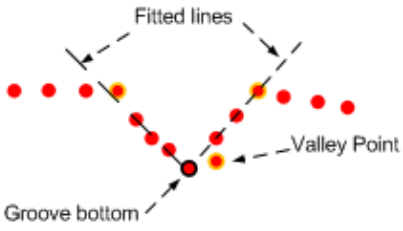
The algorithm derives search parameters from the user settings to prevent noise from triggering false detections. When detecting multiple grooves, an adaptive algorithm is used to ensure that candidate grooves are approximately the same scale.




The valley points of open grooves may not be visible or may fall outside of the measurement region. Voids in the data (regions with no profile data) between pairs of valid points are detected. A valley point is added midway between the pair of valid points. The Z position of the valley point is either the minimum groove depth below the lower of the corners or the bottom edge of the measurement region. The algorithm then proceeds as if to find a U-shaped groove.

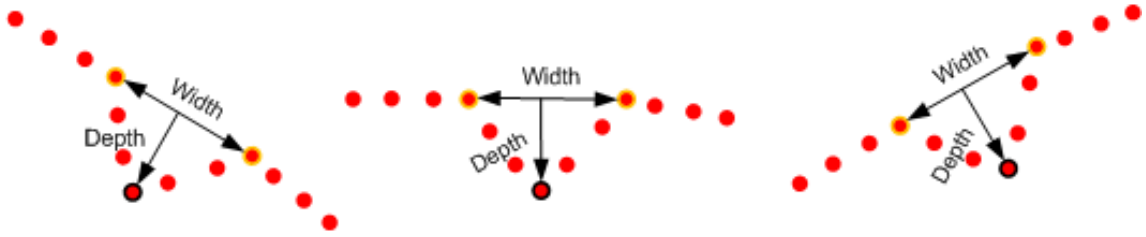



The actual groove bottom is calculated differently for different shapes. For a V-shaped groove, a line is fitted to the sides of the valley points starting from the corners, up to (but not including) the valley point. The groove bottom is the intersection of the left and right lines. Line fitting is used such that an accurate groove bottom can be found even when the real bottom is not visible (i.e., blocked by reflections).



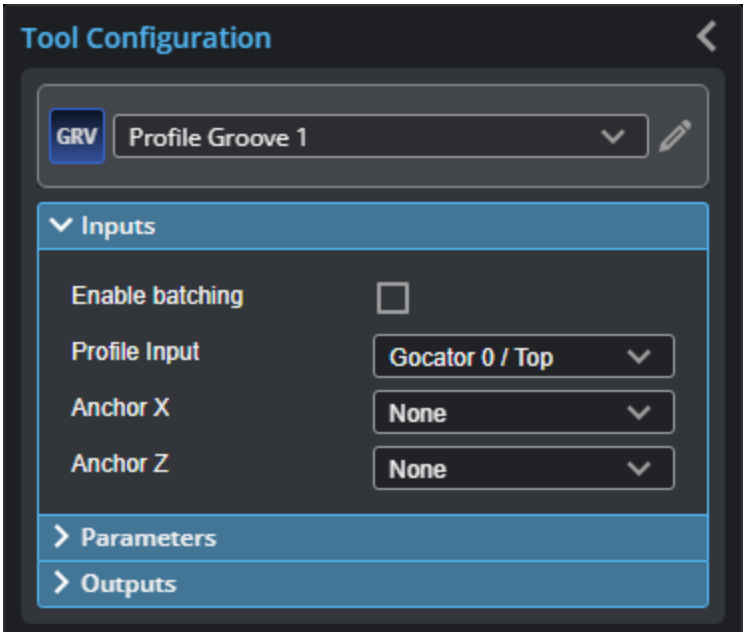

For U-shaped and open groove, the X and Z positions are at the bottom of the groove.

Groove candidates that do not meet the minimum and maximum width and depth settings are rejected. The width and depth measurements are invariant to the groove rotation. The width is the distance between the groove corners and the depth is perpendicular distance of the groove bottom from the groove width.




## Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

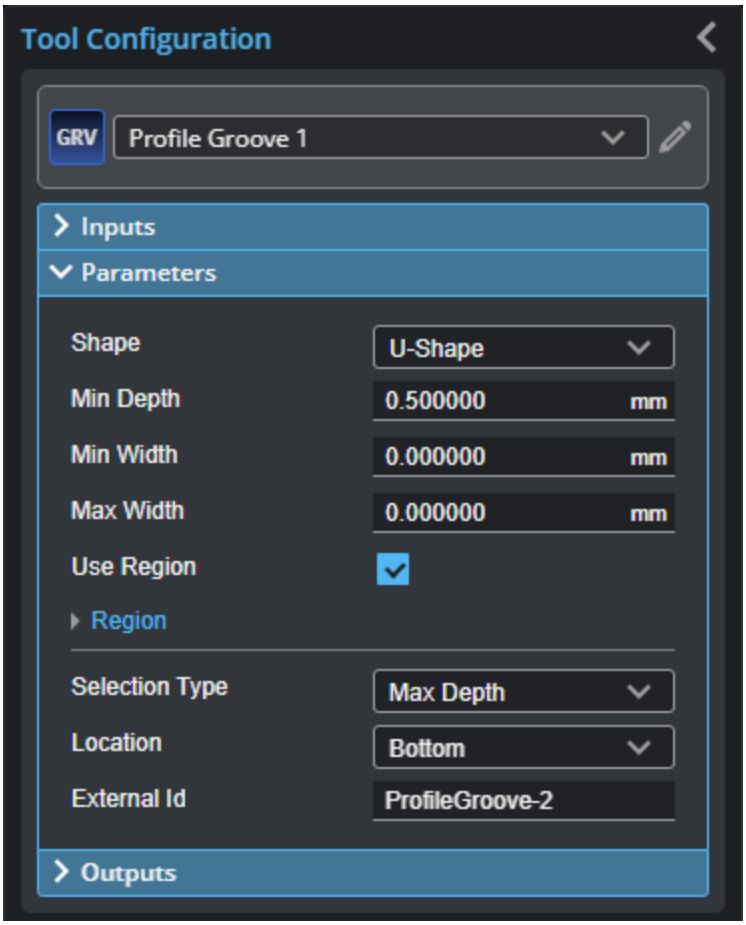
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor. |

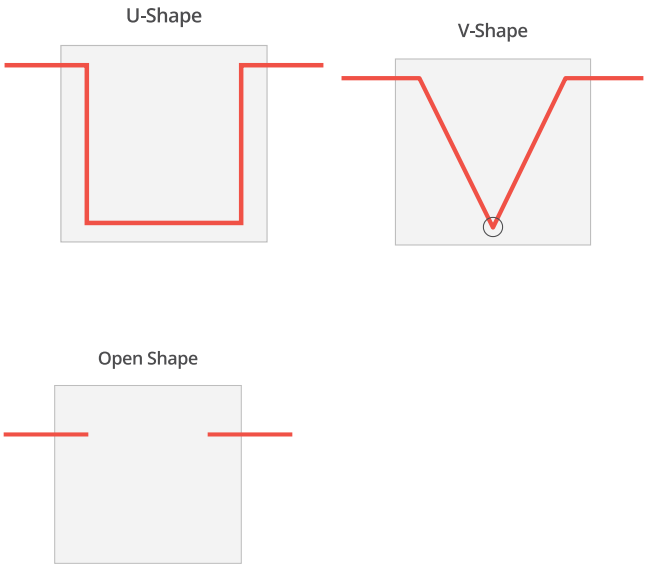
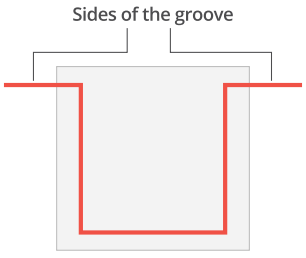
| Name | Description |
| --- | --- |
| | When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



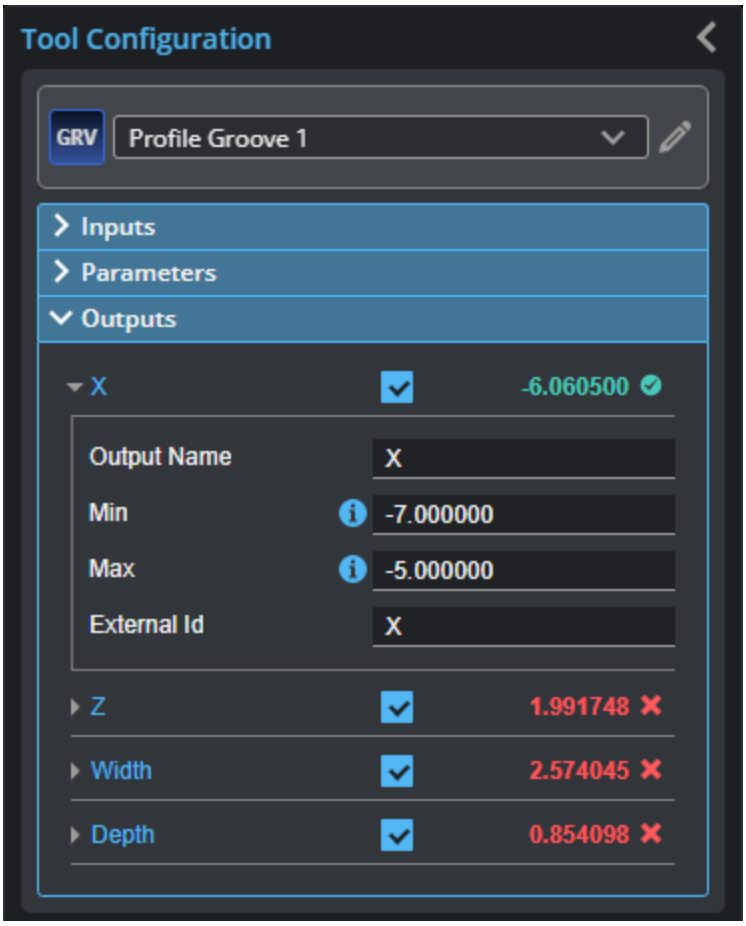
*Parameters*

| Parameter | Description |
|---|---|
| Shape | One of the following: U-Shape, V-shape, or Open.<br>  |
| Min Depth | Minimum depth for a groove to be considered valid. When set to 0, any groove depth is accepted. |
| Min Width | Minimum width for a groove to be considered valid. The width is the distance between the groove corners. When set to 0, any groove width is accepted. |
| Max Width | Maximum width of a groove to be considered valid. If set to 0, the maximum is the width of the region of interest, or the entire profile if **Use Region** is disabled. |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The measurement region defines the region in which the tool searches for a groove. For a stable measurement, the measurement region should be large enough to cover some data on the left and right sides of the groove.<br>  <br>For more information on regions, see *Regions* on page 181. |

| Parameter | Description |
| --- | --- |
| Selection Type | Specifies how a groove is selected when there are multiple grooves the profile data. One of the following:<br>**Maximum Depth**: The groove with the maximum depth.<br>**Index from The Left**: A 0-based groove index, counting from left to right.<br>**Index from the Right**: A 0-based groove index, counting from right to left.<br><br>When you choose either of the "Index from" selection types, a **Selection Index** parameter is displayed. |
| Selection Index | The 0-based groove index the tool uses to select a groove when multiple grooves are visible in the data. The direction depends on whether you set **Selection Type** to **Index from the Left** or **Index from the Right**. |
| Location<br>*(For the X and Z measurements only)* | Specifies the location type to return. One of the following:<br>**Bottom**: The groove bottom. For a U-shape and open-shape groove, the X position is at the center of the bottom of the groove. For a V-shape groove, the X position is at the intersection of lines fitted to the left and right sides of the groove. For more details, see *Groove Algorithm* on page 250.<br>**Left Corner**: The groove's left corner.<br>**Right Corner**: The groove's right corner. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

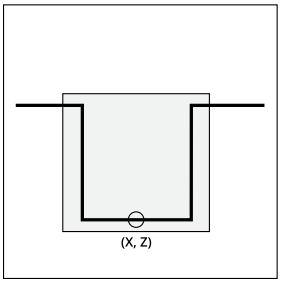
Most tools provide measurements, geometric features, or data as outputs.

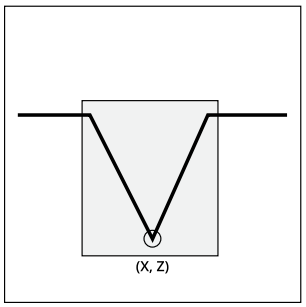
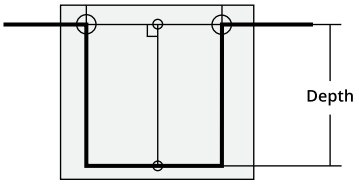
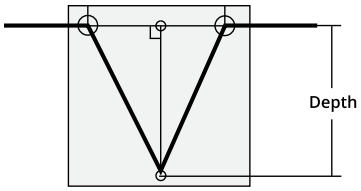



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X, Z**<br>Measures the X and Z position, respectively, of the bottom of a groove. |  |

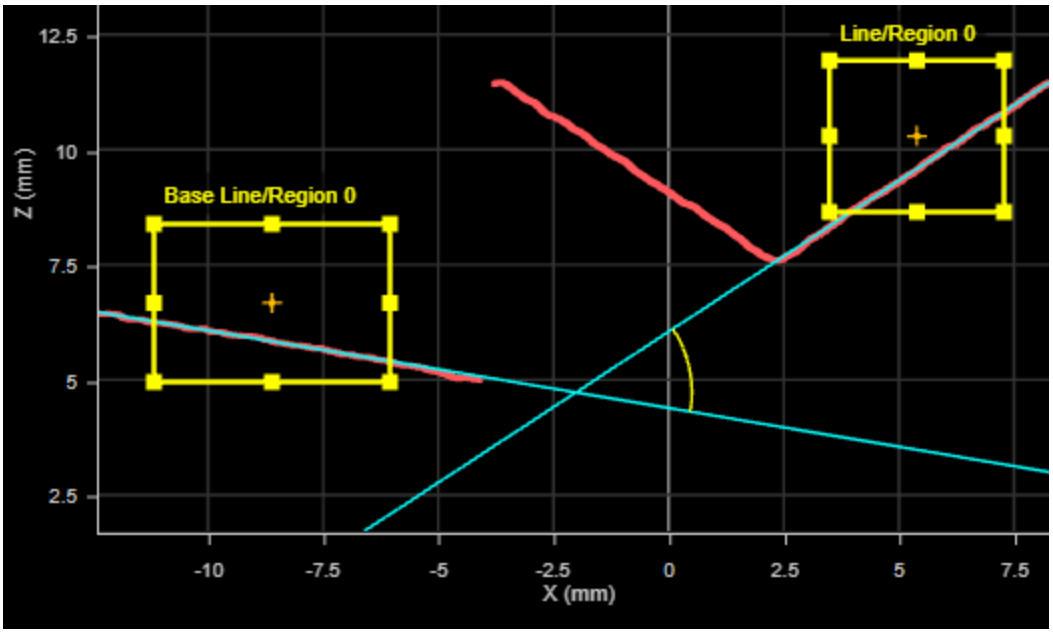
| Measurement | Illustration |
| --- | --- |
| |  |
| **Width**<br>Measures the width of a groove. | <br> |
| **Depth**<br>Measures the depth of a groove as the maximum perpendicular distance from a line connecting the edge points of the groove. |  <br>  |

## Profile Intersect

The Intersect tool determines intersect points and angles.

The Intersect tool's measurements require two fit lines, one of which is a reference line set to one of the following:

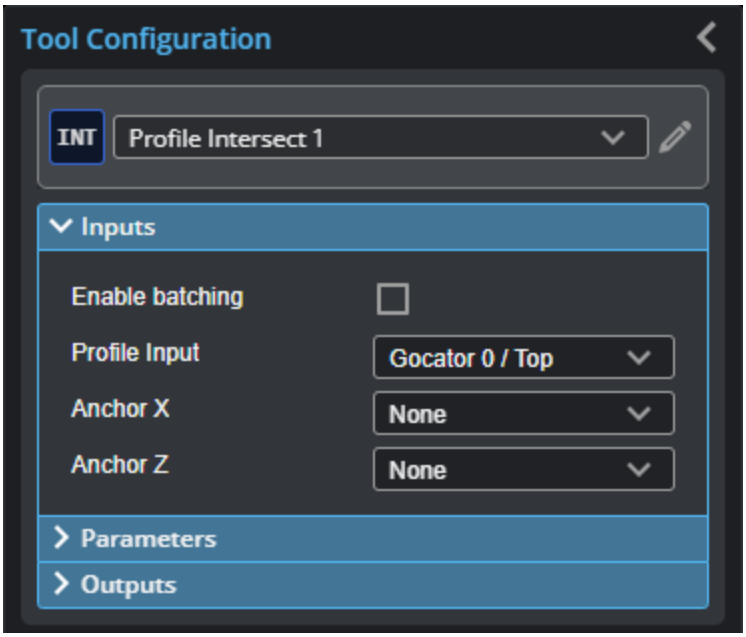
- the X axis (z = 0)
- the Z axis (x = 0)
- a user-defined line




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



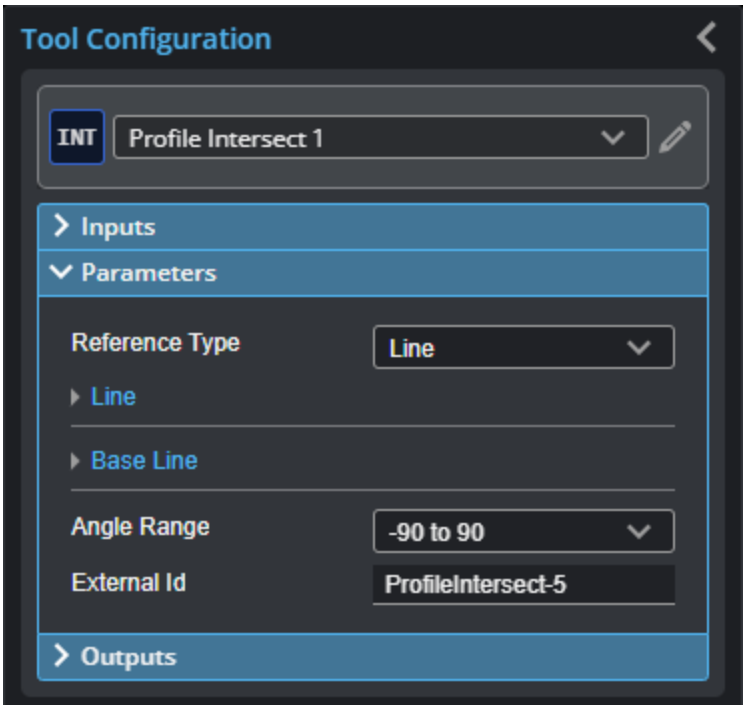

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

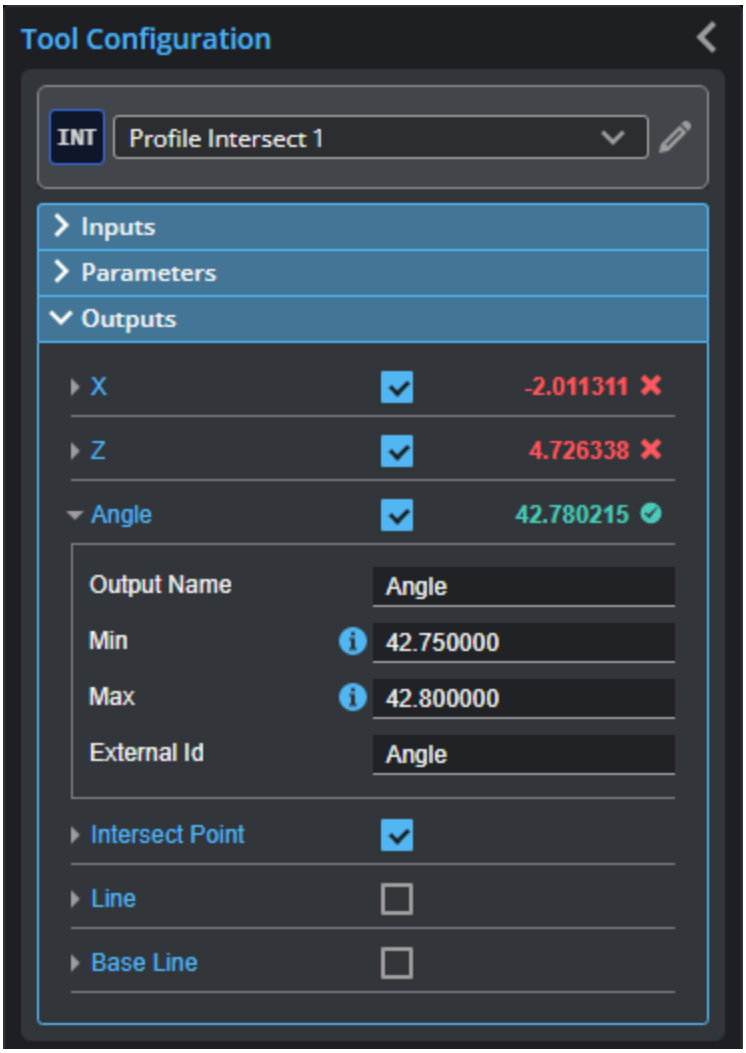



*Parameters*

| Parameter | Description |
|---|---|
| Reference Type | Determines the type of the reference line. One of the following: X Axis, Z Axis, or Line.<br>**X-Axis**The reference line is set to the X axis.<br>**Z-Axis**: The reference line is set to the Z axis.<br>**Line**: You define the reference line manually using the parameters in the **Base Line** section. You can define the line using one or two regions. |
| Line | You can use one or two fit areas for the fit line. To set the region (or regions) of the fit line, adjust it graphically in the data viewer, or expand the feature and enter the values in the fields. For more information on regions, see *Regions* on page 181.<br>For more information on fit lines, see *Fit Lines* on page 192. |
| Base Line | Used to define the reference line when the **Reference Type** parameter is set to **Line**. For more information on regions, see *Regions* on page 181.<br>For more information on fit lines, see *Fit Lines* on page 192. |
| Angle Range | Determines the range returned by the Angle measurement. One of the following:<br>**-90 – 90**<br>**0 – 180** |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

### Outputs

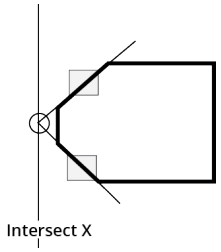
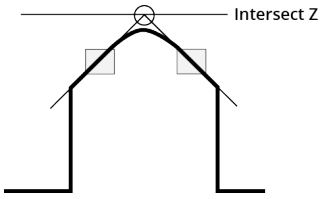
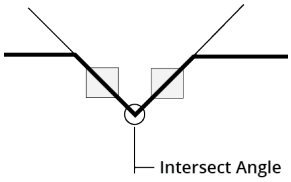
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Finds the intersection between two fitted lines and measures the X axis position of the intersection point. |  |
| **Z**<br>Finds the intersection between two fitted lines and measures the Z axis position of the intersection point. |  |
| **Angle**<br>Finds the angle subtended by two fitted lines. |  |

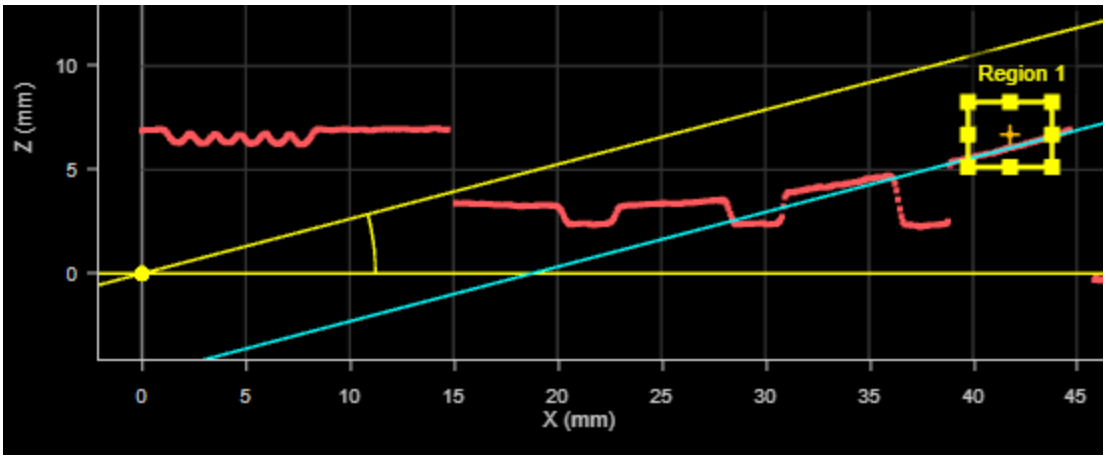
*Features*

| Type | Description |
|---|---|
| Intersect Point | The point of intersection. |
| Line | The intersect line. |
| Base Line | The base line. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Line

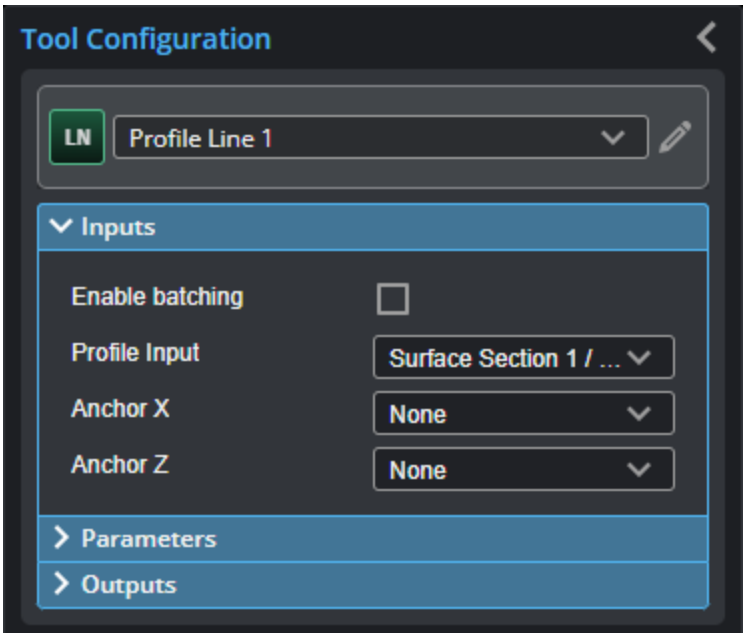
The Line tool fits a line to the profile and measures the deviations from the best-fitted line. The tool also provides two “roughness parameter” measurements: Arithmetic Average and Rz. For a complete list of the measurements the tool provides, see *Measurements* on page 267.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



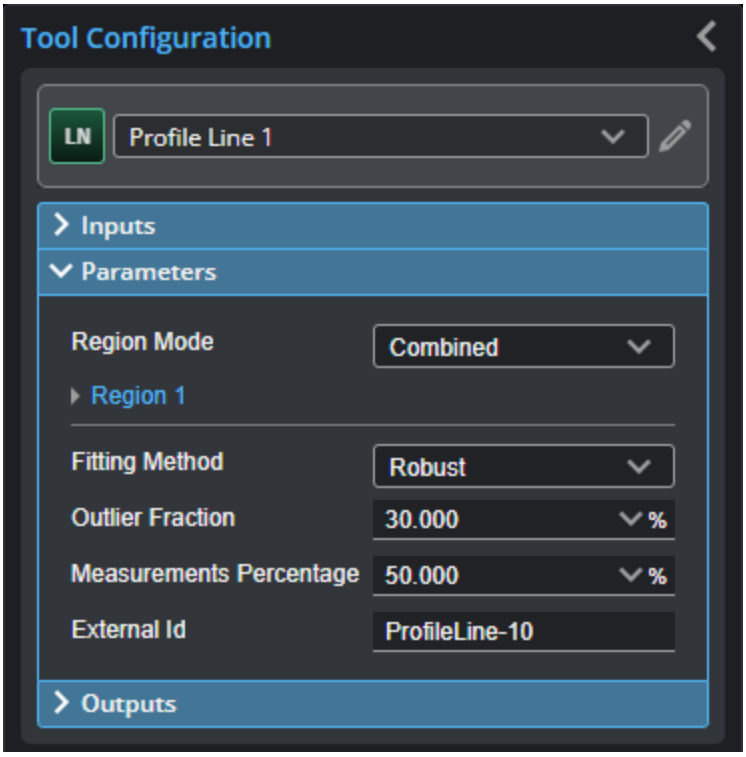

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

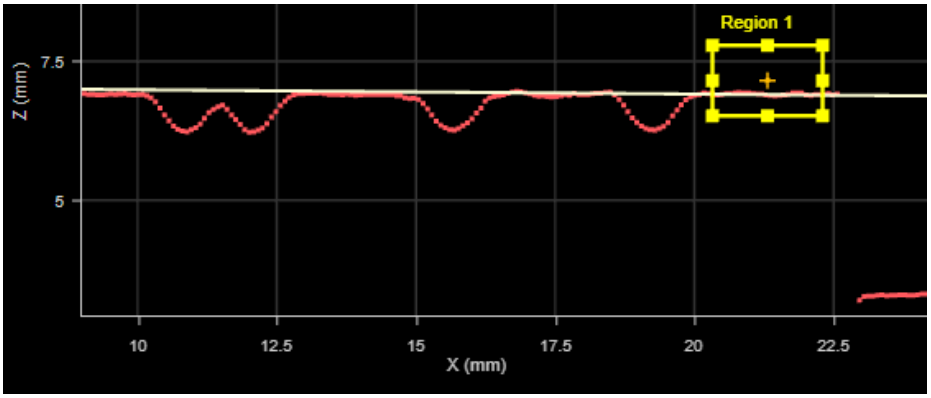
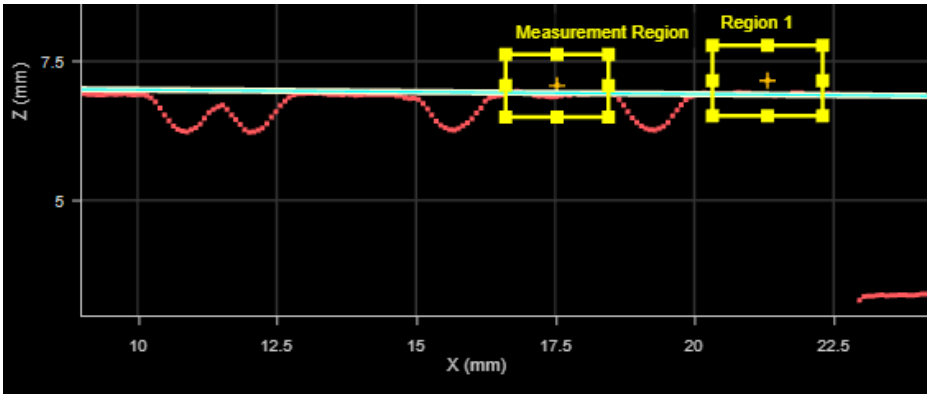
**Parameters**

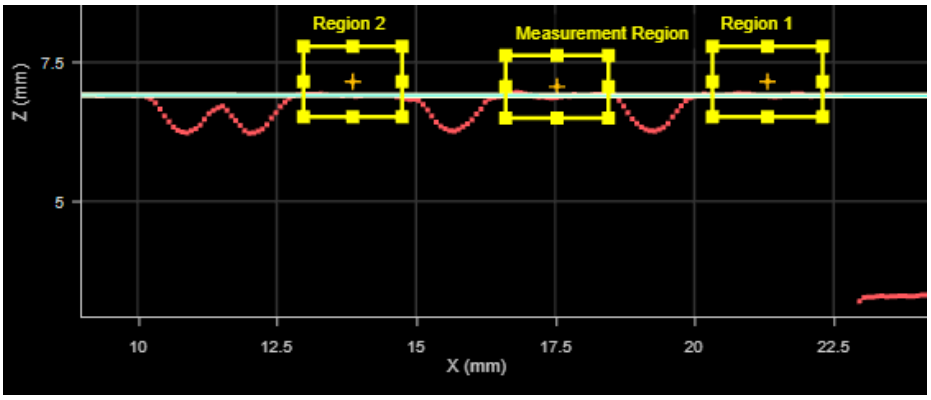
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

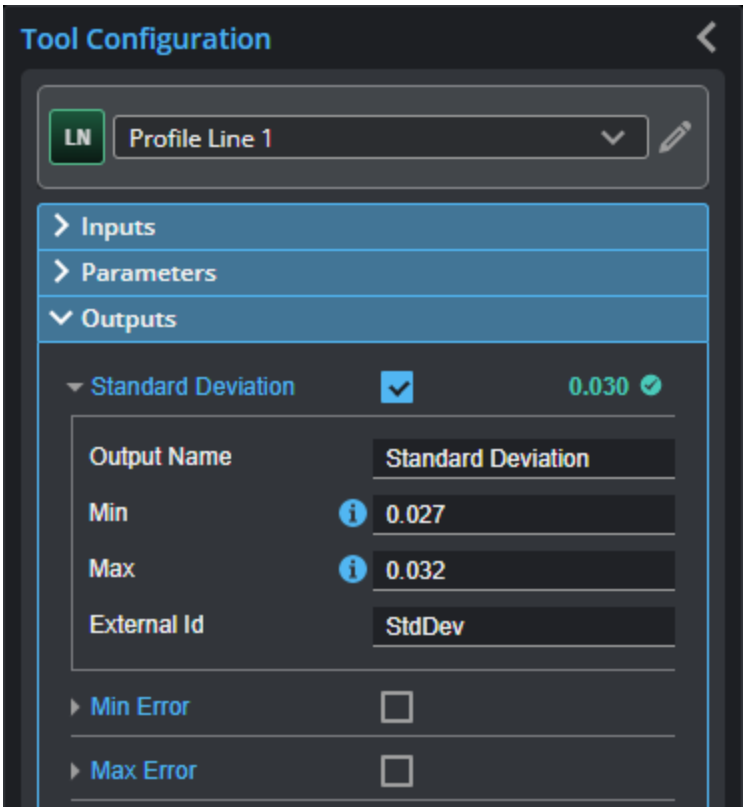
| Name | Description |
|---|---|
| Region Mode | Whether the fitting and measurement regions are used, and whether they are combined or separate. One of the following: |

| Name | Description |
| --- | --- |
| | **None**<br>The tool uses the entire profile both to fit the line and to perform measurements.<br>**Combined**<br>The tool uses a single, user-defined region to fit the line, in which it also performs measurements.<br>  <br><br>**Separated**<br>The tool uses one or two regions to fit the line (selected using the **Number of Regions** parameter), and a single, separate region in which it performs measurements. (Offset and Angle measurements are related to the fitted line and are associated with the fitting region, rather than the measurement region.)<br>In the following, the tool uses a single region to the left to fit the line, and performs measurements in the measurement region to the right:<br>  <br><br>In the following image, the uses two regions to the left to fit the line, and performs measurements in the measurement region to the right: |

| Name | Description |
|---|---|
| |  |
| Number of Regions | When **Region Mode** is set to Separated, lets you choose the number of regions. |
| Region {n}<br>Measurement Region | Use these expandable region sections to define the position and size of the fitting and measurement regions precisely. (Use the mouse to position and size them more roughly.)<br>The number of region parameters displayed depends on the mode selected in **Region Mode**. |
| Fitting Method | Determines how the tool fits the line to the profile. One of the following:<br>**Simple**<br>Uses a less accurate but faster line-fitting method.<br>**Robust**<br>An iterative line-fitting method that removes points and attempts to fit a line until only the fraction set in **Outlier Fraction** of the original profile data points is left. More accurate but takes longer. When **Fitting Method** is set to Robust, set **Outlier Fraction** (see below). |
| Outlier Fraction | The fraction of outlier points to be removed during line fitting. Adjust this value based on how much noise is present in the profile. By default, 30%.<br>Only displayed when **Method** is set to **Robust**. |
| Measurements Percentage<br>*(Percentile measurement only)* | The specified percentage of points around the best-fitted line that the Percentile measurement uses. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

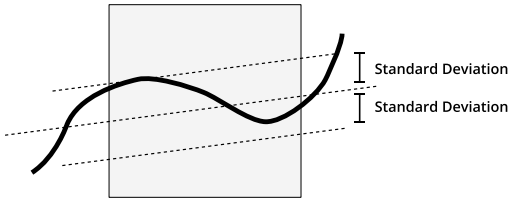
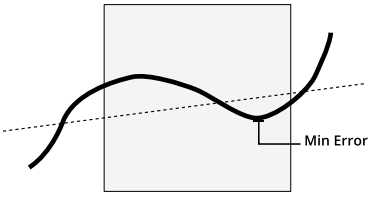
Most tools provide measurements, geometric features, or data as outputs.

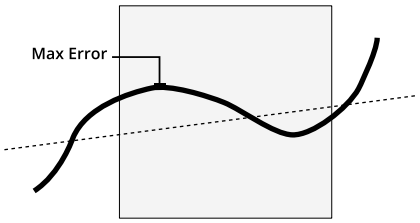
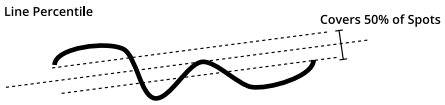
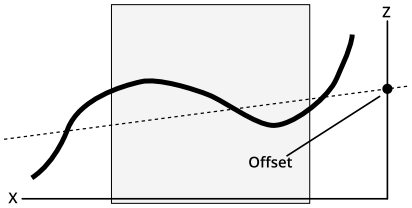
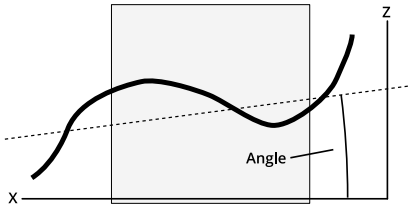
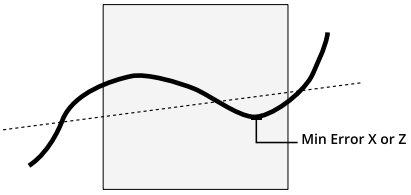
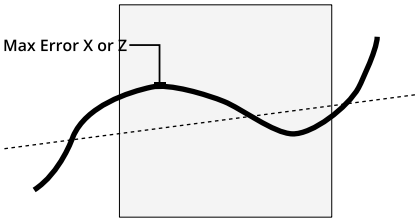
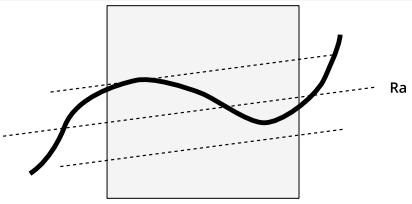


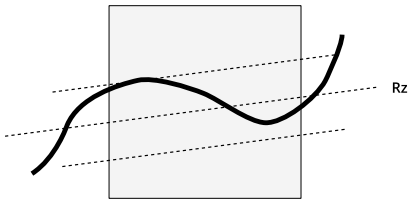

*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Standard Deviation**<br>Finds the best-fitted line and measures the standard deviation of the data points from the line. |  |
| **Min Error**<br>Finds the best-fitted line and measures the minimum error from the line (the maximum distance below the line). |  |

| Measurement | Illustration |
| --- | --- |
| **Max Error**<br>Finds the best-fitted line and measures the maximum error from the line (the maximum distance above the line). |  |
| **Percentile**<br>Finds the best-fitted line and measures the range (in Z) that covers a percentage of points around the line. |  |
| **Offset**<br>Finds the best-fitted line and returns the intersection point between that line and the Z axis. |  |
| **Angle**<br>Finds the best-fitted line and returns the angle relative to the X axis. |  |
| **Min Error X**<br>**Min Error Z**<br>Finds the best-fitted line and returns the X or Z position of the minimum error from the line (the maximum distance below the line). |  |
| **Max Error X**<br>**Max Error Z**<br>Finds the best-fitted line and returns the X or Z position of the maximum error from the line (the maximum distance above the line). |  |
| **Arithmetic Average**<br>Returns the roughness average of the profile data.<br>Ra = SUM_N(abs(distance)) / (N)<br>where N is the total number of non-outlier points, and the distance is from each point to the fitted line. |  |

| Measurement | Illustration |
|---|---|
| **Rz**<br>Returns the maximum height of the profile data.<br>Rz = abs(smallest distance) + abs(biggest distance)<br>The distance is from each non-outlier point to the fitted line. |  |

*Features*

| Type | Description |
|---|---|
| Line | The fitted line. |
| Min Error Point | The point of minimum error. |
| Max Error Point | The point of maximum error. |

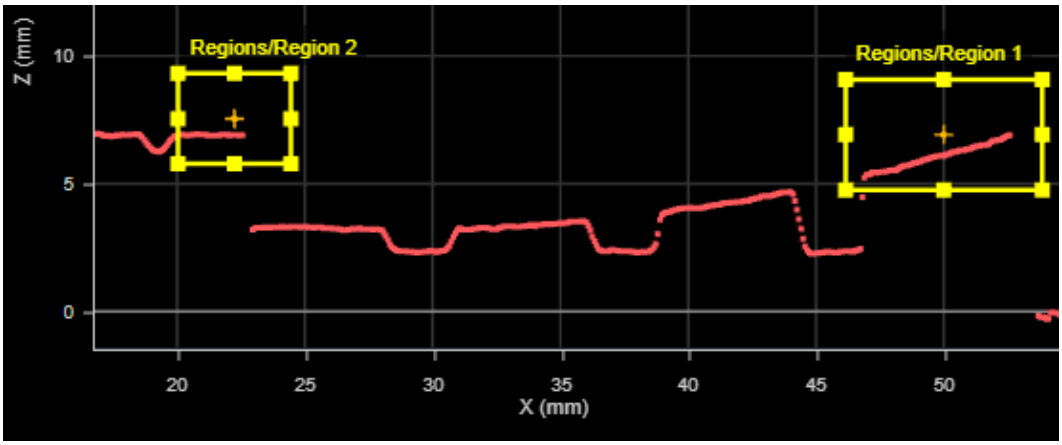
For more information on geometric features, see *Geometric Features* on page 191.

## Profile Mask

The Profile Mask tool lets you define up to 16 regions to extract data from a profile. Each region's size, position, and shape (circular, elliptical, and rectangular) can be individually configured, and regions can overlap. The tool can also exclude inner data of circular and elliptical regions, letting you avoid measuring noise or unwanted areas of profile data. Extracted data is output in a single profile.

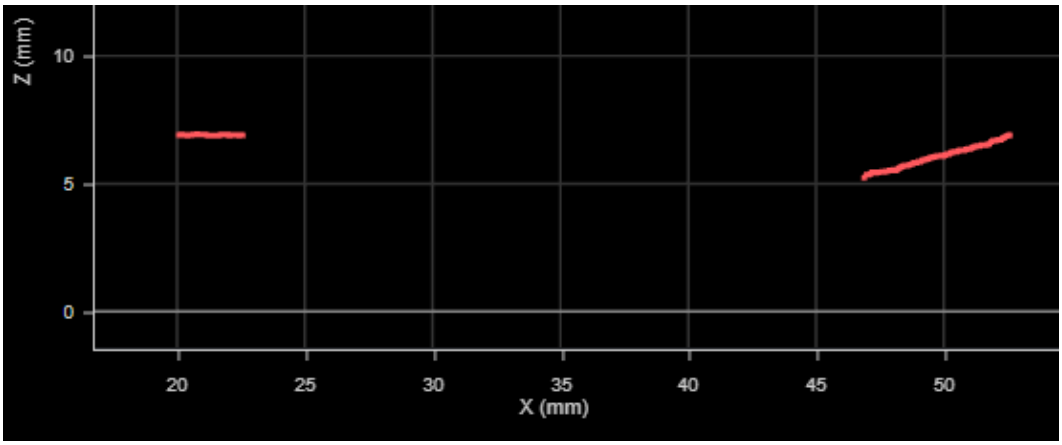
The resulting profile can then be further processed or measured by other tools.

For example, given the following scan data:




*Two mask regions defined on a profile (original profile, all data included)*

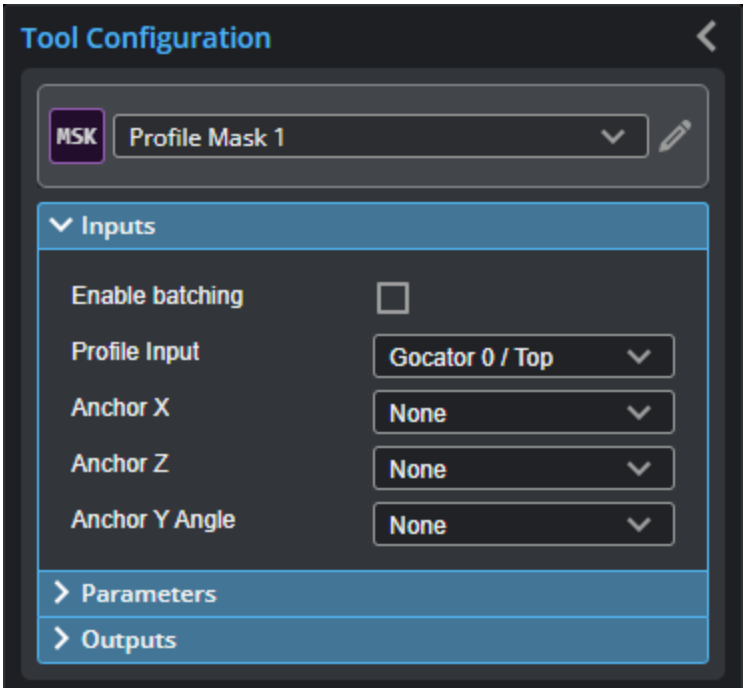
The image below shows the extracted data. The extracted profile data can then be further processed by other tools, or measurements can be applied to the surface data.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

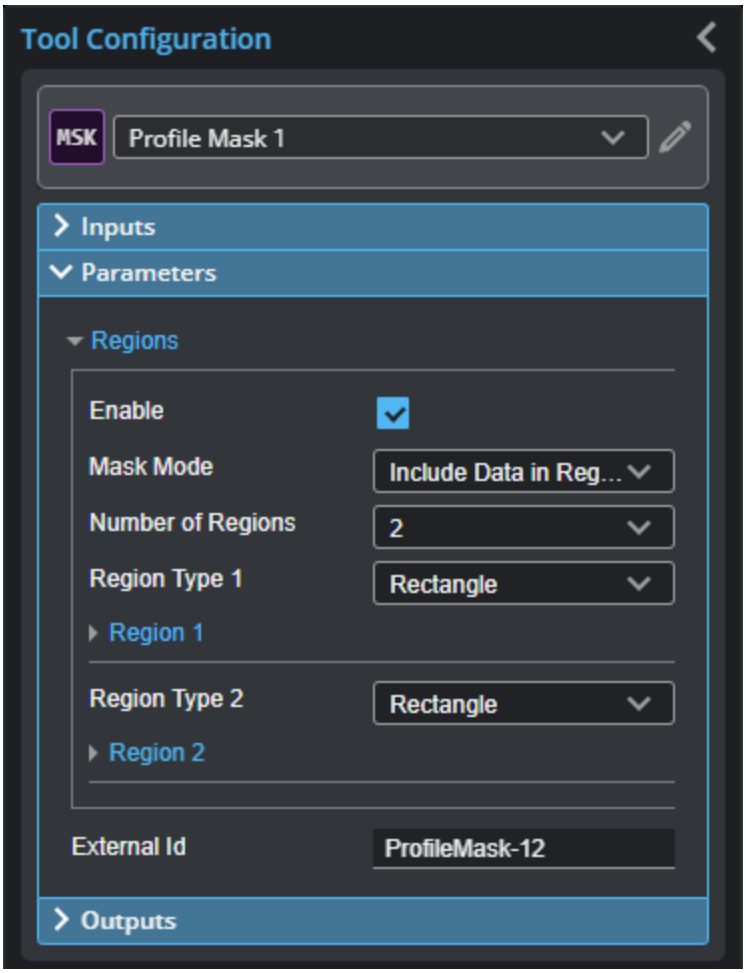
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the |

| Name | Description |
|---|---|
| | array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Y Angle | The Y angle measurement of another tool that this tool uses as a rotational anchor. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



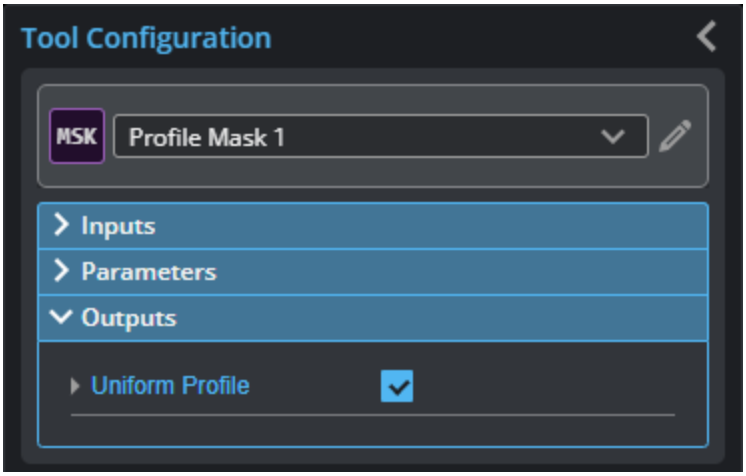

*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays region-related settings. For details on the regions and their settings, see *Flexible Regions* on page 183. |

| Parameter | Description |
| --- | --- |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

| Type | Description |
| --- | --- |
| Uniform Profile<br>Point Cloud Profile | The profile containing the extracted region or regions. |

## Profile Panel

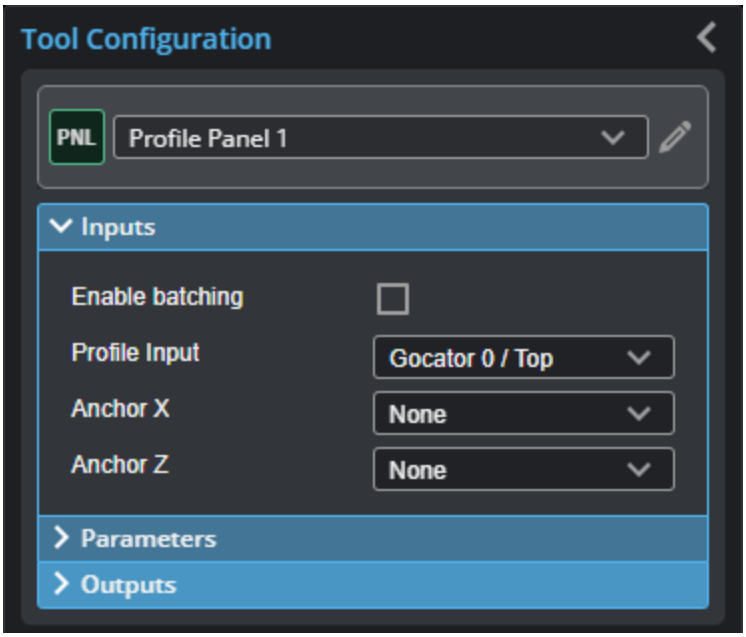
The Panel tool provides Gap and Flush measurements.

The Panel tool uses a complex feature-locating algorithm to find the gap or calculate flushness and return measurements. The behavior of the algorithm can be adjusted by changing the tool's parameters. For a detailed explanation of the algorithm, see *Gap and Flush Algorithms* on page 281.

> You must make sure that there are enough data points to define the edge in the profile, by properly setting up exposure, etc. If not, the algorithm will not function.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs




> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

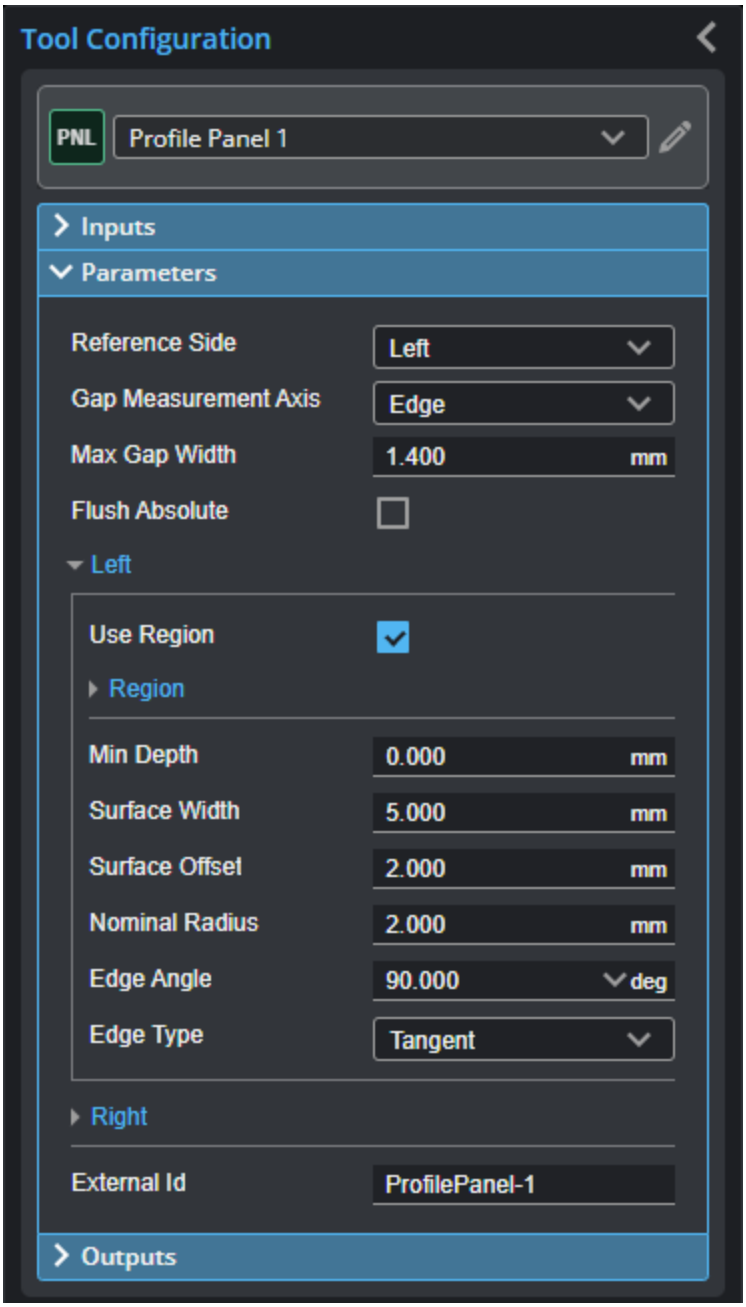
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |

| Name | Description |
| --- | --- |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

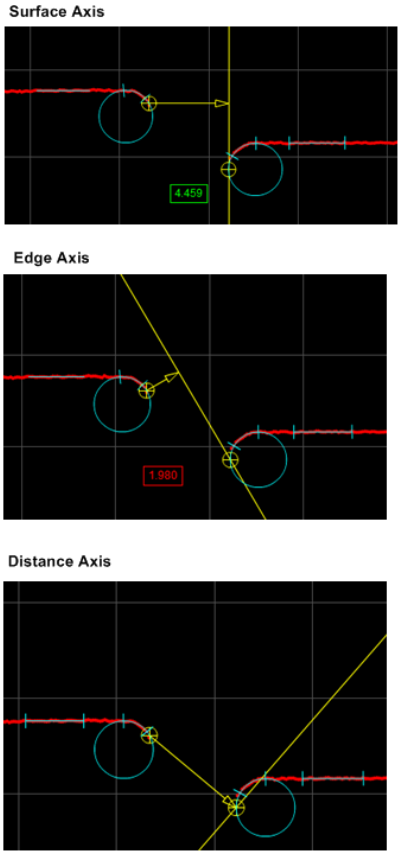
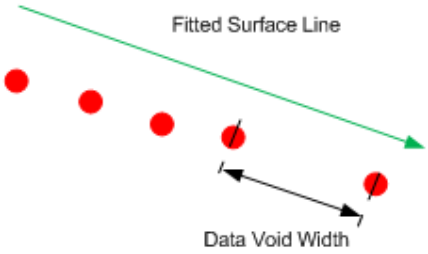
**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

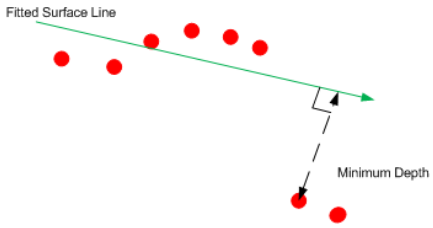
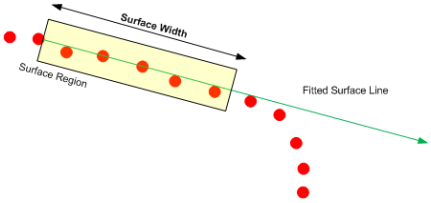
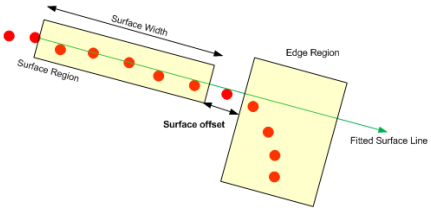
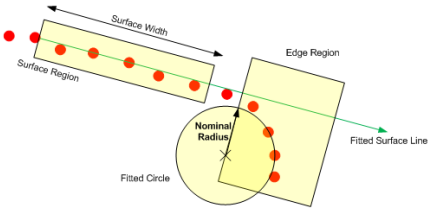


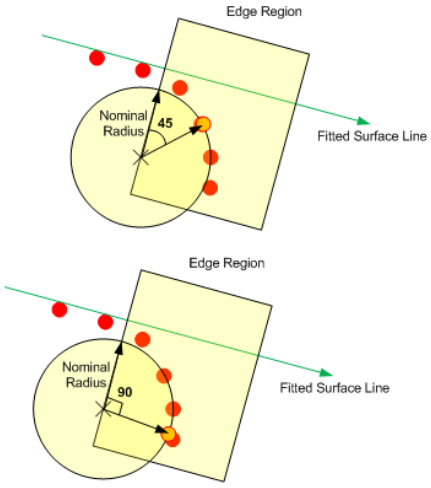
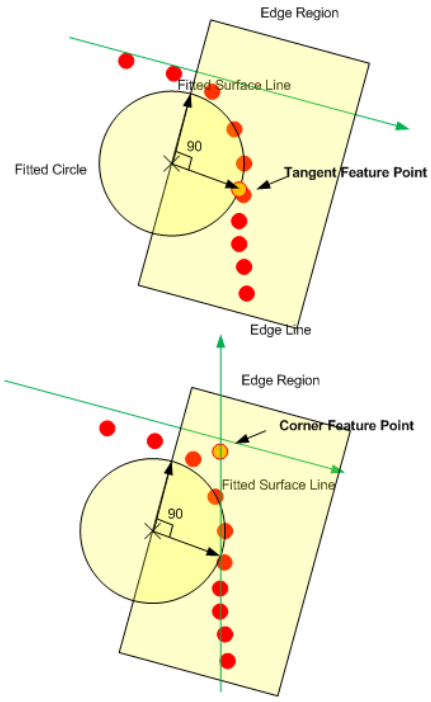

*Parameters*

| Parameter | Description |
|---|---|
| Reference Side | Defines the side used to calculate the measurement axis (see below) rounded corner. |
| Gap Measurement Axis<br>*Gap measurement only* | Defines the direction that the gap is calculated, in relation to the reference side (see above).<br>**Surface**: In the direction of the fitted surface line of the reference surface.<br>**Edge**: In the direction perpendicular to the edge of the reference surface. |

| Parameter | Description |
| --- | --- |
| | **Distance**: The Cartesian distance between the two feature locations.<br>  |
| Max Gap Width | The maximum width of the gap. Allows the tool to filter gaps greater than the expected width. This can be used to single out the correct gap when there are multiple gaps in the field of view.<br>  |
| Flush Absolute<br>*Flush measurement only* | When enabled, the Flash measurement returns an absolute value instead of a signed value. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

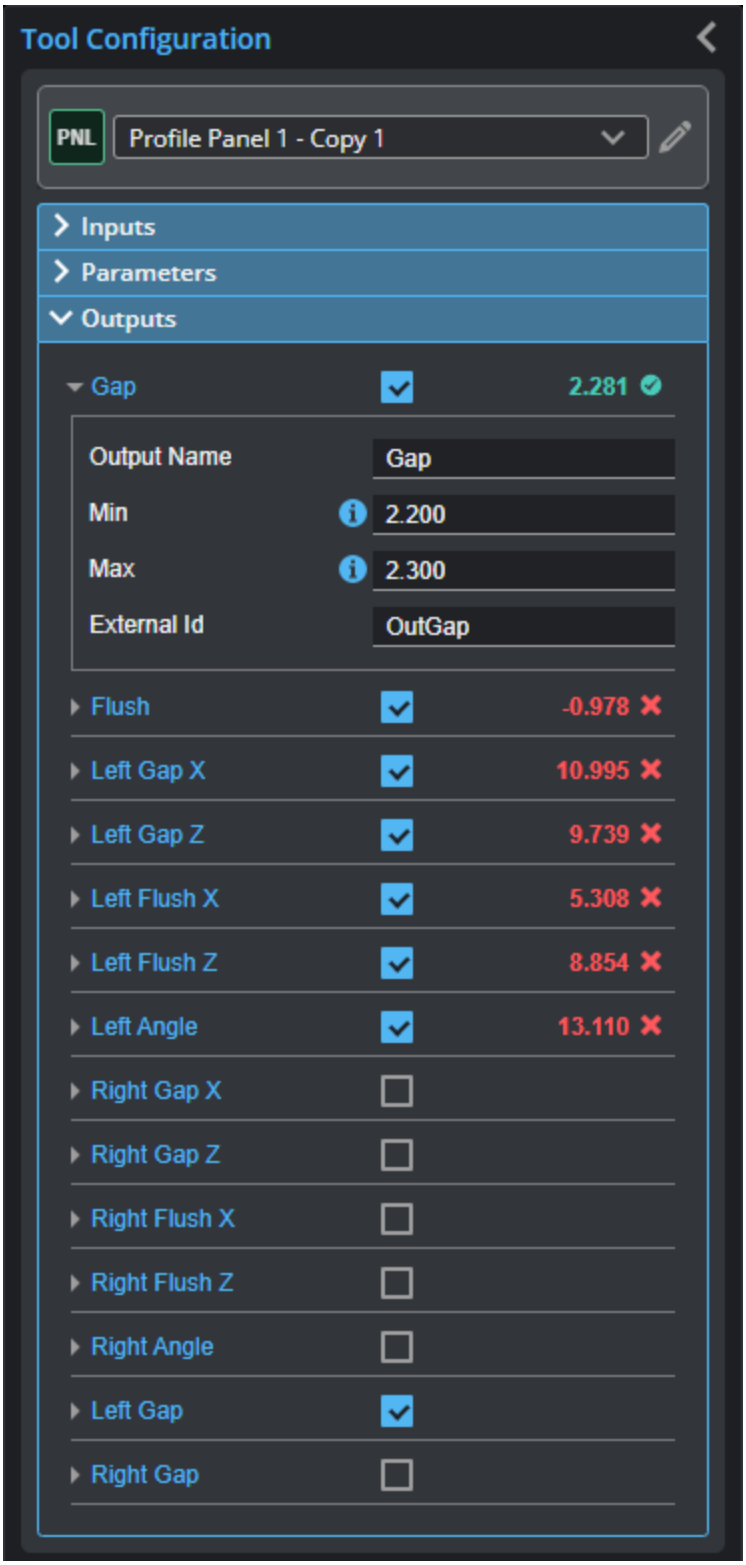
*Left and Right Parameters*

| Parameter | Description |
|---|---|
| Min Depth | Defines the minimum depth before an opening can be considered to have a potential edge. The depth is the perpendicular distance from the fitted surface line.<br>  |
| Surface Width | The width of the surface area in which data is used to form the fitted surface line. This value should be as large as the surface allows. Make sure the surface width does not go beyond the edge of the region of interest (that is, with **Region** enabled).<br>  |
| Surface Offset | The distance between the edge region and the surface region.<br>  <br>Setting a small value allows the edge within a tighter region to be detected. However, the measurement repeatability could be affected if the data from the edge are considered as part of the surface region (or vice versa). A rule of thumb is to set **Surface Offset** equal to **Nominal Radius**. Make sure the surface offset does not move the surface width (see above) beyond the end of the region of interest (that is, with **Region** enabled). |
| Nominal Radius | The radius of the curve edge that the tool uses to locate the edge region.<br>  |
| Edge Angle | A point on the best fit circle the tools uses to calculate the feature point. The selected point is on the circumference at the specified angle from the start of the |

| Parameter | Description |
| --- | --- |
| | edge region.<br>  <br><br>The angle is measured from the axis perpendicular to the fitted surface line. |
| Edge Type | Defines the type of feature point to use for the edge (Corner or Tangent).<br>  <br><br>A tangent edge point is the point selected based on the defined Edge Angle. A corner edge point is the intersect point between the fitted surface line and an edge line formed by interpolating the points at and after the tangent within the edge region. |

**Outputs**

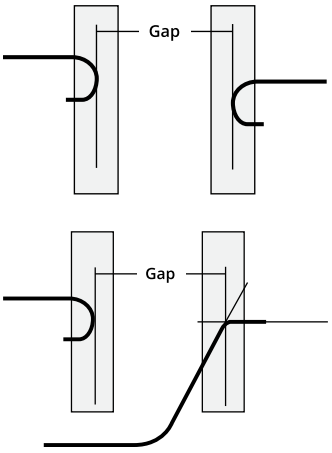
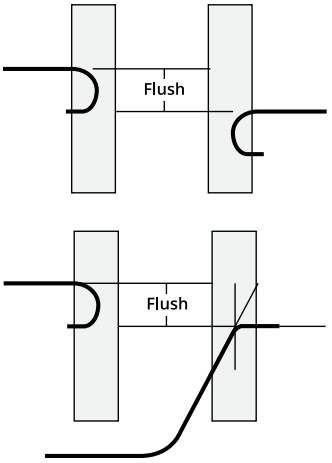
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Gap**<br>Measures the distance between two surfaces. The surface edges can be curved or sharp. |  |
| **Flush**<br>Measures the flushness between two surfaces. The surface edges can be curved or sharp. |  |
| **Left Gap X**<br>**Left Gap Z**<br>The X and Z position of the edge feature on the left side used to measure the gap. | |
| **Left Flush X**<br>**Left Flush Z**<br>Returns the X and Z position of the feature on the left side used to measure flushness. | |
| **Left Angle**<br>**Right Angle**<br>The angle of the left and right side surface relative to the X axis. | |

| Measurement | Illustration |
|---|---|
| **Right Gap X**<br>**Right Gap Z**<br>Returns the X and Z position of the edge feature on the right side used to measure the gap. | |
| **Right Flush X**<br>**Right Flush Z**<br>Returns the X and Z position of the feature on the right side used to measure flushness. | |

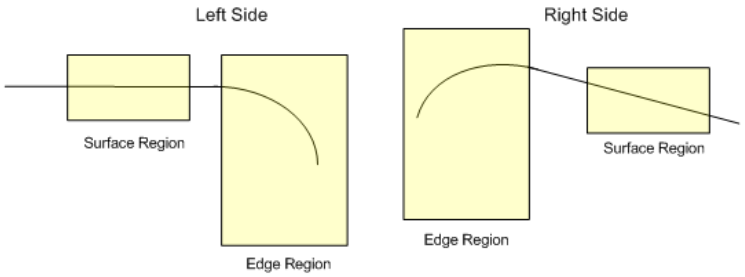
*Data*

| Type | Description |
|---|---|
| Left Gap<br>Right Gap | Point geometric features representing the point defined by Left Gap X and Left Gap Z, and Right Gap X and Right Gap Z, respectively.<br>Use a side's **Edge Angle** parameter to choose where on the fitted circle the points fall. |

**Gap and Flush Algorithms**

The Panel measurement tool uses the same algorithm to find a feature using either the Gap or the Flush measurement. The Round Corner tool uses the same algorithm, but applies it only to the left or the right; you must choose the side in the tool.

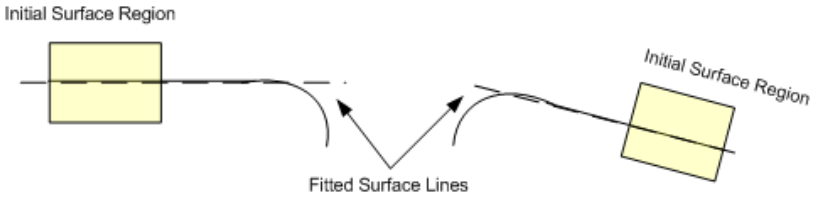
This algorithm first searches for two regions on a side: a surface region and an edge region. (See the tables below for the parameters used by the algorithm.)



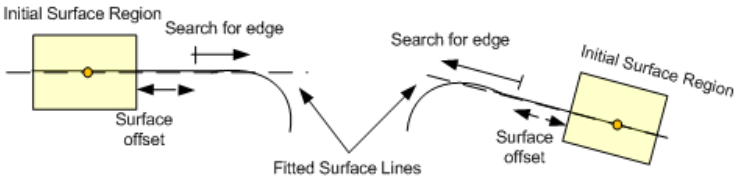

After the algorithm finds the regions, it places a feature point on the surface region based on a set of parameters. You can control the measurement regions, which contain the surface and the edge regions, for the left and the right side. A measurement region also defines the region in which the measurement tool will search for the feature points. Feature points are located on a side using the following algorithm.

1. On the left side, search from left to right to find a surface region with data that covers at least the value specified in the **Surface Width** setting. For the right side, do the same, searching from right to left.

2. If a surface region is found, fit a line, called the surface line, using the data within the area.

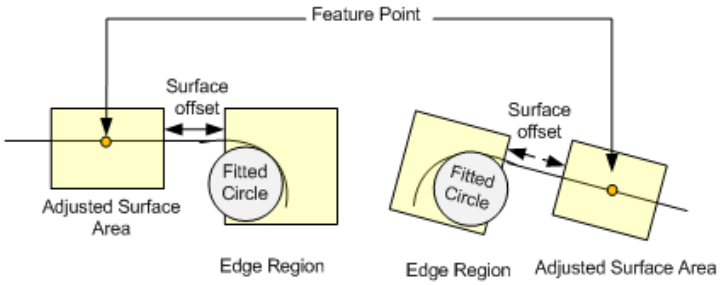



3. Search for a valid edge region that is located at least the distance specified in the **Surface Offset** setting from the end of the surface region. If a surface region is not found, move along the search direction and repeat step 1.




A valid edge region is detected when an edge matches the value in the **Nominal Radius** setting or when the depth exceeds the value in the **Min Depth** setting.

4. If a valid edge region is detected, a model fit is applied to the surface and edge regions to accurately determine the region positions and feature point locations. The model fit takes into account the **Surface Width**, **Surface Offset**, **Edge Angle** and the **Edge Type** parameters.



## Profile Part Detection

Profile sensors can produce Surface data for applications where a transport system such as a conveyor continuously feeds discrete parts or material under a sensor. Typically, you will set a sensor to Surface mode on the **Acquire** page, set **Surface generation type** to Continuous, and then configure the part detection parameters on the **Acquire** page. The sensor will then output Surface data for each part it detects.

The Profile Part Detection tool uses the same parameters available with continuous generation Surface mode, but also provides diagnostics that can be useful for troubleshooting. After troubleshooting part detection using this tool, you can copy the settings from the tool to the **Acquire** page. The diagnostics are output as measurements by the tool.

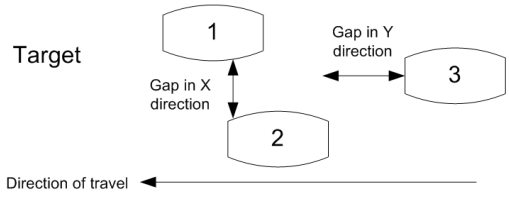
Note that the Profile Part Detection has a **Frame of Reference** parameter not available when using continuous Surface generation.

For more information on Surface generation, see *Surface Generation* on page 113.

Remember that when using this tool, the sensor is set to *Profile* mode.

The Profile Part Detection tool takes a series of profiles as input, analyzes the characteristics of each profile based on the configuration of the tool's parameters, and identifies discrete objects and then outputs them as Surface data. Surface measurements can then be performed on each object. This method of surface generation is typically used when a transport system such as a conveyor continuously feeds parts or material under a sensor. The parts or material must have a distinguishable start and stop edge. The sensor continuously generates surfaces of parts that are detected under the sensor.

Multiple parts can pass through the laser or LED light at the same time and will be individually tracked. Parts can be separated along the profile line (X axis), in the direction of travel (Y axis), or by gated external input.




Gocator also lets you isolate and then measure parts using one of two Surface measurement tools (for more information on these tools, see *Surface Blob* on page 399 and *Surface Segmentation* on page 569).

Part detection can be performed when **Source** on the **Acquire** page in the **Trigger** panel is set to **Time** or **Encoder**. To use the **Time** trigger source, the travel speed must be calibrated. To use the **Encoder** trigger source, the encoder resolution must be calibrated.

The Profile Part Detection tool is only available when **Enable uniform spacing (resampling)** is checked: the tool does not support point cloud profile data.

In addition to a Part Surface output, the tool also returns the Point geometric feature of center of the detected part, and several measurement tool that you can use as diagnostics (for example, to see

the number of parts accepted, the number of parts rejected and why, the part's length, and so on). For a complete list of the diagnostics, see below.

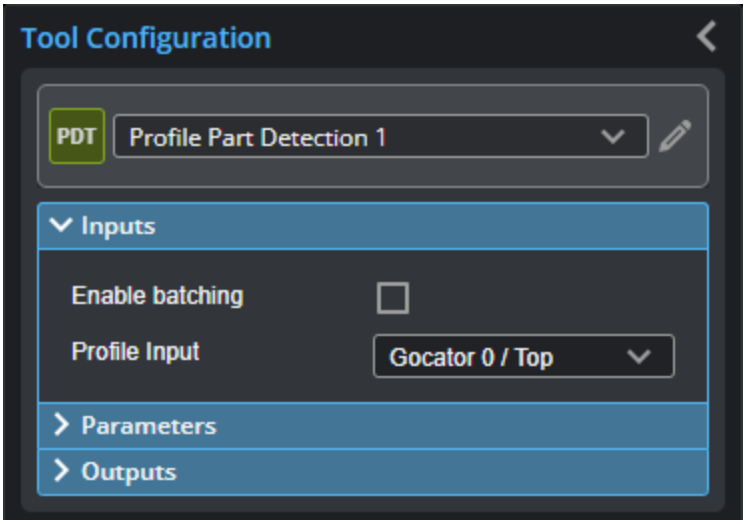
When working with previously recorded Profile scan data, you can set the FPS replay setting to a value high enough that parts are displayed in a reasonable amount of time. You can also optionally enable the Continuous Loop to loop through parts continuously.

> In order to see a detected part's Surface data when the Profile Part Detection tool is selected in the list of added tools, the Part Surface must be selected in the list of outputs or pinned below the data viewer.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

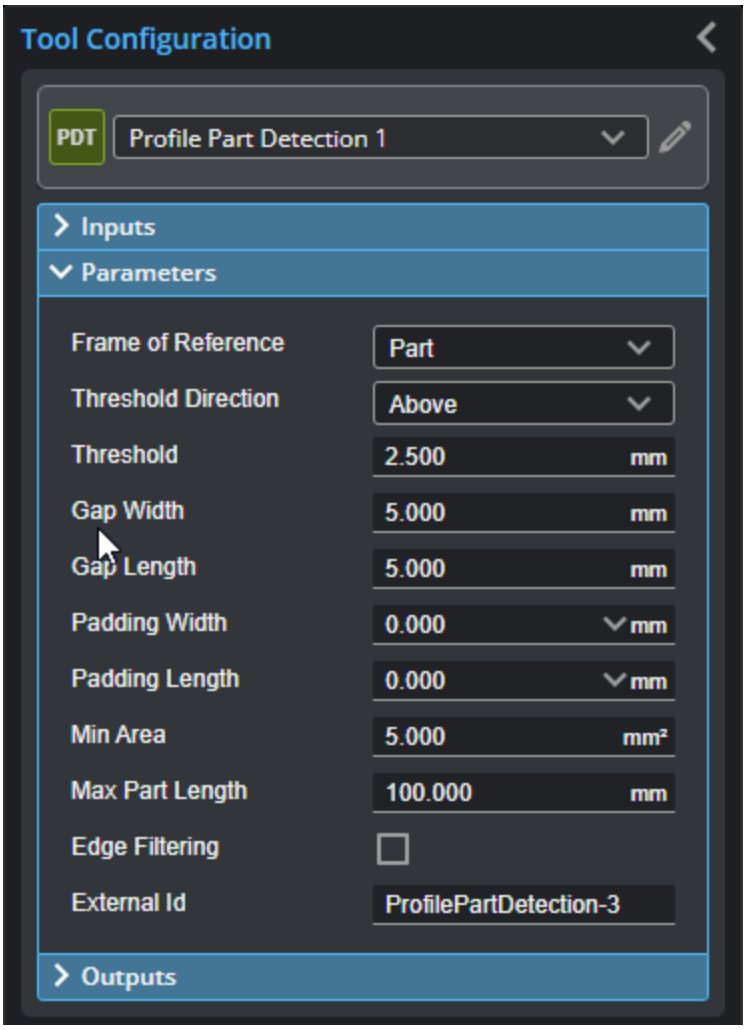



*Inputs*

| Name | Description |
|---|---|
| Profile Input | The source of profiles for the tool. |

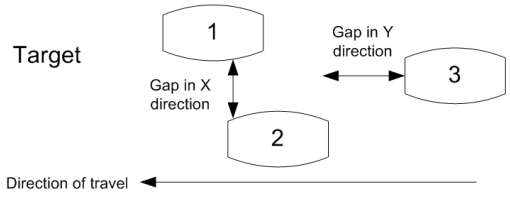
### Parameters

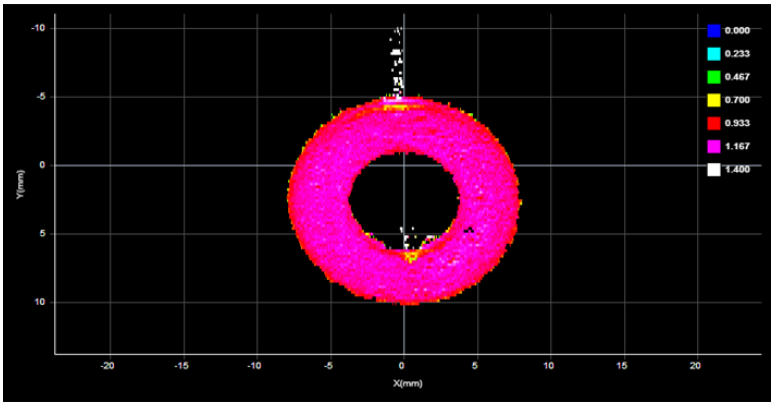
You configure the tool's parameters in the expandable **Parameters** section.

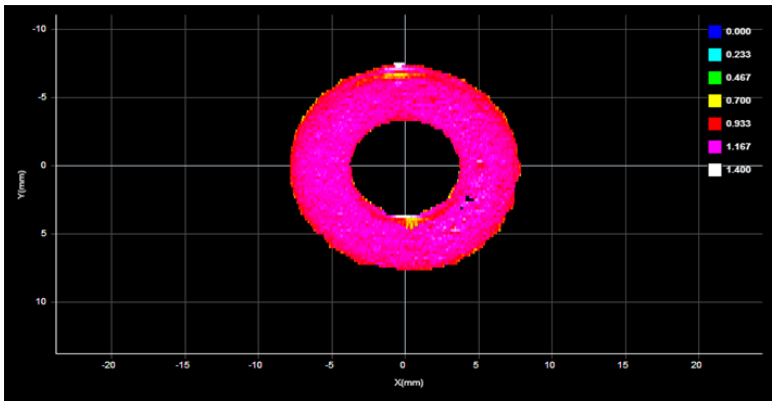
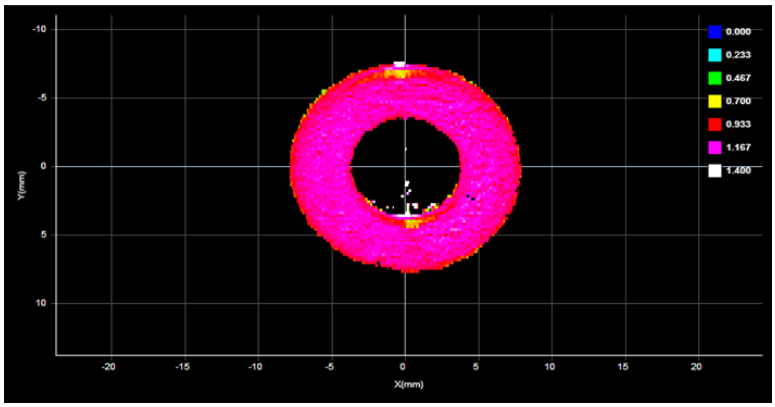



*Parameters*

| Parameter | Description |
|---|---|
| Height threshold | Determines the height threshold for part detection. The setting for **Threshold Type** (see above) determines if parts should be detected above or below the value in **Threshold**. Above is typically used to prevent the belt surface from being detected as a part when scanning objects on a conveyor. |
| Threshold direction | Determines if parts should be detected above or below the height threshold. |
| Gap Width<br>Gap Length | **Gap Width** and **Gap Length** determine the minimum separation between objects on the X and the Y axis, respectively. If parts are closer than the gap interval, they will be merged into a single Surface output. |

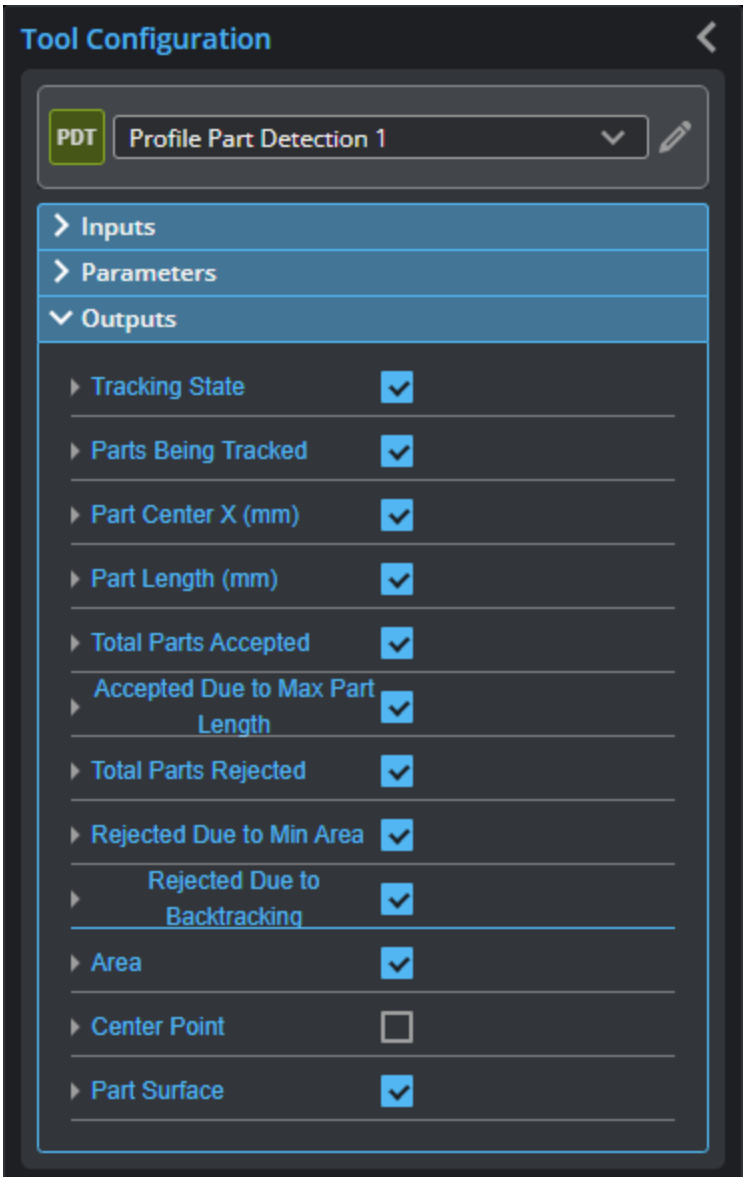


| Parameter | Description |
| --- | --- |
| Padding Length | These parameters are useful when processing part data with third-party software such as HexSight, Halcon, etc.<br>**Padding Width** and **Padding Length** control the amount of additional scan data output in the X and Y directions, respectively. The padding can contain data points that were outside the height threshold and excluded from the initial part detection. |
| Min Area | Determines the minimum area for a detected part. Set this value to a reasonable minimum in order to filter out small objects or noise. |
| Max Length | Determines the maximum length of the part object. When the object exceeds the maximum length, it is automatically separated into two parts. This is useful to break a long object into multiple sections and perform measurements on each section. |
| Edge Filter | When **Edge Filter** is enabled, an **Edge Filter** expanding section is displayed that contains the settings described below.<br>Part scans sometimes contain noise around the edges of the target. This noise is usually caused by the sensor's light being reflected off almost vertical sides, rounded corners, etc. Edge filtering helps reduce edge noise in order to produce more accurate and repeatable volume and area measurements, as well as to improve positioning of relative measurement regions.<br>(The following screenshots are from a G2 sensor.)<br>  <br>*Edge Filter disabled (scan shows reflection noise)* |

| Parameter | Description |
| --- | --- |
| |  <br>*Edge Filter enabled (reflection noise eliminated or reduced)*<br>  <br>*Edge Filter enabled, Keep Interior enabled* |
| Keep Interior | The **Keep Interior** setting limits filtering to the outside edges of the target. |
| Edge Width<br>Edge Length | The **Edge Width** and **Edge Length** settings represent the size of the filter on the X axis and the Y axis, respectively. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

One of the most common issues when setting up part detection is that surface data is not generated after scanning the target or targets. The Profile Part Detection tool's measurements provide information on the status of the part detection engine. You can use these measurements to diagnose why the tool is not detecting parts.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
| --- |
| **Tracking State**<br>Part detection state for largest currently tracking part. The possible values returned by are the following:<br>0: Not In Part<br>1: In Part, Min area not achieved<br>2: In Part, Min area achieved<br>3: In Gap, Min area not achieved |

| Measurement |
| --- |
| 4: In Gap, Min area achieved |
| **Parts Being Tracked** |
| The number of parts the engine is currently tracking. |
| **Part Center X** |
| The center of the partial part, midway between the minimum X and maximum X detected for the part. |
| **Part Length** |
| The length of the part. In cases of backtracking, the number decreases. |
| **Total Parts Accepted** |
| The number of parts that meet the part detection criteria (based on the configuration of the tool's parameters). |
| **Due to Max Part Length** |
| The number of parts accepted because they have reached the value in the **Max Part Length** parameter (see above). If too many parts are being accepted, increase **Max Part Length**. |
| **Total Parts Rejected** |
| The number of parts that fail to meet the part detection criteria. |
| **Rejected Due to Min Area** |
| The number of parts rejected because they are below the value in the **Min Area** parameter (see above). If too many parts are being rejected, reduce **Min Area**. |
| **Rejected Due to Backtracking** |
| The number of parts rejected due to backtracking, for example, when the user reverses the direction of the transport mechanism while the sensor is actively scanning a part. |
| **Area** |
| The area of the current part. |

*Features*

| Type | Description |
| --- | --- |
| Center Point | The center point of the detected part. |

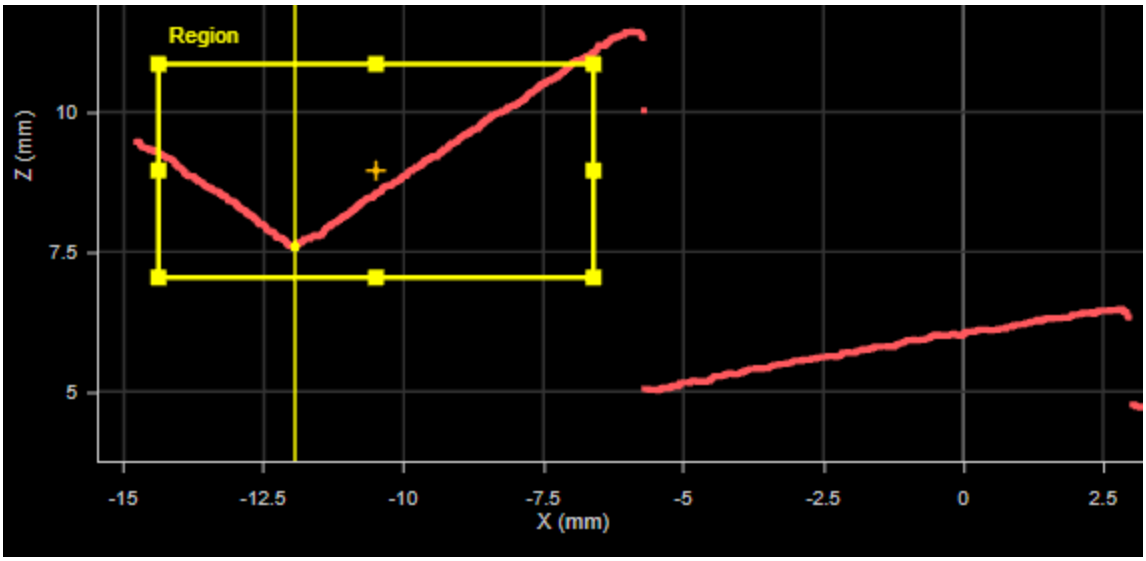
For more information on geometric features, see *Geometric Features* on page 191.

*Data*

| Type | Description |
| --- | --- |
| Part Surface | The Surface data of the detected part. |

## Profile Position

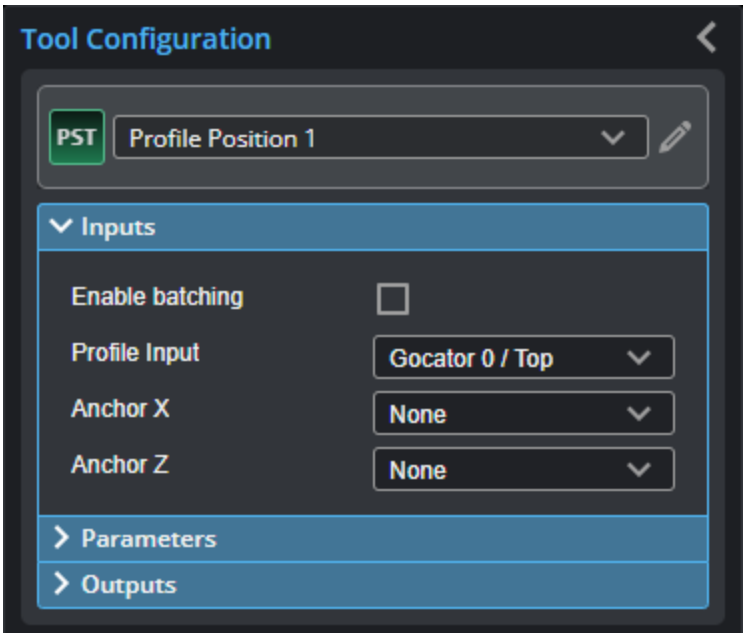
The Position tool finds the X or Z axis position of a feature point. The feature type must be specified (see below).




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



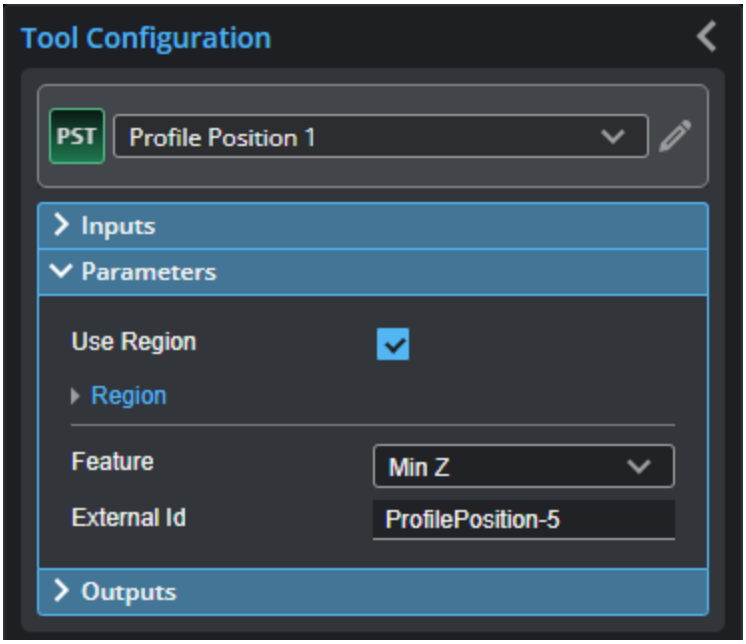

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



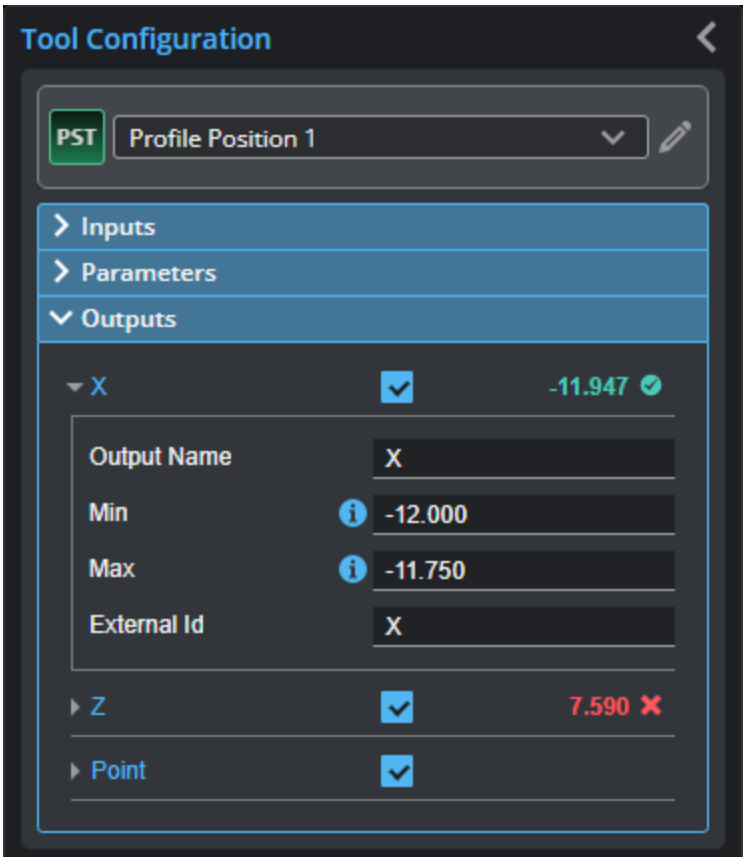

*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |

| Parameter | Description |
| --- | --- |
| Feature | The feature the tool uses for its measurements. One of the following:<br>• Max Z<br>• Min Z<br>• Max X<br>• Min X<br>• Corner<br>• Average<br>• Rising Edge<br>• Falling Edge<br>• Any Edge<br>• Top Corner<br>• Bottom Corner<br>• Left Corner<br>• Right Corner<br>• Median<br>For more information on feature points, see *Feature Points* on page 188.<br>To set the region of a feature, adjust it graphically in the data viewer, or expand the feature in the **Parameters** section and enter the values in the fields. For more information on regions, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

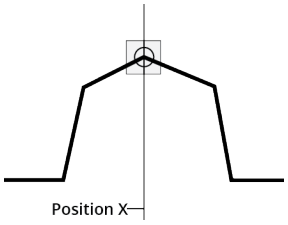
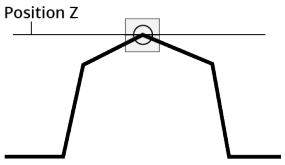
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Finds the position of a feature on the X axis. |  |
| **Z**<br>Finds the position of a feature on the Z axis. |  |

## Profile Roughness

The Profile Roughness tool calculates multiple measurements of profile roughness according to different industry standards, including the following:

ISO 21920

ISO 4287

ASME B46.1

JIS B0601

ISO 13565

ISO 12085

VDA 2006

VDA 2007

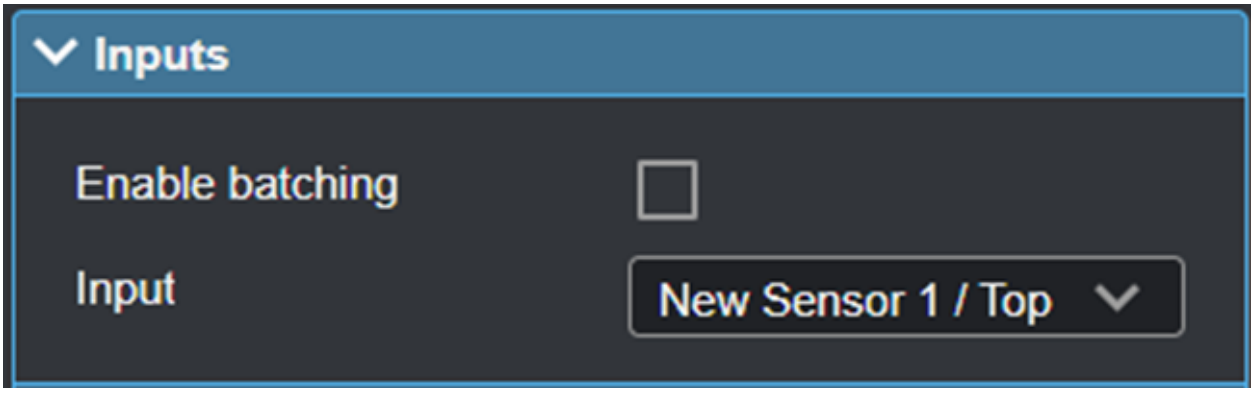
Parameters and measurements differ with standards. Choose the standard appropriate for your application.

> There cannot be a large invalid point range for Profile roughness. Use the region to restrict the valid range in the tool for the calculation.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

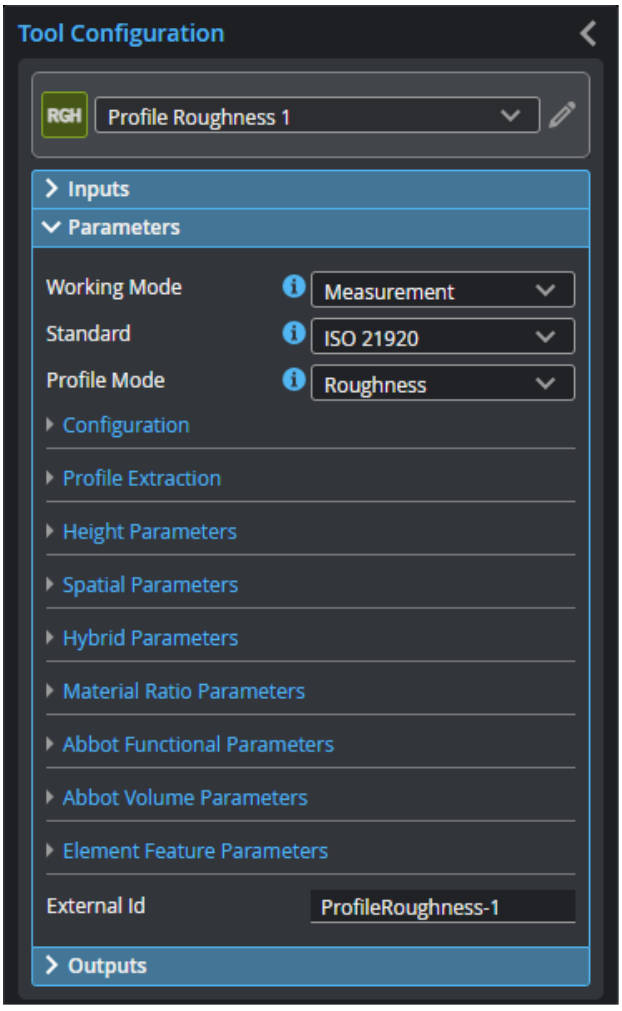
*Inputs*

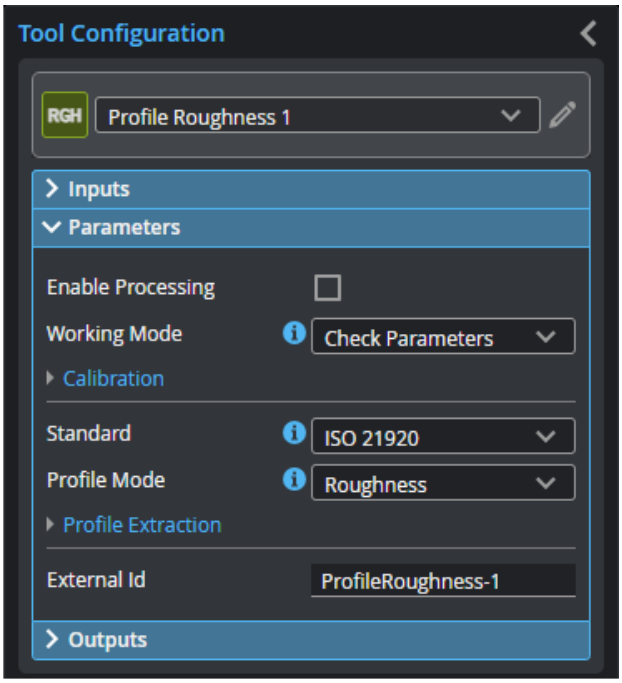
| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |

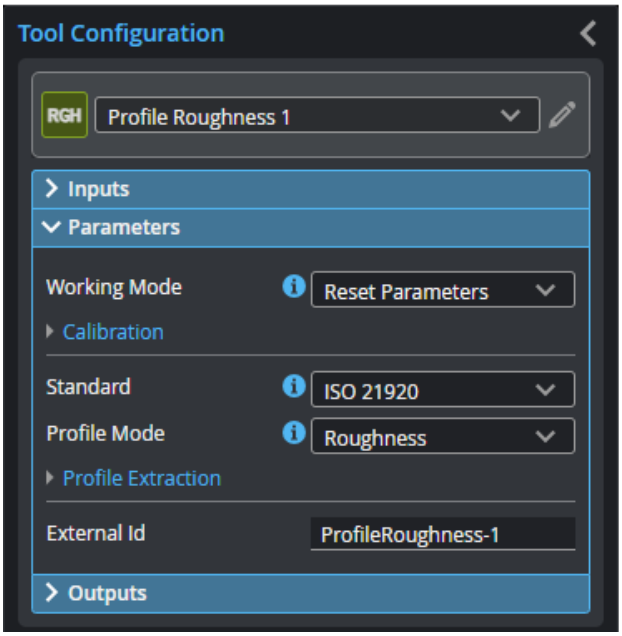
**Parameters**

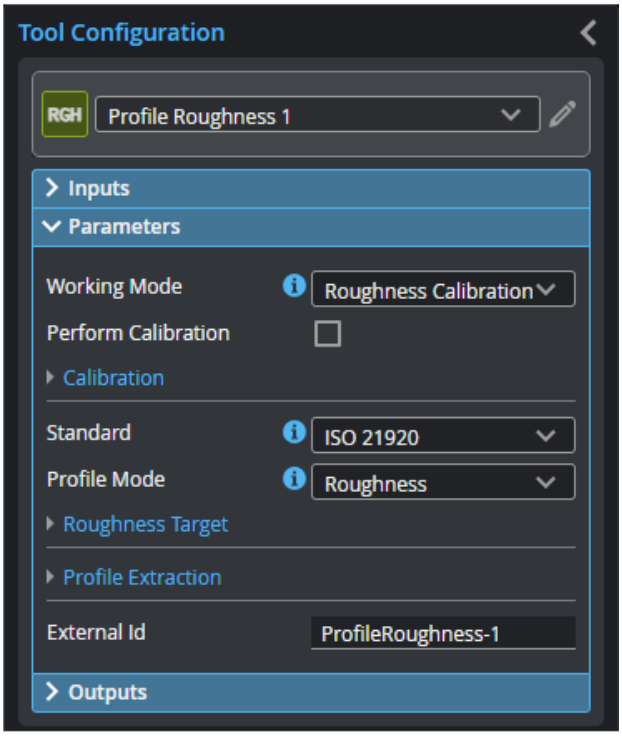
You configure the tool's parameters in the expandable **Parameters** section.

Note that the tool displays different sets of parameters based on what you set **Working Mode** to.


Tool Configuration
RGH
Profile Roughness 1
Inputs
Parameters
Working Mode
Measurement
Standard
ISO 21920
Profile Mode
Roughness
Configuration
Profile Extraction
Height Parameters
Spatial Parameters
Hybrid Parameters
Material Ratio Parameters
Abbot Functional Parameters
Abbot Volume Parameters
Element Feature Parameters
External Id
ProfileRoughness-1
Outputs

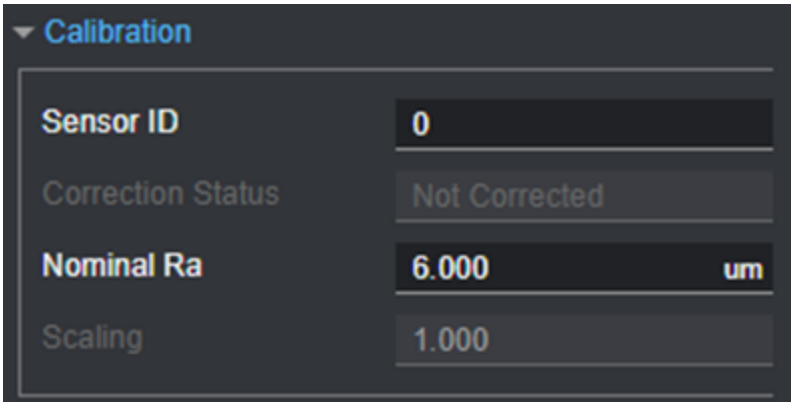

Tool Configuration
RGH
Profile Roughness 1
Inputs
Parameters
Enable Processing
Working Mode
Check Parameters
Calibration
Standard
ISO 21920
Profile Mode
Roughness
Profile Extraction
External Id
ProfileRoughness-1
Outputs

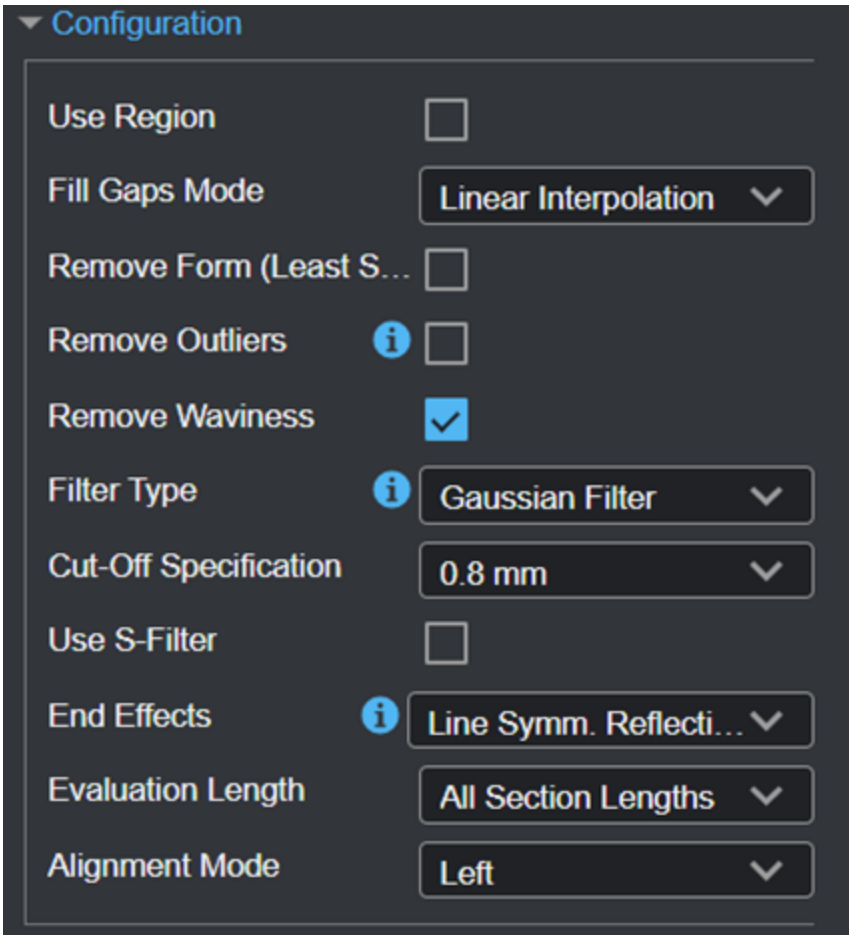

Tool Configuration
RGH
Profile Roughness 1
Inputs
Parameters
Working Mode
Reset Parameters
Calibration
Standard
ISO 21920
Profile Mode
Roughness
Profile Extraction
External Id
ProfileRoughness-1
Outputs


Tool Configuration
RGH
Profile Roughness 1
Inputs
Parameters
Working Mode
Roughness Calibration
Perform Calibration
Calibration
Standard
ISO 21920
Profile Mode
Roughness
Roughness Target
Profile Extraction
External Id
ProfileRoughness-1
Outputs

*Parameters*

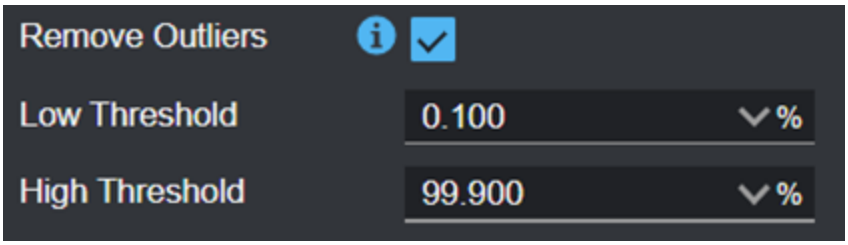
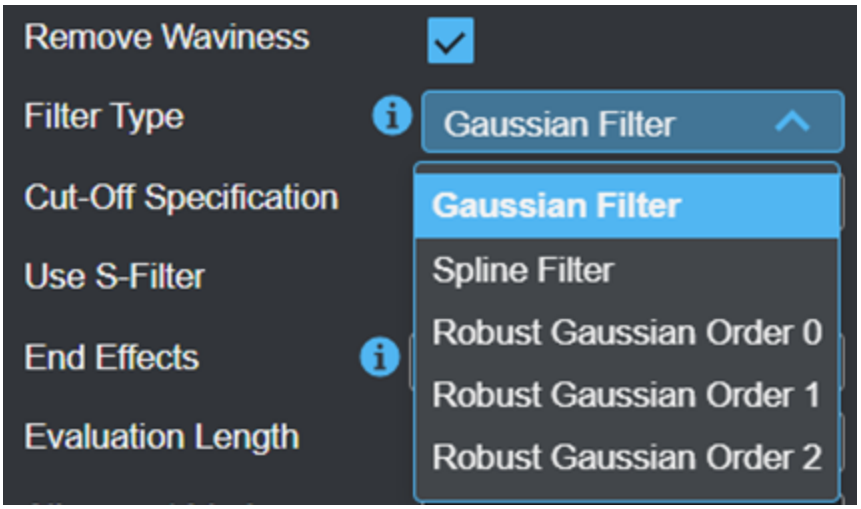
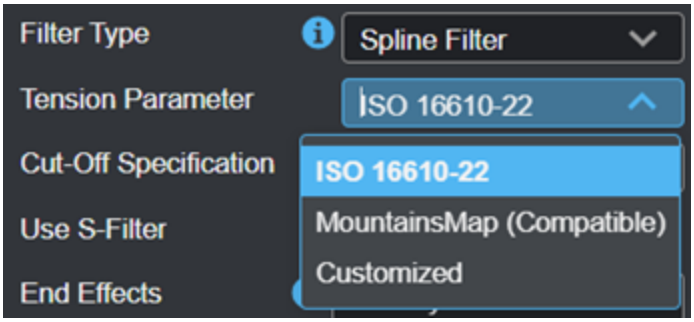
| Parameter | Description |
|---|---|
| Enable Processing | The calculation starts only when this is checked. Only displayed when **Working Mode** is set to Check Parameters or Roughness Calibration. (Processing happens automatically in other modes.) |
| Working Mode | Support the following four working modes:<br>• Measurement<br>• Check Parameters<br>• Reset Parameters<br>• Roughness Calibration<br>Before starting the calibration, make sure to remove the old calibration. |
| Perform Calibration | Performs the calibration. Only displayed when **Working Mode** is set to Roughness Calibration. |
| Standard | The standard the tool uses. Some standards change how options in **Evaluation Length** behave. For some standards, you should follow the recommendations below.<br><br>**ISO 21920**<br>Set **All Section Lengths** and **All Sections (no Averaging)**. These parameters behave the same with this standard.<br><br>**ISO 4287**<br>Typically, you will set **Evaluation Length** to "n Section Lengths", and set **Section Count** to 5. You can also choose "All Section Length" with this standard.<br><br>**ASME B46.1**<br>Typically, you will set **Evaluation Length** to "n Section Lengths", and set **Section Count** to 5. If you use a different **Evaluation Length** option, note that "All Section Lengths" and "All Sections (no Averaging)" are treated the same with this standard.<br><br>**JIS B0601**<br>According to the original definition, “All Section Lengths” should be used.<br><br>**ISO 13565**<br>“Total Profile Length” should be used.<br><br>**ISO 12085**<br>The same as definitions in ISO 4287, or using “Total Profile Length”. |

| Parameter | Description |
|---|---|
| | **VDA 2006**<br>“All Section Lengths” and "All Sections (no Averaging)" are the same.<br><br>**VDA 2007**<br>“Total Profile Length” should be used. |
| Profile Mode | In the standards, many parameters are also defined in relation to Primary or Waviness Profile. Select the profile mode after setting a standard. |
| Configuration | Shows when **Working Mode** is set to "Measurement". See *Configuration* on the next page for details. |
| Calibration | Shows when **Working Mode** set to any mode other than "Measurement”<br>  |
| Roughness Target | Shows when **Working Mode** is “Roughness Calibration”. The parameters are the same as the **Configuration**group. |
| Height Parameters | Shows different parameters depending on what you select in **Standard**. See *Height Parameters* on page 304. |
| Spatial Parameters | See *Spatial Parameters* on page 306 for details. |
| Hybrid Parameters | See *Hybrid Parameters* on page 306 for details. |
| Material Ratio Parameters | See *Material Ratio Parameters* on page 307 for details. |
| Abbot Functional Parameters | See *Abbot Functional Parameters* on page 307 for details. |
| Abbot Volume Parameters | See *Profile Roughness* on page 294 for details. |
| Element Feature Parameters | See *Element Feature Parameters* on page 309 for details. |
| Motif Parameters | See *Motif Parameters* on page 310 for details. |

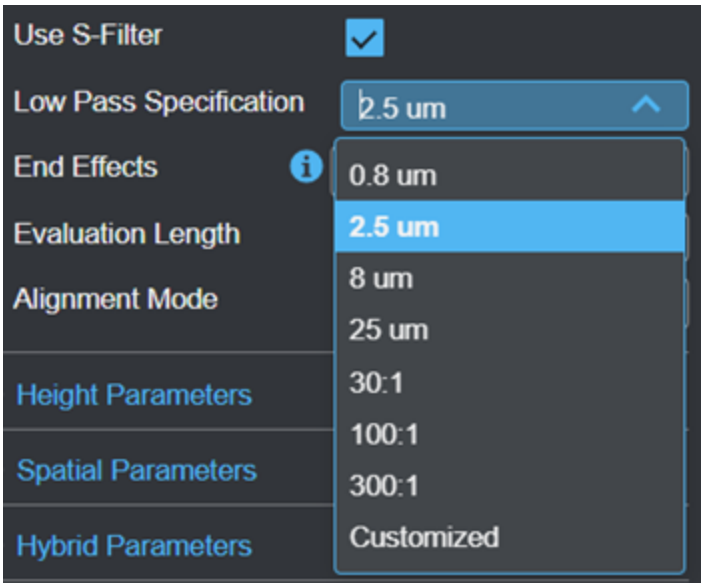
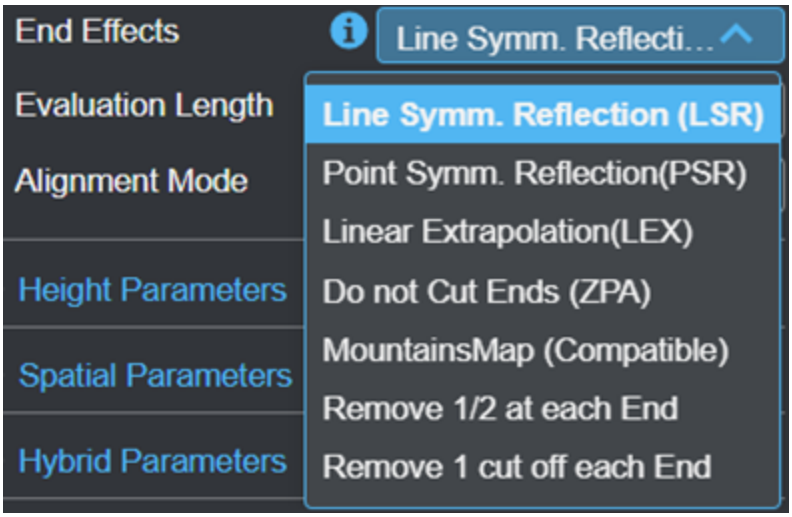


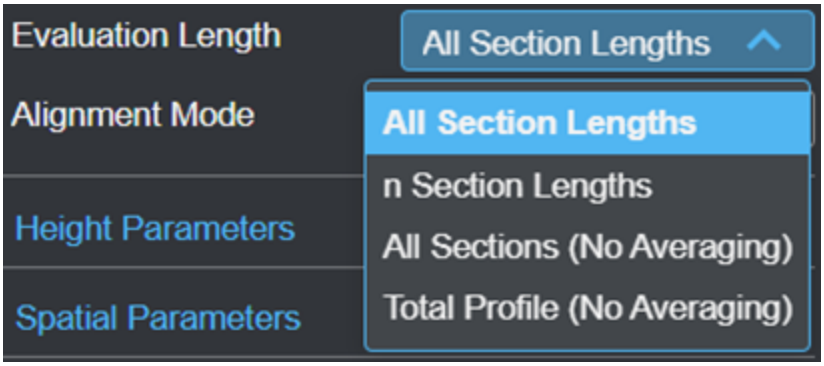

*Configuration*

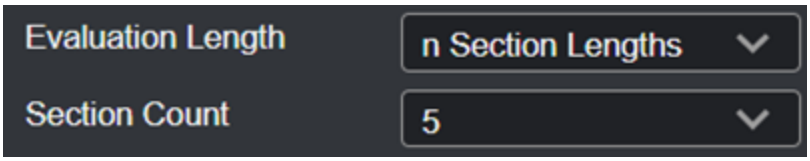
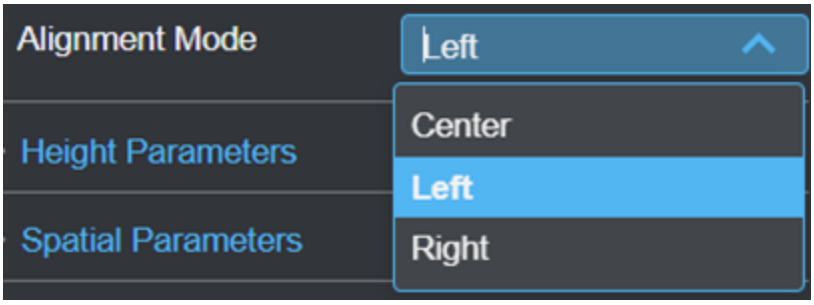
| Parameter | Description |
|---|---|
| Use Region<br>Region | Check to set region size. |
| Fill Gaps Mode | Choose **Linear Interpolation** to fill gaps in the profile but keep the profile as natural as possible. |
| Remove Form (Least Squares) | When checked, displays a drop-down containing one of the following:<br>• Linear Alignment<br>• Polynomial Subtraction: Show “Polynomial Order (<21)” for edit if selected<br>• Circular Unwrapping<br>• Circle With Nominal Radius: Show “Nominal Radius” for edit if selected. |
| Remove Outliers | Check to remove outliers from the profile and set Low Threshold and High Threshold. The outliers are defined according to the Sigma Rule in terms of the given percentage multiplied by 1.5. |

| Parameter | Description |
| --- | --- |
| |  |
| Remove Waviness | Check to remove the waviness of the profile. Select the filter in **Filter Type**.<br>  <br>The tool provides the following filters according to the ISO 16610 standards series, which allow different filter kernels having different shapes. Choose the filter depending on your application and its sensitivity to the curvature of the waviness.<br><br>**Gaussian Filter**: According to ISO 16610-21, ISO 16610-28<br>If selected, set choose the appropriate option in **End Effects** (see *End Effects* on page 302).<br><br>**Spline Filter**: According to ISO 16610-22, ISO 16610-28.<br>If selected, set **Tension Parameter** to control how tightly the spline curve fits through the data points.<br>  |

| Parameter | Description |
|---|---|
| | **Robust Gaussian Order 0**: According to ISO 16610-31, ISO 16610-28.<br>Using Savitzky-Golay filter coefficients:<br>$\alpha = \sqrt{ln(2)/\pi}$<br>Retaining the zeros moment means to reduce end effects.<br><br>**Robust Gaussian Order 1**: According to ISO 16610-31, ISO 16610-28.<br>Using Savitzky-Golay filter coefficients:<br>$\alpha = \sqrt{ln(2)/\pi}$<br>Retaining the first moment means to reduce end effects.<br><br>**Robust Gaussian Order 2**: According to ISO 16610-31, ISO 16610-28.<br>Using Savitzky-Golay filter coefficients<br>$\gamma = \sqrt{(-1 - W(-1/(2e))/\pi}$<br><br> <br>The cut-off is selected depending on the workpiece surface either according to the valley spacing, or the expected roughness values. At the same time the total evaluation length and the corresponding total profile length are defined according to standards. Deviations are necessary if the workpiece does not allow the required total profile length.<br>If the actual possible total profile length on the workpiece surface is not enough for lt, the number of sampling lengths is reduced accordingly and specified in the drawing. If the actual available total profile length is less than a sampling length, the total height of profile Pt of the primary profile is evaluated instead of Rt or Rz. |
| Use S-Filter | Check to use a low pass filter with the cut-off wavelength defined in **Low Pass** |

| Parameter | Description |
| --- | --- |
| | **Specification**.<br>  |
| End Effects | Shows when **Remove Waviness** is checked. The end effect is the unintended changes in filtration response in the both end sections of an open profile, and the end effect correction methods are according to standard ISO 16610-28.<br>  <br>**Line Symm. Reflection (LSR)**<br>A measured profile is extended by horizontal reflection on the left hand and right hand, respectively.<br>**Point Symm. Reflection (PSR)**<br>A measured profile is extended by horizontal reflection in conjunction with vertical |

| Parameter | Description |
| --- | --- |
| | reflection on the left and right hand respectively. Both reflection lines shall intersect at the respective end point of the profile.<br><br>**Linear Extrapolation (LEX)**<br>In the case of linear extrapolation, a least-squares line is fitted to the profile within the left and right end effect regions.<br><br>**Do not Cut Ends (ZPA)**<br>Zero padding is a simple method for retaining the total length after filtering the profile. Profile z(x) is padded with zeros over the total length.<br><br>**MountainsMap (Compatible)**<br>Tries to make filtering compatible with MMP "Manage End Effect". This setting only applies to Guassian filters.<br><br>**Remove 1/2 at each end**<br>No end effects treatment required as the critical regions are not involved in the calculation.<br><br>**Remove 1 cut off each end**<br>No end effects treatment required as the critical regions are not involved in the calculation. |
| Evaluation Length | The evaluation length. One of the following:<br>  <br>**All Section Lengths**<br>The maximum available sections will be used.<br><br>**n section lengths**<br>Set the number of sections in **Section Count**. The effective section number is always limited by the available length. |

| Parameter | Description |
|---|---|
| |  <br>**All Sections (no Averaging)**<br>All parameters as long as the definition allows are calculated in the entire evaluation length.<br>**Total Profile (no averaging)**<br>All parameters as long as the definition allows are calculated in the total profile length. |
| Alignment Mode |  <br>Note: The alignment in MountainsMap is left-justified. |

*Height Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Ra | **Roughness average**<br>Ra is the arithmetic average of the absolute values of the roughness profile ordinates, in µm. | ISO 21920<br>ISO 4287<br>ASME B46.1<br>JIS B0601<br>VDA 2006<br>ISO 13565-2 |
| Rq | **RMS roughness**<br>Rq is the root mean square average of the roughness profile ordinates, in µm. | ISO 4287<br>ISO 21920<br>JIS B0601 |
| Rz | **Mean roughness depth**<br>Rz is the arithmetic mean value of the single roughness depths Rzi of consecutive sampling lengths, in µm. | ISO 21920<br>JIS B0601 |
| Rz1max | **Maximum height**<br>Rz1max is the greatest Rz value from the n sampling lengths lr, in µm. | ISO 4287 |

| Parameter | Description | Standard |
|---|---|---|
| Rz(JIS) | **The ten point height**<br>RzJIS is defined on each sampling length as being the sum of the 5 highest peaks and the 5 deepest holes, divided by 5. The result is expressed in the length unit of the Z-axis, in µm. | JIS B0601 |
| Rz(n) | Maximum height inside the nth section length, in µm. | ISO 4287<br>JIS B0601 |
| Rmax | **Maximum roughness depth**<br>Rmax is the largest single roughness depth within the evaluation length, in µm. | |
| Rt | **Total height of profile**<br>Rt is the distance between the highest peak and the deepest valley of the profile of the total evaluation length ln, in µm. | ISO 21920<br>ISO 4287<br>JIS B0601 |
| Rsk | **Skewness**<br>Rsk is a measure of the asymmetry of the amplitude density curve. A negative skewness value indicates a surface with good bearing properties. (No unit.) | ISO 21920<br>ISO 4287<br>JIS B0601 |
| Rku | **Kurtosis**<br>Rku is a measure of the peakedness of the amplitude density curve. (No unit.) | ISO 21920<br>ISO 4287<br>JIS B0601 |
| Rp<br>Rpm | Rp is the height of the highest profile peak of the roughness profile within one sampling length. According to ASME, the Rp mean value (average calculated over the evaluation length) is called Rpm. Both in µm. | ISO 21920 |
| Rv | Rv is the depth of the deepest profile valley of the roughness profile within one sampling length, in µm. | ISO 21920 |
| Rz | The sum of Rp + Rv is the single roughness depth Rzi, in µm. | JIS B0601 |
| Rzx | **Maximum height** (peak-to-valley), within a section length, in µm. | ISO 21920 |
| Rc | **Mean height of profile elements**<br>A horizontal discrimination of 1% of the sampling length and a vertical discrimination of 10% of Rz are applied to avoid taking into account segments with outlying values due to noise. In µm. | ISO 4287<br>JIS B0601 |
| Rp1max | **Maximum local profile peak height**<br>Rp1max is the Maximum of Rpi values which are calculated within a sampling length, in µm. | ISO 4287<br>JIS B0601 |
| Rv1max | **Maximum local profile valley depth**<br>Rv1max is the Maximum of Rvi values which are calculated within a sampling length, in µm. | ISO 4287<br>JIS B0601 |
| Rz1max | **Maximum local height of the profile** | |

| Parameter | Description | Standard |
|---|---|---|
| | Rz1max is the Maximum of Rzi values which are calculated within a sampling length, in µm. | |
| Rpt | Maximum hill height, in µm. | ISO 21920 |
| Rvt | Maximum dale depth, in µm. | ISO 21920 |

*Spatial Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Ral | Autocorrelation length Ral is the horizontal distance of the autocorrelation function (tx) which has the fastest decay to a specified value s, with 0 < s < 1. The default value for s in the software is 0.2.<br>This parameter expresses the content in wavelength of the surface. A high value indicates that the surface has mainly high wavelengths (low frequencies). In mm. | ISO 21920 |
| Rsw | Dominant spatial wavelength Rsw is the wavelength corresponding to the largest value of the FFT. In mm. | ISO 21920 |
| WDsm | Mean horizontal values determined from the amplitude spectrum Size of the profile elements (mean period length of the dominant waviness). In mm. | VDA 2007 |
| WDc | Average of the heights of the profile elements within the evaluation length, in µm. | VDA 2007 |
| WDt | Vertical difference between the highest and lowest point of the WD profile within the evaluation length, in µm. | VDA 2007 |

*Hybrid Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Rdq | **Root mean square gradient**<br>Rdq is the root mean square value of the ordinate slopes dZ/dX, within the sampling length, in degrees. | ISO 21920 |
| Rda | Arithmetic mean absolute gradient, in degrees. | ISO 21920 |
| Rdt | Maximum absolute gradient, in degrees. | ISO 21920 |
| Rdl | **Developed length**<br>Rdl is the Length measured following the profile curve, in mm. | ISO 21920 |
| Rdr | **Developed length ratio**<br>Rdr is the Ratio between the length measured following the profile curve ("real profile"), and the profile length, expressed as a percentage in excess of 100%. | ISO 21920 |

*Material Ratio Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Rmr | **Material ratio**<br>Rmr indicates what ratio the totaled length in the material has assumed relative to the evaluation length (in %). The comparison is made in the specified section height c and the total evaluation length ln. The material ratio curve indicates the material ratio as a function of the section height. | ISO 21920<br>ISO 4287<br>JIS B0601 |
| Rmr (Rz/4) | **Automatic relative material ratio**<br>Rmr (Rz/4) is the Material ratio calculated at cut level c = 0.25 Rz, relative to a specified reference level, as a percentage. | ISO 4287<br>JIS B0601 |
| Rmc | **Inverse material ratio**<br>Rmc is the height distance between highest level and the cut level c corresponding to a given material ratio, in µm. | ISO 21920 |
| Rdc | **Profile section height difference**<br>Rdc is the Profile section height difference or bearing height. Gives the vertical distance between two cut levels given by their bearing ratio, in µm. | ISO 4287<br>ISO 21920<br>JIS B0601 |

*Abbot Functional Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Rk | **Core roughness height**<br>Rk is the effective roughness of the profile. It is the height of the roughness profile, without taking into account the elevated hills or the very deep dales, in µm. | ISO 13565-2<br>ISO 21920 |
| Mr1 | **Upper material ratio**<br>Mr1 is the smallest material ratio at the limits of the roughness core area, as a percentage. | ISO 13565-2<br>ISO 21920 |
| Mr2 | **Lower material ratio**<br>Mr2 is the highest material ratio at the limits of the roughness core area, as a percentage. | ISO 13565-2<br>ISO 21920 |
| Rpk | **Reduced peak height**<br>Rpk is the mean height of the peaks protruding from the roughness core profile, in µm. | ISO 13565-2<br>ISO 21920 |
| Rpkx<br>Rpk* | **Maximum peak height**<br>Rpkx is the roughness height of the hills, before area correction, in µm. | ISO 13565-2<br>ISO 21920 |
| Rvk | **Reduced valley depth**<br>Rvk is the mean depth of the valleys protruding from the roughness core profile, in µm. | ISO 13565-2<br>ISO 21920 |

| Parameter | Description | Standard |
|---|---|---|
| Rvkx<br>Rvk* | **Maximum dale depth**<br>Rvkx is the roughness depth of the dales, before area correction, in µm. | ISO 13565-2<br>ISO 21920 |
| A1 | **Upper area**<br>A1 is calculated as the area of the triangle equivalent to the peaks, $\mu m^2/mm$. | ISO 13565-2 |
| A2 | **Lower area**<br>A2 is calculated as the area of the triangle equivalent to the holes, $\mu m^2/mm$. | ISO 13565-2 |
| CV | **Crevice volume**<br>Equivalent to A2, but expressed in specific units ($\mu m^3/\mu m^2$). Note: 10 $\mu m^3/\mu m^2$ = 1 $mm^3/cm^2$, so the CV value is 10 times the A2 value. | |
| APH | **Peak height**<br>APH is the maximum height of the protruding peaks above the roughness core profile, in µm. | ISO 13565-2 |
| AVH | **Valley depth**<br>AVH is the maximum depth of the profile valleys below the roughness core profile, in µm. | ISO 13565-2 |
| Rvk/Rk | **Valley-core depth ratio**<br>Rvk/Rk is the ratio of the reduced valley depth Rvk over the core roughness depth Rk. (No unit.) | ISO 13565-2 |
| Rvq | **Valley root-mean square roughness**<br>Rvq is the slope of the linear regression calculated on the dale zone, in µm. | ISO 13565-3<br>ISO 21920 |
| Rpq | **Plateau root-mean square roughness**<br>Rpq is the slope of the linear regression calculated on the hill zone, in µm. | ISO 13565-3<br>ISO 21920 |
| Rmq | **Material ratio**<br>Rmq is the Intersection of both regression lines. Gives information about the depth of the intersection between fine surface finish (plateau zone) and rough surface finish (valley zone), as a percentage. | ISO 13565-3<br>ISO 21920 |

*Abbot Volume Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Rvm | **Material volume**<br>Rvm is the volume of material at a material ratio p (as a percentage), in $\mu m^3/mm^2$. | ISO 21920 |
| Rvv | **Void volume** | ISO 21920 |

| Parameter | Description | Standard |
|---|---|---|
| | Rvv is the volume of voids at a material ratio p (as a percentage), in $\mu m^3/mm^2$. | |
| Rvmp | **Hill material volume**<br>Rvmp is the volume of material in the hills, between 0% material ratio and a material ratio p (as a percentage), calculated in the zone above c1, in $\mu m^3/mm^2$. | ISO 21920 |
| Rvmc | **Core material volume**<br>Rvmc is the volume of material in the core, between two material ratios p and q (as a percentage), calculated in the zone between c1 and c2, in $\mu m^3/mm^2$. | ISO 21920 |
| Rvvc | **Core void volume**<br>Rvvc is the volume of void in the core, between two material ratios p and q (as a percentage), calculated in the zone between c1 and c2, in $\mu m^3/mm^2$. | ISO 21920 |
| Rvvv | **Dale void volume**<br>Rvvv is the volume of void in the dales, between a material ratio p (as a percentage) and 100% material ratio, calculated in the zone below c2, in $\mu m^3/mm^2$. | ISO 21920 |

*Element Feature Parameters*

| Parameter | Description | Standard |
|---|---|---|
| Rsm | **Mean width of the profile elements**<br>Rsm gives information about the spacing of<br>motifs (length of the period), in mm. | ISO 4287<br>ISO 21920<br>JIS B0601 |
| Rsmx | Maximum profile element width, in mm. | ISO 21920 |
| Rsmq | **Standard deviation of the profile element widths**<br>Rsmq is the root mean square deviation of widths, in mm. | ISO 21920 |
| Rc | Mean height of the profile elements, in µm. | ISO 21920 |
| Rcx | Maximum height of the profile elements, in µm. | ISO 21920 |
| Rcq | **Standard deviation of the profile element heights**<br>Rcq is the root mean square deviation of heights, in µm. | ISO 21920 |
| RPc | **Peak count parameter**<br>RPc corresponds to the number of mean widths of profile elements (XSm) inside a given length (default length 10 mm). (No unit.) | ISO 4287<br>ISO 21920<br>JIS B0601 |

The principle of the Motif standard consists of looking for local peaks and valleys in the primary profile, and associating one valley with the closest preceding and following peaks in order to create a Motif. Several iterative combinations of two Motifs each assure that the most important Motifs, the width of which fall below the limit A, are considered. If not otherwise specified, the default value is A = 0.5 mm. The limit A has a similar function as the cut-off in the Gaussian filtering.

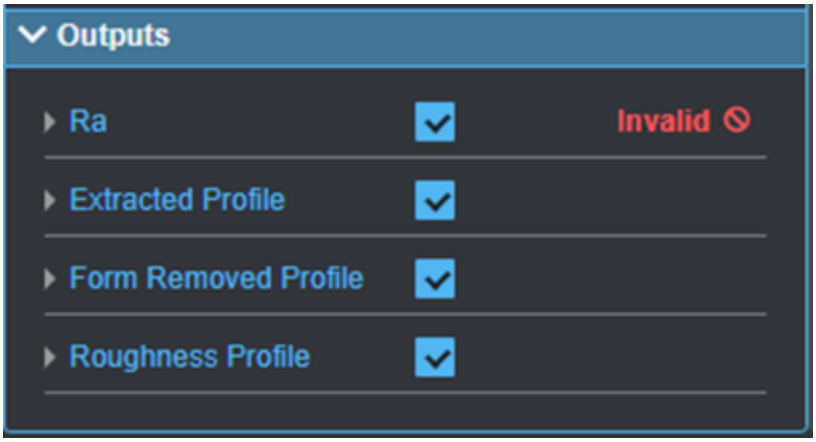
*Motif Parameters*

| Parameter | Description | Standard |
|---|---|---|
| R | **Mean depth of roughness Motifs**<br>R is the arithmetic mean value of the depths Hj of the roughness Motifs within the evaluation length, in µm. | ISO 12085 |
| AR | **Mean spacing of roughness Motifs**<br>AR is the arithmetic mean value of the lengths ARi of the roughness Motifs within the evaluation length, in mm. | ISO 12085 |
| Rx | **Maximum depth of the roughness motifs**<br>Rx is the deepest depth Hj within the evaluation length, in µm. | ISO 12085 |
| Rt | Total height of the profile, in µm. | ISO 12085 |
| Kr | Mean slope of the roughness motifs. (No unit.) | ISO 12085 |
| Nr | **Number of roughness motifs**<br>If the number of roughness motifs is less than 3, only the Rx and the Pt can be computed. (No unit.) | ISO 12085 |
| SR | **Standard deviation of the depths of the roughness motifs**<br>SR computes the dispersion of the Ri values, in µm. | ISO 12085 |
| SAR | **Standard deviation of the spacings of the roughness motifs**<br>SAR computes the dispersion of the ARi values, in mm. | ISO 12085 |
| W | **Mean depth of waviness Motifs**<br>W is the arithmetic mean value of the depths Hj of the roughnes Motifs within the evaluation length, in µm. | ISO 12085 |
| AW | **Mean spacing of waviness Motifs**<br>AW is the arithmetic mean value of the lengths ARi of the roughness Motifs within the evaluation length, in mm. | ISO 12085 |
| Wx | **Maximum depth of the waviness motifs**<br>Wx is the biggest of all Wi within the evaluation length, in µm. | ISO 12085 |
| Wte | Total depth of waviness, in µm. | ISO 12085 |
| Kw | Mean slope of the waviness motifs. (No unit.) | ISO 12085 |
| Nw | **Number of waviness motifs**<br>If the number of roughness motifs is less than 3, only the Wx and the Wte can be computed. (No unit.) | ISO 12085 |
| SW | **Standard deviation of the depths of the waviness motifs**<br>SW calculates the dispersion of the Wi values, in µm. | ISO 12085 |
| SAW | **Standard deviation of the spacings of the waviness motifs**<br>SAW calculates the dispersion of the AWi values, in mm. | ISO 12085 |
| Trc | **Micro Geometric material ratio**<br>Trc is the bearing fraction at a given depth c of the envelope leveled | ISO 12085 |

| Parameter | Description | Standard |
|---|---|---|
| | profile, as a percentage. | |
| HTrc | Micro geometric criterion, in µm. | |
| Rke | Kernel roughness of the envelope leveled profile, in µm. | |
| Rpke | Reduced height of the envelope leveled profile, in µm. | |
| Rvke | Reduced depth of the envelope leveled profile, in µm. | |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

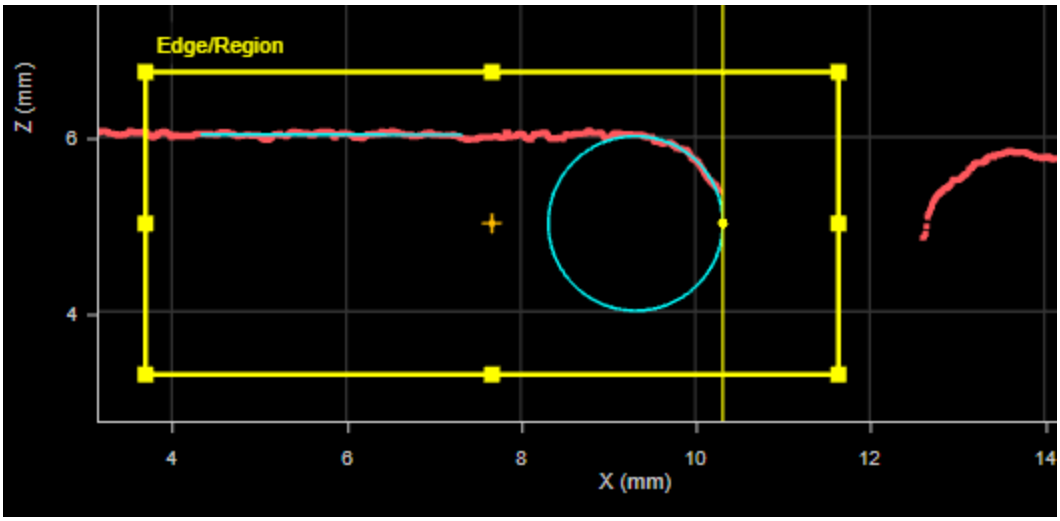
| Measurement |
|---|
| **Ra**<br>Arithmetic average of the absolute values of the roughness profile ordinates.<br>For the other measurements, see the parameter details above. |

*Data*

| Type | Description |
|---|---|
| Extracted Profile | Extraction of the measured profile with the defined region. |
| Form Removed Profile | Obtained after removal of the nominal form (F-operation). |
| Roughness Profile | Obtained after filtering including a (high-pass) L-filter (λc) rejecting long wavelengths. When presenting the roughness profile, the mean line is the zero line. |

## Profile Round Corner

The Round Corner tool measures corners with a radius, returning the position of the edge of the corner and the angle of adjacent surface with respect to the X axis.

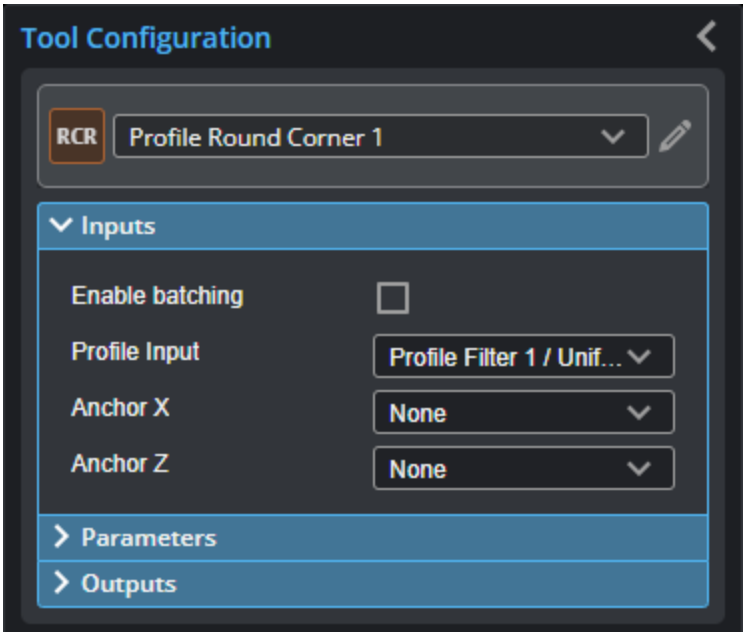



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

> You must make sure that there are enough data points to define the edge (proper exposure, etc.). If not, the algorithm will not function.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



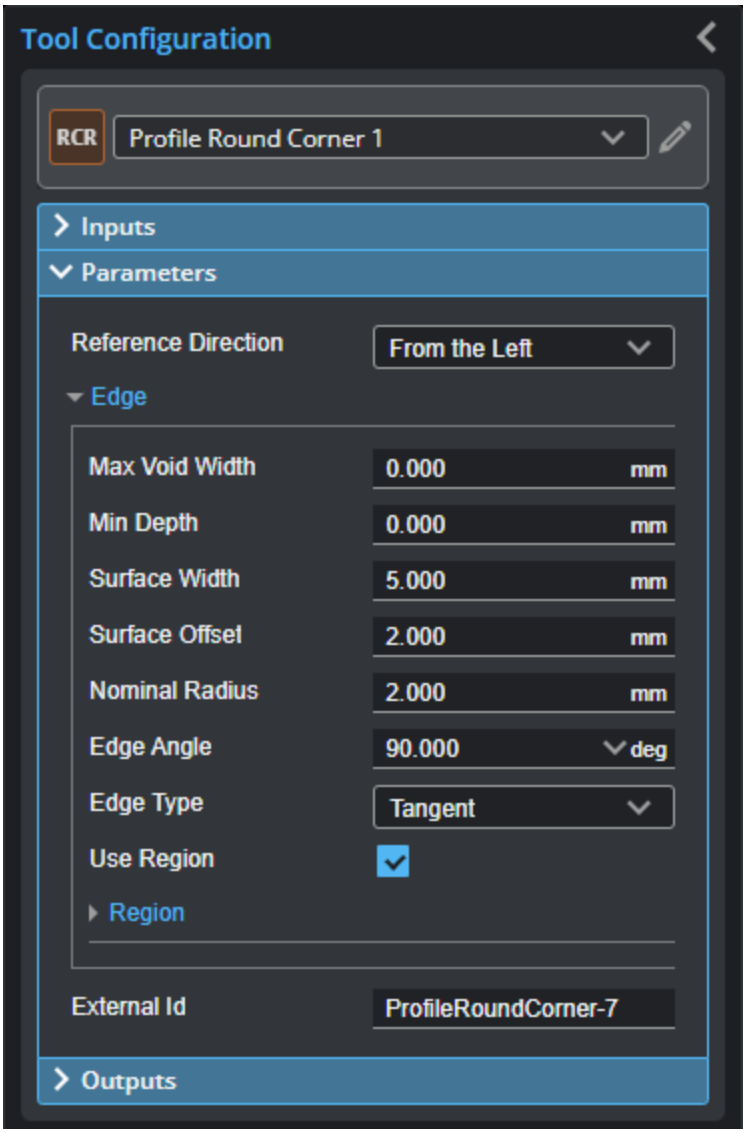
> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. If **Enable Batching** is *disabled* and the passed array contains more than two elements, GoPxL displays an error. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

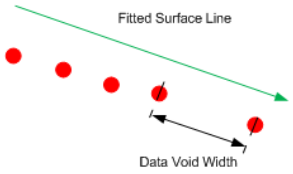
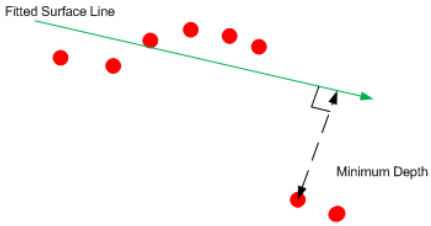
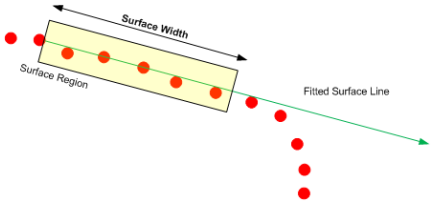
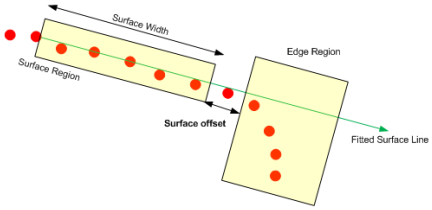
**Parameters**

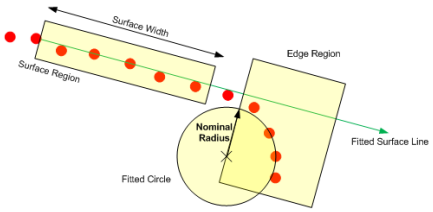
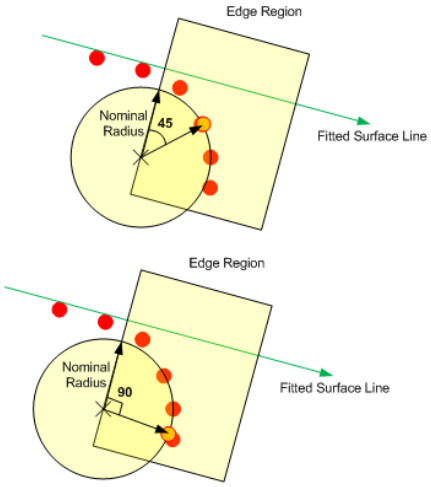
You configure the tool's parameters in the expandable **Parameters** section.

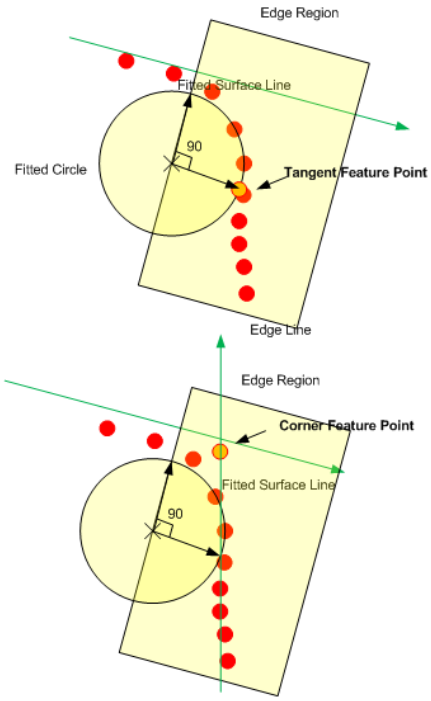



*Parameters*

| Parameter | Description |
|---|---|
| Reference Direction | Defines the side used to calculate the rounded corner. |
| Edge | When expanded, displays the parameters for defining the edge (see below). |
| Max Void Width | The maximum allowed width of missing data caused by occlusion or data dropout.<br>A larger value prevents the algorithm from registering a section of missing data as an edge.<br>Setting the value to 0 causes the algorithm to try to detect an edge in every missing data section. |

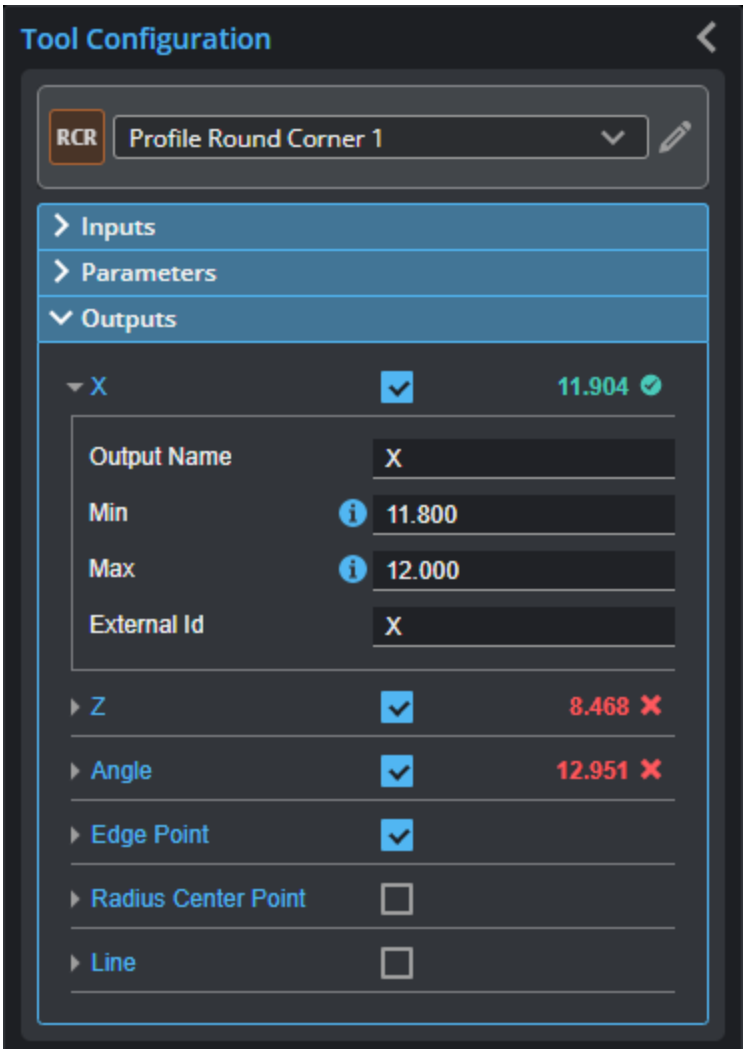
| Parameter | Description |
| --- | --- |
| |  |
| Min Depth | Defines the minimum depth before an opening could be considered to have a potential edge. The depth is the perpendicular distance from the fitted surface line.<br>  |
| Surface Width | The width of the surface area in which data is used to form the fitted surface line. This value should be as large as the surface allows.<br>  |
| Surface Offset | The distance between the edge region and the surface region.<br>Setting a small value allows the edge within a tighter region to be detected. However, the measurement repeatability could be affected if the data from the edge are considered as part of the surface region (or vice versa). A rule of thumb is to set **Surface Offset** equal to **Nominal Radius**.<br>  |
| Nominal Radius | The radius of the curve edge that the tool uses to locate the edge region.<br>The algorithm searches for a start position in which the remaining data most resemble a circle of the specified nominal radius. |

| Parameter | Description |
| --- | --- |
| |  |
| Edge Angle | A point on the best fit circle to be used to calculate the feature point. The selected point is on the circumference at the specified angle from the start of the edge region.<br>The angle is measured from the axis perpendicular to the fitted surface line.<br>  |
| Edge Type | Defines the type of feature point to use for the edge (Corner or Tangent).<br>A tangent edge point is the point selected based on the defined Edge Angle. A corner edge point is the intersect point between the fitted surface line and a edge line formed by interpolating the points at and after the tangent within the edge region. |

| Parameter | Description |
|---|---|
| |  |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

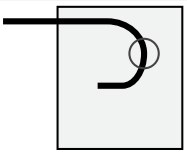
Most tools provide measurements, geometric features, or data as outputs.

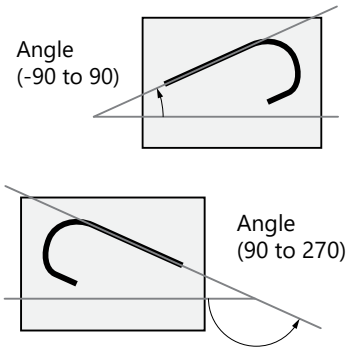



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Measures the X position of the location where the tangent touches the edge, or intersect of the tangent and the line fitted to the surface used by the measurement (see **Reference Side**, below). |  |
| **Z**<br>Measures the Z position of the location where the tangent touches the edge, or intersect of the tangent and the line fitted to the surface used by the | |

| Measurement | Illustration |
|---|---|
| measurement (see **Reference Side**, below). | |
| **Angle**<br>Measures the angle of the line fitted to the surface next to the corner (see **Reference Side**, above), with respect to the X axis. Left edge angles are from -90 to 90. Right edge angles are from 90 to 270. |  |

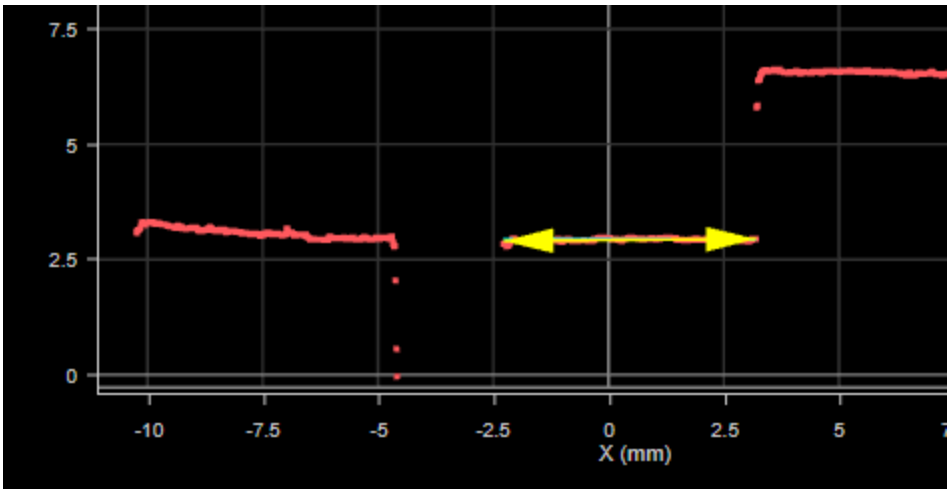
*Features*

| Type | Description |
|---|---|
| Edge Point | The position of the edge. |
| Radius Center Point | The center of the radius. |
| Line | The fitted surface line. |

For more information on geometric features, see *Geometric Features* on page 191.

## Profile Strip

The Strip tool returns various measurements related to a strip, such as its X and Z positions, width, and height.



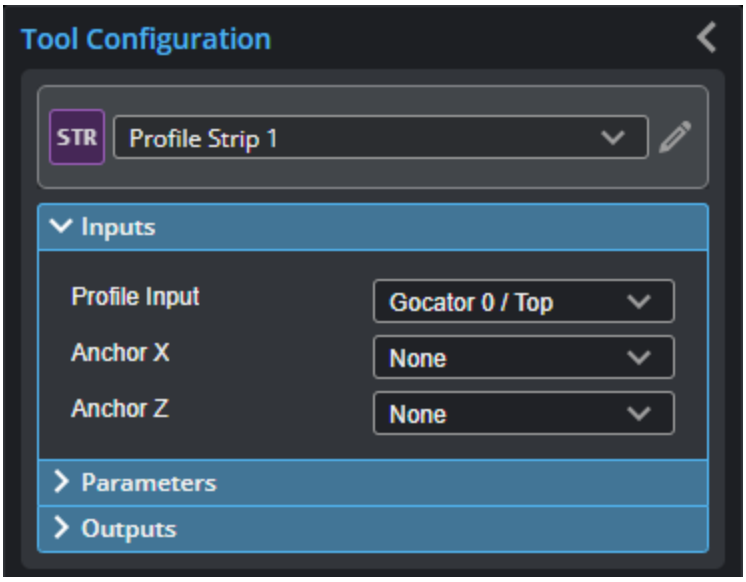

The tool lets you optionally set an index to return the measurements of a specific strip when more than one is visible in the region of interest. If you need to return multiple strips from a profile, add a Profile Strip tool for each strip, configure it to represent the desired strip, and set its **Selection Index** parameter to the desired strip (0-based index).

The Strip tool uses a complex feature-locating algorithm to find a strip and then return measurements. For a detailed explanation of the algorithm, see *Strip Algorithm* on page 326. The behavior of the algorithm can be adjusted by changing the tool's parameters.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



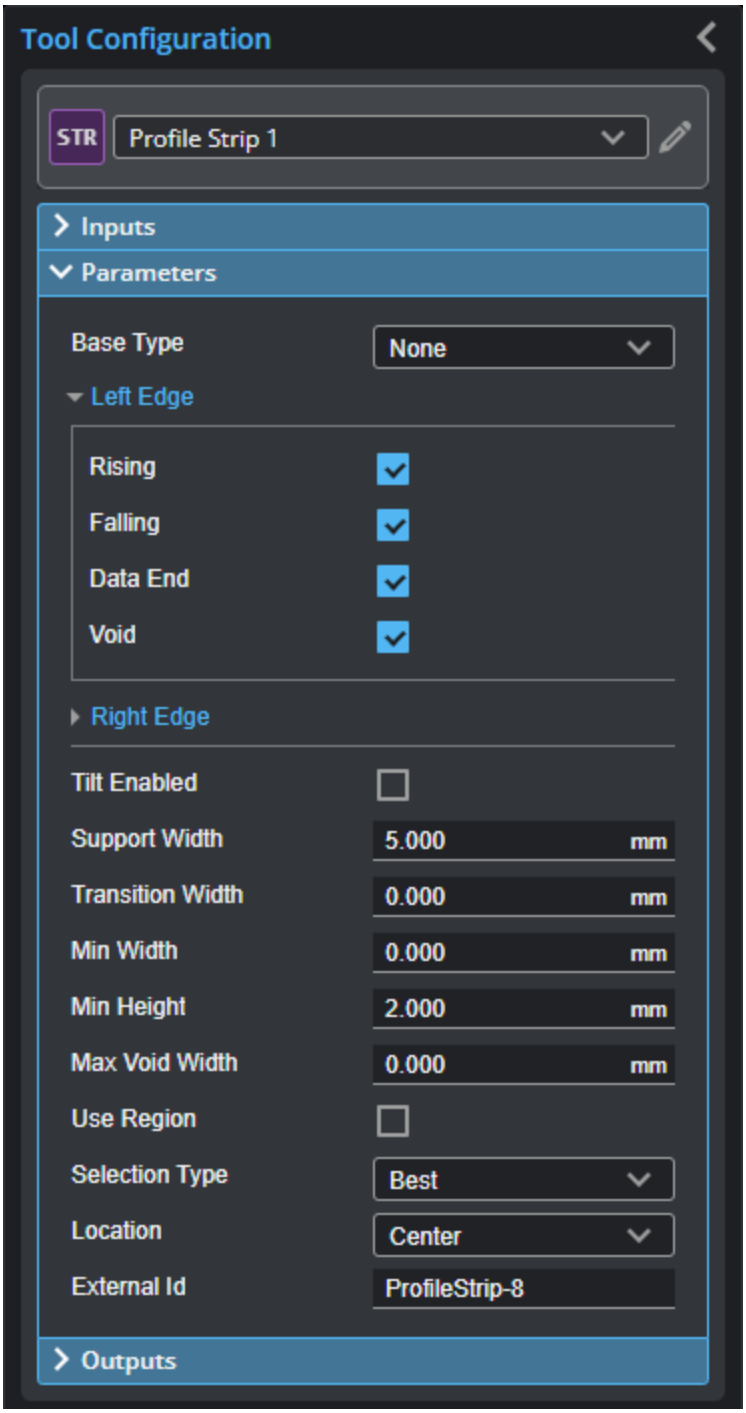

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

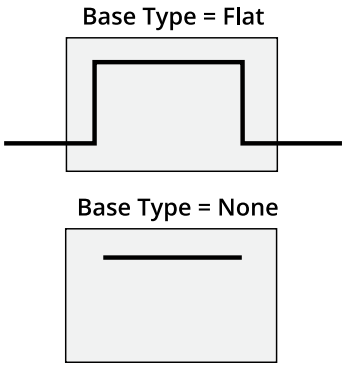
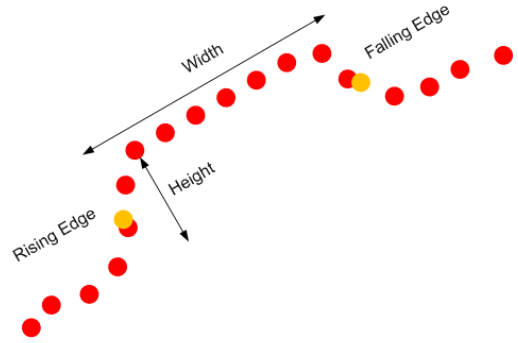
**Parameters**

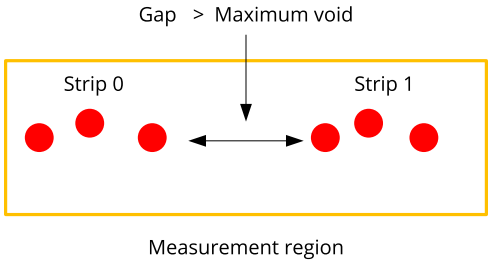
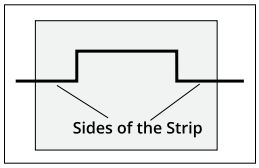
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

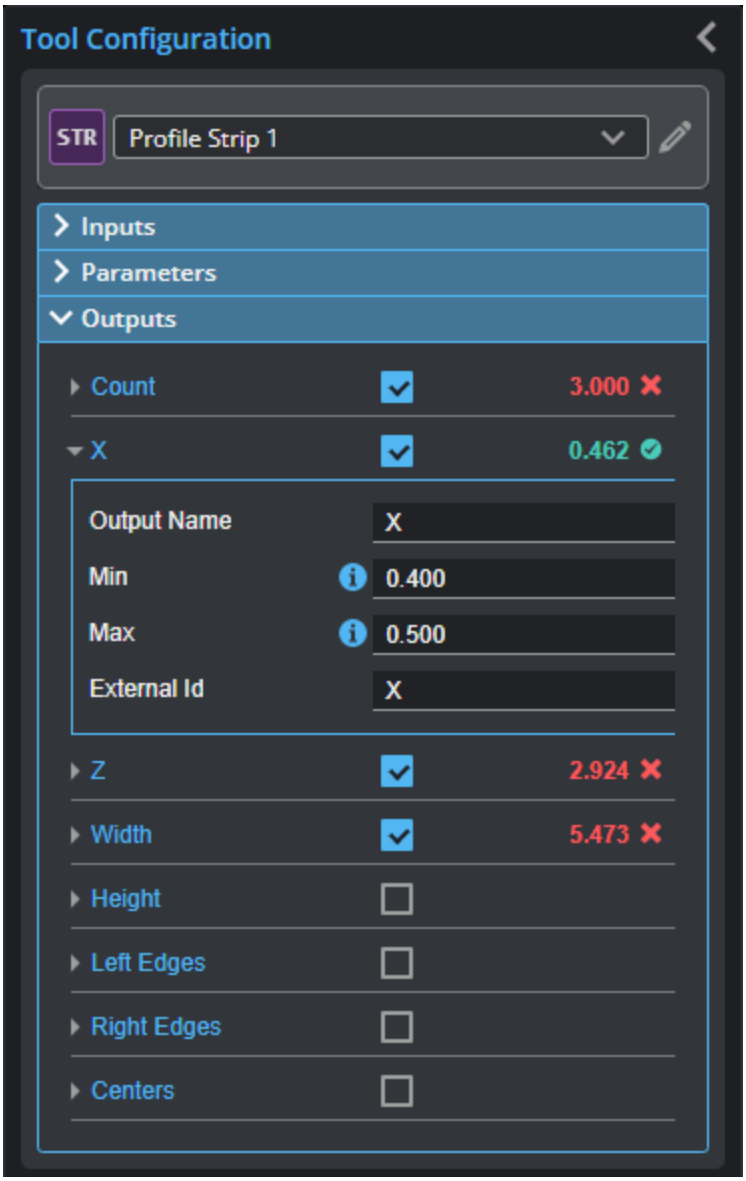
| Parameter | Description |
|---|---|
| Base Type | Affects detection of rising and falling edges. |

| Parameter | Description |
|---|---|
| |  <br>When **Base Type** is set to **Flat**, both strip (raised area) and base support regions are needed. When set to **None**, only a point that deviates from a smooth strip support region is needed to find a rising or falling edge. |
| Left Edge<br>Right Edge | Specifies the features that will be considered as the strip's left and right edges. You can select more than one condition.<br>**Rising** - Rising edge detected based on the strip edge parameters.<br>**Falling** - Falling edge detected based on the strip edge parameters.<br>**Data end** - First valid profile data point in the measurement region.<br>**Void**- Gap in the data that is larger than the maximum void threshold. Gaps connected to the measurement region's boundary are not considered as a void.<br>For the definitions of these conditions, see *Strip Start and Terminate Conditions* on page 327. |
| Tilt Enabled | Enables and disables tilt correction.<br>The strip may be tilted with respect to the sensor's coordinate X axis. This can be caused by conveyor vibration. If the Tilt option is enabled, the tool will report the width and height measurements, corrected by the tilt angle of the strip.<br>  |
| Support Width | Specifies the width of the region around the edges from which the data is used to calculate the step change. For information on how this parameter is used by different base types, see *Strip Step Edge Definitions* on page 329. |
| Transition Width | Specifies the nominal width needed to make the transition from the base to the |

| Parameter | Description |
|---|---|
| | strip. For information on how this parameter is used by different base types, see *Strip Step Edge Definitions* on page 329. |
| Min Width | Specifies the minimum width for a strip to be considered valid. |
| Min Height | Specifies the minimum deviation from the strip base. For information on how this parameter is used by different base types, see *Strip Step Edge Definitions* on page 329. |
| Max Void Width | The maximum width of missing data allowed for the data to be considered as part of a strip when **Void** is selected in the **Left** or **Right** parameter. This value must be smaller than the edge **Support Width**.<br>  |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The measurement region defines the region in which to search for the strip. If possible, the region should be made large enough to cover the base on the left and right sides of the strip.<br>  <br>For more information, see *Regions* on page 181. |
| Location<br>*(Strip Height, Strip X, and Strip Z measurements only)* | Specifies the strip position from which the measurements are performed.<br>**Left** - Left edge of the strip.<br>**Right** - Right edge of the strip.<br>**Center** - Center of the strip. |
| Selection Type | Specifies how a strip is selected when there are multiple strips within the measurement area.<br>**Best** - The widest strip.<br>**Index Left** - 0-based strip index, counting from left to right.<br>**Index Right** - 0-based strip index, counting from right to left. |
| Index | 0-based strip index. Only displayed when **Selection Type** is set to an "Index" option. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.

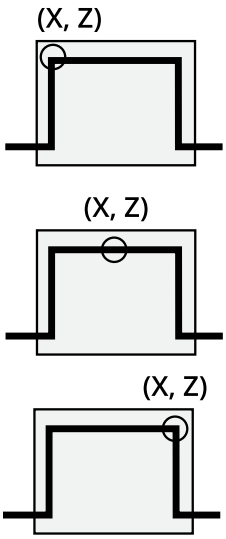
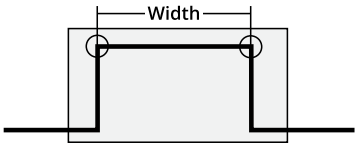
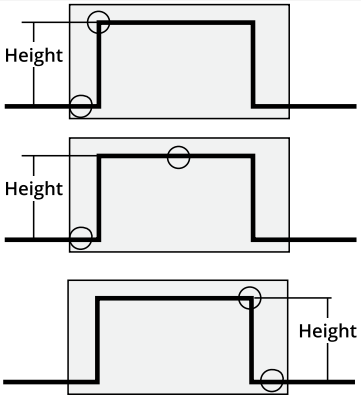



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Count**<br>The number of strips. | |

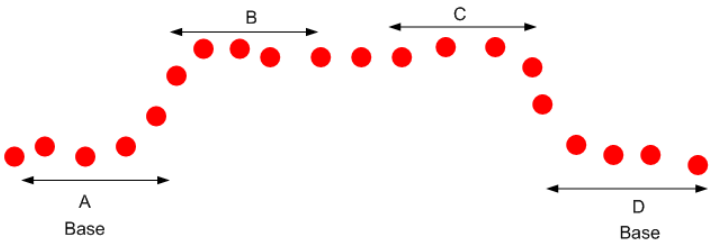
| Measurement | Illustration |
|---|---|
| **X, Z**<br>Measures the X and Z position, respectively, of a strip. |  |
| **Width**<br>Measures the width of a strip. |  |
| **Height**<br>Measures the height of a strip. |  |

*Features*

| Type | Description |
|---|---|
| Left Edges<br>Right Edges<br>Centers | Arrays of Point geometric features representing the left edges, right edges, and centers of all strips, from left to right. |

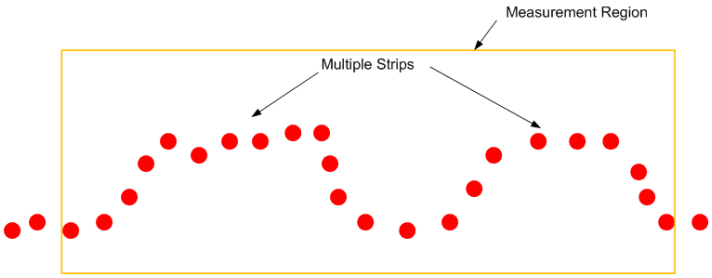
**Strip Algorithm**

A strip is a flat region bounded on the left and on the right by edges. The Strip tool can measure the edge positions, width, and height of a strip. The Strip tool assumes that regions outside the strip, referred to as the base regions (Region A and D below), deviate in height from the start and end parts of a strip (Region B and C).




When the target is sitting on the surface, the base is lower than the strip (as shown above). Alternatively for a groove the base is above the strip surface. The base could be missing when the target is hanging in the air or the surface holding the target falls outside the sensor's active area. You can control the base type in the measurement panel.

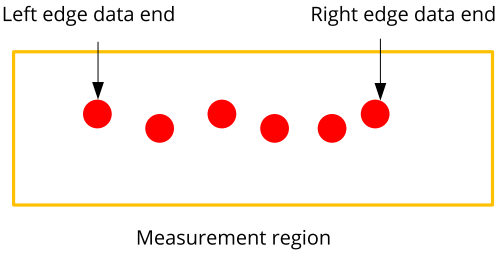
The Strip tool can detect multiple strips. You can select a region of interest, referred to as the measurement region, from which the algorithm search for multiple strips.

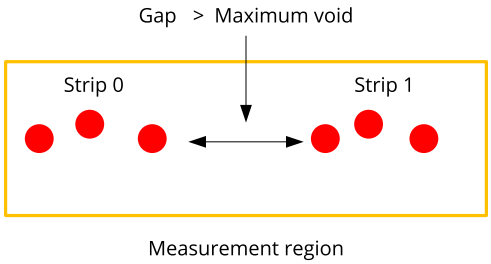
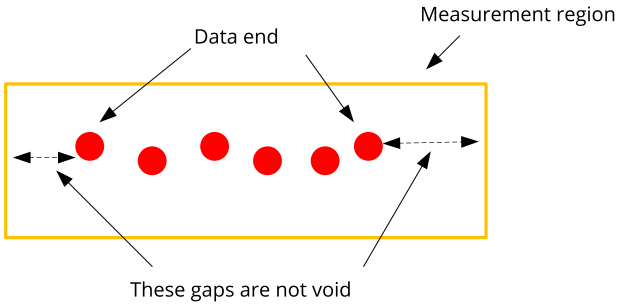



### Strip Start and Terminate Conditions

The Strip tool allows you to define how a strip starts and ends. The Left Edge parameter controls how a strip starts and the Right Edge parameter controls how a strip ends.

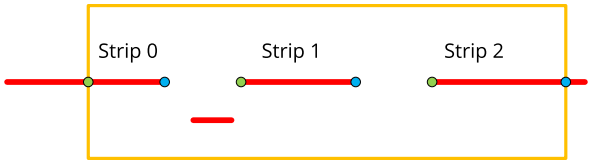
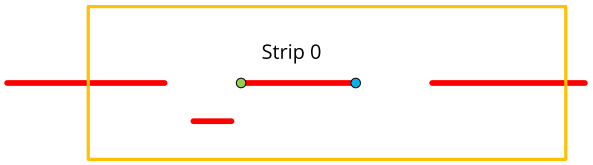
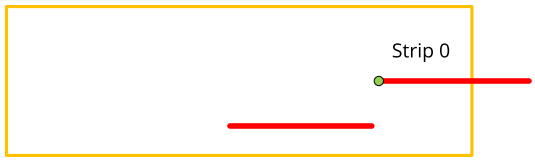
*Start / terminate conditions*

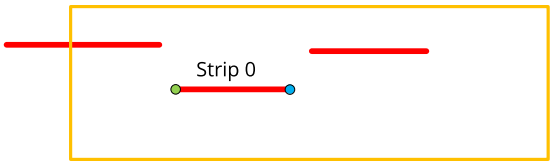
| Condition | Description |
|---|---|
| Rising | Rising step edge detected based on the strip edge parameters. For details on how the step edge is detected, *Strip Step Edge Definitions* on page 329. |
| Falling | Falling step edge detected based on the strip edge parameters. For details on how the step edge is detected, *Strip Step Edge Definitions* on page 329. |
| Data end | The first (for the left edge) or the last (for the right edge) valid profile data point in the measurement region.<br>  |
| Void | Gaps in the data that are larger than the maximum void threshold. |

| Condition | Description |
|---|---|
| |  <br>Gaps at the ends of the measurement region's boundary are not considered as a void.<br>  |

The following examples show how the parameters affect the strip detection in different scenarios.

*Left and Right Edge conditions*

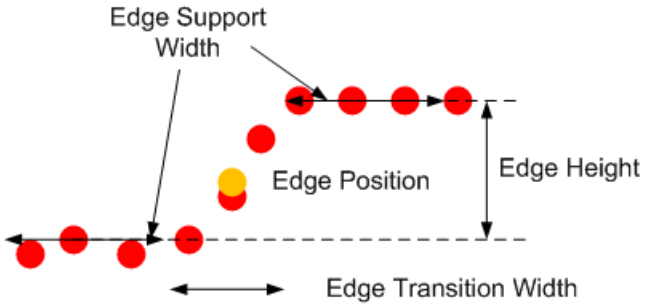
| Condition | Example |
|---|---|
| Left: Rising, data end, void<br>Right: Falling, data end, void |  |
| Left: Rising, void<br>Right: Falling, void |  |
| Left: Rising<br>Right: Data end, void |  |
| Left: Data end, void<br>Right: Falling | |

| Condition | Example |
| --- | --- |
| Left: Falling<br>Right: Rising |  |

**Strip Step Edge Definitions**

The Strip tool detects step edges based on the parameters Base Type, Edge Transition Width, Edge Support Width, and Minimum Edge Height.

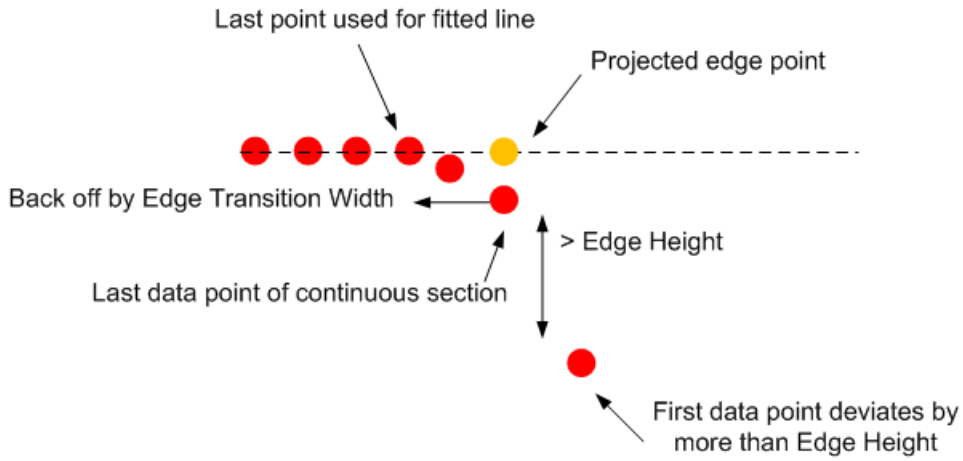
When Base Type is set to Flat, the regions around the edges are visible and the edge positions are between the base and the strip surface.




The Minimum Edge Height parameter defines the size of the step edge. The Edge Transition Width parameter specifies the nominal width of the transition, from the base to the strip surface.

The Edge Support Width parameter defines the width of the region around the edges from which the data is used to measure the step change. To improve noise immunity, the height level of the Edge Support Width parameter is calculated by averaging the data within the region.

When the base is set to None, the tool looks for continuous sections that are wider than the Edge Support Width parameter and have no data points that deviate positively or negatively more than the value of the Minimum Edge Height parameter. The data in the strip support region (the raised area) must be smooth. The height level of the continuous region is calculated based on the fitted line as shown below.




The algorithm then backs off by the value of the Edge Transition Width parameter and uses the data up to the back-off point to create the fitted line and projects the edge point on the line. This step prevents the points near the end of a rounded strip from affecting the height of the strip.

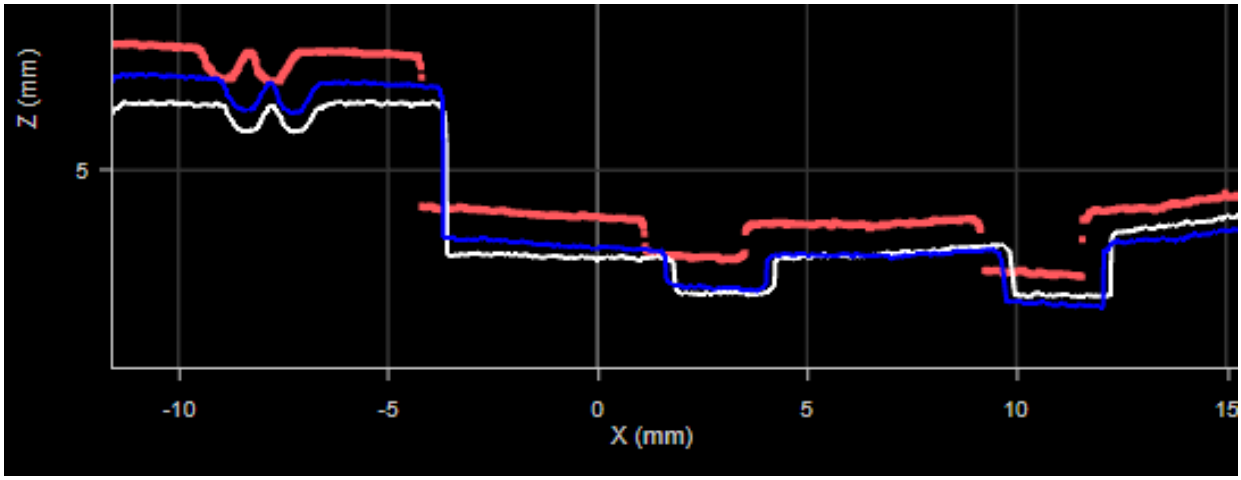
## Profile Template Matching

The Profile Template Matching tool lets you align a profile to a "master" template profile you create in the tool (a "golden template"), compensating for movement of the target from frame to frame. As a result, you can perform measurements on a "stabilized" profile.

The tool returns measurements that represent differences between the profile and the master, letting you perform simple defect detection and location from within the tool.

The tool also outputs an aligned profile that other Profile measurement tools can use as input. Finally, the tool produces a "difference" profile on which you can similarly perform measurements.

In the data viewer, the profiles are rendered using different colors.




*The master profile is rendered in white. The aligned profile is rendered in blue. The current profile is rendered in red.*

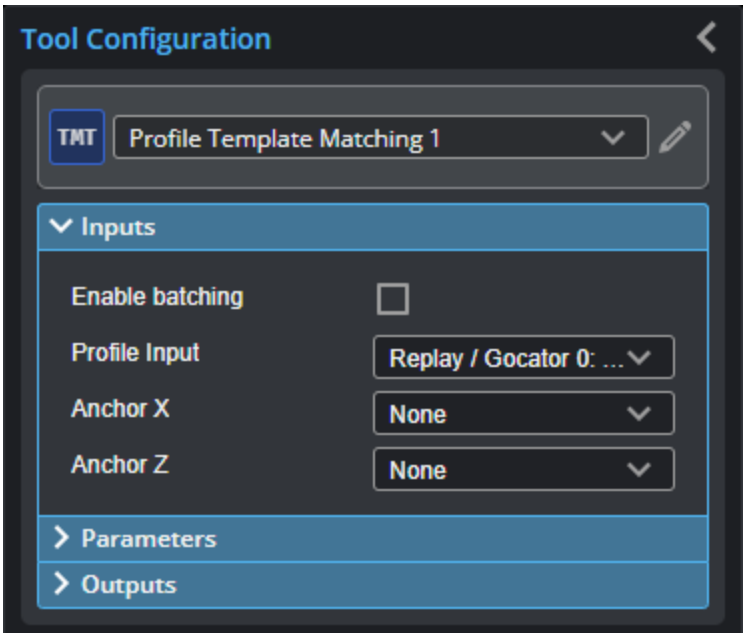
Note that in the image above, the tool is performing only a rough alignment to ensure that the different profiles are clearly visible. Typically, the aligned profile will be on top of the master profile.

The actual colors that are used for aligned and difference profiles *outputs*, as opposed to the profiles toggled with the **Display Master** and **Display Aligned Profile** parameters, will depend on how each profile's color is configured in the Displayed Outputs panel.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

If no profile alignment is performed (both **Coarse Align** and **Fine Align** are disabled), for example, if the targets are sufficiently fixed from profile to profile, the following measurements return 0.000:

- Transform X
- Transform Z
- Transform Y Angle

**Master Compare** must be enabled for the following measurements; otherwise, they return Invalid values:

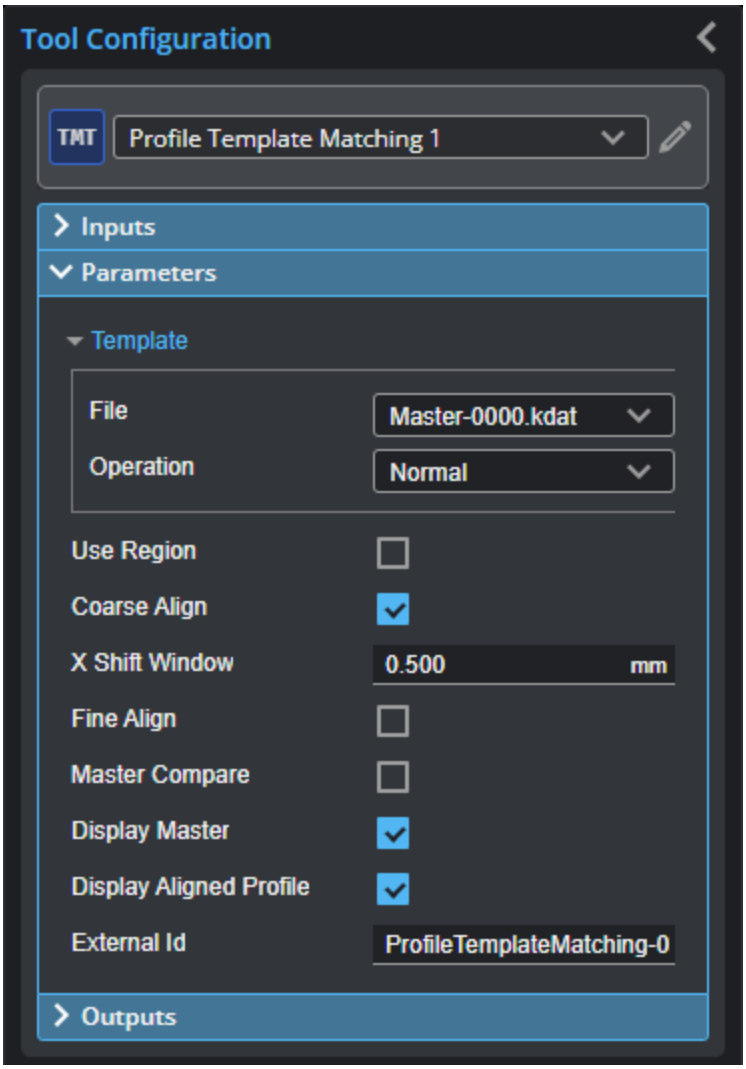
- Max Height Difference
- Max Difference Position X
- Max Difference Position Z

- Standard Deviation
- Difference Average
- Difference Sum
- Variance
- Matching Score

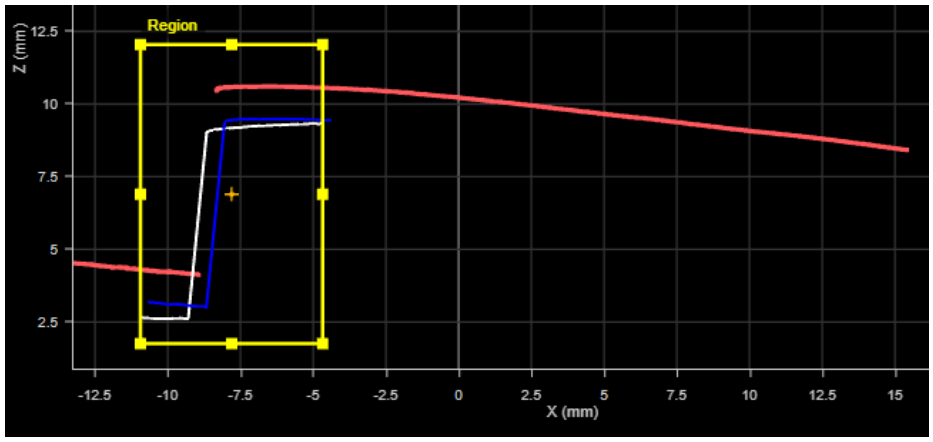
Also, for these “master compare” measurements, if the profile has been aligned to the master (either **Coarse Align** or **Fine Align** is enabled), the measurements compare the *aligned* profile and the master. If the profile has not been aligned (both alignment parameters are disabled), the measurement compares the *original* (unaligned) profile and the master.

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.



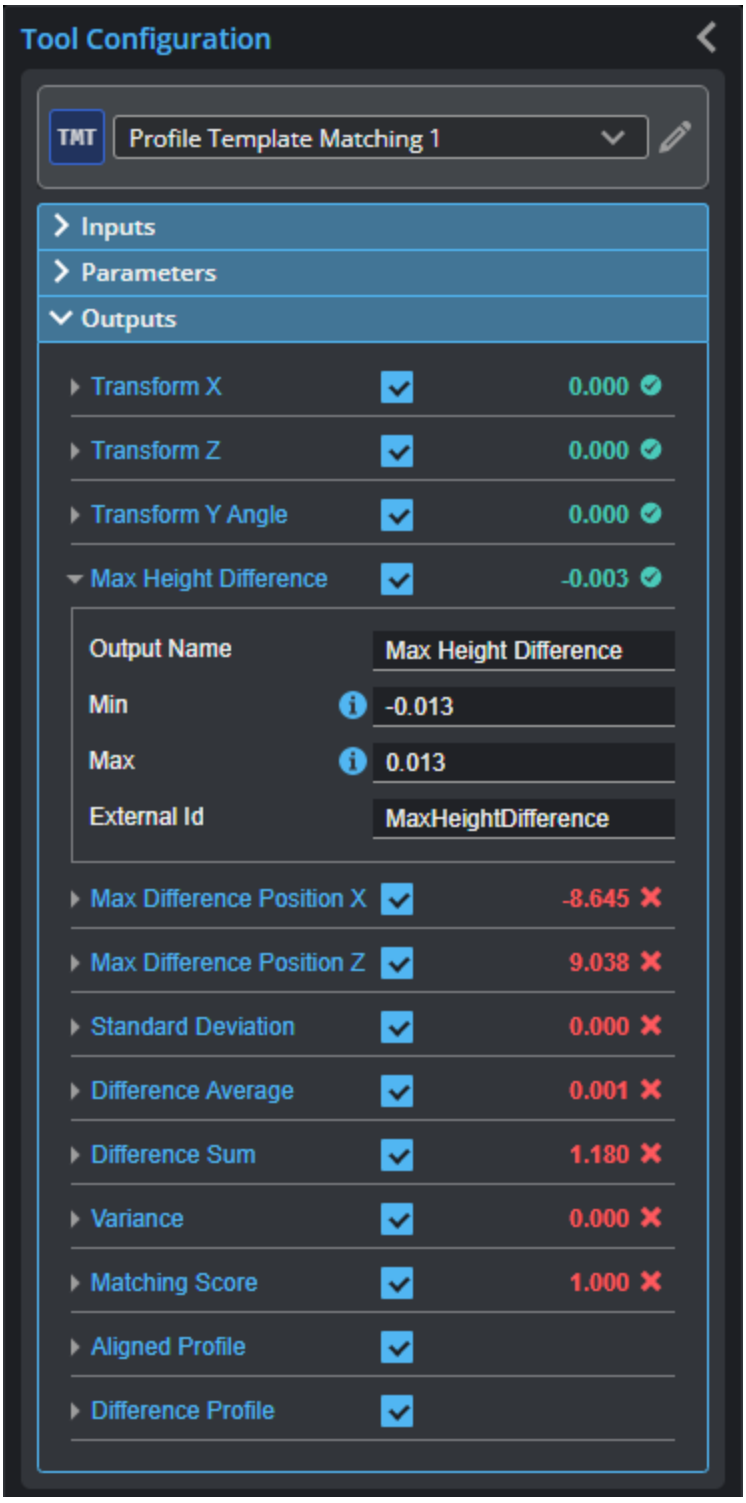
*Parameters*

| Parameter | Description |
|---|---|
| Template | When expanded, displays **File** and **Operation** parameters. |
| File | A list of templates available to the tool. The template containing the profile the tool uses as a master profile for alignment and comparisons. Use the **Operation** parameter to add and remove templates to this list. |
| Operation | Provides operations related to profile template files (masters). One of the following:<br>• **Normal**: Selected by the tool after you perform another file operation.<br>• **Create**: Creates a new template file.<br>• **Load**: Loads the template selected in **File**.<br>• **Save**: Saves the current profile to a template file in the local file system and adds it to the list in **File**. Multiple templates can be available.<br>• **Delete**:Deletes the template file selected in **File**.<br>• **Refresh**: Refreshes the list of files. |
| Use Region | Whether the tool uses a user-defined region to perform *matching*. (The tool uses *only* the data profile and master data in this region to perform matching.)<br>If this option is not checked, the tool performs matching using data from the entire active area.<br>For more information on regions, see *Regions* on page 181. |
| Region | The size and position of the region in which the matching (alignment) is performed. This can be useful if only a small part of the profiles is suitable for alignment.<br>Master comparison measurements however are applied to the entire profile (current profile and master). For example, in the following image, the tool limits matching to the data in the match region. But the measurement (Max Height Difference in this case) is calculated on the data outside the region.<br>  |
| Coarse Align | When enabled, shows the **X Shift Window** parameter. Use this setting by itself if you expect targets will only move along the X and Z axes (that is, you don't expect |

| Parameter | Description |
|---|---|
| | rotation). Otherwise, when combined with **Fine Align**, it provides a good initial start position for fine alignment. |
| X Shift Window | The maximum distance on the X axis the tool can move the current profile in order to align it. Should be set to the maximum amount the part is expected to shift left or right. (Enabled using the **Coarse Align** parameter.) |
| Fine Align | When enabled, lets you set the **Max Iteration** and **Match Window** parameters for fine alignment. This alignment method is more accurate than coarse alignment but takes more time to run. |
| Max Iteration | The maximum number of iterations the tool uses to perform fine alignment of the profile to the master. |
| Match Window | The region in which points are evaluated for a match. It there's a larger difference between the current profile and the master than the match window size, it would ignore the point. |
| Master Compare | Causes the tool to compare the current profile to the master profile and return results in some of the tool's measurements. (See list above.)<br>When disabled, the measurements that compare the profile to the master return invalid values. |
| Difference Profile Median Size | Defines the size of the window the tool uses to smooth out noise in the Difference Profile data output. |
| Tolerance | The difference tolerance for the master comparison. |
| Display Master | Displays the Master template (white profile). |
| Display Aligned Profile | Displays the aligned (blue profile). |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement |
| --- |
| **Transform X**<br>**Transform Z**<br>The distance the profile has shifted on the X and Z axis after alignment to the master, respectively. |
| **Transform Y Angle**<br>The rotation of the profile around the Y axis after alignment. |
| **Max Height Difference**<br>The maximum height difference between the profile and the master. |
| **Max Difference Position X**<br>**Max Difference Position Z**<br>The X and Z positions of the maximum height difference between the profile and the master. |
| **Standard Deviation**<br>The standard deviation between the profile and the master. |
| **Difference Average**<br>The average difference on the Z axis between the profile and the master. |
| **Difference Sum**<br>The sum of the differences on the Z axis between the profile and the master. |
| **Variance**<br>Returns the variance of a difference profile calculated by subtracting the current profile from the master. |
| **Matching Score**<br>Returns a value between 0 and 1 that is the is the percentile of standard deviation of a difference profile (calculated by subtracting the current profile from the master) from the tolerance. |

*Data*

| Type | Description |
| --- | --- |
| Aligned Profile | The profile aligned to the master. |
| Difference Profile | A profile representing the differences between the profile and the master.<br>Z values in the difference profile above 0 represent data points higher in the profile than in the master.<br>Z values in the difference profile below 0 represent data points lower in the profile than in the master.<br>Z values in the difference profile at 0 represent data points that are the same in the profile and the master. |

## Raw Profile Matching

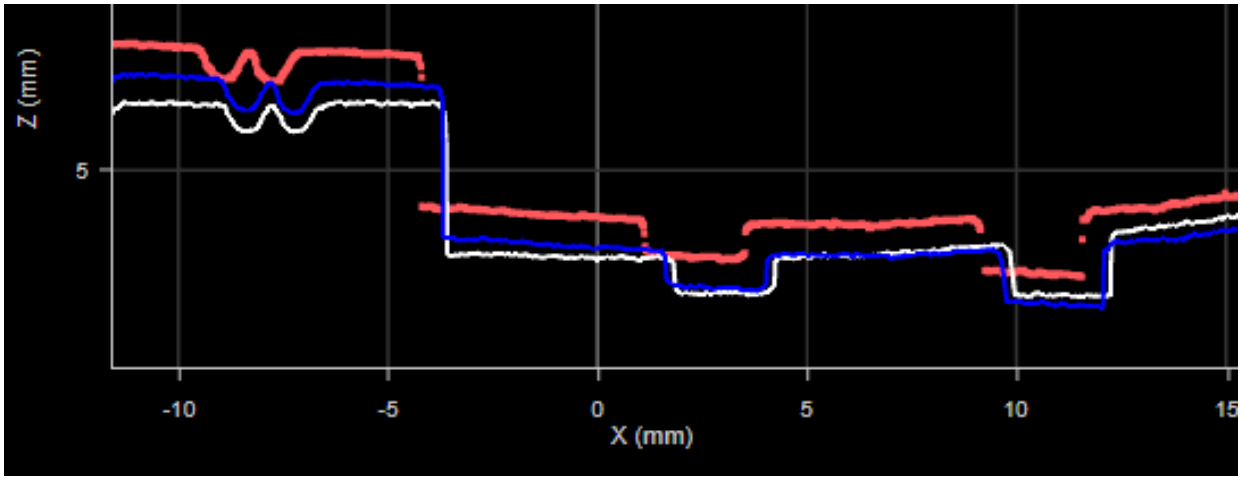
> The Raw Profile Matching tool takes unresampled profile data as input (the **Enable uniform spacing** setting is disabled on Acquire > Scanners).

The Raw Profile Matching tool lets you align a profile to a "master" template profile you create in the tool (a "golden template"), compensating for movement of the target from frame to frame. As a result, you can perform measurements on a "stabilized" profile.

The tool returns measurements that represent differences between the profile and the master, letting you perform simple defect detection and location from within the tool.

The tool also outputs an aligned profile that other Profile measurement tools can use as input (via their **Stream** parameter).

In the data viewer, the profiles are rendered using different colors:



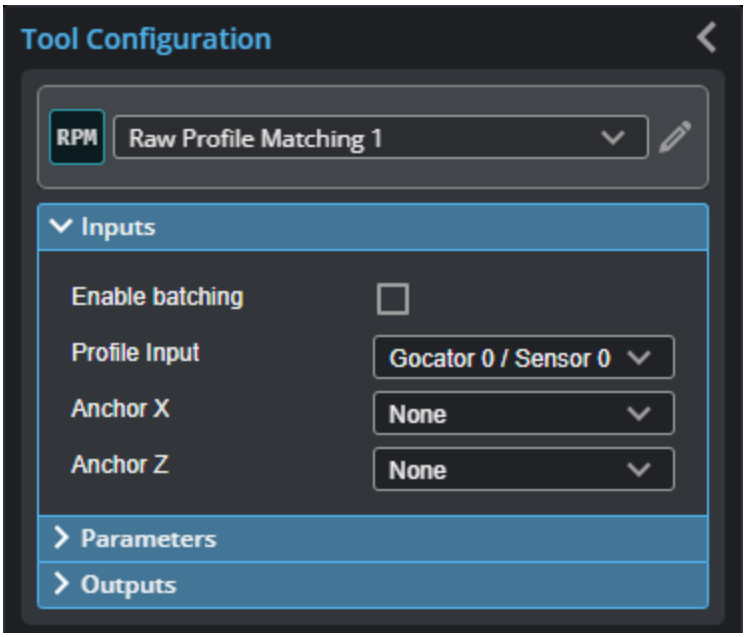

*The master profile is rendered in white. The aligned profile is rendered in blue. The current profile is rendered in red.*

Note that in the image above, the tool is performing only a rough alignment to ensure that the different profiles are clearly visible for illustration purposes. Typically, the blue aligned profile will be on top of the white master profile.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



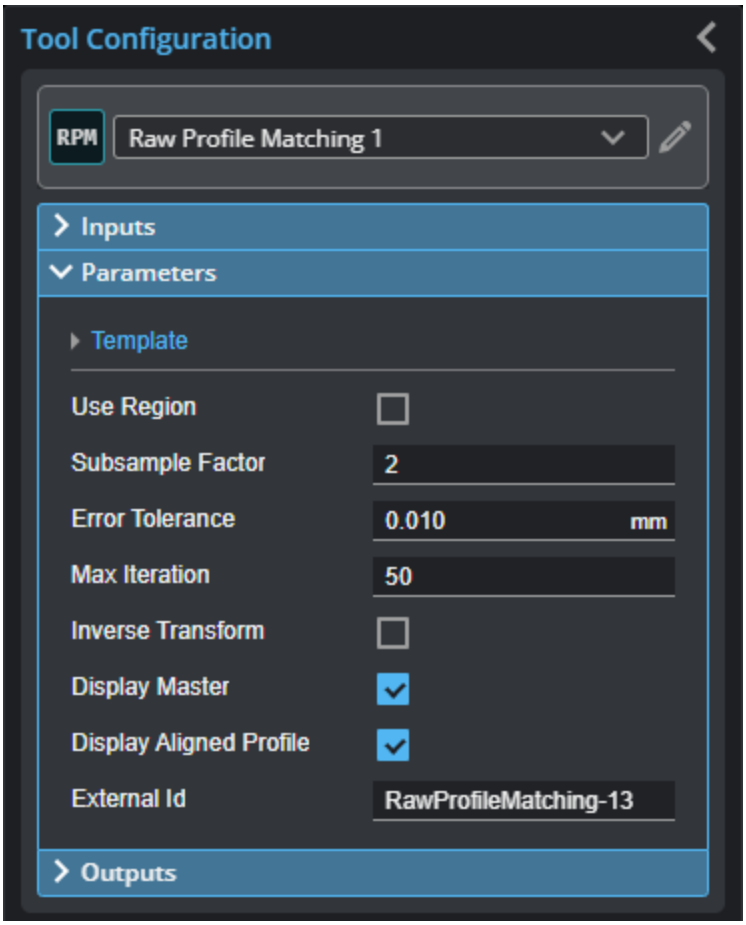

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

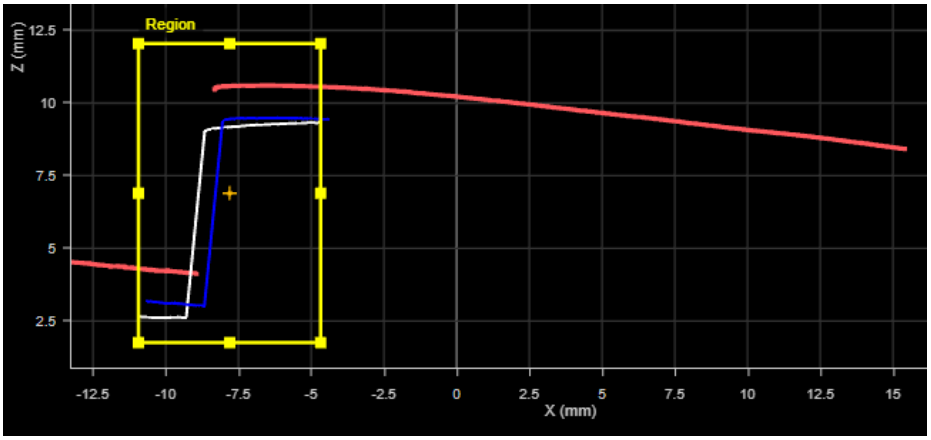
**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



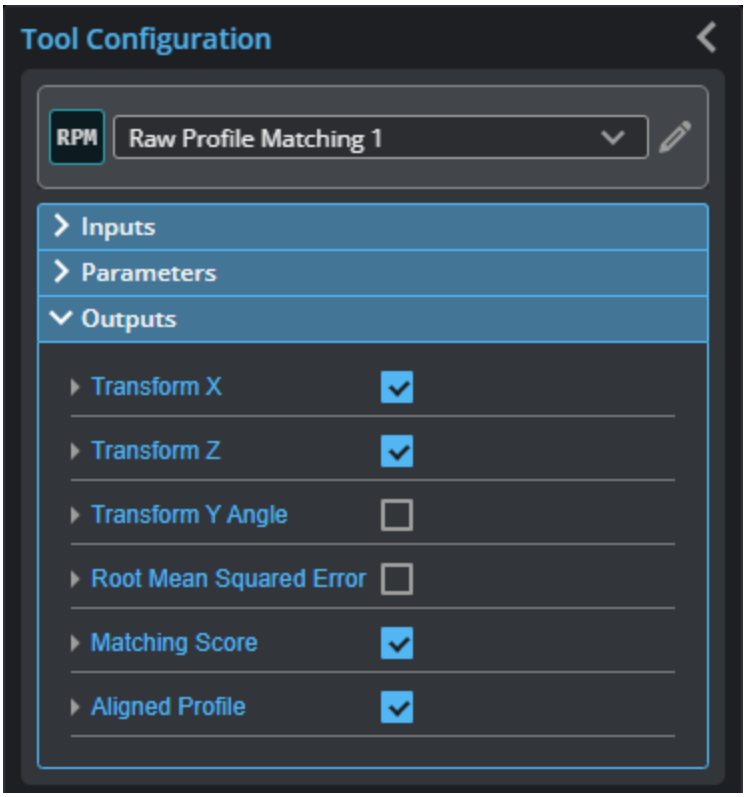

*Parameters*

| Parameter | Description |
|---|---|
| Template | When expanded, displays **File** and **Operation** parameters. |
| File | A list of templates available to the tool to use as a master profile for alignment and comparisons. Use the **Operation** parameter to add and remove templates. |
| Operation | Provides operations related to profile template files (masters). One of the following:<br>• **Normal**: Selected by the tool after you perform another file operation.<br>• **Create**: Creates a new template file.<br>• **Load**: Loads the template selected in **File**.<br>• **Save**: Saves the current profile to a template file in the local file system and adds it to the list in **File**. Multiple templates can be available.<br>• **Delete**:Deletes the template file selected in **File**.<br>• **Refresh**: Refreshes the list of files. |
| Use Region | Indicates whether the tool uses a user-defined region to perform *matching*. (The tool uses *only* the data profile and master data in this region to perform matching.) |

| Parameter | Description |
|---|---|
| | If this option is not checked, the tool performs matching using data from the entire active area.<br>For more information on regions, see *Regions* on page 181. |
| Match Region | When **Use Region** is enabled, provides settings for the size and position of the region in which the matching (alignment) is performed..<br>Master comparison measurements however are applied to the entire profile (current profile and master). For example, in the following image, the tool limits matching to the data in the match region. But the measurement (Max Height Difference in this case) is calculated on the data outside the region.<br>  <br>(The dashed lines are added to illustrate the hidden aligned profile and master.) |
| Subsample Factor | The sampling interval of the input profile point cloud. |
| Error Tolerance | The difference tolerance for the master comparison. |
| Max Iteration | The maximum number of iterations the tool uses to perform iterative closest point (ICP). The tool stops iterating once the input profile is considered within the error tolerance (see above). |
| Inverse Transform | When enabled, inverts the output transformation. |
| Display Master | Displays the Master template (white profile). |
| Display Aligned Profile | Displays the aligned profile (blue profile). |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

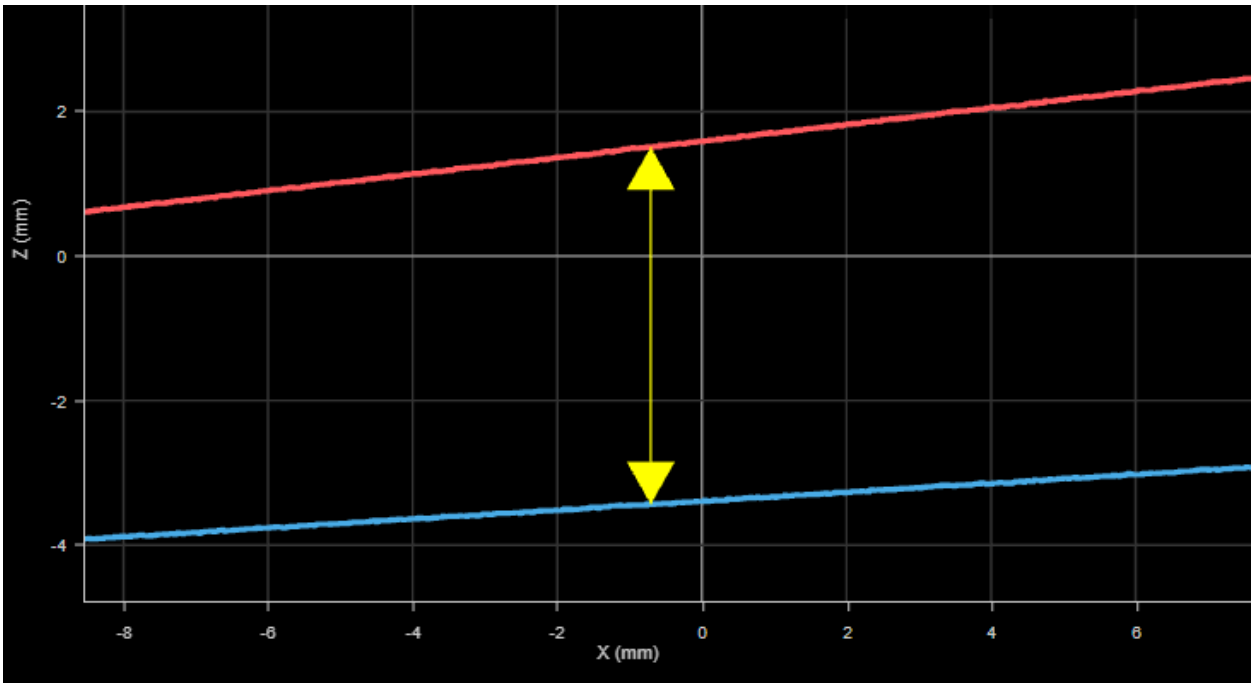
| **Measurement** |
|---|
| **Transform X**<br>**Transform Z**<br>The distance the profile has shifted on the X and Z axis after alignment to the master, respectively. |
| **Transform Y Angle**<br>The rotation of the profile around the Y axis after alignment. |
| **Root Mean Squared Error**<br>The root mean squared error of the alignment. |
| **Matching Score**<br>Returns a value between 0 and 1 representing the percentile of standard deviation of a difference profile (calculated by subtracting the current profile from the master) from the tolerance. |

*Data*

| **Type** | **Description** |
|---|---|
| Aligned Profile | The profile aligned to the master. |

## Profile Thickness

The Thickness tool lets you perform thickness measurements between the two profiles you specify.

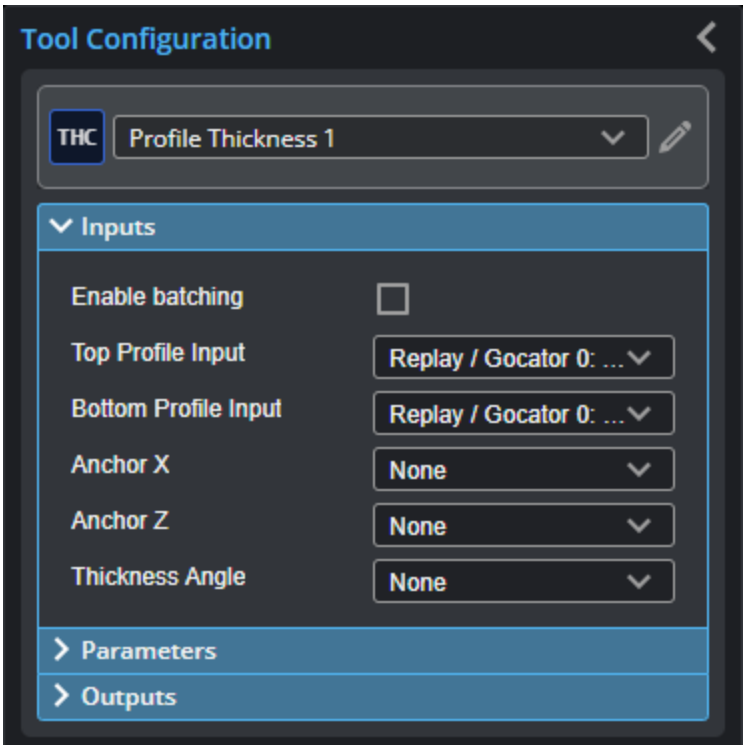



The tool also lets you specify an angle measurement relative to which the tool performs the thickness measurements, up to a maximum of 20 degrees, to compensate for minor tilt of the target. To get the compensation angle, you could first fit a straight line to the top profile using the Profile Line tool, and pass that tool's Angle measurement to Profile Thickness. (For information on Profile Line, see *Profile Line* on page 263.)

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

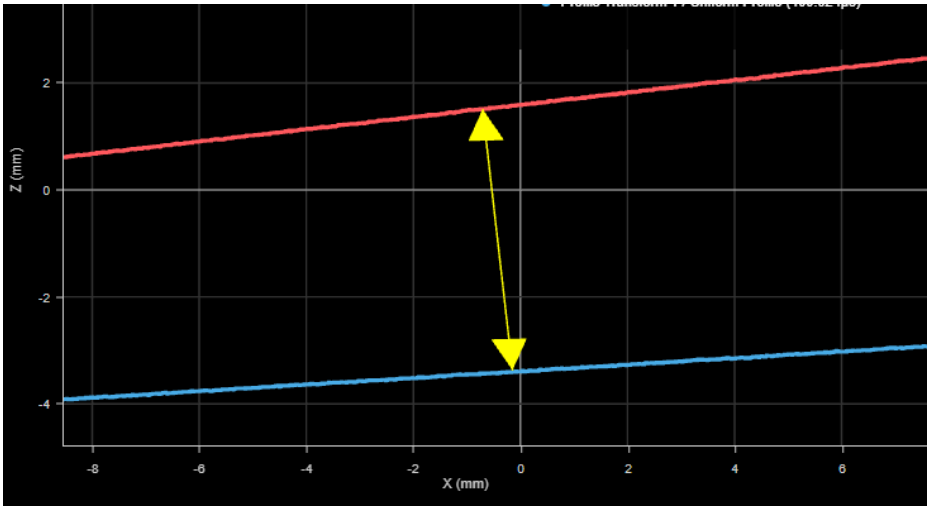
You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

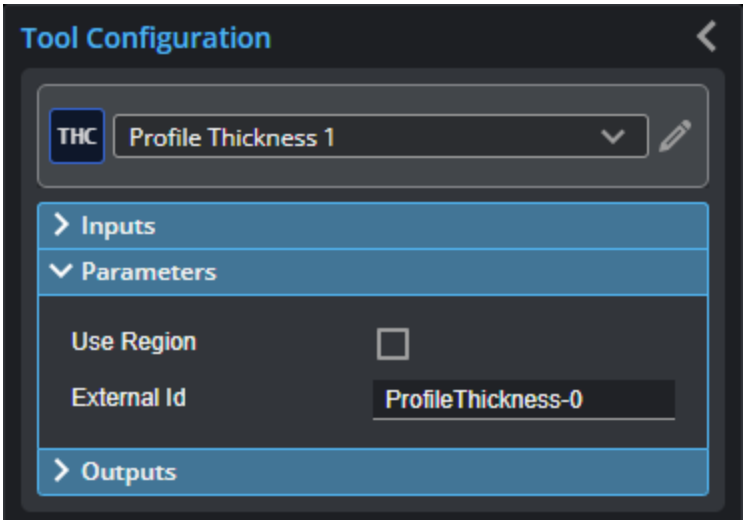
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Top Profile Input | The top and bottom profiles the tool uses to perform thickness measurements. If **Enable Batching** is checked, each input takes an array. |

| Name | Description |
|---|---|
| Bottom Profile Input | |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Thickness Angle | An angle measurement from another tool that the Thickness tool uses for the angle of the thickness measurement. If no angle is provided, the thickness measurement is perpendicular to the X axis.   |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



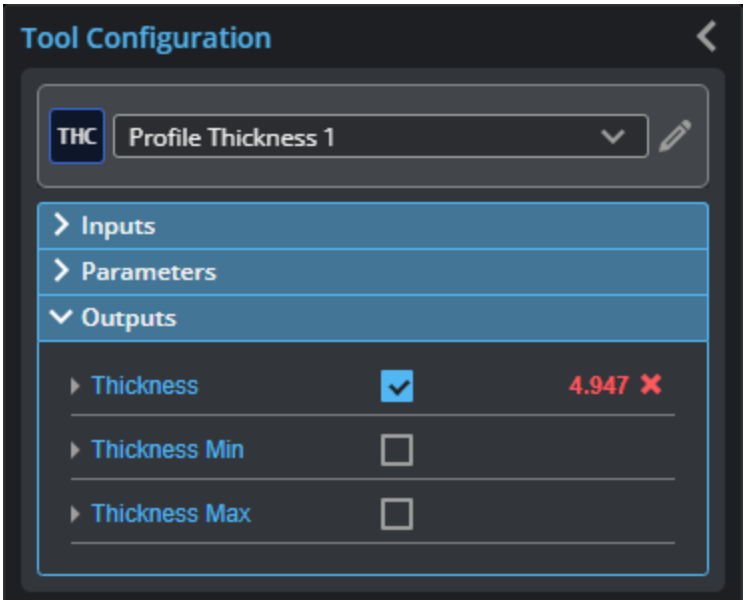

*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |

| Parameter | Description |
|---|---|
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

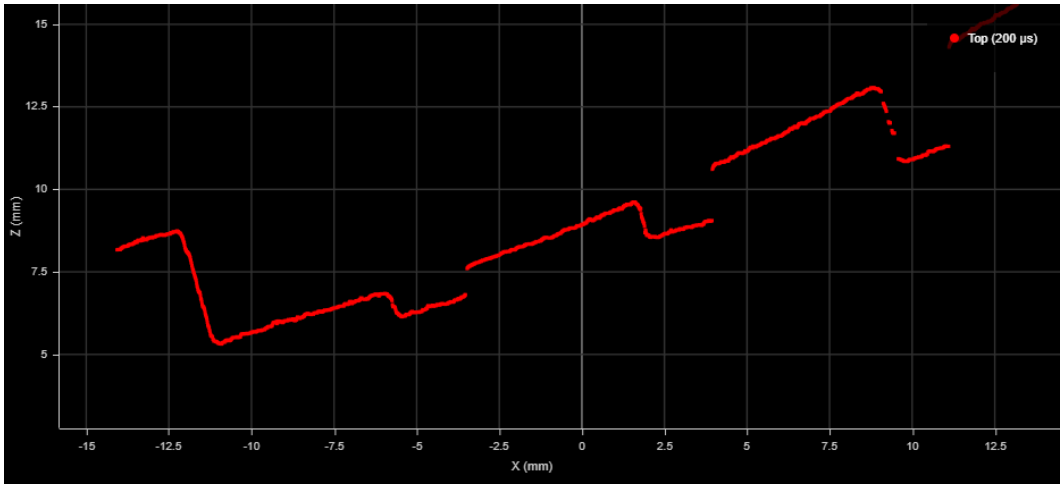
*Measurements*

| Measurement |
|---|
| **Thickness**<br>The thickness measured in the scan data. |
| **Thickness Min**<br>The minimum thickness measured in the scan data. |
| **Thickness Max**<br>The maximum thickness measured in the scan data. |

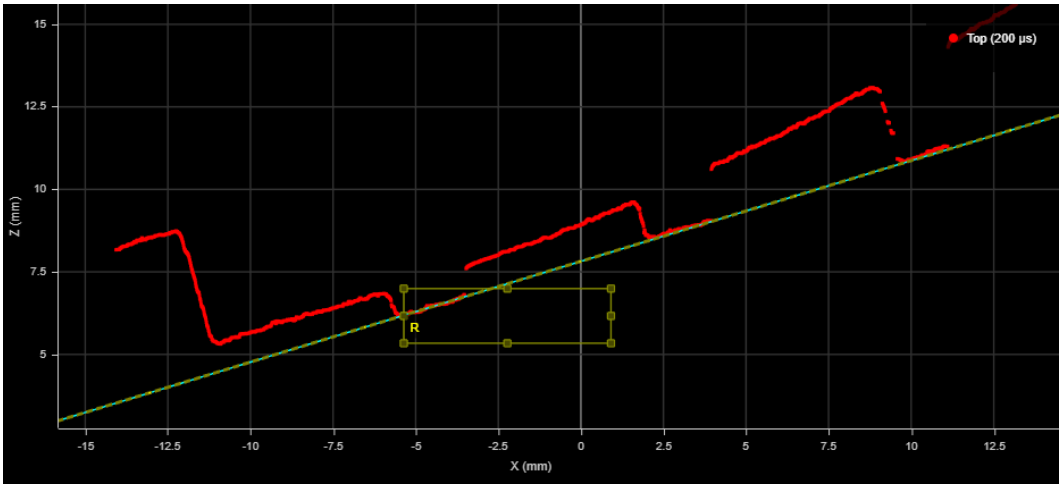
## Profile Transform

The Profile Transform creates a new profile based on the coordinate system of geometric features the tool uses as input and/or fixed input values. The tool accepts a Line geometric feature (rotating the profile so that the line is parallel to the X axis) and/or a Point geometric feature (using it as the X and Z origin).

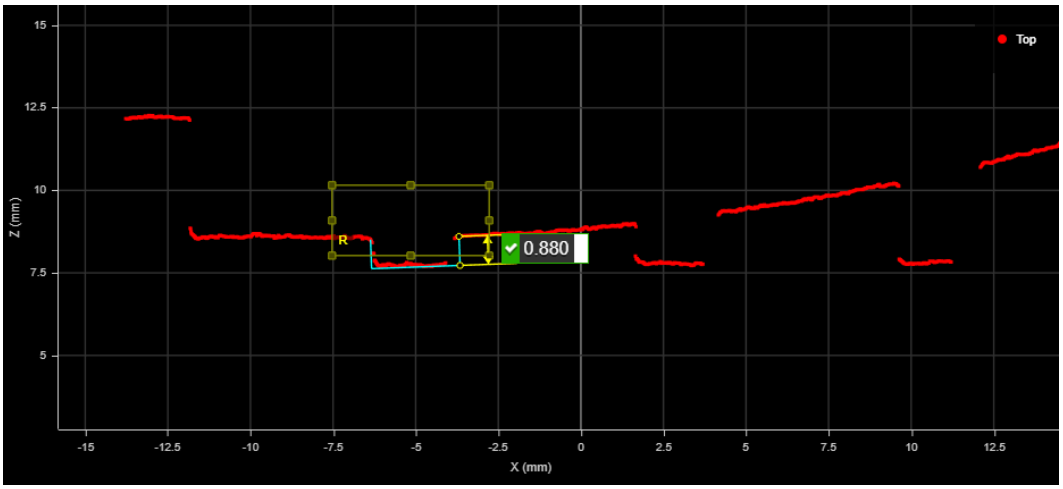
For example, in the following, if you want to measure the characteristics of the first groove on the left, you can use the tool to rotate the profile.




First, a Profile Line tool is added and configured on the bottom of the groove. The tool is configured to output a line geometric feature.



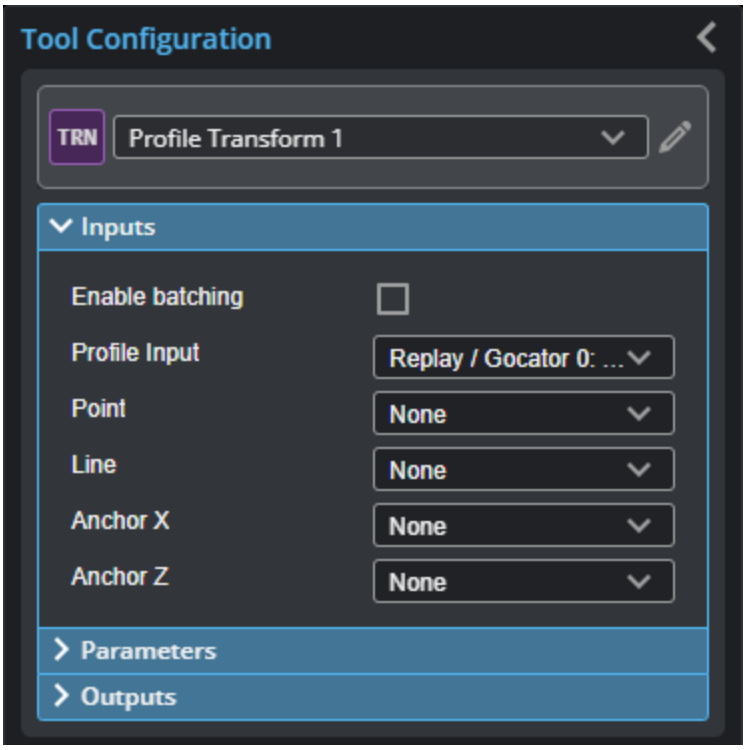

A Profile Transform tool takes the line geometric feature as input, and the transformed profile from that tool is used as input for a Profile Groove tool, which measures the groove's characteristics:




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



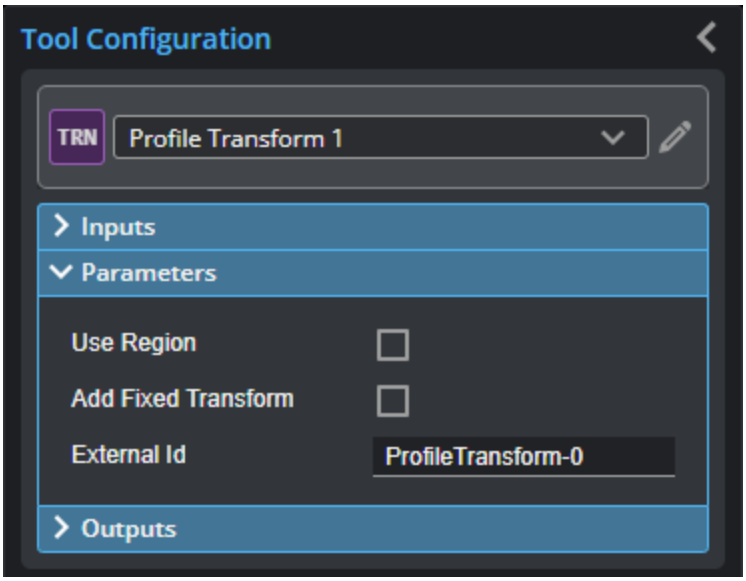

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Profile Input | The data the tool applies measurements to or processes. |
| Point | The Point geometric feature the tool uses to offset a profile to an X and Z origin of 0. |
| Line | The Line geometric feature the tool uses to position (X and Z) and to rotate a profile Y rotation). |
| Anchor X or Anchor Z | The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



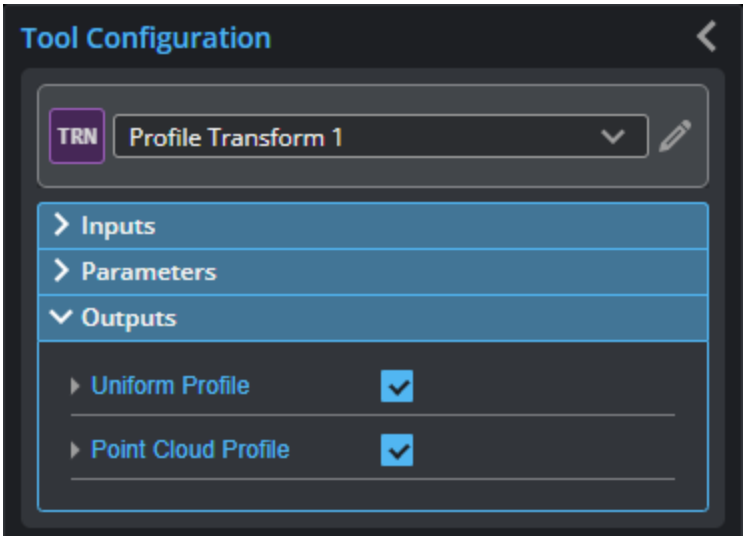

*Parameters*

| Parameter | Description |
|---|---|
| Use Region | Whether the tool should limit the transformed profile that it outputs to a user-defined region. When enabled, the tool displays a **Region** parameter you use to define the region.<br>If this option is not enabled, the tool transforms the entire profile. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Add Fixed Transform | Enables **X Offset**, **Y Offset**, and **Angle** parameters you can use to manually set a |

| Parameter | Description |
|---|---|
| | transformation. Useful if you know the profiles in the scan data will always be in a certain position or orientation. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

| Type | Description |
|---|---|
| Profile Uniform | The transformed profile. |
| Profile Point Cloud | The outputs will contain the same profile data, but the type (uniform vs. point cloud) will differ, so any Profile tool will be able to take this tool's output as input. |

## Surface Measurement

Surface measurement involves capturing scan data, optionally identifying discrete objects, and measuring properties of the surface or the objects, such as the volume of the object or the height at a certain position of the object. All volumetric tools have the ability to operate either on the entire surface or the full object, or within a region of interest at a certain position in relation to the surface or an object.

Multiple measurements can be performed on the entire surface or each discrete object, limited only by the available CPU resources.

### Isolating Parts from Surface Data

Gocator lets you isolate and then measure parts in different ways. This section describes some of the differences between these methods.

- For line profiler sensors, on the **Acquire** page, by enabling continuous Surface generation and configuring the part detection settings. (For more information, see *Surface Generation* on page 113.)
- By using the Surface Blob or Surface Segmentation measurement tools (for more information, see *Surface Blob* on page 399 and *Surface Segmentation* on page 569).
- For snapshot sensors (and G2, G4, or G5 sensors when Surface generation is *not* set to Continuous), by using the Surface Part Detection tool.
- For line profile sensors, by using the Profile Part Detection tool.

The table below lists several differences between the different methods. A key difference however is that Scan page part detection extracts scan data that is identified as a "part" and outputs it as a *separate frame*. This lets you use any measurement tool on parts individually. Note however that parts must be clearly separated and be relatively consistently spaced for the part detection algorithm to separate the parts. In general, if you can successfully isolate parts using part detection, use this method rather than the Surface tools.

With Surface Blob and Surface Segmentation, on the other hand, areas are not extracted as individual frames. They are extracted either as individual outputs or as elements in an array. (For more information on arrays, see *Arrays, Batching, and Aggregation* on page 171.) These tools also provide measurements such as length, width, and area, which lets you handle common pass/fail needs.

*Main Differences Between Part Detection, Surface Blob, and Surface Segmentation*

| | Part Detection | Surface Blob | Surface Segmentation |
|---|---|---|---|
| Allows output of individual surfaces to separate frames | Yes | No | No |
| Allows separating touching objects | No | Yes - Limited<br>Through Open filter, some connections between parts can be separated, but the control is more limited than | Yes |

| | Part Detection | Surface Blob | Surface Segmentation |
|---|---|---|---|
| | | with Surface Segmentation. | |
| Supports background present | Yes<br>Height threshold must be set above or below the background | Yes<br>Height threshold must be set above or below the background | Yes |
| Supports background with significant tilt or intensity gradient | No<br>Fixed height threshold is used | No<br>Fixed height threshold is used | Yes<br>Adaptive threshold is used |
| Integrated Width/Length/Area measurements | N/A | Yes | Yes |
| Includes circularity and convexity filtering | No | Yes | No |
| Fast operation | Yes | Yes | No |
| Finds objects above or below background | Yes | Yes | Yes<br>But requires careful region placement |

## Surface Align Ring

This tool is only intended for performing high-accuracy alignment of multi-sensor ring and partial ring layouts with G2 (line profile) sensors, using recorded scan data.

### Surface Align Wide

This tool is only intended for trouble-shooting high-accuracy alignment of multi-sensor wide layouts with G2 (line profile) sensors, using recorded scan data.

### Surface Anomaly Detector

> This tool requires a special dongle and license to function with live sensor data. (Available for purchase from LMI.) You must also install the dongle's supporting CodeMeter runtime to license the tool, which you do in GoPxL Manager. For more information, see *Installing Licensing Software* on page 821.

> The Surface Anomaly Detector toolset only runs on GoMax ORIN / ORIN+ and on PC.
>
> For information on getting and uploading a GoMax firmware that provides this tool, see the GoMax ORIN / ORIN+ user manual.

The GoPxL Anomaly Detector toolset, which is part of LMI's new GoPxL Pro Tools, lets you train and deploy AI-powered anomaly detection in parts and surfaces in scan data produced by a compatible Gocator sensor.

You can download the Pro Tools package for PC, which contains the toolset (`14658-1.2.x.x_SOFTWARE_GoPxL_Pro_Utilities.exe`), from the downloads area of the LMI Technologies website: https://lmi3d.com/product-downloads/. Run the installer, and provide a location where the content of the package will be unzipped.

The toolset includes the following:

- The Surface Anomaly Detector tool: This tool provides an AI-based model training routine and an inference engine that uses a trained model to predict whether something in production scan data is an anomaly. The training routine steps you through the process of training on "good" (OK) and "bad" (NG) example frames. The tool can also simulate part orientation and acquisition variations, as well as synthetic NG frames to improve model performance.
- The Training Archive tool: An auxiliary tool that conditionally saves frames to a project created in Surface Anomaly Detector, letting you improve the model on scan data acquired at a later time. For information on the Training Archive tool, see *Training Archive* on page 381.

The toolset supports both 2D intensity and 3D data. Surface Anomaly Detector runs on GoMax NX / ORIN / ORIN+ hardware accelerators or on PC. You must install a special firmware that includes the tool on your GoMax unit, and the on-sensor firmware version must match the GoMax firmware version.

Sample datasets are available in a package on LMI's Download page. For more information, see *Sample Files* on page 384.

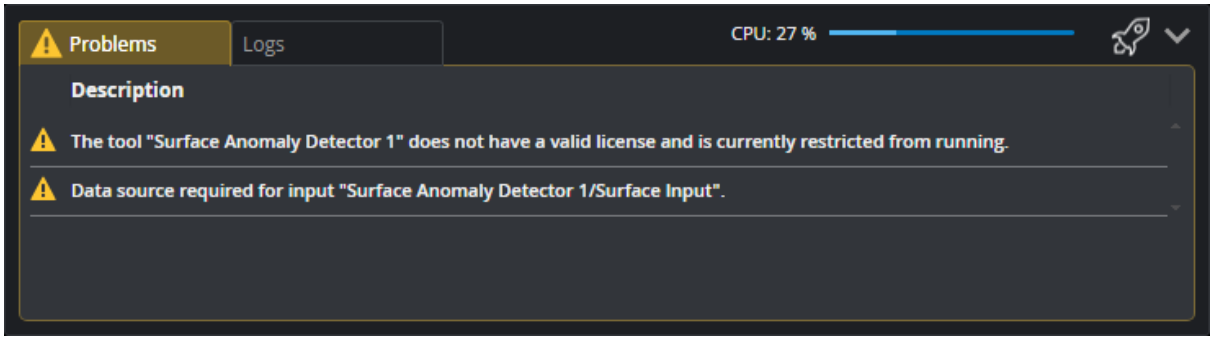
> The Anomaly Detector tool can be used with all Gocator sensors, except G1 sensors, G200 sensors, and G2300 revision A or B G2 models.

#### Hardware and Software Requirements

The following hardware and software is required to use the GoPxL Anomaly Detector in production:

1. One or more compatible Gocator 3D sensors: G2, G3, G4, or G5. Note that GoPxL can only accelerate a single G3 sensor.
2. A GoPxL Anomaly Detector license and dongle, inserted into a USB port on the GoMax unit or PC.

A license and dongle are required for running the tool on live scan data. Without the dongle, you can only evaluate the tool on previously scanned data. The tool will also display an error message without a dongle:




Plugging in the license dongle will license the tool. If the sensor system is running when you insert the dongle (that is, acquiring scan data), you must stop the system before it will license the tool.

3. A GoMax NX, GoMax ORIN, or GoMax ORIN+ accelerator, depending on scan resolution, cycle time and pre- or post-processing requirements.

   GoPxL Anomaly Detector can also run on a PC. If you choose to run GoPxL Anomaly Detector on a PC instance of GoPxL, the PC must have a graphics card with a recent Nvidia GPU that supports Nvidia GeForce Game Ready Driver version 528.33 or higher, and a compute capability of 7.5 or higher. To verify the driver version of your video card, launch the NVIDIA Control Panel, and in the main panel of the application, make note of the driver version. To exceed the capabilities of GoMax ORIN in terms of training times and inference, an RTX 4070 or higher is recommended.

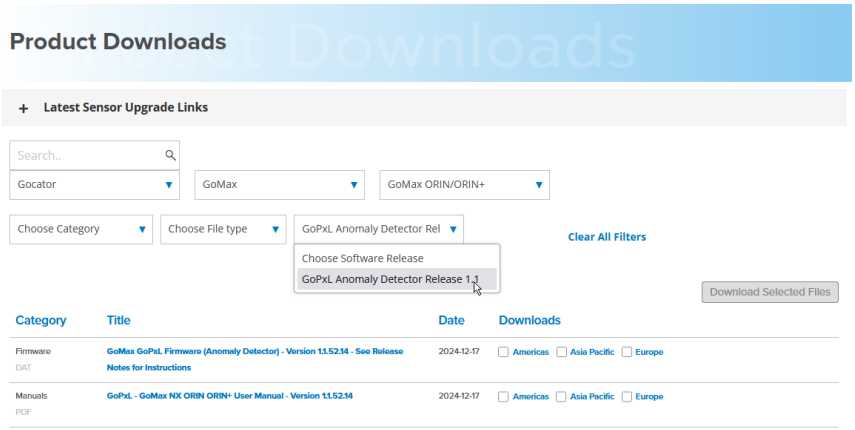
Note the following general requirements for running GoPxL on a PC:

- Processor: x86-64 (Core i3 or equivalent)
- RAM: 8 GB
- Hard drive: 64 GB
- Operating system: Windows 10 or 11 (64-bit only)
- Display: 1366 x 768

4. A special version of GoPxL that includes GoPxL Anomaly Detector for GoMax or for PC.

   You can find the appropriate version of GoPxL on LMI's Product Downloads page (https://lmi3d.com/product-downloads/).

   For GoMax, choose "Gocator" as the Product Brand, and then choose GoMax under Product Family, and your model under "Product Series." Under "Choose Software Release," choose a release that specifies Anomaly Detector. Scroll to find the firmware.




   For sensors and GoPxL for PC, under "Product Family," choose your the family of your sensor. Scroll to find the firmware and software, respectively.

5. If you are running GoPxL Anomaly Detector on a PC, a version of the CodeMeter runtime that is compatible with the dongle and license is required.

   You install the runtime in GoPxL Manager; for more information, see *Installing the CodeMeter Runtime on a Windows PC* below.

**Installing the CodeMeter Runtime on a Windows PC**

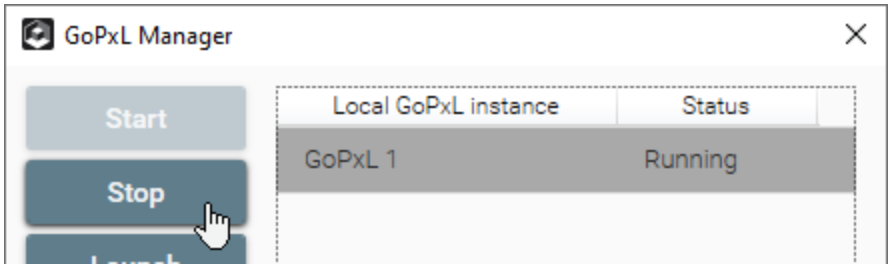
If you are using the Anomaly Detector toolset on a PC, you must the CodeMeter runtime, which is required by the GoPxL Anomaly Detector license and dongle. You install the runtime from GoPxL Manager.

*To install the CodeMeter runtime*

1. If GoPxL it is not already running, start GoPxL Manager.

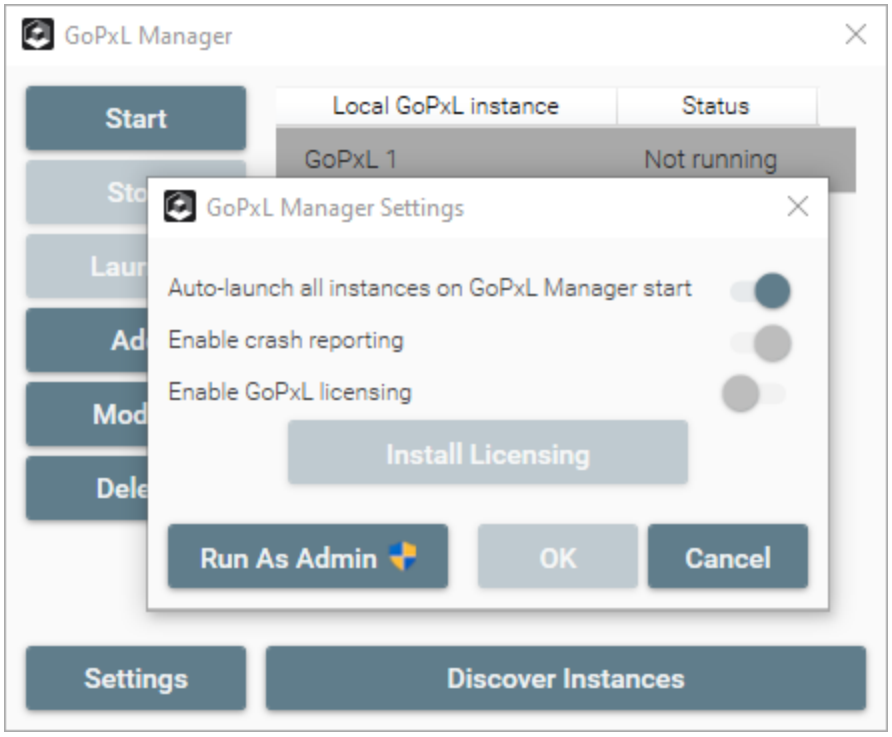
   For more information, see *Running GoPxL on a Windows PC* on page 814.

2. Stop any running instances of GoPxL.

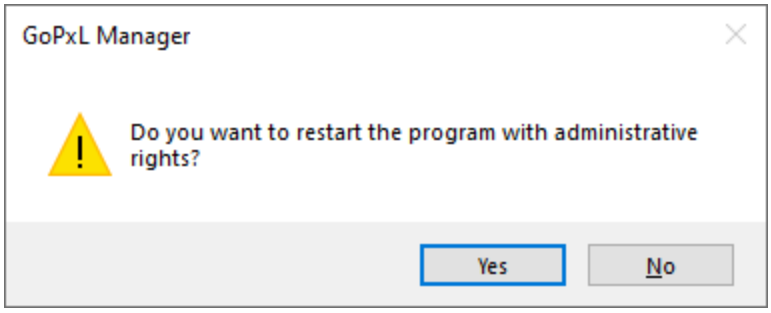



   When an instance stops, its status becomes "Not running."

3. Click **Settings**, and in the **GoPxL Manager Settings** dialog, click **Run As Admin**.



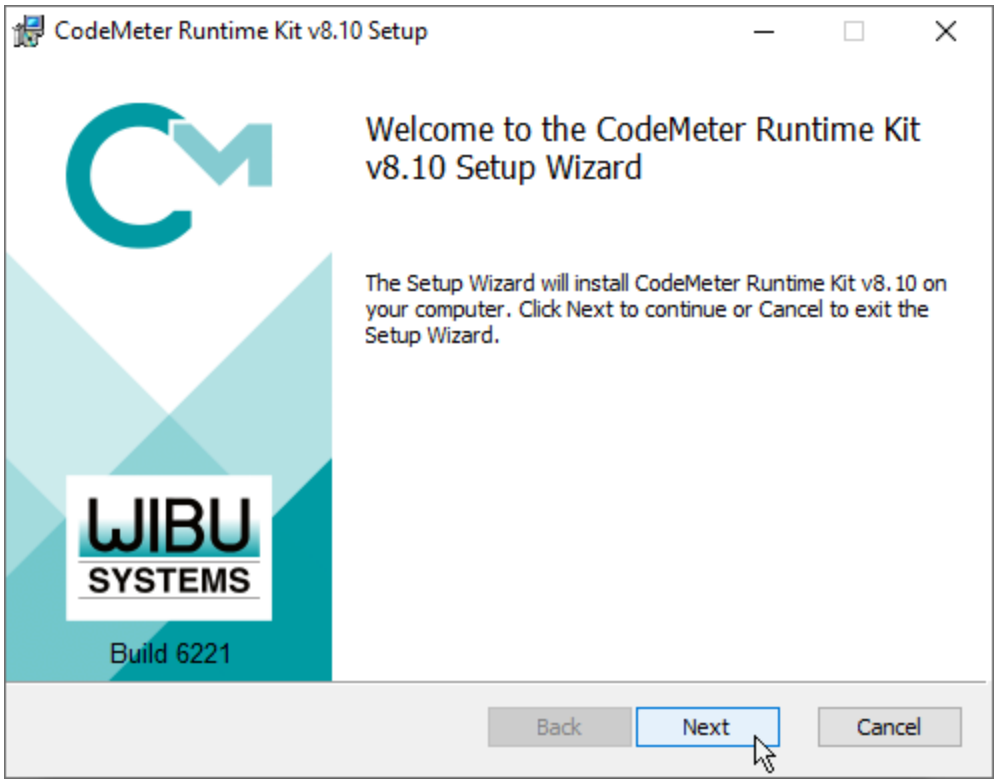
4. Answer Yes in the dialog that appears.




You will need to click Yes in the User Account Control dialog.

5. Click **Settings** again, and in the dialog, toggle on **Enable GoPxL licensing** and click **Install Licensing**.

The CodeMeter Runtime setup wizard launches.

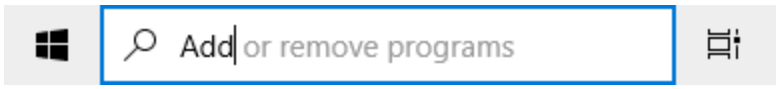


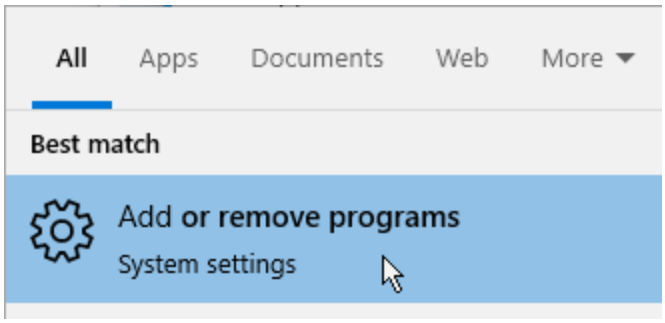

6. Go through the steps in the wizard to install the runtime.

You will need to accept the license agreement before continuing with the installation, and choose whether CodeMeter will be installed for all users on the PC. Leave the defaults in the Custom Setup step.

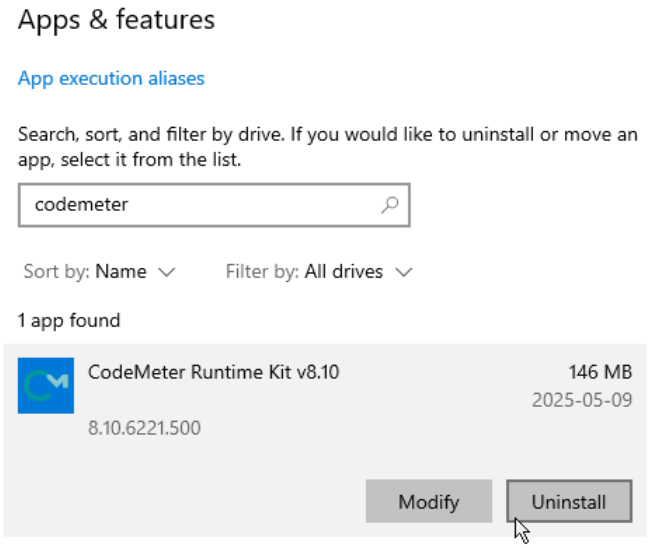
If you no longer need to use Anomaly Detector on your PC, remove the licensing software:

1. On your PC desktop, in the Search field, type "Add" and click "Add or remove programs" in the "Best match" list.



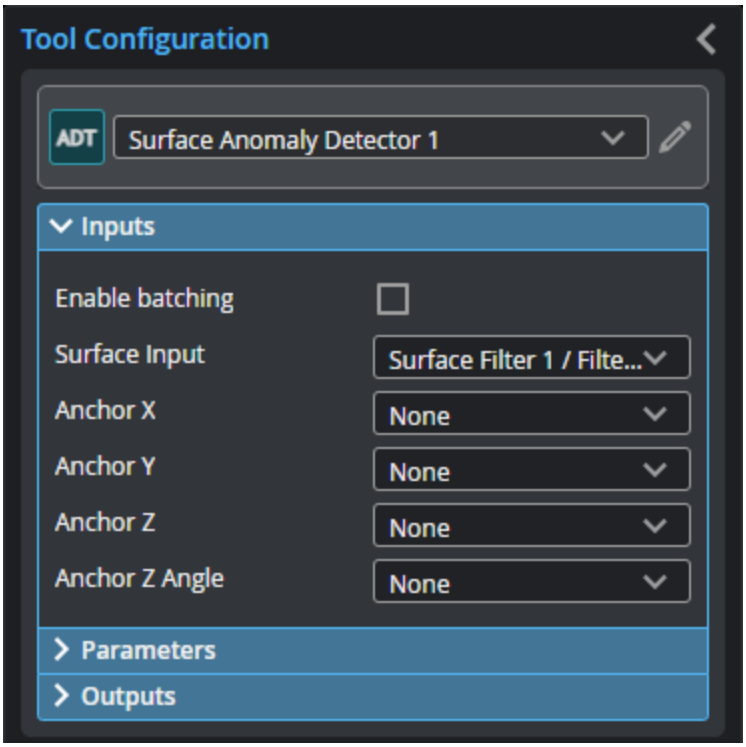



2. In the "Search this list" field, type "codemeter", click CodeMeter Runtime Kit to expand it, click **Uninstall**, and follow the instructions.




**Inputs**

You configure the tool's inputs in the expandable **Inputs** section.



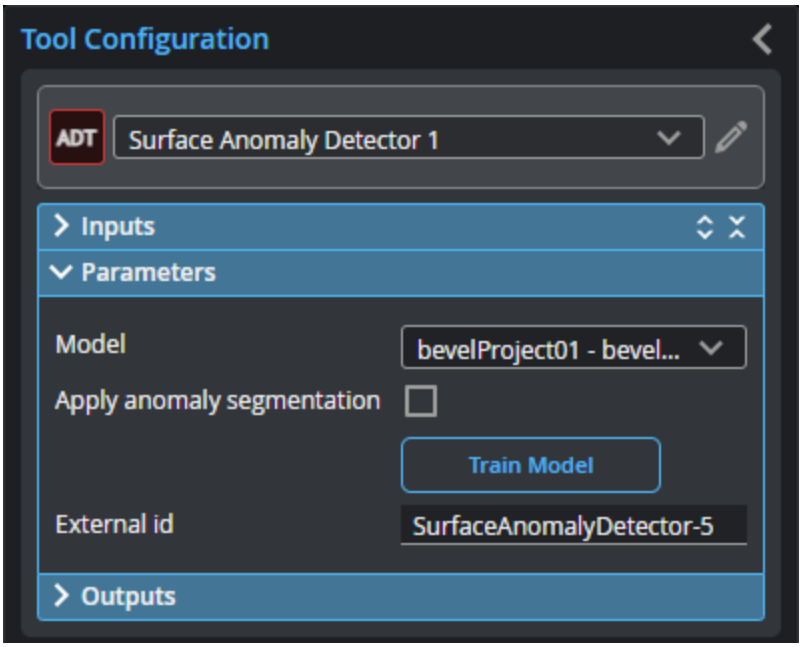

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Model | Chooses the trained model the tool uses to detect anomalies during production. |
| Apply anomaly segmentation | When you set **Model** to a previously trained model, this parameter is available.<br>When you enable this parameter, configure the parameters in **Segmentation parameters** (see below). |
| Segmentation parameters | The parameters that control anomaly output.<br><br>**Threshold Offset**<br>The offset that determines whether data is considered an anomaly.<br><br>**Open kernel X**<br>**Open kernel Y**<br>The X and Y kernel size, respectively, for morphological opening to remove small areas of data. Use these settings, for example, to remove bridges between areas to properly isolate them or to remove small areas entirely (perhaps caused by noise). Use different values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of unwanted data you see in the scan data.<br><br>**Close kernel X**<br>**Close kernel Y**<br>The X and Y kernel size, respectively, for morphological closing to fill in holes smaller than the specified kernel size. Use these settings, for example, to fill small areas within potential anomalies that may be caused by drop-outs. Use different |

| Parameter | Description |
|---|---|
| | values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of holes you see in the scan data.<br><br>**Use area filter**<br>If **Use Area Filter** is enabled, the tool applies an area filter to anomalies using the values you provide in **Max area** and **Min area**.<br><br>**Ordering**<br>Orders the measurements, features, and surface data of the individual anomalies output by the tool. One of the following:<br>• Position - X increasing<br>• Position - X decreasing<br>• Position - Y increasing<br>• Position - Y decreasing<br>• Area - Large to small<br>• Area - Small to large |
| Train Model | Starts the model training routine, which steps you through process. For more information, see *Train Model* on the next page. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Development Workflow**

The high level workflow is as follows:

1. Collect representative scans of the part you need to inspect in order to train an Anomaly Detector model. In addition to "good" parts, you need to scan "bad" parts, that is, ones with typical defects.
2. Create a pre-processing toolchain and train an Anomaly Detector model on GoMax.
3. Deploy the Anomaly Detector model and connect post-processing tools.
4. Optionally, collect new production data for model retraining on a GoMax.

**Collect dataset**

Unless you are using a previously created dataset, you must create the dataset that the GoPxL Anomaly Detector will use for training a model before it can detect anomalies in new production data. To do this, perform the following steps:

1. Record representative scans of 20 or more OK targets (targets with no flaws) and 20 or more NG targets (targets with flaws).

   You can record the scans to a single .gprec file or to multiple files. If you record scans to a single file, grouping each type (OK and NG) together will make it easier to label them later in the wizard. Make sure there are no empty frames: each frame should contain either an OK or an NG target. Do not rely on .gpsup or .rec for this as the Anomaly Detector wizard requires .gprec files when importing from PC.

2. Save a separate .gpsup file with the sensor configuration settings such as exposure time and related imaging parameters.

   Ensure the same parameters are used on the production system. Otherwise, you will need to collect new training data.

### Implement a Preprocessing Toolchain

The preprocessing tool chain limits variation in the scan data to the region or surface of interest (with and without anomalies). With less variation in the scan data, the total number of frames needed for training is reduced.

The preprocessing tool chain must not change between training and inference. Otherwise, the system will not function properly. You must save your preprocessing toolchain in the .gpsup file created previously or using a separate .gpjob file.

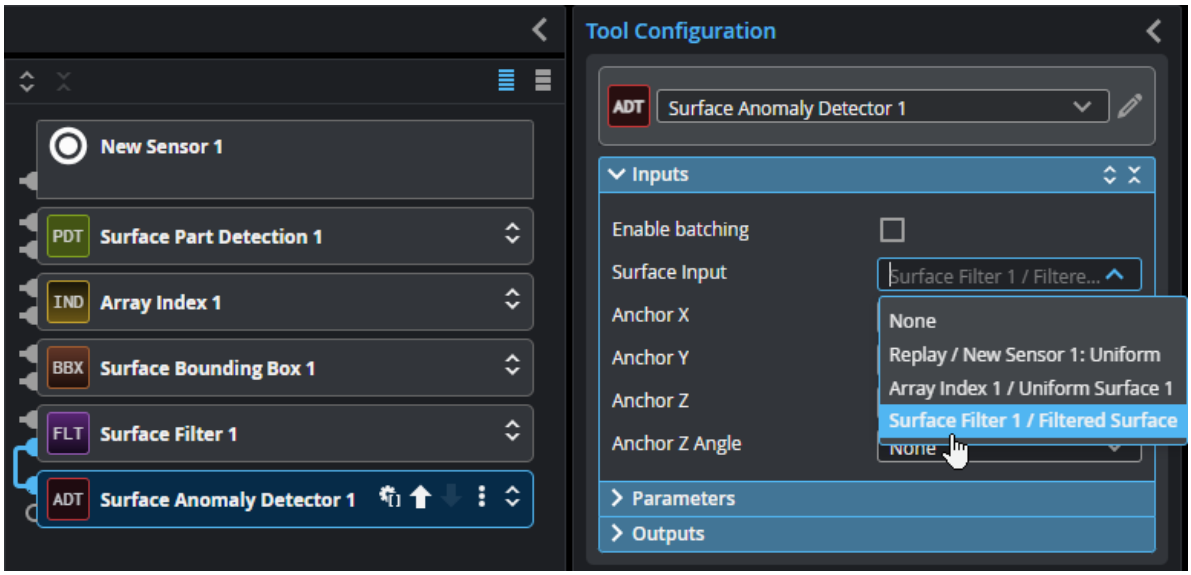
> You *must* use the same preprocessing toolchain for training and inference to ensure proper detection of anomalies.

### Train Model

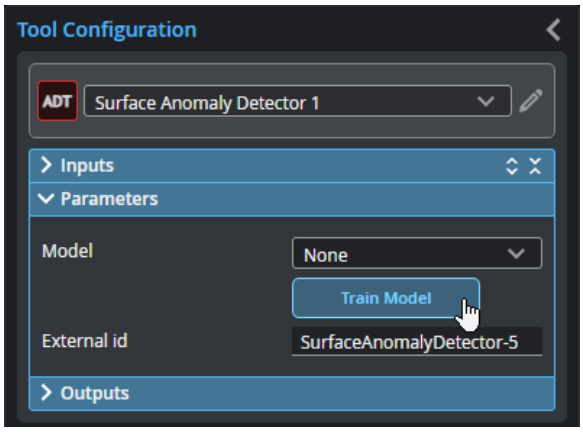
#### Add Surface Anomaly Detector Tool

1. Add and connect a Surface Anomaly Detector tool to the output of the preprocessing tool chain.

   In the following the first four tools in the Tool Diagram on the left are the preprocessing tool chain. The last tool in the chain, Surface Filter, is used as input for the Anomaly Detector tool.




2. In tool's **Parameters** section, click the **Train Model** button.

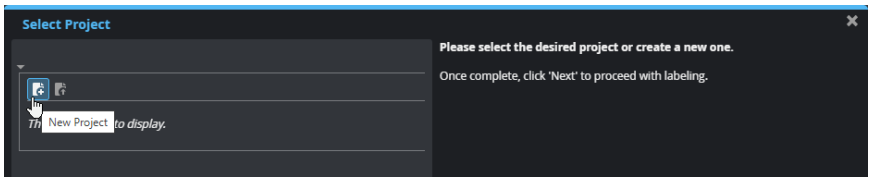


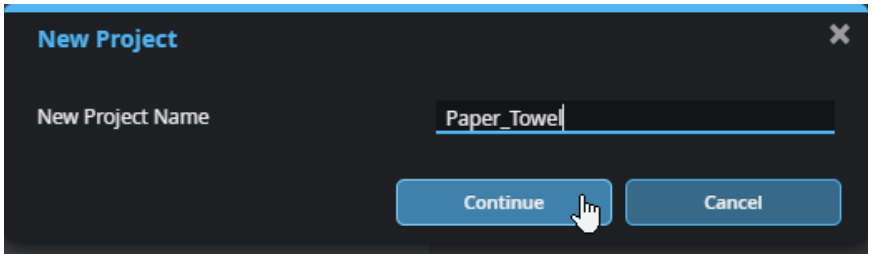

The routine starts and the **Select Project** page opens. You will create a new project in this page, or open a previously created project.

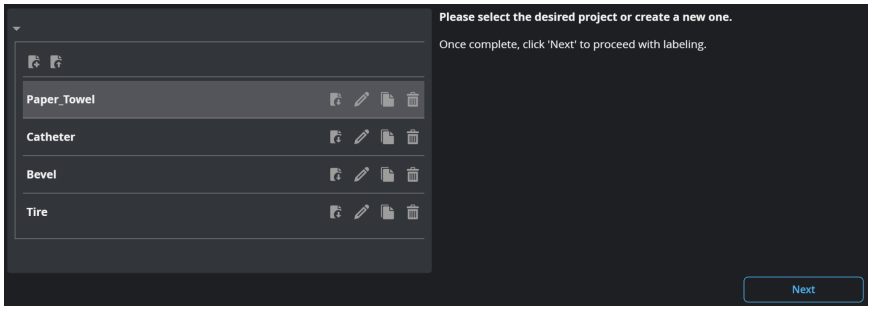
**Create New or Open Project**

A project is a collection of frames used for training, labels you apply to those frames (OK and NG), and the models trained on those frames. You should choose a meaningful project name, such as the part name, especially when working with multiple projects.

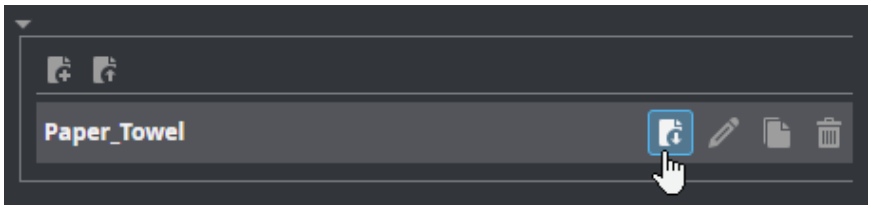
1. On the **Select Project** page, click the New Project icon, provide a project name, click **Continue**, and then click **Next**.



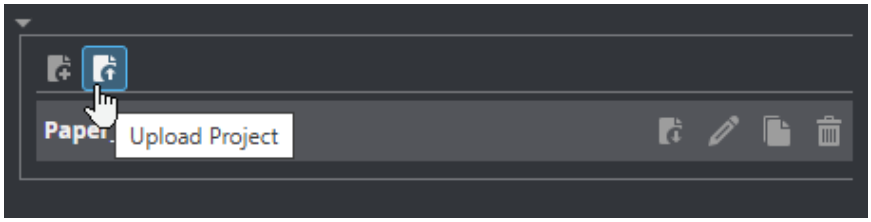



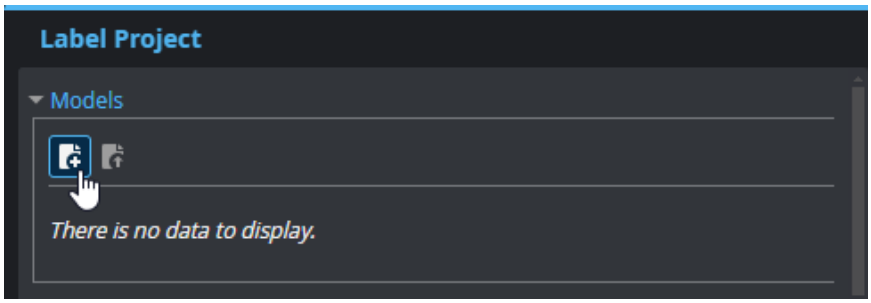

Use the download icon on a project's row to download this to your PC and upload to another device.

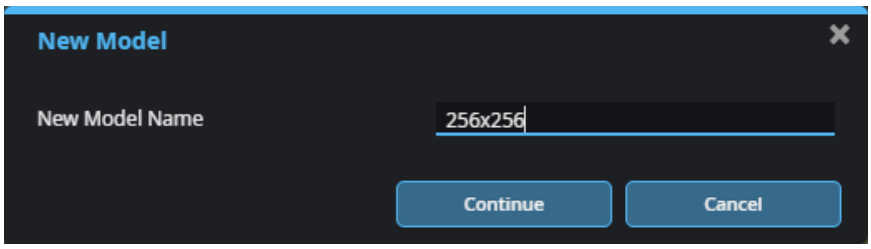



Use the upload icon to import a previously downloaded project.

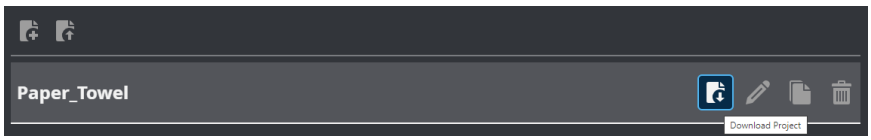



2. In the **Label Project** page, in the **Models** section, create a new model and click **Continue**.

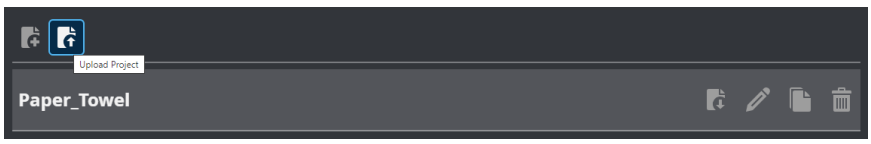



3. (Optional) To download a project to the connected PC in order to upload it to another GoMax accelerator, click the Download icon on a project's row .

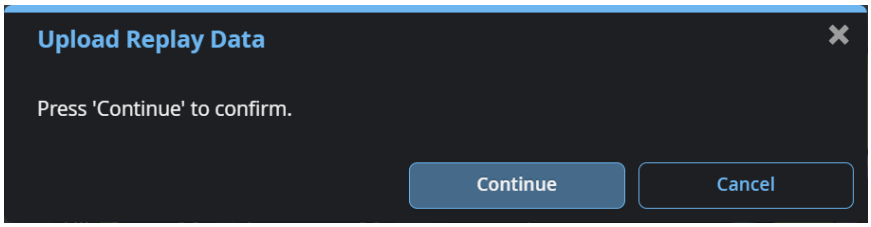



4. (Optional) Click the Upload icon to import a previously downloaded project.




5. In the **Frames** section, do one of the following

- To upload currently loaded replay data, click the Upload Replay Data button ( ) , and then click **Continue**.




- To upload the data from a .gprec file on the local PC, click the Upload From Disk button ( ), choose a file in the Open dialog a, click Open.

The tool loads the frames into the model.

> ⚠ Loading replay data into the project can take several minutes. If a “Delayed Response” message displays, click “Wait.” In this case, add a Decimation Filter to the pipeline.

#### Label Frames and Choose Set

You must now label each frame as “OK” or “NG” (under the **User Label** column). You must also choose the set each frame belongs to (Train or Test, under the **Set** column).

1. (Optional) To have the system automatically place frames in the Train or Test set, click the Auto-split icon.

   The Set column will become read only. When you set a frame's user label, the tool assigns it to the sets in the proportions described below.

   Auto-split uses the proportions recommended for training to place each frame into a set:

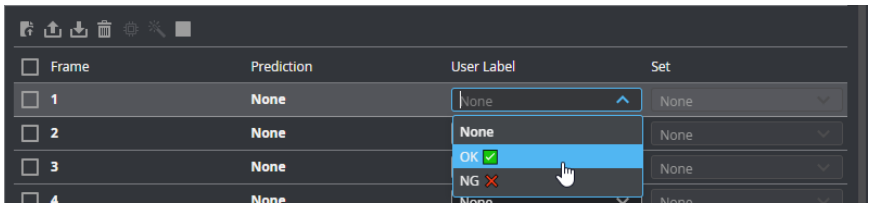
   80% of OK is in Train

   20% of OK is in Test

   100% of NG is in Test

   You can also enable auto-split after setting the user labels.

2. In the row of each frame, under **User Label**, choose the correct label.




   If you have not enabled auto-split, also choose the frame's set under **Set**. Make sure you use the proportions described in step 1.

To quickly choose the label and set for multiple frames, do one of the following to first select the frames:

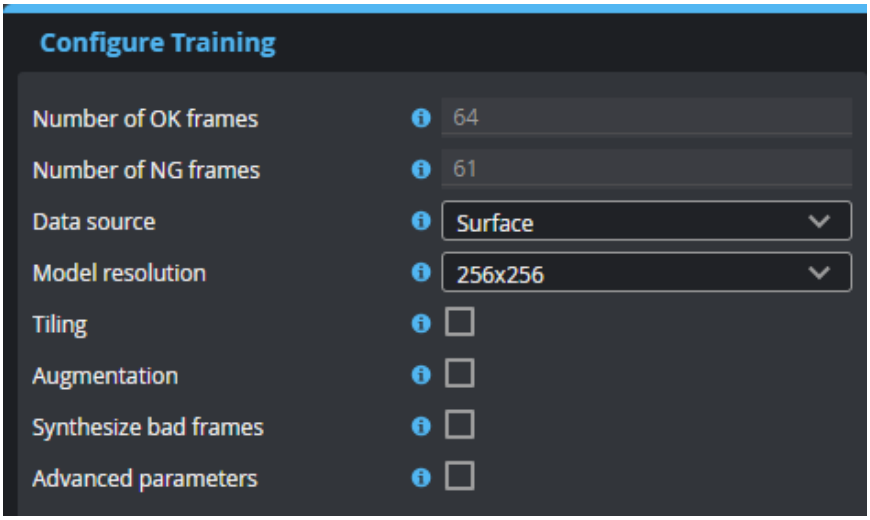
- To select a range of frames, click the checkbox of the first frame, press Shift, and click the checkbox of the last frame of the range.
- To select multiple frames, click the checkbox of the first frame, press Ctrl, and click the checkbox for each frame you want to select.
- To select non-contiguous ranges, alternate between clicking Ctrl and Shift.

After selecting the frames, choose the label and the set as described above. To deselect all frames, click anywhere between the checkbox and the User Label and Set drop-down menus.

3. Click **Train Model** to configure training.

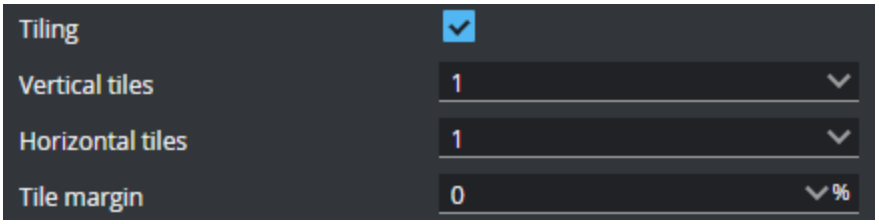
#### Configure Training

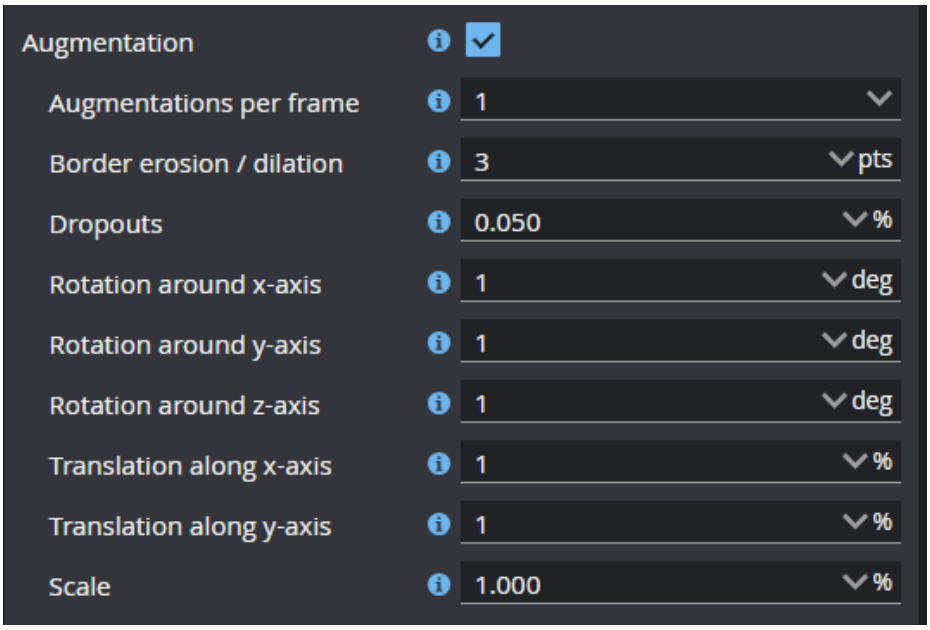
After labeling the frames and choosing the set they belong to, you must configure training. For descriptions of the settings, see below.




*Training Parameters*

| Parameter | Description |
|---|---|
| Number of OK images<br>Number of NG images | Read-only fields that display the number of frames you have labeled OK and NG, respectively. |
| Data source | The source the tool uses during training: Surface or, if available, Intensity data. You use Surface data for defects detectable on a 3D surface (that is, using height data). You use Intensity data for defects on flat surfaces, such as printing flaws. For more information on scan modes, see *Scan Modes and Intensity* on page 111. |

| Parameter | Description |
| --- | --- |
| Model resolution | Decimates the input data to the specified resolution for processing. A higher resolution improves anomaly location accuracy but increases processing time for training. For most applications, leave this at 256x256. |
| Tiling | Enables tiling. Tiling divides the frames of training data into sections. The tool uses the same model for each tile, which increases the resolution of the model. This lets the tool potentially find smaller defects or increase detection accuracy. You should only use tiling with homogenous targets (for example, paper towel, wood decking, and so on) or symmetric targets. For discrete parts with a complex or asymmetric shape, disable this setting.<br>After enabling tiling, set the number of vertical and horizontal tiles.<br>You can also set tiles to overlap in **Tile margin**. Use this to detect anomalies that might fall on a boundary between tiles. Generally, you should use a value between 12.5% and 25%.<br>Note that using tiling and tiling margins increases the memory requirements for training considerably. For example, with 5x5 tiling, the tool uses 25 times more memory.<br>  |
| Augmentation | When **Augmentation** is enabled, the tool simulates random part orientation, size, and acquisition variations to generate more training data, which improves training. The rotation, translation, and scale values are used to create a range. So for example, a Z axis rotation value of 1 degree results in a range between -1 and 1, from which the tool chooses a random value to generate data. For **Dropouts**, the value represents the upper limit of the range between 0 and the provided percentage.<br>Choose augmentations that are representative of the variations you encounter during production. Augmentations that aren't representative may lead to poor results.<br>You can visualize example augmentations on the Model Performance page, which is available after training is complete; for more information, see *Test Model Performance* on page 373. |

| Parameter | Description |
| --- | --- |
| |  |

**Augmentations per frame**

The number of augmentations generated for each frame in the project (OK and NG). Augmentations are not added to the total number of frames in the project itself.

**Border erosion / dilation**

Performs erosion and dilation operations on each frame. Set to 1 or higher for discrete parts, and set to 0 for continuous surfaces or when using a pre-processing pipeline that crops the input surface.

**Dropouts**

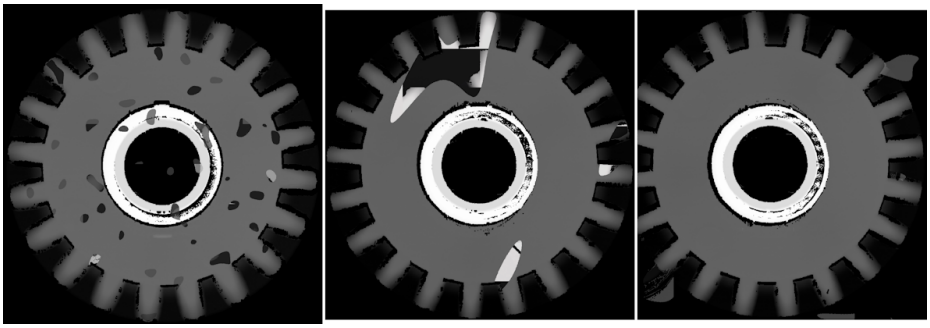
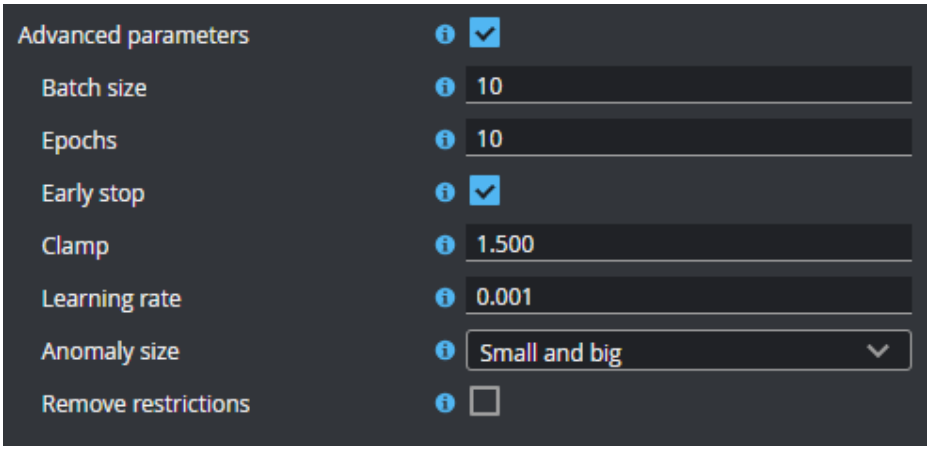
Removes data points randomly to simulate low exposure, up to the specified percentage of the original scan data. Set this to 0 if you are using gap filling or don't expect exposure issues.

**Rotation** settings

The Rotation settings limit rotation of simulated data around the X, Y, and Z axis.

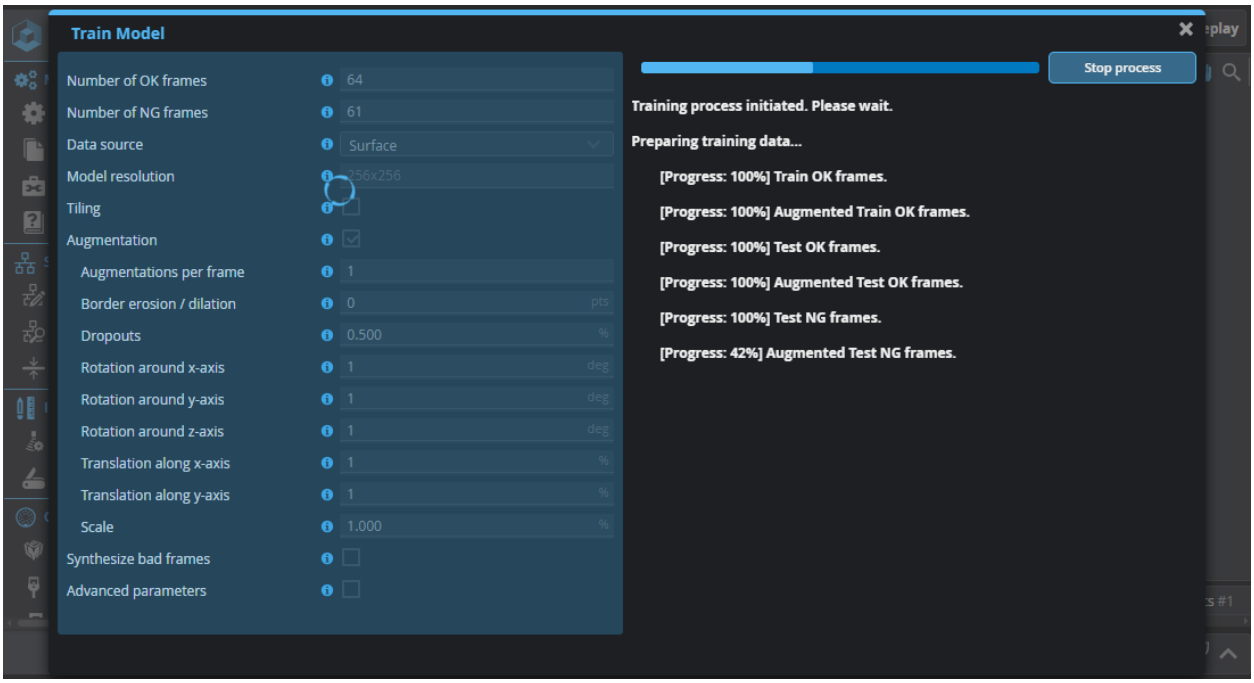
**Translation** settings

The Translation settings limit movement of simulated data on the XY plane, as a percentage of the data points in the frame.

| Parameter | Description |
| --- | --- |
| | **Scale**<br>Limits the scaling of simulated data. |
| Synthesize bad frames | When this setting is enabled, the tool synthesizes bad (NG) frames from the good (OK) frames in the project. The frames are used internally during training and are not added to the frames in the project or shown in the tool. The following are examples of synthesized frames:<br>  <br>Enable this setting if your project contains very few NG frames. The setting is automatically enabled if the project contains *no* NG frames. |
| Advanced parameters | If the training results are generally good but the tool is reporting a small number of false positives or false negatives, you can modify these parameters to further improve results.<br>  <br>**Batch size**<br>The number of frames in a batch (a subset of the entire dataset passed to the training algorithm for an iteration).<br>If you are using a model with a 512x512 resolution or tiling and the tool has memory issues during training, decrease this value.<br>**Epochs** |

| Parameter | Description |
| --- | --- |
| | The number of times the entire dataset passes through the training algorithm. To reduce false positives or negatives, increase this value. Note that training will take longer.<br><br>**Early stop**<br>Leave enabled for the initial training runs. To help model performance, disable to improve model performance; note that training will take longer.<br><br>**Clamp**<br>The range within which the data values should be clamped. Reduce this value to help reduce false positives or false negatives.<br><br>**Learning rate**<br>Set this to a higher value to reduce training time. Note that a value that is too high can cause the model to miss the point where the difference between predicted and actual OK / NG is at its smallest (that is, overshooting it). A lower value causes the model to learn more slowly, but potentially more accurately; if the value is too low, the model can get stuck.<br><br>**Anomaly size**<br>One of the following: Small and big, Big, Small.<br>Choose Big to reduce false positives caused by smaller features like reflections or drop-outs. Choose Small to ignore large features in the data. For most applications, leave this as Big and small.<br><br>**Remove restrictions**<br>By default, this option is disabled, and the following limitations are in place to ensure the system trains successfully and does not run out of memory:<br>• The maximum number of tiles under the **Tiling** parameter is limited to 6.<br>• The highest resolution in **Model resolution** is 512x512. |

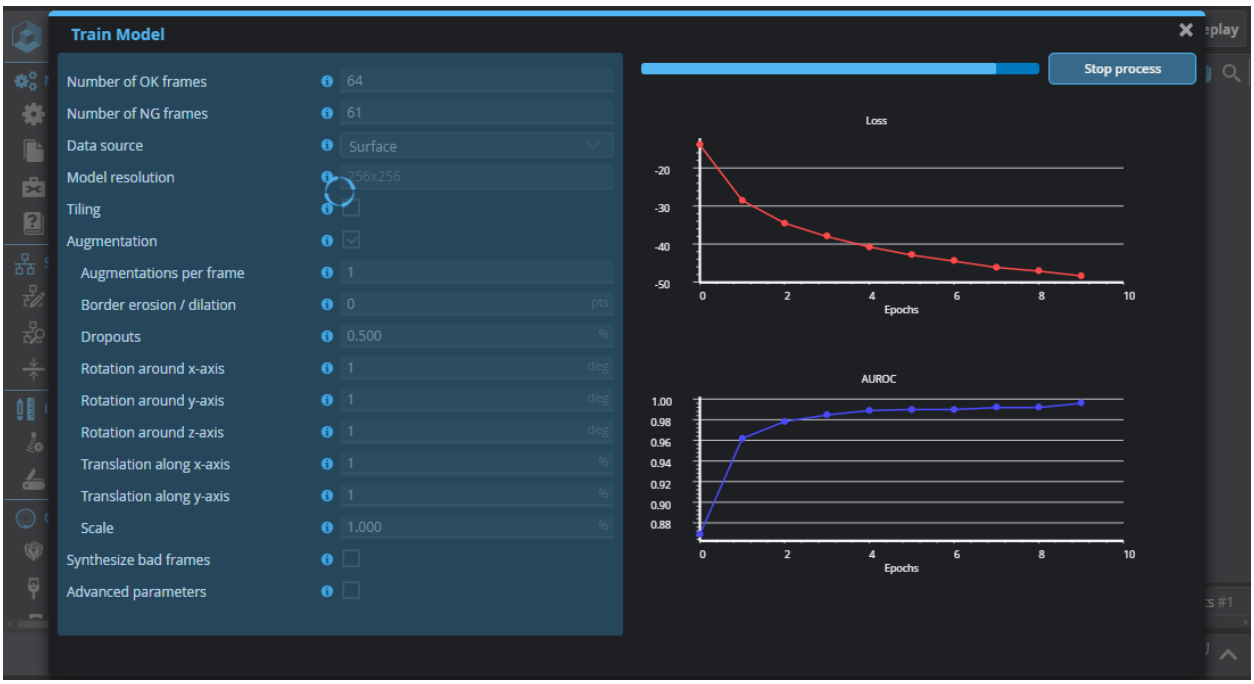
After you configure training, click **Start Training** to train the model. The tool will start by preparing the training data, providing progress feedback:




After the data is prepared, the tool will start generating Loss and AUROC graphs.

**Loss**: This graph represents the cumulative error for each frame in the Test set, determined after each training run iteration or epoch. A decreasing number (the graph's line is moving down) implies the model is improving.

**AUROC**: This graph defines how well the model can distinguish between the OK and NG user labels. A value of 1 (the graph's line is moving up) represents the best possible result.



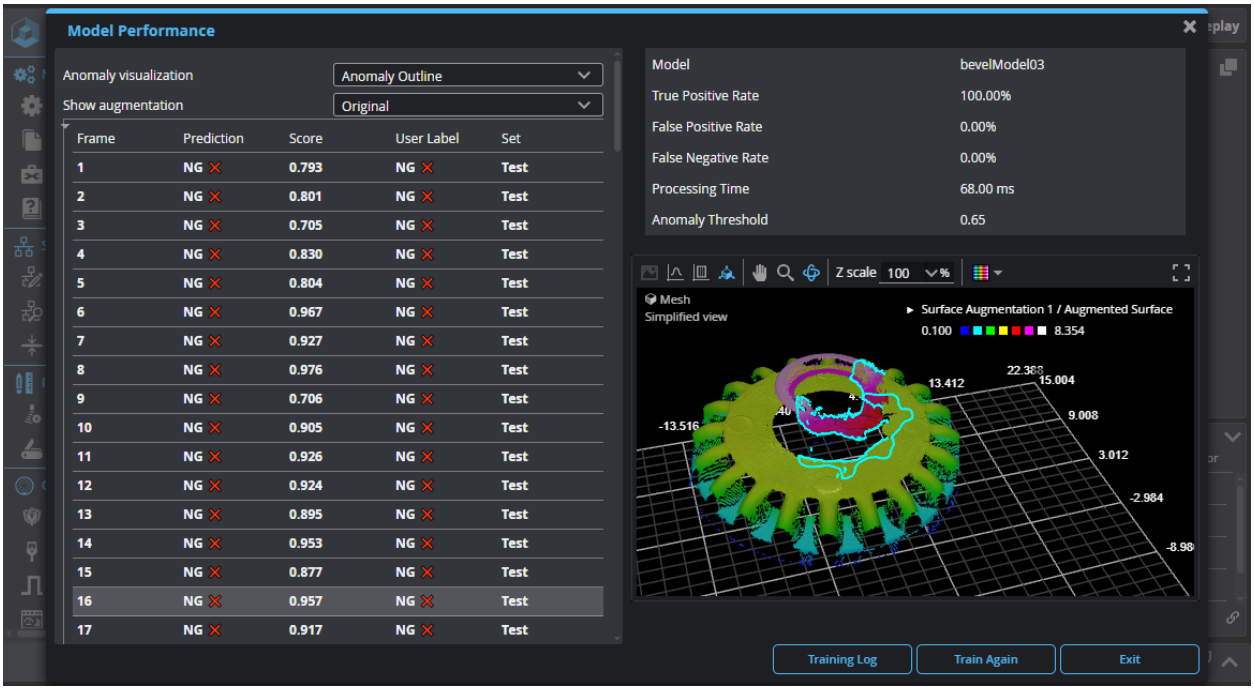
As the tool trains the model on the labeled frames, the graphs should converge, that is, Loss will decrease, and AUROC will increase, approaching 1 (the best possible result). After the training has completed, click **Next** to test the model. Note that training can take several minutes.

#### Test Model Performance

After the tool has finished training the model, it will use the model to make predictions on the frames to determine the anomaly score for each frame, as well as the anomaly threshold. The Model Performance page displays the following results:

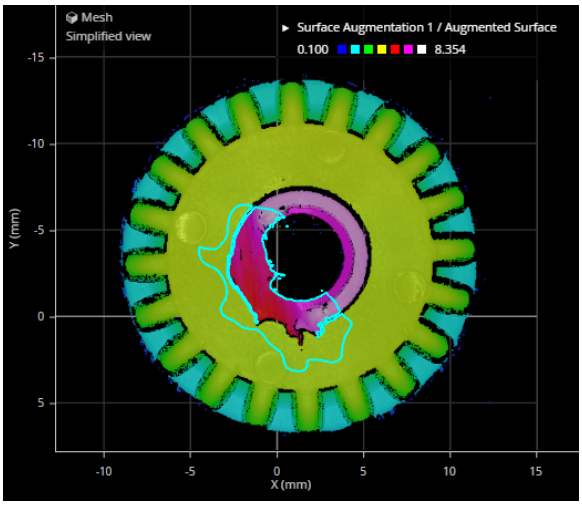
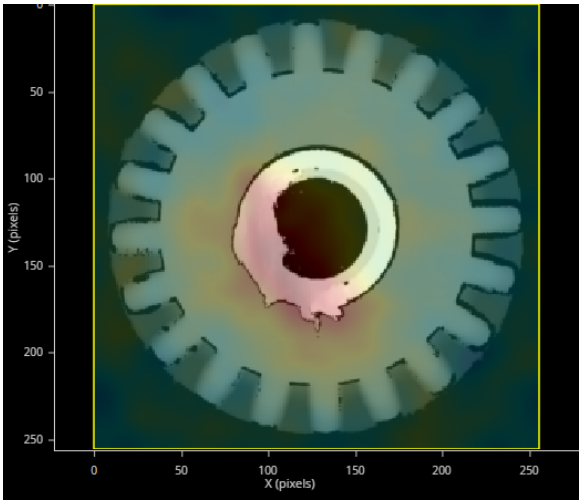
*Performance Results*

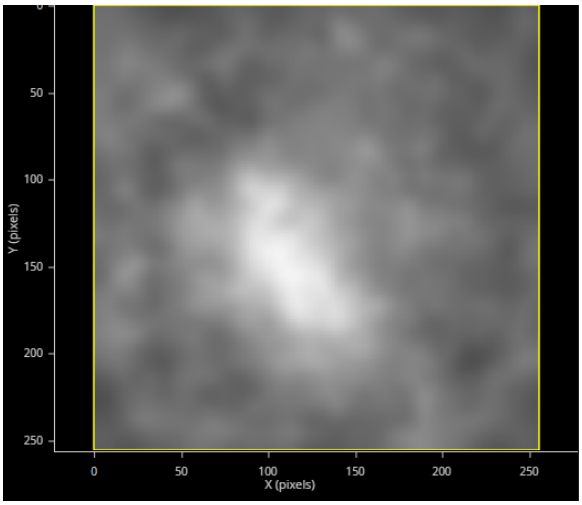
| Name | Description |
|---|---|
| Model | The trained model the tool used to detect anomalies during the model performance phase. |
| True Positive Rate | The percentage of frames correctly predicted as OK. |
| False Positive Rate | The percentage of frames incorrectly predicted as OK. |
| False Negative Rate | The percentage of frames incorrectly predicted as NG. |
| Processing Time | The average time required for inference. Includes the pre-processing tool chain. |
| Anomaly Threshold | The threshold to which a frame's Anomaly Score measurment is compared to determine whether the frame is an anomaly. An anomaly score above this value is an anomaly. |




You can use the **Anomaly visualization** drop-down to view different visualizations of the selected frame:

*Anomaly visualizations*

| Name | Description |
|---|---|
| Anomaly Outline | Displays the Surface data of the frame with anomalies outlined, if present.<br>  |
| Heatmap | A diagnostic Image output overlaying the Anomaly Map output on the input data. This output can make it easier to see whether the brighter areas in the anomaly map correspond with flaws in the target.<br>  |
| Anomaly Map | A diagnostic Image output that contains grayscale values representing a per-pixel score of how anomalous that pixel is. Brighter areas should correspond to flaws. When Anomaly Map is passed to segmentation tools such as Surface Blob, the data can be used to locate and measure the size of the anomalies. |

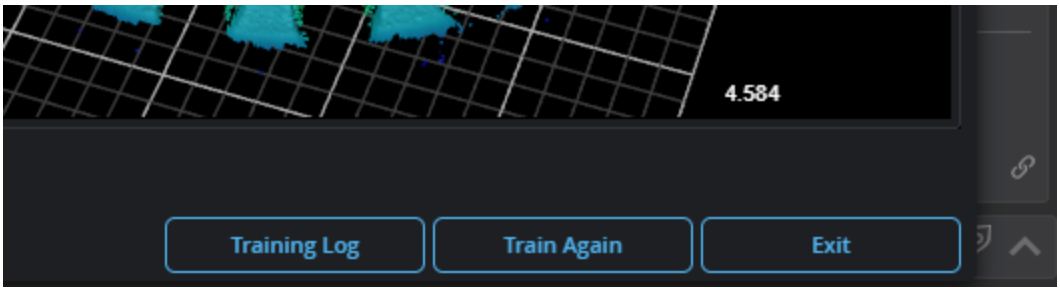
| Name | Description |
| --- | --- |
| |  |

If you have enabled augmentations in the training configuration, you can use the **Show augmentations** drop-down to switch between a frame's original scan data and a simulated frame to get an idea of the effect of the augmentation settings. Note that the augmentations the tool shows are not the ones used in training, which are generated randomly during training using the provided ranges. Also, the score displayed in the selected row is the original frame's score, not the augmented frame. The following options are available:

*Augmentations*

| Name | Description |
| --- | --- |
| Original | The frame's original scan data. |
| Upper Limit<br>Lower Limit | These options display a frame with maximum and minimum augmentation values applied to the scan data, respectively. Note that the maximum / minimum values are determined by the settings in the Configure Training step of the routine.<br>For example, if you have set the Z axis rotation to 1 degree, Upper Limit will show the frame rotated 1 degree clockwise. Lower Limit will show the frame rotated 1 degree counter clockwise. For **Border erosion / dilation**, Upper Limit and Lower Limit show the effect of dilation and erosion operations, respectively, using the provided kernel size. If you have enabled dropouts (by setting the **Dropouts** slider in the training configuration to a non-zero value), with Upper Limit, the tool removes a random selection of data points using the percentage provided. With Lower Limit (which is equivalent to 0% in the setting), no data points are removed. |
| Random | The tool applies random values chosen from the augmentation ranges provided during the Configure Training step. |

The Model Performance page also lets you download a tar archive containing reports and other diagnostics. You typically only need to do this if asked to do so by LMI Support.




You can also retrain the model with different training configuration if you wish.

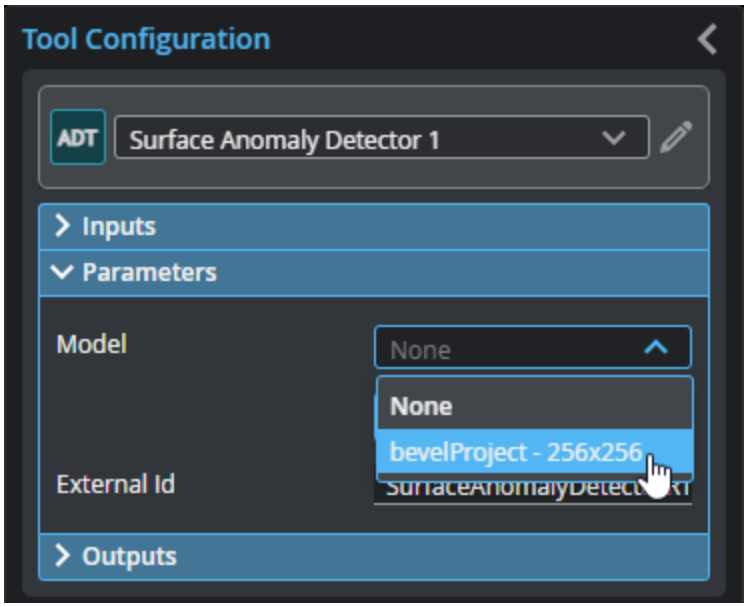
You are now ready to use the trained model on new scan data in production.

## Deploy in production

### Anomaly Tool Setup

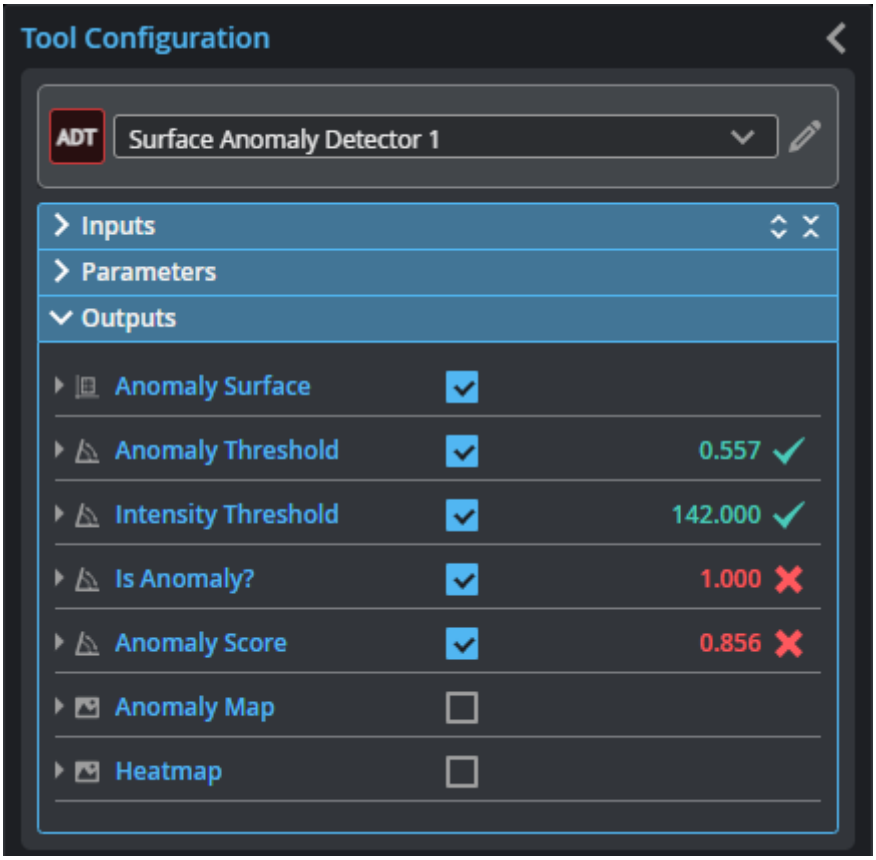
1. Connect to the GoMax using a laptop or PC on the same network.
2. Upload a .gpsup or .gprec file created during the dataset collection.

   Ensure the recording contains the same preprocessing pipeline used during training.
3. Discover the Gocator sensor and create a new sensor group.
4. Insert the GoPxL Anomaly Detector USB dongle to a USB port on the GoMax.
5. In the Surface Anomaly Detector tool, in **Model**, choose the model you trained and want to use in production.




6. Configure the outputs as required, and implement post-processing to isolate and prepare anomalies for measurement. For more information, see *Outputs* on the next page and *Surface Anomaly Detector* on page 354.

**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

Although the tool has several outputs, the "Is Anomaly" measurement and "Anomaly Surface" output are the main outputs intended for processing by tools later in the tool chain.

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

Some outputs are only displayed if **Apply anomaly segmentation** is enabled in the **Parameters** section.

*Measurements*

| **Measurement** |
| --- |
| **Anomaly Count**<br>The number of anomalies detected in the frame. |
| **Anomaly Threshold**<br>Threshold value (0..1) of the 'Anomaly Score' above which the model considers an input surface anomalous. This value is determined during training to achieve the best possible detection rate. |
| **Intensity Threshold** |

| Measurement |
| --- |
| A grayscale value in the ‘Anomaly Surface’ intensity data above which the model considers input intensity data anomalous. The value is constant for a trained model.<br>The value is equivalent to ‘Anomaly Threshold’ x 255 and rounded to the nearest integer. |
| **Is Anomaly?**<br>Indicates whether the tool has detected an anomaly in the current frame of scan data. |
| **Anomaly Score**<br>Indicates how strongly the tool believes the current frame contains an anomaly. When the value is higher than the Anomaly Threshold measurement, this measurement is set to 1.0. |
| **Center X**<br>**Center Y**<br>Arrays of the X and Y positions of the centers of mass of the anomalies in the frame. |
| **Average Z**<br>An array of the average Z positions of the anomalies in the frame. |
| **Min Z**<br>**Max Z**<br>Arrays of the minimum and maximum Z positions of the anomalies in the frame. |
| **Width**<br>**Length**<br>Arrays of the length and width of the rotated bounding boxes that encapsulate the anomalies in the frame. These are always the major and minor axis of a blob, respectively. |
| **Area**<br>An array of the areas of the anomalies in the frame.<br>The area is calculated using the contour of the blob and resampling. For this reason, areas calculated using the Surface Volume tool will produce different measurements; for more information, see *Area* on page 625. |

*Data*

| Type | Description |
| --- | --- |
| Anomaly Surface | Contains the Surface data of the frame, with the anomaly map (see Anomaly Map below) added as intensity data. The intensity data represents a per-pixel score of how anomalous that pixel is. |
| Anomaly Map | Diagnostic Image output containing the output anomaly map in the form that is produced by the deep learning inference algorithm. Brighter areas should correspond to flaws. |
| Heatmap | Diagnostic Image output overlaying the Anomaly Map output on the input scan data. This output can make it easier to see whether the brighter areas in the anomaly map correspond with flaws in the target. |
| Blob Surface | An array containing the frame's anomalies. Pass these to other tools for measurement or further processing. |

### Store production data

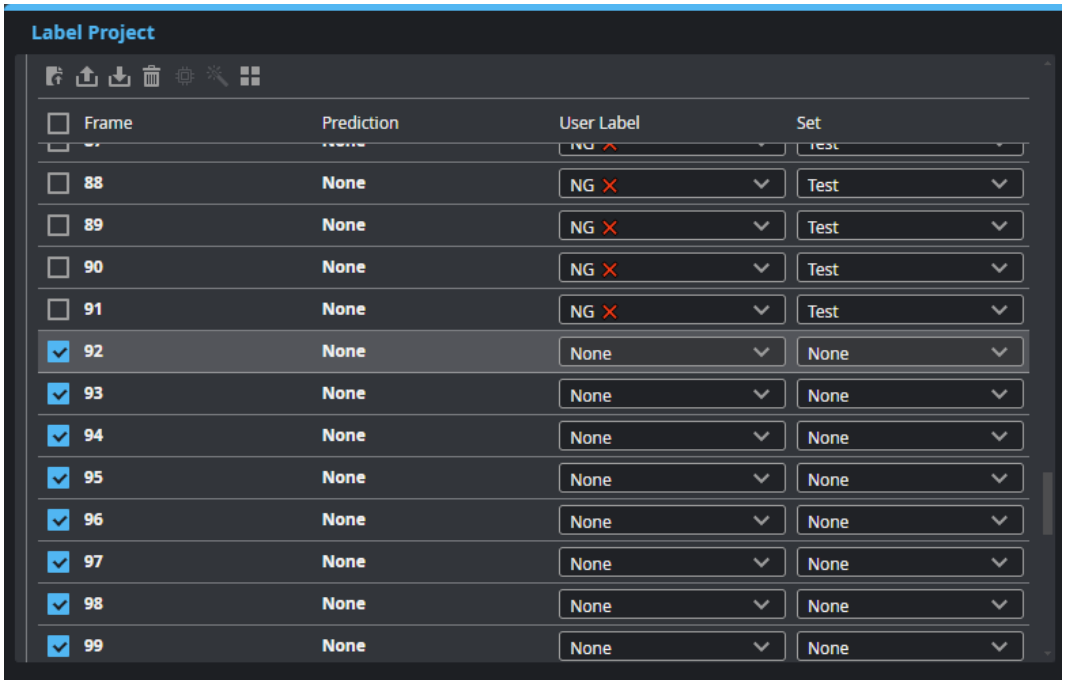
You can use the Training Archive tool to conditionally add frames to a Surface Anomaly Detector project. For more information, see *Training Archive* on page 381.

### Train using additional data

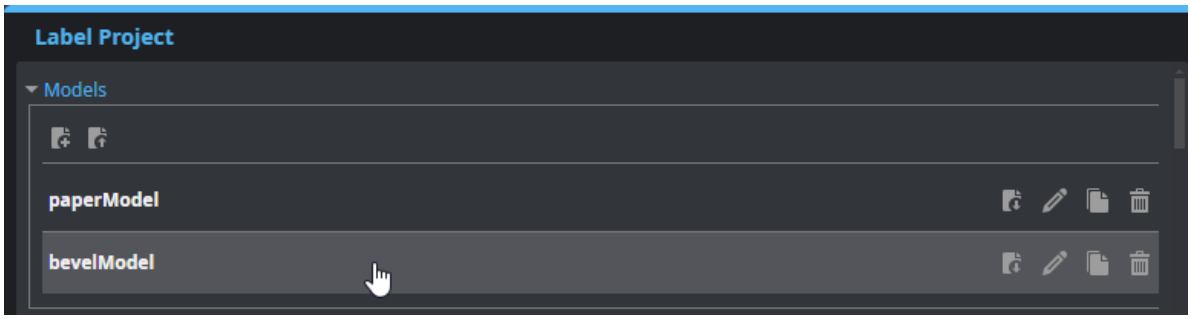
After adding new frames to a project using the Training Archive tool (see *Training Archive* on page 381) or uploading additional frames manually (from the replay buffer or from a .gprec file), you can further train the model with new frames, taking advantage of the trained model's prediction capabilities to automatically label frames as OK or NG.

*To train using new data:*

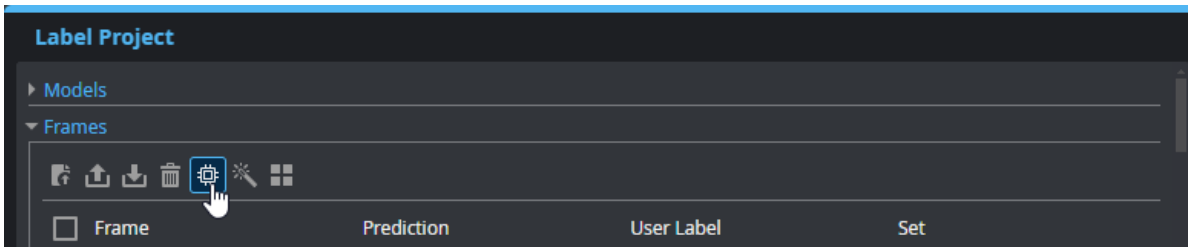
1. After adding frames to a project, go to the Label Project page.
2. Select the new frames.



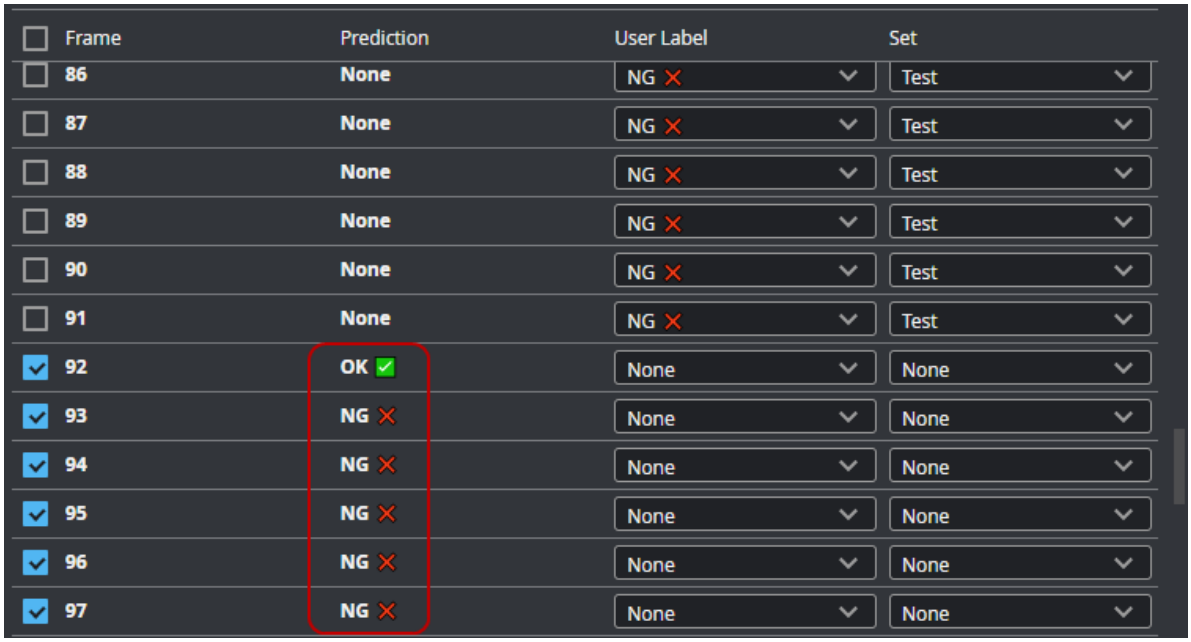

3. Choose the correct model you want to use for prediction.




4. At the top of the Frames section, click the Generate Prediction button.

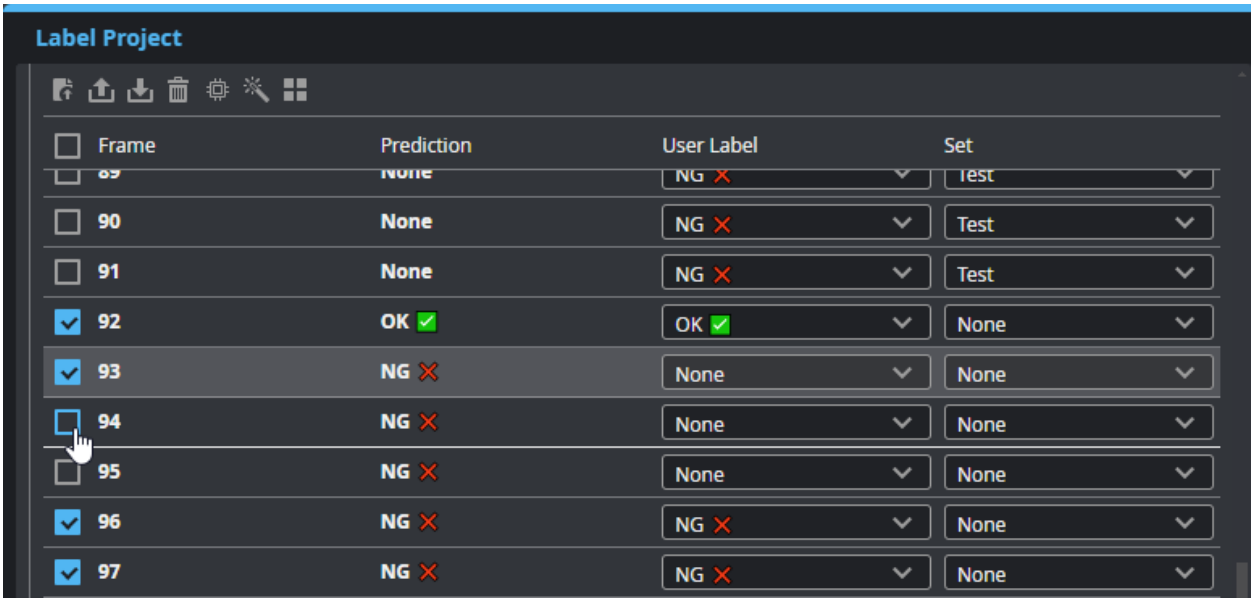



The tool uses the selected model to generate predictions (OK or NG) for the selected, unlabeled frames. Note that the user labels of the frames are unchanged at this point.

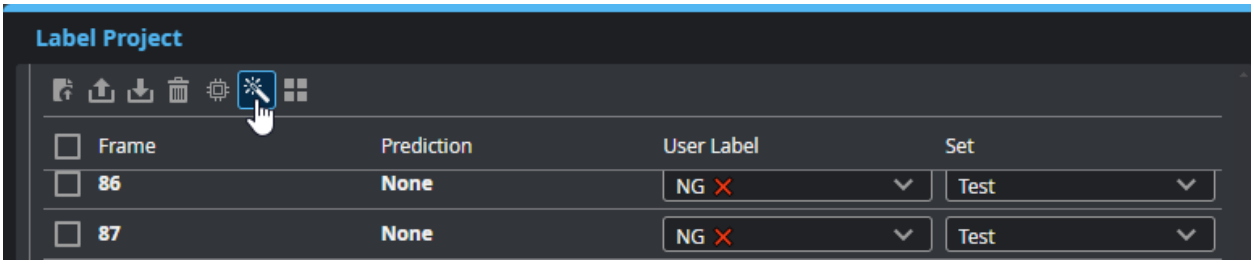



5. Review the predictions and do the following:

   a. Uncheck any invalid predictions.



b. Click the Apply Prediction button.




c. Toggle Auto-Split to On to automatically set the Set of the selected frames.

d. Manually set the user label of any incorrectly predicted frames.

The predictions of the selected frames are copied to the user label drop-down.

6. Retrain the model with the newly added frames.

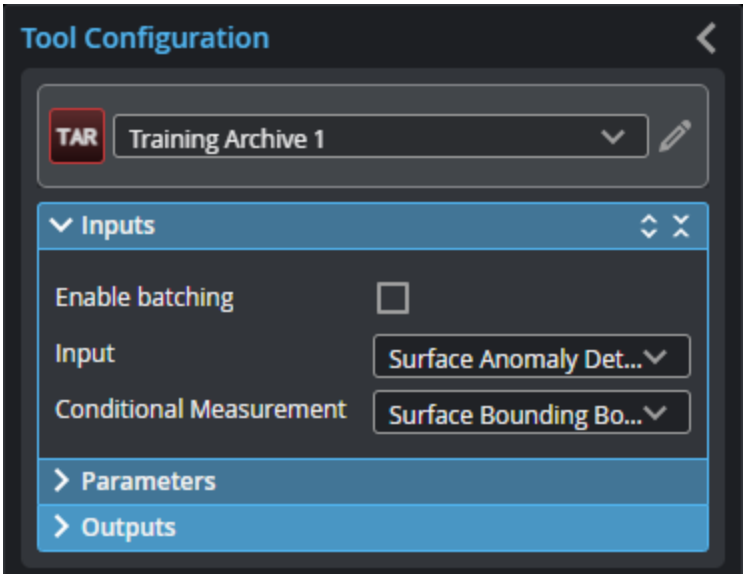
For more information, see *Train Model* on page 363.

### Training Archive

The Training Archive tool lets you conditionally add frames to a Surface Anomaly Detector project. (For more information on the Surface Anomaly Detector tool, see *Surface Anomaly Detector* on page 354.)

#### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



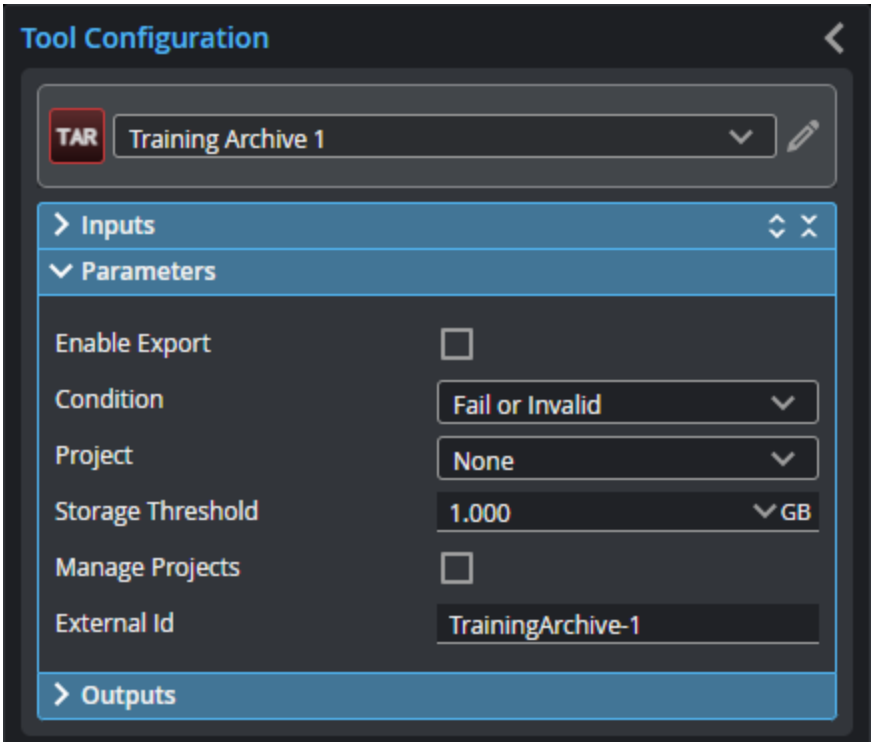

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see Arrays, Batching, and Aggregation. |
| Conditional Measurement | The measurement the tool uses as a condition to add frames to a project. Some examples of measurements typically used are the "Is Anomaly" output of the Surface Anomaly Detector tool, the Result measurement of the Measurement Formula tool, or an "Output" output from a Script tool. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



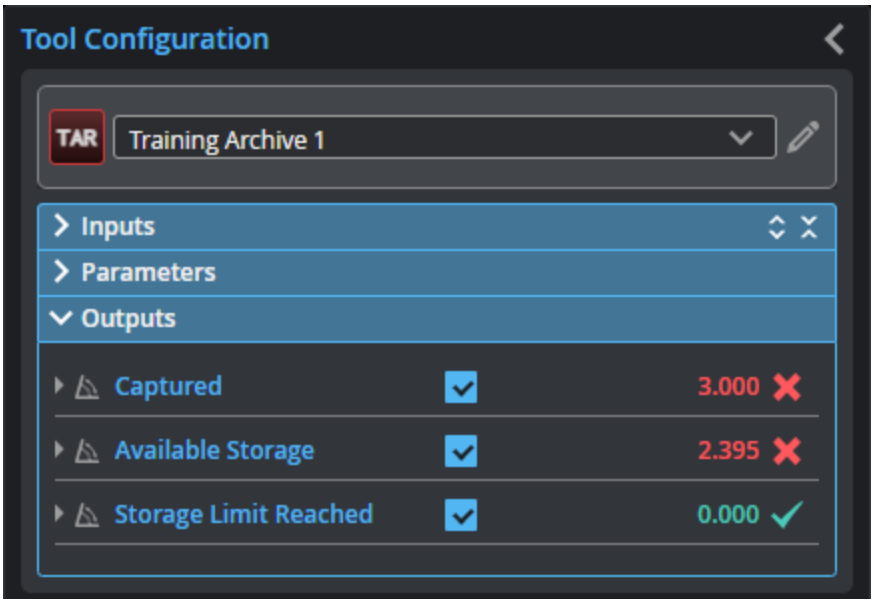

*Parameters*

| Parameter | Description |
|---|---|
| Enable Export | When this setting is checked,<br>if the conditions are met (**Condition** and **Condition Threshold** parameters) the tool will add the current frame to the selected project. |

| Parameter | Description |
|---|---|
| Condition | Displayed if the **Conditional Measurement** input is set to a measurement.<br>Set this to the type of condition (with respect to the measurement set in **Conditional Measurement**) the tool should use to determine whether to add a frame to the selected project. The frame is added based on the following options:<br><br>**Fail or Invalid**: If the selected measurement returns a Fail or Invalid result.<br><br>**Invalid**: If the selected measurement returns an Invalid result.<br><br>**Pass**: If the selected measurement returns a Pass result.<br><br>**Less or Equal to**: If the selected measurement less than or equal to the value provided in **Condition Threshold**.<br><br>**Greater or Equal to**: If the selected measurement greater than or equal to the value provided in **Condition Threshold**. |
| Condition Threshold | The value the tool compares with the measurement set in **Conditional Measurement** to determine whether to add a frame to the selected project. This parameter is only displayed when **Condition** is set to "Less or Equal to" or "Greater or Equal to". |
| Project | The project the tool will add frames to if the selected conditions are met. |
| Storage Threshold | The minimum amount of storage allowed on the GoMax unit or the PC. If the storage goes below this value, Training Archive will stop adding frames to the selected project, and the Storage Limit Reached output will be set to 1.<br>Use the Available Storage output to see the current amount of storage on the device. |
| Manage Projects | When you enable **Manage Projects**, in the **Action** drop-down, you can delete the project currently selected in **Project**, or delete *all* of the projects on the device. |
| Action | ⚠ You are not prompted to confirm whether to delete projects! |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

#### Outputs

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
| --- |
| **Captured**<br>The number of frames added to the project selected in **Project** so far. |
| **Available Storage**<br>The amount of storage available on the GoMax or PC. |
| **Storage Limit Reached**<br>When the available storage goes below the value in the **Storage Threshold** parameter, this output returns 1. |

**Sample Files**

Sample files are available in a package on LMI's Download page (https://lmi3d.com/product-downloads/) to help you better understand the Surface Anomaly Detector tool and the required workflow. The sample data includes scans of Lego bevel gears, paper towel with debris, and tires with bulges. For each sample type, the following is provided:

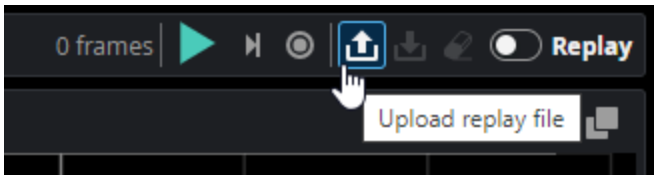
- A `.gprec` file containing a small set of "bad" (NG) frames of previously recorded scans. You can use these to test inference on a trained model. These files also contain a pre-processing tool chain appropriate for the sample, both for the training phase and the inference phase, and a Surface Anomaly Detector tool. You should load these first.
- An Anomaly Detector project file that contains previously scanned and labeled OK and NG frames, as well as a trained model. You can use the project files to try out configuring and training a new model without needing to acquire data. Note that loading a project file can take a few minutes.

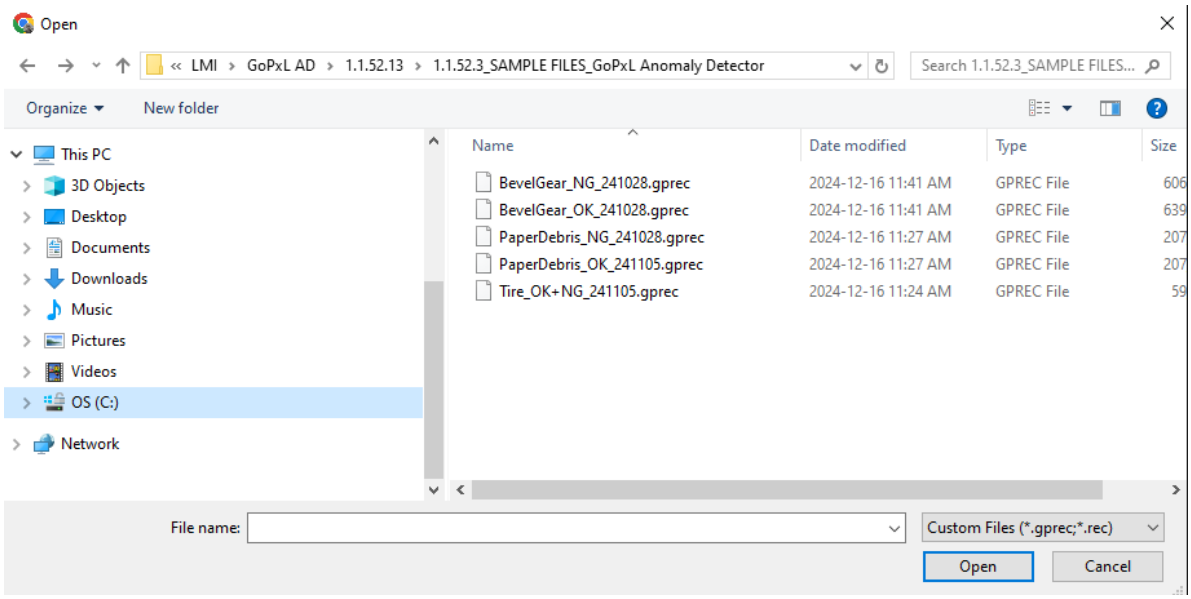
*To load any of these samples:*

1. Using a browser, connect to your GoMax unit.

   By default, it's IP address is 192.168.1.6.

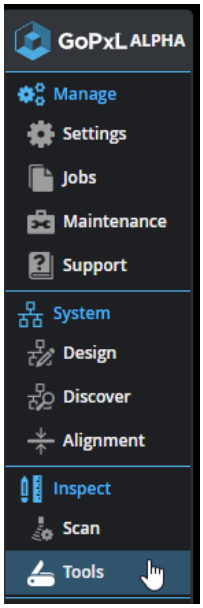
2. Upload the `.gprec` file corresponding to the sample you want by clicking the Upload replay file button and navigating to the location of the sample files.

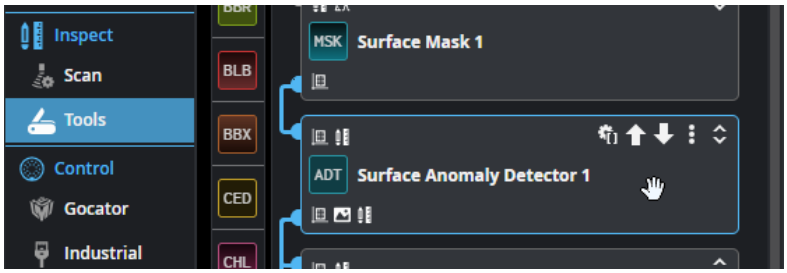


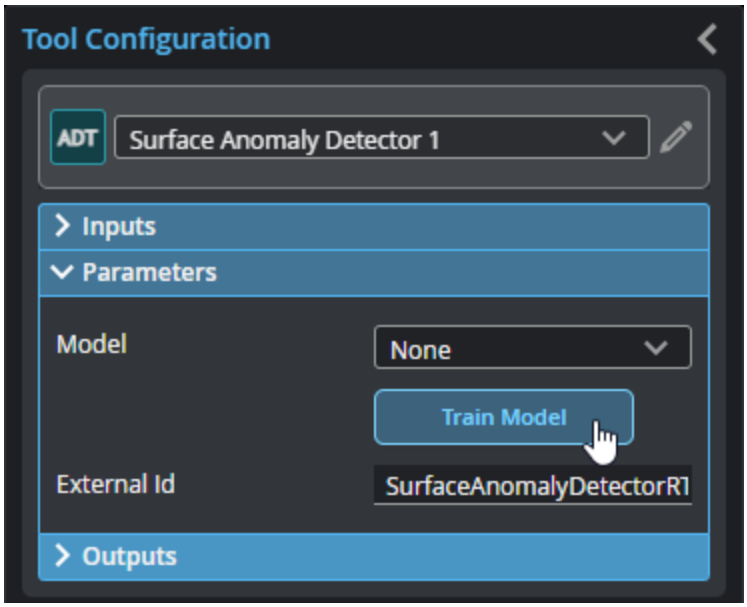

   The replay data, with a previously added pre-processing tool chain, opens.

3. Switch to the Tools page and click the Surface Anomaly Detector tool.

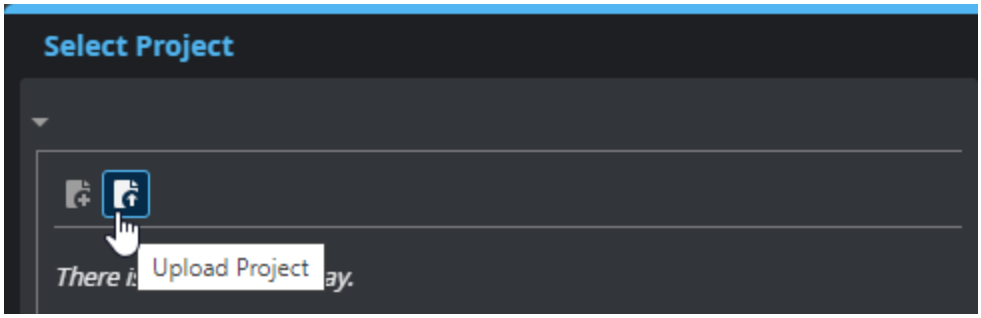


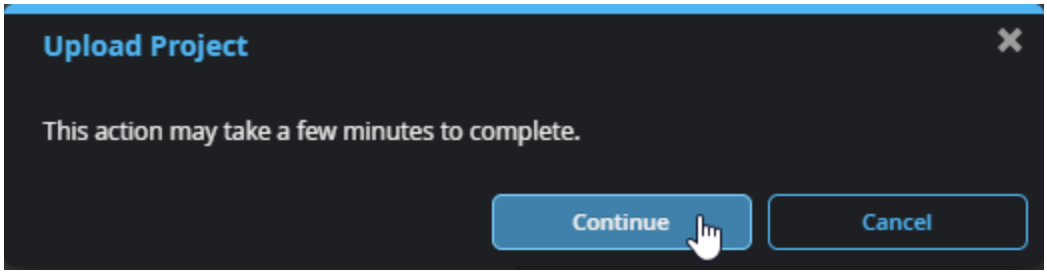



4. In the Tool Configuration panel, click **Train Model**.

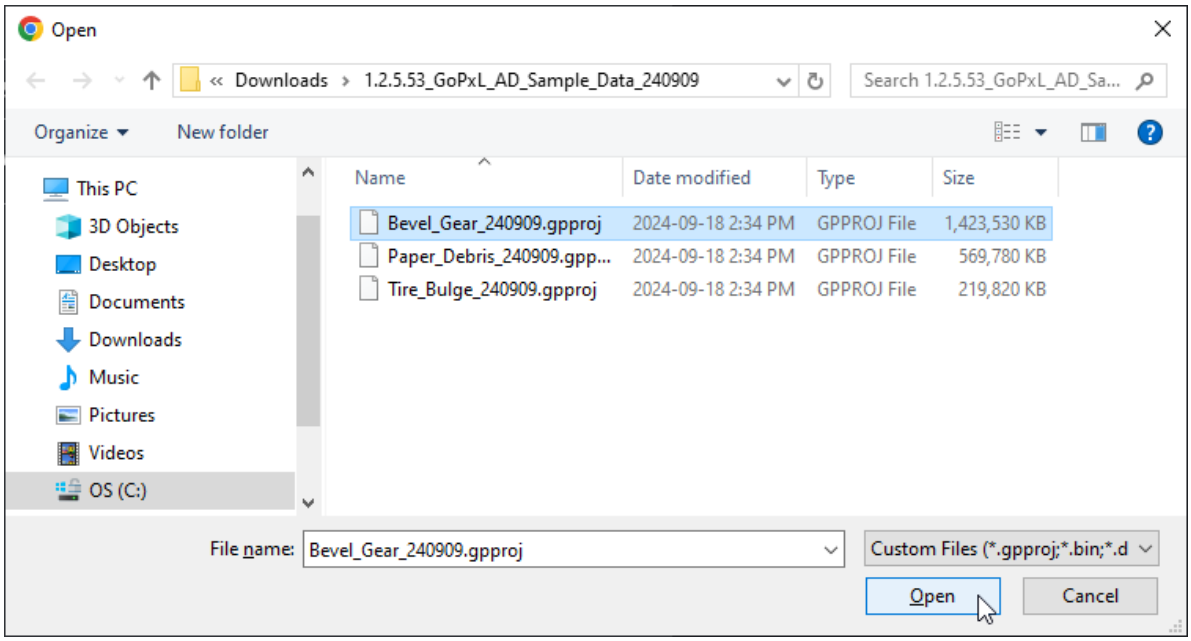



5. In the Select Project page, click Upload project and click **Continue**.

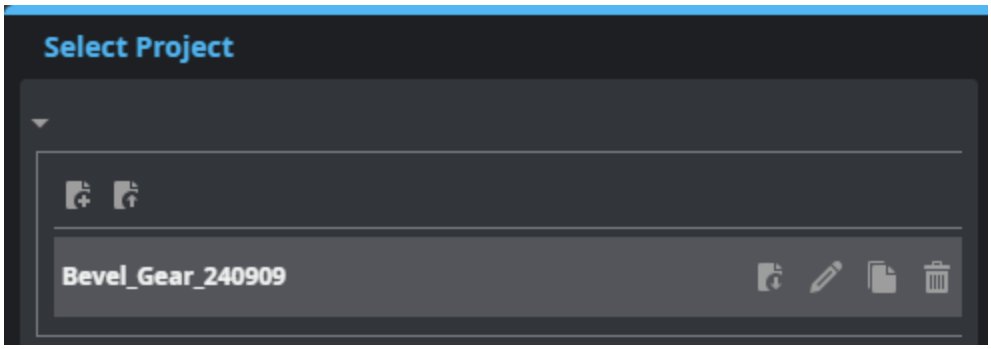



6. Go to the location of the sample files and select and open the corresponding project file.

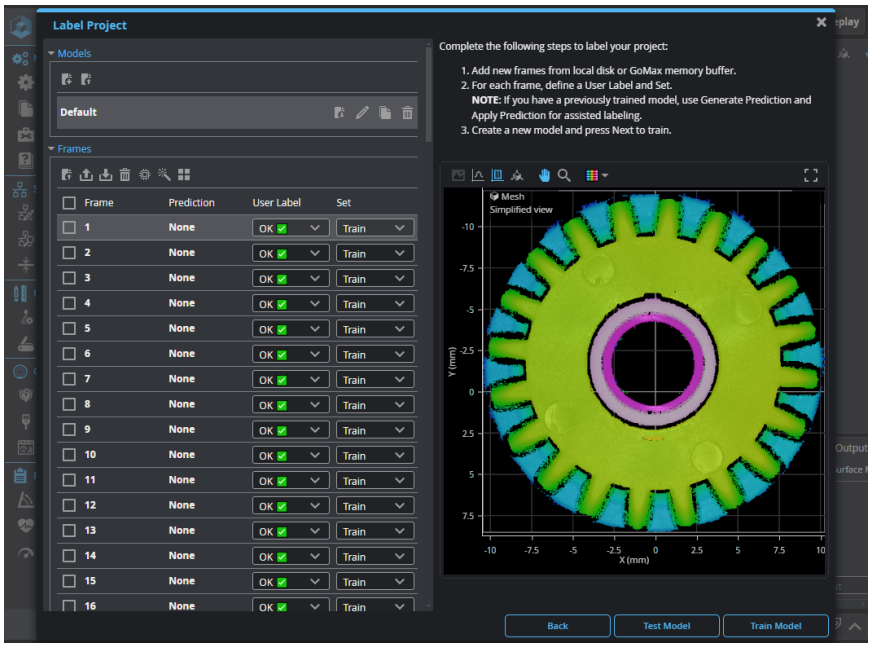



Loading the project may take several minutes.



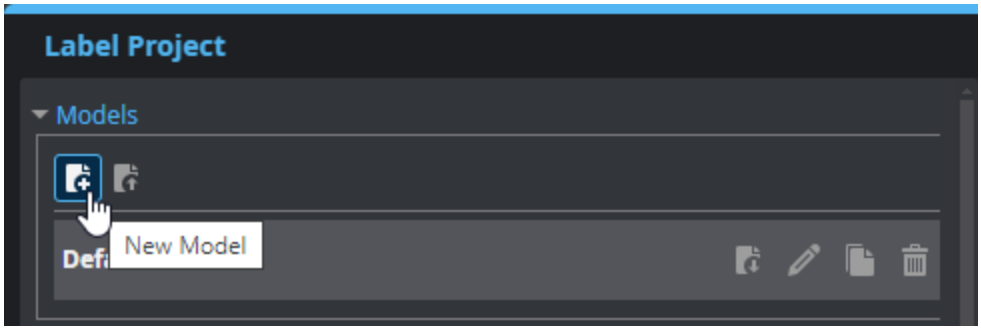

7. After the file has loaded, click **Next** in the lower right of the Select Project page.

   The Label Project page opens, displaying the labeled frames in the project.




At this point, you can familiarize yourself with the Label Project page, or do one of the following:

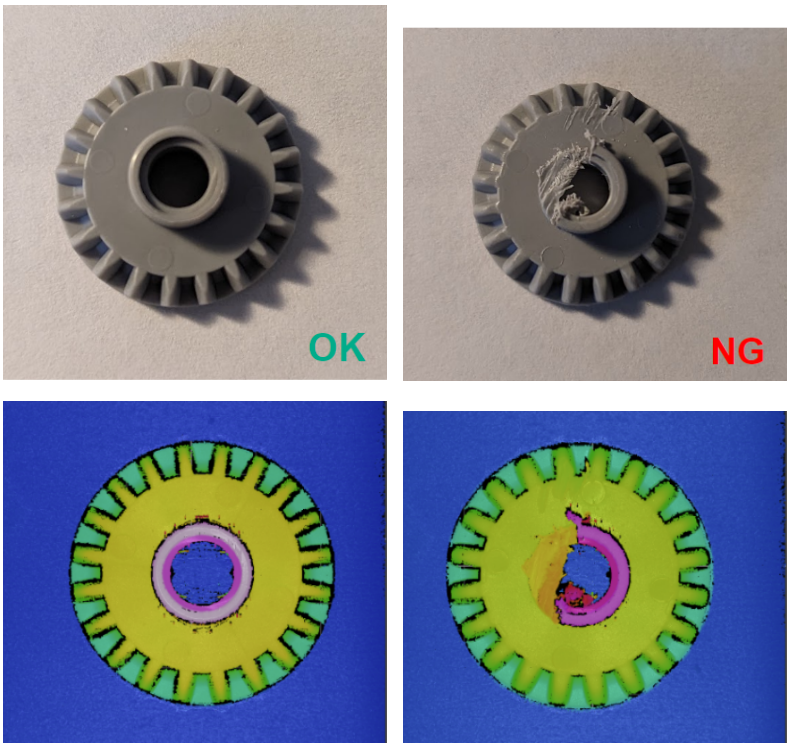
- Click **Test Model** to test the performance of the previously trained model on the frames. For more information, see *Test Model Performance* on page 373.
- Create a new model, click **Train Model** at the lower right of the Label Project page, configure the new model's training parameters, and start the training. For more information, see *Configure Training* on page 367.

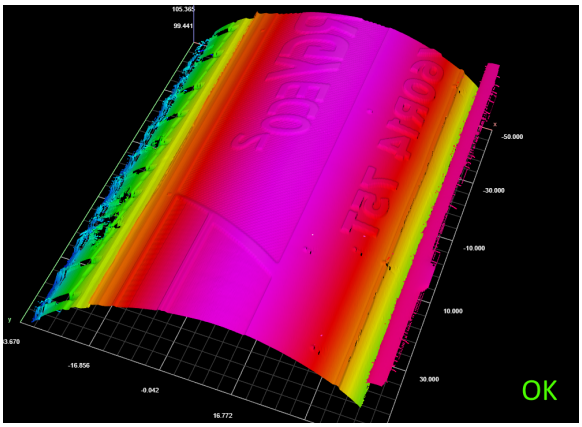
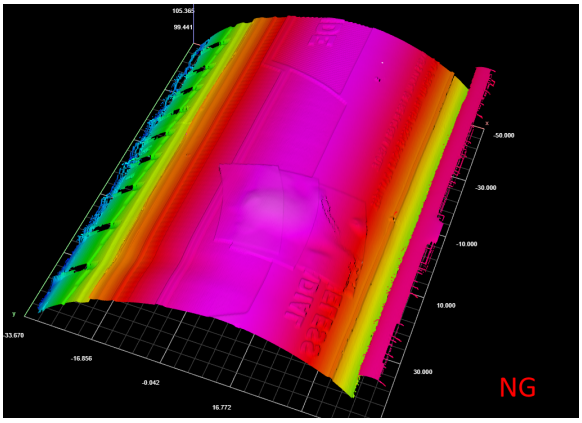


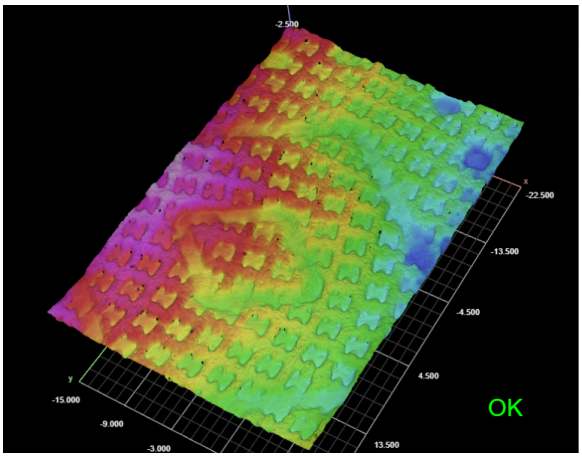
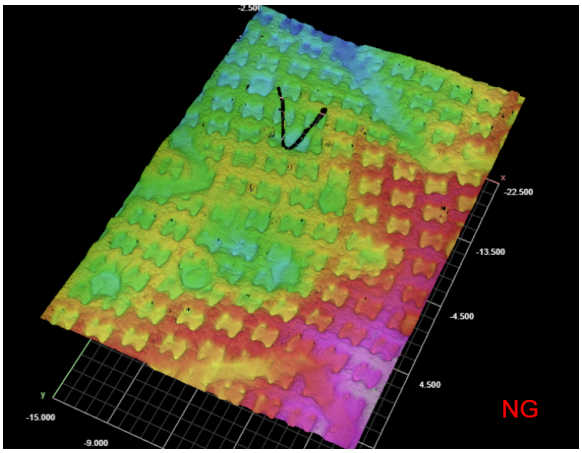

The following datasets are available:

*Datasets*

| Sample | Description |
|---|---|
| Bevel gear | This dataset demonstrates discrete part inspection of mechanical parts, such as gears and automotive components. We added defects manually to simulate anomalies. |

| Sample | Description |
| --- | --- |
| |  |
| Tire bulge | This dataset was created to demonstrate detection of a bulge defect on a tire. This type of defect could be the result of foreign materials.<br> |

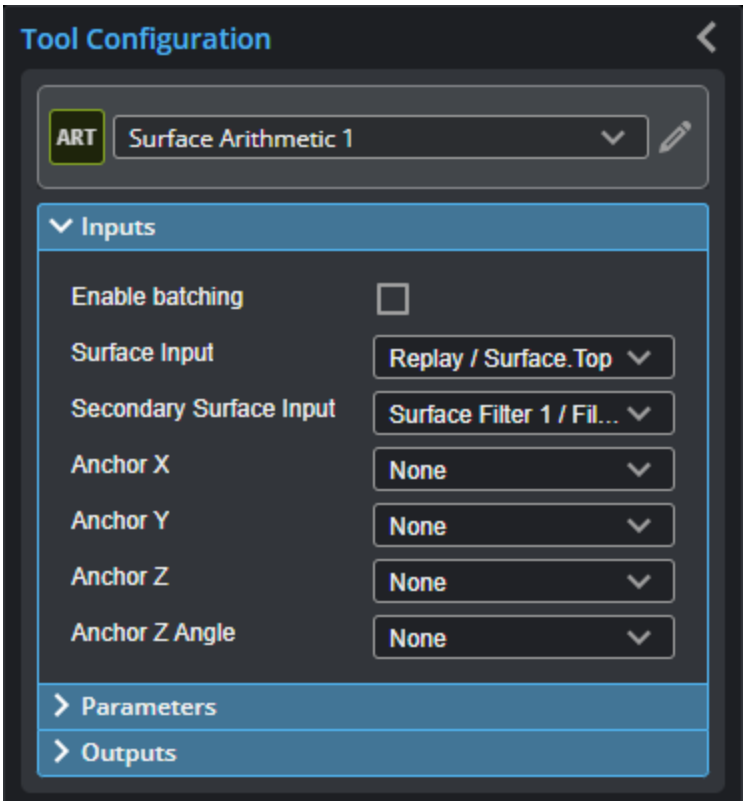
| Sample | Description |
| --- | --- |
| |  <br>  <br>The previously trained model uses a **Model resolution** setting of 512x512 and includes augmentations. In the advanced settings, **Epochs** is set to 20 and **Clamping** is set to 1. |
| Paper debris | This dataset demonstrates foreign object detection on web materials such as foil, metal, tire, battery, paper, and so on.<br> |

| Sample | Description |
| --- | --- |
| |  <br>  <br>The previously trained model uses a **Model resolution** setting of 512x512. |

## Surface Arithmetic

The Surface Arithmetic tool lets you perform various operations on a pair of surfaces. For example, you can use the tool to perform dynamic masking from frame to frame. The tool performs bitwise operations (AND or OR) on the corresponding data points in the source surfaces, and also combines height and intensity data with add, subtract, average, and mask operations.

### Inputs




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

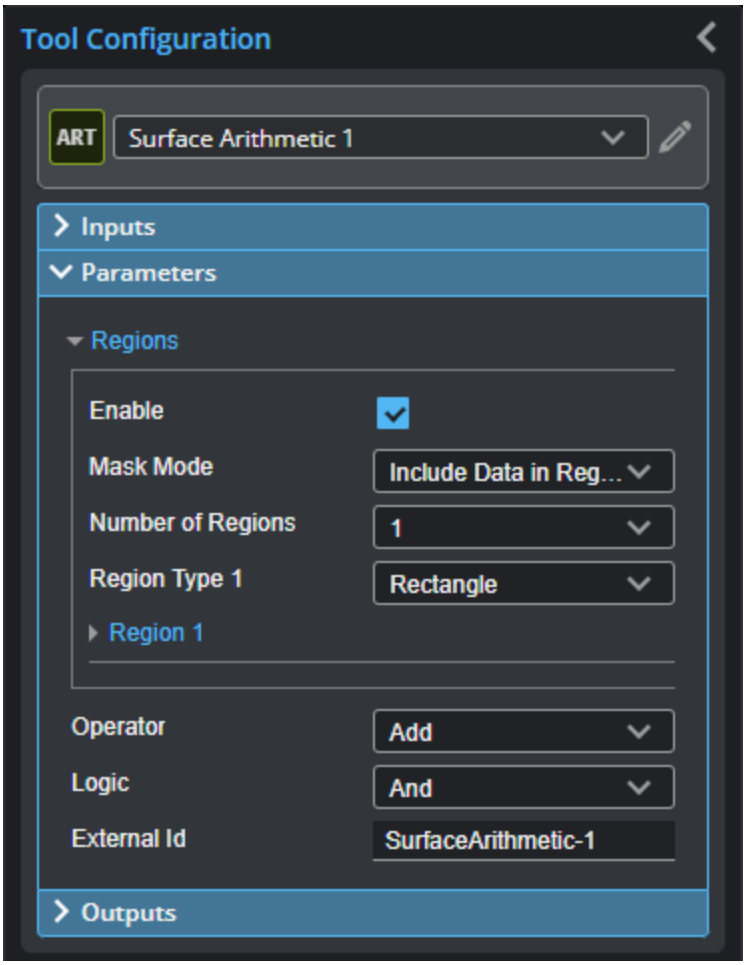
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Secondary Surface Input | The secondary input the tool uses to perform arithmetic. |
| Anchor X | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

| Name | Description |
|---|---|
| Anchor Y | |
| Anchor Z | |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

The following parameters are in the expandable **Parameters** section in the tool's configuration.

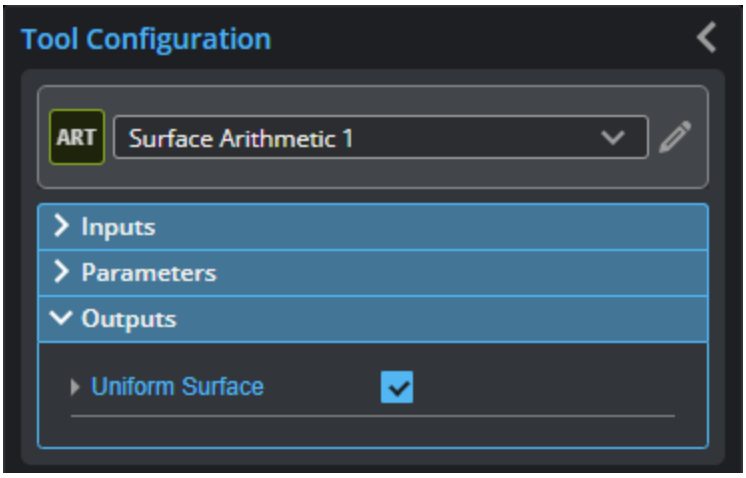



*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and |

| Parameter | Description |
|---|---|
| Region {n} | "flexible" regions, see *Regions* on page 181. |
| Operator | One of the following:<br>**Add**: Adds the height values of the corresponding data points in the two sources.<br>**Subtract**: Subtracts the height values of the corresponding data points in the two sources.<br>**Average**: Averages the height values of the corresponding data points in the two sources.<br>**Mask**: Uses the secondary source as a mask. |
| Logic | Performs bitwise-operations on the source and secondary source surface data. One of the following: **And** or **Or**. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

*Data*

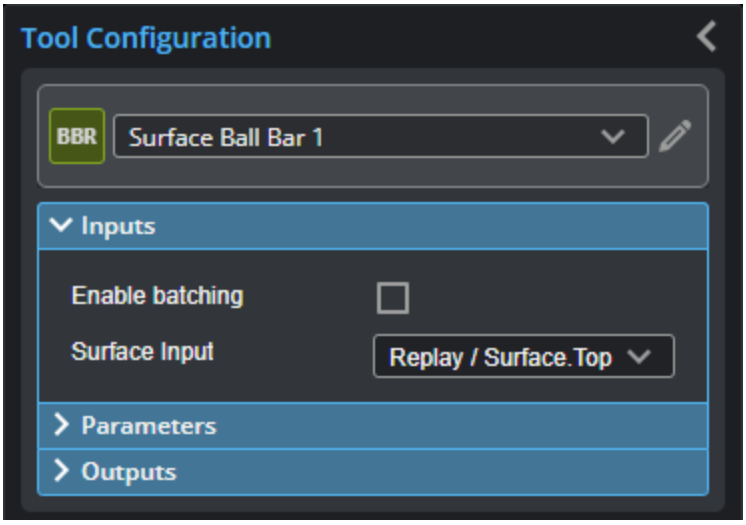
| Type | Description |
|---|---|
| Uniform Surface | The processed surface data. |

## Surface Ball Bar

The Surface Ball Bar tool returns measurements useful for calibrating systems using a ball bar, particularly systems that include a robot.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

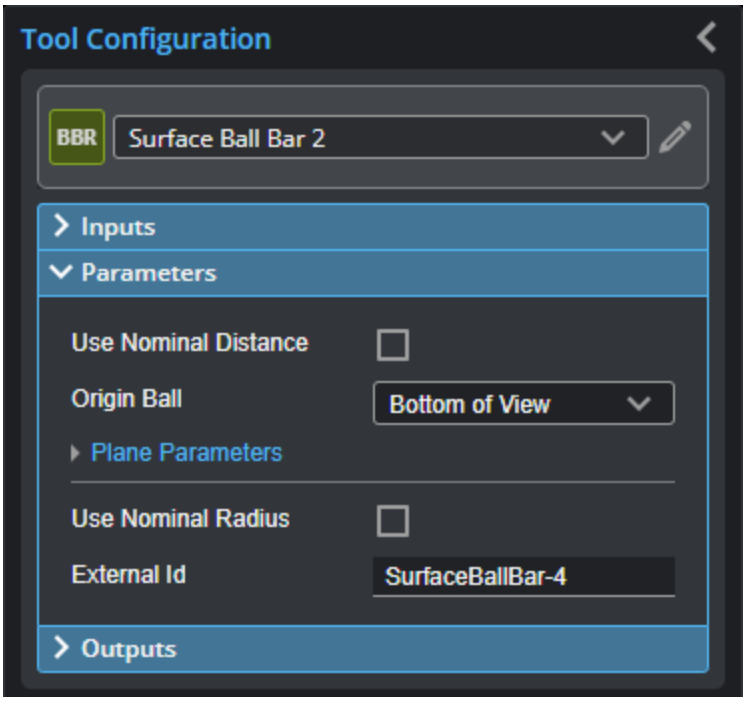



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | Leave this setting unchecked. |
| Surface Input | The data the tool applies measurements to or processes. |

### Parameters

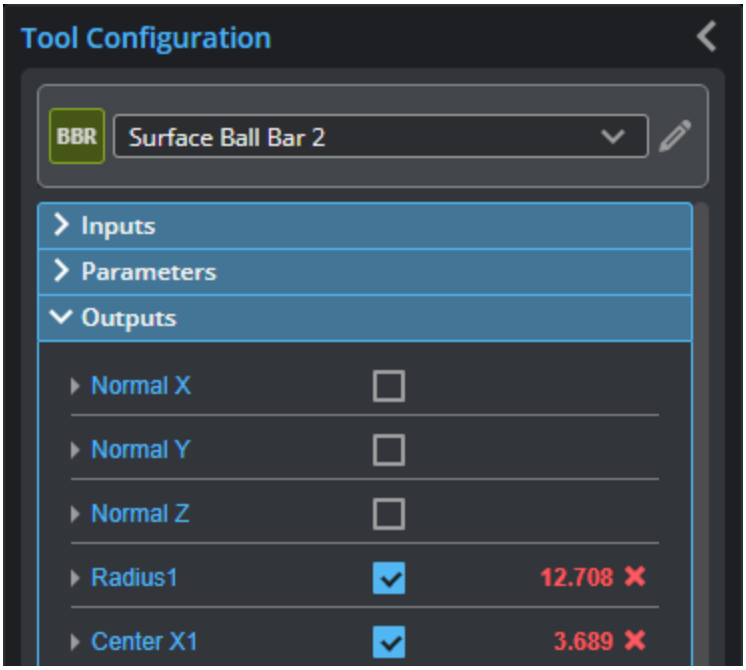
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Use Nominal Distance | When enabled, displays **Nominal Distance** and **Distance Tolerance** settings. Set these to the distance between the balls of the ball bar (refer to the specifications of the ball bar) and the tolerance you need. This can be useful to ensure invalid results due to false or inaccurate detection are rejected. |
| Origin Ball | Determines which ball is used as the origin. The **Bottom of View** option selects the ball at the bottom of the data viewer in the web interface. |
| Plane Parameters | Enables advanced plane settings. For UR integration, you should leave the settings at their default. These parameters allow ensuring the plane detection is accurate and robust to variations. |
| Use Nominal Radius | When enabled, displays **Nominal Radius {n}** settings. Set these to the radius of the balls of the ball bar (refer to the specifications of the ball bar) and the tolerance you need. This can be useful to ensure invalid results due to false or inaccurate detection are rejected. The tool uses these as a starting point and will not necessarily reject targets based on these. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




*Measurements*

| **Measurement** |
| --- |
| **Normal X / Y / Z**<br>These measurements return the X, Y, and Z components of the normal vector of the surface surrounding the calibration target. |
| **Radius1**<br>**Radius2**<br>These measurements return the radius of each ball. |
| **Center X1 / Y1 / Z1**<br>**Center X2 / Y2 / Z2**<br>These measurements return the X, Y, and Z positions of the centers of the spheres fitted to the balls.<br>Ball 1 (Center X1 / Y1 / Z1) is always used as the origin. (Corresponds to the values returned in Tx / Ty / Tz.) |
| **Distance 3D**<br>The direct distance between the centers of the spheres fitted to the balls. |
| **Ix / Iy / Iz**<br>**Jx / Jy / Jz**<br>**Kx / Ky / Kz**<br>These measurements return the X, Y, and Z components of the I, J, and K unit vectors defining the coordinate system orientation. |
| **Tx / Ty / Tz**<br>These measurements return the X, Y, and Z components of the translation vector defining the coordinate system origin location. |

*Data*

| Type | Description |
| --- | --- |
| Difference Surface | The difference between the scan data and the provided nominal dimensions. Used for diagnostics. |

## Surface Blob

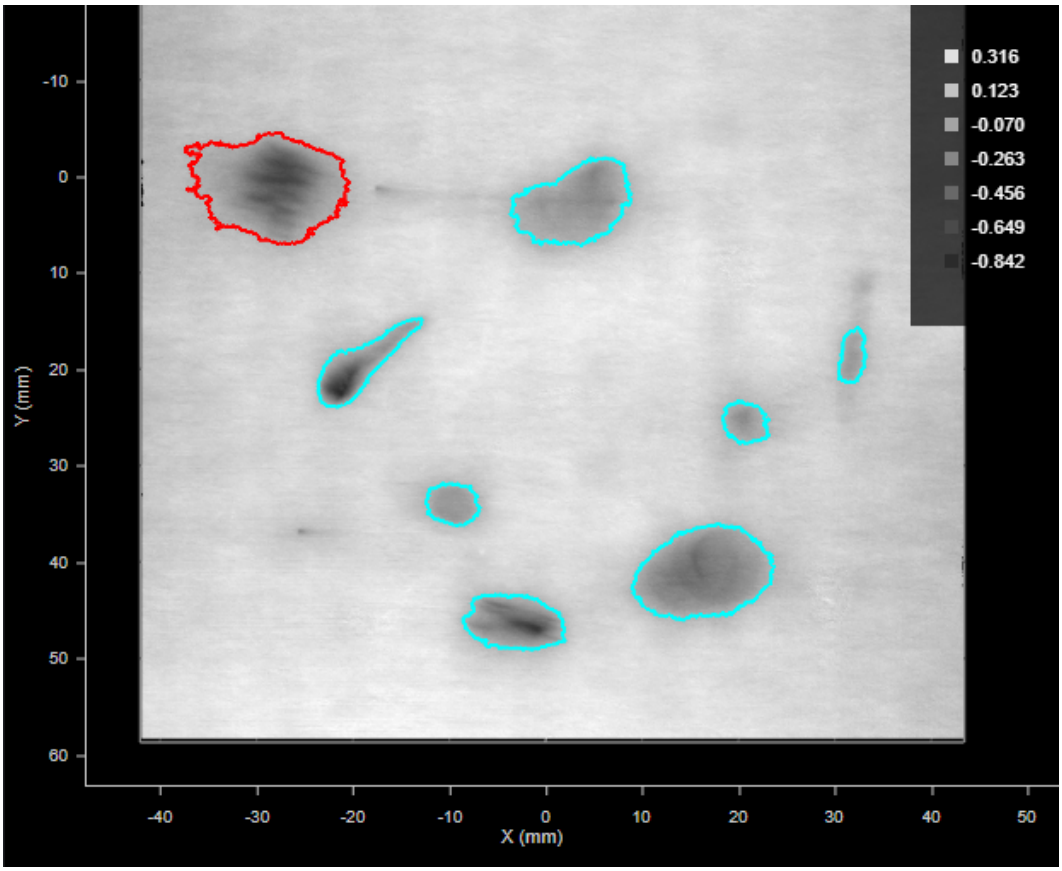
The Surface Blob tool lets you detect surface defects, such as uneven or excess material, gouges, or blemishes, on a relatively uniform or flat background, in either 3D height map data or intensity data. It can also extract targets from the surface. The tool optionally lets you set its height threshold relative to a user-defined reference region. It also lets you use a reference plane to correct for a minor tilt of the target surface (up to 10 degrees); this lets you detect low or shallow defects that would otherwise not be detectable due to a tilt.

The Surface Blob tool provides functionality similar to the Surface Segmentation tool. For information on the Surface Segmentation tool, see *Surface Segmentation* on page 569.

For a comparison of these tools and the part detection capabilities you can configure on the **Acquire** page, see *Isolating Parts from Surface Data* on page 351.

The tool first filters data based on a height or intensity threshold (above or below it), and then uses configurable morphological operations to better isolate parts. Finally, the tool uses various size- and shape-based filters that let you exclude or include the expected defects or the targets you need (potential blobs).

The tool lets you configure the maximum number of "blobs" to output, and returns the total blob count, and for each blob, the X and Y center, the width and length, and the area. The center point of each blob is available as a geometric feature.



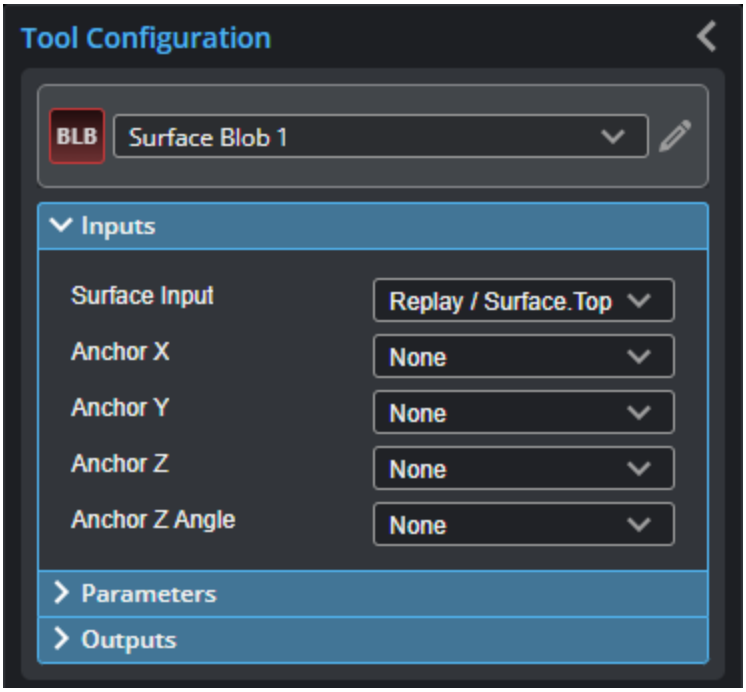

*Several dents outlined by the tool on a surface in cyan. The currently selected blob is outlined in red. (Grayscale heightmap mode is used to better see the outlines.)*

Note that knowing the rough size and shape of the kinds of detects you expect is important when you are configuring the open and close kernels and the tool's filters.

When **Enable Array Output** is checked, the tool outputs the blobs in an array called Blob Surface. Be *sure* to enable Blob Surface in the **Outputs** section after enabling this parameter.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

## Inputs



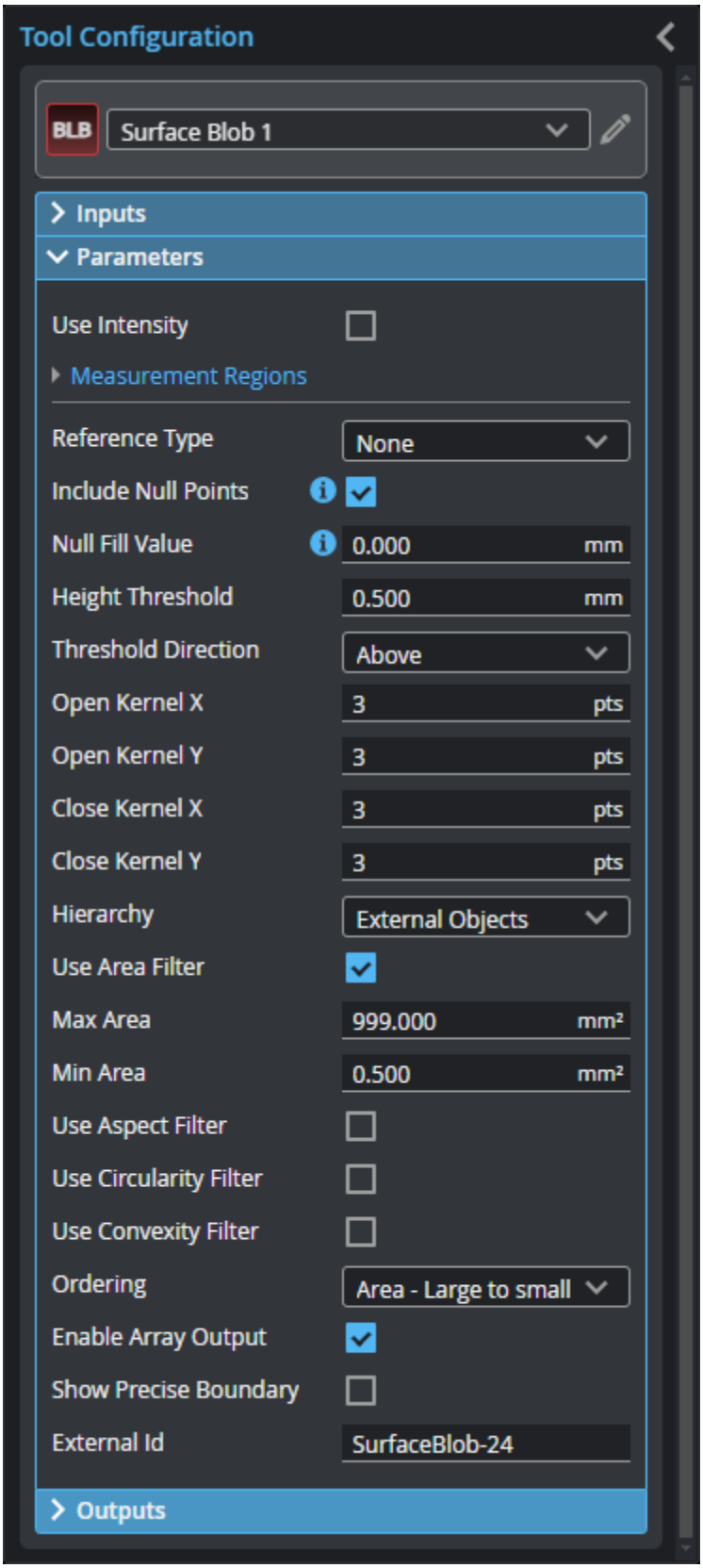

> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

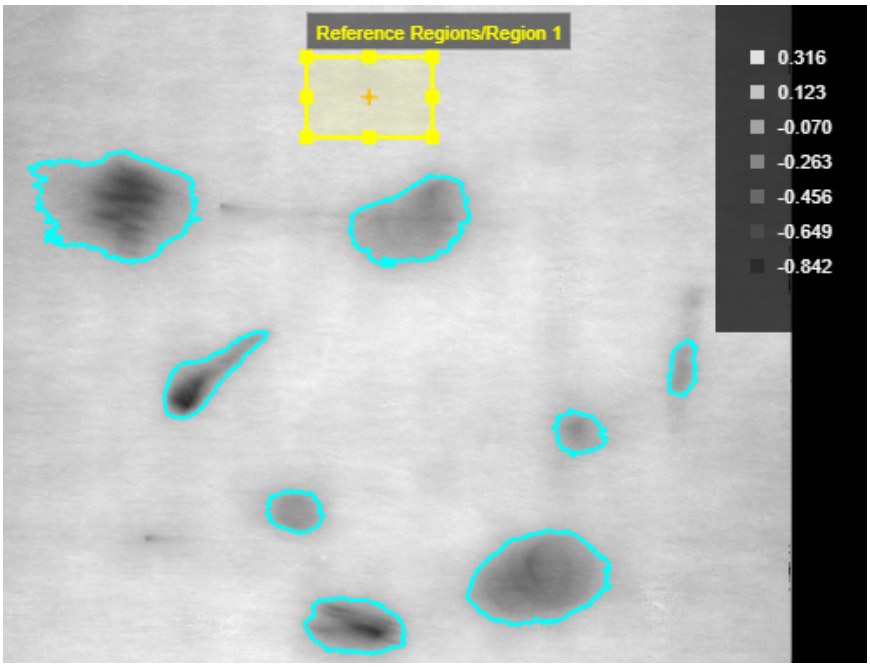
| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |
| Plane | The Plane geometric feature the tool uses when **Reference Type** is set to Reference Plane. |

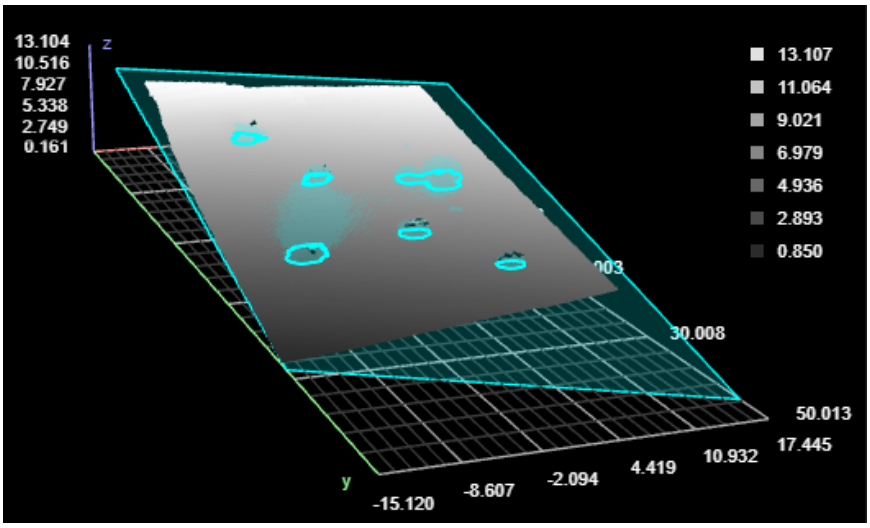
## Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

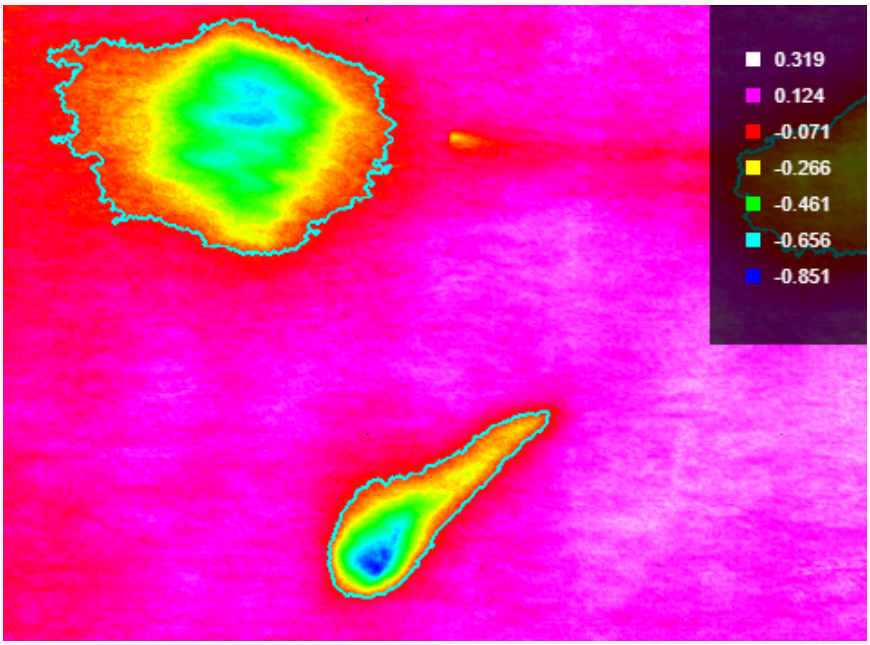
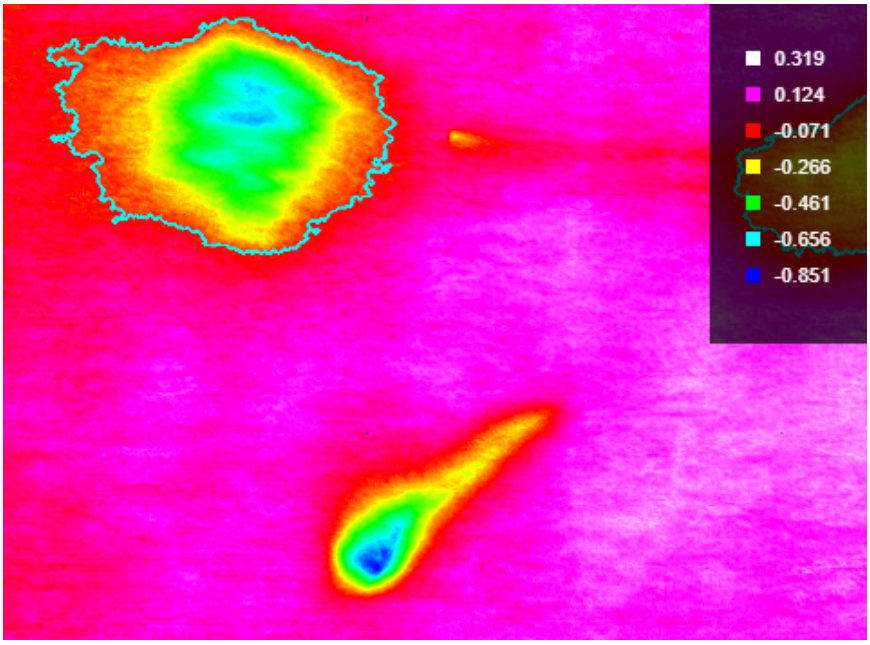

Tool Configuration
BLB
Surface Blob 1
Inputs
Parameters
Use Intensity
Measurement Regions
Reference Type
None
Include Null Points
Null Fill Value
0.000
mm
Height Threshold
0.500
mm
Threshold Direction
Above
Open Kernel X
3
pts
Open Kernel Y
3
pts
Close Kernel X
3
pts
Close Kernel Y
3
pts
Hierarchy
External Objects
Use Area Filter
Max Area
999.000
mm²
Min Area
0.500
mm²
Use Aspect Filter
Use Circularity Filter
Use Convexity Filter
Ordering
Area - Large to small
Enable Array Output
Show Precise Boundary
External Id
SurfaceBlob-24
Outputs

*Parameters*

| Parameter | Description |
|---|---|
| Use Intensity | If enabled, the tool uses intensity data instead of heightmap data. Only available if **Acquire intensity** is enabled on the **Acquire** page, in the **Scan mode** section during scanning; for more information, see *Scan Modes and Intensity* on page 111. |
| Measurement Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Reference Type | Provides three options: None, Reference Region, and Reference Plane. If the reference type is set to None, the **Height Threshold** setting is absolute (relative to zero). For the Reference Region and Reference Plane options, see the descriptions of the **Reference Region Type** and **Reference Plane** parameters below. |
| Reference Region Type | If you set **Reference Type** (see above) to Reference Region, the tool displays a drop-down that lets you configure the reference region. (For details, see *Flexible Regions* on page 183.) The tool calculates an average height or intensity of the data in the reference region. **Height Threshold** is relative to this value.<br>For example, in the following, blobs are detected using a relative height threshold of -0.2 mm, relative to the average in the reference region:<br>  <br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |

| Parameter | Description |
|---|---|
| Reference Plane | If you set **Reference Type** (see above) to Reference Plane, the tool uses the specified plane geometric feature to correct for a tilt of the target. Note however that using a reference plane to correct the tilt distorts the scan data: it sheers the data by the same angle as the tilt. The maximum tilt angle with which you can use the tool therefore depends on how much sheer angle you can tolerate in your application (which can effect the tool's ability to detect blobs). Typically, you add and configure a Surface Plane tool to generate a plane (for more information, see *Surface Plane* on page 543). For information on geometric features, see *Geometric Features* on page 191.<br>For applications where sheer distortion can't be tolerated, use Surface Transform to correct the tilt (see *Surface Transform* on page 606), and use the latter tool's output as the input for Surface Blob.<br>For example, in the following, despite the overall tilt of the target, the tool detects the flaws on the surface. (Note the gradient of the heightmap colors, indicating a height difference of roughly 9 millimeters between the lower and higher areas near the dents on the target's surface.)<br>  |
| Include Null Points | Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in **Null Fill Value** as a general “background level” or to fill gaps to aid in isolating blobs.<br>If **Use Intensity** is enabled, the value in **Null Fill Value** is an intensity. |
| Height Threshold<br>Intensity Threshold | The threshold above or below which data is considered for being a blob. Use the **Threshold Direction** setting to determine whether data above or below the threshold is considered.<br>If **Use Intensity** is enabled, this setting is **Intensity Threshold**. Otherwise, it is named **Height Threshold**. |
| Threshold Direction | Determines whether data above or below the threshold is considered as being a |

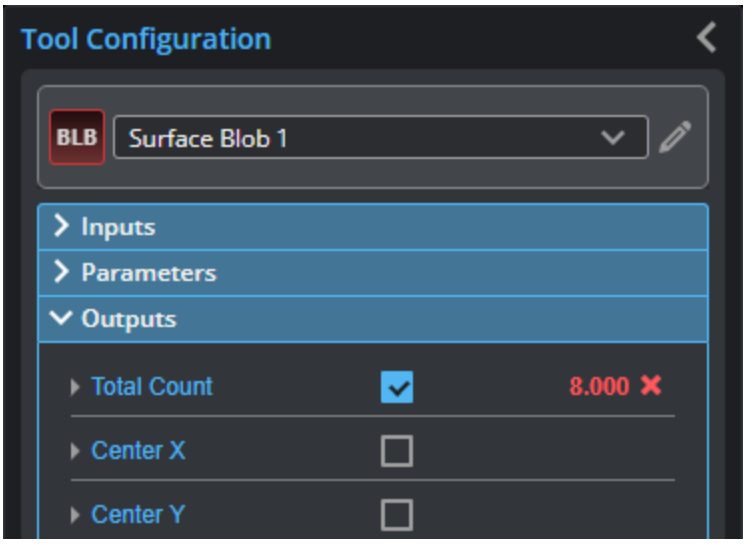
| Parameter | Description |
| --- | --- |
| | blob.<br>**Below**: The **Height Threshold** value is the maximum that will be considered as part of a blob (for example, a dent below the surrounding surface).<br>**Above**: The **Height Threshold** value is the minimum that will be considered as part of a blob (so a raised feature). |
| Open Kernel X<br>Open Kernel Y | The X and Y kernel size, respectively, for morphological opening to remove small areas of data. Use these settings, for example, to remove bridges between areas to properly isolate them or to remove small areas entirely (perhaps caused by noise). Use different values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of unwanted data you see in the scan data. |
| Close Kernel X<br>Close Kernel Y | The X and Y kernel size, respectively, for morphological closing to fill in holes smaller than the specified kernel size. Use these settings, for example, to fill small areas within potential blobs that may be caused by drop-outs. Use different values of X and Y to use a non-rectangular filter to adapt the kernel to the kinds of holes you see in the scan data. |
| Hierarchy | Provides options to let you find either external objects only or all objects.<br>**External Objects**<br>Use this option to ignore smaller objects in larger objects. Only the outermost objects are returned.<br>**All objects**<br>Use this option to include smaller objects in larger objects.<br>**Holes**<br>Use this option to get holes inside objects.<br>**All Contours**<br>Use this option to get all detected contours. When you choose this option, an **Include Inner** checkbox is displayed (see below). |
| Use Area Filter | If **Use Area Filter** is enabled, the tool applies an area filter to potential blobs using the values in **Max Area** and **Min Area**. |
| Use Aspect Filter | If **Use Aspect Filter** is enabled, the tool applies an aspect filter (ratio of length and width) to the rotated bounding box that would encapsulate the area, using the values in **Max Aspect** and **Min Aspect**.<br>For example, the lowest dent in a surface is included as a blob if the aspect values are set to 1 and 0.350, respectively (the rotated bounding box encapsulating would be 13.461 mm x 4.782 mm). |

| Parameter | Description |
| --- | --- |
| |  <br>In the following, the same dent is excluded if **Min Aspect** is set to a value greater than 0.354.<br>  |
| Use Circularity Filter | If **Use Circularity Filter** is enabled, the tool applies a circularity filter to potential blobs to measure how close to a circle the blob is, using the values in **Max Circularity** and **Min Circularity** . Circularity is determined from area within the contour of the blob and the perimeter of its contour. With increasing perimeter for the same area, circularity is reduced. |

| Parameter | Description |
|---|---|
| Use Convexity Filter | If **Use Convexity Filter** is enabled, the tool applies a convexity filter to potential blobs, using the values in **Max Convexity** and **Min Convexity** . Convexity is defined as the (Area of the Blob / Area of its convex hull), and "convex hull" of a shape is the tightest convex shape that completely encloses the shape. |
| Ordering | Orders the measurements, features, and surface data of the individual blobs output by the tool. One of the following:<br>• Position - X increasing<br>• Position - X decreasing<br>• Position - Y increasing<br>• Position - Y decreasing<br>• Area - Large to small<br>• Area - Small to large |
| Enable Array Output | When **Enable Array Output** is unchecked, the tool outputs each blob as an individual Surface output.<br>When **Enable Array Output** is checked, the tool outputs the blobs in an array called Blob Surface. Be *sure* to enable Blob Surface in the **Outputs** section after enabling this parameter. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Number of Blob Outputs | Determines the number of blobs the tool outputs as measurements, features (center points of blobs), and surface data. Currently limited to 200 blobs. If **Enable Array Output** is checked, this parameter is hidden. |
| Show Precise Boundary | Displays the boundaries of the blobs so that they appear on the Surface data, rather than floating above the Surface. This makes it easier to evaluate the blob boundaries in relation to the Surface data.<br>This setting does not affect measurements or other outputs.<br>Disable this setting for maximum performance. |
| Include Inner | Uncheck this to detect blobs without inner data. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

If **Enable Array Output** is checked, the tool outputs arrays for the center position, length, width, and area measurements, as well as the Center Point output.

If **Enable Array Output** is unchecked, the tool outputs individual, numbered measurements. Use the **Number of Blob Outputs** setting to determine the number of measurements listed in the **Measurements** tab.

*Measurements*

| **Measurement** |
| --- |
| **Total Count**<br>Returns the total number of blobs identified, based on the tool's parameters. |
| **Center X {n} / Center X**<br>**Center Y {n} / Center Y**<br>The X and Y positions of the center of mass of a blob extracted from the surface. |
| **Average Z {n} / Average Z**<br>The averaged Z positions of a blob extracted from the surface.<br>Average Z is calculated from all valid blob points, whereas Center.Z is calculated from a relatively small rectangle region around the center (7 by 7 data points); for this reason they are usually not consistent. |
| **Min Z {n} / Min Z**<br>**Max Z {n} / Max Z**<br>The minimum and maximum Z positions of a blob extracted from the surface. |
| **Width {n} / Width** |

**Measurement**

**Length {n} / Length**

The length and width of the rotated bounding box that encapsulates the blob extracted from the surface. These are always the major and minor axis of a blob, respectively.

**Area {n} / Area**

The area of a blob.

The area is calculated using the contour of the blob and resampling. For this reason, areas calculated using the Surface Volume tool will produce different measurements; for more information, see *Area* on page 625.

*Features*

| Type | Description |
|---|---|
| Center Point {n} / Center Point | The point representing the center of a blob. |

For more information on geometric features, see *Geometric Features* on page 191.

*Data*

| Type | Description |
|---|---|
| Diagnostic Surface | Surface data you can use to evaluate the impact of the tool's parameters, after filters are applied, to properly separate the areas corresponding to the defects or targets you need to detect. |
| Surface {n} / Blob Surface | Surface data corresponding to each blob.<br>When the tool is configured to output arrays, the blob surfaces are in Blob Surface. |

## Surface Bounding Box

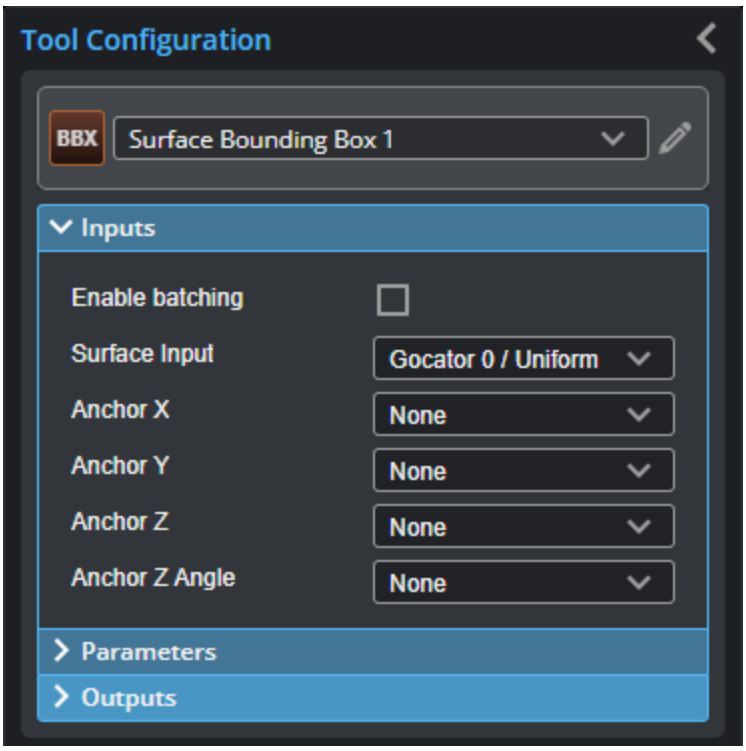
The Bounding Box tool provides measurements related to the smallest box that contains the *scan data* from a part (for example, X position, Y position, width, length, etc.). The tool also lets you get the height of bounding box relative to the Z origin (typically the conveyor on which the target is sitting). This lets you determine, for example, the height of a box or other container on the conveyor as part of a product packaging process. Various settings let you easily filter out noise that can affect height, width, and length measurements.

A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the Position centroids tools are referenced.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

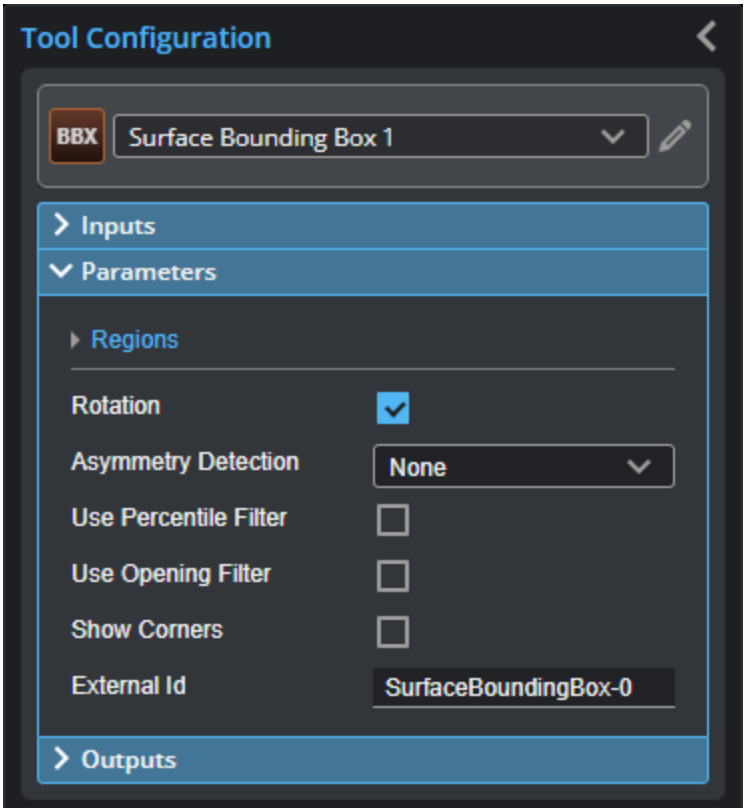
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the |

| Name | Description |
|---|---|
| | array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

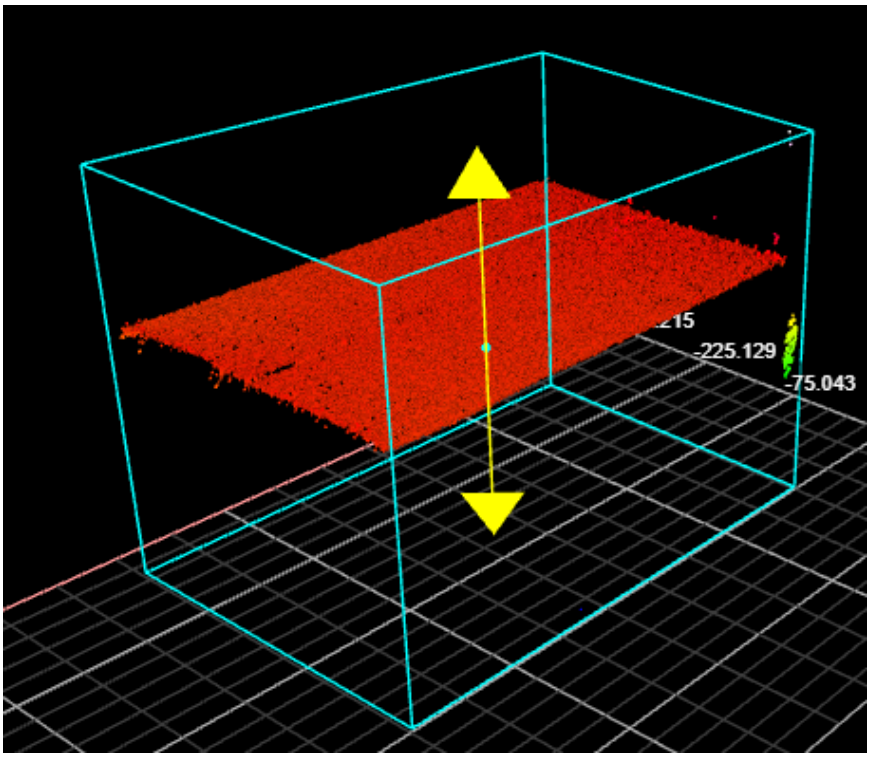
**Parameters**

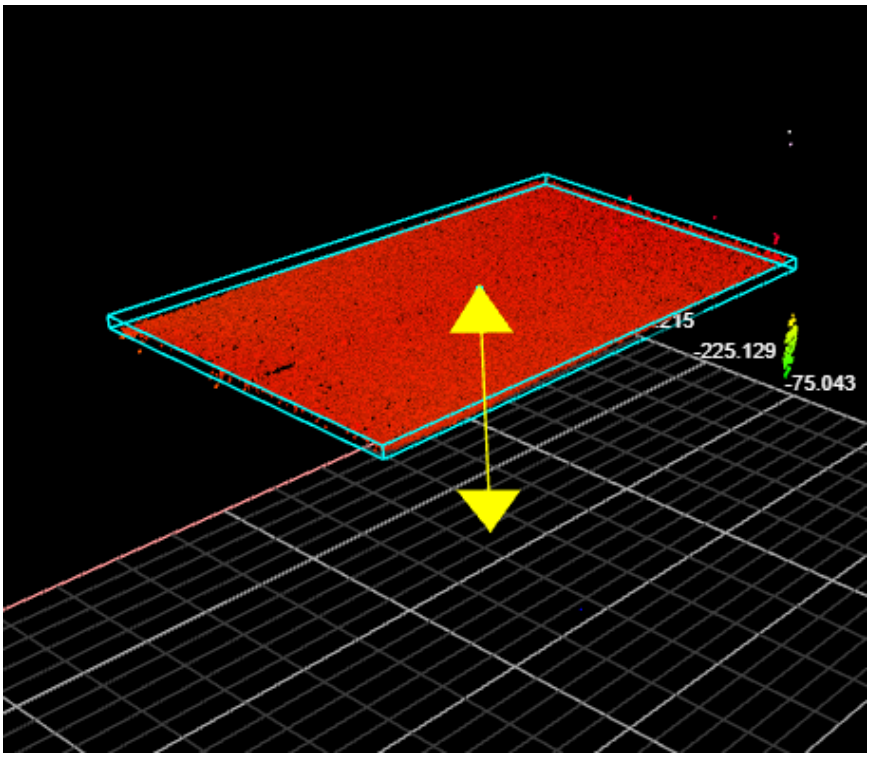
You configure the tool's parameters in the expandable **Parameters** section.

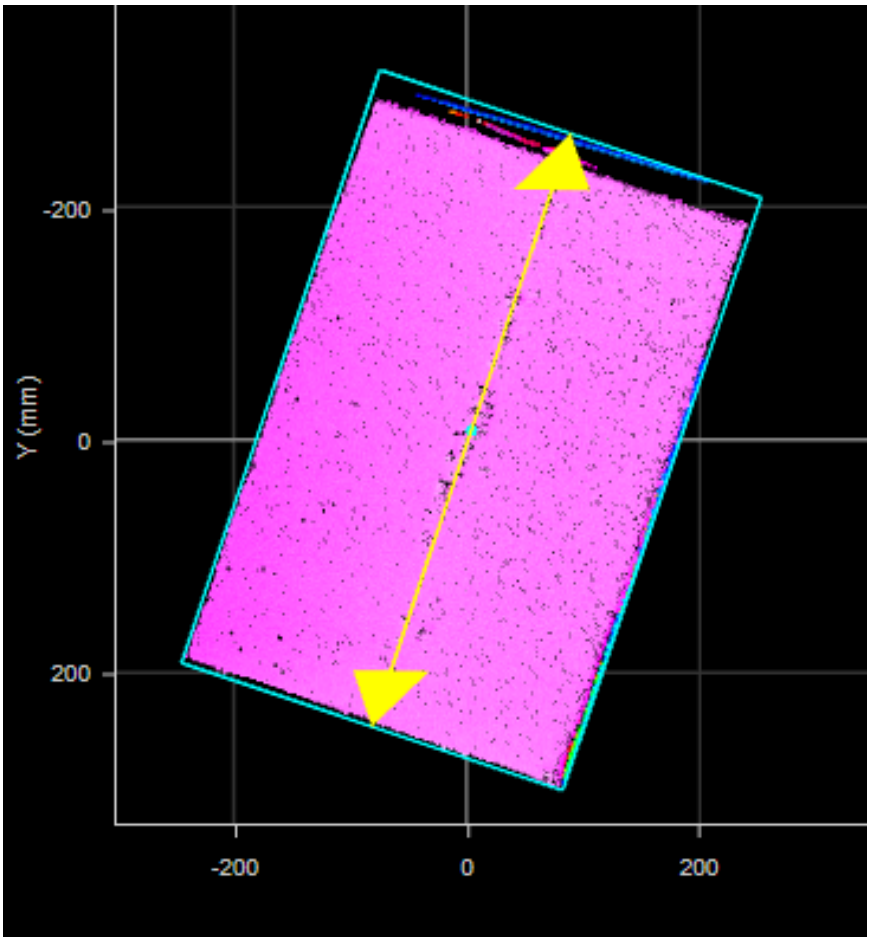


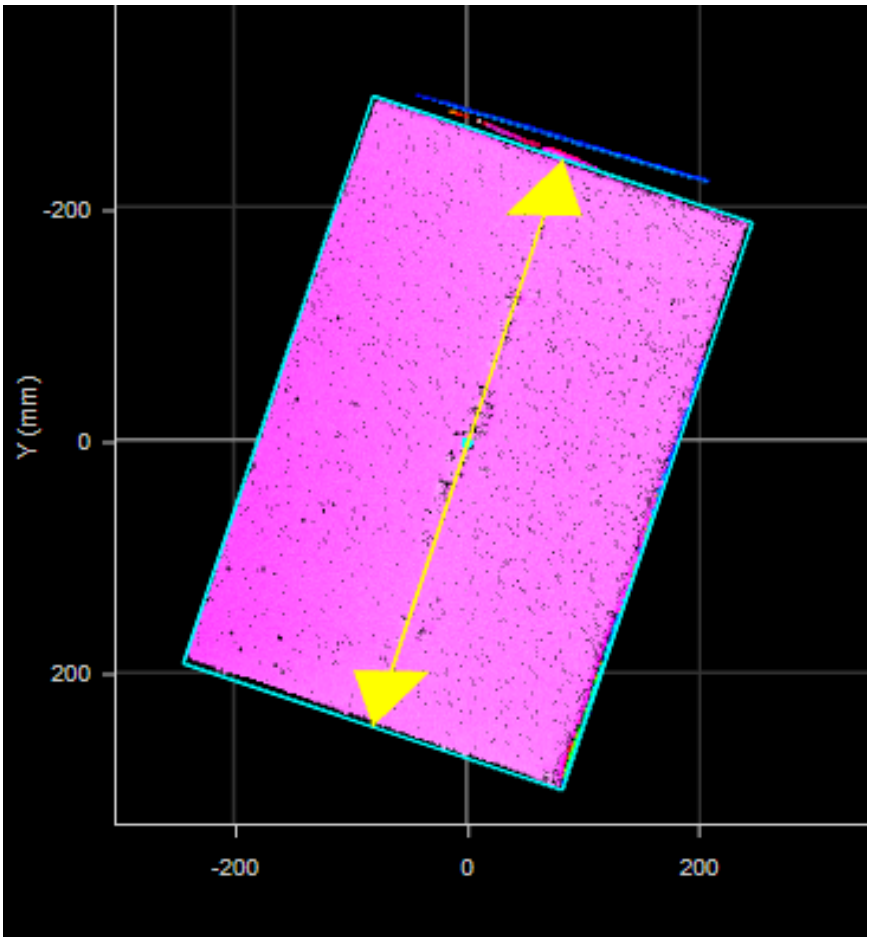
*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Region Type 1<br>Region 1 | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Rotation | A bounding box can be vertical or rotated. A vertical bounding box provides the absolute position from which the part's Position centroid measurements are referenced. Check the **Rotation** setting to select rotated bounding box. When this setting is enabled, an Asymmetry Detection setting is displayed. |
| Asymmetry Detection | Resolves the orientation of an object over 360 degrees. The possible values are:<br>0 – None<br>1 – Along Major Axis<br>2 – Along Minor Axis<br>This setting is only visible if **Rotation** is checked. |
| Use Percentile Filter | Limits the bounding box to data points along the Z axis between the values you set in **High Percentile** and **Low Percentile**, which are displayed when you choose this option. Use this setting to obtain more "robust" height measurements.<br>This setting is useful to exclude noise that would otherwise cause inaccurate height measurements. For example, in the following scan of a box, without excluding a small percentage of the highest data points, data points caused by noise to the upper right produces an inaccurate height measurement (from the Z origin) of the box of 406.457 mm.<br>(The following screenshots are from a G2 sensor.) |

| Parameter | Description |
| --- | --- |
| |  <br>When **High Percentile** is set to 99%, the highest 1 percent of data points is excluded from the placement of the bounding box, and an accurate height of the target box of 270.477 mm is returned. |

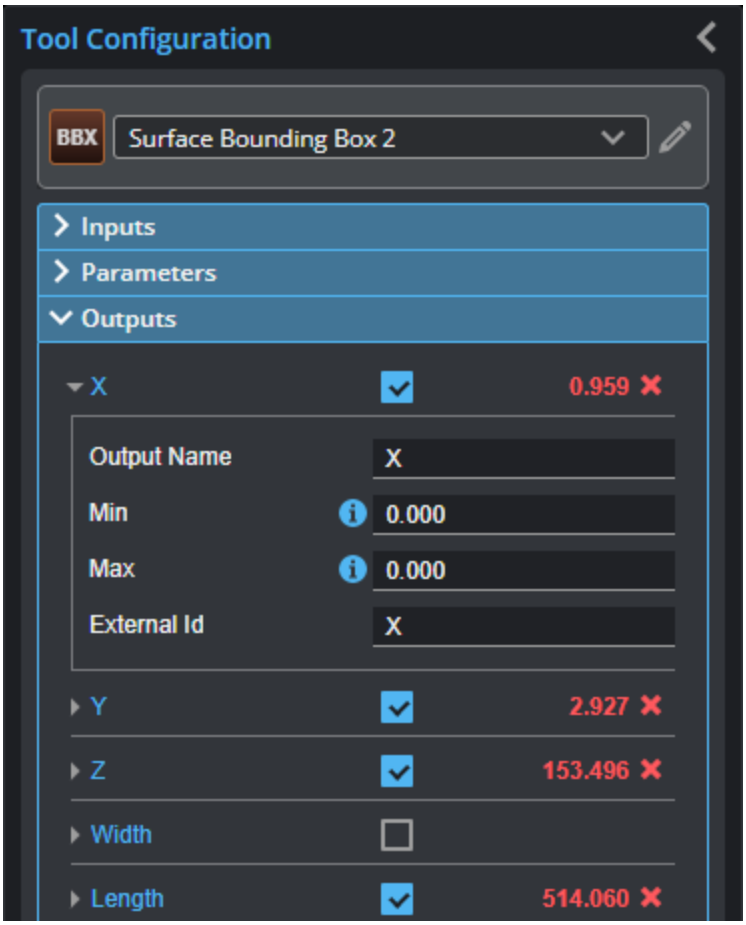
| Parameter | Description |
| --- | --- |
| |  |
| High Percentile<br>Low Percentile | See **Use Percentile Filter** above. |
| Use Opening Filter | When enabled, this setting lets you set the value of **Kernel Size** for an *opening* morphological operation applied to the scan data on the XY plane, letting you achieve "robust" width and length measurements.<br>This filter removes noise or small objects from scan data, while keeping the shape and size of the larger objects in the scan data. For example, in the following, noise along the edge at the top of the data viewer results in an inaccurate length measurement.<br>(The following screenshots are from a G2 sensor.) |

| Parameter | Description |
| --- | --- |
| |  <br>When the filter is set to an appropriately sized kernel (here, 11 points), the noise is excluded from the calculation of the bounding box, and an accurate length is returned. |

| Parameter | Description |
| --- | --- |
| |  <br>Use the Diagnostics Surface on the **Data** tab to evaluate the impact of the open filter, to avoid removing too much data. |
| Kernel Size | See **Use Opening Filter** above. |
| Show Corners | When this setting is enabled, the tool outputs a Point geometric feature for each corner of the box. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

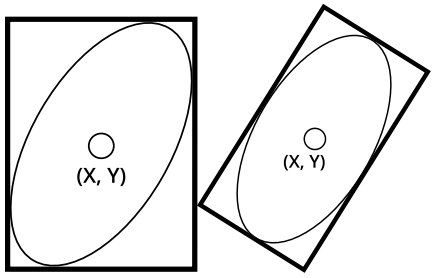
Most tools provide measurements, geometric features, or data as outputs.

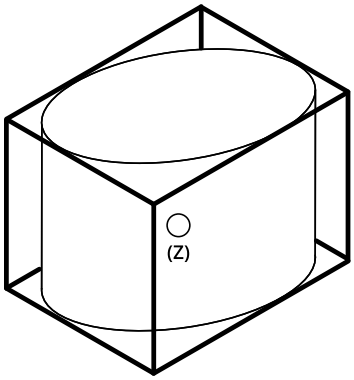
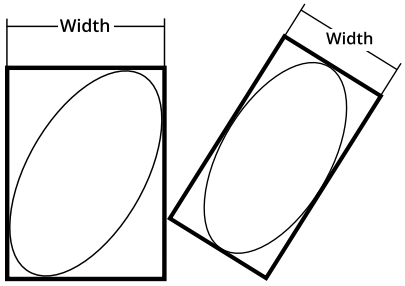
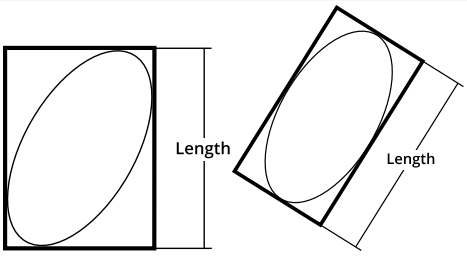
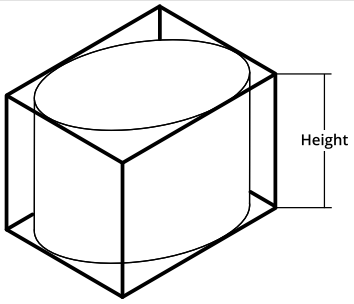


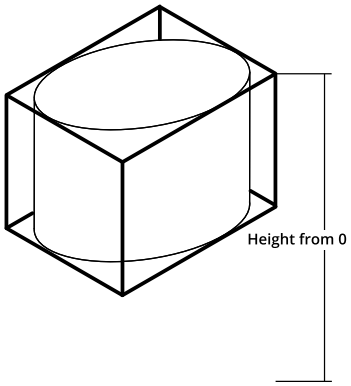
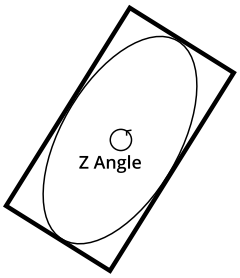

*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the center of the bounding box that contains the part.<br>The value returned is relative to the *part*. |  |
| **Y**<br>Determines the Y position of the center of the bounding box that contains the part.<br>The value returned is relative to the *part*. | |

| Measurement | Illustration |
| --- | --- |
| **Z**<br>Determines the Z position of the center of the bounding box that contains the part.<br>The value returned is relative to the *part*. |  |
| **Width**<br>Determines the width of the bounding box that contains the part.<br>When the **Rotation** setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Width is on the X axis.<br>When **Rotation** is enabled, the width is the smaller side dimension. |  |
| **Length**<br>Determines the length of the bounding box that contains the part.<br>When the **Rotation** setting is disabled, the bounding box is the smallest rectangle whose sides are parallel to the X and Y axes. Length is on the Y axis.<br>When **Rotation** is enabled, the length is the longer side dimension. |  |
| **Height**<br>Determines the height of the bounding box that contains the part. |  |

| Measurement | Illustration |
|---|---|
| **Height from 0**<br>Determines the distance from the top of the bounding box to the Z origin (Z = 0). |  |
| **Z Angle**<br>Determines the rotation around the Z axis and the angle of the longer side of the bounding box relative to the X axis.<br>If **Rotation** is not enabled, the measurement returns 90.000 degrees.<br>In order to use this measurement for angle anchoring, you must enable **Rotation**; for more information on anchoring, see *Measurement Anchoring* on page 193. |  |

*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the bounding box. |
| Box Axis Line | The axis of the bounding box. |
| Corner {n} | Point geometric features representing the corners of the box. Only displayed when **Show Corners** is checked. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Circular Edge

The Circular Edge tool fits a circle to a circular edge in the scan data, using either height map or intensity data. The edge can be the outer edge of a disc-like feature or the inner edge of a hole. The tool can optionally work with partial data, as little as 1/4 of a circle, letting it work with rounded corners.

The tool lets you measure the position and radius of the circular feature and determine its roundness error. The feature is expected to be relatively round and not, for example, ovoid.

The tool also returns minimum and maximum error points to either side of the circle and gives the error distance measurement of minimum/ maximum points to the circle.

The tool uses one of four standard methods to calculate roundness. The choice of method affects the other measurements.

- Least Square Circle (LSC)
- Minimum Zone Circle (MZC)
- Maximum Inscribed Circle (MIC)
- Minimum Circumscribed Circle (MCC)

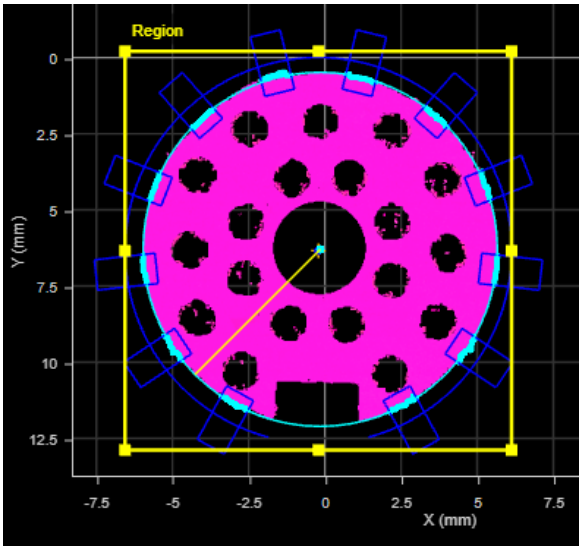
The tool can also generate circle and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see *Feature Measurement* on page 626.

Some of the tool parameters are hidden unless **Show Advanced Parameters** is checked.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Calipers, Extracted Paths, and Edge Points

To fit a circle to the scan data, the Surface Circular Edge tool starts by overlaying evenly spaced calipers along a circular path constrained by the region of interest.




*Rectangular calipers (dark blue) placed along circular path (dark blue), constrained by the region*

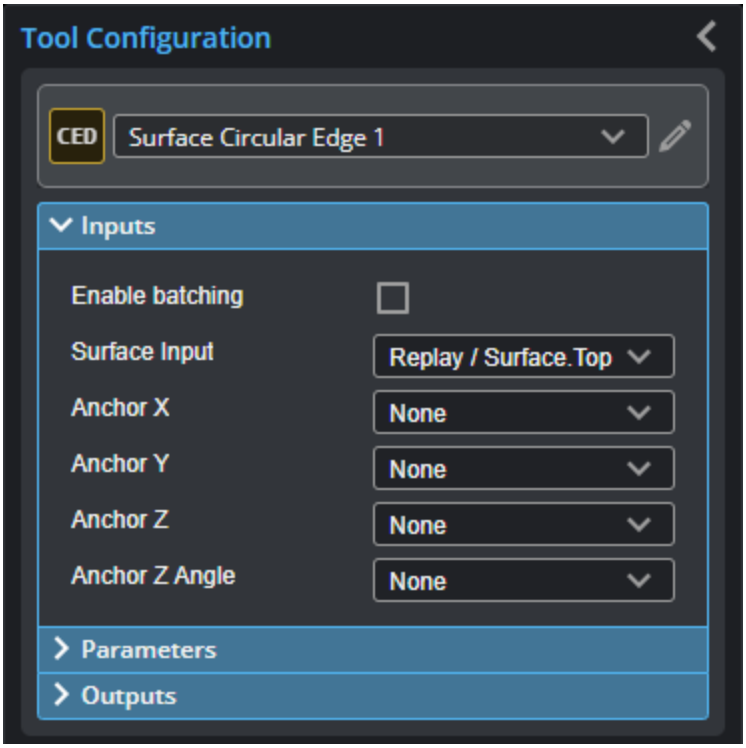
The circular path can optionally be partial, and starts at a defined orientation around the Z axis. The circular path can be as short as 1/4 of a circle, letting it work with rounded corners. Calipers extend vertically to fill the entire region of interest.

Internally, the tool extracts profiles from the data within each caliper, running from the end of the caliper closest to the center of the tool's region of interest to the end farthest from the center. The tool then searches for steps in each profile that meet the criteria set by the tool's settings, such as minimum height, direction (whether it is rising or falling), and so on.

The tool places an edge point on each selected step. The tool then uses the edge points in all the calipers to fit a circle. The various characteristics of the fitted circle are then returned as measurements.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

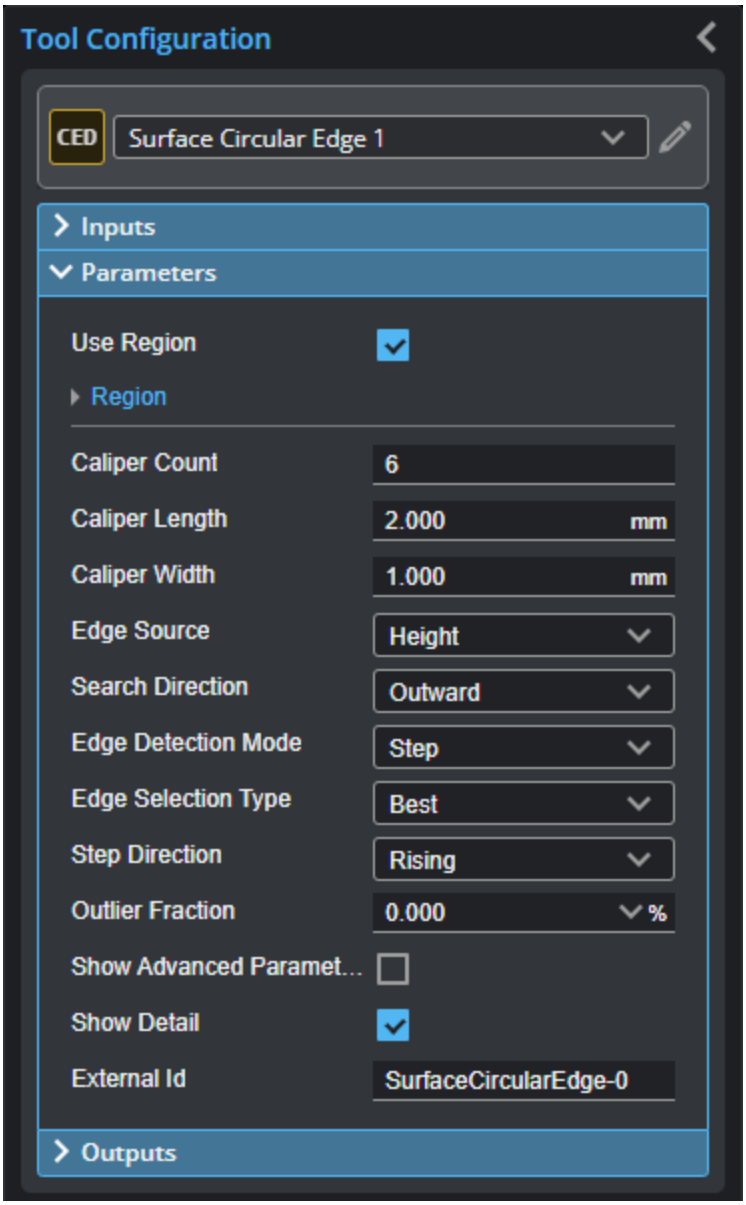
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor. |

| Name | Description |
| --- | --- |
| | For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |
| Reference Plane | Uses the feature output of a Surface Plane tool as a reference plane. Useful to correct the scan data if the target is slightly tilted. Only displayed when **Show Advanced Parameters** is enabled. |

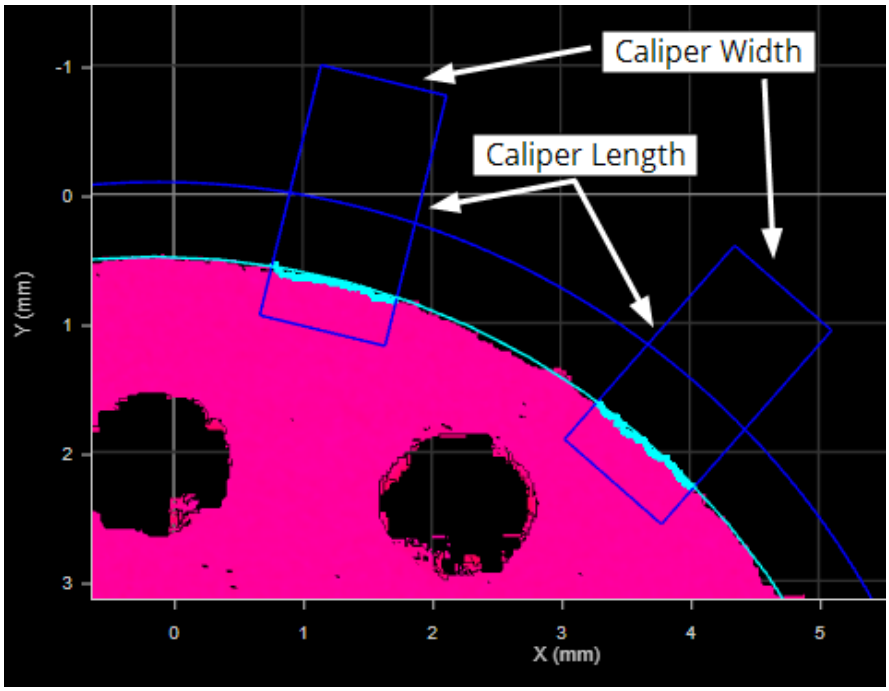
**Parameters**

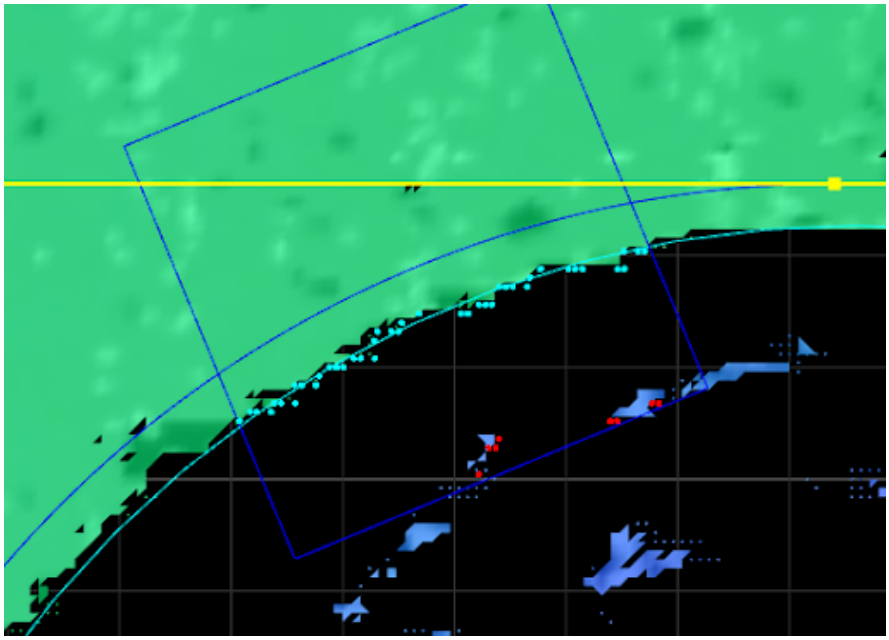
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Caliper Count | The number of calipers the tool places along the circular path. Using a higher number of calipers increases the amount of data available to the tool, but also increases the amount of time the tool takes to run.<br>Choose a balance between the runtime of the tool and the number of calipers needed to get enough edge points to properly fit the circle to the scan data. |

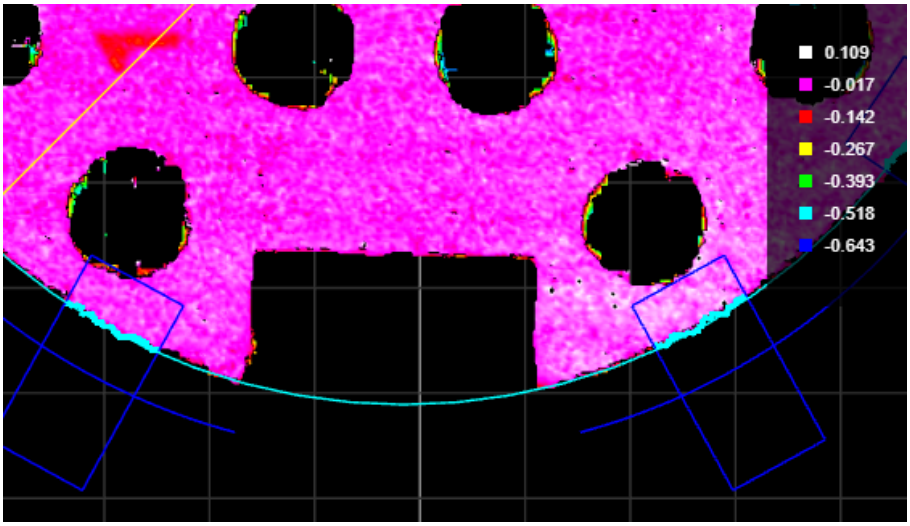
| Parameter | Description |
| --- | --- |
| Caliper Length<br>Caliper Width | **Caliper Length** is the length of the calipers (extending perpendicular to a tangent on the circular caliper path, centered on the path). The length of the calipers determines the length of the extracted profiles the tool examines for steps. Longer calipers increase the amount of data the tool must analyze and therefore the time the tool takes to run; longer calipers can also include unwanted steps when the tool searches for the edge.<br>**Caliper Width** is the width of the calipers (extending parallel to a tangent on the circular path). A wider caliper increases the time the tool takes to run. It does however increase the number of edge points, which may help the tool fit the circle.<br>  <br> |
| Edge Source | Specifies the type of data the tool uses. Either Height or Intensity.<br>Use intensity data as the edge source when contrast differences on a flat area of a target, which would not be detected using height map data, are distinct, letting the tool use the detected edge to fit the circle. |
| Search Direction | Specifies the search direction along the calipers. Either Inward (toward the center of the region of interest) or Outward. |
| Edge Detection Mode | One of the following: Step or Corner.<br>**Step**: Searches for steps on each path profile.<br>**Corner**: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden. |

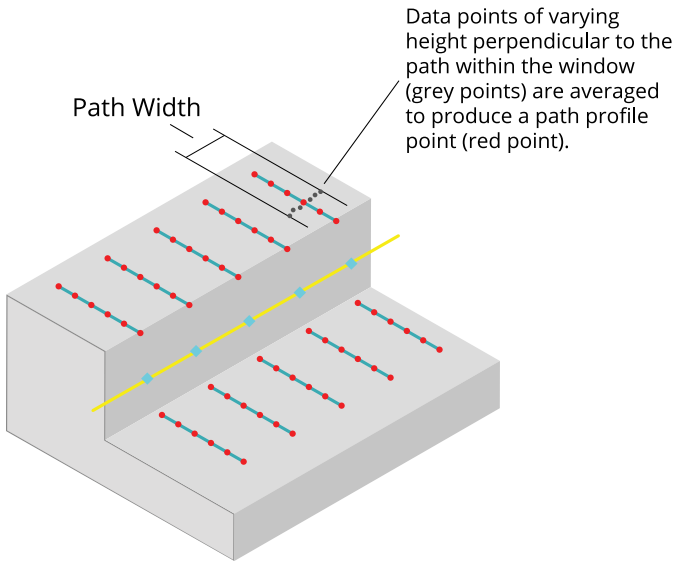
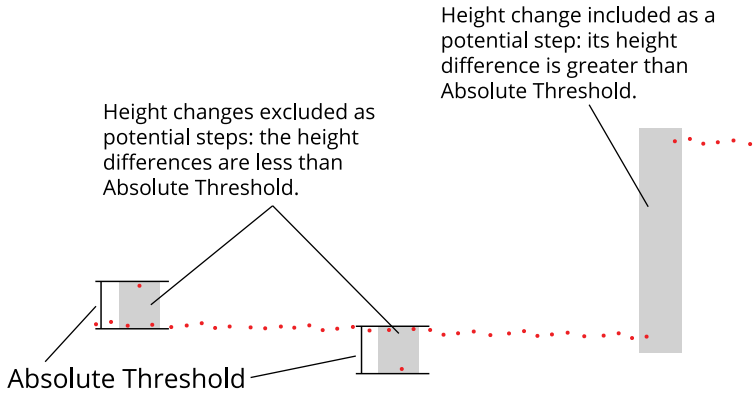
| Parameter | Description |
| --- | --- |
| Edge Selection Type | Determines which step the tool uses on each of the profiles internally extracted from the calipers when there are multiple steps. An edge point is placed on each chosen step, and is used to fit the circle. Steps must pass the criteria of the tool's settings, such as threshold and outlier exclusion.<br>**Best**: Selects the greatest step in the search direction on each profile.<br>**First**: Selects the first step in the search direction on each profile.<br>**Last**: Selects the last step in the search direction on each profile. |
| Corner Type | Determines which corner in the search direction on each profile the tool selects. One of the following:<br>**Best**: Selects the greatest corner.<br>**First**: Selects the first corner.<br>**Last**: Selects the last corner.<br>**Top**: Selects the top corner.<br>**Bottom**: Selects the bottom corner. |
| Step Direction | Determines whether the expected step in the data rises or falls, or moves from valid to null or null to valid. Note that this setting depends on the **Edge Search Direction** setting for its interpretation of what "rises" and "falls." One of the following:<br>**Rising & Falling**: Searches for edge points on rising or falling edges.<br>**Rising**: Searches for edge points only on rising edges.<br>**Falling**: Searches for edge points only on falling edges. |
| Outlier Fraction | The percentage of outlier points to exclude. Setting this to a small value can help the tool fit the circle better to the edge.<br>  |

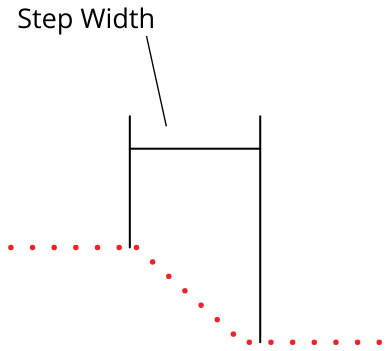
| Parameter | Description |
|---|---|
| Show Advanced Parameters | When enabled, displays advanced settings. Note that most of these settings are applied *even when they are hidden*. For information on these settings, see *Advanced Parameters* below. |
| Show Detail | When disabled, hides the calipers and caliper path, as well as the edge points. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

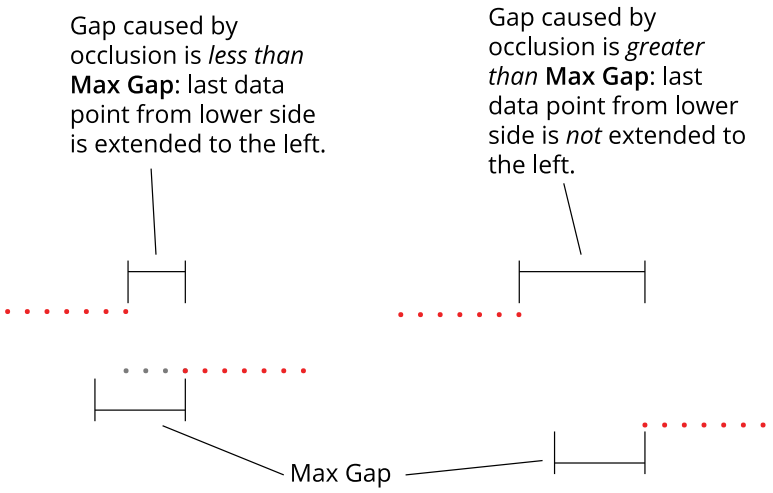
> The following parameters are hidden when **Show Advanced Parameters** is unchecked. All advanced parameters, *except***Reference Plane**, are applied when they are hidden. Mask regions are not rendered, even though they are applied.

*Advanced Parameters*

| Parameter | Description |
|---|---|
| Angle Start<br>Angle Span | These settings work together to let you set a partial path and exclude part of the data. In the following close-up image of a circular feature, the dark blue path starts to the right of the notch, continues counter-clockwise around the circular feature, and ends to the left of it.<br>  <br>**Angle Start** is the starting angle, around the Z axis on the XY plane, for the circular path along which calipers are placed. Setting this to 0 aligns the start angle with the positive direction of the X axis.<br>**Angle Span** is the length of the circular path along which calipers are placed. |
| Path Spacing | Sets the spacing between paths in the calipers used to extract the profiles that determine the edge. A higher number of paths results in a higher number of edge points, which makes the fitting of the edge line more accurate. However, a higher number of edge points results in a greater tool execution time.<br>When **Path Spacing** is set to 0, the resolution of the scan data is used as the basis for spacing. |

| Parameter | Description |
|---|---|
| Path Width | The size of the windows perpendicular to the path used to calculate an average for each data point on a path profile. Useful to average out noise along the path caused by reflections, and so on.<br>  <br><br>If **Path Width** is set to 0, no averaging is performed (only the data point under the path is used).<br>For averaging along the path, use **Step Smoothing** (see below). |
| Absolute Threshold | When **Use Intensity** is disabled, the setting specifies the minimum *height* difference between points on a path profile for that step to be considered for an edge point.<br>The setting can be used to exclude smaller steps on a part that should not be considered for an edge, or to exclude height differences caused by noise. When used in conjunction with **Relative Threshold**, **Absolute Threshold** is typically set to a small value, greater than the general surface roughness.<br>  <br><br>When **Use Intensity** is enabled, the setting specifies the minimum difference in intensity. (**Acquire Intensity** must enabled in the **Scan Mode** panel.) |
| Use Relative Threshold | When this option is enabled, the **Relative Threshold** field is displayed. |

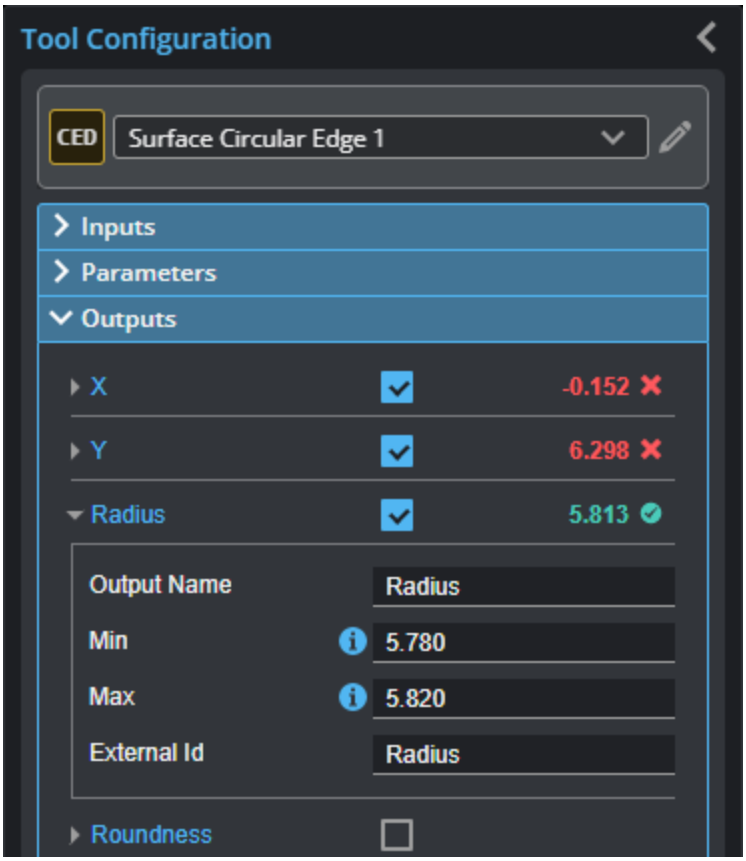
| Parameter | Description |
| --- | --- |
| Relative Threshold | The value for the relative threshold.<br>The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in **Relative Threshold**. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height.<br>For a height or intensity difference to be considered a valid step, both **Absolute Threshold** and **Relative Threshold** must pass. |
| Step Smoothing | The size of the windows along the path used to calculate an average for each data point on a path profile. The setting is useful for averaging out noise.<br>If **Step Smoothing** is set to 0, no averaging is performed (only the data point under the path is used).<br>For averaging perpendicular to the path, use **Path Width** (see above). |
| Step Width | The distance, along a path profile, separating the points used to find steps on a path profile.<br>  <br>The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting **Step Width** to a value greater than the width of the edge ensures that the tool measures the height difference between the flat regions on either side of the edge. As a result, the height of the step is accurately measured, and the edge is correctly located.<br>Setting **Step Width** wider than necessary can reduce the precision of edge location. |

| Parameter | Description |
|---|---|
| Max Gap | Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When **Max Gap** is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in **Max Gap**.<br>  <br> |
| Include Null Edges | Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in **Null Fill Value** as a general "background level." If **Use Intensity** (see above) is enabled, the intensity value in **Intensity Null Fill Value** is also used.<br>A typical example is a discrete part produced by the part detection of an object sitting on a flat background (for more information on part detection, see *Profile Part Detection* on page 283). The background is not visible in the part, so the tool assumes that any null region are at the background level.<br>To find edges along a region of null points, you must use either this option and an appropriate value in **Null Fill Value** (and **Intensity Null Fill Value** if **Use Intensity** is enabled) or **Max Gap**. Otherwise, only edges within areas of contiguous data will be detected. |
| Null Fill Value | The height value (in mm) used to replace null points not filled by **Max Gap** when **Include Null Edges** is enabled. |
| Intensity Null Fill Value | The intensity value (0-255) used to replace null points when **Include Null Edges** and **Use Intensity** are enabled. |

| Parameter | Description |
| --- | --- |
| Mask Regions | Lets you enable up to five regions that you can use to mask data you want the tool to ignore.<br>You can resize and reposition the mask regions using the mouse in the data viewer, or by configuring values manually in the **Mask Region** sections the tool displays in the tool settings for each region. You can only set the rotation of the mask regions manually by modifying the region's **Z angle** parameter.<br>By default, when you add multiple mask regions, they are initially placed in the same position, one on top of the other. |
| Reference Plane | Uses the output of a Surface Plane tool as a reference plane. Useful to correct the scan data if the target is slightly tilted.<br>When **Show Advanced Parameters** is unchecked and **Reference Plane** is set to a plane, the plane is *ignored*. |
| Fit Type | The method the tool uses to calculate the roundness of the feature. One of the following:<br>**Least Square Circle (LSC)**<br>**Minimum Zone Circle (MZC)**: If you choose this method, set the circle the tool uses with the **Which Circle** parameter.<br>**Maximum Inscribed Circle (MIC)**: Typically used to measure the inner edge of a circular feature, such as a hole.<br>**Minimum Circumscribed Circle (MCC)**: Typically used to measure the outer edge of a circular feature. |
| Which Circle | Tells the tool which circle (Inner or Outer) to use when Minimum Zone Circle is the fit method in **Fit Type**. |

**Outputs**

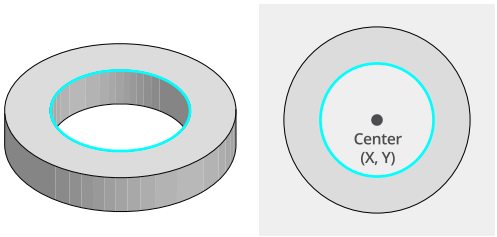
Most tools provide measurements, geometric features, or data as outputs.

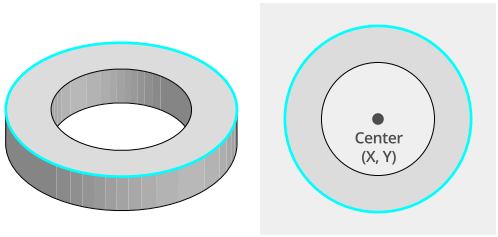
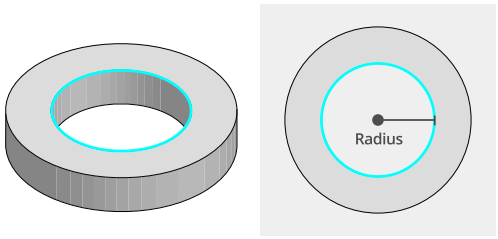
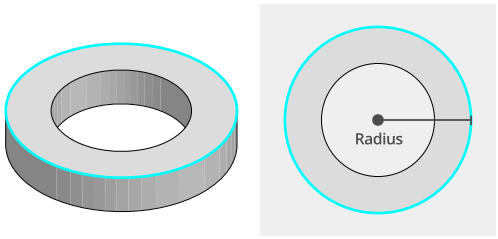
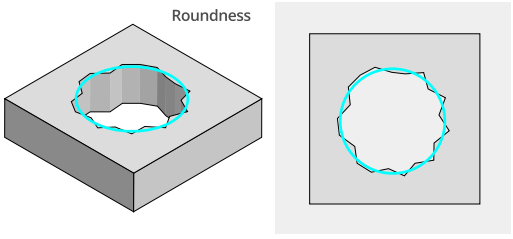
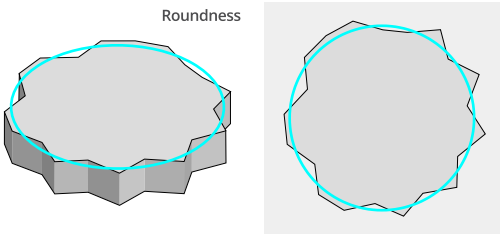



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>**Y**<br>Returns the X and Y position of the center of the fitted circle, respectively. |  |

| Measurement | Illustration |
| --- | --- |
| |  |
| **Radius**<br>Returns the radius of the fitted circle. |  |
| |  |
| **Roundness**<br>Returns the roundness or circularity of the edge points with respect to the reference circle of the selected roundness error method set in **Fit Type**. |  |
| |  |
| **Min Error**<br>**Max Error**<br>These measurements return information on the points | |

| Measurement | Illustration |
| --- | --- |
| furthest inside and outside the fitted circle, respectively. | |

*Features*

| Type | Description |
| --- | --- |
| Center Point | The center of the fitted circle. |
| Circle | The fitted circle. |
| Min Error Point | The point of minimum error which is furthest inside of the circle. |
| Max Error Point | The point of maximum error which is furthest outside of the circle. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Countersunk Hole

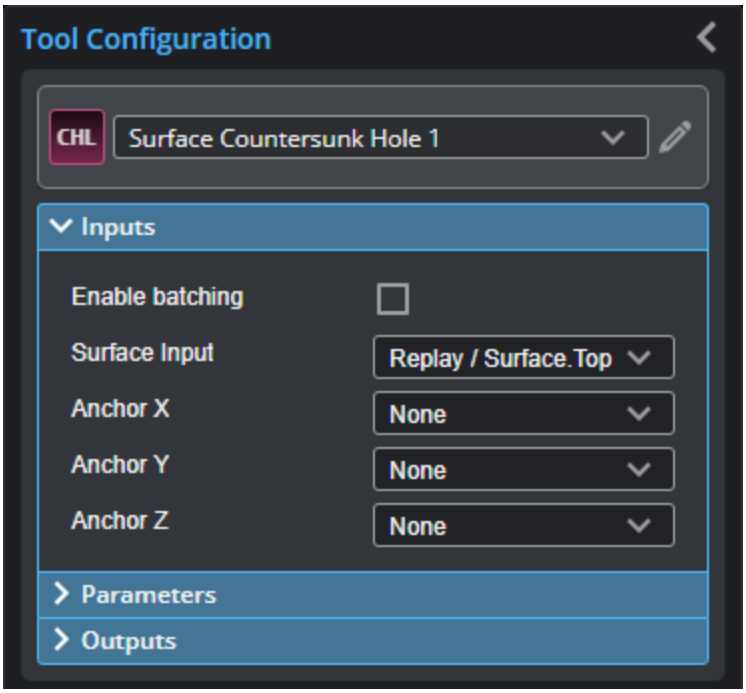
The Countersunk Hole tool locates a countersunk circular opening within a region of interest on the surface and provides measurements to evaluate characteristics of countersunk holes, including the position (X, Y, and Z) of the center of the hole, outside radius of the hole, hole bevel angle, and the depth of the hole. The countersunk hole can be on a surface at an angle to the sensor. The tool also supports measuring holes drilled at an angle relative to the surrounding surface.

> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

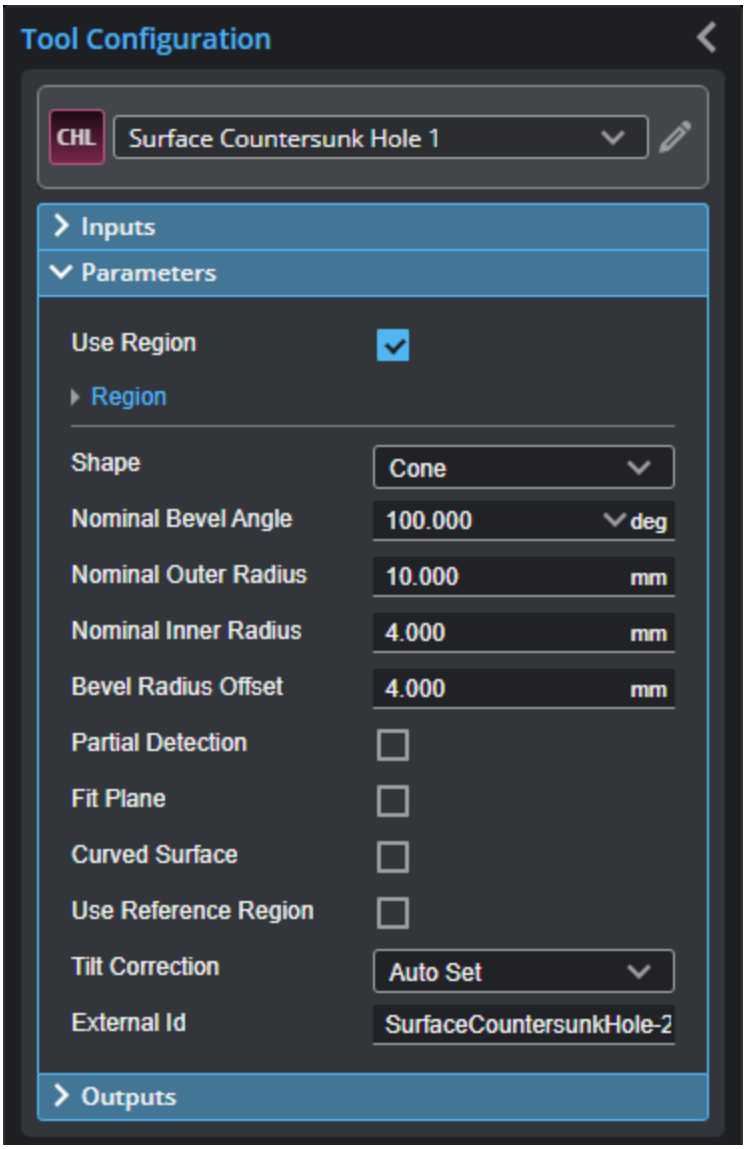
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor. |

| Name | Description |
| --- | --- |
| | For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

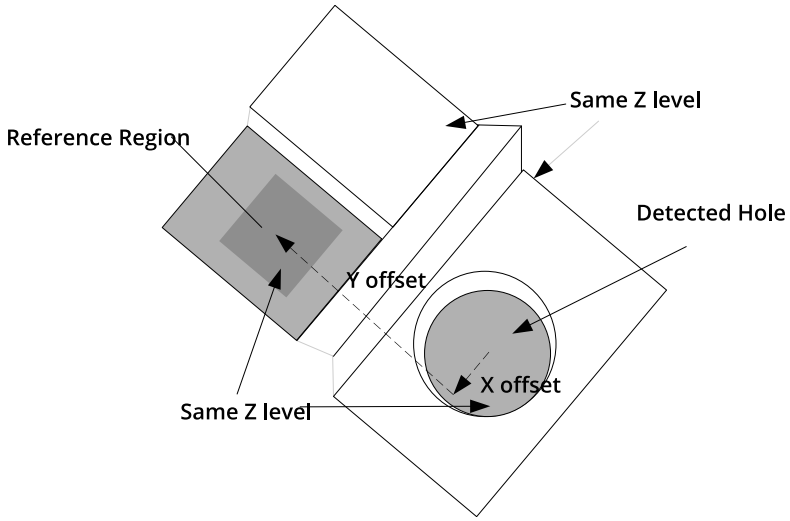
**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



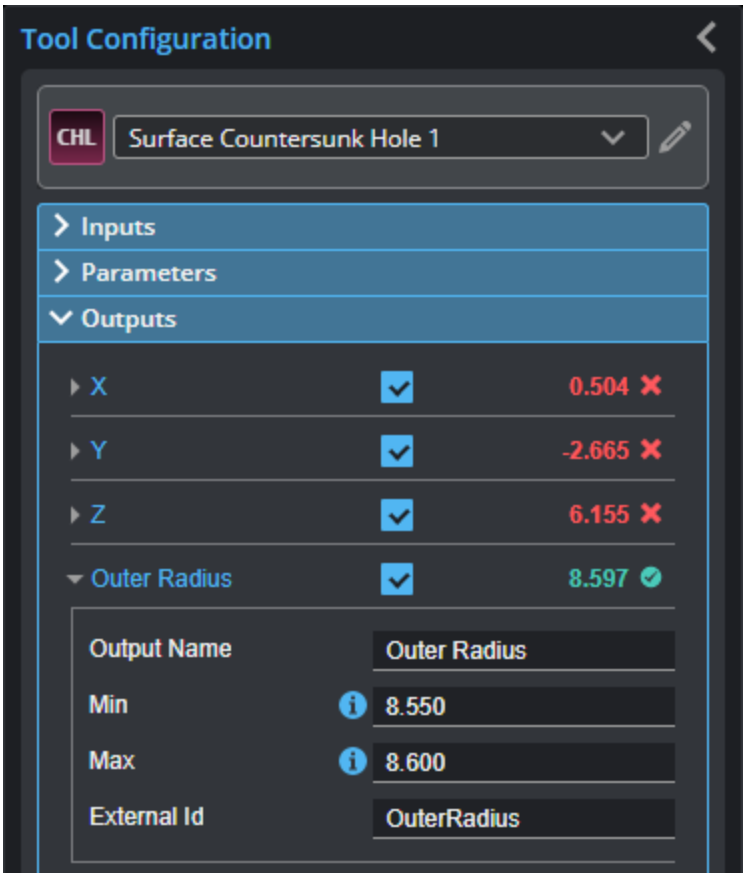
*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Shape | The shape of the countersunk hole. (See illustrations below.)<br>0 – Cone<br>1 – Counterbore |
| Nominal Bevel Angle | The expected bevel angle of the countersunk hole. |
| Nominal Outer Radius | The expected outer radius of the countersunk hole. |
| Nominal Inner Radius | The expected inner radius of the countersunk hole. |
| Bevel Radius Offset | The offset, relative to the surface that the countersunk hole is on, at which the bevel radius will be measured. |
| Partial Detection | Enable if only part of the hole is within the measurement region. If disabled, the hole must be completely in the region of interest for results to be valid. |
| Fit Plane | When enabled, excludes data beyond the distance from the plane surrounding the hole, using the value you provide in the **Plane Fit Range** parameter. You can use this setting to exclude surfaces close to the countersunk hole that step down from the plane surrounding the hole that could make measurement of the hole less reliable. |
| Plane Fit Range | The distance from the plane surrounding the hole beyond which data is excluded. |
| Curved Surface | Whether the surface that the countersunk hole is on is curved. |
| Curve Orientation | The orientation of the curvature in degrees. Only visible when **Curved Surface** is enabled. |
| Use Reference Region | When enabled, displays settings you use to configure reference regions. |
| Reference Type | The tool uses the reference regions to calculate the Z position of the hole. It is typically used in cases where the surface around the hole is not flat. |

| Parameter | Description |
|---|---|
| |  <br>When this option is set to **Autoset**, the algorithm automatically determines the reference region.<br>You can also set this option to one or two regions, which you manually set. Note that the location of manual reference regions is relative to the detected center of the hole and positioned on the nominal surface plane.<br>When **Reference Region** is disabled, the tool measures the hole's Z position using all the data in the measurement region, except for a bounding rectangular region around the hole. |
| Tilt Correction | Tilt of the target with respect to the alignment plane.<br>**Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes.<br>**Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below). |
| X Angle<br>Y Angle | The X and Y angles you must specify when **Tilt Correction** is set to **Custom**.<br>You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the **X Angle** and **Y Angle** parameters of this tool. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

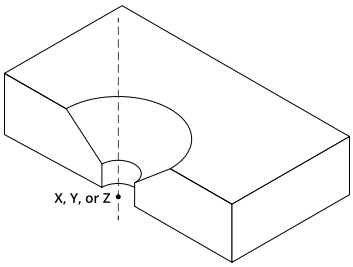
Most tools provide measurements, geometric features, or data as outputs.

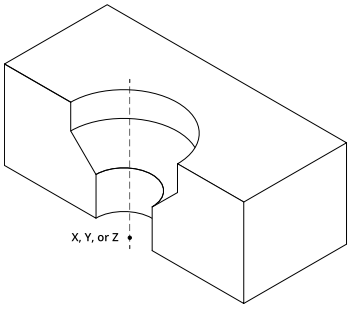
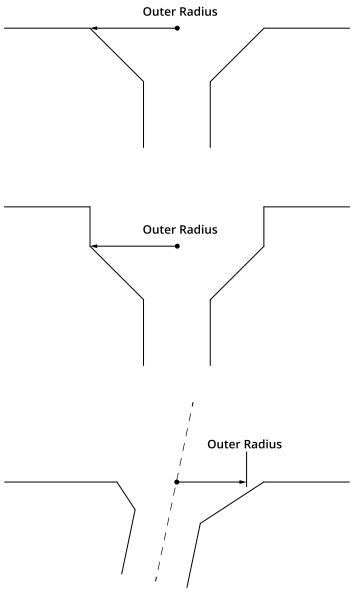
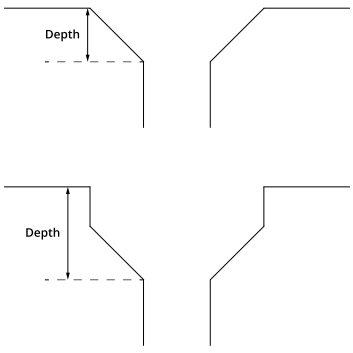
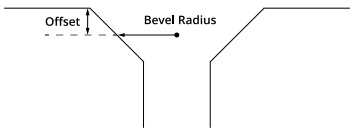


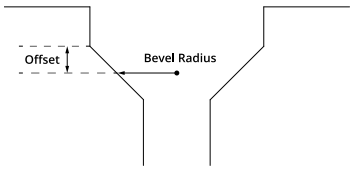
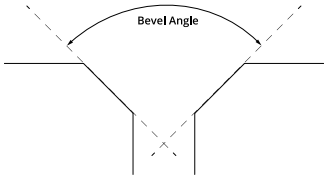
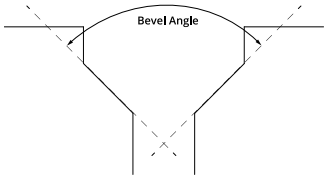
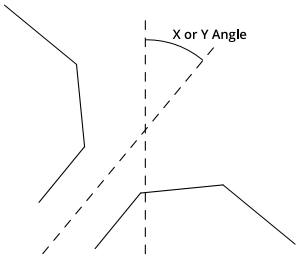
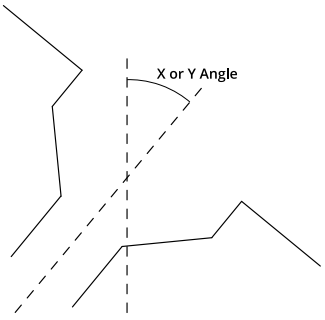

*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

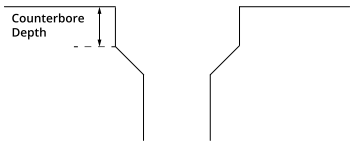
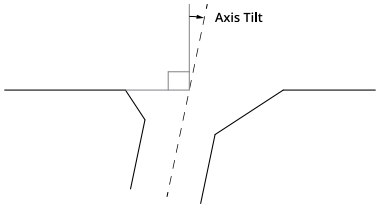
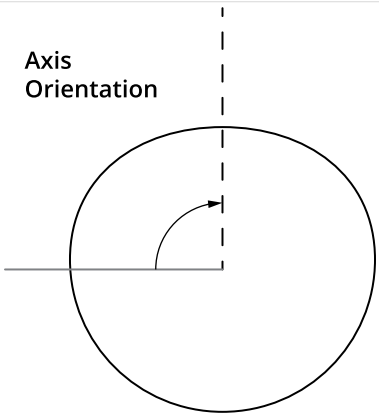
You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the center of the countersunk hole. |  |

| Measurement | Illustration |
| --- | --- |
| **Y**<br>Determines the Y position of the center of the countersunk hole.<br>**Z**<br>Determines the Z position of the center of the countersunk hole. |  |
| **Outer Radius**<br>Determines the outer radius of the countersunk hole.<br>When a hole is cut at an angle relative to the surrounding surface, the outer radius is calculated as if the hole were not cut at an angle.<br>To convert the radius to a diameter, use an instance of the Measurement Formula too with the Formula field set to M1*2, for example. For more information, see *Measurement Formula Tool* on page 700. |  |
| **Depth**<br>Determines the depth of the countersunk hole relative to the surface that the countersunk hole is on. |  |
| **Bevel Radius**<br>Determines the radius at a user-defined offset (**Bevel Radius Offset** setting) relative to the surface that the countersunk hole is on. |  |

| Measurement | Illustration |
| --- | --- |
| To convert the radius to a diameter, use an instance of the Measurement Formula too with the Formula field set to M1*2, for example. For more information, see *Measurement Formula Tool* on page 700. |  |
| **Bevel Angle**<br>Determines the angle of the hole's bevel. |  <br>*Cone*<br>  <br>*Counterbore* |
| **X Angle**<br>Determines the angle the hole relative to the X axis. |  <br>*Cone* |
| **Y Angle**<br>Determines the angle of the hole relative to the Y axis. |  <br>*Counterbore* |

| Measurement | Illustration |
|---|---|
| **Counterbore Depth**<br>Determines the depth of a counterbore. |  |
| **Axis Tilt**<br>Measures the tilt of the axis of the hole relative to the surface surrounding the hole.<br>This measurement is not supported when **Shape** is set to **Counterbore**. |  |
| **Axis Orientation**<br>Measures the angle of the axis of the hole around the normal of the surface surrounding the hole, relative to the X axis.<br>This measurement is not supported when **Shape** is set to **Counterbore**. |  |

*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the countersunk hole. The Z position of the center point is at the Z position of the surrounding surface. |

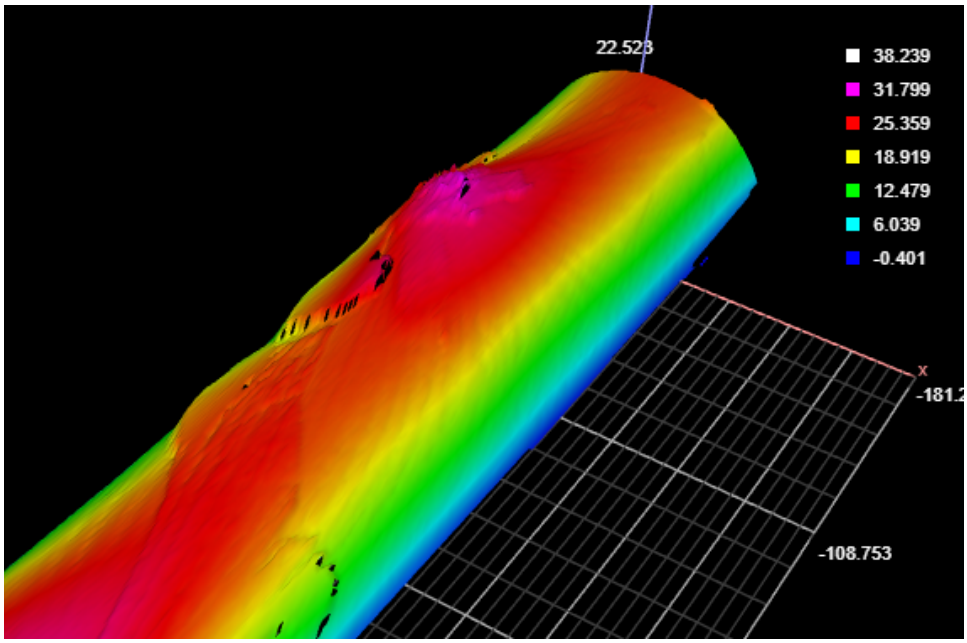
For more information on geometric features, see *Geometric Features* on page 191.

## Surface Curvature Correction

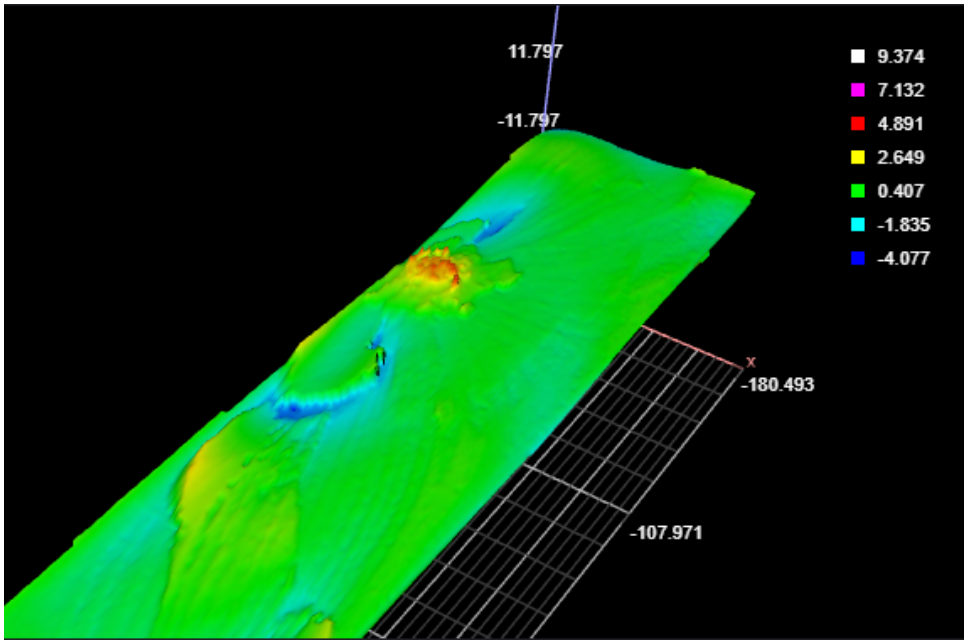
The Surface Curvature Correction tool removes curvature from curved surfaces while preserving surface features or defects, using a configurable polynomial order (the tool performs a 2D polynomial fit on X and Y to process surfaces). You can then use the tool's output as input to other measurement tools to apply measurements to the "flattened" surface.

The tool does not support rotational scans (that is, polar "unwrapping").

In the following images, a curved surface (top) is flattened out (bottom), preserving the surface detail.

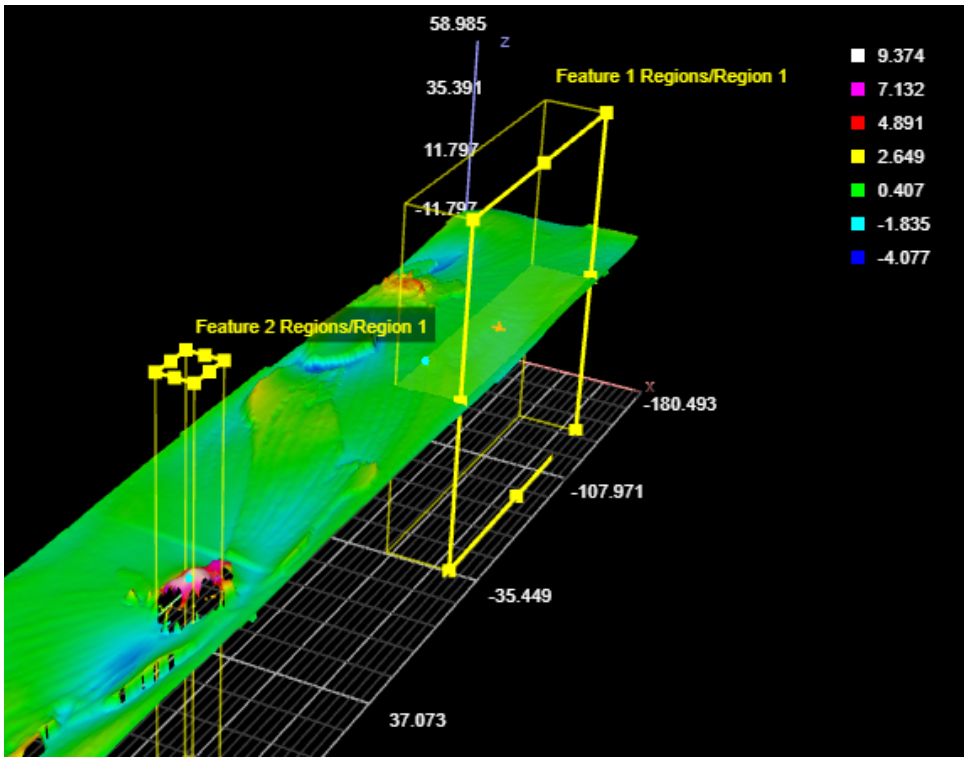



*The original, curved scan of a target.*




*The "flattened" surface data (the tool's Difference Surface data output).*

In the following image, a Surface Dimension tool's height measurement runs on the "flattened" output (the Surface Curvature tool's Difference Surface output) to determine the height of one of the raised areas:

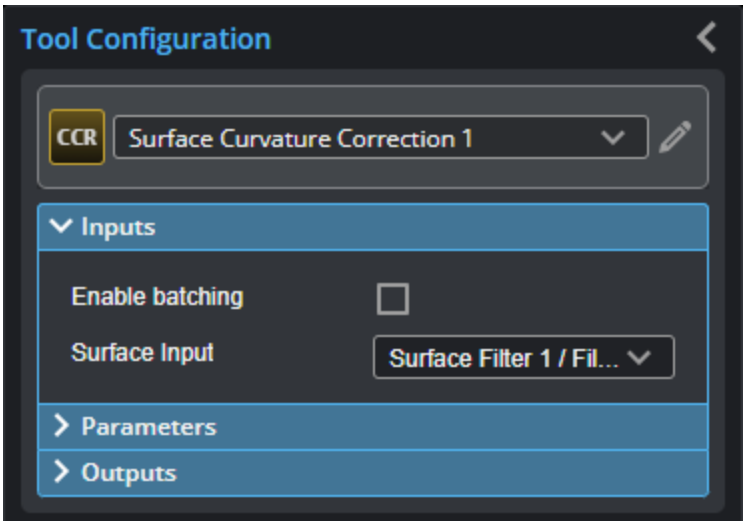



*Height of a raised feature relative to the flattened surface.*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

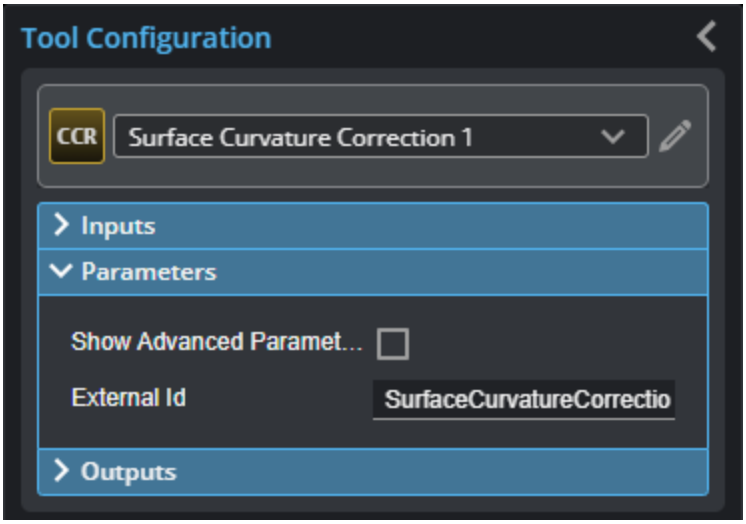


*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

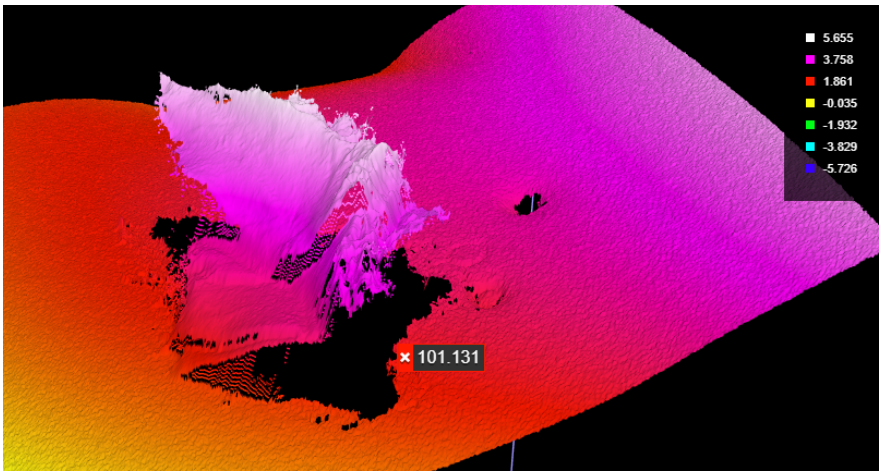
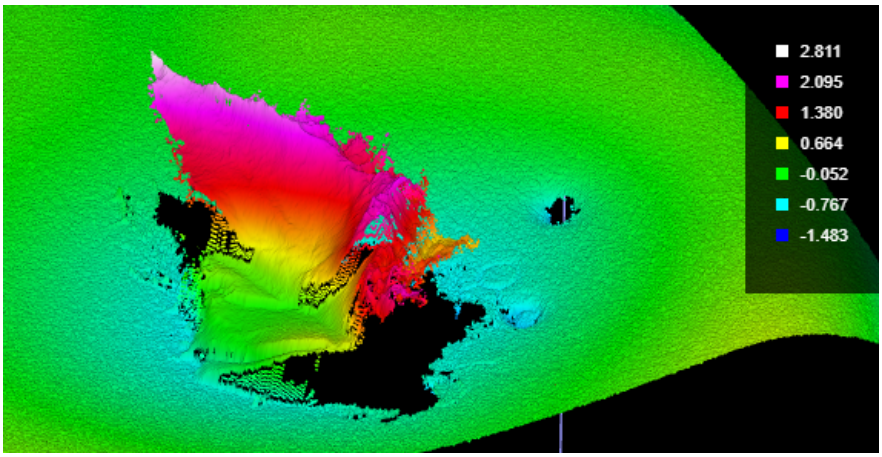


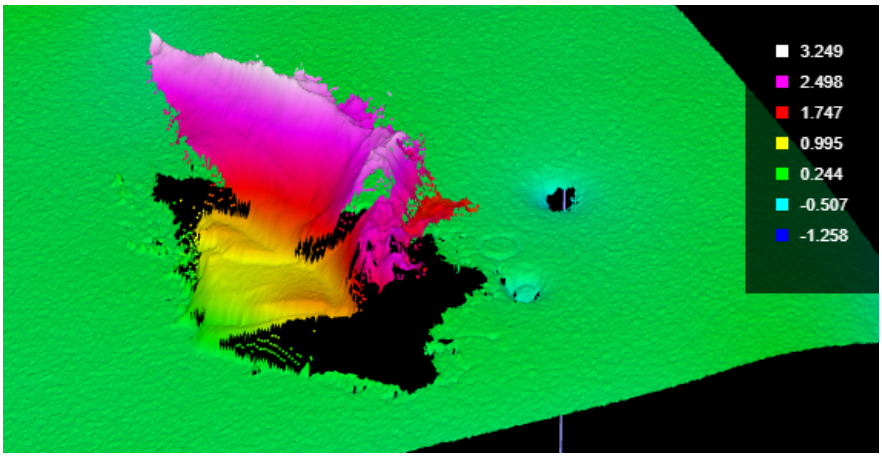

*Parameters*

| Parameter | Description |
|---|---|
| Show Advanced Parameters | Enables a set of advanced parameters. (See *Advanced Parameters* below.) |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

*Advanced Parameters*

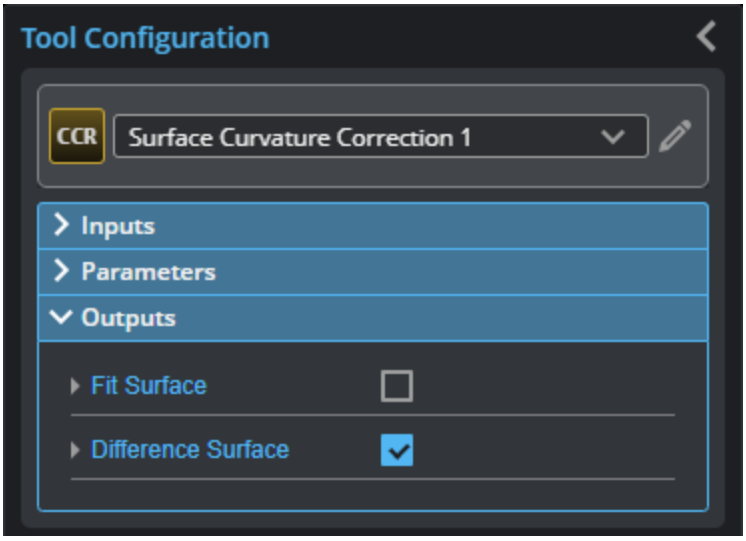
| Parameter | Description |
|---|---|
| Number of Regions | Lets you specify and configure one or more regions the tool will process. Use this parameter to limit the tool to specific areas on the target. |
| Exclude Features | Lets you exclude features or surface details from the polynomial fit. This can allow you to get a better fit on the surrounding surface.<br>Checking this option enables the **Negative area**, **Positive area**, and **Iterative Steps** parameters. (See below.)<br>For example, in the following scan data, we would like to accurately measure the |

| Parameter | Description |
| --- | --- |
| | circular divots and the small hole near the center of the data on the curved surface.<br>  <br>If the large feature to the left is *not* excluded for the polynomial fit, the measurements on the smaller features will be inaccurate. In the following "flattened" scan data, without excluding the larger feature, the smaller features would be difficult to accurately measure:<br>  <br>When the larger feature is excluded from the polynomial fitting, the surrounding surface and the smaller features are more properly "flattened." |

| Parameter | Description |
|---|---|
| |  |
| Polynomial Order | Selects the order (or degree) of the polynomial to be fit to the surface. A higher order results in a better fit but increases processing time. |
| Sampling Step | The step in data points in both directions with which the surface is sampled. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points. |
| Iterative Steps | The number of times the tool repeats the feature exclusion calculation (see **Exclude Features**, above). |
| Negative area<br>Positive area | These settings exclude the specified percentage of a histogram of the height values of the scan data from the bottom up (**Negative area**) and from the top down (**Positive area**), respectively. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.

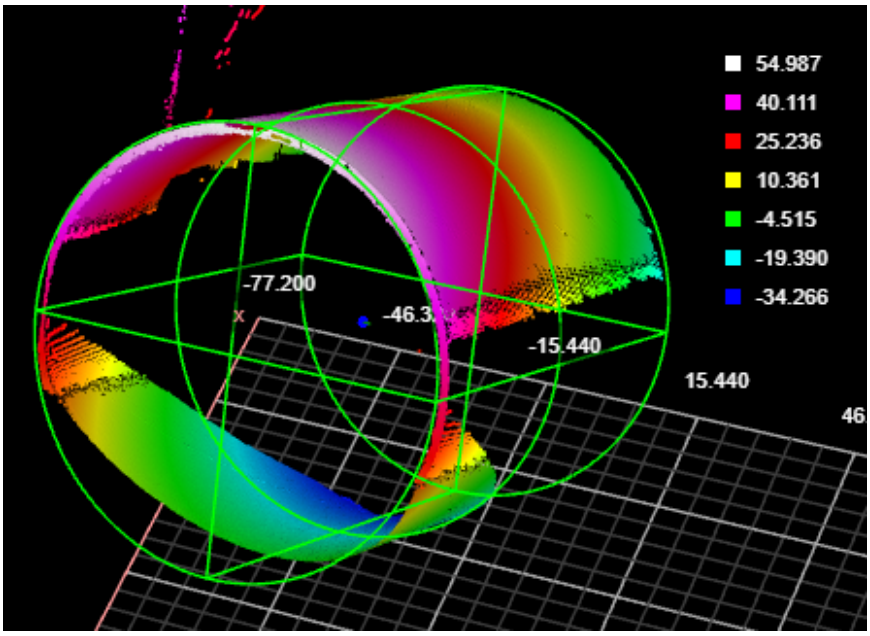


*Data*

| Type | Description |
|---|---|
| Fit Surface | The fitted polynomial the tool uses to flatten the original surface. Use this as a diagnostic to better fit the polynomial. |
| Difference Surface | The “flattened” surface: this is the original surface with the fitted polynomial removed. |

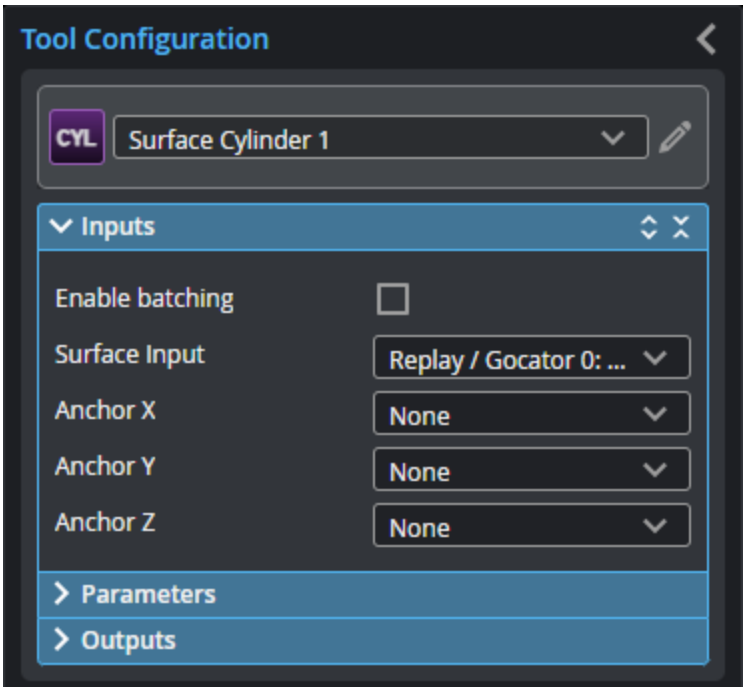
## Surface Cylinder

The Surface Cylinder fits a cylinder to scan data and returns measurements and geometric features related to the fitted cylinder. Unlike the Surface Stud tool, the Surface Cylinder tool does not rely on a flat surface perpendicular to the cylindrical object. Examples uses of the tool include fitting to the outside of a cylinder and fitting inside a drilled hole.




### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

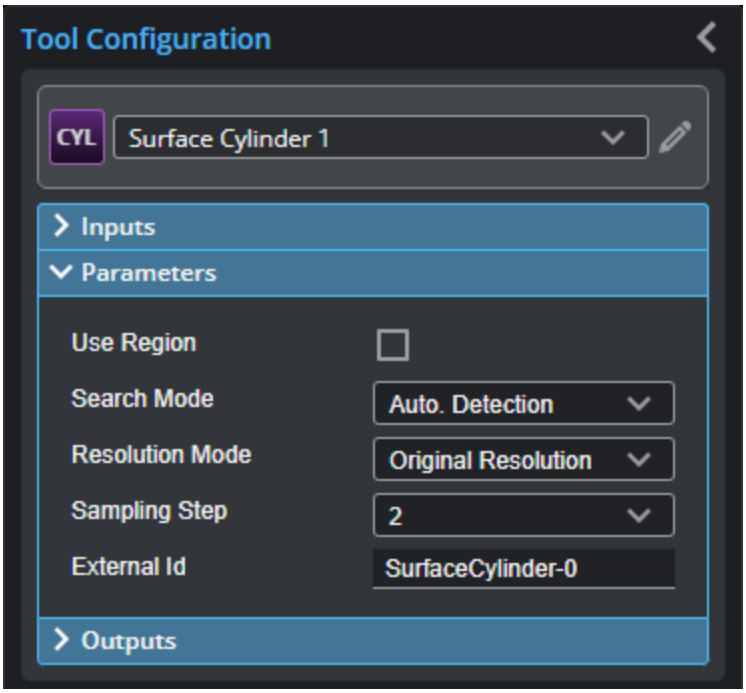


*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

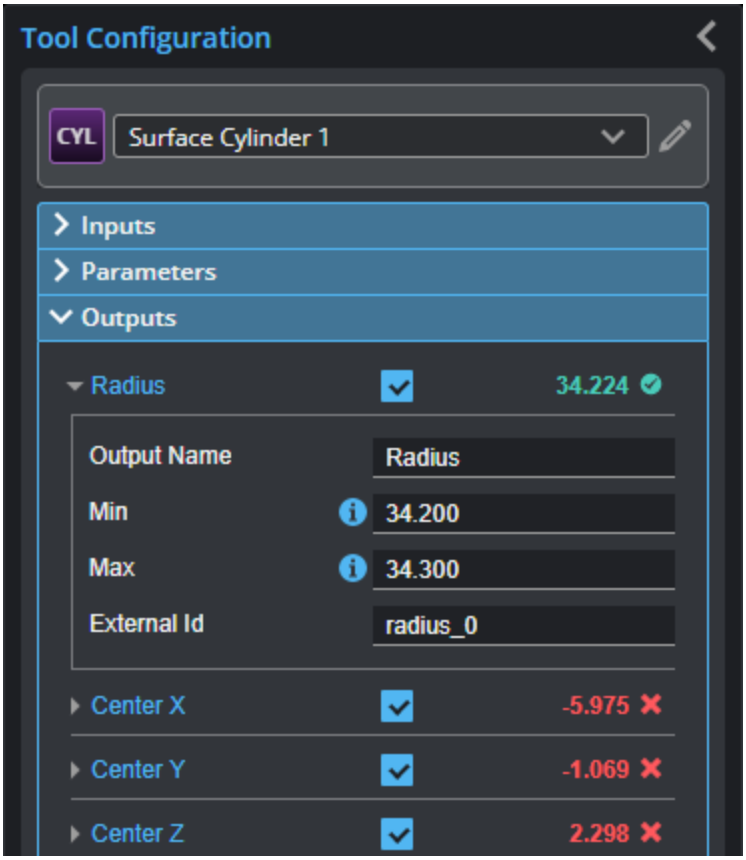



*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Search Mode | Indicates the expected orientation of the cylindrical target's axis around the Z axis.<br>One of the following:<br>**Auto Detection** – The cylindrical target can be in any orientation. |

| Parameter | Description |
|---|---|
| | **Axis in X Direction** or **Axis in Y Direction** – The cylindrical target's axis is expected to be roughly parallel to the X or the Y axis, respectively. Variation typically must be less than +/- 3 or 4 degrees.<br>**Advanced Detection** – As with Auto. Detection, the cylindrical target can be in any orientation. This mode can handle some complex scenarios, such as when trying to fit a cylinder to the inside of a hole. Processing time is greater with this search mode. |
| Resolution Mode | On G3 sensors, leave this set to the default **Original Resolution**.<br>Determines whether the tool scales the X or Y resolution so that they are the same (a 1:1 ratio), or leaves the X and Y resolutions as the original. One of the following.<br>• **Optimal (uniform)**<br>Brings the X/Y resolution ratio to 1:1 while preserving the pixel area. Best for random rotation around Z. Provides a balance between the highest and lowest possible resolutions, requiring an average amount of memory and processing time compared to the **High Oriented (uniform)** or **Low Oriented (uniform)** options.<br>• **High Oriented (uniform)**<br>Interpolates the lower resolution to match the higher resolution (between X and Y) in the input. Choose this option when increased resolution is preferred over speed and low memory usage. (This can result in a very high resolution output, creating a lot of data for subsequent tools to process. This can in turn result in slower processing.)<br>• **Low Oriented (uniform)**<br>Decimates the higher resolution to match the lower resolution (between X and Y) in the input. Choose this option when speed and low memory usage is preferred over resolution. (It can result in significant data quality reduction with large Z rotations if the X and Y resolutions of the input are very different.)<br>• **Original Resolution**<br>Keeps the original X and Y resolution of the scan. Use this option only when you expect little or no Z rotation. Otherwise, with X/Y resolution ratios that are not 1:1, large rotation around Z results in severe data quality reduction. |
| Sampling Step | The step in data points in both directions with which the surface is sampled. Choosing a higher sampling step reduces the processing time the tool requires, but reduces fit accuracy. Useful if the surface being processed has a large number of data points. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
| --- |
| **Radius**<br>Returns the radius of the fitted cylinder. |
| **Center X**<br>**Center Y**<br>**Center Z**<br>The X, Y, and Z position of the center of a circle place in the middle of the fitted cylinder |
| **Tilt Angle**<br>The angle of the cylinder relative to the XY plane. A cylinder parallel to the XY plane has an angle of 90 degrees. |
| **Direction Angle**<br>The angle of the cylinder's axis around the Z axis. An angle of 0 degrees is parallel to the X axis. |
| **Normal X** |

| Measurement |
|---|
| **Normal Y** |
| **Normal Z** |

These measurements return the X, Y, and Z components of the direction vector of the cylindrical target.

*Features*

| Type | Description |
|---|---|
| Point | A point representing the center of a circle at the midpoint of the fitted cylinder |
| Line | A line representing the axis of the fitted cylinder. |

For more information on geometric features, see *Geometric Features* on page 191.

*Data*

| Type | Description |
|---|---|
| Fit Surface | The Surface data the tool uses to fit the cylinder (for example, excluding data outside the defined region). Use this output, for example, to confirm that the tool is using the correct part of the target to fit the cylinder. |
| Difference Surface | Deviations in the Surface from the fitted cylinder. Use this output, for example, to evaluate if blemishes or distortions in the Surface data are preventing the tool from properly fitting the cylinder. |

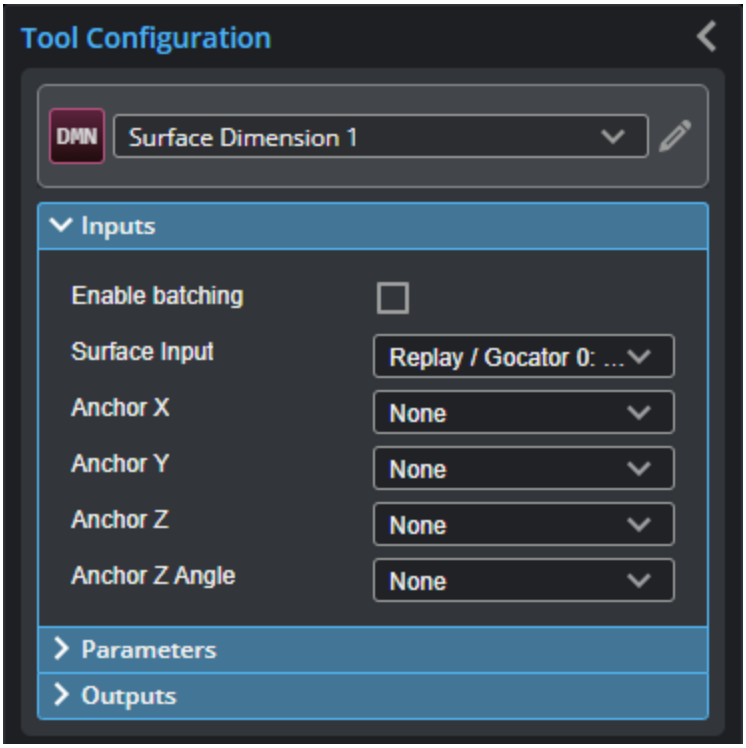
## Surface Dimension

The Dimension tool returns various dimensional measurements of a part. You must specify two feature types (see below).

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

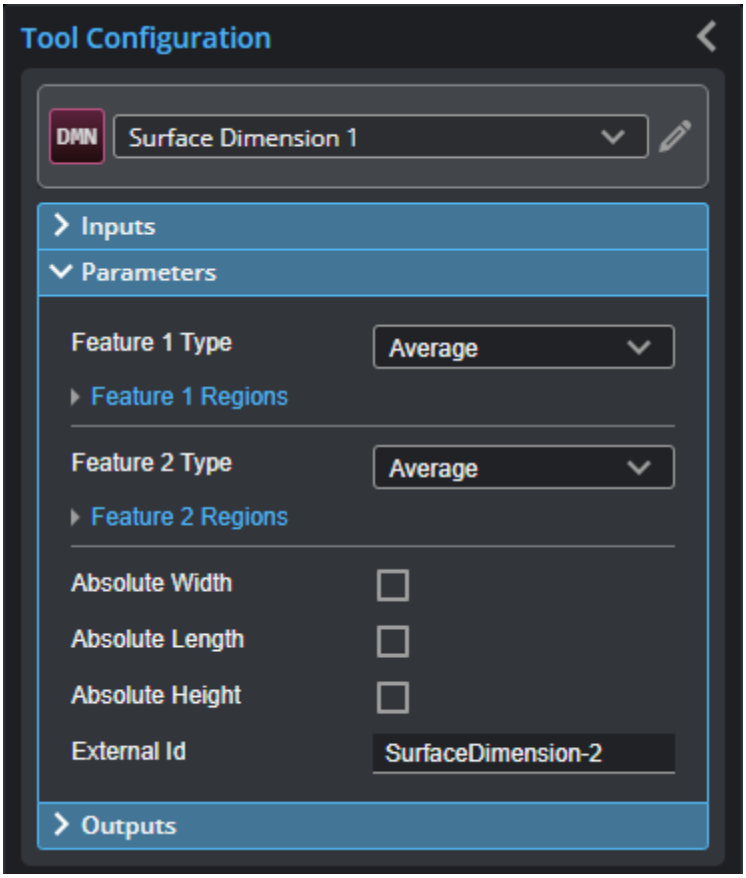
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

| Name | Description |
|---|---|
| Anchor Z | |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



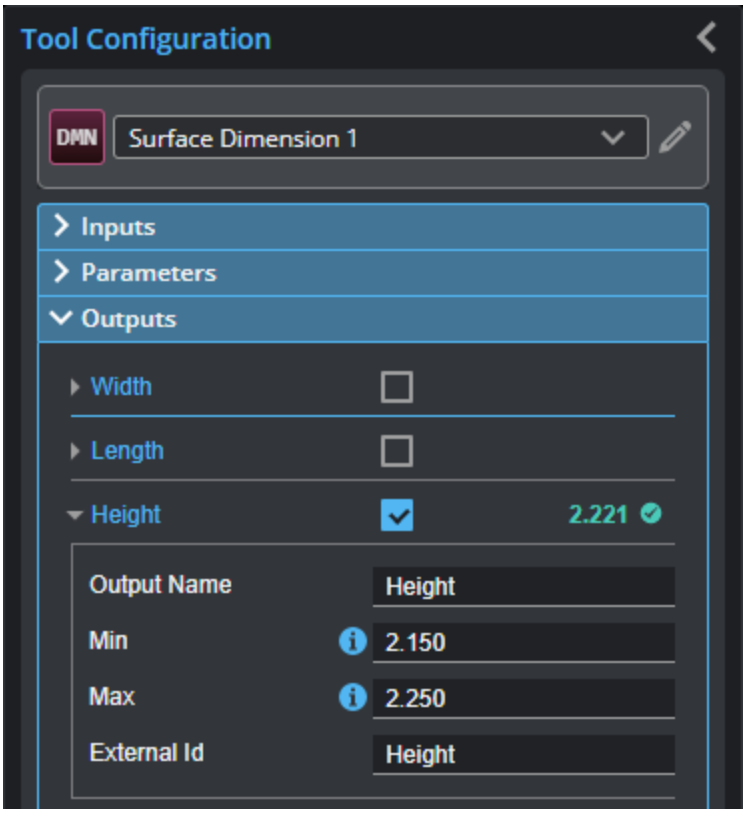

*Parameters*

| Parameter | Description |
|---|---|
| Feature 1 Type<br>Feature 2 Type | The feature point types the tool uses. For each, one of the following (for more information, see *Feature Points* on page 188):<br>• Average<br>• Median<br>• Centroid<br>• Max X<br>• Min X<br>• Max Y<br>• Min Y<br>• Max Z |

| Parameter | Description |
| --- | --- |
| | • Min Z<br>When more than one point is at minimum Y or maximum Y (and the feature is set to Min Y or Max Y, respectively), the rightmost point (the one at greater positive X) is selected by the tool.<br>When more than one point is at minimum X or maximum X (and the feature is set to Min X or Max X, respectively), the bottom point (the one at greater positive Y) is selected by the tool. |
| Feature 1 Regions<br>Feature 2 Regions | When these are expanded, they display the region- and mask-related settings associated with the two features the tool uses to perform measurements.<br>The feature parameters associated with these regions are **Feature 1** and **Feature 2**, respectively; for more information, see below. |
| Enable | When enabled, the region- and mask-related settings are displayed. |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Absolute Width<br>Absolute Length<br>Absolute Height | Enable these parameters to return an absolute value, regardless of the relative positions of the first and second regions of interest. (Dimensions are calculated by subtracting the position of the feature point in region 1 from that of the feature point in region 2.) |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

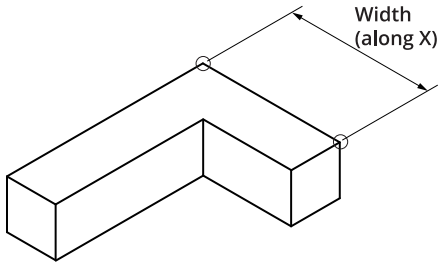
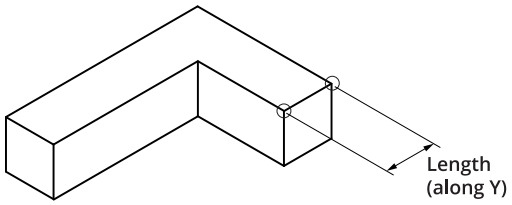
Most tools provide measurements, geometric features, or data as outputs.

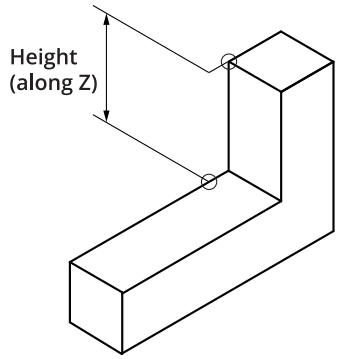
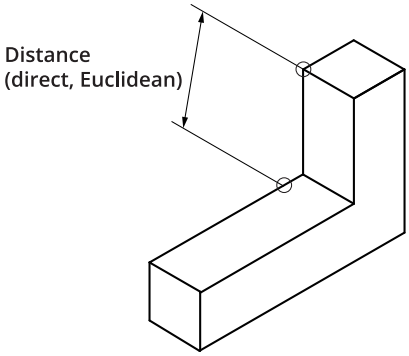
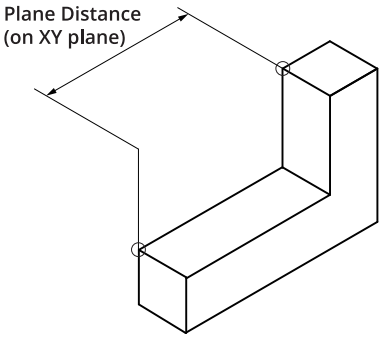
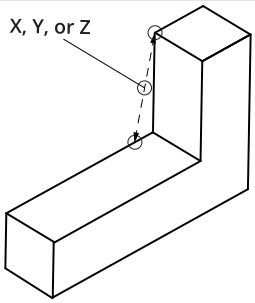



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

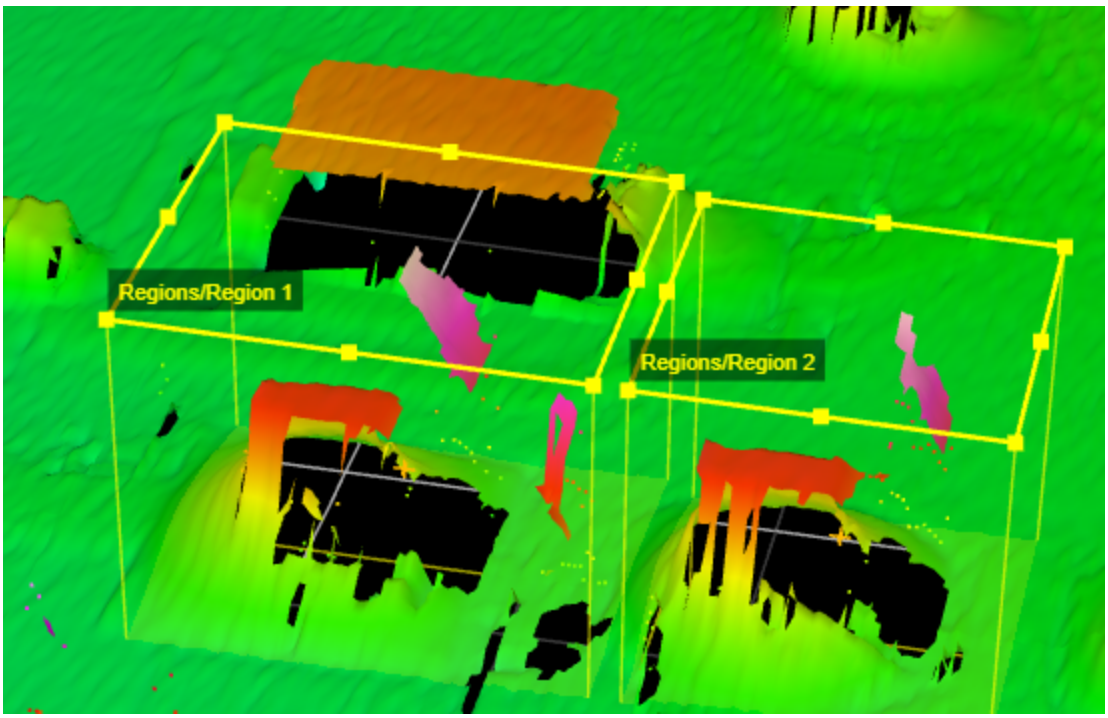
| Measurement | Illustration |
|---|---|
| **Width**<br>Determines the distance between the selected features along the X axis. |  |
| **Length**<br>Determines the distance between the selected features along the Y axis. |  |

| Measurement | Illustration |
|---|---|
| **Height**<br>Determines the distance between the selected features along the Z axis. |  |
| **Distance**<br>Determines the direct, Euclidean distance between the selected features. |  |
| **Plane Distance**<br>Determines the distance between the selected features. The position of the lowest feature point is projected onto the XY plane of the highest feature point. |  |
| **Center X**<br>**Center Y**<br>**Center Z**<br>These measurements determine the X, Y, or Z position, respectively, of the center point between the selected features. |  |

## Surface Direction Filter

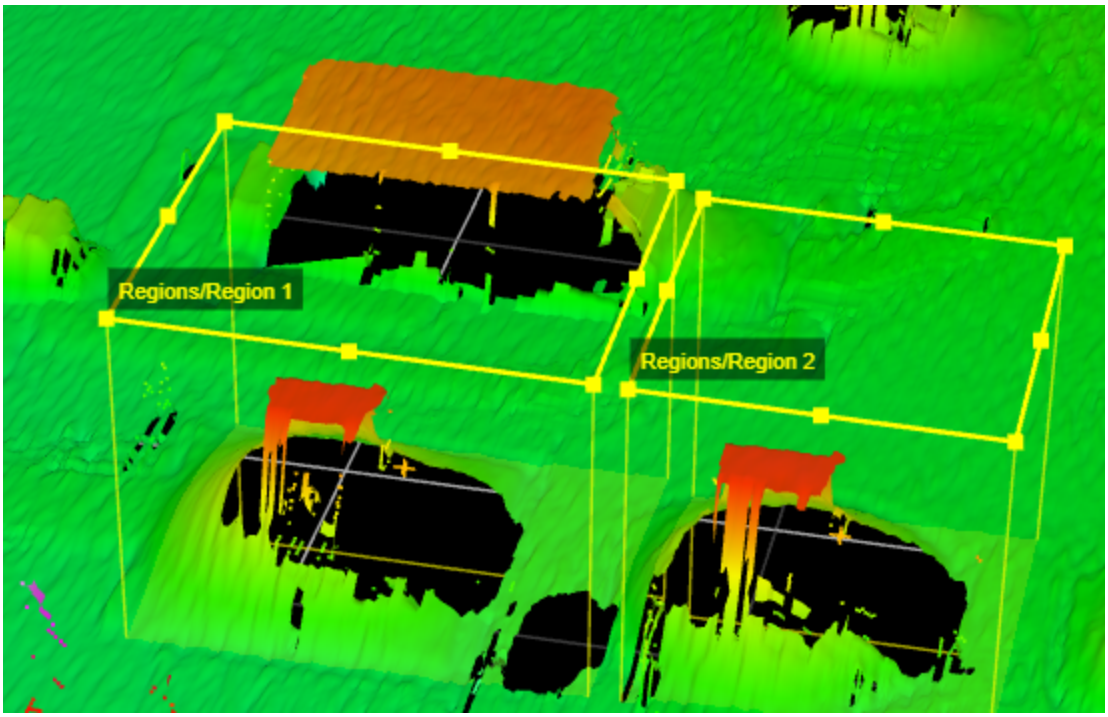
The Surface Direction Filter helps exclude unwanted data points based on their “orientation” (the polar angle relative to surrounding data points) in 3D space, for example, data points resulting from reflections. The tool can provide better results than median or height based filters. The tool lets you define up to 16 regions to which the filtering is applied.

For example, in the following scan data, noise appears to the right of two surface mount components on a PCB (pink areas). In this case, the "direction" of the noise is roughly 75 to 85 degrees, relative to Z.




*Surface before direction filtering.*

In the following scan data, the tool has removed the noise.



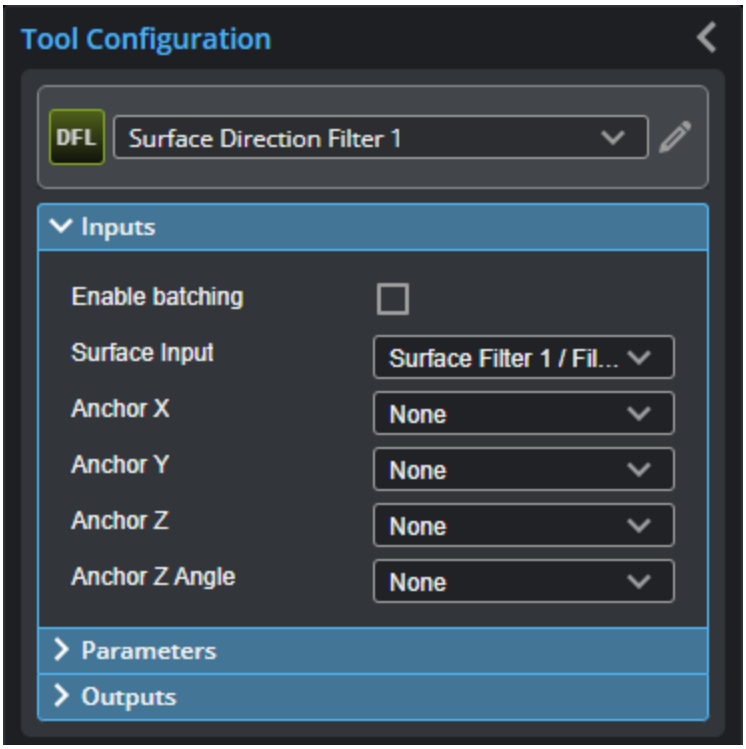

*Surface after direction filtering.*

Note that the tool's filtering parameters apply to all enabled regions. To apply different filtering parameters, you can add additional instances of the tool and chain them together, setting the input of subsequent instances to the output of the preceding instance.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

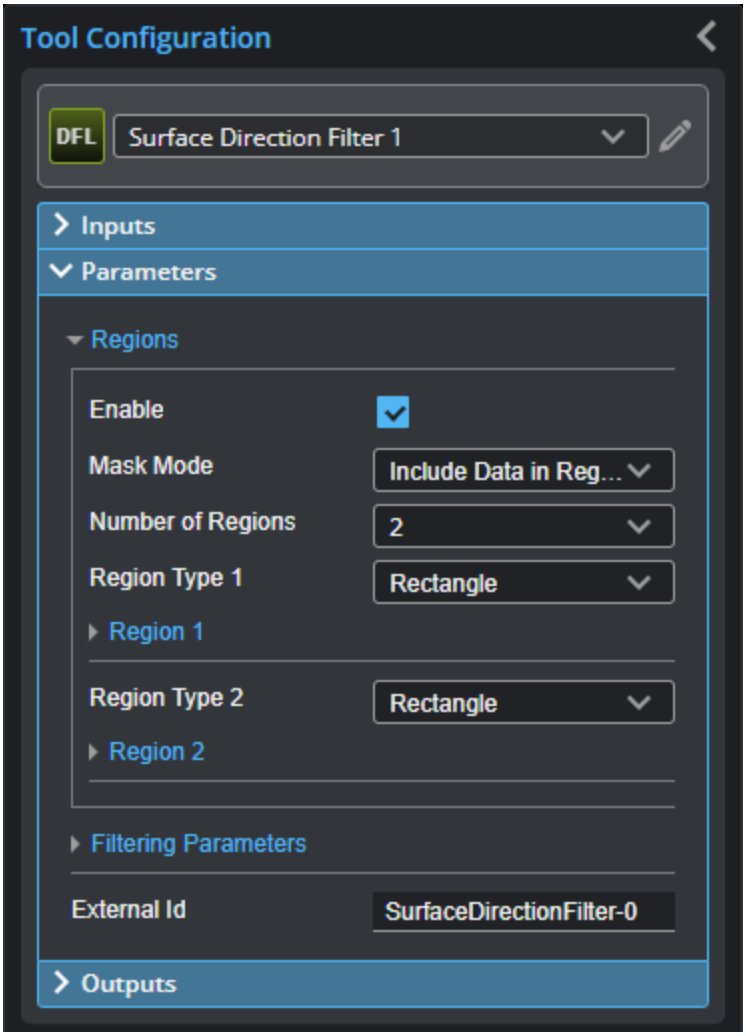
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

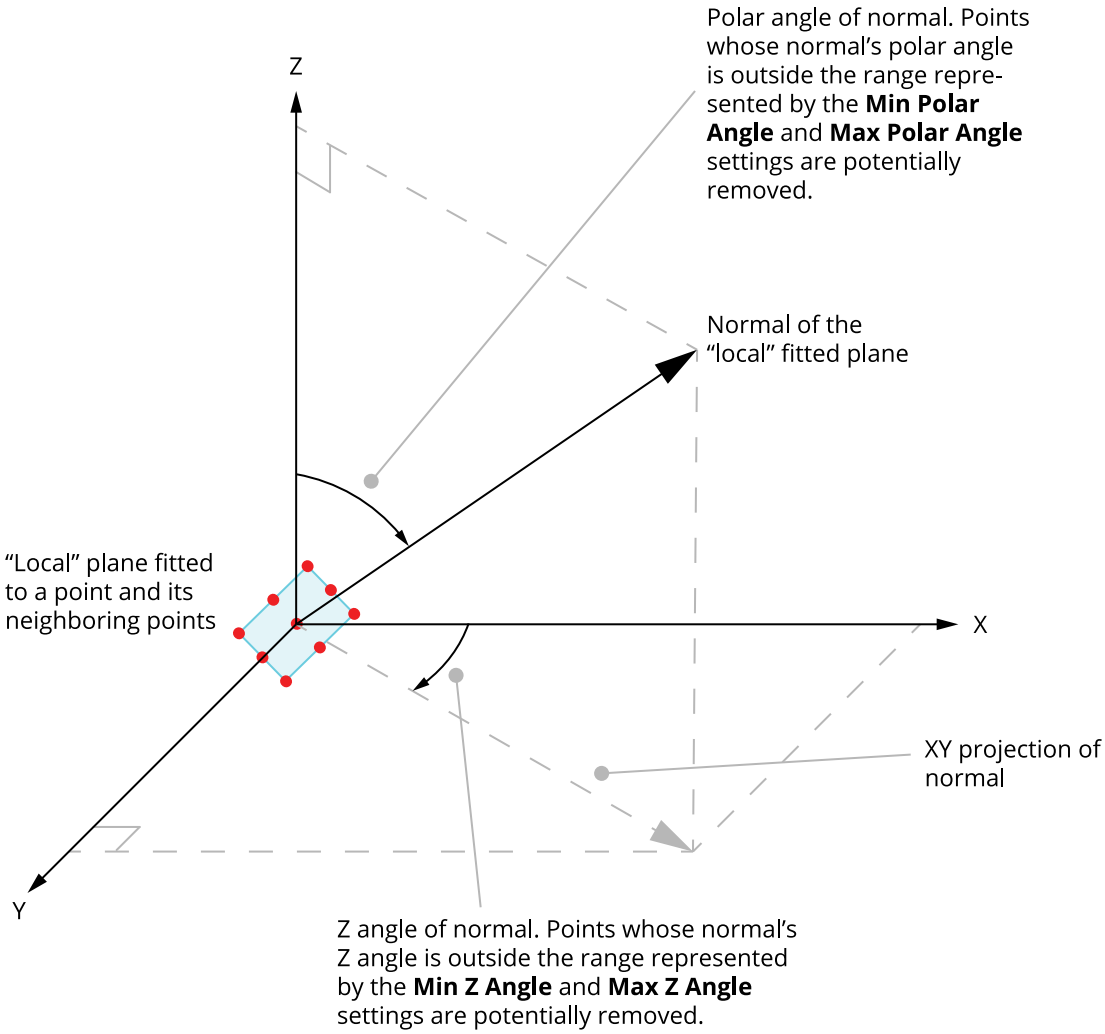
| Name | Description |
| --- | --- |
| Anchor Z | |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




The following illustrates the angle parameters that control which data points are excluded in scan data:




*The number of neighboring points shown above is for illustrative purposes only.*

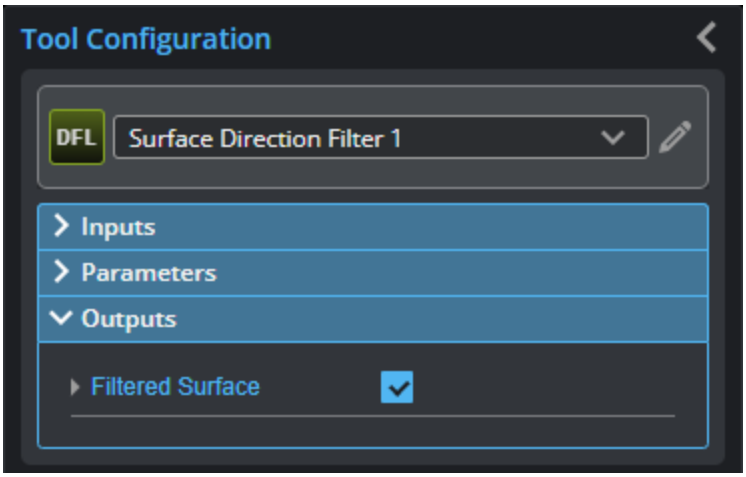
*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Filtering Parameters | When expanded, displays the filtering parameters the tool uses. |
| Min Z Angle<br>Max Z Angle | The minimum and maximum acceptable angles around the Z axis of the XY projection of the normal of the surface surrounding a data point, where 0 degrees is defined as positive X and positive rotation is clockwise around the Z axis. |
| Min Polar Angle | The minimum and maximum acceptable angles of the normal of the surface |

| Parameter | Description |
|---|---|
| Max Polar Angle | surrounding a data point with respect to the Z axis. |
| Smooth Size | A mean filter applied to the surface data before calculating the normals in order to avoid abrupt normal changes due to noise. |
| Noise Removal | Eliminates noise that can be introduced by the tool's normal calculation. |
| Preserve Data Outside Region | When enabled, data outside the regions is preserved in the output. Otherwise, only the data in the regions is output. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

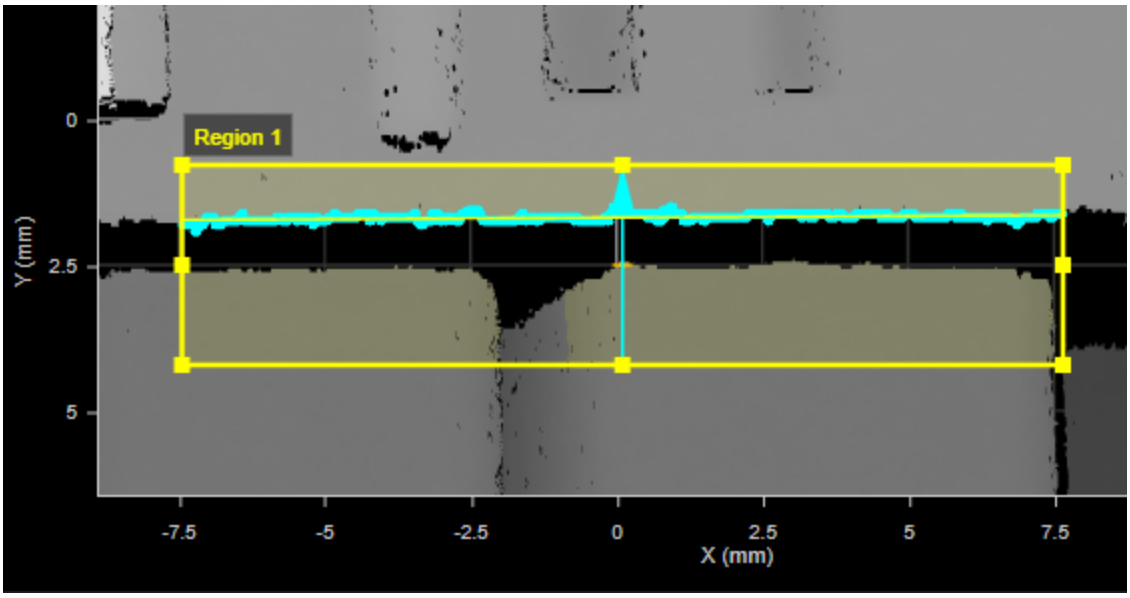
| Type | Description |
|---|---|
| Filtered Surface | The surface after filtering. |

## Surface Edge

The Edge tool fits a line to a straight edge in the scan data, using either height map or intensity data. The tool can search for an edge using either a step (an abrupt change in the data) or a corner (a contiguous change in the shape of surface). The tool's settings help fit the line when multiple potential edges are in the region of interest. After the tool locates an edge, it returns the position (X, Y, and Z) of the center of the edge line in the region of interest. The tool also returns its angle around the Z axis, the step height between the upper and lower surfaces adjacent to the edge, minimum and maximum error points to either side of the line, and a point count.

You can use the Z Angle measurement of the edge line with some tools to perform angle anchoring, compensating for minor part rotations around the Z axis, greatly increasing repeatability between part scans; for more information see *Measurement Anchoring* on page 193.

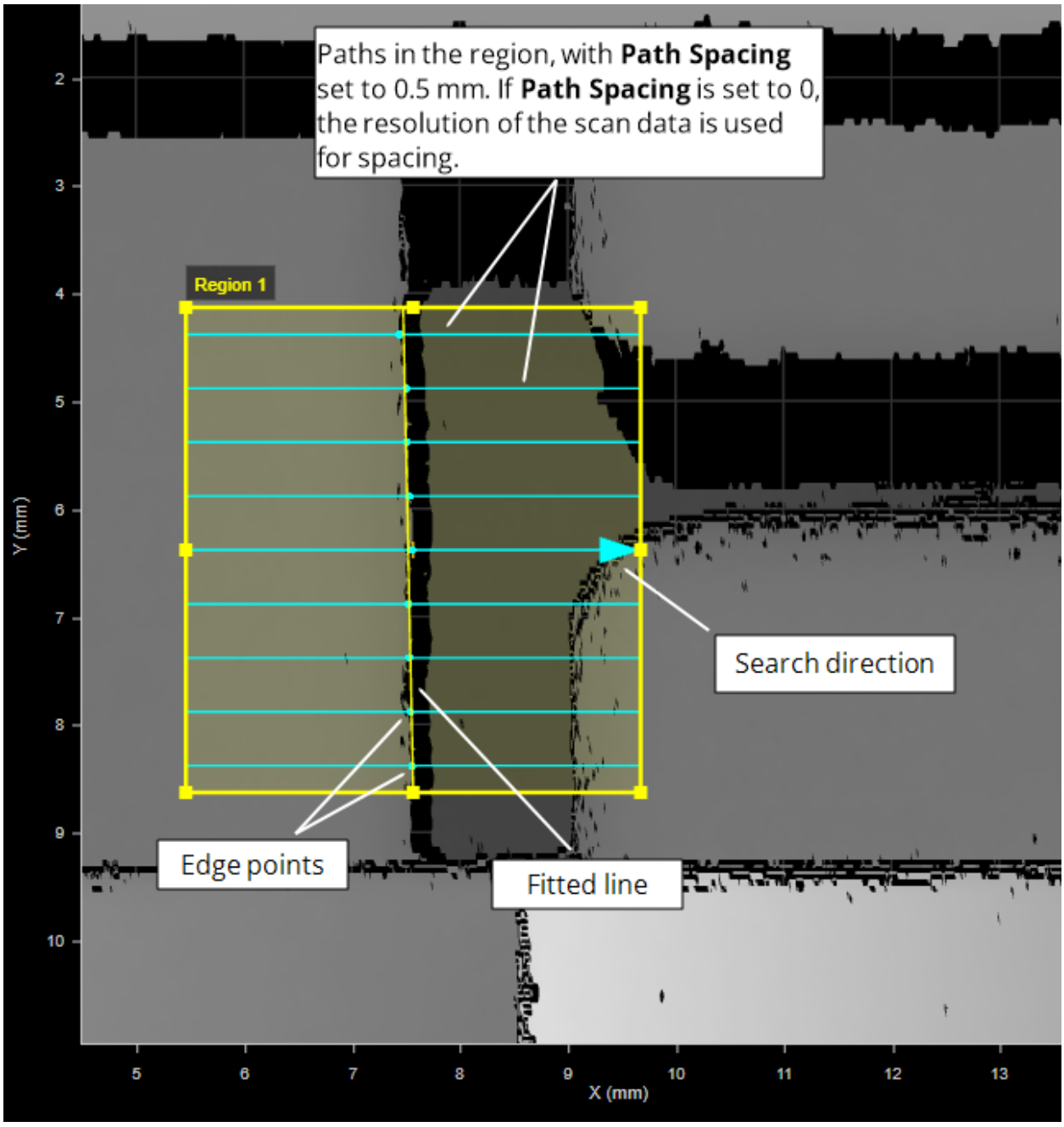
The tool can also generate edge line and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see *Feature Measurement* on page 626.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

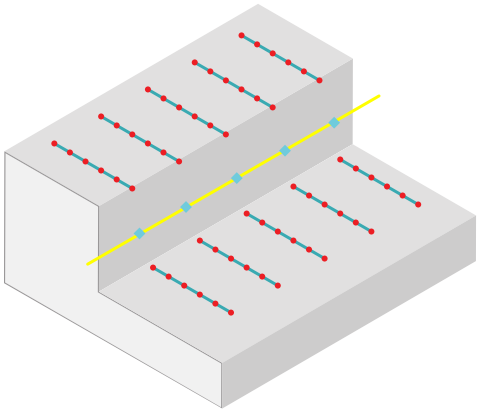
**Paths and Path Profiles**

To fit an edge line to the scan data, the Surface Edge tool overlays evenly spaced, parallel *paths* (light blue lines in the interface; see below) in the defined region of interest. (Note that the paths are only displayed if **Path Spacing** is greater than 0.)



For each path, a profile is generated internally from the height map's data points that fall under or, optionally, near the path. The tool then examines each path profile for steps (changes in height) that meet the criteria set by the tool's settings, such as minimum height, direction (whether it is rising or falling), and so on.

Red dots are data points from the scan data that fall under paths (light blue lines).

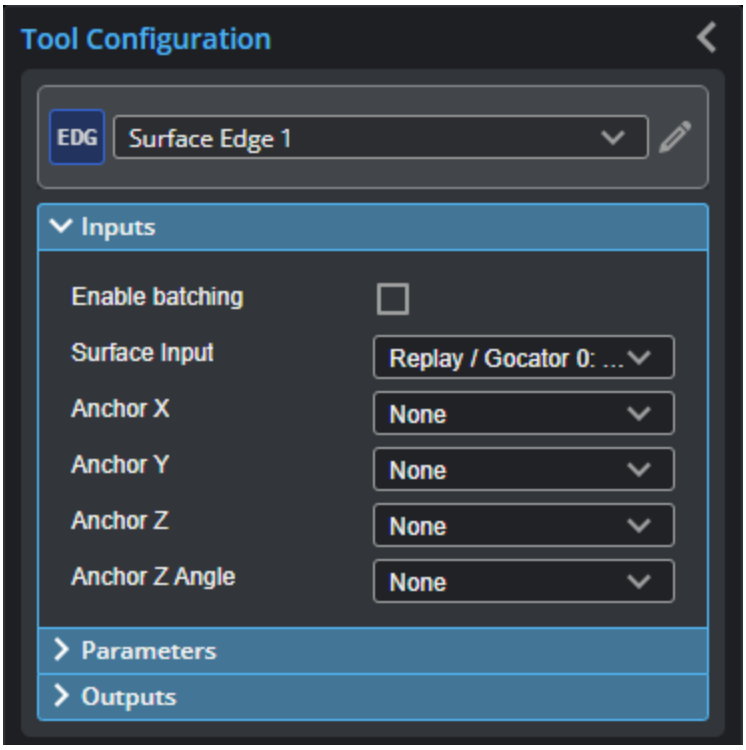


A single path profile extracted from a path.

For the step on each path profile that matches the settings, the tool places an edge point between the upper and lower area (light blue diamonds in the interface). The tool then fits a line to those edge points (yellow line in the interface). You can choose the orientation of the paths around the Z axis to accommodate different edge orientations.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



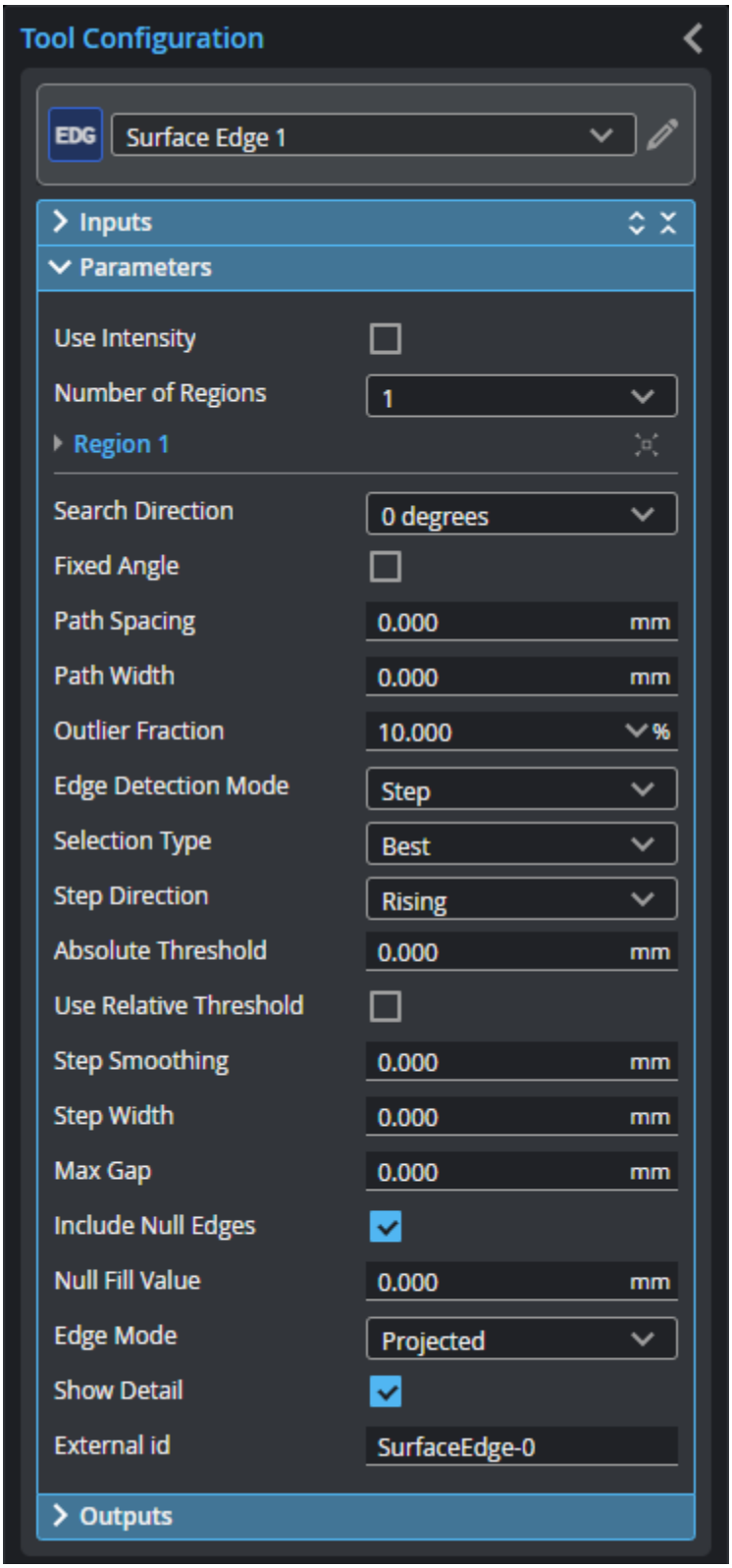
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

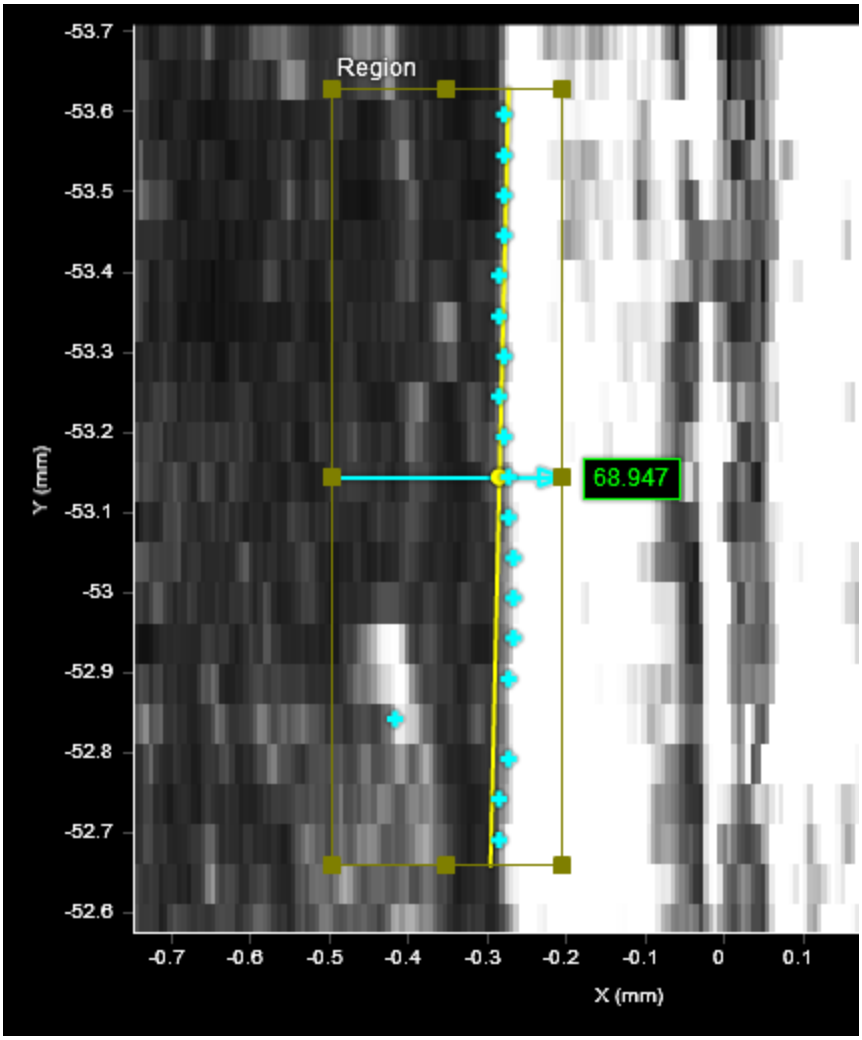
**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

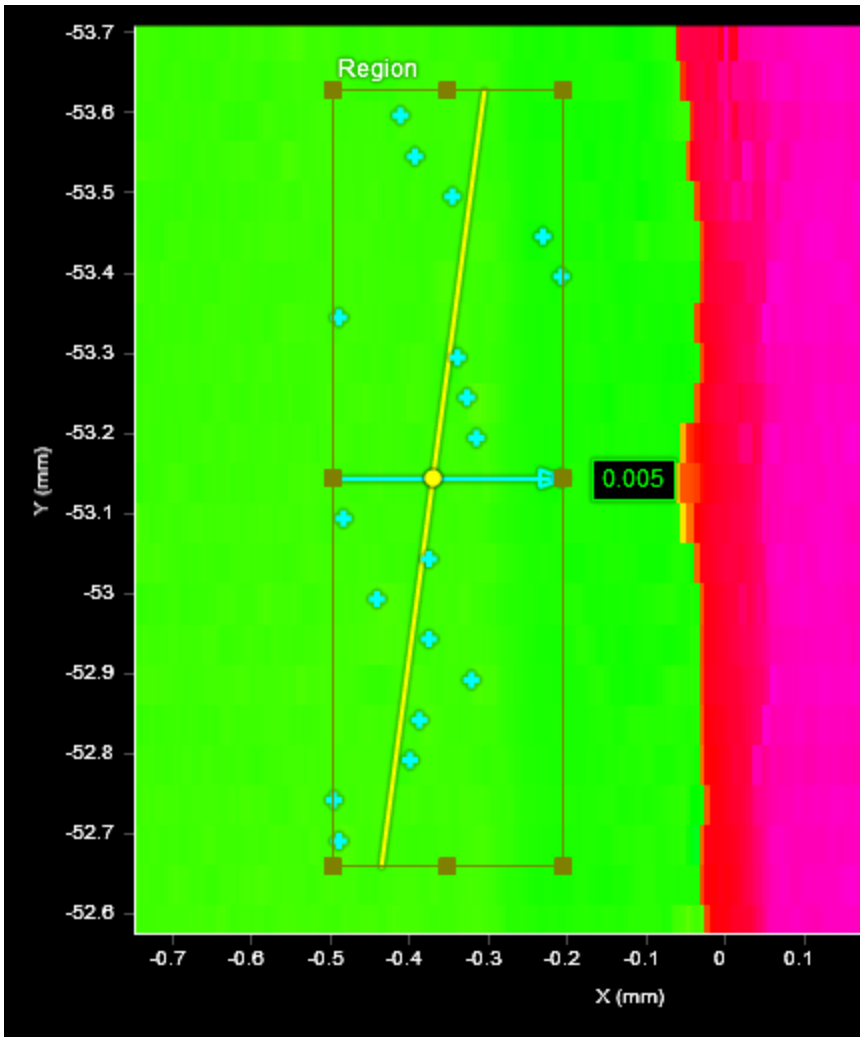

Tool Configuration
EDG
Surface Edge 1
Inputs
Parameters
Use Intensity
Number of Regions
1
Region 1
Search Direction
0 degrees
Fixed Angle
Path Spacing
0.000
mm
Path Width
0.000
mm
Outlier Fraction
10.000
%
Edge Detection Mode
Step
Selection Type
Best
Step Direction
Rising
Absolute Threshold
0.000
mm
Use Relative Threshold
Step Smoothing
0.000
mm
Step Width
0.000
mm
Max Gap
0.000
mm
Include Null Edges
Null Fill Value
0.000
mm
Edge Mode
Projected
Show Detail
External id
SurfaceEdge-0
Outputs

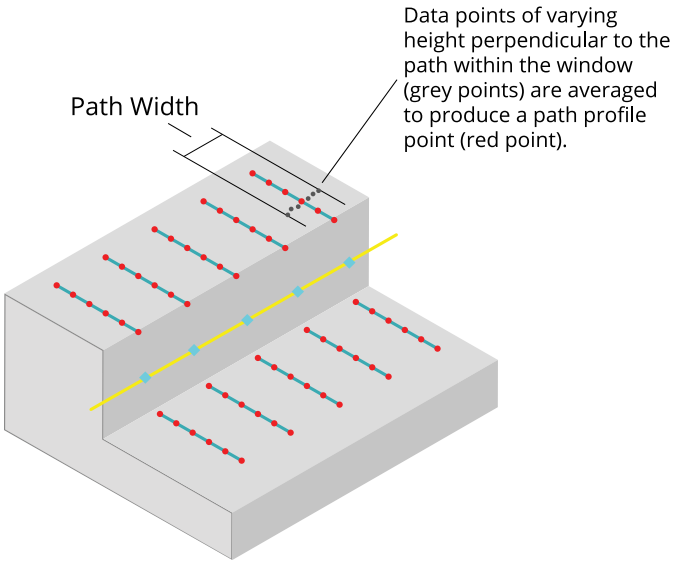
*Parameters*

| Parameter | Description |
|---|---|
| Use Intensity | Uses intensity data rather than height data to find an edge. Useful when color differences on a flat area of a target, which would not be detected using height map data, are distinct, letting you use the detected "line" as an anchor source or perform geometric feature measurements. |




***Use Intensity** enabled (intensity view): Surface Edge tool finds the edge using intensity data.*

| Parameter | Description |
|---|---|
| |  <br>***Use Intensity*** *disabled (heightmap view of the same area): Surface Edge tool unable to find edge using height data.* |
| Number of Regions | The number of regions the tool will use to fit the line. You must configure each region (see *Region {n}* below).<br>Using multiple regions allows you to fit a line to an edge that is not straight along its entire length or that is not continuous. |
| Region {n} | The region or regions the tool uses to fit a line. For more information, see *Regions* on page 181.<br>The **Search Direction** setting applies to all of the regions.<br>You can configure the **Z Angle** of each region independently to accommodate the particularities of the feature or target (for example, to exclude unwanted scan data next to one of the regions in the fitting of the line to the edge). |
| Search Direction | The search direction for steps, specified as an orientation around the Z axis, relative to the X axis. Can be 0, 90, 180, or 270 degrees. Choose a value that is |

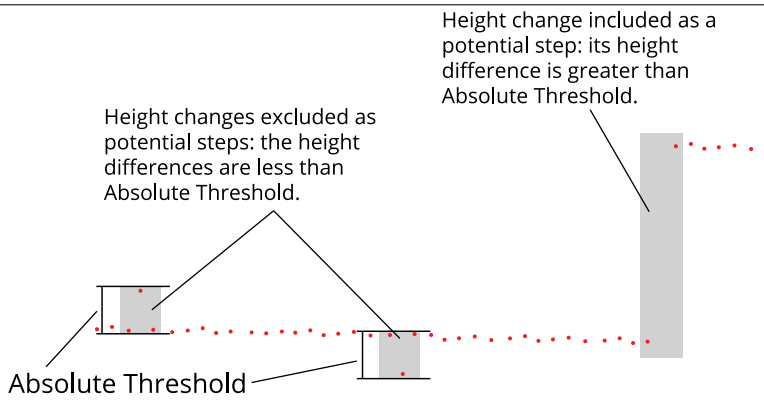
| Parameter | Description |
|---|---|
| | roughly perpendicular to the edge on the target.<br>The direction is indicated by a light blue arrow in the data viewer. |
| Fixed Angle<br><br>*Dependent settings*<br>Fixed Angle Value | When this option is enabled, the value in **Fixed Angle Value** replaces the value the Z Angle measurement returns.<br>Useful when the angle of the feature is known and noise in the scan data could otherwise cause the measurement to return an incorrect angle. |
| Path Spacing | Sets the spacing between paths in the measurement region used to extract the profiles that determine the edge. A higher number of paths results in a higher number of edge points, which makes the fitting of the edge line more accurate. However, a higher number of edge points results in a greater tool execution time.<br>When **Path Spacing** is set to 0, the resolution of the scan data is used as the basis for spacing. No paths are displayed in the data viewer in this case. |
| Path Width | The size of the windows perpendicular to the path used to calculate an average for each data point on a path profile. Useful to average out noise along the path caused by reflections, and so on.<br>  <br>If **Path Width** is set to 0, no averaging is performed (only the data point under the path is used).<br>For averaging along the path, use **Step Smoothing** (see below). |
| Outlier Fraction | The percentage of outlier points to exclude. Setting this to a small value can help the tool fit the line better to the edge. |
| Edge Detection Mode | One of the following: Step or Corner.<br>**Step**: Searches for steps on each path profile. For additional settings when you choose this mode, see *Step Edge Detection Mode Parameters* on the next page.<br>**Corner**: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden. |

| Parameter | Description |
|---|---|
| Selection Type<br>Corner Type | Determines which step (when **Edge Detection Mode** is set to Step) or corner (when **Edge Detection Mode** is set to Corner) the tool uses on each path profile when there are multiple steps or corners in the profile. An edge point is placed on each chosen step or corner. Steps must pass the criteria of the tool's **Absolute Threshold**, **Step Direction**, and **Relative Threshold** settings (see *Step Edge Detection Mode Parameters* below).<br>**Best**: Selects the greatest step or corner on each path profile.<br>**First**: Selects the first step or corner on each path profile.<br>**Last**: Selects the last step or corner on each path profile.<br>**Index**: Selects the step at the index provided in **Edge Index** on each path profile, with 0 being the first step. (Only available when **Edge Detection Mode** is set to Step.)<br><br>When **Edge Detection Mode** is set to Corner, the following additional options are available in Corner Type:<br>**Top**: Selects the top-most corner on each path profile.<br>**Bottom**: Selects the bottom-most corner on each path profile. |
| Edge Index | When **Selection Type** is set to Index, indicates which step to select; 0 is the first step from the start of the region. |
| Max Step Width | When **Selection Type** is set to Index, specifies the maximum width of the step, before considering the next step to be a new edge. The step width is the distance between the beginning and the end of the step. |
| Show Detail | When disabled, hides the light blue path lines and edge points. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

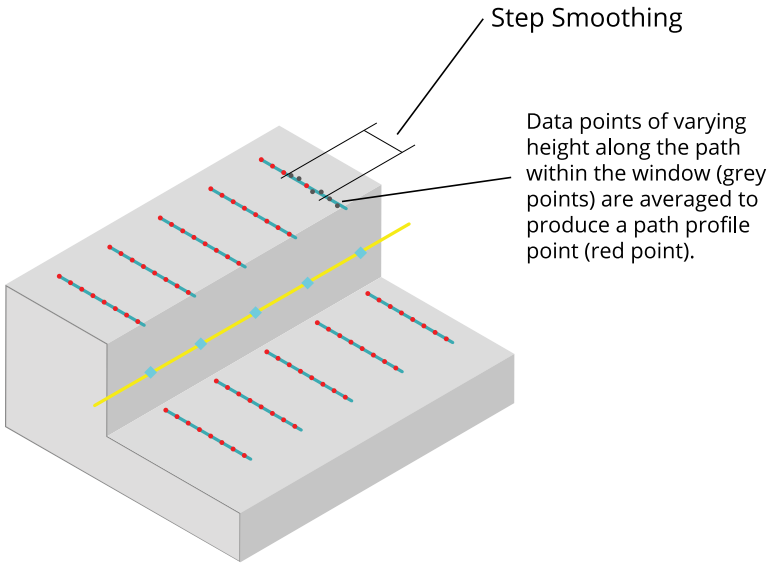
The following parameters are only displayed if you set **Edge Detection Mode** to Step.

*Step Edge Detection Mode Parameters*

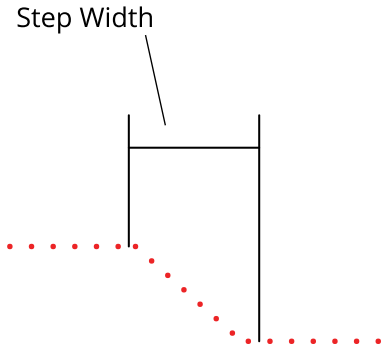
| | |
|---|---|
| Step Direction | Determines whether the expected step rises or falls along the path, moving from left to right. Either **Rising**, **Falling**, or **Rising or Falling**. |
| Absolute Threshold | When **Use Intensity** is disabled, the setting specifies the minimum *height* difference between points on a path profile for that step to be considered for an edge point.<br>The setting can be used to exclude smaller steps on a part that should not be considered for an edge, or to exclude height differences caused by noise. When used in conjunction with **Relative Threshold**, **Absolute Threshold** is typically set to a small value, greater than the general surface roughness. |




When **Use Intensity** is enabled, the setting specifies the minimum difference in intensity. (**Acquire Intensity** must enabled in the **Scan Mode** panel.)

| | |
|---|---|
| Use Relative Threshold | When this option is enabled, the **Relative Threshold** field is displayed. |
| Relative Threshold | The value for the relative threshold.<br>The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in **Relative Threshold**. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height.<br>For a height or intensity difference to be considered a valid step, both **Absolute Threshold** and **Relative Threshold** must pass. |
| Step Smoothing | The size of the windows along the path used to calculate an average for each data point on a path profile. The setting is useful for averaging out noise.<br>  <br><br>If **Step Smoothing** is set to 0, no averaging is performed (only the data point under the path is used).<br>For averaging perpendicular to the path, use **Path Width** (see above). |
| Step Width | The distance, along a path profile, separating the points used to find steps on a |

path profile.

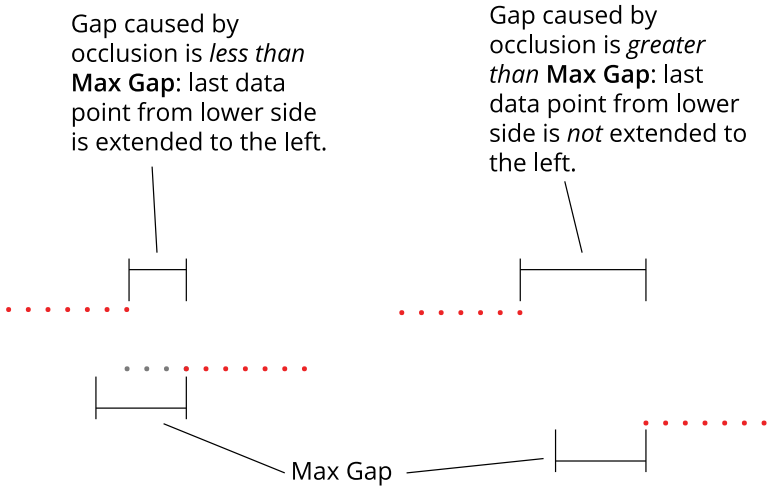



The setting is useful when you must detect a slope as an edge, rather than a sharply defined edge: setting **Step Width** to a value greater than the width of the edge ensures that the tool measures the height difference between the flat regions on either side of the edge. As a result, the height of the step is accurately measured, and the edge is correctly located.

> Setting **Step Width** wider than necessary can reduce the precision of edge location.

Max Gap

Fills in regions of missing data caused by an occlusion near the desired edge. Use this setting when continuity on the target is expected. When **Max Gap** is set to a non-zero value, the tool holds and extends the last data point on the low side next to an edge across a gap of null points, up to the distance specified in **Max Gap**.




Include Null Edges

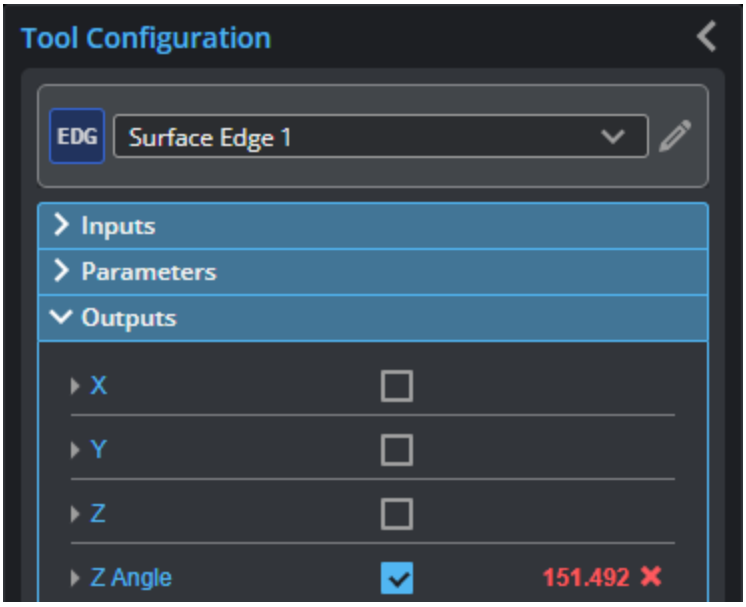
Indicates whether null points (points where no height or intensity value is available, due to dropouts or regions outside of the measurement range) are filled with the value in **Null Fill Value** as a general "background level." If **Use Intensity** (see above) is enabled, the intensity value in **Intensity Null Fill Value** is also used.

A typical example is a discrete part produced by the part detection of an object sitting on a flat background (for more information on part detection, see *Profile Part Detection* on page 283). The background is not visible in the part, so the tool assumes that any null region are at the background level.

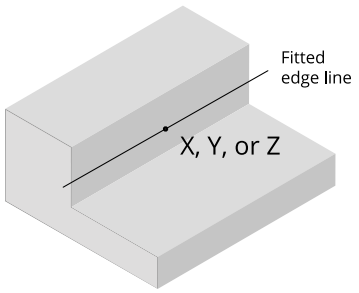
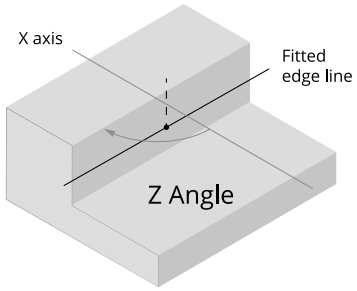
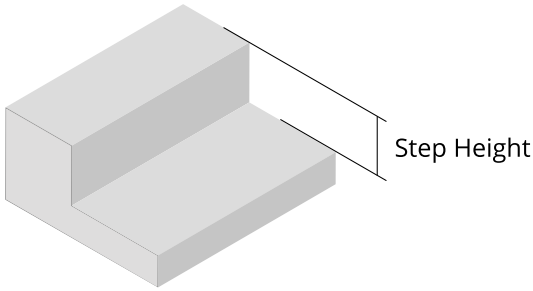
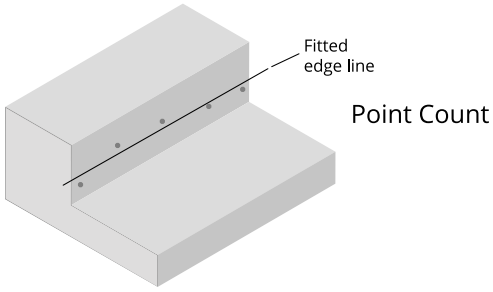
| | |
|---|---|
| | To find edges along a region of null points, you must use either this option and an appropriate value in **Null Fill Value** (and **Intensity Null Fill Value** if **Use Intensity** is enabled) or **Max Gap**. Otherwise, only edges within areas of contiguous data will be detected. |
| Null Fill Value | The height value (in mm) used to replace null points not filled by **Max Gap** when **Include Null Edges** is enabled. |
| Intensity Null Fill Value | The intensity value (0-255) used to replace null points when **Include Null Edges** and **Use Intensity** are enabled. |
| Edge Mode | One of the following:<br>**Projected**: The line fitted to the edge is projected onto the XY plane. This mode is typically used with an edge that is parallel to the XY plane.<br>**3D**: The line fitted to the edge follows the slope of the edge. This mode is typically used with a sloped edge. |

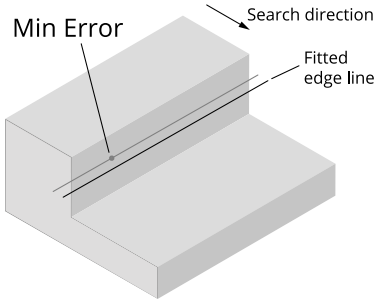
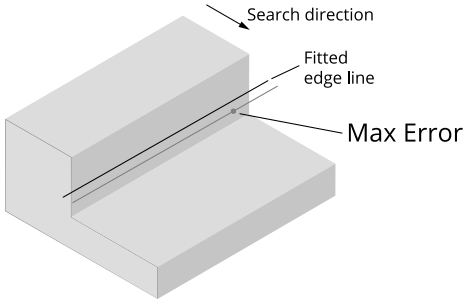
**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

| Measurement | Illustration |
|---|---|
| **X**<br>Returns the X position of the center point of the fitted edge line.<br>**Y**<br>Returns the Y position of the center point of the fitted edge line.<br>**Z**<br>Returns the Z position of the center point of the fitted edge line. |  |
| **Z Angle**<br>Returns the rotation, around the Z axis, of the fitted edge line. Rotating the measurement region has no impact on the angle that is returned unless a different edge is detected.<br>Useful for using minor variations in the rotation of an edge on target as an anchor for other measurements. For more information, see *Measurement Anchoring* on page 193. |  |
| **Step Height**<br>Returns the height of the step, calculated by averaging the step heights of all of the path profiles.<br>(When **Use Intensity** is enabled, the value returned is the difference in intensity.)<br>This measurement returns Invalid when **Edge Detection Mode** is set to Corner. |  |
| **Point Count**<br>The number of points used to fit the line. Useful for determining if the number of points is above an acceptable minimum. |  |

| Measurement | Illustration |
|---|---|
| **Min Error**<br>**Max Error**<br>These measurements return the distances of the point furthest before the line (Min Error) and the point furthest after the line (Max Error), based on the search direction specified in the tool.<br>The measurements ignore points excluded using the **Outlier Fraction** parameter. |  <br>  |

*Features*

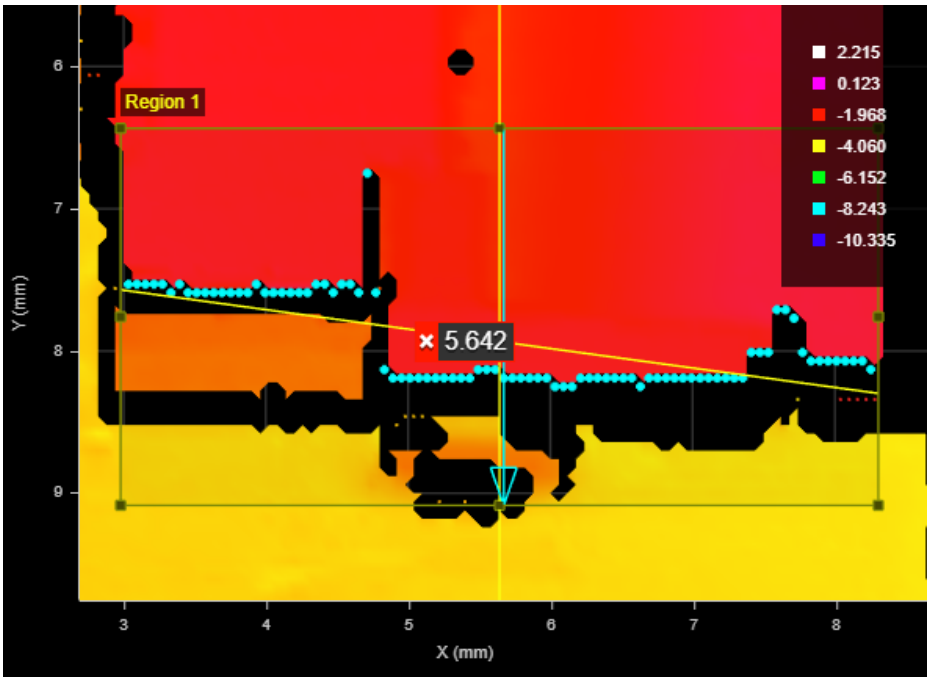
| Type | Description |
|---|---|
| Edge Line | The fitted edge line. |
| Center Point | The intersection point of the fitted edge line and the line representing the search direction through the center of the region of interest. |
| Edge Plane | A plane on the XZ axes at the fitted edge line. |

For more information on geometric features, see *Geometric Features* on page 191.

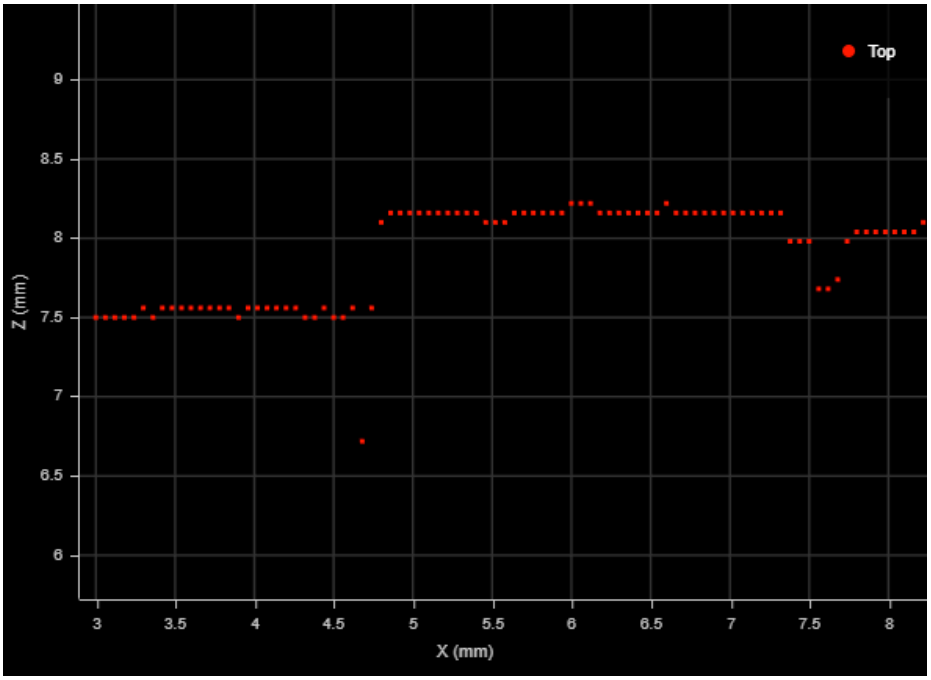
*Data*

| Type | Description |
|---|---|
| Profile Point Cloud<br>Profile Region {n} | A point cloud profile (Profile Point Cloud) and one or more uniform spacing profiles (Profile Region {n}) representing the edge, respectively, made up of the tool's edge points. The XY positions of the edge points on the surface (cyan dots below) are represented as the XZ positions of the profile points, where X => X and Y => Z.<br>Given the following edge, the resulting profile is shown further below: |

| Type | Description |
| --- | --- |




The profile is mirrored vertically when compared to the edge: Note how the single edge point toward the top of Region 1 in the surface data above is at the bottom of the extracted profile (below).

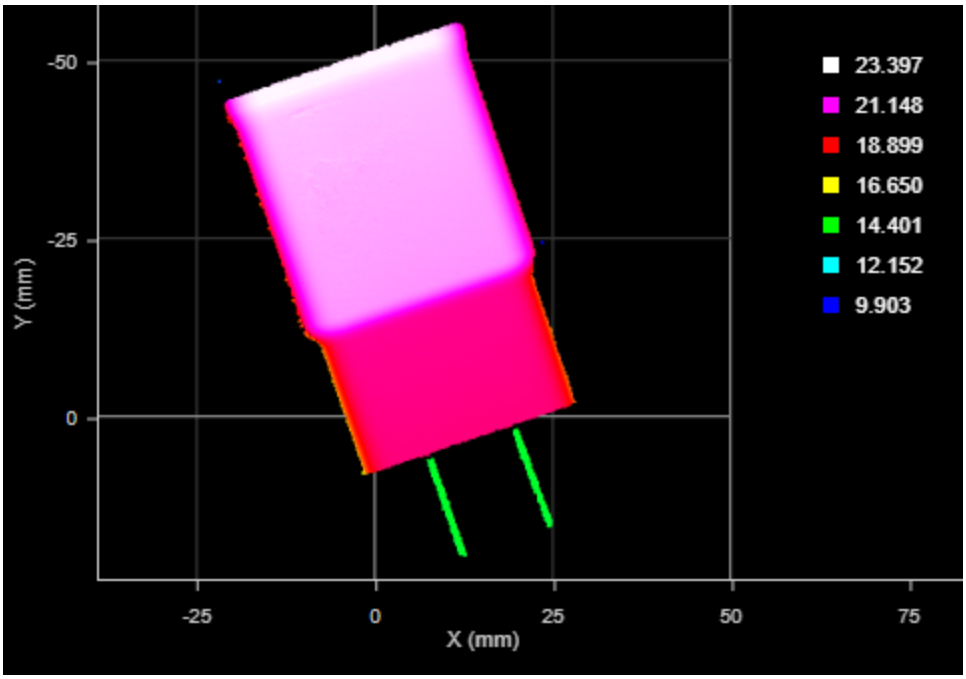


## Surface Ellipse

The Ellipse tool provides measurements for the major and minor axis lengths of an ellipse roughly aligned to the part's shape in the XY plane, and also for the ratio of the major and minor axis lengths and for the orientation angle of the ellipse. The tool is typically used to find the general orientation of a part, for example, potatoes on a conveyor that are longer in one dimension than the other.

Note that the ellipse fit is not the minimum area ellipse around the data. (Technically, it is the ellipse with matching moments as the data.) For surfaces with no holes, this results in an ellipse approximately the same size and orientation of the part. But for surfaces with holes, the resulting ellipse can be larger than the part.

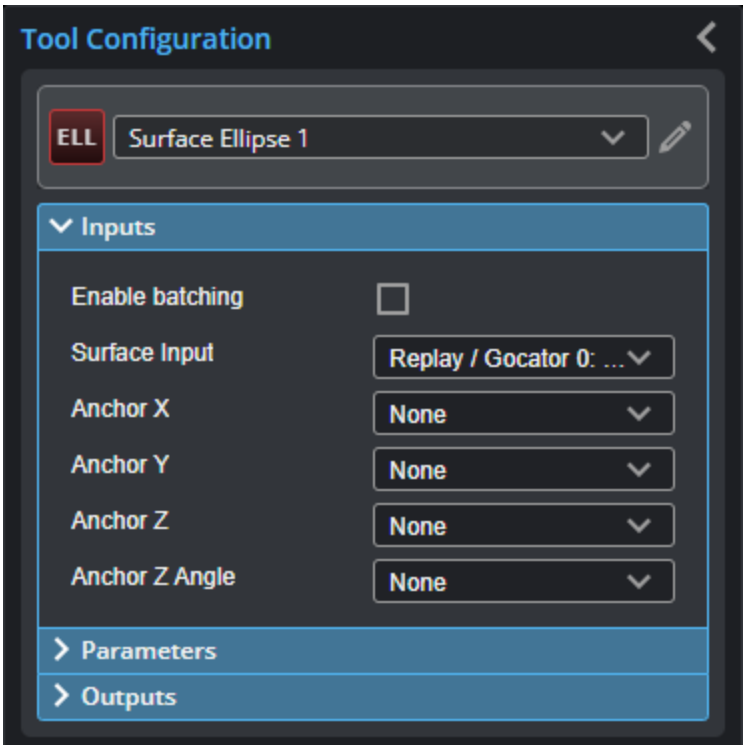
(The following screenshot is from a G2 sensor.)




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



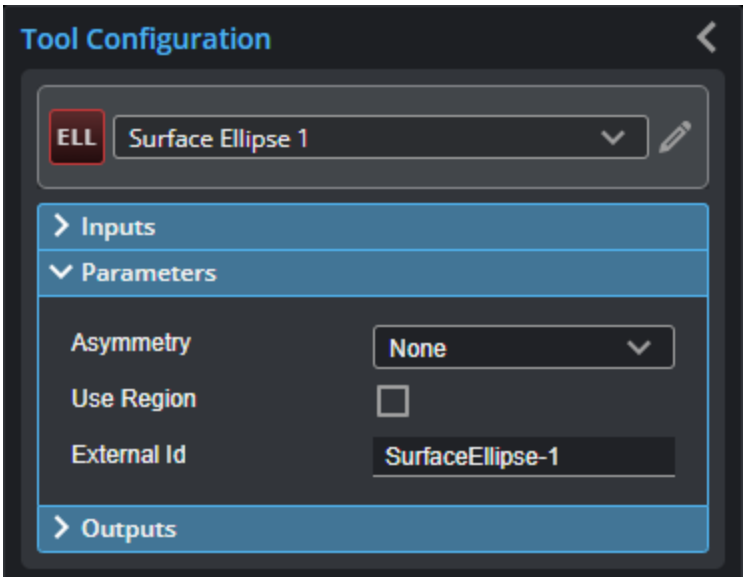

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

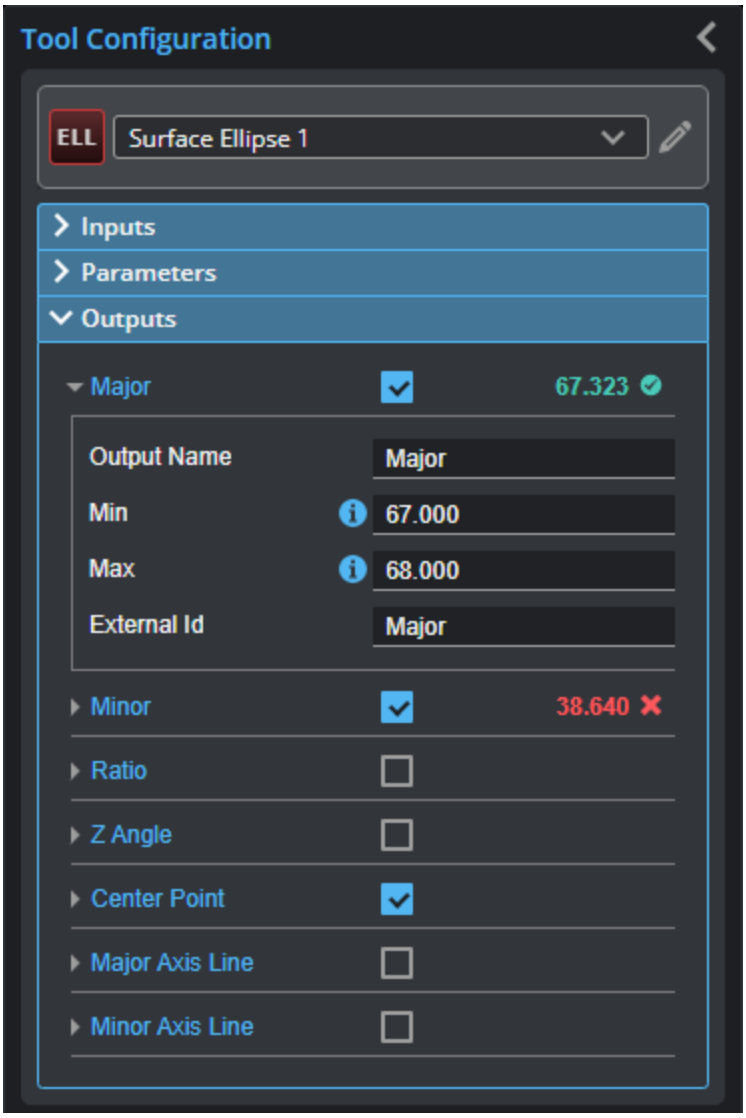



*Parameters*

| Parameter | Description |
|---|---|
| Asymmetry | Resolves the orientation of an object over 360 degrees. The possible values are:<br>0 – None<br>1 – Along Major Axis<br>2 – Along Minor Axis |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

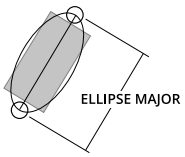
Most tools provide measurements, geometric features, or data as outputs.

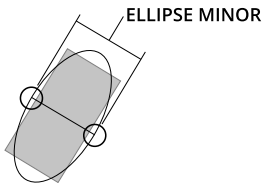
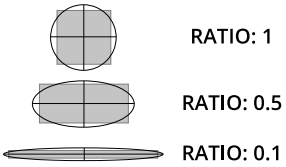
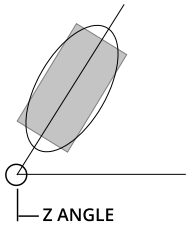



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Major**<br>Determines the major axis length of an ellipse fitted to the part's area in the XY plane. |  |

| Measurement | Illustration |
|---|---|
| **Minor**<br>Determines the minor axis length of an ellipse fitted to the part's area in the XY plane. |  |
| **Ratio**<br>Determines the minor/major axis ratio of an ellipse fitted to the part's area in the XY plane. |  |
| **Z Angle**<br>Determines the orientation angle of an ellipse fitted to the part's area in the XY plane. |  |

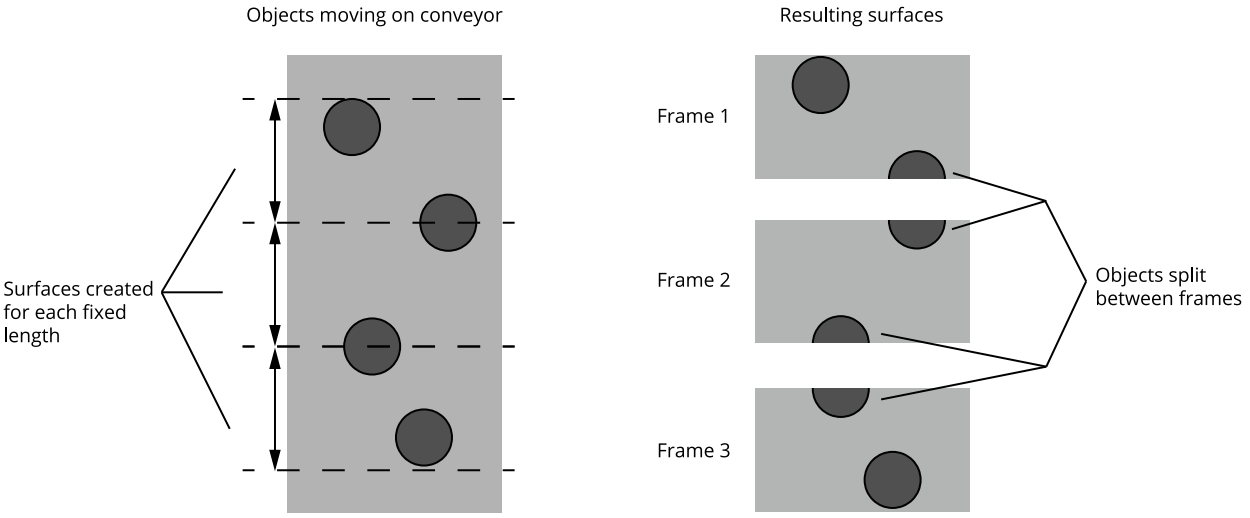
*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the fitted ellipse. |
| Major Axis Line | A line representing the major axis of the fitted ellipse. |
| Minor Axis Line | A line representing the minor axis of the fitted ellipse. |

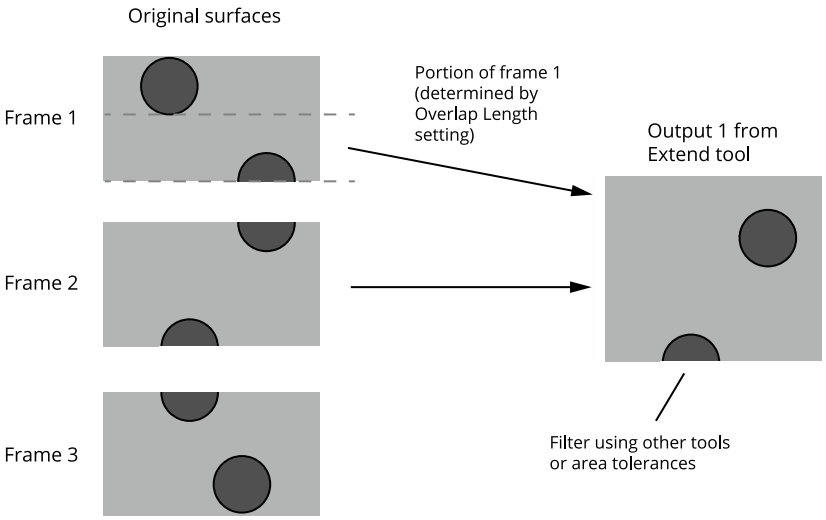
For more information on geometric features, see *Geometric Features* on page 191.

## Surface Extend

The Extend tool creates a new surface by appending part of the previous frame's data to the current frame's data. The tool outputs the new surface data, which can be used as input by other tools.




The following shows how the tool combines data:

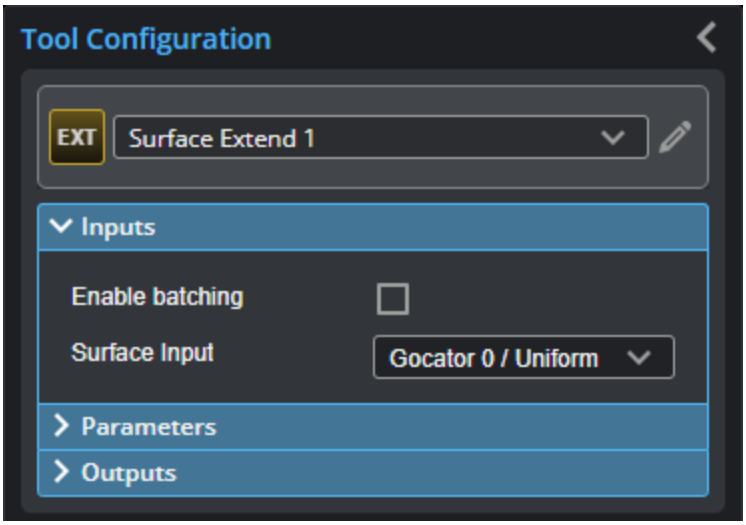



Data is only appended in one direction. Partial objects in the resulting surface output from the tool must be filtered out using downstream tools, for example, excluding them based on the expected area.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



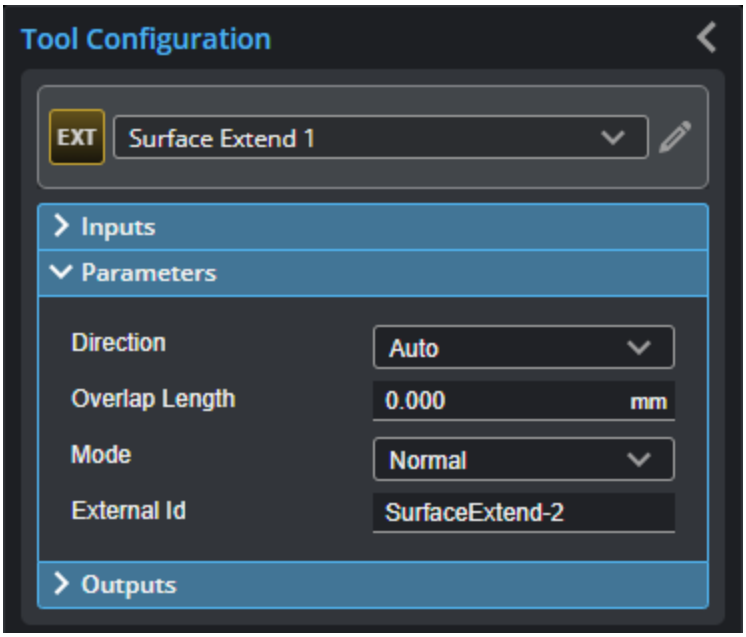

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

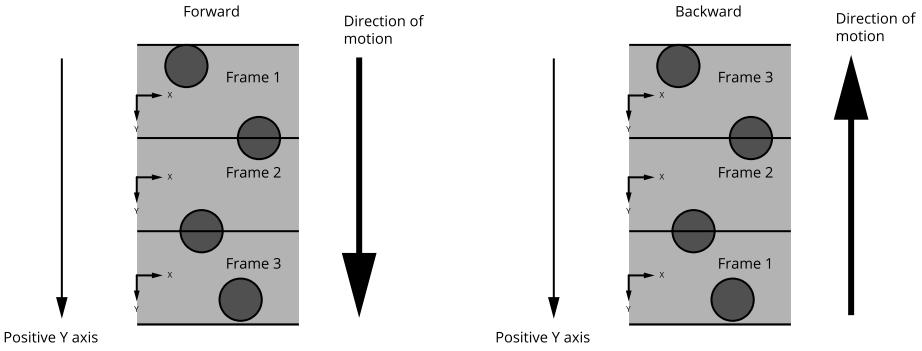
| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



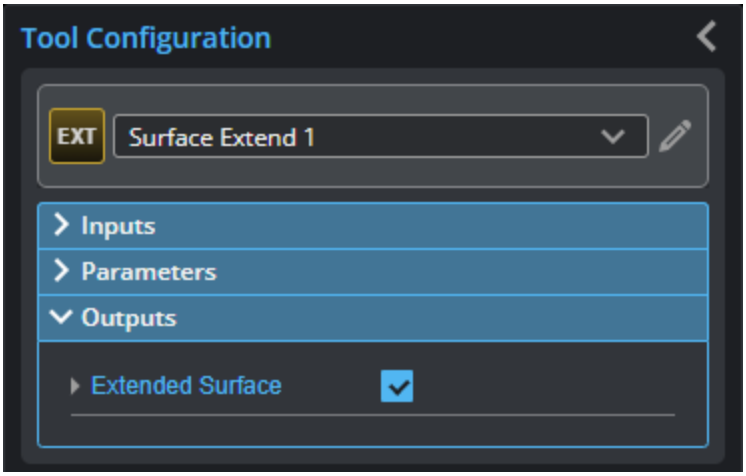

*Parameters*

| Parameter | Description |
|---|---|
| Direction | Determines whether the previous frame's data is appended above or below the current frame's data.<br>  <br><br>One of the following. Note that these settings depend on whether the trigger source has been set to Encoder (see *Triggers* on page 120) and the orientation of the sensor.<br>• **Auto**: Choose this when Encoder is selected as the trigger source, in which case the tool will detect the direction of travel relative to encoder increase / decrease.<br>• **Forward**: Choose this option when the trigger source is not set to Encoder and the direction of motion matches the sensor's positive Y axis.<br>• **Backward**: Choose this option when the trigger source is not set to Encoder and the direction of motion is the opposite of the sensor's positive Y axis. |
| Overlap Length | The amount, in millimeters, of the previous frame's data to append to the current frame's data. The combination will be output as tool data. Choose the overlap length to accommodate the size of your scan targets. |

| Parameter | Description |
|---|---|
| Mode | Determines the mode of the tool. One of the following:<br>• **Normal**: The tool's output is unlocked and functions normally.<br>• **Lock**: Lets you lock the current processing and outputs of the tool. Useful when you need to add another tool that will use this tool's output (for example, a Surface Section tool). If you do not lock the tool, as soon as you add the other tool, the output is cleared, which means you must re-execute the combined output again to configure the additional tool. Be sure to unlock the tool after you have configured any other tools. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

| Type | Description |
|---|---|
| Extended Surface | Data containing an extended surface, available for use as input in the **Stream** drop-down in other tools. |

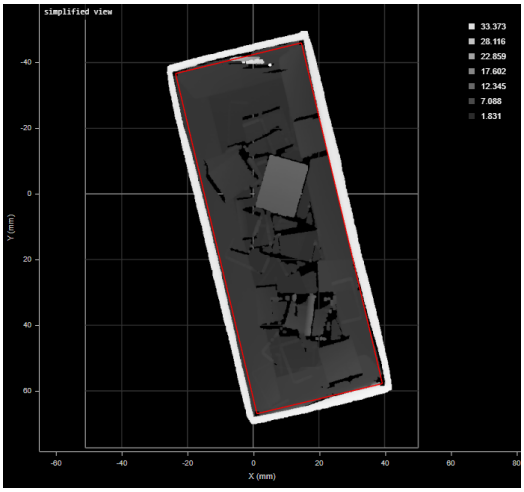
## Surface Feature Mask

The Surface Feature Mask dynamically defines a polygon or circle mask using Point geometric features produced by other tools to crop a uniform surface and output it. You can use this tool in void fill applications with bins of varying sizes and varying orientations.

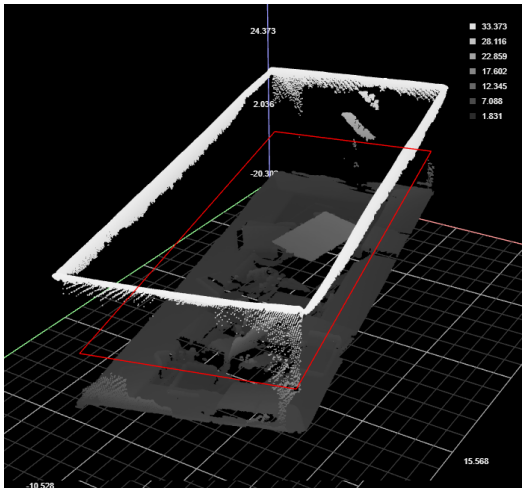
The following is a possible tool chain for calculating the fill volume of rectangular bin using Surface Feature Mask:

- Surface Bounding Box tool: Finds the orientation and position of the center of a box that must be filled. You would use the tool's X, Y, and Z Angle measurements as anchors for the other tools.
- Surface Edge tools (one for each edge of the bin): Using the Bounding Box tool's measurements as anchors, these tools find the edges of the bin.
- Feature Intersect tools: Using pairs of lines from the Surface Edge tools as inputs, these tools return Point geometric for the corners of the bin.
- Surface Feature Mask tool: Using the Point geometric features from the Feature Intersect tools as inputs, this tool outputs Surface data delimited by corners of the bin. To exclude the edges of the bin itself, use the **Padding Distance** parameter to exclude the bin walls.

When only two Point geometric features are passed as input to the tool, it creates a circular mask, where one point is the circle's center point, and the other is a point on the circle.




*2D View*

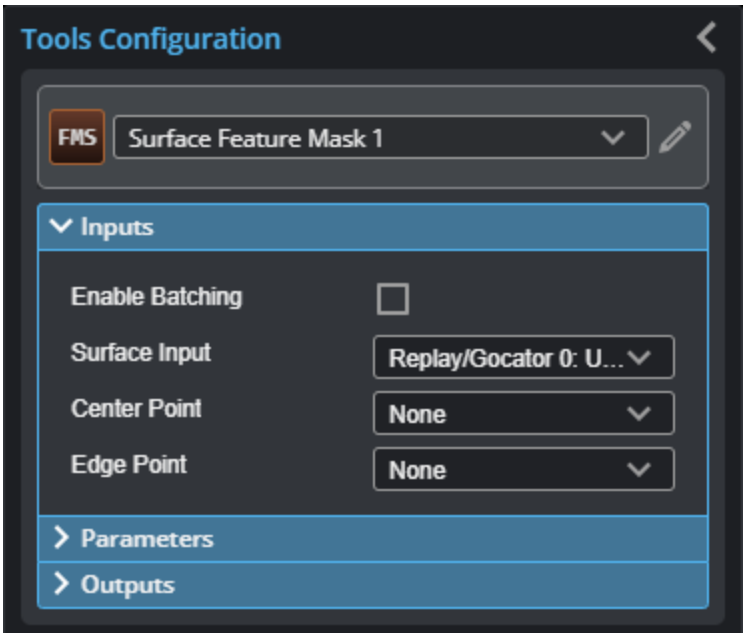



*3D View*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



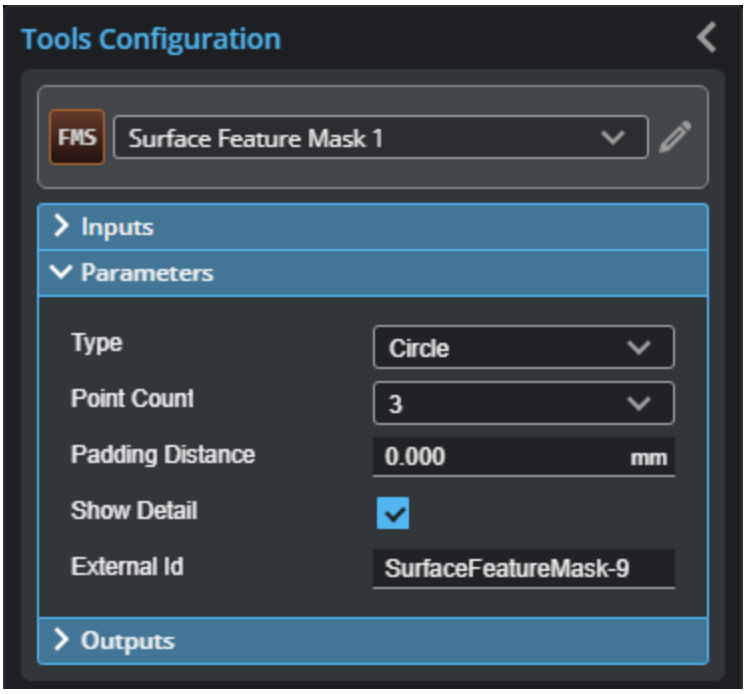

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Point {n} | The nth Point geometric feature.<br>Only displayed if you set **Point Count** to 3 or higher. |
| Center Point | The center Point geometric feature of the circle.<br>Only displayed if you set **Type** to Circle and **Point Count** to 2. |
| Edge Point | The Point geometric feature on the circle.<br>Only displayed if you set **Type** to Circle and **Point Count** to 2. |
| Surface Input | The data the tool applies measurements to or processes. |

For more information on geometric features, see *Geometric Features* on page 191.

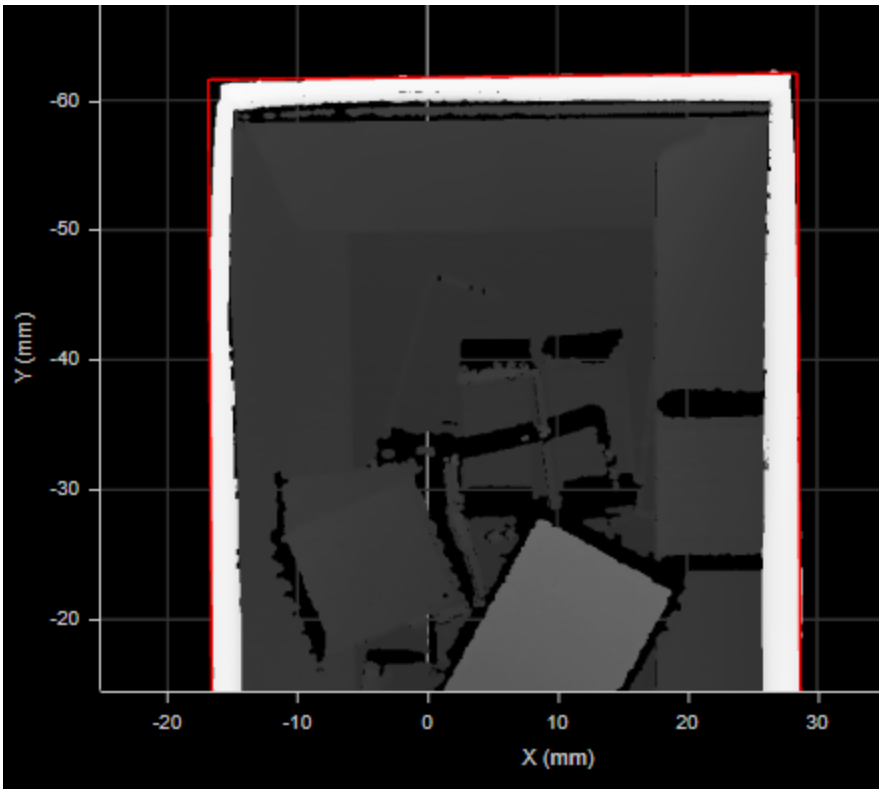
**Parameters**

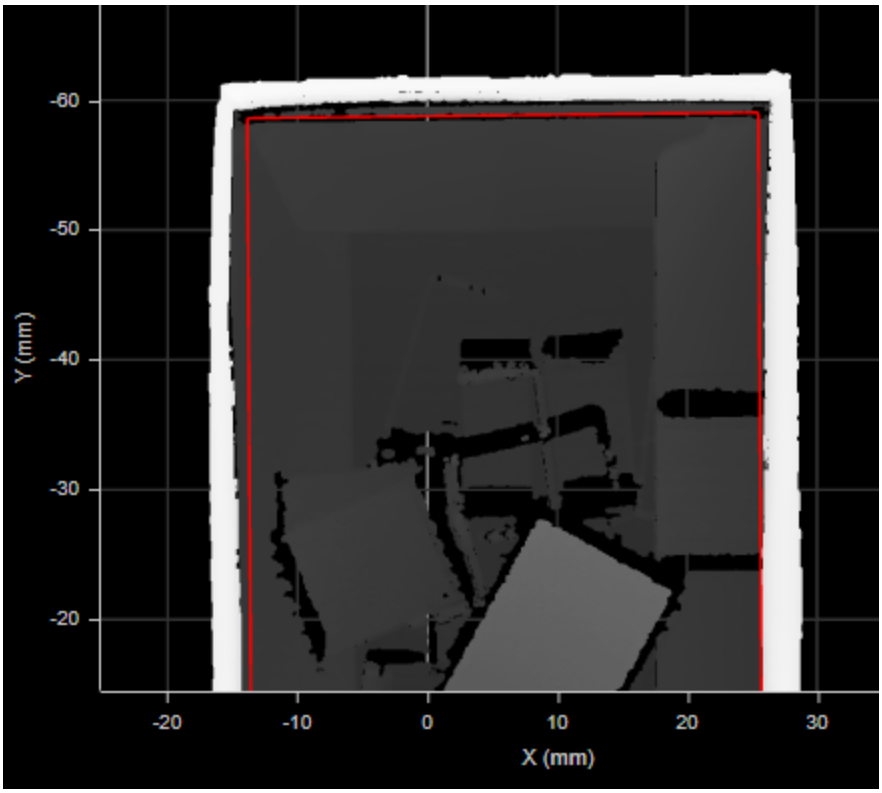
You configure the tool's parameters in the expandable **Parameters** section.

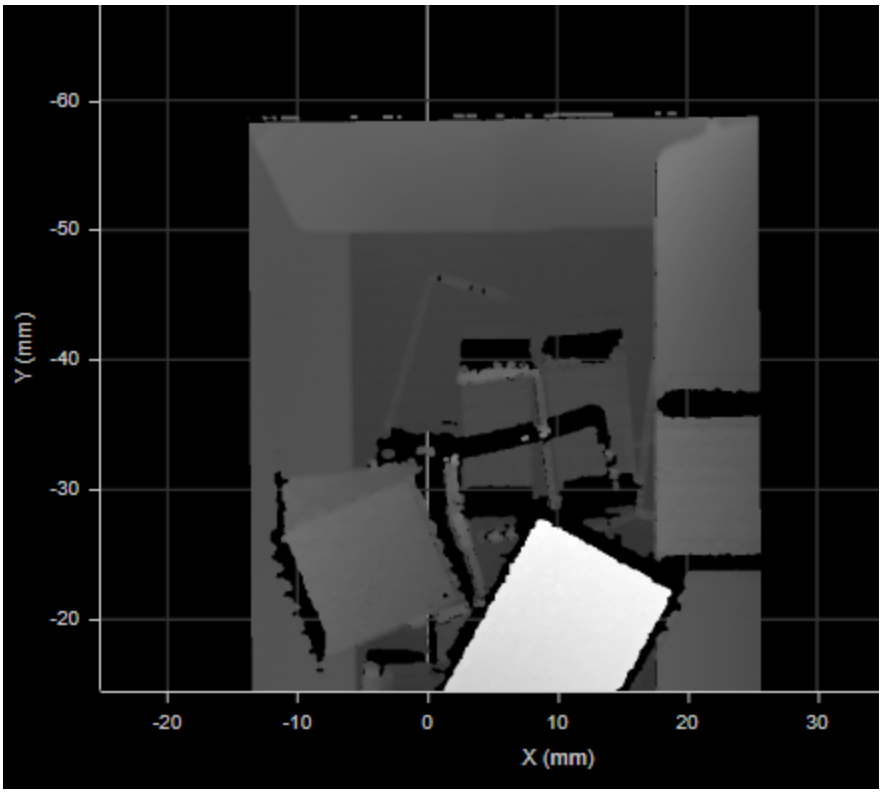



*Parameters*

| Parameter | Description |
|---|---|
| Type | The shape type of the mask. It supports two options:<br>**Polygon** - The tool needs at least 3 Point geometric features.<br>**Circle** - The tool needs 2 or 3 point geometric features. |
| Point Count | The count of the input point features.<br>For the Polygon **Type** option, the tool supports integers in the range of 3 to 10.<br>For the Circle **Type** option, the tool supports integers of 2 or 3.<br>After setting this parameter, set the point inputs in the Inputs section to the appropriate Point geometric features. |
| Padding Distance | The offset from the mask.<br>When the value is greater than 0, the offset is outward. When the value is less than 0, the offset is inward.<br>You can use this for example to exclude a bin that contains parts from the output Surface data. For example, in the following, before padding is set to a non-zero value, the bin is included in the output. |

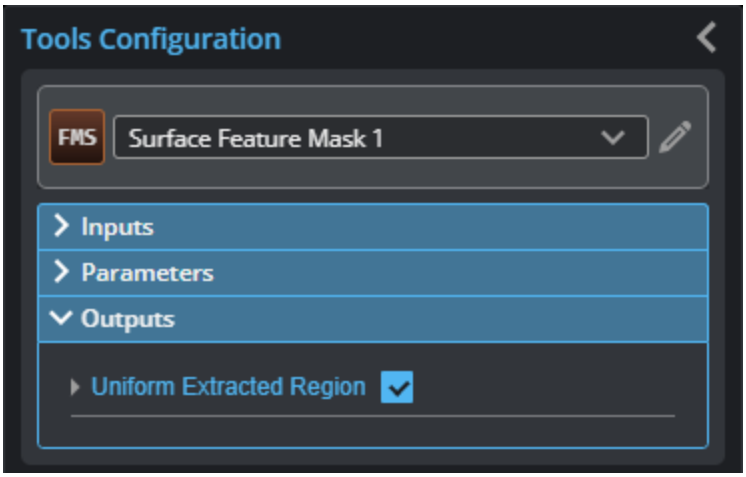
| Parameter | Description |
| --- | --- |
| |  <br>In the following, padding has been set to -3, which moves the mask "inward," excluding the bin. |

| Parameter | Description |
| --- | --- |
| |  <br>The resulting Uniform Extracted Region outpu contains only the content of the bin. |

| Parameter | Description |
|---|---|
| |  |
| Show Detail | Toggles whether to display the graphics of the mask region. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum

and minimum values; the range is inclusive.

All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

*Data*

| Type | Description |
| --- | --- |
| Uniform Extracted Region | The cropped Surface data. |

## Surface Filter

The Filter tool provides several common vision processing filters that you can apply to surface data, as well as two "cropping" filters that output a subset of the surface data, letting you pre-process scan data to get more repeatable measurements. Any Surface or Feature tool can use the resulting filtered surface data as input.

For a list of the filters, see *Filters* on page 497.

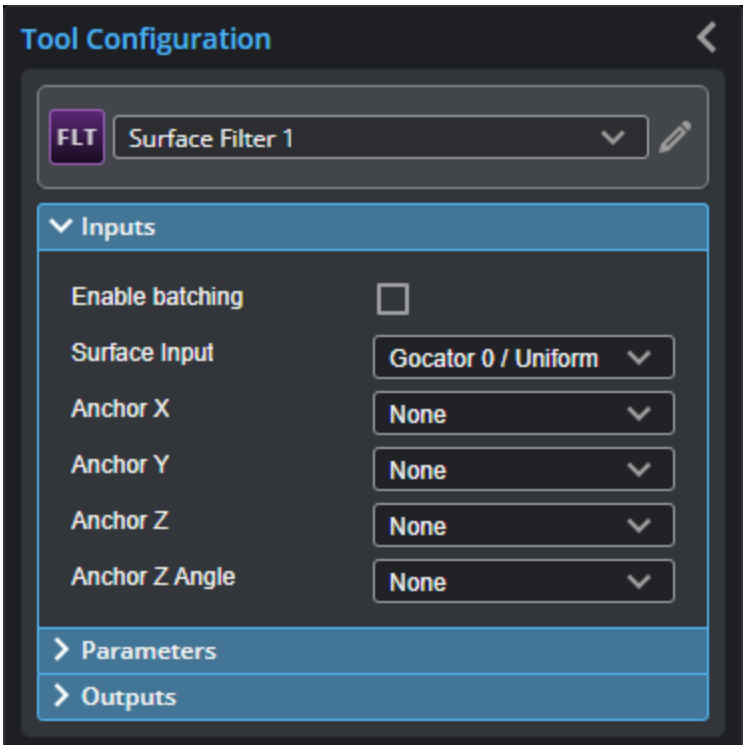
The Filter tool provides no measurements or decisions, as its only purpose is to output processed surface data.

> A limited set of filters is also available on the **Acquire** page, in the **Filters** section. These filters let you process scan data without needing to add tools. This can be useful if you are using a sensor mostly as an acquisition device.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



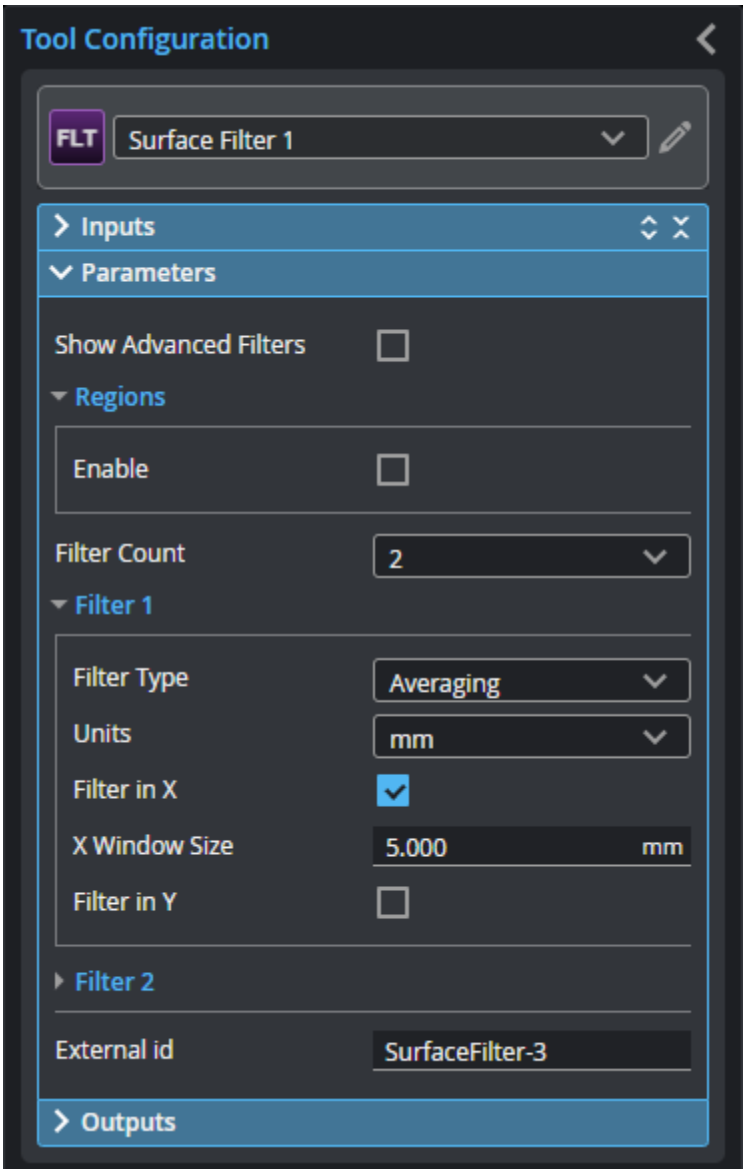

> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Show Advanced Filters | When enabled, displays advanced filters in **Filter Type** (see below), in addition to the standard filters (Gap Filling, Median, Averaging, and Decimation). |
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |

| Parameter | Description |
|---|---|
| | |
| Filter Count | Sets the number of filters in the tool. |
| Filter Type | The type of the filter. For information on the available filters, see *Filters* below. |
| Units | Specifies whether filters use data points (**pts**) or millimeters (**mm**). Not available with all filters. |
| Preserve Data Outside Region | Enable this setting when **Mask Mode** is set to **Include Data in Region** to include data outside the region in the Filtered Surface data output. Otherwise, the Filtered Surface data output only includes the data in the region.<br>This setting is only displayed if regions are enabled. |
| Threshold | The threshold that the filter uses. (Not available on all filters.) |
| Symmetry | One of the following: Symmetrical, Horizontal, or Vertical. (Not available on all filters.) |
| Kernel Size | The kernel size that the filter uses. (Not available on all filters.) |
| Filter in X<br>Filter in Y | These parameters enable filtering along the X and the Y axis, respectively. Set the corresponding window sizes in **X Windows Size** and **Y Window Size**.<br>The filter window sizes are specified in millimeters (and additionally, in the tools, in data points). To calculate the number of data points that a window covers when the units are millimeters, use the following calculation:<br>• User-specified window size divided by the X spacing interval (that is, the number of millimeters per point) on the **Spacing** tab in the **Sensor** panel. (For more information on spacing intervals, see *Uniform Spacing* on page 112.)<br>• *With the exception of the gap filling filter*, round the result of the division to the nearest integer value. With the gap filling filter, filling is performed within the provided window size.<br>For example, if you set the size of the filter's window to a value between 1.5 mm and 2.49 mm (inclusively), and the X spacing interval is set to 1 mm, the filter covers 2 data points. A filter window size from 2.5 mm to 3.49 mm results in a filter covering 3 data points. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

The following filters are available in the Filter tool. Filters described below as advanced are only displayed if **Show Advanced Filters** is enabled.

*Filters*

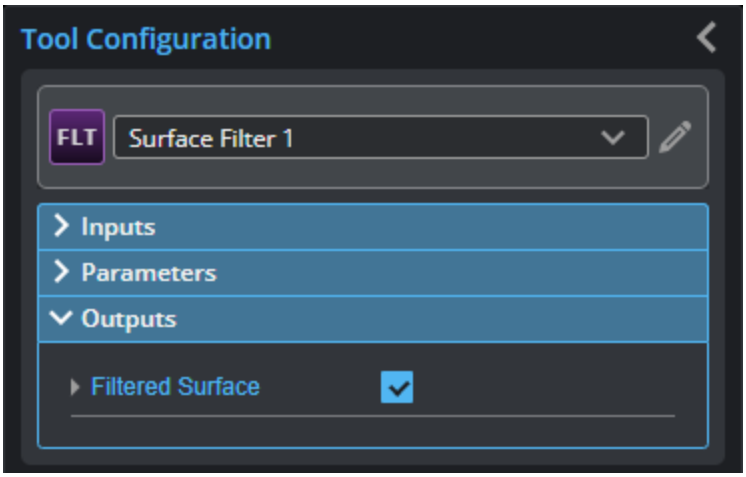
| Name | Description |
|---|---|
| Gap Filling | Fills in missing data using information from the nearest neighbor data points, for example, when data is missing due to occlusions. Gap filling also fills gaps where no data is detected, which can be due to low surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The values in **Filter in X** |

| Name | Description |
| --- | --- |
| | and **Filter in Y** represent the maximum gaps the sensor will fill. Wider gaps are not filled.<br>Gap filling works by filling in missing data points using either the lowest values from the nearest neighbors or linear interpolation between neighboring values (depending on the Z difference between neighboring values), in the specified window. The sensor can fill gaps along both the X axis and the Y axis.<br>In Profile mode, gap filling is limited to the X axis. |
| Median | Substitutes the value of a data point with the median calculated within the window or windows set in **X Window Size** or **Y Window Size** around the data point. If the number of valid (non-null) data points in the window is even, the average of the two values in the center is used. If the number of valid points is odd, the value in the center of the sorted list of values is used.<br>Missing data points will not be filled with the median value calculated from data points in the neighborhood.<br>With an odd-numbered window size, the output is at the center of the window. With an even window size, the output is 0.5 pixels to the right of the center (that is, using window / 2-1 values from the left, and window / 2 from the right. |
| Averaging | Substitutes a data point value with the mean value of that data point and its nearest neighbors within the window or windows set in **X Window Size** or **Y Window Size**. X smoothing works by calculating a moving average across samples within the same profile. Y smoothing works by calculating a moving average in the direction of travel at each X location.<br>If both X and Y smoothing are enabled, the data is smoothed along X axis first, then along the Y axis.<br>Missing data points will not be filled with the mean value calculated from data points in the neighborhood. |
| Decimation | Decimation reduces the number of data points along the X or Y axis by choosing data points at the end of a specified window around the data point. For example, by setting **X Window Size** to 0.2, only points every 0.2 millimeters will be used. The filter generates points starting from the leftmost edge of the scan data, stepping in equal steps away from that side. |
| Gaussian (advanced) | A Gaussian filter. Set the **Sigma**, **Units**, and **Preserve Data Outside Region** parameters as required. |
| Opening (advanced) | Erosion followed by dilation. |
| Closing (advanced) | Dilation followed by erosion. |
| Erosion (advanced) | Applies an erosion filter. Lets you specify the direction of the erosion; one of the following:<br>• Horizontal<br>• Vertical<br>• Symmetrical |

| Name | Description |
|---|---|
| Dilation (advanced) | Applies a dilation filter. Lets you specify the direction of the dilation; one of the following:<br>• Horizontal<br>• Vertical<br>• Symmetrical |
| Morph Gradient (advanced) | Applies a morphological gradient. The difference between dilation and erosion. |
| Sobel Magnitude (advanced) | Applies a Sobel magnitude filter.<br>Lets you specify the direction of the filter; one of the following:<br>• Horizontal<br>• Vertical<br>• Symmetrical |
| Laplacian (advanced) | Applies a Laplacian filter. Useful for detecting areas of distinct edges. Uses the following kernel:<br>0 -1 0<br>-1 4 -1<br>0 -1 0 |
| Negative (advanced) | Inverts the height or intensity values in the scan data. When **Use Nulls** is enabled, null values in the input are replaced by the highest height value. |
| Equalize (advanced) | Normalizes the norm or value range of an array. |
| Binarize (advanced) | Sets height values to a fixed value for each point that is present in the data. Can be used with a region Z offset to threshold points above/below a Z value.<br>When **Use Intensity** is enabled, the tool sets data points with an intensity value over |
| Percentile (advanced) | Limits the scan data to points between the values you set in **High Percentile** and **Low Percentile**, which are displayed when you choose this option. |
| Relative Threshold (advanced) | Crops scan data relative to a user-specified reference.<br>When **Reference Type** is set to Range, specify minimum and a maximum heights in the threshold fields.<br>When the type is Region, use **Reference Region** to set the heights relative to one or more reference region.<br>When the type is Plane, set the **Plane** input in the tool's Inputs section to a plane geometric feature. |
| Crop only (advanced) | Crops the scan data to the user-defined region. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

| Type | Description |
|---|---|
| Filtered Surface | The filtered data, available for use as input in the **Stream** drop-down in other tools. |

## Surface Flatness

The Flatness tool returns various measurements related to the flatness of one or more regions on the surface of your target. The tool is ideal for general fit and finish inspection.

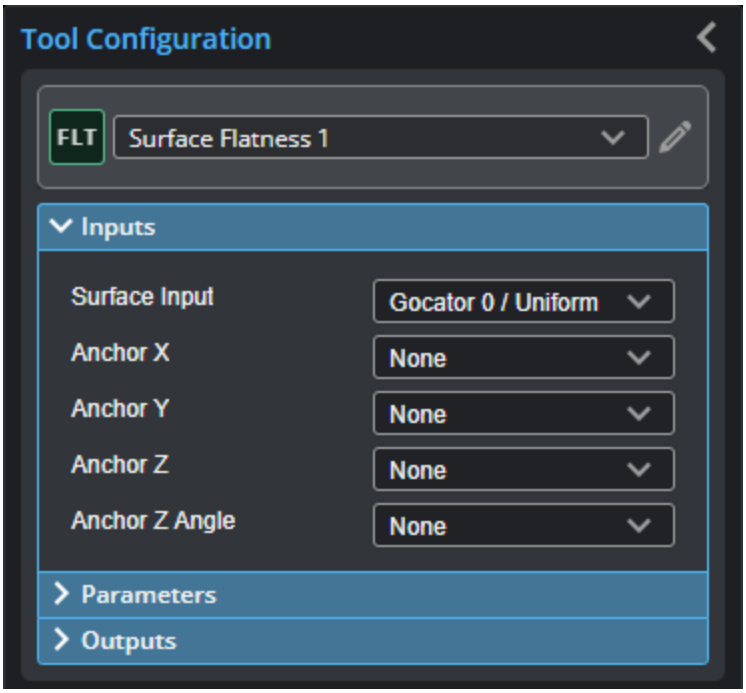
The tool lets you set a grid with user-defined cell sizes over a region, or more flexibly with multiple individual regions manually. In each case, "local" minimum and maximum heights, as well as flatness indicators (maximum - minimum), are returned. In addition, "global" minimum, maximum, and flatness measurements, which combine data from all flatness measurement areas, can also be returned. The tool measures the maximum and minimum distances from a best-fit plane for each cell or flexible region, and from another plane fit to all data for the "global" measurements.

You can control how many data points the tool uses in its calculations to account for noise or smooth data, or otherwise exclude unwanted data.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

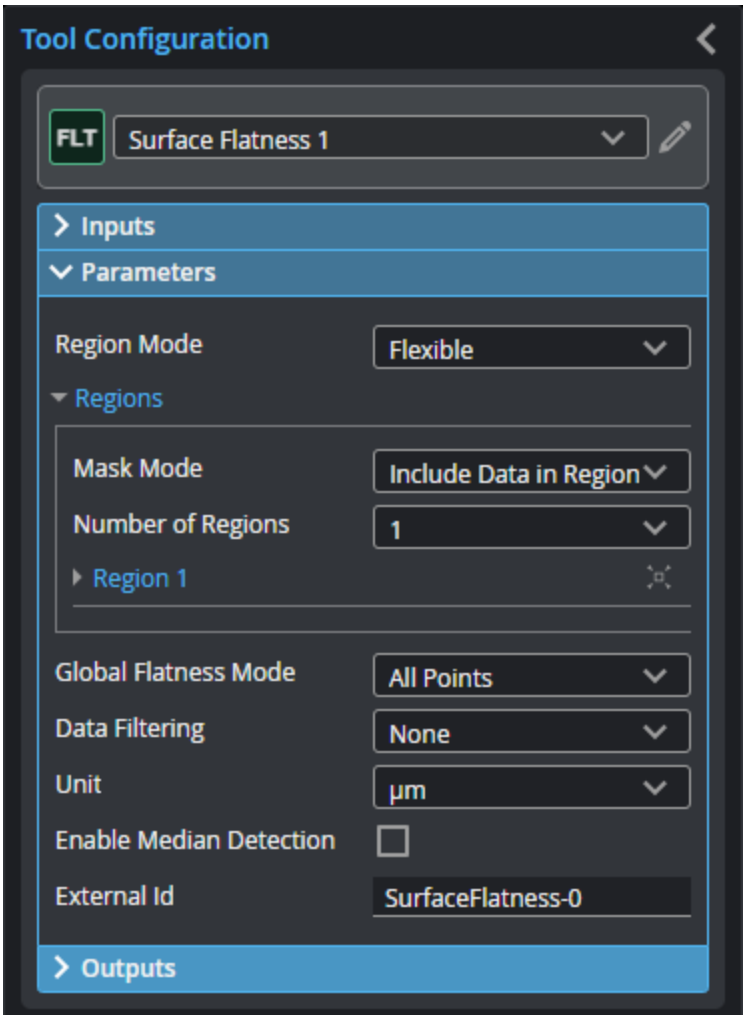
*Inputs*

| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |

| Name | Description |
|---|---|
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

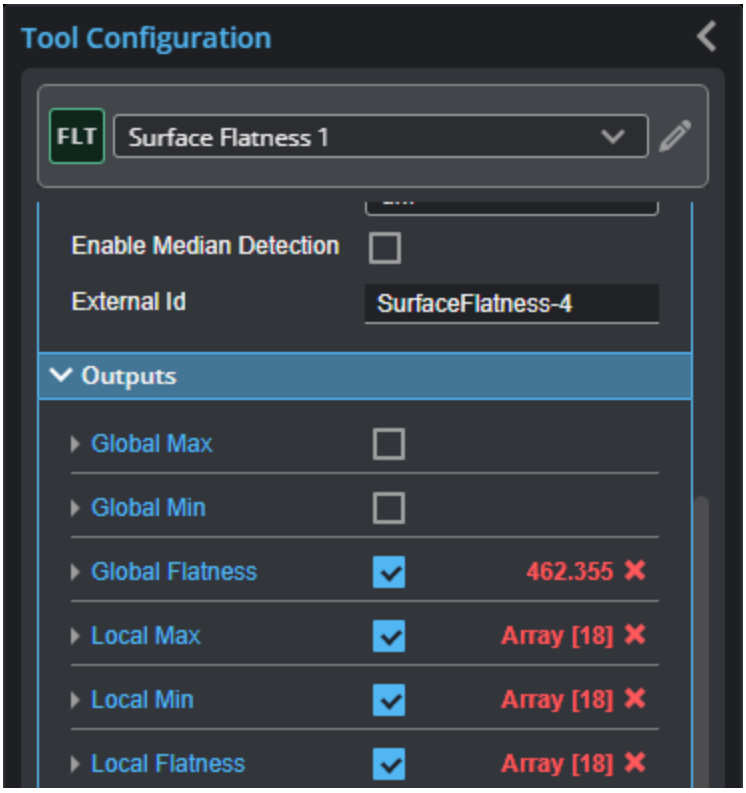
| Parameter | Description |
|---|---|
| Region Mode | Determines how flatness measurement areas are set up on the target. One of the following:<br>**Grid Pattern**: The tool determines flatness in a grid you define on the target. This |

| Parameter | Description |
| --- | --- |
| | option enables settings that let you set the size and location of a region that contains the grid (**Grid Region** setting), as well as the width and length of the grid cells (**Grid Width** and **Grid Length**). The combination of the values of these settings determines the number of cells in the grid region.<br>**Flexible**: The tool determines flatness using one or more regions that you define individually on the target. |
| Grid Region<br>*(used with Grid Pattern region mode)* | Determines the size of the grid region. (See details under **Grid Pattern** in **Region Mode** above.) |
| Grid Width (X)<br>Grid Length (Y)<br>*(used with Grid Pattern region mode)* | These settings determine the size of the cells in the grid. (See details under **Grid Pattern** in **Region Mode** above.) |
| Regions | When expanded, displays the region- and mask-related settings. |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Global Flatness Mode | Chooses which points the tool uses to calculate global flatness. One of the following:<br>**All Points**: The tool uses all points in the measurement area (all flexible regions or the grid pattern in the region).<br>**Single Average Point**: The tool uses an average of the points in the measurement area. When you choose this option, the global measurements require at least four data points to calculate the plane and statistics. This means that if you set **Region Mode** to **Flexible**, you must choose a minimum of four regions; if you set Region Mode to Grid Pattern, the size of the grid and the cells must result in at least four cells. |
| Data Filtering | Lets you filter scan data before the tool performs its calculations.<br>When you use Local Percentile or Global Percentile, you must set **High Percentile** and **Low Percentile**.<br>**None** - The tool performs no filtering.<br>**Local Percentile** - Applies the percentile filter to local masks first, and then merges to a global mask.<br>**Global Percentile** - Merges to a global mask first, and then applies the percentile filter to the global mask. |
| Unit | Lets you choose which units the tool uses for measurement results. One of the following: |

| Parameter | Description |
|---|---|
| | • um (micrometers)<br>• mm (millimeters) |
| Enable Median Detection | When enabled, Point geometric features for the global median and the local median are output. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

The unit of measurement values is set with the **Unit** drop-down.

*Measurements*

| Measurement |
|---|
| **Global Max** |
| **Global Min** |
| **Global Flatness** |

**Measurement**

The maximum distance, minimum distance, and flatness (maximum - minimum) calculated using the valid data points from *all* the cells in the grid (when **Region Mode** is set to **Grid Pattern**), or *all* the individual regions (when **Region Mode** is set to **Flexible**).

**Local Max**

**Local Min**

**Local Flatness**

Arrays containing the maximum distance, minimum distance, and flatness (maximum - minimum) calculated using the valid data points from the grid cells (when **Region Mode** is set to **Grid Pattern**), or the individual regions (when **Region Mode** is set to **Flexible**).

For more information on arrays, see *Arrays, Batching, and Aggregation* on page 171.

*Features*

| Type | Description |
|---|---|
| Global Plane | The plane fitted to the valid data points from *all* the cells in the grid (when **Region Mode** is set to **Grid Pattern**), or *all* the individual regions (when **Region Mode** is set to **Flexible**). |
| Local Plane | An array of the planes fitted to the valid data points from the grid cells (when **Region Mode** is set to **Grid Pattern**), or those from the individual regions (when **Region Mode** is set to **Flexible**). |
| Global Average Point<br>Global Max Point<br>Global Min Point<br>Global Median Point | Point geometric features representing the global average, the global maximum / minimum, and, if **Enable Median Detection** is enabled, the global median. |
| Local Average Point<br>Local Max Point<br>Local Min Point<br>Local Median Point | Arrays of point geometric features representing the local average, local maximum / minimum, and, if **Enable Median Detection** is enabled, local median. |

## Surface Hole

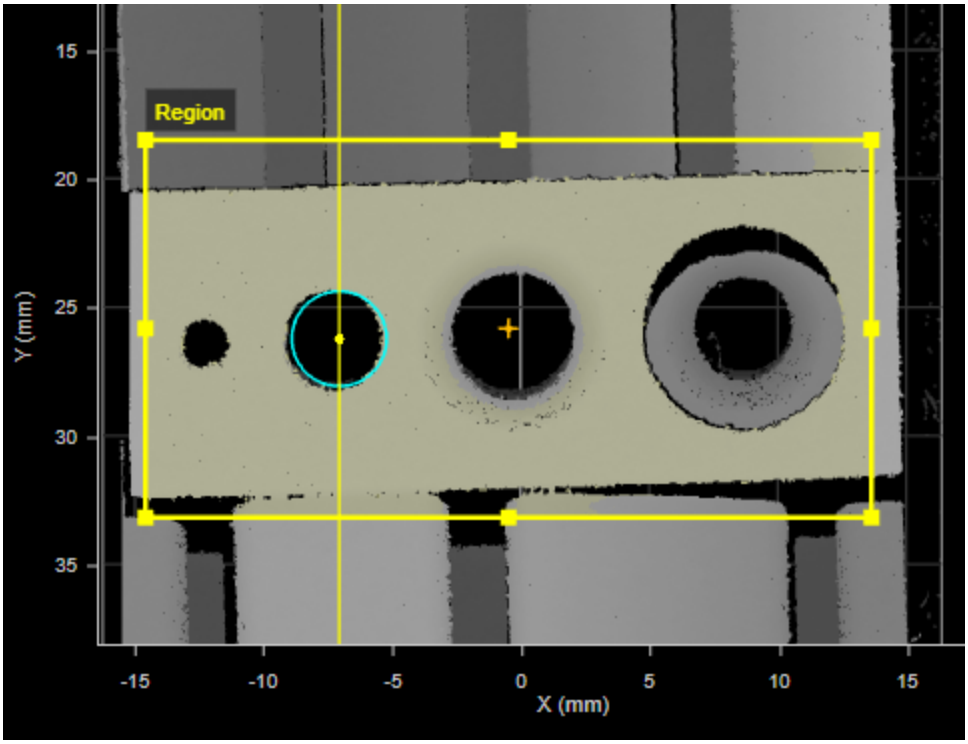
The Hole tool measures a circular opening within a region of interest on the surface and returns its position and radius.

> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

The hole can be on a surface at an angle to the sensor.

The tool uses a complex feature-locating algorithm to find a hole and then return measurements. For a detailed explanation of the algorithm, see *Hole Algorithm* on the next page. The behavior of the algorithm can be adjusted by changing the tool's parameters.

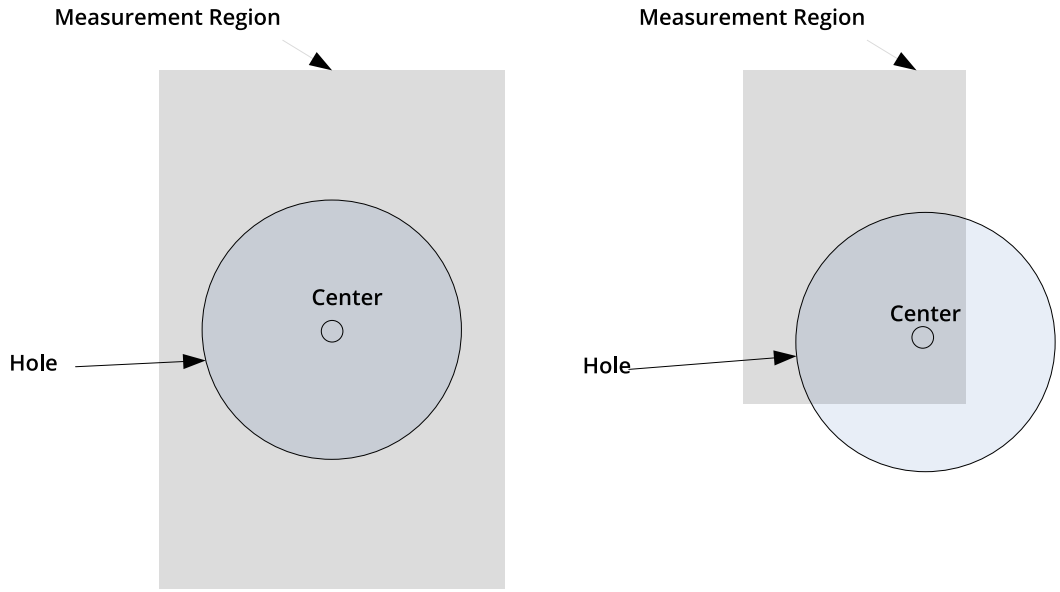
(The following screenshot is from a G2 sensor.)




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Measurement Region

The center of the hole must be inside the measurement region, even if the Partial Detection option is enabled. Either of the following is acceptable.




**Hole Algorithm**

The Hole tool processes the data in three phases: Search, Measure, and Filter. The algorithm can separate out background information that appears inside the hole. It can also detect holes that only partially appear in the data.

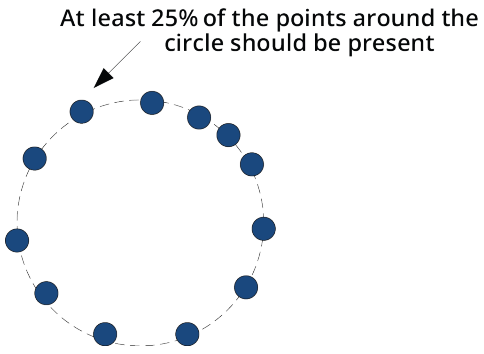
See the tool's parameters for an explanation of the options that affect the tool's algorithm.

**Search phase** - The tool searches for coarse data transitions (edge data) and performs a coarse fitting of the hole model (specified by the orientation angles and the nominal value) to determine the most likely candidate. If **Tilt Correction** is set to **Autoset**, the algorithm uses the data within the measurement region to estimate the orientation of the part.

**Measure phase** - A more rigorous edge detection algorithm is applied to precisely determine the edges around the feature. Edge detection at this stage will reject outliers and noise. The algorithm requires at least 25% of the data around the hole for the candidate to remain valid.

The accuracy of the algorithm improves when the points are spread more evenly along the hole's circumference.

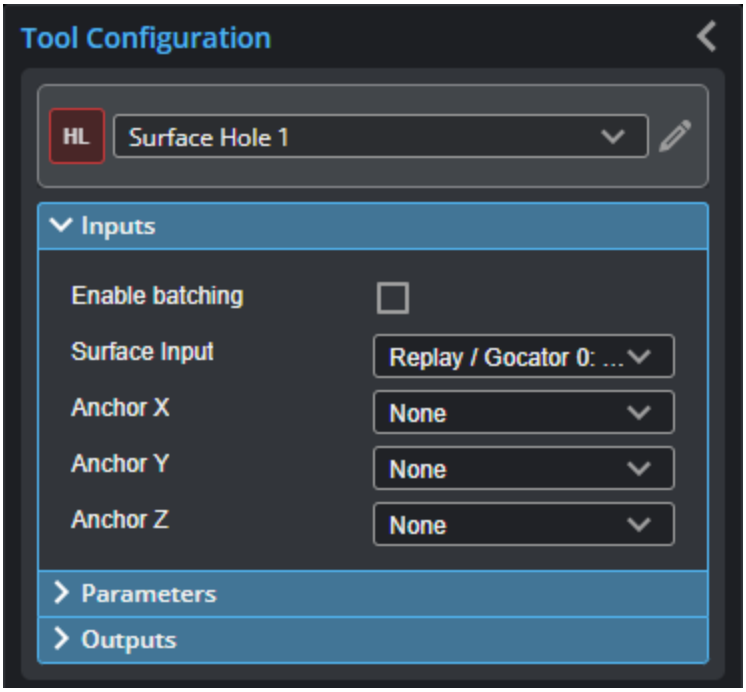
The set of refined edges is then used to locate and inspect the feature. If the Reference Regions option is enabled and set to AutoSet, the edges are also used to calculate the location of the reference regions.



**Filter phase** - The detected location and dimensions are then compared to the nominal and tolerance settings. If the refined feature falls within the measurement region and its measurements fit within the specified tolerance, the results are reported. If not, an invalid result is returned.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



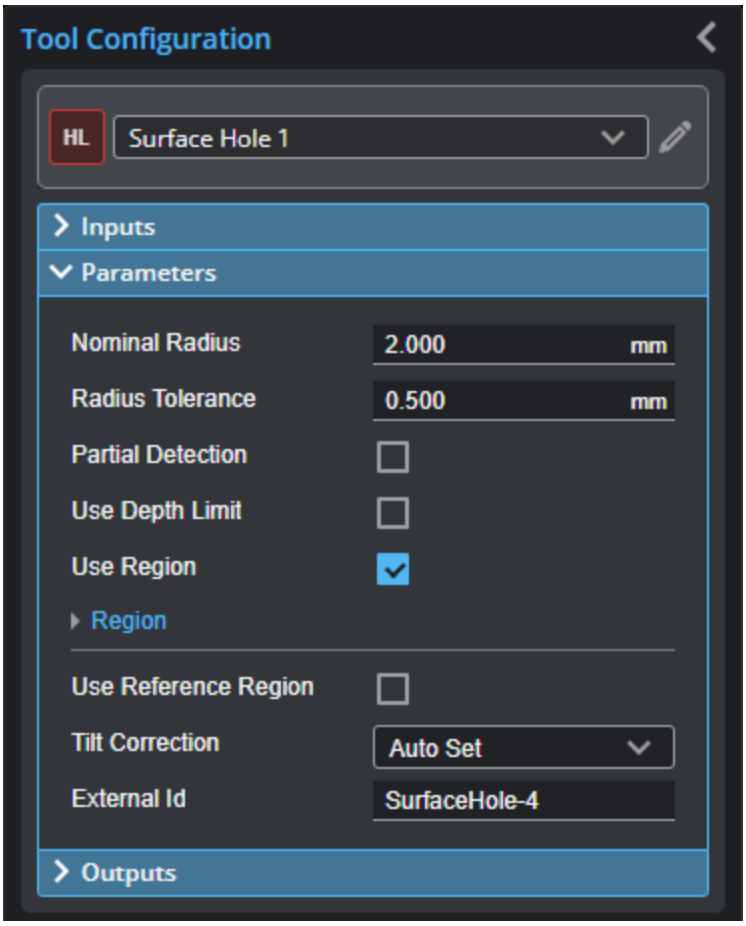

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

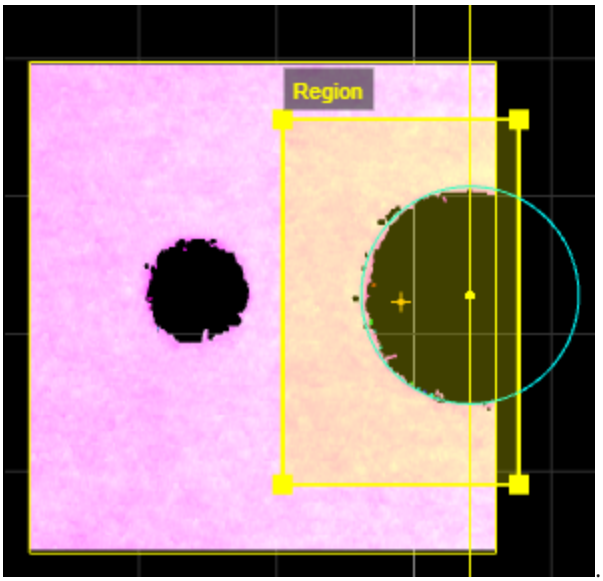
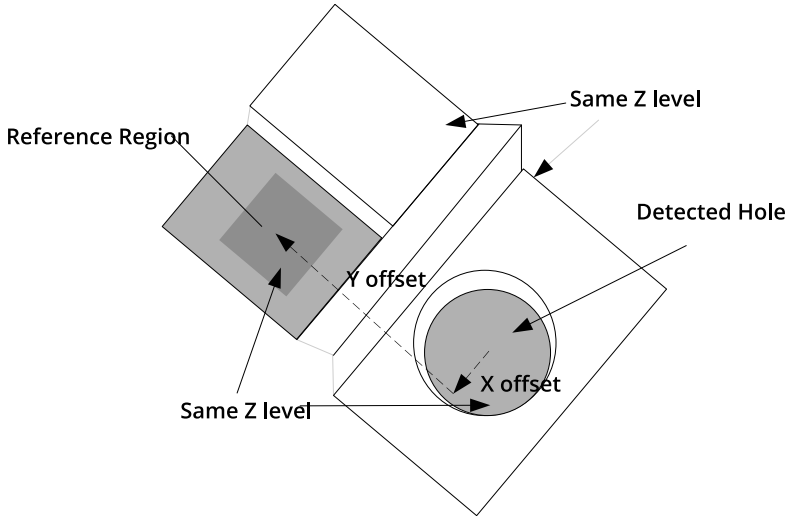
### Parameters

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

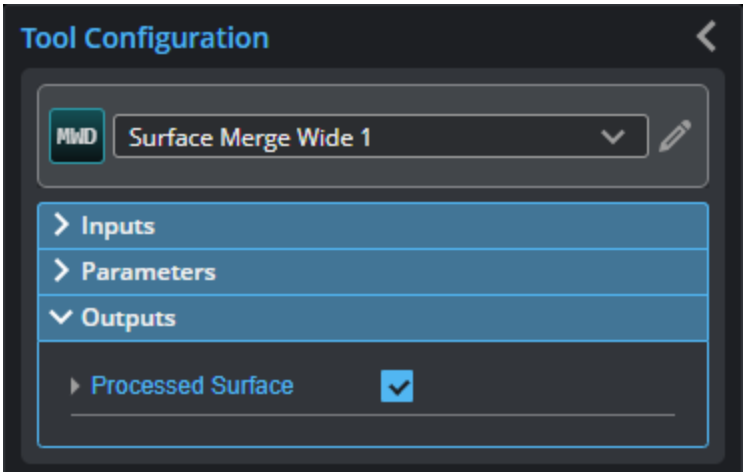
| Parameter | Description |
|---|---|
| Nominal Radius | Expected radius of the hole. |
| Radius Tolerance | The maximum variation from the nominal radius (+/- from the nominal radius). |
| Partial Detection | Enable if only part of the hole is within the measurement region; the centre of the hole must be in the measurement region to be located. If disabled, the hole must be completely in the region of interest for results to be valid. |

| Parameter | Description |
| --- | --- |
| |  |
| Use Depth Limit | When **Use Depth Limit** is enabled, data below the value set in **Depth Limit** (relative to the surface) is excluded from the hole calculations. |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Use Reference Region | When enabled, displays additional settings to let you set a reference region (see below). |
| Reference Region | The tool uses the reference regions to calculate the Z position of the hole. It is typically used in cases where the surface around the hole is not flat.  <br>When this option is set to **Autoset**, the algorithm automatically determines the |

| Parameter | Description |
|---|---|
| | reference region. When the option is set to **1 Region** or **2 Regions**, you must manually define the reference regions. The location of the reference region is relative to the detected center of the hole and positioned on the nominal surface plane.<br>When **Reference Region** is disabled, the tool measures the hole's Z position using all the data in the measurement region, except for a bounding rectangular region around the hole. |
| Tilt Correction | Tilt of the target with respect to the alignment plane.<br>**Autoset**: The tool automatically detects the tilt.<br>**Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below). |
| X Angle<br>Y Angle | The X and Y angles you must specify when **Tilt Correction** is set to **Custom**.<br>You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the **X Angle** and **Y Angle** parameters of this tool. For more information, see Plane. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

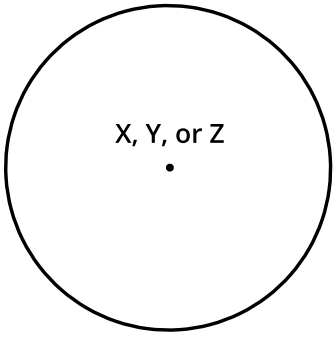
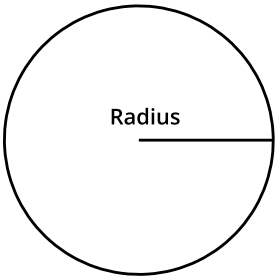
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the hole center. |  |
| **Y**<br>Determines the Y position of the hole center. | |
| **Z**<br>Determines the Z position of the hole center. | |
| **Radius**<br>Determines the radius of the hole. |  |

*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the hole. The Z position of the center point is at the Z position of the surrounding surface. |

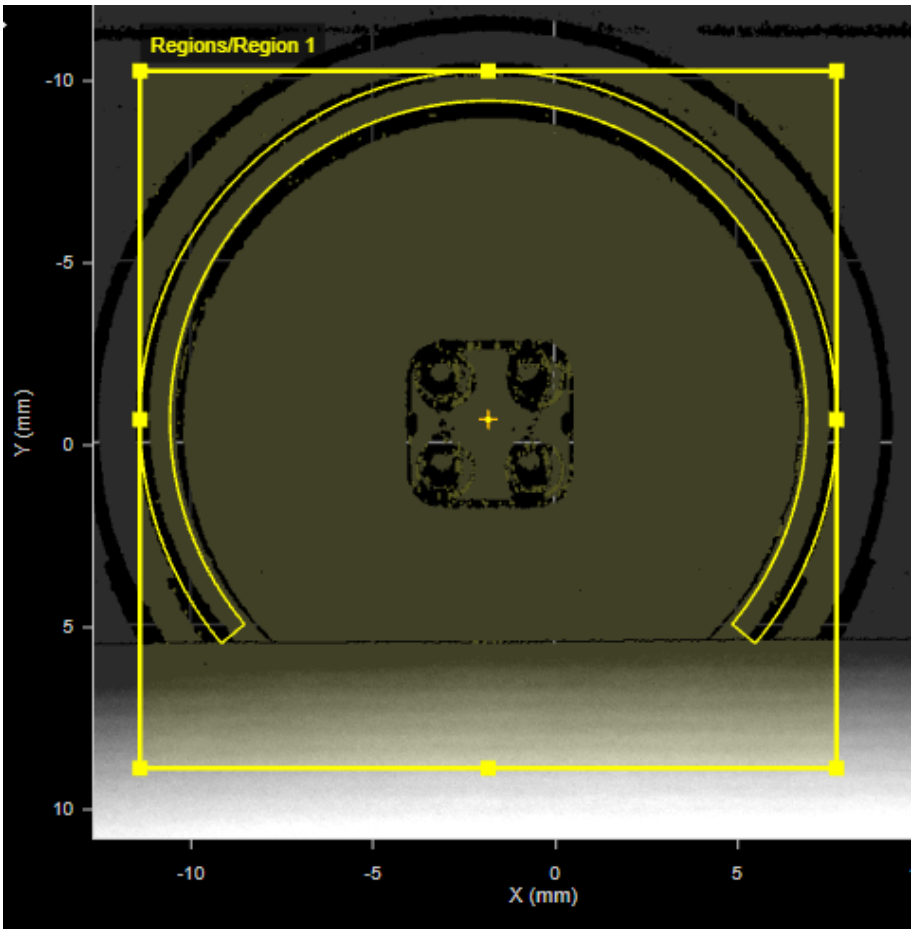
For more information on geometric features, see *Geometric Features* on page 191.

## Surface Mask

The Surface Mask tool lets define up to 16 regions to extract data from a surface. Each region's size, position, and shape (circular, elliptical, and rectangular) can be individually configured, and regions can overlap. The tool can also exclude inner data of circular and elliptical regions, letting you extract rings of surface data. Extracted data is output in a single surface.

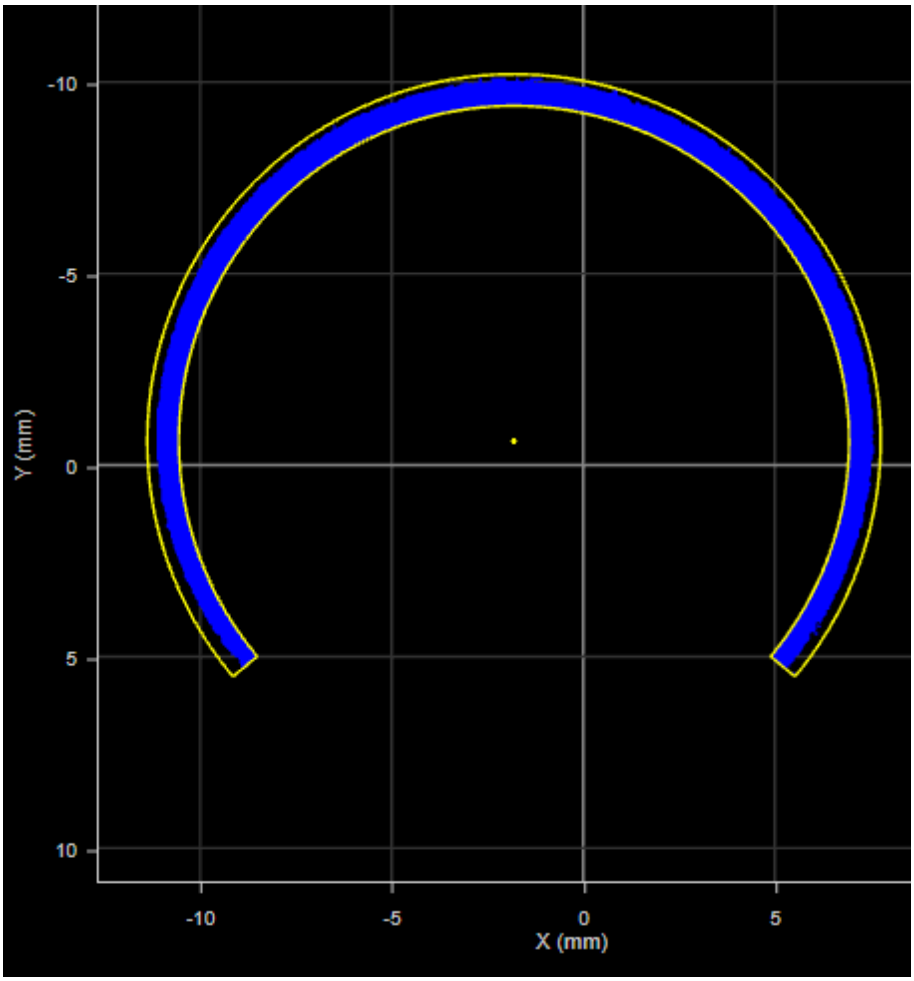
The resulting surface can then be further processed or measured by other tools.

For example, given the following scan data:




*A circle region box containing a partial ring (cyan)*

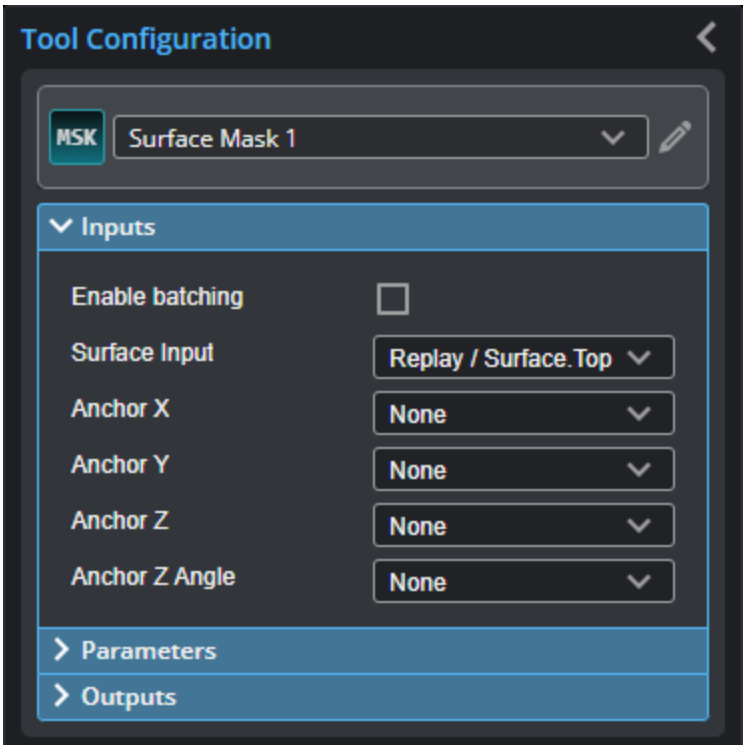
The image below shows the extracted data. The extracted surface data can then be further processed by other tools, or measurements can be applied to the surface data.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



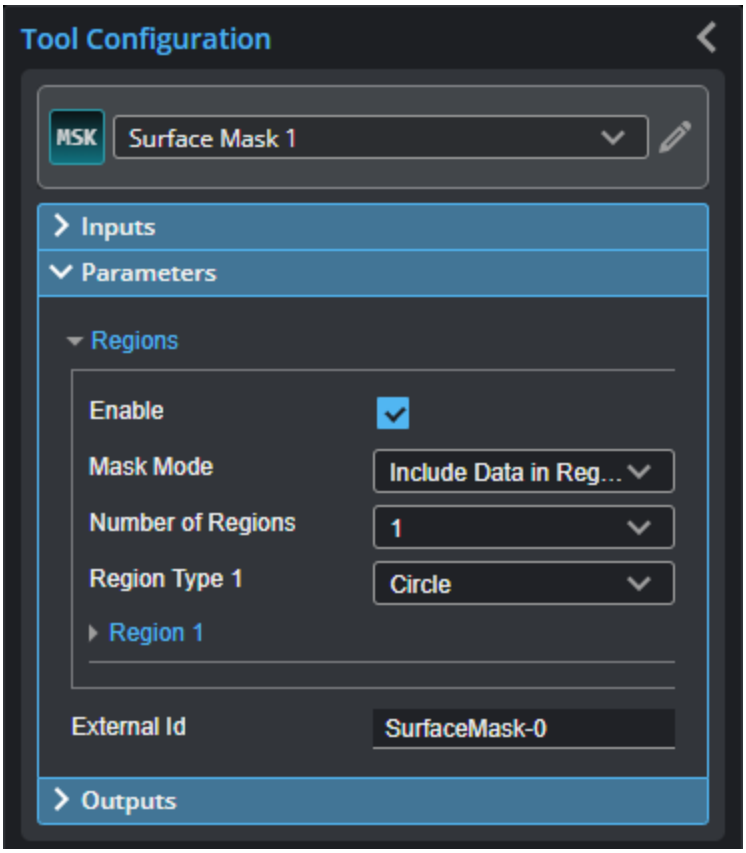

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

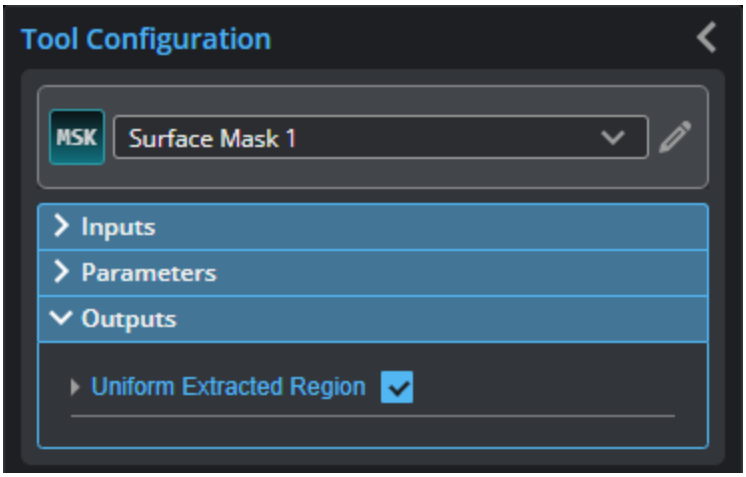



*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

| Type | Description |
|---|---|
| Uniform Extracted Region<br>Point Cloud Extracted Region | The surface containing the extracted region or regions. (Uniform and point cloud data, respectively.) |

## Surface Merge Wide

This tool is only intended for use with a multi-sensor G2 (line profile) system.

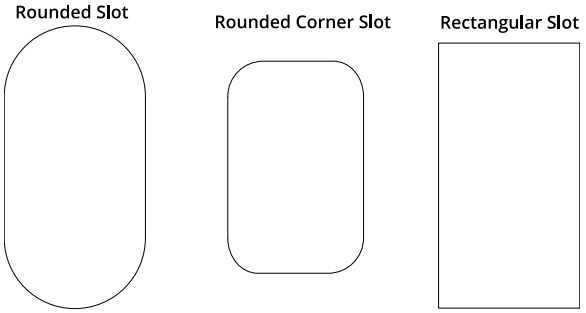
## Surface Mesh

This tool is only intended for use with a multi-sensor G2 (line profile) system.

## Surface Opening

The Opening tool locates rounded, rectangular, and rounded corner openings. The opening can be on a surface at an angle to the sensor.

> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

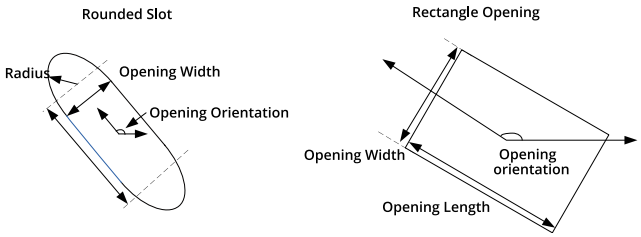



The tool uses a complex feature-locating algorithm to find a hold and then return measurements. For a detailed explanation of the algorithm the tool uses, see *Opening Algorithm* on the next page. The behavior of the algorithm can be adjusted by changing the tool's parameters.

The tool can separate out background information that appears inside the opening. It can also detect a slot that only partially appears in the data.

The shape of the opening is defined by its type and its nominal width, length, and radius.

The orientation defines the rotation around the normal of the alignment plane.

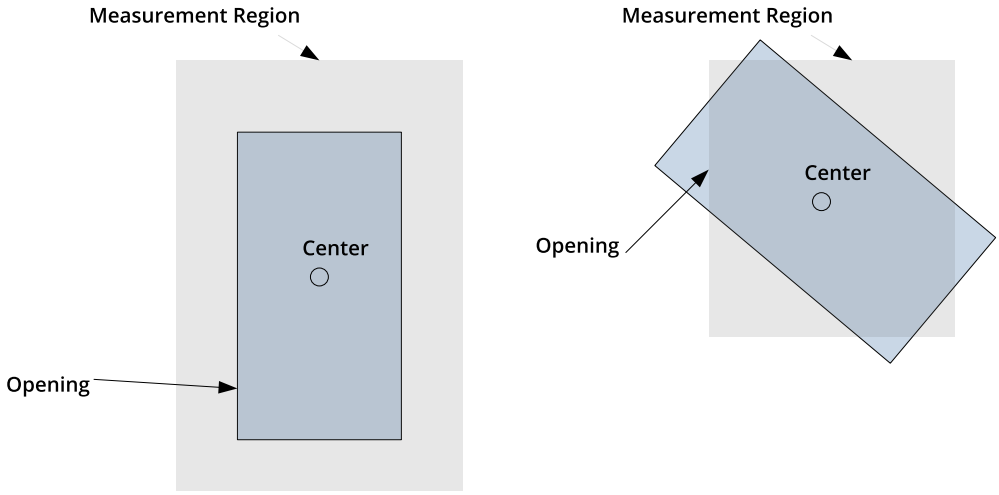



*Measurement Panel*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Measurement Region

The center and the two sides and ends of the opening must be within the measurement region, even if **Partial Detection** is enabled.




### Opening Algorithm

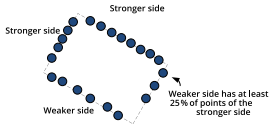
The Opening tool processes the data in three phases: Search, Measure, and Filter.

See the tool's parameters for an explanation of the options that affect the tool's algorithm.

**Search phase** - The tool searches for coarse data transitions (edge data) and performs a coarse fitting of the opening shape (specified by the orientation angles and the nominal dimensions) to determine the most likely candidate. If **Tilt Correction** is enabled, the algorithm uses the flat surface in the measurement region to estimate the orientation of the part.

**Measure phase** - A more rigorous edge detection algorithm is applied to precisely determine the edges around the feature. Edge detection at this stage will reject outliers and noise. The algorithm requires opposite sides and ends to be associated with a comparable number of edge pixels, with the weaker side or end having at least 25% of the stronger.

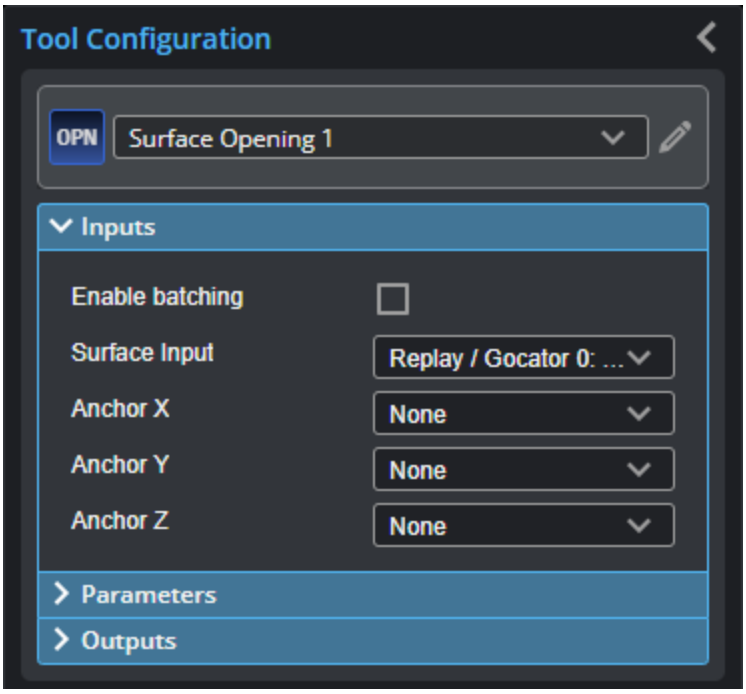
The set of refined edges is then used to locate and inspect the feature. If the **Reference Regions** setting is enabled, the edges are also used to calculate the location of the reference regions.




**Filter phase** - The detected location and dimensions are compared to the nominal and tolerance settings. If the refined feature falls within the measurement region and its measurements fit within the specified tolerance, the results are reported. If not, an invalid result is returned.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



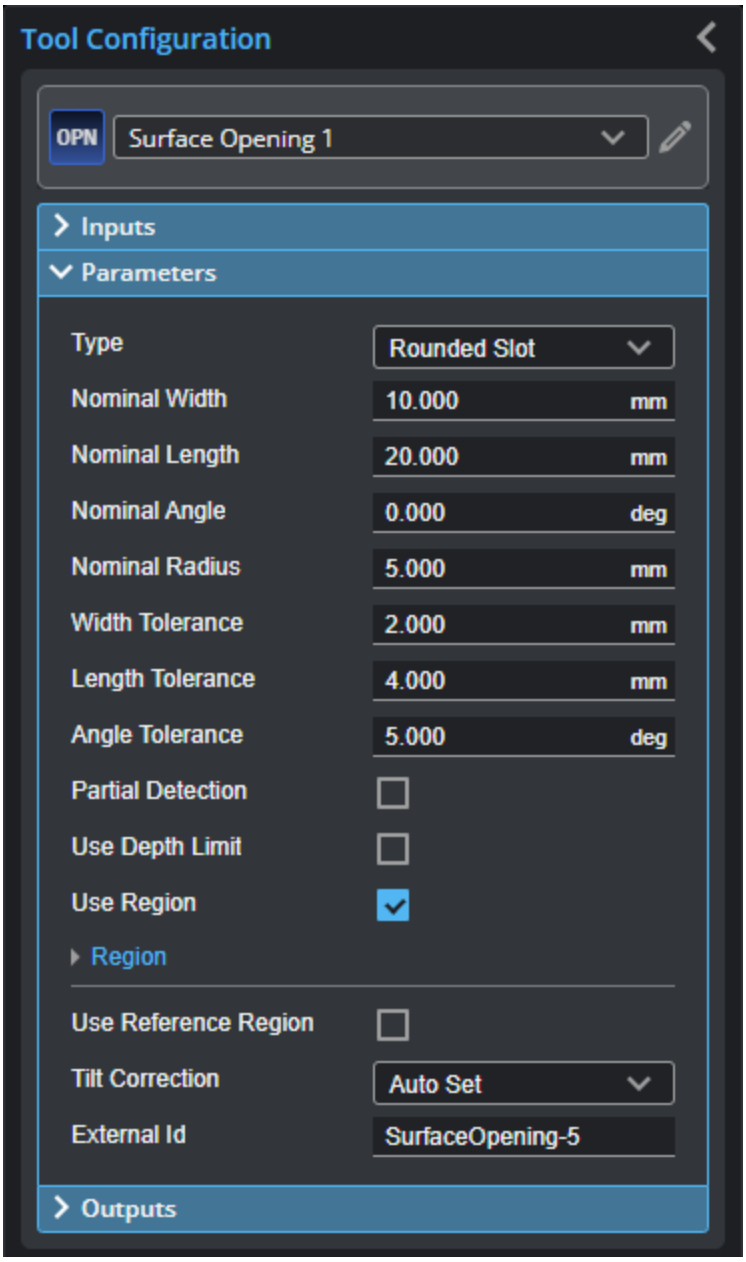

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

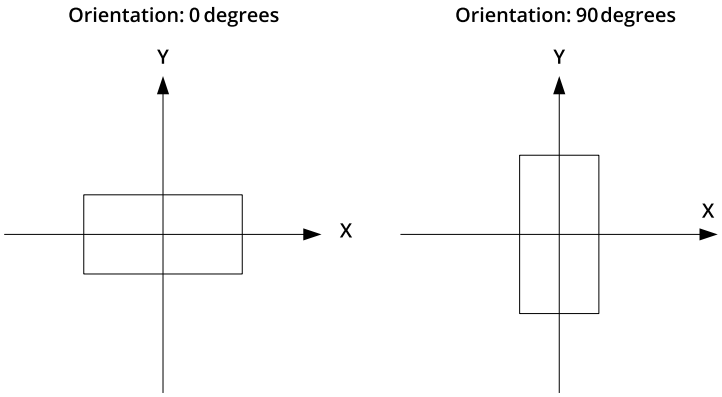
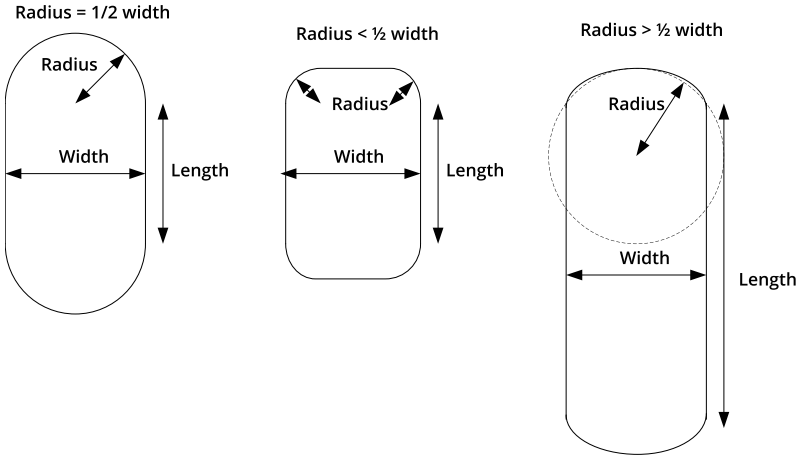
**Parameters**

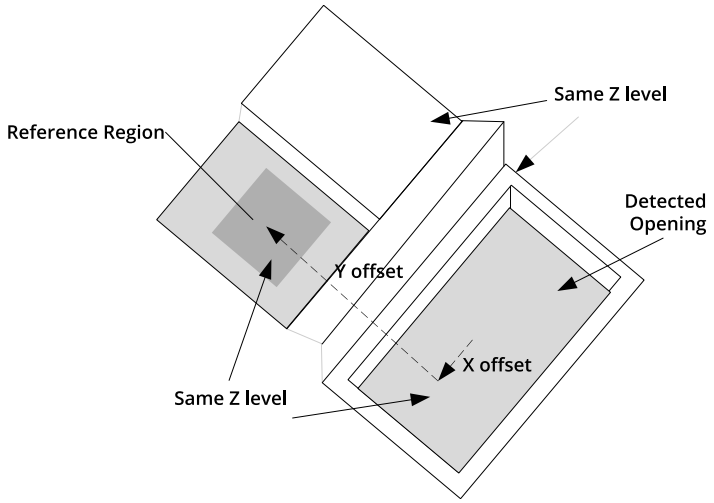
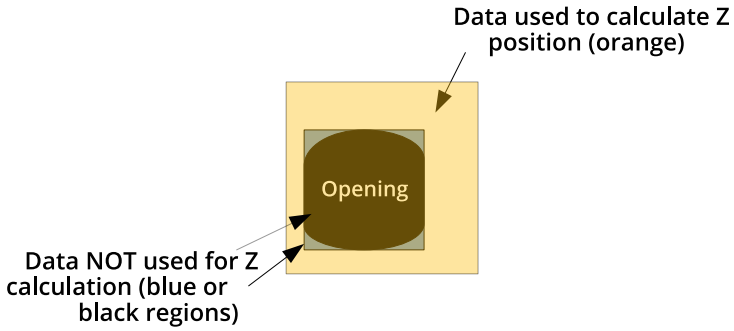
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

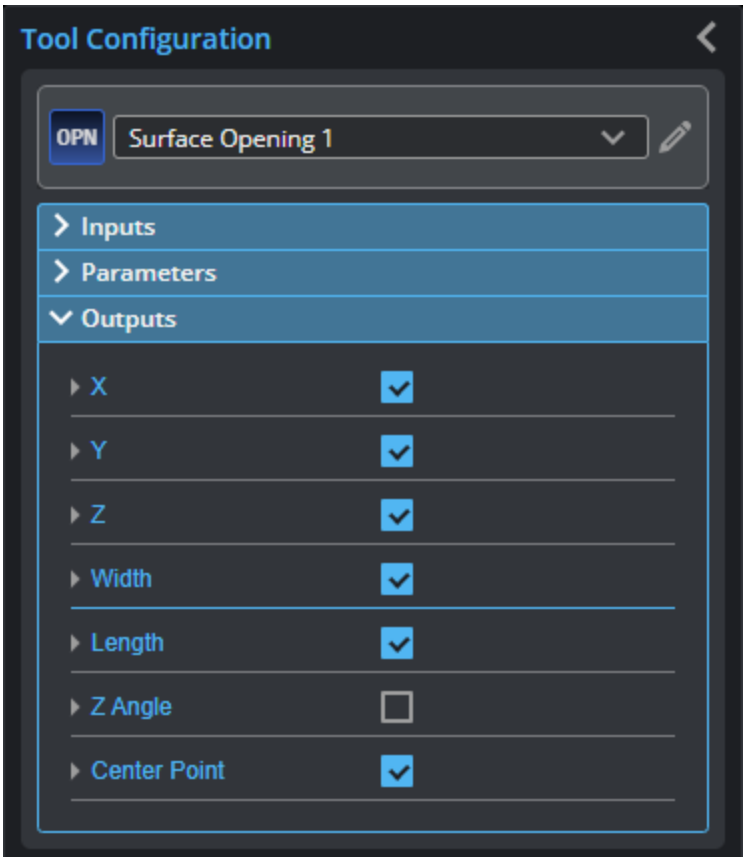
| Parameter | Description |
|---|---|
| Type | One of the following: Rounded Slot, Rectangle. |
| Nominal Width | Nominal width of the opening. |
| Nominal Length | Nominal length of the opening. |
| Nominal Angle | Nominal angle of the opening. The default orientation is the length of the opening along the X axis. |

| Parameter | Description |
|---|---|
| |  |
| Nominal Radius | Nominal radius of the opening ends. If the opening type is set to rectangular, the radius setting is disabled. The opening has an oval shape if the radius is equal to ½ of the width. The opening is a rounded rectangle when the radius is less than ½ of the width.<br>  |
| Width Tolerance<br>Length Tolerance<br>Angle Tolerance | The maximum variation from the nominal width, length, and angle (+/- from the nominal value). |
| Partial Detection | Enable if only part of the opening is within the measurement region. If disabled, the opening must be completely in the region of interest for results to be valid. |
| Use Depth Limit<br>Depth Limit | When **Use Depth Limit** is enabled, data below the value set in **Depth Limit** (relative to the surface) is excluded from the opening calculations. |
| Use Region | If enabled, displays an expandable region section where you define the region. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Use Reference Region<br>Reference Type<br>Reference Region {n} | When **Use Reference Region** is enabled, the tool uses reference regions to calculate the Z position of the opening. Reference regions are relative to the center location of the feature. This option is typically used in cases where the |

| Parameter | Description |
| --- | --- |
| | surface around the opening is not flat.<br>  <br><br>When the Reference Regions setting is disabled, the tool measures the opening's Z position using all data in the measurement region, except for a bounding rectangular region around the opening.<br>  <br><br>With one or more reference regions, the algorithm calculates the Z positions as the average values of the data within the regions.<br>When you place the reference region manually, all of the data is used, whether the data is inside or outside the opening. You should place the reference region carefully. |
| Tilt Correction | Tilt of the target with respect to the alignment plane.<br>**Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes.<br>**Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below). |
| X Angle<br>Y Angle | The X and Y angles you must specify when **Tilt Correction** is set to **Custom**.<br>You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to |

| Parameter | Description |
|---|---|
| | the **X Angle** and **Y Angle** parameters of this tool. For more information, see Plane. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

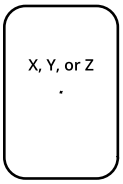
**Outputs**

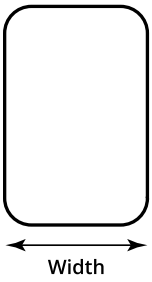
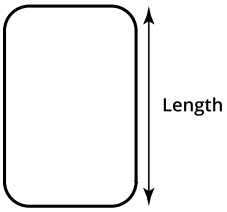
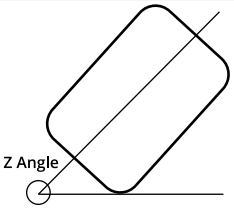



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the opening's center. |  |
| **Y**<br>Determines the Y position of the opening's center. | |
| **Z**<br>Determines the Z position of the opening's center. | |

| Measurement | Illustration |
|---|---|
| **Width**<br>Determines the width of the opening. |  |
| **Length**<br>Determines the length of the opening. |  |
| **Z Angle**<br>Determines the angle (rotation) around the normal of the alignment plane. |  |

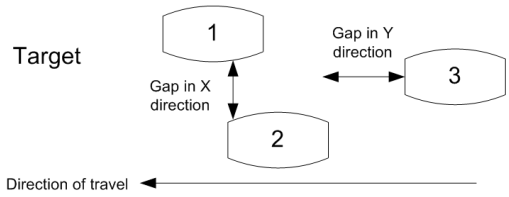
*Features*

| Type | Description |
|---|---|
| Center Point | The center point of the opening. The Z position of the center point is at the Z position of the surrounding surface. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Part Detection

The Surface Part Detection tool identifies discrete objects in Surface data and then outputs them as Surface data. Surface measurements can then be performed on each object.

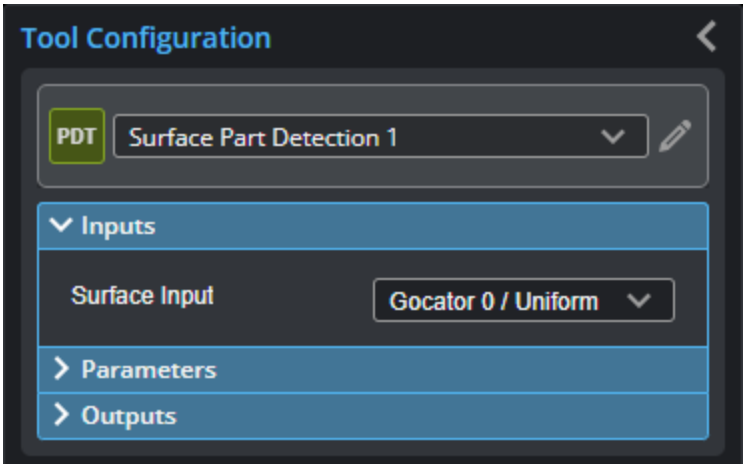



Part detection can be performed when **Source** on the **Acquire** page in the **Trigger** panel is set to **Time** or **Encoder**. To use the **Time** trigger source, the travel speed must be calibrated. To use the **Encoder** trigger source, the encoder resolution must be calibrated.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

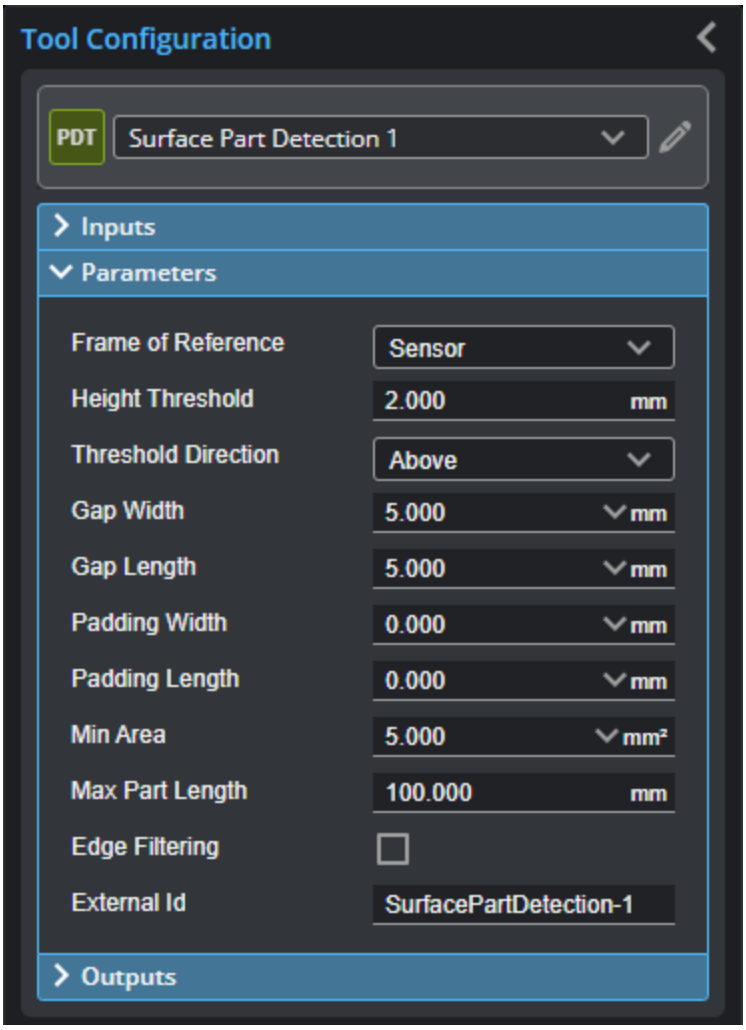



*Inputs*

| Name | Description |
|---|---|
| Surface Input | The source of data for the tool. |

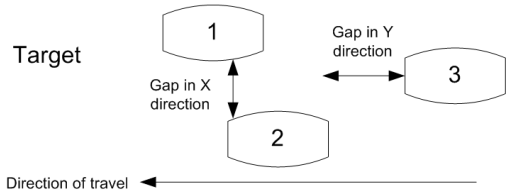
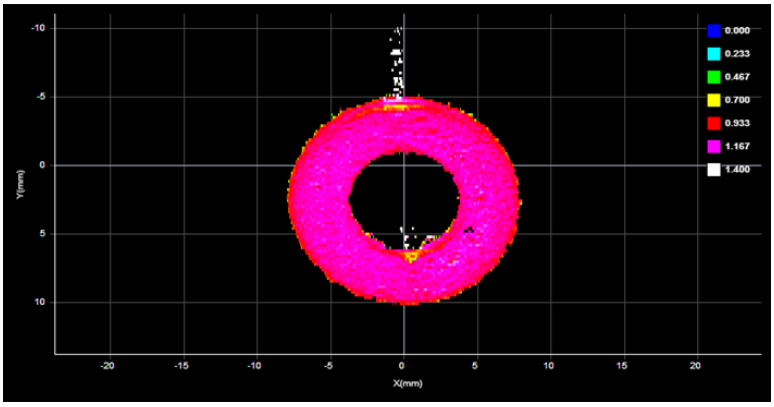
### Parameters

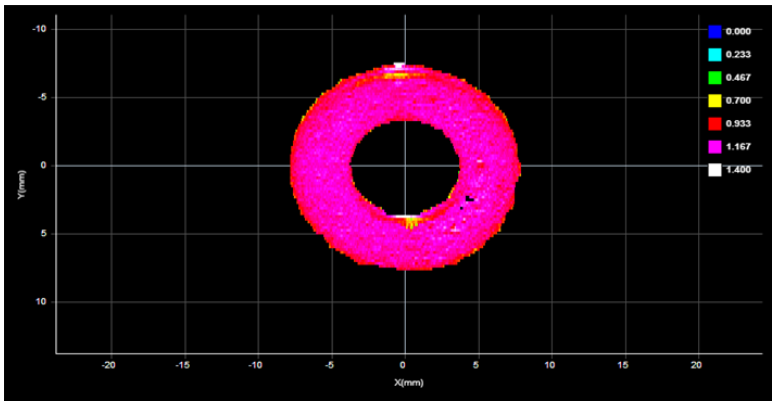
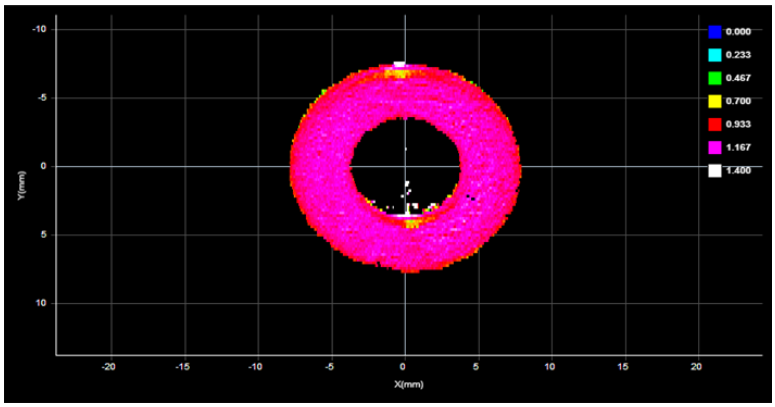
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

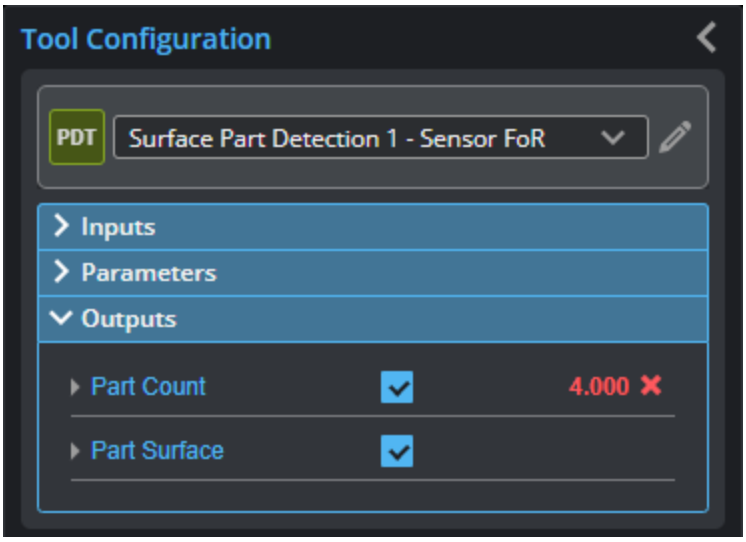
| Parameter | Description |
|---|---|
| Frame of Reference | Determines the coordinate reference for surface measurements.<br><br>**Sensor**<br>When **Frame of Reference** is set to **Sensor**, the sensor's frame of reference is used.<br><br>**Part**<br>When **Frame of Reference** is set to **Part**, all measurements are relative to the center of the bounding box of the part. |
| Height Threshold | Determines the height threshold for part detection. The setting for **Threshold Direction** (see below) determines if parts should be detected above or below the value in **Height Threshold**. Above is typically used to prevent the belt surface from being detected as a part when scanning objects on a conveyor. |

| Parameter | Description |
|---|---|
| Threshold Direction | Determines if parts should be detected above or below the height threshold. |
| Gap Width<br>Gap Length | **Gap Width** and **Gap Length** determine the minimum separation between objects on the X and the Y axis, respectively. If parts are closer than the gap interval, they will be merged into a single Surface output.<br>  |
| Pad Length | These parameters are useful when processing part data with third-party software such as HexSight, Halcon, etc.<br>**Pad Width** and **Pad Length** control the amount of additional scan data output in the X and Y directions, respectively. The padding can contain data points that were outside the height threshold and excluded from the initial part detection. |
| Min Area | Determines the minimum area for a detected part. Set this value to a reasonable minimum in order to filter out small objects or noise. |
| Max Length | Determines the maximum length of the part object. When the object exceeds the maximum length, it is automatically separated into two parts. This is useful to break a long object into multiple sections and perform measurements on each section. |
| Edge Filter | When **Edge Filter** is enabled, an **Edge Filter** expanding section is displayed that contains the settings described below.<br>Part scans sometimes contain noise around the edges of the target. This noise is usually caused by the sensor's light being reflected off almost vertical sides, rounded corners, etc. Edge filtering helps reduce edge noise in order to produce more accurate and repeatable volume and area measurements, as well as to improve positioning of relative measurement regions.<br>(The following screenshots are from a G2 sensor.)<br>  <br>*Edge Filter disabled (scan shows reflection noise)* |

| Parameter | Description |
| --- | --- |
| |  <br>*Edge Filter enabled (reflection noise eliminated or reduced)*<br>  <br>*Edge Filter enabled, Keep Interior enabled* |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Measurements*

| Measurement |
| --- |
| **Part Count** |
| The number of parts the engine detects. |

*Data*

| Type | Description |
| --- | --- |
| Part Count | The number of parts detected. |
| Part Surface | The Surface data of the detected part. |

## Surface Pattern Matching

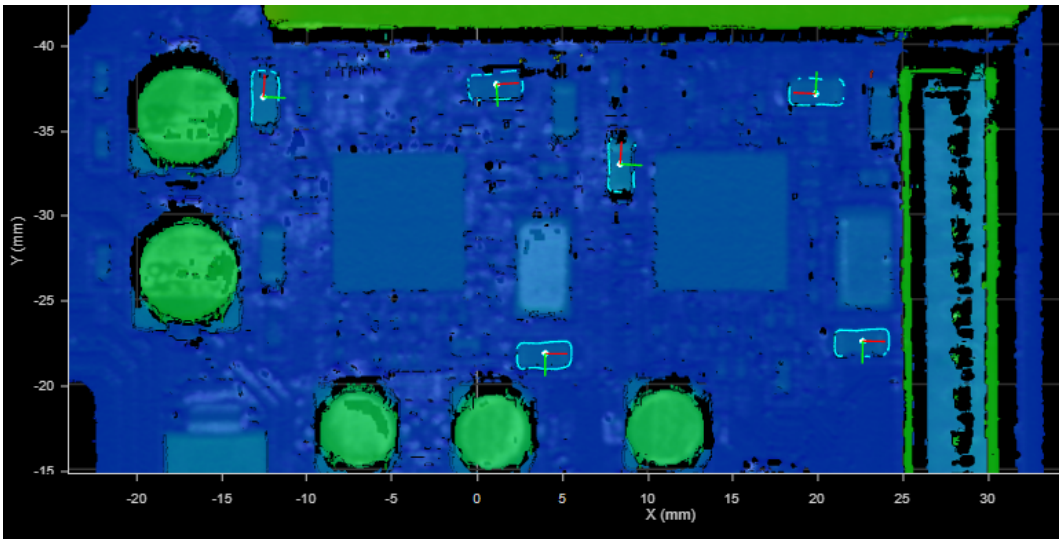
The Surface Pattern Matching tool locates parts and features by comparing 2D contours (on the XY plane) found in scan data to pattern models you have defined; note that the tool does not use height data in its algorithms. Models represent contour-based "golden parts" or "golden features."

The tool can process multiple occurrences of a part or feature in a frame of scan data. For each matching part or feature (called an instance), the tool returns X and Y position and rotation (angle) measurements, which you can use to anchor other measurements (for more information on anchoring, see *Measurement Anchoring* on page 193).

The tool also returns a point and a line geometric feature for each instance, which you can use in conjunction with Surface Transform tools to shift and rotate scan data to reliably position the target.

Finally, the tool returns a match quality that you can use as a general conformity measure for matching instances (for example, checking for dents in a target), as well as a count of located instances.

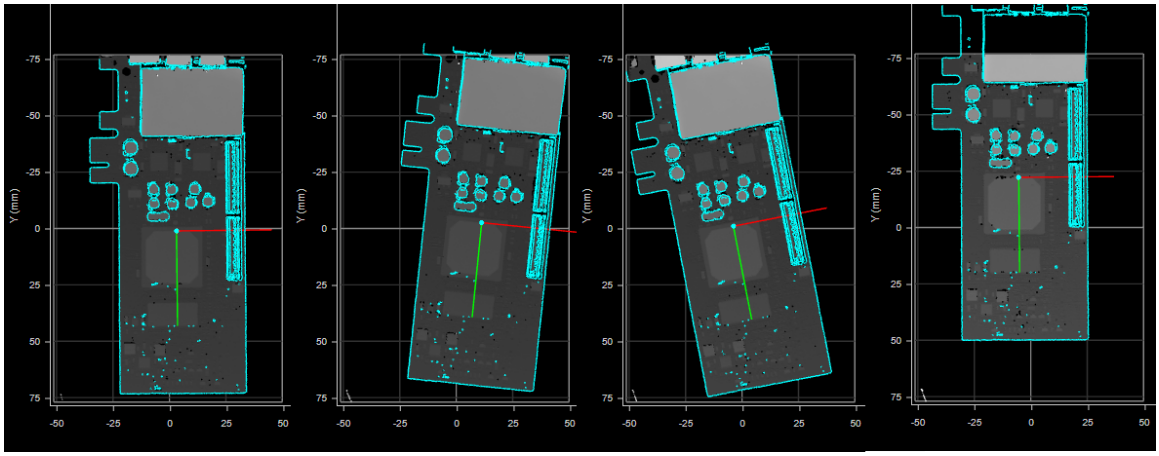
> In order to create a template for a *feature* on a target, you typically need to enable the **Use Region** checkbox to limit the tool to the contours related to that feature. After that, when running the tool to find instances of the feature, you should either modify the region to limit it to areas of the target that might contain the feature you are looking for or *disable* **Use Region** so that the tool can locate instances of the feature in all of the scan data. You can also use the **Use Region** parameter when creating a template to limit it to a unique portion of an outer edge of a target.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

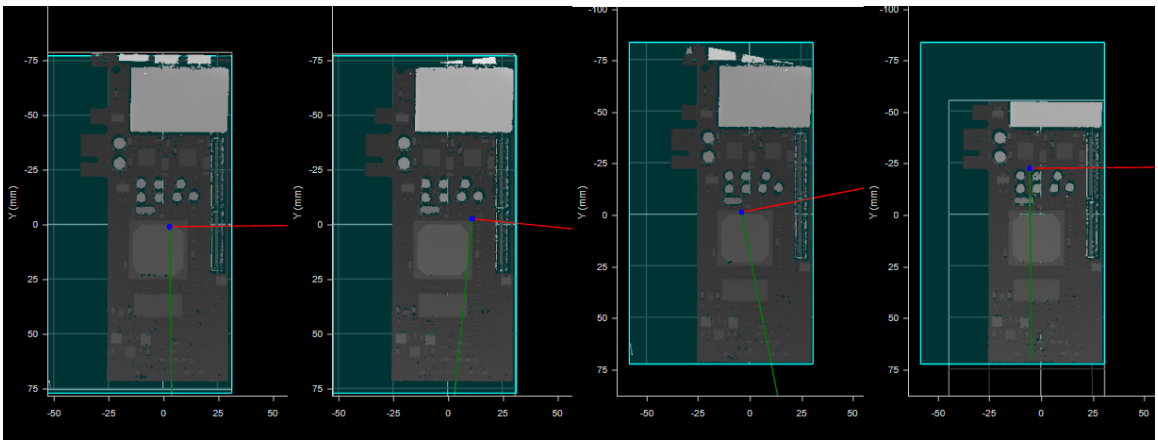
Note that when you use the geometric features with a Surface Transform tool to transform the scan data from frame to frame, you can often avoid the need to anchor other measurements, because the transforms ensure that any features you are interested are always in the same location. This can save considerable setup time and reduce the complexity of an application. For example, in the

following frames of scan data, in which a PCB shifts from frame to frame, a Surface Pattern Matching tool successfully locates the entire PCB using its outer contours and the contours of various components on the PCB, as indicated by a dark blue outline. Note the “missing” data in the second and fourth frames, on the lower right and left edges, respectively: the tool still locates the PCB, despite the occlusions.



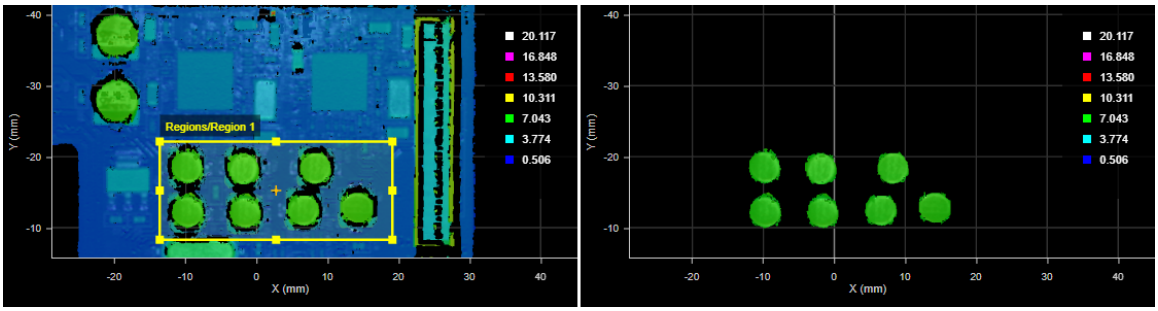
*Four frames of scan data. Light blue outline represents the matching template. The first frame was used to create the template.*

When the tool’s Point and Line geometric features are passed to a Surface Transform tool, the transformed scan data ensures that features are always in the same location and orientation.



*Transformed scan data of the four frames.*

Other measurement tools can then be placed over the capacitors, without needing to anchor them. In the following image (the third frame, which was significantly shifted and rotated), a Surface Filter tool isolates the capacitors based on height. Subsequent tools can perform measurements on the isolated data to verify that all capacitors are present, are seated properly, and so on.

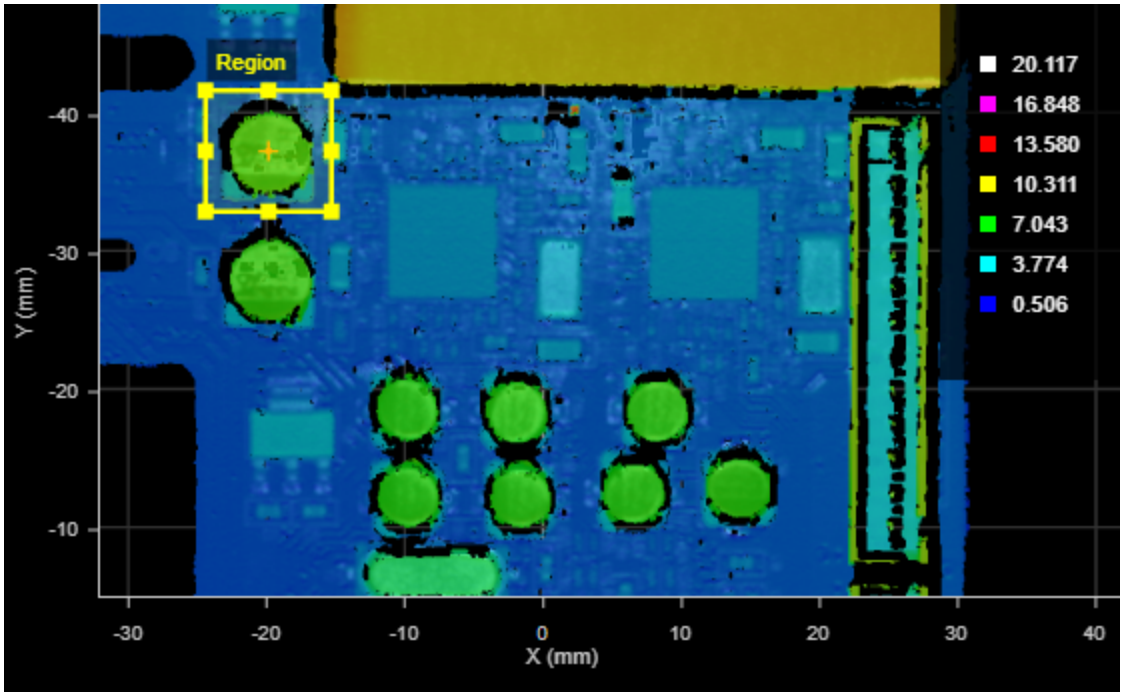



By adding multiple Surface Pattern Matching tools to a job and defining different templates for each, you can match multiple types of features or parts, for example, matching different parts moving on a conveyor, or different types of features on a single target.

### Creating a Template

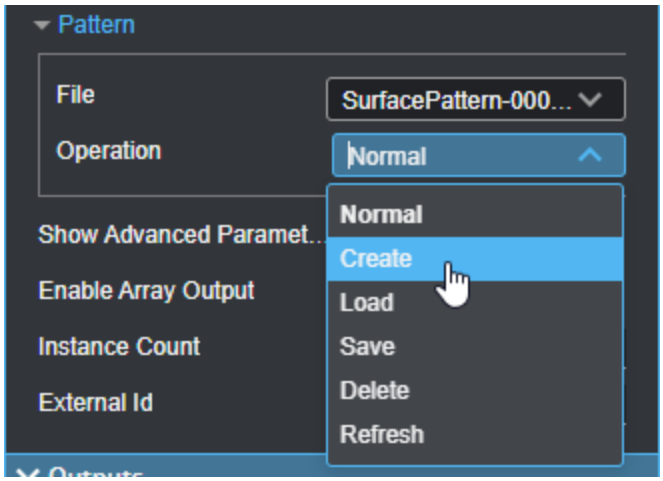
*To create a template:*

1. Scan a part that is representative of a "good" part (no damage, all features are present, and so on).
2. Add an instance of Surface Pattern Matching.
3. If you need to perform pattern matching on a feature on the part, enable **Use Region** and position the region over the feature.

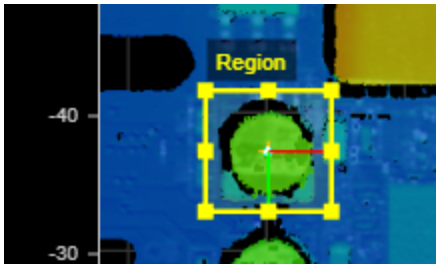



Otherwise, if you need to match the entire part, for example to orient parts from frame to frame, leave **Use Region** disabled to perform pattern matching on all of the scan data. This only works if no unwanted data is in the frame, such as the conveyor.

4. In the **Operation** drop-down, choose **Create**.




The tool creates a model and saves it either to the PC or to the sensor. The tool also "matches" the pattern.

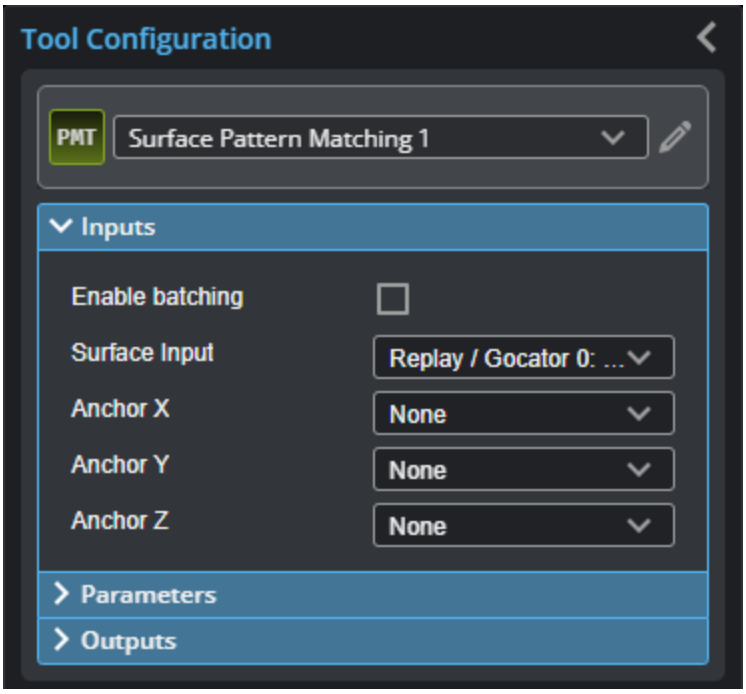



5. Disable, resize, or reposition the region as necessary to match the pattern in parts you will be scanning in production.

After creating a template, configure the tool's parameters (see below) for use during production runs.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



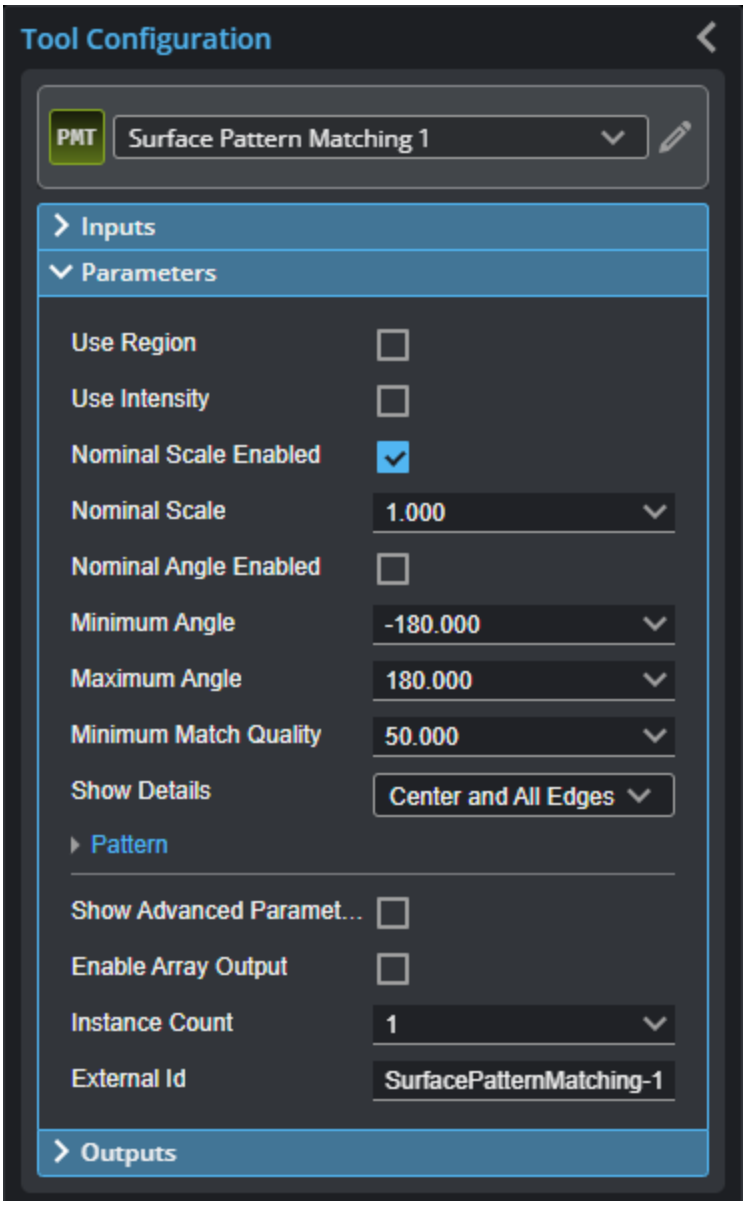

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Use Region | Determines whether the tool uses a user-defined region to search for matching instances, or, when first creating a template, whether the tool limits establishing template contours to the data in the ROI. |
| Region | Settings related to the region. For more information, see *Regions* on page 181. |
| Use Intensity | Determines whether the tool uses intensity instead of heightmap data to locate instances or create templates. |
| Nominal Scale Enabled | If **Nominal Scale Enabled** is checked, the tool displays the **Nominal Scale** setting and the tool uses the user-defined nominal scale. Otherwise, the tool displays **Minimum Scale** and **Maximum Scale** settings and uses the user-defined range. |

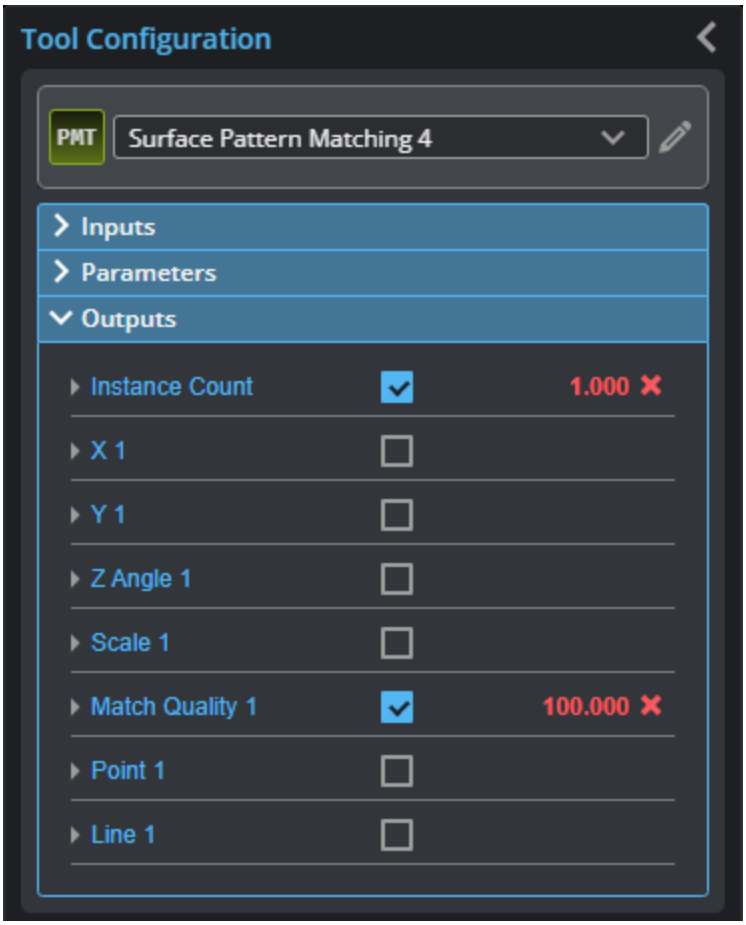
| Parameter | Description |
|---|---|
| Nominal Scale | The scale factor the tool requires to recognize an instance.<br>Displayed when **Nominal Scale Enabled** is enabled. |
| Minimum Scale<br>Maximum Scale | The minimum and maximum scale factors set the acceptable scaling range of an instance.<br>Displayed when **Nominal Scale Enabled** is disabled. |
| Nominal Angle Enabled | If enabled, displays the **Nominal Angle** setting and the tool uses the user-defined nominal angle. Otherwise, the tool displays **Minimum Angle** and **Maximum Angle** settings and uses the user-defined range. |
| Nominal Angle | The angle the tool requires to recognize an instance.<br>Displayed when **Nominal Angle Enabled** is enabled. |
| Minimum Angle<br>Maximum Angle | The minimum and maximum angles allowed for the tool to recognize an instance, respectively.<br>Displayed when **Nominal Angle Enabled** is disabled. |
| Minimum Match Quality | Minimum percentage of template contours that must match in the scan data for the tool to consider the object instance as valid. |
| Show Detail | Toggles whether to overlay tool details.<br>**Center only**: The center of the found pattern and its XYZ axes.<br>**Center and All Edges**: The center of the found pattern and its XYZ axes, as well as the outline of the full pattern template.<br>**Center and Matched Edges**: The center of the found pattern and its XYZ axes, as well as the matched edges only. |
| Pattern | When expanded, displays parameters related to template files.<br><br>**File**<br>A drop-down containing the currently available templates.<br><br>**Operation**<br>The operation to perform on the currently selected template in the File drop-down. One of the following:<br>**Normal**: The default value after having performed another operation.<br>**Create**: Creates a new template based on the current frame of scan data. Limited to the region if **Use Region** is enabled.<br>**Load**: Loads the currently selected template.<br>**Save**: Saves contour data to the currently selected template, overwriting its contour data.<br>**Delete**: Deletes the currently selected template.<br>**Refresh**: Refreshes the list of templates. This is useful if you have renamed a template (using the Pattern Editor or manually in the client PC's file system). |

| Parameter | Description |
| --- | --- |
| Show Advanced Parameters | When enabled, the tool displays the following additional advanced parameters.<br><br>**Sorting**<br>The sort order of instances the tool uses. One of the following:<br>• Evidence: The instances are ordered according to their hypothesis strength.<br>• Quality: The instances are ordered according to their match quality. This setting can significantly increase the tool's search time because it can't output instance results until it has found and compared all instances to determine their order. The time required to output the first instance corresponds to the total time needed to search the image and analyze all the potential instances. The time for additional instances is zero since the search process is already complete.<br>• Position - X increasing<br>• Position - X decreasing<br>• Position - Y increasing<br>• Position - Y decreasing<br><br>**Recognition Level**<br>The "effort" the tool will expend on recognizing an instance in scan data. Ranges from Fast to Accurate (that is, there is a trade-off between accuracy and speed). Only used during pattern matching (and not during pattern template creation).<br><br>**Positioning Level**<br>How accurately the tool determines the position of the instance. Ranges from Fast to Accurate. Only used during pattern matching (and not during pattern template creation).<br><br>**Match Tolerance Mode**<br>The tolerance the tool uses when attempting to match contours in the scan data to the loaded template; this is the maximum distance between the contours in the template and in the scan data. Either Pattern-based (a looser tolerance, the default), Resolution-based (a tighter tolerance), or Manual. Typically, the Pattern-based option should produce a better match quality. However, if you are getting too many false matches, try setting the mode to Resolution-based or set the value manually. The tolerances calculated from the pattern-based and resolution-based modes are displayed in the mode drop-down.<br>Note that the resolution-based mode results in a much tighter tolerance with high resolution scan data.<br><br>**Add Border** |

| Parameter | Description |
|---|---|
| | Considers a drop to NULL, outside the region, as an edge. Use this when performing part detection or when there is no data around the part. If there is nothing in the region, then there will be nothing in the template either. |
| Enable Array Output | When **Enable Array Output** is disabled, the tool produces individual outputs for each instance. (For example, X 1 and Y 1 for the first instance, X 2 and Y 2 for the second instance, and so on.)<br>When **Enable Array Output** is enabled, the tool produces an array for each output. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Instance Count | The maximum number of instances the tool will locate. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement |
| --- |
| **Instance Count**<br>Returns the number of parts or features matching the loaded template up to the value set in the Instance Count parameter. |
| **X {n}**<br>**Y {n}**<br>The X and Y position of the center of matched instance {n}. |
| **Z Angle {n}**<br>The angle of matched instance {n} relative to the sensor's coordinate system. |
| **Scale {n}**<br>The scale of matched object {n} relative to the loaded template. |
| **Match Quality {n}**<br>Percentage of matched model contours for the selected object instance. Match quality ranges from 0 to 100, with 100 being the best quality. A value of 100 means 100% of the model contours were successfully matched to the actual contours detected in the scan data. Use the **Minimum Match Quality** parameter to set the minimum acceptable value. |

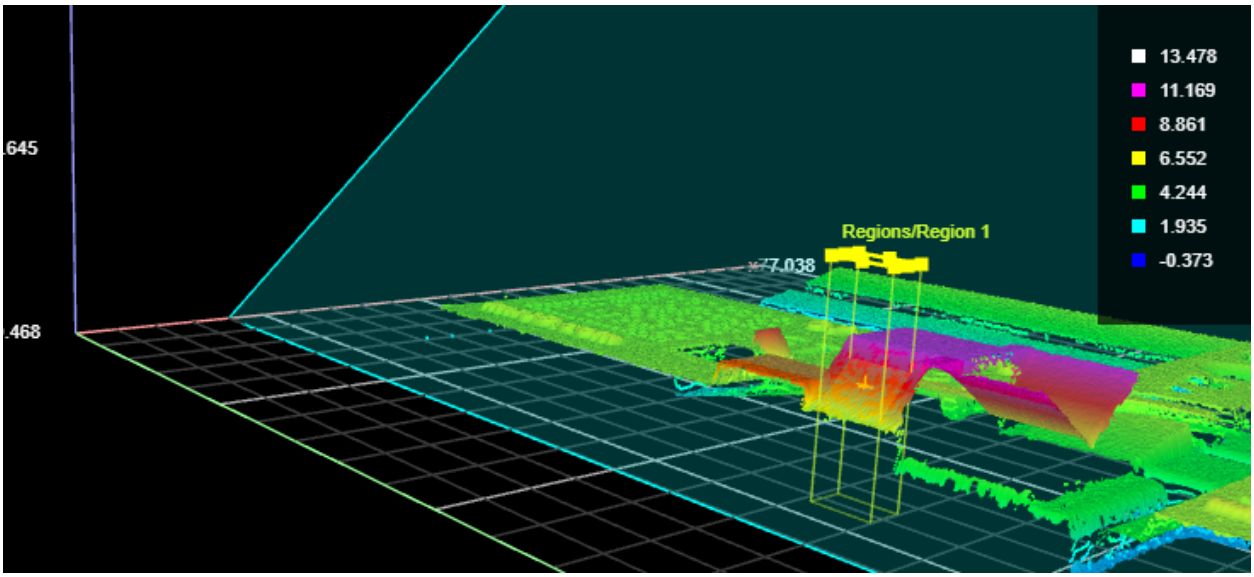
*Features*

| Type | Description |
| --- | --- |
| Point | A point representing the center of the region used when creating a template and the template's default reference point. (Note that the reference point of a template can be changed in the model editor.) |
| Line | A line parallel to the X axis passing through the Point feature. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Plane

The Plane tool provides measurements that report a plane's position and orientation (X Angle, Y Angle, Z Offset, Normal, Distance), as well as the maximum and average deviations from the plane.



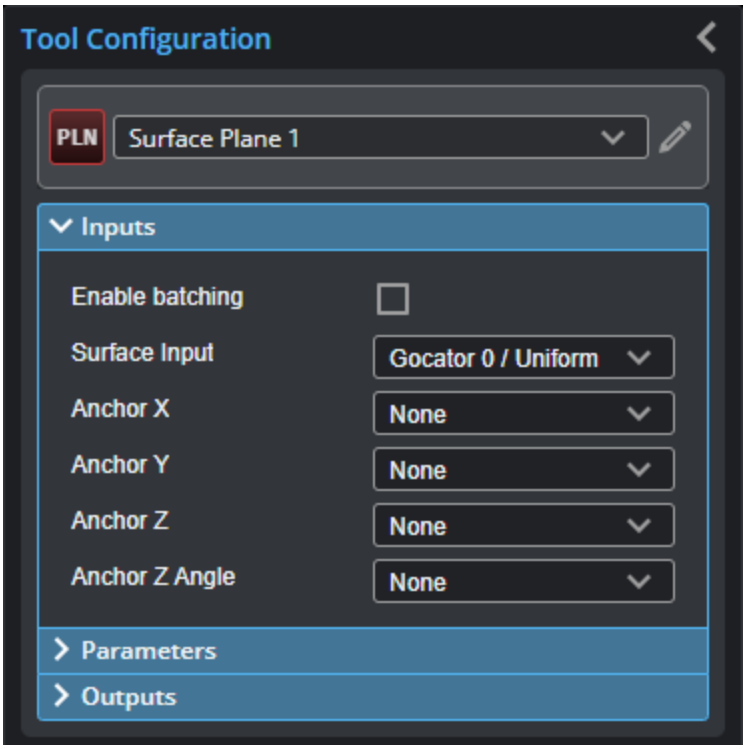

The Z offset reported is the Z position at zero position on the X axis and the Y axis.

The results of the Angle X and Angle Y measurements can be used to manually customize the tilt angle in the Hole, Opening, and Stud tools.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



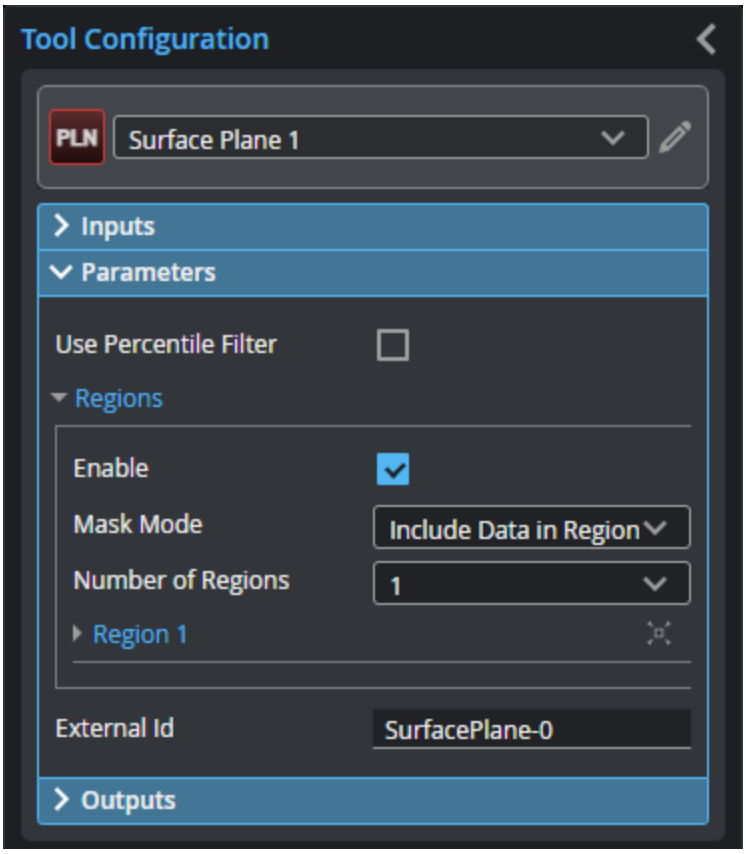

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

### Parameters

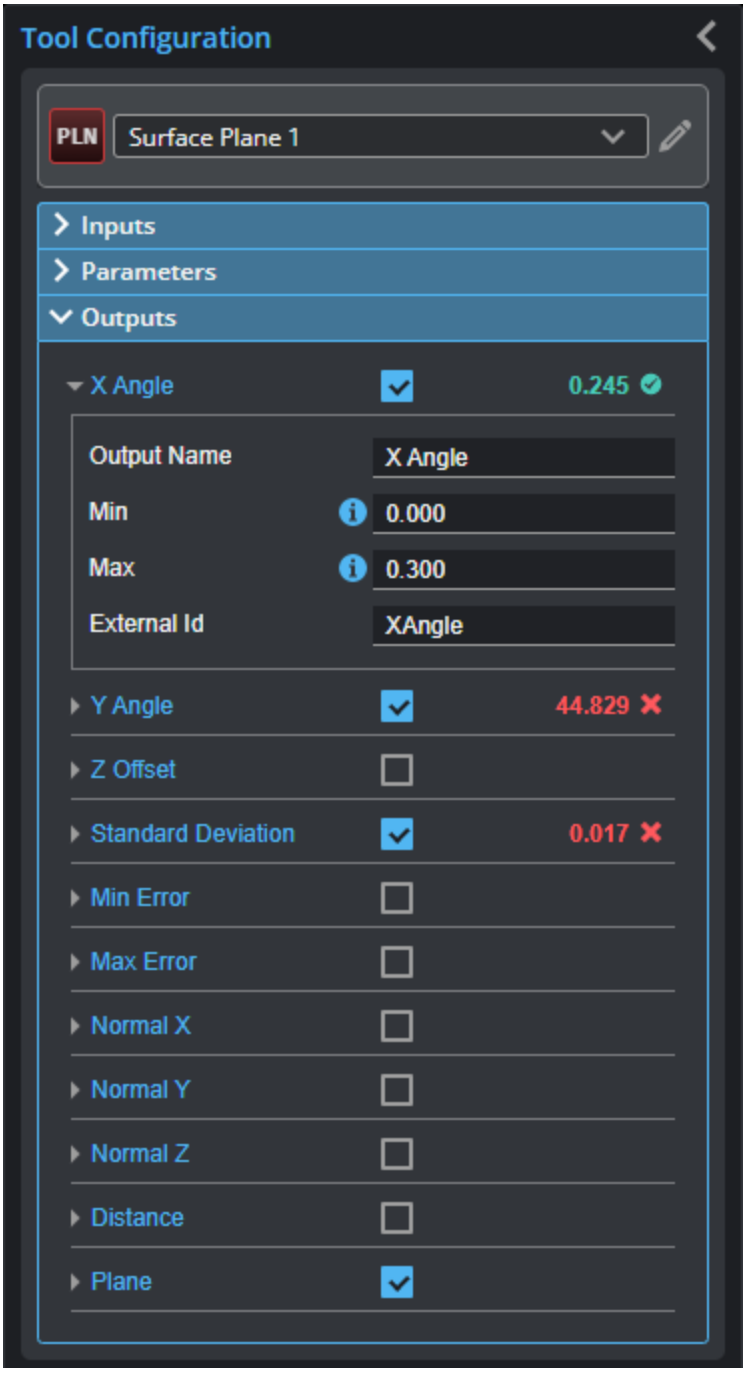
The following parameters are in the expandable **Parameters** section in the tool's configuration.




*Parameters*

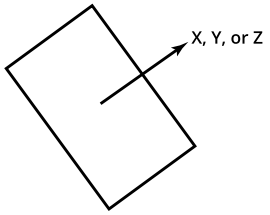
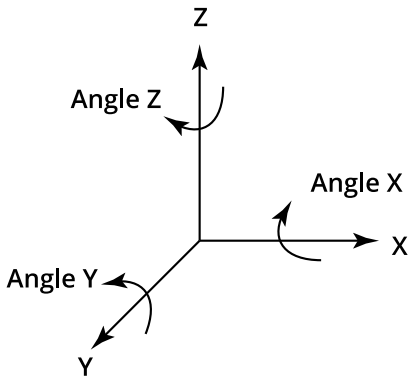
| Parameter | Description |
|---|---|
| Use Percentile Filter<br>High Percentile<br>Low Percentile | When **Use Percentile Filter** is checked, displays parameters to set the low and high percentile. Use this to remove outliers. |
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

| Measurement | Illustration |
|---|---|
| **X Angle**<br>Determines the X angle of the surface with respect to the alignment target. |  |
| **Y Angle**<br>Determines the Y angle of the surface with respect to the alignment target. |  |
| **Z Offset**<br>Determines the Z value of intersection of the plane and the Z axis. | |
| **Standard Deviation**<br>Measures the standard deviation of the points of the surface from the detected plane within the specified region or regions. | |
| **Min Error**<br>Measures the minimum error from the detected plane (the maximum distance below the plane, perpendicular to the plane) within the specified region or regions. | |
| **Max Error**<br>Measures the maximum error from the detected plane (the maximum distance above the plane, perpendicular to the plane) within the specified region or regions. | |
| **Normal X**<br>Returns the X component of the surface normal vector. | |
| **Normal Y**<br>Returns the Y component of the surface normal vector. | |
| **Normal Z**<br>Returns the Z component of the surface normal vector. | |

| Measurement | Illustration |
| --- | --- |
| **Distance**<br>Distance from the origin to the plane. | |

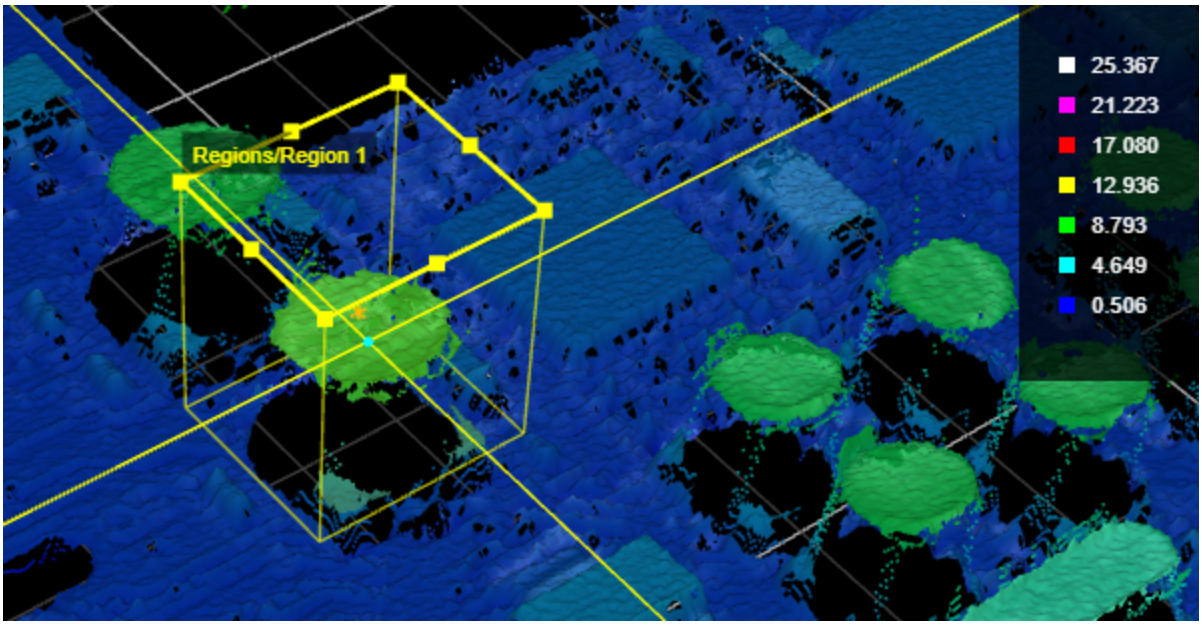
*Features*

| Type | Description |
| --- | --- |
| Min Error Point | Points representing the minimum and maximum errors. |
| Max Error Point | |
| Plane | The fitted plane. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Position

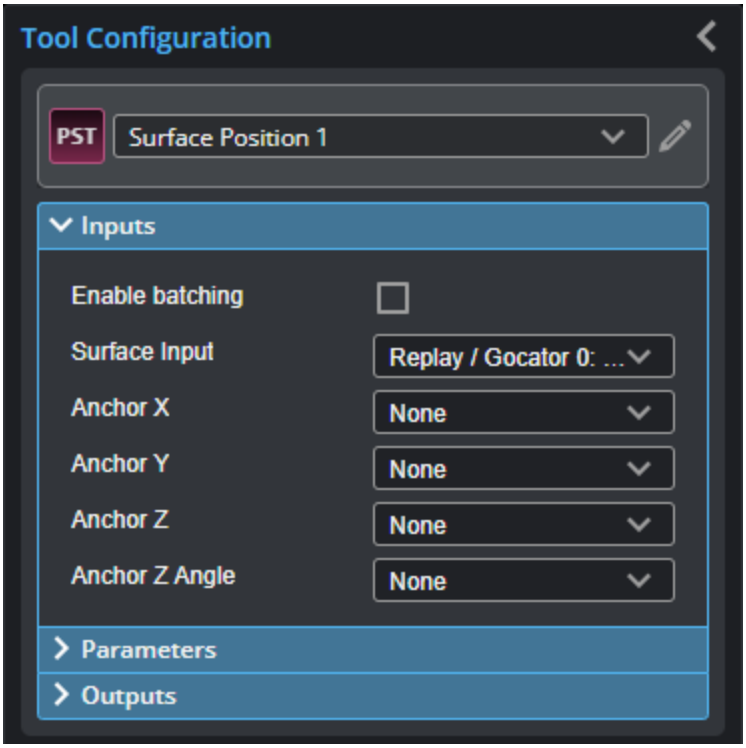
The Position tool reports the X, Y, or Z position of a part. You must specify the feature type specified and is one of the following: Average (the mean X, Y, and Z of the data points), Median (median X, Y, and Z of the data points), Centroid (the centroid of the data considered as a volume with respect to the z = 0 plane), Min X, Max X, Min Y, Max Y, Min Z, or Max Z.




*Position X and Y on a PCB component*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

**Inputs**



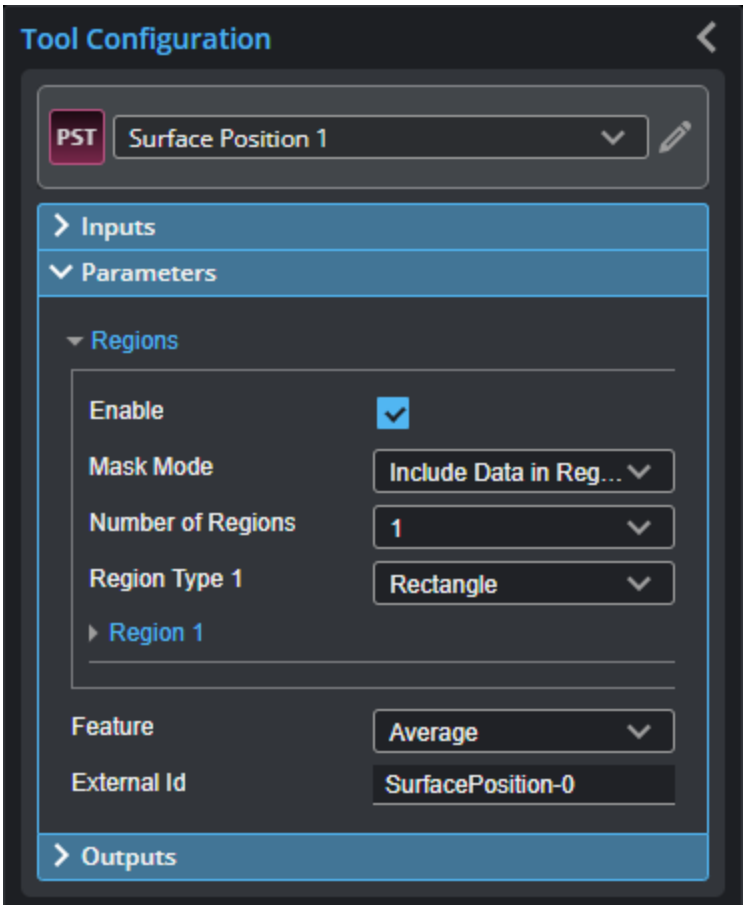

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

### Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

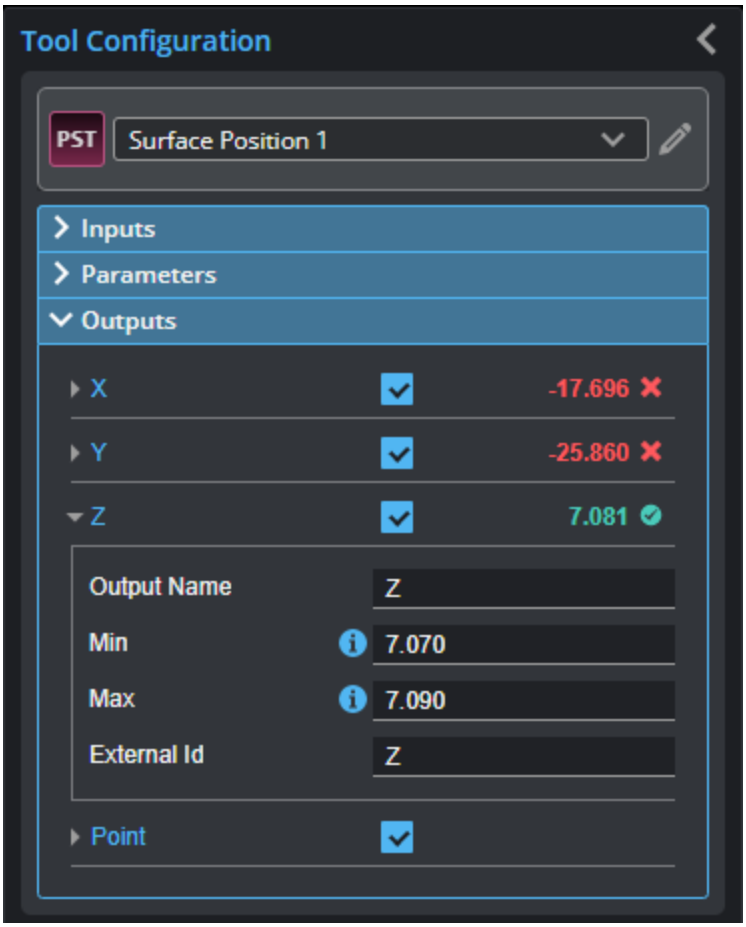



*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Feature | The feature point types the tool uses. For each, one of the following (for more information, see *Feature Points* on page 188):<br>• Average<br>• Median<br>• Centroid<br>• Max X<br>• Min X |

| Parameter | Description |
| --- | --- |
| | • Max Y<br>• Min Y<br>• Max Z<br>• Min Z<br><br>When more than one point is at minimum Y or maximum Y (and the feature is set to Min Y or Max Y, respectively), the rightmost point (the one at greater positive X) is selected by the tool. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

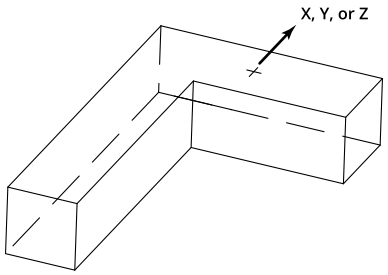
**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **X**<br>Determines the X position of the selected feature type. |  |
| **Y**<br>Determines the Y position of the selected feature type. | |
| **Z**<br>Determines the Z position of the selected feature type. | |

*Features*

| Type | Description |
|---|---|
| Point | A Point geometric feature representing the returned position. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Roughness

The Surface Roughness tool generates measurements of surface roughness.

The following measurements are available:

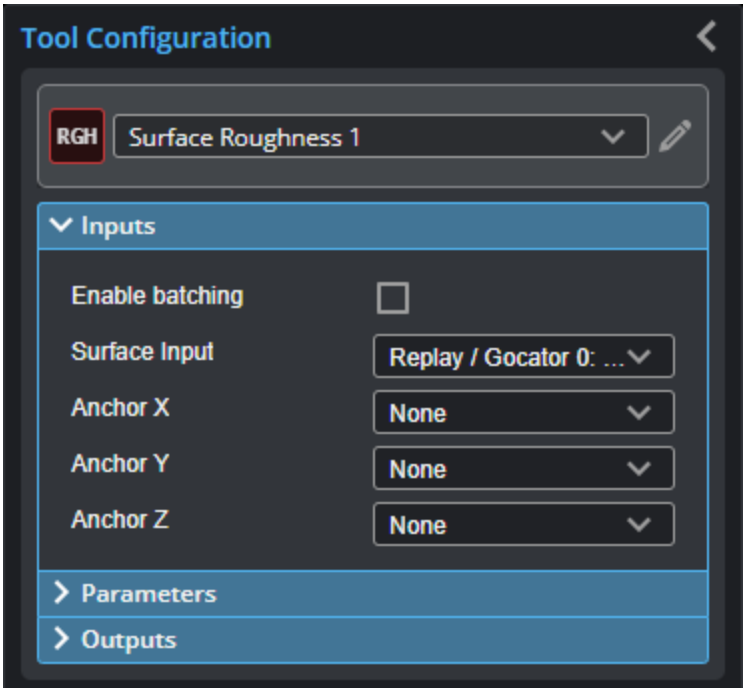
| | |
|---|---|
| Sa | Sk |
| Sq | Spk |
| Sp | Svk |
| Sv | Smr1 |
| Sz | Smr2 |
| Sku | Sal |
| Ssk | Str |

The tool offers five filter operations that can be enabled or disabled individually as required. The following filters are available:

- Filling Gaps: Designed to fill any holes in the surface and on the edge while trying to keep the surface as natural as possible.
- Remove Form: Offers both homogeneous and inhomogeneous polynomial filters from 1 to 8 orders.
- Remove Outliers: Used to remove outliers which are defined as a percentage of points in relation to the total number of points at the furthest distance from the height center.
- Gaussian and Cubic Spline filters: The tool offers Gaussian and Cubic Spline filters as standard filters for removing waviness. The Gaussian filter is used by default. The tool offers 4 conventional "end-effect" treatment options that are recommended by ISO 16610-28.
- The tool offers Gaussian filters with small Cut-Off wavelength (3 µm) as a low pass filter.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

## Inputs



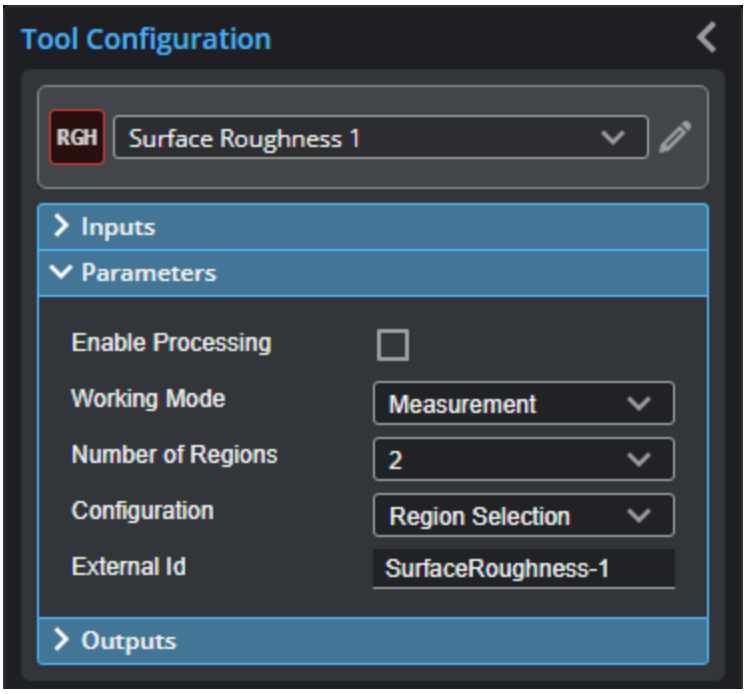

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

## Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

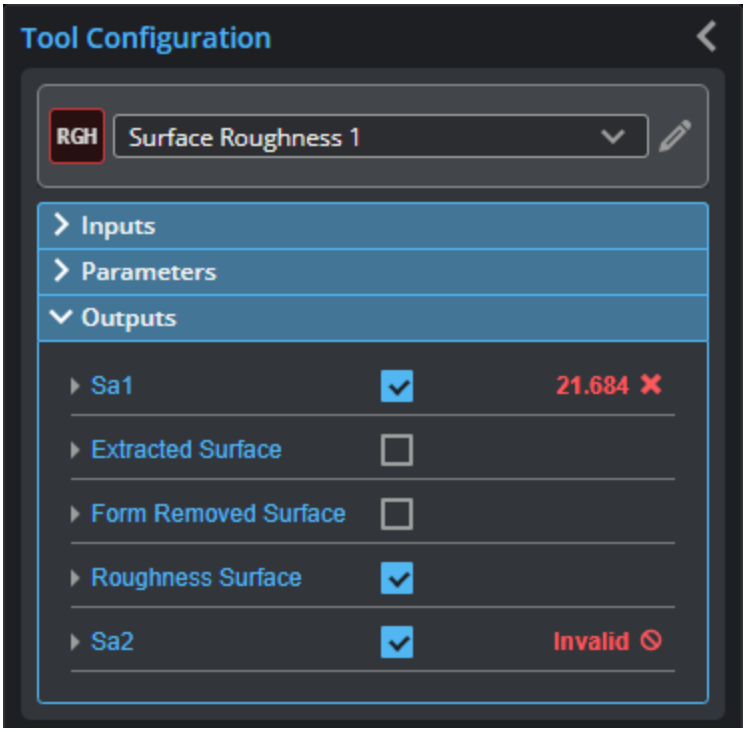



*Parameters*

| Parameter | Description |
|---|---|
| Enable Processing | When enabled, the tool starts performing measurements. |
| Working Mode | The tool's working mode. One of the following:<br>• Measurement<br>• Check Parameters: Use this to check the calibration parameters. When you set the tool to this mode, an expandable **Calibration** section displays, containing additional parameters. For more information, see *Calibration* below.<br>• Reset Parameters: If the calibration parameters are no longer used or a new calibration is carried out, select **Reset parameters** once.<br>• Roughness Calibration: See *Roughness Calculation Procedure* on page 561.<br>See *Calibration Procedure* on page 561. |
| Number of Regions | Sets the number of regions to be calculated, currently up to 16. (Two additional regions are reserved for calibration.) |
| Calibration | An expandable section displayed when **Working Mode** is set to **Check Parameters**.<br>The tool gives the summed mean values and the recorded sample number after each measurement.<br>For mirror calibration, the mean values of the background noise of Sa and Sq and the number of measurements are returned.<br>For roughness calibration, the nominal values of Sa and Sq must be specified before the measurement starts. |

| Parameter | Description |
|---|---|
| | The mean scaling value and the number of measurements are returned. |
| Configuration | Lets you choose which region to configure in the expandable Region {n} section. Regions are independent.<br>The two regions for mirror and roughness calibration targets are suspended after the specified number of evaluation regions, that is, after changing the number of evaluation regions, the settings for “Mirror” and “Roughness” must be checked again. |
| Region | An expandable section containing the parameters for the region selected in **Configuration**. |
| Use Region | If enabled, uses the region you define. |
| Number of Regions | Select the number of regions to be calculated, currently up to 18. Two regions are available for selection (the last 2 are reserved for calibration). |
| Fill Gaps Mode | Set to Linear Interpolation to fill any holes in the surface and on the edge while trying to keep the surface as natural as possible. |
| Remove Form | Check to remove form from the surface with homogeneous or inhomogeneous polynomial filter. |
| Polynomial Order | Order of polynomial function. |
| Remove Outliers | The outlier is defined here as a percentage of points in relation to the total number of points at the furthest distance from the height center. When using the integrated histogram curve, the outliers outside the threshold range are replaced by the corresponding limit values, which are calculated by the points within the threshold range. |
| Remove Waviness | Check to remove waviness using Gaussian or Cubic Spline filter. |
| Filter Type | Choose Gaussian filter or Spline Filter. |
| End Effect | Methods for dealing with end-effects. One of the following:<br>• Zero Padding criterion (ZPA)<br>• Linear Extrapolation (LEX)<br>• Line Symmetric Reflection (LSR)<br>• Point Symmetrical Reflection (PSR) |
| Use Low Pass Filter<br>Low Pass Cut-off | Check **Use Low Pass Filter** to use low pass filter with cut-off wavelength defined in **Low Pass Cut-off**. |
| Margins | Custom margin distance. |
| Output Parameters | Some combination of measurement outputs can be selected. Dynamic measurement management is used. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

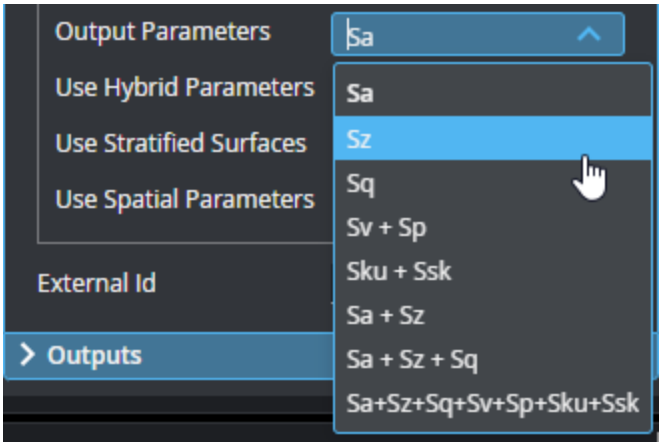
**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

You select the following parameters (or a combination of the parameters) in the **Output Parameters** drop-down to list them in the tool's **Outputs** section.



| Measurement | Formula |
|---|---|
| **Sa {n}**<br>Arithmetical mean height in µm, which is the difference in height of each point compared to the arithmetical mean of the surface. | $Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy.$ |
| **Sz {n}**<br>Maximum height in µm, which is defined as the sum of the largest peak height value and the largest pit depth value within the defined area. | $Sz = Sp + \lvert Sv\rvert$ |
| **Sq {n}**<br>Root mean square height in µm, which is equivalent to the standard deviation of heights. | $Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$ |
| **Sv {n}**<br>Maximum pit Height in µm, which is the absolute value of the height of the largest pit within the defined area. | $Sv = \lvert \min_A z(x,y)\rvert$ |
| **Sp {n}**<br>Height of the highest peak within the defined area in µm. | $Sp = \max_A z(x,y)$ |
| **Sku {n}**<br>Kurtosis, which is a measure of the sharpness of the roughness profile. (No unit.) | $Sku = \frac{1}{Sq^4}\frac{1}{A}\iint_A z^4(x,y)dxdy.$ |
| **Ssk {n}**<br>Skewness, which represents the degree of bias of the roughness shape (asperity). (No unit.) | $Ssk = \frac{1}{Sq^3}\frac{1}{A}\iint_A z^3(x,y)dxdy.$ |
| **Sdq {n}, Sdr {n}**<br>Areal roughness hybrid parameters. To enable these parameters, check **Use Hybrid Parameters**.<br>Sdq is the root mean square gradient. (No unit.)<br>Sdr is the developed interfacial area ratio, as a percentage. | |
| **Sk {n}, Spk {n}, Svk {n}, Smr1 {n}, Smr2 {n}**<br>Areal parameter for stratified surfaces. | |

| Measurement | Formula |
| --- | --- |
| Sk is the core roughness depth, in µm. | |
| Spk is the reduced summit height, in µm. | |
| Svk is the reduced valley depth, in µm. | |
| Smr1 is the upper bearing area, as a percentage. | |
| Smr2 is the lower bearing area, as a percentage. | |

To add the following parameters in the tool's **Outputs** section, check **Use Hybrid Parameters**. The parameter outputs are enabled by default.

*Measurements (Hybrid Parameters)*

| Measurement | Formula |
| --- | --- |
| **Sdq {n}, Sdr {n}** | |
| Areal roughness hybrid parameters. To enable these parameters, check **Use Hybrid Parameters**. | |
| Sdq is the root mean square gradient. (No unit.) | |
| Sdr is the developed interfacial area ratio, as a percentage. | |

To add the following parameters in the tool's **Outputs** section, check **Use Stratified Surfaces**. The parameter outputs are enabled by default.

*Measurements (Areal Parameters)*

| Measurement | Formula |
| --- | --- |
| **Sk {n}, Spk {n}, Svk {n}, Smr1 {n}, Smr2 {n}** | |
| Areal parameters for stratified surfaces. | |
| Sk is the core roughness depth, in µm. | |
| Spk is the reduced summit height, in µm. | |
| Svk is the reduced valley depth, in µm. | |
| Smr1 is the upper bearing area, as a percentage. | |
| Smr2 is the lower bearing area, as a percentage. | |

To add the following parameters in the tool's **Outputs** section, check **Use Spatial Parameters**. The parameter outputs are enabled by default.

*Measurements (Areal Parameters)*

| Measurement | Formula |
| --- | --- |
| **Sal {n}, Str {n}** | |
| Spatial parameters. | |
| Sal is the auto-correlation length, in µm. | |
| Str is the texture aspect ratio. (No unit.) | |

*Data*

| Type | Description |
|---|---|
| Extracted Surface | Surface data after filling gaps. |
| Form Removed Surface | Surface data after subtracting the polynomial pattern. |
| Roughness Surface | Surface data after a high pass filtering. |

**Calibration Procedure**

1. Deactivate "Enabled Processing" to get into the editing mode.
2. Use "Check Parameters" in the "Working Mode" option to check the last calibration.
3. Use Reset Parameters to ensure that all parameters from the last calibration are reset. If no correction is used, this action can also be used.
4. Change the "Working Mode" to "Mirror calibration".
5. Editing position and size of the region and other settings.
6. Use the input data measured with a mirror.
7. Activate "Enabled Processing" to start the mirror calibration.
8. Repeat the measurement as necessary. The tool gives the summed up mean value of background noise and the recorded sample number after each measurement. 25 measurements is recommended, but there is no upper limit to the number of measurements.
9. Deactivate "Enabled Processing" to get into the editing mode.
10. Change the "Working Mode" to "Roughness calibration".
11. Enter the nominal values of Sa and Sq of the calibration target. Depending on requirements, Sa, Sq can be calculated separately or together, (since the two correlate very well, a mean value of the correction factor can be formed if the two are activated).
12. Editing position and size of the region and other settings.
13. Use the input data measured with a roughness calibration target.
14. Activate "Enabled Processing" to start the roughness calibration.
15. Repeat the measurement as necessary. The tool gives the summed up mean value of correction factor and the recorded sample number after each measurement. 25 measurements is recommended, but there is no upper limit to the number of measurements.
16. It is assumed that a job file is created after the calibration, so the information is preserved in the job file.

**Roughness Calculation Procedure**

1. Deactivate "Enabled Processing" to get into the editing mode.
2. Select the number of regions to be calculated, currently up to 20 - 2 regions are available for selection (the last 2 are reserved for calibration).
3. Configure individual regions. The default settings correspond roughly to the settings when using Mountains Map, so only the region should be set. Otherwise, all available configurations for each region should be set according to specification.

4. Activate the measurements and output surfaces.

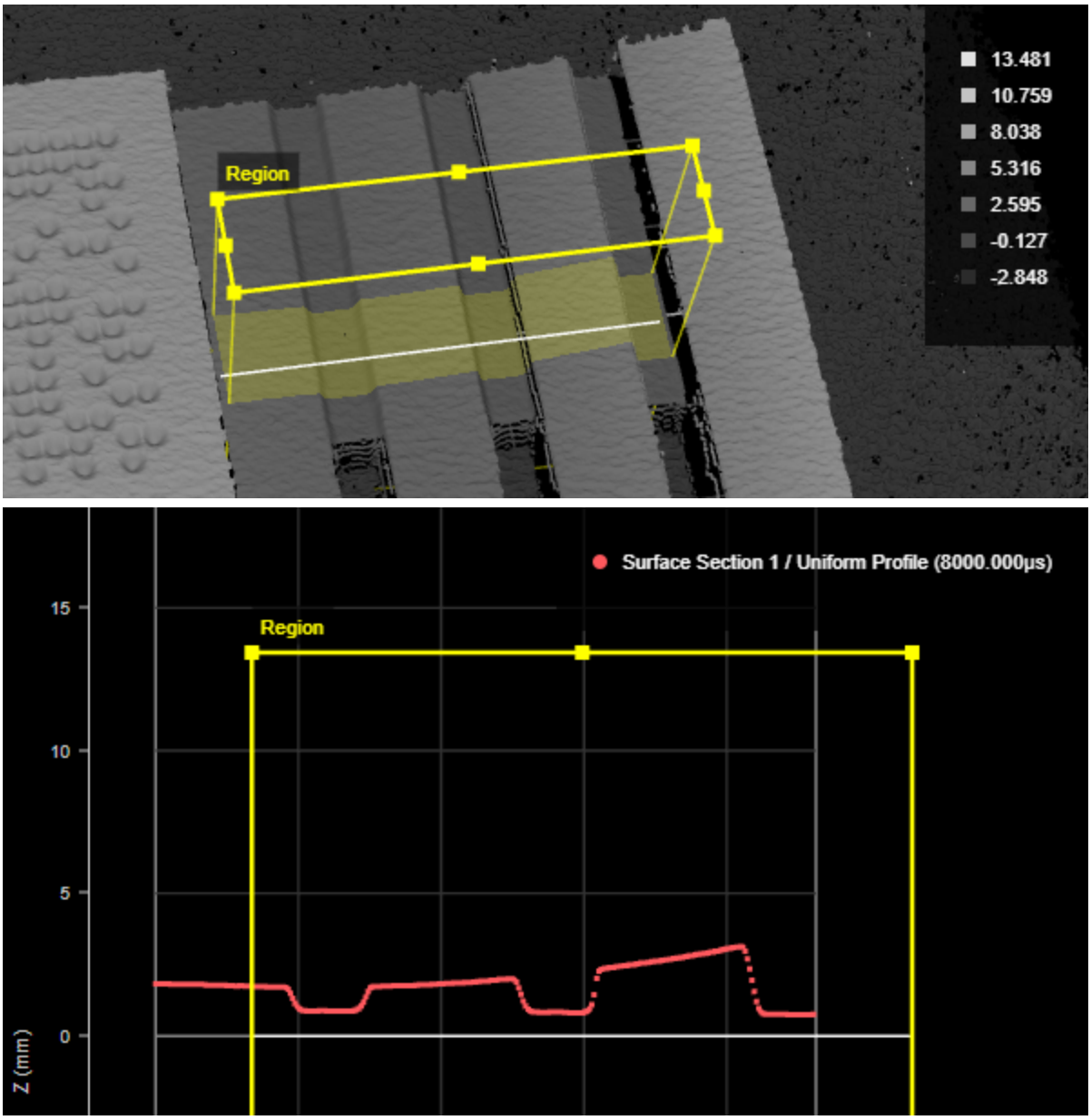
5. Activate "Enabled Processing" to start the calculation.

### Surface Section

The Surface Section tool lets you define a line on a surface (a "section") from which the tool extracts a profile. You can then apply any Profile tool to the resulting profile (see *Profile Measurement* on page 199). A section can have any XY orientation on the surface. The resulting profile is on the XZ plane.

Using sections and the profile measurements, you can therefore use measurements that are not otherwise possible in Surface mode, for example:

- Gap and flush measurements
- Surface radius measurements (for example, rounded edges or corners)
- Intersections
- Point-to-point dimension measurements between profile features



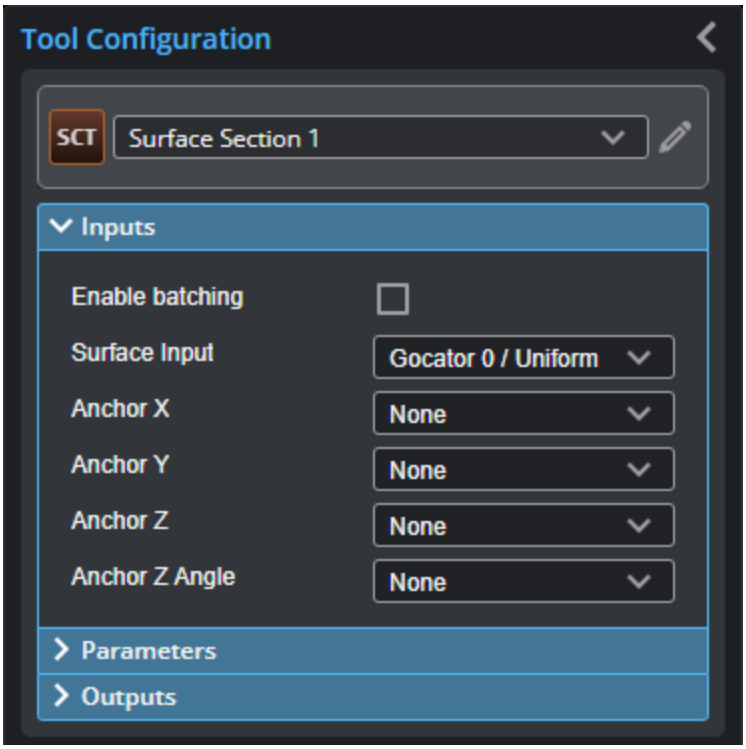

*The resulting profile. The leftmost point of the profile is at the X origin. The region is positioned showing the X and Z position of the center of the region on the surface.*

You can anchor the tool to some other easily identifiable feature on the scan target, which "shifts" the section in relation to that feature in case the target moves. This increases repeatability. For more information, see *Measurement Anchoring* on page 193.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

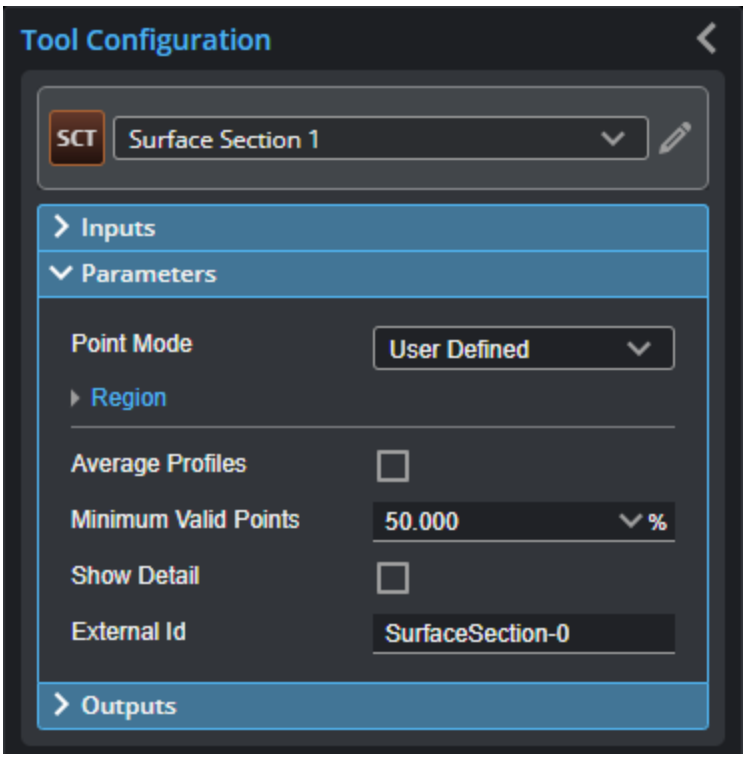
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

| Name | Description |
|---|---|
| Point 1<br>Point 2 | The Point geometric features the tool uses to define the end points of the section. Only displayed if **Point Mode** is set to Feature Points. |

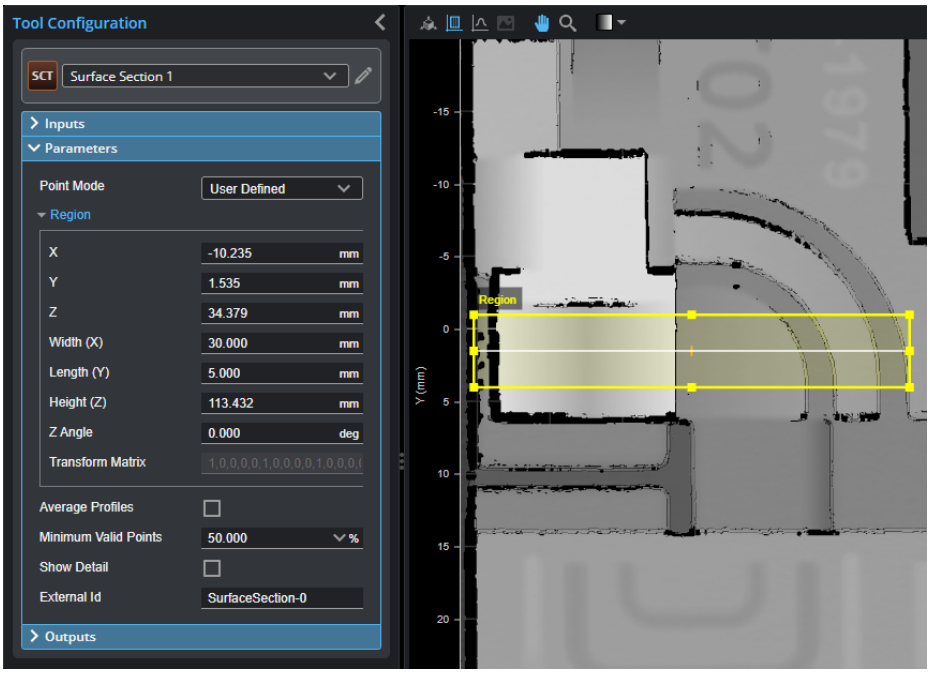
**Parameters**

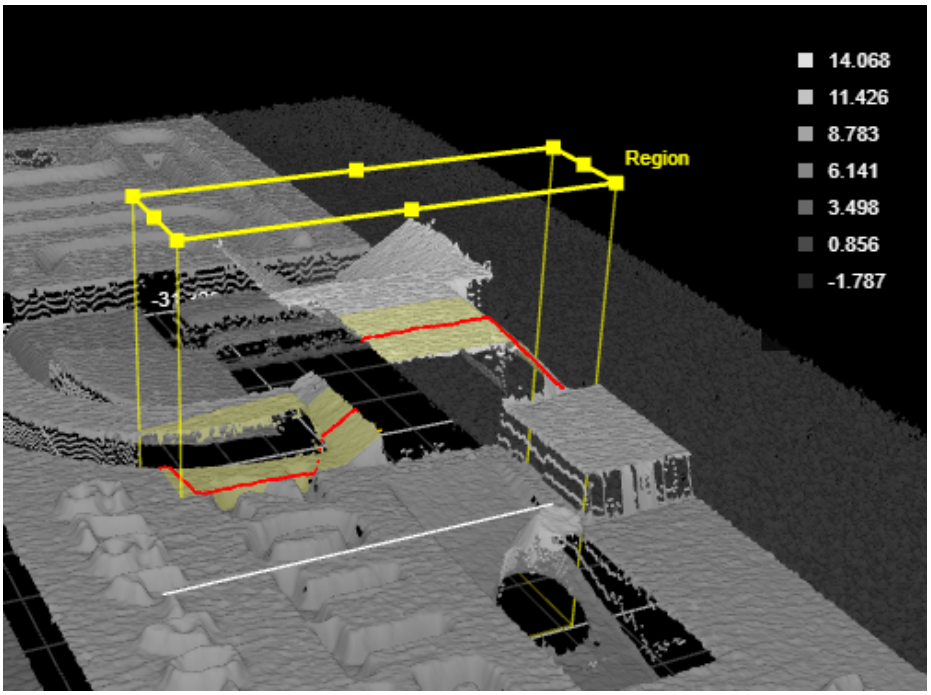
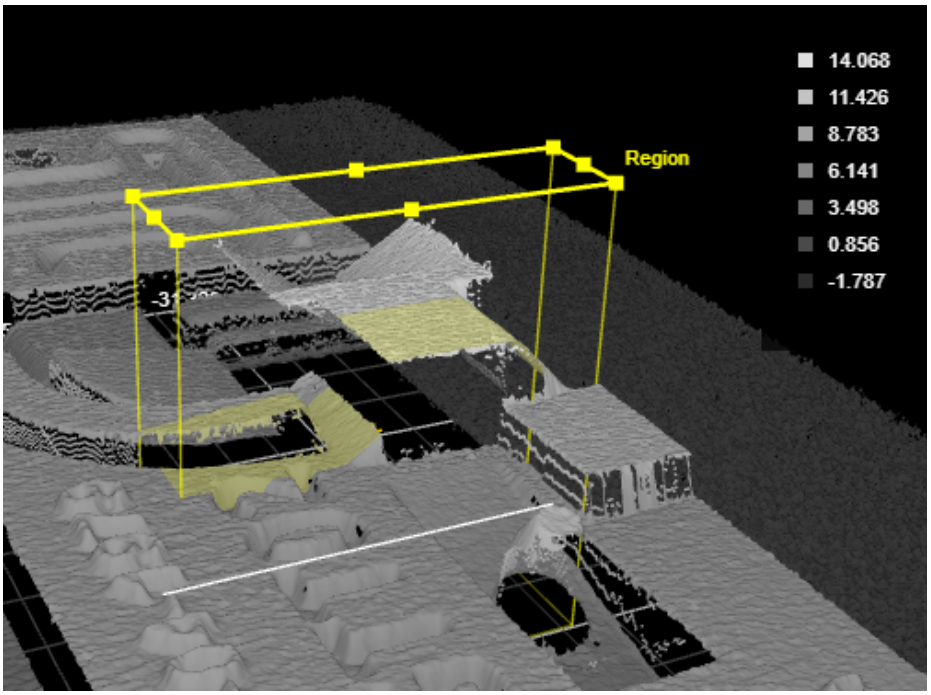
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

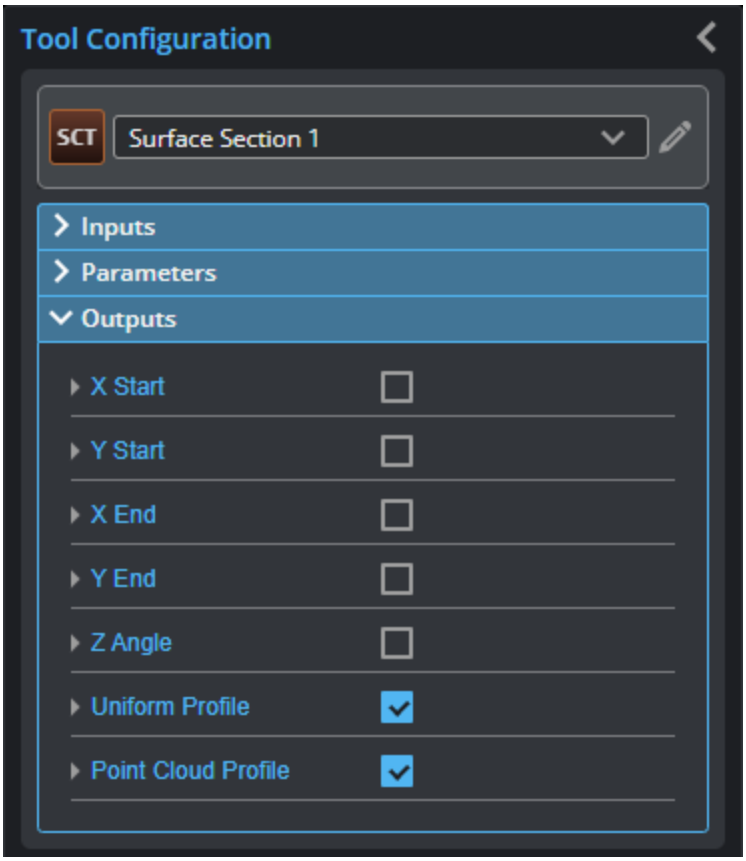
| Parameter | Description |
|---|---|
| Point Mode | Selects how the tool defines the end points of the section. One of the following:<br>**User-Defined**: Enables a region (see **Region** below) whose size, position, and rotation you define. The section is placed along the X axis in the middle of the region.<br>**Feature Points**: Uses two Point geometric feature inputs as the end points of the section. |
| Region | A rectangular region to define the section to extract. By default, the section is taken along the X axis of the region.<br>The length of the region (along the Y axis) is the averaging width for the section.<br>In the following, the region is set to a length of 5 mm and a width of 30 mm. The tool will therefore use a 5 mm averaging window, perpendicular to the X axis (width) of the region, to calculate the data point using its neighbor. If **Average Profiles** is enabled, the tool averages the points along the entire length of the |

| Parameter | Description |
| --- | --- |
| | region.<br>  <br><br>For more information, see *Regions* on page 181. |
| Average Profiles | When enabled, averages the profiles in the region to produce the section profile. Otherwise, the tool only uses the data points under the line running parallel to the X axis in the middle of the region. |
| Minimum Valid Points | When **Average Profiles** is enabled, the minimum percentage of neighboring points across the averaging width (perpendicular to the section) that need to be valid for a point to be output on the resulting profile. |
| Show Detail | Determines whether data points (in red) are displayed under the section in the data viewer. If this setting is disabled, only the line representing the defined section is displayed.<br>**Show Details** enabled: |

| Parameter | Description |
| --- | --- |
| |  <br>**Show Details** disabled:<br>  |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

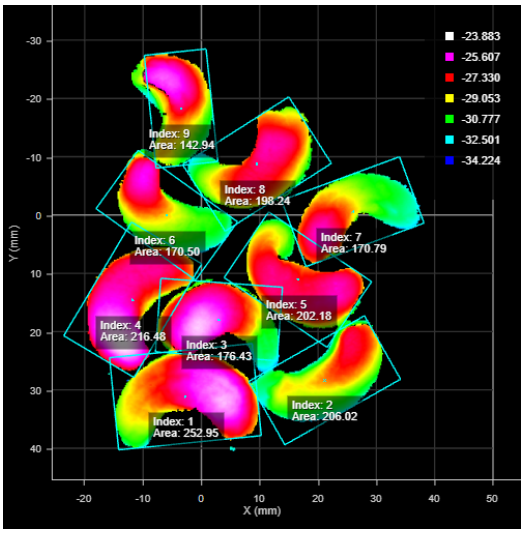
| **Measurement** |
|---|
| **X Start**<br>**Y Start**<br>These measurements return the X and Y position of the start of the section, respectively. |
| **X End**<br>**Y End**<br>These measurements return the X and Y position of the end of the section, respectively. |
| **Z Angle**<br>Returns the rotation of the section around the Z axis. |

*Data*

| **Type** | **Description** |
|---|---|
| Uniform Profile<br>Point Cloud Profile | The profile (uniform or point cloud, respectively) that the tool extracts from the surface. Available to profile tools for profile measurement. |

## Surface Segmentation

The Segmentation tool separates surface data into "segments," based on the tool's parameters. Segments can be touching and overlapping to a certain degree. The Segmentation tool is especially useful in the food industry, for example to identify food items that are too small or too big, or items that are damaged.




For each segment, the tool returns the X and Y position of the center of its bounding box, its length and width, and its area, as well as several more global measurements, such as maximum / minimum width or length, and so on. For a complete list, see below.

The Segmentation tool can also be used as a second stage of processing after part detection. For example, part detection could be used to detect a tray (containing parts), and the Segmentation tool could then separate the parts within the tray. For information on part detection, see *Profile Part Detection* on page 283.

| | |
|---|---|
| | The Segmentation tool cannot handle large overlaps. |

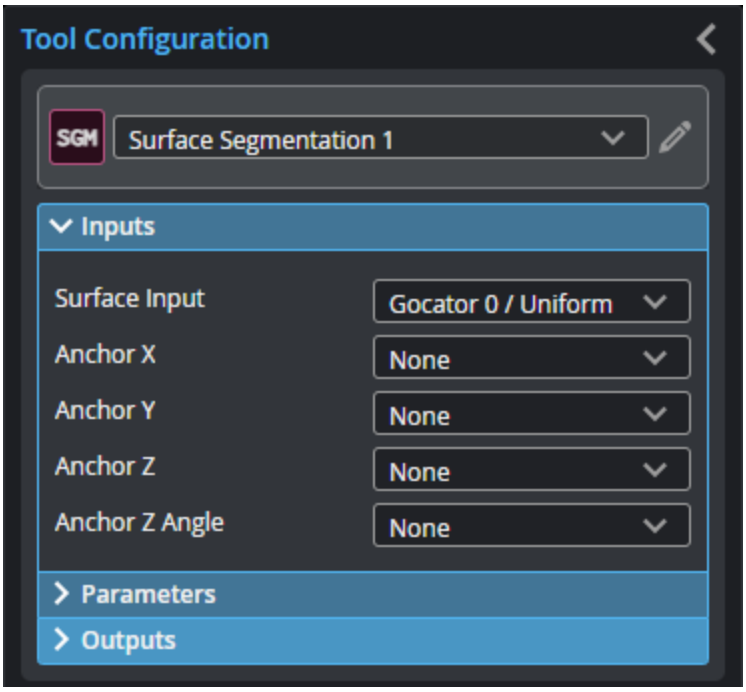
| | |
|---|---|
| | The Segmentation tool does not perform template matching. |

| | |
|---|---|
| | To reduce processing time, consider using the decimation filter. For more information on this filter, see *Surface Filter* on page 494. |

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



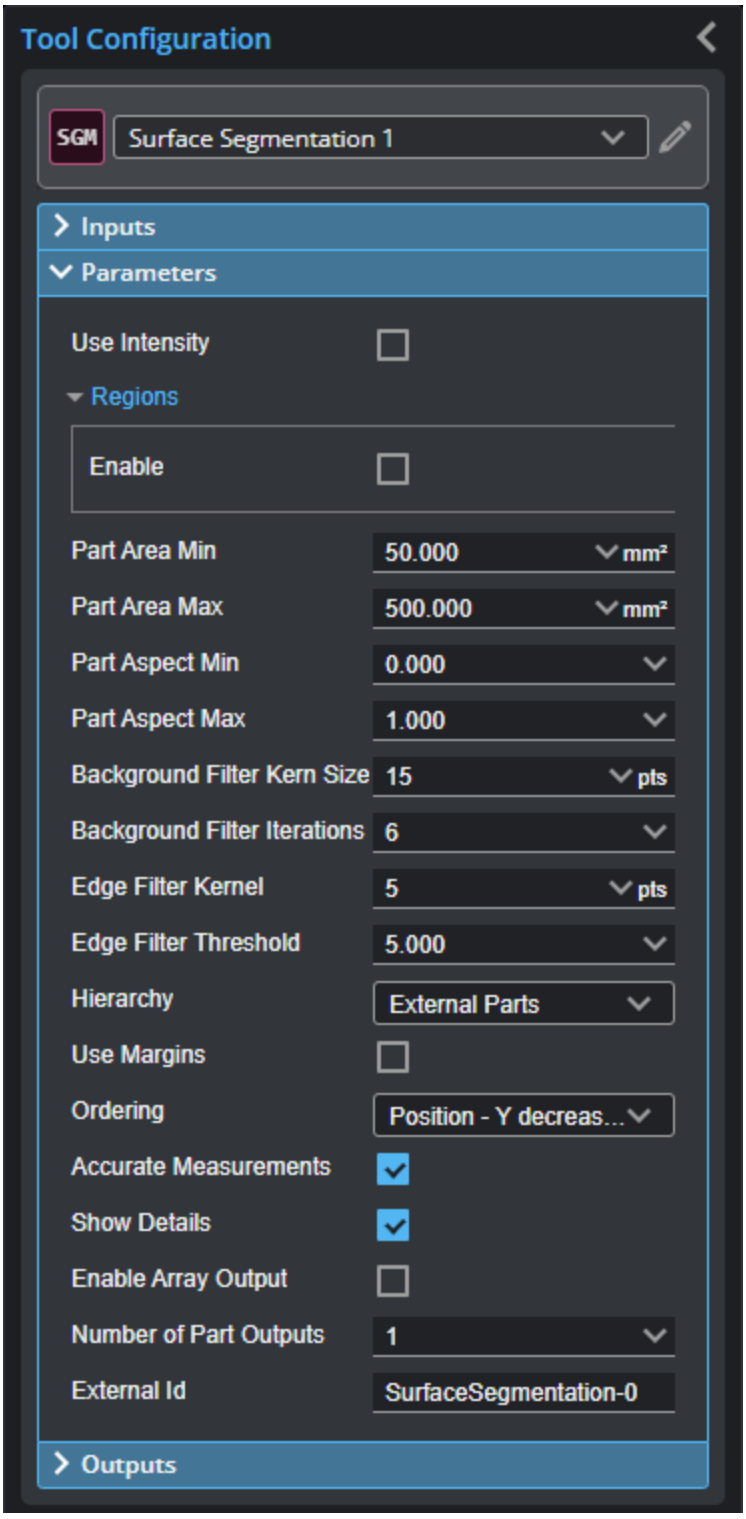

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

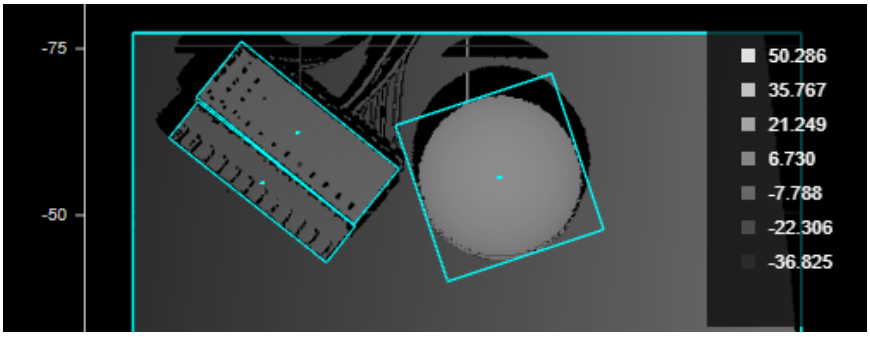
**Parameters**

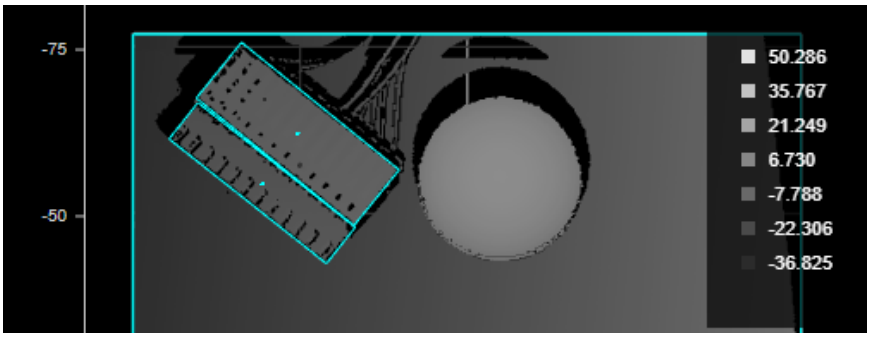
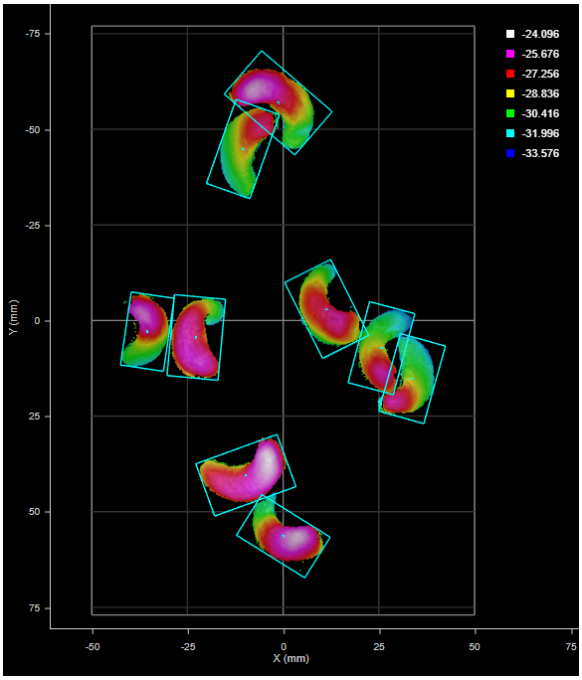
You configure the tool's parameters in the expandable **Parameters** section.

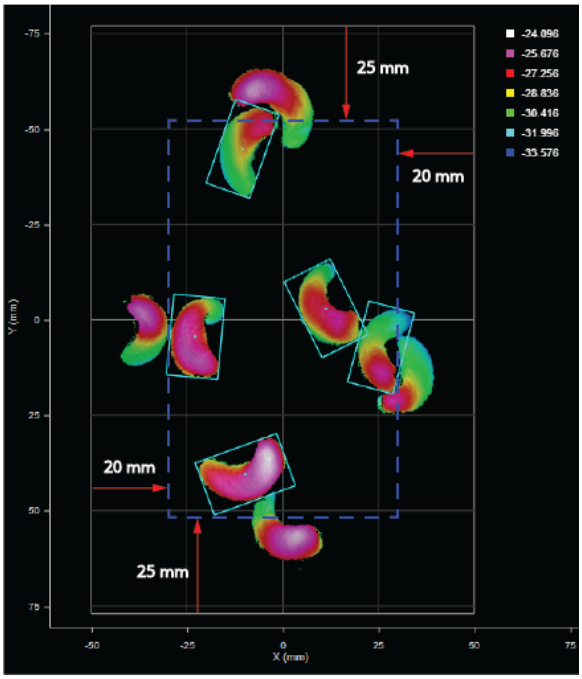



*Parameters*

| Parameter | Description |
|---|---|
| Use Intensity | Causes the tool to use intensity. **Acquire intensity** must be enabled on the **Scan** |

| Parameter | Description |
|---|---|
| | page; otherwise, the tool will display an error. |
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Part Area Min<br>Part Area Max | The minimum and maximum areas in square millimeters for a part of the scan data to be identified as a segment. |
| Part Aspect Min<br>Part Aspect Max | The minimum and maximum aspect ratios (minimum axis length in mm) / (maximum axis length in mm) of the best fit ellipse to the segment contour points for a segment to qualify to be added to the list of found segments. |
| Background Filter Kern Size<br>Background Filter Iterations | These settings perform background separation. The greater each of these values is, the more separation will be achieved. You must find a balance that removes noise adequately without degrading the segment find quality. |
| Edge Filter Kernel | Use this value to adjust the “granularity” of the part edge detection. |
| Edge Filter Threshold | Controls the separation of the parts, increasing the gap between the parts so that they can be detected more easily. |
| Hierarchy | Use this setting to detect segments when they are surrounded by background data. Choose one of the following: **All Parts** or **External Objects**.<br><br>**All Objects**<br>This option lets you segment parts with surrounding background data.<br>For example, in the following image, with **All Parts** selected, the sphere is correctly segmented from the surrounding background.<br>  <br>Note that this option may result in "over-segmentation": the tool may segment a part into two segments.<br>**External Objects** |

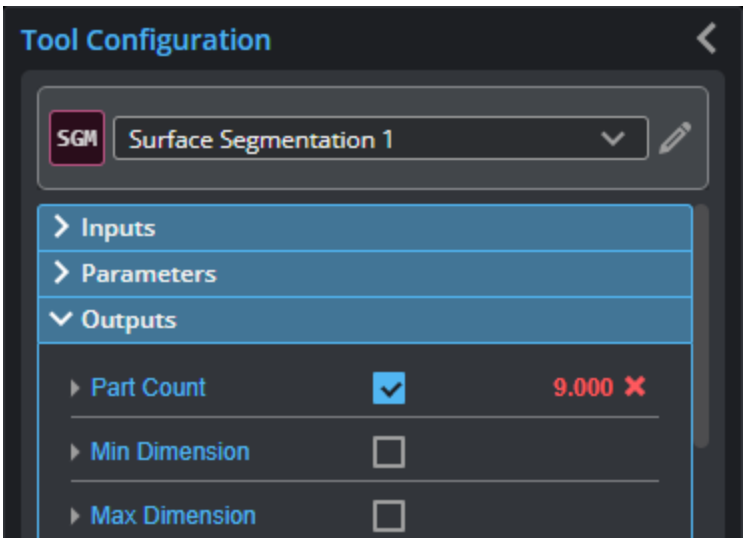
| Parameter | Description |
| --- | --- |
| | In the following image, the sphere is not identified as a segment because of the surrounding background. It is treated as part of a large segment that includes all of the scan data.<br>  <br><br>**Holes**<br>Use this option to get holes inside objects.<br>**All Contours**<br>Use this option to get all detected contours. |
| Use Margins<br>Margins<br>Left<br>Right<br>Top<br>Bottom | When **Use Margins** is enabled, the tool discards parts whose center point is within the margins defined in the expandable Margins section. Margins extend inwards from the outer edges of the sensor's FOV (XY scan area) and are positive.<br>In the following, with margins set to 0, nine parts are detected<br>  <br> |

| Parameter | Description |
| --- | --- |
| | In the following, the left and right margins are set to 20 mm, and the top and bottom margins are set to 25 mm. The sensor's FOV is 100 x 154 mm. The tool discards the four parts whose center points are within those margins. (Total part count is reduced to five.)<br>  |
| Ordering | Orders the measurements, features, and surface data of the individual parts output by the tool. Choose one of the following:<br>• Area - Large to small<br>• Area - Small to large<br>• Position - X increasing<br>• Position - X decreasing<br>• Position - Y increasing<br>• Position - Y decreasing<br>• Position - Z increasing<br>• Position - Z decreasing |
| Accurate Measurements | Returns more accurate width, height, and area measurements, as well as a better Surface output, but the trade-off is greater processing time. If you only need center points or the number of parts, disable this parameter for faster processing.. |
| Show Details | Toggles whether the tool displays the index and area of each individual part. Enabling this will increase processing time. |
| Enable Array Output | When **Enable Array Output** is disabled, the tool outputs each part as an individual Surface output.<br>When **Enable Array Output** is enabled, the tool outputs parts in arrays. Be sure to enable the Part Surface in the **Outputs** section after enabling this parameter. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and* |

| Parameter | Description |
|---|---|
| | *Aggregation* on page 171. |
| Number of Part Outputs | Determines the number of parts the tool outputs as measurements, features (center points of parts), and surface data. Currently limited to 200 parts. If **Enable Array Output** is checked, this parameter is hidden and all parts are output in arrays. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

When **Enable Array Output** is unchecked, individual measurement and feature outputs are produced for each part, for example, Max Z 1, Max Z 2, and so on, or Center 1, Center 2, and so on. When this parameter is checked, these measurements and features are output as arrays.

*Measurements*

| Measurement |
|---|
| **Part Count**<br>Returns the total number of segments identified, based on the tool's parameters. |
| **Min Dimension**<br>**Max Dimension**<br>The minimum and maximum dimensions among all of the identified segments, respectively. |
| **Mean Width**<br>**Mean Length** |

| Measurement |
| --- |
| The mean width and length of the segments, respectively. |
| **Min Area**<br>**Max Area**<br>The minimum and maximum area among all of the identified segments, respectively. |
| **Sum Area**<br>The sum of the areas of the segments. |
| **Mean Area**<br>The mean area of the segments. |
| **Min Height**<br>**Max Height**<br>**Mean Height**<br>The minimum, maximum, and mean heights among all of the identified segments, respecitvely. |
| **X Center {n}**<br>**Y Center {n}**<br>The X and Y positions of the center of a part segmented from the surface. |
| **Width {n}**<br>**Length {n}**<br>The width and length of a part segmented from the surface. These are always the major and minor axis of a part, respectively. |
| **Area {n}**<br>The area of a part segmented from the surface.<br>The area is calculated using the contour of the part and resampling. For this reason, areas calculated using the Surface Volume tool will produce different measurements; for more information, see *Area* on page 625. |

*Features*

| Type | Description |
| --- | --- |
| Center {n} | The point representing the center of a segmented part. |

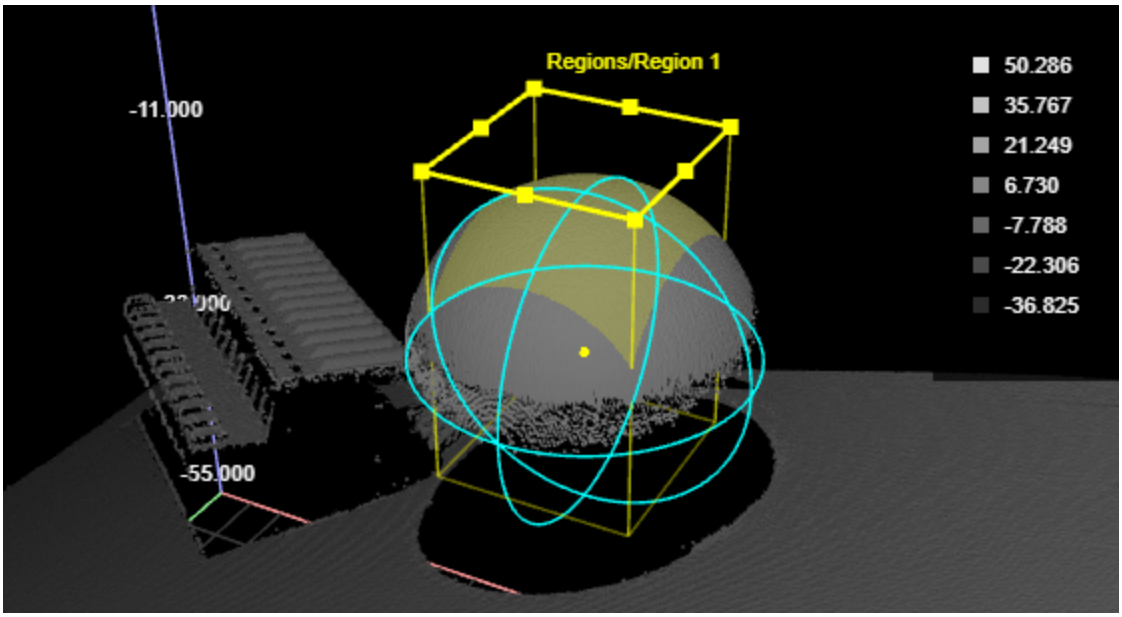
*Data*

| Type | Description |
| --- | --- |
| Part Surface {n} | Surface data corresponding to each segmented part. |
| Diagnostic | Surface data you can use to evaluate the impact of the tool's kern size and iteration settings, which the tool uses to separate potential segments. |

## Surface Sphere

The Sphere tool lets you compute characteristics of a scanned sphere by specifying a region to inspect.

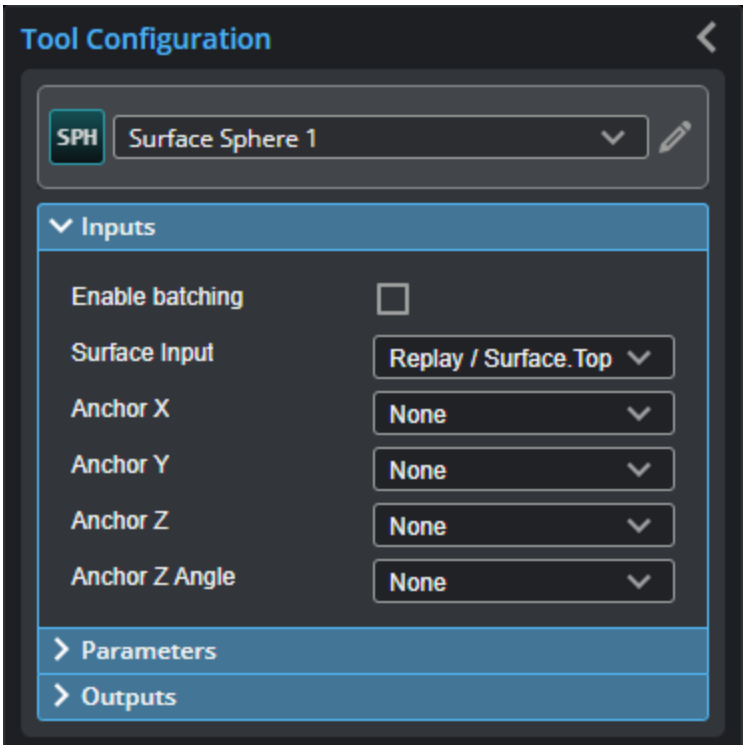
> For the tool to work properly, the tool's region must usually be enabled and properly placed to include only the sphere's scan data.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.



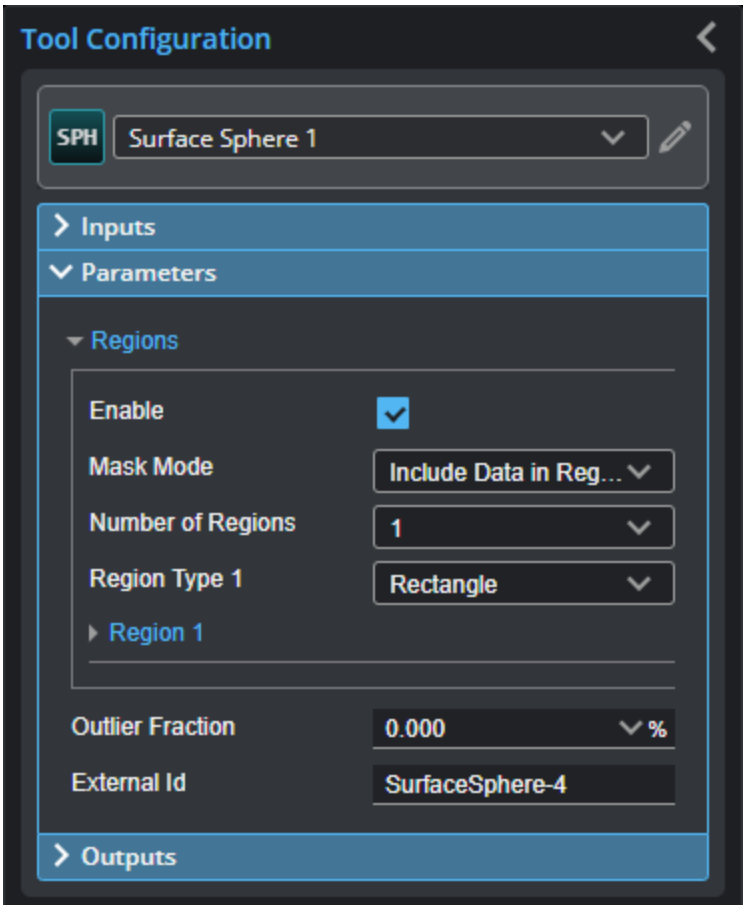

To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

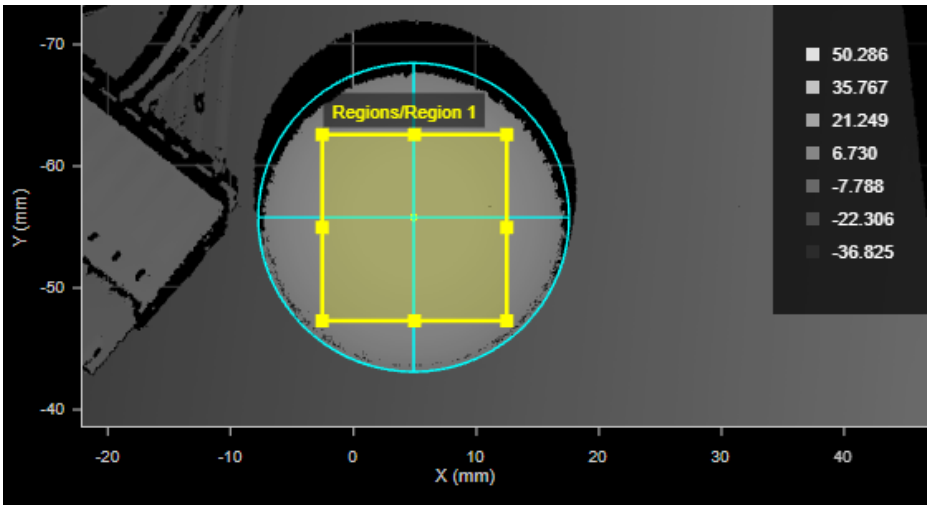
### Parameters

You configure the tool's parameters in the expandable **Parameters** section.



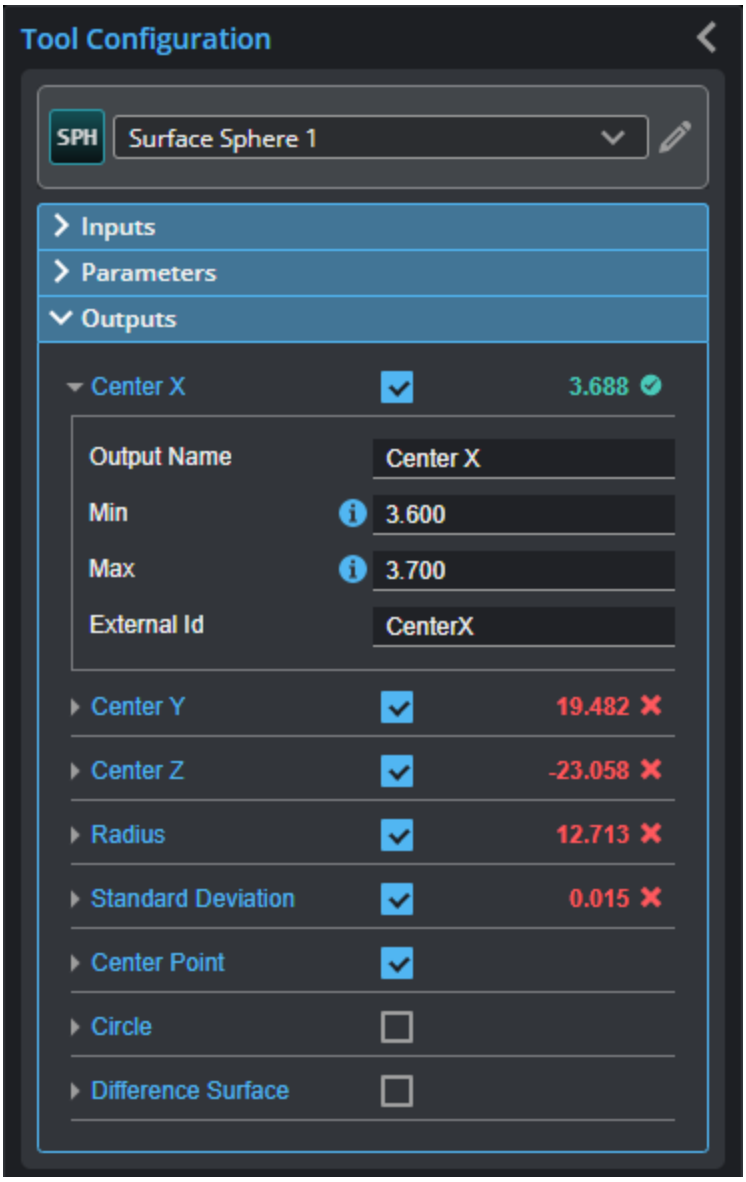

*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Number of Regions<br>Region Type {n}<br>Region {n} | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181.<br>In order for the tool to correctly fit a sphere to the scan data, you must set the region so that it only contains data from the sphere on the target. |

| Parameter | Description |
| --- | --- |
| |  |
| Outlier Fraction | The percentage of outlier points to exclude. Setting this to a small value can help the tool fit a better sphere when noise is present. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

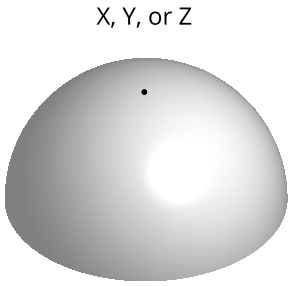
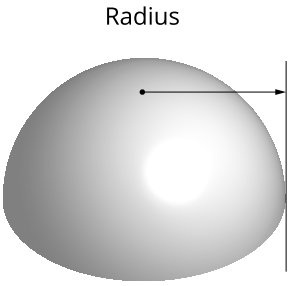
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Center X**, **Center Y**, **Center Z**<br>These measurements determine the X, Y, Z position of the center of the sphere, respectively. |  |
| **Radius**<br>Determines the radius of the sphere. |  |
| **Standard Deviation**<br>Determines the error of the points compared to the computed sphere. It is defined as the square root of the variance of the distance of every point to the computed sphere. | |

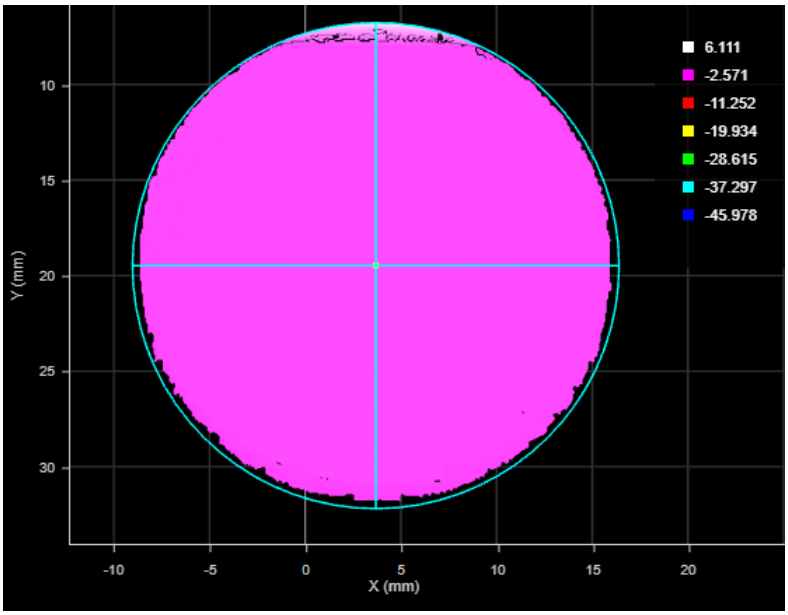
*Features*

| Type | Description |
|---|---|
| Center Point | The center of the circle encompassing the widest part of the fitted sphere. |
| Circle | The circle encompassing the widest part of the fitted sphere. |

For more information on geometric features, see *Geometric Features* on page 191.

*Data*

| Type | Description |
|---|---|
| Difference Surface | Shows the fit error at each point in the height map. |

| Type | Description |
| --- | --- |
| |  |

## Surface Stitch

The Stitch tool lets you combine up to 24 frames of scans into a single Surface scan. This lets you get a much larger scan volume with fewer sensors (either in a single sensor system or a multi-sensor system). For each scan, you can specify not only X, Y, and Z offsets (translations), but also X, Y, and Z angles (rotations), defining its relationship with the others. This means that when the sensor system is mounted to a robot, or if you are using, for example, an X-Y table, you can get a complete scan with fewer sensors. The resulting combined scan can then be used as input by any other Surface or Feature tool from its **Surface Input** drop-down.

The tool performs rotation first, and then translation.

| | |
|---|---|
| | The tool combines data simply by overwriting in sequence: it performs no averaging or blending. The tool also performs no fitting. |

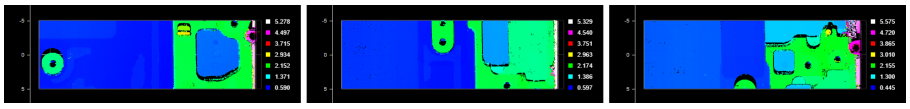
| | |
|---|---|
| | Results are only as accurate as the motion system. |

| | |
|---|---|
| | Seams are often seen in combined data in stitching performed in anything other than along the Y axis. |

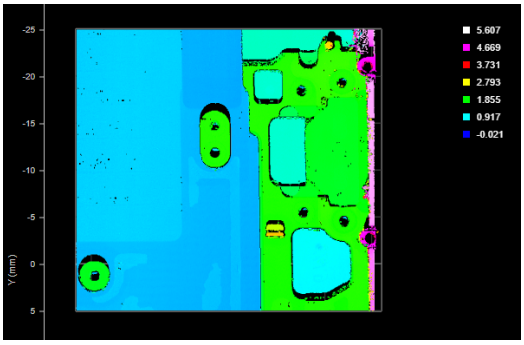
The tool returns one measurement, which simply indicates the number of scans successfully added to the combined scan data.

The following shows three individual frames.

(The following screenshots are from a G2 sensor.)

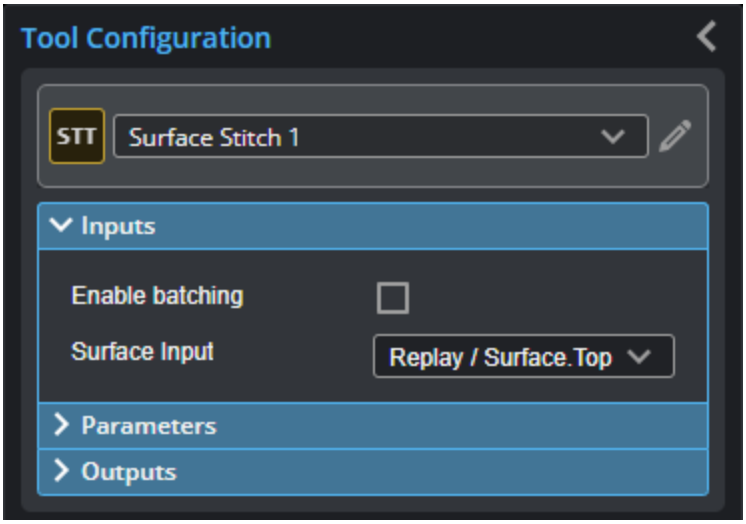


In the following, the tool has combined the frames into a single surface.




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

## Inputs

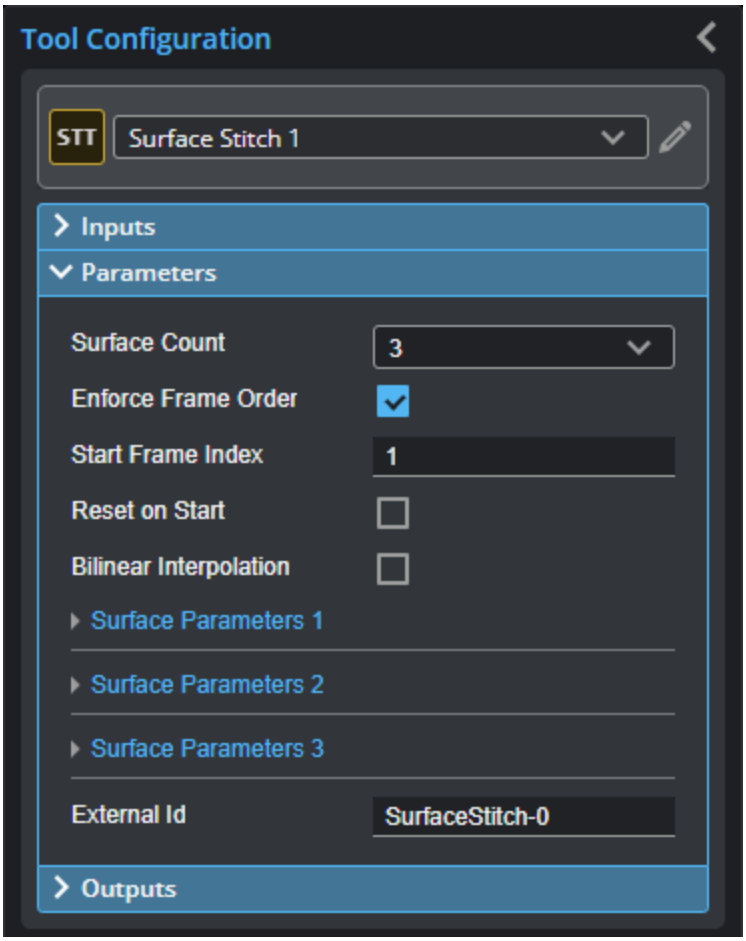



*Inputs*

| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |

## Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

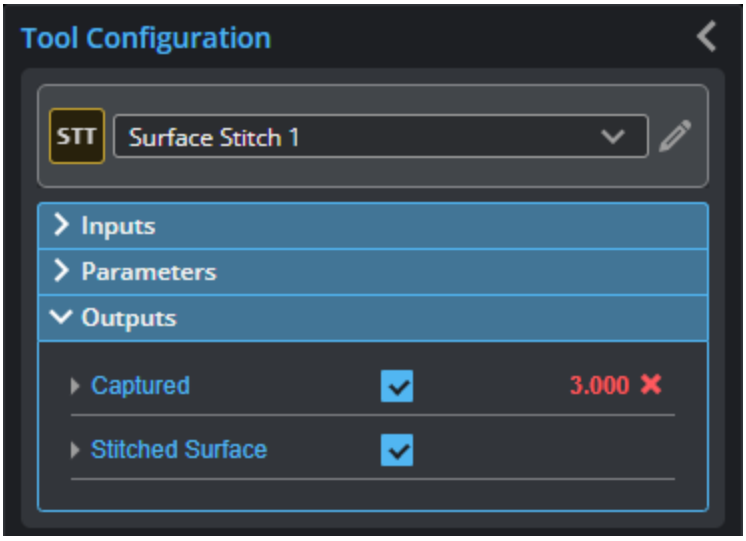



*Parameters*

| Parameter | Description |
|---|---|
| Surface Count | The number of scans to combine into a single surface. For each, a "Surface Parameters" section is added. The tool accepts setting the number of scans to one: in this case it, behaves like a transform tool. |
| Enforce Frame Order | Restricts the stitching for specific frame indexes, starting at the frame indicated in **Start Frame Index**. If unchecked, an **Operation** drop-down is displayed.<br>This setting is disabled if you attempt to stitch data from individual scans acquired using the Snapshot button (that is, all frame indexes are at 1). |
| Start Frame Index | The start frame index. |
| Operation | If **Enforce Frame Order** is disabled, the **Operation** drop-down is displayed. One of the following:<br>• **Normal**: The tool automatically chooses this operation after you have chosen another operation.<br>• **Reset buffers**: Resets the buffers used to stitch frames.<br>• **Lock**: Lets you lock the current processing and outputs of the tool. Useful when you need to add another tool that will use this tool's output (for example, |

| Parameter | Description |
| --- | --- |
| | a Surface Section tool). If you do not lock the tool, as soon as you add the other tool, the output is cleared, which means you must re-execute the combined output again to configure the additional tool. Be sure to unlock the tool after you have configured any other tools. |
| Reset On Start | Clears buffers for the stitched surface when the sensor is started. Useful for situations where the sensor is started and stopped frequently (to capture a small number of frames), rather than starting the sensor and letting it run for a long period. Enable this parameter to prevent data from a previous capture session being stitched with data from the current capture session. |
| Interpolation Mode | Provides three interpolation modes the tool uses to stitch the input Surface data scans together to produce the uniform output (Stitched Surface). These modes do nothing when the input is point cloud data.<br><br>**Nearest Neighbor Interpolation**<br>Data points are generated in the stitched output by interpolating with the nearest neighbor. In earlier versions of this tool, this is equivalent to **Bilinear Interpolation** being unchecked.<br><br>**Bilinear**<br>Data points are generated in the stitched output by using bilinear interpolation with the points to the left and right. This mode is best for applications with a non-zero Z rotation and minor X and Y rotation. In earlier versions of this tool, this is equivalent to **Bilinear Interpolation** being checked.<br><br>**Gaussian**<br>When stitching uniform Surface data where there is a larger X or Y angle, use this option to improve stitching. |
| Surface Parameters {n} | For each scan to be added to the combined surface scan, an expandable **Surface Parameters** section is added. The following settings are available:<br>• X, Y, and Z Offset<br>• X, Y, and Z Angle<br>• Mirror: Mirrors input Surface {n}. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
|---|
| **Captured** |
| Indicates the number of scans successfully added to the combined surface scan. |

> Only one of the following data types will contain data, depending on whether **Uniform Spacing** is enabled. For more information, see *Scan Modes and Intensity* on page 111.

*Data*

| **Type** | **Description** |
|---|---|
| Stitched Surface | The stitched surface scan. |
| Stitched Raw Surface | |

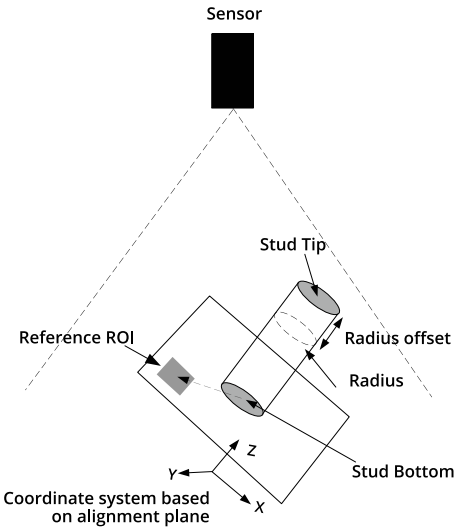
## Surface Stud

The Stud tool measures the location and radius of a stud.

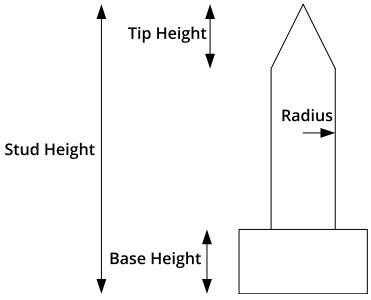
> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

The tool uses a complex feature-locating algorithm to find a hold and then return measurements. For a detailed explanation of the algorithm, see *Stud Algorithm* on the next page.

The location of the stud is defined at either the stud tip or the stud base. The tip is the intersection of the stud axis and the top of the stud; the base is the intersection of the stud axis and the surrounding plane.




The stud shape is defined by the tip height and base height. The base and tip heights specify where the shaft with the nominal radius begins and ends.




*Measurement Panel*

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Stud Algorithm

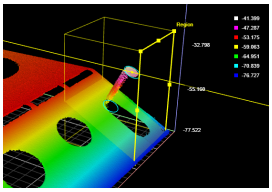
The Stud algorithm measures the stud in three steps: searching for the tip, finding the reference plane, and shaft fitting. Note that the tip and the side of the stud must be within the measurement region.

See the tool's parameters for an explanation of the options that affect the tool's algorithm.

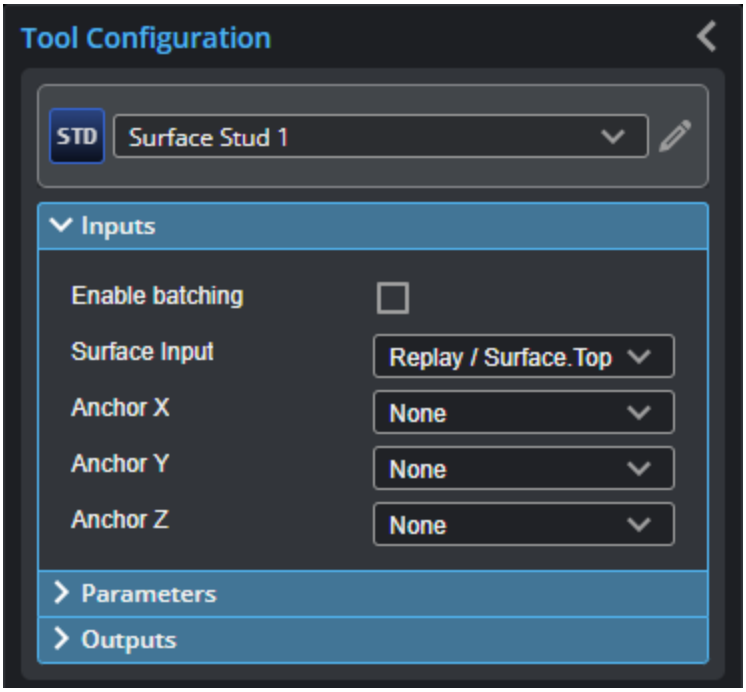
**Searching for the tip** - The algorithm looks for the approximate location of the tip. If Auto-Tilt is enabled, the algorithm uses the flat surface around the tip to estimate the orientations of the part. The approximate tip is the location of the highest (maximum Z) pixel after correction for the nominal tilt angle.

**Finding the reference plane** - The reference regions are positioned using the approximate tip, the nominal angle values, and the nominal stud length. Compared to the hole/opening, misplaced stud reference regions are more likely to cause a failure to produce any measurement.

**Shaft fitting** - The shaft region is determined based on the approximate tip position, the nominal angles, the reference plane position, and the stud nominal size parameters. Shaft fitting is successful if the algorithm can fit at least three circles with the stud diameter along the shaft. Fitting each circle requires sufficient data along the top portion the shaft. Because of occlusions, the bottom of the shaft is often not visible to the sensor and the algorithm is designed to handle this situation.



### Inputs



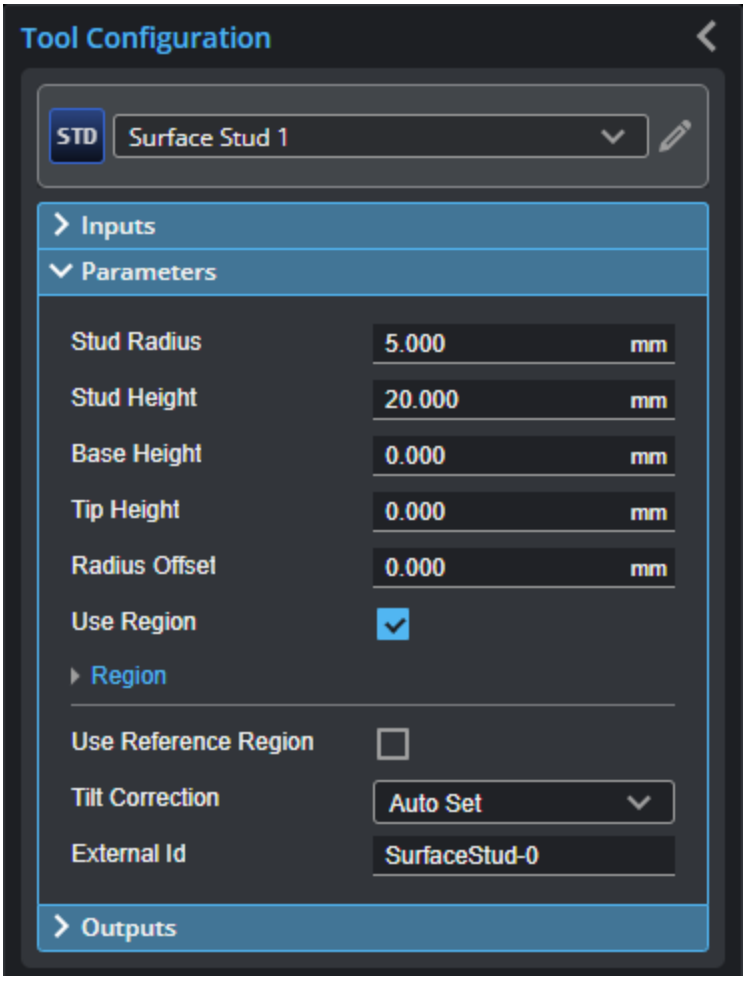
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Anchor X<br>Anchor Y<br>Anchor Z | The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional. |

**Parameters**

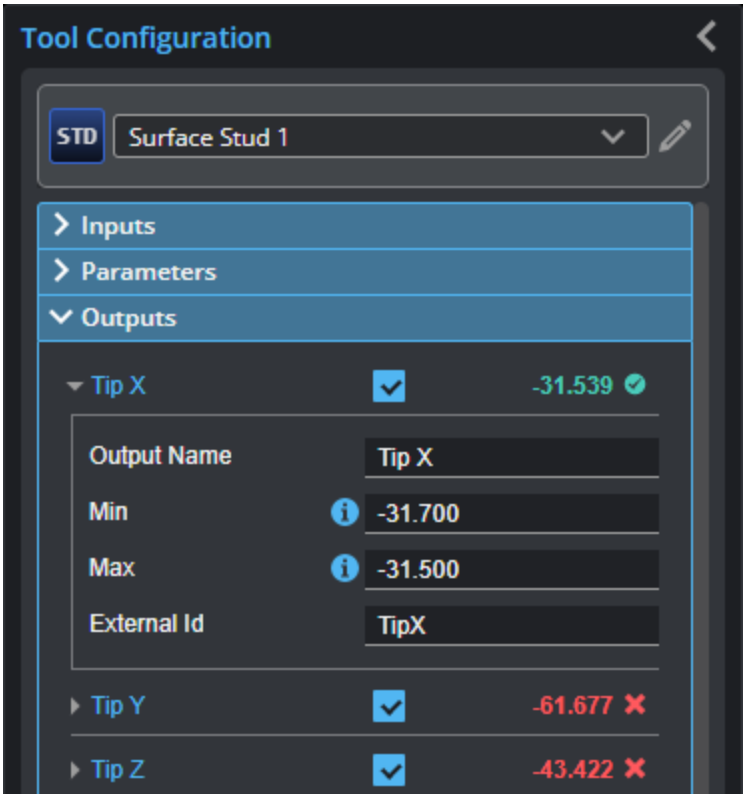
The following parameters are in the expandable **Parameters** section in the tool's configuration.



*Parameters*

| Parameter | Description |
|---|---|
| Stud Radius | Expected radius of the stud. |
| Stud Height | Expected height/length of the stud. |
| Base Height | The height above the base surface that will be ignored when the (truncated) cone is fitted to the stud data. |
| Tip Height | The height from the top of the surface that will be ignored when the (truncated) cone is fitted to the stud data. |
| Radius Offset<br>*(Radius measurement only)* | The distance from the tip of the stud from which the radius is measured. |
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Use Reference Region | When enabled, displays the **Reference Type** setting. |
| Reference Type | The tool uses the reference regions to calculate the base plane of the stud. Reference regions are relative to the base of the stud. |
| Tilt Correction | Tilt of the target with respect to the alignment plane.<br>**Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes.<br>**Custom**: You must enter the X and Y angles manually in the **X Angle** and **Y Angle** parameters (see below). |
| X Angle<br>Y Angle | The X and Y angles you must specify when **Tilt Correction** is set to **Custom**.<br>You can use the Surface Plane tool's X Angle and Y Angle measurements to get the angle of the surrounding surface, and then copy those measurement's values to the **X Angle** and **Y Angle** parameters of this tool. For more information, see Plane. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

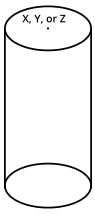
**Outputs**

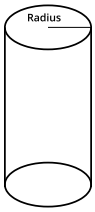



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Tip X**<br>Determines the X position of the stud tip. |  |
| **Tip Y**<br>Determines the Y position of the stud tip. | |
| **Tip Z**<br>Determines the Z position of the stud tip. | |
| **Shaft X**<br>Determines the X position of the stud shaft. The position is defined with the parameter Radius Offset. | |
| **Shaft Y**<br>Determines the Y position of the stud shaft. The position is defined with the parameter Radius Offset. | |
| **Shaft Z** | |

| Measurement | Illustration |
| --- | --- |
| Determines the Z position of the stud shaft. The position is defined with the parameter Radius Offset. | |
| **Base X**<br>Determines the X position of the stud base. | |
| **Base Y**<br>Determines the Y position of the stud base. | |
| **Base Z**<br>Determines the Z position of the stud base. | |
| **Radius**<br>Determines the radius of the stud. |  |

*Features*

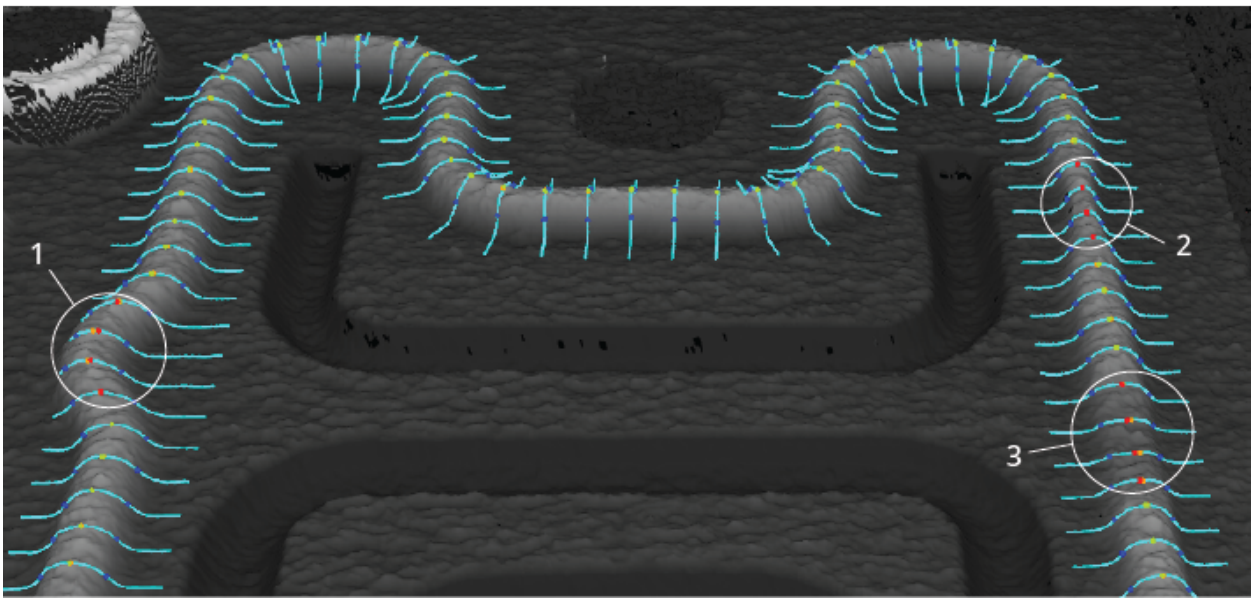
| Type | Description |
| --- | --- |
| Tip Point | The center point of the stud tip. |
| Shaft Point | The center point of the stud shaft. |
| Base Point | The center point of the stud base. |

For more information on geometric features, see *Geometric Features* on page 191.

## Surface Track

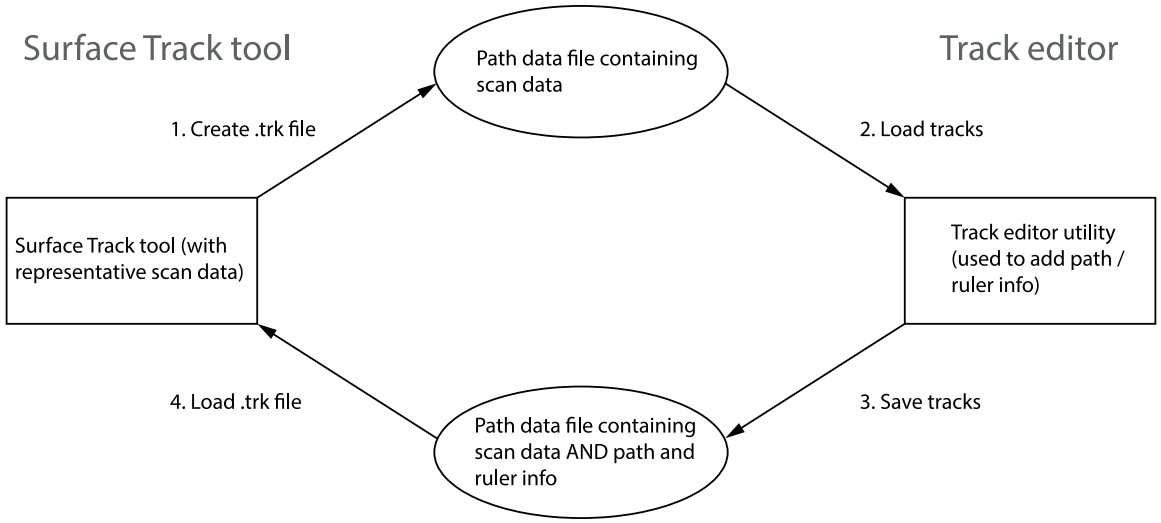
The Track tool lets you perform quality control and inspection along a path you define on representative scan data. The Track tool is especially useful for inspecting materials such as glue / sealant beads. The tool returns width and height measurements of the material, as well as OK and NG ("no good") counts, which let you monitor material overflow and breaks. A major advantage of the tool is that it removes the need to configure individual tools for each location along the path. You can use point and line geometric features to anchor the tool (for more information on geometric features, see *Geometric Features* on page 191).

> Gocator sensors have a limited amount of space for storing path files. For this reason, when working with large datasets, we recommend that you run the Track tool through a PC instance of GoPxL. For more information, see *Running GoPxL on a Windows PC* on page 814.




| | Element | Description |
|---|---|---|
| 1 | Offset fails | The center points in this area of the track are too far off the defined path. |
| 2 | Width fails | The center points in this area of the track are too narrow. |
| 3 | Height failes | The center points in this area of the track are too low. (Note how the profiles are flatter than other profiles.) |

You define the path along which the tool performs its measurements using a separate, PC-based utility (the "track editor"). The following shows the relationship between the Surface Track tool and the track editor.




For more information on the track editor, see *Track Editor* on page 950.

> All instances of the Track tool on a sensor or in a PC instance of GoPxL share the same path file set in **File** (ending in .trk). For this reason, you must be careful when editing or removing path files shared by another instance of the tool.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

**Key Concepts**

The following are important concepts for using both the track editor (see *Track Editor* on page 950) and the Surface Track tool itself:

**Track**: The material being measured, for example glue or sealant. The material can sit on a flat area on the target, or sit in a groove where the material touches one or both sides.

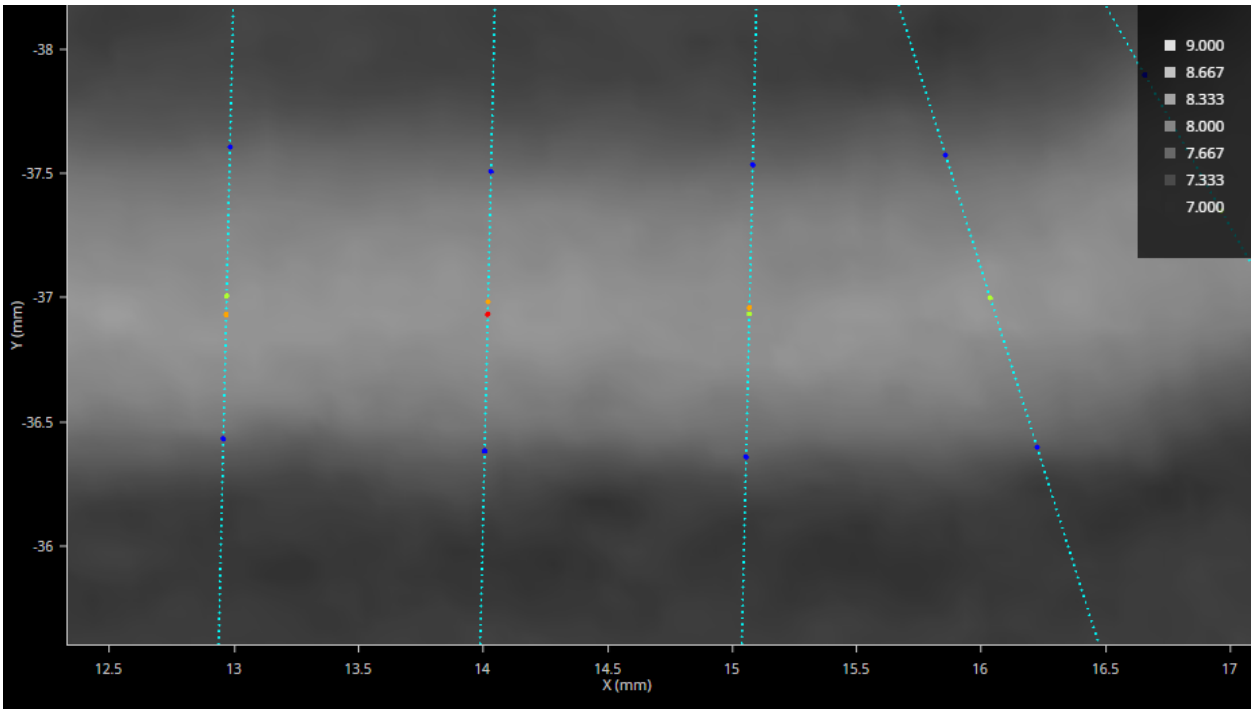
**Path**: The ideal center line of the track. You define the path in the track editor. You can define more than one path for use on scanned targets, but the Surface Track tool returns measurements for all paths.

**Caliper / ruler**: A caliper (in the tool) or ruler (in the track editor) is an area perpendicular to the path you define. You define the size (length and width) and spacing of the rulers in the track editor. The Surface Track tool extracts a profile from the surface data beneath a caliper and performs measurements based on the values you set in the tool's parameters.

**Caliper / ruler profiles**: The profiles extracted from the surface data under a caliper. The tool's measurements, which are configured using the tool's settings, are applied to these profiles.

**Segment**: One portion of the path, between points created by clicking on an image of scan data in the track editor. You can choose to configure rulers in segments independently, or choose to configure them in a batch mode.

The following shows a track with calipers. Colored dots provide important information (see below).




*Track tool in data viewer, showing a track (lighter grey horizontal strip in the middle), calipers running perpendicular to the track (light blue dots). Dots of other colors provide additional information (see below).*

When you enable **Show Measurement Results**, the tool displays dots on the calipers to provide the following information (see also the images below):

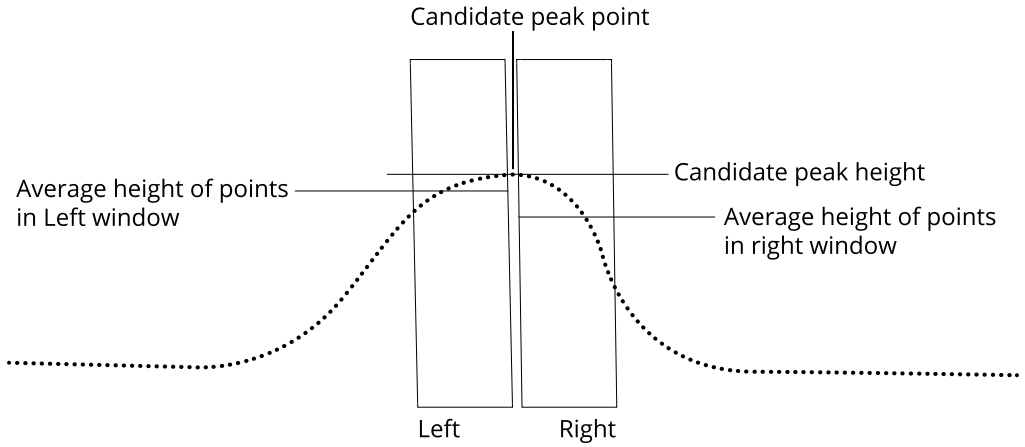
- Light blue dots: The data points in the caliper profile. When you enable **Show Path and Calipers**, the tool displays a white line centered on these dots to indicate the location of the caliper.
- Dark blue dotes: The detected sides of the track. These represent the width of the track under that caliper.
- Green dot: The center point (between the two sides of the track) on a caliper that *passes* all criteria set in the tool. These count toward the "OK Count" measurement.
- Red dots: The center point (between the two sides of the track) on a caliper that *fails* at least one of the criteria set in the tool. These count toward the "NG Count" measurement. Causes for failures include the width and the height of the track, as well as the area under the caliper profile.
- Orange dots: The peak (highest) point on the ruler. If the center point (green or red) is the same as the peak point, the tool only shows the center point.

### Track Location

The tool attempts to locate the track using the profile data it extracts under each caliper, and does this by first locating the "peak" (the highest point on the caliper profile, based on certain criteria) and then locating the side points representing the "sides" of the track.

**Peak Detection**

The tool determines the peak point on a caliper profile by moving two windows—one to each side of the point being examined—and comparing the average height in those windows with the height of the point being examined. (The size of these windows is specified in **Center Window Size**.) If the height of the point being examined is greater than both the left and right average height by the value specified in **Center Threshold**, that point is considered a candidate peak point. The tool uses the candidate point with the *highest* height over both windows as the peak point.




**Side Detection**

After the tool has located the peak point, it locates the sides of the track starting from the peak point. You can choose between two methods for side detection: Maximum Gradient and Height Threshold.

### **Maximum Gradient**:

Use this side detection method when the slope of the two sides show a clear drop-off. The following settings define the area in which the tool searches for a maximum gradient, which will determine the edge of the track.

*Maximum Gradient Side Detection Parameters*

| | |
|---|---|
| Side Window Size | The size of the two adjacent windows the tool uses to determine the maximum slope on the left and right side of the track. Set this to roughly 3 to 5 times the smaller of the X and Y resolution of the sensor. |
| Max Track Width | The maximum width of the track over the caliper profile the tool searches for edge points. The tool uses this value to limit where the edge of the track might be detected. |

### **Height Threshold**:

Use this side detection method when the slope of two sides is very gradual. The tool finds the left and right edges by averaging the height of small fixed-size windows moving away from the peak point. Edge points are the left-most and right-most window locations where the average height is *below* a minimum height threshold.

*Height Threshold Side Detection Parameters*

| | |
|---|---|
| Side Height Threshold | The minimum height that the average calculated in the fixed-width height threshold windows must be below. |

**Center Point Detection**

The Track tool calculates the center point as the mid point between the left and right side points. This means that the center point may be different from the peak point.

### Configuring the Surface Track Tool

To configure the tool, you must first acquire scan data of a representative target; preferably, the material on the target will fall within the expected tolerances. Next, you save the scan data from within the Track tool, and then load the scan data into the track editor. Then, after adding a path or paths, and configuring rulers on the data, you load the track data back into the Track tool. Finally, you configure the tool. For more information on key concepts you need to understand to configure the Track tool, see *Key Concepts* on page 596.

*To configure the Track tool:*

1. Scan a representative target, or load previously scanned data.

   For more information on loading previously scanned data, see *Recording and Working with Scan Data* on page 87.

2. Add a Surface Track tool.

   For more information on adding a tool, see *Adding a Tool* on page 150.

3. In the Surface Track tool, choose **Create** from the **Operation** drop-down.

   The tool creates a file (for example, SurfaceTrack-0000.trk) containing scan data. Creating the file may take a few seconds.

4. Launch the track editor and configure the path or paths.

   For information on using the track editor, see *Track Editor* on page 950.

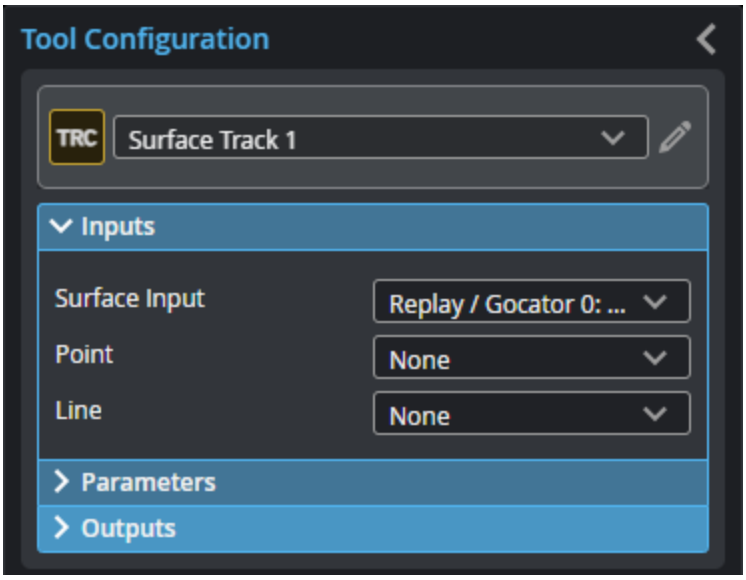
5. After you have finished editing the track data in the track editor, in the Surface Track tool, choose **Load** in the **Operation** drop-down to load the path data you just created.

6. Configure the Track tool as required.

   For information on the tool's measurements and settings, see the below.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

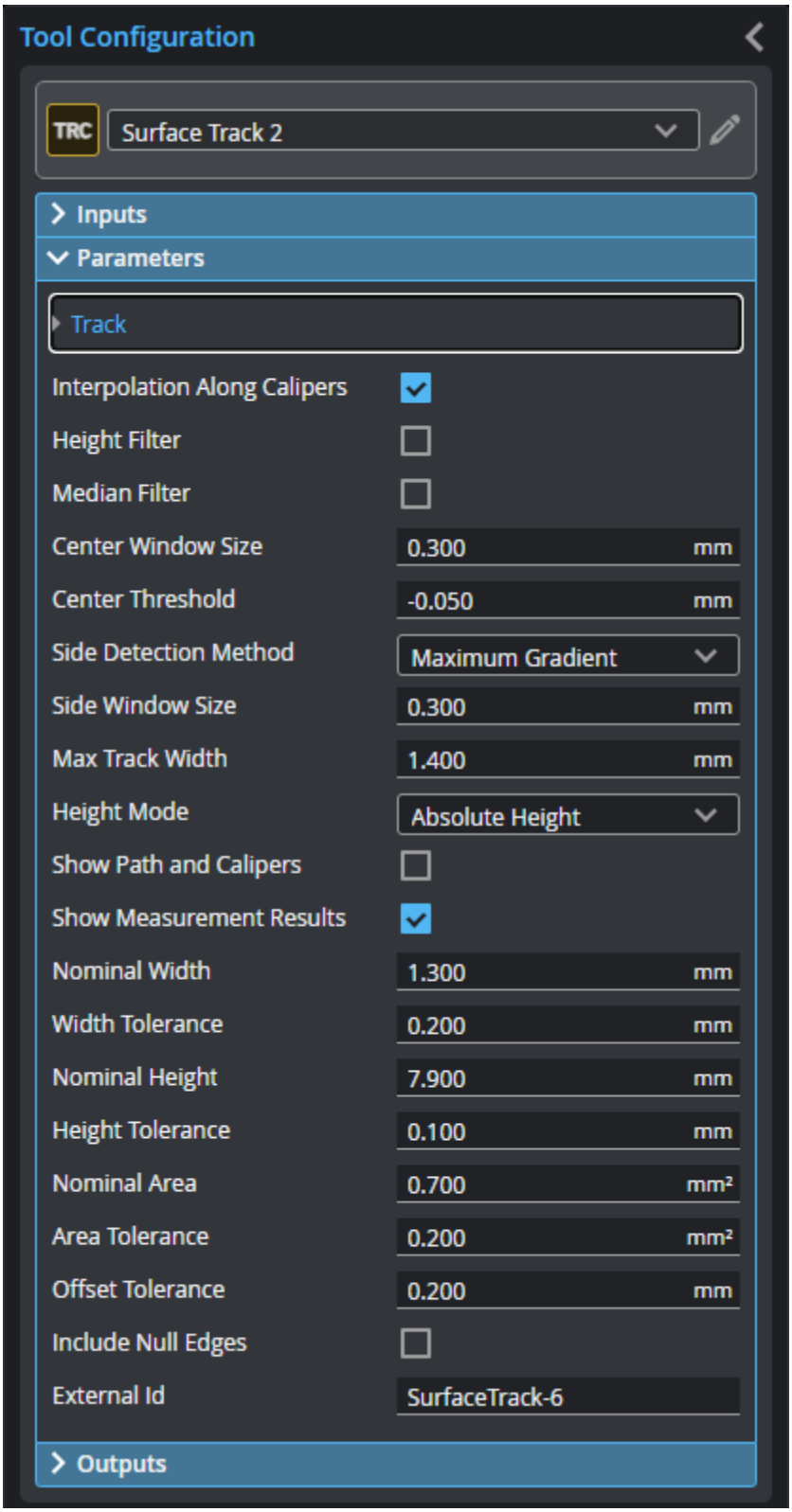



*Inputs*

| Name | Description |
|---|---|
| Surface Input | The data the tool applies measurements to or processes. |
| Point<br>Line | Point and line geometric features (produced by another tool) that you can select as anchors for translation and rotation transformations, respectively. Currently, you must select both in order for anchoring to work. For more information on geometric features, see *Geometric Features* on page 191. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.


Tool Configuration
TRC
Surface Track 2
Inputs
Parameters
Track
Interpolation Along Calipers
Height Filter
Median Filter
Center Window Size
0.300
mm
Center Threshold
-0.050
mm
Side Detection Method
Maximum Gradient
Side Window Size
0.300
mm
Max Track Width
1.400
mm
Height Mode
Absolute Height
Show Path and Calipers
Show Measurement Results
Nominal Width
1.300
mm
Width Tolerance
0.200
mm
Nominal Height
7.900
mm
Height Tolerance
0.100
mm
Nominal Area
0.700
mm²
Area Tolerance
0.200
mm²
Offset Tolerance
0.200
mm
Include Null Edges
External Id
SurfaceTrack-6
Outputs

*Main Parameters*

| Parameter | Description |
|---|---|
| Track | When expanded, displays file-related operations. |
| File | The track file that contains scan and path data. You add paths and calipers to the file using the track editor. For more information on the track editor, see *Track Editor* on page 950. |
| Operation | Provides operations related to the track file. One of the following:<br>• **Normal**: Selected by the tool after you perform another file operation.<br>• **Create**: Creates a new track file for use with the track editor.<br>• **Load**: Loads the path file selected in **File**.<br>• **Save**: Saves changes made in the scan data, as well as the geometric features used as anchors in the **Point Feature** and **Line Feature** settings, to the file selected in **File**.<br>• **Delete**: Deletes the path file selected in **File**.<br>• **Refresh**: Refreshes the list of files. |
| Interpolation Along Calipers | Enables linear interpolation on the profile extracted from the calipers to achieve sub-pixel accuracy in the width and height measurements. |
| Height Filter<br><br>*Dependent settings*<br>Threshold High<br>Threshold Low | When **Height Filter** is enabled, use the **Threshold Low** and **Threshold High** settings to set a range to filter out noise or exclude other undesired data along the caliper profiles. |
| Median Filter<br><br>*Dependent settings*<br>Window Size | When **Median Filter** is enabled, specify the window the tool will use to smooth the height values of the points in the caliper profiles in the **Window Size** setting. |
| Center Window Size | The size of the left and right windows the tool moves along the caliper profile to detect whether the point centered between the two is the highest point along a caliper (the center point).<br>Set this to roughly 50% of the typical width of the track as a starting point. |
| Center Threshold | The center point is determined by moving two side-by-side windows (left and right, **Center Window Size** setting) over each caliper profile. At each point, the height value between the two windows is compared to the average height of the left and right windows.<br>If the center point height is greater, by the amount set in **Center Threshold**, than the average height in both the left and right windows, that point is considered a candidate center point. The candidate center point with the highest average height over both windows is used as the center point.<br>It may be necessary to use a negative number in some cases, for example, when |

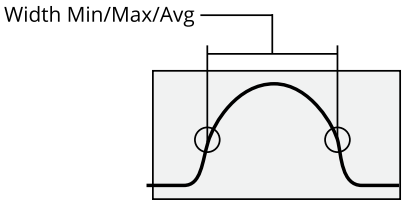
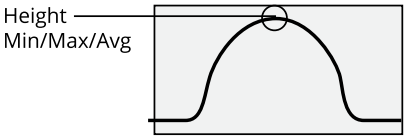
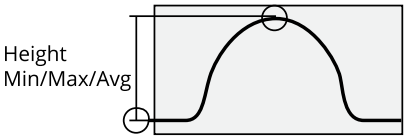
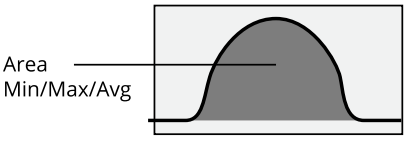
| Parameter | Description |
| --- | --- |
| | the top point slightly dips below its surroundings. |
| Side Detection Method<br><br>*Dependent settings*<br>Side Window Size<br>Max Track Width<br><br>Side Height Threshold | The method the tool uses to detect the two sides of the track. One of the following: **Maximum Gradient** or **Height Threshold**. For more information on side detection method settings, see *Side Detection* on page 598. |
| Height Mode | Determines how height values are interpreted in the tool's **Nominal Height** setting and what the returned height measurements represent. One of the following:<br>**Absolute Height** - Height values are interpreted globally (all of the scan data).<br>**Step Height** - Height values are relative to the surrounding area of the track. |
| Show Path and Calipers | Displays the path and calipers (as defined in the track editor) on the scan data. |
| Show Measurement Result | Shows dots on each caliper representing the results of the measurements on the profile extracted from the surface data under the caliper. For more information, see *Key Concepts* on page 596. |
| Nominal Width | The expected width of the track. |
| Width Tolerance | The tolerance applied to the nominal width. |
| Nominal Height | The expected height of the track. The **Height Mode** setting determines how the height is interpreted (absolute or step); for more information, see *Height Mode* above.<br>This setting applies to the peak point, not the center point. |
| Height Tolerance | The tolerance applied to the nominal height. This setting applies to the peak point, not the center point. |
| Nominal Area | The expected cross-sectional area under the calipers on the track. |
| Area Tolerance | The tolerance applied to the nominal area. |
| Offset Tolerance | The maximum allowed distance between the center (highest) point on a ruler and the path. This setting applies to the center point. |
| Include Null Edges<br><br>*Dependent settings*<br>Null Fill Value | When enabled, displays a **Null Fill Value** parameter you can set to replace null values with the value. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.

*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

| Measurement | Illustration |
|---|---|
| **OK Count**<br>Returns the number of rulers along the path that pass all of the criteria set in the tool's parameters. | |
| **NG Count**<br>Returns the number of rulers along the track path that fail the criteria set in the tool's parameters. (They are "no good.") | |
| **Min Width**<br>**Max Width**<br>**Mean Width**<br>These measurements return the minimum, maximum, and mean width of the track. |  <br>*Width measurements on a ruler profile. The Track tool's settings determine the locations of the "sides" of the track.* |
| **Min Height**<br>**Max Height**<br>**Mean Height**<br>These measurements return the minimum, maximum, and mean height of the track at the center point.<br>When **Height Mode** is set to **Absolute Height**, the height returned is the global height. When it is set to **Step Height**, the height is relative to the surface next to the track. |  <br>*Height measurements on a ruler profile with Height Mode set to Absolute Height.*<br>  <br>*Height measurements on a ruler profile with Height Mode set to Step Height.* |
| **Min Area**<br>**Max Area**<br>**Mean Area**<br>These measurements return the minimum, maximum, and mean area under the rulers. |  <br>*Area measurements under a ruler profile.* |
| **Width**<br>**Peak Height** | |

| Measurement | Illustration |
|---|---|
| **Offset**<br>Arrays containing the widths, peak heights, and offsets of each ruler. | |

*Features*

| Type | Description |
|---|---|
| Center Point | An array of Point geometric feature representing the center point of each ruler. |

For more information on geometric features, see *Geometric Features* on page 191.

*Data*

| Type | Description |
|---|---|
| Diagnostic Surface | Surface data created by combining the extracted profiles. Use for diagnostics. |

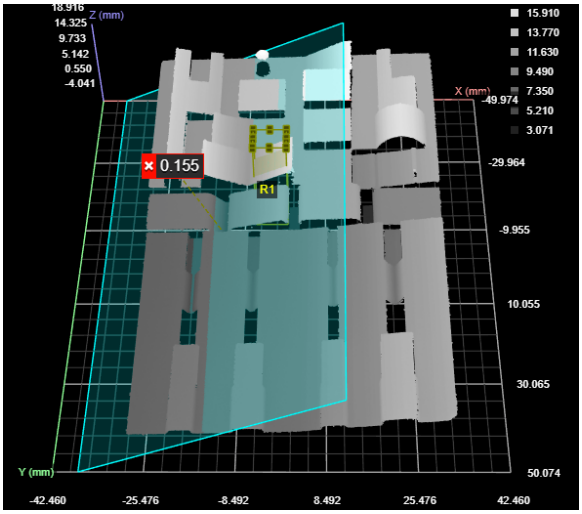
## Training Archive

The Training Archive tool lets you conditionally add frames to a Surface Anomaly Detector project. Training Archive is only intended to be used with Surface Anomaly Detector. For more information, see *Training Archive* on page 381.

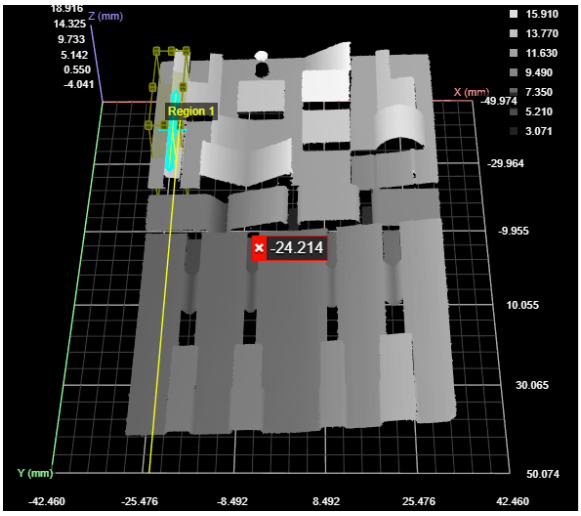
## Surface Transform

The Surface Transform tool generates a new surface based on the coordinate system of geometric features the tool uses as input. The tool can take a zero-plane, line, and origin point to define this new coordinate system. You can then apply the built-in measurement tools or GDK tools to this new surface data. This could let you, for example, get the height of a feature relative to a slightly tilted or warped adjacent or surrounding reference surface, rather than the absolute height in the original scan volume relative to the sensor. The result is increased repeatability of your measurements.

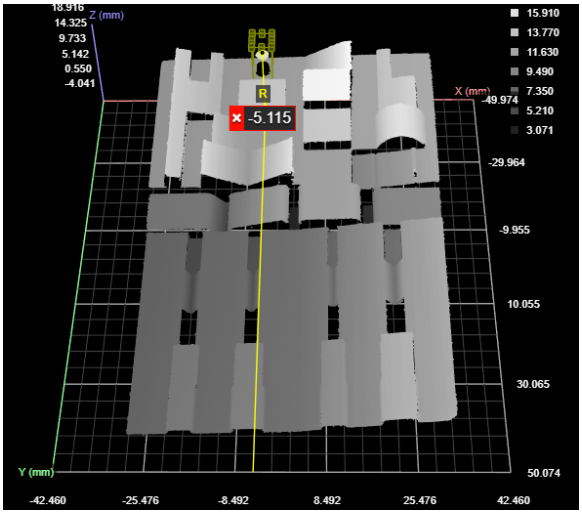
In *Combinations of geometric feature inputs and results* on page 609, the following geometric features are used by a Surface Transform tool in various combinations (a plane, a line, and a point).




*A Surface Plane tool, with the region set to a small left-facing angled surface*

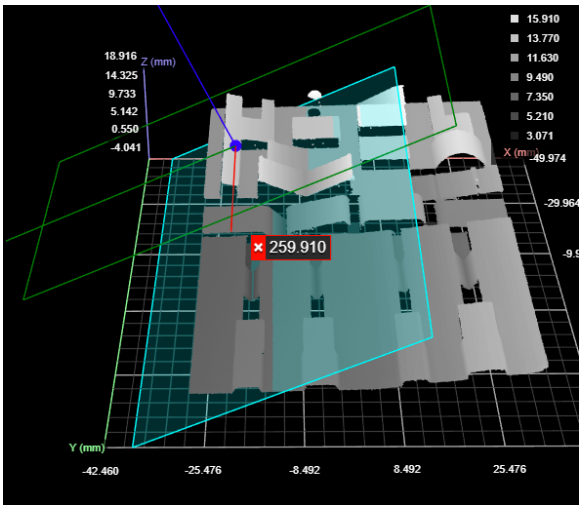



*A Surface Edge tool, with the region set to the left edge of a raised surface (upper left of data viewer).*




*A Surface Position tool (maximum Z), with the region set to the raised point near the top of the data viewer.*

Furthermore, in the sections below, two types of data are shown: the original (input) scan data and the transformed data. When the tool displays the original data, it overlays indicators of the new, transformed coordinate system on the data.




*A Surface Transform tool using all three types of geometric feature inputs.*
*The data viewer is set to display the input surface data with an overlay of the transformed coordinate system.*

In the data viewer, the following is displayed:

### X, Y, and Z axes

The transformed axes are represented above by the red, green, and blue lines intersecting on the surface data above. Note how these are rotated with respect to the original coordinate system (the background grid, axes, and values along the axes).

### Origin

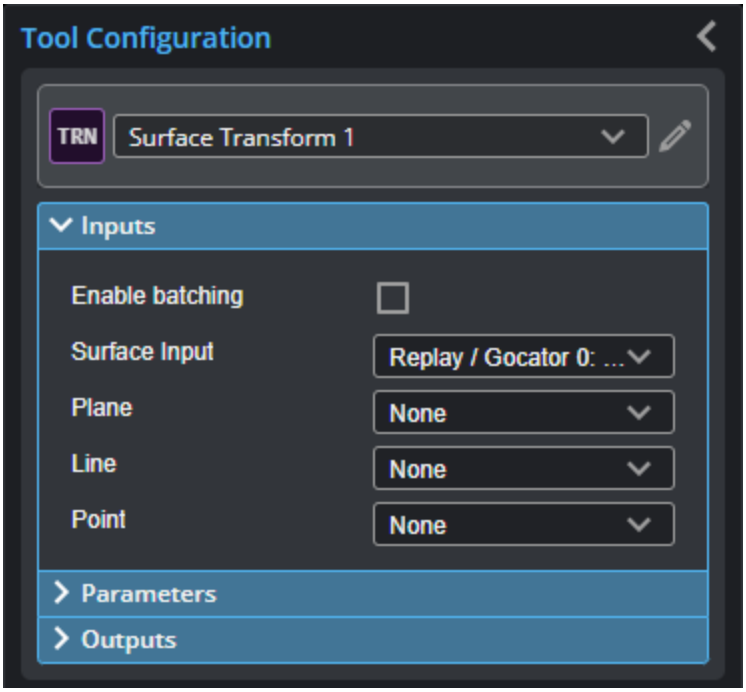
The new origin is represented by the dark blue dot at the intersection of the transformed axes.

### Plane

The new plane is represented by the cyan rectangle.

> To switch between the original and transformed data, choose the output under the data viewer or in the tool's list of outputs.

## Inputs




*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |
| Plane<br>Line<br>Point | The Plane, Line, and Point geometric features the tool uses to perform transformations. The required geometric features depends on your application. For more information, see *Combinations of geometric feature inputs and results* below. |

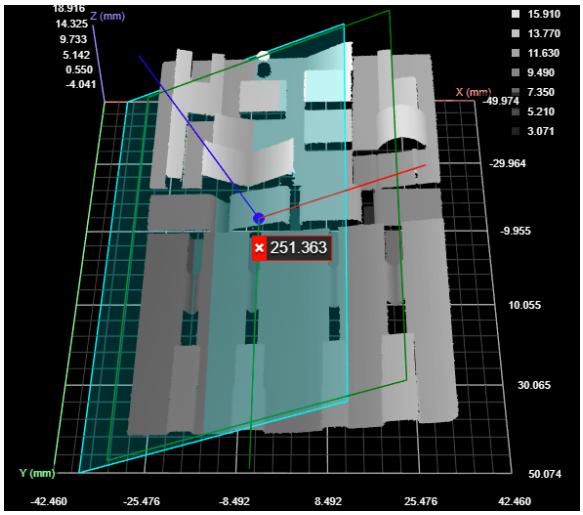
## Combinations of geometric feature inputs and results

The Surface Transform tool accepts all combinations of input geometric features (plane, line, and point). For details and examples of each, see the following sections.

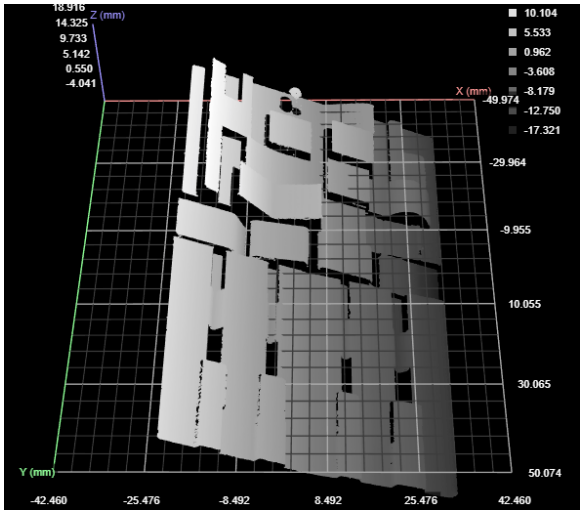
#### Plane

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| Matches the input plane. | Parallel to the old X axis. | Old origin projected to plane. |

## Original data with overlay



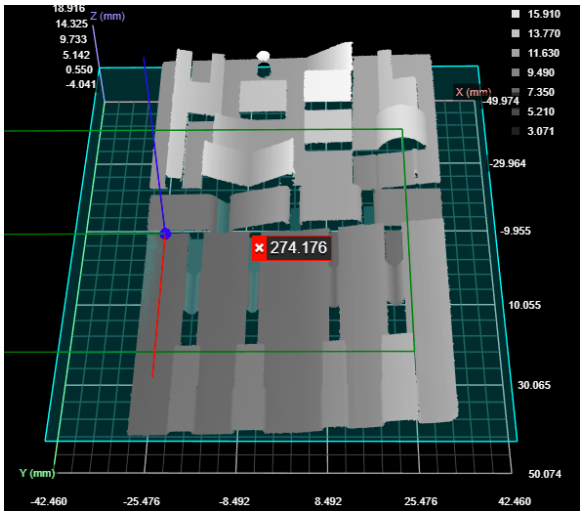

## Transformed data



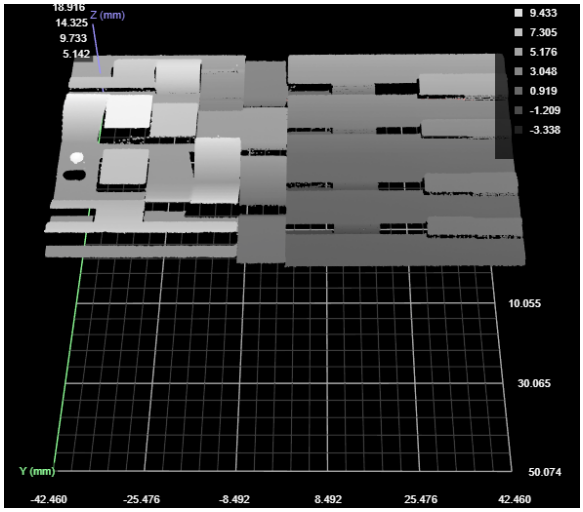

**Line**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| The new plane contains the line. The intersection of the new plane and the old plane is perpendicular to the input line. | Matches the line. | Old origin projected onto the line. |

### Original data with overlay




### Transformed data

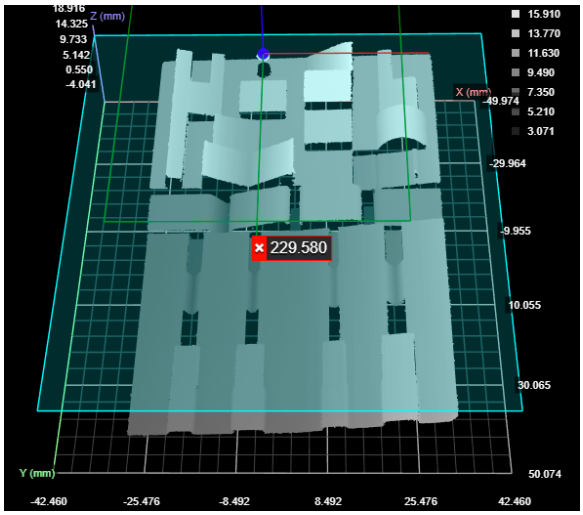



The direction of the X axis depends on the tool generating the line that Surface Transform takes as input. You may need to adjust the direction using the **Add Fixed Transform** settings.

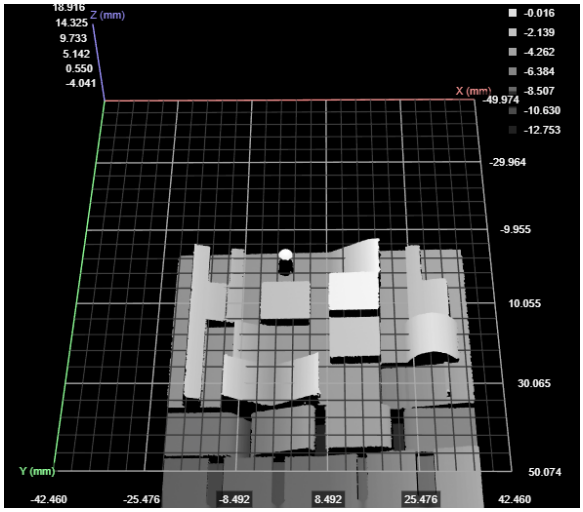
**Point**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| Through the input point, parallel to old Z=0 plane. | Parallel to the old axis. | The input point. |

## Original data with overlay



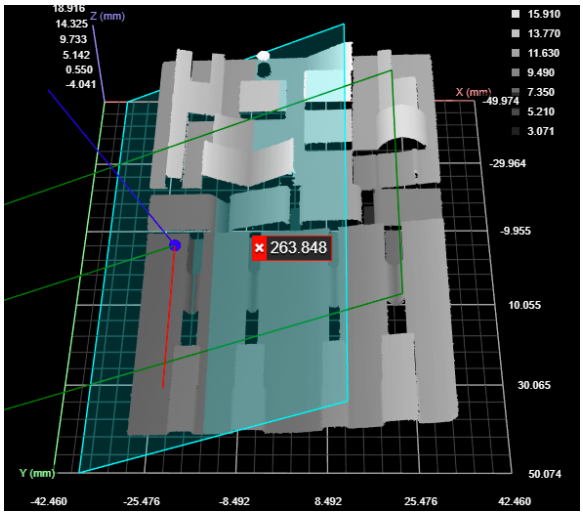

## Transformed data



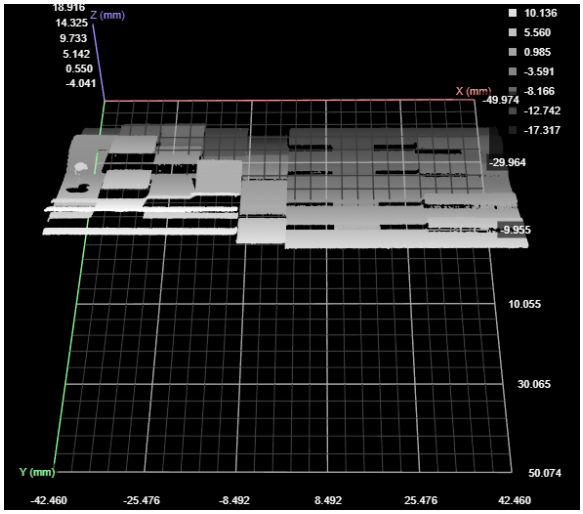

**Plane + Line**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| Matches the input plane. | Line projected onto the plane. | Old origin projected onto the projected line. |

## Original data with overlay



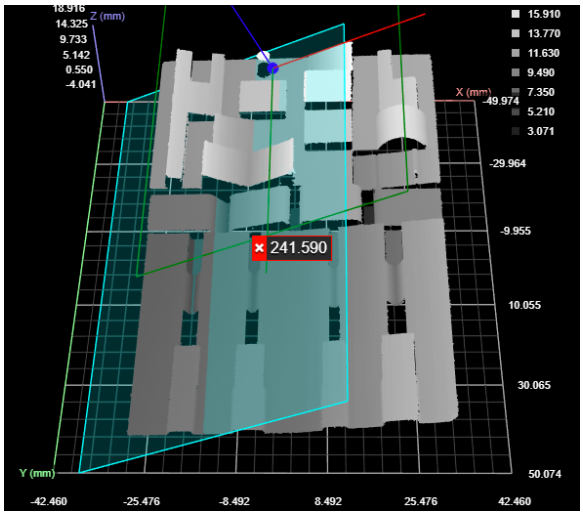

## Transformed data



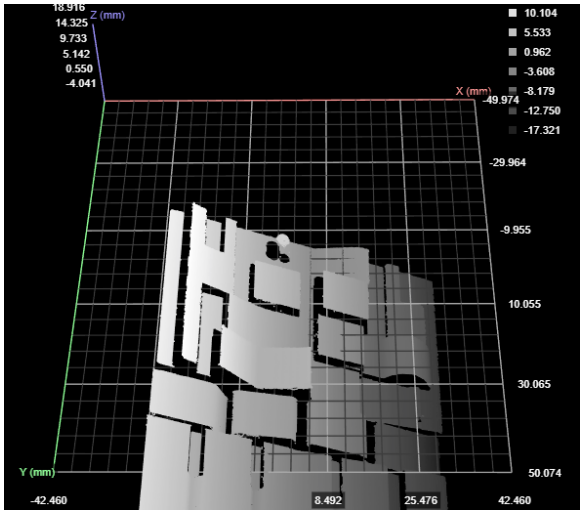

**Plane + Point**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| Matches the input plane. | Parallel to the old X axis. | At the input point, projected onto the plane. |

### Original data with overlay



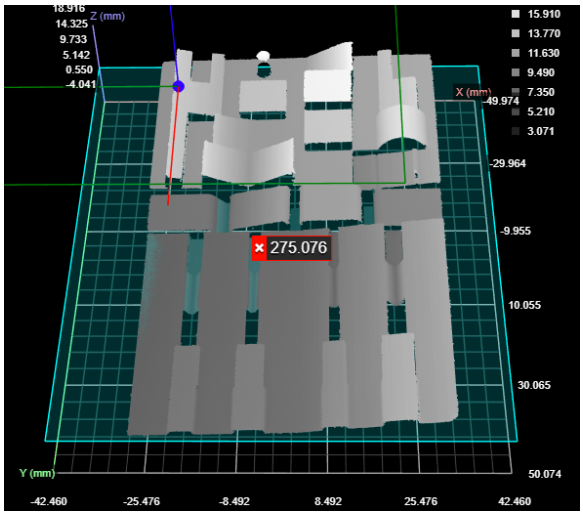

### Transformed data



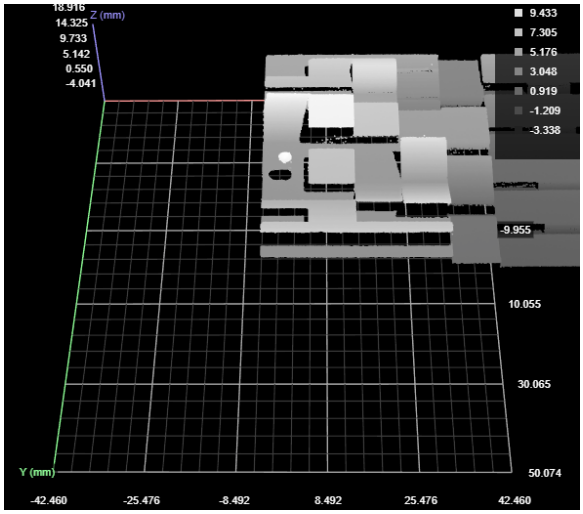

**Line + Point**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| The new plane contains the line. The intersection of the new plane and the old plane is perpendicular to the input line. | Matches the line. | The input point projected onto the line. |

### Original data with overlay



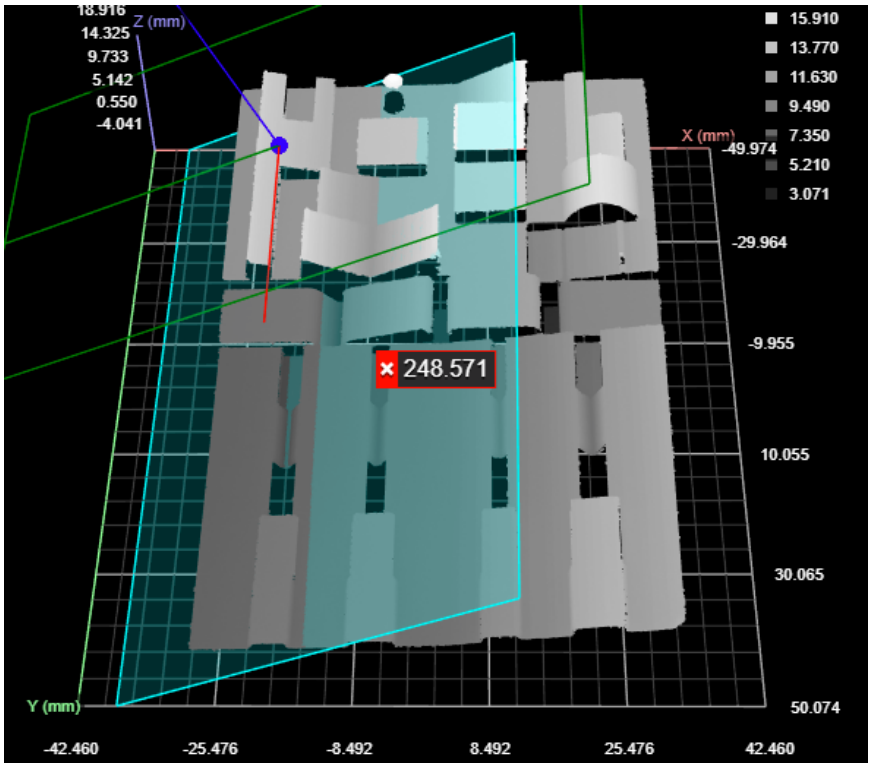

### Transformed data



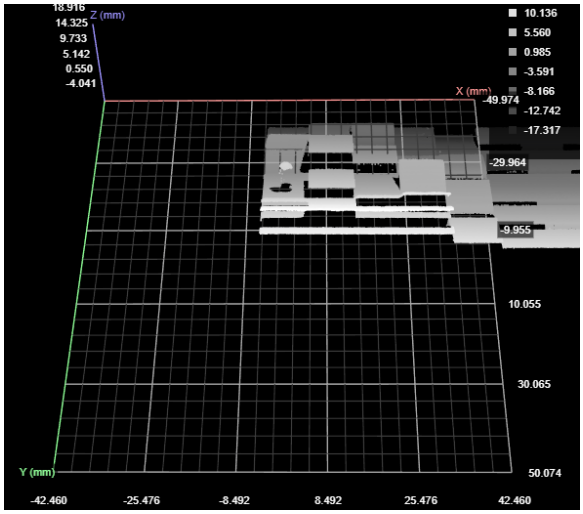

**Plane + Line + Point**

| New Z=0 XY Plane | New X Axis | New Origin |
|---|---|---|
| Matches the input plane. | The input line projected onto the plane. | The input point projected onto the input line. |

### Original data with overlay



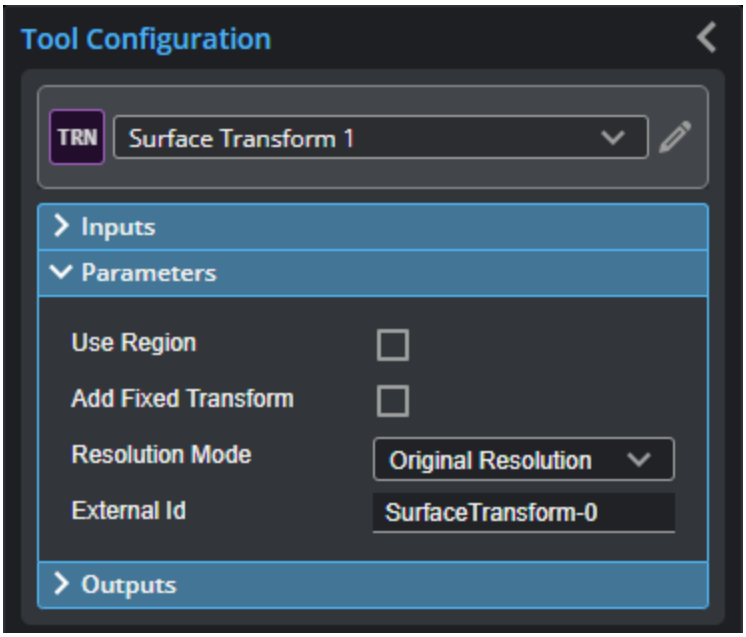

### Transformed data




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

#### Parameters

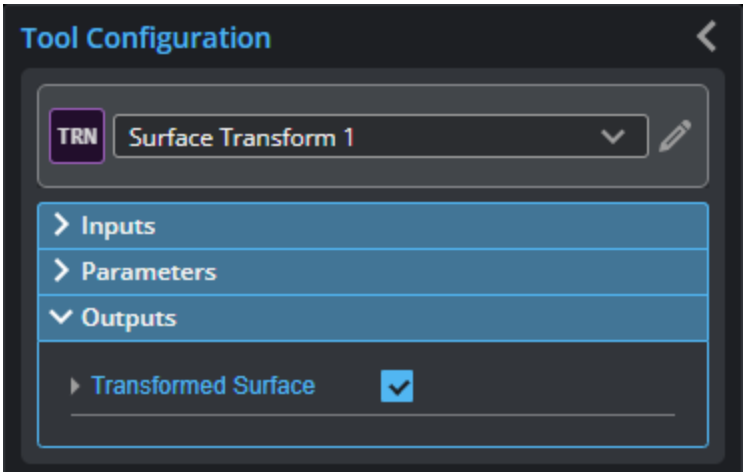
The following parameters are in the expandable **Parameters** section in the tool's configuration.




*Parameters*

| Parameter | Description |
|---|---|
| Use Region | When enabled, displays Region parameters (see below). When disabled, the tool uses all data. |
| Region | The region to which the tool's measurements will apply. For more information, see *Regions* on page 181. |
| Add Fixed Transform | When enabled, displays X, Y, and Z offset and angle fields you can use to set additional transformations, which are applied after any transformations supplied by the input geometric features.<br>Setting a fixed transformation can be useful if the geometric features the tool uses results in data rotated to an unusual orientation; you could, for example, rotate the data 90 or 180 degrees so that it is in the "expected" orientation, or shift it so that it's easier to work with. |
| Resolution Mode | |

**Outputs**




*Data*

| Type | Description |
|---|---|
| Transformed Surface | The transformed surface. |

## Surface Vibration Correction

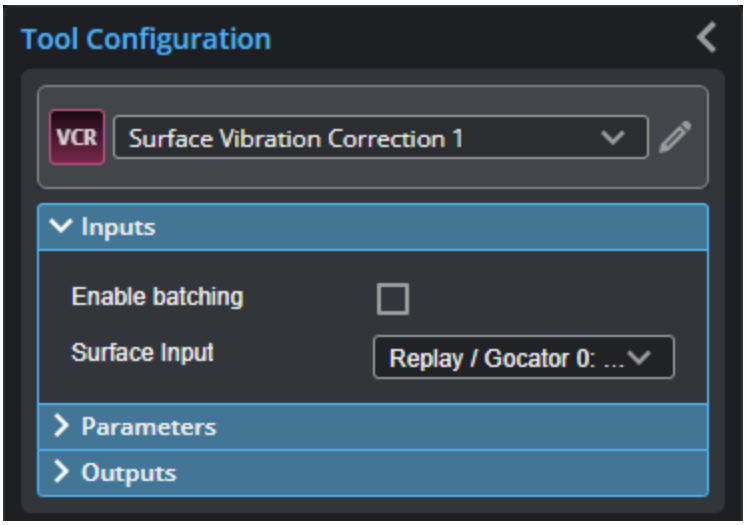
The Vibration Correction tool analyzes variation in surface data to remove high frequency noise in the data. The tool is useful for improving repeatability and accuracy of measurements when subtle vibrations in your transport system introduce height variations. The tool's intended use is to send corrected surface data to other tools.

> The Vibration Correction tool requires at least 64 lines of data in the surface data it receives as input to be able to output corrected surface data.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

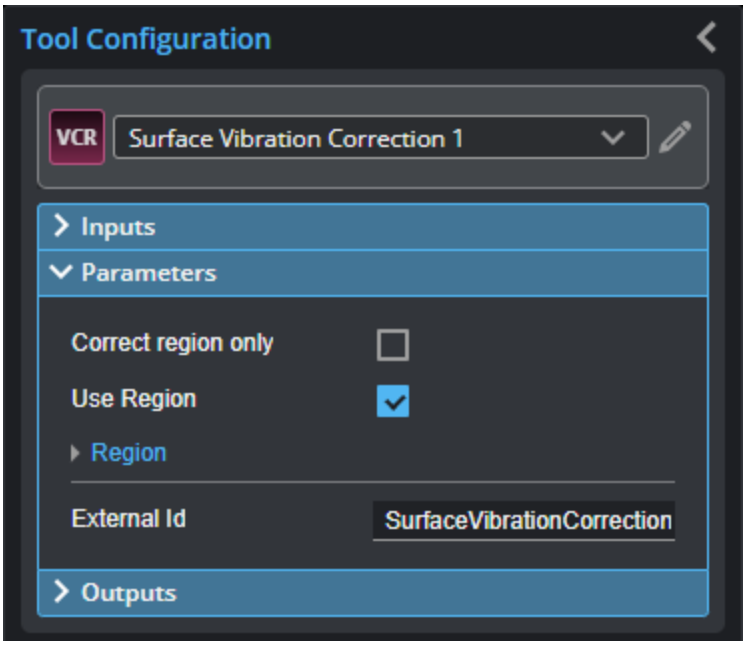



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Surface Input | The data the tool applies measurements to or processes. |

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.

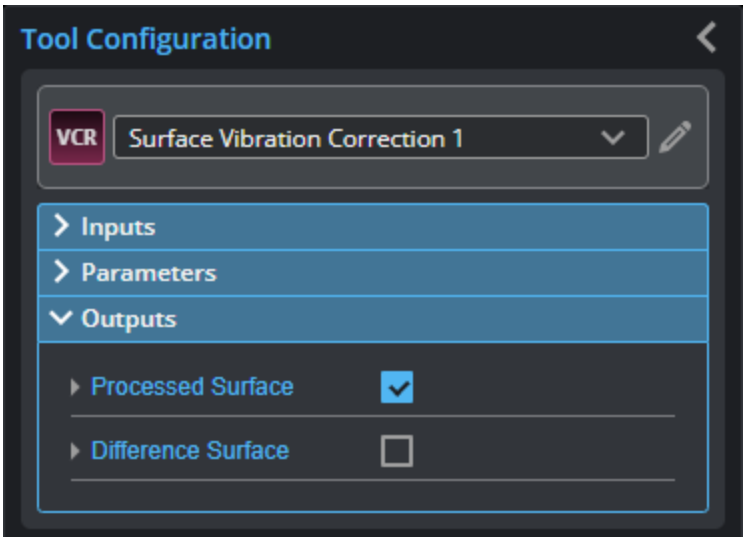



*Parameters*

| Parameter | Description |
|---|---|
| Correct Region Only | If enabled, only the area under the region is corrected for vibration in the Surface data the tool outputs. This setting can be useful if vibration regularly occurs in a specific area of the scan data.<br>When disabled, the tool applies correction to all of the scan data.<br>This option is only displayed if **Use Region** is enabled. |
| Use Region | When enabled, lets you set a region and optionally choose to apply vibration correction only to that region (by enabling **Correct Region only**). |
| Region | The region whose data the tool will use to calculate the vibration correction.<br>If **Correct Region Only** is enabled, the tool applies vibration correction *only* to the region.<br>If **Correct Region Only** is disabled, the tool applies vibration correction to all of the scan data. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Data*

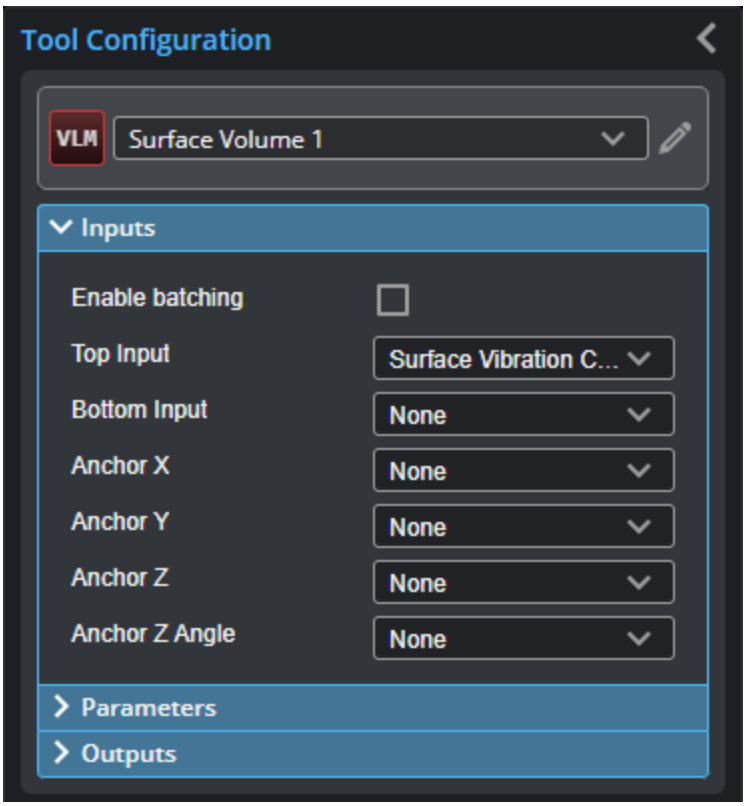
| Type | Description |
|---|---|
| Processed Surface | Surface data corrected for vibration, available for use as input in other tools. |
| Difference Surface | Diagnostic Surface data showing the difference between the corrected surface and the original. |

## Surface Volume

The Volume tool returns the volume, area, and thickness of a part.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs




To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 193.

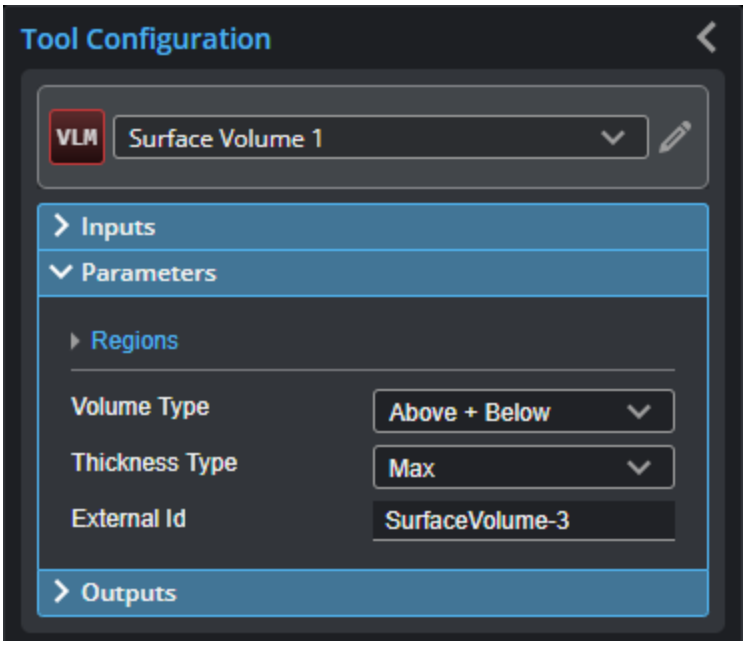
*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Top Input | The data the tool applies measurements to or processes. |
| Bottom Input | This tool can optionally take a second, bottom input.<br>When **Enable Batching** is checked, both inputs take an array. |
| Anchor X | The X, Y, or Z measurement of another tool that this tool uses as a positional |

| Name | Description |
|---|---|
| Anchor Y<br>Anchor Z | anchor. Positional anchors are optional. |
| Anchor Z Angle | The angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional. |

**Parameters**

The following parameters are in the expandable **Parameters** section in the tool's configuration.



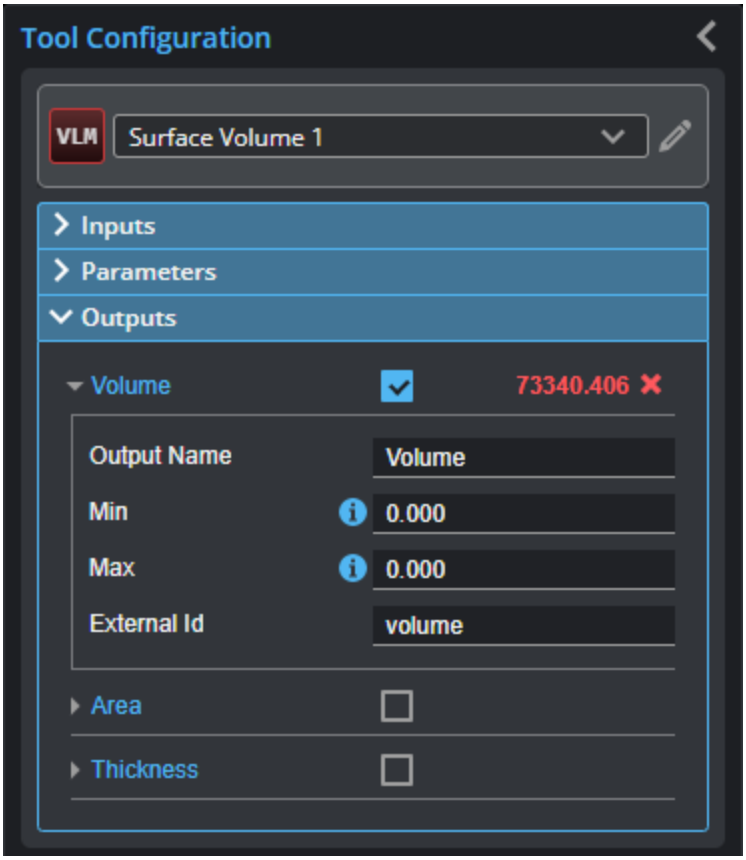

*Parameters*

| Parameter | Description |
|---|---|
| Regions | When expanded, displays the region- and mask-related settings. |
| Enable | Enables regions and displays the region- and mask-related settings (see below). |
| Mask Mode<br>Region Type 1<br>Region 1 | When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 183.<br>For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 181. |
| Volume Type | Used to compute different kinds of surface volumes. One of the following:<br>• Above<br>• Below<br>• Above + Below (default)<br>• Above - Below<br>Above means the volume calculated using Surface data that is above the Z = 0 plane. |

| Parameter | Description |
| --- | --- |
| | Below means the volume calculated using Surface data that is below the Z = 0 plane.<br>Note that Above and Below can't be negative, but Above - Below can be negative if Below > Above. |
| Thickness Type<br>*(Thickness measurement only)* | Determines which feature in the Surface data the tool uses to calculate thickness. One of the following:<br>• Max<br>• Min<br>• Average<br>• Median<br>• Centroid 2D (height of the centroid in the XY plane)<br>• Centroid 3D (height of the centroid in the XYZ space). |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

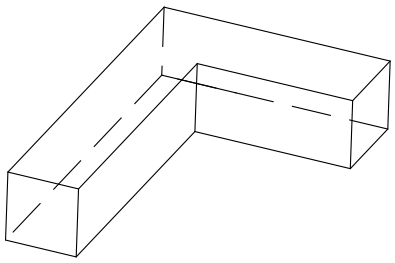
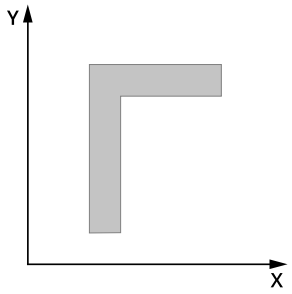
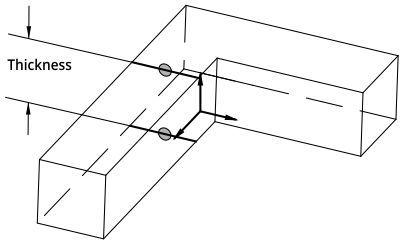
Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Volume**<br>Measures volume in XYZ space. |  |
| **Area**<br>Measures area in the XY plane.<br>The area is the number of valid points multiplied by the X and Y resolution. Note that this is different compared to the area calculations produced by Surface Segmentation and Surface Blob; for more information, see the descriptions of the *Area {n}* measurements in *Surface Segmentation* on page 569 and *Surface Blob* on page 399. |  |
| **Thickness**<br>Measures thickness (height) of a part.<br>Uncheck this measurement if you don't need it. |  |

## Feature Measurement

The following sections describe the Feature tools.

Feature tools generate or measure geometric features; for more information on geometric features, see *Geometric Features* on page 191. The tools let you work with more complex geometry, letting you implement applications more quickly by reducing dependence on scripts and GDK tools to perform these kinds of measurements.

The "Create" tools (such as Feature Circle Create) generate geometric features from other tools or using values you provide.

The Feature Dimension tool lets you take measurements using geometric features.

The Feature Robot Pose tool is for use with robots.

## Feature Circle Create

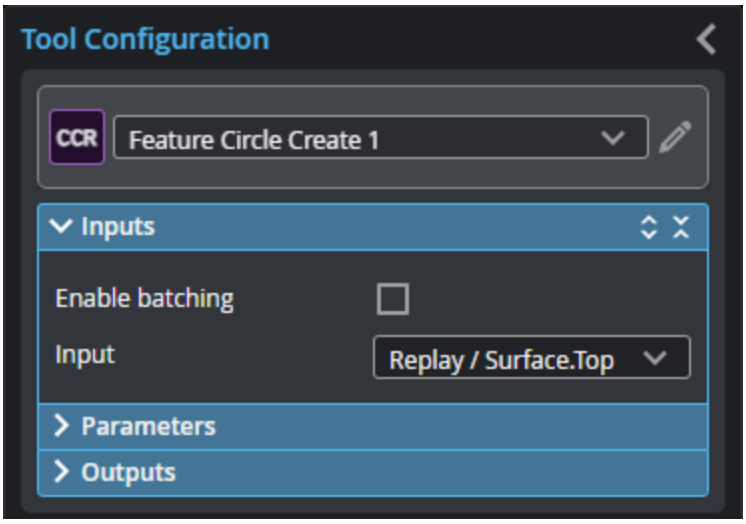
The Feature Circle Create tool lets you generate a Circle geometric features from geometric features generated by other tools. You can also generate a circle from an arbitrary position and radius. The following outputs are available (for more information, see *Output Types* on the next page):

- Constant circle
- Circle from points
- Circle from point and plane

For more information on geometric features, see *Geometric Features* on page 191.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

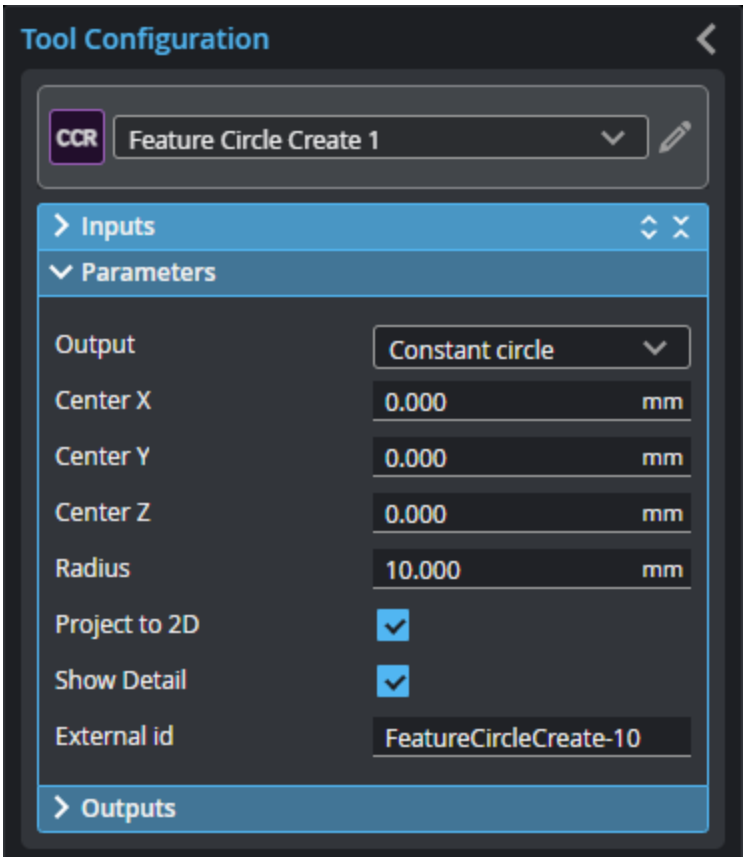



This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171.

The tool's geometric feature inputs depend on the output type you choose in the **Output** parameter. For information on the required inputs and parameters of each output type, see *Output Types* on the next page.

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Output | The type of output the tool generates. Switching between the options changes the input types displayed in Input section and the parameters displayed in the Parameters section.<br>For information on the output types and the required inputs and related parameters, see *Output Types* below. |
| Project To 2D | If checked, generates a circle in the XZ plane for Profile mode and in the XY plane for Surface mode. Otherwise, generates a 3D circle.<br>Not shown when **Output** is set to “Circle from point and plane”. |
| Show Detail | Toggles the display of the input geometric features in the data viewer. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

### Output Types

The following sections describe the output types available in the tool's **Output** parameter, in addition to the required inputs and parameters.

#### Constant Circle

The **Constant circle** output type is useful if scan data from frame to frame is reliably fixed and you want to measure from an arbitrary circle to another feature. When you choose this output type, the

tool displays the following parameters you can manually fill in to create a constant circle.

Disable **Project To 2D** to input an arbitrary normal vector (using the **Normal** parameters) to get a tilted 3D circle.

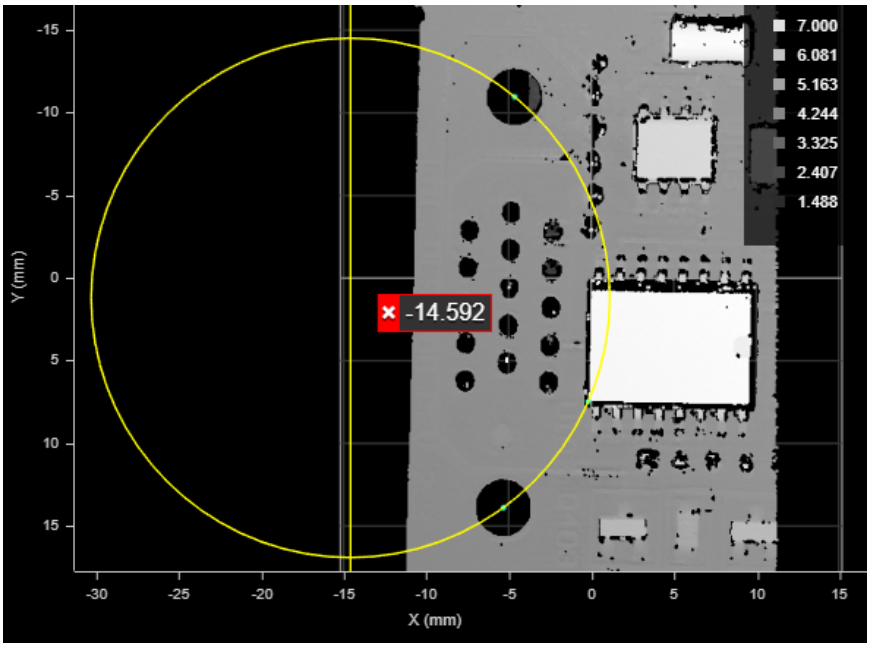
*Constant Circle Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Center X**, **Center Y**, **Center Z**<br>The X, Y, and Z position, respectively, of the center of the constant circle. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z offsets the tool will apply to the generated circle. | **Normal X**, **Normal Y**, **Normal Z**<br>The X, Y, and Z for the normal vector. Only displayed when **Project To 2D** is disabled. |
| | **Radius**<br>The radius of the constant circle. |

#### Circle from Points

The **Circle from points** output type takes three point geometric features generated by another tool and fits a circle to those points. The circle is always on the XY plane.

When **Project To 2D** is enabled, the circle is projected to the XY plane. When **Project To 2D** is disabled, circle is tilted to fit the plane the three point inputs create.




*Circle generated from the center points of the two holes and the corner of the chip (cyan points).*
*(The corner is the intersect point resulting from the Feature Intersect tool,*
*taking the left vertical and lower horizontal line edges of the chip as input.)*

The X, Y, and Z measurements return the center of the circle. The X, Y, and Z Angle measurements return arbitrary values.

*Circle from points Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z offsets the tool will apply to the generated circle. | |
| **Point 1**, **Point 2**, **Point 3**<br>The three Point geometric features the tool uses as the center of the circle. | |

#### Circle from point and plane

The **Circle from point and plane** output type generates a circle using Point and Plane geometric features and a user-defined radius. The circle is on the Plane received as input.

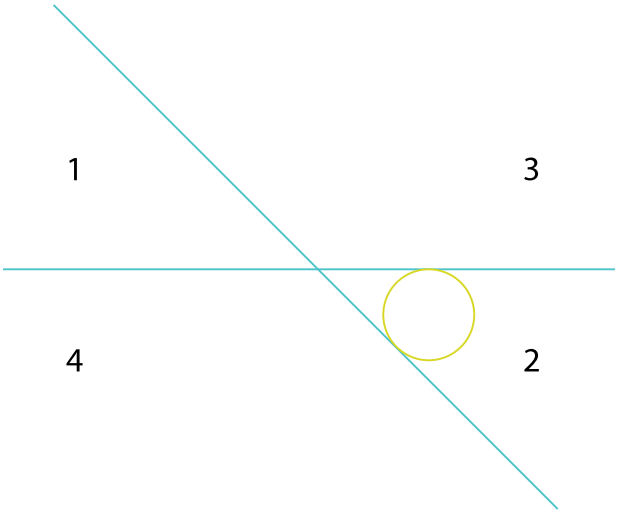
*Circle from point and plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Radius**<br>The radius of the circle. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z offsets the tool will apply to the generated circle. | |
| **Point**<br>The Point geometric features the tool uses as the center of the circle. | |
| **Plane**<br>The Point geometric features the tool uses as the center of the circle. | |

#### Circle tangent to two lines

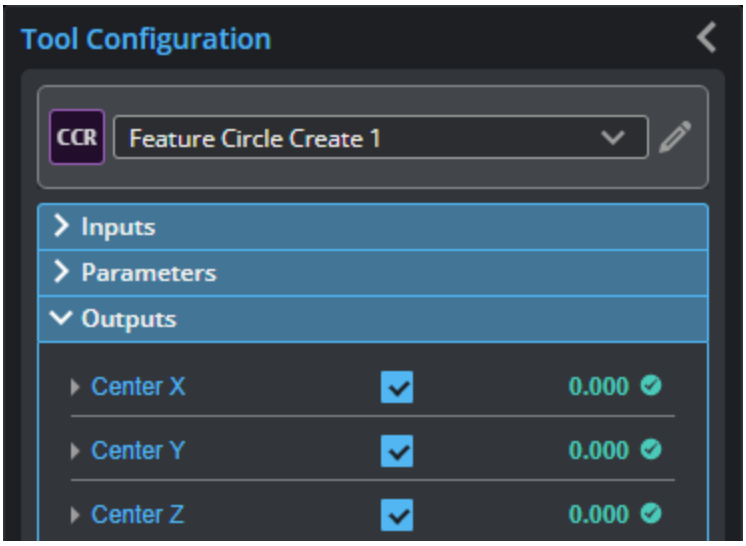
The **Circle tangent to two lines** takes two Line geometric features and an optional Plane geometric feature to create a circle that is tangent to the two provided lines. The circle is on the Plane received as input.

*Circle from point and plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **From Acute Angle**<br>Toggles between using the acute angle between the lines (enabled) or the obtuse angle (disabled). |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z offsets the tool will apply to the generated circle. | **Circle Selection**<br>Selects whether the tool fits the circle between the upper or lower angle. |
| **Point**<br>The Point geometric features the tool uses as the center of the circle. | **Circle Radius**<br>The radius of the circle. |
| **Plane**<br>The Point geometric features the tool uses as the center of the circle. | The tool uses **From Acute Angle** and **Circle Selection** together to determine where to fit the circle. For example, given these two lines, the tool fits the circle between the line segments as described below:<br>  <br><br>1: **From Acute Angle** enabled, "Upper circle" selection.<br>2: **From Acute Angle** enabled, "Lower circle" selection. (Circle fitted here.)<br>3: **From Acute Angle** disabled (uses obtuse), "Upper circle" selection.<br>4: **From Acute Angle** disabled (uses obtuse), "Lower circle" selection. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

For information specific to the different output types, see *Output Types* on page 628.

*Measurements*

| **Measurement** |
|---|
| **Center X**, **Center Y**, **Center Z**<br>The X, Y, and Z positions of the center of the circle. |
| **Radius**<br>The radius of the circle. |
| **Z Offset**<br>The Z position of the intersection between the circle plane and the Z axis. |
| **Distance**<br>The distance from the origin to the circle plane. |
| **Normal X**, **Normal Y**, **Normal Z**<br>The X, Y, and Z normal vectores of the circle. |

*Features*

| **Type** | **Description** |
|---|---|
| Circle | The generated Circle geometric feature. For more information, see *Output Types* on page 628. |

## Feature Dimension

The Feature Dimension tool returns dimensional measurements from a point geometric feature to a reference point, line, or plane geometric feature. Geometric features are available as outputs from many tools, for example a Point geometric feature from Surface Position, or a line from Surface Edge. The feature creation tools such as Feature Circle Create, Feature Line Create, and so on, can also create geometric feature. For more information on geometric features, see *Geometric Features* on page 191.

Some examples:

- Measuring the thickness between multiple surfaces or profiles.
- Measuring the distance between the center of a hole and an edge.
- Measuring the distance between the centers of two holes.
- Measuring the distance between a point and a plane.
- Measuring the distance between a point and the closest point on a circle.
- Obtaining the length of a stud by measuring the distance between its tip and base.

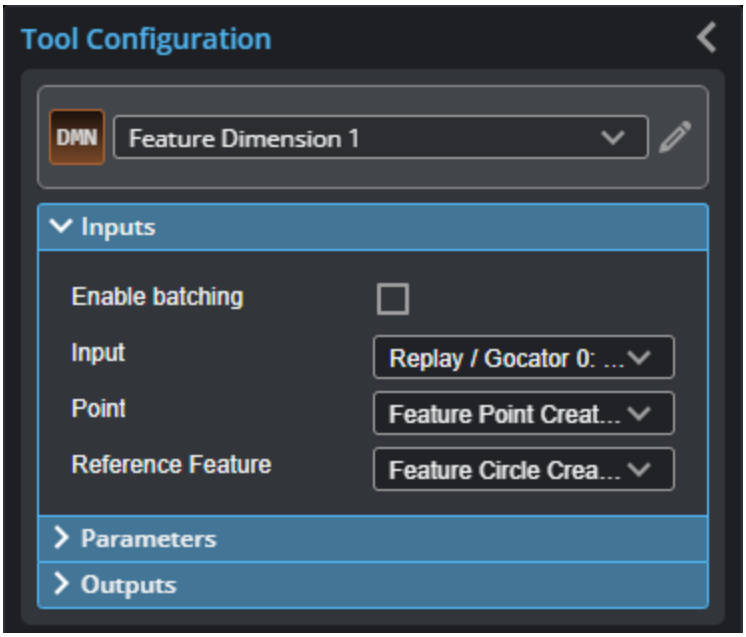
See *Adding a Tool* on page 150 for instructions on how to add measurement tools.

> In the following measurement descriptions, the first geometric feature is set in the **Point** drop-down. The second geometric feature is set in the **Reference Feature** drop-down.

> When **Reference Feature** is set to a feature other than a point, such as a circle or a line, measurements are between the point in **Point** and the *nearest point* on the reference feature (for example, the nearest point on a circle).

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

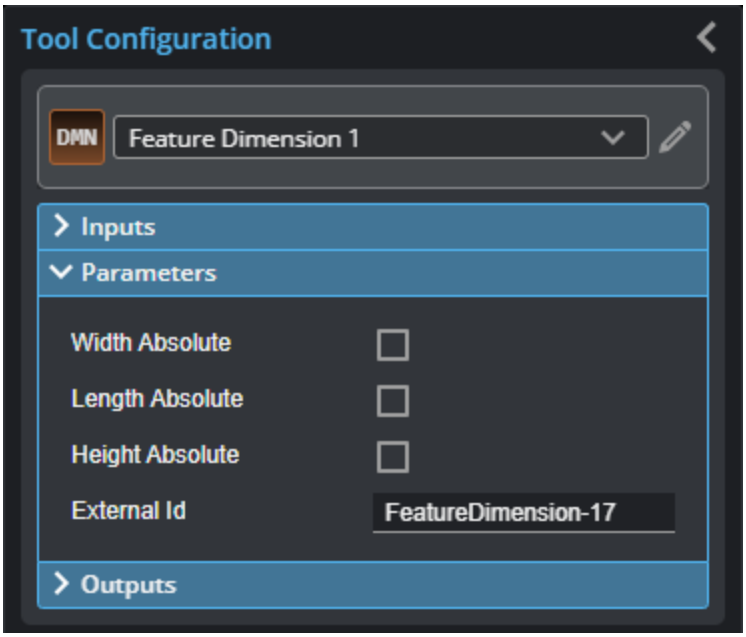



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Input | The data the tool applies measurements to. |
| Point | A point geometric feature generated by another tool. |
| Reference Feature | A geometric feature generated by another tool. Dimensional measurements are calculated *from* the reference feature *to* the point in the **Point** input. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

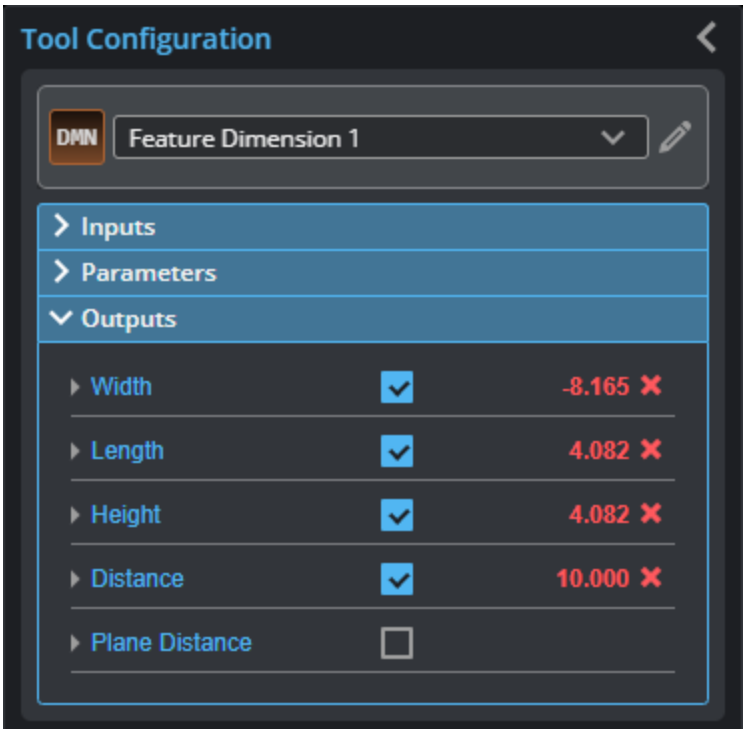



*Parameters*

| Parameter | Description |
|---|---|
| Width Absolute<br>Length Absolute<br>Height Absolute | The tools returns measurements as absolute values. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

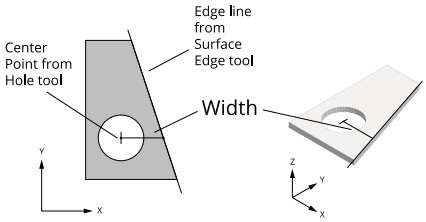
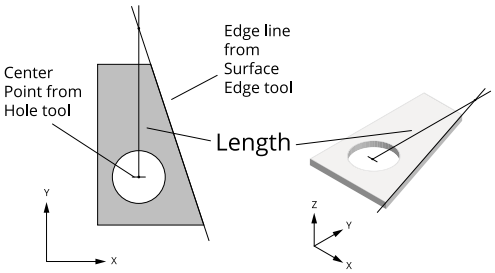
Most tools provide measurements, geometric features, or data as outputs.

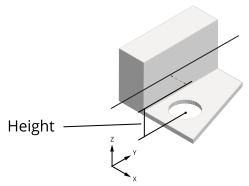
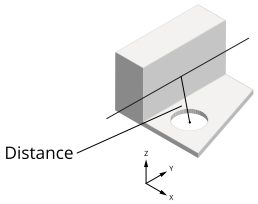
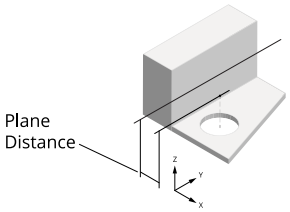



*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement | Illustration |
|---|---|
| **Width**<br>*Point-point*: The difference on the X axis between the points.<br>*Point-line*: The difference on the X axis between the point and a point on the line. For profiles, the point on the line is at the same Z position as the first point. |  |
| **Length**<br>*Point-point*: The difference on the Y axis between the points.<br>*Point-line*: The difference on the Y axis between the point and, for profiles, the nearest point on the line; currently, always zero. |  |

| Measurement | Illustration |
| --- | --- |
| **Height**<br>*Point-point*: The difference on the Z axis between the points.<br>*Point-line*: The difference on the Z axis between the point and, for profiles, a point on the line at the same X position as the first point. |  |
| **Distance**<br>*Point-point*: The direct, Euclidean distance between two point geometric features.<br>*Point-line*: The direct, Euclidean distance between a point and the nearest point on the line. |  |
| **Plane Distance**<br>*Point-point*: The distance between two point geometric features. For profile data, the points are projected onto the XZ plane (always the same as the Distance measurement).<br>*Point-line*: The distance between a point and a line. For profile data, projected onto the XZ plane (always the same as the Distance measurement). |  |

## Feature Line Create

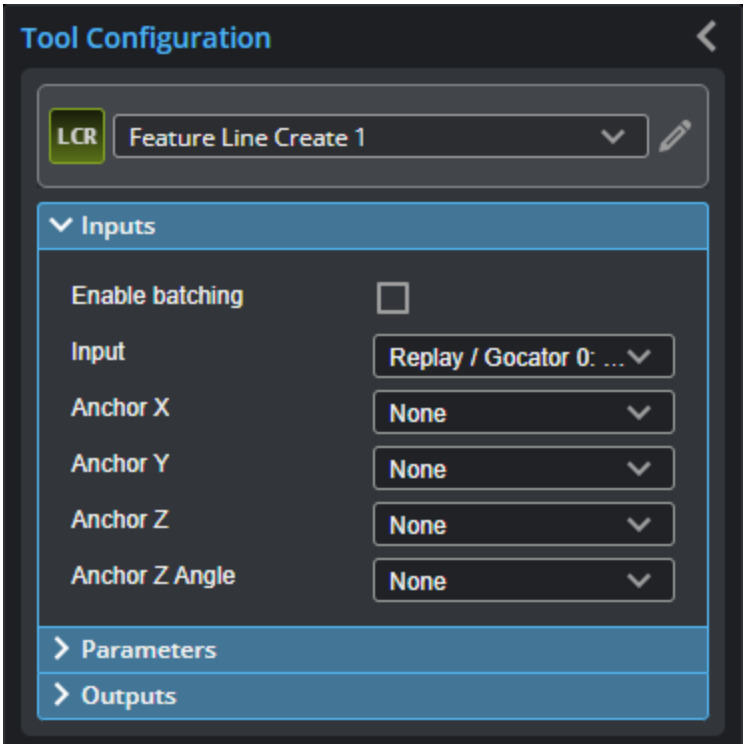
The Feature Line Create tool lets you generate a Line geometric features from geometric features generated by other tools. You can also generate a line from arbitrary positions you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- Line
- Constant line
- Line from two points
- Perpendicular line from point and line
- Perpendicular line from point and plane
- Parallel line from point and line
- Intersect line of two planes
- Projected line on plane
- Bisect projected lines on plane
- Rotate line around point

For more information on geometric features, see *Geometric Features* on page 191.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

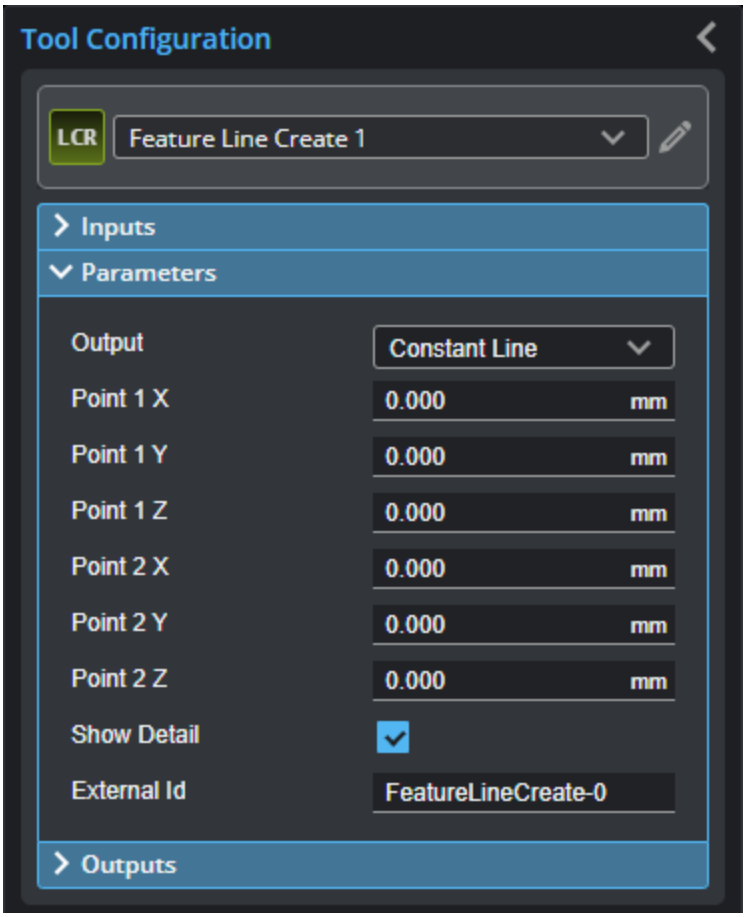



This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171.

The tool's inputs depend on the output type you choose in the **Output** parameter. For information on the required inputs and parameters of each output type, see *Output Types* on the next page.

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Output | The type of output the tool generates. Switching between the options changes the input types displayed in Input section and the parameters displayed in the Parameters section.<br>For information on the output types and the related parameters, see *Output Types* below. |
| Show Detail | Toggles the display of the input geometric features in the data viewer. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

### Output Types

The following sections describe the output types available in the tool's **Output** parameter, in addition to the required inputs and parameters.

#### Line

The **Line** output type takes a Line geometric feature as input. This output is useful if the tool takes a feature generated by another Feature Create tool as input, on which you want to perform measurements in a second Feature Create tool. This tool can also be useful if you have developed GDK tools that only generate geometric features (no measurements): you can use this tool to extract those measurements.

The X, Y, and Z measurements return the midpoint of the line. The Z Angle measurement returns the angle of the line around the Z axis. The X angle and Y angle measurements return arbitrary values.

*Line Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Line**<br>The Line geometric feature the tool uses to create another Line geometric feature. | |

#### Constant Line

The **Constant line** output type displays parameters you can manually fill in to create a geometric feature. This output type is useful if the scan data from frame to frame is reliably fixed and you want to measure from an arbitrary line to another feature.

*Line Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Point 1 X**, **Point 1 Y**, **Point 1 Z**<br>The X, Y, and Z position, respectively, of the first end point of the constant line.<br><br>**Point 2 X**, **Point 2 Y**, **Point 2 Z**<br>The X, Y, and Z position, respectively, of the second end point of the constant line. |

#### Line from Offset

The **Line from offset** output type takes a Line geometric features as input.

The X, Y, and Z measurements return the midpoint of the line.

*Line from offset Output Type - Inputs and Parameters*

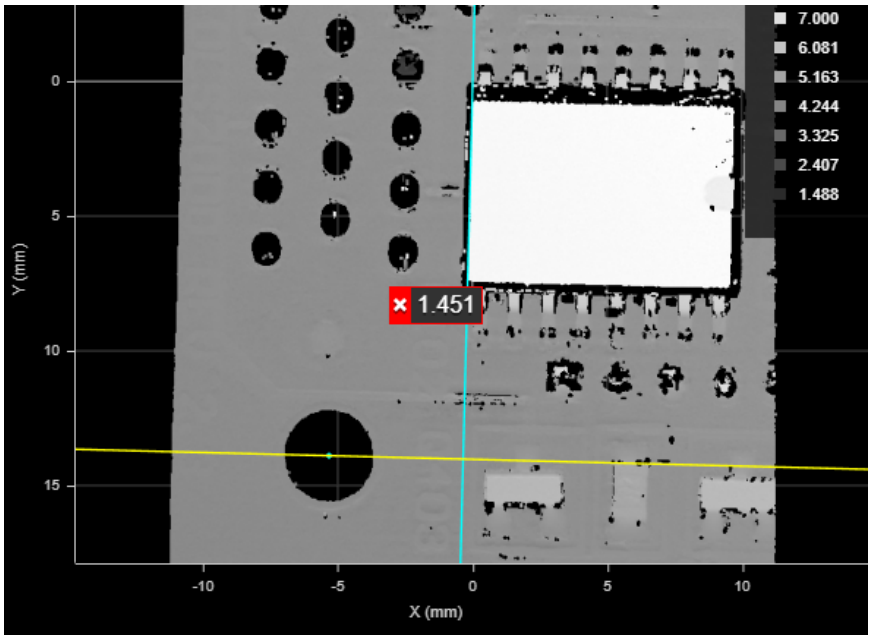
| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | For Surface data:<br><br>**X Distance** / **Y Distance** |

| Inputs | Parameters |
| --- | --- |
| **Line**<br>The Line geometric feature the tool uses to create another Line geometric feature. | Offsets the input line by the provided X and Y distance.<br><br>For Profile data:<br><br>**Offset Direction**<br>The offset direction. Either Positive X or Positive Z.<br><br>**Offset Distance**<br>The distance along the axis specified in **Offset Direction**. |

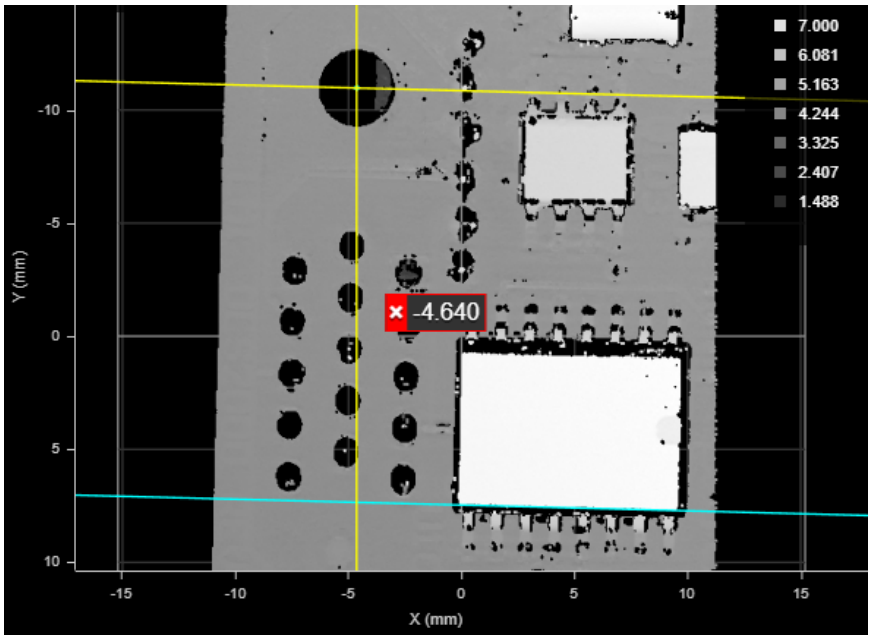
#### Perpendicular or Parallel Line from Point and Line

The **Perpendicular line from point and line** and **Parallel line from point and line** output types take a Point and a Line geometric feature as input to create another line.

In the following, the tool generates a roughly vertical line (yellow) perpendicular to the input line (cyan line along the left edge of the large integrated circuit), passing through the input point (cyan dot at the center of the hole).




In the following, the tool generates a roughly horizontal line (yellow) parallel to the input line (cyan line along the bottom edge of the large integrated circuit), passing through the input point (cyan dot at the center of the hole).




For both of these types of line output, the X, Y, and Z measurements return the position of the point.

For perpendicular line output, the X, Y, and Z angle measurements return the angles of the line.

For parallel line output, the Z angle measurement returns the angle of the line; the X and Y angle measurements both return arbitrary values.

*Line from Point and Line Output Types - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Point**<br>The Point geometric feature the tool uses to create the line. | |
| **Line**<br>The Line geometric feature the tool uses to create the line. | |

#### Perpendicular Line from Point to Plane

The **Perpendicular line from point to plane** output type generates a perpendicular line from a point up to a plane.

*Perpendicular line from point to plane Output Types - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input** | None. |

| Inputs | Parameters |
| --- | --- |
| The Surface or Profile input.<br><br>**Point**<br>The Point geometric feature the tool uses to create the line.<br><br>**Plane**<br>The Plane geometric feature the tool uses to create the line. | |

#### Intersect Line of Two Planes

The **Intersect line of two planes** output type takes two plane geometric features as input and creates a line at their intersection.

The X, Y, and Z measurements return the midpoint. The X, Y, and Z Angle measurements return the angle of the line.

*Intersect line of two planes Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input.<br><br>**Plane 1**, **Plane 2**<br>The two Plane geometric feature the tool uses to create the line. | None. |

#### Projected Line on Plane

The **Projected line on a plane** output type takes a Line and a Plane geometric feature to create a line projected onto a plane.

*Projected line on a plane Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input.<br><br>**Line**<br>The Line geometric feature the tool uses to create the line.<br><br>**Plane**<br>The Plane geometric feature the tool uses to create the line. | **Projection Direction**<br>One of the following: **Perpendicular to Plane** or **Along Z Axis**. |

#### Projected Center Line from Two Lines and a Plane

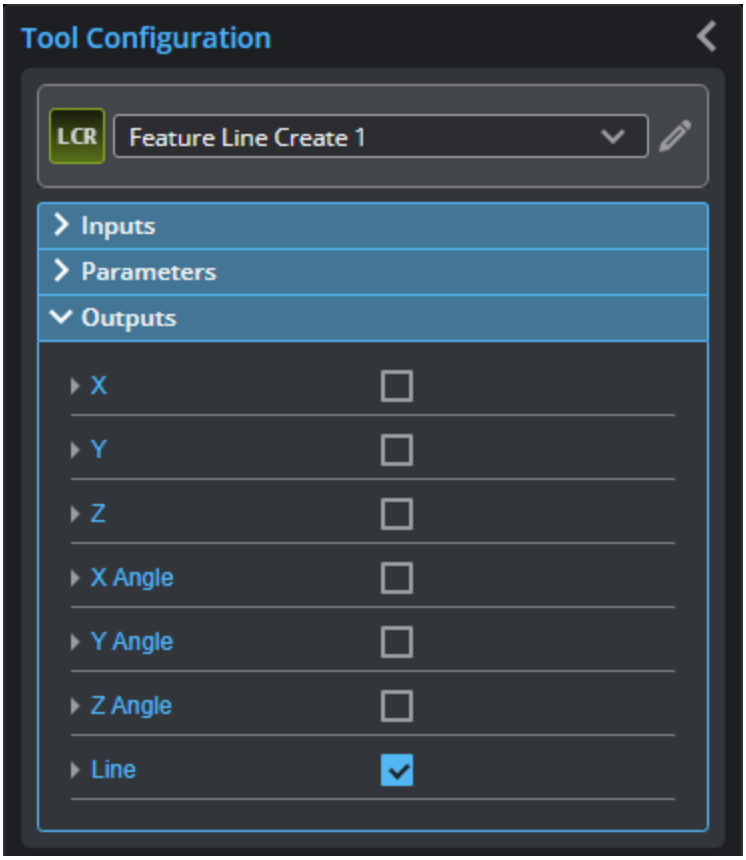
The **Projected Center Line from Two Lines and a Plane** output type takes creates a two Line and a Plane geometric feature as input and creates a line.

*Bisect projected lines on plane Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Line**<br>The Line geometric feature the tool uses to create the line. | |
| **Plane**<br>The Plane geometric feature the tool uses to create the line. | |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

For information specific to the different output types, see *Output Types* on page 639.

*Measurements*

| **Measurement** |
| --- |
| **X**, **Y**, **Z**<br>The X, Y, and Z positions of the midpoint of the line described by the Point geometric features. For more information, see the sections above. |
| **X Angle**, **Y Angle**, **Z Angle**<br>The X, Y, and Z angles of the line. For more information, see the sections above. |

*Features*

| **Type** | **Description** |
| --- | --- |
| Line | The generated Line geometric feature. |

## Feature Plane Create

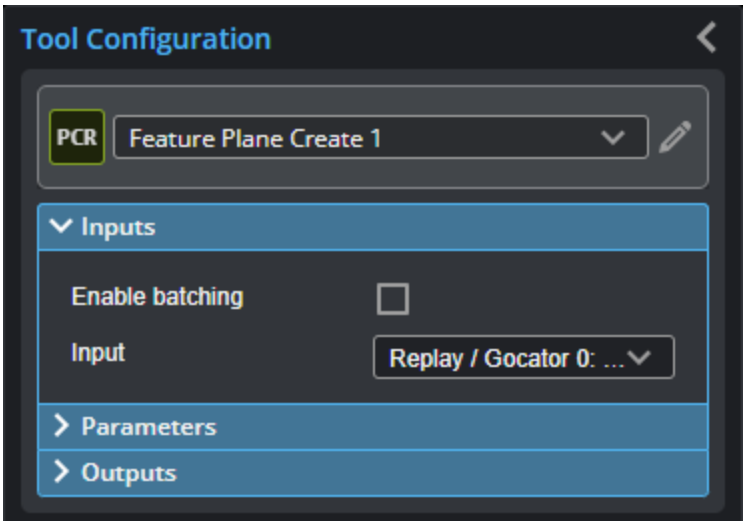
The Feature Plane Create tool lets you generate a Plane geometric features from geometric features generated by other tools. You can also generate a plane from arbitrary values you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- Constant plane
- Plane from point and normal
- Plane from point and line
- Plane from three points
- Plane from circle
- Parallel plane from point and plane
- Perpendicular plane from point and plane
- Perpendicular plane from line and plane
- Bisect plane from two planes

For more information on geometric features, see *Geometric Features* on page 191.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

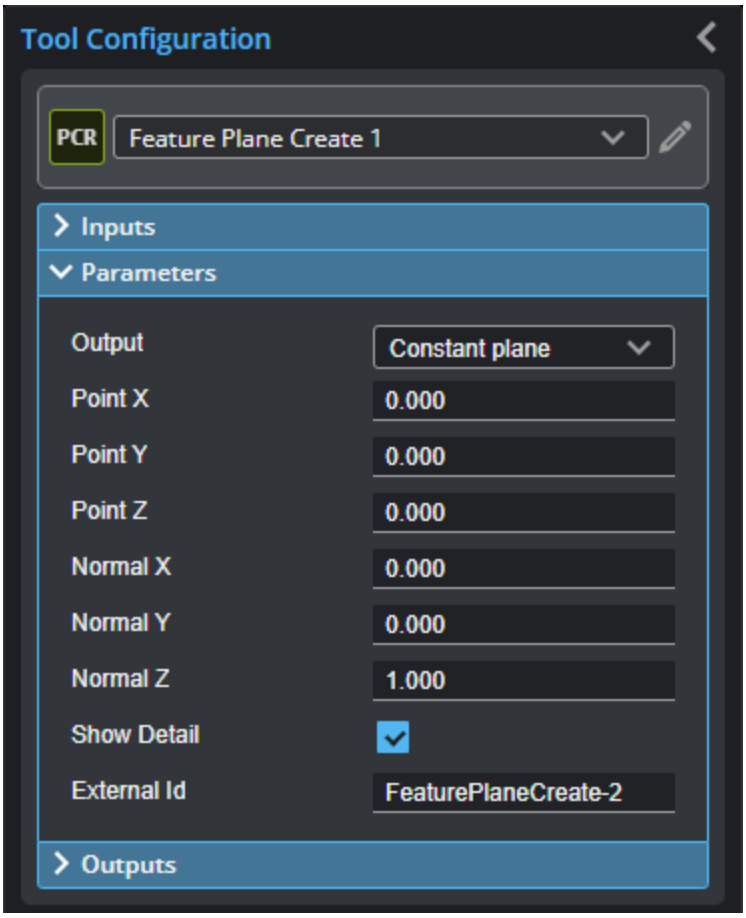



This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171.

The tool's inputs depend on the output type you choose in the **Output** parameter. For information on the required inputs and parameters of each output type, see *Output Types* on the next page.

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Output | The type of output the tool generates. Switching between the options changes the input types displayed in Input section and the parameters displayed in the Parameters section.<br>For information on the output types and the related parameters, see *Output Types* below. |
| Show Detail | Toggles the display of the input geometric features in the data viewer. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

## Output Types

The following sections describe the output types available in the tool's **Output** parameter, in addition to the required inputs and parameters.

### Constant Plane

The **Constant plane** output type is useful if scan data from frame to frame is reliably fixed and you want to measure from an arbitrary plane to another feature. When you choose this output type, the tool displays the parameters listed below you can manually fill in to create a constant plane.

*Constant Plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Point X**, **Point Y**, **Point Z**<br>The X, Y, and Z points that define the plane.<br><br>**Normal X**, **Normal Y**, **Normal Z**<br>The X, Y, and Z normals, respectively, of the constant plane. |

#### Plane from a Point and Normal

The tool uses the Line geometric feature as the normal of a plane, and positions the plane so that it intersects the Point geometric feature.

*Plane from Point and Normal Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input.<br><br>**Point**<br>The Point geometric feature with which the plane intersects.<br><br>**Line**<br>A Line geometric feature representing the normal that the tool uses to create the plane. | None. |

#### Plane from a Point and Line

The tool uses Line and Point geometric features to create a plane.

*Plane from Point and Line Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input.<br><br>**Point**<br>The Point geometric feature with which the plane intersects.<br><br>**Line**<br>A Line geometric feature with which the plane intersects. | None. |

#### Plane from Three Points

The **Plane from three points** output type creates a plane that intersects the three Point geometric features passed to the tool as input.

*Plane from Three Points Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Point 1**, **Point 2**, **Point 3**<br>The three Point geometric features the tool uses to create the plane. | |

#### Plane from Circle

The **Plane from circle** output type creates a plane that intersects the Circle geometric feature passed to the tool as input.

*Plane from Three Points Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Circle**<br>The Circle geometric features the tool uses to create the plane. | |

#### Parallel Plane from Point and Plane

The **Parallel plane from point and plane** output type creates a plane parallel to the provided Plane geometric feature that intersects the provided Point geometric feature.

*Parallel Plane from Point and Plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Point**<br>The Point geometric feature with which the created plane intersects. | |
| **Plane**<br>The Plane geometric feature with which the created plane is parallel. | |

#### Perpendicular Plane from Point and Plane

The **Perpendicular plane from point and plane** output type creates a plane perpendicular to the provided Plane geometric feature that intersects the two provided Point geometric features.

*Perpendicular Plane from Point and Plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Point 1**, **Point 2**<br>The Point geometric features with which the created plane intersects. | |
| **Plane**<br>The Plane geometric feature with which the created plane is perpendicular. | |

#### Perpendicular Plane from Line and Plane

The **Perpendicular plane from line and plane** output type creates a plane perpendicular to the provided Plane geometric feature, which intersects the provided Line geometric feature.

*Perpendicular Plane from Line and Plane Output Type - Inputs and Parameters*

| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Line**<br>The Line geometric feature that bisects the created plane. | |
| **Plane**<br>The Plane geometric feature with which the created plane is perpendicular. | |

#### Bisect Plane from Two Planes

The **Bisect plane from two planes** output type creates a plane from the two provided Plane geometric features.

*Bisect Plane from Two Planes Output Type - Inputs and Parameters*

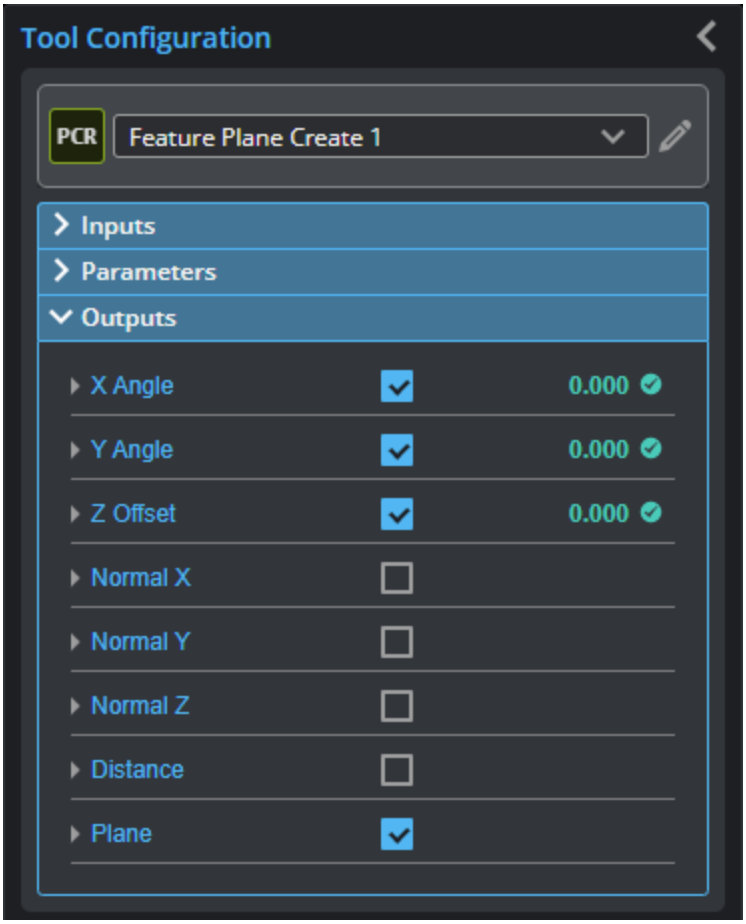
| Inputs | Type-Related Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |

| Inputs | Type-Related Parameters |
|---|---|
| **Plane 1**, **Plane 2**<br>The Plane geometric features the tool uses to create a bisecting plane | |

See *Adding a Tool* on page 150 for instructions on how to add measurement tools.

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

For information specific to the different output types, see *Output Types* on page 647.

*Measurements*

| Measurement |
| --- |
| **X Angle**, **Y Angle**<br>Rotation angles of the plane, that is, angles such that rotating (0,0,1) around the Y axis by the Y Angle, and then around X axis by X Angle produces the normal. |
| **Z Offset**<br>The Z value of intersection of the plane and the Z axis. |
| **Normal X**, **Normal Y**, **Normal Z**<br>The normal X, Y, and Z vectors of the plane. |
| **Distance**<br>The distance from the origin to the plane. |

*Features*

| Type | Description |
| --- | --- |
| Plane | The generated Plane geometric feature. For more information, see *Output Types* on page 647. |

## Feature Point Create

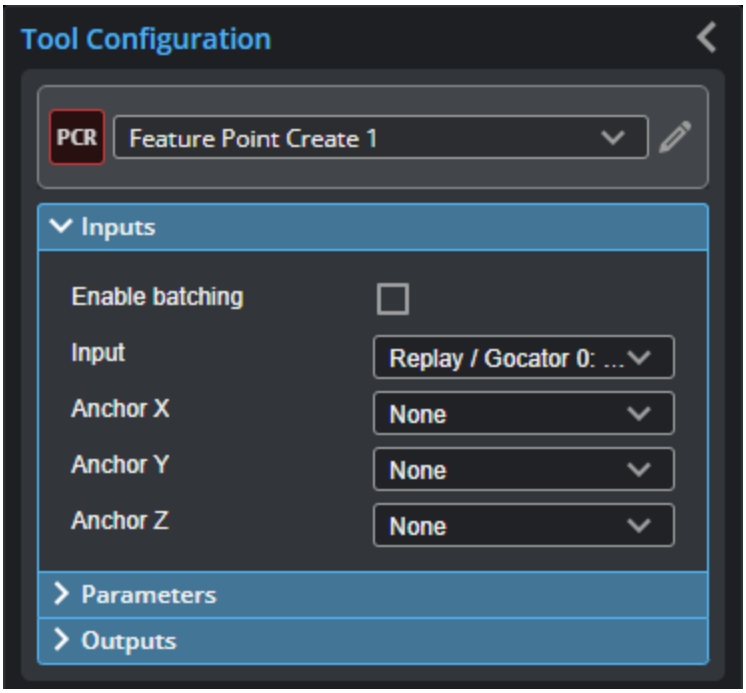
The Feature Point Create tool lets you generate a Point geometric features from geometric features generated by other tools. You can also generate a point from an arbitrary position you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- Point
- Constant point
- Point from offset
- Point from three planes
- Point from line and circle
- Point from line and line
- Point from line and plane
- Projected point on line
- Projected point on plane

For more information on geometric features, see *Geometric Features* on page 191.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

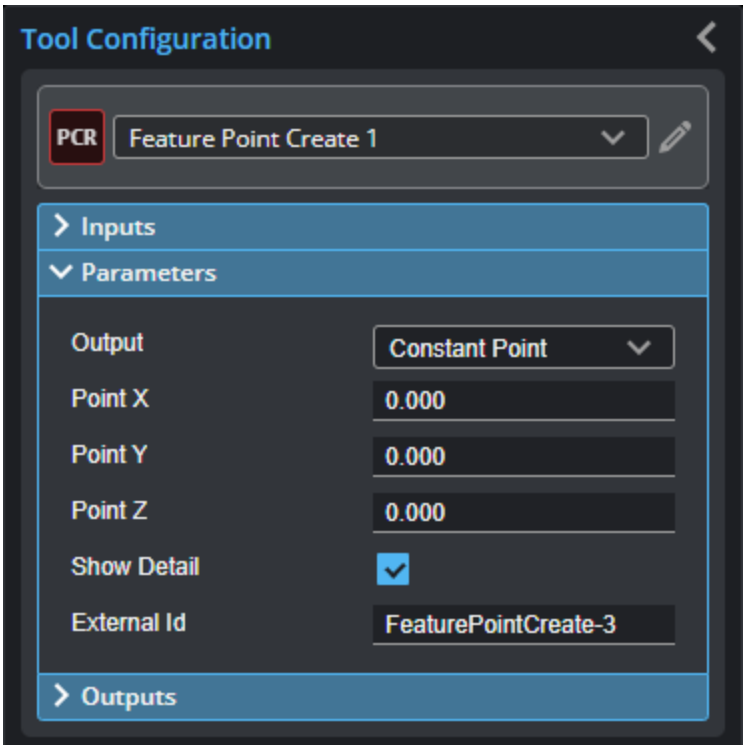



This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171.

The tool's inputs depend on the output type you choose in the **Output** parameter. For information on the required inputs and parameters of each output type, see *Output Types* on the next page.

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Output | The type of output the tool generates. Switching between the options changes the input types displayed in Input section and the parameters displayed in the Parameters section.<br>For information on the output types and the related parameters, see *Output Types* below. |
| Show Detail | Toggles the display of the input geometric features in the data viewer. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

## Output Types

The following sections describe the output types available in the tool's **Output** parameter, in addition to the required inputs and parameters.

#### Point

The **Point** output type takes a Point geometric feature as input. This output is useful if the tool takes a feature generated by another Feature Create tool as input, on which you want to perform measurements in a second Feature Create tool. This tool can be useful if you have developed GDK tools that only generate geometric features (no measurements): you can use this tool to extract those measurements.

*Point Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | None. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |
| **Point**<br>The Point geometric feature the tool uses to create another Point geometric feature. | |

#### Constant Point

The **Constant point** output type displays parameters you can manually fill in to create a geometric feature. This output type is useful if the scan data from frame to frame is reliably fixed and you want to measure from an arbitrary point to another feature.

*Constant Point Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Point X**, **Point Y**, **Point Z**<br>The X, Y, and Z position, respectively, of the first end point of the constant line. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |

#### Point from Offset

The **Point from offset** output type takes two Point geometric feature as input, and generates a point on the line connecting the two input Point features. You specify the offset direction and the distance along the line.

*Point from Offset Output Type - Inputs and Parameters*

| Inputs | Parameters |
|---|---|
| **Input**<br>The Surface or Profile input. | **Offset Direction**<br>The direction along the line running through the two input Point geometric features that the point is offset. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | One of two values: Forward or Backward. A Forward offset direction offsets the point along the line moving from Point 1 to Point 2. A Backward offset direction offsets the point along the line moving from Point 2 to Point 1. |
| **Point 1**, **Point 2** | |

| Inputs | Parameters |
| --- | --- |
| The Point geometric features the tool uses to create the line along which the offset Point geometric feature is placed. | **Offset Distance**<br>The distance along the line running through the Point geometric features that the point is offset. |

#### Point from Three Planes

The **Point from three planes** output type takes three Plane geometric features as input and generates a Point geometric feature at the intersection of those planes.

*Point from Three Planes Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input.<br><br>**Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors.<br><br>**Plane 1**, **Plane 2**, **Plane 3**<br>The Plane geometric features the tool uses to generate the Point geometric feature. The point is at the intersection of the planes. | None. |

#### Point from Line and Circle

The **Point from line and circle** output type takes a Line and a Circle geometric feature as input and generates a Point geometric feature where the line intersects the circle. The tool uses an intersection option to decide which intersection point to use.

*Point from Line and Circle Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input.<br><br>**Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors.<br><br>**Line**<br>The Line geometric feature the tool uses to generate the Point geometric feature.<br><br>**Circle** | **Intersection Option**<br>The intersection between the line and the circle that the tool uses to generate the Point geometric feature. One of the following: Upper, Lower, or Middle.<br><br>**Upper**: The uppermost intersection point in the data viewer.<br><br>**Lower**: The lowermost intersection point in the data viewer.<br><br>**Middle**: The midpoint between the two intersection |

| Inputs | Parameters |
| --- | --- |
| The Circle geometric features the tool uses to generate the Point geometric feature. | points. |

#### Point from Line and Line

When the **Output** parameter is set to **Point from line and line**, the tool takes two Line geometric feature as input and generates a Point geometric feature where the lines intersect. The tool also returns an angle measurement for the angle between the lines.

*Point from Line and Line Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input. | **Angle Range**<br>The range returned by the XY Angle measurement. One of the following: "-180 to 180" or "0 to 360". |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |
| **Line 1**, **Line 2**<br>The Line geometric features the tool uses to generate the Point geometric feature. | |

#### Point from Line and Plane

When the **Output** parameter is set to **Point from line and plane**, the tool takes a Line and a Plane geometric feature as input and generates a Point geometric feature where the lines intersect. The tool also returns an angle measurement for the angle between the lines.

*Point from Line and Plane Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input. | **Angle Range**<br>The range returned by the Angle measurement. One of the following: "-180 to 180" or "0 to 360". |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |
| **Line**<br>The Line geometric features the tool uses to generate the Point geometric feature. | |
| **Plane**<br>The Plane geometric features the tool uses to generate | |

| Inputs | Parameters |
| --- | --- |
| the Point geometric feature. | |

#### Projected Point on Line

The **Projected point on line** output type takes a Point and a Line geometric feature as input and generates a Point geometric feature.

*Projected Point on Line Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input. | None. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |
| **Point**<br>The Point geometric features the tool uses to generate the Point geometric feature. | |
| **Line**<br>The Line geometric features the tool uses to generate the Point geometric feature. | |

#### Projected Point on Plane

The **Projected point on plane** output type takes a Point and a Plane geometric feature as input and generates a Point geometric feature.

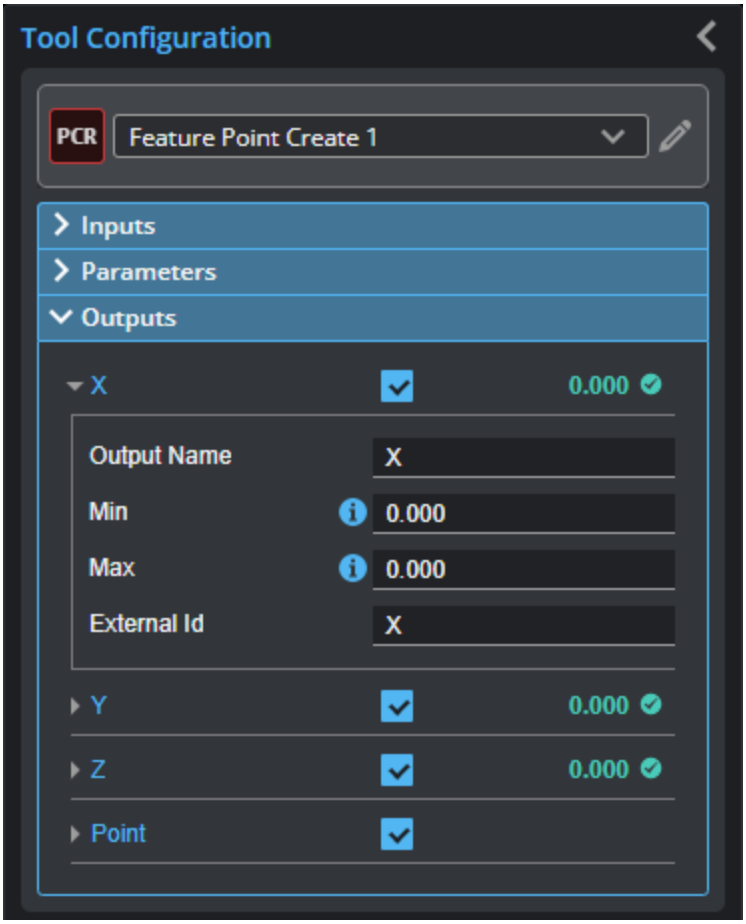
*Projected Point on Plane Output Type - Inputs and Parameters*

| Inputs | Parameters |
| --- | --- |
| **Input**<br>The Surface or Profile input. | **Projection Direction**<br>The direction of the projection. One of the following: Perpendicular to Plane or Along Z Axis. |
| **Anchor X**, **Anchor Y**, **Anchor Z**<br>The X, Y, and Z position measurements the tool uses as anchors. | |
| **Point**<br>The Point geometric features the tool uses to generate the Point geometric feature. | |

| Inputs | Parameters |
|---|---|
| **Plane**<br>The Plane geometric features the tool uses to generate the Point geometric feature. | |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

For information specific to the different output types, see *Output Types* on page 654.

*Measurements*

| Measurement |
|---|
| **X**, **Y**, **Z**<br>The X, Y, and Z positions of the Point geometric feature. For more information, see the sections above. |

| Measurement |
| --- |

**XY Angle**
The angle measurement.

*Features*

| Type | Description |
| --- | --- |
| Point | The generated Point geometric feature. |

## Feature Intersect

The Feature Intersect tool returns the intersection of a line or plane geometric feature and a second line or plane geometric feature. For line-line intersections, the lines are projected onto the Z = reference Z line plane for features extracted from a surface, and the intersection of the lines projected onto the Y = 0 plane for features extracted from a profile. The angle measurement between the two lines is also returned. The lines the tool takes as input are generated by other tools, such as Surface Edge or Surface Ellipse.

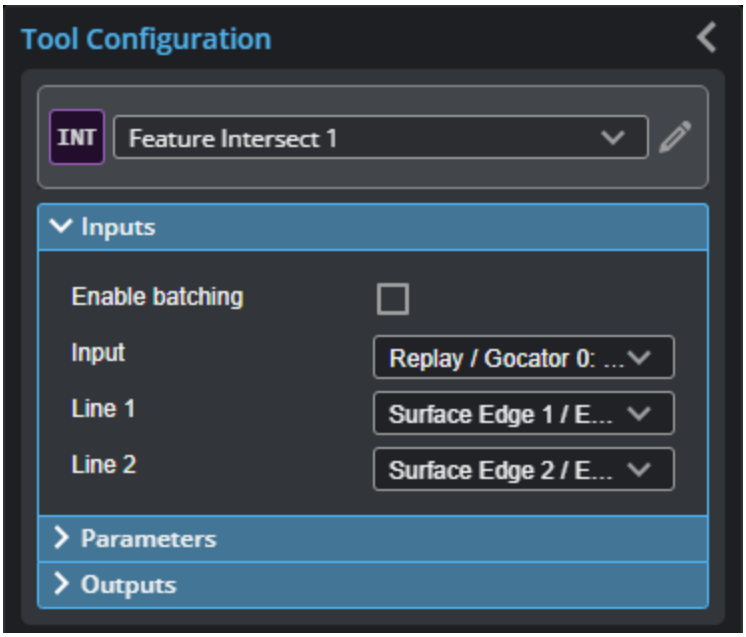
The Feature Intersect tool can also generate a point geometric feature representing the point of intersection of the lines that the Feature Dimension tool can use in measurements.

See *Adding a Tool* on page 150 for instructions on how to add measurement tools.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

The tool's inputs depend on the intersection type you choose in the **Intersection Type** parameter. For information on the required inputs and parameters of each output type, see *Feature Intersect* above.

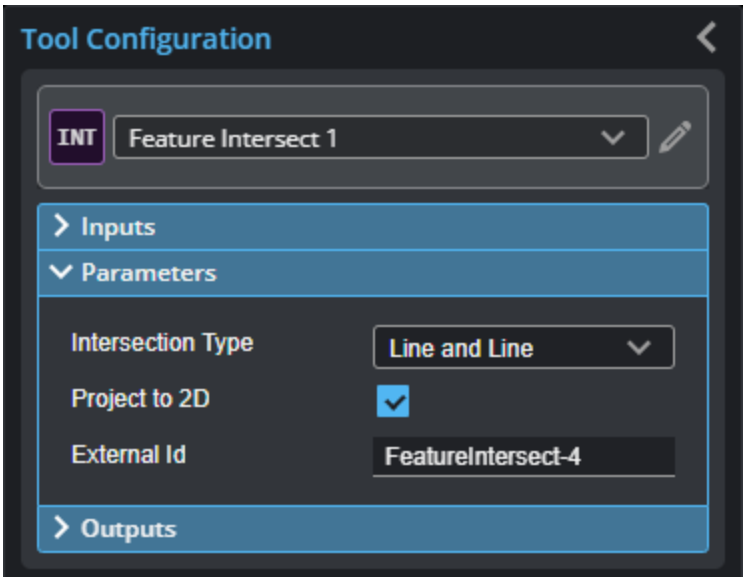



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Input | The data the tool applies measurements to or processes. |
| Line or Plane | The geometric features the tool uses to calculate an intersect. A combination of Line or Plane geometric features, depending on the **Intersection Type** parameter. |

**Parameters**

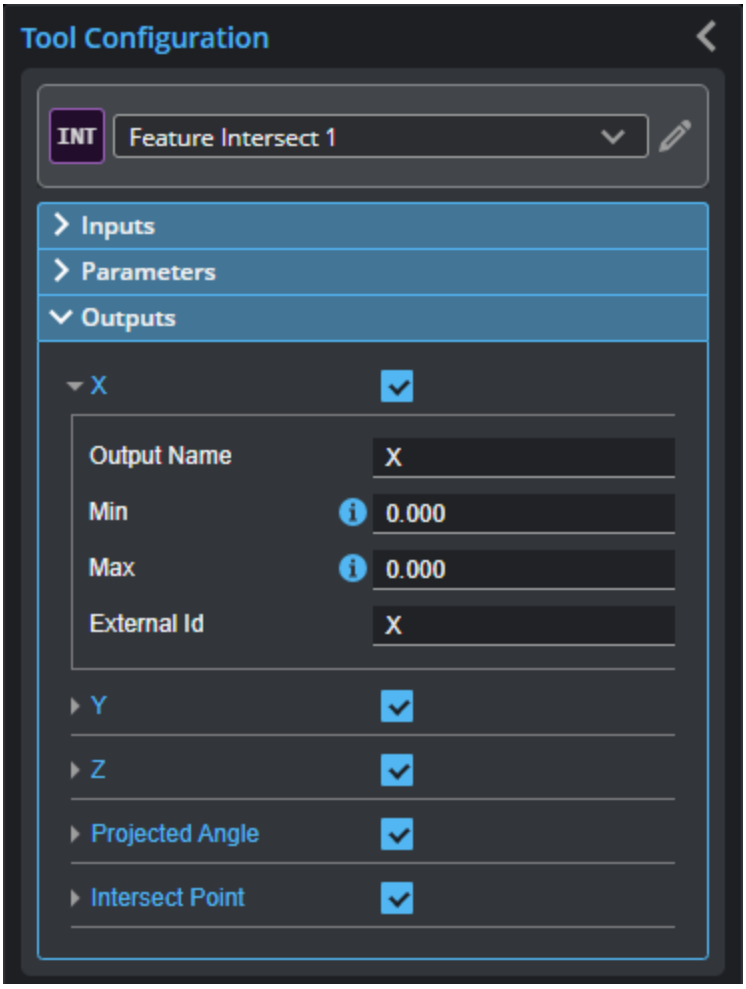
You configure the tool's parameters in the expandable **Parameters** section.




*Parameters*

| Parameter | Description |
|---|---|
| Intersection Type | One of the following:<br>• Line and Line<br>• Line and Plane<br>• Plane and Plane<br>The intersection type determines which inputs are available in the **Inputs**. |
| Project to 2D | Only shows when Intersection Type is “Line and Line”. If checked, the intersection angle is projected to the XZ plane for Profile mode and XY plane for Surface mode. Otherwise, outputs the 3D angle. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
|---|
| **X** |
| *Line-Line*: The X position of the intersect point between the lines. |
| *Line-Plane*: The X position of the intersect point between the line and the plane. |
| *Plane-Plane*: The X position of the center of the line intersecting the planes. |
| **Y** |
| *Line-Line*: The Y position of the intersect point between the lines. |
| *Line-Plane*: The Y position of the intersect point between the line and the plane. |
| *Plane-Plane*: The Y position of the center of the line intersecting the planes. |

| Measurement |
| --- |
| **Z**<br>*Line-Line*: The Z position of the intersect point between the lines.<br>*Line-Plane*: The Z position of the intersect point between the line and the plane.<br>*Plane-Plane*: The Z position of the center of the line intersecting the planes. |
| **Angle** or **Projected Angle**<br>(<br>*Line-Line*: The angle between the lines, as measured from the line selected in **Reference Feature** to the line selected in **Line**. If **Project To 2D** is enabled, the output is Projected Angle.<br>*Line-Plane*:The angle between the line and the perpendicular projection of the line onto the plane, as measured from the plane geometric feature selected in **Reference Feature** to the line selected in **Line**.<br>*Plane-Plane*:The angle between the two planes, as measured from the plane geometric features selected in **Feature 1** and **Feature 2**. |

*Features*

| Type | Description |
| --- | --- |
| Intersect Point | The intersect point of the two features. |
| Intersect Line | The line representing the intersection of two planes. |

## Feature Robot Pose

Gocator line confocal sensors are not typically used with robots.

## Data Export

The Data Export tool saves frames of scan data to local PC storage (by default, `C:\GoTools\DataExport`), letting you import and evaluate scan data in 3rd-party applications.

> This tool is only available in a PC instance of GoPxL. It is not available on a sensor or on GoMax NX.

You can optionally use a measurement as a condition for data export. For example, you could configure the tool to only export data if a Surface Position's Z measurement is a Fail (or a Pass).

The tool supports exporting the following formats. The available formats depend on the tool's input.

*Output formats*

| Format | Surface | Profile | Image | Description |
|---|---|---|---|---|
| CSV (.csv) | ✓ | ✓ | | CSV format. For more information, see *CSV File Format* on page 922. |
| PRO (.pro) | | ✓ | | MountainsMap format. Uniform data only. |
| Wavefront OBJ (.obj) | ✓ | | | Mesh with comma-separated vertices and facets in text format. |
| ODSCAD OMC (.omc) | ✓ | | | ODSCAD heightmap. |
| PCL PCD (.pcd) | ✓ | | | Point Cloud Data (PCD) file format for the Point Cloud Library (PCL). |
| PNG (.png) | ✓ | | ✓ | **Surface**<br>The heightmap as a PNG image.<br>The image is either a 24-bit RGB image or a 16-bit grayscale image, depending on whether **16-bit Depth** is enabled (see below).<br><br>**Image**<br>An image from the sensor camera. The bit-depth depends on the camera. |
| STL ASCII (.stl) | ✓ | | | Mesh in the standard STL text format (can become very large). |
| STL Binary (.stl) | ✓ | | | Mesh in the binary STL format. |
| MountainsMap SUR (.sur) | ✓ | | | MountainsMap SUR heightmap. |
| TIFF (.tif) | ✓ | | ✓ | **Surface**<br>The heightmap as a TIFF image.<br>The image is either a 24-bit RGB image or a 16-bit grayscale image, depending on whether **16-bit Depth** is enabled (see below). |

| Format | Surface | Profile | Image | Description |
|---|---|---|---|---|
| | | | | **Image**<br>An image from the sensor camera. The bit-depth depends on the camera. |
| GoPxL Recording (.gprec) | ✓ | ✓ | ✓ | GoPxL replay data. |

The file naming convention is as follows:

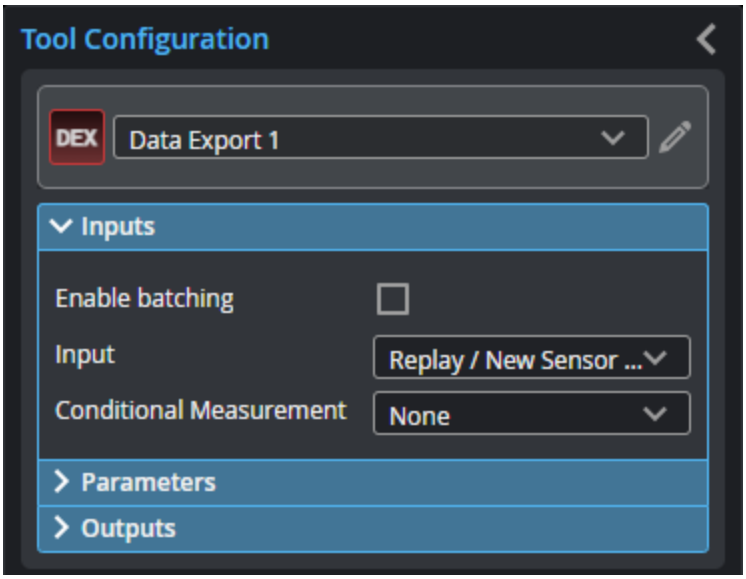
`<frame>_<timestamp>_<counter>.<extension>`

`<counter>` is optional: It is only present if a file with the same name is already in the output folder.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

## Inputs

You configure the tool's inputs in the expandable **Inputs** section.



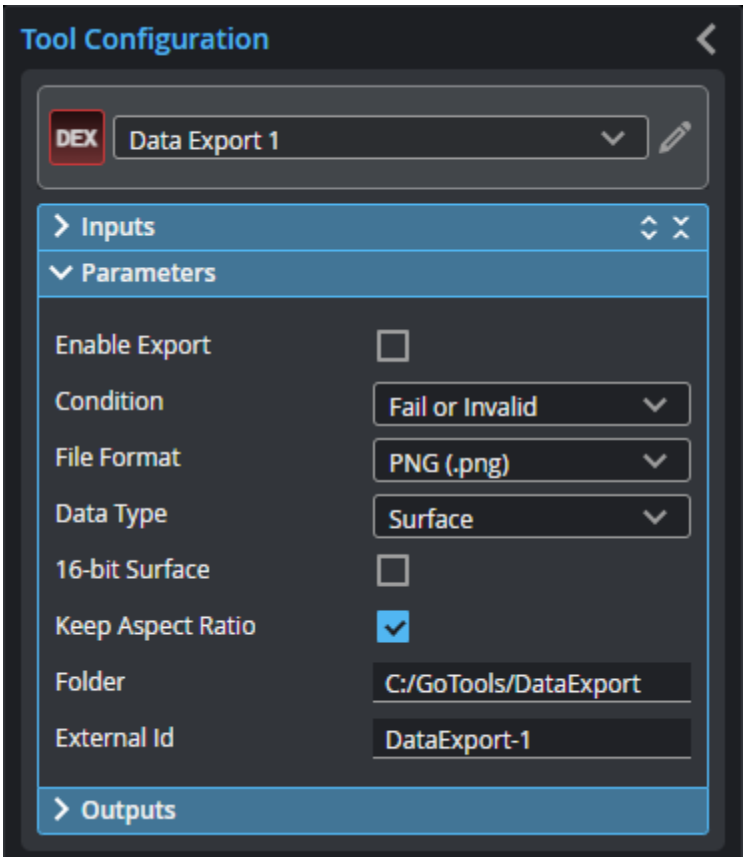

*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and exports the data for each item in the array individually.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole. |

| Name | Description |
|---|---|
| | For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Input | The data the tool exports.<br>This tool can optionally take an array as input. For more information, see Arrays, Batching, and Aggregation. |
| Conditional Measurement | The measurement the tool uses to determine whether to export data. Can be None, in which case the tool exports all frames.<br>In the **Parameters** section, set **Condition** to the condition type (see below). |

## Parameters

You configure the tool's parameters in the expandable **Parameters** section.



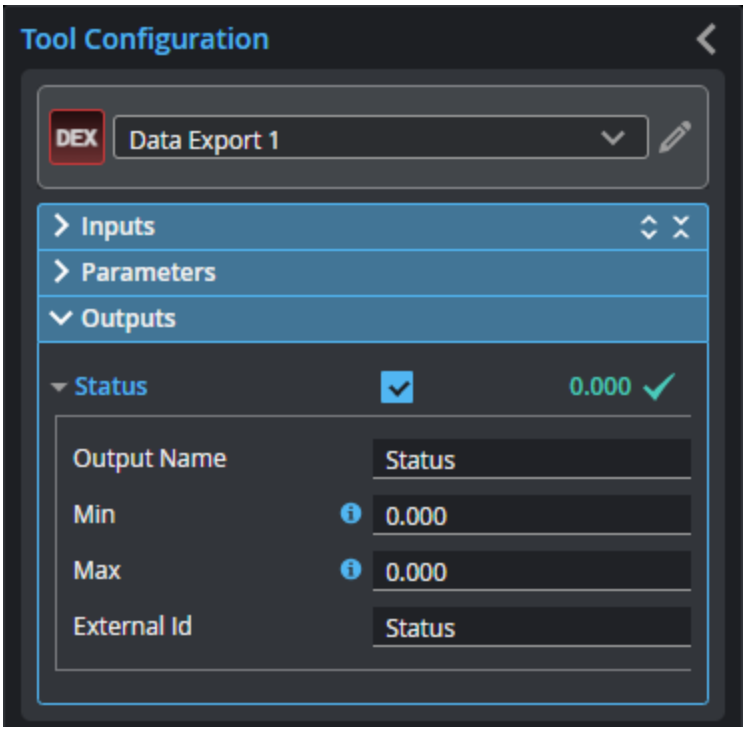

*Parameters*

| Name | Description |
|---|---|
| Enable Export | When this parameter is checked, the tool exports frames in the format you select in **File Format** to the folder specified in **Folder**. |
| Condition | If the **Conditional Measurement** input is set to a measurement, this determines which state of the measurement causes the tool to export data. One of the |

| Name | Description |
| --- | --- |
| | following:<br>• Fail or Invalid<br>• Invalid<br>• Pass<br>The setting is only displayed if the **Conditional Measurement** input is set to a measurement. |
| File Format | The format the tool uses to export data. For a list of the formats, see *Output formats* on page 666. |
| Data Type | The type of data the tool outputs, using the format selected in **File Format**. One of the following:<br>**Surface**<br>Outputs Surface data.<br>**Intensity**<br>If intensity data is available, the tool outputs this data. Otherwise, no output is produced.<br>**Surface and Intensity**<br>Outputs Surface data and, if it is available, intensity data. The tool appends "_surface" and "_intensity" to the file names of the outputs. |
| 16-bit Surface | The bit depth of the heightmap output as an image.<br>When disabled, the tool outputs a 24-bit RGB image.<br>When enabled, the tool outputs a 16-bit grayscale image.<br>Only available for PNG and TIFF outputs. |
| Keep Aspect Ratio | Preserves the aspect ration of the image outputs (PNG and TIFF) by resampling to equal XY spacing. |
| Folder | The folder in which the tool saves exported data. If the folder doesn't exist, the tool creates the folder. By default, `C:/GoTools/DataExport`. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

## Outputs

This tool provides no outputs other than saving exported data in `C:\GoTools\DataExport`.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| **Measurement** |
| --- |
| **Status**<br>Indicates whether the current frame has been exported. One of the following values:<br>1: The frame is saved.<br>0: The frame is not saved because the condition is not met. For more information, see *Condition* on page 668.<br>-1: The frame save fails because of insufficient disk space, incorrect file permissions, and so on. |

## Array Tools

Array tools let you create and work with arrays, or extract individual elements from an array.

> Arrays can contain any type of data supported in GoPxL (such as Surface, Profile, or Image data, or measurements). For more information on this and on arrays in general, see *Arrays, Batching, and Aggregation* on page 171.

The following Array tools are available:

- Array Decision: Takes an *array* of *measurements* and lets you apply different minimum/maximum thresholds to each measurement in the array.

  The tool is typically used in electronics pin inspection applications.

  For more information on this tool, see *Array Decision* on page 674.

- Array Index: Takes an *array* of data as input and extracts one or more pieces of data at the user-provided index. You can then perform measurements on the individual outputs, or perform measurements using more than one piece of data, such as measuring the thickness represented by two profiles or surfaces.

  Usage examples include separating the multiple layers produced by a confocal sensor into individual profiles or surfaces.

  For more information on this tool, see *Array Index* on page 677.

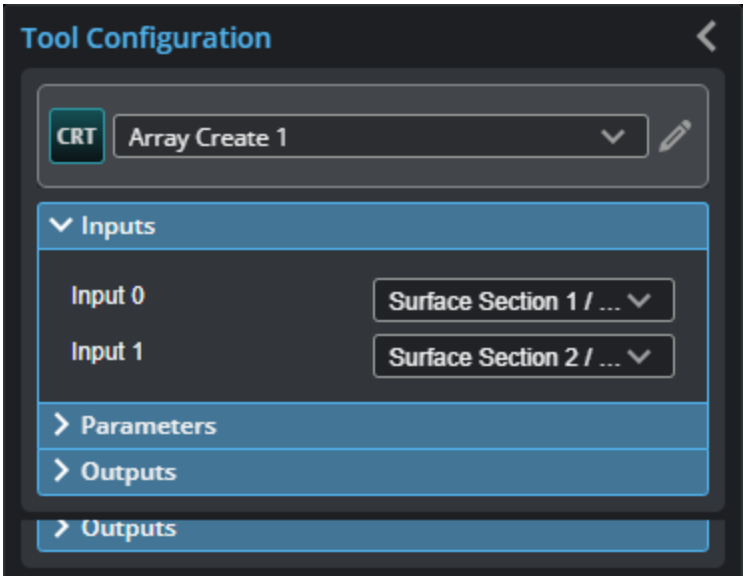
- Array Create: Takes *individual* inputs and creates an array containing those pieces of data as elements. For more information on this tool, see *Array Create* on the next page.

## Array Create

The Array Create tool combines individual pieces of data (Profile, Surface, measurements, and so on) into an array. For example, a number of Surface scans could be combined into an array made up of those pieces of Surface data. Compatible measurement and processing tools can then take the array as input and perform batch operations on the elements in the array, such as measurements on each element's data or processing each element's data. For more information, see *Arrays, Batching, and Aggregation* on page 171.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

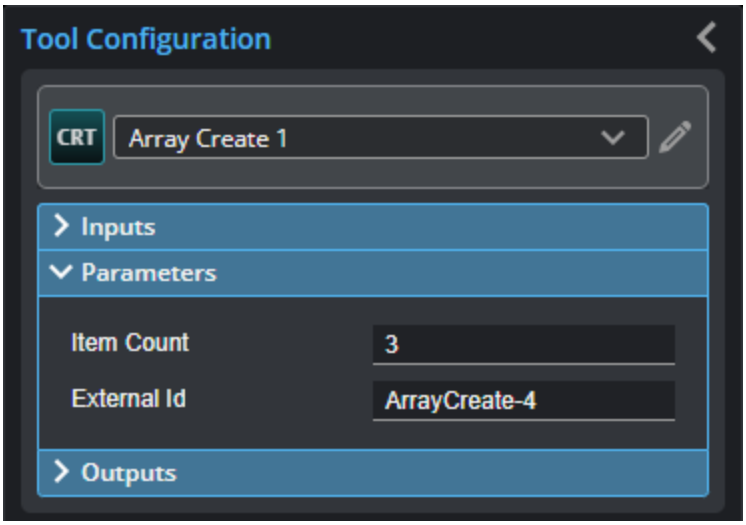



*Inputs*

| Name | Description |
|---|---|
| Input {n} | An input that the tool will add to the output array. The number of inputs depends on the **Item Count** parameter. All inputs must be of the same type. |

### Parameters

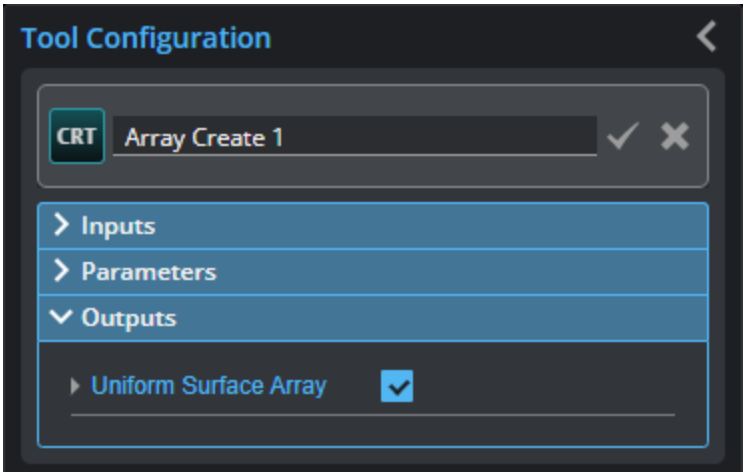
The following parameters are in the expandable **Parameters** section in the tool's configuration.




*Parameters*

| Parameter | Description |
|---|---|
| Item Count | The number of items expected in the array. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




The type of the output depends on the type of the inputs.

## Array Decision

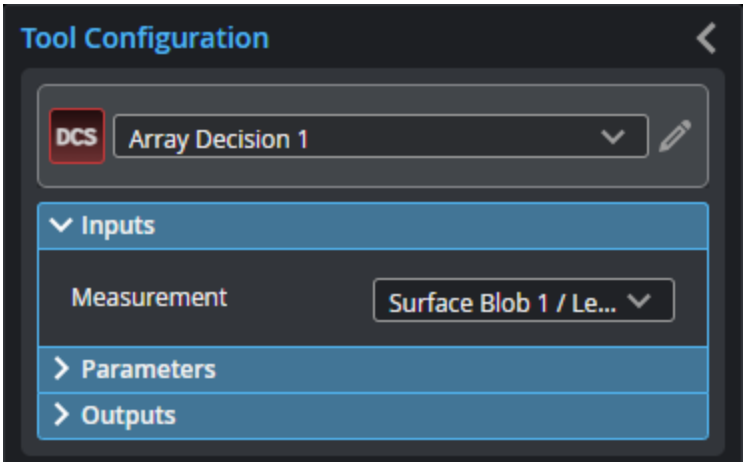
The Array Decision tool takes an array of measurements as input and applies individual minimum / maximum thresholds to one or more of the array elements. The tool returns results related to fails (number of fails, index and value of max/min fail, as well as arrays of failed measurements and their indices).

A common use case of Array Decision is to make pass/fail decisions for electronics pin inspection applications.

For general information on the Array tools, see *Array Tools* on page 671.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

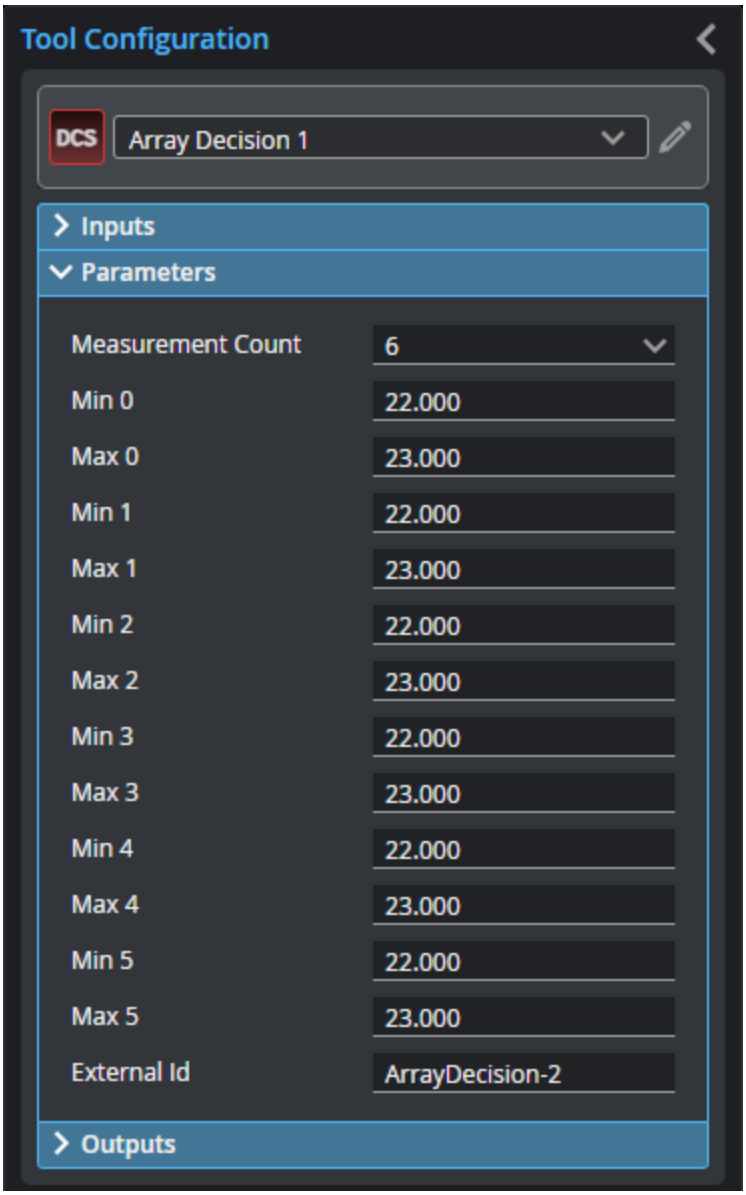



*Inputs*

| Name | Description |
|---|---|
| Measurement | The array of measurements the tool takes as input. |

### Parameters

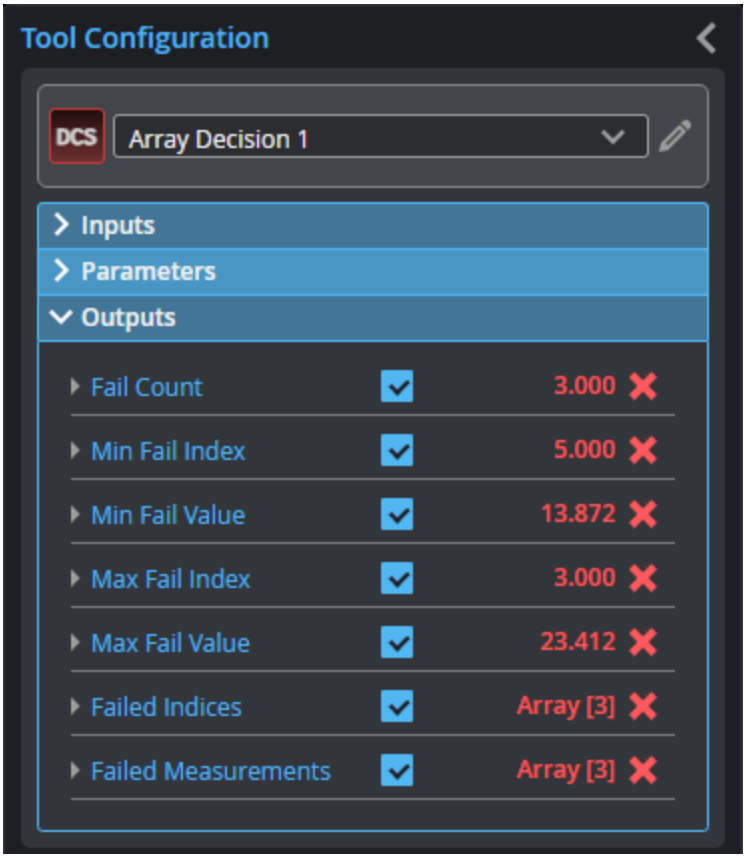
The following parameters are in the expandable **Parameters** section in the tool's configuration.




*Parameters*

| Parameter | Description |
|---|---|
| Measurement Count | The maximum number of array elements expected in the input array. The tool displays Min{n} and Max{n} fields for each element. |
| Min {n}<br>Max {n} | The minimum and maximum threshold for measurement element {n} in the input array of measurements. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




*Measurements*

| Measurement |
| --- |
| **Fail Count**<br>The number of array values that are outside their Min/Max thresholds. |
| **Min Fail Index**<br>The index of the array element with the greatest difference with respect to its Min threshold. |
| **Min Fail Value**<br>The value of the array element at Min Fail Index. |
| **Max Fail Index**<br>The index of the array element with the greatest difference with respect to its Max threshold. |
| **Max Fail Value**<br>The value of the array element at Max Fail Index. |
| **Failed Indices**<br>An array of the indices of the failed measurements. |
| **Failed Measurements**<br>An array of the failed measurement values. |

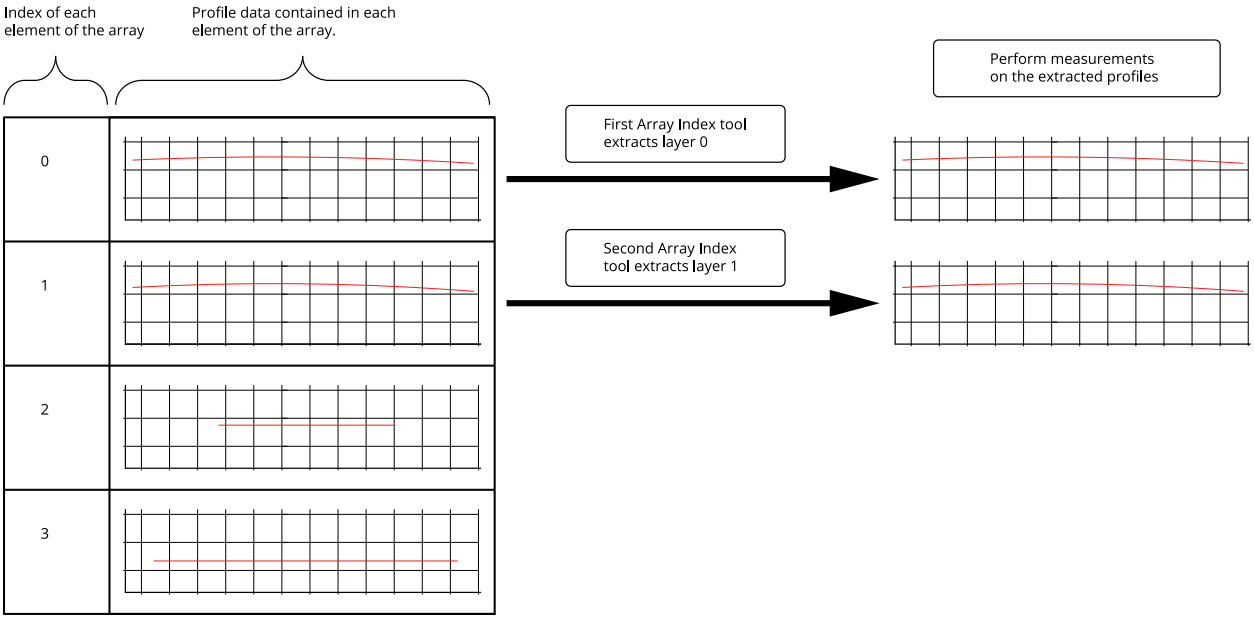
## Array Index

The Array Index tool extracts a *single* piece of data (such as a profile or a surface) from the array it takes as input at the position (the index) you specify.

A common use of the Array Index tool is to extract individual layers from the multilayer data produced by confocal sensors for measurement or processing.

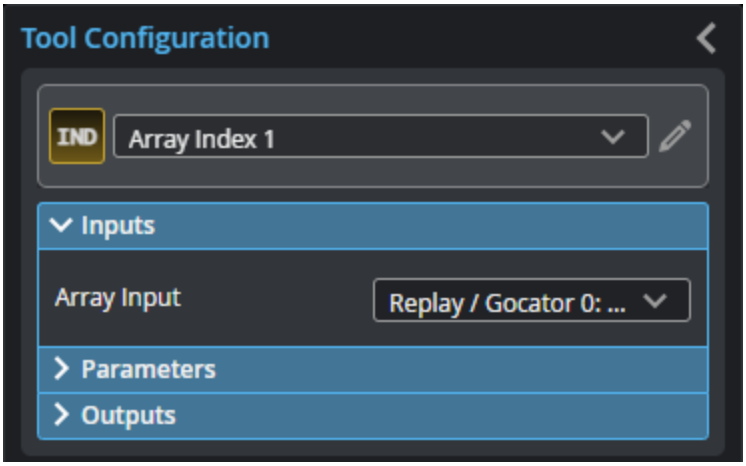
> If you have configured a confocal profile sensor to output only a single layer, you do not need to use the Array Index tool to extract the layer's profile.

For example, if your sensor is producing four layers of Profile data and you want to measure the thickness between the top two profiles, you can use two Array Index tools to extract those layers, one for each layer. You can then perform measurements on those extracted profiles, either individually or combined, for example, in the Profile Thickness tool. (For more information on the Profile Thickness tool, see *Profile Thickness* on page 343.)




For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

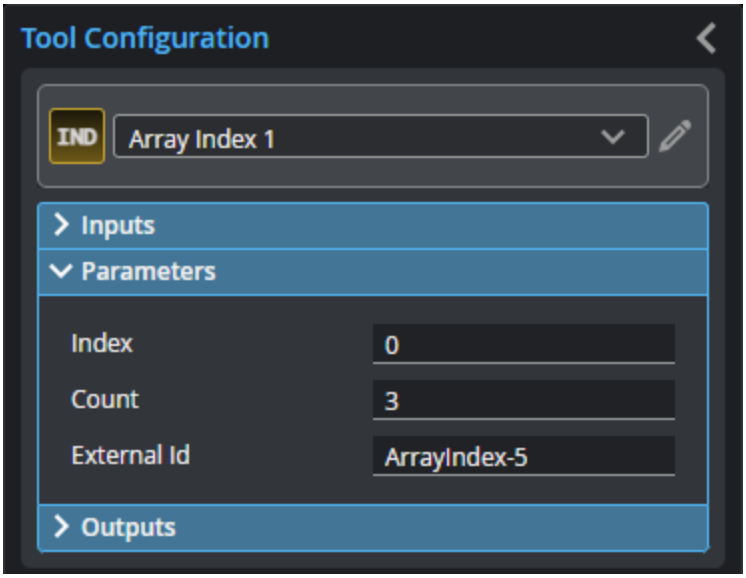



*Inputs*

| Name | Description |
|---|---|
| Array Input | The data the tool applies measurements to or processes. |

### Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

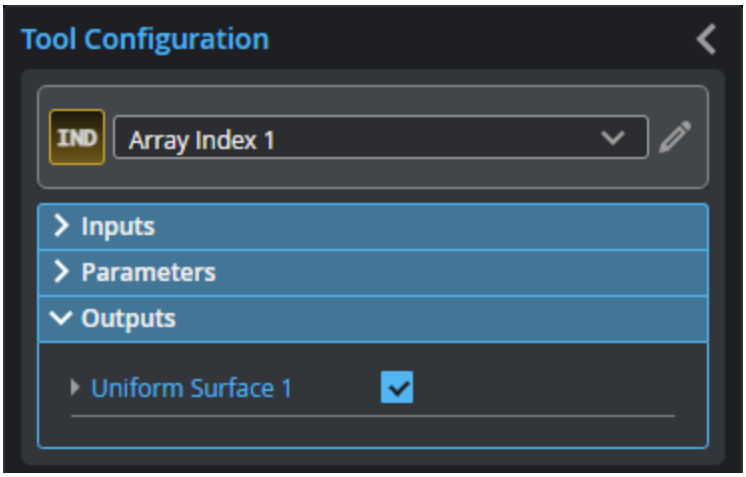



*Parameters*

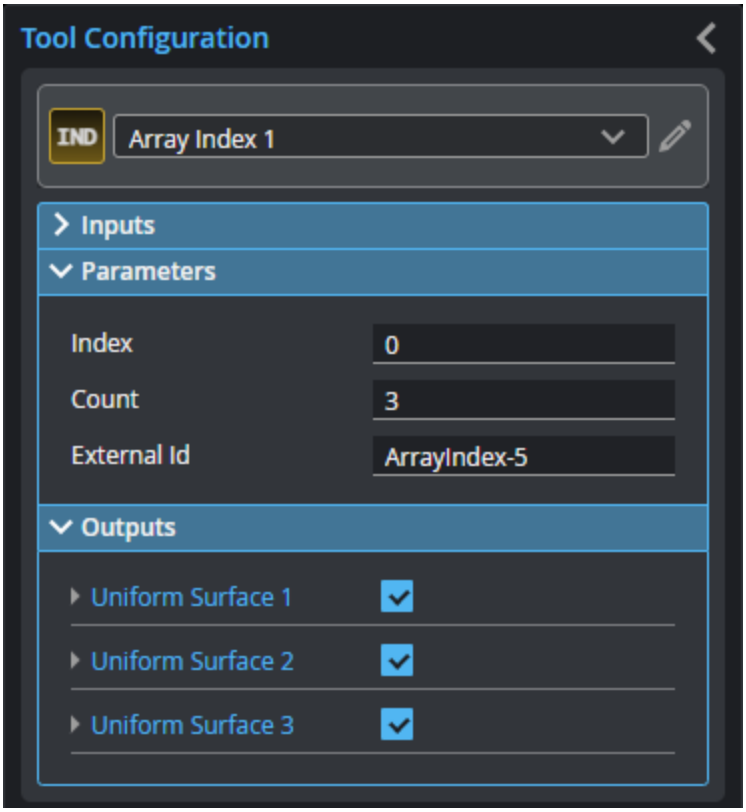
| Parameter | Description |
|---|---|
| Index | The position (the index) in the array at which the tool extracts and outputs. If **Count** is set to a value greater than 1, the index is the starting point for array element outputs. |
| Count | The number of individual outputs the tool produces, starting at the provided index (see above). This setting makes sending multiple outputs over protocols easier. |

| Parameter | Description |
| --- | --- |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**




If **Count** is set to a value greater than 1, the tool produces multiple outputs.




The type of the output depends on the type of the input array.

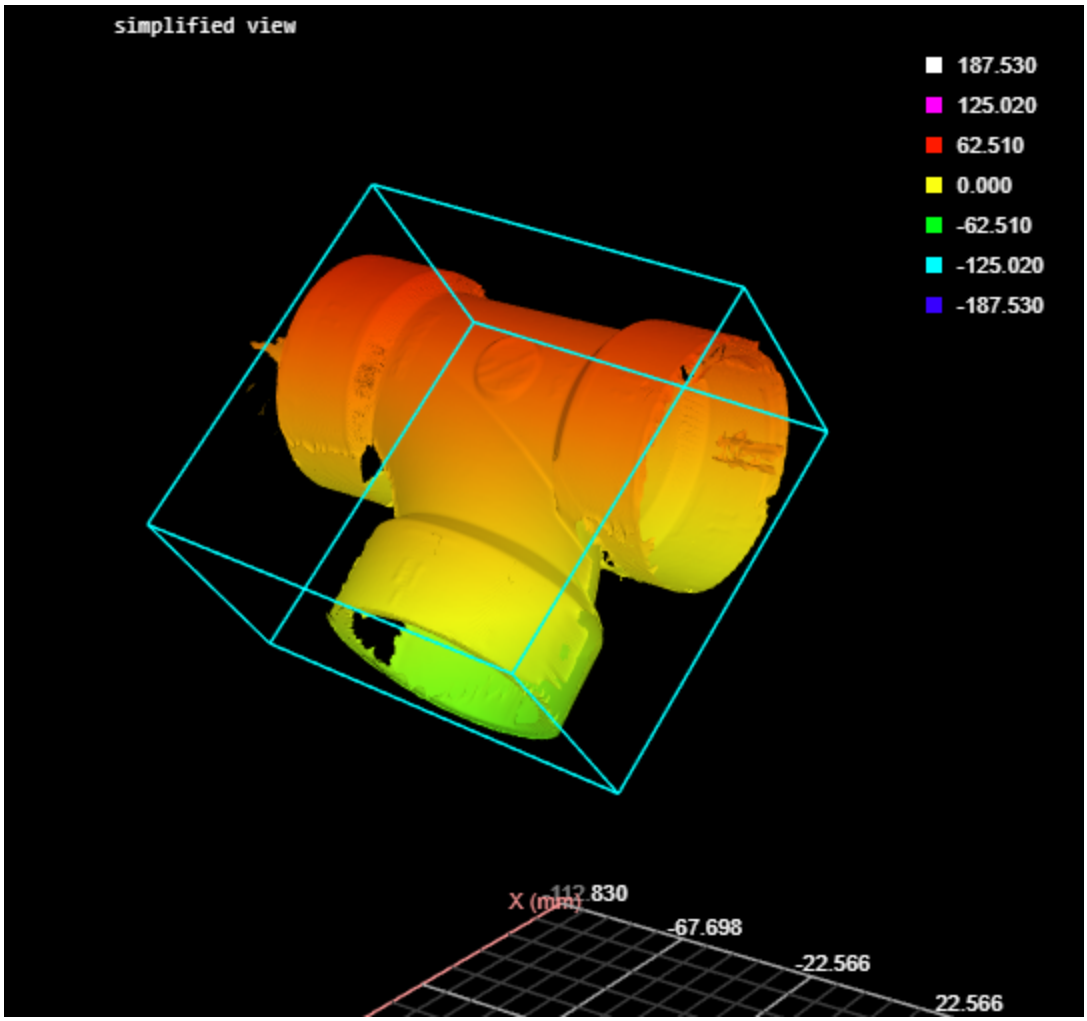
## Mesh Measurement

The Mesh tools are only intended for use with G2 sensors.

## Mesh Bounding Box

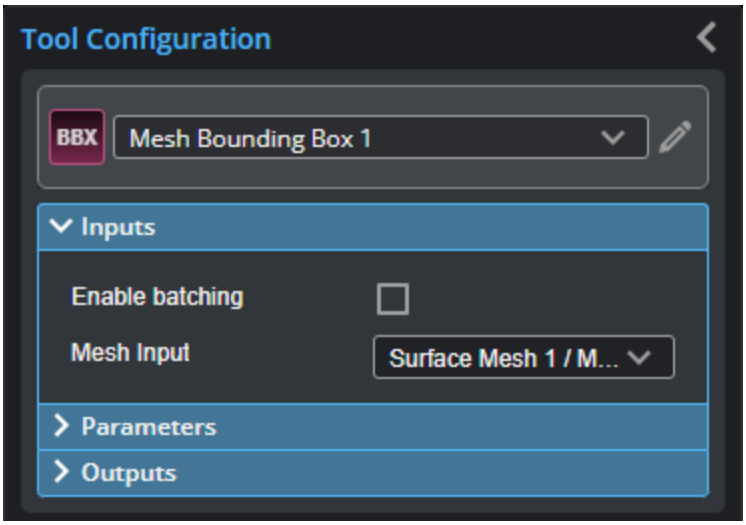
This tool is *only* intended for use with G2 sensors.

The Mesh Bounding Box tool takes in Mesh scan data (produced by the Surface Mesh tool and some other Mesh tools) and returns measurements related to the bounding box encapsulating the scan data in the region of interest, such as the rotation of the bounding box, the dimensions of the bounding box, and its location. In addition to a Point geometric feature, the tool returns the Mesh data in the bounding box. You can apply one of the other Mesh tools to this data, or after extracting Surface data using Mesh Projection or Mesh Plane, you can apply any built-in or custom GDK-based tool to the extracted surface data.




### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

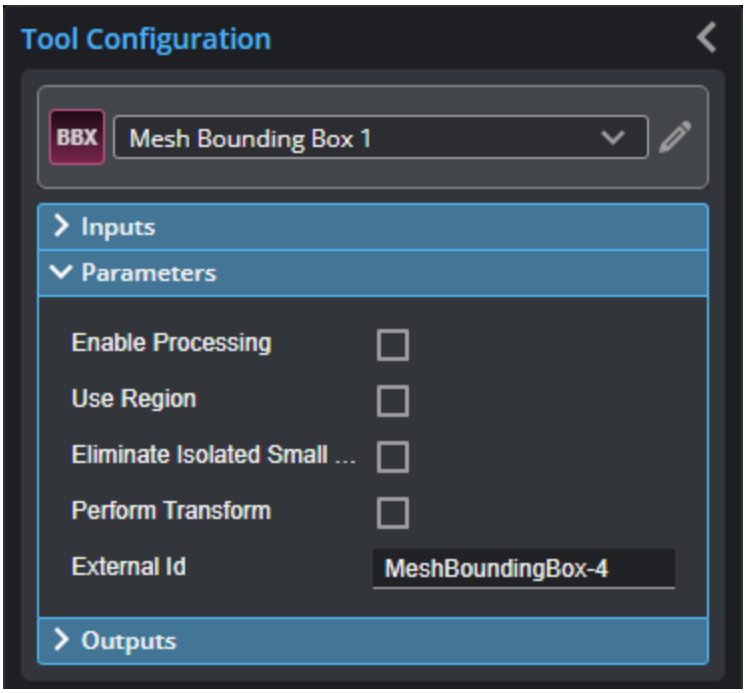



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Mesh Input | The data the tool applies measurements to or processes. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.

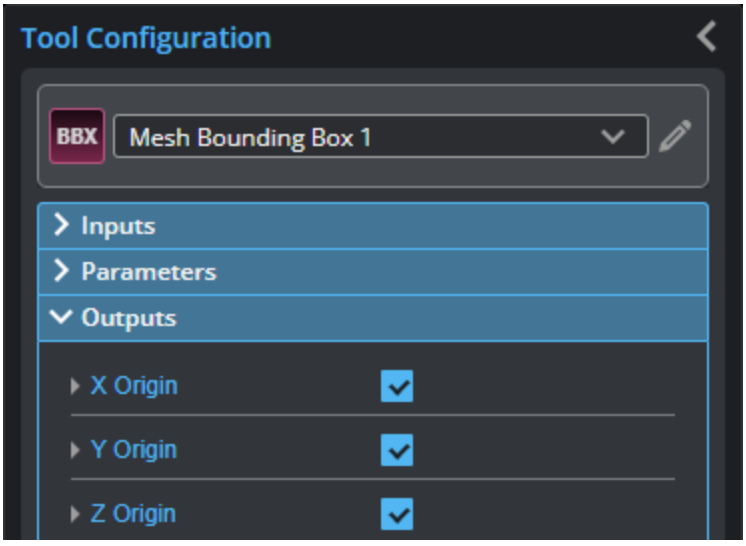


*Parameters*

| Parameter | Description |
|---|---|
| Enable Processing | Causes the tool to start processing scan data from individual sensors. Make sure to properly configure the tool *before* enabling this option. |
| Use Region | Determines whether the tool limits the bounding box fit to Mesh data in a user-defined region to fit a bounding box. Enabling this option displays parameters you use to define the size and position of the region. |
| Eliminate Isolated Small Surface | Excludes small, unconnected data from the Mesh output. |
| Perform Transform<br>Transform Mode | When **Perform Transform** is enabled, you can choose the which axes are the major, minor, and tertiary axes. The tool also centers the Mesh data at origin 0. This lets you align the part data however you want.<br>**Transform Mode** is one of the following:<br>• Minimal Alignment: The closest coordinate axes are arranged for alignment.<br>• X > Y > Z Order<br>• X > Z > Y Order<br>• Y > X > Z Order<br>• Y > Z > X Order<br>• Z > X > Y Order<br>• Z > Y > X Order |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

*Measurements*

| Measurement |
| --- |
| **X Origin**<br>**Y Origin**<br>**Z Origin**<br>These measurements return the X, Y, and Z position of the center of the fitted bounding box, respectively. |
| **X Angle**<br>**Y Angle**<br>**Z Angle**<br>The angle of the fitted bounding box around the X, Y, and Z axis, respectively. |
| **Width**<br>**Length**<br>**Height**<br>The width, length, and height of the fitted bounding box. |

*Features*

| Type | Description |
| --- | --- |
| Point | A point representing the center of the fitted bounding box. |

For more information on geometric features, see *Geometric Features* on page 191.

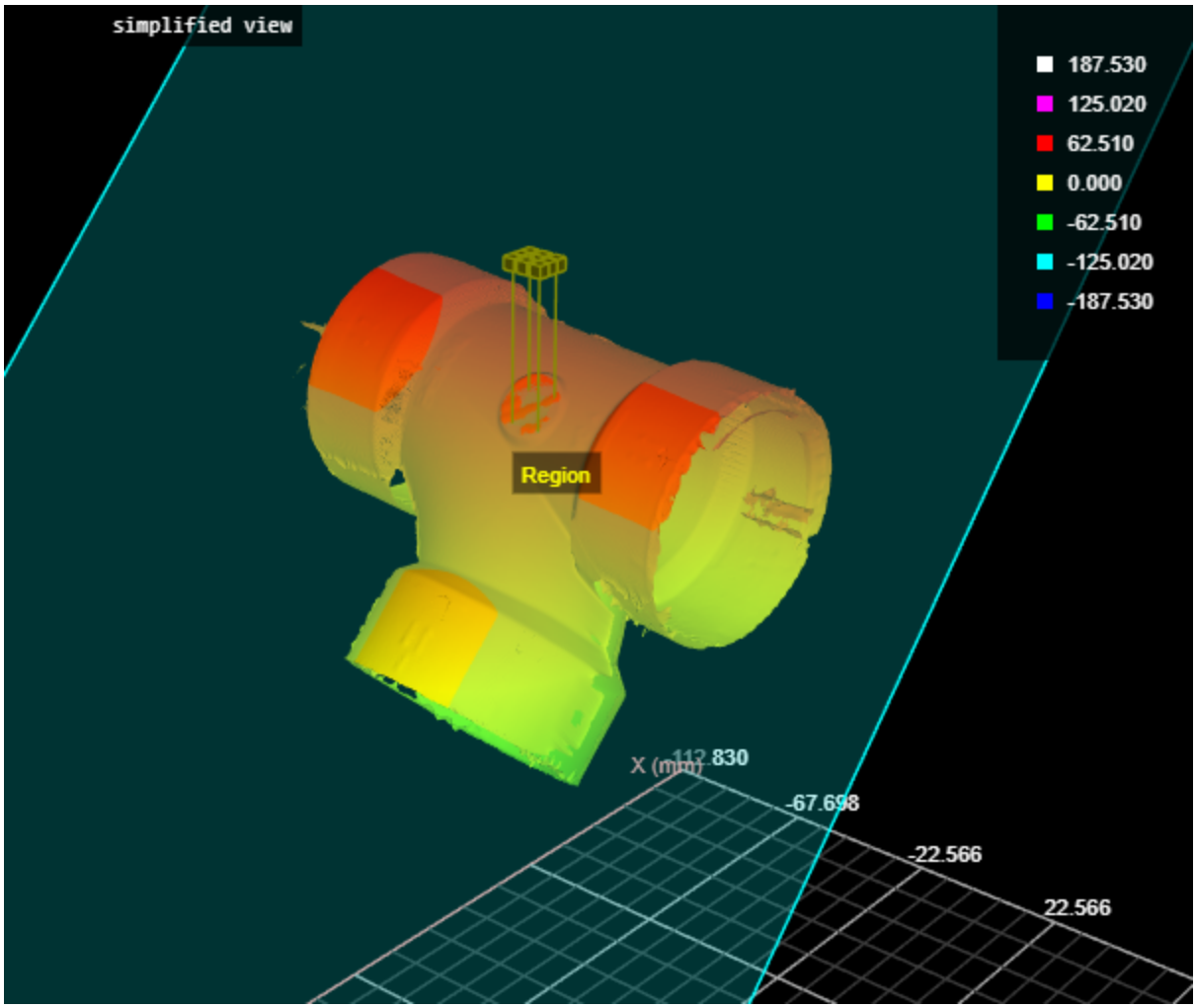
*Data*

| Type | Description |
| --- | --- |
| Mesh | The Mesh data contained in the bounding box. |

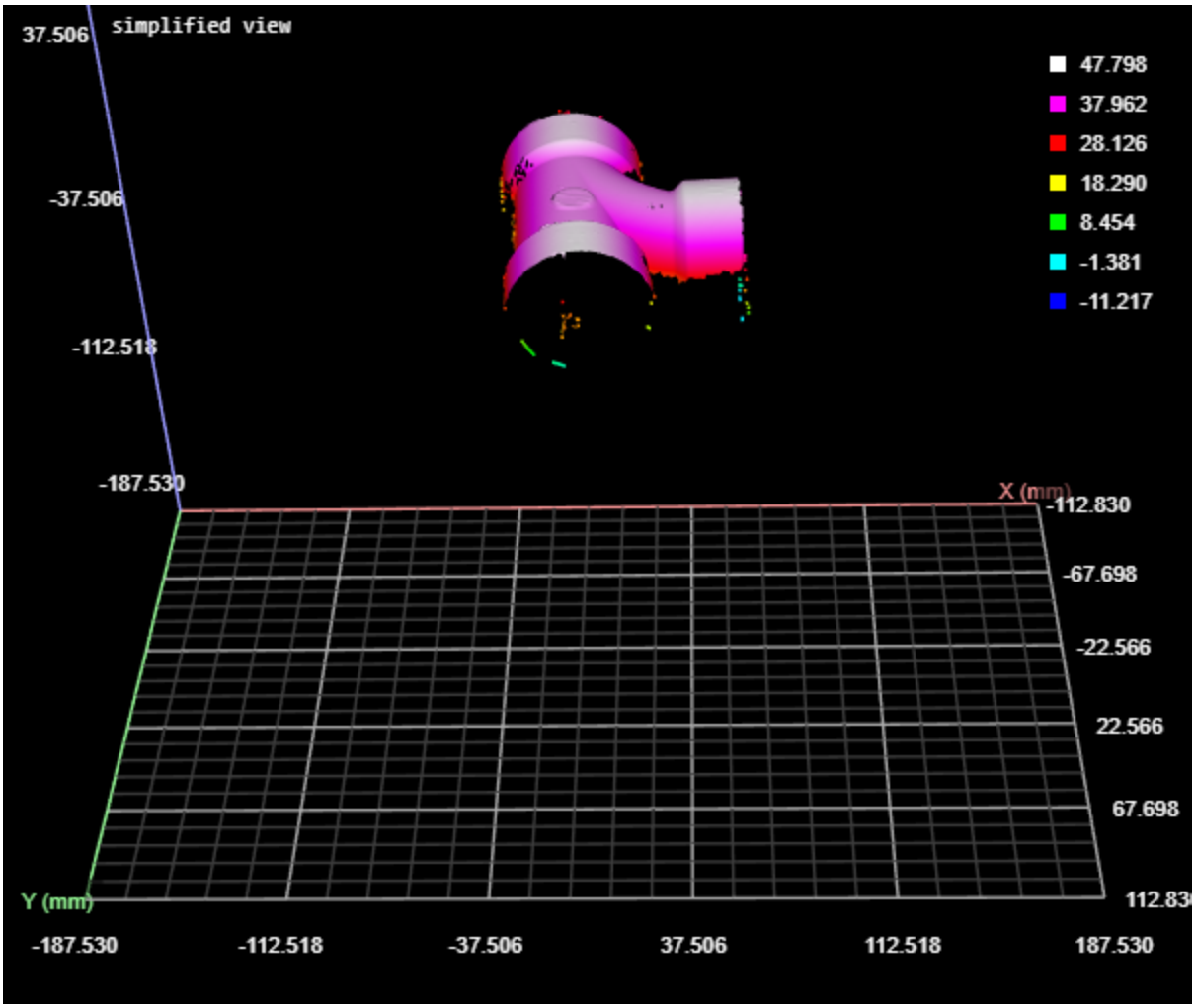
## Mesh Plane

This tool is *only* intended for use with G2 sensors.

The Mesh Plane tool takes in Mesh scan data (produced by the Surface Mesh tool and some other Mesh tools) and returns measurements on the plane fitted within the region of interest, such as deviations of the data points relative to the plane. The tool also returns a Plane geometric feature that can be used as input by the Mesh Projection tool (see *Mesh Projection* on page 690). Finally, the tool returns front and back Surface data extracted from the plane: you can apply any built-in or custom GDK-based tools to the resulting data. This means that with 360-degree scan data, you can, for example, apply measurements to the sides or bottoms of your target, rather than just the top.



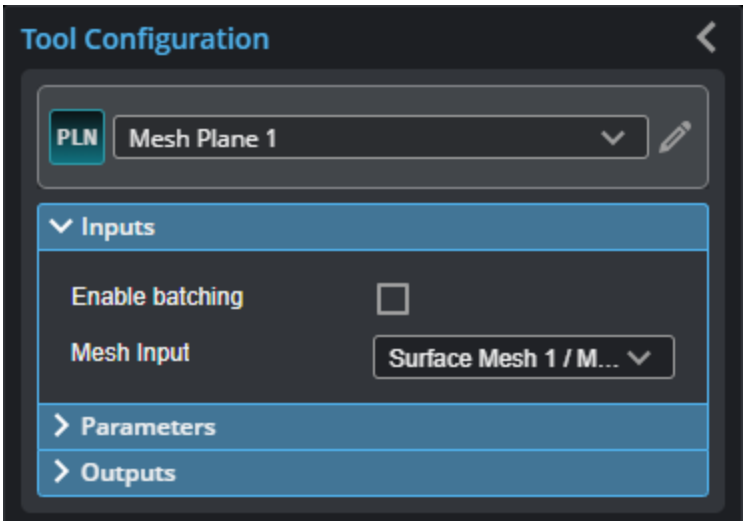

*Mesh data with a region placed on a circular flat area. The plane fitted to the data in this region is shown in cyan.*




*The Front Surface data output is rotated by the plane's X, Y, and Z rotation.*

**Inputs**

You configure the tool's inputs in the expandable **Inputs** section.

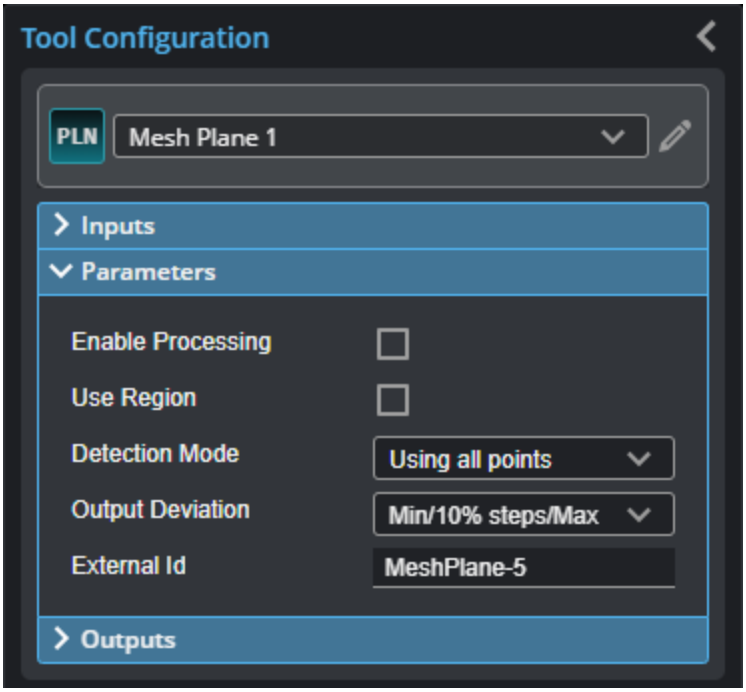


*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Mesh Input | The data the tool applies measurements to or processes. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



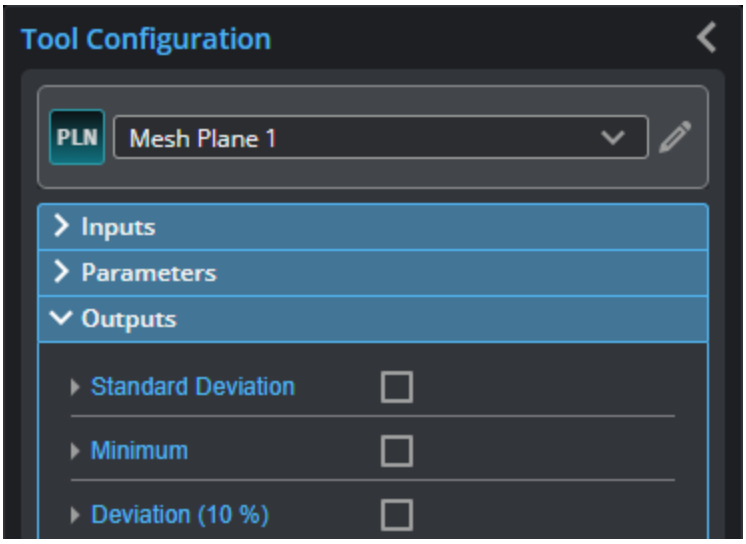

*Parameters*

| Parameter | Description |
|---|---|
| Enable Processing | Enables processing. |
| Use Region | When enabled, displays region settings. |
| Region | Region settings. |
| Detection Mode | The plane detection mode. One of the following:<br>**With Largest Area**<br>**With Maximum Distance**<br>**With Minimum Distance**<br>Chooses the plane at the maximum or minimum distance in the region, respectively, from the 0 origin. Use these options when more than one plane fit is possible in the region. Works in conjunction with **Search Direction**. |

| Parameter | Description |
| --- | --- |
| | **Using all points**<br>Uses all data points of the scan data in the region. |
| Search Direction | The search direction the tool will use to fit a plane. For example, when **Search Direction** is set to +Z, the tool starts searching from origin Z = 0 and moves along the positive Z axis.<br>This parameter is only useful when **Plane Detection Mode** is set to one of the following:<br>• With Largest Area<br>• With Maximum Distance<br>• With Minimum Distance<br>The corresponding surface normals are taken into account in the processing so that the uninvolved points can be sorted out relatively quickly and safely. The fixed search angle is 45 degrees around the set direction.<br>When **Search Direction** is set to **Input Direction**, the tool displays additional parameters: **Tilt Angle** and **Direction Angle**.<br>**Tilt Angle** - The angle between the Z axis and the vector.<br>**Direction Angle** - The vector is projected onto the XY plane and then rotated around the X axis.<br>Specifically:<br>X = sin(TiltAngle) * cos(DirectionAngle)<br>Y = sin(TiltAngle) * sin(DirectionAngle)<br>Z = cos(TiltAngle) |
| Output Deviation | Determines which deviations are output as measurements, which can be a combination of minimum and maximum, and a set of Deviation (x %) measurements (with the specified step between them). Can also be set so that no deviations are output.<br>Use this to get a rough idea of the distribution of the deviation values (or a histogram of the deviations). |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




*Measurements*

| **Measurement** |
|---|
| **Standard Deviation**<br>The standard deviation of the data points from the fitted plane. |
| **Minimum**<br>**Maximum**<br>The minimum and maximum error of the data points from the fitted plane, respectively. |
| **Deviation (x%)**<br>Deviations of the data points from the fitted plane, sorted into stepped percentiles. You set number of steps using the **Output Deviation** parameter. |

*Features*

| **Type** | **Description** |
|---|---|
| Plane | A plane geometric feature. |

For more information on geometric features, see *Geometric Features* on page 191.

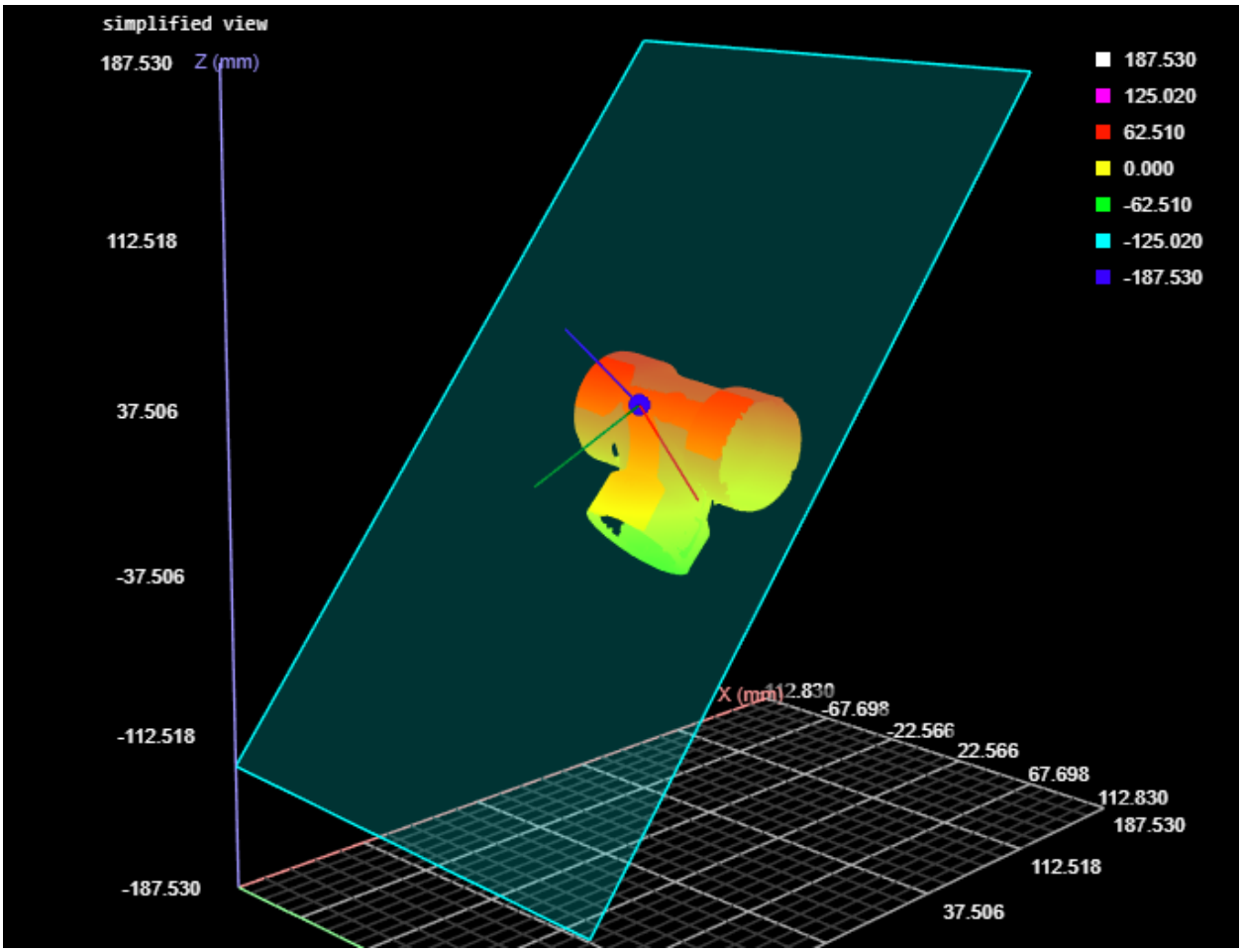
*Data*

| **Type** | **Description** |
|---|---|
| Front Surface | Surface data representing the front of the meshed target. |
| Back Surface | Surface data representing the back of the meshed target. |
| Difference Surface | A Surface output that shows the fit error at each point in the height map. |

## Mesh Projection

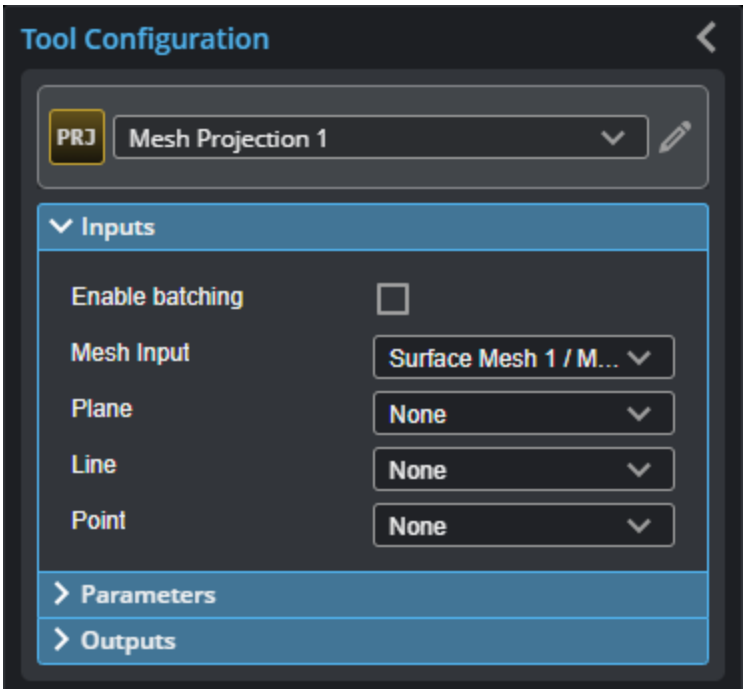
This tool is *only* intended for use with G2 sensors.

The Mesh Projection tool takes in Mesh scan data (produced by the Surface Mesh tool) and extracts Surface data. The tool can optionally take plane, line, or point geometric features to perform transformations on the output surface data (if no geometric features are used as inputs, the surface parallel to the XY plane is output), or you can manually apply fixed transformation. You can then apply any built-in or custom GDK-based Surface tool to the resulting Surface data. This means that with 360-degree scan data, you can, for example, apply measurements to the sides or bottoms of your target, rather than just the top.




### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

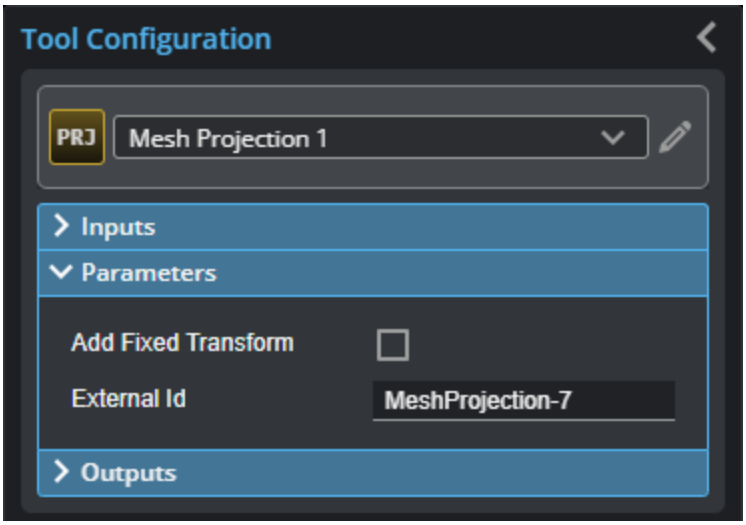



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with any number of elements. When **Enable Batching** is unchecked, the tool takes either a single surface, or an array of surfaces with any number of elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Mesh Input | The data the tool applies measurements to or processes. |
| Plane | The tool aligns the XY plane to the selected plane geometric feature in the output Surface data. |
| Line | The tool aligns the X axis to the selected line geometric feature in the output Surface data. |
| Point | The tool uses the selected point geometric feature the origin in the output Surface data. |

### Parameters

You configure the tool's parameters in the expandable **Parameters** section.

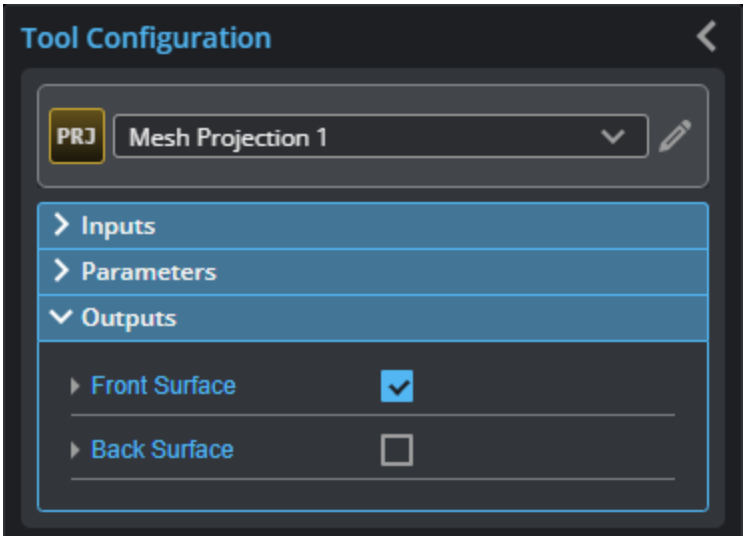



*Parameters*

| Parameter | Description |
|---|---|
| Add Fixed Transform | When this parameter is enabled, you can provided fixed X, Y, and Z offsets, as well as X, Y, and Z angles, which the tool uses in the output Surface data. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

### Outputs

Most tools provide measurements, geometric features, or data as outputs.



*Data*

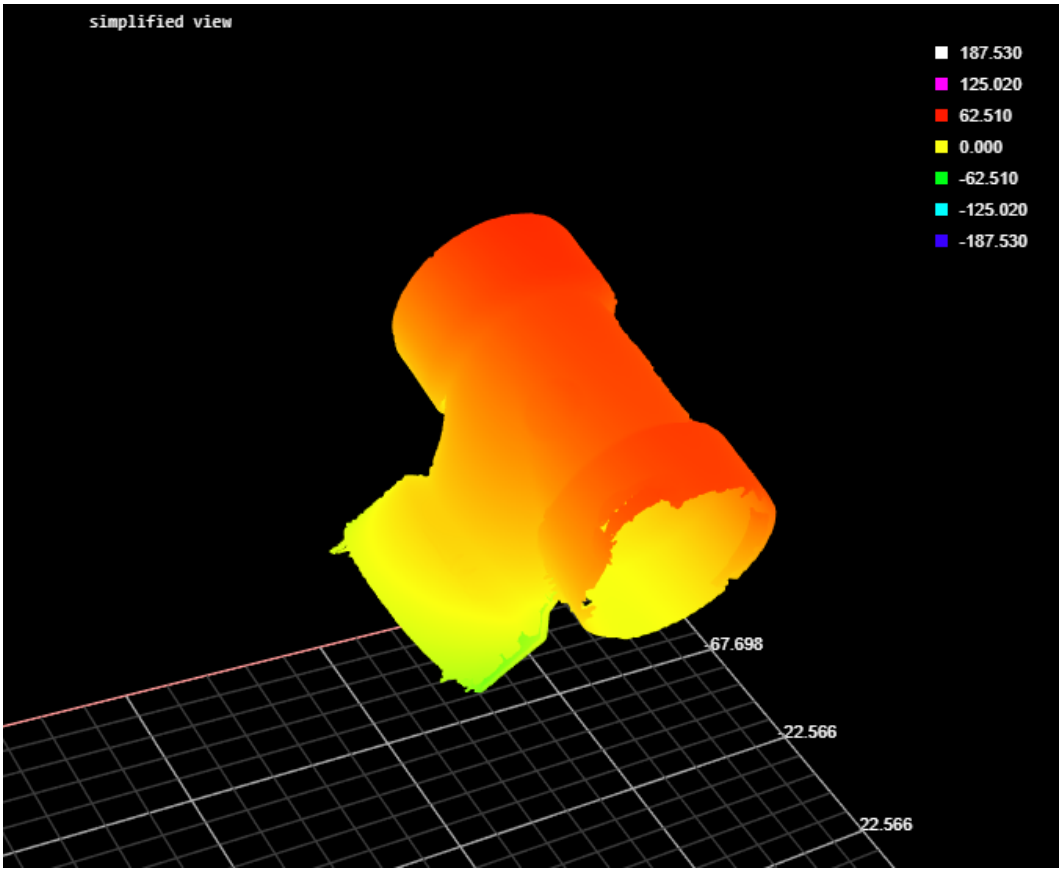
| Type | Description |
|---|---|
| Front Surface | Surface data representing the front of the meshed target. |
| Back Surface | Surface data representing the back of the meshed target. |

## Mesh Template Matching

| | |
|---|---|
| | This tool is *only* intended for use with G2 sensors. |

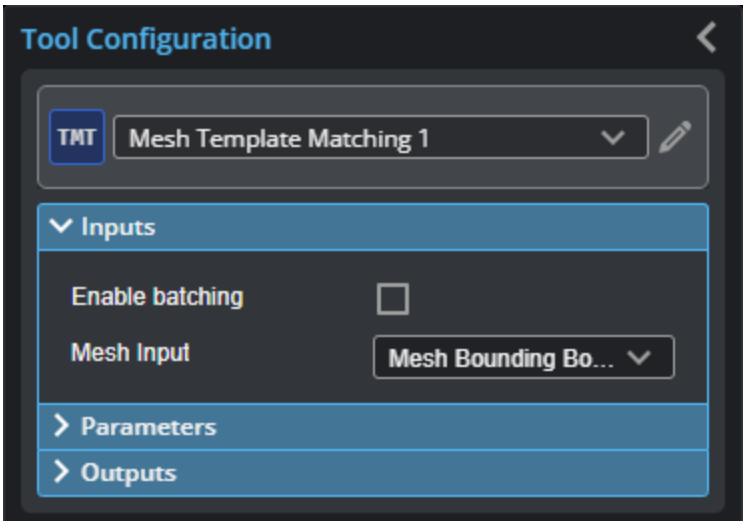
| | |
|---|---|
| | This tool is not supported on A and B revision Gocator 2100 and 2300 sensors that are not accelerated (either by a PC-based application or by GoMax). The tool is supported in emulator scenarios. |

The Mesh Template Matching tool takes in Mesh scan data (produced by the Surface Mesh tool) and a template you previously defined based on a "golden part" (itself created using the Mesh Template Matching tool). The tool returns measurements related to the position and orientation of the scan data relative to the template, such as offsets and rotations, as well as standard deviations between the scan data and the template. The tool can also output Mesh scan data.




### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

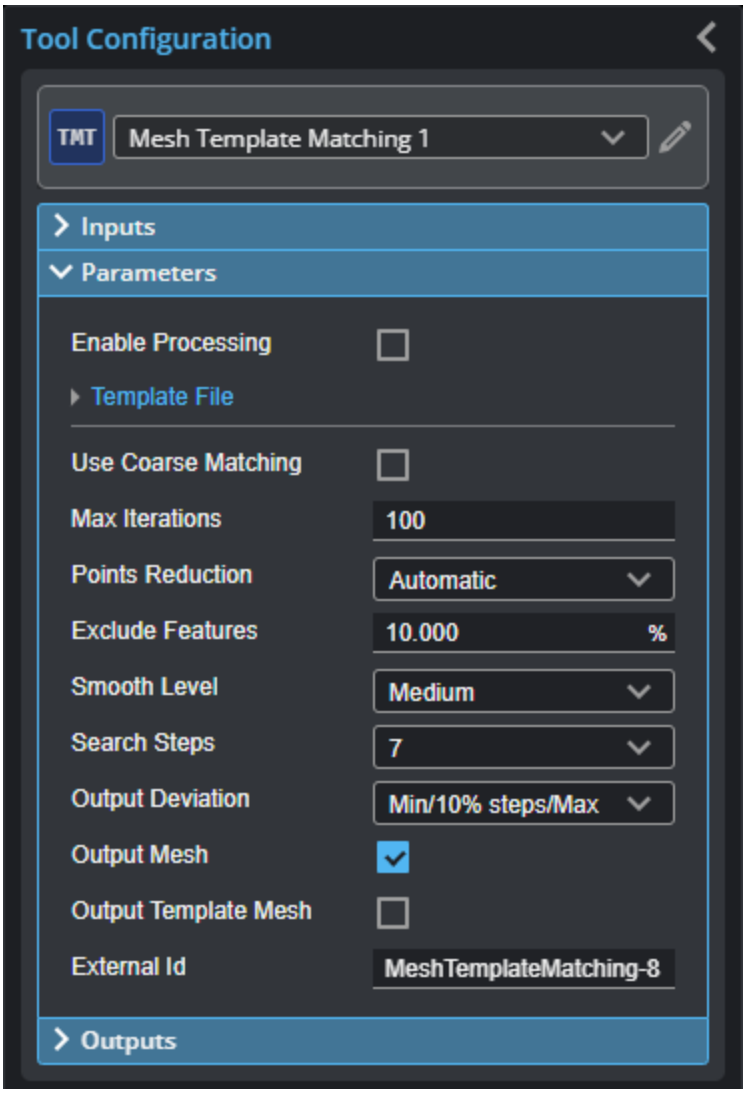



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each data element in the array individually. There is no limit to the size of the array, other than the processing limitations of the sensor.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Mesh Input | The data the tool applies measurements to or processes. |

**Parameters**

You configure the tool's parameters in the expandable **Parameters** section.



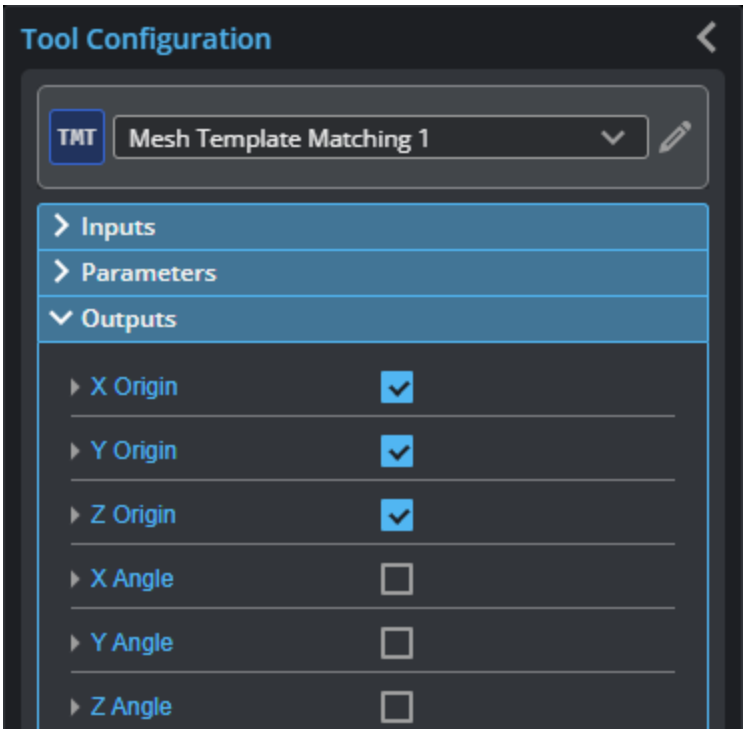

*Parameters*

| Parameter | Description |
|---|---|
| Enable Processing | When this option is enabled, the tool compares the Mesh data to the loaded template. |
| Template File | Expanding section containing template-related parameters. |
| Operation<br>Template Name<br>Template File | The tool's operation mode. One of the following:<br>**Normal**: When Enable Processing is enabled, the tool compares the Mesh scan data and the loaded template.<br>**Load**: Displays a list of Mesh template files you can load (in the **Template File** drop-down). Supports the following three formats:<br>• BCD: Internally used by the tool. To reduce the conversion processing time, a BCD file with the same name is automatically generated if the data is imported with a different format. |

| Parameter | Description |
|---|---|
| | • OBJ: A format for defining the 3D geometry for the surface of one or more objects.<br>• STL: A file format commonly used for 3D printing and computer-aided design (CAD).<br>**Save**: Saves the current frame of Mesh scan data as a template (in C:\GoTools\Mesh Template Matching\) in BCD format. Type the name of the template in the **File Name** field, and then check **Enable Processing** to save the file. A user message is displayed if the template is saved successfully. Note this option is only available if there is no template currently loaded in this tool.<br>**Delete**: Deletes the template file you select in the **Template File** field.<br>**Refresh**: Refreshes the template file list.<br>**Remove**: Unload an existing template to make the Save option visible. So that user is aware that just the current input mesh data will be declared and saved as a template, when selecting the Save option. |
| Use Course Matching | Enable this parameter when the body surfaces to be matched are not symmetrical, and the original orientation and position deviate significantly from the measured data set. |
| Max Iterations | The maximum number of iterations the tool uses to match the Mesh scan data with the template. This parameter can be used to speed up the optimization process to some degree. Typically, leave this at the default value. |
| Points Reduction | Controls the number of points used in the matching process, which can improve processing time. |
| Exclude Features | Use this when there are high or low features on the part that should not be included in the matching. For example, at 10%, the tool excludes 10% of the points with maximum or minimum deviation from the matching process. |
| Smooth Level | The amount of smoothing the tool applies. LMI recommends leaving this setting at its default. |
| Search Steps | Determines the neighborhood level in which to search for connection point pairs. |
| Output Deviation | Determines which deviations are output as measurements, which can be a combination of minimum and maximum, and a set of Deviation (x %) measurements (with the specified step between them). Can also be set so that no deviations are output.<br>Use this to get a rough idea of the distribution of the deviation values (or a histogram of the deviations). |
| Output Mesh | Outputs the transformed mesh. |
| Output Template Mesh | Outputs a mesh template. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

**Outputs**

Most tools provide measurements, geometric features, or data as outputs.




You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833.

*Measurements*

| **Measurement** |
| --- |
| **X Origin**<br>**Y Origin**<br>**Z Origin**<br>**X Angle**<br>**Y Angle**<br>**Z Angle**<br>These measurements represent the transform matrix that matches the input mesh against the template. |
| **Standard Deviation**<br>The standard deviation of pairs of matching points. |
| **Minimum**<br>**Maximum**<br>The minimum and maximum deviation of pairs of matching points. |
| **Deviation (x%)**<br>The deviations of pairs of matching points, sorted into stepped percentiles. You set the number of steps using the **Output Deviation** parameter. |

*Data*

| Type | Description |
|---|---|
| Mesh | The transformed Mesh. Only listed if the **Output Mesh** parameter is enabled. |
| Mesh Template | A template Mesh. Only listed if the **Output Template Mesh** parameter is enabled. |

## Measurement Formula Tool

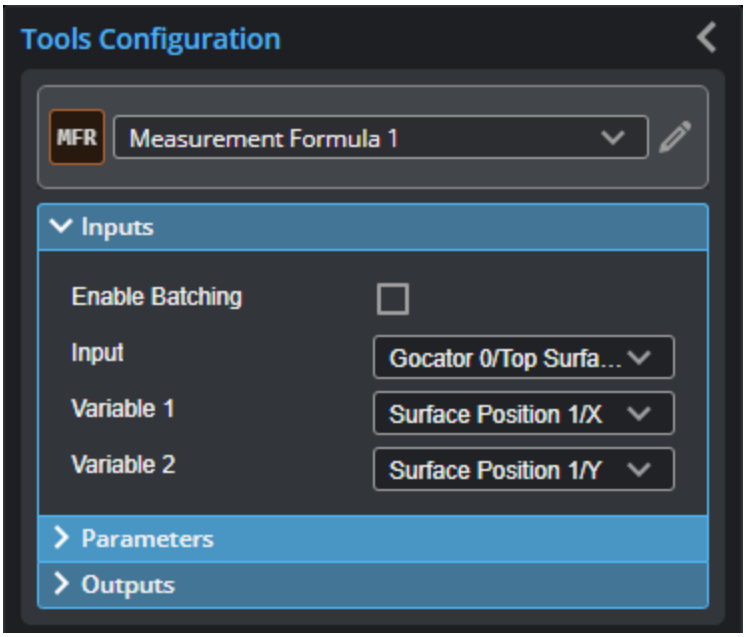
The Measurement Formula tool lets you create a mathematical expression containing aliases to one or more measurements from other measurement tools, up to a maximum of 20. The result of the calculation is returned in the tool's Result measurement.

The tool's default timeout is 5 seconds: if the tool fails to complete the calculation after 5 seconds, the result is set to Invalid.

The tool uses the C++ Mathematical Expression Toolkit Library (ExprTk). For full details on what it supports, see the toolkit's page (http://www.partow.net/programming/exprtk/).

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Inputs

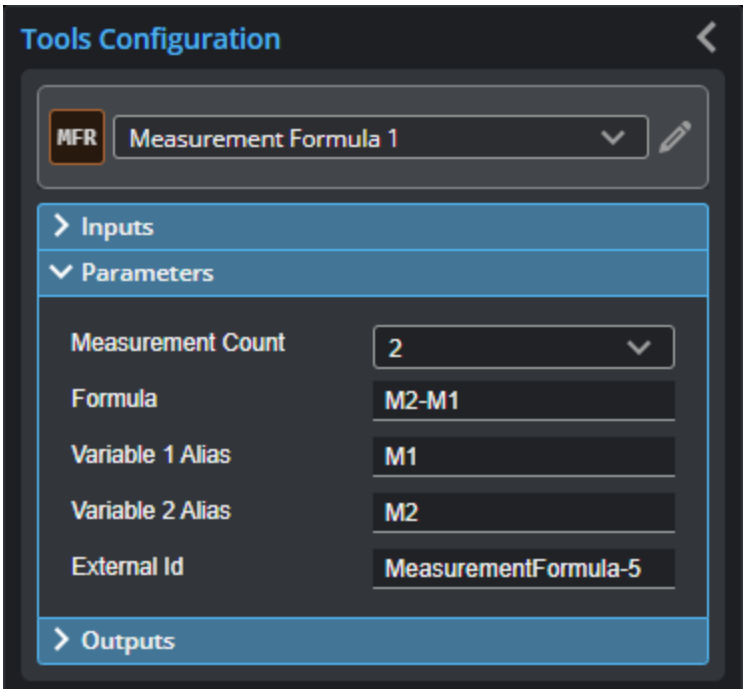



*Inputs*

| Name | Description |
|---|---|
| Enable Batching | When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually.<br>For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 171. |
| Input | Set this parameter to any available input. The selected input has no effect on the tool's calculations. |
| Variable {n} | A measurement from another tool that you use in the formula.<br>The **Measurement Count** parameter controls the number of variable inputs. |

### Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

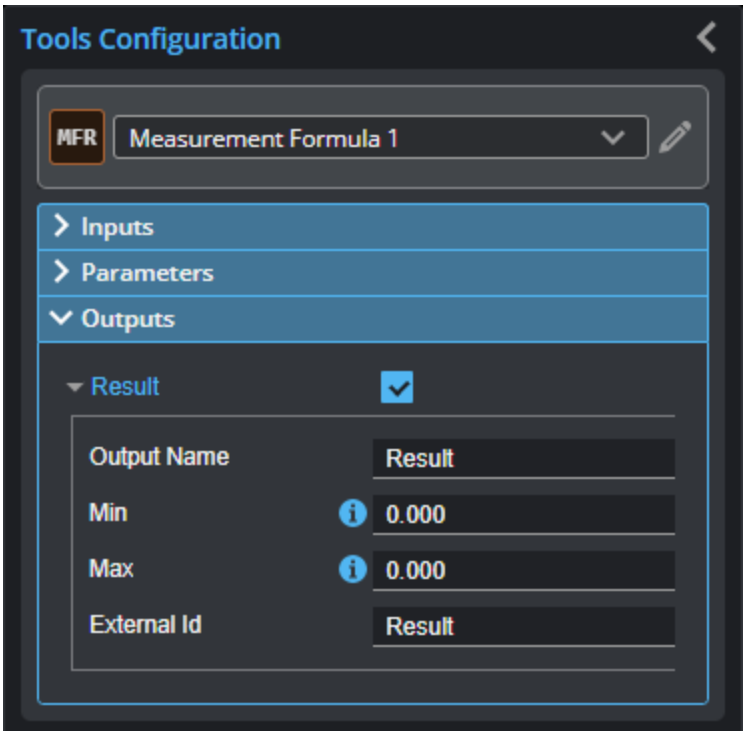



*Parameters*

| Parameter | Description |
|---|---|
| Measurement Count | Sets the number of variable inputs in the **Inputs** section. For each, a **Variable {n}** input and a **Variable {n} Alias** parameter is added, and<br>for use in the expression. |
| Formula | The mathematical expression.<br>Use the variable aliases from the **Variable {n} Alias** parameters in the expression. For example:<br>• M1*3+M2/2+4<br>• tan(M1/180*pi)<br>• max(M1, M2, M3)<br>The tool supports complex mathematical formulas. For example, the following:<br>$\sqrt{\frac{1-a\times e^{2t}+w^{\pi}}{sin(\frac{2x}{\pi})+cos(\frac{\pi}{y})}}$<br>can be produced using the following formula:<br>`sqrt((1-a*exp(2t)+w^(pi))/(sin(2x/pi)+cos(pi/y)))`<br>The following shows how to perform a *while* loop:<br>`y:=0; while(x<10){y:=y+x;x+=1;};y` |

| Parameter | Description |
|---|---|
| | Note that ":=" is the assignment operator, and "=" is the equality operator.<br>The following shows how to use an if-else structure:<br>`if(x>2){x:=x+2;}else{x:=x-2;};x` |
| Variable {n} Alias | The alias of Variable {n} (that is, a measurement set in the **Inputs** section). Use these aliases in **Formula**. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

## Outputs




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement |
|---|
| **Result**<br>The result of the calculation in **Formula**. |

## Script

The Script tool executes a user-defined Python-based script. For a list of the tool's supported classes and methods, see *Functions and Classes* on page 707.

For examples, see *Examples* on page 716.

The tool supports all GoPxL data types as input and output:

- Surface and Profile data (including intensity)
- Measurements (values and decisions, and anchor sources for other tools)
- Geometric features
- Arrays of the supported types

> The Script tool does *not* support writing files when it is running on a sensor or GoMax NX device, and will display a permissions error if you attempt this. Writing to files is only supported when the tool is running on a PC instance of GoPxL. When writing to files, you should explicitly set the path to a writable location.

The tool does not support using `print()`, `sys.stdout`, or Python's `logging` module functions to send messages to GoPxL's system log. Instead, use one of the "log_" functions. For more information, see *Logging* on page 711.

Script tools are added, configured, and removed like other measurement tools.

> The Script tool uses Python version 3.8.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 169.

### Included Python Modules

In addition to the standard Python library modules, the tool also includes the NumPy 1.19 module. NumPy is useful for operating on arrays.

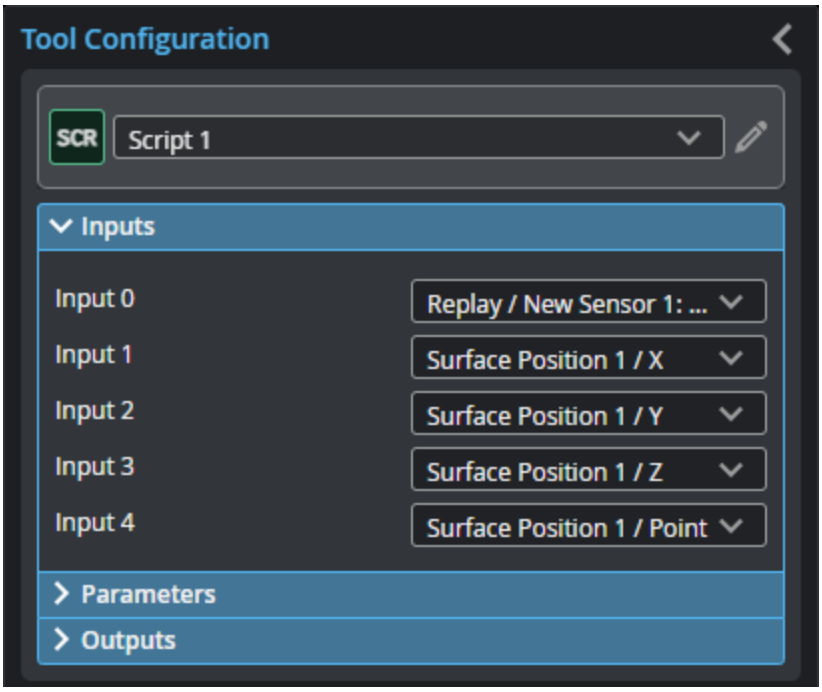
On Windows, you can install additional modules with `pip` by running the following command under the `GoPxL\res\python` folder:

```
python3.exe -m pip install <modulename>
```

Note that for some libraries you may need to specify a specific version to ensure compatibility with the version of Python included with GoPxL.

### Inputs

You configure the tool's inputs in the expandable **Inputs** section.

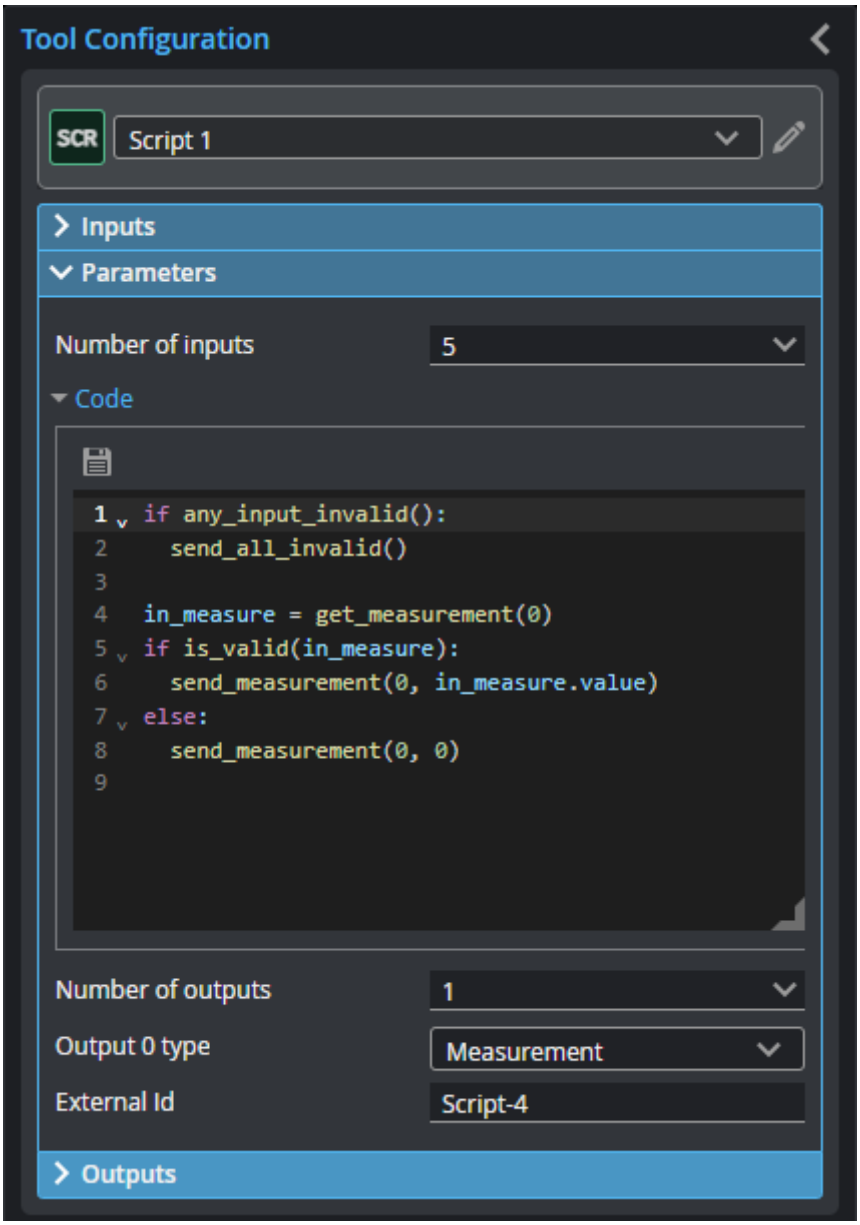



*Inputs*

| Name | Description |
|---|---|
| Input {n} | Selects the input for the script where {n} is the index of the input. All input types are allowed. Input cannot be 'None'. In the `get_` functions' `index` parameters, use this index.<br>The **Number of inputs** parameter (see below) determines the number of inputs.<br>This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 171. |

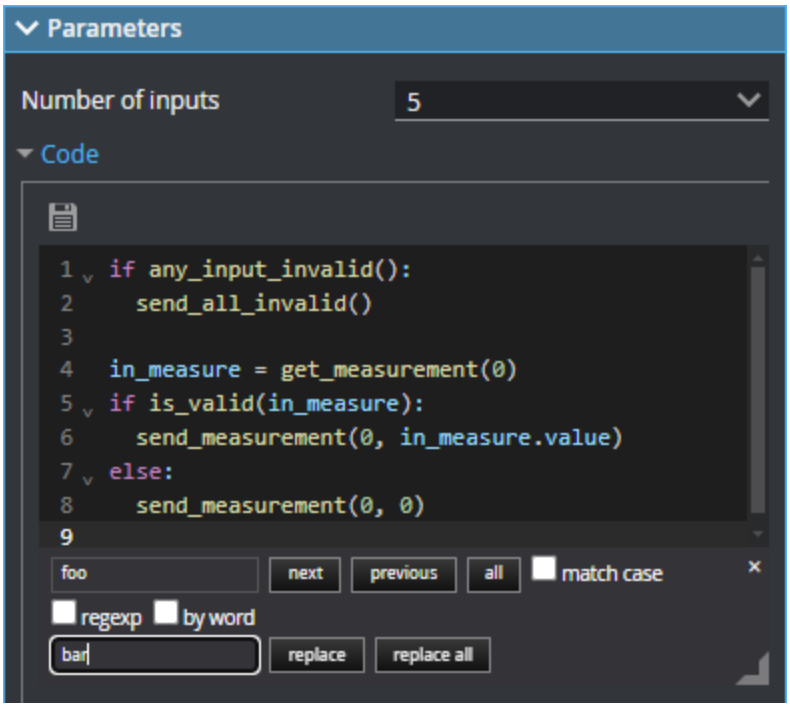
## Parameters

You configure the tool's parameters in the expandable **Parameters** section.



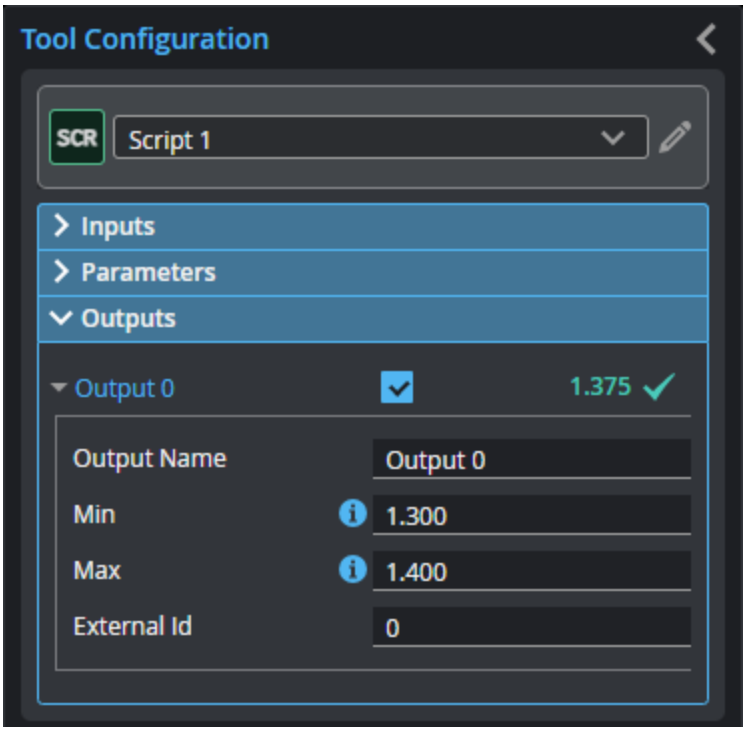

*Parameters*

| Name | Description |
|---|---|
| Number of Inputs | Specifies the number of inputs needed in the script. |
| Code | The Python code the tool runs. Supports expanding and collapsing of code blocks. You can resize the editor vertically with the grabber to the lower left of the editor. You can resize the width of the editor by resizing the **Tool Configuration** panel.<br>The following keyboard shortcuts are available in the editor.<br>**Ctrl-S**: Saves the script. The tool checks the syntax. Use Cmd-S on macOS.<br>**Ctrl-F**: Opens a search and replace panel. The search and replace panel supports regular expressions. Use Cmd-F on macOS. To close the panel, click the "x" to the |

| Name | Description |
| --- | --- |
| | upper right.<br>  <br><br>**Ctrl-D**: Highlights all occurrences of the word under the cursor. Each time you press Ctrl-D after that, the cursor moved to the next occurrence. Use Cmd-D on macOS.<br>**Alt-ArrowLeft / Alt-ArrowRight**: Move the cursor over the next element to the left or right, respectively.<br>**Alt-ArrowUp / Alt-ArrowDown**: Move the selected lines up or down one line, respectively. Combining this with Shift copies lines instead.<br>**Ctrl-/**: Toggles commenting. Use Cmd-/ on macOS.<br>**Ctrl-[ / Ctrl-]**: Decreases or increases the indentation of the selected line. Use Cmd-[ or Cmd-] on macOS. |
| Number of outputs | Specifies the number of outputs the script produces. |
| Output type {n} | Selects the output type for each output, where {n} is the index of the output. |
| External ID | The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 833. |

## Outputs

Most tools provide measurements, geometric features, or data as outputs.




*Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID*

You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

*Measurements*

| Measurement |
| --- |
| **Output {n}**<br>Output from the Python script, where {n} is the index of the output. The number of outputs and the type of each output is determined by the **Number of outputs** and **Output type {n}** parameters, respectively. |

## Functions and Classes

### Getting Input

The following Python functions are available for performing input operations and testing input validity.

The index of the input is given as an argument. If the input at the index is missing or it is the wrong type, None is returned. Functions will return an array if input is an array.

For information on the returned types, see *Data Structures* on page 711.

*Input Functions*

| Function | Description |
| --- | --- |
| is_valid(obj) | Checks whether the object is valid or not.<br>*Parameters* |

| Function | Description |
| --- | --- |
| | **obj**: Input message.<br>*Returns*<br>True if valid. |
| get_surface(index) | Gets a surface message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>SurfaceMsg, array of SurfaceMsg, or None. |
| get_profile(index) | Gets a profile message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>ProfileMsg, array of ProfileMsg, or None. |
| get_measurement(index) | Gets a measurement message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>MeasureMsg, array of MeasureMsg, or None. |
| get_point(index) | Gets a point message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>PointFeatureMsg, array of PointFeatureMsg, or None. |
| get_circle(index) | Gets a circle message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>CircleFeatureMsg, array of CircleFeatureMsg, or None. |
| get_plane(index) | Gets a plane message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>PlaneFeatureMsg, array of PlaneFeatureMsg, or None. |
| get_line(index) | Gets a line message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index.<br>*Returns*<br>LineFeatureMsg, array of LineFeatureMsg, or None. |
| get_image(index) | Gets an image message or array of messages from the specified input.<br>*Parameters*<br>**index**: Input index. |

| Function | Description |
|---|---|
| | *Returns*<br>ImageMsg, array of ImageMsg, or None. |

**Sending Output**

The following Python functions are available for performing output operations.

The index of the output is given as an argument.

For information on the output types, see *Data Structures* on page 711.

*Output Functions*

| Function | Description |
|---|---|
| is_output_enabled(index) | Checks whether the output at the specified index is enabled.<br>*Parameters*<br>**index**: Output index.<br>*Returns*<br>True if the output is enabled. |
| send_surface(index, offset, scale, points, intensity=None, is_adjacent=None, header=None) | Sends a surface message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**offset**: Offset of the data or array of offsets.<br>**scale**: Scale of the data or array of scales.<br>**points**: Surface points data or array points data. Points for uniform data are in an array of size (height, width). Points for point cloud (non-uniform) data are in an array of size (height, width, 3).<br>**intensity**: Surface intensity data of size (height, width), or array of intensity data.<br>**is_adjacent**: Set to true if the surface data is adjacent. Can also be an array of adjacent info.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_profile(index, offset, scale, points, intensity=None, slices=None, header=None) | Sends a profile message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**offset**: Offset of the data or array of offsets.<br>**scale**: Scale of the data or array of scales.<br>**points**: Profile point data or array of profile points. Data is in array of size (width) or (width,2).<br>**intensity**: Profile intensity data of size (width), or array of profile intensities.<br>**slices**: Not used.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_measurement(index, value, label_ | Sends a measurement message or array of messages to the specified output. Note that the decision can't be set with this function because the decision of a |

| Function | Description |
| --- | --- |
| position=None, header=None) | measurement is only set after output using the Min and Max thresholds on the outputs.<br>*Parameters*<br>**index**: Output index.<br>**value**: Value of the data message, or array of values. Numpy.nan if measurement is invalid.<br>**label_position**: Position of point in measurement message, or array of positions.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_point(index, position, header=None) | Sends a point message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**position**: Position of feature point in data message, or array of positions.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_line(index, position, direction, header=None) | Sends a line message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**position**: Point vector in the line, or array of point vectors.<br>**direction**: Direction vector of the line, or array of direction vectors.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_circle(index, position, normal, radius, header=None) | Sends a circle message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**position**: Center position of the circle, or array of center positions.<br>**normal**: Normal vector of the circular plane, or array of normal vectors.<br>**radius**: Radius of the circle, or array of radii.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_plane(index, normal, origin_distance, header=None) | Sends a plane message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index.<br>**normal**: Normal vector of the plane, or array of normal vectors.<br>**origin_distance**: Shortest distance from origin to plane, or array of distances.<br>**header**: Header part of the data message. Uses header from the first input if not set. |
| send_image(index, pixels, pixel_format= PixelFormat.MONO_8, | Sends an image message or array of messages to the specified output.<br>*Parameters*<br>**index**: Output index. |

| Function | Description |
|---|---|
| flipped_x=False, flipped_y=False, transposed=False, header=None) | **pixels**: Pixel data of image of size (height, width, pixel size), or array of image pixels.<br>**pixel_format**: Pixel format of the image, or array of pixel formats. For more information, see *PixelFormat* on page 714.<br>**flipped_x**: Set to `true` if the image data is flipped on the X axis, or array of flags.<br>**flipped_y**: Set to `true` if the image data is flipped on the Y axis, or array of flags.<br>**transposed**: Set to `true` if the image data is transposed, or array of flags.<br>**header**: Header part of the data message. Uses header from the first input if not set. |

**Logging**

Logging a message causes GoPxL to add a message to the log at the bottom of the user interface. There are three types of log messages.

*Logging Functions*

| Function | Description |
|---|---|
| log_info(msg) | Logs a user informational message.<br>*Parameters*<br>**msg**: Message to be logged. |
| log_warning(msg) | Logs a user warning message.<br>*Parameters*<br>**msg**: Message to be logged. |
| log_error(msg) | Logs a user error message and displays a pop-up containing the message.<br>*Parameters*<br>**msg**: Message to be logged. |

**Memory**

You can use a Script tool's `memory` dictionary for storing values during runtime. The dictionary is erased when scanning starts.

**Data Structures**

*Data Structures*

| Function | Description |
|---|---|
| Region | 2D Region box (center-based).<br>*Constructor*<br>Region(x=None, z=None, width=None, height=None)<br>*Parameters*<br>**x**: X position of the center of the region.<br>**z**: Z position of the center of the region.<br>**width**: Width of the region.<br>**height**: Height of the region. |

| Function | Description |
|---|---|
| Region3d | 3D Region box (center-based).<br>*Constructor*<br>Region3d(x=None, y=None, z=None, width=None, length=None, height=None, z_angle=None)<br>*Parameters*<br>**x**: X position of the center of the region.<br>**y**: Y position of the center of the region.<br>**z**: Z position of the center of the region.<br>**width**: Width of the region.<br>**height**: Height of the region.<br>**length**: Length of the region.<br>**z_angle**: Z Angle of the region. |
| Rect3d | 3D rectangular region box.<br>*Constructor*<br>Rect3d(x=None, y=None, z=None, width=None, height=None, depth=None)<br>*Parameters*<br>**x**: X position of the center of the region.<br>**y**: Y position of the center of the region.<br>**z**: Z position of the center of the region.<br>**width**: Width of the region.<br>**height**: Height of the region.<br>**depth**: Depth of the region. |
| Anchor3d | 3D anchor (center-based).<br>*Constructor*<br>Anchor3d(x=None, y=None, z=None, z_angle=None)<br>*Parameters*<br>**x**: X position of the anchor.<br>**y**: Y position of the anchor.<br>**z**: Z position of the anchor.<br>**z_angle**: Z Angle of the anchor. |
| Point | 2D Point class.<br>*Constructor*<br>Point(x=None, y=None)<br>*Parameters*<br>**x**: X position of the Point.<br>**y**: Y position of the Point. |
| Point3d | 3D Point class.<br>*Constructor*<br>Point3d(x=None, y=None, z=None)<br>*Parameters*<br>**x**: X position of the Point.<br>**y**: Y position of the Point.<br>**z**: Z position of the Point. |

| Function | Description |
|---|---|
| Stamp | Represents acquisition metadata associated with a data message. Note that `width`, `height`, `x`, and `y` parameters refer to the dimensions of the camera image; for more information, see `points` in *SurfaceMsg* on page 715.<br>*Constructor*<br>Stamp(frame=None, time=None, signature=None, status=None, state=None, tag=None, encoder=None, encoder_snapshot=None, exposure=None, delay=None, width=None, height=None, y=None, x=None, x_subsampling=None, y_subsampling=None, temperature=None, subframe=None, reserved=None)<br>*Parameters*<br>**signature**: Equal to `kSTAMP_SIGNATURE` for camera messages; otherwise unused.<br>**status**: Digital inputs, gate state, and other information at the time of message capture.<br>**state**: Camera state id associated with message.<br>**tag**: Optional tag that can be used for debugging or other special purposes.<br>**frame**: Frame index of message data (counts up from zero).<br>**time**: Timestamp corresponding to message data (µs).<br>**encoder**: Encoder value corresponding to message data (encoder ticks).<br>**encoderSnapshot**: Encoder value at time of most recent encoder snapshot signal (encoder ticks).<br>**exposure**: Source image exposure (ns).<br>**delay**: Delay before exposure (ns).<br>**width**: Source camera image width, before subsampling.<br>**height**: Source camera image height, before subsampling.<br>**y**: Source camera image Y position.<br>**x**: Source camera image X position.<br>**x_subsampling**: X subsampling amount, expressed as power of 2.<br>**y_subsampling**: Y subsampling amount, expressed as power of 2.<br>**temperature**: Temperature corresponding to message data (centidegrees Celsius).<br>**subframe**: Subframe status information.<br>**reserved**: Reserved for future use. |
| Transform3d | 3D transform matrix.<br>*Constructor*<br>Transform3d(xx, xy, xz, xt, yx, yy, yz, yt, zx, zy, zz, zt)<br>*Parameters*<br>**xx**, **xy**, **xz**, **xt**: X vector (first three) and origin.<br>**yx**, **yy**, **yz**: Y vector and origin.<br>**zx**, **zy**, **zz**: Z vector and origin. |
| MsgHeader | Header class of data message.<br>*Constructor*<br>MsgHeader(stamp=None, transform=None, bounding_box=None)<br>*Parameters* |

| Function | Description |
| --- | --- |
| | **stamp**: Data stamp.<br>**transform**: Transform matrix.<br>**bounding_box**: Bounding box for the data. |
| PixelFormat | Enum class of pixel formats for image data message.<br><br>**Mono formats**<br>MONO_8 = <PixelFormat.MONO_8: 0x0001><br>MONO_10 = <PixelFormat.MONO_10: 0x0003><br>MONO_12 = <PixelFormat.MONO_12: 0x0005><br>MONO_14 = <PixelFormat.MONO_14: 0x0025><br>MONO_16 = <PixelFormat.MONO_16: 0x0007><br><br>**RGB formats**<br>RGB_8 = <PixelFormat.RGB_8: 0x0014><br>BGR_8 = <PixelFormat.BGR_8: 0x0015><br>RGB_10 = <PixelFormat.RGB_10: 0x0018><br>BGR_10 = <PixelFormat.BGR_10: 0x0019><br>RGB_12 = <PixelFormat.RGB_12: 0x001A><br>BGR_12 = <PixelFormat.BGR_12: 0x001B><br>RGB_14 = <PixelFormat.RGB_14: 0x005E><br>BGR_14 = <PixelFormat.BGR_14: 0x004A><br>RGB_16 = <PixelFormat.RGB_16: 0x0033><br>BGR_16 = <PixelFormat.BGR_16: 0x004B><br><br>**YUV/YCBR formats**<br>Y_CB_CR_8_CB_Y_CR = <PixelFormat.Y_CB_CR_8_CB_Y_CR: 0x003A><br>Y_CB_CR_411_8_CB_YY_CR_YY = <PixelFormat.Y_CB_CR_411_8_CB_YY_CR_YY: 0x003C><br>Y_CB_CR_422_8_CB_Y_CR_Y = <PixelFormat.Y_CB_CR_422_8_CB_Y_CR_Y: 0x0043><br><br>**Bayer formats**<br>BAYER_GR8 = <PixelFormat.BAYER_GR8: 0x0008><br>BAYER_RG8 = <PixelFormat.BAYER_RG8: 0x0009><br>BAYER_GB8 = <PixelFormat.BAYER_GB8: 0x000A><br>BAYER_BG8 = <PixelFormat.BAYER_BG8: 0x000B><br>BAYER_GR10 = <PixelFormat.BAYER_GR10: 0x000C><br>BAYER_RG10 = <PixelFormat.BAYER_RG10: 0x000D> |

| Function | Description |
|---|---|
| | BAYER_GB10 = <PixelFormat.BAYER_GB10: 0x000E><br>BAYER_BG10 = <PixelFormat.BAYER_BG10: 0x000F> |
| ImageMsg | ImageMsg class for image data message.<br>*Constructor*<br>ImageMsg(header=None, pixel_format=None, flipped_x=False, flipped_y=False, transposed=False, pixels=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**pixel_format**: Pixel format of the image. For more information, see *PixelFormat* on the previous page.<br>**flipped_x**: Set to `true` if the image data is flipped on the X axis.<br>**flipped_y**: Set to `true` if the image data is flipped on the Y axis.<br>**transposed**: Set to `true` if the image data is transposed.<br>**pixels**: Pixel data of image of size (height, width, pixel size). |
| SurfaceMsg | SurfaceMsg class for surface data message.<br>*Constructor*<br>SurfaceMsg( header=None, offset=None, scale=None, points=None, intensity=None, is_adjacent=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**offset**: Offset of the data.<br>**scale**: Scale of the data.<br>**points**: Surface point data of size (height, width) or (height,width,3).<br>**intensity**: Surface intensity data of size (height, width).<br>**is_adjacent**: Set to `true` if the surface data is adjacent. |
| ProfileMsg | ProfileMsg class for profile data message.<br>*Constructor*<br>ProfileMsg(header=None, offset=None, scale=None, points=None, intensity=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**offset**: Offset of the data.<br>**scale**: Scale of the data (with x and z). This is the spacing between points.<br>**points**: Profile point data of size (width) or (width,2) .<br>**intensity**: Profile intensity data of size (width). |
| MeasureMsg | MeasureMsg Class for measurement data message.<br>*Constructor*<br>MeasureMsg(header=None, value=None, status=None, label_position=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**value**: Value of the data message.<br>**status**: Types from the MeasurementDecision enum class. For more |

| Function | Description |
|---|---|
| | information, see *MeasurementDecision* below.<br>**label_position**: Position of point in measurement message. |
| MeasurementDecision | Enum class of decision type for measurement data message.<br><br>FAIL= <MeasurementDecision.FAIL: 0><br>PASS= <MeasurementDecision.PASS: 1> |
| PointFeatureMsg | PoinFeaturetMsg class for point feature message.<br>*Constructor*<br>PointFeatureMsg(header=None, position=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**position**: Position of feature point in data message. |
| LineFeatureMsg | LineFeatureMsg class for line feature message.<br>*Constructor*<br>LineFeatureMsg(header=None, position=None, direction=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**position**: Point vector in the line.<br>**direction**: Direction vector of the line. |
| CircleFeatureMsg | CircleFeatureMsg class for circular feature message.<br>*Constructor*<br>CircleFeatureMsg(header=None, position=None, normal=None, radius=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**position**: Center position of the circle.<br>**normal**: Normal vector of the circular plane.<br>**radius**: Radius of the circle. |
| PlaneFeatureMsg | PlaneFeatureMsg class for planar feature message.<br>*Constructor*<br>PlaneFeatureMsg(header=None, normal=None, origin_distance=None)<br>*Parameters*<br>**header**: Header part of the data message.<br>**normal**: Normal vector of the plane.<br>**origin_distance**: Shortest distance from origin to plane. |

## Examples

### Measurement input and output

The following example shows how to read a measurement value input and output a new measurement value that is equal to the input multiplied by a factor of two.

```
# Get the measurement object at input 0
measurement = get_measurement(0)

# Extract the value from the measurement
measurement_value = measurement.value

# Calculate a new measurement value
measurement_output = 2 * measurement_value

# Send the calculated value as a new measurement to output 0
send_measurement(0, measurement_output)
```

The following example shows how to read measurement value inputs and write them to a CSV file. (This example is only intended for use on a PC instance of GoPxL, as writing to files on-sensor or on a GoMax device is blocked.)

```
import csv

# Get measurement objects
measurement_1 = get_measurement(0)
measurement_2 = get_measurement(1)

# Extract values from measurement objects
measurement_1_value = measurement_1.value
measurement_2_value = measurement_2.value

# Path to the output CSV file
output_path = r'C:\GoTools\Script\measurement.csv'

# Write measurements to CSV file
with open(output_path, 'a') as f:
    writer = csv.writer(f)
    writer.writerow([measurement_1_value, measurement_2_value])
```

### Math operations

You can access mathematical operations through the standard Python math module.

```
# Import the math module to access mathematical functions
import math

# Get the measurement object at input 0
measurement = get_measurement(0)

# Extract the value from the measurement
measurement_value = measurement.value

# Calculate the square root of the absolute value using the Math module
sqrt_value = math.sqrt(math.fabs(measurement_value))

# Send the square root as a new measurement to output 0
send_measurement(0, sqrt_value)
```

### Accessing valid/invalid and decision pass/fail

You can use the `is_valid()` function of the `MeasureMsg` class to check whether the value is valid or invalid. An invalid measurement is represented by the value `numpy.nan`. Other input classes also have `is_valid()` functions, which return `true` if the object data is not null.

The pass/fail criteria for the input `MeasureMsg` can be checked using the `decision` member variable.

```
# Check if any inputs are invalid
if any_input_invalid():
    send_all_invalid()

# Get the input measurement
measurement0 = get_measurement(0)

# Access validity from a measurement
if is_valid(measurement0):
    log_info("The input measurement is Valid")
else:
    log_info("The input measurement is Invalid")

# Access decision from a measurement
if measurement0.decision == MeasurementDecision.PASS:
    log_info("The input measurement has a Pass decision")
else:
    log_info("The input measurement has a Failed decision")
```

### Smoothing / moving average of measurement values

This script shows how to use the memory feature to implement a smoothing filter / moving average of measurement values. Values from each frame are stored in the memory and with each new frame the oldest item is removed from memory before calculating the average.

```
import numpy as np

measurement_1 = get_measurement(0)
new_value = measurement_1.value
#log_info(f'Measurement values: {new_value}')

class MovingAverage:
    def __init__(self, window_size=10):
        self.window_size = window_size

    def add_value(self, value):
        memory.setdefault("Values", []).append(value)
        if len(memory["Values"]) > self.window_size:
            memory["Values"].pop(0)
        return self.calculate_average()

    def calculate_average(self):
```

```
        if len(memory["Values"]) == 0:
            return np.nan  # if no value present
        return np.mean(memory["Values"])

moving_avg = MovingAverage(window_size=10)
avg = moving_avg.add_value(new_value)
# log_info(f'Avg: {avg}')

send_measurement(0, avg)
```

### Stamp access

```
profile = get_profile(0)

stamp = profile.header.stamp

log_info('Stamp = {}'.format(vars(stamp)))

send_measurement(0, stamp.frame)
send_measurement(1, stamp.time)
send_measurement(2, stamp.encoder)
```

### Arrays

The following code reads an array input and outputs an array.

```
# Get an array of measurement objects at input 0
measurements = get_measurement(0)

# Extract the values from each measurement object
measurement_values = []
for measurement in measurements:
    measurement_values.append(measurement.value)

# Calculate new values
measurements_output = [value * 2 for value in measurement_values]

# Send the calculated values as an array to output 0
send_measurement(0, measurements_output)
```

### Inverting a Surface in Z with null handling

The following code inverts a Surface in Z with null handling. It also shifts the output Surface in X by the bounding box width in order to not overlap the original.

```
surf = get_surface(0)
```

```
flipped_points = surf.points.copy()
flipped_offset = surf.offset

flipped_points[flipped_points != -32768] *= -1
flipped_offset.x += surf.header.bounding_box.width

send_surface(0, flipped_offset, surf.scale, flipped_points, surf.intensity)
```

### Combining two point cloud surfaces into a single message

```
s0 = get_surface(0)
s1 = get_surface(1)

if s0.scale.x != s1.scale.x or s0.scale.y != s1.scale.y or s0.scale.z != s1.scale.z or
s0.offset.x != s1.offset.x or s0.offset.y != s1.offset.y or s0.offset.z != s1.offset.z:
    log_error("The input surfaces are not using the same resolution and offset. Cannot
concatenate.")
    log_info(f"Scale0 = {vars(s0.scale)}")
    log_info(f"Scale1 = {vars(s1.scale)}")

    log_info(f"Offset0 = {vars(s0.offset)}")
    log_info(f"Offset1 ={vars(s1.offset)}")

    return

points_final = numpy.concatenate((s0.points, s1.points))
intensity_final = numpy.concatenate((s0.intensity, s1.intensity))

send_surface(0, s0.offset, s0.scale, points_final, intensity_final, is_adjacent = False)
# Set is_adjacent to True to visualize polygons and intensity
```

```
s0 = get_surface(0)
s1 = get_surface(1)

if s0.scale.x != s1.scale.x \
    or s0.scale.y != s1.scale.y \
    or s0.scale.z != s1.scale.z \
    or s0.offset.x != s1.offset.x \
    or s0.offset.y != s1.offset.y \
    or s0.offset.z != s1.offset.z:

    log_error("The input surfaces do not use the same resolution and offset. Cannot
concatenate.")
    log_info(f"Scale0 = {vars(s0.scale)}")
    log_info(f"Scale1 = {vars(s1.scale)}")

    log_info(f"Offset0 = {vars(s0.offset)}")
    log_info(f"Offset1 ={vars(s1.offset)}")

    return

points_final = numpy.concatenate((s0.points, s1.points))
intensity_final = numpy.concatenate((s0.intensity, s1.intensity))
```

```
send_surface(0, s0.offset, s0.scale, points_final, intensity_final, is_adjacent = False)
# Set is_adjacent to True to visualize polygons and intensity
```

### Surface Transform based on Plane

```
surface_obj = get_surface(0)
plane_obj = get_plane(1)
int_surface_points = surface_obj.points
intensity_data = surface_obj.intensity

# Store original shape and reshape for processing
original_shape = int_surface_points.shape
num_points = original_shape[0] * original_shape[1]
points_reshaped = int_surface_points.reshape((num_points, 3))

# Convert 3DPoint objects to numpy arrays for calculations
scale = numpy.array([surface_obj.scale.x, surface_obj.scale.y, surface_obj.scale.z])
offset = numpy.array([surface_obj.offset.x, surface_obj.offset.y, surface_obj.offset.z])
normal_vec = numpy.array([plane_obj.normal.x, plane_obj.normal.y, plane_obj.normal.z])

# Convert integer surface to floating-point "world space"
float_surface_points = points_reshaped.astype(float) * scale + offset

# Normalize the normal vector
norm_of_normal = numpy.linalg.norm(normal_vec)
if norm_of_normal == 0:
    raise ValueError("The normal vector cannot be a zero vector.")
unit_normal = normal_vec / norm_of_normal

# Find the center of the object
center_point = float_surface_points.mean(axis=0)
# Find a point on the plane to establish a reference
point_on_plane = plane_obj.origin_distance * unit_normal

# Determine if the normal points towards or away from the center
vec_to_center = center_point - point_on_plane
if numpy.dot(vec_to_center, unit_normal) > 0:
    # The normal points towards the center of the object. We flip it to get the
    # "outward" normal, ensuring the plane is consistently treated as the "top".
    unit_normal = -unit_normal

# Define the target vector
down_vector = numpy.array([0.0, 0.0, -1.0])

# Calculate the rotation matrix to align the normal with the down_vector
rotation_axis = numpy.cross(unit_normal, down_vector)
cos_angle = numpy.dot(unit_normal, down_vector)

if numpy.allclose(cos_angle, 1.0):
    rotation_matrix = numpy.identity(3)
elif numpy.allclose(cos_angle, -1.0):
    perp_axis = numpy.array([1.0, 0.0, 0.0])
    if numpy.allclose(numpy.abs(numpy.dot(unit_normal, perp_axis)), 1.0):
        perp_axis = numpy.array([0.0, 1.0, 0.0])
    u = perp_axis / numpy.linalg.norm(perp_axis)
    rotation_matrix = 2 * numpy.outer(u, u) - numpy.identity(3)
```

```
else:
    # shortcut to the sin between the vectors (based on cross product definition)
    sin_angle = numpy.linalg.norm(rotation_axis)
    rotation_axis /= sin_angle
    K = numpy.array([[0, -rotation_axis[2], rotation_axis[1]],
                     [rotation_axis[2], 0, -rotation_axis[0]],
                     [-rotation_axis[1], rotation_axis[0], 0]])
    rotation_matrix = numpy.identity(3) + sin_angle * K + (1 - cos_angle) * (K @ K)

# Create the full 4x4 homogeneous transformation matrix for rotation only
translation_to_origin = numpy.identity(4)
translation_to_origin[:3, 3] = -center_point
rotation_4x4 = numpy.identity(4)
rotation_4x4[:3, :3] = rotation_matrix
translation_back = numpy.identity(4)
translation_back[:3, 3] = center_point
transformation_matrix = translation_back @ rotation_4x4 @ translation_to_origin

homogeneous_surface = numpy.hstack([float_surface_points, numpy.ones((num_points, 1))])
transformed_homogeneous = (transformation_matrix @ homogeneous_surface.T).T
transformed_float_surface = transformed_homogeneous[:, :3]

# Calculate a new offset to prevent overflow
min_coords = transformed_float_surface.min(axis=0)
```

### Minimum and maximum Z value of a uniform Surface with null handling

```
surf = get_surface(0)

s = surf.points[surf.points != -32768]

max_z = numpy.max(s) * surf.scale.z + surf.offset.z
min_z = numpy.min(s) * surf.scale.z + surf.offset.z

send_measurement(0, min_z)
send_measurement(1, max_z)
```

### Exporting a surface as a PCD file

```
import numpy as np


filename = "outsurface.pcd"
msg = get_surface(0)
height_map = msg.points
intensity_map = msg.intensity
scale = msg.scale
```

```
rows, cols = height_map.shape


# Prepare the header for the PCD file
header = (
    "# .PCD v0.7 - Point Cloud Data file format\n"
    "VERSION 0.7\n"
    "FIELDS x y z intensity\n"
    "SIZE 4 4 4 4\n"
    "TYPE F F F F\n"
    "COUNT 1 1 1 1\n"
    f"WIDTH {cols}\n"
    f"HEIGHT {rows}\n"
    "VIEWPOINT 0 0 0 1 0 0 0\n"
    f"POINTS {rows * cols}\n"
    "DATA ascii\n"
)


# Write the header and points to the PCD file
with open(filename, 'w') as file:
    file.write(header)
    for i in range(rows):
        for j in range(cols):
            x = i * scale.x
            y = j * scale.y
            z = height_map[i, j] * scale.z if height_map[i, j] != -32768 else 0
            intensity = intensity_map[i, j] if height_map[i, j] != -32768 else 0
            file.write(f"{x} {y} {z} {intensity}\n")


log_info(f"PCD file saved successfully as {filename}")
```

### Grid of coordinates for anchoring

The following script shows how you can perform the same inspection using a single tool at many locations on a grid. It generates X and Y measurement arrays that you use as anchor inputs in another tool (the anchored tool).

In the anchored tool, you must check **Enable batching** so that the tool generates an array of outputs.

```
x = numpy.linspace(-15, 15, 10) # 10 points spanning 0..30 mm range
y = numpy.linspace(-15, 15, 10) # 10 points spanning 0..30 mm range

xv, yv = numpy.meshgrid(x, y)

send_measurement(0, xv.flatten())
send_measurement(1, yv.flatten())
```

### Image processing (subtracting two images)

```
im0 = get_image(0)
im1 = get_image(1)

delta = im0.pixels.astype(numpy.float32) - im1.pixels.astype(numpy.float32)
stdev = numpy.std(delta)

new_pixels = numpy.clip(delta / (2*stdev) * 128 + 128, 0, 255).astype(numpy.uint8)

send_image(0, new_pixels, PixelFormat.RGB_8)
send_measurement(1, stdev)
```

### Image Processing (Subtracting two images and normalizing the result)

```
im0 = get_image(0)
im1 = get_image(1)

delta = im0.pixels.astype(numpy.float32) - im1.pixels.astype(numpy.float32)
stdev = numpy.std(delta)

new_pixels = numpy.clip(delta / (2*stdev) * 128 + 128, 0, 255).astype(numpy.uint8)

send_image(0, new_pixels, PixelFormat.RGB_8)
send_measurement(1, stdev)
```

### Image processing (forward to HTTP server)

```
# Script (using built in urlib package)
import urllib.request
import json
import numpy as np

# Assuming get_image(0).pixels returns a numpy array
array = get_image(0).pixels
array_bytes = array.tobytes()

# Encode shape information as JSON in the headers
headers = {'Content-Type': 'application/octet-stream', 'X-Array-Shape': json.dumps
(array.shape)}
url = 'http://127.0.0.1:5000/receive_array'

# Encode array bytes data and prepare request
req = urllib.request.Request(url, data=array_bytes, headers=headers)
urllib.request.urlopen(req)


# SERVER (server.py)

from flask import Flask, request, Response
import numpy as np
```

```
import cv2
import json

app = Flask(__name__)

@app.route('/receive_array', methods=['POST'])
def receive_array():
    # Get the content of the request
    data = request.data

    # Extract shape information from headers
    shape_info = json.loads(request.headers.get('X-Array-Shape'))
    height, width, channels = shape_info

    # Extract image bytes
    image_array = np.frombuffer(data, dtype=np.uint8)
    image_array = image_array.reshape((height, width, channels))

    # Display image
    #cv2.imshow('Received Image', image_array)
    #cv2.waitKey(0)
    #cv2.destroyAllWindows()

    # Print size of received image
    print("Received image size:", image_array.shape)

    return Response(status=200)

if __name__ == '__main__':
    app.run(debug=False, threaded=True, port=5000)
```

The following is a sample client to demonstrate the functionality of the HTTP server forwarding snippet above.

```
# SAMPLE CONSOLE CLIENT (client.py)
# A standalone demonstration of the functionality used by the image HTTP
# forwarding script.

import requests
import numpy as np
import json

# Assuming you have a function to generate numpy arrays as images
def generate_numpy_array():
    # Generating a sample numpy array
    array = np.random.rand(100, 100, 3) * 255  # Random 100x100x3 array of floats between
0 and 255
    return array.astype(np.uint8)

def send_array_to_server(array):
    url = 'http://127.0.0.1:5000/receive_array'
    array_bytes = array.tobytes()

    # Encode shape information as JSON in the headers
    headers = {'Content-Type': 'application/octet-stream', 'Array-Shape': json.dumps
(array.shape)}
```

```
    response = requests.post(url, data=array_bytes, headers=headers)

# Generate and send arrays to the server
while True:
    array = generate_numpy_array()
    send_array_to_server(array)
```

### Image Processing - Warp an image based on four corners

```
import cv2
import numpy as np

def warp_image_to_rectangle(image: np.ndarray, src_corners: np.ndarray, output_size:
tuple) -> np.ndarray:
    """
    Resample an image to a rectangle based on four corner points.

    :param image: Input image as a NumPy array.
    :param src_corners: Source corner points as a (4, 2) NumPy array (float32).
    :param output_size: Desired output size (width, height).
    :return: Warped and resampled image.
    """
    if src_corners.shape != (4, 2):
        raise ValueError("src_corners must be a (4, 2) array of corner points.")

    width, height = output_size

    # Define destination rectangle corners
    dst_corners = np.array([
        [0, 0],
        [width - 1, 0],
        [width - 1, height - 1],
        [0, height - 1]
    ], dtype=np.float32)

    # Compute perspective transform matrix
    matrix = cv2.getPerspectiveTransform(src_corners.astype(np.float32), dst_corners)

    # Warp the image
    warped = cv2.warpPerspective(image, matrix, (width, height), flags=cv2.INTER_LINEAR)

    return warped

if any_input_invalid():
    send_all_invalid()
    return

image = get_image(0).pixels
c0 = get_point(1).position
c1 = get_point(2).position
c2 = get_point(3).position
c3 = get_point(4).position

src_corners = np.array([
```

```
    [c0.x, c0.y],
    [c1.x, c1.y],
    [c2.x, c2.y],
    [c3.x, c3.y]
], dtype=np.float32)

output_size = (800, 400)
result = warp_image_to_rectangle(image, src_corners, output_size)
result = result.reshape((output_size[1], output_size[0], 1))

send_image(0, result, PixelFormat.MONO_8)
```

### Profile processing (using a profile from disk as a correction to new profiles from sensor)

```
# Save profile template to disk
import csv

profile = get_profile(0)
points = profile.points

template_path = r'C:\GoTools\Script\profile.csv'
numpy.savetxt(template_path, points, delimiter=',', fmt='%d')

send_measurement(0, 1)

# Load and correct
import csv

profile = get_profile(0)
points = profile.points

# load template
template_path = r'C:\GoTools\Script\profile_template.csv'

if 'template' not in memory:
    template_points = numpy.genfromtxt(template_path, delimiter=',', dtype=numpy.int16)
    memory['template'] = template_points
    log_info("Loaded template")
else:
    template_points = memory['template']

# subtract while handling null values
mask = (template_points != -32768) & (points != -32768)
result = numpy.full_like(points, -32768)
numpy.subtract(points, template_points, out=result, where=mask, dtype=numpy.int16)

send_profile(0, profile.offset, profile.scale, result)

# optionally send original profile and template as outputs
send_profile(1, profile.offset, profile.scale, points)
send_profile(2, profile.offset, profile.scale, template_points)

# optionally save all three into a new CSV file

output_path = r'C:\GoTools\Script\profile_log.csv'
```

```
combined_array = numpy.vstack((points, template_points, result)).T

with open(output_path, 'w', newline='') as csv_file:
    writer = csv.writer(csv_file)
    writer.writerow(['Profile', 'Template', 'Difference'])
    writer.writerows(combined_array)
```

### Getting function signatures

Instead of looking up functions in the manual to see arguments to be passed in, you can use the `signature` function in the `inspect` module to get the signature of any function. For example, the code below displays an error message: (`index, value, label_position=None, header=None`).

```
from inspect import signature

log_error(str(signature(send_measurement)))
```

### FTP - Writing surface data to disk, and sending it to an FTP server

This sample was tested with Rebex Tiny FTP server.

```
import os
import struct
import zlib
from datetime import datetime
from ftplib import FTP
import numpy as np
import time

# FTP Configuration
FTP_HOST = '192.168.1.200'       # CHANGE THIS TO THE FTP HOSTNAME OR IP ADDRESS
FTP_USER = 'tester'              # Default User for Rebex Tiny FTP
FTP_PASS = 'password'            # Default Password for Rebex Tiny FTP

try:
    # Get the surface data
    surface = get_surface(0)

    # Convert surface points to numpy array (height data)
    height_data = np.array(surface.points)

    # Intensity data (already in the 0-255 range, so no normalization needed)
    intensity_data = np.array(surface.intensity)

    # Normalize height data to 0-255, handle NaNs, and convert to uint8
    def normalize(data):
        return np.nan_to_num(((data - np.nanmin(data)) / (np.nanmax(data) - np.nanmin
(data) + 1e-8)) * 255).astype(np.uint8)

    # Correct orientation (flip vertically and transpose)
```

```
    def correct_orientation(arr):
        return np.flipud(arr.T)

    # Normalize and correct the orientation for height data
    height_img = correct_orientation(normalize(height_data))

    # Intensity data is already in the range 0-255, just ensure it is uint8
    intensity_img = correct_orientation(intensity_data.astype(np.uint8))

    # Write the PNG image to the specified path
    def write_png(path, image):
        try:
            if image.size == 0:
                log_info("Image is empty. Skipping write.")
                return

            # Helper function to create PNG chunks
            def chunk(typ, dat):
                return struct.pack('>I', len(dat)) + typ + dat + struct.pack('>I',
zlib.crc32(typ + dat) & 0xffffffff)

            # Open the file and write the PNG data
            with open(path, 'wb') as f:
                f.write(b'\x89PNG\r\n\x1a\n')
                f.write(chunk(b'IHDR', struct.pack(">IIBBBBB", image.shape[1], image.shape
[0], 8, 0, 0, 0, 0)))  # Write header chunk
                raw = b''.join([b'\x00' + image[i].tobytes() for i in range(image.shape
[0])])  # Write pixel data
                f.write(chunk(b'IDAT', zlib.compress(raw)))  # Write compressed image data
                f.write(chunk(b'IEND', b''))  # End of PNG file
                f.flush()  # Ensure data is written
                os.fsync(f.fileno())  # Sync the file to disk

        except Exception as e:
            log_info(f"Exception in write_png: {e}")

    # Define output directory and file paths for saving images
    output_dir = r'C:\Temp'  # Use a simpler directory for testing
    os.makedirs(output_dir, exist_ok=True)  # Create the output directory if it doesn't
exist
    timestamp = datetime.now().strftime('%Y%m%d_%H%M%S')
    path_height = os.path.join(output_dir, f"{timestamp}_height.png")
    path_intensity = os.path.join(output_dir, f"{timestamp}_intensity.png")

    # Write the height and intensity images to files
    try:
        write_png(path_height, height_img)
        log_info(f"Height image written: {path_height}")
    except Exception as e:
        log_info(f"Error writing height image: {e}")

    try:
        write_png(path_intensity, intensity_img)
        log_info(f"Intensity image written: {path_intensity}")
    except Exception as e:
        log_info(f"Error writing intensity image: {e}")

    # Function to wait for file size to stabilize before proceeding with upload
    def wait_for_file_stability(path, check_interval=0.1, max_wait_time=2):
```

```
        last_size = -1
        start_time = time.time()

        # Continuously check if the file size has stabilized within the given timeout
        while time.time() - start_time < max_wait_time:
            try:
                current_size = os.path.getsize(path)
                if current_size == last_size:
                    # If file size is stable, exit the loop
                    return True
                last_size = current_size
                time.sleep(check_interval)  # Sleep for a very short interval before
checking again
            except FileNotFoundError:
                pass  # Ignore if the file doesn't exist yet
        return False

    # FTP upload function to send files
    def upload(path):
        try:
            with FTP(FTP_HOST) as ftp:
                ftp.login(FTP_USER, FTP_PASS)
                with open(path, 'rb') as f:
                    ftp.storbinary(f'STOR {os.path.basename(path)}', f)  # Upload the file
            return 1
        except Exception as e:
            log_info(f"FTP error: {e}")
            return 0

    # Upload both height and intensity images via FTP
    send_measurement(0, upload(path_height))
    send_measurement(1, upload(path_intensity))

except Exception as e:
    log_info(f"Error in processing surface data: {e}")
    send_measurement(0, 0)  # Indicate failure if an exception occurs during processing
```

### Moving Average Using Memory

```
import numpy as np


class MovingAverage:
    def __init__(self, window_size=10):
        self.window_size = window_size

    def add_value(self, value):

        # Add value if the 'Values' key is present else initialize with an empty list.
        memory.setdefault("Values", []).append(value)
        if len(memory["Values"]) > self.window_size:
            memory["Values"].pop(0)
        return self.calculate_average()

    def calculate_average(self):
```

```
        if not memory["Values"]:
            return np.nan
        return np.mean(memory["Values"])


# Get values
measurement = get_measurement(0)
measurement_value = measurement.value

# Process values
moving_avg = MovingAverage(window_size=10)
avg = moving_avg.add_value(measurement_value)

# Send values
send_measurement(0, measurement_value)
send_measurement(1, avg)
```

### Communicate with Another Sensor via ASCII Using Socket Programming

```
import socket

HOST = "192.168.1.10"
PORT = 8190

DELIMITER = ','
TERMINATION = '\r\n'  # Matches %r%n set by default in GoPxL > Ethernet ASCII page

START_COMMAND = f'start{TERMINATION}'
STOP_COMMAND = f'stop{TERMINATION}'
TRIGGER_COMMAND = f'trigger{TERMINATION}'
SYSTEM_STATE_COMMAND = f"readprop{DELIMITER}/system#/runState{TERMINATION}"

try:
    s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
    s.settimeout(15)
    s.connect((HOST, PORT))
    log_info(f"Connected to sensor at {HOST}:{PORT}")

    _ = s.send(SYSTEM_STATE_COMMAND.encode()) # Requires data to be sent in byte format
    response = s.recv(1024).decode().strip().split(',') # Receives up to 1024 bytes of
data from the socket connection
    log_info(f"Response received: {response}")

    if len(response) > 1 and response[0] == "OK":
        run_state = response[1]
        if run_state == "0": # If sensor is not running, first run then trigger
            _ = s.send(START_COMMAND.encode())
            _ = s.send(TRIGGER_COMMAND.encode())
        elif run_state == "1":
            _ = s.send(TRIGGER_COMMAND.encode())
        else:
            log_info(f"Unexpected system state: {run_state}")

except socket.timeout:
    log_error(f"Error: Operation timed out. ASCII is disabled or sensor is unreachable at
```

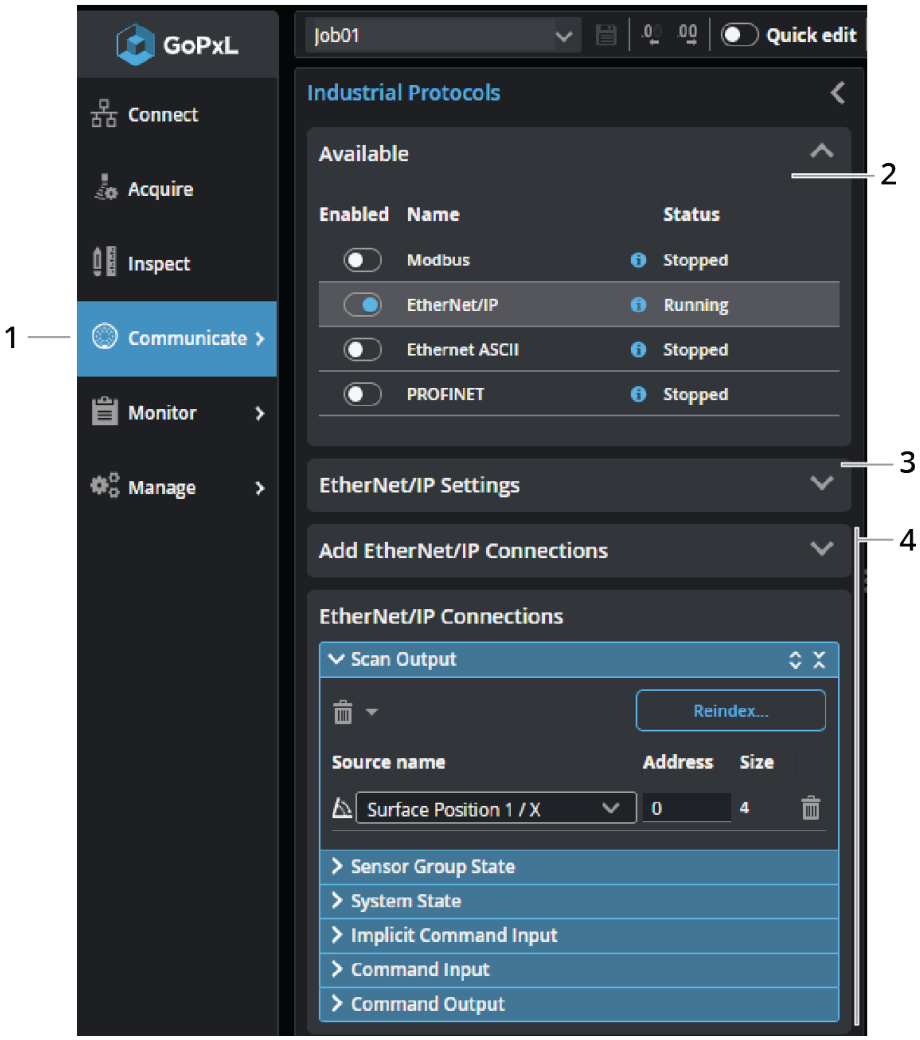
```
{HOST}:{PORT}.")
except Exception as e:
    log_error(f"An error occurred: {e}")
finally:
    s.close()
    log_info("Socket closed.")
```

## Communicate - PLC, Digital, GDP, HMI

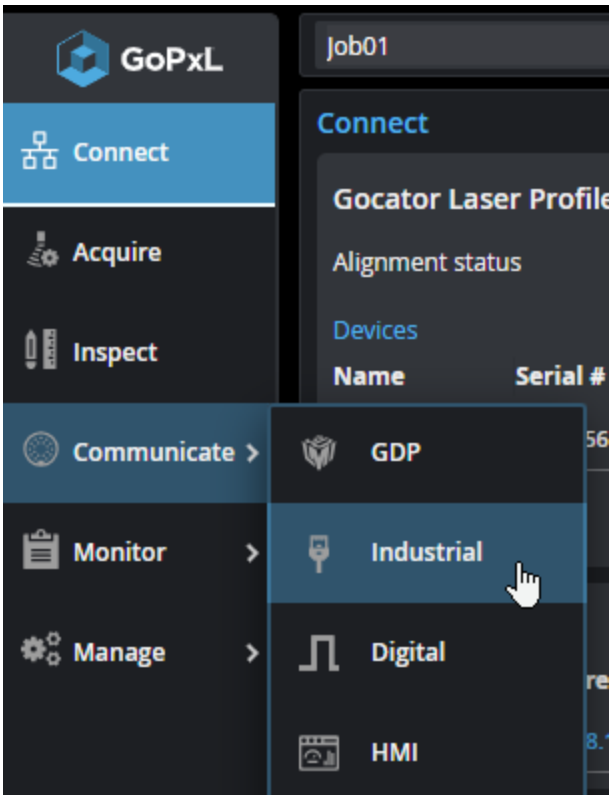
External devices such as PLCs (programmable logic controllers) can control Gocator sensors using various communication protocols and hardware interfaces. Sensors can also send scan data, measurement results, and measurement decisions to these devices. PLCs can in turn control other devices such as ejection chutes.

You can also use the GoPxL Data Protocol (GDP) with software written using the GoPxL SDK and REST API to control a sensor and receive data.

The following sections describe the **Communicate** category and the available protocols and interfaces.



To select the communication type, hover the mouse pointer over **Communicate**, and choose the required type.

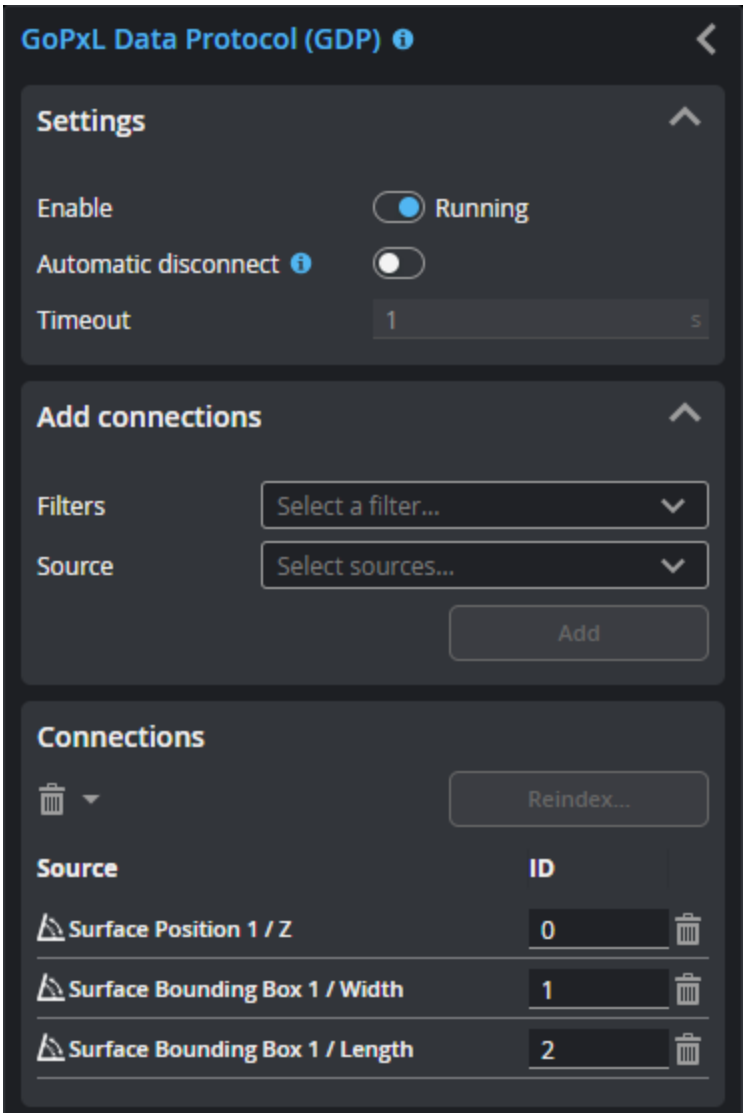


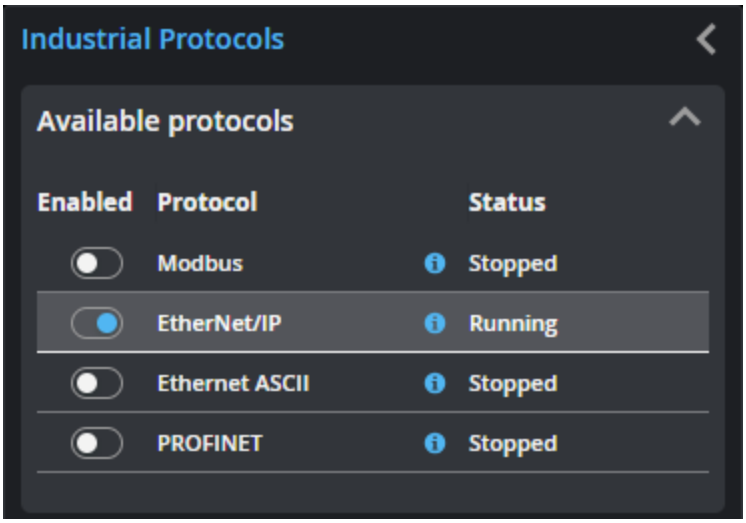

| | Element | Description |
|---|---|---|
| 1 | Communicate category | Pages corresponding to the different control and data output methods available in GoPxL.<br>For information on the available control methods, see *Communication interfaces* below. |
| 2 | Available Protocols | When you are on the Industrial page, this displays the available industrial protocols and whether a protocol is enabled. Use the toggles to start a protocol. |
| 3 | Settings | Lets you configure protocols. |
| 4 | Connections | Lets you add and remove the connections (such as stamps, measurements and decisions) to the connections map (industrial protocols) and outputs (Gocator protocol). |

For more information on the available communication methods, see *Communication interfaces* below.

*Communication interfaces*

| Interface | Description |
|---|---|
| GDP | The **Communicate** > **GDP** page lets you enable and configure the GoPxL Data |

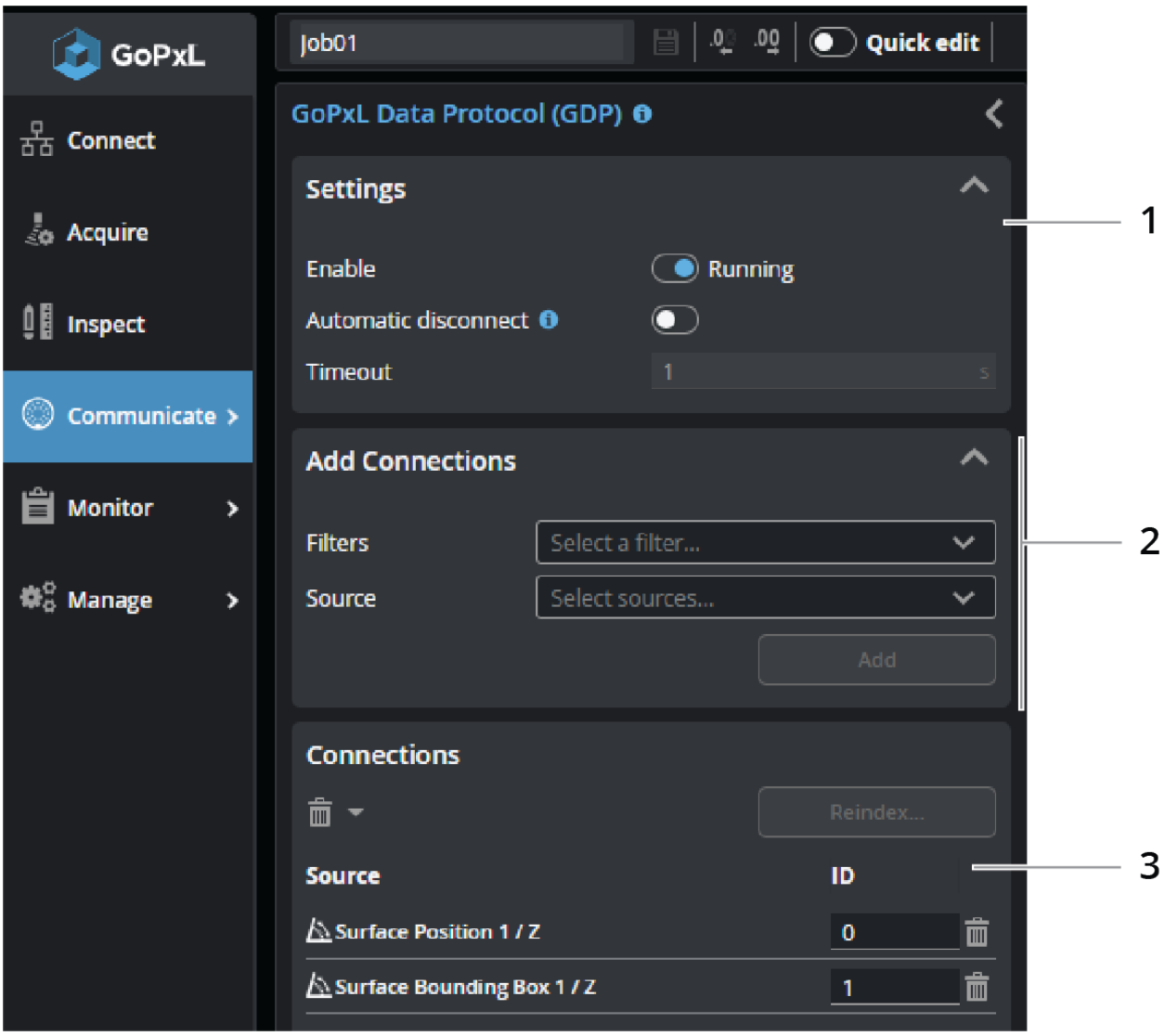
| Interface | Description |
| --- | --- |
| | Protocol, which sends to data and measurements to external applications that use the GoPxL SDK. For more information, see *GoPxL Data Protocol* on page 736.<br>  <br>For information on configuring the GoPxL Data Protocol in GoPxL, see *GoPxL Data Protocol* on page 736.<br>For information on the SDK and REST API, see *GoPxL SDK and REST API* on page 863. |
| Industrial | The Industrial page lets you enable and configure the following protocols over an Ethernet connection:<br>• Modbus<br>• EtherNet/IP<br>• Ethernet ASCII<br>• PROFINET |

| Interface | Description |
| --- | --- |
| |  <br>**Modbus**<br>The Modbus protocol lets you communicate with a sensor from a PLC that supports Modbus.<br>For more information on configuring the Modbus protocol in GoPxL, see *Modbus TCP Protocol* on page 740.<br>For the Modbus protocol specification, see *Modbus TCP Protocol Format - PLC Information* on page 744.<br><br>**EtherNet/IP**<br>The EtherNet/IP protocol lets you communicate with a sensor from a PLC that supports EtherNet/IP.<br>For more information on configuring the EtherNet/IP protocol in the GoPxL UI, see *EtherNet/IP Protocol* on page 749.<br>For the EtherNet/IP protocol specification, see *EtherNet/IP Protocol Format - PLC Information* on page 755.<br><br>**Ethernet ASCII**<br>The Ethernet ASCII protocol lets you communicate with a sensor using an ASCII format.<br>For more information on configuring the ASCII protocol over Ethernet in the GoPxL interface, see *Ethernet ASCII Protocol* on page 763.<br>For a list of the commands, see *Ethernet ASCII Protocol Format - PLC Information* on page 768.<br><br>**PROFINET**<br>The PROFINET protocol lets you communicate with a sensor from a PLC that |

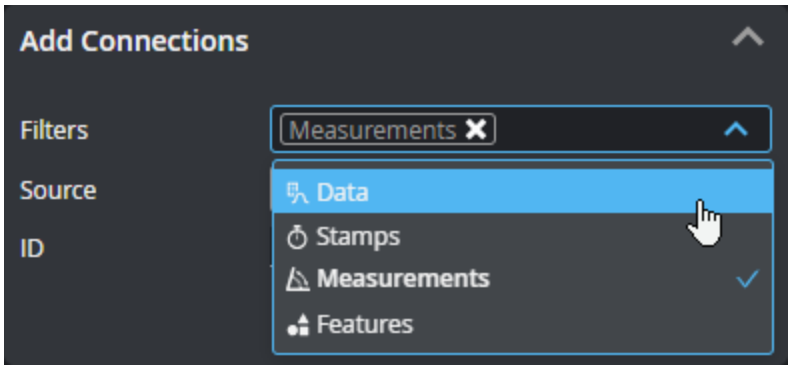
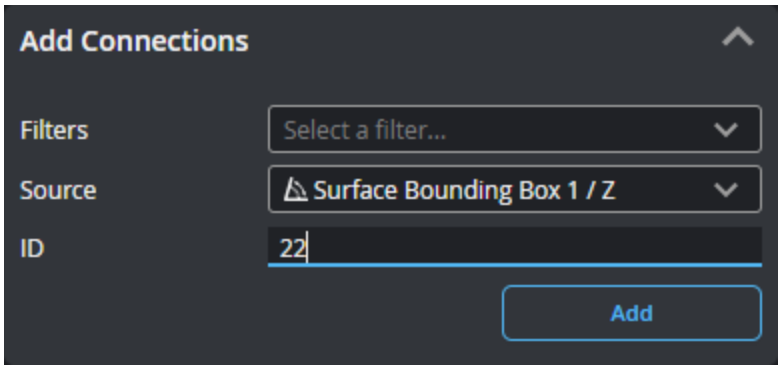
| Interface | Description |
| --- | --- |
| | supports PROFINET.<br>For more information on configuring the PROFINET protocol in the GoPxL UI, see *PROFINET Protocol* on page 775.<br>For the PROFINET protocol specification, see *PROFINET Protocol Format - PLC Information* on page 780. |
| Digital | Lets you configure digital outputs. For more information, see *Digital Output* on page 784. |
| GoHMI | GoHMI and the GoHMI Designer let you create a custom user interface connected to Gocator outputs that users can access from a browser on a PC, a touchscreen, or a mobile device. For more information, see *GoHMI and GoHMI Designer* on page 833. |

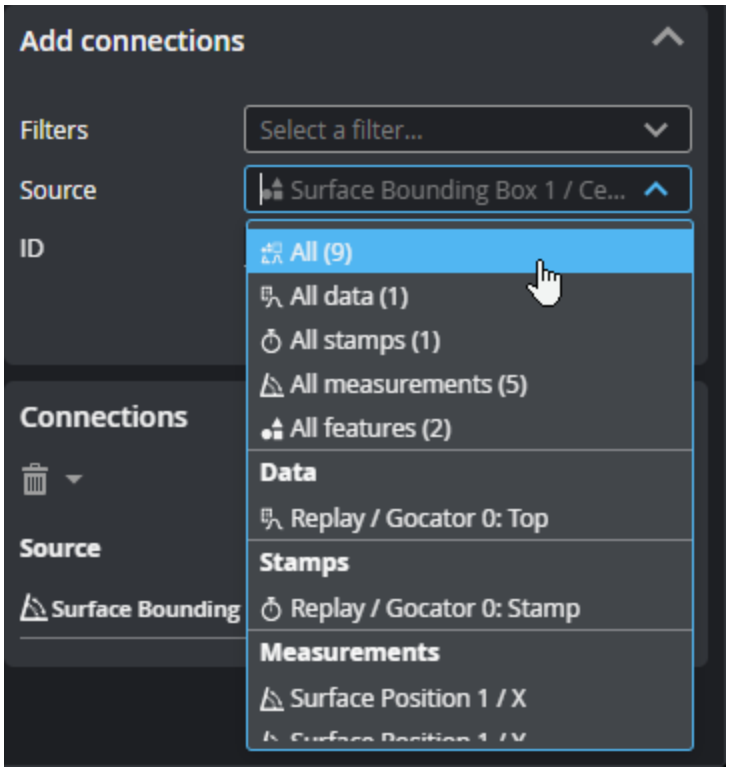
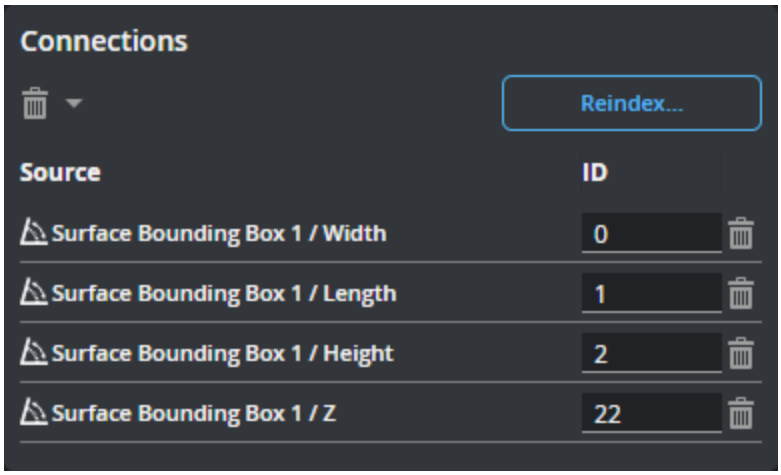
## GoPxL Data Protocol

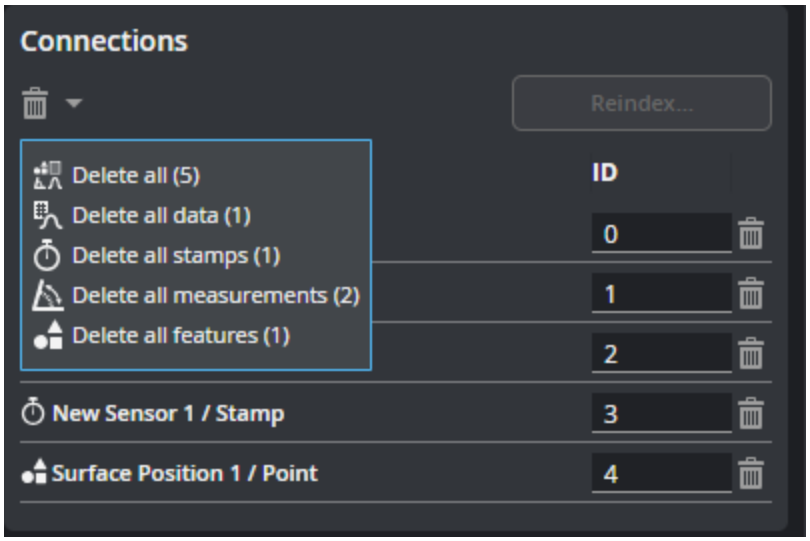
The GoPxL Data Protocol sends TCP messages containing data and measurement results to client applications that use the GoPxL SDK. You can select which measurements and what type of scan data to send (range, profile, or surface depending on sensor model; image; or intensity). Note that GDP does not have to be enabled for the client application to read and write configurations, only to receive data and measurements.




| | Element | Description |
|---|---|---|
| 1 | Protocol settings | Lets you disable or configure the protocol. For information on the settings available here, see *Configuration area parameters* on page 740. |
| 2 | Add Connections | Lets you add sources (data, stamp, measurement, or geometric feature) to send over the protocol. Added connections appear in the **Connections** section at the bottom of the panel<br>If you have many sources, you can filter them by type to make it easier to find the source you want in the **Source** drop-down. You can enable more than one filter. |

| Element | Description |
| --- | --- |
| |  <br>Choose a source in **Source**. If you leave ID as "Auto" GoPxL automatically increments the ID; otherwise, you can set it yourself. The field is hidden if more than one source is selected in **Source**.<br>  <br>You can also add all sources, or all sources of a given type. Adding multiple sources automatically increments the ID |

| | Element | Description |
|---|---|---|
| | |  <br>Click **Add** to add the source to the Connections table below. |
| 3 | Connections | The connections listed here will be sent by the GoPxL Data Protocol to an application developed using the GoPxL SDK.<br>You can delete a connection using the trashcan icon in its row or change its ID. If you set an ID to the ID of another source, all other source automatically shift up to make room for it.<br>  <br>You can also use shortcut commands to delete all of the connections, or specific categories of connections. |

| Element | Description |
|---|---|
| |  <br>If you set an ID to the index of another tool, all sources following the changed index are incremented.<br>Click the **Reindex** button to reorder the connections and fill any gaps between index numbers. |

*Configuration area parameters*

| Parameter | Description |
|---|---|
| Enable | Toggles whether the Gocator communication protocol is enabled. |
| Automatic disconnect | When enabled, automatically disconnects from the client after the timeout value in **Timeout** if the sensor is unable to send data. |
| Timeout | Sets the timeout value when **Automatic disconnect** is enabled. |

### GoPxL Data Protocol

When the GoPxL Data Protocol is enabled in the GoPxL interface, you can use the GoPxL SDK and REST API to send commands from and receive data from SDK-based applications.

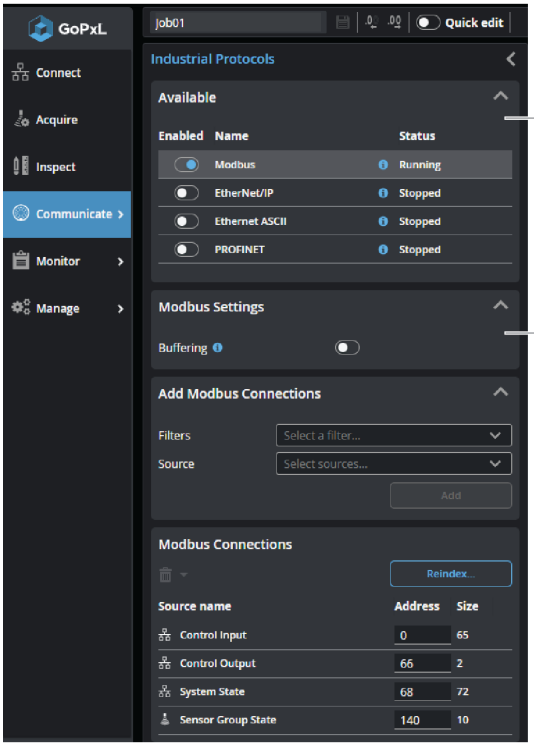
For information on configuring the Gocator protocol in GoPxL on the **Control** page, see *GoPxL Data Protocol* on page 736.

For information on the GoPxL SDK and the REST API, see *GoPxL SDK and REST API* on page 863.

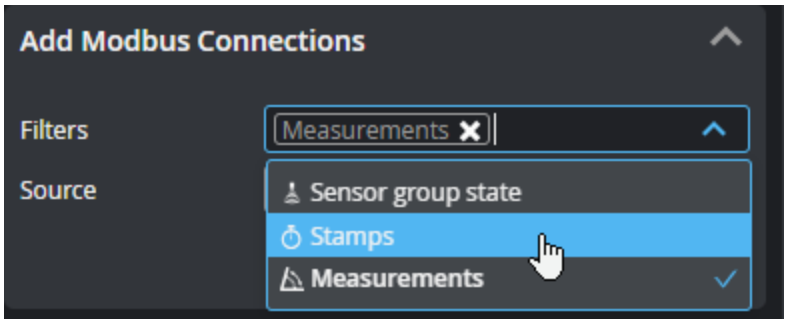
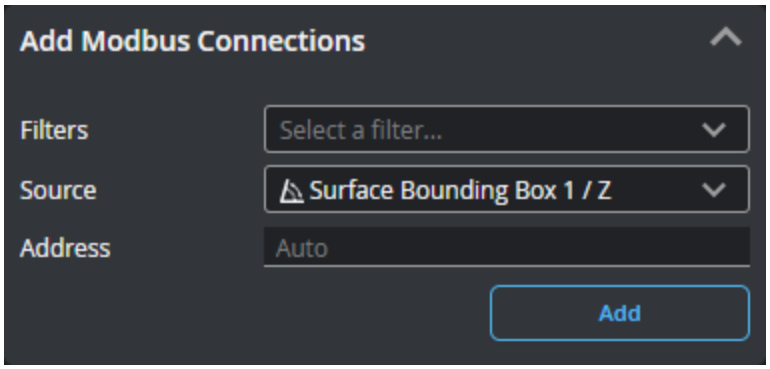
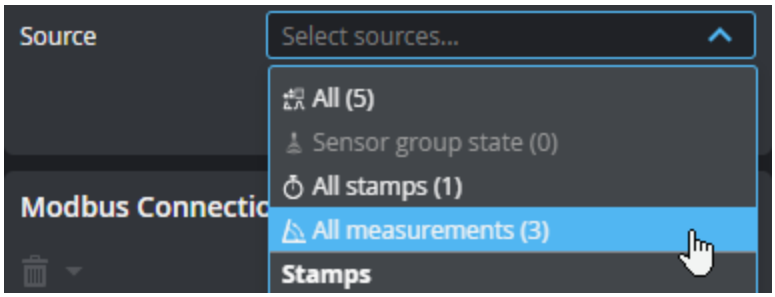
## Modbus TCP Protocol

You can use a Modbus TCP programmable logic controller (PLC) over Ethernet to operate a sensor and receive measurement values. Modbus only supports a subset of the tasks that can be accomplished in the web interface (for example, starting and stopping sensors, and switching jobs). Scan data can't be sent to the PLC.

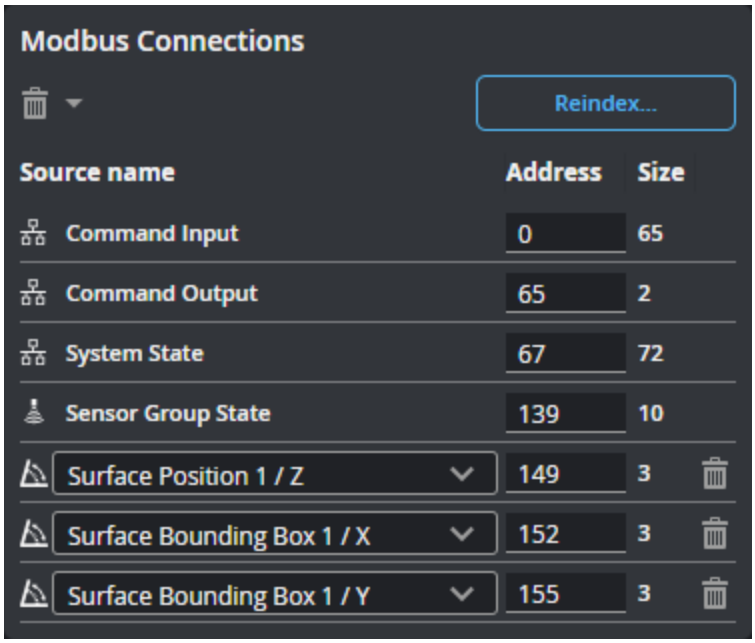
You configure the protocol on the **Communicate** > **Industrial** page. After configuring the Modbus protocol in GoPxL (see below), use the information in *Modbus TCP Protocol Format - PLC Information* on page 744 to configure your PLC.



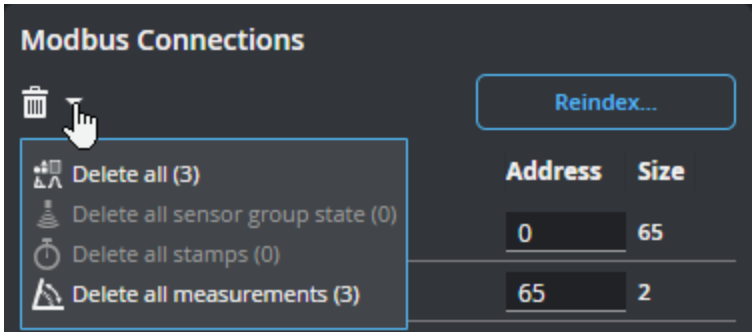

| | Element | Description |
|---|---|---|
| 1 | Available Protocols | Click a row in the table to choose which protocol to configure. Enable a protocol by toggling the slider to the right. |
| 2 | Modbus Settings | **Buffering**<br>Toggle the slider to enable/disable buffering of scan outputs.\<br>On line profile sensors, buffering should be enabled in Surface mode when **Surface Generation Type** is set to Continuous mode and if multiple objects may be detected within a time frame shorter than the polling rate of the PLC. If buffering is enabled, the PLC must send the 'Buffer Advance' command to advance the queue before reading the measurement results. For more information, see *Control Input* on page 746. For information on continuous surface generation and its settings, see *Surface Generation* on page 113. |
| 3 | Add Modbus Connections | Lets you add sources (such as stamps or measurements) to send over the protocol. Added connections appear in the **Modbus Connections** section at the bottom of the panel.<br>If you have many sources, you can filter them by type to make it easier to find the source you want in the **Source** drop-down . You can enable more than one filter. |

| | Element | Description |
|---|---|---|
| | |  <br>Choose a source in the **Source** drop-down. If you leave **Address** as "Auto", GoPxL automatically increments the value; otherwise, you can set it yourself.<br>  <br>You can also add all sources, or all sources of a given type.<br>  <br>Click **Add** to add the source to the Modbus Connections table below. |
| 4 | Modbus Connections | The connections listed here will be sent by the protocol to a compatible PLC.<br>You can delete a connection using the trashcan icon in its row, or change its ID. When changing an ID, make sure to use the size of the source to correctly calculate the minimum offset. |

| Element | Description |
| --- | --- |




You can also use shortcut commands to delete all of the connections, or specific categories of connections.




Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.

## Modbus TCP Protocol Format - PLC Information

GoPxL supports the Modbus TCP communication to provide system, sensor group, and scan output data to a PLC, as well as accept incoming commands. After enabling Modbus in the GoPxL web interface (for more information, see *Modbus TCP Protocol* on page 740), the sensor starts listening on port 502 for one or more Modbus clients. GoPxL operates as a Modbus server (slave), and a PLC that connects to it acts as the Modbus client (master). All communication is initiated by the PLC, with GoPxL responding to the Modbus requests.

> The connection mappings for the industrial protocols (PROFINET, EtherNet/IP, and Modbus) have changed to correct a byte alignment issue. To allow communication between PLCs and GoPxL 1.2, you may need to update PLC logic created for GoPxL 1.1.
>
> For EtherNet/IP, the EDS file has been updated to reflect the changes.

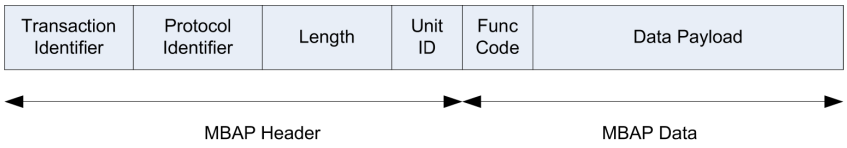
While the Modbus protocol includes several types of requests, the two basic operations are reading and writing registers. Commands are invoked by the PLC sending write-register requests. Data is requested by the PLC by sending read-register requests.

There are 16-bits per register in the Modbus protocol. 32-bit and 64-bit values are stored in consecutive registers in Big-Endian format.

If buffering is enabled with the Modbus protocol (when part detection is used and if multiple objects may be detected within a time frame shorter than the polling rate of the PLC), the PLC must send the Buffer Advance command to advance the queue before reading the measurement results (see *Control Input* on page 746). For more information on part detection, see *Profile Part Detection* on page 283.

### Messages

All Modbus TCP messages consist of an MBAP header (Modbus Application Protocol), a function code, and a data payload.




The MBAP header contains the following fields:

*Modbus Application Protocol Header*

| Field | Length (Bytes) | Description |
|---|---|---|
| Transaction ID | 2 | Used for transaction pairing. The Modbus Client sets the value and the Server (the sensor) copies the value into its responses. |
| Protocol ID | 2 | Always set to 0. |
| Length | 2 | Byte count of the rest of the message, including the Unit identifier and data fields. |
| Unit ID | 1 | Used for intra-system routing purpose. The Modbus Client sets the value and the Server (the sensor) copies the value into its responses. |

Modbus Application Protocol Specification describes the standard function codes in detail. Gocator supports the following function codes:

*Modbus Function Code*

| Function Code | Name | Data Size (bits) | Description |
|---|---|---|---|
| 3 | Read Holding Registers | 16 | Read multiple data values from the sensor. |
| 4 | Read Input Registers | 16 | Read multiple data values from the sensor. |
| 6 | Write Single Register | 16 | Send a command or parameter to the sensor. |
| 16 | Write Multiple Registers | 16 | Send a command and parameters to the sensor. |

The data payload contains the registers that can be accessed by Modbus TCP messages. If a message accesses registers that are invalid, a reply with an exception is returned. Modbus Application Protocol Specification defines the exceptions and describes the data payload format for each function code.

The sensor data includes 16-bit, 32-bit, and 64-bit data. All data are sent in big endian format, with the 32-bit and 64-bit data spread out into two and four consecutive registers.

*32-bit Data Format*

| Register | Name | Bit Position |
|---|---|---|
| 0 | 32-bit Word 1 | 31 .. 16 |
| 1 | 32-bit Word 0 | 15 .. 0 |

*64-bit Data Format*

| Register | Name | Bit Position |
|---|---|---|
| 0 | 64-bit Word 3 | 63 .. 48 |
| 1 | 64-bit Word 2 | 47 .. 32 |
| 2 | 64-bit Word 1 | 31 .. 16 |
| 3 | 64-bit Word 0 | 15 .. 0 |

### Connections Map

The Modbus protocol supports various blocks types. Each block type can be either an input block or an output block. Input blocks contain write-only registers and are used by the Modbus client to send commands such as starting or stopping a scan. Output blocks contain read-only registers and are used to store various types information, such as control, system, and sensor group state data as well as scan output data.

The starting address location of each block within the Modbus register map may be assigned using the GoPxL web interface.

The register address of a specific field within a block is equal to the block's address plus the field's address offset. For example, the command identifier in the Control Input block has an address offset equal to 1. If the Control Input block is located at register address 100, the command identifier value is located at register address 101.

#### Supported Block Types

The block types supported by the Modbus protocol are listed in the table below. The size field indicates the number of registers that each block type requires.

*Supported Block Types*

| Supported Block Type | Read or Write only? | Size (number of Modbus registers) | Description |
|---|---|---|---|
| "ControlInput" | WO | 65 | Command message set by the Modbus client. |
| "ControlOutput" | RO | 2 | Result data corresponding to a command that was written to the Control Input block. |
| "Measurement" | RO | 3 | Measurement data of a scan output measurement data message. |
| "Scanner" | RO | 10 | Information about a specific sensor group. |
| "Stamp" | RO | 17 | Stamp message information. |
| "System" | RO | 72 | Information about the LMI device. |

#### Control Input

The input of the Control Input block contains the fields described below:

*Control Input Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Command Sequence Number | 16u | 0 | The command sequence number is set by the external client to uniquely identify a command request. This number is sent back in the Control Output.<br>This is an optional field but is recommended that Modbus clients use this to help the clients correlate the Command Status in the Control Output with a specific command request in Control Input. |
| Command Identifier | 16u | 1 | Identifies the requested action from the external client.<br>Supported actions:<br>0 = No Command<br>1 = Start Scanning<br>2 = Stop Scanning<br>3 = Align Sensor Group<br>4 = Clear Alignment<br>5 = Load Job File<br>6 = Software Trigger<br>7 = Buffer Advance |
| Command Arguments | 16u | 2 | Arguments for commands that require arguments.<br>For the Load Job File command, the command arguments will contain the *NULL terminated* job file name. The job file name must *not* include the job file extension. The job extension is automatically appended by the Modbus server. |

| Field | Type | Address offset | Description |
|---|---|---|---|
| | | | This field takes up a maximum of 63 registers. |

#### Control Output

The output of the Control Output block contains the fields described below:

*Control Output Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Command Sequence Number | 16u | 0 | The command sequence number received from the client in the Control Input. |
| Command Status | 16u | 1 | Status of the command, referenced by the Command Sequence Number.<br>0 = No Command Received<br>1 = In Progress<br>2 = Success<br>3 = Fail<br>This field takes up 1 register. |

#### System State

The output of the System State block contains the fields described below:

*System State Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| System Uptime | 64u | 0 | Amount of time the application has been running, in seconds. |
| System State | 16u | 4 | Whether system is running or not.<br>0 = System is stopped<br>1 = System is running |
| Current Job File Name Length | 16u | 5 | Number of characters in the current job file name. |
| Current Job File Name | 16u | 6 | Name of the job file currently loaded into the system, without the extension.<br>Maximum length of job file name is 64 characters. Each register contains a single character.<br>Job file name is *not* null terminated. |
| Buffer Count | 16u | 70 | The current amount of buffered scan output data when buffering is enabled. |
| Buffer Overflow | 16u | 71 | A value of 0 indicates that no overflow has occurred.<br>A value of 1 indicates that overflow occurred and data is being lost.<br>This field takes up 1 register. |

#### Sensor Group State

The output of the Sensor Group State block contains the fields described below:

*Sensor Group State Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Current Encoder Position | 64s | 0 | The current encoder position. |
| Current Sync Time | 64u | 4 | Current time of the clock used to stamp all scan output messages, in microseconds. |
| Alignment State | 16u | 8 | Indicates whether all devices under the sensor group are aligned (that is, devices in the sensor group all have a non-identity transform matrix).<br>0 = Not Aligned<br>1 = Aligned<br>2 = Aligning |
| Laser Enabled | 16u | 9 | Whether one or more devices under a scanner has its laser enabled to be able to turn on.<br>0 = All devices' lasers are disabled and cannot turn on<br>1 = One or more devices' lasers can be turned on<br>This field takes up 1 register. |

#### Stamp

The output of the Stamp block contains the fields described below:

*Stamp Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Z Position | 64s | 0 | Encoder position at time of last index pulse of last frame. |
| Encoder Position | 64s | 4 | Encoder position of last frame when the image data was scanned/taken. |
| Time | 64u | 8 | The timetick of the last frame.<br>A timetick is a 64-bit positive integer that is guaranteed to increase monotonically starting from zero. It is guaranteed to be unique for every scan from a given sensor group.<br>To convert this value to microseconds, use the following:<br>`time in microseconds = timetick / 1.024` |
| Frame Index | 64u | 12 | The frame number of the last frame.<br>This field takes up 4 registers. |
| Digital Input States | 16u | 16 | Digital input states of last frame.<br>Bit 0: State of digital input 1 on master or sensor<br>Bit 1: State of digital input 2 on master or sensor |

#### Measurement

The output of the Measurement Block contains the fields described below:

*Measurement Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Value | 32s | 0 | Measurement value. This value is the actual measurement value multiplied by 1000.<br>If the measurement value is invalid, the first register of the measurement value is set to 0x80000000.<br>This means the first register of the measurement value is set to 0x8000 and the second register value is 0x0000. |
| Decision | 16u | 2 | Measurement decision.<br>Bit 0:<br>0 = Fail<br>1 = Pass<br>Bit 1:<br>0 = Decision value is valid<br>1 = Decision value is invalid<br>This field takes up 1 register. |

**String**

The output of the String Block contains the fields described below:

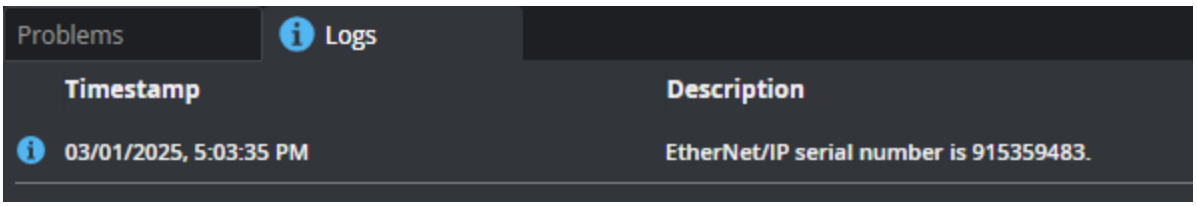
*Measurement Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| String | string | 0 | String value. If invalid, the block's buffer is entirely set to null (0x0), equivalent to an empty string. |

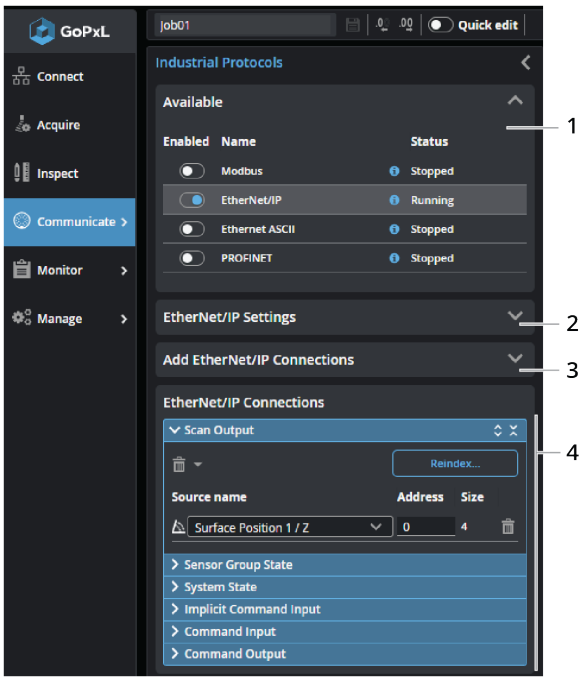
## EtherNet/IP Protocol

You can use an EtherNet/IP programmable logic controller (PLC) over Ethernet to operate a sensor and receive measurement values. EtherNet/IP only supports a subset of the tasks that can be accomplished in the web interface (for example, starting and stopping sensors, and switching jobs). Scan data can't be sent to the PLC.

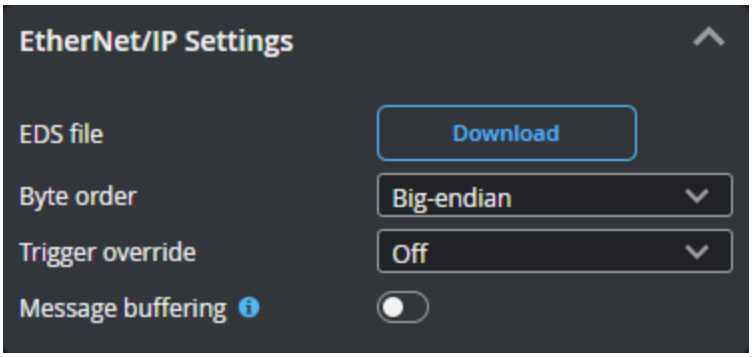
When you enable the protocol, a log entry displays the EtherNet/IP serial number you should use in your PLC.




You configure the protocol on the **Communicate** > **Industrial** page. After configuring the EtherNet/IP protocol in GoPxL (see below), use the information in *EtherNet/IP Protocol Format - PLC Information* on page 755 to configure your PLC.




| | Element | Description |
|---|---|---|
| 1 | Available Protocols | Click a row in the table to choose which protocol to configure. Enable a protocol by toggling the slider to the right. |
| 2 | EtherNet/IP Settings | You configure the protocol's settings in this section. |




**EDS file**

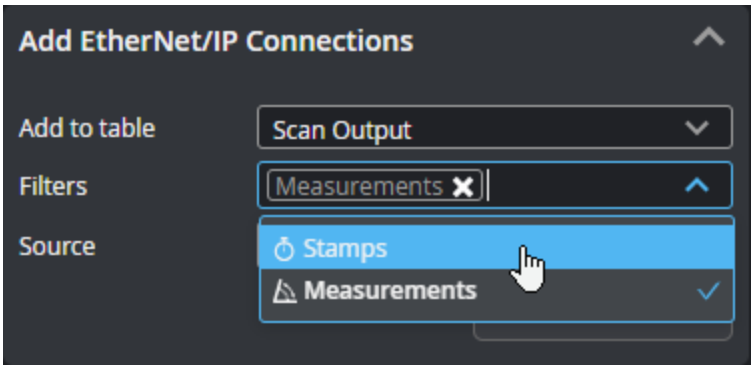
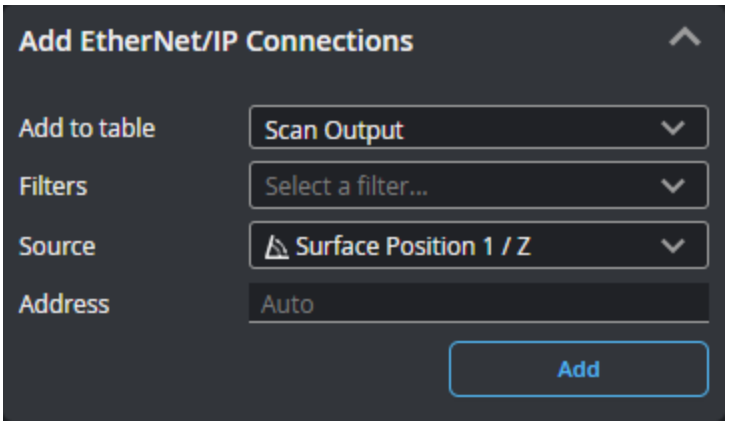
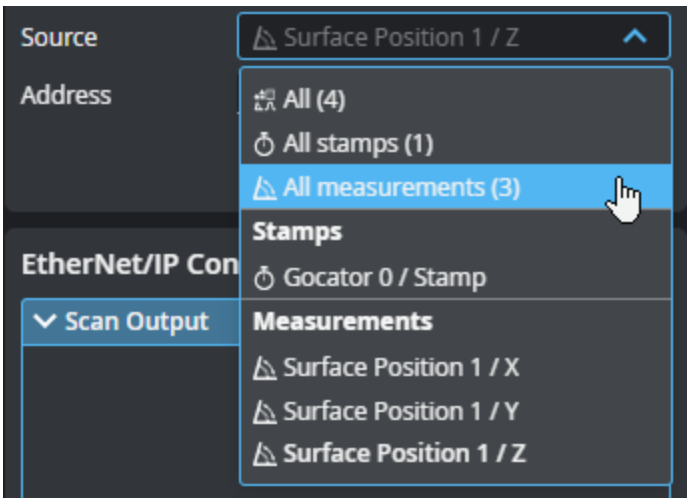
Click **Download** to save an EDS file to the client computer for later installation on the PLC.

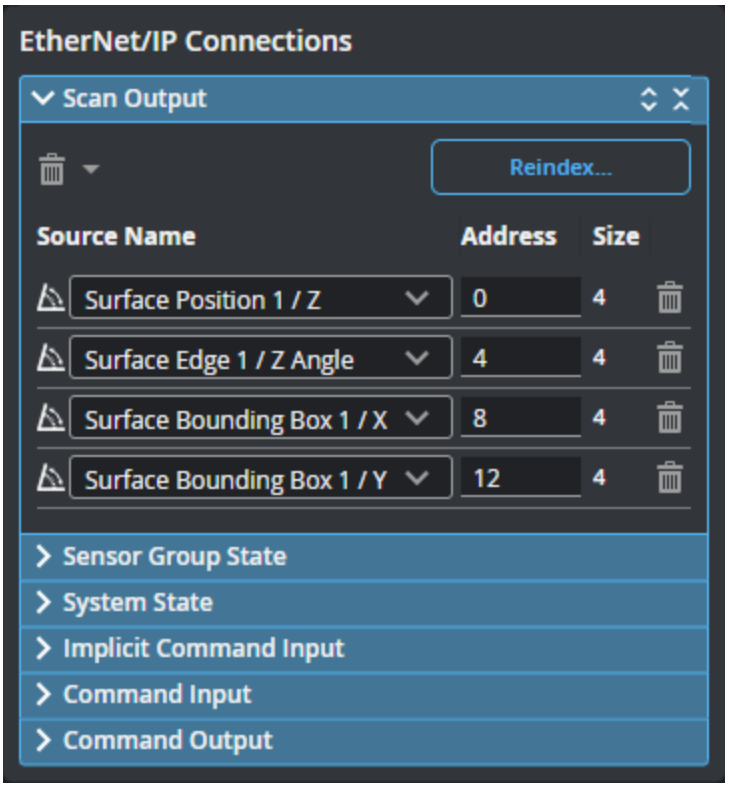
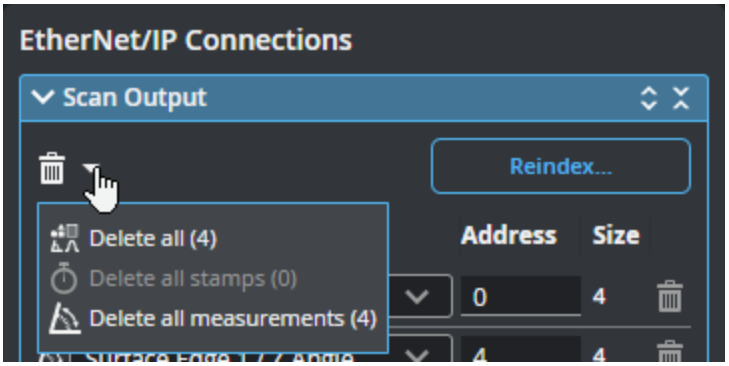
**Byte order**

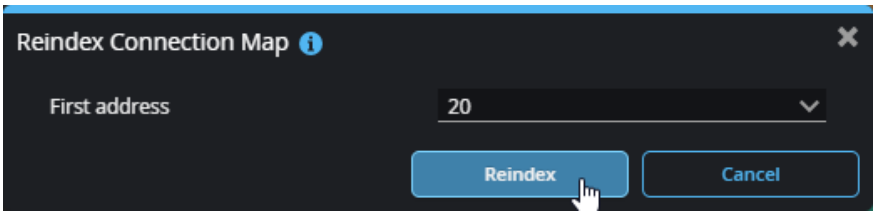
One of the following:

**Big-endian**: The most significant byte (the "big end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of decreasing significance in the next three bytes of memory.

| | Element | Description |
|---|---|---|
| | | **Little-endian**: The least significant byte (the "little end") of the data is placed at the byte with the lowest address. The rest of the data is placed in order of increasing significance in the next three bytes in memory.<br>Most Allen-Bradley PLCs default to Little Endian addressing formats, but you should verify this when configuring the PLC.<br><br>**Trigger override**<br>One of the following: **Off**, **Cyclic**, and **Change of State**.<br>When you set up the PLC to communicate with a Gocator using change of state implicit messaging, an event task must be created on the PLC to rapidly check whether the sensor is running; if the frame count increases, data is copied to an array. The event task period must allow the event task to be executed at a higher rate than Gocator frame rate.<br><br>**Message buffering**<br>Used to enable and disable buffering of scan outputs. You should enable buffering if you are using part detection and if multiple objects may be detected within a period shorter than the polling rate of the PLC.<br>If buffering is enabled with the EtherNet/IP protocol, the buffer is automatically advanced when the Sample State assembly object is read (see *EtherNet/IP Protocol Format - PLC Information* on page 755).<br>Message buffering only applies to tool outputs sent over explicit messaging.<br>For more information on part detection, see Continuous in *Surface Generation* on page 113. |
| 3 | Add EtherNet/IP Connections | Lets you add sources (such as stamps or measurements) to send over the protocol. Added connections appear in the **EtherNet/IP Connections** section at the bottom of the panel.<br>When GoPxL is running on a standalone sensor (one not controlling others), **Add to Table** only contains one value (Scan Output) that represents a register assembly. When GoPxL is running on a sensor controlling other sensors, or on a PC or GoMax NX, **Add to Table** contains an additional entry (Sensor Group State). Use this to choose which register a source is added to.<br>If you have many sources, you can filter them by type to make it easier to find the source you want in the **Source** drop-down . You can enable more than one filter. |

| Element | Description |
| --- | --- |
| |  <br>Choose the source in the **Source** drop-down. If you leave **Address** as "Auto", GoPxL automatically increments the value; otherwise, you can set it yourself. By default, connections are added directly after the last source in the connections map. You can optionally set the address at which a source is added using the **Address** parameter.<br>  <br>You can also add all sources, or all sources of a given type.<br>  <br>Click **Add** to add the source to the EtherNet/IP Connections table below. |

| | Element | Description |
|---|---|---|
| 4 | EtherNet/IP Connections | The connections listed here will be sent by the protocol to a compatible PLC.<br>You can delete a connection using the trashcan icon in its row, or change its ID. When changing an ID, make sure to use the size of the source to correctly calculate the minimum offset.<br>  <br>You can also use shortcut commands to delete all of the connections, or specific categories of connections.<br>  <br>Use **Reindex...** to remove gaps of unused addresses between connections. You can also set the value of the first index. |

| Element | Description |
| --- | --- |
| |  |

## EtherNet/IP Protocol Format - PLC Information

EtherNet/IP is an industrial protocol that allows bidirectional data transfer with PLCs that support the protocol. It encapsulates the object-oriented Common Industrial Protocol (CIP). EtherNet/IP communication enables the client to:

- Start and stop sensors
- Load job files
- Align sensors
- Receive sensor states, stamps, and measurement results

Before configuring your PLC, make sure to enable and configure EtherNet/IP in GoPxL. For more information on this, see *EtherNet/IP Protocol* on page 749.

Implicit messaging is always enabled.

This section describes the EtherNet/IP message and data formats. The commands described in the sections below are those specific to the Gocator protocol and not the complete EtherNet/IP reference command set.

GoPxL supports EtherNet/IP communication to provide system state, sensor group state, and scan output data to a PLC, and also receive commands. After you enable EtherNet/IP in the GoPxL web interface, the sensor starts listening on the standard EtherNet/IP port 44818 for one or more EtherNet/IP clients. GoPxL operates as an EtherNet/IP server, and a PLC that connects to it acts as the EtherNet/IP client. All communication is initiated by the PLC, with GoPxL responding to the EtherNet/IP requests.

While the EtherNet/IP protocol includes several types of requests, the two core operations are reading and writing EtherNet/IP objects. Commands are invoked by the PLC sending *set* requests. Data is requested by the PLC by sending *get* requests for EtherNet/IP objects.

EtherNet/IP supports both explicit messaging and implicit messaging. Data can be read in Big-Endian or Little-Endian format based on the protocol's configuration selected in the web interface.

### Supported EtherNet/IP Objects

All mandatory EtherNet/IP objects required for explicit messaging, including Assembly objects, are supported by the sensors. Except for mandatory objects (see below), the remaining objects are mapped to register assemblies.

Mandatory objects (*Identity Object (Class 0x01)* on page 757, *TCP/IP Object (Class 0xF5)* on page 757, and *Ethernet Link Object (Class 0xF6)* on page 758 objects) are always present in the EtherNet/IP service, regardless of the configured measurement object.

Implicit messaging supports only Assembly objects.

### Object and Register Assembly Mapping

*Object and Register Assembly Mapping*

| Object name | Register assembly | Supported Block Type Internal Identifier[1] | Description | Service | Messaging Type | Instance ID | Max Size (bytes) |
|---|---|---|---|---|---|---|---|
| Command input | Control Input | ControlInput | Receives commands from the PLC. | Explicit | SetAttributeSingle (0x10) | 112 (0x70) | 67 |
| Command output | Control Output | ControlOutput | Sends command response or feedback to the PLC. | Explicit | GetAttributeSingle (0x0E) | 113 (0x71) | 3 |
| Sensor Group State | Sensor Group State | Scanner | Provides status of the sensor group. | Explicit | GetAttributeSingle (0x0E) | 114 (0x72) | 18 |
| System State | System State | System | Reports overall system health and connection info. | Explicit | GetAttributeSingle (0x0E) | 115 (0x73) | 76 |
| Sample State | Sample State | MeasurementValue Stamp | Returns the latest measurement results and stamp. | Explicit | GetAttributeSingle (0x0E) | 116 (0x74) | 375 |
| Implicit Messaging Input | Implicit Control Input | ControlInput | Receives control commands via cyclic connection. | Implicit | SetAttributeSingle (0x10) | 100 (0x64) | 67 |
| Implicit Messaging Output | Sample State | MeasurementValue Stamp | Sends measurement results and stamps to the PLC on cycle. | Implicit | GetAttributeSingle (0x0E) | 101 (0x65) | 375 |

1. For more information on the supported block types, see *Supported Block Types* below.

### Supported Block Types

The block types supported by the EtherNet/IP protocol are listed in the table below. The size field indicates the number of registers that each block type requires.

*Supported Block Types*

| Block Type Internal Identifier | Read or Write only? | Size (number of EtherNet/IP registers) | Description |
|---|---|---|---|
| ControlInput | Write-Only | 67 | Accepts control commands from the EtherNet/IP client. |
| ControlOutput | Read-Only | 3 | The result of the last command written to the ControlInput block. |
| MeasurementValue | Read-Only | 4 | Measurement values. |
| Scanner | Read-Only | 18 | The current state and configuration of the sensor group. |
| Stamp | Read-Only | 36 | Stamp message information. |
| System | Read-Only | 76 | Overall device state and configuration of the GoPxL system. |

### Identity Object (Class 0x01)

*Identity object (Class 0X01)*

| Attribute | Name | Type | Value | Description | Access |
|---|---|---|---|---|---|
| 1 | Vendor ID | UINT | 1256 | ODVA-assigned vendor ID for LMI | Get |
| 2 | Device Type | UINT | 43 | Device type | Get |
| 3 | Product Code | UINT | 1 | Product code | Get |
| 4 | Revision | Structure (USINT, USINT) | Major: 1, Minor: 3 | Firmware revision | Get |
| 6 | Serial number | UDINT | [device-specific] | Sensor serial number | Get |
| 7 | Product Name | SHORT_STRING[32] | Gocator | Gocator product name | Get |

### TCP/IP Object (Class 0xF5)

The TCP/IP Object (Instance ID 0x01) provides read-only attributes related to the network configuration of the device. This object is used by EtherNet/IP clients to retrieve information such as the current IP address and interface status.

> GoPxL does not support writing or modifying TCP/IP settings via EtherNet/IP. Network parameters must be configured through the GoPxL web interface or external methods such as DHCP.

For complete structural definitions, see CIP Specification Volume 2, Chapter 5-3.

| Attribute | Name | Type | Value | Description | Access |
|---|---|---|---|---|---|
| 1 | Status | UDINT | 0 | TCP interface status | Get |
| 2 | Configuration Capability | UINT | 0 | Indicates which configuration methods (e.g., BOOTP, DHCP) are supported. | Get |

| Attribute | Name | Type | Value | Description | Access |
|---|---|---|---|---|---|
| 3 | Configuration Control | UINT | 0 | Indicates which method is currently active. | Get |
| 4 | Physical Link Object | Structure | - | Contains: Path Size (UINT), Path (Padded EPATH)<br>See §5.3.3.2.4 CIP V2. | Get |
| 5 | Interface Configuration | Structure | - | Contains: IP Address, Subnet Mask, Gateway, DNS, Domain<br>See §5.3.3.2.5. | Get |

**Ethernet Link Object (Class 0xF6)**

The Ethernet Link Object (Instance ID 0x01) exposes read-only attributes related to the physical Ethernet interface, such as link speed, status, and MAC address. These attributes provide diagnostic and identification information for EtherNet/IP clients.

For full attribute definitions and behavior, see CIP Specification Volume 2, Chapter 5-4.

| Attribute | Name | Type | Value | Description | Access |
|---|---|---|---|---|---|
| 1 | Interface Speed | UDINT | 1000 | Data rate of the Ethernet interface, in Mbps. | Get |
| 2 | Interface Flags | UDINT | [bitfield] | Bit-level status flags:<br>Bit 0 – Link Status (0 = Inactive, 1 = Active)<br>Bit 1 – Duplex (0 = Half, 1 = Full) | Get |
| 3 | Physical Address | Array[6] OF USINT | e.g., 00 16 20 00 2E 42 | Device MAC address. | Get |

**Command Input**

The Command Input block is used by an EtherNet/IP client to send control instructions to GoPxL. It maps to the `ControlInput` register assembly and uses Class `0x04`, Attribute `0x03`, Instance ID 112 (`0x70`).

This assembly supports the `SetAttributeSingle (0x10)` service and has a maximum size of 67 bytes.

| Information | Value |
|---|---|
| Register Assembly | Control Input register assembly |
| Supported Block Type Identifier | ControlInput |
| Class | 0x4 |
| Instance | 112 (0x70) |
| Attribute Number | 3 |
| Max Size | 67 bytes |

**Input Structure**

The input data block consists of the following fields:

| Attribute | Name | Type | Value |
|---|---|---|---|
| Command Sequence Number | UINT16 | 0 | Optional. A unique value set by the client to identify each command. Echoed back in the Control Output. |
| Command Identifier | UINT8 | 2 | Identifies the action to perform:<br>0 = No Command<br>1 = Start Scanning<br>2 = Stop Scanning<br>3 = Align Sensor Group<br>4 = Clear Alignment<br>5 = Load Job File<br>6 = Software Trigger |
| Unused | UINT8 | 3 | Reserved unused field. |
| Command Arguments | ARRAY [UINT8] (max 63) | 4 | Optional. Arguments for commands that require them (e.g., file name for Load Job File).Each byte stores one character. The name must be null-terminated and must not include the file extension .job. |

**Command Output**

The Command Output block provides the result of the last command sent to the device via the Control Input block. It maps to the `ControlOutput` register assembly and uses Class `0x04`, Attribute `0x03`, Instance ID 113 (`0x71`).

This assembly supports the `SetAttributeSingle (0x0E)` service and has a maximum size of 3 bytes.

| Information | Value |
|---|---|
| Register Assembly | Control Output register assembly |
| Supported Block Type Identifier | ControlInput |
| Class | 0x4 |
| Instance | 113 (0x71) |
| Attribute Number | 3 |
| Max Size of Register Assembly | 3 bytes |

#### Output Structure

The fields below are fixed in size and structure:

| Attribute | Name | Type | Value |
|---|---|---|---|
| Command Sequence Number | UINT16 | 0 | The sequence number echoed from the most recent Control Input. |
| Command Status | UINT8 | 2 | Status of the referenced command:<br>0 = No Command Received<br>1 = In Progress |

| Attribute | Name | Type | Value |
|---|---|---|---|
| | | | 2 = Success |
| | | | 3 = Failure |

### Sensor Group State

The Sensor Group State block provides real-time status data about the active sensor group (scanner). It maps to the `Scanner` register assembly and uses Class `0x04`, Attribute `0x03`, Instance ID 114 (`0x72`).

This assembly supports the `GetAttributeSingle (0x0E)` service and has a maximum size of 3 bytes.

| Information | Value |
|---|---|
| Register Assembly | Sensor Group State register assembly |
| Supported Block Type Identifier | Scanner |
| Class | 0x4 |
| Instance | 114 (0x72) |
| Attribute Number | 3 |
| Max Size | 18 bytes |

#### Output Structure

The output of the Sensor Group Block contains the following fields:

| Attribute | Name | Type | Value |
|---|---|---|---|
| Current Encoder Position | INT64 | 0 | The current position from the encoder, used to synchronize with motion systems. |
| Current Sync Time | UINT64 | 8 | Current system time used to timestamp scan outputs, in microseconds. |
| Alignment State | UINT8 | 16 | Indicates sensor group alignment:<br>0 = Not Aligned<br>1 = Aligned<br>2 = Aligning |
| Laser Enabled | UINT8 | 17 | Indicates laser readiness:<br>0 = All lasers disabled<br>1 = One or more lasers enabled |

### System State

The System State block reports the current runtime status of the GoPxL system. It maps to the `System State` register assembly and uses Class `0x04`, Attribute `0x03`, Instance ID 115 (`0x73`).

This assembly supports the `GetAttributeSingle (0x0E)` service and has a maximum size of 76 bytes.

| Information | Value |
|---|---|
| Register Assembly | System State register assembly |
| Supported Block Type Identifier | System |
| Class | 0x4 |
| Instance | 115 (0x73) |
| Attribute Number | 3 |
| Max Size | 76 bytes |

#### Output Structure

This block contains system-level runtime information and file state useful for diagnostics and monitoring:

| Attribute | Name | Type | Value |
|---|---|---|---|
| System Uptime | UINT64 | 0 | Number of seconds the GoPxL application has been running.<br>On Sensor/GoMax, this reflects device uptime.<br>On PC, it reflects how long the GoPxL service has been running—not total PC uptime. |
| System State | UINT8 | 8 | Indicates if the system is actively running:<br>0 = Stopped<br>1 = Running |
| Job File Name Length | UINT8 | 9 | Number of characters in the loaded job file name. |
| Job File Name | ARRAY[UINT8] (max 64) | 10 | Name of the loaded job file, including extension. Not null-terminated. Each register stores one character. |
| Buffer Count | UINT8 | 74 | Number of buffered scan output messages (when buffering is enabled). |
| Buffer Overflow | UINT8 | 75 | 0 = No overflow<br>1 = Overflow occurred; some scan data may have been lost. |

### Sample State

The Sample State block reports metadata and measurement data related to the most recent scan frame. It maps to the `Stamp` and `MeasurementValue` register assemblies and uses Class `0x04`, Attribute `0x03`, Instance ID 116 (`0x74`).

This assembly supports the `GetAttributeSingle (0x0E)` service and has a maximum size of 375 bytes.

| Information | Value |
|---|---|
| Register Assembly | Sample State register assembly |
| Supported Block Type Identifier | Stamp, MeasurementValue |
| Class | 0x4 |
| Instance | 116 (0x74) |

| Information | Value |
|---|---|
| Attribute Number | 3 |
| Max Size of Register Assembly | 375 bytes |
| Supported Service | GetAttributeSingle (0x0E) |

#### Stamp Block

The Stamp block provides frame-level metadata useful for alignment, timing, and synchronization across devices. Values reflect the most recent frame acquired by the system

| Field | Type | Offset (bytes) | Value |
|---|---|---|---|
| Z Position | INT64 | 0 | Encoder position at time of last index pulse of the last frame. |
| Encoder Position | INT64 | 8 | Encoder position at time of scan capture. |
| Time | UINT64 | 16 | Unique, monotonically increasing timetick of the last frame.<br>`Time (µs) = Timetick / 1.024` |
| Frame Index | UINT64 | 24 | Frame number of the last scan. |
| Digital Input States | UINT8 | 32 | Bitfield of digital inputs:Bit 0 = Digital Input 1Bit 1 = Digital Input 2 |
| Buffer (reserved) | UINT8[3] | 33-35 | Reserved. Unused padding bytes. |

#### Measurement Value Block

The MeasurementValue block returns the actual scan measurement value. GoPxL 1.2 does not support measurement + decision blocks—only measurement is reported.

| Field | Type | Offset (bytes) | Value |
|---|---|---|---|
| [measurement value] | INT32 | 0 | Measurement value ×1000. For example, 12.345 mm is sent as 12345. If the value is invalid, this field is set to 0x80000000. |

### Implicit Messaging Output

The Implicit Messaging Output object streams live scan data from GoPxL to the PLC. It maps to the `Sample State` register assembly, which includes both Stamp and MeasurementValue blocks `0x04`, Attribute `0x03`, Instance ID 101 (`0x65`).

| Information | Valu |
|---|---|
| Register Assembly | Sample State register assembly |
| Supported Block Type Identifier | Stamp, MeasurementValue |
| Class | 0x4 |
| Instance | 101 (0x65) |
| Attribute Number | 3 |
| Max Size of Register Assembly | 375 bytes |

#### Stamp Block

The Stamp block provides frame-level metadata useful for alignment, timing, and synchronization across devices. Values reflect the most recent frame acquired by the system

| Field | Type | Offset (bytes) | Value |
|---|---|---|---|
| Z Position | INT64 | 0 | Encoder position at time of last index pulse of the last frame. |
| Encoder Position | INT64 | 8 | Encoder position at time of scan capture. |
| Time | UINT64 | 16 | Unique, monotonically increasing timetick of the last frame.<br>`Time (µs) = Timetick / 1.024` |
| Frame Index | UINT64 | 24 | Frame number of the last scan. |
| Digital Input States | UINT8 | 32 | Bitfield of digital inputs:Bit 0 = Digital Input 1Bit 1 = Digital Input 2 |
| Buffer (reserved) | UINT8[3] | 33-35 | Reserved. Unused padding bytes. |

#### Measurement Value Block

The MeasurementValue block returns the actual scan measurement value. GoPxL 1.2 does not support measurement + decision blocks—only measurement is reported.

| Field | Type | Offset (bytes) | Value |
|---|---|---|---|
| [measurement value] | INT32 | 0 | Measurement value ×1000. For example, 12.345 mm is sent as 12345. If the value is invalid, this field is set to 0x80000000. |

## Ethernet ASCII Protocol

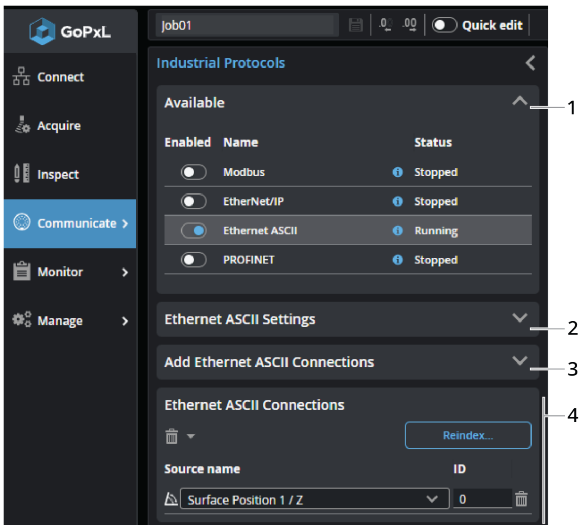
You can use a Programmable Logic Controller (PLC) that supports the Ethernet ASCII protocol to operate a sensor and receive values and decisions (together called results).

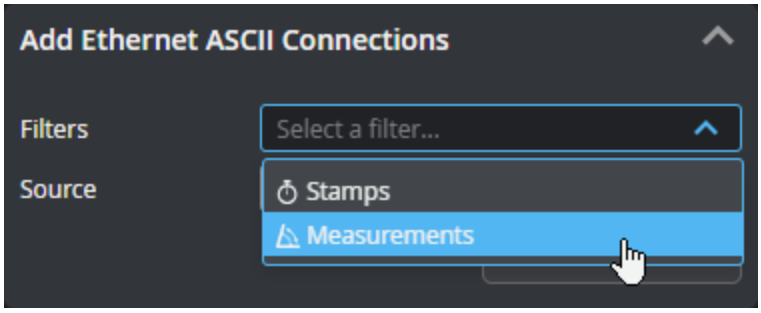
Two modes are available: asynchronous and polling.

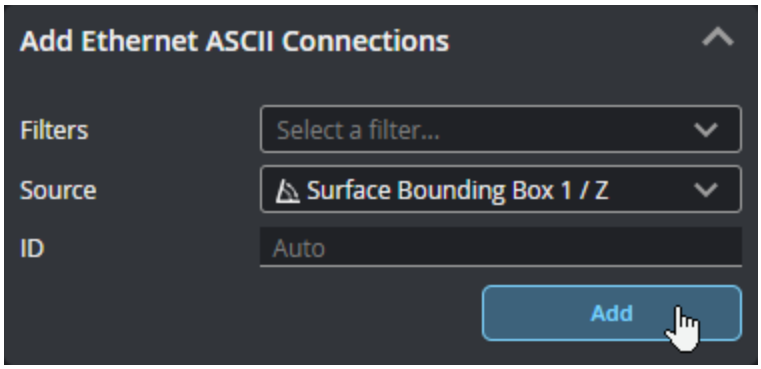
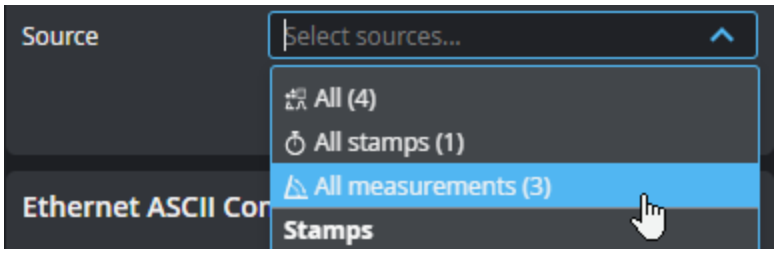
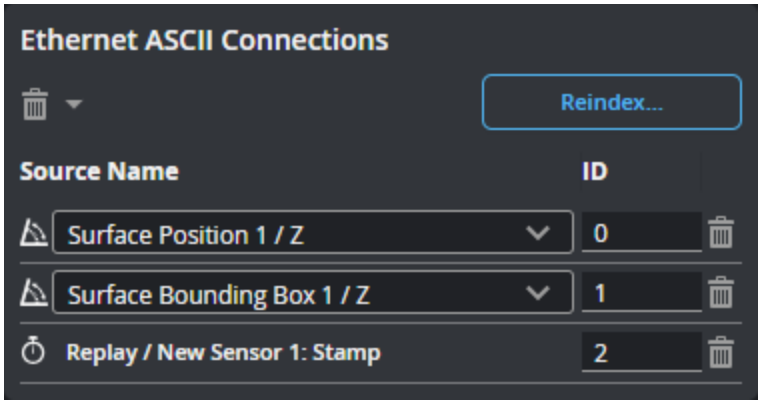
When the sensor is in asynchronous mode, results are sent automatically, as soon as they are available. Data is still available synchronously (that is polled) using the supported polling commands.

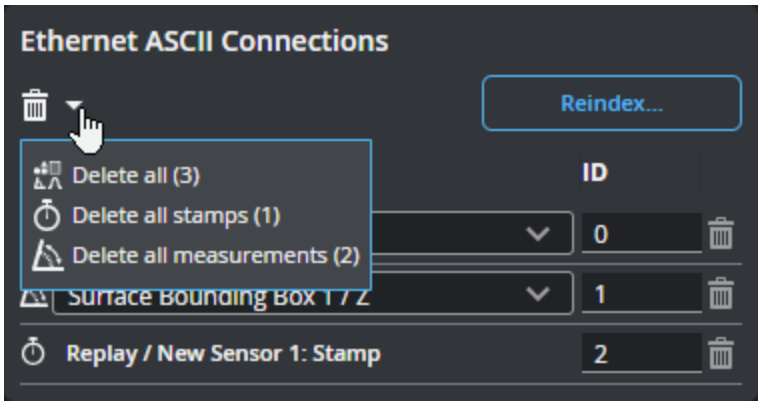
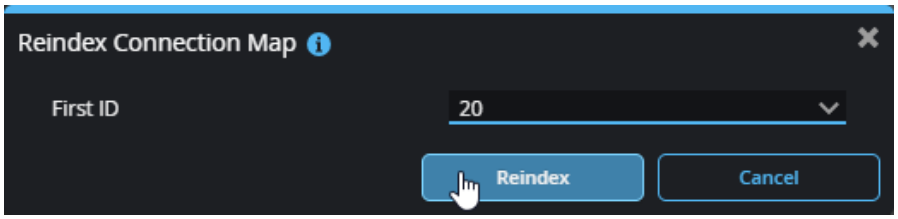
When the sensor is in polling mode (asynchronous mode is disabled), you must use commands on the PLC to operate the sensor and to retrieve results. Ethernet ASCII protocol in polling mode only supports a subset of the tasks that can be accomplished in the web interface, and only measurement results can be transmitted to the PLC (scan data is not sent).

You configure the protocol on the **Communicate** > **Industrial** page. After configuring the ASCII protocol parameters in GoPxL (see below), see *Ethernet ASCII Protocol Format - PLC Information* on page 768 for information on the available polling commands.

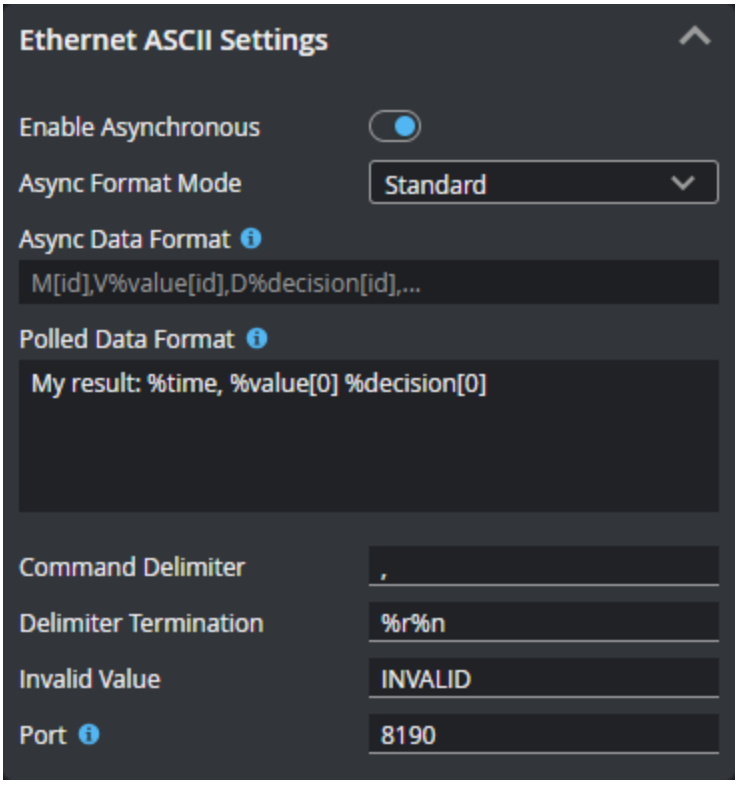



| | Element | Description |
|---|---|---|
| 1 | Available protocols | Click a row in the table to choose which protocol to configure. Enable a protocol by toggling the slider to the right. |
| 2 | Ethernet ASCII Settings | Lets you configure the Ethernet ASCII protocol.<br>For descriptions of the settings, see *Ethernet ASCII settings* on page 767. |
| 3 | Add Ethernet ASCII Connections | Lets you add sources (such as stamps or measurements) in the connection map. Added connections appear in the **Ethernet ASCII Connections** at the bottom of the panel.<br>If you have many sources, you can filter them by type to make it easier to find the source you want in the **Source** drop-down. You can select more than one filter at once.<br>  <br>Choose the source in the **Source** drop-down. If you leave **Address** as "Auto", GoPxL automatically increments the value; otherwise, you can set it yourself. By default, connections are added directly after the last source in the connections map. You can optionally set the address at which a source is added using the **Address** parameter. |

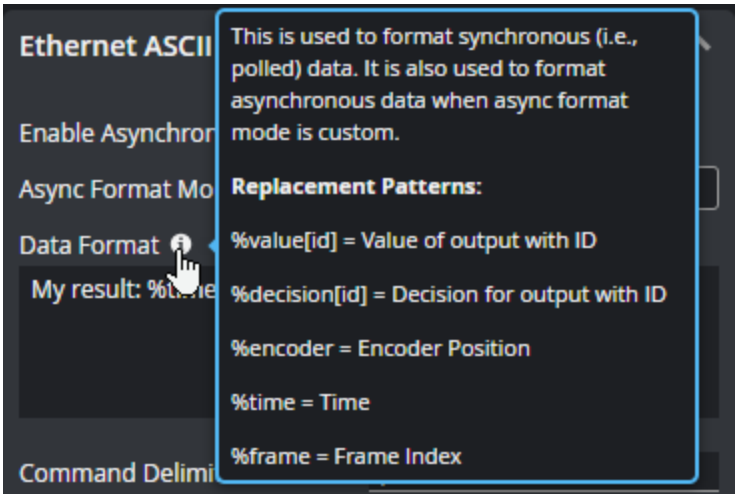
| | Element | Description |
|---|---|---|
| | |  <br>You can also add all sources, or all sources of a given type.<br>  <br>Click **Add** to add the source to the EtherNet/IP Connections table below. |
| 4 | Ethernet ASCII Connections | The connections listed here will be sent by the protocol to a compatible PLC.<br>You can delete a connection using the trashcan icon in its row, or change its ID.<br>  <br>You can also use shortcut commands to delete all of the connections, or specific categories of connections. |

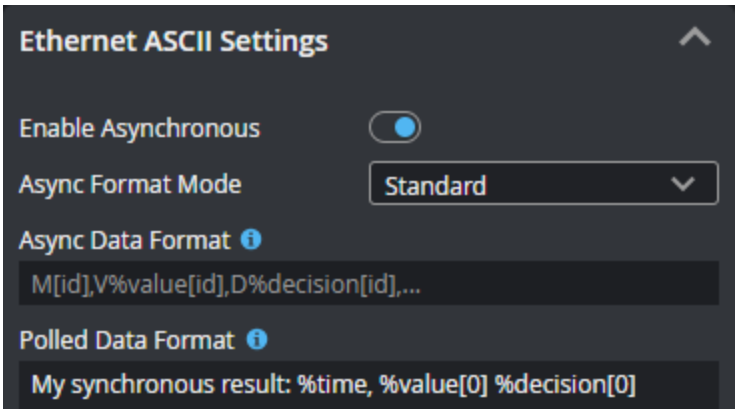
| Element | Description |
| --- | --- |
| |  <br>Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.<br>  |

The Ethernet ASCII protocol provides several settings you must configure. The settings that are displayed change depending on the operation mode (polling vs. asynchronous) and the format mode.



*Ethernet ASCII settings*

| Parameter | Description |
|---|---|
| Enable Asynchronous | Toggles asynchronous operation.<br>In asynchronous mode, the data results are transmitted when they are available. Choose the **Async Format Mode** and, if you chose Custom in **Async Data Format**, set the format. (These parameters are only displayed when asynchronous mode is enabled.) Note that when asynchronous mode is enabled, data is still available using polling commands.<br>When this option is disabled, the protocol only runs in polling (or synchronous) mode, and you must send commands on the data channel to request the latest result. For a list of the polling commands, see *Commands and Formats* on page 769. |
| Async Format Mode | When you enable asynchronous operation, you must choose the format mode. The format mode is one of the following: Standard, Standard with Stamp, and Custom. For more information on the formats, see below. |
| Async Data Format<br>and<br>Polled Data Format<br><br>Data Format | These fields contain the formats the protocol uses for the data it sends. GoPxL displays different "Format" fields depending on whether you enable asynchronous operation and what you set **Async Format Mode** to.<br>For details on the supported replacement patterns you can use in the formats, click on the info icon next to the field's name:<br>  <br><br>When asynchronous operation is disabled, you configure the format in **Data Format**.<br>When asynchronous operation is enabled and you choose either of the "Standard" modes, the format for asynchronous data is displayed in the read-only **Async Data Format** field. For polled data (which is always available), you can set a different format under **Polled Data Format**. |

| Parameter | Description |
|---|---|
| |  <br>In asynchronous mode, when you set the mode to Custom, you set the format for both asynchronous and polling data in the **Data Format** field.<br>C language *printf*-style formatting is also supported: for example, %sprintf[%09d, %value[0]]. This allows fixed length formatting for easier input parsing in PLC and robot controller logic. |
| Command Delimiter | Sets the command delimiter character. |
| Delimiter Termination | Sets the command termination character. |
| Invalid Value | Sets the invalid value characters. |
| Control Port | Sets the port. This is the port to which you PLC must connect. |

## Ethernet ASCII Protocol Format - PLC Information

You can use a programmable logic controller (PLC) that supports the Ethernet ASCII protocol to operate a sensor and receive values and decisions. To use the ASCII protocol, it must be enabled and configured in the active job. By default, the control port used to connect to the sensor is 8190. For information on enabling Ethernet ASCII, as well as changing the control port and other protocol configurations in GoPxL, see *Ethernet ASCII Protocol* on page 763.

Two modes are available: asynchronous and polling.

When the sensor is in asynchronous mode, results are sent automatically, as soon as they are available. No commands are required, but the client can still send a command to the sensor to receive output data or to control the device.

When the sensor is in polling mode, you use commands to operate the sensor and to retrieve results. Ethernet ASCII protocol in polling mode only supports a subset of the tasks that can be accomplished in the web interface, and only measurement results can be transmitted to the PLC (scan data is not sent).

This section describes the following aspects of the Ethernet ASCII protocol:

- the polling operation commands you can use to control a sensor and retrieve results from it
- result formats

The protocol communicates using ASCII strings. The output result format from the sensor is user-configurable.

**Commands and Formats**

Commands are sent from the client to the sensor. The commands are not case sensitive. However, the `readprop` command's metrics path argument *is* case sensitive.

The command format is:

<COMMAND><DELIMITER><PARAMETER><TERMINATION>

If a command has more than one parameter, each parameter is separated by the delimiter.

Similarly, the reply has the following format:

<STATUS><DELIMITER><OPTIONAL RESULTS><DELIMITER>

The status can either be "OK" or "ERROR". The optional results can be relevant data for the command if successful, or a text based error message if the operation failed. If there is more than one data item, each item is separated by the delimiter.

You can change the delimiter and termination characters in the **Special Character** settings in the GoPxL interface. For more information, see *Ethernet ASCII Protocol* on page 763.

Measurement IDs come from the **ID** field in the connection map. Be sure to add measurements to the connection map and make note of the IDs of the measurements you need to add to the data format.

**Ethernet ASCII client commands**

*Ethernet ASCII client commands*

| Command | Arguments | Description |
|---|---|---|
| start | - | Starts the sensor. |
| stop | - | Stops the sensor. |
| trigger | - | Software Trigger. |
| loadjob | Job name | Load the specified job file, up to 63 character long, including the last null terminating character. |
| result | - | Return the measurement data specified in the custom format string.<br>For a description of the measurement value (prefixed with the letter "V") and decision (prefixed with the letter "D") format, see *Measurement Output Format* on page 775. |
| | One or more measurement ids, separated by command delimiter. | Return the measurement data for each measurement id in the following format string: M[ID],V[VALUE],D[DECISION],...<br>Example: result,0,1<br>Output: OK,M0,V-5000,D0,M1,V5000,D1 |
| measurement | One or more | Return the measurement data for each measurement id in the |

| Command | Arguments | Description |
|---|---|---|
| | measurement ids, separated by command delimiter. | following format string: M[ID],V[VALUE],D[DECISION],...<br>For a description of the measurement value (prefixed with the letter "V") and decision (prefixed with the letter "D") format, see *Measurement Output Format* on page 775.<br>Example: measurement,0,1<br>Output: OK,M0,V-5000,D0,M1,V5000,D1 |
| value | One or more measurement ids, separated by command delimiter. | Return the measurement value for each measurement id in the following format string: M[ID],V[VALUE],...<br>For a description of the measurement value (prefixed with the letter "V") format, see *Measurement Output Format* on page 775.<br>Example: value,0,1<br>Output: OK,M0,V-5000,M1,V5000 |
| decision | One or more measurement ids, separated by command delimiter. | Return the measurement decision for each measurement id in the following format string: M[ID],D[DECISION],...<br>For a description of the measurement decision (prefixed with the letter "D") format, see *Measurement Output Format* on page 775.<br>Example: decision,0,1<br>Output: OK,M0,D0,M1,D1 |
| stamp | - | Return the time, encoder and frame index stamp values for the first stamp id found.<br>Order of values returned is: Time, Encoder, Frame.<br>For the "time" argument, this is the timetick of the last frame.<br>A timetick is a 64-bit positive integer that is guaranteed to increase monotonically starting from zero. It is guaranteed to be unique for every scan from a given sensor group.<br>To convert this value to microseconds, use the following:<br>`time in microseconds = timetick / 1.024`<br>Example: stamp<br>Output: OK,Time,381497381349,Encoder,0,Frame,18, |
| | One or more of these arguments in any order, separated by the command delimiter:<br>"time"<br>"encoder"<br>"frame" | Return the specified stamp value(s) in the order of the provided arguments.<br>Example: stamp,time,frame<br>Output: OK,381497381349,18 |
| | A stamp ID. | Return the time, encoder, and frame index stamp values for the passed stamp ID. |

| Command | Arguments | Description |
|---|---|---|
| | | Example: stamp,1 |
| time | One or more stamp ids, separated by command delimiter. | Return the stamp's time value for each stamp id.<br>The timetick of the last frame.<br>A timetick is a 64-bit positive integer that is guaranteed to increase monotonically starting from zero. It is guaranteed to be unique for every scan from a given sensor group.<br>To convert this value to microseconds, use the following:<br>`time in microseconds = timetick / 1.024`<br>Example: time,1<br>Output: OK,381497381349 |
| encoder | One or more stamp ids, separated by command delimiter. | Return the stamp's encoder value for each stamp id.<br>Example: encoder,1<br>Output: OK,0 |
| frame | One or more stamp ids, separated by command delimiter. | Return the stamp's frame index stamp value for each stamp id.<br>Example: frame,1<br>Output: OK,18 |
| align | - | Performs the alignment operation. |
| clearalign | - | Clears sensor alignment. |
| readprop | One or more strings representing a resource whose property to return, separated by command delimiter. | Returns the resource JSON object specified by the resource path.<br>It is possible to use JSON pointers to retrieve a specific value within the JSON document.<br><br>Example #1: readprop,/system<br>Output: OK,{"_links":{"self":{"href":"/system"}},"_schema": {"properties":{"autoLiveSimEnabled":{"sortOrder":200,"title": "autoLiveSimEnabled","type":"boolean"},"autoStart":{"sortOrder": 100,"title":"autoStart","type":"boolean"},"runState":{"enum": [0,1,2],"enumText": ["Ready","Running","Conflict"],"readOnly":true,"sortOrder":0,"title": "runState","type":"integer"}},"sortOrder":0,"title":"","type":"object"}, "autoLiveSimEnabled":true,"autoStart":true,"runState":1},<br><br>Example #2: readprop,/system#/runState,/system#/autostart<br>Output: OK,1, true,<br><br>Example #3: readprop,/jobs#/loadedJob<br>Output: OK,"Job02", |

| Command | Arguments | Description |
|---|---|---|
| | | Example #4: readprop,/jobs#/loadedJobDirty<br>Output: OK,false, |

The following lists the possible errors for each command.

*Ethernet ASCII error handling*

| Command | Arguments | Description |
|---|---|---|
| start | ERROR,Could not start the sensor | |
| stop | ERROR,Could not stop the sensor | |
| trigger | ERROR,Could not trigger | |
| loadjob | ERROR,Job name required. | Job name has to be provided as a command argument. |
| | ERROR,Failed to load job <job name>.job | |
| result | ERROR,There is no measurement data to output. Please confirm that the sensor is running | Could not find any measurements. Make sure protocol's connection map is not empty and the sensor is running. |
| | ERROR,Invalid parameter. Please verify your input | Provided command argument was invalid. It must be a number. |
| | ERROR,Specified measurement ID not found. Please verify your input | Could not find a measurement data for specified ID. |
| | ERROR,The custom format string is not valid. Please verify your input | Custom format string is invalid. |
| measurement | ERROR,One or more measurement id must be provided | Measurement ID has to be provided as an argument. |
| | ERROR,There is no measurement data to output. Please confirm that the sensor is running | Could not find any measurements. Make sure protocol's connection map is not empty and the sensor is running. |

| Command | Arguments | Description |
|---|---|---|
| | ERROR,Invalid parameter. Please verify your input | Provided command argument was invalid. It must be a number. |
| | ERROR,Specified measurement ID not found. Please verify your input | Could not find a measurement data for specified ID. |
| value | ERROR,One or more measurement id must be provided | Measurement ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided command argument was invalid. It must be a number. |
| | ERROR,Measurement with ID not found. | Could not find a measurement data for specified ID. |
| decision | ERROR,One or more measurement id must be provided | Measurement ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided command argument was invalid. It must be a number. |
| | ERROR,Measurement with ID not found. | Could not find a measurement data for specified ID. |
| stamp | ERROR,Invalid stamp command format | Invalid command arguments. |
| | ERROR,One or more stamp id must be provided | Stamp ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided stamp ID was invalid. It must be a number. |
| | ERROR,Stamp with ID not found | Could not find a stamp data for specified ID. |
| time | ERROR,One or more stamp id must be provided | Stamp ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided stamp ID was invalid. It must be a number. |
| | ERROR,Stamp with ID | Could not find a measurement data for specified ID. |

| Command | Arguments | Description |
|---|---|---|
| | not found | |
| encoder | ERROR,One or more stamp id must be provided | Stamp ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided stamp ID was invalid. It must be a number. |
| | ERROR,Stamp with ID not found | Could not find a measurement data for specified ID. |
| frame | ERROR,One or more stamp id must be provided | Stamp ID must be provided as an argument. |
| | ERROR,Invalid parameter. Please verify your input | Provided stamp ID was invalid. It must be a number. |
| | ERROR,Stamp with ID not found | Could not find a measurement data for specified ID. |
| align | ERROR,Could not align | |
| clearalign | ERROR,Could not clear alignment | |
| readprop | ERROR,String representing a resource must be provided | Resource path must be provided as an argument. |
| | ERROR,Could not read property | Resource may not exist. |

**Data Output Format Mode**

## Polling Mode

Polled data output is displayed using the custom format. You can modify this format in the GoPxL interface. For more information, see *Ethernet ASCII Protocol* on page 763. Because polling mode is always available, even when asynchronous output is enabled, you can always modify the custom format.

| Format Mode | Description |
|---|---|
| Custom | This format can be changed/edited by the user.<br>The default format is: %time, %value[0] %decision[0] |

## Asynchronous Mode

When asynchronous output mode is enabled, the data output can be in one of three formats:

| Format Mode | Description |
|---|---|
| Standard | This is a pre-defined format that cannot be changed:<br>M[id],V%value[id],D%decision[id],... |
| Standard with Stamp | The format is the Standard format pre-pended with the time and encoder information.<br>This is a pre-defined format that cannot be changed:<br>T%time,E%encoder,M[id],V%value[id],D%decision[id],.. |
| Custom | This format is the same as the format used by polling mode. You can change this in the GoPxL interface. For more information, see *Ethernet ASCII Protocol* on page 763.<br>Default format: %time, %value[0] %decision[0] |

## Measurement Output Format

A measurement contains the fields described below.

| Field | Type | Address offset | Description |
|---|---|---|---|
| Value | 32s | 0 | Measurement value. This value is the actual measurement value multiplied by 1000.<br>If the measurement value is invalid, the string "INVALID" is the output for the measurement value. |
| Decision | 8u | 4 | Measurement decision.<br>Bit 0:<br>0 = Fail<br>1 = Pass<br>Bit 1:<br>0 = Decision value is valid<br>1 = Decision value is invalid |

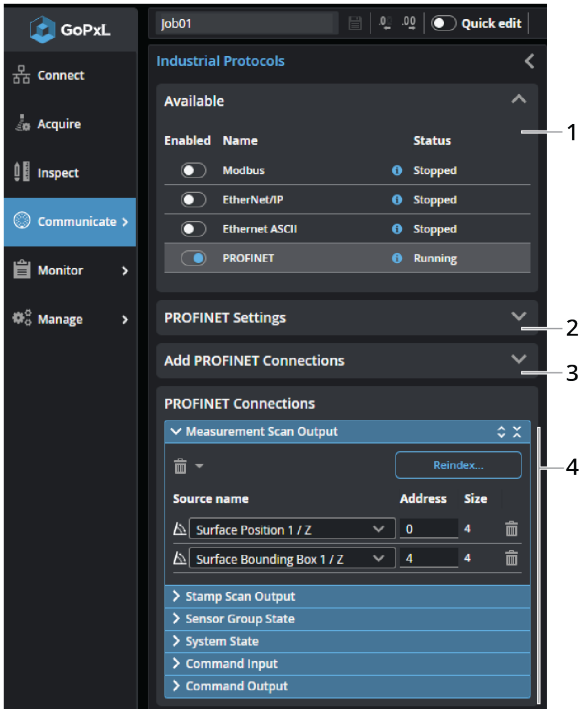
## PROFINET Protocol

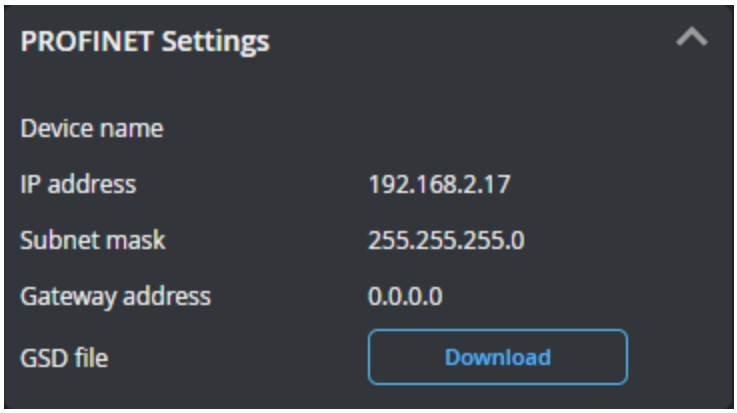
You can use a PROFINET Programmable Logic Controller (PLC) over Ethernet to operate a sensor and receive measurement values. PROFINET only supports a subset of the tasks that can be accomplished in the web interface (for example, starting, stopping, and aligning sensors, and switching Jobs). Scan data can't be sent to the PLC.

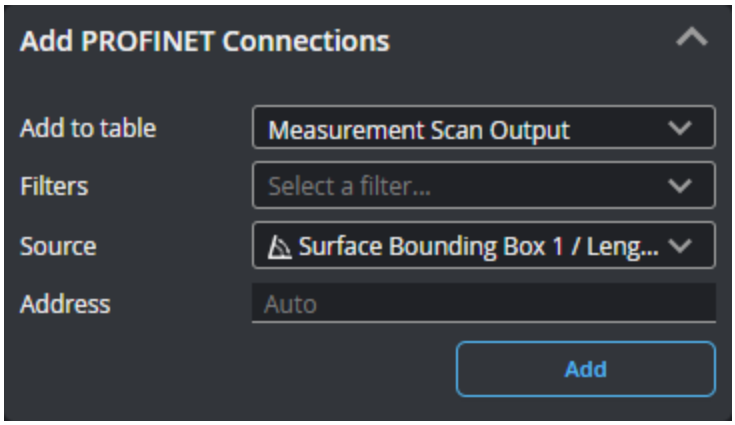
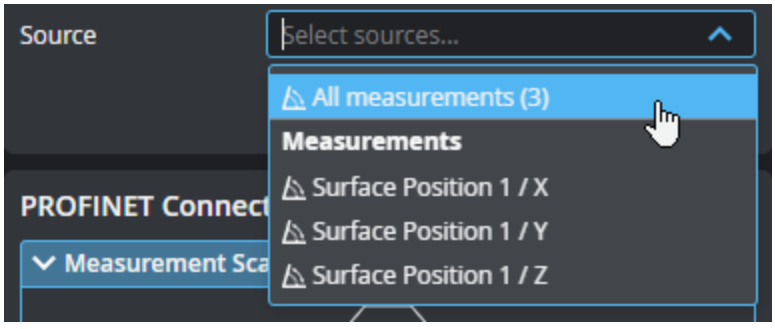
GoPxL supports PROFINET on sensors, on GoMax ORIN / ORIN+ / NX, and in PC instances of GoPxL.

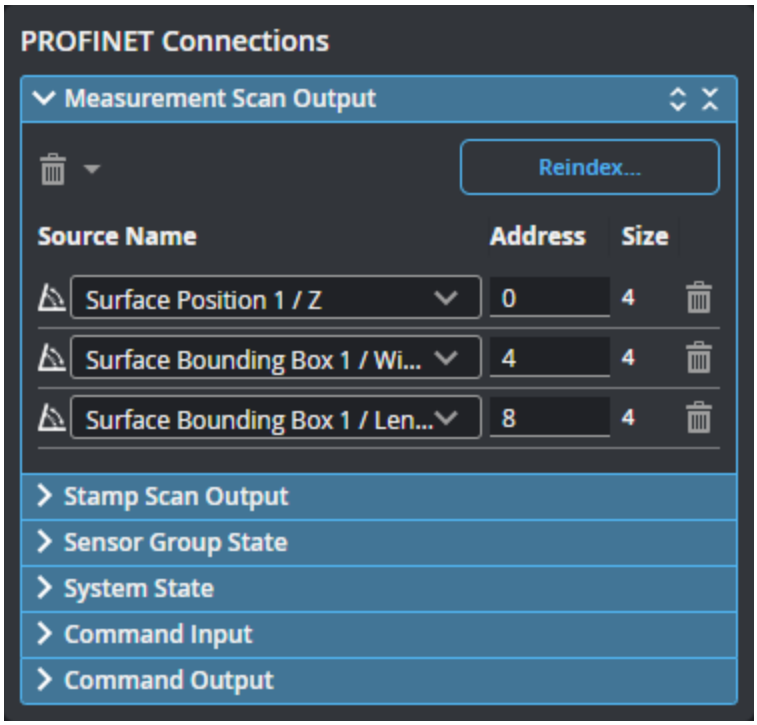
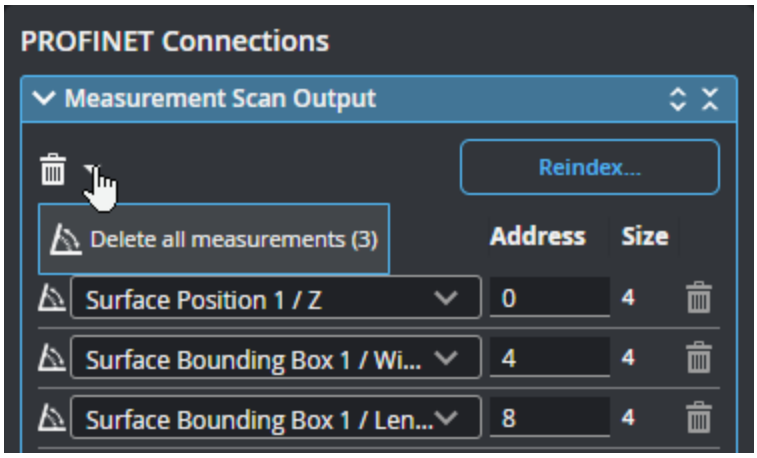
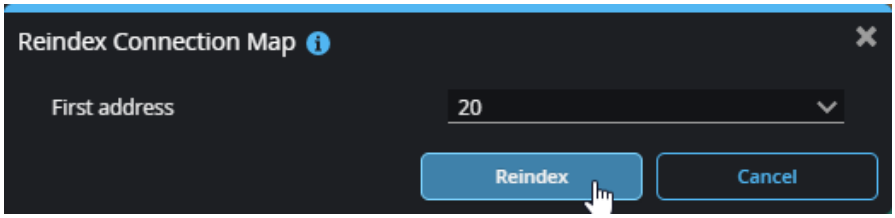
Due to library limitations, PROFINET cannot be stopped manually after it has started. To stop it, disable the service (an error will be displayed in the log), save your job file, and restart the sensor.

You configure the protocol on the **Communicate** > **Industrial** page. After configuring the PROFINET protocol in GoPxL (see below), use the information in *PROFINET Protocol Format - PLC Information* on page 780 to configure your PLC.




| | Element | Description |
|---|---|---|
| 1 | Available protocols | Click a row in the table to choose which protocol to configure. Enable a protocol by toggling the slider to the right. |
| 2 | PROFINET Settings |  <br>**GSD File**<br>Click **Download** to save a GSD file to the client computer for later installation on the PLC.<br><br>This section also provides network information. |

| | Element | Description |
|---|---|---|
| 3 | Add PROFINET Connections | Lets you add sources (such as stamps or measurements) to send over the protocol. Added connections appear in the **PROFINET Connections** section at the bottom of the panel.<br><br>When GoPxL is running on a standalone sensor (one not controlling others), **Add to Table** only contains two options (Measurement Scan Output and Stamp Scan Output), which represent register assemblies. When GoPxL is running on a sensor controlling other sensors, or on a PC or GoMax NX, **Add to Table** contains an additional entry (Sensor Group State). Use this parameter to choose which register a source is added to.<br><br>Choose the source in the **Source** drop-down. If you leave **Address** as "Auto", GoPxL automatically increments the value; otherwise, you can set it yourself. By default, connections are added directly after the last source in the connections map. You can optionally set the address at which a source is added using the **Address** parameter.<br><br>  <br><br>You can also add all sources, or all sources of a given type.<br><br>  <br><br>Click **Add** to add the source to the PROFINET Connections table below. |
| 4 | PROFINET Connections | The connections listed here are the ones that will be sent by the protocol to a compatible PLC.<br><br>You can delete a connection using the trashcan icon in its row, or change its ID. When changing an ID, make sure to use the size of the source to correctly |

| Element | Description |
| --- | --- |
| | calculate the minimum offset.<br>  <br><br>You can also use shortcut commands to delete all of the connections, or specific categories of connections.<br>  <br><br>Use **Reindex...** to remove gaps of unused addresses between connections. You can also set the value of the first index.<br>  <br> |

### Using PROFINET on a PC

If you are using PROFINET on a PC (using the GoPxL Manager or software developed using the GoPxL SDK), be aware of the following:

- The PC instance must either run in Administrator or be installed as a service. Otherwise, the TIA portal will not be able to discover the instance.
- The IP address of the PC instance must be a specific hardware address (such as the PC's network adapter), and not the "Any IP (0.0.0.0)" or "Localhost (127.0.0.1)".
- You must install a pcap-API compatible driver such as as Npcap or WinPcap. This lets the PC capture and send the raw network traffic necessary for the PC to interact directly with the PROFINET protocol.
- Because Windows is not a realtime OS, you must fully test a PC-based sensor system and limit the use of unnecessary software. Otherwise, you might encounter timing issues, and PLC requirements may not be met or connections may get dropped. The PC should have a CPU able of handling occasional processing spikes from either Windows or other software.

For information on running GoPxL on a PC, see *Running GoPxL on a Windows PC* on page 814.

## PROFINET Protocol Format - PLC Information

PROFINET is an Industrial Ethernet network protocol that allows controllers such as PLCs to communicate with sensors. Sensors are PROFINET IO devices with Conformance Class A.

> The connection mappings for the industrial protocols (PROFINET, EtherNet/IP, and Modbus) have changed to correct a byte alignment issue. To allow communication between PLCs and GoPxL 1.2, you may need to update PLC logic created for GoPxL 1.1.
>
> For EtherNet/IP, the EDS file has been updated to reflect the changes.

GoPxL supports PROFINET communication to provide system state, sensor group state, stamp, and measurement output data to a PLC, as well as accept incoming commands. PROFINET defines the entire data exchange between controllers (called "IO-Controllers") and the devices (called "IO-Devices"). GoPxL operates as a PROFINET IO-Device, and a PLC that connects to it acts as the PROFINET IO-Controller. All communication is initiated by the PLC, with GoPxL responding to the PROFINET requests.

> GoPxL supports PROFINET on sensors, on GoMax ORIN / ORIN+ / NX, and in PC instances of GoPxL.

If you are using PROFINET on a PC, see *Using PROFINET on a PC* on the previous page for important information.

While the PROFINET protocol includes several types of requests, the two basic operations are reading and writing PROFINET objects. Commands are invoked by the PLC sending *set* requests. Data is requested by the PLC by sending *get* requests for PROFINET objects.

### Connections Map

The PROFINET protocol supports the following objects.

#### Assembly Objects

A register assembly is a container that contains register blocks. This is a one-to-one mapping, which means each PROFINET module will have a corresponding control framework register assembly. These modules are added to the GoPxL irrespective of the selection of register assembly, but the data is added to this PROFINET module based on the selection of register assembly.

*Assembly Objects*

| PROFINET Module Name | Register assembly | Supported Register Block Types | Service | Instance ID | Slot Number |
|---|---|---|---|---|---|
| Command input module | Control Input register assembly | "ControlInput" | Write | 0x30 | 1 |
| Command output module | Control Output register assembly | "ControlOutput" | Read | 0x31 | 2 |
| System State module | System State register assembly | "System" | Read | 0x32 | 3 |
| Stamp module | Sample State register assembly | "Stamp" | Read | 0x33 | 4 |
| Measurement module | Sample State register | "MeasurementValue" | Read | 0x34 | 5 |

| PROFINET Module Name | Register assembly | Supported Register Block Types | Service | Instance ID | Slot Number |
|---|---|---|---|---|---|
| | assembly | | | | |
| Sensor Group State module | Sensor Group State register assembly | "Scanner" | Read | 0x35 | 6 |

The PROFINET protocol supports various block types. Each block type can be either an input block or an output block. Input blocks contain write-only objects and are used by the PROFINET IO-Controller to send commands such as starting or stopping a scan. Output blocks contain read-only objects and are used to store various types information, such as control, system, and sensor group state data as well as scan output data (stamp and measurements).

#### Supported Block Types

The block types supported by the PROFINET protocol are listed in the table below. The size field indicates the number of registers that each block type requires.

*Supported Block Types*

| Block Type | Read or Write only? | Size (number of PROFINET registers) | Description |
|---|---|---|---|
| "ControlInput" | WO | 67 | Command message set by the PROFINET IO-Controller. |
| "ControlOutput" | RO | 3 | Result data corresponding to a command that was written to the Control Input block. |
| "MeasurementValue" | RO | 4 | Measurement data of a scan output measurement data message. |
| "Scanner" | RO | 18 | Information about a specific sensor group. |
| "Stamp" | RO | 36 | Stamp message information. |
| "System" | RO | 76 | Information about the LMI device. |

### Control Input

The input of the Control Input Block contains the fields described below:

*Control Input Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Command Sequence Number | 16u | 0 | The command sequence number is set by the external IO-Controller to uniquely identify a command request. This number is sent back in the Control Output.<br>This is an optional field but is recommended that PROFINET IO-Controllers use this to help the IO-Controllers correlate the Command Status in the Control Output with a specific command request in Control Input. |
| Command Identifier | 8u | 2 | Identifies the requested action from the external client.<br>Supported actions: |

| Field | Type | Address offset | Description |
|---|---|---|---|
| | | | 0 = No Command<br>1 = Start Scanning<br>2 = Stop Scanning<br>3 = Align Sensor Group<br>4 = Clear Alignment<br>5 = Load Job File<br>6 = Software Trigger |
| Unused | UINT8 | 3 | Reserved. |
| Command Arguments | Array[8u] | 4 | Arguments for commands that require arguments.<br>For the Load Job File command, the command arguments will contain the null terminated job file name. The job file name must not include the job file extension. The job extension is automatically appended by the PROFINET IO-Device.<br>This field takes up a maximum of 64 registers. Each byte contains a single character. |

## Control Output

The output of the Control Output Block contains the fields described below:

*Control Output Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Command Sequence Number | 16u | 0 | The command sequence number received from the IO-Controller in the Control Input. |
| Command Status | 8u | 2 | Status of the command, referenced by the Command Sequence Number.<br>0 = No Command Received<br>1 = In Progress<br>2 = Success<br>3 = Fail |

## System State

The output of the System State Block contains the fields described below:

*System State Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| System Uptime | 64u | 0 | Amount of time the application has been running, in seconds. |
| System State | 8u | 8 | Whether system is running or not.<br>0 = System is stopped |

| Field | Type | Address offset | Description |
|---|---|---|---|
| | | | 1 = System is running |
| Current Job File Name Length | 8u | 9 | Number of characters in the current job file name. |
| Current Job File Name | Array[8u] | 10 | Name of the job file currently loaded into the system, without the extension.<br>Maximum length of job file name is 64 characters. Each register contains a single character.<br>Job file name is NOT null terminated. |
| Buffer Count | 8u | 74 | The current amount of buffered scan output data when buffering is enabled. |
| Buffer Overflow | 8u | 75 | A value of 0 indicates that no overflow has occurred.<br>A value of 1 indicates that overflow occurred and data is being lost. |

## Sensor Group State

The output of the Sensor Group Block contains the fields described below:

*Sensor Group State Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Current Encoder Position | 64s | 0 | The current encoder position. |
| Current Sync Time | 64u | 8 | Current time of the clock used to stamp all scan output messages, in microseconds. |
| Alignment State | 8u | 16 | Indicates whether all devices under the sensor group are aligned (that is, all devices in the sensor group have a non-identity transform matrix).<br>0 = Not Aligned<br>1 = Aligned<br>2 = Aligning |
| Laser Enabled | 8u | 17 | Whether one or more devices under a sensor group has its laser enabled to be able to turn on.<br>0 = All devices' lasers are disabled and cannot turn on<br>1 = One or more devices' lasers can be turned on |

## Stamp

The output of the Stamp Block contains the fields described below:

*Stamp Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Z Position | 64s | 0 | Encoder position at time of last index pulse of last frame. |
| Encoder Position | 64s | 8 | Encoder position of last frame when the image data was scanned/taken. |
| Time | 64u | 16 | The timetick of the last frame.<br>A timetick is a 64-bit positive integer that is guaranteed to increase monotonically starting from zero. It is guaranteed to be unique for every scan from a given sensor group.<br>To convert this value to microseconds, use the following:<br>`time in microseconds = timetick / 1.024` |
| Frame Index | 64u | 24 | The frame number of the last frame. |
| Digital Input States | 8u | 32 | Digital input states of last frame.<br>Bit 0: State of digital input 1 on master or sensor<br>Bit 1: State of digital input 2 on master or sensor |
| Buffer | 8u | 33 | Unused |
| Buffer | 8u | 34 | Unused |
| Buffer | 8u | 35 | Unused |

### Measurement

The output of the Measurement Block contains the fields described below:

*Measurement Fields*

| Field | Type | Address offset | Description |
|---|---|---|---|
| Value | 32s | 0 | Measurement value. This value is the actual measurement value multiplied by 1000.<br>If the measurement value is invalid, the 32-bit value is set to 0x80000000. |

## Digital Output

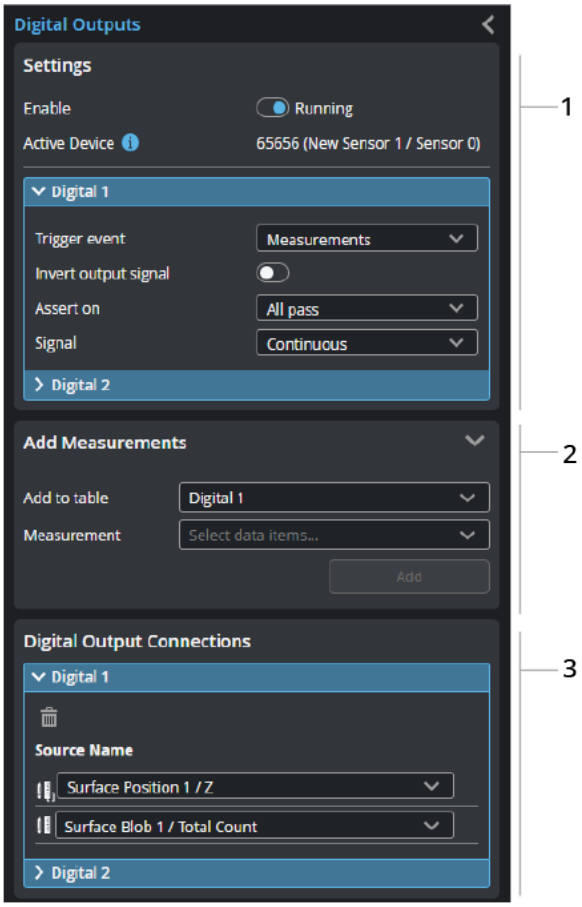
GoPxL can send digital signals over a sensor's digital outputs based on measurement decisions, software commands, and other events. These signals can then be used to control a PLC or other external device, such as indicator lights or air ejectors. The following trigger events are available:

- Measurements
- Software (that is, a command sent from GoPxL SDK applications)
- Alignment state
- Exposure begin or end
- Part detection
- System state (that is, when the system is ready to accept digital input triggers)

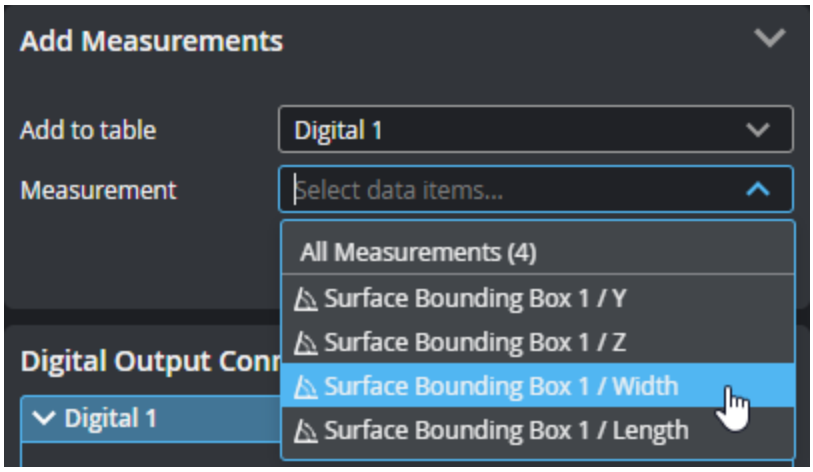
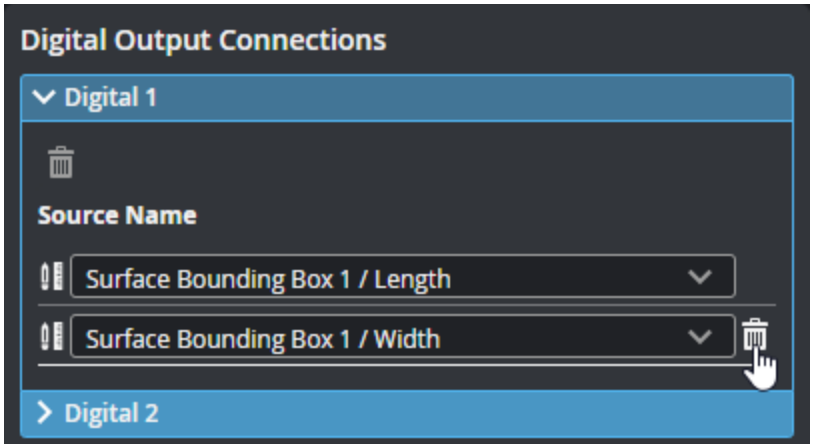
GoPxL provides two digital output channels. For information on wiring digital outputs to external devices, see the following: *Digital Outputs* on page 978.

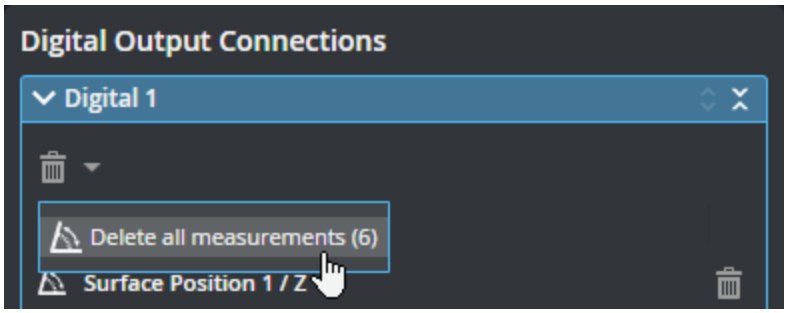
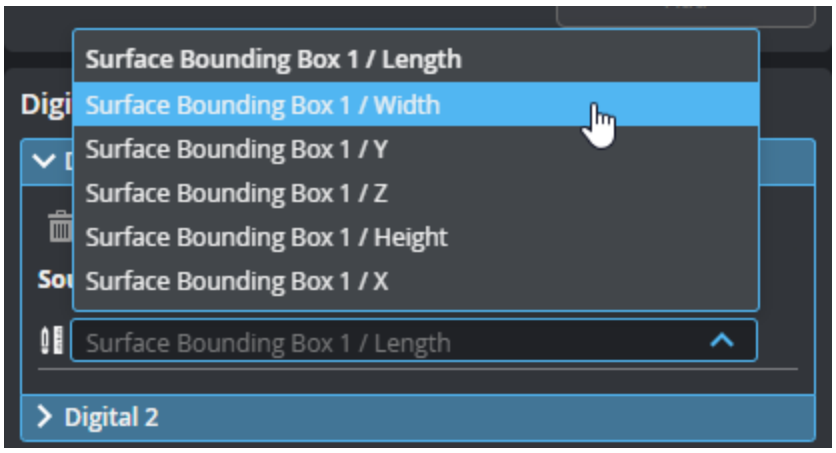
Counts of low and high digital signals, as well as digital output drops, are available on the **Health** page, in the expandable **Sensor {n}** sections. For more information, see *Health* on page 796.

> Digital outputs cannot be used when taking scans using the Snapshot button, which takes a single scan and is typically used to test measurement tool settings. Digital outputs can only be used when a sensor is running, taking a continuous series of scans.




| | Element | Description |
|---|---|---|
| 1 | Settings | **Enable** lets you enable digital output.<br>**Active Device** shows which sensor's digital output port GoPxL will send digital signals.<br>Each expandable "Digital {n}" section lets you choose the type of trigger event and configure settings related to the signal. When you set **Trigger event** to Measurements, you use the **Add Measurements** and **Digital Output Connections** sections to add and manage the measurements that GoPxL sends as digital outputs. Otherwise, a digital signal is sent when the selected trigger event occurs.<br>For information on the trigger settings, see *Digital Output Settings* on page 787. |
| 2 | Add Measurements | Lets you choose a measurement and which digital output the signal is sent over. |

| | Element | Description |
|---|---|---|
| | | This section is only displayed if at least one digital output's trigger is set to Measurements.<br>To set a measurement for digital output, choose the output in **Add to table**, choose the measurement in **Measurement**, and click **Add**. You can also add all measurements at once by selecting "All Measurements".<br>  <br>After adding a measurement, it appears in the **Digital Output Connections** section of the digital output you chose. |
| 3 | Digital Output Connections | Lets you view, delete, and change the measurements that trigger a digital output signal.<br>This section is only displayed if at least one digital output's trigger is set to Measurements.<br>To delete a measurement, click the trashcan icon next to it.<br>  <br>You can also use shortcut commands to delete all of the connections. |

| Element | Description |
| --- | --- |
| |  <br>To change a measurement, click an output's drop-down and choose a different measurement.<br>  |

*Digital Output Settings*

| Parameter | Description |
| --- | --- |
| Trigger event | GoPxL can send a digital output signal when one of several trigger events occurs. Depending on the event you choose, other parameters are displayed that you may need to configure. For more information, see the other parameter descriptions below.<br><br>**Measurements**<br>GoPxL sends a digital signal based on the decisions, for each frame, returned by the measurements added to the digital output. Set **Signal** to choose between a pulsed or continuous signal. Optionally, set a pulsed signal to be scheduled with **Scheduled**. You must set **Assert on** to configure what types of measurement decisions result in a digital signal.<br><br>**Software**<br>When GoPxL receives a software command from a GoPxL SDK application, it sends a digital signal over the configured digital output. Use **Signal** to choose between a pulsed or continuous signal. Optionally, set a pulsed signal to be scheduled with **Scheduled**. For pulsed or scheduled pulse, the sensor must be scanning before |

| Parameter | Description |
| --- | --- |
| | sending the command. For continuous signal, the sensor does not have to be scanning<br><br>**Alignment**<br>When a sensor is in an aligned state, GoPxL sends a continuous digital signal. Only alignment performed using the **Alignment** routine on the **Acquire** page results in a trigger event (for more information, see *Aligning Sensors with up to 5 Degrees of Freedom* on page 98): alignment performed using the Surface Align Wide or Surface Align Ring tools does not. Whether the sensor is running does not affect the output.<br><br>**Exposure begin**<br>GoPxL sends a pulsed digital signal with the provided pulse width when exposure begins.<br><br>**Exposure end**<br>GoPxL sends a pulsed digital signal with the provided pulse width when exposure ends.<br><br>**Part detection**<br>You can use GoPxL's part detection capabilities as a digital output trigger. This lets you use the sensor as a photo-eye, for example, eliminating the cost of installing a separate photo-eye. In this mode, GoPxL sends a continuous digital signal if the part detection logic is currently scanning at least one part, that is, GoPxL determines it is currently "in" at least one part. When GoPxL is no longer scanning a part, the signal goes low.<br><br>**System state**<br>GoPxL sends a continuous digital signal when the sensor is ready to receive digital input to start triggering for scanning when the following modes are set on the **Acquire** page:<br>• "External Input" triggering enabled in **Source** in the **Trigger** panel.<br>• "Fixed Length" surface generation type enabled in the **Scan mode** panel with **Start trigger** set to "External Input".<br>• "Variable Length" surface generation.<br>For more information on triggers, see *Triggers* on page 120.<br>For more information on surface generation, see *Surface Generation* on page 113. |
| Invert output signal | Inverts the output signal. Normally, GoPxL will send a high digital signal when an event occurs. Toggling this setting causes GoPxL to send a low signal when the |

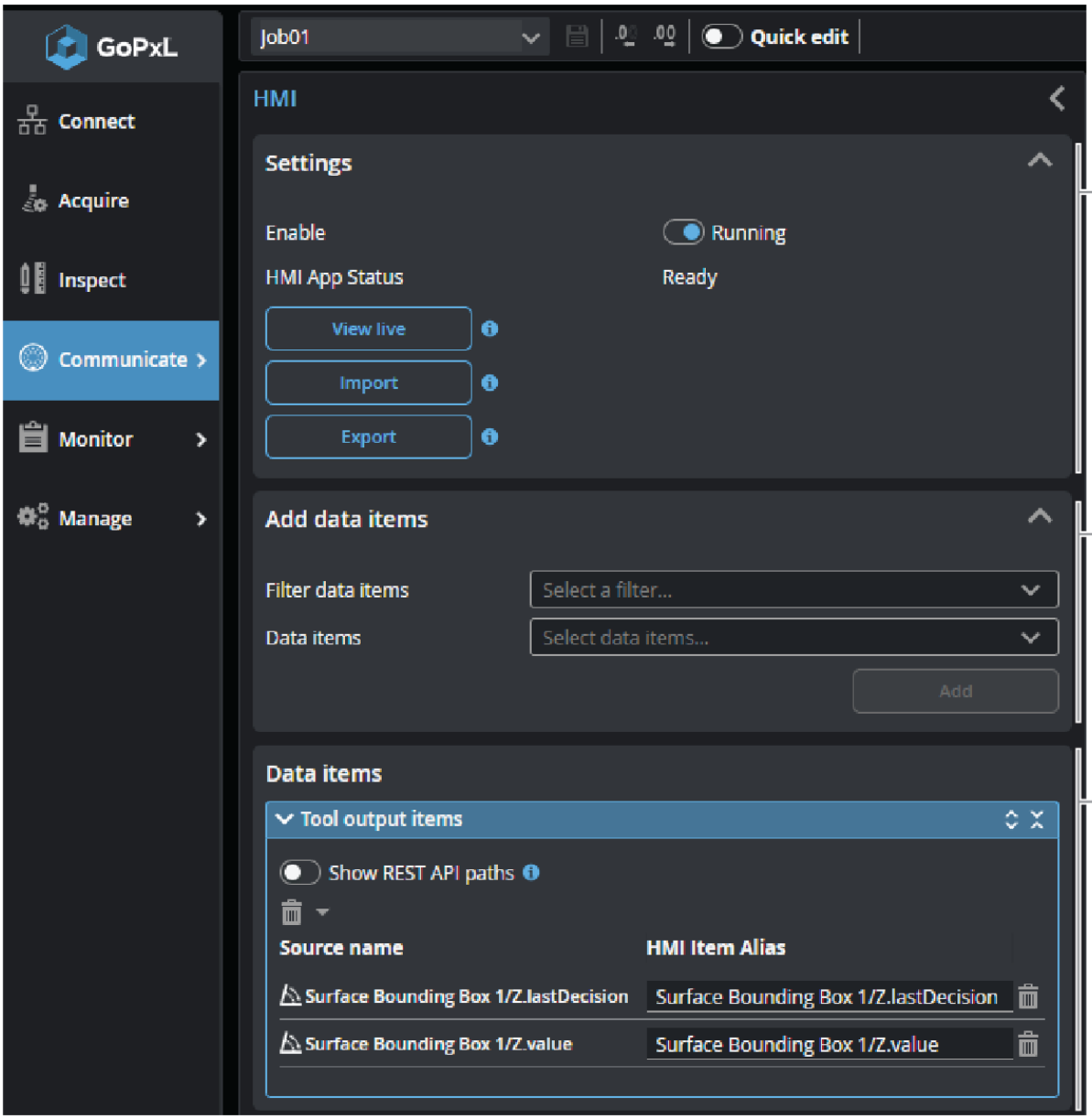
| Parameter | Description |
| --- | --- |
| | event occurs. |
| Assert on | When **Trigger event** is set to Measurement, use this setting to determine which type of decision in the measurements added to the output in **Digital output connections** cause GoPxL to send a digital signal. GoPxL checks decisions for each frame. One of the following:<br><br>**All pass**: If all added measurements return a pass decision, GoPxL sends a digital signal.<br><br>**Any fail or invalid**: If any added measurement returns a fail decision or Invalid, GoPxL sends a digital signal.<br><br>**Always**: GoPxL sends a digital signal, for each frame, after the tools producing the selected decisions have finished processing, regardless of the result (pass, fail, or invalid). The output activates only once for each frame even if multiple decision sources are selected. LMI recommends using pulsed digital signals with this mode, as otherwise the signal will remain high indefinitely. |
| Signal | Measurement and Software trigger events let you choose the signal type (pulsed or continuous).<br><br>**Pulsed**<br>GoPxL sends a pulsed signal over the digital output, using the value you set in **Pulse width**.<br><br>**Continuous**<br>GoPxL sends a continuous signal over the digital output. When the trigger event is Measurement and **Assert on** is set to always, LMI recommends using pulsed digital signals instead of continuous. |
| Pulse width | The pulse width used when the signal type is pulsed. Note that Measurement and Software trigger events let you choose between pulsed and continuous, whereas the exposure types are always pulsed. |
| Scheduled | When this setting is enabled, you can set a delay using **Delay** and **Delay Domain**.<br>Only Measure and Software trigger events let you schedule output. |
| Delay Domain | The delay and domain GoPxL uses when **Scheduled** is enabled. The delay domain is either time-based or based on encoder distance. |
| Delay | The unit depends on whether the domain is time (microseconds) or encoder (millimeters). |

## HMI

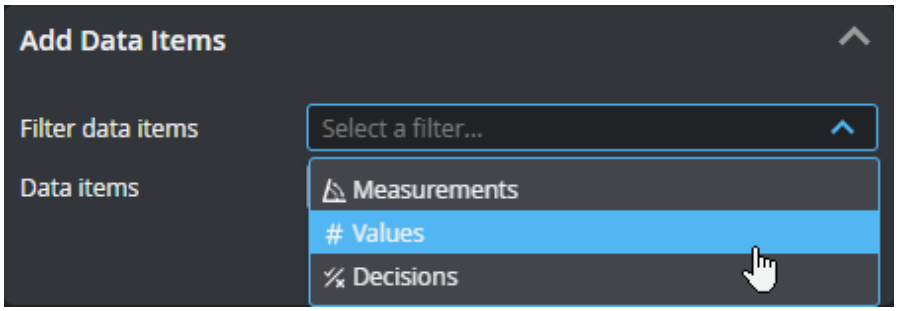
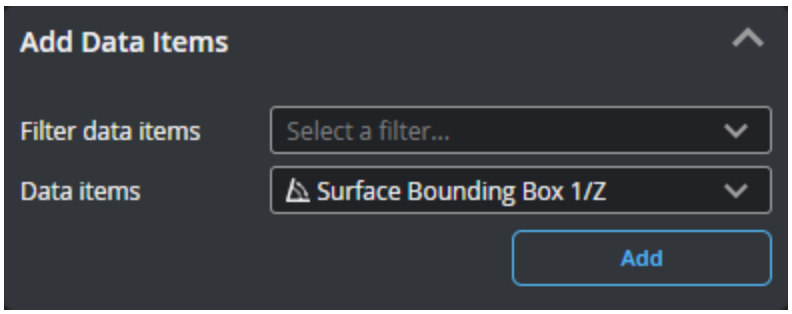
The HMI panel lets you enable GoHMI, choose which outputs you want to send to an HMI application, and launch with the HMI. You can also import and export an HMI.

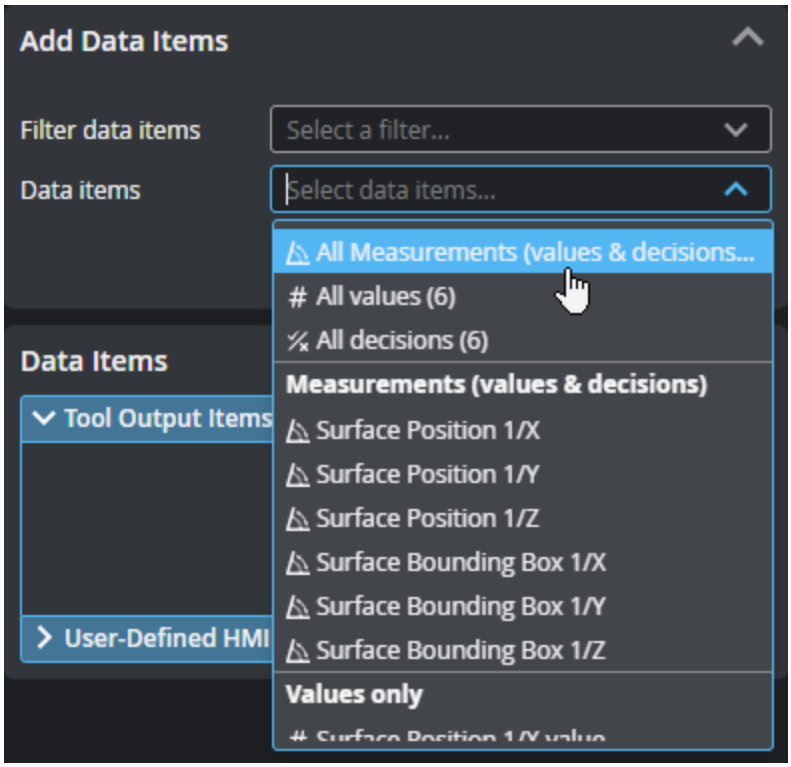
You can send measurement data items (which contain both values and decisions), or values or decisions individually.

You configure the HMI on the **Communicate** > **HMI** page. For information on how to design an HMI app, see *GoHMI and GoHMI Designer* on page 833.

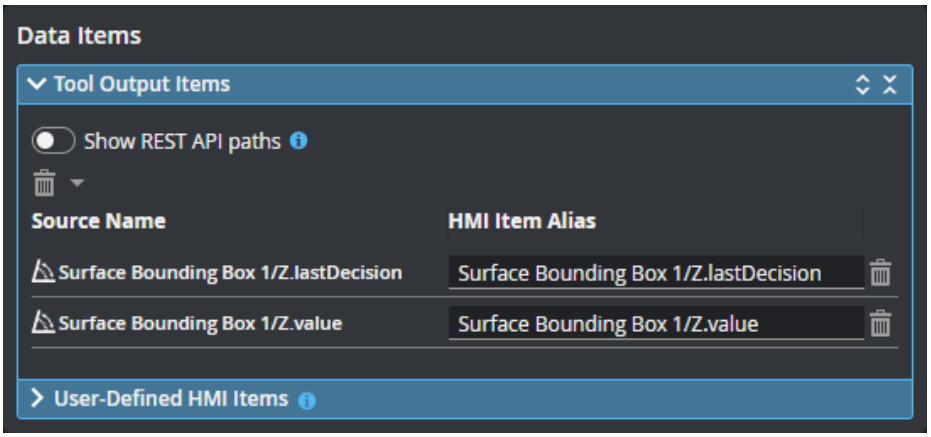


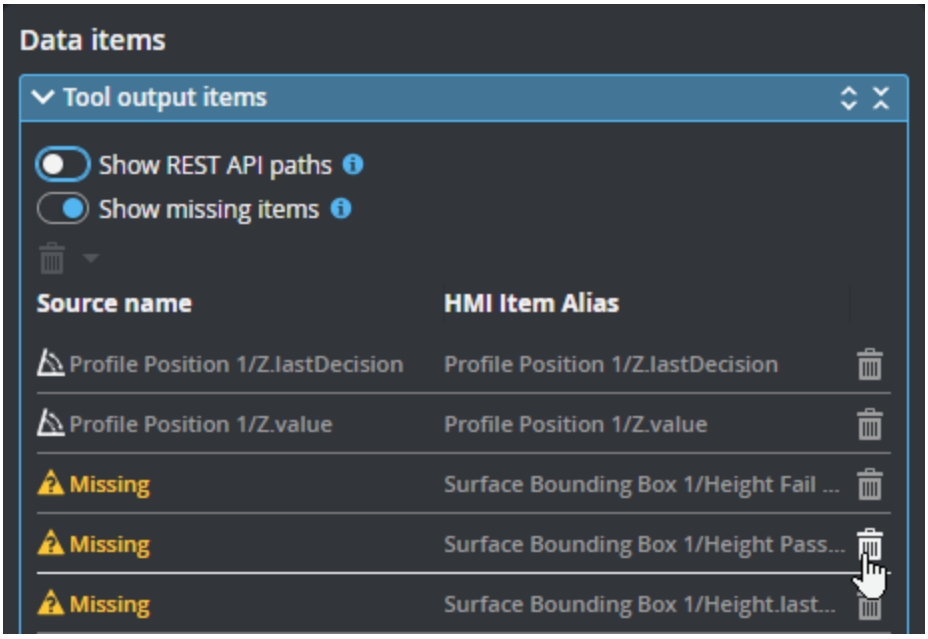

When you start HMI on a PC instance of GoPxL, a helper application (WebIQ Server) launches.

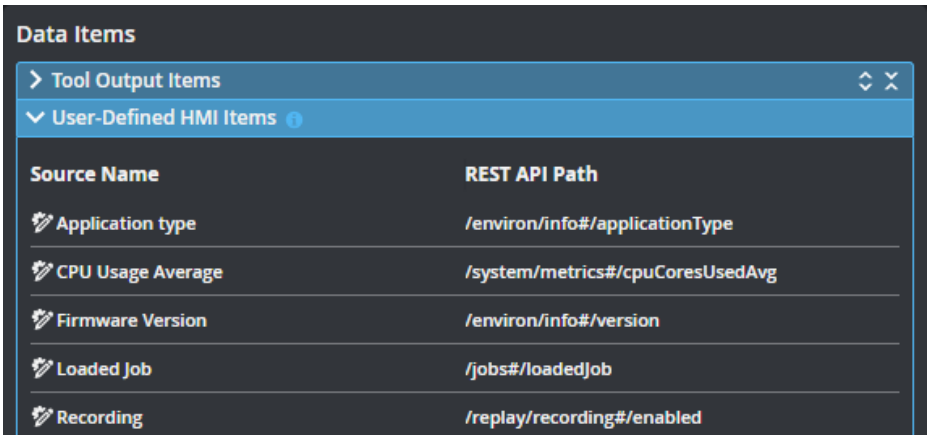
| | Element | Description |
|---|---|---|
| 1 | Settings | After you have enabled the service, the following functions are available:<br><br>**View live**<br>Opens the HMI in a browser tab.<br><br>**Import / Export**<br>Lets you import and export HMIs so that you can transfer them to a different platform, for example, going from a PC to a GoMax device, or back up an HMI.<br><br>**HMI App Status**<br>Shows the status of the app. |
| 2 | Add Data Items | Lets you add sources (such as stamps or measurements) that GoPxL will send to the running HMI. Added connections appear in the **Data Items** section at the bottom of the panel.<br>If you have many measurements, you can filter them by type to make it easier to find the item you want in the **Data Item** drop-down. You can enable more than one filter.<br>  <br>Choose an item in **Data items**. You can also<br>  <br>You can also add all items, or all items of a given type. |

| Element | | Description |
|---|---|---|
| | |  |
| 3 | Data Items | The data listed here will be sent to the running HMI app.<br>For more information, see *Data Items* below. |

*Data Items*

| Type | Description |
|---|---|
| Tool Output Items | This section contains the measurement decisions and values you added, which will be sent to the HMI.<br>  <br>You can delete an item using the trashcan icon in its row. You can also use shortcut commands to delete all of the items, or specific categories of items. |

| Type | Description |
| --- | --- |
| | **Show REST API Paths**<br>Toggles between showing the full internal path to an item, and an alias, which is a simplified representation of the item. In GoHMI Designer, you will see the REST API path for the items you add. Enabling this setting in GoPxL can help make it easier to find which item is which when developing an HMI.<br><br>**Show missing items**<br>If the source for an item is missing (that is, the tool providing the source has been removed in the job, or an output has been disabled), this option is displayed. Enabling it lists connections whose source can't be found.<br>You can delete the missing connection, enable the source measurement in the tool if it has just been disabled. If the tool itself is missing and you add it again, you may still need to delete missing items on the HMI panel, and add them back again, to make sure you add the correct ones.<br>.<br>  <br> |
| User-Defined HMI Items | This section contains GoPxL REST API resources that are not tool outputs. They are defined and managed from within GoHMI Designer. |

| Type | Description |
| --- | --- |
| |  |

# Monitor - Measurement Stats, Health & Performance

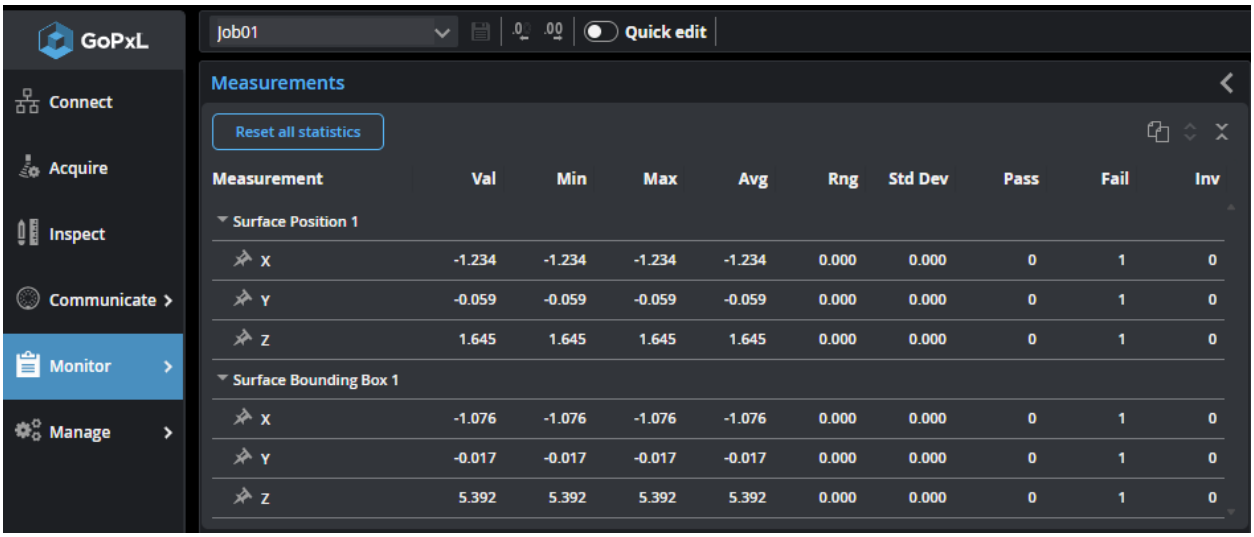
The **Monitor** category summarizes sensor and system health information and provides tool and measurement statistics. It also provides tool performance statistics.

*Available report pages*

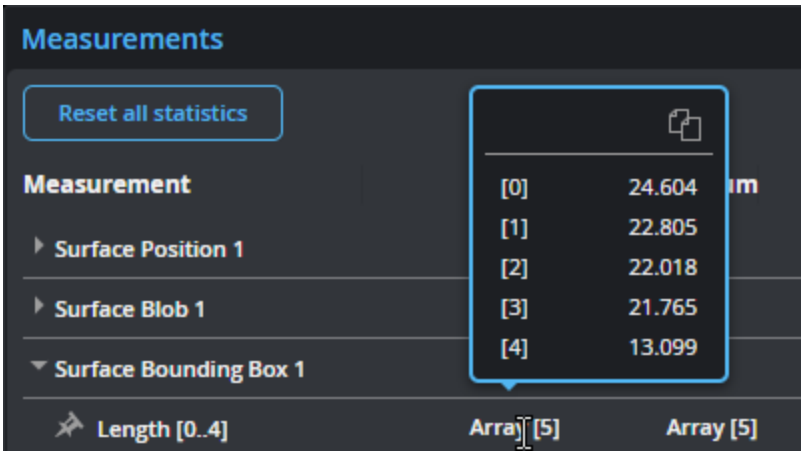
| Report | Description |
|---|---|
| Measurements | The **Measurements** page provides statistics for each enabled measurement. For more information, see *Measurements* below. |
| Health | The **Health** page lets you monitor system and sensor health indicators, as well as various counters, such as processing drops. For more information, see *Health* on the next page. |
| Performance | The **Performance** page provides performance statistics. For more information, see *Performance* on page 799. |

## Measurements

The **Monitor** > **Measurements** page displays statistics for each measurement enabled in the **Inspect** page, grouped by the tool that contains the measurement. Values are reset when the sensor is started. To reset statistics manually, click the **Reset All Statistics** button.




For arrayed measurements, hover over "Array [n]" to see values in the array. Click the Copy icon to copy the values to the clipboard.



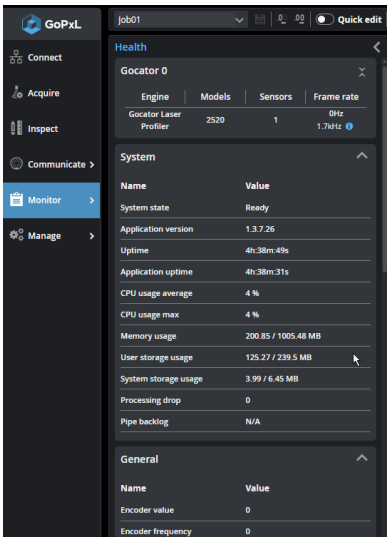

For each measurement, the following information is available:

*Measurement statistics*

| Name | Description |
|---|---|
| Value | The most recent measurement value. |
| Minimum | The minimum measurement value that has been returned. |
| Maximum | The maximum measurement value that has been returned. |
| Average | The average of all measurement values collected since the sensor was started. |
| Range | The difference between Maximum and Minimum. |
| Std dev | The standard deviation of all measurement values collected since the sensor was started. |
| Pass count | The number of pass decisions the measurement has generated. |
| Fail count | The number of fail decisions the measurement has generated. |
| Invalid count | The number of frames that returned no valid measurement value. |

## Health

In the **Health** panel, you can monitor system, sensor group, and sensor health indicators, as well as various counters, such as processing drops.




The following tables list the information available in the Health panel.

> When a sensor is being accelerated (by a PC instance of GoPxL or by GoMax), the value reported in the System section comes from the accelerator. However, only the following metrics are appreciably different from the physical device when accelerated: Uptime, CPU Usage, Memory Usage, and System/User Storage Usage.

*System*

| Name | Description |
|---|---|
| System state | Current system state indicating whether the device is scanning or not. |
| Application version | System software version. |
| Uptime | Time since the system was power-cycled or reset. (If the sensor is accelerated by a PC or a GoMax accelerator, this is the uptime of the PC or GoMax.) |
| Application uptime | Time since GoPxL started. (On a PC, indicates how long the PC has been running.) |
| CPU usage average | Average system CPU usage for the system. |
| CPU usage max | Maximum system CPU usage for the system. |
| Memory usage | Sensor memory (MB used / MB total available). When a sensor is accelerated, this displays N/A. |
| User storage usage | Sensor flash storage (MB used / MB total available). When a sensor is accelerated, this displays N/A. |
| System storage usage | Non-volatile storage available (MB used / MB total available). |
| Processing drop | The sum of various indicators related to processing drops including drops due to insufficient CPU and buffer overflows. |
| Pipe backlog | Number of bytes queued for processing. |

*General*

| Name | Description |
|---|---|
| Encoder value | Current encoder value (ticks). |
| Encoder frequency | Current encoder frequency (Hz). |
| Processing latency | Last delay from camera exposure start to when the results are ready for output. |
| Processing latency (Max) | Peak delay from camera exposure start to when the results are ready for output. |
| Scan count | Number of scans performed since system state last changed to Running. |
| Scanner drops | Number of sensor group (scanner) drops. |
| Current speed | Current scanning frame rate. |
| Trigger drops | Count of camera frames dropped due to excessive trigger speed. |
| CUDA in use | With G3 sensors accelerated by PC or GoMax, indicates whether GoPxL is using CUDA. |

For each sensor in a system, GoPxL displays a table in the expandable **Sensors** section listing the health indicators for that sensor.

*Sensor {n} health*

| Name | Description |
|---|---|
| Master connected | Whether the sensor is connected to a Master sensor networking hub. |
| Laser safety | Whether Laser Safety is enabled. |
| Sensor uptime | Time since the sensor was power-cycled or reset. |
| CPU usage average | Average system CPU usage for the sensor. |
| CPU usage max | Maximum system CPU usage for the sensor. |
| Ethernet receive rate | Rate at which data is being received by the sensor over Ethernet (Mbps). |
| Ethernet send rate | Rate at which data is being sent to the sensor over Ethernet (Mbps). |
| Ethernet link speed | Speed of the Ethernet link (Mbps). |
| Memory usage | Sensor memory usage (MB used / MB total available). |
| User storage usage | Sensor flash storage usage (MB used / MB total available). |
| System storage usage | Non-volatile storage available (MB used / MB total available). |
| Max spot count | Maximum available spots, across all cameras. (G2) |
| Total exposure time | Total amount of time the laser light (G2), projector (G3), or light source (G5) has been turned on to make scans. |
| Internal temperature | Internal sensor temperature (degrees Celsius). |
| Laser driver temperature | Laser driver control temperature (degrees Celsius). (G2) |
| Light driver temperature | Light driver control temperature (degrees Celsius). (G4 / G5) |
| LED PCB temperature | LED PCB temperature (degrees Celsius). (G4 / G5) |
| External thermistor temp. | External thermistor temperature (degrees Celsius). (G4 / G5) |
| Projector illumination | Projector temperature (degrees Celsius) (G3). |

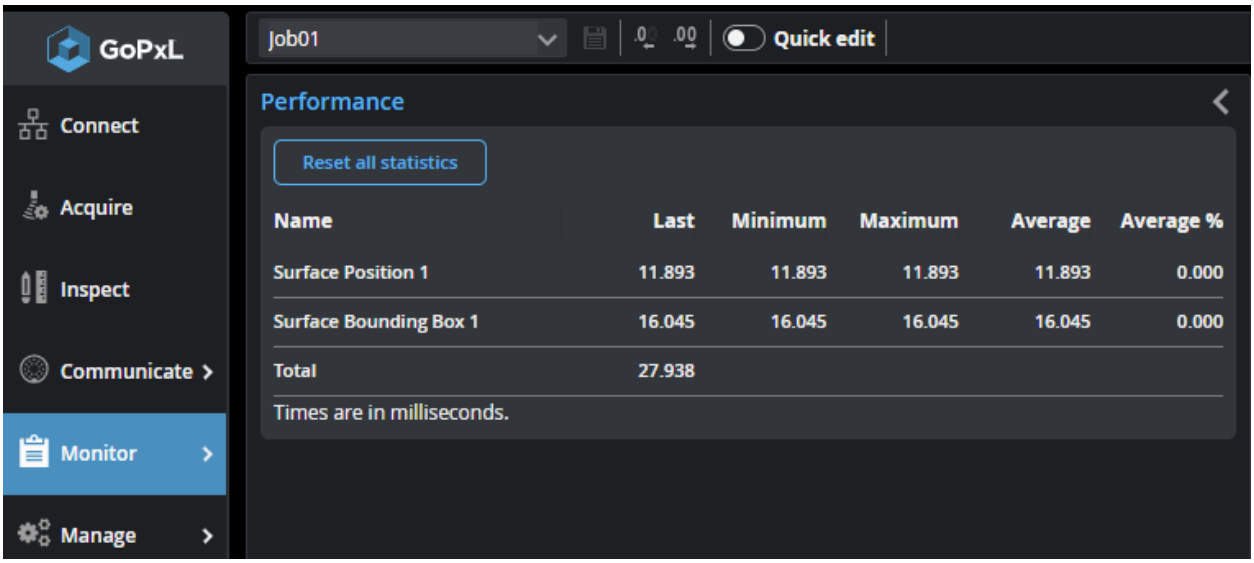
| Name | Description |
|---|---|
| temp | |
| Trigger drops | Count of camera frames dropped due to excessive trigger speed. |
| Camera buffer drops | Count of camera buffer drops due to excessive trigger speed. For G3, the buffer drops are shown for each camera. |
| Digital Output {n} drops | Count of digital output drops because the output signal could not be generated. |
| Digital Output {n} high count | Number of times the digital output line was set to high. |
| Digital Output {n} low count | Number of times the digital output line was set to low. |

*Control*

| Name | Description |
|---|---|
| Gocator control drop | The number of Gocator protocol drops. |

## Performance

The **Monitor** > **Performance** page displays performance statistics (execution time in milliseconds) for each tool added in the **Inspect** page.




For each tool, the following information is available:

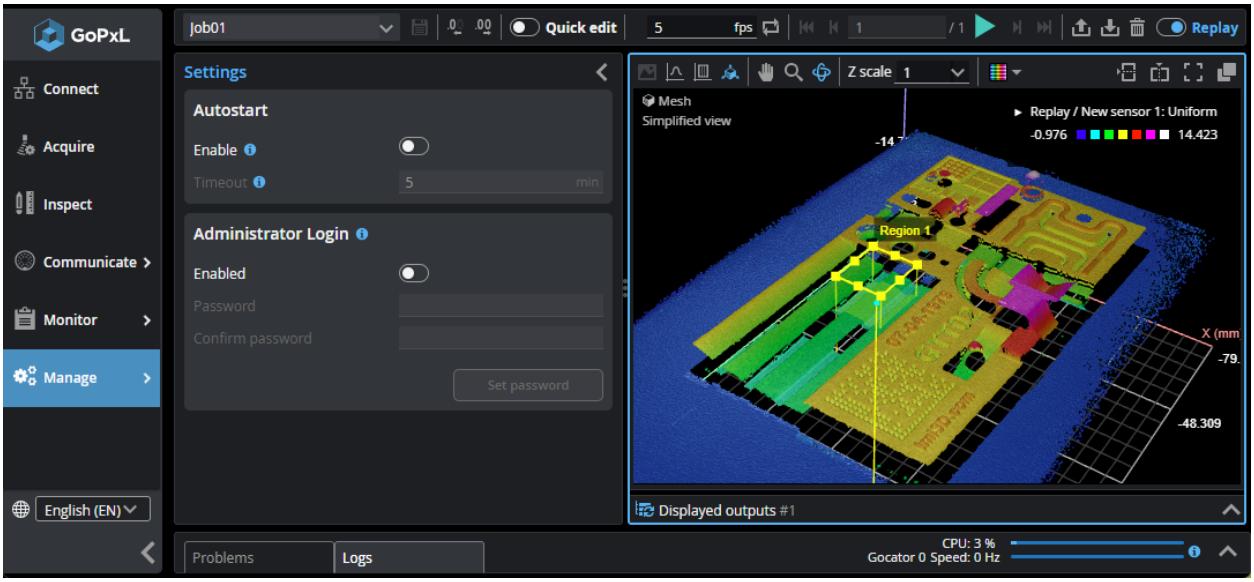
*Performance Statistics*

| Name | Description |
|---|---|
| Last | The latest execution time of the tool. |
| Minimum | The minimum execution time of the tool. |
| Maximum | The maximum execution time of the tool. |

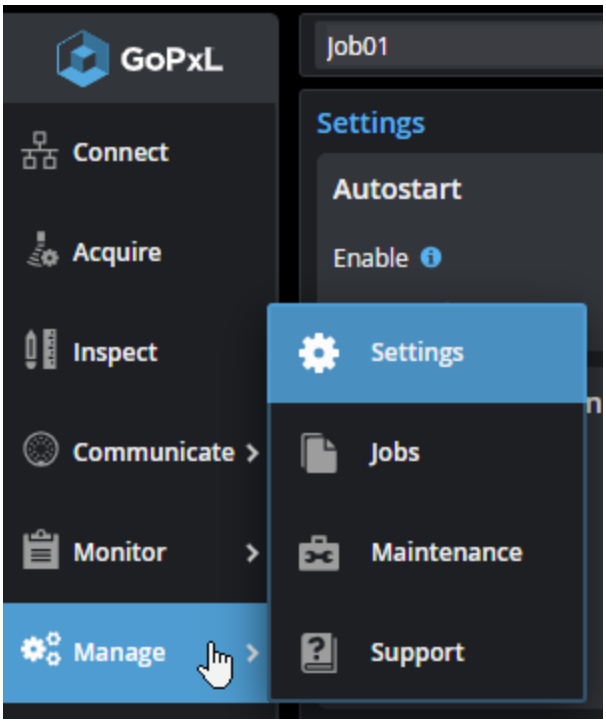
| Name | Description |
| --- | --- |
| Average | The average execution time of the tool. |
| Average % | The average percentage of the execution time of the tool. |

# Manage - Sensor Management and Maintenance

You use the pages in the **Manage** category to perform networking, management, and maintenance tasks (such as software updates and sensor factory restores).




To access a specific management page, hover the mouse pointer over **Manage** and choose the required page.



| Manage Page Name | Description |
|---|---|
| Settings | The **Settings** page lets you configure the network settings of a sensor. For more information, see *Settings* below. |
| Jobs | The **Jobs** page lets you create, delete, and manage jobs. For more information, see *Jobs* on page 805. |
| Maintenance | The **Maintenance** page lets you upgrade a device's software, perform a backup or restore of a device, perform a factory restore of a device, or restart it. For more information, see *Maintenance* on page 808. |
| Support | The **Support** page provides software version information and lets you download a support file for troubleshooting; it also lets you upload a support file to GoPxL.<br>You can also access and download the GoPxL documentation, download the SDK, and go to LMI's online support page.<br>For more information, see *Support* on page 811. |

## Settings

The **Settings** page under **Manage** provides autostart and administrator login settings.

### Autostart

If your application requires maintaining uninterrupted scanning, you can configure GoPxL to automatically restart sensors that are running after various events, by enabling **Autostart**. Unaccelerated single sensors and sensors grouped with a controlling sensor, as well as sensors accelerated by GoMax or a PC instance of GoPxL, will automatically start scanning in the situations listed below. The setting persists after restarts, and is a global setting (that is, not saved in a job). Performing a factory restore disables autostart.

- "Launch" events:
  - Power cycle
  - Restarting a GoMax unit or relaunching a PC instance of GoPxL that is accelerating sensors
  - Restoring a running sensor with a backup in which Autostart is enabled
- Network disconnections with accelerated sensors (such as when a network cable is disconnected or a switch is power cycled)
  - With sensors running

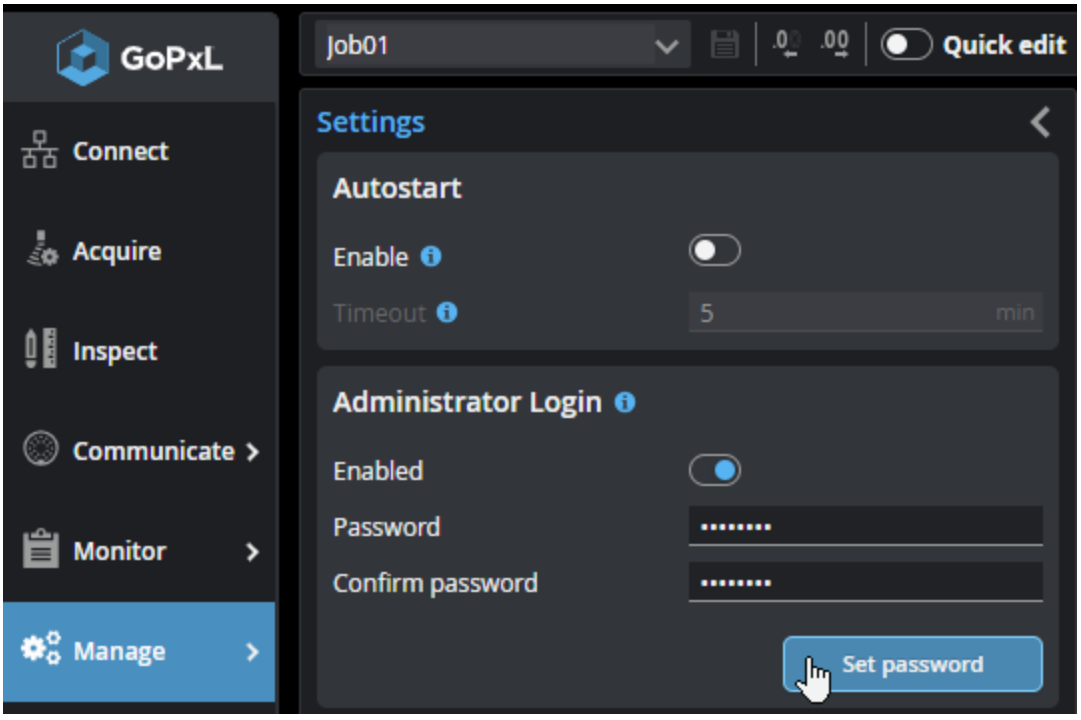
LMI does not recommend enabling **Autostart** on sensors you intend to accelerate by running them through GoPxL on PC or a GoMax unit. This can result in timing issues.

### Administrator Login

You can prevent unauthorized access to sensors by setting an administrator password. When a password is set, GoPxL displays a password field when the interface loads. To continue you must

provide the password. In a password-protected system, there are no limitations in terms of functionality.

You set the administrator password on the **Settings** page:

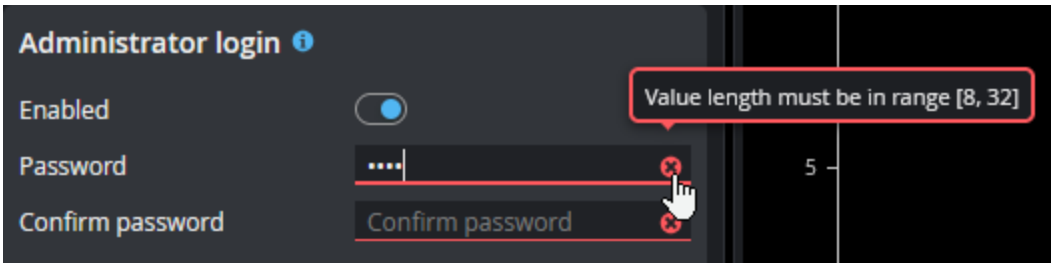



| | |
|---|---|
| ⚠ | On a sensor, if you forget the password or want to completely clear a password, you must perform a factory restore. You can do this in GoPxL from **Manage** > **Maintenance** (see *Factory Restore* on page 810) or from the Discovery tool (see *GoPxL Discovery Tool* on page 917). |

When GoPxL is running on a PC, in both you must delete the password-protected instance and create a new instance.

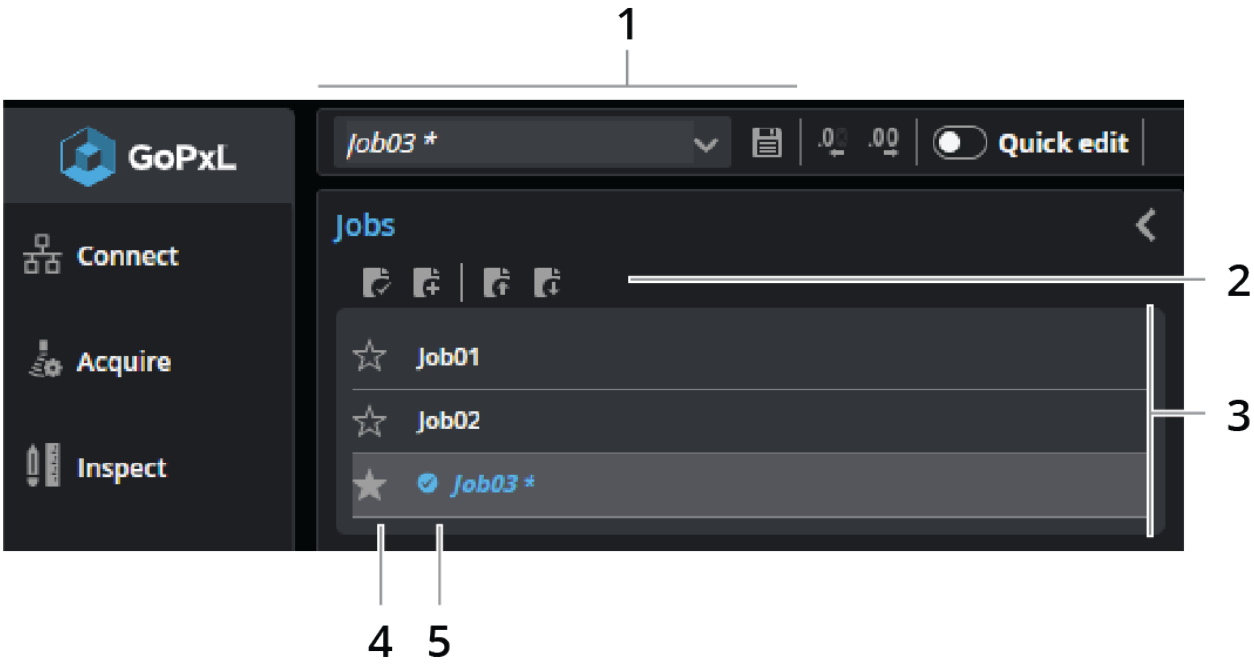
Note the following:

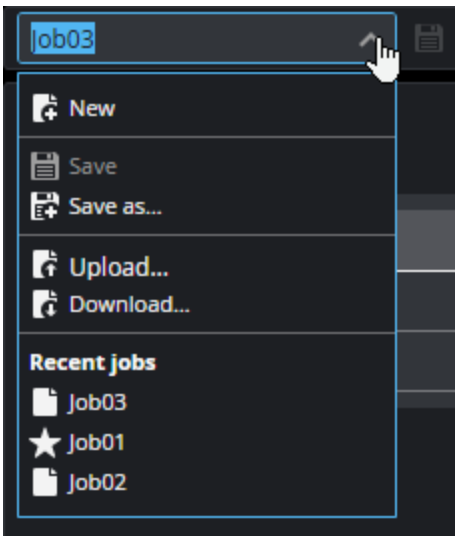
- Passwords must be 8 to 32 characters long.
- All characters are accepted.
- The password can't be empty.
- There are otherwise no constraints or checks on passwords (that is, no minimum number of special characters, no combination of uppercase / lowercase, and so on).
- After setting a password, the password is stored even if administrator login is disabled. If you re-enable the password, the previously set password is active.
- You don't need to know the current password to change the password, so anyone with access to a logged-in sensor can change the password.
- If the password is not accepted by GoPxL, hover over the red "x" icon ( ) for more information.



## Jobs

The **Jobs** page lets you manage jobs. The




| | Element | Description |
|---|---|---|
| 1 | Job-related operations on global toolbar | Job menu and Save button. Use the job menu to create new jobs, save jobs, load recent jobs, and also upload or download jobs between the PC and the sensor.<br>You can rename the currently loaded job from the job name field, simply by changing it and pressing enter or clicking outside the field.<br>  <br>When a job has unsaved changes, it is displayed in italics with an asterisk. Click |

| | Element | Description |
|---|---|---|
| | | the Save button in the global toolbar to save it. A star icon indicates the job that has been set as the default. |
| 2 | Job-related operations | These controls let you load or reload jobs, create new jobs, and upload or download jobs between the PC and the sensor. For explanations of the job related operations, see *Job-related operations* below. |
| 3 | Job list | The list of available jobs. You can rename a job by double-clicking it in the list.<br>When you move the mouse pointer over a job in the list, additional tools are displayed that let you rename the job, duplicate it, or delete it.<br>When a job has unsaved changes, it is displayed in italics with an asterisk. Click the Save button in the global toolbar to save it. |
| 4 | Default job indicator | Clicking the default job indicator ( ) sets the job as the default, which will load when the sensor starts. |
| 5 | Loaded job indicator | The loaded job indicator ( ) shows which job is currently loaded. |

The following table describes the job-related operations.

*Job-related operations*

| Operation | Description |
|---|---|
| | Loads or reloads the job that is currently selected in the job list. |
| | Creates a new job called "untitled {n}" and loads it. |
| | Saves the current job. (Disabled if the job contains no changes.) |
| <br> | Uploads or downloads a job between GoPxL and the client computer. Job files have a .gpjob extension. |
| | Lets you edit the name of the job under the mouse pointer. You can also double-click on the job's name to stat editing it. |
| | Duplicates the job under the mouse pointer. |
| | Deletes the job under the mouse pointer. |

## Characters Allowed in Job Names

When setting a job's name, you can use alphanumeric characters (numbers and letters), including accented characters in languages other than English and characters in languages such as Chinese and Japanese. Some special characters are also allowed.

The following special characters are also supported:

*Allowed Special Characters*

| | |
|---|---|
| space | & (ampersand) |

| | |
|---|---|
| - (hyphen) | ( ) { } [ ] (parentheses, brackets, and braces) |
| _ (underscore) | + (plus) |
| . (period) | , (comma) |
| ' (single quote) | ; (semi-colon) |
| @ (at) | = (equals) |
| # (pound) | |

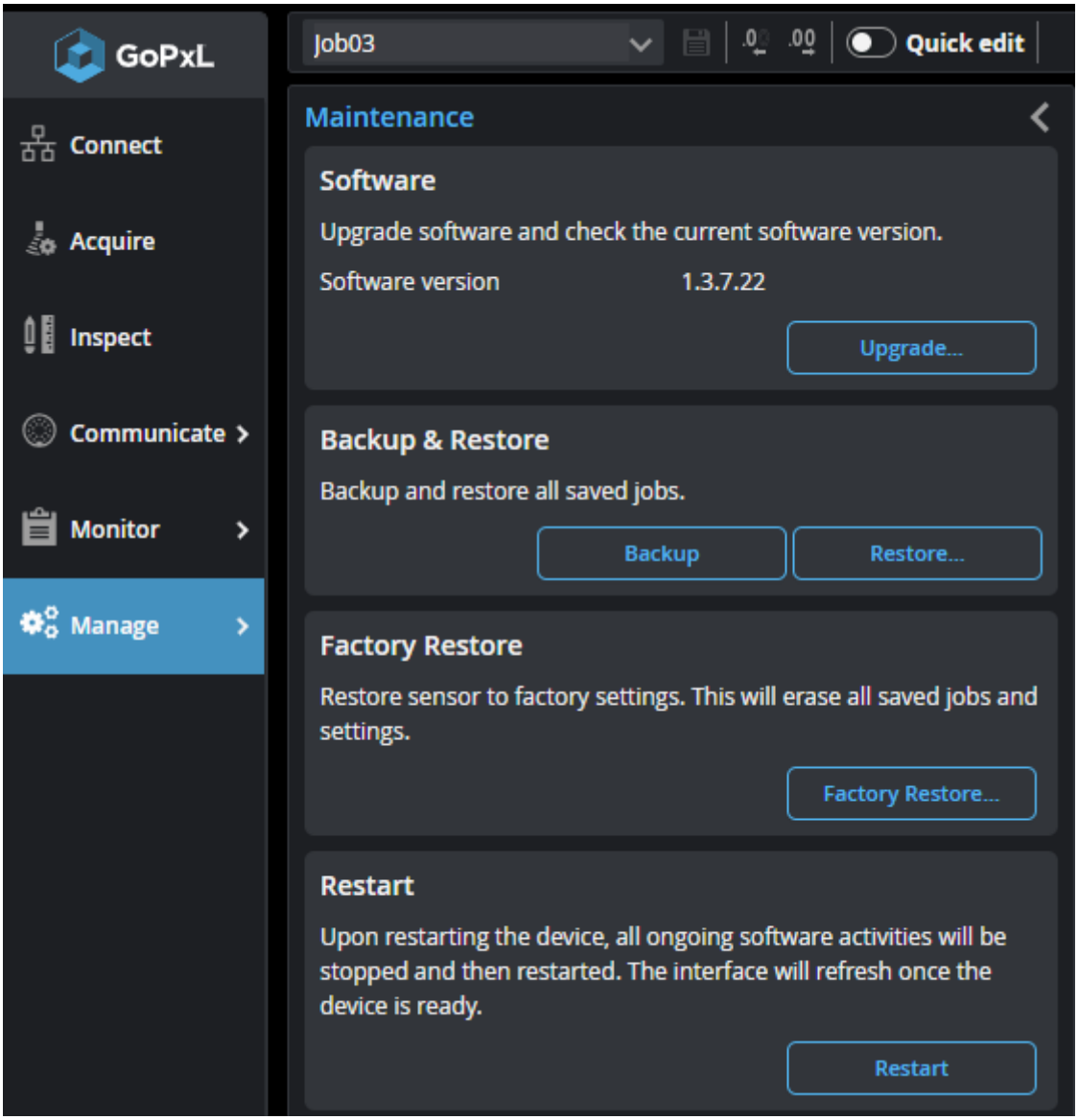
The following special characters are *not* supported:

*Disallowed Special Characters*

| | |
|---|---|
| < (less than) | \| (vertical bar or pipe) |
| > (greater than) | ? (question mark) |
| : (colon) | * (asterisk) |
| " (double quote) | % (percent) |
| / (forward slash) | ~ (tilde) |
| \ (backslash) | $ (dollar) |

## Maintenance

You use the **Maintenance** page in the **Manage** category to perform basic maintenance.




The **Maintenance** panel lets you do the following:

- **Upgrade...**: Upgrade the device's software. Note that you can't upgrade a sensor if you are running it through a PC instance of GoPxL. For more information on upgrading a sensor's software, see *Software Upgrade* on the next page.
- **Backup** / **Restore...**: Back up and restore all saved jobs and recorded data. Note that backing up and restoring on a PC instance of GoPxL only affects the PC instance, not the sensor. For more information, see *Backup and Restore* on the next page.
- **Factory Restore...**: Restore GoPxL to factory defaults; this applies to sensors and PC instances of GoPxL. This erases *all* saved jobs and settings, as well as files created by tools. Performing a

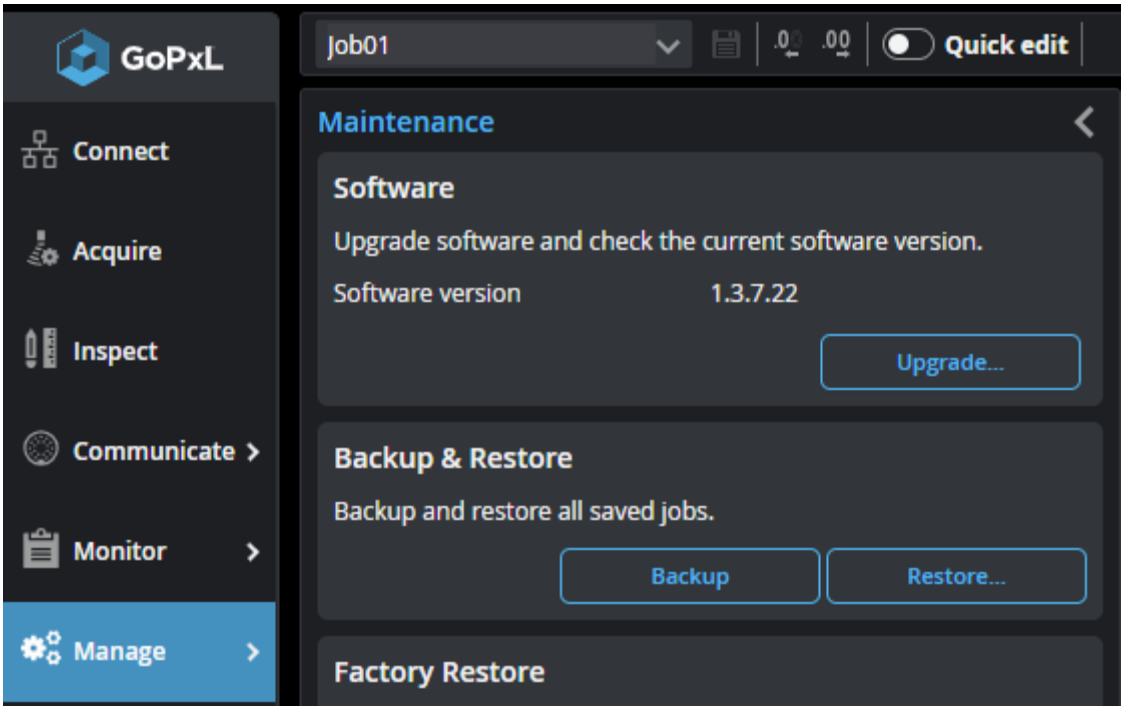
factory restore on a PC instance of GoPxL connected to a sensor *only* affects the PC instance, not the sensor; doing this also disconnects the sensor from the PC instance.

- **Restart**: Restart the sensor. Note that you can't restart a sensor running through a PC instance of GoPxL. To do this, you must remove the sensor from the PC instance; for more information, see *Stopping Acceleration* on page 829.

## Software Upgrade

LMI recommends routinely updating software to ensure that sensors always have the latest features and fixes.

Note that if you are running a sensor through a PC instance of GoPxL, you can't upgrade its software. To do this, you must temporarily remove it from the sensor group in the PC instance, access the sensor directly at its IP address, and perform the upgrade. You can then add it back to the sensor group on a PC instance. (Note that it must be the same software version.) For more information, see *Stopping Acceleration* on page 829.



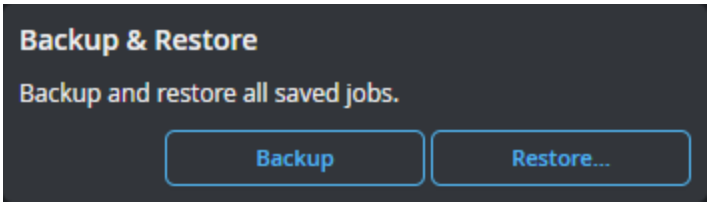

In multi-sensor systems, all sensors must use the same software version.

## Backup and Restore

Sensor backups let you keep the state of a sensor or system in a safe location, and restore a sensor to a previous state in case you have made unwanted changes. You create backups in the **Maintenance** page. Backup files contain the following:

- All jobs
- Current recorded data
- Layout set up on the **Connect** page

- Alignment performed on the **Acquire** page
- Other configurations such as scan settings and control settings



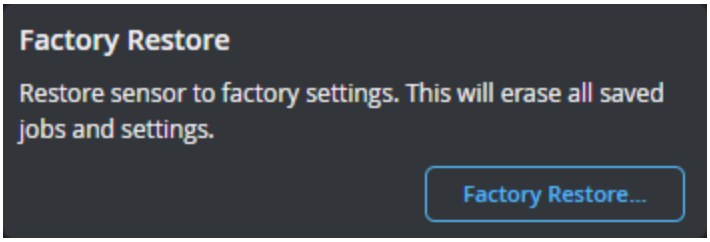

> You should always create a sensor backup file in the unlikely event that a sensor fails and a replacement sensor is needed. If this happens, the new sensor can be restored with the backup file.

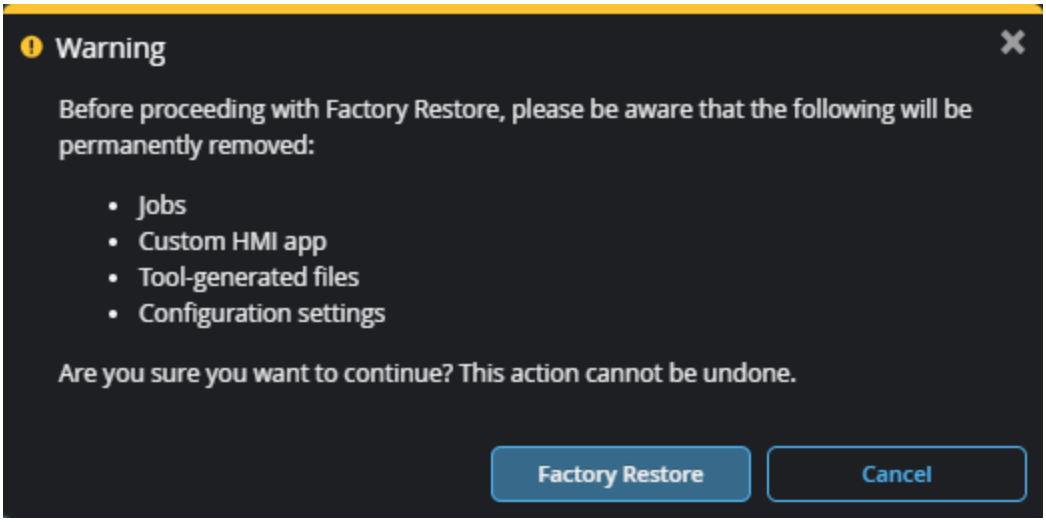
When you create a backup, your browser may ask if you want to allow downloading the file.

If you are running a sensor through a PC instance of GoPxL, performing backup, restore, and factory restore operations only affects the PC instance of GoPxL: jobs and recorded data saved on the sensor are not backed up and are not overwritten by a restore.

### Factory Restore

You can perform a factory restore to quickly remove all jobs and configurations, as well as the files created by tools (such as Surface Pattern Matching, Surface Track, and so on). This also removes Custom HMI apps.



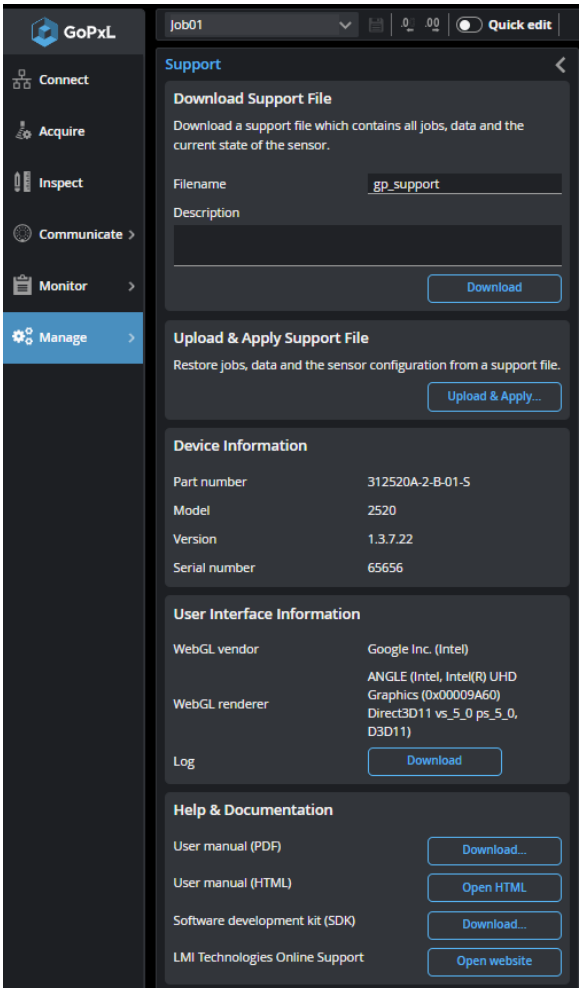



You should create a backup file of your sensor in case of unwanted changes and in the unlikely event that a sensor fails and a replacement sensor is needed. If this happens, the new sensor can be restored with the backup file.

## Support

The **Support** page in the **Manage** category lets you download or upload a support file and get software version information. Support files are useful for supporting development and diagnosing issues.

You can also access the user manual, download the SDK, and go to online support from here. Additionally, you can download log; you would normally only need to download the log if told to do so by LMI's support team.




Support files contain everything in backup files, but also contain *additional diagnostic information*:

- All jobs
- Current recorded data
- Layout set up on the **Connect** page

- Alignment performed on the **Acquire** page
- Other configurations such as scan settings and control settings

# Accelerating Sensors

For performance-critical applications, you can run a sensor through a PC instance of GoPxL or through a GoMax NX, ORIN, or ORIN+ device. LMI *STRONGLY* recommends running confocal sensors through a PC or GoMax NX. Note that for confocal sensors, LMI has only tested single-layer scanning with GoMax NX. For more information on running GoPxL through a PC, see *Running GoPxL on a Windows PC* on page 814.

# Running GoPxL on a Windows PC

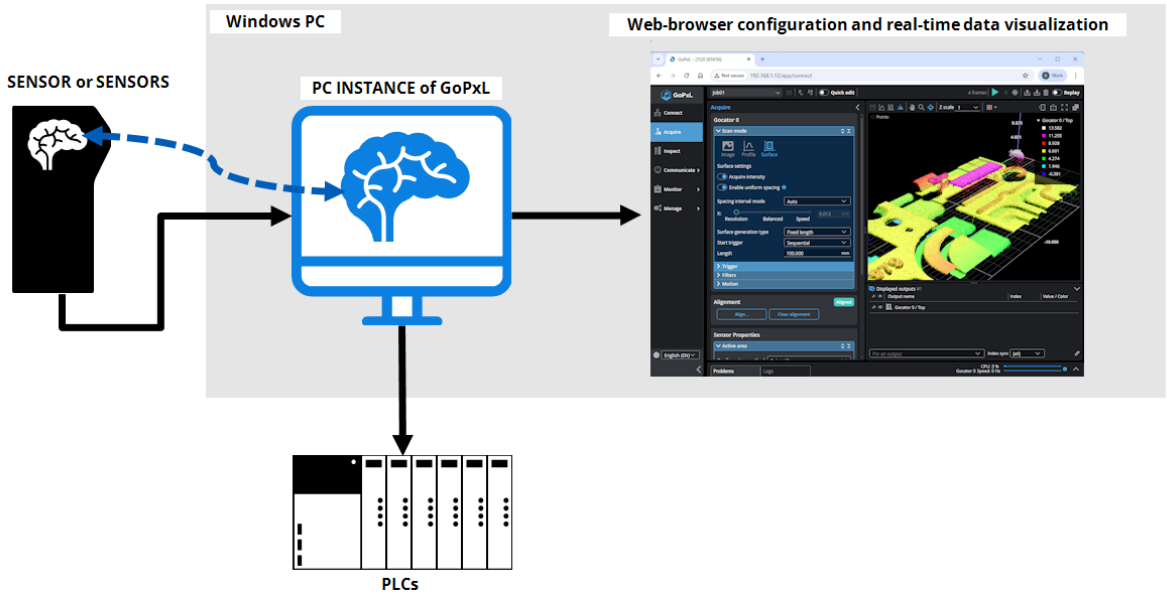
GoPxL is the software you use to configure Gocator sensors. Typically, you connect directly to a sensor's IP address via a web browser, and use the GoPxL software running on the sensor to configure and run the sensor. (By default, a sensor's IP address is 192.168.1.10. If you can't find a sensor, see *GoPxL Discovery Tool* on page 917.)

You can also run GoPxL on a Windows PC. We call GoPxL running on a PC a "PC (or local) instance of GoPxL."

If your Windows account has Administrator rights, you can install a PC instance of GoPxL as a Windows service. For more information, see *Running GoPxL Manager in Administrator Mode* on page 818.

A PC instance of GoPxL lets you do the following:

- Accelerate sensors: For applications where performance is critical, you should run a sensor through a PC instance of GoPxL. After you connect a sensor to GoPxL running on a PC, the instance automatically starts accelerating it, handling the processing of the scan data, rather than the sensor. This improves system performance, potentially letting you increase scan rates or add more tools. For more information, see *Accelerating a Sensor* on page 825.




- Load previously recorded scan data to examine it or to configure measurement tools offline, without a sensor, using that data. For more information, see *Loading Scan Data* on page 830.

LMI *STRONGLY* recommends running confocal sensors through the PC version of GoPxL.

For information on the ports a PC instance uses (for example, in order to ensure ports are not blocked over your network), see *Required Ports* on page 37.

If your Windows account has Administrator rights, you can install a PC instance of GoPxL as a Windows service. A PC instance installed (and running) as a service can run a sensor without the need for a user to be logged into Windows. For more information, see *Instance Settings* on page 822

The user interface of GoPxL running on a sensor and GoPxL running on a PC is almost identical. When running a sensor through a PC instance of GoPxL, you can't upgrade or restart the sensor. You must remove the sensor from the PC instance and then connect to the sensor directly to upgrade the sensor.

Job files you create in a PC instance of GoPxL are separate from any jobs that are on the sensor. Be sure to back up jobs in a PC instance if ever you need to run them directly on the sensor.

## System Requirements

The following are the minimum system requirements for using GoPxL on a Windows PC:

- Processor: x86-64 (Core i3 or equivalent)
- RAM: 8 GB
- Hard drive: 64 GB
- Operating system: Windows 10 or 11 (64-bit only)
- Display: 1366 x 768

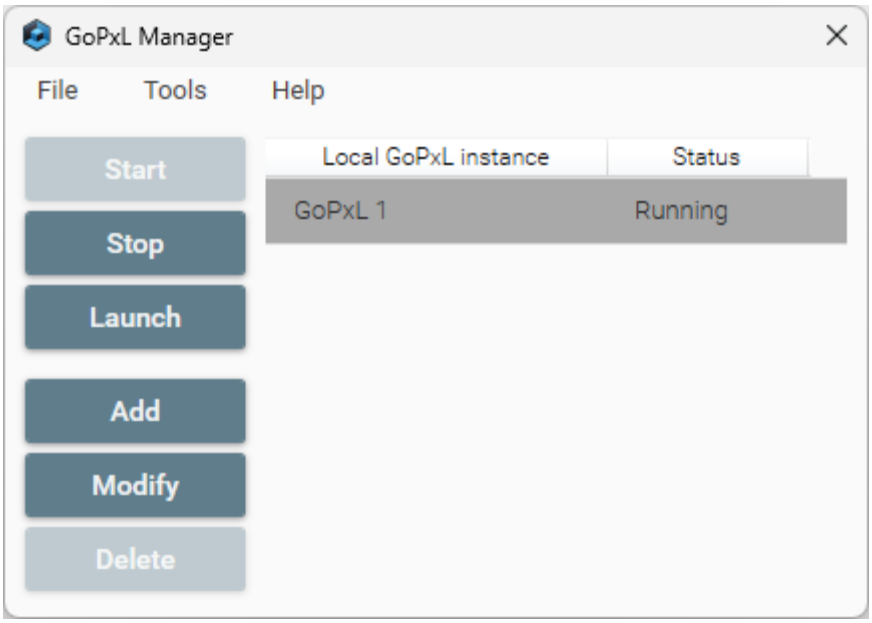
To accelerate more sensors or to run the system at higher speeds, use a computer with more system resources.

Note that acceleration of line profile sensors does not currently use a computer's graphics card.

If you choose to run GoPxL Anomaly Detector on a PC instance of GoPxL, the PC must have a graphics card with a recent Nvidia GPU that supports Nvidia GeForce Game Ready Driver version 528.33 or higher, and a compute capability of 7.5 or higher. To verify the driver version of your video card, launch the NVIDIA Control Panel, and in the main panel of the application, make note of the driver version. To exceed the capabilities of GoMax ORIN in terms of training times and inference, an RTX 4070 or higher is recommended.

## Launching GoPxL on a Windows PC

The first time you launch GoPxL for Windows, a GoPxL instance is automatically created and started, and the GoPxL interface opens in your default browser. You use the GoPxL Manager application (which is started when you start GoPxL.exe) to add, remove, and configure instances. The following assumes you have connected a sensor to a network and that you can access its web interface.




*The GoPxL Manager application. An instance is automatically added the first time you launch GoPxL.*

### *To launch GoPxL on a PC*

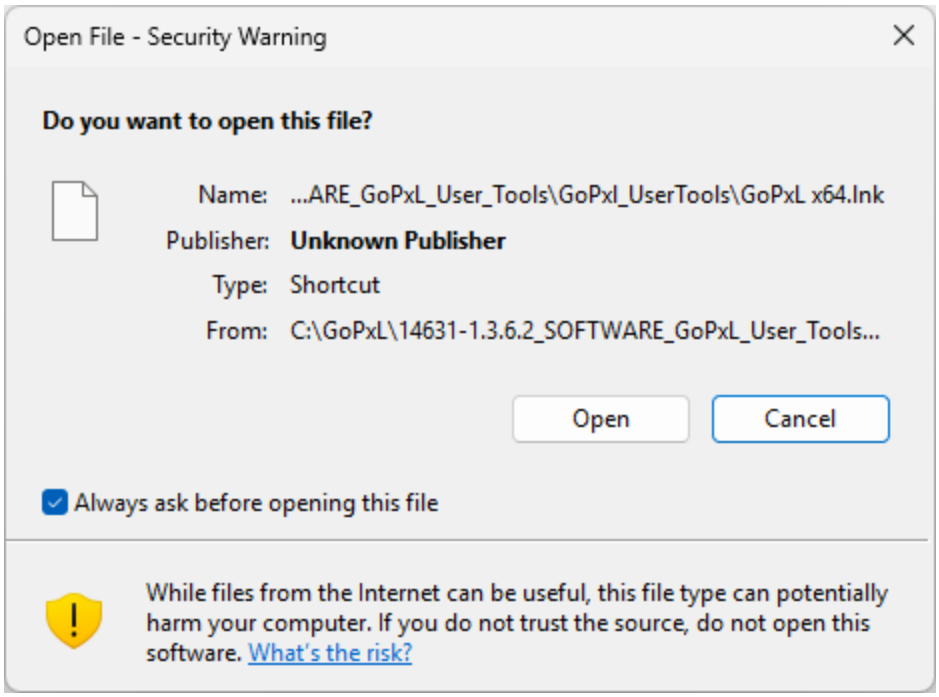
1. Download and unpack the GoPxL Utilities package (`14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.exe`) by double-clicking on it.

   If you are using GoPxL on PC to accelerate a sensor, the version of the package must match the version of GoPxL on the sensor.

2. From the `GoPxL` folder, launch `GoPxL x64`.

   GoPxL Manager creates a local, PC-based instance of GoPxL and launches it in a new tab in your default browser, using IP address 127.0.0.1.

   Windows may display a security warning asking if you want to launch GoPxL. Click **Open** to continue.



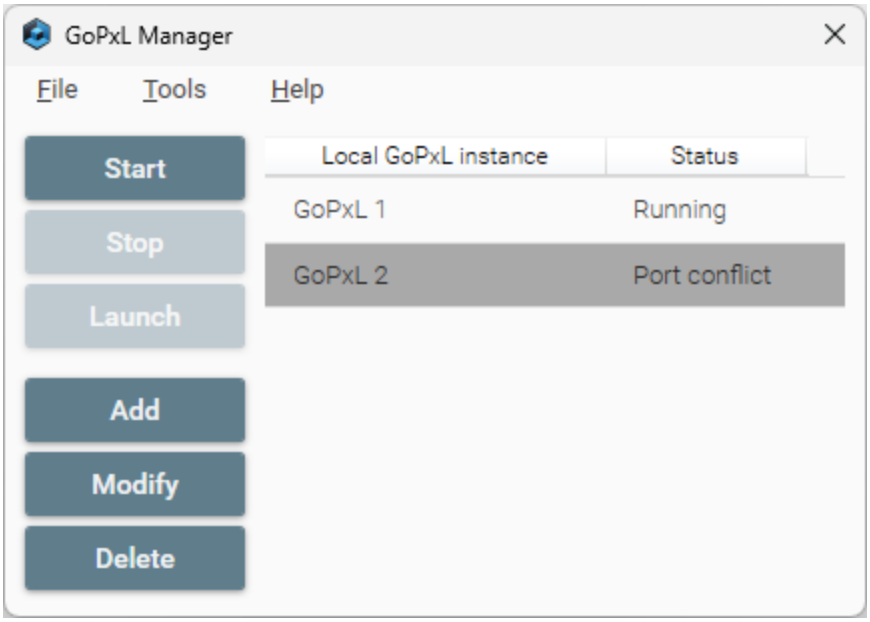

Additionally, your firewall may ask if you want to allow the GoPxL Service Application to communicate over your network. To avoid issues, LMI recommends allowing communication over both Public and Private networks.

Note that GoPxL Manager starts minimized in the tray area.

At this point, you can do one of the following:

- Add one or more sensors to the PC instance to accelerate the sensors. For information on adding a sensor to a sensor group, see *Accelerating a Sensor* on page 825.
- Open scan data someone has previously recorded (in a .gprec, .gpbak, or .gpsup file) and examine the data or use it to configure measurement tools without taking your sensor system offline. For more information, see *Loading Scan Data* on page 830. (For information on the file formats used with GoPxL, see *File Formats* on page 62.)

All ports used by PC instances must be unique. In some situations, it is possible to accidentally set the ports of two or more instances to the same port.




To correct this, select one of the instances, click **Modify**, and change the duplicated port to a different one. You can also delete any instances that use duplicate ports.

> You can select multiple instances in GoPxL Manager and perform most of the actions on the selected instances.
>
> Press Ctrl + Left click to toggle whether an additional instance is selected. Press Shift + Left click to select a range of instances (from the currently selected instance to the one you Shift + Left click).

## Running GoPxL Manager in Administrator Mode

To perform certain operations, you need to start GoPxL Manager in Administrator mode.

- Change certain applications settings (for more information, see *Application Settings* on the next page).
- Install or uninstall a PC instance as a service, or delete it.
- Install licensing for tools like GoPxL Anomaly Detector.

> Before switching to Administrator mode, you should stop all running PC instances of GoPxL.

To run GoPxL Manager in Administrator mode, click **Run As Admin** either in the GoPxL Manger Settings dialog (see *Application Settings* on the next page), or in the Modify GoPxL Instance Configuration dialog (see *Instance Settings* on page 822).

> After you have finished making any of the changes listed above, you should fully exit GoPxL Manager to avoid permission issues with your instances. For more information, see *Closing GoPxL Manager and Stopping All PC Instances* on the next page.

## Closing GoPxL Manager and Stopping All PC Instances

After you have finished making any of the changes listed in *Running GoPxL Manager in Administrator Mode* on the previous page, you should fully exit GoPxL Manager to leave Administrator mode to avoid permission issues with your instances as described below. You use the same steps if you just need to exit GoPxL Manager and stop all PC instances. Note that clicking the X button at the top right in GoPxL Manager only hides the utility's main window.

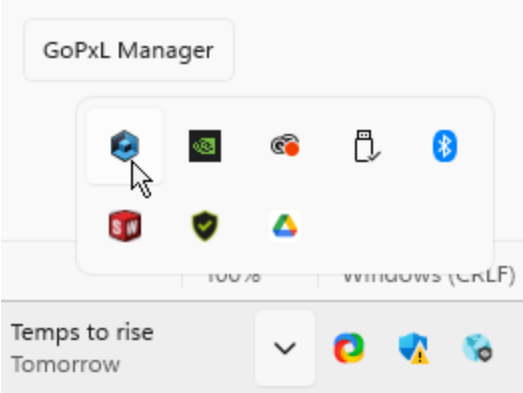
*To close GoPxL Manager and all PC instances*

1. Look for the small GoPxL Manager icon ( ) in the taskbar's notification area.

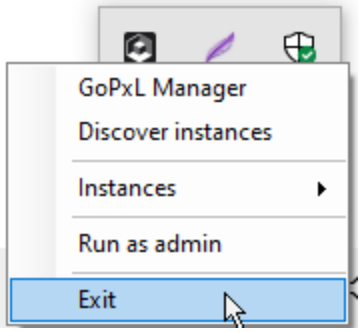
   This is normally at the bottom of the screen, to the right.

2. If you don't see the GoPxL Manager icon, click the "Show hidden icons" arrow.

   A menu containing the hidden icons appears.

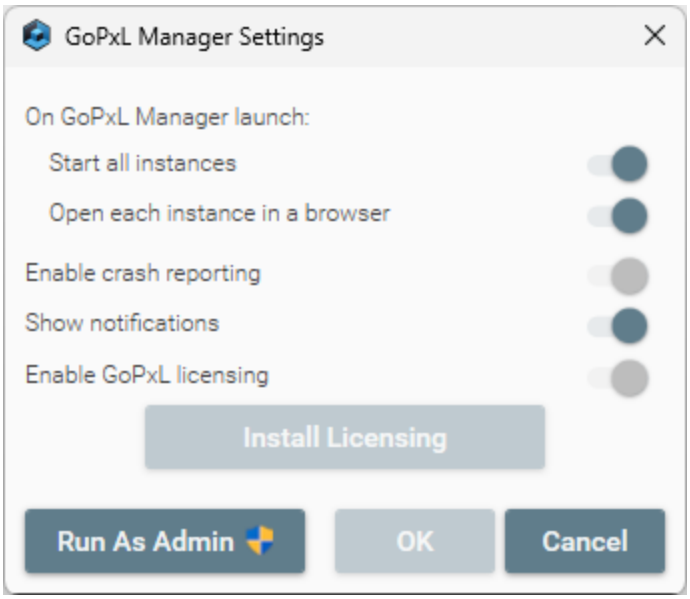



3. Right-click the GoPxL Manager icon.
4. In the menu that appears, click Exit.

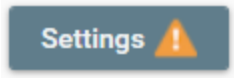



## Application Settings

The following application settings are available. To open the settings, click **Tools** > **Settings** at the top of the application.




*Parameters*

| Parameter | Description |
|---|---|
| On GoPxL Manager launch | **Start all instances**<br>When enabled, all instances not installed as a service will automatically start when GoPxL Manager starts.<br><br>**Open each instance in a browser**<br>Each instance opens in the default browser. (Instances installed as a service will start when the computer is started.) |
| Enable crash reporting | If a PC instance of GoPxL crashes, a report will be generated. This can be useful if you need to troubleshoot problems with LMI support. LMI recommends leaving crash reporting enabled. If you choose to disable crash reporting, an icon on the **Settings** button will indicate that it is disabled.<br>  <br>To change this setting, you must be running GoPxL Manager as an administrator. For more information on using GoPxL Manager in Administrator mode, see *Running GoPxL Manager in Administrator Mode* on page 818. |
| Show notifications | GoPxL Manager will show notifications in the tray area. |
| Enable GoPxL licensing | In order to use tools such as GoPxL Anomaly Detector with live scan data, you must purchase a license and dongle. Then in GoPxL Manager, you must enable licensing and install the licensing software if necessary. For more information see *Installing Licensing Software* on the next page.<br>To change this setting, you must be running GoPxL Manager as an administrator. For more information on using GoPxL Manager in administrator mode, see *Running GoPxL Manager in Administrator Mode* on page 818. |

# Installing Licensing Software

If you have purchased a license and dongle for using tools such as GoPxL Anomaly Detector, you must install the licensing software, Wibu-Systems CodeMeter.

*To install the licensing software*

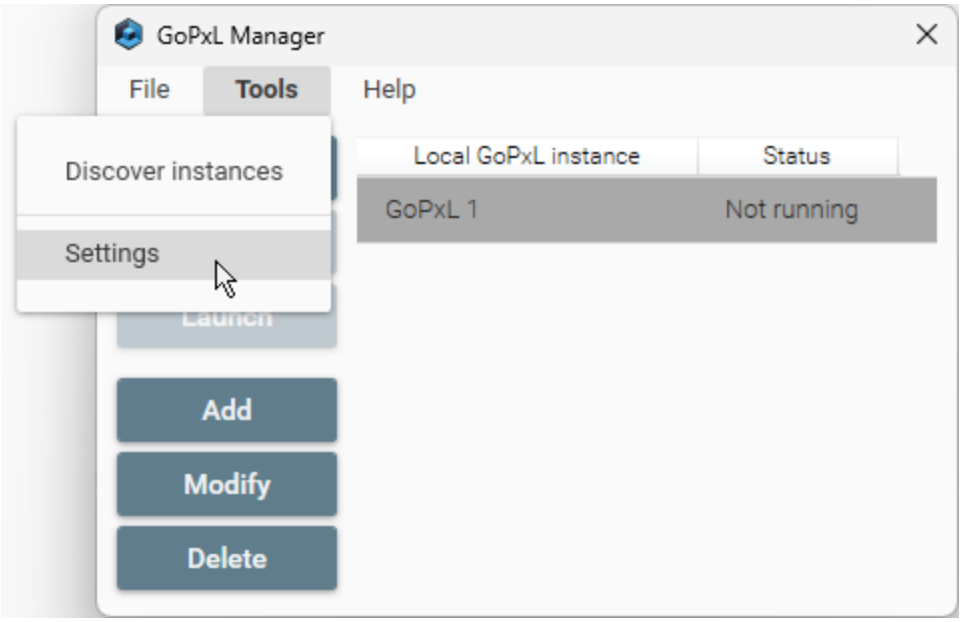
1. If it is not already running, start `GoPxL.exe` and open GoPxL Manager.

   For more information, see *Launching GoPxL on a Windows PC* on page 815.

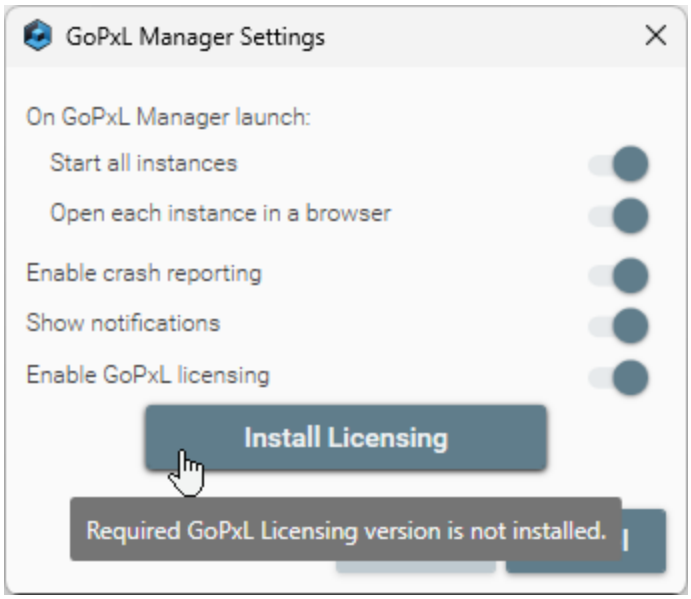
2. Restart GoPxL Manager in Administrator mode.

   For more information, see *Running GoPxL Manager in Administrator Mode* on page 818.

3. Click **Open** > **Settings**.




4. In GoPxL Manager Settings, if licensing isn't already enabled enable it.
5. Click **Install Licensing**.

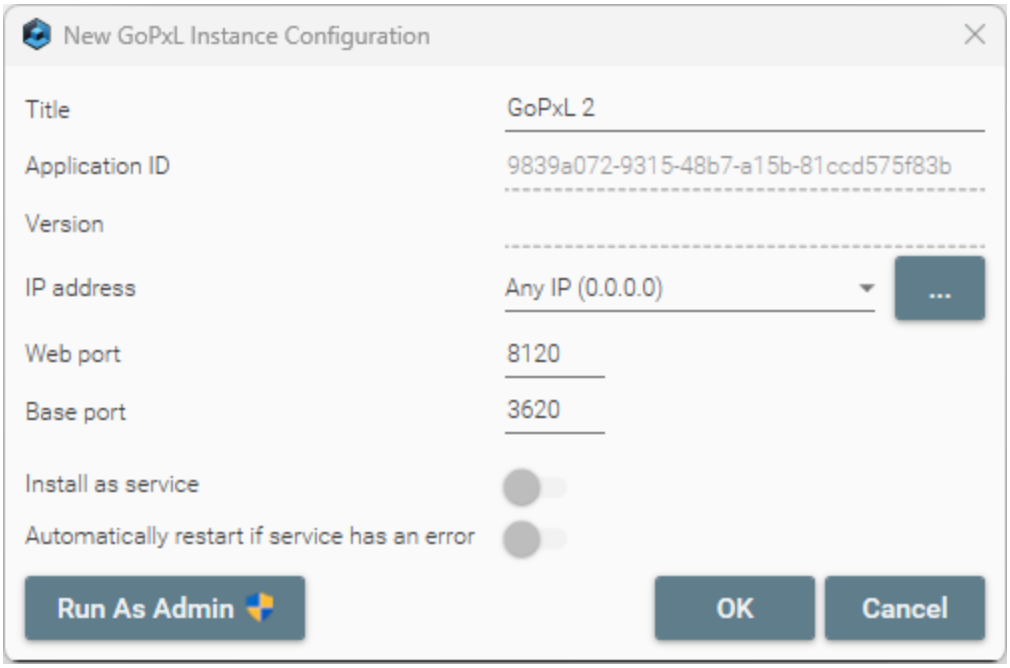



6. Follow the instructions in the CodeMeter installer.

   In the Custom Setup step, leave the selection of features as the default.

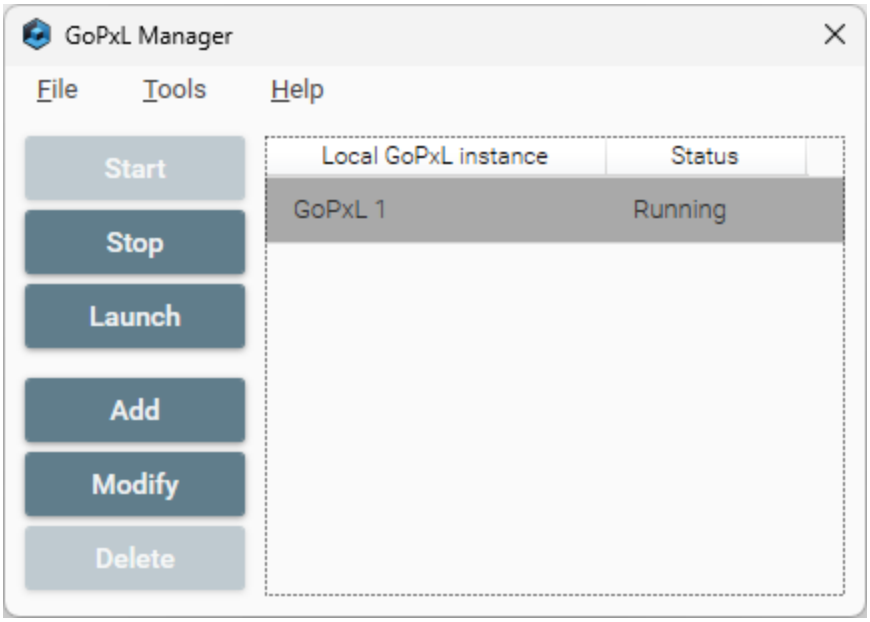
## Instance Settings

When adding or modifying an instance, you can change various settings (see *Instance Configuration* on the next page).



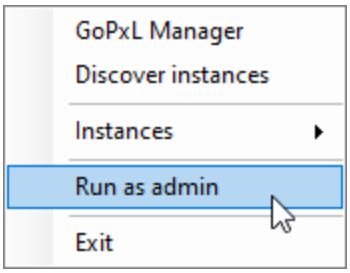

To add an instance, click **Add** and configure it if needed, and then click OK.

To modify an instance, select it in the list of instances and click **Modify**. To make changes to an instance, it must be stopped; select the instance and click **Stop** if needed.



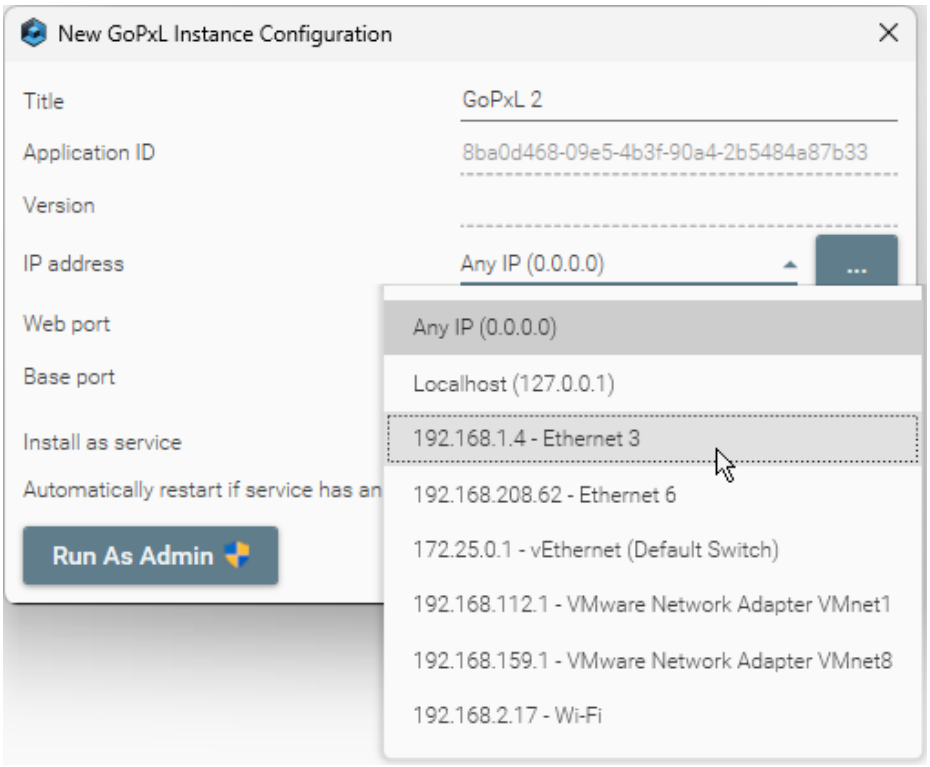

*GoPxL Manager with one instance running.*

To change the settings of a service instance or delete it, you must be running GoPxL Manager as an administrator. You can do this by clicking **Run As Admin** in the Instance Configuration dialog (see above), which restarts GoPxL Manager with administrator rights. You can also run right-click its icon in the Windows taskbar and click **Run as admin**.




*Instance Configuration*

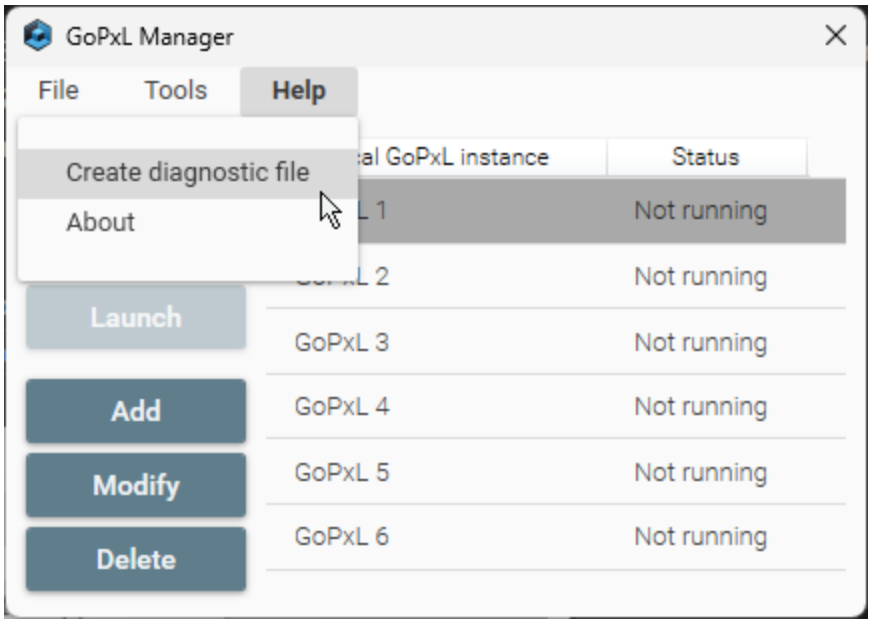
| Parameter | Description |
|---|---|
| Title | The name of the instance in GoPxL Manager. |
| Application ID | The ID of the GoPxL instance. Not editable. |
| Version | The version of the GoPxL instance. Not editable. |
| IP address | The IP address of the instance (that is, the IP the instance is bound to). The drop-down lists the available interfaces on your PC. |

| Parameter | Description |
| --- | --- |
| |  <br>Using the address you provide followed by the instance's Web port in a web browser connects to GoPxL. You can find the Web port of an instance in the Instance Configuration dialog or in the Discovery tool by clicking **Discover Instances**.<br>Choose a specific Ethernet or Wi-Fi interface to bind the instance to that interface only. The instance will be visible to other PCs on your network at that IP address, provided that this is not blocked by a firewall.<br>Choose "Any IP (0.0.0.0)" to bind the instance to *any* available interfaces. You can then connect to the sensor using any of the interfaces available on the PC (Ethernet, Wi-Fi, localhost, and so on). Except for the localhost address, the instance will be visible to other PCs on your network at those IP addresses, provided that this is not blocked by a firewall. Note that when you launch the GoPxL interface of an instance set to "Any IP" from GoPxL Manager, it opens at http://127.0.0.1/ followed by the Web port. Also, in the Discovery tool, the first IP found by the tool is listed in the table.<br>If you are using PROFINET, you must set this to a specific interface: PROFINET does not support "Any IP" or Localhost.<br>Choose Localhost to bind the instance to http://127.0.0.1/. The instance will only be visible to the PC it's running on. |
| Web port | The main ports the instance uses. These must be unique for each instance. |

| Parameter | Description |
| --- | --- |
| Base port | **Web port**<br>The port you use when connecting to the instance, for example, to `http://127.0.0.1:8120/`.<br><br>**Control port**<br>The port you use with the GoPxL SDK and REST API (see *GoPxL SDK and REST API* on page 863). |
| Install as a service | A PC instance installed (and running) as a service can run a sensor without the need for a user to be logged into Windows. |
| Automatically restart if service has an error | If an instance of GoPxL is configured to be a service and it has an error, it will restart automatically. |

# Creating a Diagnostic File

To help troubleshoot issues related to PC instances of GoPxL, you can create a diagnostic file containing logs and instance files. You usually only need to do this when asked to do so by LMI support.




After choosing Create diagnostic file, Windows will prompt you for a location.

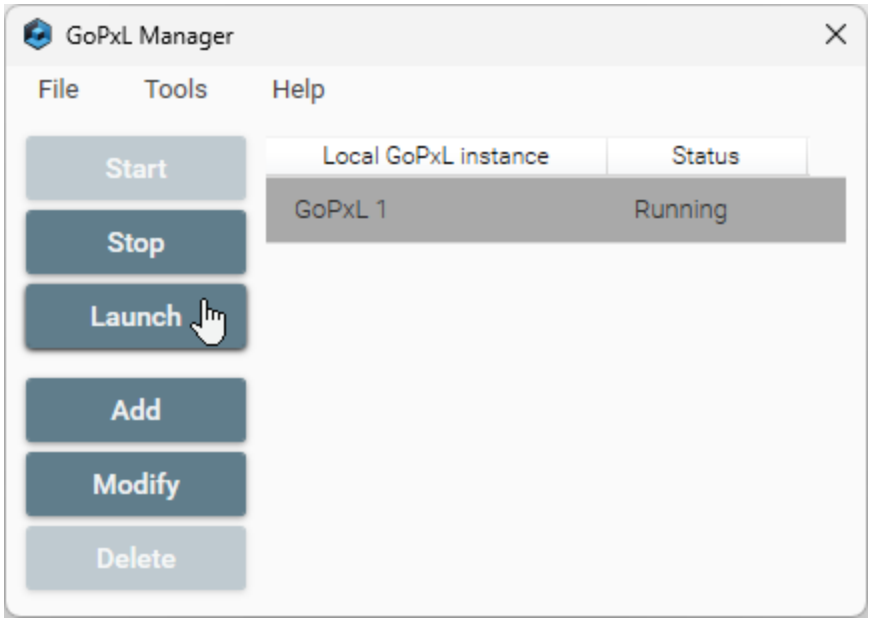
# Accelerating a Sensor

You accelerate a sensor (or group of sensors) by connecting it to a PC instance of GoPxL.

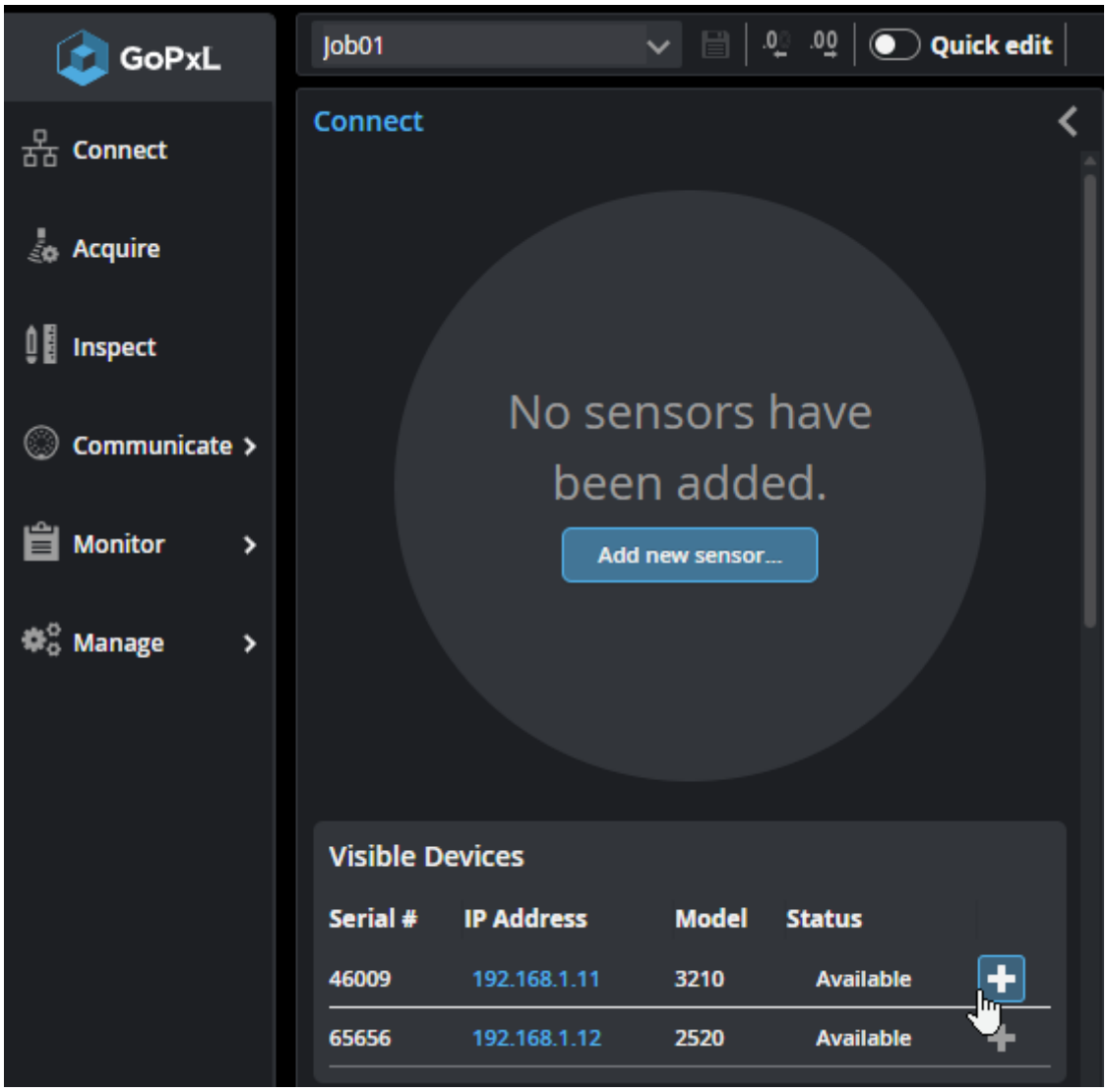
*To accelerate a sensor*

1. In a web browser, go to the IP address of the PC instance.

You can also launch the PC instance from GoPxL Manager.

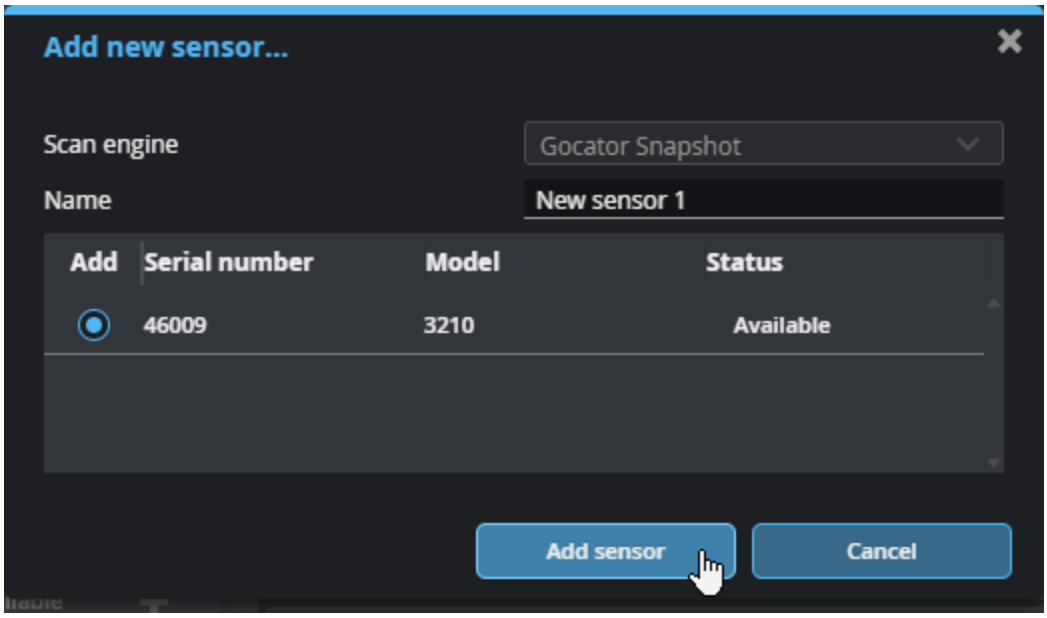



2. On the **Connect** page, in the **Visible Devices** area, click the plus symbol next to the sensor you want to add.

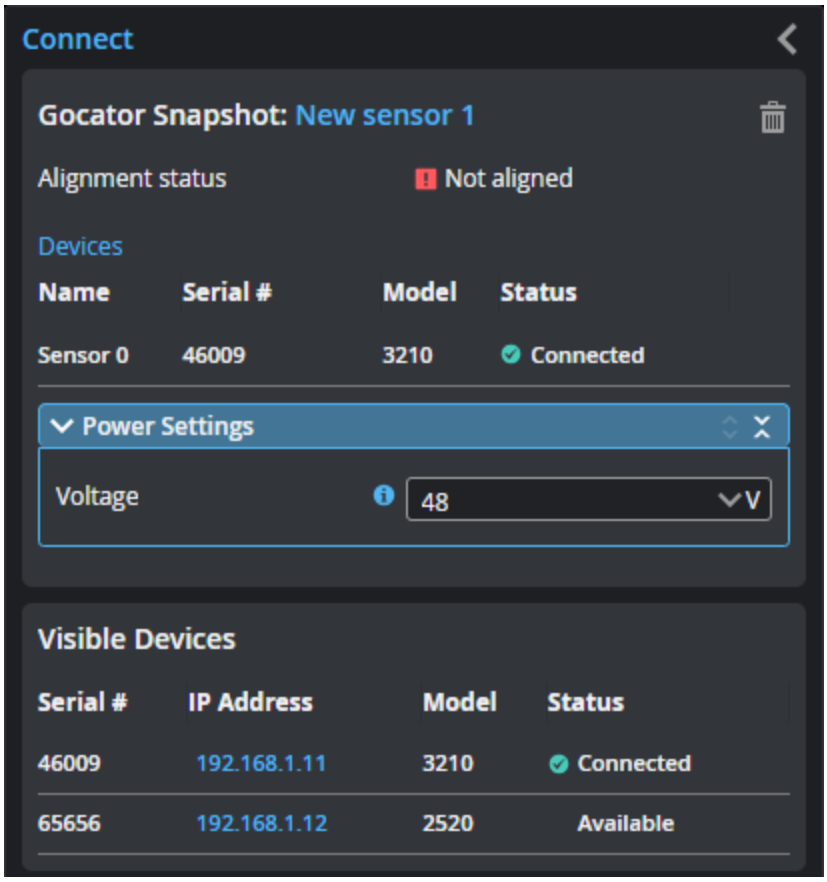



3. In **Add new sensor...**, if the sensor is not already selected, click next to it in the **Add** column, and click **Add Sensor**.

   You can optionally set the name of the sensor.




The physical sensor is now connected to the PC instance of GoPxL and is automatically accelerated.



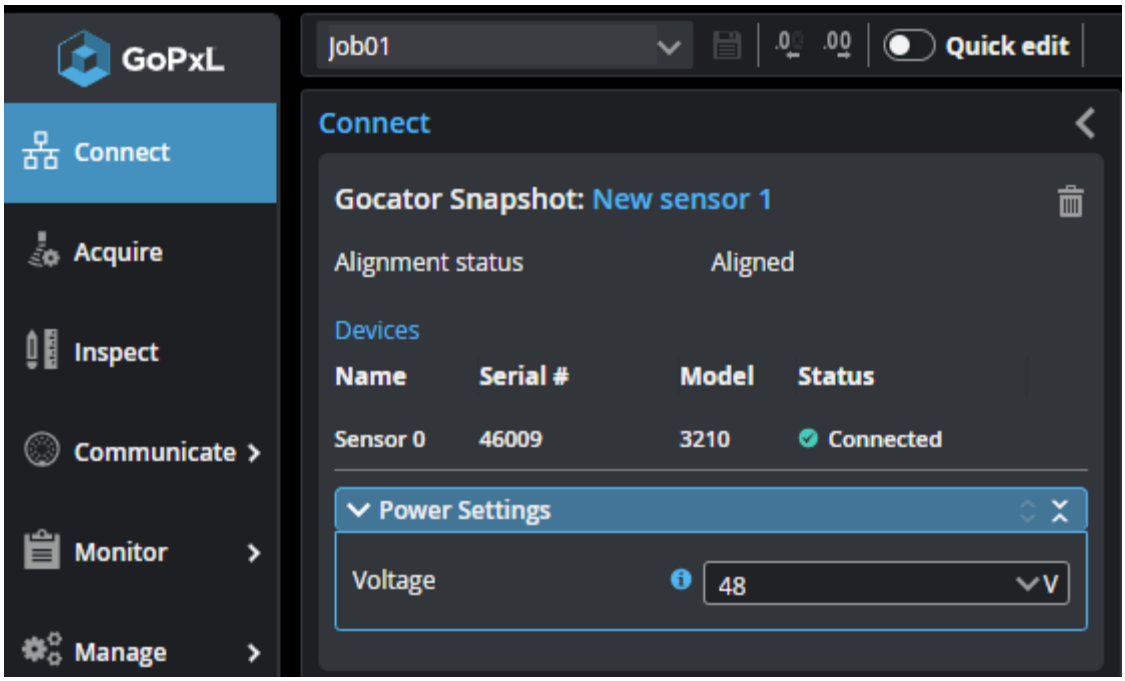

You access the sensor via the IP address of the PC instance, through which you control and configure it.

## Stopping Acceleration

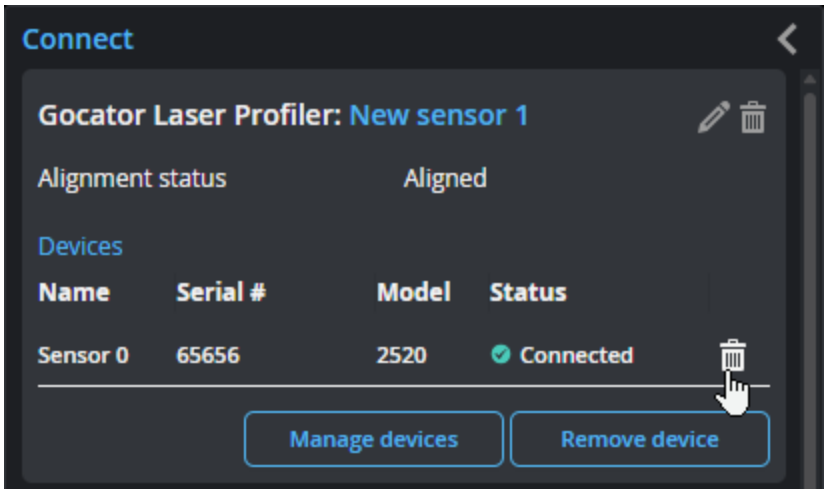
To stop accelerating a sensor, you remove it from the PC instance of GoPxL it's connected to. You also need to remove a sensor from a PC instance to upgrade the sensor's firmware.

*To remove a sensor from a PC instance*

1. In the GoPxL interface of the PC instance, go to the **Connect** page.

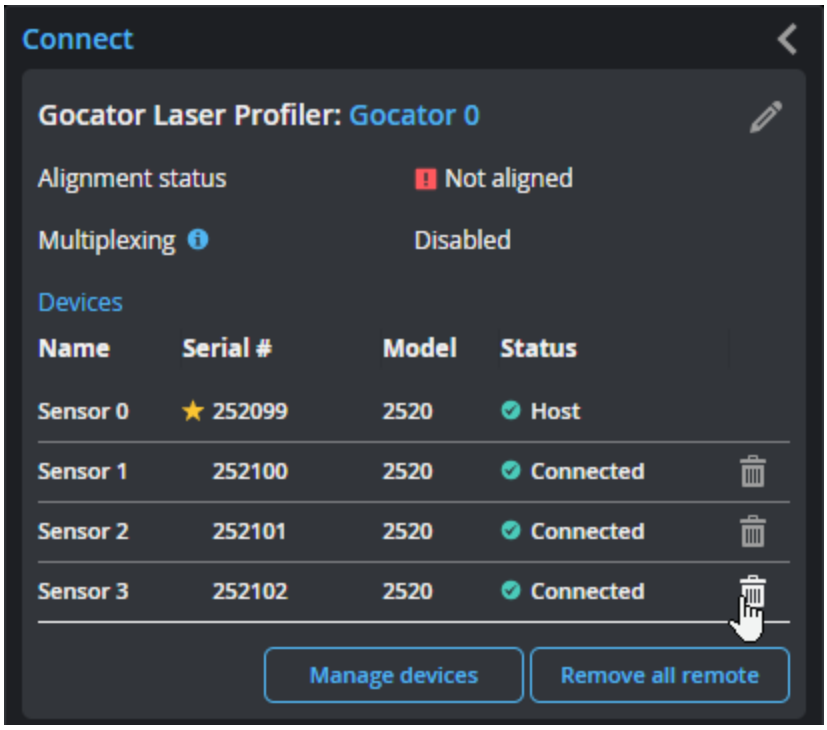



2. With a single accelerated line profile sensor, click the trashcan icon or **Remove device**.

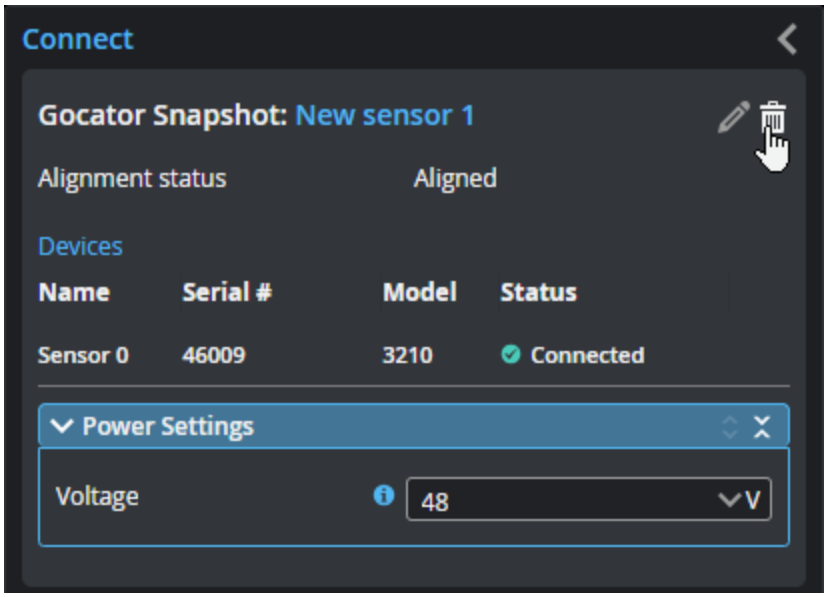



**Remove sensor from the group**: Choose this if you have started configuring settings on the **Acquire** page and just need to add a different sensor to the sensor group.

3. With a multi-sensor line profile system, click a trashcan icon to remove a single sensor, or **Remove all remote** to remove all sensors.




4. With G3 sensors, click the trashcan icon.




The sensor is removed from the PC instance.

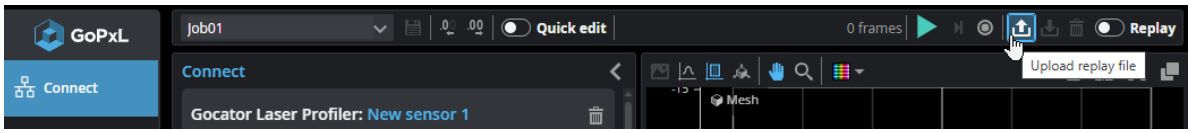
## Loading Scan Data

To examine previously recorded scan data offline, you load a .gprec file into the PC instance of GoPxL.

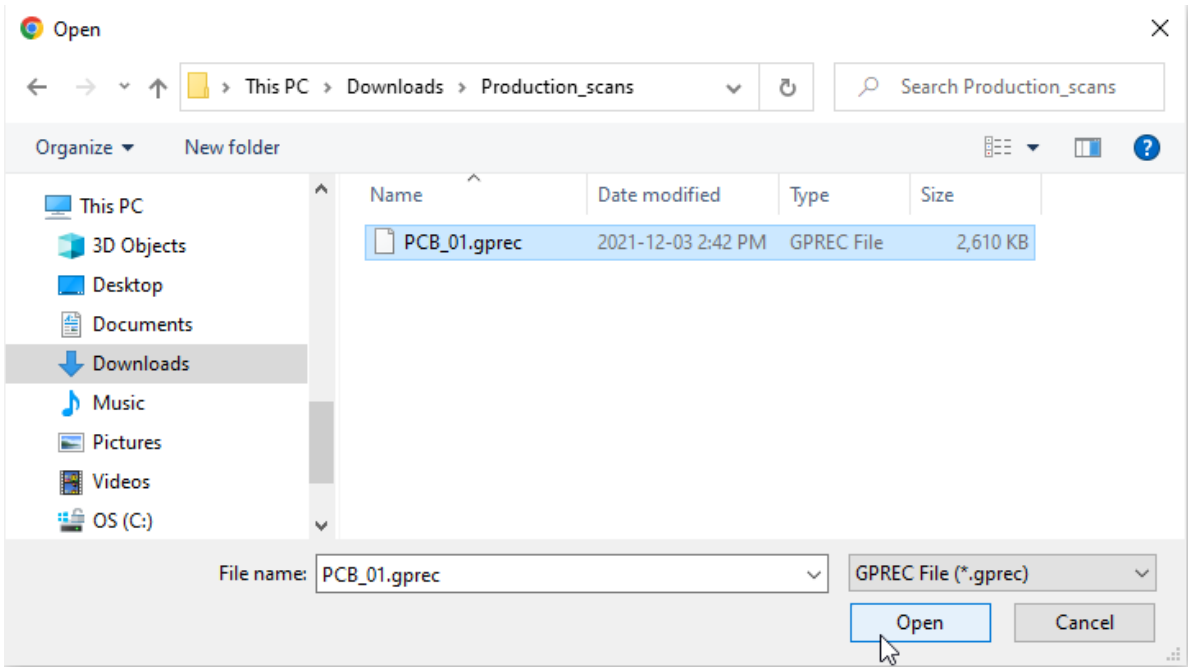
| | |
|---|---|
| | You can also load a backup file or a support file to examine previously recorded scan data. |

*To load recorded data (.gprec)*

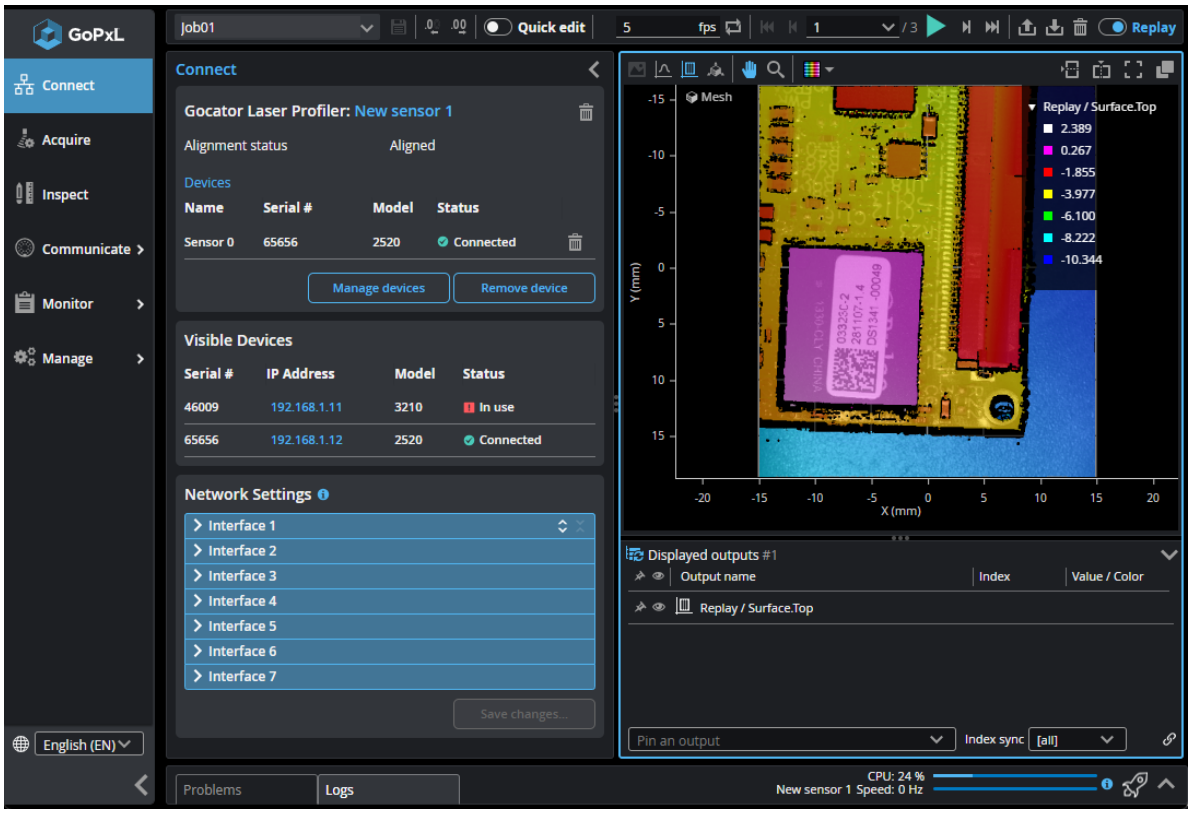
1. In the GoPxL interface, above the data viewer, click the Upload replay file button.




2. In the **Open** dialog, locate and select the recording (.gprec) you want to load, and click **Open**.



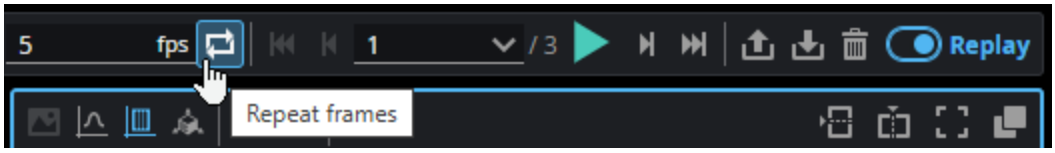

The recording loads in GoPxL, and GoPxL automatically switches to Replay mode.




You can now examine the recorded data and configure tools run on it.

3. Use the replay controls above the data viewer to move through the frames, go to a specific frame, toggle and configure the speed of repeat frames mode (continuous loop), and so on.

   Hover over the replay controls for tooltips describing their function.

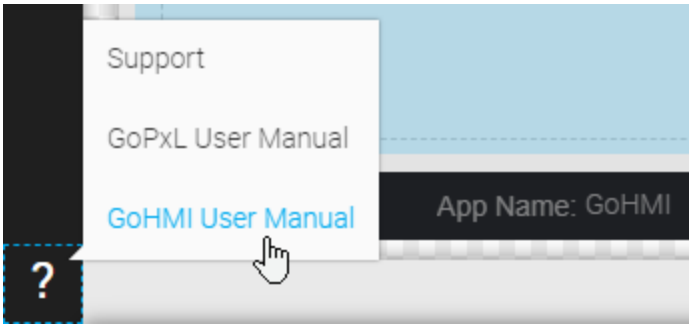



Using repeat frames mode with a low frame speed is useful for adjusting measurement tool settings and seeing the impact on scan data, without having to click Start or step through the frames of scan data manually. Repeat frames mode is also useful for demos.

# GoHMI and GoHMI Designer

GoHMI lets you create flexible human-machine interfaces (HMIs) and provide a custom GUI containing system and inspection metrics. Your HMI can also be touch-enabled. You create and edit HMIs in GoHMI Designer. You can design different layouts for different devices so that, for example, your HMI will adapt to the screen it is being displayed on (a PC monitor, a laptop, a tablet, or a phone), as well as its orientation on the screen.

For complete information on creating an HMI app, click the question mark in the lower left of the designer, and click **GoHMI User Manual**.




If you don't see changes you have made in the GoHMI app, or an HMI you've just uploaded, you may need to clear your browser's cache to make it available: the GoHMI is cached for 60 seconds.

Before using the designer, you must enable GoHMI on GoPxL; for more information, see *Enabling and Configuring GoHMI in GoPxL* on page 837.

GoHMI and GoHMI Designer only support a single HMI app, called "GoHMI." Also, GoHMI can only be enabled on one PC instance at a time. If you try to start GoHMI another instance, GoPxL displays an error.

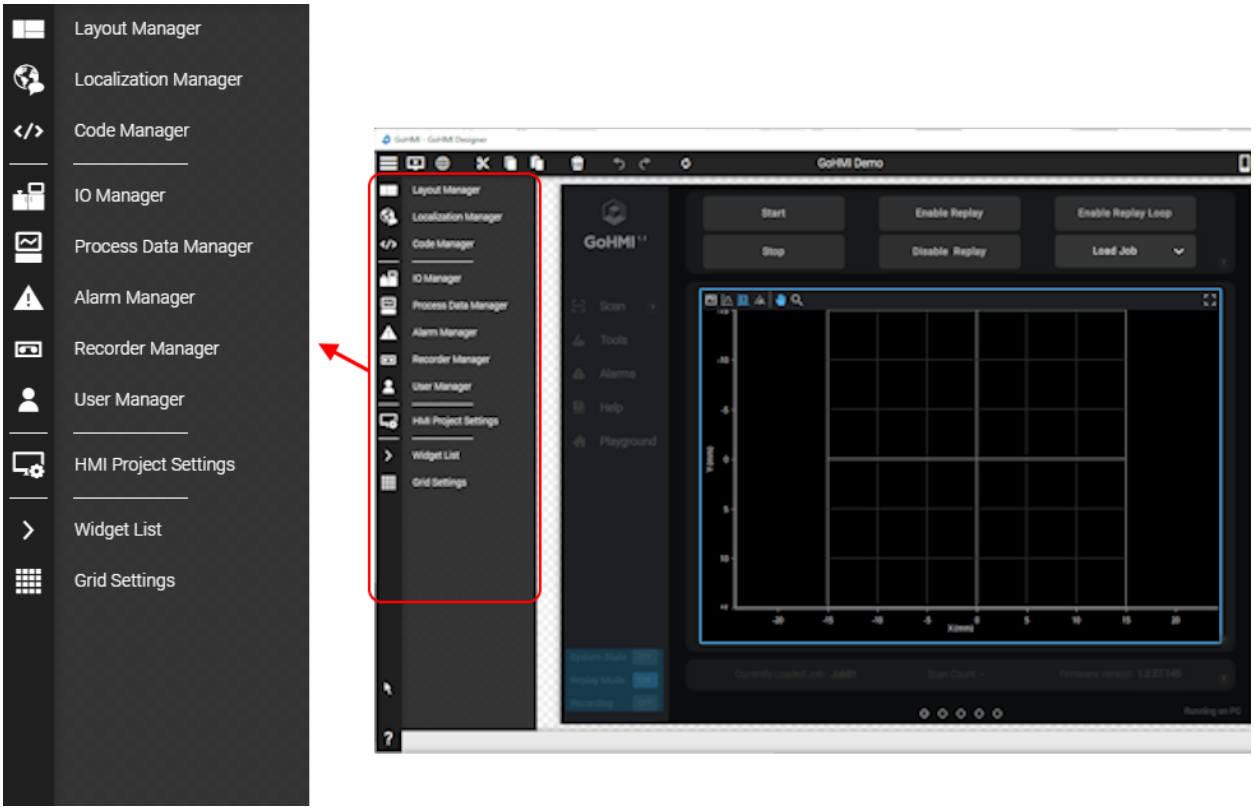
LMI provides a default HMI app with GoHMI that you use as a starting point or simply to explore the capabilities of GoHMI. When you launch GoHMI Designer, the default app loads in the designer.

GoHMI Designer is available in the GoPxL Utilities package (`14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.zip`), available on LMI's Product Downloads page (https://lmi3d.com/product-downloads/). After you have downloaded the package, unzip it and make note of the folder's location; the shortcut to the designer is in the `GoPxL` folder.

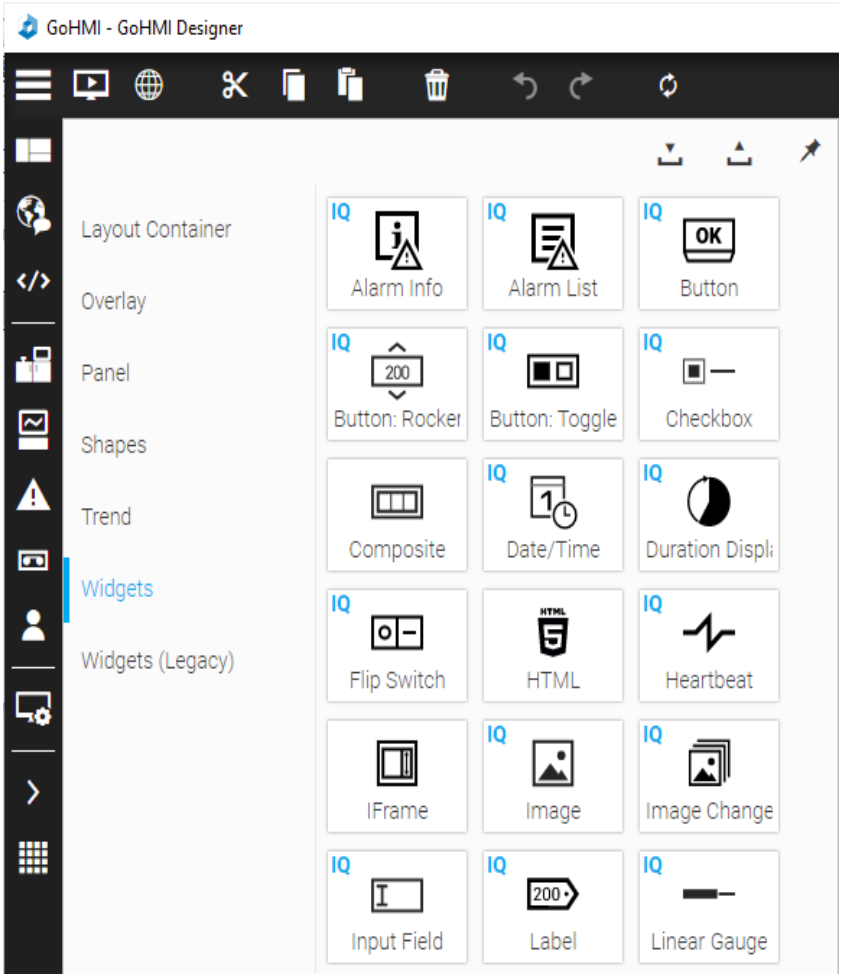
GoHMI Designer requires the Microsoft Visual C++ Redistributable package. This package is usually already installed on most PCs. If you are unable to launch HMI Designer, you may need to install this package, which can be downloaded at https://docs.microsoft.com/en-us/cpp/windows/latest-supported-vc-redist?view=msvc-170.

| | |
|---|---|
| ⚠ | If you decide to run your HMI application on a sensor, instead of on a PC instance or a GoMax NX device, you *should not* use the HMI data trending functionality. Data trending writes data repeatedly to storage, which can shorten the lifespan of the device's flash memory. Also, if the sensor's storage becomes full, the device may not be able to start. If you need data trending, you should run the HMI on a PC or on GoMax. |

GoHMI Designer organizes the available design functionalities and settings into "managers" and settings pages. After you have opened an HMI app in GoHMI Designer, they are listed in a collapsible panel along the left side of the application. Move your mouse over the left side of the designer to expand it. Click on a manager or settings item to switch to it.




The side panel also lets you access the list of widgets (user interface controls such as buttons) and layout containers you use to create your HMI. Click on "Widget List" to open the list. The widgets are grouped into categories. Below, the "Widgets" category is open.




GoHMI application layout development involves the concept of containers. Containers contain widgets or other containers (that is, containers can be nested). Containers can display their contents horizontally (for example, a row of buttons and fields) or vertically (for example, a stack of buttons). By nesting containers and adjusting their alignment, you have complete control over your HMI app's layout and design.

The following provides a high level view of what you need to do to start creating an HMI. The first steps below refer to general acquisition and measurement tool setup, which is described elsewhere in the manual. The remaining steps are described in further details below.

1. Install a sensor or group of sensors.

   For more information, see the installation and networking topics under .

2. Configure the sensor acquisition settings.

   For information on configuring acquisition settings, see *Acquire - Alignment and Acquisition* on page 96.

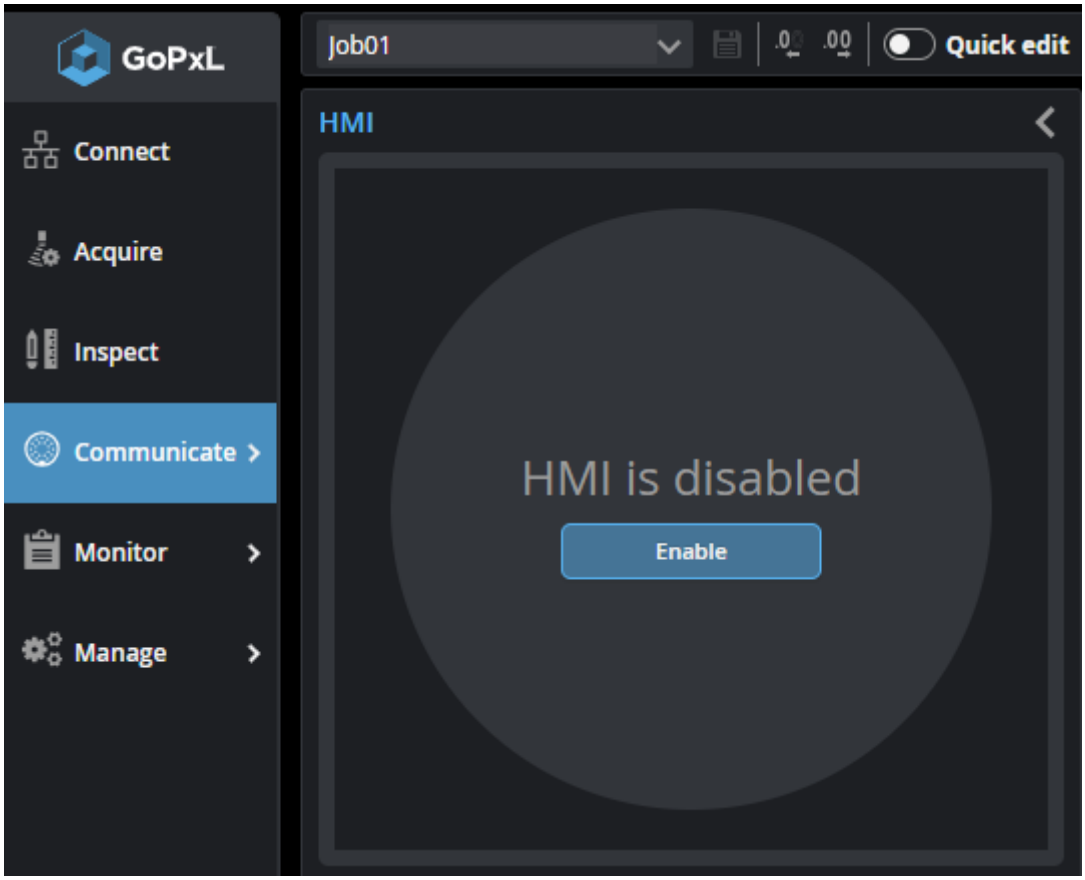
3. Add and configure measurement and processing tools.

   For more information, see *Inspect - Measurement and Processing* on page 147 or the topics for specific tools.

4. (Optional) If your application requires the Gocator communication protocol or any of the industrial protocols, enable and configure these.

For more information on the protocols available in GoPxL, see *Protocols (PLCs and other hardware)* on page 886.

5. Enable the HMI control settings in the **Communicate** > **HMI** page using the toggle and configure GoHMI.




For more information, see *Enabling and Configuring GoHMI in GoPxL* on the next page.

6. Launch GoHMI Designer.

For more information, see *Launching GoHMI Designer* on page 843.

The following lists the browser requirements of GoHMI apps:

- Chrome 80 (released 04.02.2020)
- Firefox 74 (released 10.03.2020)
- Edge 80 (released 07.02.2020)
- Safari 14 (released 16.09.2019)
- Opera 67 (released 25.02.2020)

# Overview of Managers and Settings Pages

For information on the editors (called "managers") you use in GoHMI Designer, see the following table.

*Overview of managers and settings pages*

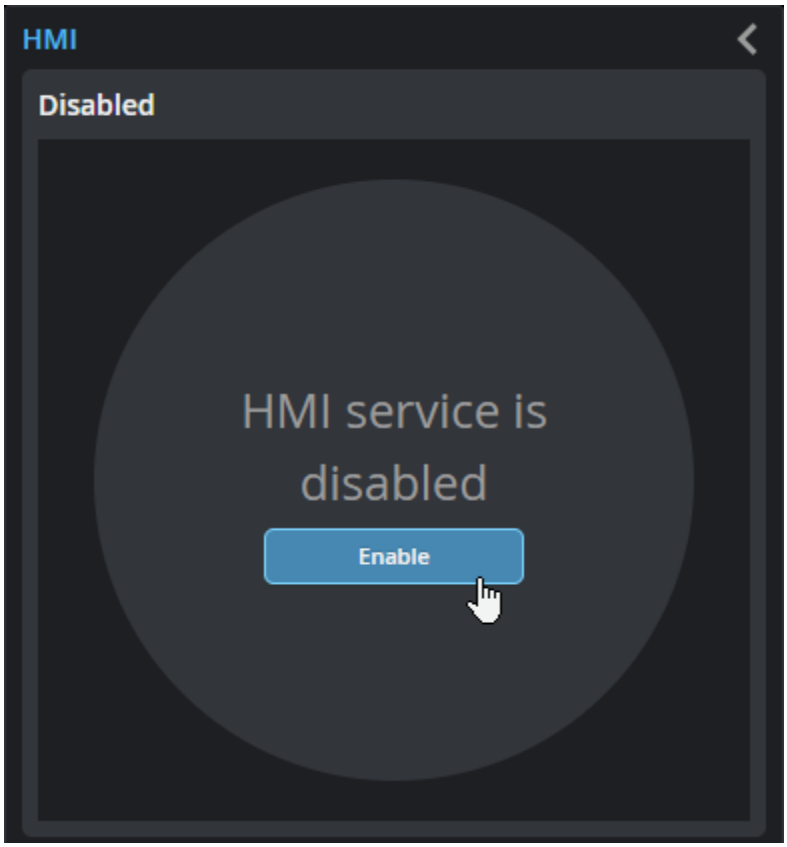
| Task | Manager | Description |
|---|---|---|
| Creating HMIs with Multiple Views | • Layout Manager | Creating views in your HMI using panels in GoHMI Designer. |
| Laying Out Your HMI | • Layout Manager | Styling your HMI in GoHMI Designer. |
| Using Widgets | • Layout Manager | Using the widgets provided in GoHMI Designer. |
| Styling the HMI | • Layout Manager | Laying out views and widgets in GoHMI Designer. |
| Using UI Actions | • Layout Manager | Defining UI-actions (such as mouse clicks on buttons in the HMI) to implement simple behaviors in GoHMI Designer. |
| Localizing the HMI | • Localization Manager | Localizing your HMI in GoHMI Designer. |
| Using the Integrated Code Editor | • Code Manager | Using scripts to add capabilities and features to your web HMI or to modify the appearance of widgets. |
| Processing Data Interface and Data Items | • IO Manager<br>• Process Data Manager | Configuring the data interface and connecting your HMI to a sensor system using GoHMI Designer. |
| Simulating Process Values | • Process Data Manager | Simulating process values in GoHMI Designer to evaluate or to demonstrate your web HMI without a connected sensor system. |
| Using Alarms and Alarm Lists | • Alarm Manager | Defining alarms and messages, store them as historical alarms, and display the corresponding messages in the HMI. |
| Using Recorder and Trend Display | • Recorder Manager | Recording process variables and displaying them in a trend diagram in the HMI. The integrated data recorder supports both live trends and trends from historical data. |
| Using Recipes and Recipe Widgets | • Recipe Template Manager | Generating recipe templates and useful metadata such as "article numbers," "customer description," and so on, which serve only for documentation. In applications, recipe process values can be applied or captured. |
| Managing Users and Access Groups | • User Manager | Creating users and user groups and how to assign access rights. |
| Managing Packages | • Package Manager | Extending GoHMI Designer with additional packages for widgets, themes, and starter apps. |
| Adjusting App Settings | • HMI Project Settings | Changing application settings such as project settings in GoHMI Designer. |
| Adjusting Grid Settings | • Grid Settings | Adjusting the snap-to grid size in the designer. |

# Enabling and Configuring GoHMI in GoPxL

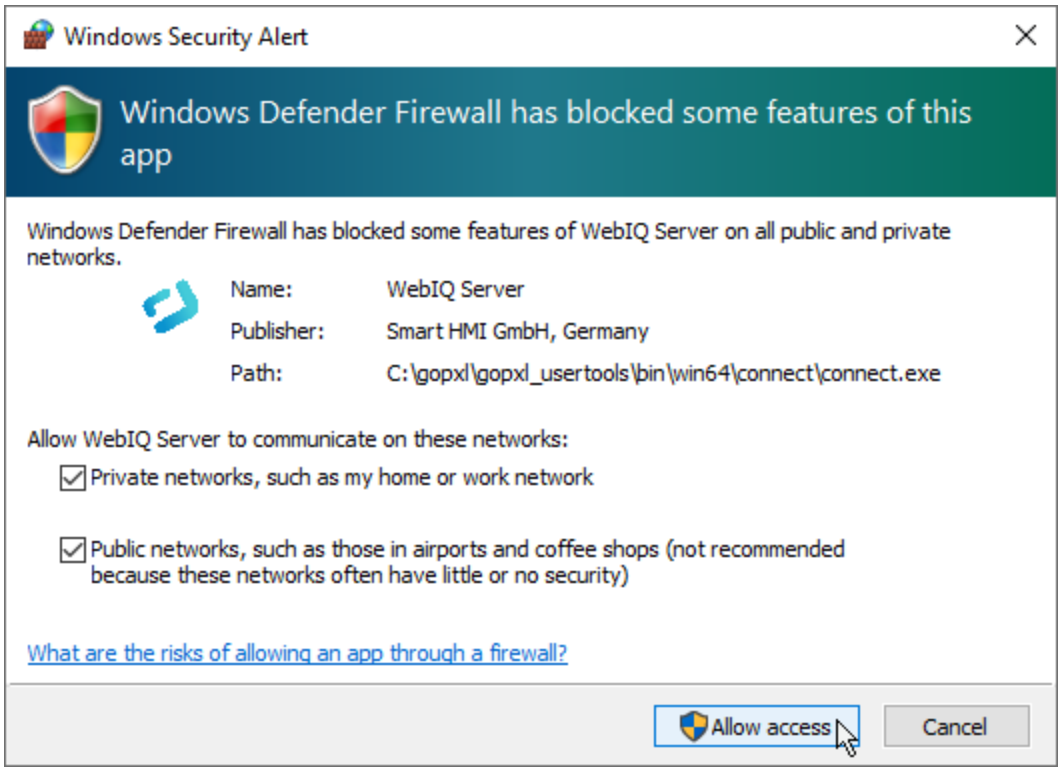
This section describes how to enable and configure GoHMI in the GoPxL interface. Before continuing, make sure you have created a sensor system, configured acquisition, and added and enabled the tools and measurements you want to display in the HMI.

*To enable and configure GoHMI*

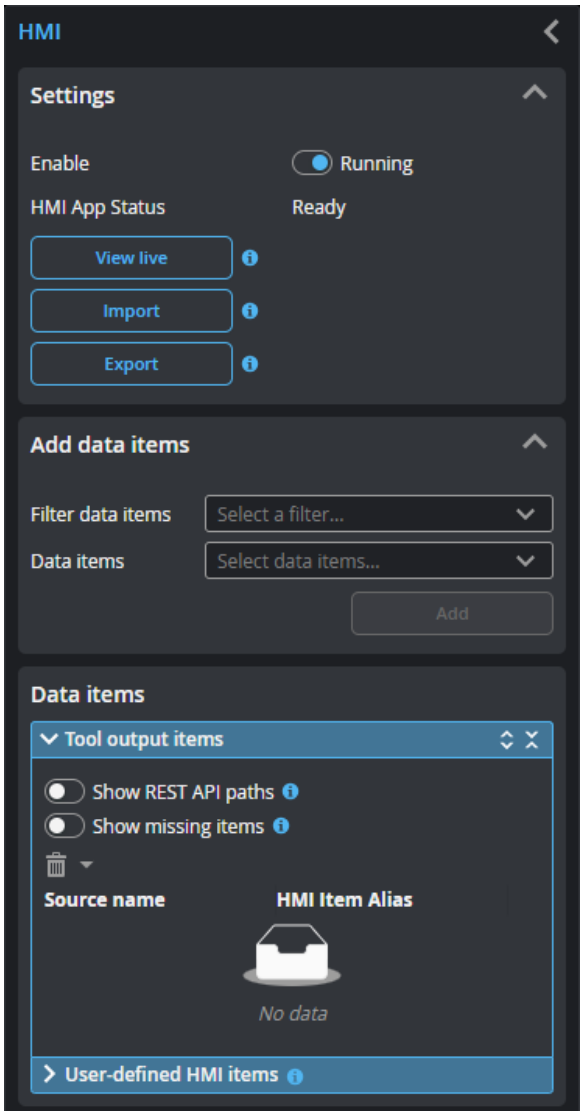
1. On the **Communicate** page, in the **HMI** panel, enable the HMI service.




If you are running GoPxL on a PC, a Windows Security Alert referring to WebIQ (the service on which GoHMI Designer runs) may appear. Enable both networks.




The HMI service launches, and the HMI panel displays the following:



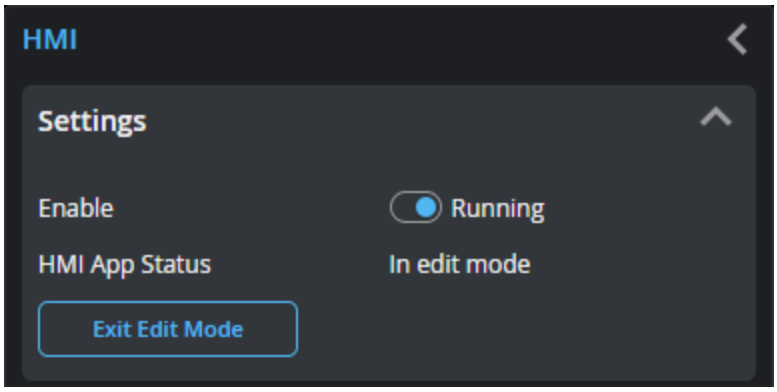

In addition to letting you disable the service and see the HMI app's status, the **Settings** panel Lets you perform various operations..

When the application is running, you can open the HMI app in your browser by clicking the **View live** button. You can make note of the URL of the HMI in this tab for future use.

**Import** lets you import an HMI application.

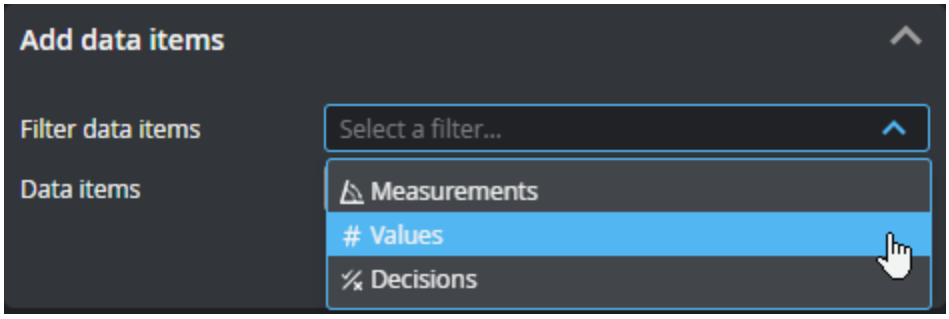
**Export** lets you export the HMI application currently available on the device (or in the PC instance), to back it up or transfer it to another sensor or PC.

2. If you see "In edit mode" as the HMI status instead of "Ready", you must remove it from the GoHMI Designer.

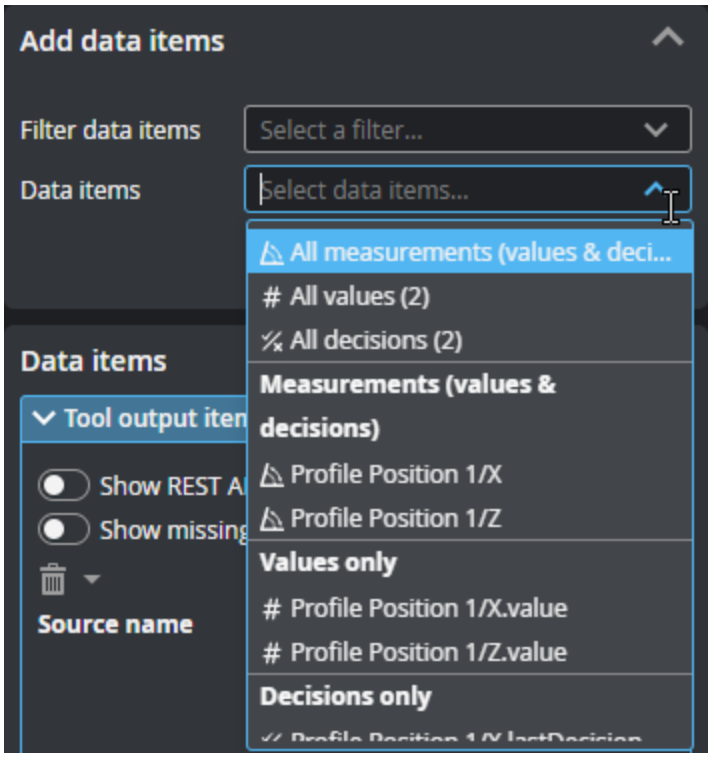



The status **In edit mode** means that the HMI app is currently loaded into the GoHMI Designer workspace. If you know you have finished making changes in GoHMI Designer, and have closed it without publishing it (to the sensor or PC instance of GoPxL), you can "force" exiting edit mode by clicking **Exit Edit Mode**. Note that doing this removes any unpublished changes in GoHMI Designer. For information on properly closing the designer and publishing changes, see *Publishing Changes or Exiting* on page 853.

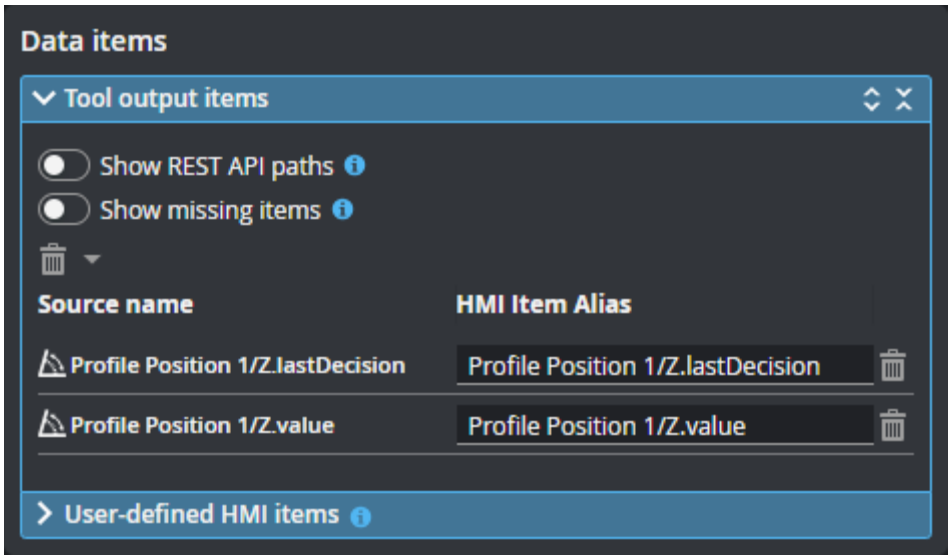
3. (Optional) You can filter the outputs to limit them to only values or decisions.




4. In the **Add Data Items** section, expand the **Data outputs** drop-down and click an output you want to send to the HMI.




After a few seconds, the output appears in the list of outputs that GoPxL will send to the HMI.



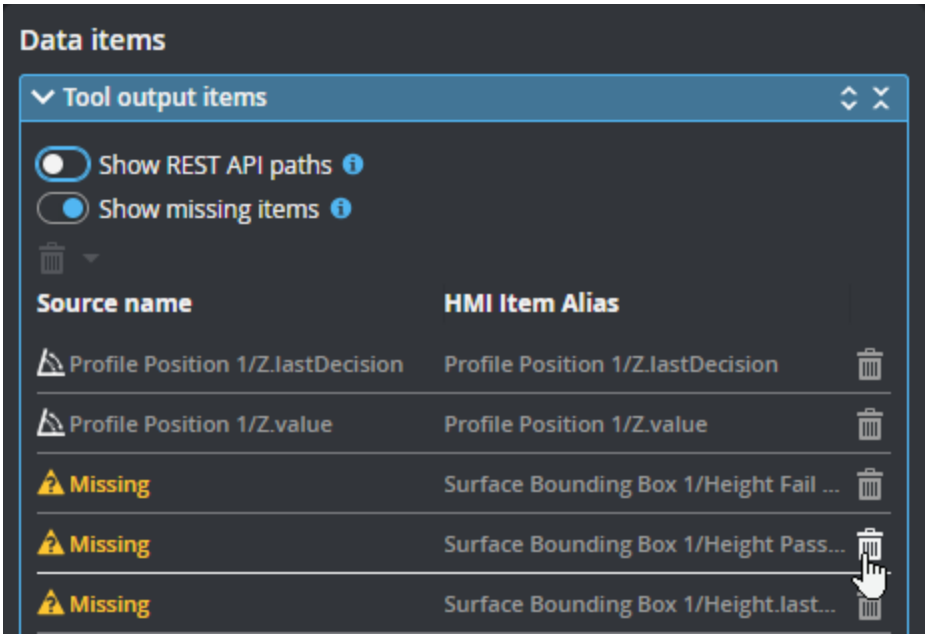

If you don't see the output you want to add in **Data items**, check that you have enabled it in the measurement tool, on the **Inspect** page.

5. (Optional) Toggle **Show REST API paths** to switch between showing the HMI item aliases and REST API of the outputs.

   HMI item aliases are how data outputs appear in GoHMI Designer.

   REST API paths are how the data output is represented in the REST API.

If GoPxL outputs referenced in an HMI are accidentally disabled or renamed in GoPxL, or the tool containing the outputs is removed, a **Show missing items** toggle will be displayed. Toggle this on to see which outputs are missing, and resolve the issue as required.

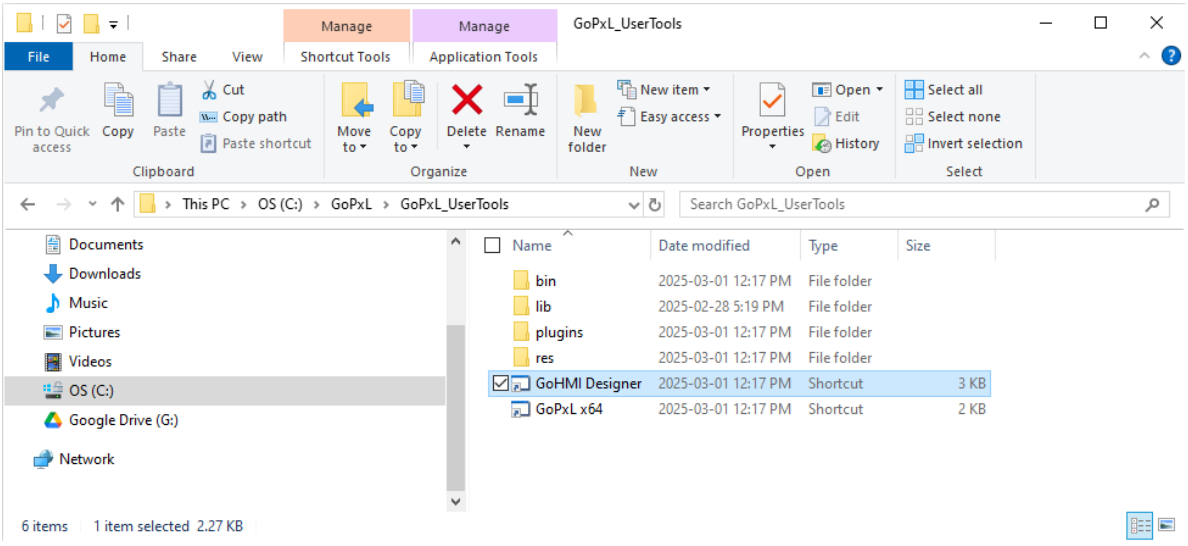



# Launching GoHMI Designer

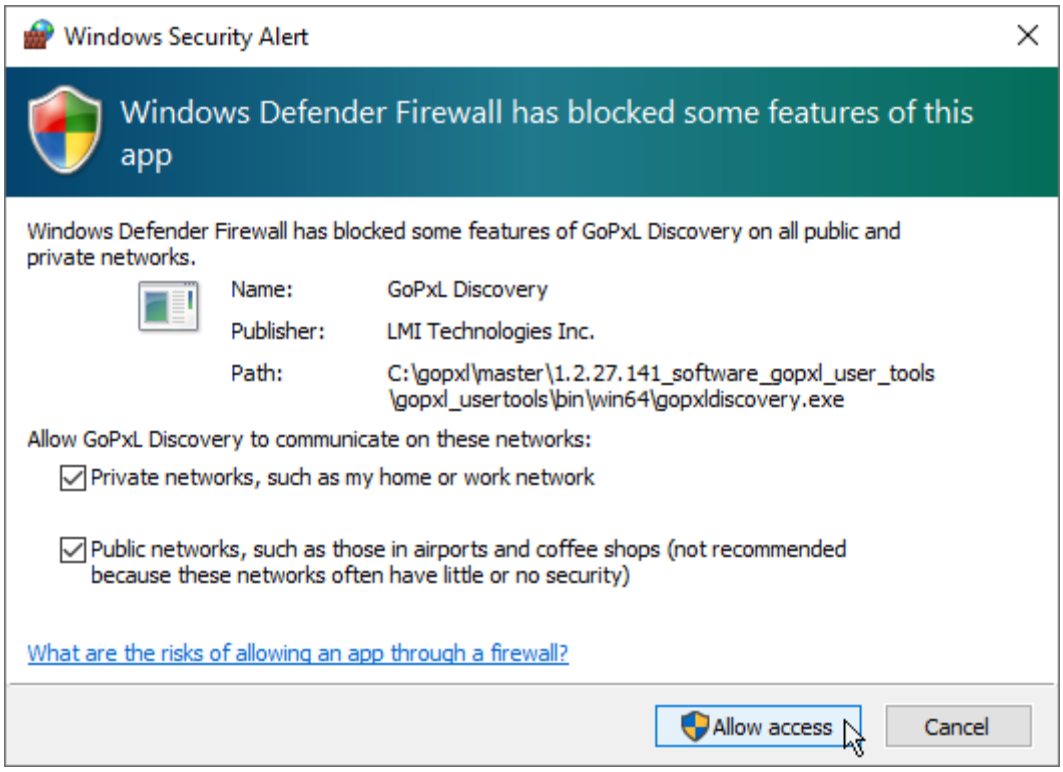
After you have enabled the HMI service in GoPxL and configured it by adding the outputs you want to send to the HMI, you can launch GoHMI Designer to create or edit an HMI.

*To launch GoHMI Designer*

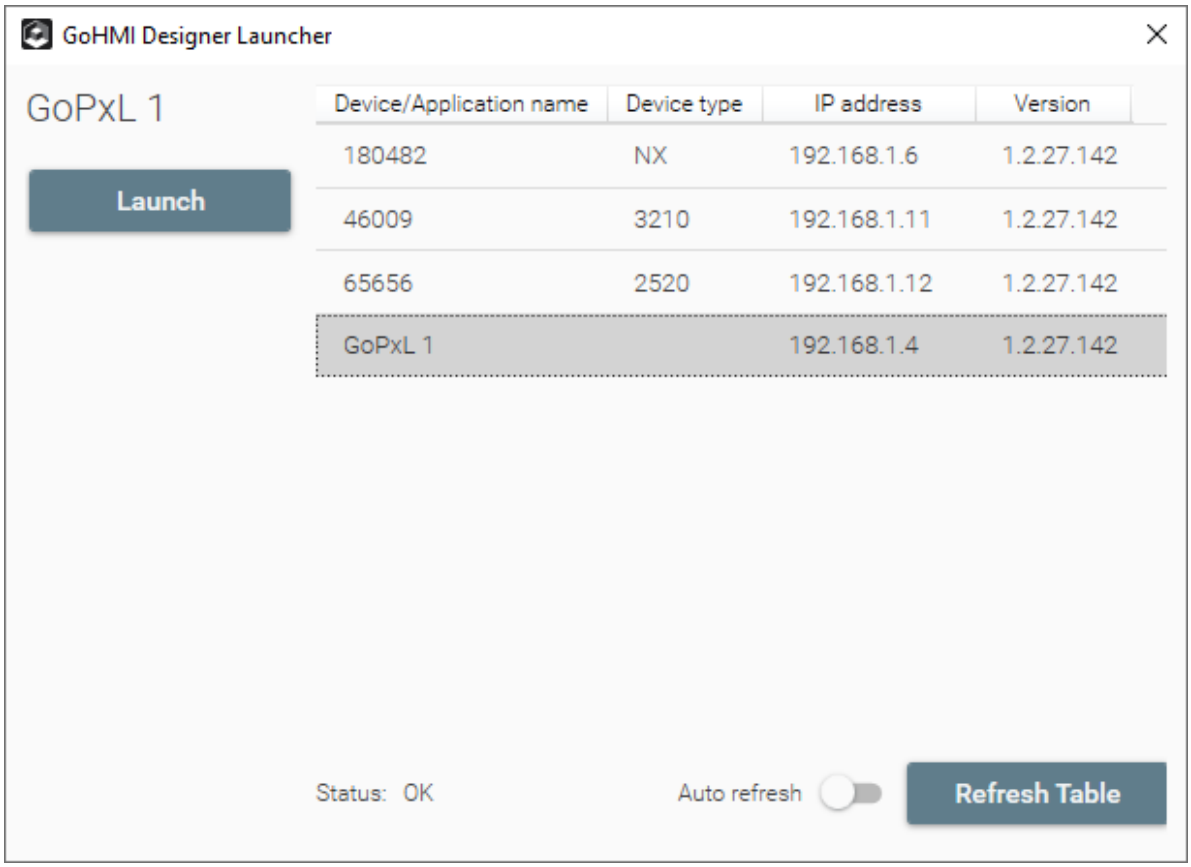
1. Go to where you extracted the GoPxL tools, and double-click the GoHMI Designer shortcut.



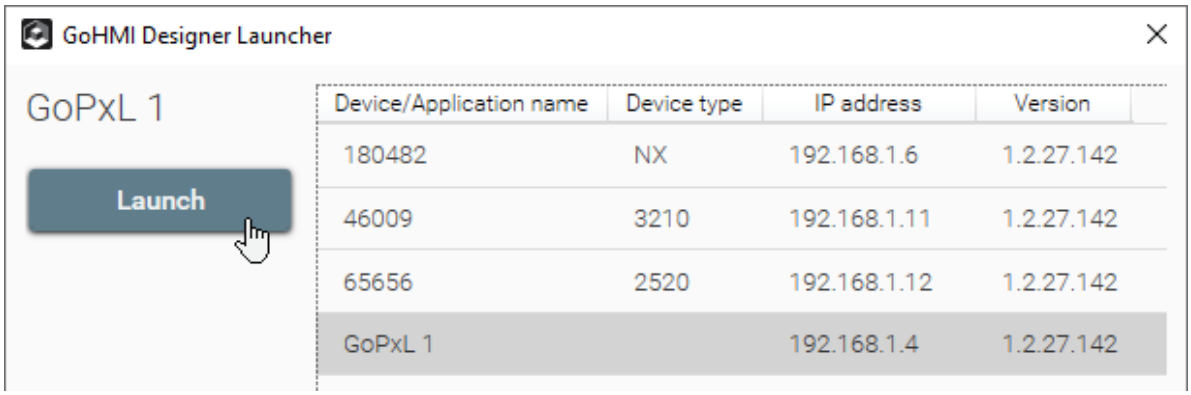

2. (Optional) If a Windows Security Alert opens, enable both networks and click **Allow access**.




GoHMI Designer Launcher opens and lists the available instances of GoPxL. In the following, we see two sensors, a PC instance of GoPxL called "GoPxL 1," and a GoMax NX device.



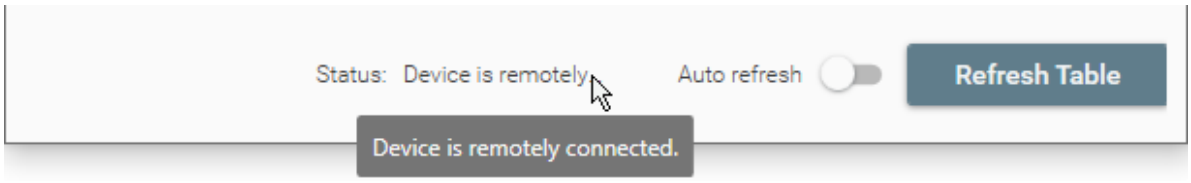

3. In the launcher, select the row of the GoPxL instance for which you want to launch GoHMI Designer and click **Launch**.




You may need to refresh the table to get the most up-to-date list by clicking **Refresh Table**. You can toggle **Auto Refresh** to have the table refresh automatically.

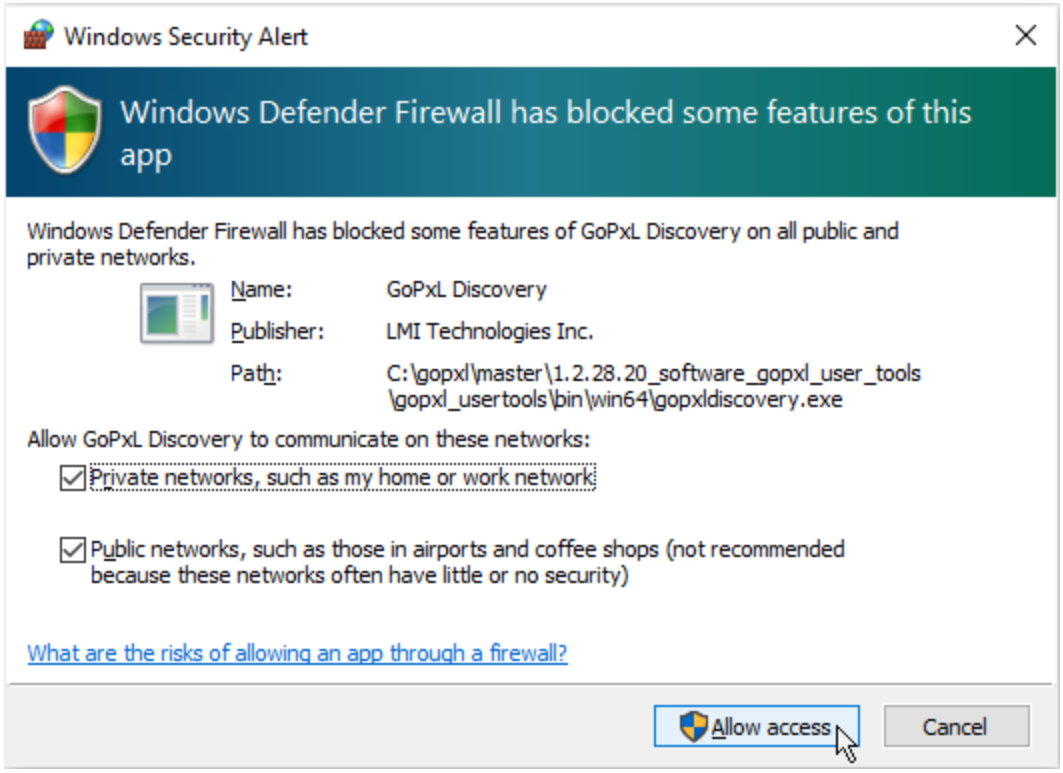
Note that you can only launch one instance of GoHMI Designer at a time.

If a sensor is currently running through a PC instance of GoPxL, its status is "Device is remotely connected." In this case, you can only launch GoHMI Designer from the PC instance through which the sensor is running.

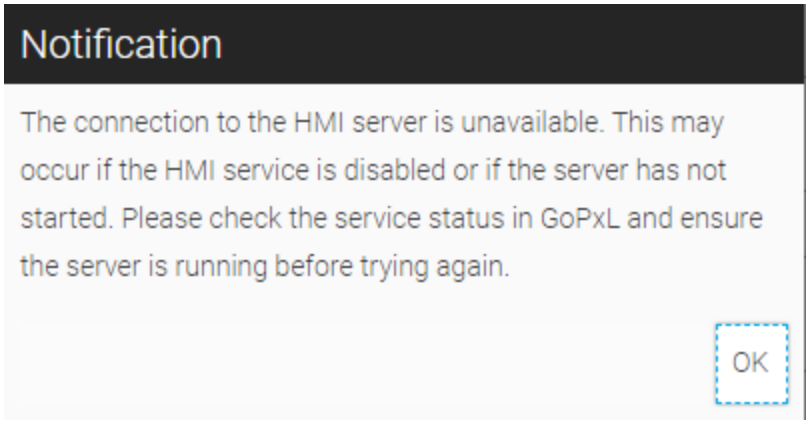



The launcher closes and GoHMI Designer starts.

A Windows Security Alert may appear. If so, allow the designer to communicate over both networks.




If you see a notification warning that the connection to the server has been interrupted, make sure you have enabled the HMI service in GoPxL. After enabling the service, click OK in the notification. (For more information, see *Enabling and Configuring GoHMI in GoPxL* on page 837.)




4. If necessary, log in to the designer.

   By default, use "gohmi" for the user name and "gohmi" or "gohmi123" for the password.

# Opening, Editing, and Saving a Project

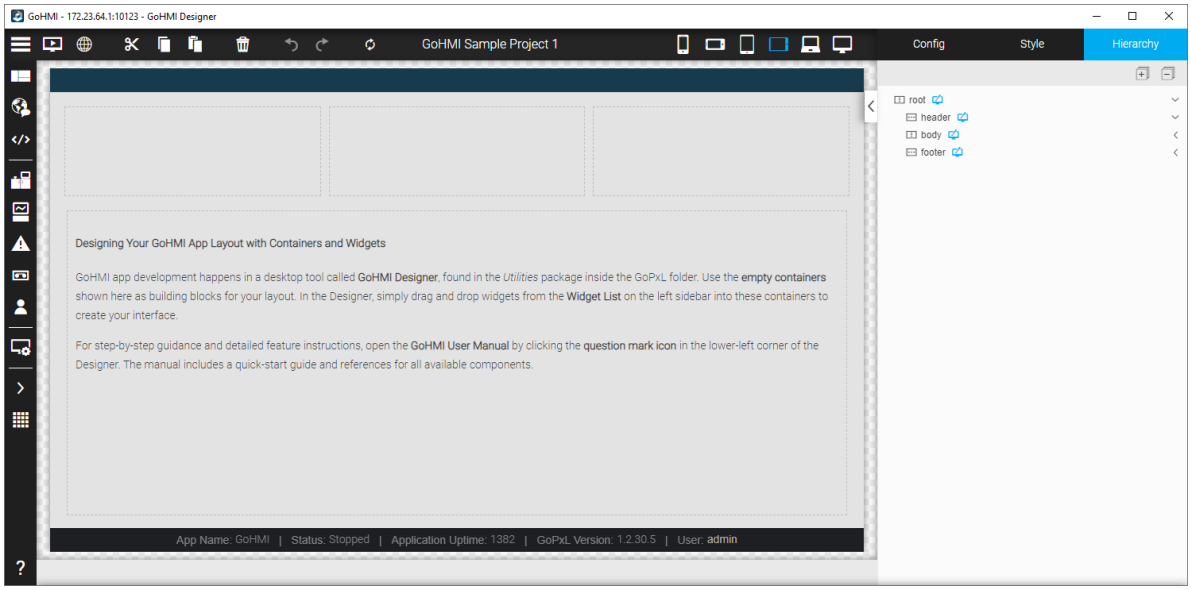
This section describes how to open the GoHMI project (called GoHMI), modify it, and save it.

> GoHMI Designer only supports a single HMI application at a time.

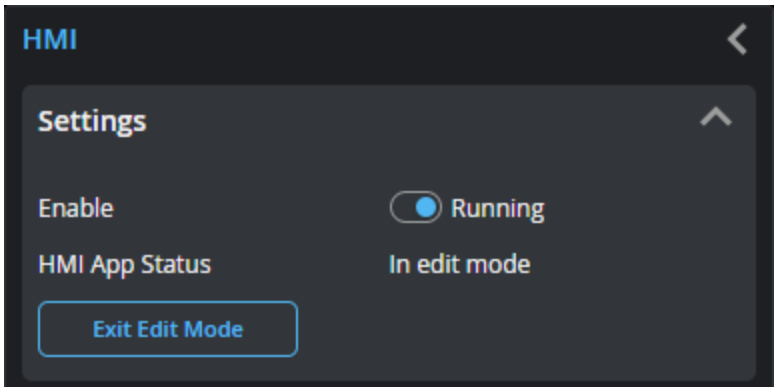
*To open a project*

1. In the GoHMI Designer main screen, hover the mouse over the GoHMI project and click it.

The project opens in the Layout Manager.




Note that after the HMI loads in GoHMI Designer, in the GoPxL interface the HMI app status becomes "In edit mode."



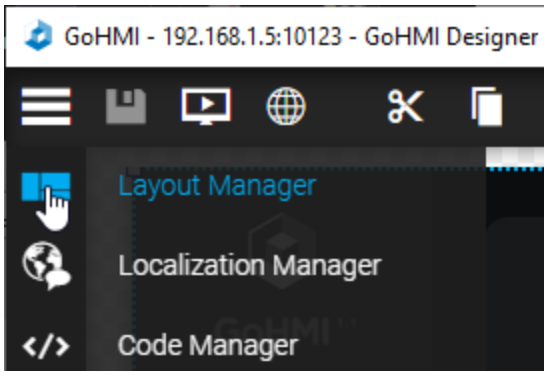

## Adding a Widget

This section describes how to add a widget to the demo app. To keep things simple, we will simply describe how to add a label to the sample HMI app, change the text it displays, and modify the color of the text.

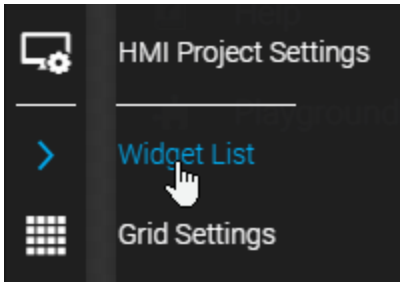
> Before modifying the sample HMI, you should export it for safe-keeping. For more information, see *Importing and Exporting an HMI* on page 854.

*To add a widget*

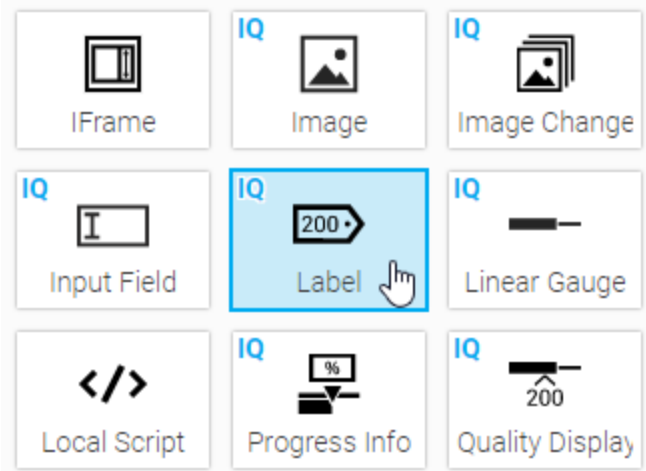
1. Move the mouse over side bar on the left and click Layout Manger to make sure you're in the Layout Manager.



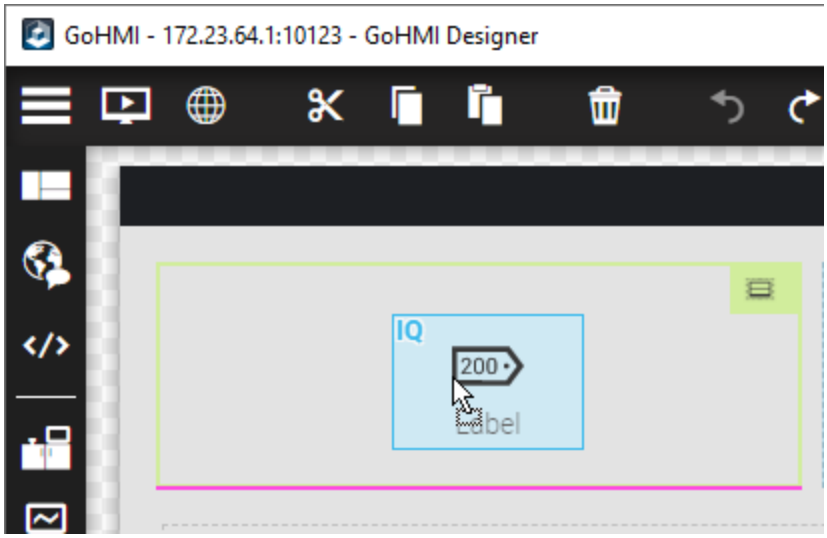

2. While still hovering over the side bar, move down to Widget List and click it.



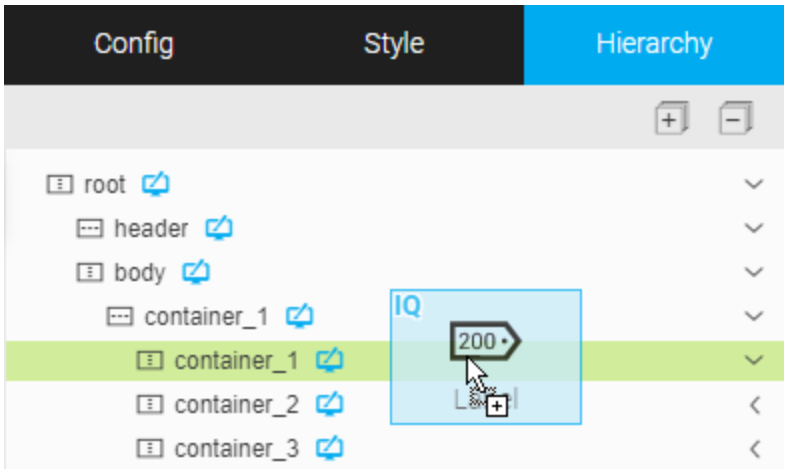

3. In the Widget List panel that opens, click and drag the Label widget toward the HMI in the Layout Manager.




As you move the widget over the HMI, notice that the container to which the widget would be added if you dropped it is indicated by a green rectangle. A pink line indicates where in the container it would be dropped.

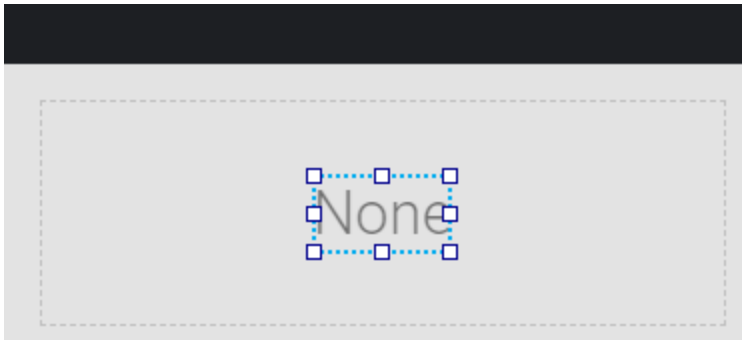



Note that as you move the widget over the HMI, its position is also shown in the hierarchy of containers and widgets in the **Hierarchy** panel to the right. You can also drag widgets onto this hierarchy to position them between widgets.

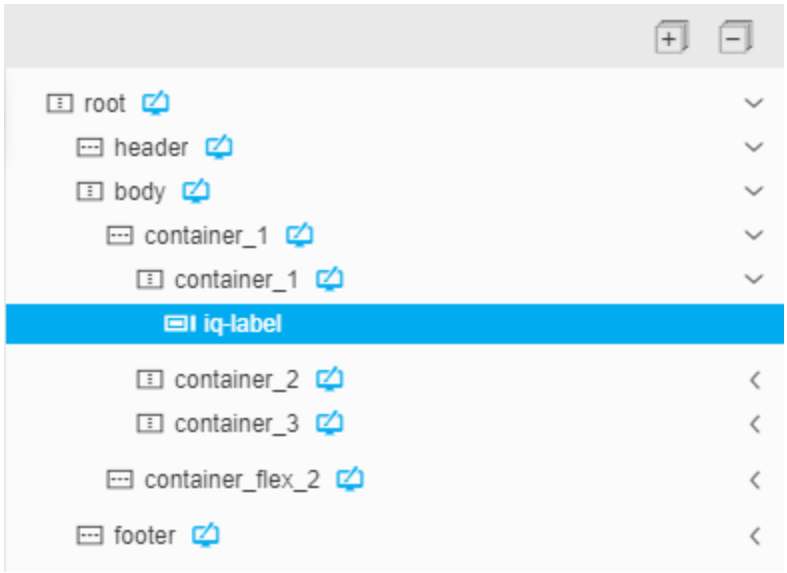



4. Drop the widget, for example in the first container.

   The widget is added to the HMI, and initially shows "None".

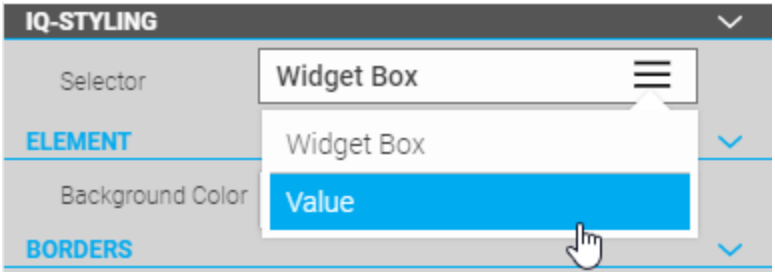



   The Label widget now appears in the hierarchy as "iq-label," between the "brand" and "container" items.

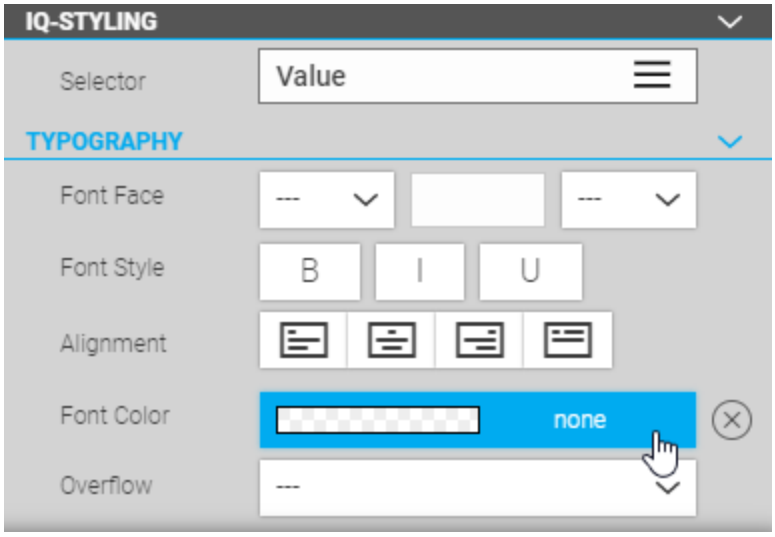



   Understanding where widgets will "land" involves understanding container types and their alignment settings.

To style widgets, you will typically use a stylesheet, which is beyond the scope of this document. However, you can manually style a widget by selecting the widget in the **Hierarchy** panel, switching to the **Style** panel, scrolling down to the **IQ-Styling** section, and applying the desired style. For this example, you must change **Selector** from Widget Box to Value.

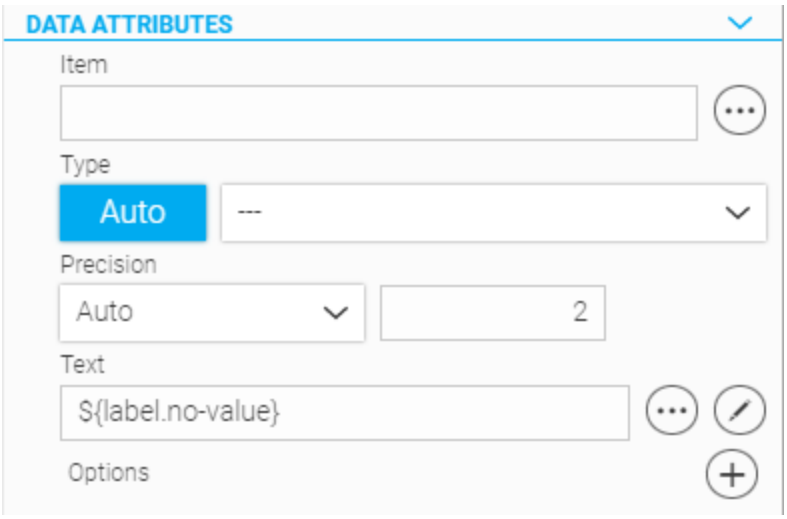



Click the **Font Color** selector.



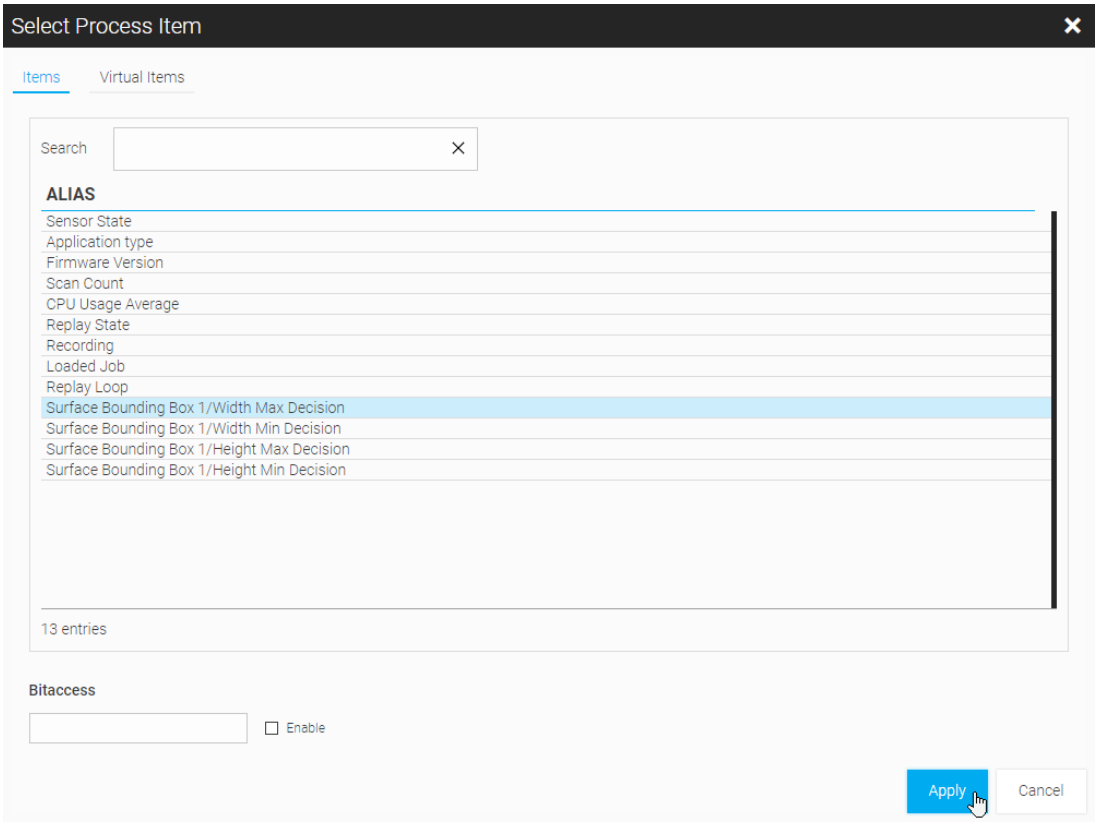

In the selector, replace "000000" with "ff0000", and click outside the selector to apply the change. The text should become red.

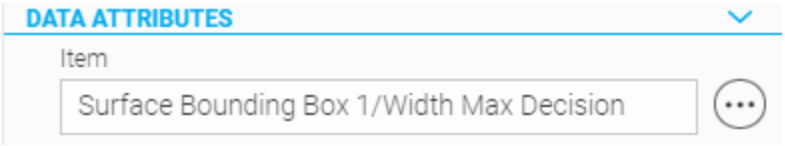
To set the value of the label, switch to the **Config** tab, and set it in the **Data Attributes** section. If you need to set the label to static text, edit the **Text** field. You can set the value directly here (by replacing the variable in the field with text), for example, with "My label".




You can set up a variable in the Localization Manager and set the widget's text using that variable.

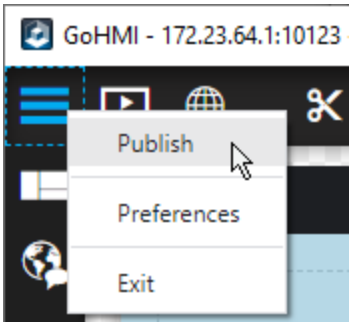
You can also set the value of the label to something the HMI is receiving from the sensor, such as a measurement value. To do this, in the **Data Attributes** section, click the three dots next to the **Item** field, choose the item in the **Select Process Item** dialog, and click **Apply**.



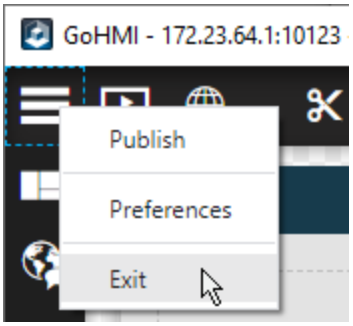



## Publishing Changes or Exiting

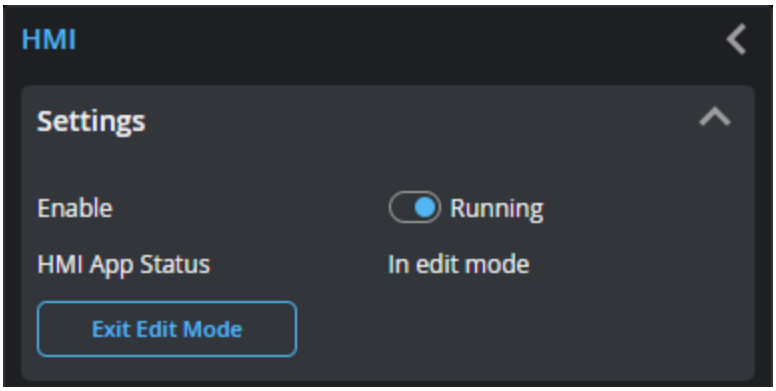
As you work on an HMI, the designer automatically saves changes locally. To save changes onto a device (sensor or GoMax) or into a PC instance of GoPxL, you must publish the HMI app from the main menu at the upper left of the Designer.



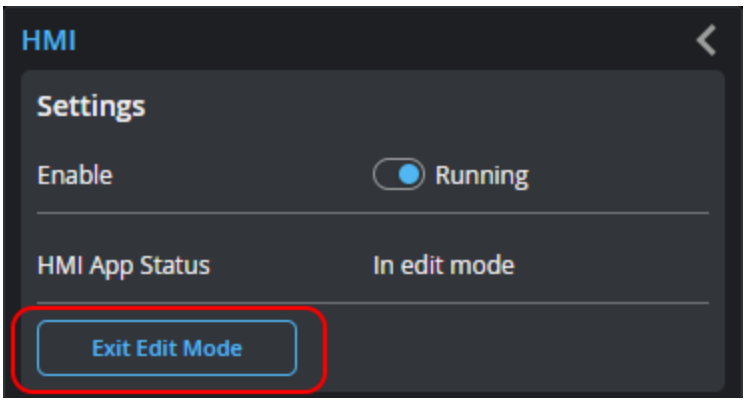

When you have finished working on your HMI, you should exit the designer by clicking Exit on the menu.




If you close the designer by using the Close icon (✕) at the upper right of the designer, the current state of the project is kept in the designer. If you have unpublished changes when you close it this way, the changes will still be present when you open the designer again, and you can continue from where you stopped. Note that when you close the designer using the Close icon (✕), the HMI remains in "edit mode," and you can't open the HMI, or import / export it from GoPxL until you publish the HMI from the designer.



In some situations, such as when you have closed the designer without publishing unneeded changes, you can "force" exiting edit mode by clicking **Exit Edit Mode** in GoPxL, in the **Communicate** > **HMI** page. Note that doing this removes any unpublished changes in GoHMI Designer, so make sure it is safe to do this.




## Changing Mapped Outputs in GoPxL

Before trying to add or remove measurements at a later date to outputs sent to the HMI application, the **HMI App Status** in GoPxL must say "Ready". If **HMI App Status** shows "In edit mode" and if you have unpublished changes in the designer that you want to keep, follow the steps in *Launching GoHMI Designer* on page 843 and then, in GoHMI Designer, publish the changes. For more information on publishing changes, see *Publishing Changes or Exiting* on the previous page. Otherwise, you can force GoPxL to exit edit mode by clicking **Exit Edit Mode**, but you will lose any unpublished changes.

## Importing and Exporting an HMI

You can import an HMI app from the GoPxL interface. After importing an HMI app, you can then edit it in GoHMI Designer. After you have imported an HMI you can also launch it in a browser from the GoPxL interface by clicking **Start** and then **View live**.

| | |
|---|---|
| ⚠ | Importing an HMI app overwrites the HMI app currently in GoHMI Designer. Consider exporting the HMI app from the GoPxL interface on a regular basis. |

To back up an HMI you have created or to provide it to someone else, you can export it.

| | |
|---|---|
| 🗋 | Imported and exported HMI apps are zip files. |

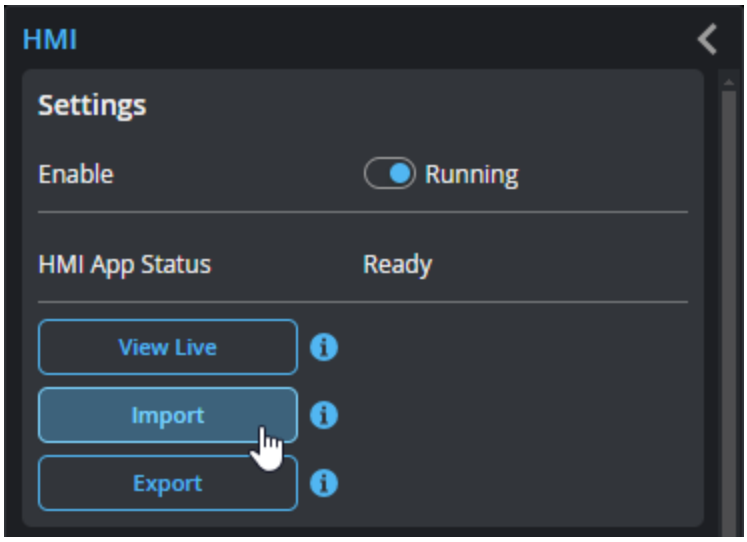
*To import an HMI app*

1. Make sure you have backed up the current HMI or that it is OK to overwrite it.

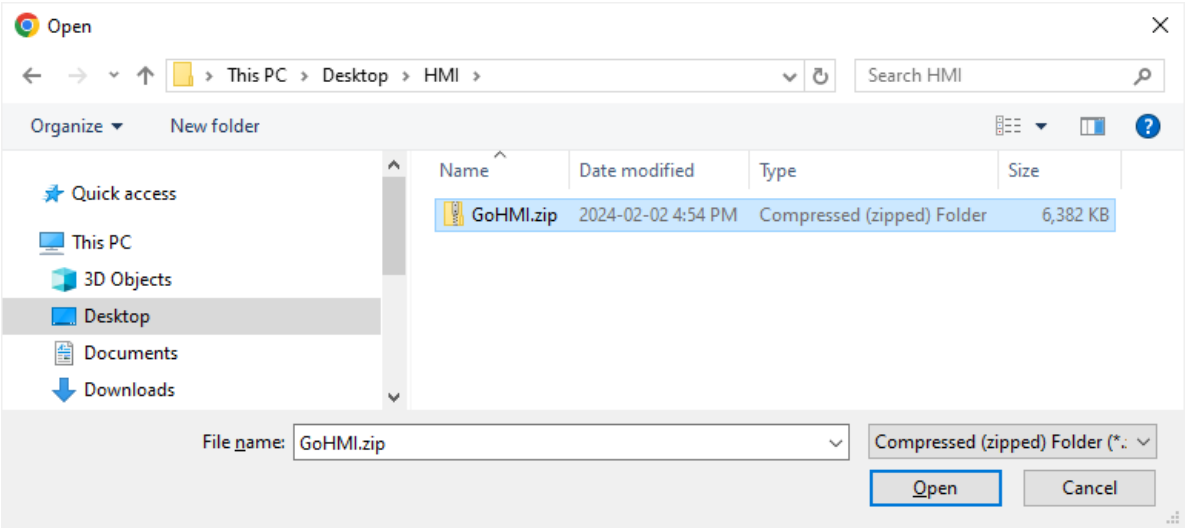
   Importing an HMI app overwrites the app in GoHMI Designer.

   For information on exporting an HMI, see *To export an HMI app* on the next page.

2. In the GoPxL interface, click **Import**.




3. In the Open dialog that displays, go to the location of the zipped HMI app project and click **Open**.

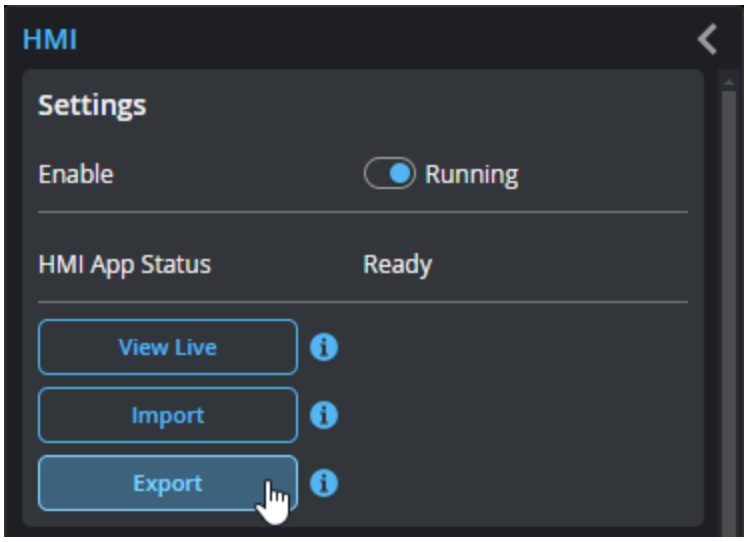



GoPxL imports the HMI app. The app is now available for editing in GoHMI Designer (see See *Opening, Editing, and Saving a Project* on page 847).

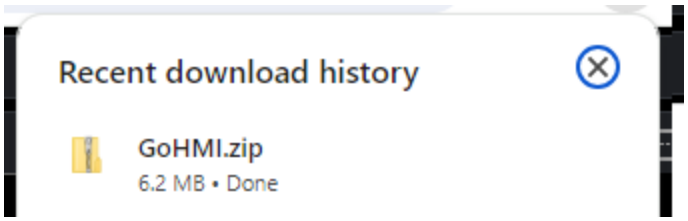
If you want to back up your HMI app or import it into another device or PC instance, you export it in GoPxL interface.

*To export an HMI app*

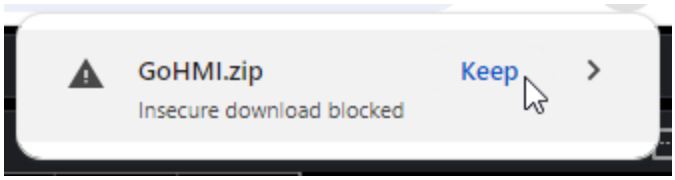
- In the GoPxL interface, click **Export**.




GoPxL downloads the HMI app and saves it as a zip file (GoHMI.zip).

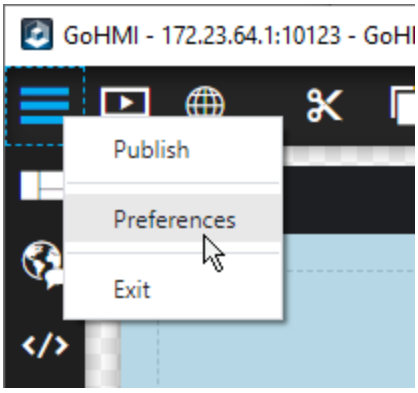



You may need to tell your browser to accept the download (Chrome).




## Setting Preferences

You can set various preferences in GoHMI Designer, from the main menu.




The following preferences are available:

- System Users: You can add and remove users, and also set passwords.
- Log Settings: You can set the log path and its maximum size, and choose the severity of the logging.
- Designer Settings: You can set the port used by the preview in the designer, or disable preview entirely.

## Using a Data Viewer in an HMI

You add a data viewer to an HMI by adding an IFrame widget in GoHMI Designer, and then copying a link from the GoPxL web interface (in the Displayed Outputs panel) and pasting it into the IFrame. The link tells the HMI the IP address of the sensor, as well as which sensor output and measurements it should display.

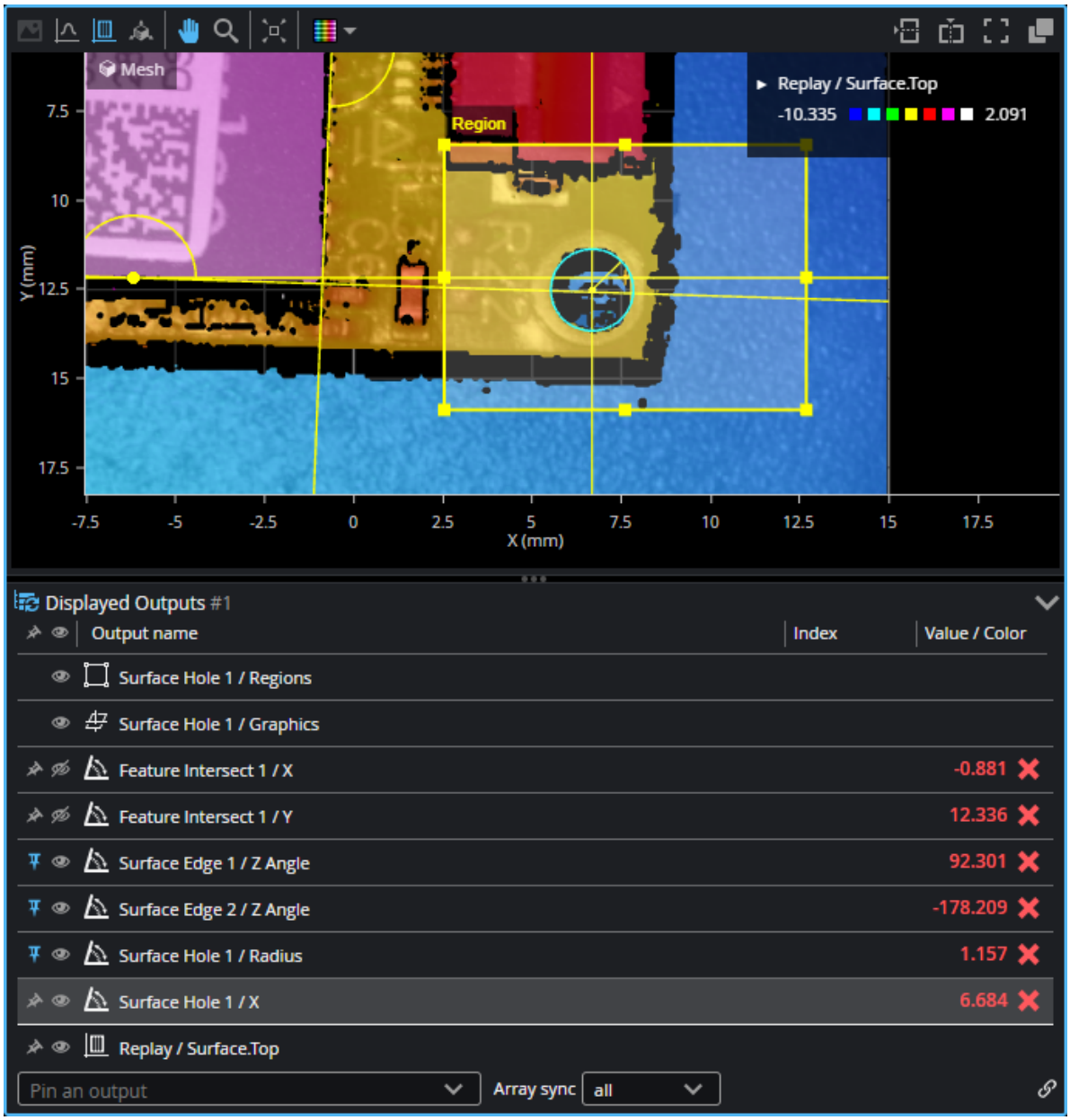
> The default HMI app includes an IFrame widget configured to display the data viewer. The IP address used in the link is 127.0.0.1:8100, which is valid for a PC instance of GoPxL (if one is running at that address and port).
>
> If you want to try out the default app with your sensor, follow the steps below to get the link from your sensor, and update the IFrame's **Source URL** field with that link (see steps 1 to 3, and step 8).

*To add a data viewer to an HMI*

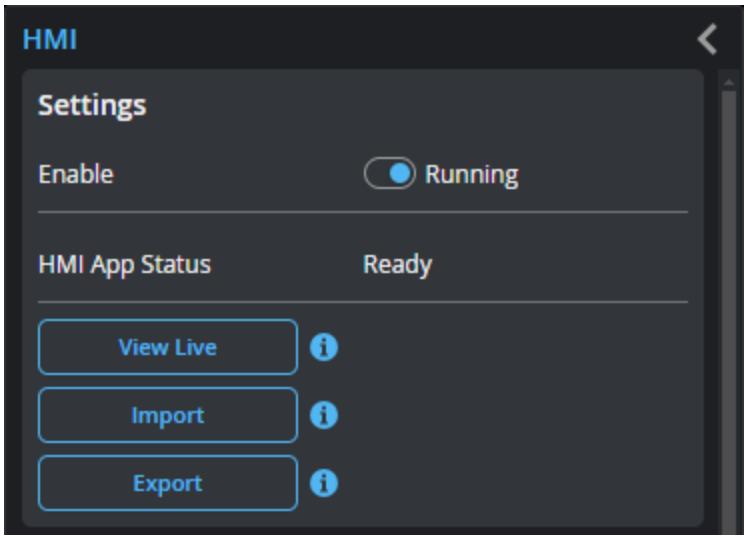
1. In GoPxL, set up a data viewer as required.

   For example, you can pin measurements so that they appear in the data viewer.

2. Under the data viewer window, make sure the Displayed Outputs pane is expanded.




3. Click the link icon ( ) in the lower right of the Displayed Outputs pane to copy the path for the data viewer.
4. Make sure GoHMI is enabled and configured in the **Communicate** > **HMI** page.

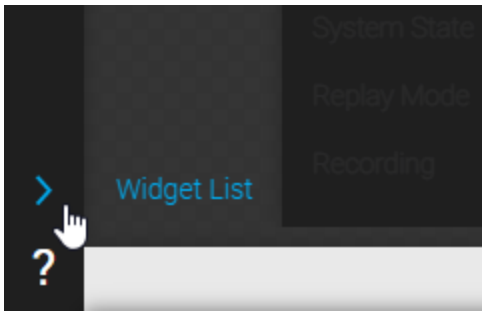



For more information, see *HMI* on page 790.

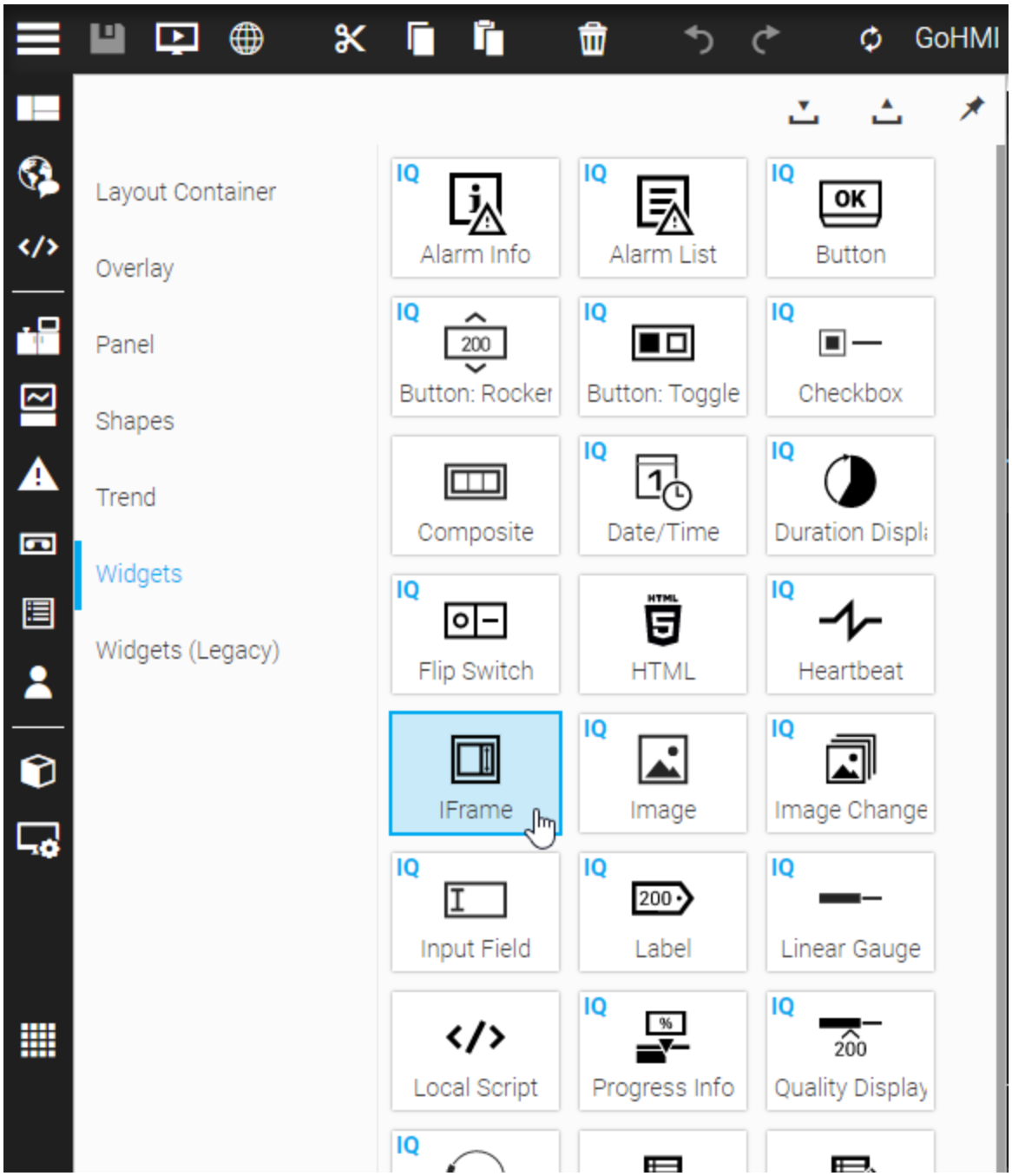
5. Launch GoHMI Designer.

   For information on launching GoHMI Designer, see *Launching GoHMI Designer* on page 843.

6. In GoHMI Designer, in the Layout Manager, expand the widget list.

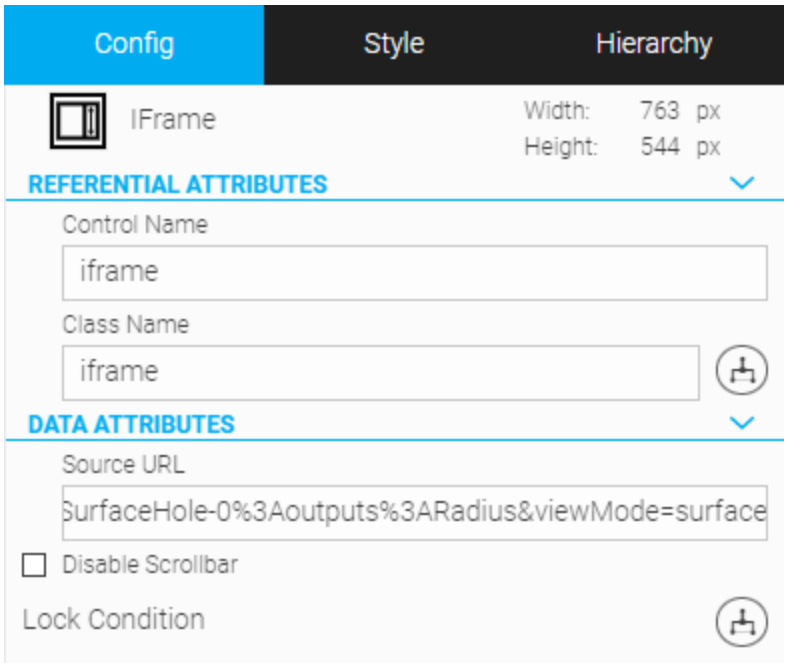



7. From the widget list, drag an IFrame widget into the HMI.




Resize the IFrame widget if necessary.

8. In the **Config** tab, paste the URL you copied in step 1 into **Data Attributes** > **Source URL**.

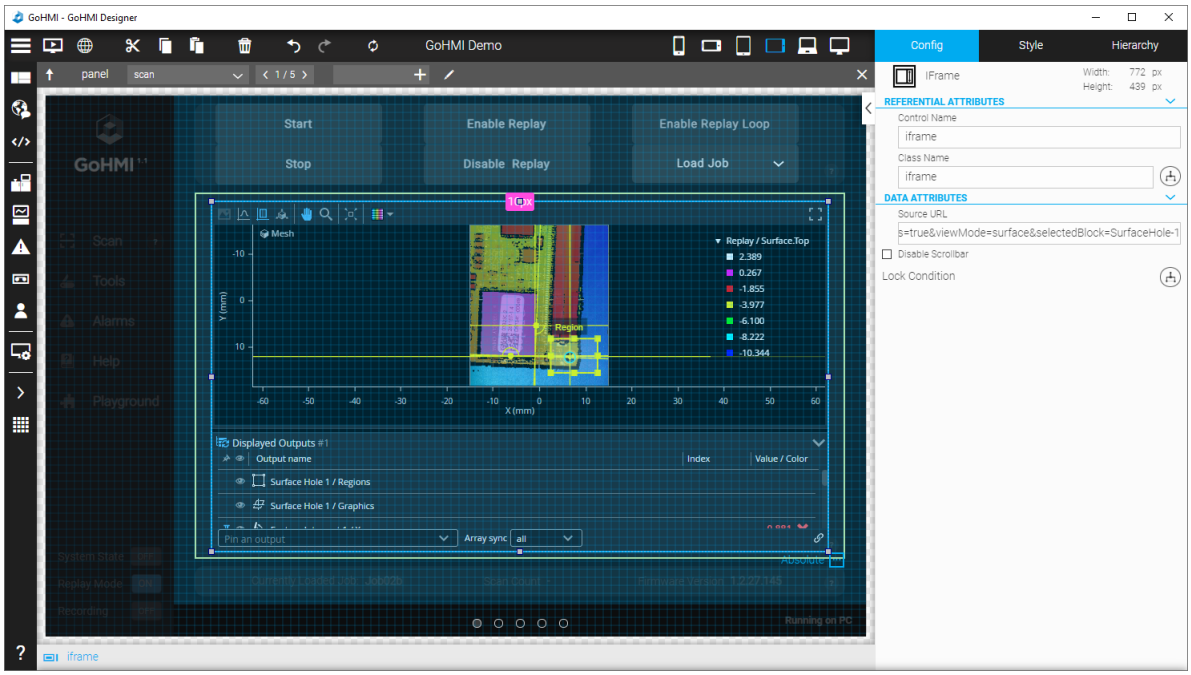



The URL will look something like this:

```
http://127.0.0.1:8100/?host=127.0.0.1&webPort=8100&visualizerOnly=true&displayedOutputs=Surface.Top,tools%3AFeatureIntersect-5%3Aoutputs%3AX,tools%3AFeatureIntersect-5%3Aoutputs%3AY,tools%3ASurfaceEdge-2%3Aoutputs%3AZAngle,tools%3ASurfaceHole-1%3Aoutputs%3AX&viewMode=surface
```

After a few seconds, the data viewer from the connected instance of GoPxL appears in the IFrame widget.

The following shows what the default HMI app looks like after updating the IFrame widget's source URL.



## Limiting Flash Memory Write Operations

Several operations and REST API / SDK functions write to the sensor's flash memory. The lifetime of the flash memory is limited by the number of write cycles. Therefore it is important to avoid frequent write operation to the sensor's flash memory when you design your system with the SDK or GoHMI.

| | |
|---|---|
| | Power loss during flash memory write operation will also cause sensors to enter rescue mode. |

# GoPxL SDK and REST API

The GoPxL Software Development Kit (GoPxL SDK) includes open-source software libraries and documentation that you can use to programmatically access and control GoPxL devices.

> The GoPxL SDK and REST API use the term "scanner" instead of "sensor group." The two are interchangeable.

> The GoPxL SDK uses mm, $mm^2$, $mm^3$, hertz, microseconds, and degrees as standard units unless otherwise mentioned.

The following sections describe the Software Development Kit (GoPxL SDK).

## Installation Guide

### Location of GoPxL SDK and Documentation

The GoPxL SDK, and the SDK and REST API references are available in the `14630-x.x.x.x_SOFTWARE_GoPxL_SDK.zip` package.

The zip file contains both a C++ and a .NET SDK organized as follows:

- `GoPxL_SDK_Cpp\`
- `GoPxL_SDK_dotNet\`

### Visual Studio Solution Files and Linux Makefile

For Windows, Visual Studio solution files are included for both the C++ and .NET SDKs.

- C++: `GoPxL_SDK_Cpp\Gocator`
- .NET: `GoPxL_SDK_dotNet\Gocator`

For Linux, first ensure that you have the g++ compiler package and then run the following command from the `GoPxL_SDK_Cpp\Gocator\GoPxLSdk` directory:

```
make -f GoPxLSdk-Linux_X64.mk
```

Note that only the C++ SDK is supported on Linux.

### Building the SDK

To compile in Visual Studio, you may need to retarget the solution to the installed Windows SDK version. To retarget a solution, open the solution in Visual Studio, right-click the solution in the Solution Explorer, choose **Retarget solution** in the context menu. In the dialog box that appears, select the desired version from the drop-down list and click **OK**.

The compiled Linux output libraries can be found in the `GoPxL_SDK/lib/linux_x64` directory.

## Running SDK Applications

When running an SDK application, be aware that performance may vary significantly between Debug and Release configurations. The Debug configuration disables optimizations and includes additional debugging information, which may result in slower execution times, specifically during asynchronous data retrieval.

## System Requirements

The GoPxL SDK can be compiled using the following environment.

For Windows:

- Visual Studio 2017 or later
- Windows SDK (included with Visual Studio installation)

For Linux:

- GCC X64 compiler, version 7.5.0 (GccX64_7.5.0-p3)
- GNU Make

## Accessing Documentation

The full SDK class references and REST API resources are available at the following locations:

#### GoPxL SDK Class Reference

C++: `GoPxL_SDK_Cpp\doc\class-reference.html`

.NET: `GoPxL_SDK_dotNet\doc\class-reference.html`

#### REST API Resources

C++: `GoPxL_SDK_Cpp\doc\api-protocol-manual.html`

.NET: `GoPxL_SDK_dotNet\doc\api-protocol-manual.html`

## Sample Projects

Sample projects showing how to perform various operations are provided, each one demonstrating a specific area. Examples are located in the following folders:

- C++: `GoPxL_SDK_Cpp\Gocator\GoPxLSdk\samples`
- .NET: `GoPxL_SDK_dotNet\Gocator\GoPxLSdkNet\samples`

## Header Files

When including header files from the GoPxL SDK, reference the GoPxLSDK directory as the source directory. For example:

```
#include <GoPxLSdk/GoRestClient.h>.
```

Additionally, note that the SDK header files reference files from the kApi directory. For example:

`#include <kApi/kApiDef.h>`.

# Getting Started with the SDK

GoPxL offers a simple programming API interface for connecting, configuring, and acquiring data from sensors and the GoMax vision accelerator.

> Example code shown below is for C++.

All GoPxL SDK programs should have the sequence described below, at a minimum.

## Connecting a Device

The following sequence assumes you know the IP address of the device. If you do not know the IP address, or if the address is dynamic, an application can discover the devices that are available on the network using the GoPxL SDK discovery capability. For more information, see *Discover Devices* on the next page.

1. Initialize the SDK library

   For C++ SDK programs only, construct the SDK library by calling `GoApiLib_Construct`. You must call `GoApiLib_Construct` before any API functions are used. (.NET SDK programs don't require this.)

```
// Constructs GoPxL API core framework.
GoApiLib_Construct(&goApiLib)
```

   After completing your operations with the SDK library, don't forget to release the resources using `kDestroyRef()`.

```
// Releases resources and resets the object handle to kNULL
kDestroyRef(&goApiLib)
```

2. Instantiate a `GoSystem` object and connect the device.

```
// Define device IP address and control port
constexpr const char* DEVICE_IP_ADDRESS = "192.168.1.10";
constexpr const uint16_t CONTROL_PORT = GO_PXL_SDK_DEFAULT_CONTROL_PORT; // Defaults is 3600


// Parse device IP address
kIpAddress deviceIpAddress;
kIpAddress_Parse(&deviceIpAddress, DEVICE_IP_ADDRESS);

// Create a GoSystem object
GoSystem system;

// Set up connection
system.SetAddress(deviceIpAddress);
system.SetControlPort(CONTROL_PORT);

// Connect to the device
system.Connect();
```

## GoSystem Class Member Functions

The `GoSystem` class represents a single Gocator system. A Gocator system consists of one or more sensors/devices. Below are the member functions of the GoSystem class

```
// SetAddress: Sets the IP address used for connecting to the device.
void SetAddress(const kIpAddress& ipAddress);

// Address: Gets the IP address used for connecting to the device.
kIpAddress Address() const;

// SetControlPort: Sets the control port used for connecting to the device.
void SetControlPort(k16u port);

// ControlPort: Gets the control port used for connecting to the device.
k32u ControlPort() const;

// Connect: Connects to the device.
void Connect();

// Disconnect: Disconnects from the device.
void Disconnect();

// IsConnected: Checks if the device is connected.
bool IsConnected();

// Start: Starts the device.
void Start();

// Stop: Stops the device.
void Stop();

// RunningState: Gets the current state of the device.
State RunningState();

// Client: Returns a reference to the REST API client for performing operations.
GoRestClient& Client();

// SensorPath: Retrieves the REST API resource path of a sensor based on its serial number.
ResourcePath SensorPath(SerialNum serialNum);
```

## Discover Devices

If a device IP address is not known (for example, because it is assigned through DHCP), you can discover the devices available on the network using the GoPxL SDK discovery function:

1. Include the `GoDiscoveryClient` header file.
2. Create an instance of `GoDiscoveryClient` and call the `BlockingDiscover` function with a specified timeout.
3. Access the list of discovered instances.

```
#include "GoDiscoveryClient.h"
auto discovery = std::make_unique<GoDiscoveryClient>();
```

```
discovery->BlockingDiscover(3000);
auto& instances = discovery->InstanceList();
```

4. After discovering the instances, you can loop through the instances to get IP addresses and other instance-related information.

```
// Print instance IP address and GDP port.
for (const auto& instance : instances) {
   std::cout << "IP Address: " << kIpAddress_AsString(instance.GetIpAddress()) << std::endl;
   std::cout << "GDP Port: " << instance.GetGdpPort() << std::endl;
}
```

For more information, see the *Discover* sample.

## Configure Device Settings

You configure GoPxL device settings, which are represented as JSON resources, through JSON-based REST API commands. The `GoRestClient` class provides access to read and write settings. You can use methods like Call, Read, Update, Create, and Delete, among others, to interact with the device settings.

Start by instantiating a `GoSystem` object. Through this object, you can directly access the `GoRestClient` instance via `system.Client()`. Then, to perform `Read()` or other operations, simply continue chaining the methods, for example, `system.Client().Read()`.

These methods follow a similar format:

```
"command /path/to/callable/resource {'argument':'value'}"
```

For example the following command:

```
call /jobs/commands/rename { "sourceName" : "job1", "destName" : "renamedJob1" }
```

can be implemented as follows:

```
// Rename job.
auto payload = GoJson(R"({
    "sourceName" : "SDK-demo",
    "destName" : "SDK-demo-job"
})");

system.Client().Call("/jobs/commands/rename", payload);
```

For the full list of resources available, see the *GoPxL 1.1 - REST API Resources and User Guide*:

C++: `GoPxL_SDK_Cpp\doc\api-protocol-manual.html`

.NET: `GoPxL_SDK_dotNet\doc\api-protocol-manual.html`

It's important to understand that GoPxL device settings are divided into two general types:

- sensor-level: These settings only apply to individual sensors.
- scanner-level: These settings apply to all of the sensors in a group of sensors (a "scanner").

To help explain the functions, some sections below include definitions of the API resources.

## Accessing Sensor Resources

The most common use case is modifying settings that apply to individual sensors, such as exposure or active area.

If you know a device's serial number, you can access the corresponding resource using the `SensorPath` function. You can then modify the settings under the sensor's resources.

```
// Update single exposure value.
auto sensorPath = system.SensorPath(sensorSerialNumber);
auto payload = GoJson(R"({
    "parameters" : {
        "exposureSettings" : {
            "exposureMode" : 0,
            "singleExposure" : 400
        }
    }
})");

system.Client().Update(sensorPath, payload);
```

## Accessing Scanner Resources

You access system-level settings (those that apply to a group of sensors) through the `scanner` resources.

If you know the engine ID and scanner ID (available in the REST API reference documentation), you can use the following to access the sensor group and modify the trigger setting:

```
// Access and modify trigger settings for the scanner.
auto scannerPath = "/scan/engines/LMILaserLineProfiler/scanners/scanner-0";
auto payload = GoJson(R"({
    "parameters" : {
        "triggerSettings" : {
            "source" : 3
        }
    }
})");

system.Client().Update(scannerPath, payload);
```

Configuring scanner resources through the SDK is less common. These resources are related to physical setup. Normally, you configure these settings through the user interface during the initial system installation and setup, and the settings don't need to change for different production runs.

## Accessing an Array Element

Some resources are returned as an array. One example is the `visibleSensors` resource, which can have multiple elements.

The following returns an array of sensors under the `/scan/visibleSensors` resource path.

```
sensors = system.Client().Read("/scan/visibleSensors/").GetResponse().Content().At
("sensors");

// Get the first element in the array
auto sensor = sensors.Begin();
auto sensorSerialNumber = sensor.Value().At("/serialNumber").Get<std::string>();

// Alternatively, iterate through each sensor in the array
for (auto sensor = sensors.Begin(); sensor != sensors.End(); ++sensor)
    auto sensorSerialNumber = sensor.At("/serialNumber").Get<std::string>();
}
```

## Receive Device Data

GoPxL streams out acquired data (such as Profile and Surface data, and measurements) using the GoPxL Data Protocol (GDP). To receive the data, you use a `GoGdpClient` instance, which you first need to connect to the device. You can use `GoPxLSdk::MessageType` to identify the type of data received and the associated stamp information. Stamps contain encoder and trigger timing information, current time, and frame index, and are grouped into datasets with their corresponding data.

Data can be received on the same thread used for controlling the sensors (that is, synchronously) or on a different thread (that is, asynchronously). Note that data is received as the `GoDataSet` type. For more information on `GoDataSet`, see *GDP Data Types* on page 872.

For synchronous data retrieval, use the `ReceiveData()` method:

1. Instantiate a GoPxL Data Protocol client and connect to a device.

```
#include <GoPxLSdk/GoGdpClient.h>

constexpr k16u GDP_PORT = GO_PXL_SDK_DEFAULT_GDP_SERVER_PORT; // Default port is 3601

// Instantiate a GoGdpClient object
auto gdpClient = std::make_unique<GoGdpClient>();

// Connect the GoGdpClient to the device using sensor IP and GDP port
gdpClient->Connect(SENSOR_IP, GDP_PORT);
```

2. Receive data.

```
// Establish a synchronous data transfer with a 3-second timeout.
gdpClient->ReceiveDataSync(3000);

```

```
// Retrieve the received data set.
const GoDataSet& receivedDataSet = gdpClient->DataSet();
```

Then loop through each message (a unit of data received from the GoPxL sensor) to handle the data based on its type (Profile, Surface, Measurements, and so on) using the `MessageType` enum. For example:

```
for (size_t i = 0; i < receivedDataSet.Count(); ++i)
{
    switch (receivedDataSet.GdpMsgAt(i).Type())
    {
        case GoPxLSdk::MessageType::STAMP:
            // Handle stamp message
            ...

        case GoPxLSdk::MessageType::UNIFORM_SURFACE:
            // Handle uniform surface data
            ...
    }
}
```

For more information on synchronous data retrieval, see the `ReceiveProfile` and `ReceiveSurface` samples.

For asynchronous data retrieval, you use the following steps:

1. Instantiate a GoPxL Data Protocol client and connect to a device.
2. Start the data reception thread

   Call `GoGdpClient::ReceiveDataAsync(func)` to initiate data reception asynchronously. This starts a background thread (`receiveThread`) to receive and deserialize messages continuously.
3. Handle received data.

   Upon receiving individual data messages, they are reassembled into a `GoDataSet` object. The data reception continues until you call `GoGdpClient::Close()`.
4. Process the data.

   The received data sets are added to a message queue (`Go::MsgQueue<GoDataSet> dataQueue`). A separate thread (`dataThread`) removes the data sets from the queue for processing.
5. Access the data

   Define a callback function to handle the received data sets.

The following is an example of retrieving data asynchronously:

```
void onData(const GoDataSet& receivedDataSet)
{
    for (size_t i = 0; i < receivedDataSet.Count(); i++)
    {
        switch (receivedDataSet.GdpMsgAt(i).Type())
        {
            case GoPxLSdk::MessageType::STAMP:
            {
                const GoGdpStamp& stampMsg = (const
```

```
    GoGdpStamp&)receivedDataSet.GdpMsgAt(i);
                // Process stamp message
                ...
            }
            // Handle other message types as needed
        }
    }
}

// Connect to GDP and start receiving data asynchronously
gdpClient->Connect(SENSOR_IP, GDP_PORT);
gdpClient->ReceiveDataAsync(onData);
```

For details, see the `ReceiveAsync` sample.

The following lists the `GoGdpClient` class methods you can use to interact with the GoPxL Data Protocol (GDP) server.

```
// Constructs GoGdpClient.
GoGdpClient();

// Destructs GoGdpClient.
~GoGdpClient();

// Connects to the GdpServer.
void Connect(kIpAddress ipAddr, k16u port);

// Closes the TCP connection.
void Close();

// Receives data synchronously from the GDP server.
void ReceiveDataSync(k64u receiveTimeoutInMilliseconds);

// Receives data asynchronously from the GDP server.
void ReceiveDataAsync(std::function<void(const GoDataSet& receivedDataSet)>& func);

// Gets the pointer to the received data set over the Goctor Data Protocol.
const GoDataSet& DataSet() const;
```

## Receive Health and Metrics Information

Health information, along with various metrics, is transmitted using the REST API. To handle received metrics data, set up a callback function as shown below:

```
// Callback function for handling received metrics data.
static void onMetrics(const GoStreamResponse&)
{
    // Extract payload & content from the received data
    auto content = notification.Payload();
  int appUptime = content.Get<int>("/appUpTime");
  ...
}

```

```
// Set up the callback function for receiving metrics data asynchronously.
system.Client().SetStreamHandler(onMetrics);

// Start the stream to receive metrics data from the specified path
system.Client().StartStream("/system/metrics");

// Stop the stream and disconnect from receiving metrics data, call StopStream
system.Client().StopStream("/system/metrics");
```

For more information, see the `ReceiveHealth` sample.

## Accelerated Devices

Control of devices accelerated by GoMax NX or a PC instance of GoPxL uses the same function API. The only difference is that you must use the IP address of the GoMax NX device or the PC running GoPxL when connecting to the device (that is, in `system->Connect()`).

# GDP Data Types

### Value Types

The GoPxL SDK is built on a set of basic data structures, utilities, and functions, which are contained in the *kApi* library.

The following basic value types are used by the *kApi* library.

*Value Data Types*

| Type | Description |
|---|---|
| k8u | 8-bit unsigned integer |
| k16u | 16-bit unsigned integer |
| k16s | 16-bit signed integer |
| k32u | 32-bit unsigned integer |
| k32s | 32-bit signed integer |
| k64s | 64-bit signed integer |
| k64u | 64-bit unsigned integer |
| k64f | 64-bit floating number |
| kBool | Boolean, value can be kTRUE or kFALSE |
| kStatus | For the definitions of this type, in the folder containing the GoPxL SDK, see Platform\kApi\kApi\kApiDef.h. |
| kIpAddress | IP address |

### Output Types

Data outputs are encapsulated as data messages in the GoPxL SDK. The following message types are available in the SDK.

*Output Types*

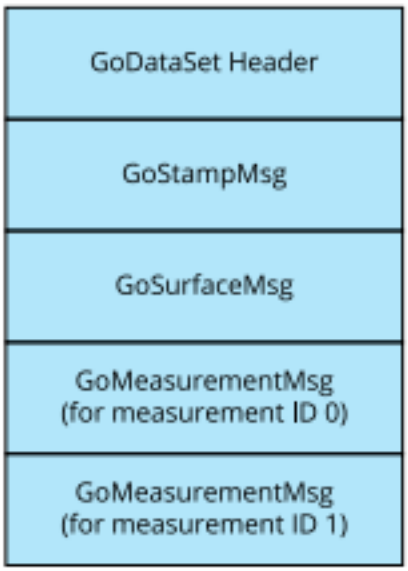
| Type | Description |
|---|---|
| GoGdpBoundingBox | Bounding Box results output based on part matching results |
| GoGdpFeaturePoint | Feature point output |
| GoGdpFeaturePlane | Feature plane output |
| GoGdpFeatureLine | Feature line output |
| GoGdpFeatureCircle | Feature circle output |
| GoGdpImage | Video image |
| GoGdpMeasurement | Measurement output |
| GoGdpMesh | Mesh data output |
| GoGdpNull | Contains no valid data. Received when a measurement tool's data output doesn't generate data when triggered. This messages allow user to synchronize message from different outputs based on number of message received. |
| GoGdpProfilePointCloud | Profile point cloud data (non-uniform spacing) |
| GoGdpProfileUniform | Uniform spacing / resampled profile data |
| GoGdpRendering | Graphics objects associated with a tool outputs* |
| GoGdpSpots | Detected spots when overlay exposure is enabled* |
| GoGdpStamp | Acquisition stamp |
| GoGdpSurfacePointCloud | Surface point cloud data (non-uniform spacing) |
| GoGdpSurfaceUniform | Uniform spacing / resampled surface data |

*Not commonly used in a production system.

All of the messages above are extended from `GoGdpMsg`. For more information, see *GoDataSet* below.

## GoDataSet

Data is passed to the data handler in a `GoDataSet` object. The `GoDataSet` object is a container that can hold any type of data, including scan data (sections or surfaces), measurements, or results from various operations. Data inside the `GoDataSet` object is represented as messages. The following illustrates the content of a `GoDataSet` object of a Surface mode setup with two measurements.




The following lists the available GoDataSet types:

```
enum struct MessageType : k16u {
    SIGNAL                  = 1,    // Signals that data on a stream is invalidated.
    NULL_TYPE               = 10,   // Null data type that contains a status code.
    STAMP                   = 11,   // Stamp information.
    UNIFORM_PROFILE         = 12,   // Uniform profile data.
    PROFILE_POINT_CLOUD     = 13,   // Raw profile data.
    UNIFORM_SURFACE         = 14,   // Raw surface data.
    SURFACE_POINT_CLOUD     = 15,   // Raw surface data.
    IMAGE                   = 16,   // Image data.
    SPOTS                   = 17,   // Spot data associated with the image.
    MESH                    = 18,   // Mesh data.
    MEASUREMENT             = 19,   // Measurement data.
    RENDERING               = 70,   // Graphical data associated with an output.
    POINT_FEATURE           = 71,   // Point feature data.
    LINE_FEATURE            = 72,   // Line feature data.
    PLANE_FEATURE           = 73,   // Plane feature data.
    CIRCLE_FEATURE          = 74,   // Circle feature data.
    HEALTH                  = 100   // Health data.
};
```

## Measurement Values and Decisions

There are two outputs for each measurement: a value and a decision. A measurement value is returned as a 64-bit number.

The measurement decision specifies the state of the measurement value as follows:

*Measurement Decisions*

| Decision | Description |
|---|---|
| 1 | The measurement value is between the maximum and minimum decision values (inclusive). This is a pass decision. |

| Decision | Description |
| --- | --- |
| 0 | The measurement value is outside the maximum and minimum. This is a fail decision. |

## Limiting Flash Memory Write Operations

Several operations and REST API / SDK functions write to the sensor's flash memory. The lifetime of the flash memory is limited by the number of write cycles. Therefore it is important to avoid frequent write operation to the sensor's flash memory when you design your system with the SDK or GoHMI.

Power loss during flash memory write operation will also cause sensors to enter rescue mode.

# Python GDK

The GoPxL Python GDK lets you develop custom measurement and processing tools that you can incorporate into your application. Once integrated into a GoPxL or GoMax firmware, the tools behave like the built-in ones. Python GDK tools are also available in the PC-based GoPxL software; for more information, see *Running GoPxL on a Windows PC* on page 814.

As with the Script tool, you use Python to add functionality and custom algorithms to GoPxL. However, using the Python GDK to create tools has these advantages:

- You can expose parameters to control the algorithm.
- Your intellectual property is better protected, if you bundle the custom tool in a firmware.
- You can debug your Python code in an IDE that supports Python.

GoPxL includes a Python interpreter and tool server that provide support for Python-based tools and the Script tool. When you use GoPxL on PC, the Python engine is started by default as part of launching a GoPxL instance.

When you develop custom tools for GoPxL, you can use an external Python interpreter, instead of the included one, and optionally a virtual environment. Doing this is useful if you will develop tools using specific libraries or environments, for example, implementing an AI program with the GDK.

## Requirements and Installation

If you are using the distribution of Python provided with the GDK, there is nothing to install. If you are using a Python distribution installed on your PC, LMI recommends version 3.8.10, as later versions have not been tested with the GDK.

You should also install the following packages using `pip install`.

- numpy
- opencv-python (optional, currently 4.5.4.60)

You can get the Python GDK by downloading and unzipping the GoPxL Utilities package (14631-1.2.x.x_SOFTWARE_GoPxL_Utilities.zip, available on LMI's Product Downloads page). The Python GDK is under the `GoPxL/plugins/GdkPy` folder.

The following lists the files you will typically need to use or modify in the `/plugins/GdkPy` folder:

- `configure_developer_start.bat`: Disables the built-in Python server in PC instances of GoPxL. When the built-in server is disabled, the `run_server.py` program (see below) provides Python GDK tools to any PC instance run from the parent folder. You *must* run this batch file before starting a PC instance to debug custom tools, or if you need to use your own distribution

of Python to run the tools. .

- `configure_built_in_start.bat`: Enables the built-in Python server in PC instances of GoPxL. You *must* run this script to re-enable the internal server before starting an instance of GoPxL if you are not using your own distribution of Python.
- `run_developer_server.bat`: Starts the Python tool server program (run_server.py) from the GDK's Python distribution. You should use this to start the Python tool server, instead of `run_server.py`.
- `run_server.py`: The Python tool server program, which loads the tools in the `plugins/GdkPy/user_tools/` (and `plugins/GdkPy/samples/`) and sets up logging. The script runs in the Python environment that executes it. You typically run this program from within a debugger, but you can also run it from the command line to run tools that use your own Python distribution. For information on debugging, see *Debugging Custom Tools* on page 881. For information on deploying tools, see *Deploying Your Custom Tools* on page 883.
- `gdk` folder: This folder contains the `tool.py` and `tool_api_def.py` files. Together, these files provide the tool API and data types you use to create custom tools, respectively. You should familiarize yourself with the content of these files.
- `samples` folder: This folder contains several sample Python GDK tools. You should copy these into the files into the `user_tools` folder as a starting point for your own custom tools.
- `standard_tools` folder: This folder contains the Script tool and the library it uses. You do not need to modify these files.
- `user_tools` folder: You should put your custom Python GDK tools and any required libraries in this folder. When you run `run_server.py`, the tool server loads these tools.
- `utilities` folder: This folder contains utilities you use to add a custom tool to a GoPxL firmware or GoPxL for PC. For more information, see *Deploying Your Custom Tools* on page 883.

## Developing Custom Tools

For full code completion such as IntelliSense and debugging support, we recommend using Visual Studio Code or an IDE that supports Python. In the following, we use Visual Studio Code.

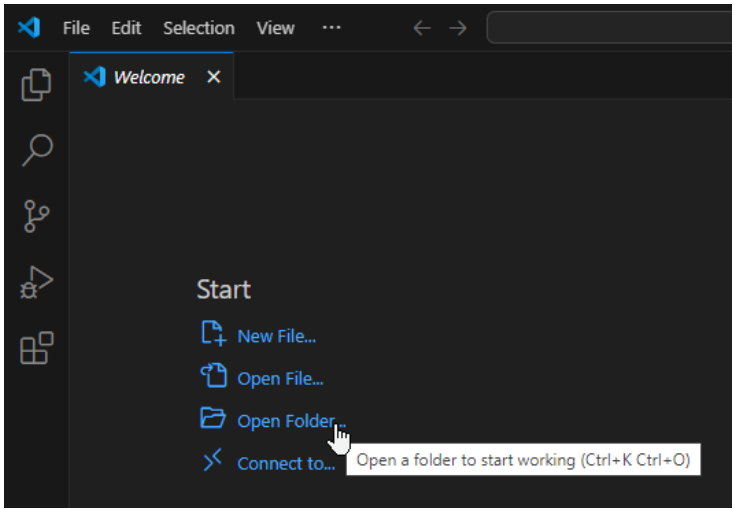
For information on setting up debugging, see *Python GDK* on the previous page.

> OpenCV is only available on GoPxL running on a PC and on GoMax. To use OpenCV in a tool, you must use `import cv2` in your tool's Python source code. Gocator sensors do not support the OpenCV module in Python tools.

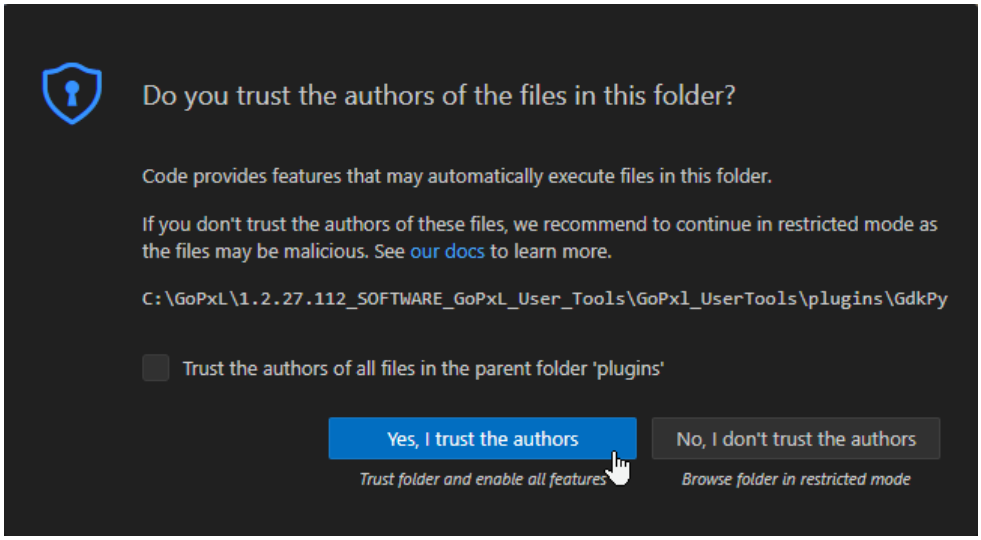
*To create a Python GDK tool*

1. If you have not already done so, install Visual Studio Code, start the program, and install the Python Extension.

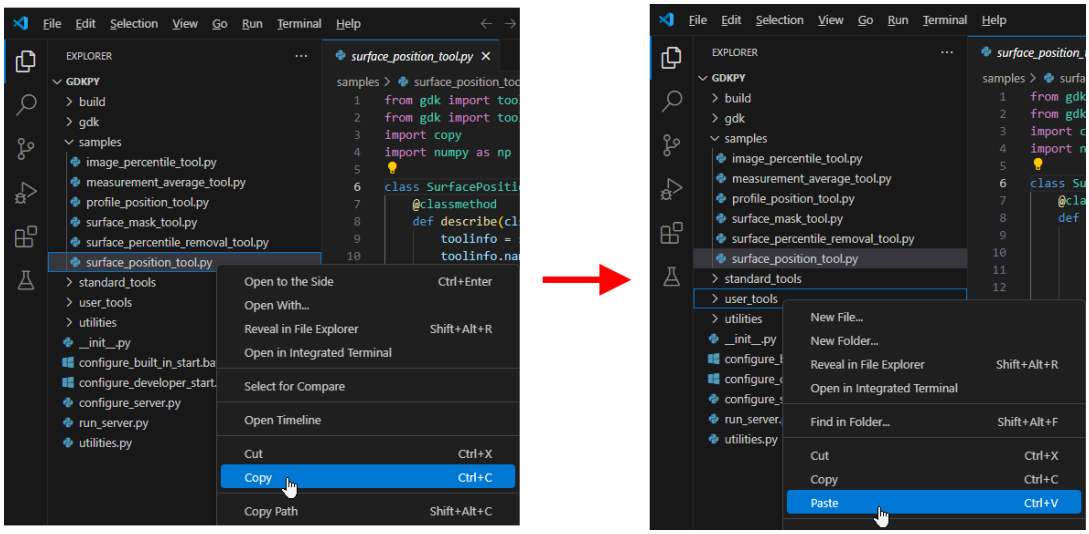
2. Open the `plugins\GdkPy` folder in the IDE.



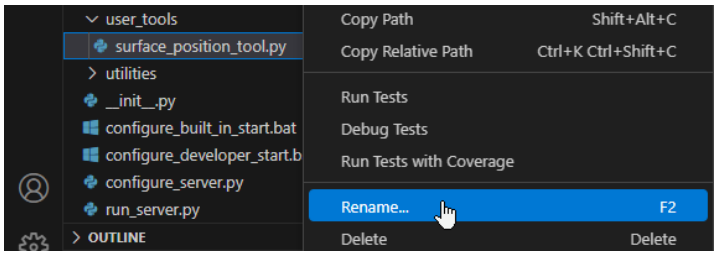

You may need to confirm that you trust the authors of the files in the folder.



3. Copy a file from the `samples` folder into the `user_tools` folder and rename it.

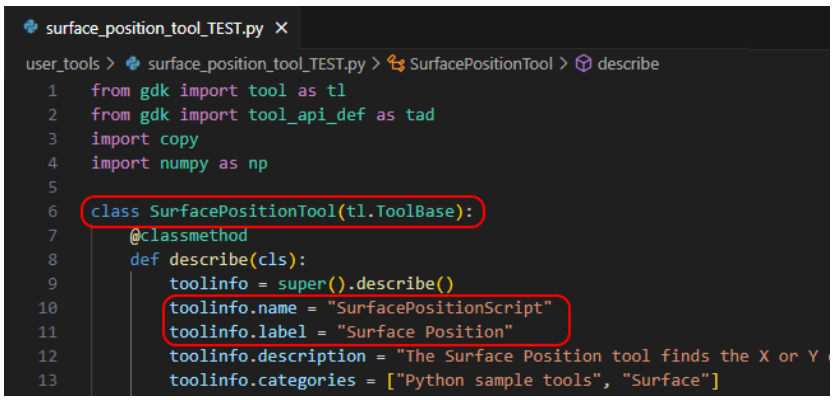



You can use any name for the tool's Python file, but using the main input type as a prefix is a useful convention, for example, "surface_" for Surface tools.




4. Modify the tool's code.

To start (and to avoid conflicts), you should change the name of the class everywhere in the code, as well as the strings assigned to `toolinfo.name` and `toolinfo.label` in the `describe` method.



You also define the tool's inputs, anchors, outputs, and parameters in the `describe` method. Note that the order of the items of a given category (that is, inputs, parameters, outputs, or anchors) in the code is the order in the tool.

```
class SurfacePositionTestTool(tl.ToolBase):
    @classmethod
    def describe(cls):
        toolinfo = super().describe()
        toolinfo.name = "SurfacePositionTestScript"
        toolinfo.label = "Surface Position Test"
        toolinfo.description = "Surface Position Test is for exploring the Python GDK API."
        toolinfo.categories = ["Python sample tools", "Surface"]

        # Inputs
        toolinfo.inputs["Input"] = tl.InputInfo("Surface", tl.DataType.UNIFORM_SURFACE)

        # Anchors
        toolinfo.anchor = tl.AnchorInfo(x=True, y=True, z=True, z_angle=False)

        # Outputs
        toolinfo.outputs["X"] = tl.OutputInfo("X", tl.DataType.MEASUREMENT_VALUE_X)

        toolinfo.outputs["Y"] = tl.OutputInfo("Y", tl.DataType.MEASUREMENT_VALUE_Y)

        toolinfo.outputs["Z"] = tl.OutputInfo("Z", tl.DataType.MEASUREMENT_VALUE_Z)

        toolinfo.outputs["Point"] = tl.OutputInfo("Position", tl.DataType.FEATURE_POINT)

        # Parameters
        toolinfo.parameters["UseRegion"] = tl.ParamInfo("Use Region", tl.ParamType.BOOL, True)
        toolinfo.parameters["Region"] = tl.ParamInfo(
            "Region",
            tl.ParamType.SURFACE_REGION,
            tl.Region3d(0, 0, 0, 5, 5, 5),
        )

        # feature position options
        cls.position_options = {0: "Average", 1: "Median", 2: "Centroid", 3: "Min X", 4: "Max X",
                                5: "Min Y", 6: "Max Y", 7: "Min Z", 8: "Max Z"}
        toolinfo.parameters["Features"] = tl.ParamInfo(
            "Features", tl.ParamType.INT, 0, options=cls.position_options
        )

        return toolinfo
```

You should closely examine the `tool.py` and the `tool_api_def.py` files in the `gdk` folder (which form the GDK's API), as well as the source code of the sample tools, to better understand how to develop your own tools. Observing how Python GDK tools work using a Python debugger can also help you develop your own tools.

5. (Optional) Place any additional modules your tool needs to import in the `user_tools` folder.

# Enabling the Local Python Tool Server

Before you can start debugging a custom tool, or run a custom tool on PC using your own distribution of Python, you must run the `configure_developer_start.bat` batch file. This batch file disables the Python tool server built into GoPxL for PC.

After this, you must run the `run_developer_server.bat` script to start the Python tool server manually. If you want to debug a tool, run `run_server.py` instead.

For information on starting the tool server for debugging purposes, see *Debugging Custom Tools* on the next page.

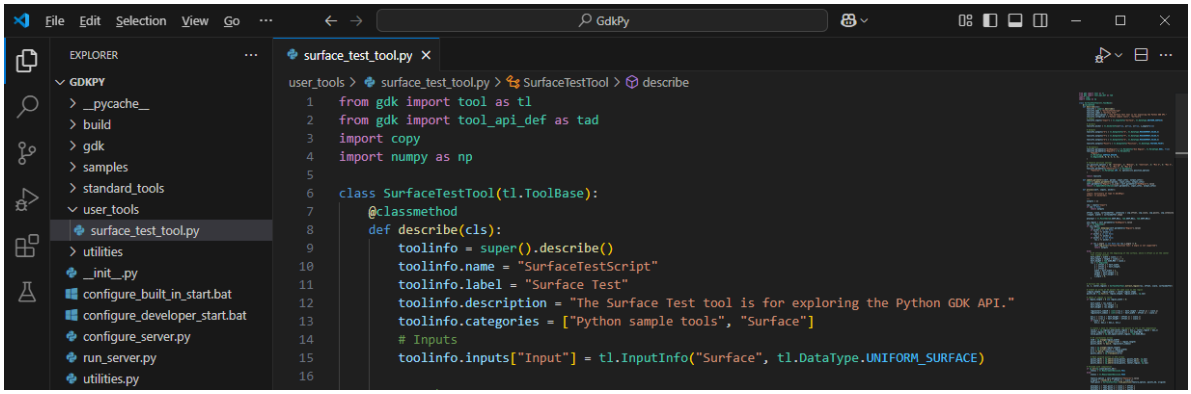
For information on starting the tool server with your own distribution of Python, see *Deploying Your Custom Tools* on page 883.

# Debugging Custom Tools

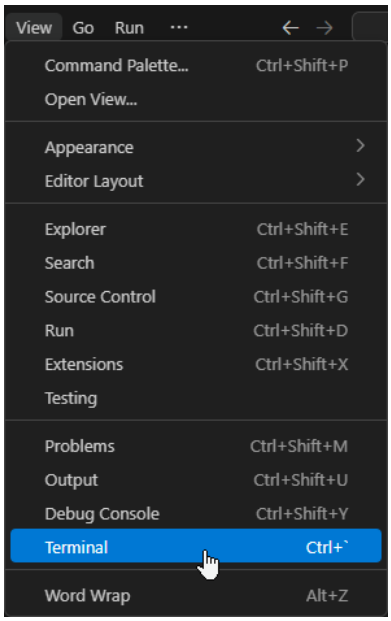
You can debug a Python GDK tool using an IDE that supports Python.

*To debug your Python tool using Visual Studio Code*

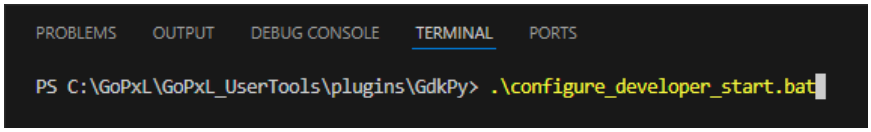
1. Open the `plugins\GdkPy` folder in the IDE.




2. Open the terminal from the **View** menu or by pressing Ctrl+` (Ctrl + back tick).

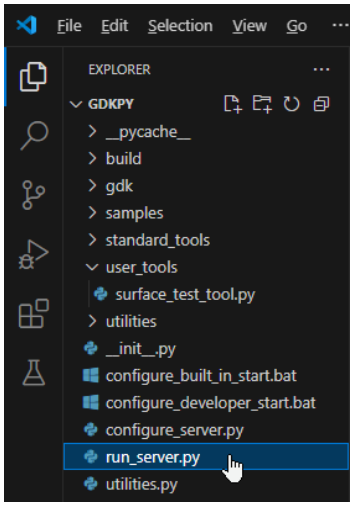



3. At the prompt, type `.\configure_developer_start.bat`.



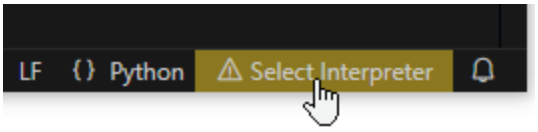

This disables the Python tool server built into GoPxL for PC. If you do not run this script, you will not be able to debug your tool.

4. From the Explorer view, open the `run_server.py` file.

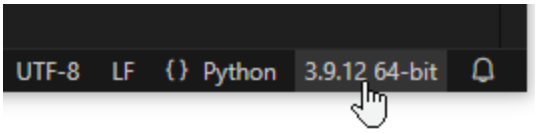



5. (Optional) If Python is not installed on your PC, you can point Visual Studio Code to the Python interpreter used by the internal tool server. To change the interpreter, do the following:

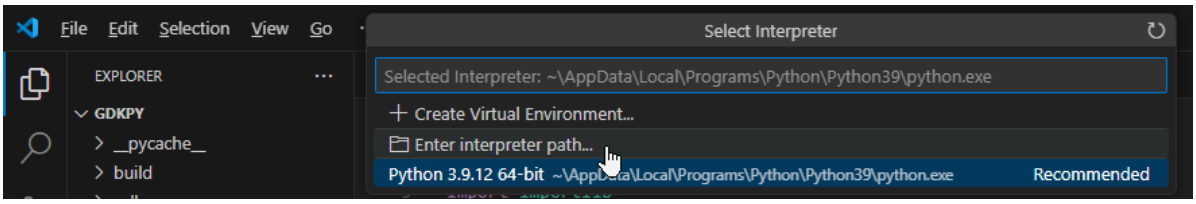
   a. At the lower right, click the Python version in the bottom right corner.




   If you have previously used Python in Visual Studio Code, you may see a version already selected.

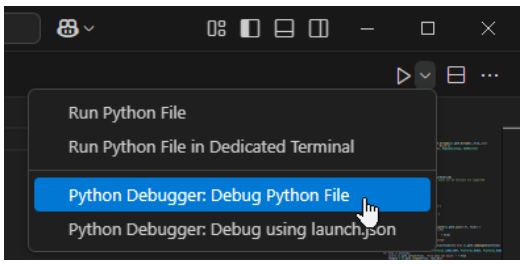



   b. At the top of the editor, click **Enter interpreter path**, and provide the path to the built-in interpreter.

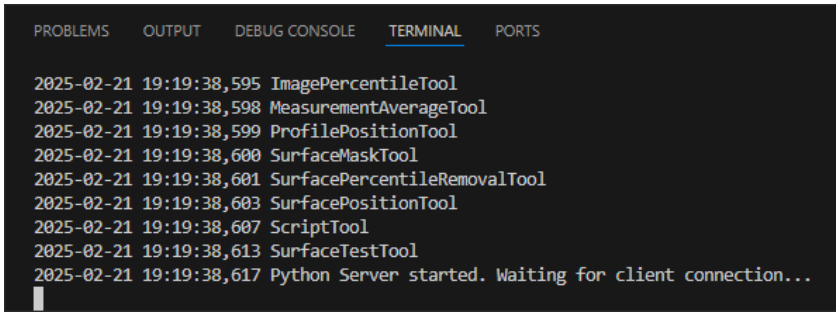



   The built-in Python interpreter is `bin\win64\python\python3.exe`.

6. Start debugging run_server.py.

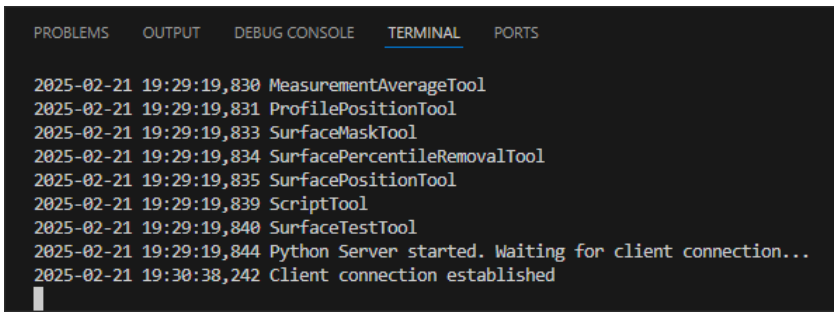


The tool server starts and waits for a connection from a PC instance of GoPxL.




7. Start an instance of GoPxL.

   The instance of GoPxL connects to the tool server.




   For more information, see *Running GoPxL on a Windows PC* on page 814.

8. Upload some previously scanned data or scan some new data and set the tool's input to this data.

   Your tool's input `must` be set in order to debug it.

9. Set a break point in your tool's Python code.

   The `process` method is good point to start: the tool's main processing occurs here.

# Deploying Your Custom Tools

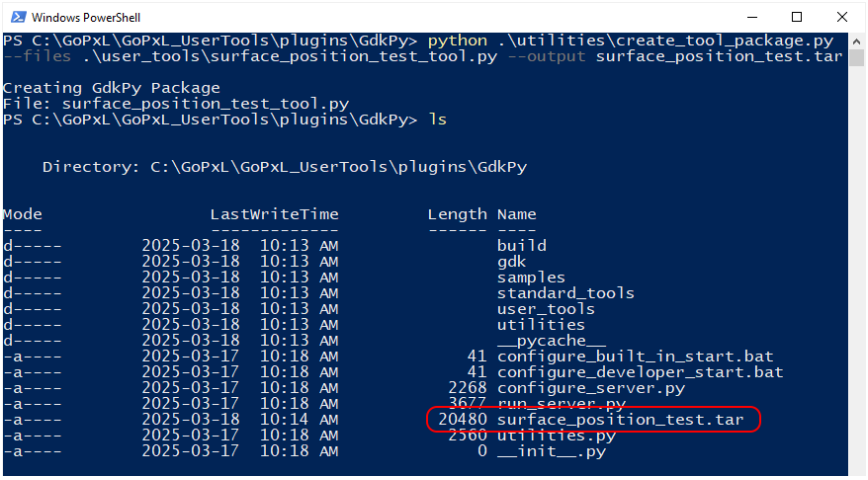
After you have finished developing your tool, you can deploy it as part of either a GoPxL firmware or GoPxL for PC. You use the `GdkPy\utilities\create_tool_package.py` script to create a .tar tool package, which you add to GoPxL using the GoPxL Add-on Tool Manager.

The `create_tool_package.py` script accepts the following arguments:

*Arguments*

| Name | Description |
|---|---|
| -h, --help | Show the help. |
| --files | The files to include in the .tar tool package. You can also pass a folder containing multiple Python tools. Files are added recursively. |
| --output | The name of the tool package with a .tar extension. If you omit this argument, the tool is packaged as `my_tool.tar`. |
| --ignore | Files or wildcards to ignore. By default, *.pyc files are excluded. |

1. Open a command prompt in the folder `plugins\GdkPy` and run `\utilities\create_tool_package.bat` (which calls `create_tool_package.py`), providing the path to your tool.




   The .tar file is created in the folder from which you started the script.

2. Use the GoPxL Add-on Tool Manager utility to add the generated `.tar` tool package to a firmware (`.dat` file) or to GoPxL for PC (in the `GoPxL` folder, where the bin folder is).

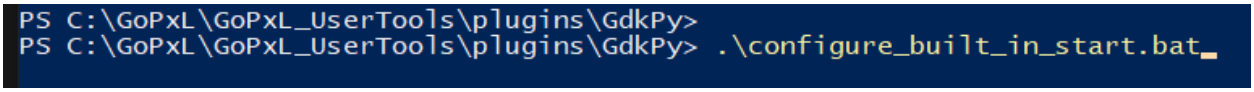
   For more information on using this utility, see *GoPxL Add-on Tool Manager* on page 926.

3. If you have added the custom tool to GoPxL for PC, open a command prompt and go to the `GdkPy` folder.

   a. Do one of the following:

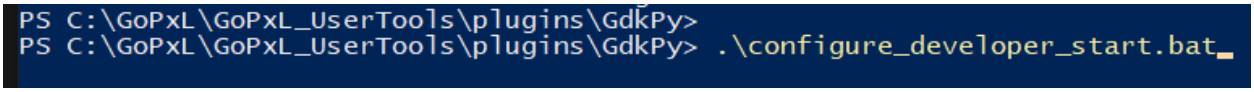
      Using the Python distribution included with GoPxL for PC:

      Run `.\configure_built_in_start.bat`.

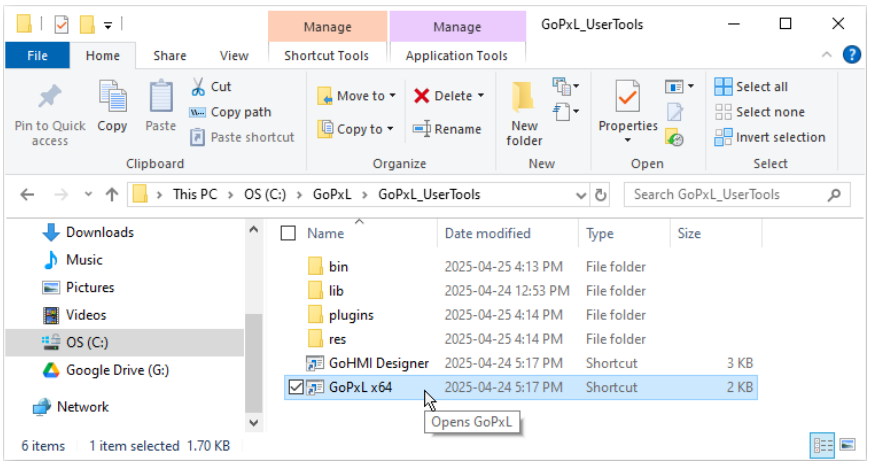



      Using your own Python distribution:

      Run `.\configure_developer_start.bat`.




   b. Go to the main GoPxL_UserTools folder, and start GoPxL.




4. If you have added the custom tool to a firmware, upload it to a device.

   For more information updating a sensor's firmware, see *Software Upgrade* on page 809.

# Integrations

GoPxL currently provides three types of integrations that you configure within GoPxL: GoPxL Data Protocol (for use with the GoPxL SDK and API), industrial protocols, and GoHMI.

For information on the Gocator protocol, see *GoPxL Data Protocol* on page 740.

For information on the protocols supported by GoPxL, see *Protocols (PLCs and other hardware)* below.

For information on GoHMI, see *GoHMI and GoHMI Designer* on page 833.

## Protocols (PLCs and other hardware)

GoPxL supports various protocols for communicating with sensors over Ethernet (TCP/IP).

The following protocols are available:

- GoPxL Data Protocol
- Modbus
- EtherNet/IP
- PROFINET
- ASCII

> The connection mappings for the industrial protocols (PROFINET, EtherNet/IP, and Modbus) have changed to correct a byte alignment issue. To allow communication between PLCs and GoPxL 1.2, you may need to update PLC logic created for GoPxL 1.1.
>
> For EtherNet/IP, the EDS file has been updated to reflect the changes.

The connection mappings for the industrial protocols (PROFINET, EtherNet/IP, and Modbus) have changed to correct a byte alignment issue. To allow communication between PLCs and GoPxL 1.2, you may need to update PLC logic created for GoPxL 1.1.

For EtherNet/IP, the EDS file has been updated to reflect the changes.

# GenICam GenTL Driver

For known issues when using GoPxL with GenTL, see the GoPxL release notes.

GenICam is an industry standard for controlling and acquiring data from an imaging device. Gocator sensors support GenICam through a GenTL Producer driver.

The included GenTL driver allows GenICam-compliant third-party software applications such as Halcon and Common Vision Blox to acquire and process 3D data and intensity generated from the sensor.

Currently, the GenTL driver can't perform an alignment if you haven't saved a job first.

The following sensor scan modes are supported:

- Video
- Profile (with **Uniform Spacing** disabled). In this mode, the point cloud profiles are resampled and accumulated into a surface.
- Surface (with **Uniform Spacing** enabled)

For more information on scan modes and uniform spacing, see *Scan Modes and Intensity* on page 111.

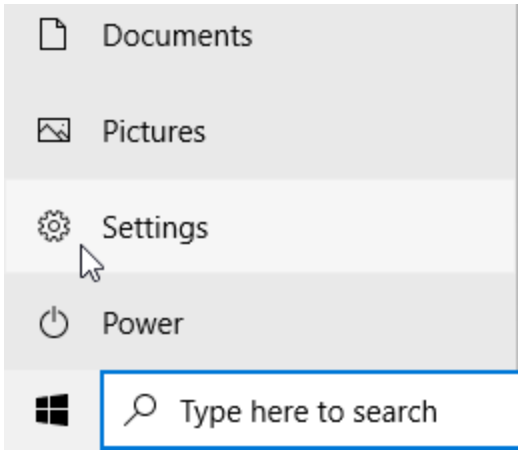
To use these third-party software applications, you *must* configure a system variable so the software can access the GenTL driver. For instructions, see *To configure system variables to use the driver in Windows 10*, below.

To get the utilities package containing the driver (14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.zip), go to https://lmi3d.com/product-downloads/, choose your product using the drop-down menus, and download the zip package.

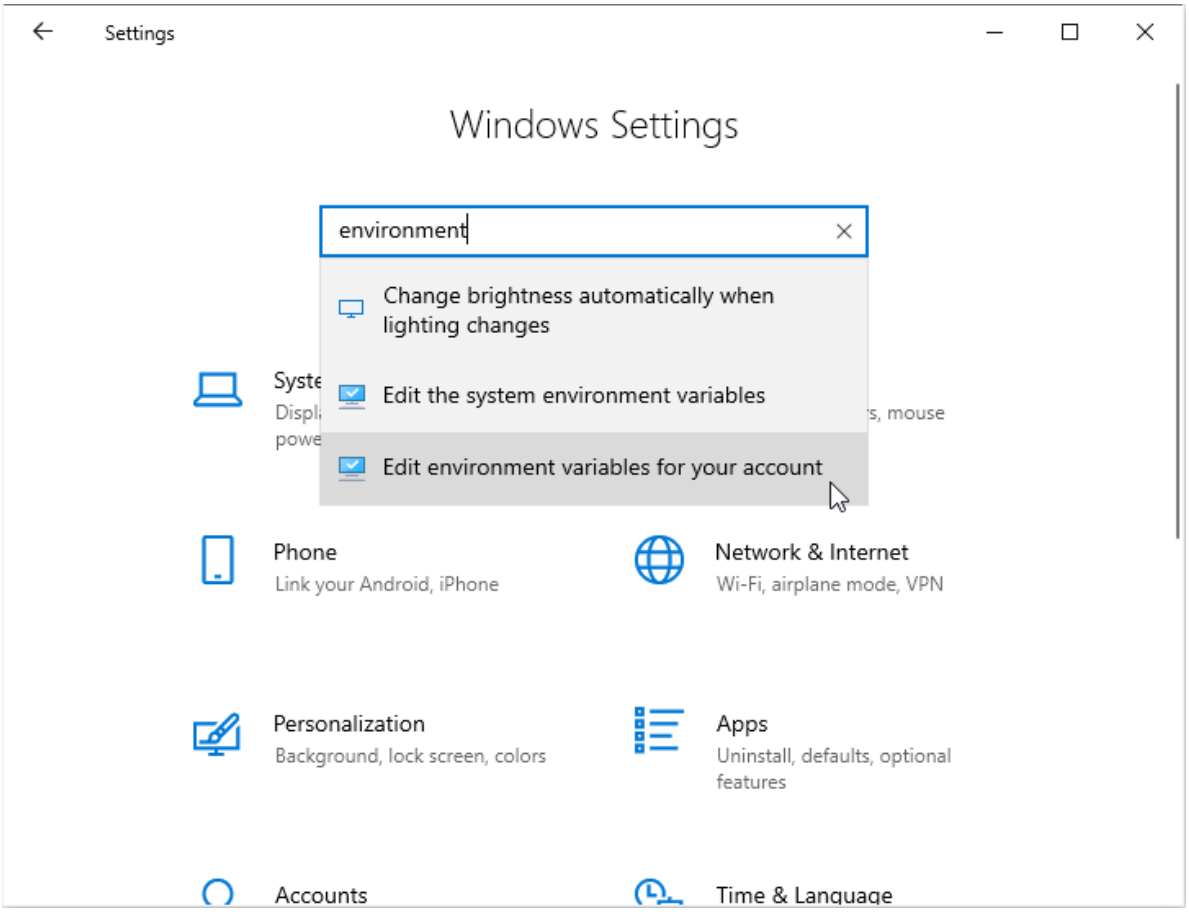
After downloading the package and unzipping the file to a location you will remember, you will find the driver in Integration\GenTL\x64 (you can move the GenTL folder to a more convenient location).

*To configure system variables to use the driver in Windows 11*

1. Click the Start menu and launch Settings.

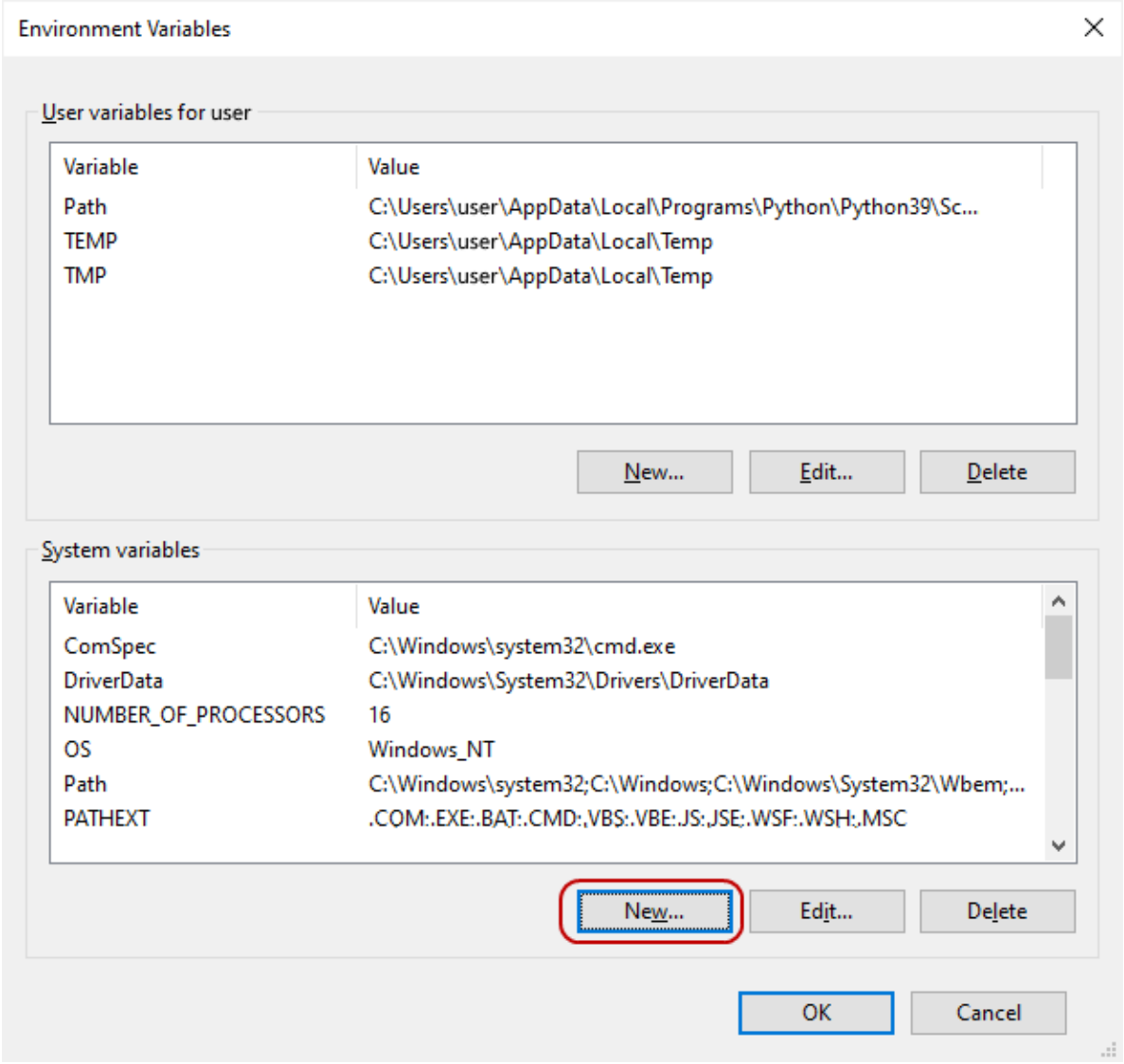


2. In the Settings application search field, type "environment".



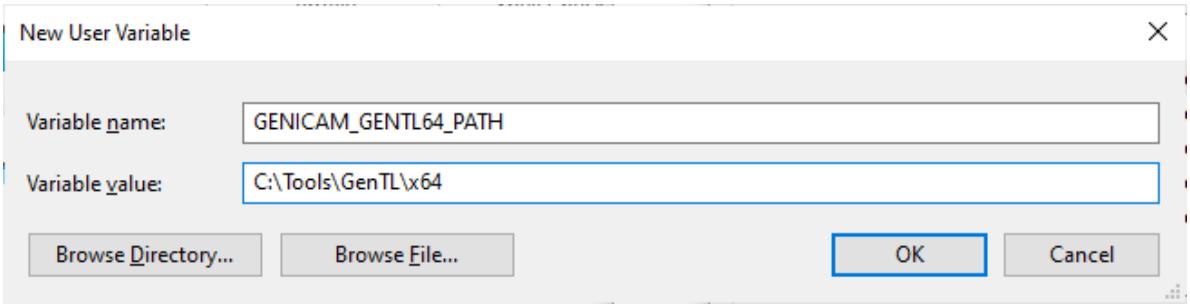

The Environment Variables dialog opens.

3. In the Environment Variables dialog, under the System variables list, click **New**.




4. In the **New System Variable** dialog, enter the following information, depending on your system:

| Variable name | Variable value |
|---|---|
| GENICAM_GENTL64_PATH | The full path to the GenTL\x64 folder. |




5. Click OK in the dialogs until they are all closed.

To work with the GenTL driver, you must enable the GoPxL Data Protocol as well as the desired outputs on the **GDP** page. For more information on configuring the protocol, see *GoPxL Data Protocol* on page 736.

If you need intensity data, check **Acquire Intensity** in the **Scan Mode** panel on the **Acquire** page. For more information on enabling intensity, see *Scan Modes and Intensity* on page 111.

The GenTL driver packs the output and stamps (e.g., time stamp, encoder index, and so on) into either a 16-bit RGB image or a 16-bit grey scale image. The driver also includes intensity if it is enabled. You can select the format in the Go2GenTL.xml setting file.

The width and height of the 16-bit RGB or grey scale image is calculated from the maximum number of columns and rows needed to accommodate the sensor's field of view and the maximum part length.

## 16-bit RGB Image

When the 16-bit RGB format is used, the height map, intensity, and stamps are stored in the red, green, and blue channel respectively.

| Channel | Details |
|---|---|
| Red | Height map information. The width and height of the image represent the dimensions in the X and Y axis. Together with the pixel value, each red pixel presents a 3D point in the real-world coordinates.<br><br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz):<br><br>X = X offset + Px * X resolution<br><br>Y = Y offset + Py * Y resolution<br><br>Z = Z offset + Pz * Z resolution<br><br>Refer to the blue channel on how to retrieve the offset and resolution values. If Pz is 0 if the data is invalid. The Z offset is fixed to -32768 * Z resolution. Z is zero if Pz is 32768. |
| Green | Intensity information. Same as the red channel, the width and height of the image represent the dimension in the X and the Y axis. Together with the pixel value, each blue pixel represents an intensity value in the real-world coordinates.<br><br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz):<br><br>X = X offset + Px * X resolution<br><br>Y = Y offset + Py * Y resolution<br><br>Z = 16-bit intensity value<br><br>The intensity value is 0 if the intensity image is not available. Gocator outputs 8-bit intensity values. The values stored in the 16-bit RGB image is multiplied by 256. To obtain the original values, divide the intensity values by 256.<br><br>Refer to the blue channel on how to retrieve the offset and resolution values. |

| Channel | Details |
|---|---|
| Blue | Stamp information. Stamps are 64-bit auxiliary information related to the height map and intensity content. The next table explains how the stamps are packed into the blue pixel channel |

The following table shows how the stamp information is packed into the blue channel. A stamp is a 64-bit value packed into four consecutive 16-bit blue pixels, with the first byte position storing the most significant byte.

*Stamp Information from GenTL driver*

| Stamp Index | Blue Pixel Position | Details |
|---|---|---|
| 0 | 0..3 | Version |
| 1 | 4..7 | Frame Count |
| 2 | 8..11 | Timestamp (µs) |
| 3 | 12..15 | Encoder value (ticks) |
| 4 | 16..19 | Encoder index (ticks)<br>This is the encoder value when the last index is triggered |
| 5 | 20..23 | Digital input states |
| 6 | 24..27 | X offset (nm) |
| 7 | 28..31 | X resolution(nm) |
| 8 | 32..35 | Y offset (nm) |
| 9 | 36..39 | Y resolution (nm) |
| 10 | 40..43 | Z offset (nm) |
| 11 | 44..47 | Z resolution (nm) |
| 12 | 48..51 | Height map Width (in pixels) |
| 13 | 52..55 | Height map length (in pixels) |
| 14 | 56..59 | Specify if the intensity is enabled |

## 16-bit Grey Scale Image

When the 16-bit grey scale format is used, the height map, intensity, and stamps are stored sequentially in the grey scale image.

The last row of the image contains the stamp information.

| Rows | Details |
|---|---|
| 0 .. (max part height - 1) | Height map information. The width and height of the image represent the dimensions in the X and Y axis. Together with the pixel value, each pixel presents a 3D point in the real-world coordinates.<br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz):<br>X = X offset + Px * X resolution |

| Rows | Details |
|---|---|
| | Y = Y offset + Py * Y resolution<br>Z = Z offset + Pz * Z resolution<br>Refer to the blue channel on how to retrieve the offset and resolution values. If Pz is 0 if the data is invalid. The Z offset is fixed to -32768 * Z Resolution. Z is zero if Pz is 32768. |
| (max part height) .. 2* (max part height)<br>If intensity is enabled | Intensity information. The width and height of the image represent the dimension in the X and the Y axis. Together with the pixel value, each blue pixel represents an intensity value in the real-world coordinates.<br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): The following formula assumes Py is relative to the first row of the intensity information, not the first row of the whole 16-bit grey scale image.<br>X = X offset + Px * X resolution<br>Y = Y offset + Py * Y resolution<br>Z = 16-bit intensity value<br>This intensity value is 0 if the intensity image is not available. Gocator outputs 8-bit intensity values. The values stored in the 16-bit Grey scale image is multiplied by 256. To obtain the original values, divide the intensity values by 256.<br>Refer to the stamps on how to retrieve the offset and resolution values. |
| The last row of the 16-bit grey scale image | Stamp information. Stamps are 64-bit auxiliary information related to the height map and intensity content. The next table explains how the stamps are packed into the blue pixel channel |

The following table shows how the stamp information is packed into the last row. A stamp is a 64-bit value packed into four consecutive 16-bit pixels, with the first byte position storing the most significant byte.

*Stamp Information from GenTL driver*

| Stamp Index | Column Position | Details |
|---|---|---|
| 0 | 0..3 | Version |
| 1 | 4..7 | Frame Count |
| 2 | 8..11 | Timestamp (µs) |
| 3 | 12..15 | Encoder value (ticks) |
| 4 | 16..19 | Encoder index (ticks)<br>This is the encoder value when the last index is triggered |
| 5 | 20..23 | Digital input states |
| 6 | 24..27 | X offset (nm) |
| 7 | 28..31 | X resolution(nm) |
| 8 | 32..35 | Y offset (nm) |

| Stamp Index | Column Position | Details |
|---|---|---|
| 9 | 36..39 | Y resolution (nm) |
| 10 | 40..43 | Z offset (nm) |
| 11 | 44..47 | Z resolution (nm) |
| 12 | 48..51 | Height map Width (in pixels) |
| 13 | 52..55 | Height map length (in pixels) |
| 14 | 56..59 | Specify if intensity is enabled or not |

## Registers

GenTL registers are multiples of 32 bits. The registers are used to control the operation of the GenTL driver, send commands to the sensors, or to report the current sensor information.

*Register Map Overview*

| Register Address | Name | Read/Write | Length (bytes) | Description |
|---|---|---|---|---|
| 260 | WidthReg | RO | 4 | Specify the width of the returned images. The part height map is truncated if it is wider than the specified width. |
| 264 | HeightReg | RO | 4 | Specify the height of the returned images (i.e., length of the part). The part height map is truncated if it is longer than the specified length. |
| 292 | ResampleMode | RO | 4 | Enable the resampling logic in the GenTL driver<br>0 – Disable resampling<br>1 – Enable resampling<br>When resampling is enabled, the GenTL driver will resample the height map so that the pixel spacing is the same in the X and Y axis. |
| 296 | EncoderValue0 | RO | 4 | Report the current encoder value (least significant 32-bit).<br>The current encoder value is latched from the sensor when this register is read. |
| 300 | EncoderValue1 | RO | 4 | Report the current encoder value (most significant 32-bit).<br>The encoder value is latched when EncoderValue0 register is read. User should read EncoderValue0 before reading EncoderValue1. |
| 304 | Configuration File | RW | 16 | Read the name of sensor live configuration file or switch (write) the sensor configuration file. The configuration name is NULL terminated and includes the extension ".job". Writing to this register causes the sensor to switch to the |

| Register Address | Name | Read/Write | Length (bytes) | Description |
|---|---|---|---|---|
| | | | | specified configuration. |
| 320 | Transformation X offset | RO | 4 | Return the sensor transformation X offset |
| 324 | Transformation Z offset | RO | 4 | Return the sensor transformation Z offset |
| 328 | Transformation Angle | RO | 4 | Return the sensor transformation angle |
| 332 | Transformation Orientation | RO | 4 | Return the sensor transformation orientation |
| 336 | Clearance distance | RO | 4 | Return the sensor clearance distance |

## XML Settings File

The settings file, Go2GenTL.xml, resides in the same directory as the Gocator GenTL driver. Users can set the resample mode and output format by changing the setting in this file.

| Element | Type | Description |
|---|---|---|
| ResampleMode | 32u | Settings to disable or enable resampling mode:<br>0 – Disable<br>1 – Enable<br>When resampling mode is enabled, the GenTL driver will resample the height map so that the pixel spacing is the same in the X and Y axis. The default value is 1. |
| DataFormat | 32u | Settings to choose 16-bit RGB or 16-bit grey scale image output:<br>0 – 16-bit RGB Image<br>1 – 16-bit grey scale Image<br>The default value is 0. |
| OverrideImageWidth<br>OverrideImageLength | 32u | If Halcon is consuming the output of a multi-sensor system or of a tool such as Surface Stitch, that is, where multiple frames are combined, you should set OverrideImageWidth and OverrideImageLength to the maximum expected size.<br>OverrideImageWidth = image width / X resolution<br>OverrideImageLength = image length / Y resolution<br>Otherwise, leave the default of 0. |
| RawPartDetectionHeightThreshold<br>RawPartDetectionMaxLength | Float | If the Gocator sensor is in Profile mode, the GenTL driver converts the profiles the sensor produces into an image that Halcon can process, using these settings.<br>RawPartDetectionHeightThreshold: Detects the start and end of a part when scanning. When data points in the profile go over this |

| Element | Type | Description |
|---|---|---|
| | | threshold, the driver starts concatenating the profiles. As soon as no data points are above this threshold, the driver stops concatenating profiles.<br>RawPartDetectionMaxLength: The maximum length of a part.<br>Either condition (data points going back below the threshold or maximum length reached) will stop profile concatenation for the part. |
| DataCapacity | 64u | The amount of memory, in bytes, used for buffered data. Adjust this depending on the needs of the GenTL consumer. |

## Interfacing with Halcon

Halcon is a comprehensive software package for machine vision applications with an integrated development environment. A sensor can use the included GenTL driver to stream Surface scan data and intensity data into Halcon in real-time. Halcon is supported in GoPxL 1.0 and higher. LMI has tested using Halcon 23.05.

> The current GenTL driver does not support scanning in profile mode.

For information on setting up the GenTL driver, see *GenICam GenTL Driver* on page 887.

This section describes how to configure Halcon to acquire data from the Gocator sensor. You should be familiar with the sensor's Surface mode. Before continuing, make sure Halcon is installed.

> Halcon sets the size of the buffer for acquisition only when the driver is initialized. For this reason, if you increase the size of the sensor output after driver initialization, the scan data Halcon receives will be cropped.

> If Halcon is consuming the output of a multi-sensor system or of a tool such as Surface Stitch, that is, where multiple frames are combined, you should set OverrideImageWidth and OverrideImageLength to the maximum expected size. For more information, see *XML Settings File* on the previous page.

### Setting Up Halcon

Before using Halcon with a sensor, you must set up Halcon.

*To set up Halcon:*

1. Connect a sensor to the PC running Halcon.

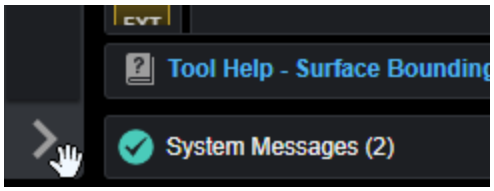
   You will need a Master hub to connect the sensor to the PC. For more information, see *Quick Start - Installation, Network & Sensor Setup* on page 27.

2. Connect to the GoPxL IP using a web browser.

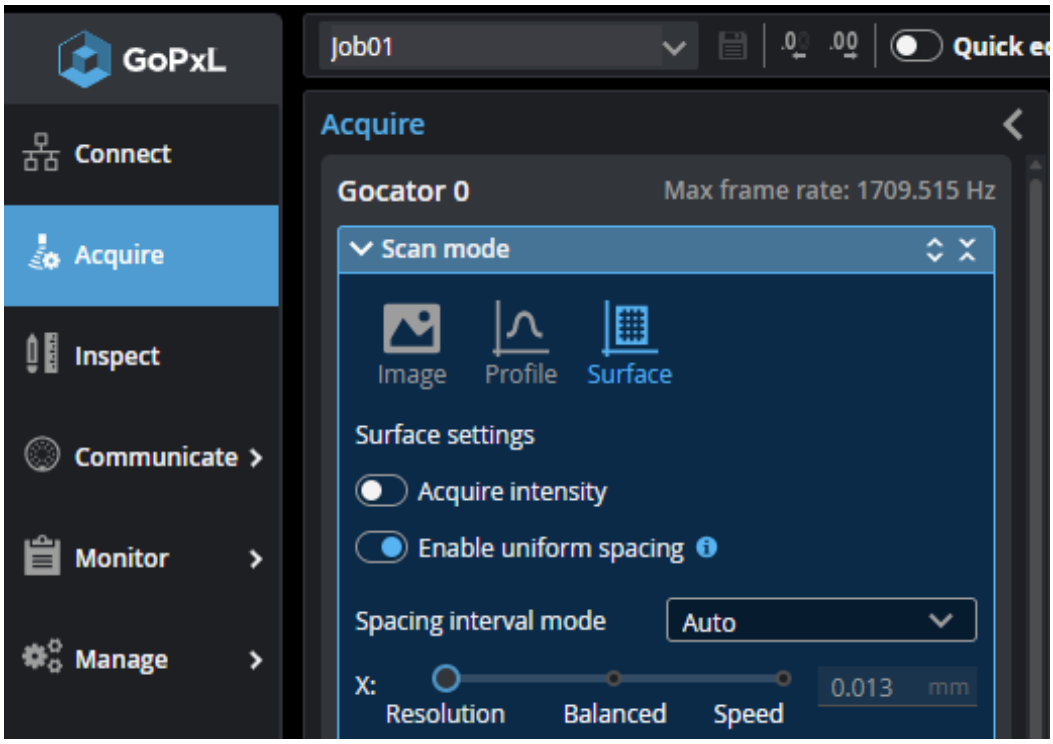
   By default, a sensor's IP is 192.168.1.10. If you have changed the sensor's IP, use that address. If you can't find your sensor, see *GoPxL Discovery Tool* on page 917.

   For more information on running GoPxL on a PC, see *Running GoPxL on a Windows PC* on page 814.

3. In the GoPxL interface, expand the navigation bar on the left side of the interface.



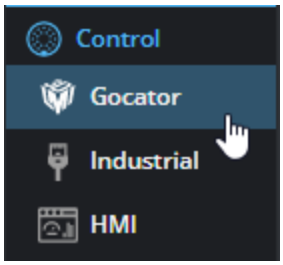

4. Go to the **Acquire** page.



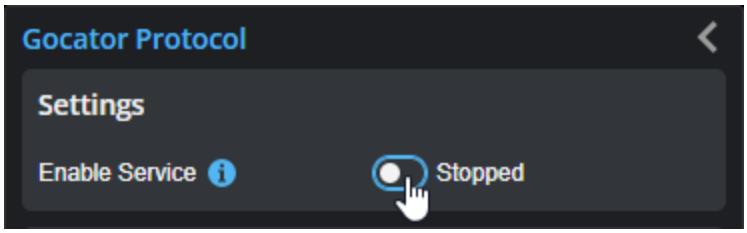

5. In the **Scan mode** section, click the **Surface** icon to switch to Surface mode.

6. (Optional) If you need intensity data, enable **Acquire Intensity**.
7. Configure the sensor to produce the desired surface data.

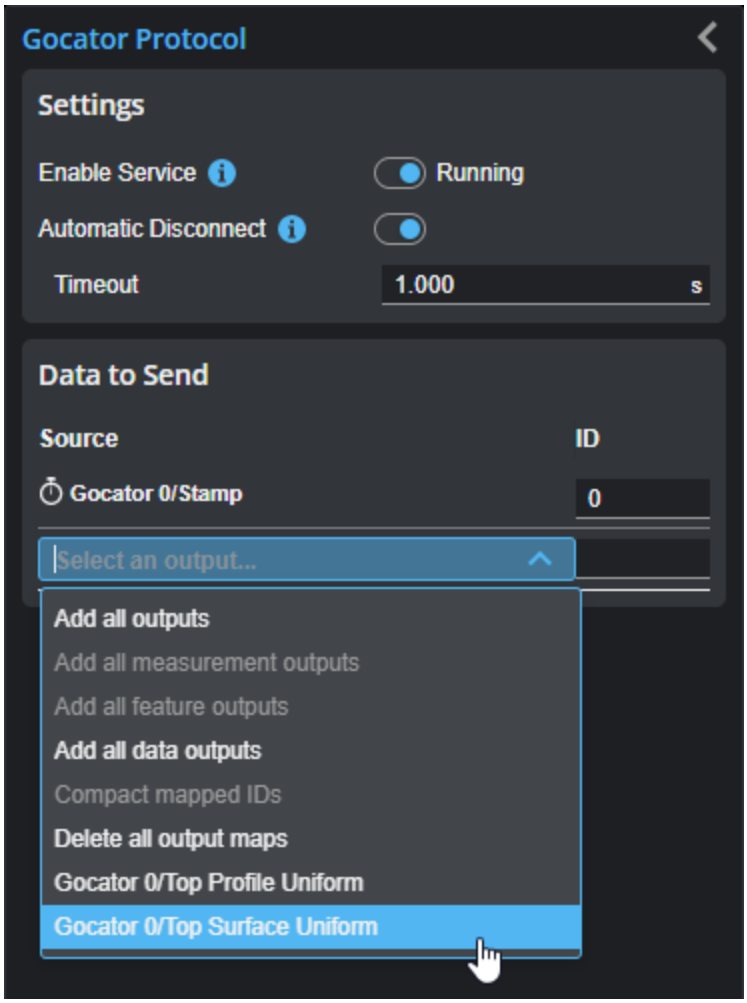
   For more information on configuring sensors, see *Acquire - Alignment and Acquisition* on page 96.
8. Click the **Gocator** page icon in the navigation bar.




9. On the **Gocator** page, enable the Gocator protocol.



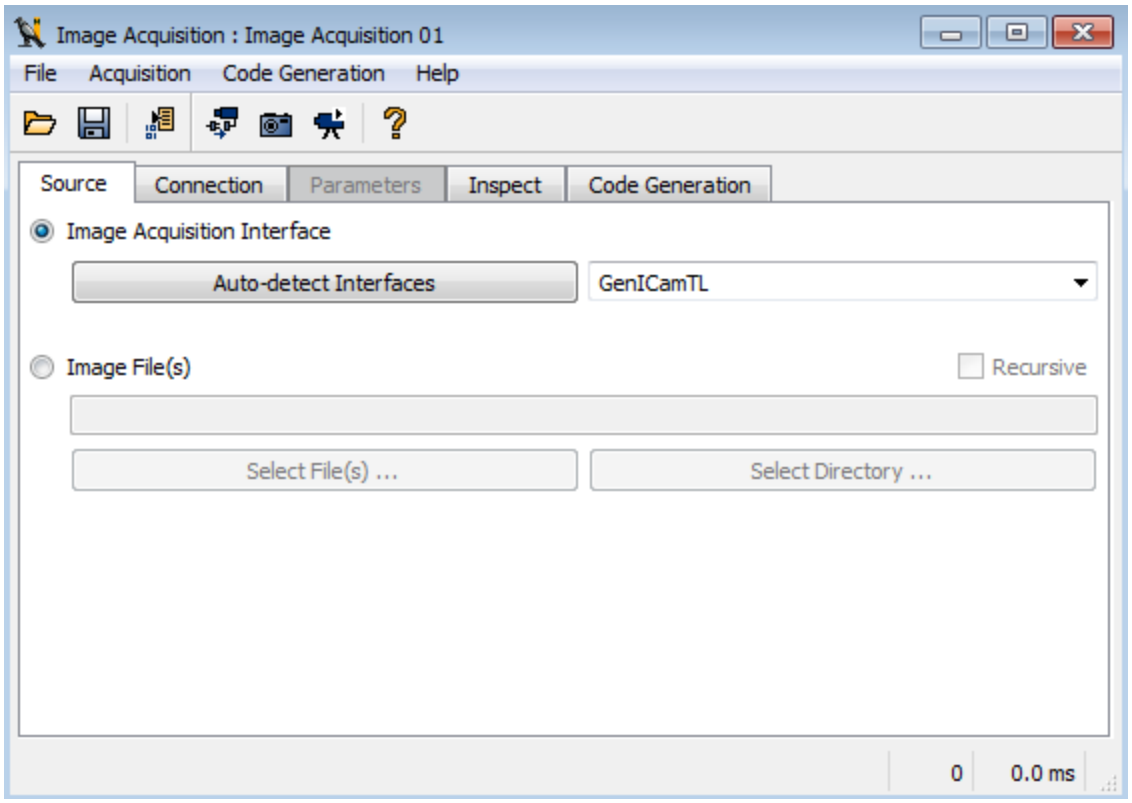

10. In the **Data to Send** section, choose the surface you want to send to Halcon.




For more information on configuring Gocator output, *GoPxL Data Protocol* on page 736.

11. Make sure the sensor is running.

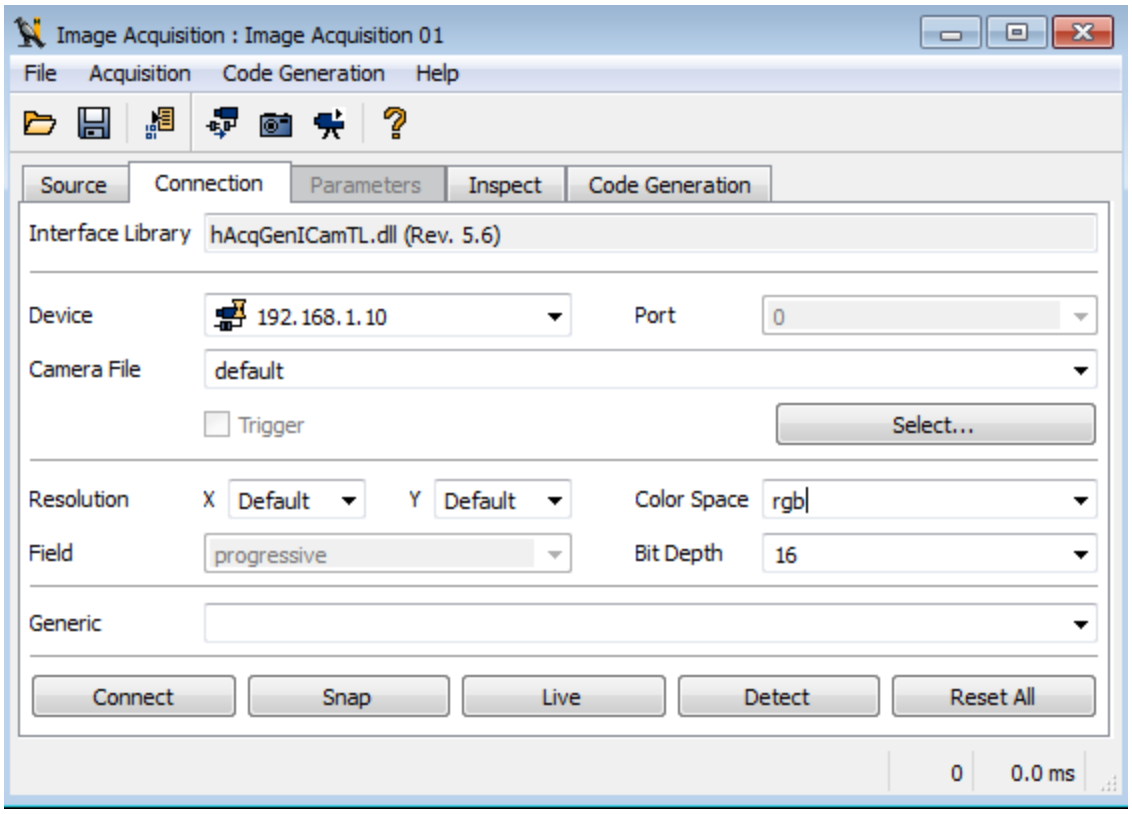
12. On the PC, launch Halcon.
13. In Halcon, in the **Assistants** menu, click **Open New Image Acquisition**.
14. In the dialog that opens, in the **Source** tab, check the **Image Acquisition Interface** option and choose `GenICamTL` in the drop-down.



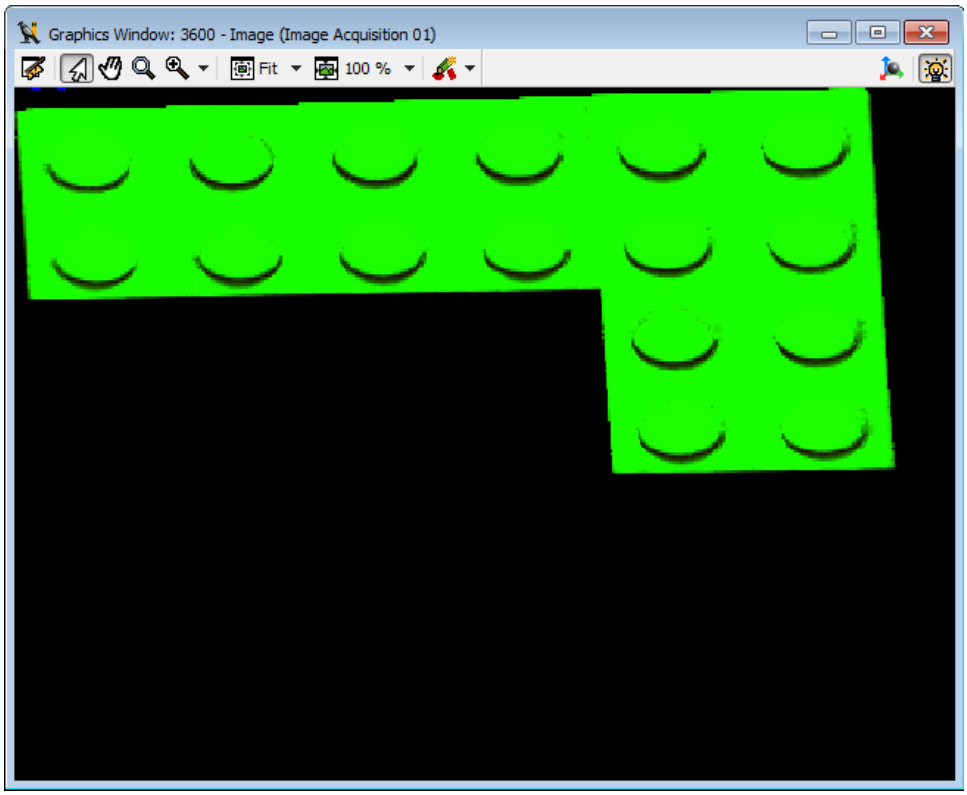

> The driver uses the Gocator protocol discovery messages to search for available Gocator sensors. Discovery messages can be blocked by a PC's firewall. You should therefore turn off the firewall and try again if the sensor can't be detected.

15. Switch to the **Connection** tab.

    If Halcon detects a sensor, the sensor's IP will be listed next to **Device**.




16. In the **Connection** tab, set **Color Space** to `RGB` and **Bit Depth** to `16`.
17. In the sensor's web interface, click the Snapshot button to trigger the output of a surface.
    The output displays in the Halcon **Graphics Window**.




Halcon is now configured for use with the sensor.

## Halcon Procedures

In Halcon, you can use various internal procedures (functions) to decompose the RGB image and to control registers that the GenTL driver opens.

You can import the procedures into your own code by selecting File > Insert Program > Insert Procedures and then choosing the example code `Continuous_Acq.hdev` under the `Examples/Halcon` directory.

The following table describes each of these procedures.

*Halcon Procedures*

| Procedures | Description |
|---|---|
| set_ framegrabber_ param | Generic Halcon function to set parameters on the sensor. Can be used to set sensor-specific settings and execute specific commands. For a complete list of settings that can be changed, see below. In the generic form:<br>`set_framegrabber_param( AcqHandle, 'Name', 'Value')`<br><br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>**Name**: The name of the parameter to set on the sensor.<br>**Value**: The parameter value to set on the sensor. |

| Procedures | Description |
|---|---|
| | For full details on using this function, see *XmlSetting and XmlCommand Parameters* on page 904. |
| get_framegrabber_param | Generic Halcon function to get parameters on the sensor. Used in conjunction with set_framegrabber_param to set the path to the setting, after which the setting's value is retrieved with get_framegrabber_param. In the generic form:<br>`get_framegrabber_param( AcqHandle, 'Name', 'Value')`<br><br>*Parameters*<br>**AcqHandle** (input): Acquisition handle created by `open_framegrabber`.<br>**Name** (input): The name of the parameter to set on the sensor.<br>**Value** (output): The variable where parameter's value will be stored.<br><br>For full details on using this function, see *XmlSetting and XmlCommand Parameters* on page 904. |
| Go2GenTL_ParseData | The GenTL driver packs the height map, intensity and stamp information into a 16-bit RGB image. The function is used to extract data from the RGB image.<br>For details on how the information is packed in the data, see the sections under *GenICam GenTL Driver* on page 887.<br>The function accepts the image acquired from `grab_image_async`, and returns the height map, intensity and stamps.<br>***Parameters*** **Image** (input): RGB Image acquired by using `grab_image_async`.<br>**HeightMap** (output): The height map image.<br>**Intensity** (output): The intensity image.<br>**Stamps** (output): The stamps structure.<br>**Index** (input): The index of the scan to extract.<br>**NumScans** (output): The number of scans in the acquired image.<br>Each output is returned as decimal value.<br>***Example*** `Go2GenTL_ParseData(Image, HeightMap, Intensity, Stamps, 0, NumScans)` |
| Go2GenTL_ParseStamps | The stamp information is encoded in the image and can be retrieved using the Go2GenTL_ParseData function. The function Go2GenTL_ParseStamps is used to extract the stamp information from the stamp structure.<br>For details on how the information is packed in the data, see the sections under *GenICam GenTL Driver* on page 887.<br>The function accepts the stamp structure acquired from the Go2GenTL_ParseData function, and returns the various values encoded in the stamps.<br>***Parameters (Input)*** **Stamps**: The stamps structure acquired by using Go2GenTL_ParseData.<br>***Parameters (Output)*** **FrameCount**: The number of frames. |

| Procedures | Description |
|---|---|
| | **Timestamp**: The timestamp.<br><br>**Encoder**: The encoder position.<br><br>**EncoderIndex**: The last index of the encoder.<br><br>**Inputs**: The digital input states.<br><br>**xOffset**: The X offset in millimeters.<br><br>**xResolution**: The X resolution in millimeters.<br><br>**yOffset**: The Y offset in millimeters.<br><br>**yResolution**: The Y resolution in millimeters.<br><br>**zOffset**: The Z offset in millimeters.<br><br>**zResolution**: The Y resolition in millimeters.<br><br>**zOffset**: The Z offset in millimeters.<br><br>**zResolution**: The Z resolution in millimeters.<br><br>**Width**: The width (number of columns) of the image that contains the part. The part width can be less than the image width requested by the user.<br><br>**Height**: The height or length (number of rows) of the image that contains the part. The part length can be less than the image height requested by the user.<br><br>**HasIntensity**: Specifies if the intensity image is available. The intensity image is available if **Acquire Intensity** is enabled in the sensor's web interface.<br><br>**NumScans**: The number of scans in the acquired image.<br><br>**SyncTimestamp**: The PTP time stamp.<br><br>**MeasurementIds**: Array of every measurement's ID.<br><br>**MeasurementValues**: Array of every measurement's value.<br><br>**MeasurementDecisions**: Array of every measurement's decision.<br><br>**MeasurementDecisionCodes**: Array of every measurement's code.<br><br>Each output is returned as decimal value.<br><br>***Example*** `Go2GenTL_ParseStamps(Stamps, FrameCount, Timestamp, EncoderPosition, EncoderIndex, Inputs, xOffset, xResolution, yOffset, yResolution, zOffset, zResolution, Width, Length, HasIntensity, NumScans, SyncTimestamp, MeasurementIds, MeasurementValues, MeasurementDecisions, MeasurementDecisionCodes)` |
| Go2GenTL_ ResampleMode | Returns the resample mode.<br><br>***Parameters (Input)*** **AcqHandle**: Acquisition handle created by `open_framegrabber`. |

| Procedures | Description |
|---|---|
| | ***Parameters (Output)*** **ResampleMode**:<br>No - Resample is disabled.<br><br>Yes - Resample is enabled.<br><br>When resampling is enabled, the GenTL driver resamples the height map so that the pixel spacing is the same on the X and Y axis.<br><br>***Example*** `Go2GenTL_ResampleMode (AcqHandle, ResampleMode)`<br><br>To set the resample mode, you must directly modify Go2GenTL.xml, which is in the same directory as the sensor GenTL driver (Go2GenTL.cti). |
| Go2GenTL_ ConfigFileName | Returns the current live sensor job file name.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>*Parameters (Output)*<br>**ConfigFile**: The name of the job file. The file name includes the extension .job.<br>*Example*<br>`Go2GenTL_ConfigFileName (AcqHandle, ConfigFile)` |
| Go2GenTL_ SetConfigFileNam e | Sets the sensor live configuration.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>**ConfigFile**: The name of the job file. The file name should include the extension .job.<br>*Example*<br>`Go2GenTL_SetConfigFileName (AcqHandle, 'test2.cfg')` |
| Go2GenTL_ Encoder | Returns the current encoder value. When this function is called, the GenTL driver retrieves the latest encoder value from the sensor. The value is returned as a two-element tuple. The first element is the least significant 32-bit value, and the second element is the most significant 32-bit value.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>*Parameters (Output)*<br>**EncoderValue**: The current encoder value.<br>*Example*<br>`Go2GenTL_Encoder(AcqHandle, EncoderValue)` |
| Go2GenTL_ ImageSize | Returns the size of the image returned by the GenTL driver.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>*Parameters (Output)*<br>**Width**: The width of the image.<br>**Height**: The height of the image.<br>*Example*<br>`Go2GenTL_ImageSize(AcqHandle, Width, Height)` |

| Procedures | Description |
|---|---|
| | To set the image size, you must directly modify Go2GenTL.xml, which is in the same directory as the sensor GenTL driver (Go2GenTL.cti). |
| Go2GenTL_ CoordinateXYZ | Returns the real-world coordinates (X, Y, Z) of the part given the row and column position in the height map.<br>The values of the offset and resolution input parameters can be retrieved using Go2GenTL_ ParseData.<br>*Parameters (Input)*<br>**HeightMap**: The height map image.<br>**Row**: The row in the height map.<br>**Column**: The column in the height map.<br>**xOffset**: The X offset in millimeters.<br>**xResolution**: The X resolution in millimeters.<br>**yOffset**: The Y offset in millimeters.<br>**yResoluion**: The Y resolution in millimeters.<br>**zOffset**: The Z offset in millimeters.<br>**zResolution**: The Z resolution in millimeters.<br>*Parameters (Output)*<br>**coordinateXYZ**: The real-world coordinates. |
| Go2GenTL_ Exposure | Returns the current exposure.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>*Parameters (Output)*<br>**Exposure**: The current exposure value (in µs). The value is returned as an integer. Decimals are truncated.<br>*Example*<br>`Go2GenTL_Exposure(AcqHandle, exposure)` |
| Go2GenTL_ SetExposure | Sets the current exposure.<br>*Parameters (Input)*<br>**AcqHandle**: Acquisition handle created by `open_framegrabber`.<br>**Exposure**: The current exposure value (in µs), as an integer.<br>*Example*<br>`Go2GenTL_SetExposure(AcqHandle, exposure)` |

## XmlSetting and XmlCommand Parameters

#### Sensor Settings

You use the `set_framegrabber_param` and `get_framegrabber_param` functions to set and get the values of advanced parameters on sensors, and additionally modify special settings and send commands at the driver level. (Examples are shown below and in *Sample Program for Various GenTL Settings* on page 908.)

When you set the second parameter of `set_framegrabber_param` to "XmlSetting", you can use the function to do the following:

- Set the path to a setting you wish to set *or* get.
- Set the value of a setting.

- Set an attribute of a setting.

When you set the second parameter of `set_framegrabber_param` to "XmlCommand", you can send commands and change driver-level settings at the driver level.

Finally, when you retrieve the value of a sensor setting, you set the second parameter of `get_framegrabber_param` to "XmlSettingReturn".

For example, to get the value for a setting, use a series of calls to `set_framegrabber_param` to set the path to the setting, by chunks of up to 32 characters, and retrieve the value into the variable passed in a call to `get_framegrabber_param`. The following gets the value of the Smoothing filter's X window size:

```
set_framegrabber_param(AcqHandle, 'XmlSetting', '/scan/engines')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/LMILaserLineProfiler')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanners/scanner-0')
set_framegrabber_param(AcqHandle, 'XmlSetting', '?parameters')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/Smoothing/winX')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', var)
```

To set a value, use `set_framegrabber_param` to set the path as above and add "=<value>". Note that when setting a value with XmlSetting, you must end the set operation with either an empty string or "\n". The following sets the Smoothing filter's X window to 2.5:

```
set_framegrabber_param(AcqHandle, 'XmlSetting', '/scan/engines')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/LMILaserLineProfiler')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanners/scanner-0')
set_framegrabber_param(AcqHandle, 'XmlSetting', '?parameters')
set_framegrabber_param(AcqHandle, 'XmlSetting', '/Smoothing/winX=2.5')
set_framegrabber_param(AcqHandle, 'XmlSetting', '')
```

Using "\n":

```
set_framegrabber_param(AcqHandle, 'XmlSetting', '/Smoothing/winX=2.5\n')
```

For a set or a get, if an index or a parameter is required, use parentheses:

```
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/ResetGocator(1)')
set_framegrabber_param(AcqHandle, 'XmlSetting', '')
```

#### GenTL Driver Settings and Commands

You can change settings or send commands at the driver level. These options always start with GenTL/, in contrast with the Setup/ node for configuring the sensor.

For example, to stop a sensor programmatically, you can do the following:

```
set_framegrabber_param(AcqHandle, 'XmlCommand', 'GenTL/StopGocator')
set_framegrabber_param(AcqHandle, 'XmlCommand', '')
```

You can also optionally add the "\n" character to the end of the last line of the set operation:

```
set_framegrabber_param(AcqHandle, 'XmlCommand', 'GenTL/StopGocator\n')
```

The following driver-level settings are available:

*Driver-level settings*

| Setting | Comment |
|---|---|
| "GenTL/Buffers" | Read-Write. Gets/Sets the number of buffers to use in the acquisition pipeline. |
| "GenTL/Encoder" | Read-only. Gets the current encoder value. |
| "GenTL/IsResponsive" | Read-only. Gets the responsiveness of the sensor. |
| "GenTL/HasChanges" | Read-only. Indicates whether the sensor needs a GenTL/Refresh command (see *Driver-level commands* on the next page). |
| "GenTL/Version" | Read-only. Returns the version of the GenTL driver. |
| "GenTL/StartStopControl" | Read-Write. Enables or disables the user defined control. Setting this value to 1 allows the user to start and stop manually the sensor, using the "GenTL/StartGocator" and "GenTL/StopGocator" commands. |
| "GenTL/State" | Read-only. |
| "GenTL/State(id)" | By default, gets the state of the controlling sensor (formerly "main"). If an ID is provided, the state of the corresponding sensor is returned. Use ID=0 for the controlling. Any other grouped sensors (formerly "buddy") start at ID=1. For a system with three grouped sensors, the index can be from 0 to 2. |
| "GenTL/BuddyState" | Read-only. |
| "GenTL/BuddyState(id)" | By default, gets the state of the first controlled (formerly "buddy") sensor in a sensor group, excluding the controlling sensor (formerly "main"). If an ID is provided, the state of the corresponding sensor is returned. Use ID=0 for the first controlled sensor. For a system with three grouped sensors, the index can be 0 or 1. |
| "GenTL/BuddyAt" | Read-only. |
| "GenTL/BuddyAt(id)" | By default, gets the serial number of the first controlled (formerly "buddy" sensor), excluding the controlling sensor. If an ID is provided, the serial number of the corresponding sensor is returned. Use ID=0 for the first controlled sensor. For a system with three grouped sensors, the index can be 0 or 1. |
| "GenTL/BuddyCount" | Read-only.<br>Returns the number of controlled sensors (formerly "buddy" sensors), excluding the sensor that is controlling the other sensors. For a system with three grouped sensors, the function will return 2. |
| "GenTL/FlushOldBuffers" | Flushes the GenTL pipeline buffers. Can be used to ensure only a new surface captured, instead of getting the previously captured surfaces. |
| "GenTL/Main" | Read-only. Returns the serial number of the main sensor. |

| Setting | Comment |
|---|---|
| "GenTL/AlignResult" | Read-only. Returns the alignment result of the last "GenTL/Align" command (see *Driver-level commands* below). |
| "GenTL/LastResult" | Read-only. Returns the last result for any GenTL XmlCommand. |
| "GenTL/TransformX(id)"<br>"GenTL/TransformY(id)"<br>"GenTL/TransformZ(id)"<br>"GenTL/TransformXAngle(id)"<br>"GenTL/TransformYAngle(id)"<br>"GenTL/TransformZAngle(id)" | Read-Write. Gets or sets the transformation value for a given transform of the specified sensor ID. |
| "GenTL/TransformEncoderResolution" | Read-Write. Gets/Sets the encoder resolution for a sensor. |
| "GenTL/DataSourceIds[ids]" | Read-Write. Gets/Sets the indices of one or more surfaces to transfer.<br>By default, this is set to the following, which returns only the first surface:<br>'GenTL/DataSourceIds=[0]\n'<br>To specify more than one, use the following syntax. which sets the data source to the first, third, and fourth surfaces:<br>'GenTL/DataSourceIds=[0,2,3]\n' |

The following driver-level commands are available:

*Driver-level commands*

| Setting | Comment |
|---|---|
| "GenTL/FlushGocatorBuffers" | Flushes the Gocator pipeline buffers. Can be used to ensure only a new surface captured, instead of getting the previously captured surfaces. |
| "GenTL/StartGocator" | In an enabled StartStopControl mode, starts the Gocator programmatically. |
| "GenTL/StopGocator" | In an enabled StartStopControl mode, stops the Gocator programmatically. |
| "GenTL/ResetGocator"<br>"GenTL/ResetGocator(wait)" | By default, this call resets the Gocator without waiting. If the wait parameter is set to 1, the command will wait for the Gocator to be reset, and reconnects to it automatically if possible. |
| "GenTL/Align(timeout)" | Performs an alignment on the sensor, waiting for the given timeout in seconds. |
| "GenTL/ClearAlignment" | Clears the current alignment on the sensor. |
| "GenTL/ResetEncoder" | Resets the encoder. Note that this only works if the encoder is directly connected to the sensor, and may not work on encoders connected to a Master. |
| "GenTL/Reconnect" | Attempts to reconnect to the sensor, after it was disconnected or reset. |
| "GenTL/Refresh" | Updates the client state to reflect any changes that have occurred in the sensor network. |
| "GenTL/ClearData" | Clears the data on message queue of the Gocator. |
| "GenTL/SoftwareTrigger" | Triggers the Gocator for an acquisition, if it is setup to use Software Triggering. |

**Sample Program for Various GenTL Settings**

```
* Connect to the sensor. This code is auto generated by the Image Acquisition dialog box.
User can manually override the directory path by editing the line below.
* Set image type to 'rgb' if the format is 16-bit RGB. 'gray' if the format is 16-bit mono
open_framegrabber ('GenICamTL', 0, 0, 0, 0, 0, 0, 'progressive', 16, 'rgb', -
1, 'false', 'default', '127.0.0.1:3190', 0, -1, AcqHandle)

* Example calls for configuring the sensor
* Go2GenTL_ResampleMode (AcqHandle, ResampleMode)
* Go2GenTL_ImageSize (AcqHandle, ImageWidth, ImageHeight)
* Go2GenTL_Encoder (AcqHandle, EncoderValue)
Go2GenTL_Exposure (AcqHandle, currentExposure)
Go2GenTL_SetExposure (AcqHandle, currentExposure + 20)
set_framegrabber_param (AcqHandle, 'grab_timeout', 100000)
* set_framegrabber_param (AcqHandle, 'XmlCommand', 'GenTL/ClearData\n')

* Note: Configuration name has to be less than 16 characters
* Go2GenTL_SetConfigFileName (AcqHandle, 'newExposure.job')
* Go2GenTL_ConfigFileName (AcqHandle, ConfigFile1)

* Other examples
* *Get fixed length
*  set_framegrabber_param(AcqHandle, 'XmlSetting', 'scan/engines')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/LMILaserLineProfiler')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanners')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanner-0')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '?parameters')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanModeSettings')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/surface')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/fixedLength')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/length')
*  get_framegrabber_param(AcqHandle, 'XmlSettingReturn', length)
*  *Set fixed length</c>
*  set_framegrabber_param(AcqHandle, 'XmlSetting', 'scan/engines')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/LMILaserLineProfiler')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanners')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanner-0')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '?parameters')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/scanModeSettings')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/surface')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/fixedLength')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '/length')
*  set_framegrabber_param(AcqHandle, 'XmlSetting', '=50.00\n')

*  set_framegrabber_param (AcqHandle, 'XmlSetting', 'GenTL/DataSourceIds=[0,1,2]\n')

* Version
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/Version')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', version)

* Transform
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformX(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', xOffset)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformX(1)=0.01\n')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformX(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', xOffset)

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformYAngle(1)')
```

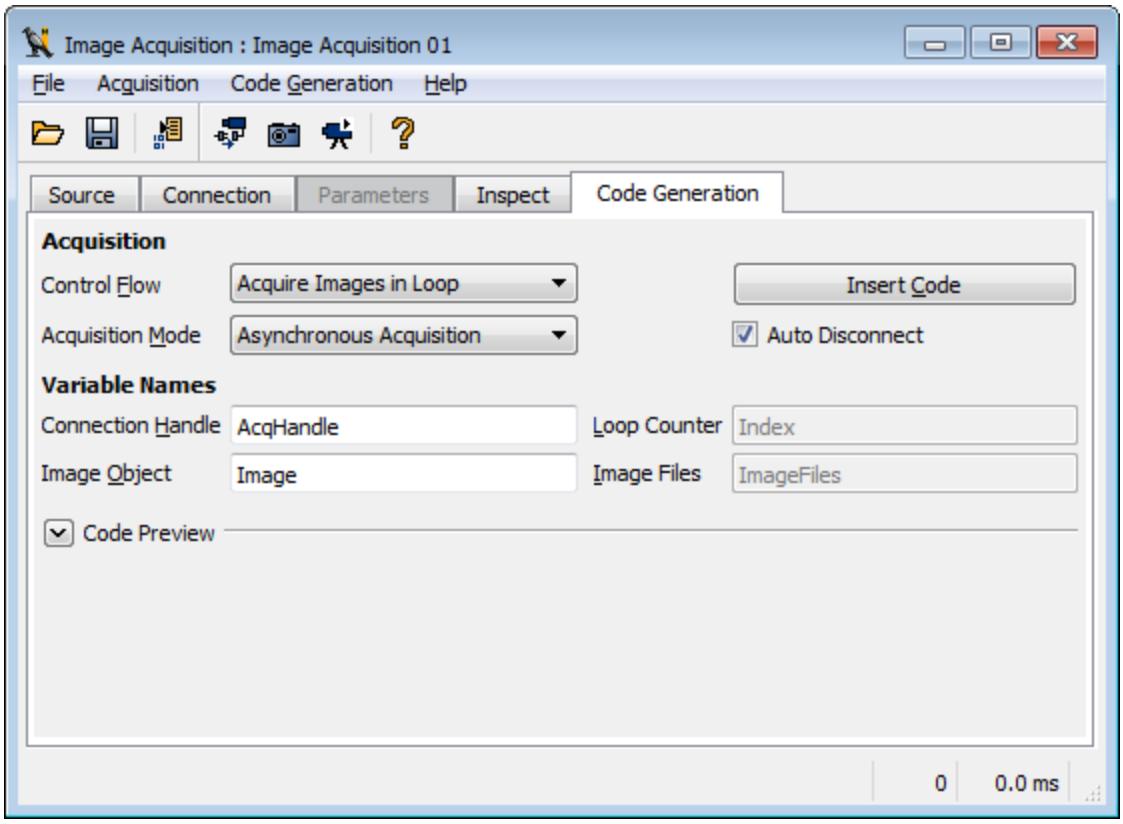
```
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', yAngle)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformYAngle(1)=0.01\n')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformYAngle(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', yAngle)

* Encoder Resolution
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformEncoderResolution')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', encoderRes)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformEncoder')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Resolution=0.002\n')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/TransformEncoderResolution')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', encoderRes)

* Buddy List
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/BuddyCount')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', buddyCount)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/BuddyAt(0)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', buddy0)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/BuddyAt(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', buddy1)

* State
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/Refresh\n')

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/State')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', state0)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/State(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', state1)

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/BuddyState')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', bstate0)
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/BuddyState(1)')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', bstate1)

* Alignment
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/ClearAlignment')
set_framegrabber_param(AcqHandle, 'XmlSetting', '')

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/AlignResult')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', alignResult)

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/Align(5)')
set_framegrabber_param(AcqHandle, 'XmlSetting', '')

set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/AlignResult')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', alignResult)

* Reset
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/ResetGocator(1)\n')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/LastResult')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', lastResult)

* Responsiveness
set_framegrabber_param(AcqHandle, 'XmlSetting', 'GenTL/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'IsResponsive')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', isResponsive)


close_framegrabber (AcqHandle)
```

## Generating Halcon Acquisition Code

Halcon lets you insert acquisition code into your code in the IDE.

*To generate acquisition code:*

1. In Halcon, in the **Assistants** menu, click **Open New Image Acquisition**.
2. In the dialog that opens, in the **Code Generation** tab, set **Acquisition Mode** to **Asynchronous Acquisition**.




3. Under **Acquisition**, click **Insert Code** to generate the code that will open the acquisition device.

> To handle cases when the `grab_image` function times out while waiting for data, add a `try-catch` statement around the `grab_image` function code.

After the example code is generated, you should add a `catch` instruction to bypass the acquisition timeout event, and use the Go2GenTL_ParseData function to extract information from the returned image.

An example, `Continuous_Acq.hdev`, is included in the `Examples/Halcon` directory.

# GoAIK Cognex VisionPro Driver

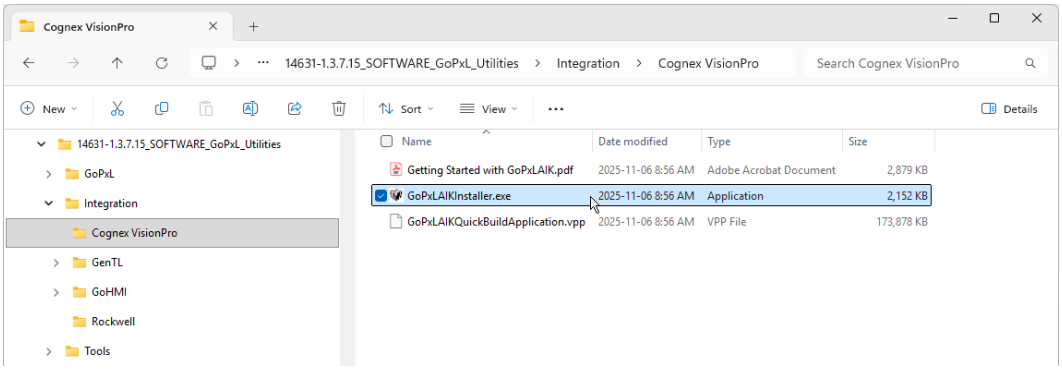
You use LMI's GoAIK driver to connect to Gocator sensors from Cognex VisionPro. The GoAIK driver only supports Surface mode with **Uniform Spacing** enabled. You must enable the required output in the Ethernet panel in the Output page. Check **Acquire Intensity** in the **Scan mode** panel on the **Acquire** page if you need intensity data.

The GoAIK driver packs the output, intensity, and stamps (that is, time stamp, encoder index, and so on) into a 16-bit grey scale image. You can select the format in the GoAIK.xml setting file.

The width and height of the grey scale image is calculated from the maximum number of columns and rows needed to accommodate the sensor's field of view and the maximum part length.

You can find the GoAIK driver installer, as well as an example tool for Cognex VisionPro and Ether-Inspect and Edit Tool Block, in the Utilities package (14631-x.x.x.x_SOFTWARE_GO_Utilities.exe), available on LMI's website (https://lmi3d.com/product-downloads/). Select Gocator as the brand, Software as the category, and the desired GoPxL release.

Once you have downloaded and extracted the Utilities package, you can find the installer and example tool in the `Integration > Cognex VisionPro` folder.




## 16-bit Grey Scale Image

When the 16-bit grey scale format is used, the height map, intensity, and stamps are stored sequentially in the grey scale image.

The last row of the image contains the stamp information.

| Rows | Details |
|---|---|
| 0 .. (max part height - 1) | Height map information. The width and height of the image represent the dimensions in the X and Y axis. Together with the pixel value, each pixel presents a 3D point in the real-world coordinates.<br><br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz):<br><br>X = X offset + Px * X resolution<br><br>Y = Y offset + Py * Y resolution<br><br>Z = Z offset + Pz * Z resolution |

| Rows | Details |
|---|---|
| | Refer to the blue channel on how to retrieve the offset and resolution values. If Pz is 0 if the data is invalid. The Z offset is fixed to -32768 * Z Resolution. Z is zero if Pz is 32768. |
| (max part height) .. 2* (max part height)<br>If intensity is enabled | Intensity information. The width and height of the image represent the dimension in the X and the Y axis. Together with the pixel value, each blue pixel represents an intensity value in the real-world coordinates.<br>The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): The following formula assumes Py is relative to the first row of the intensity information, not the first row of the whole 16-bit grey scale image.<br>X = X offset + Px * X resolution<br>Y = Y offset + Py * Y resolution<br>Z = 16-bit intensity value<br>This intensity value is 0 if the intensity image is not available. Gocator outputs 8-bit intensity values.<br>Refer to the stamps on how to retrieve the offset and resolution values. |

The following table shows how the stamp information is packed into the last row. A stamp is a 64-bit value packed into four consecutive 16-bit pixels, with the first byte position storing the most significant byte.

*Stamp Information from GoAIK driver*

| Stamp Index | Column Position | Details |
|---|---|---|
| 0 | 0..3 | Version |
| 1 | 4..7 | Frame Count |
| 2 | 8..11 | Timestamp (µs) |
| 3 | 12..15 | Encoder value (ticks) |
| 4 | 16..19 | Encoder index (ticks)<br>This is the encoder value when the last index is triggered |
| 5 | 20..23 | Digital input states |
| 6 | 24..27 | X offset (nm) |
| 7 | 28..31 | X resolution(nm) |
| 8 | 32..35 | Y offset (nm) |
| 9 | 36..39 | Y resolution (nm) |
| 10 | 40..43 | Z offset (nm) |
| 11 | 44..47 | Z resolution (nm) |
| 12 | 48..51 | Height map Width (in pixels) |
| 13 | 52..55 | Height map length (in pixels) |
| 14 | 56..59 | Specify if intensity is enabled or not |

## XML Settings File

The settings file, GoAIK.xml, resides in the same directory as the GoAIK driver.

| Element | Type | Description |
|---|---|---|
| DataCapacity | 64u | The amount of memory, in bytes, used for buffered data. By default, 500000. |
| Sensors/Sensor/LockIpAddress | | The IP address of a sensor you want to connect to.<br>You can add multiple Sensor elements (containing a LockIpAddress element) under the Sensors element. The default value of LockIpAddress is 192.168.1.10. |

## Interfacing with VisionPro and Ether-Inspect 11

The following sections assume that a Gocator sensor is already installed and accessible over a network.

### Setting Up VisionPro

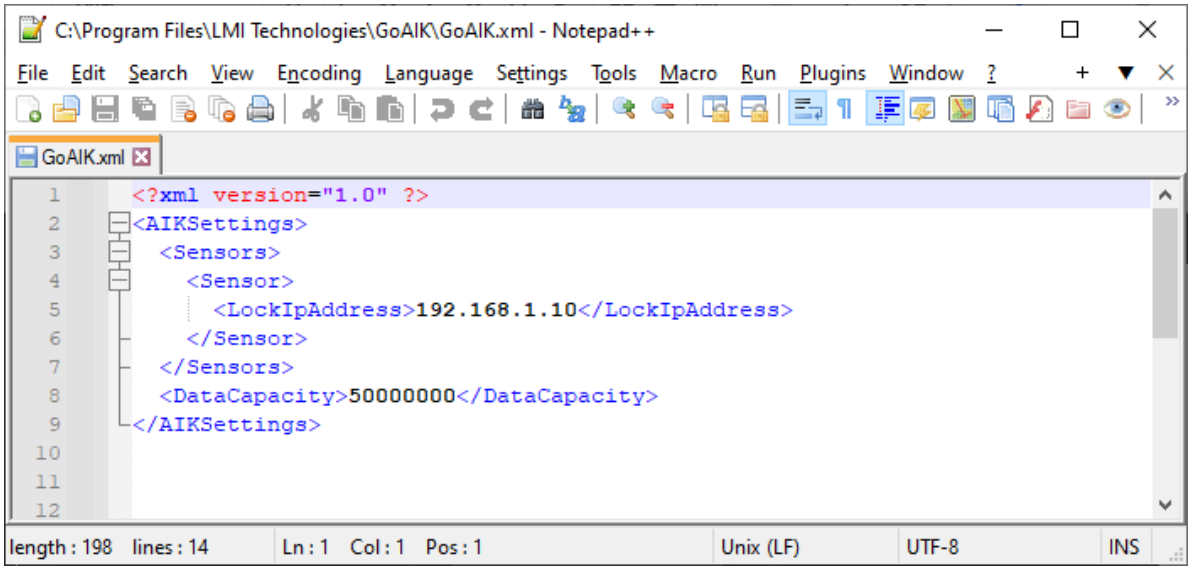
After you have installed the GoAIK driver, you need to configure the GoAIK.xml settings file and run Cognex VisionPro or Ether-Inspect 11.

*To set up VisionPro or Ether-Inspect 11*

1. Go to the folder in which you installed the GoAIK driver.

   By default, the installation location is `C:\Program Files\LMI Technologies\GoAIK`. For information on where to get the installer, see *GoAIK Cognex VisionPro Driver* on page 911.

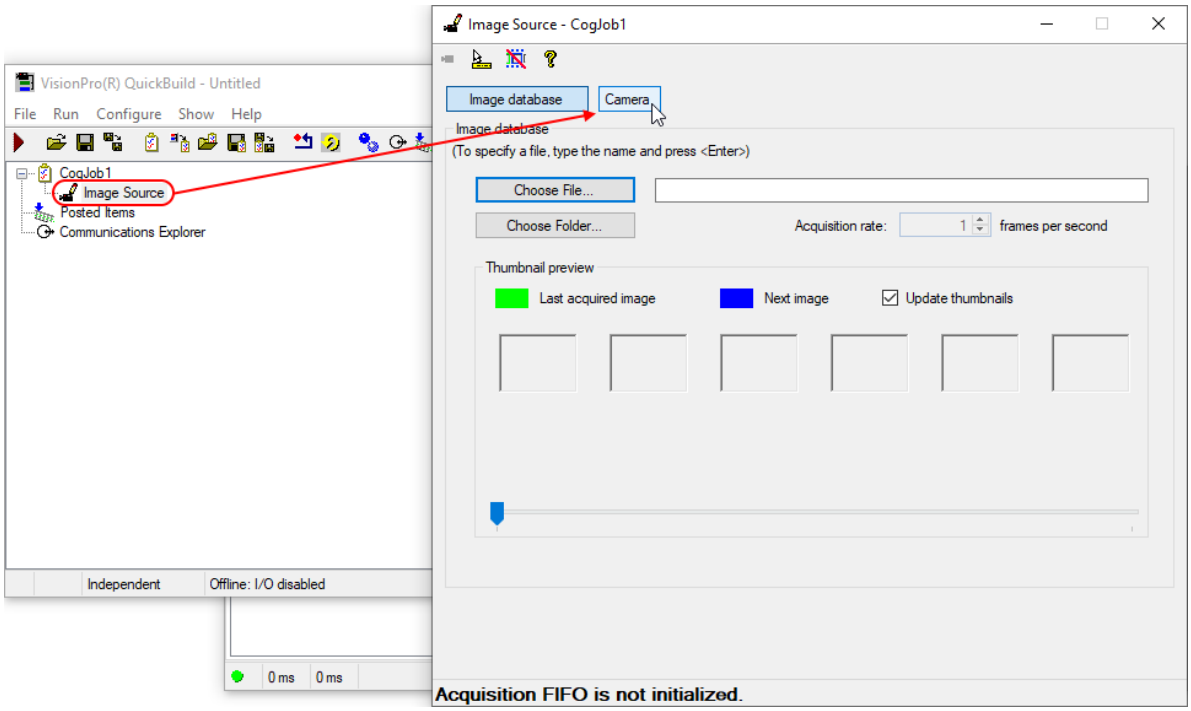
2. If necessary, edit the value of `LockIpAddress` element in GoAIK.xml to specify the IP address of the sensor you want to connect to.



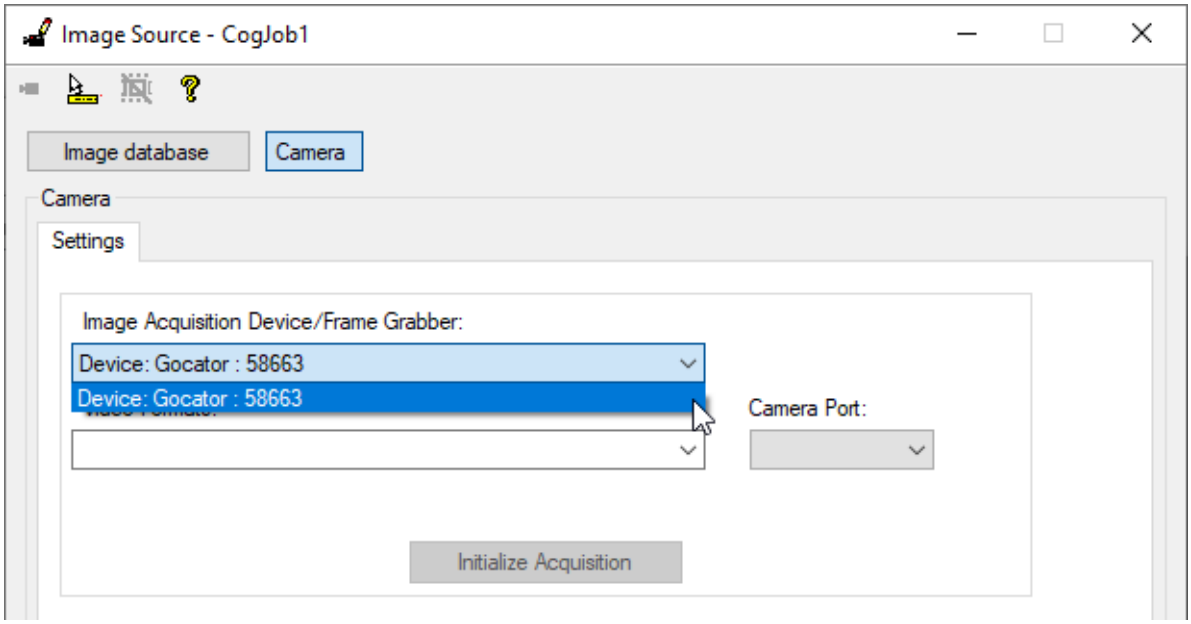

   The default value of `LockIpAddress` is 192.168.1.10. (This is the default address of Gocator sensors.)

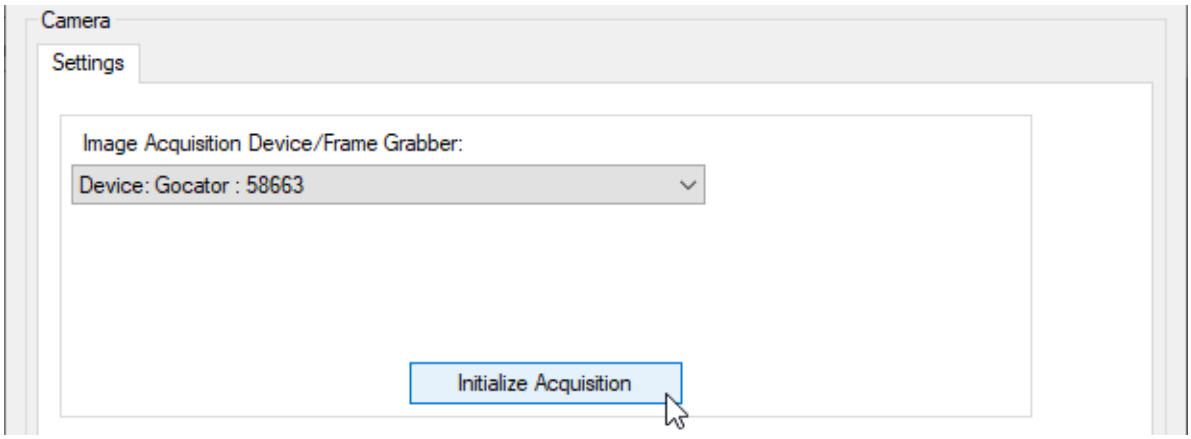
3. Open Cognex VisionPro or Ether-Inspect.

4. In VisionPro, double-click **Image Source** and in the dialog that opens, click **Camera**.




5. In the **Settings** tab, select the sensor in **Image Acquisition Device/Frame Grabber**, and then click **Initialize Acquisition**.






Additional tabs display. Close the Image Source dialog.

6. If you have previously configured the sensor and saved the configuration as a job, go to step 13.
7. Connect to the sensor and set the scan mode to Surface.
8. (Optional) If you need intensity data in your output, on the **Acquire** page, enable **Acquire intensity**.
9. Configure the sensor's Surface acquisition in the **Acquire** page in the GoPxL interface.

   For more information on setting up acquisition, see *Acquire - Alignment and Acquisition* on page 96.
10. On the **Communicate** > **GDP** page, enable GDP.
11. Add connections for the measurements, stamps, or geometric features you want to send over GDP in the Add Connections panel.

    For information on enabling and configuring GoPxL Data Protocol, see *GoPxL Data Protocol* on page 736.
12. Go to step 14.
13. (Optional) If you have configured the sensor and saved the configuration to a job on the sensor, you can use the Job command in VisionPro, to switch to that job.

    For more information on the available commands, see *Commands* below.
14. In the GoPxL interface, press Start, and in VisionPro, observe the Surface data that the sensor outputs.

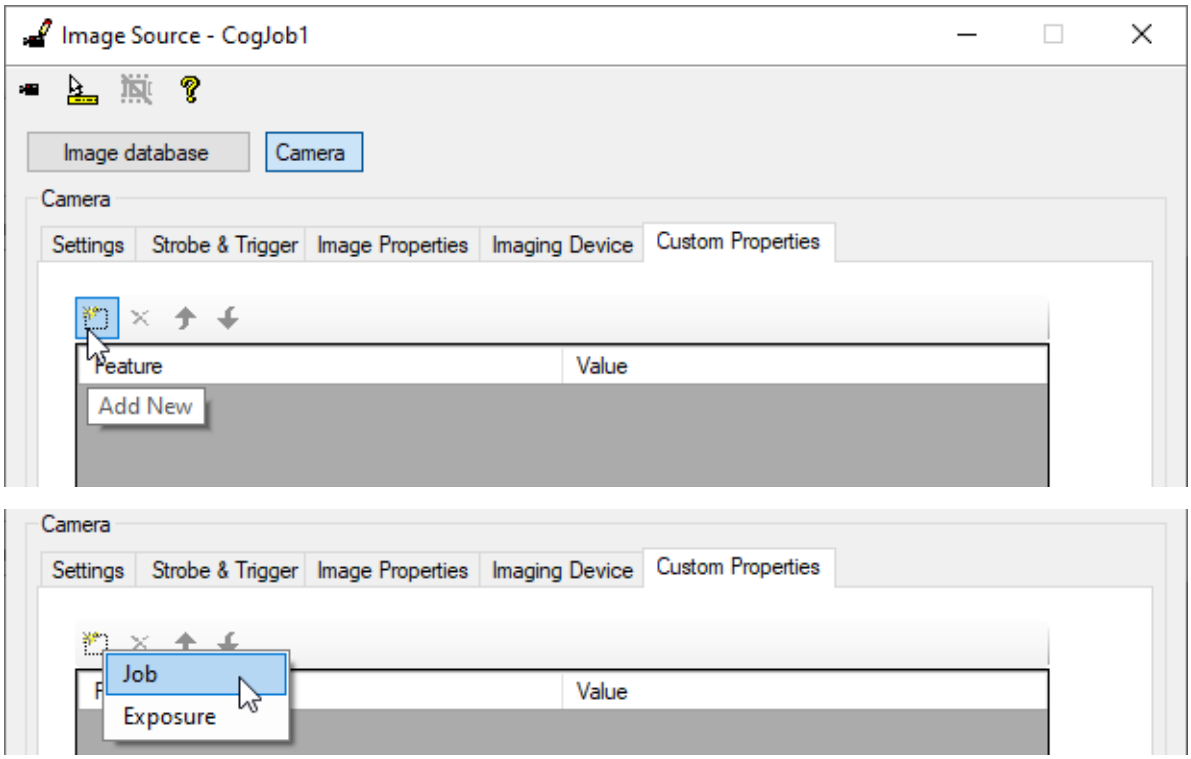
## Commands

The GoAIK driver provides two commands:

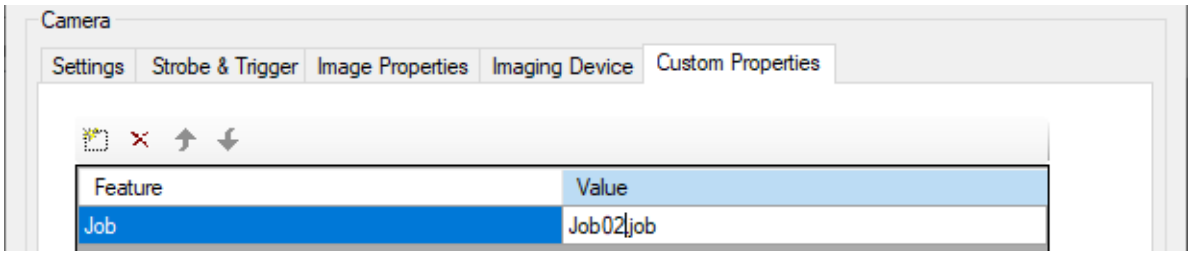
- job: Lets you set the job on the sensor
- exposure: Lets you set the exposure on the sensor.

*To add a command*

1. Open Image Source, and in the **Custom Properties** tab, click **Add New** and select a command.




2. Edit the value of the command.




Note that when you add a command and set its value, the command is sent as soon as you move the focus from the value field

# Utilities

The following sections describe some of the utilities tools provided with a Gocator sensor, as well as the CSV format that a sensor can export. For information on the integrations available with a sensor, see *Integrations* on page 886.

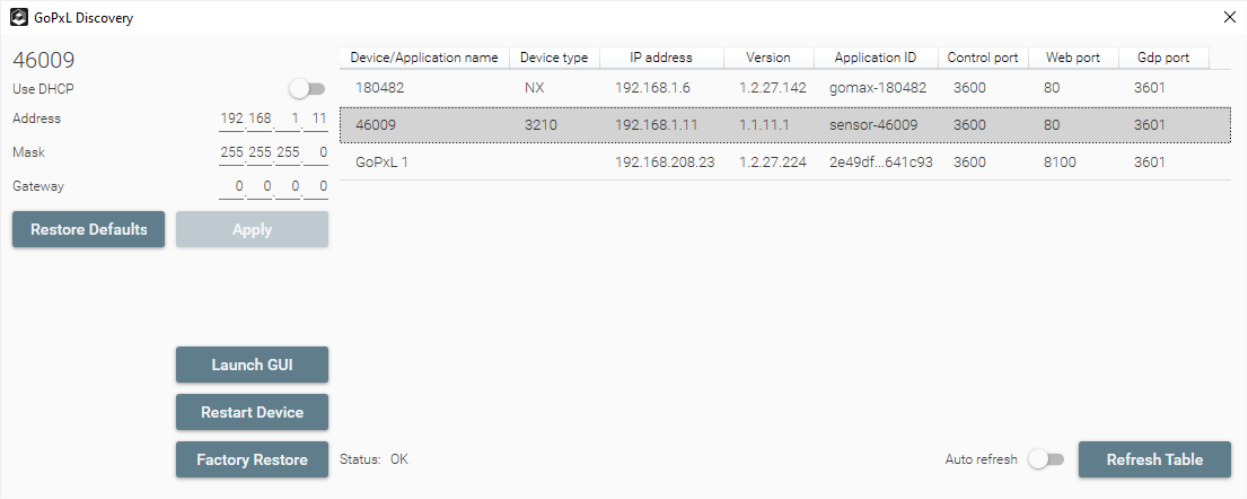
You can get the tools in the utilities package (`14631-1.2.30.5_SOFTWARE_GoPxL_Utilities.exe`) from the downloads area of the LMI Technologies website: https://lmi3d.com/product-downloads/. Run the installer, and provide a location where the content of the package will be unzipped.

The following tools are available:

- Alignment CAD (G2): CAD files for pyramid plate and double-sided pyramid alignment targets. For use with Surface Align Wide and Surface Align Ring on multi-sensor G2 systems, respectively. You should only use these if your application requires a high degree of accuracy.
- Discovery tool: Used to find devices on a network. See *GoPxL Discovery Tool* below.
- Pattern Editor: Used to edit patterns created in the pattern matching tool. For more information, see *Pattern Editor* on page 933.
- Replay Utils tool: Lets you convert between .gprec files and .srf/.sur/.pcd/.pro files. It also lets you convert .gprec files to CSV files. For more information, see *Replay Utility Tool* on page 920.
- Rescue tool: TBD.
- Track Editor: Used with the Surface Track tool. For more information, see *Surface Track* on page 595.

## GoPxL Discovery Tool

The GoPxL Discovery tool lets you perform various operations with sensors running GoPxL, PC instances of GoPxL, and GoMax NX units.




You can do the following with a sensor running GoPxL:

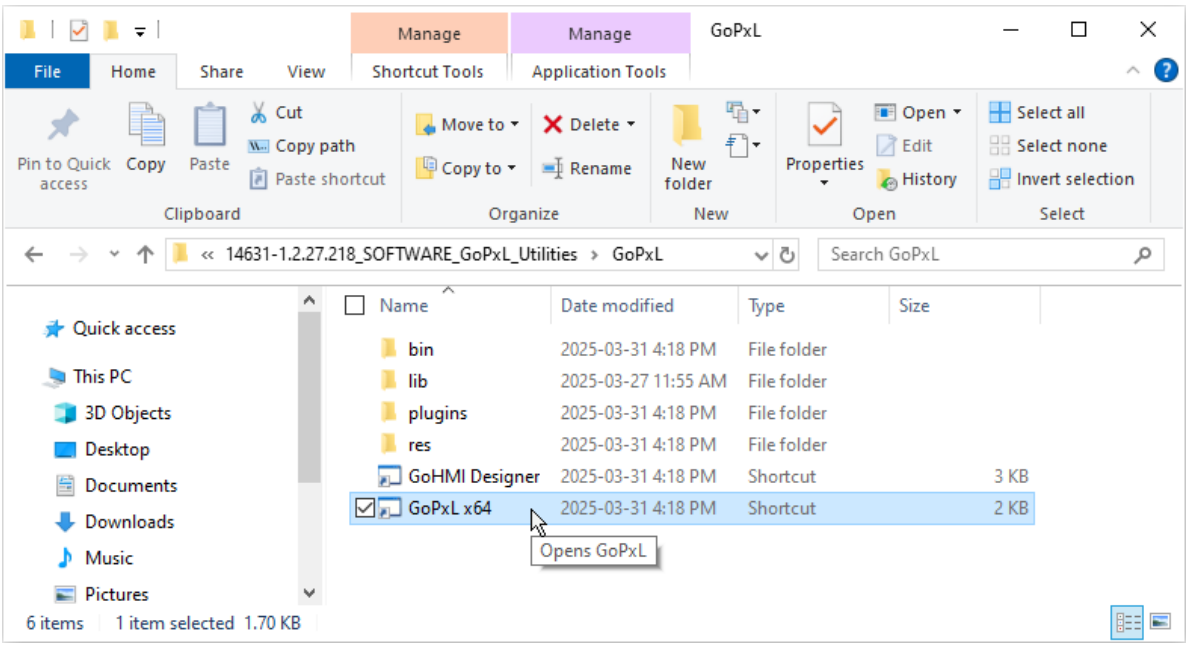
- Find a sensor if you have forgotten its IP address.
- View port information.
- Set the network configuration (IP address, mask, and so on) of a sensor, and also restore these values to the default.
- Launch the GUI of a sensor in your browser.
- Restart the sensor.
- Perform a factory restore on a sensor.

You can do the following with a PC instance of GoPxL or a GoMax NX:

- Find its IP address.
- View port information.
- Launch the GoPxL of the PC instance or GoMax NX in your browser.

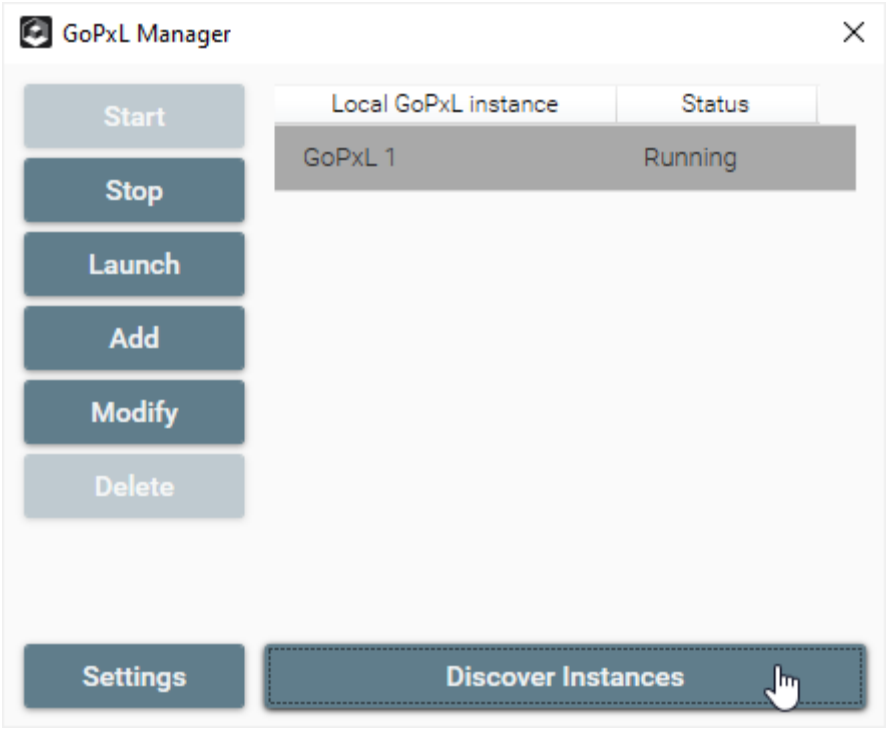
*To run the GoPxL Discovery tool*

1. If it isn't already running, start the Windows version of GoPxL.

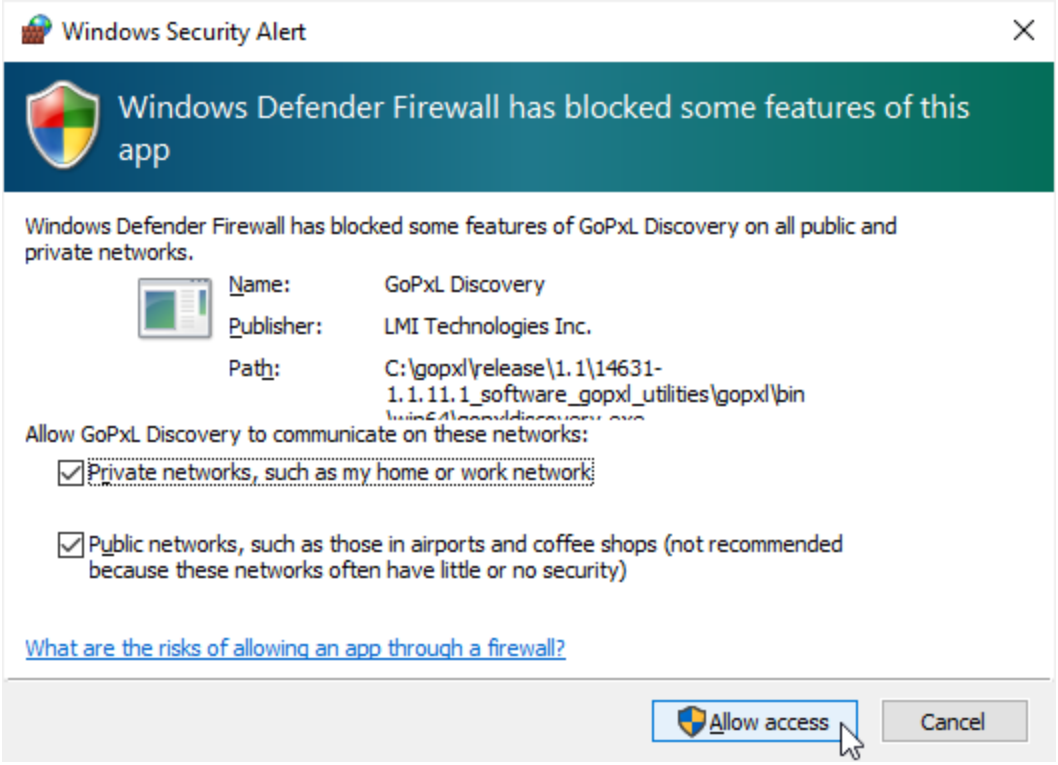



GoPxL Manager opens.

2. In the manager tool, click **Discover Instances**.




Your firewall may ask if you want to allow the GoPxL Service Application and Python to communicate over your network. To avoid issues, LMI recommends allowing communication over both Public and Private networks. Because the notifications appear one on top of the other, make sure to check the appropriate boxes and carefully click **Allow access** for both alerts.




The GoPxL Discovery tool opens.

When the GoPxL Discovery tool opens, it lists the sensors running GoPxL and the PC instances of GoPxL that are currently visible on the network. Sensors are identified in the **Device/Application Name** column by their serial number, and in the **Device Type** column by their model. If a sensor is running through a PC instance of GoPxL, its status (at the bottom of the tool) is "Device is remotely connected", and you can't perform any operations on it from the tool. Otherwise, the sensor's status is "OK".

GoPxL instances are identified in the **Device/Application Name** column by their name.

The tool provides important network-related information, namely, IP addresses and Web, Control, and GDP ports. The Web port is the port used to connect to the GoPxL interface in a browser. For sensors, the default port is 80; you don't need to specify this in the URL when connecting directly to a sensor. The Control port and the GDP ports are used by the SDK and the REST API. (For an introduction to these, see *GoPxL SDK and REST API* on page 863.)

If a sensor or GoPxL instance is missing, click the **Refresh Table** button. Optionally, you can also enable the **Auto refresh** toggle; the table refreshes .

To perform operations on a sensor or a GoPxL instance, click its row in the tool and then perform the operation.

## Replay Utility Tool

The Replay Utility tool (ReplayUtils.exe) is a console application that lets you do the following conversions with scan data. You can run it from a command line using Windows Command Prompt or Windows PowerShell.

- .gprec <=> .srf/.sur/.pcd (valid for surface recording data)
- .gprec <=> .pro (valid for profile recording data)
- .gprec <=> .csv (valid for profile/surface recording data)
- folder of .gprec files <=> .gprec file (valid for surface/profile/image/video data)

Intensity information is included when converting to and from .pcd and .srf files. Intensity is not supported when converting to and from the .sur format.

You can get the tool in the utilities package (`14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.zip`) from the downloads area of the LMI Technologies website: https://lmi3d.com/product-downloads/.

After downloading the utilities package, unzip the file. Then, open a command prompt or PowerShell instance in the folder containing the utility. To open a command line quickly, in File Explorer go to the folder containing the tool, hold Shift, right-click in empty area, and choose "Open command window here" or "Open PowerShell window here."

Run ReplayUtils.exe (under Tools\ReplayUtils). You must either copy the .gprec file into the folder containing the utility, or include its entire path in the call to the utility, for example, `ReplayUtils.exe -i \path\to\file\myData.gprec -f 0 -o myOutput.sur`.

The tool provides the following parameters:

*Parameters*

| Name | Description |
|---|---|
| --help | Show the help. |
| -i<br>--input | Specify the file name of the input file or the input directory. Required. |
| -f<br>--frame | Specify the *zero-based index* of the frame to be exported in the recording data. For example, to export the first frame in the scan data, use "-i 0"; for the second frame, use "-i 1". (Default is 0.) |
| -w<br>--width | Specify the width of the exported surface. (Only valid for importing .pcd files.) |
| -h<br>--height | Specify the height of the exported surface. (Only valid for importing .pcd files.) |
| -sxz<br>--swapXZ | Whether to swap the X and Z coordinates. (Only valid for importing .pcd files.) |
| -syz<br>--swapYZ | Whether to swap the Y and Z coordinates. (Only valid for importing .pcd files.) |
| -z<br>--zoom | Specify the zooming factor of the exported surface. (Only valid for importing .pcd files.) |
| -r<br>--remove | Remove the specific point. (Only valid for importing .pcd files.) |
| -a<br>--all | Export all the frames if the import is recording data. |

| Name | Description |
|---|---|
| -o<br>--output | Specify the file name of the output file. If the imported file isn't recording data and the exported file name isn't specified, the utility uses the imported file name as the exported file name. |

## CSV File Format

An exported CSV file contains a series of sections. Each section begins with a row containing the name of the section, and ends with a row containing the string "End". An empty line separates each section.

Each section usually contains one or more subsections. Each subsection has a header row containing a list of field names, followed by one or more rows of data. There is usually no empty line between the subsections.

Other structures within sections are possible.

> The "Part" section is unrelated to part detection. It represents Surface data when **Enable uniform spacing** is checked.

### Info

This section contains basic system information. It has one header row and one value row. The fields are described below:

*Info Fields*

| Field | Description |
|---|---|
| CSV Version | Version of the CSV file format. |
| Sensor Count | Number of sensors in the system. |
| Trigger Mode | Trigger source:<br>0 – Time<br>1 – Encoder<br>2 – Digital input<br>3 – Software |
| Trigger Rate | Frame rate for time trigger (Hz). |
| Trigger Delay Domain | Output delay domain:<br>0 – Time (µs)<br>1 – Encoder (mm) |
| Trigger Delay | Output delay (µs or mm, depending on delay domain defined above). |
| Operation Mode | The scan mode. |
| XResolution | System X resolution (mm). |
| YResolution | System Y resolution (mm). |
| ZResolution | System Z resolution (mm). |
| YSpeed | Y Speed (mm/s). |

| Field | Description |
|---|---|
| Layout | Sensor orientation:<br>0 – Normal (single-sensor system) / Wide (dual-sensor system)<br>1 – Opposite<br>2 – Reverse<br>3 – Grid |

## DeviceInfo

This section contains information about each device in the system. There is one header row, and one value row per device.

Device and firmware information (the ID, Model, and Version fields) is not currently output.

*DeviceInfo Fields*

| Field | Description |
|---|---|
| ID | Device serial number |
| Model | Device part number |
| Version | Firmware version |
| Exposure Mode | Exposure mode:<br>0 – Single exposure<br>1 – Multiple exposures<br>2 – Dynamic exposure |
| Exposure 0 through Exposure 4 | Multiple exposures |
| Exposure Min | Dynamic exposure min |
| Exposure Max | Dynamic exposure max |
| FOV X | Active area X |
| FOV Y | Active area Y |
| FOV Z | Active area Z |
| FOV Width | Active area width |
| FOV Height | Active area length (Y). (Note difference in terminology.) |
| FOV Depth | Active area height (Z). (Note difference in terminology.) |
| Transform X | Transform X offset (mm) |
| Transform Y | Transform Y offset (mm) |
| Transform Z | Transform Z offset (mm) |
| Transform X Angle | Transform X Angle (degrees) |
| Transform Y Angle | Transform Y angle (degrees) |
| Transform Z Angle | Transform Z angle (degrees) |

## RecordingFilter

Recording filters are not currently supported.

## Profile

This section describes uniform (or resampled) profile data, which is produced when the sensor is in Profile mode and uniform spacing is enabled. It has two sub-sections: attributes and data.

The attribute section has only one row of data.

*Attribute Section Fields*

| Field | Description |
|---|---|
| Frame Count | Total number of frames |
| Column Count | Number of columns |
| X Offset | X offset (mm) |
| Y Offset | Y offset (mm) |
| Z Offset | Z offset (mm) |

The data section has one or more rows of data per frame (for example, range and intensity).

*Data Section Fields*

| Field | Description |
|---|---|
| Frame | Frame index |
| Source | Source (for example, 0 for Top) |
| Time | Stamp time |
| Encoder | Stamp encoder |
| Z Encoder | Stamp encoder Z |
| Inputs | Stamp inputs |
| Exposure | Stamp exposure (µs) |
| Y | Y value (mm) |
| Axis | Axis: Z (range) or I (Intensity) |
| (x values) | Each column in the sub-header is a resampled X position<br>Each column in the data is the range (mm) or intensity (count) |

## RawProfile

This section describes point cloud profile data (or unresampled / raw data), which is produced when the sensor is in Profile mode and uniform spacing is disabled. It has two sub-sections: attributes and data.

The attribute section has only one row of data.

*Attribute Section Fields*

| Field | Description |
|---|---|
| Frame Count | Total number of frames |
| Column Count | Number of columns |
| X Offset | X offset (mm) |
| Y Offset | Y offset (mm) |
| Z Offset | Z offset (mm) |

The data section has one or more rows of data per frame (for example, range and intensity).

*Data Section Fields*

| Field | Description |
|---|---|
| Frame | Frame index |
| Source | Source (for example, 0 for Top) |
| Time | Stamp time |
| Encoder | Stamp encoder |
| Z Encoder | Stamp encoder Z |
| Inputs | Stamp inputs |
| Exposure | Stamp exposure (µs) |
| Y | Y value (mm) |
| Axis | Axis: X, Z, or I (Intensity) |
| (x values) | Each column in header is an index.<br>Each column in data is the X/Z value (mm) or intensity (count) |

## Part

This section describes uniform Surface data, which is produced when the sensor is in Surface mode and uniform spacing is enabled.

> Only the data for the frame currently selected in the UI is exported when you export part data to a CSV file.

The section has two sub-sections: attributes and data.

The attribute section has only one row of data.

*Attribute Section Fields*

| Field | Description |
|---|---|
| Frame | Frame index |
| Source | Source (for example, 0 for Top) |
| Time | Stamp time |
| Encoder | Stamp encoder |
| Z Encoder | Stamp encoder Z |
| Inputs | Stamp inputs |
| Row Count | Number of rows |
| Column Count | Number of columns |
| X Offset | X offset (mm) |
| Y Offset | Y offset (mm) |
| Z Offset | Z offset (mm) |

The data section contains the data of a single surface scan. Each data row corresponds to one Y position. The first row contains the X values, and the first column contains the Y values. The region inside contains the range values (mm) for the corresponding row and column.

### SurfacePointCloud

This section describes point cloud data (unresampled surface data), which is produced when the sensor is in Surface mode and uniform spacing is disabled. It has two sub-sections: attributes and data.

The attribute section has only one row of data.

*Attribute Section Fields*

| Field | Description |
|---|---|
| Frame | Total number of frames |
| Source | Source (for example, 0 for Top) |
| Time | Stamp time |
| Encoder | Stamp encoder |
| Z Encoder | Stamp encoder Z |
| Inputs | Stamp inputs |
| Row Count | Number of rows |
| Column Count | Number of columns |
| X Offset | X offset (mm) |
| Y Offset | Y offset (mm) |
| Z Offset | Z offset (mm) |

The data section contains the data of a single surface scan. The first row (header) can be ignored.

The data are (x,y,z) tuples expanded into a flat list of values, for example:

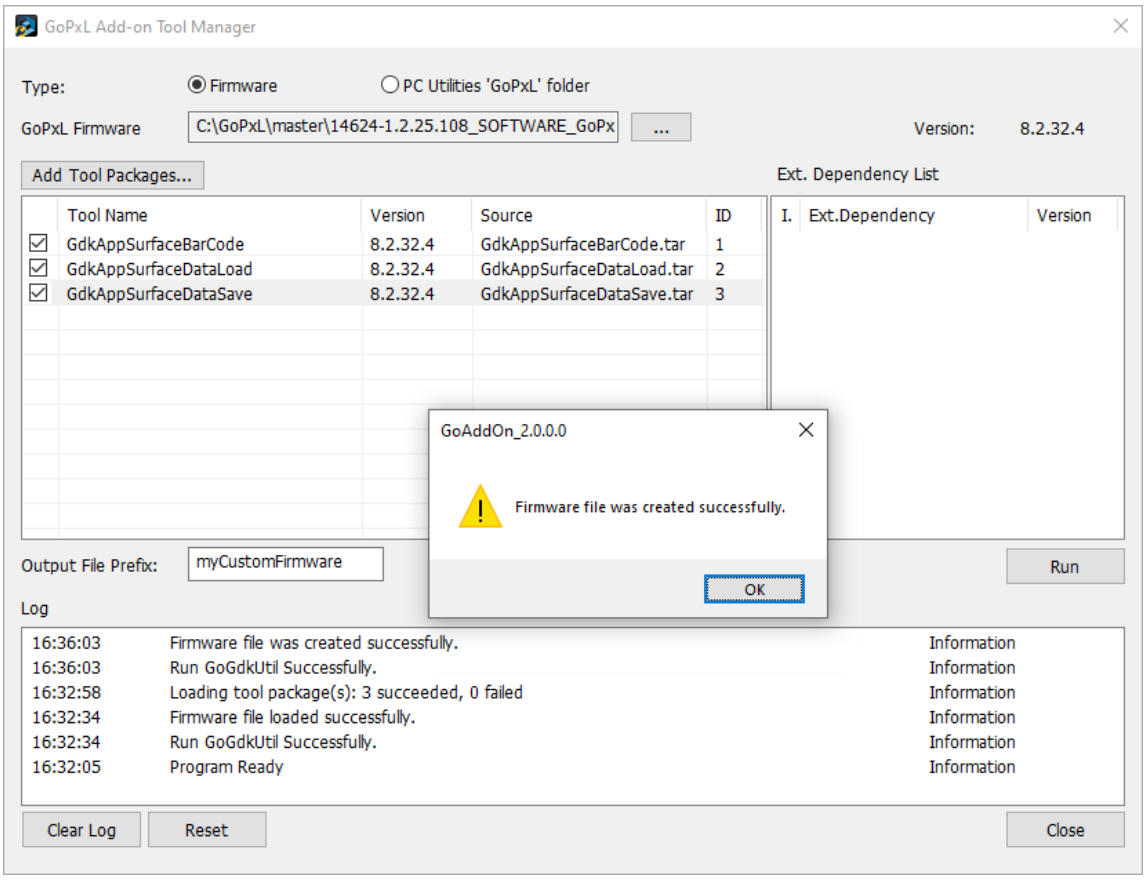
```
p0x, p0y, p0z, p1x, p1y, p1z, ..., pnx, pny, pnz
p(n+1)x, p(n+1)y, p(n+1)z, ...
...
```

Because the data has multiple rows and columns, it forms a rectangular grid of (x,y,z) tuples. The rows and columns do not correspond exactly to X and Y values, but suggest adjacency. i.e. positions with consecutive row indices or column indices are generally adjacent to each other in (x,y,z) coordinates.

The values are provided in mm, with the resolution and offset already calculated in the values.

# GoPxL Add-on Tool Manager

The GoPxL Add-on Tool Manager lets you quickly and easily add LMI-provided beta tools to GoPxL. You can also use the Manager add Python GDK tools to a firmware. After you add tools to a firmware file, upload the firmware to a compatible sensor; for more information, see *Software Upgrade* on page 809.




The tool manager is available in the 14632-x.x.x.x_SOFTWARE_GoPxL_Tools_AddOn_Beta.zip package, available on the LMI Product Downloads page (https://lmi3d.com/product-downloads/), under the *Beta Software Releases* section.

*To get the package:*

1. Go to https://lmi3d.com/product-downloads/ and log in to your account.
2. Select Gocator in the brand drop-down.
3. Choose the package that corresponds to the firmware you wish to run the tool manager on and download it.

> Remember that the tools available in the package are *beta* tools. LMI does not recommend using them in production settings.

The general workflow with the GoPxL Add-on Tool Manager is as follows:

1. Load a .dat GoPxL firmware file (or point the tool manager to the "GoPxL" folder in an unzipped Utilities package).
2. Load one or more beta tool packages (in .tar archives).
3. Enable the tools you want to add to the loaded firmware (in the checkbox column).
4. Run the tool manager on the firmware and tool packages.

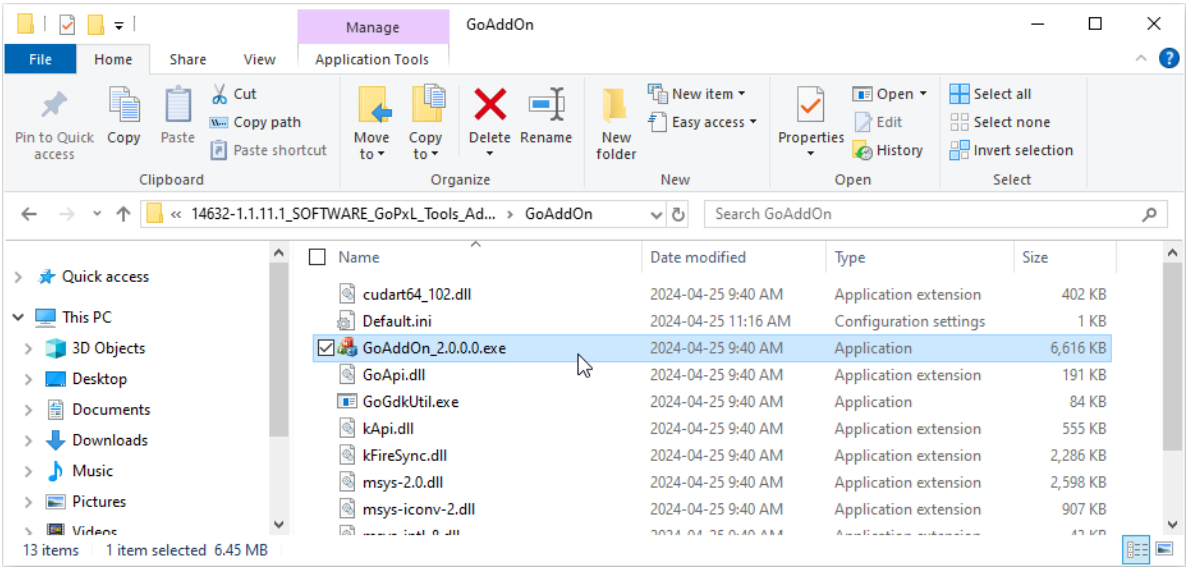
The result is a modified firmware file or GoPxL for PC that contains the tools you selected.

At any point before creating the new firmware with the tool manager, you can click **Reset** to remove the loaded firmware and tool packages, and start over.

## Adding Beta Tools

*To add beta tools to a firmware or to GoPxL for PC:*

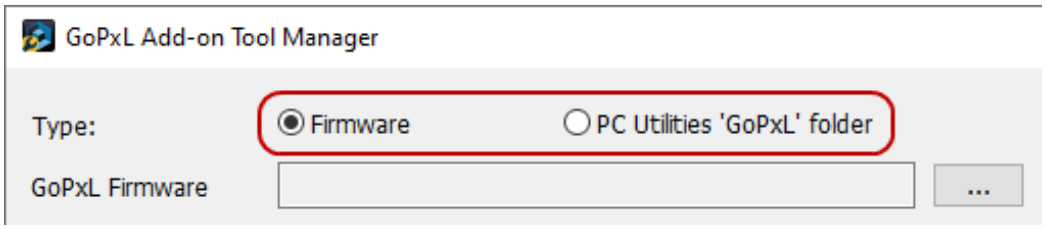
1. If you haven't already done so, download and unzip the package containing the GoPxL Add-on Tool Manager to a convenient location on your computer.
2. Launch the tool manager (GoAddOn_x.x.x.x.exe) from the \GoAddOn subfolder.



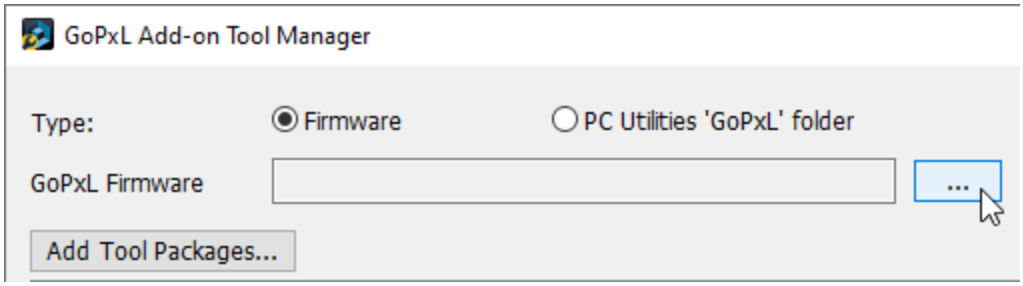

3. In the tool manager, set the type.

   To create a custom firmware you will upload to a sensor, set the type to **Firmware**.

   To create a custom Windows version of GoPxL, set the type to **Accelerator/Emu**.

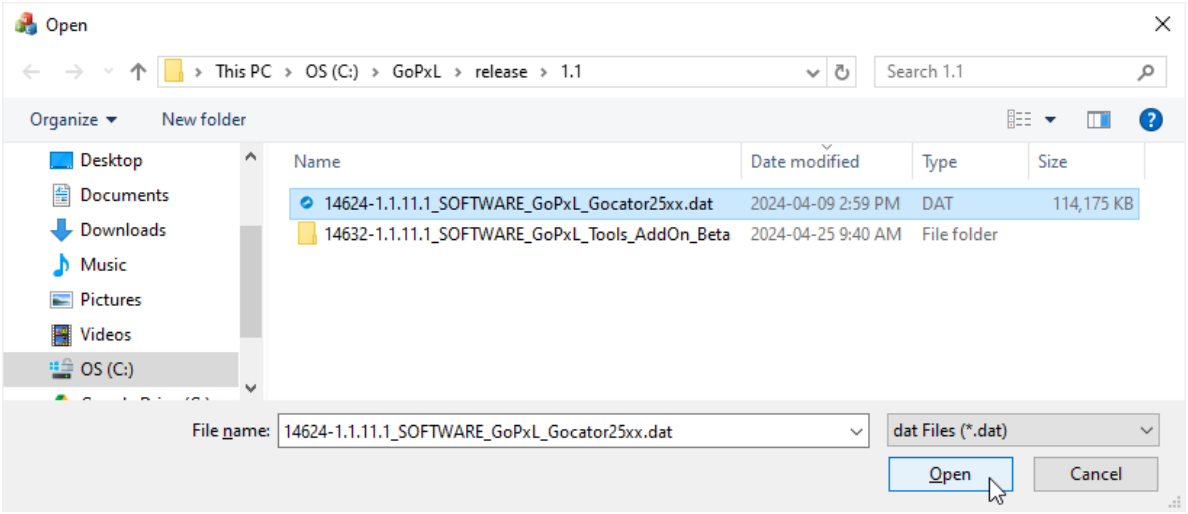



4. Below the type, click the ... button to choose the firmware or GoPxL folder.

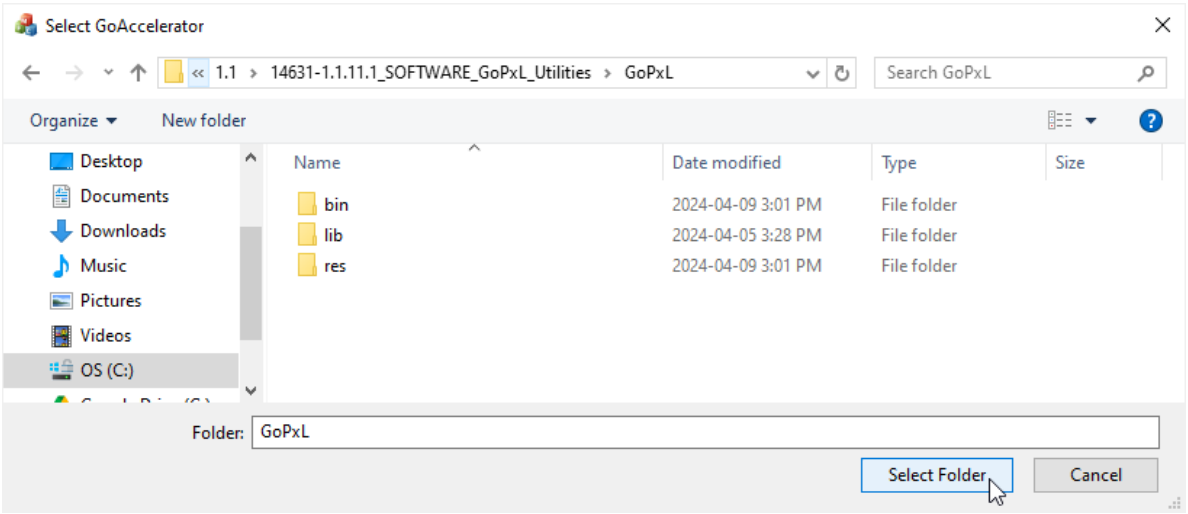


5. In the Open dialog that displays, navigate to the location of the .dat firmware file or the folder you want to use.

   Choosing a firmware:

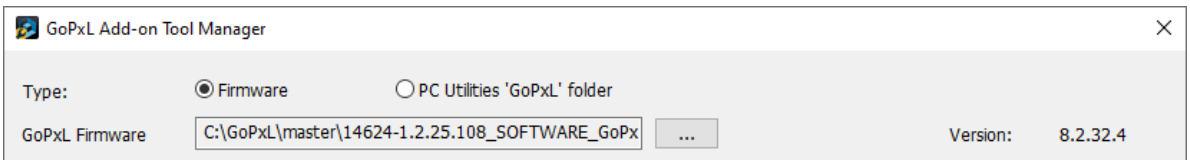



   Choosing a folder containing GoPxL for Windows:



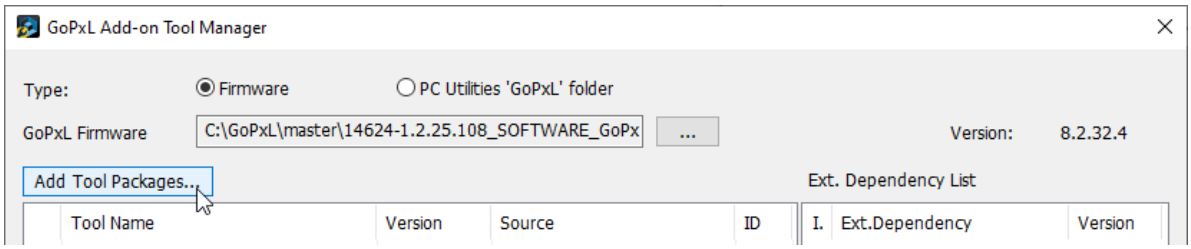

   Note that you choose the `GoPxL` folder.

   The tool manager loads GoPxL.

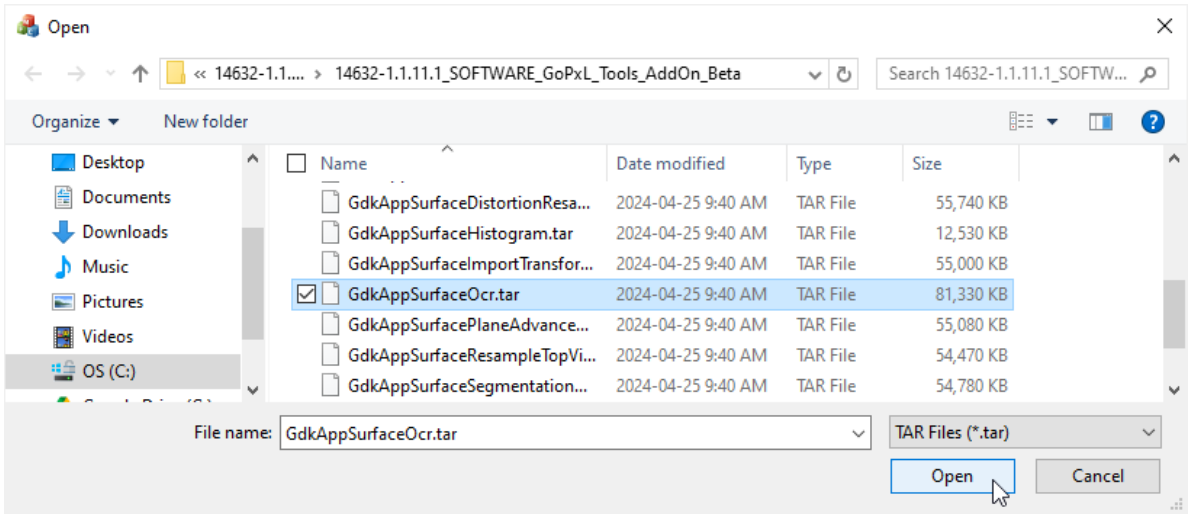



   If the version of GoPxL was previously modified using the tool manager, the tools will be listed in the tool manager. For information on removing tools, see *Removing Beta Tools* on page 931.

6. Click the **Add Tool Packages...** button above the tool list.




7. In the Open dialog, navigate to the folder containing the \GoAddOn folder, select a .tar tool package, and click **Open**.

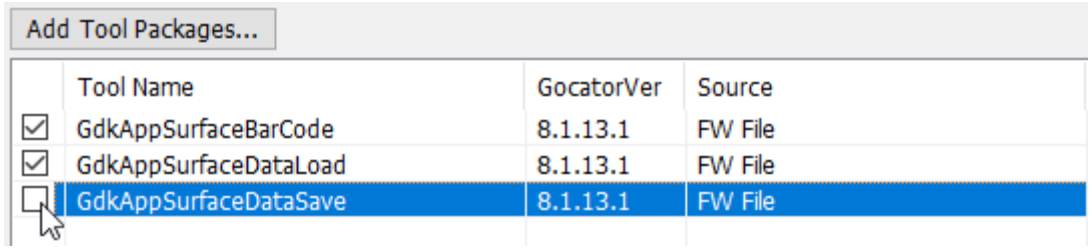



The tool manager adds the package to the tool list.

Note that you can add multiple packages at once from the Open dialog.

> The version of a tool package must match the version of the loaded firmware or folder. If a package's version does not match the firmware's, it is highlighted with grey in the tool list and can't be selected and included in the firmware. (The version of a tool package comes from the version of the GDK used to create it. It is not currently possible for users to create their own tool packages.).

8. When you have finished adding the packages, in the tool list, check the checkbox next the tools you want to add to the loaded firmware or folder.



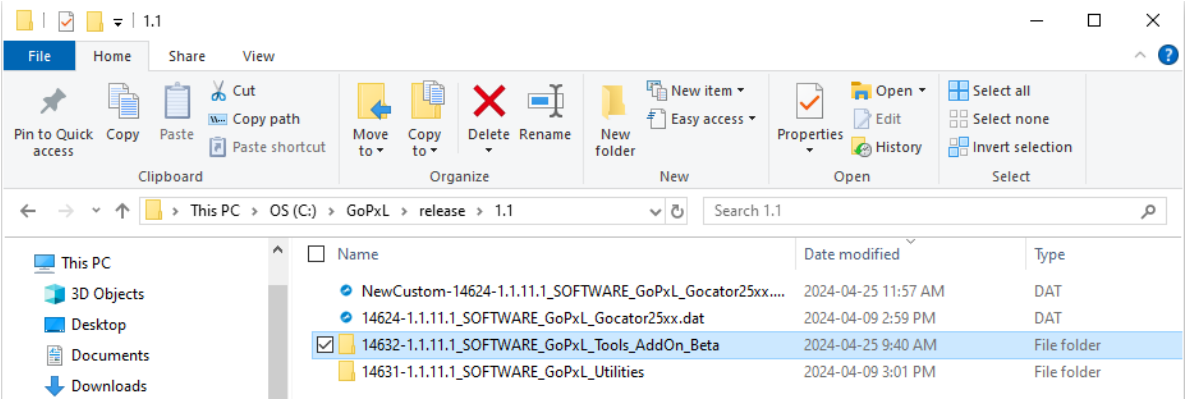

> Be sure to check at least one tool. If a tool is not checked, it will not be added to GoPxL.

9. (Optional) If you are adding tools to a firmware, in the **Output File Prefix** field, change the default "NewCustom" to something that will help you remember what the new firmware is for.

This field is hidden when you are adding tools to GoPxL for Windows folder.

10. Click **Run**.

    If you are adding tools to a firmware, the tool manager creates a new firmware file that contains the beta tools you selected, using the prefix you provided for the filename. The new firmware is created in the same location as the original firmware you loaded.




> The tool manager will overwrite an existing firmware without warning.

If you are adding tools to a GoPxL for PC folder, the tool manager updates it with the added tools.

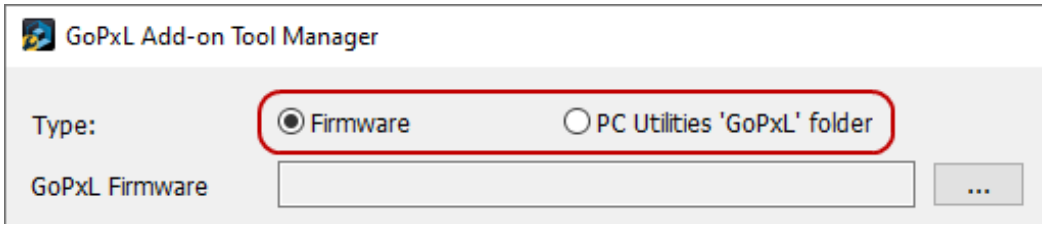
After you have successfully created the new firmware or PC version of GoPxL, you can upload it to any compatible sensor (for more information, see *Software Upgrade* on page 809) or run it (for more information, see *Running GoPxL on a Windows PC* on page 814).

## Removing Beta Tools

*To remove a tool you previously added to a firmware or from GoPxL for PC:*

1. Follow steps 1 to 5 in *To add beta tools to a firmware or to GoPxL for PC:* on page 928

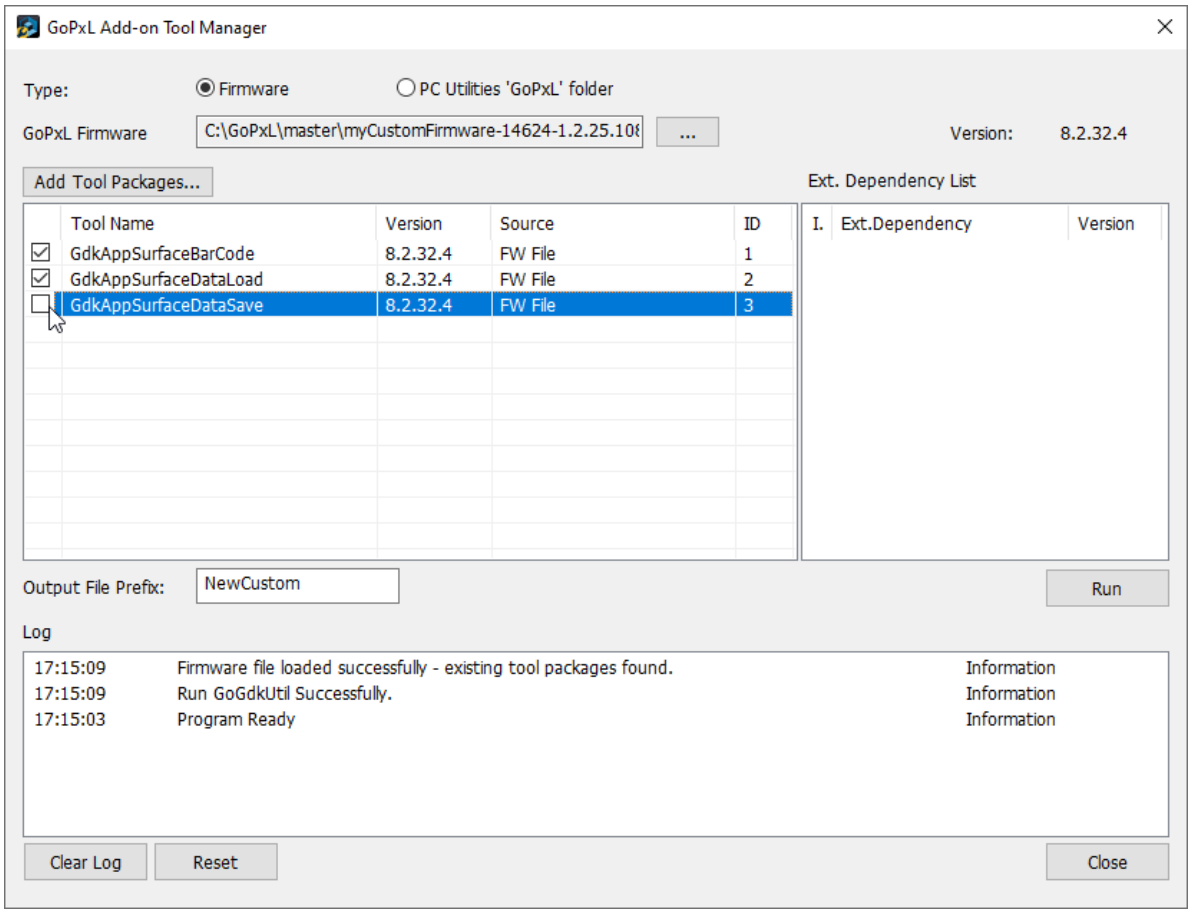
   The type should match the type used when the tool was added.




   You must navigate to the location of the previously modified GoPxL (firmware or PC version).

   After loading GoPxL, the tool list is automatically populated.

2. In the tool list, deselect the tools you want to remove.




3. Click **Run**.

   The GoPxL Add-on Tool Manager saves a new version of GoPxL with the deselected tools removed.

   The tool manager overwrites existing firmware files with no warning.

After you have successfully created the new firmware or PC version of GoPxL, you can upload it to any compatible sensor (for more information, see *Software Upgrade* on page 809) or run it (for more information, see *Running GoPxL on a Windows PC* on page 814).

# Pattern Editor

The pattern editor lets you modify patterns created in the Surface Pattern Matching tool (for more information on the tool, see *Surface Pattern Matching* on page 533). Although the patterns created in the Surface Pattern Matching tool will often result in good matches with your targets, you can use the pattern editor to improve the models, specifically by doing the following:

- Remove unwanted contours the Surface Pattern Matching tool has detected on edges in the scan data.
- Re-detect contours from the scan data using higher or lower levels of input image resolution (taken from the scan data) or contrast levels, compared to what the Surface Pattern Matching tool does internally.
- Identify certain contours as being required for a match to occur.
- Identify certain contours as being used to determine the position of a matched instance.

The Pattern Editor contains a **Pattern** setting (Surface or Image). Leave this set to Surface. The Image setting is reserved for future use.

The editor uses two folders in `C:\GoTools\`, on the PC it is running on.

`GoPxLSurfacePatternMatchingSensor`

When you choose a sensor or PC instance of GoPxL in the **Source** drop-down and click **Connect**, the editor empties this folder and copies any model files on the source into the folder. For this reason, if you have previously worked on model from this folder, make sure you have uploaded any changed models to the sensor or PC instance. The models in this folder are listed in the Model Files until you switch **Source** to PC Work Directory, or empty it by clicking **Clear Sensor Work Directory**.

The folder is referred to as the "Sensor Work Directory" in the editor.

`GoPxLSurfacePatternMatching`

This is called the "PC Work Directory" in the editor. You typically use this folder to transfer model files between sensors or PC instances of GoPxL. Also, because it is only emptied if you manually do it by clicking **Clear PC Work Directory**, it may be better to work from this folder. To get models in this folder, you first connect to a source and then click **Copy all files to the PC work directory**.

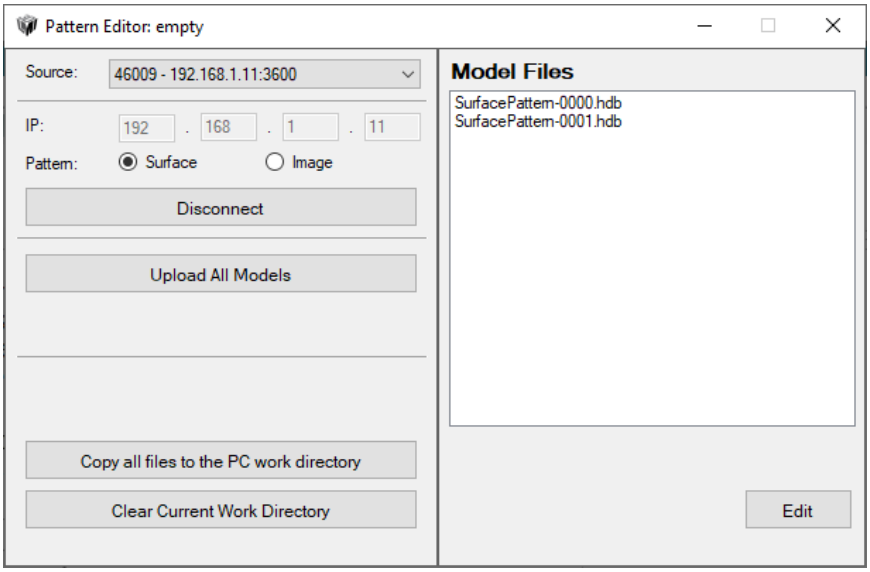
To see the files in this folder, switch **Source** to "PC Work Directory".

The pattern editor is available in the GoPxL Utilities package (`14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.zip`, in the `Tools\Pattern Editor` folder. You can find the package on LMI's Product Downloads page (https://lmi3d.com/product-downloads/).

## Launching the Pattern Editor

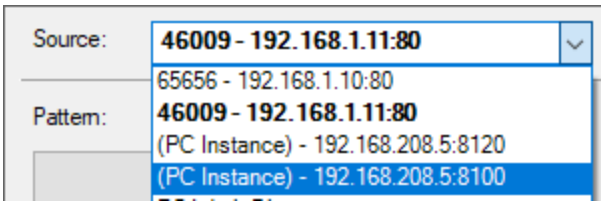
The first time you run the pattern editor, it may take longer to launch, as it will register certain DLLs required by the application.

The pattern editor can work with model files that come from an unaccelerated sensor or from a PC instance of GoPxL (which may or may not be accelerating a sensor). In all cases, the editor works with copies of the files in working folders in the local PC file system.



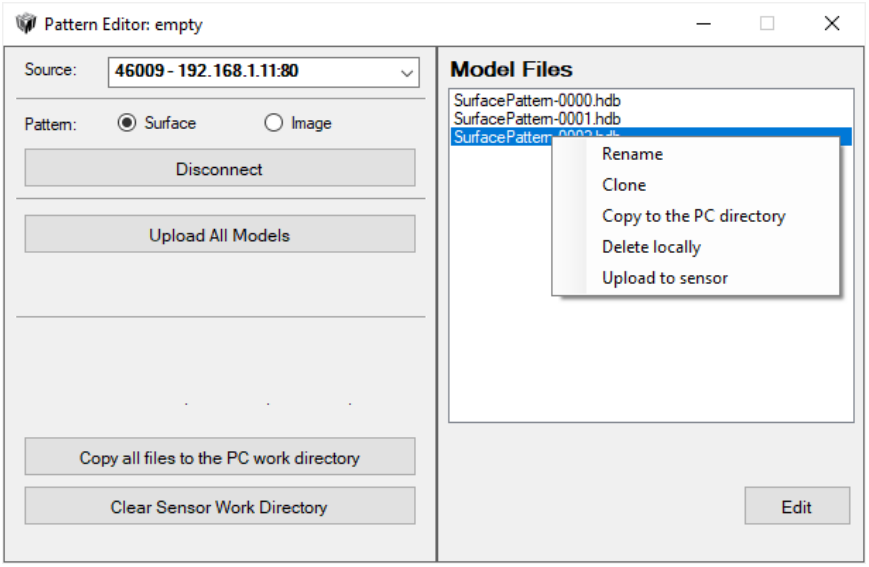

*The Pattern Editor application*

*Parameters*

| Name | Description |
|---|---|
| Source | The source from which the editor fetches model files.<br>  <br><br>The currently connected sensor is displayed in bold in the **Source** list.<br>The list contains the following types of entries:<br>**Sensor**<br>Sensors are listed with their serial number followed by their IP address.<br>**PC Instances** |

| Name | Description |
| --- | --- |
| | Instances of GoPxL running on the PC are identified by "(PC Instance)", followed by their IP address.<br><br>**PC Work Directory**<br>This is a local directory (`C:\GoTools\GoPxLSurfacePatternMatching`) that you typically use to transfer model files between sensors and PC instances of GoPxL. |
| Pattern | Leave this set to Surface. |
| Connect / Disconnect | Connects to the source in **Source**. Note that connecting to a sensor deletes all models in the sensor working folder (`C:\GoTools\SurfacePatternMatchingSensor`) and then downloads the models currently on the sensor to that folder. For this reason, if you have modified models with the Pattern Editor, make sure to upload them before disconnecting and reconnecting. To fetch any models you have created on-sensor after connecting, disconnect using the **Disconnect** button, and then reconnect. |
| Upload All Models | Uploads the models from the `GoPxLSurfacePatternMatchingSensor` local folder to the connected source (to a sensor or a PC instance of GoPxL). |
| Edit | Opens the selected model in the model editor; you can also double-click a model in the list to edit it. For more information, see *Overview of the Editor* on the next page. |
| Copy all files to the PC work directory<br>Copy all files to the sensor work directory | Copies files between the PC Work Directory and the Sensor Work Directory.<br>The name of this button depends on whether **Source** is set to **PC Work Directory**, or to a sensor or PC instance of GoPxL. |
| Clear Sensor Work Directory<br>Clear PC Work Directory | Removes all models from the local working folder.<br>The name of this button depends on whether **Source** is set to **PC Work Directory**, or to a sensor or PC instance of GoPxL. When you clear the sensor work directory, you are only deleting the files locally, not on the sensor or PC instance. |

By right-clicking on a model in the list of models, you can perform the operations listed below.




**Rename**: Renames the model.

**Clone**: Makes a copy of the selected model using the name you provide.

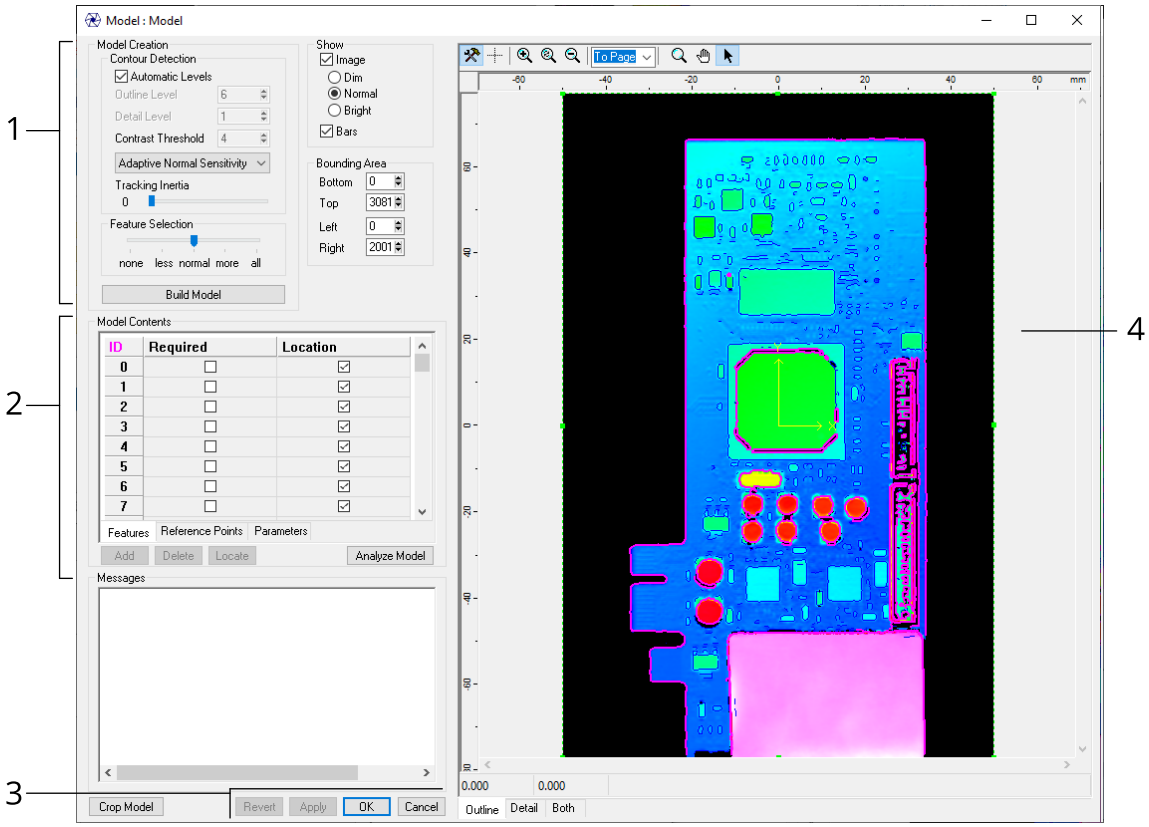
**Copy to the PC directory** / **Copy to the sensor directory**: Copies the model to a local directory.

**Delete locally**: Deletes the model from the `GoPxLSurfacePatternMatchingSensor` folder. Not displayed when **Source** is set to "PC Work Directory".

**Upload to sensor**: Uploads the model to the connected sensor.

## Overview of the Editor

After clicking Edit in the pattern editor helper application, the selected model opens in the editor window.




| | Element | Description |
|---|---|---|
| 1 | Model Creation pane | Settings related to contour detection and feature selection. After configuring these settings, or resizing the model's bounding box (green dotted line), you must rebuild the model using the **Build Model** button. |
| 2 | Model Contents | The list of the features in a model (contours used in recognition and location of an instance).<br>Note that some model contents (reference points and some settings in the **Parameters** tab) are not currently supported by the Surface Pattern Matching tool. |
| 3 | Save and discard buttons | Used to apply changes to a model, revert to the model's original state when it was loaded, and so on. |
| 4 | Outline, Detail, and Both tabs | The editor tabs that show the Outline and Detail levels of the model. The **Both** tab shows both levels together, but you can't edit models on this tab. |

## Models

Models are made up of features selected from the source contours detected either by the Surface Pattern Matching tool or by the model editor itself (if you rebuild the model using the **Build Model** button). The features are used to identify and locate instances in the scan data.

Contours, and the features selected from the contours for use in recognizing and locating an instance, work on two “coarseness” levels: the Outline level and the Detail level.

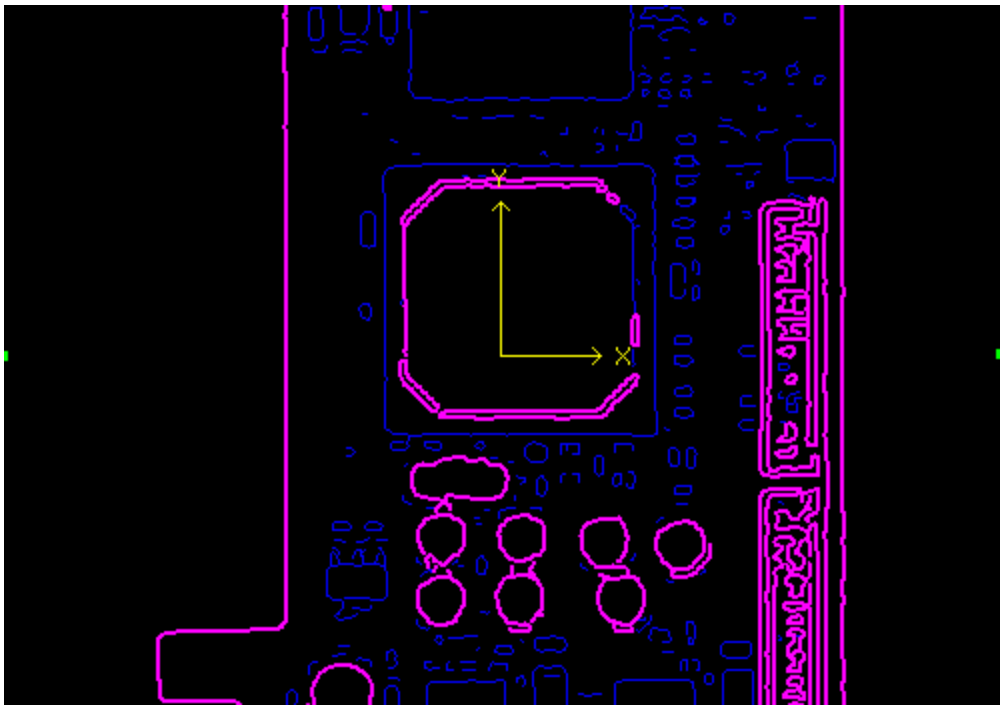
**Outline**: Used to quickly identify potential instances of a pattern in scan data. The Outline level is the "coarse" level of contours / features. The features at this level can be less stable, as they are not used to calculate the location of the instance. For example, a label whose position might change from frame to frame or a hole whose size might change from frame to frame could be kept at the Outline level.

**Detail**: Used to confirm whether an instance is in fact valid and to refine its location. The Detail level is the "fine" level of contours / features. The features at this level must be more stable and rigid with respect to one another. For this reason, given Surface scan data, include features that are all on the same plane to ensure that their positions will not be unstable due to parallax or other scanning issues. Furthermore, features on a part that might vary in size from frame to frame, or change position (such as a label), should be excluded.

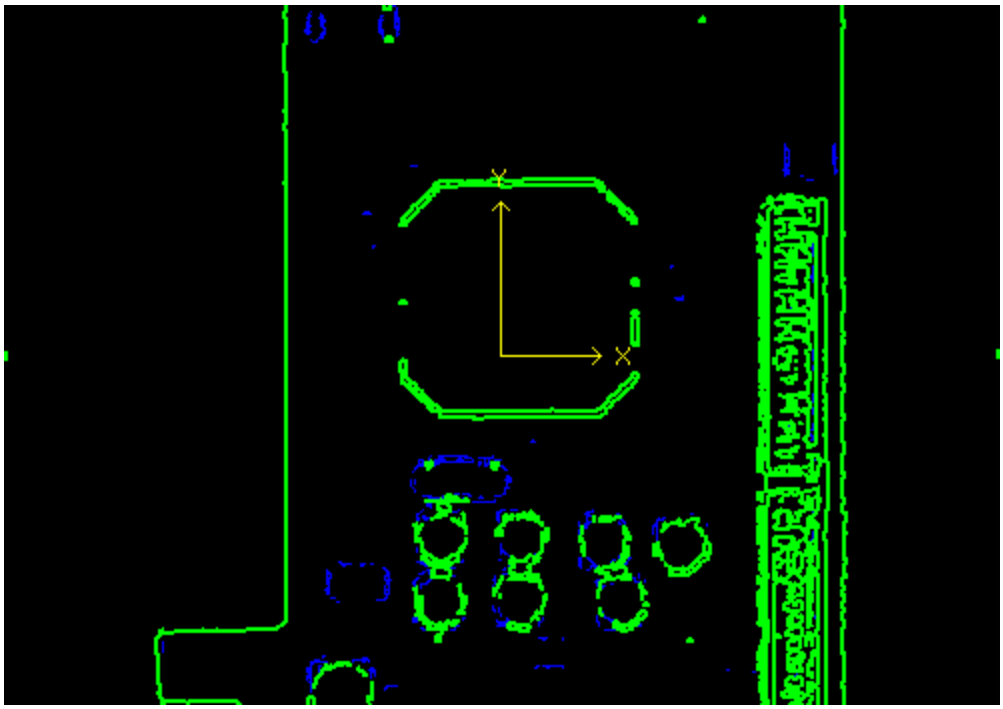
That said, the Outline and Detail levels will often be similar in terms of which features are included.

You can edit (add and remove) features at these levels separately, in the Outline and Detail panels in the main editor window. For more information on adding and removing features, see *Adding and Removing Features Manually* on the next page.

In the editor, “unused” contours (those not selected to take part in instance recognition or locating) are indicated with dark blue paths. Features (contours selected to take part in instance recognition or locating) are indicated with either magenta paths (at the Outline level) or with green paths (at the Detail level); the features in a model are listed in the **Model Contents** pane.



*Dark blue unused contours and magenta features at the Outline level.*



*Dark blue unused contours and green features at the Detail level.*

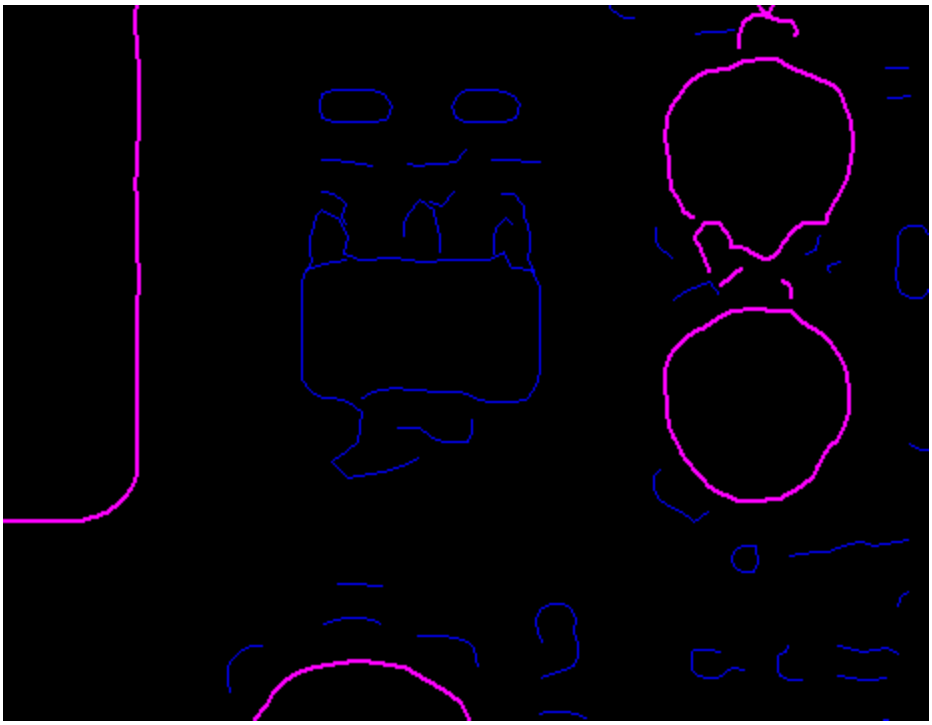
> In the Surface Pattern Matching tool, only the Detail level of features is displayed.

## Adding and Removing Features Manually

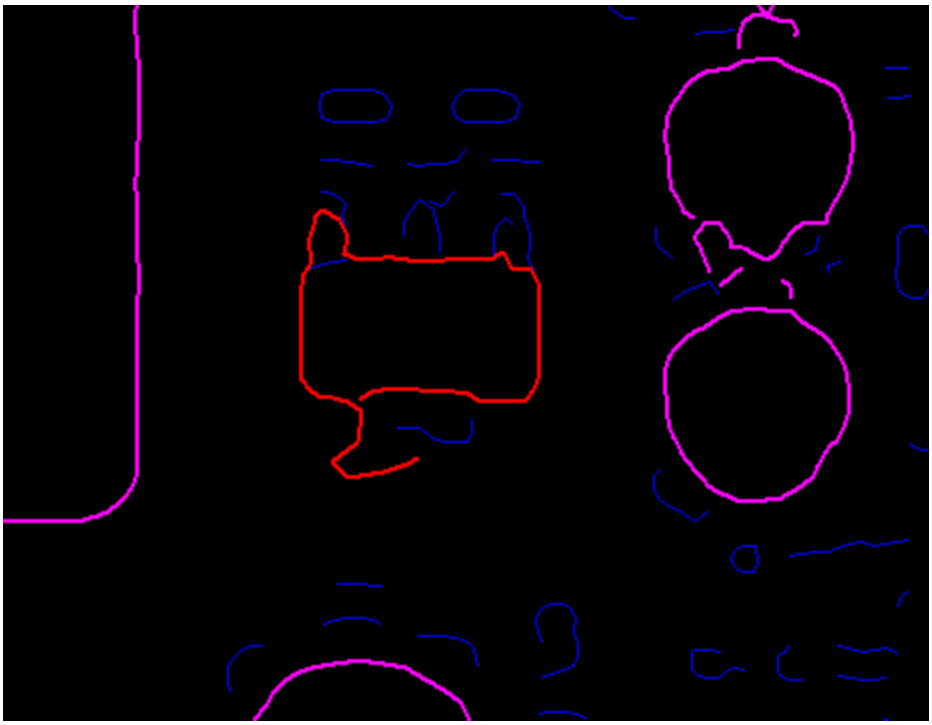
You can manually add features to a model from the source contours, or remove features currently in a model, at both the Outline and Detail levels. This can be useful if the model produced by the Surface Pattern Matching tool includes features related to parts of targets that could change or be present/absent from frame to frame. You should only include features that are constant from frame to frame.

> Adding and removing features works in the same way in the Outline and Detail tabs.

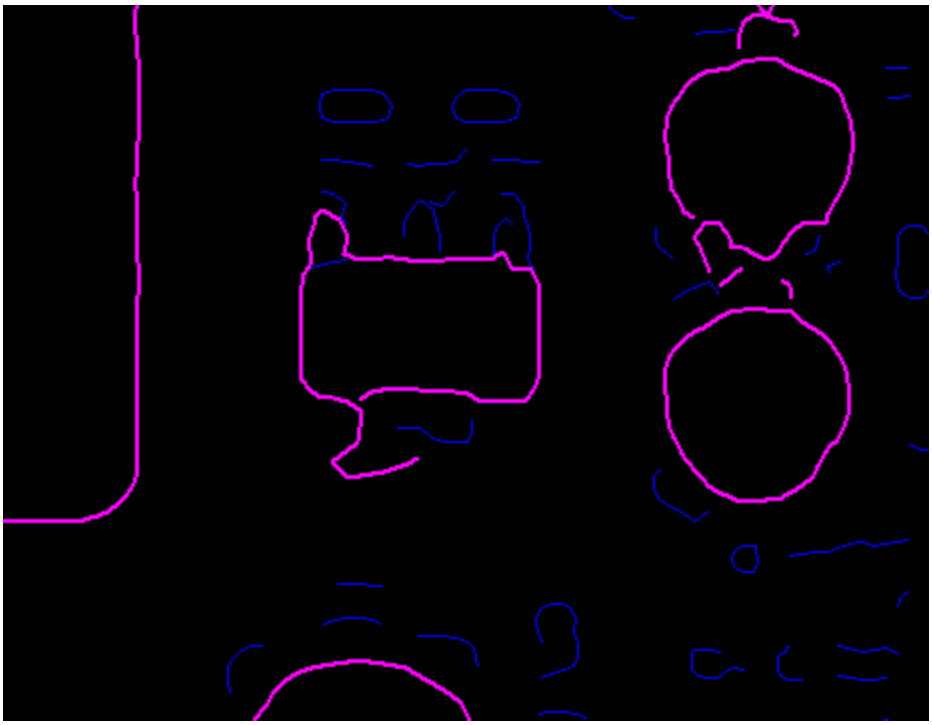
To add a feature from a source contour, double-click a dark blue contour in either the Outline or Detail tab and click Add or press the Insert key on your keyboard.



*Dark blue unused contour (contours already added as features in the model are magenta).*

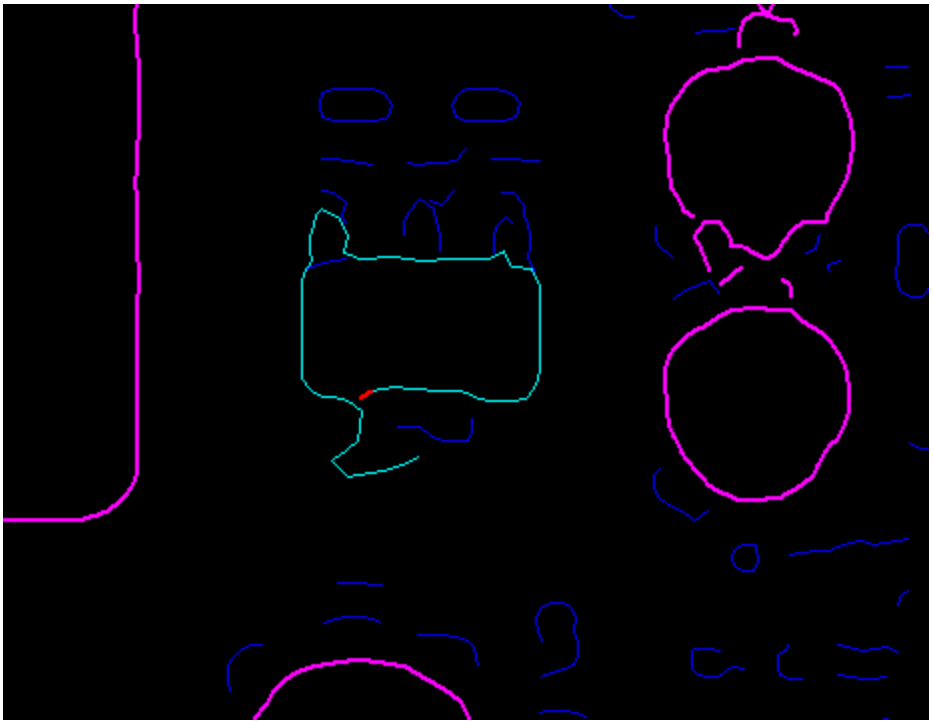


*Contour selected by double-clicking it.*



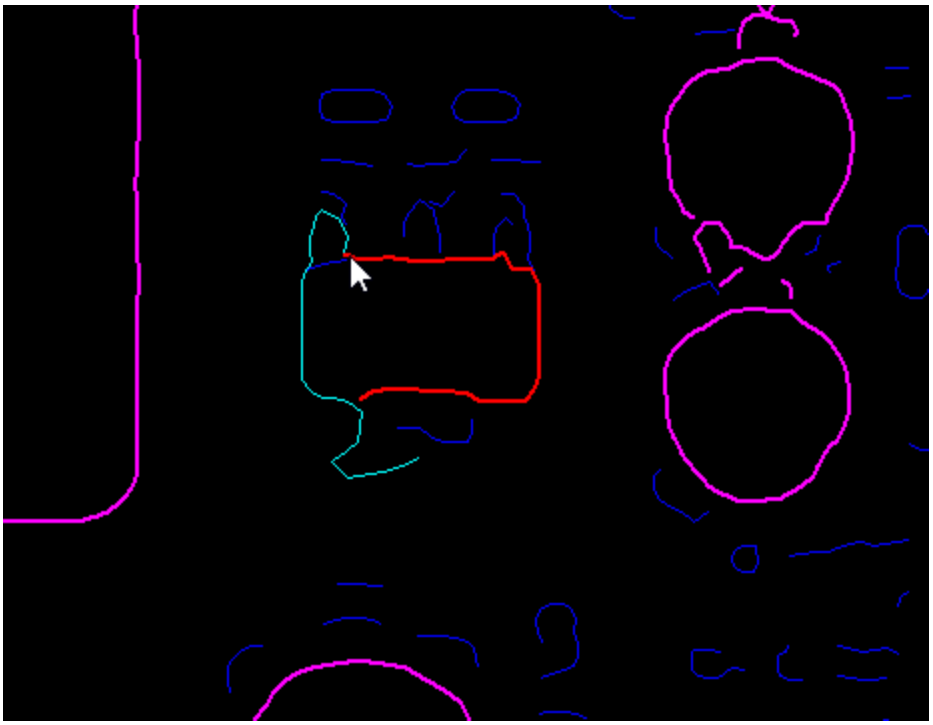
*Contour added as a feature in the model (magenta).*

If you single-click a dark blue unused contour, it turns cyan and lets you select segments of the contour.

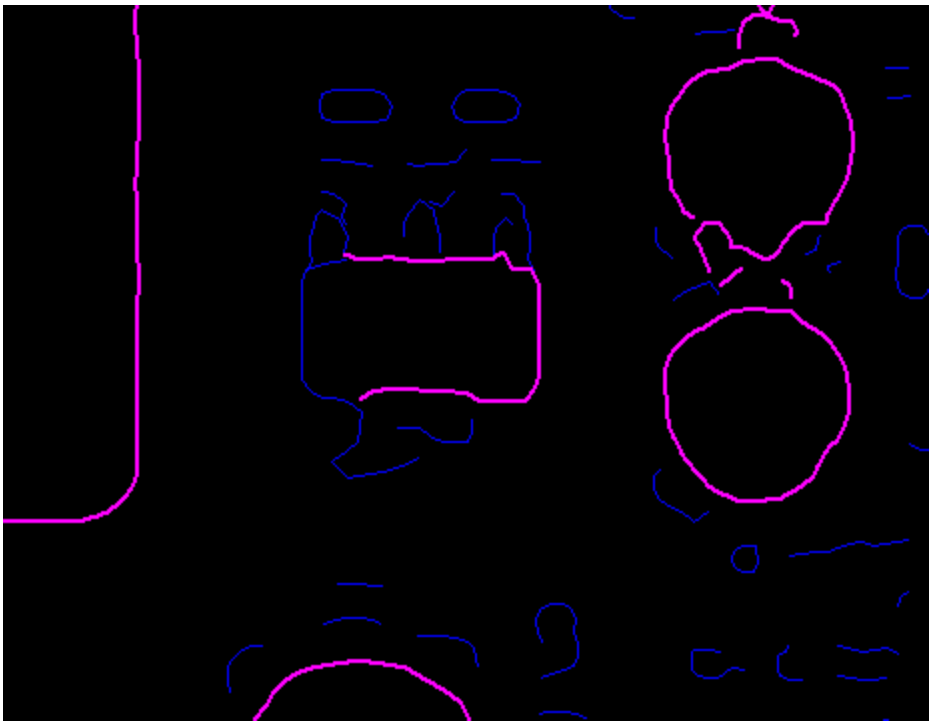


*Contour highlighted in cyan with a selected segment (red).*

Pressing the Ctrl key on your keyboard and clicking another segment selects a portion of the cyan path.



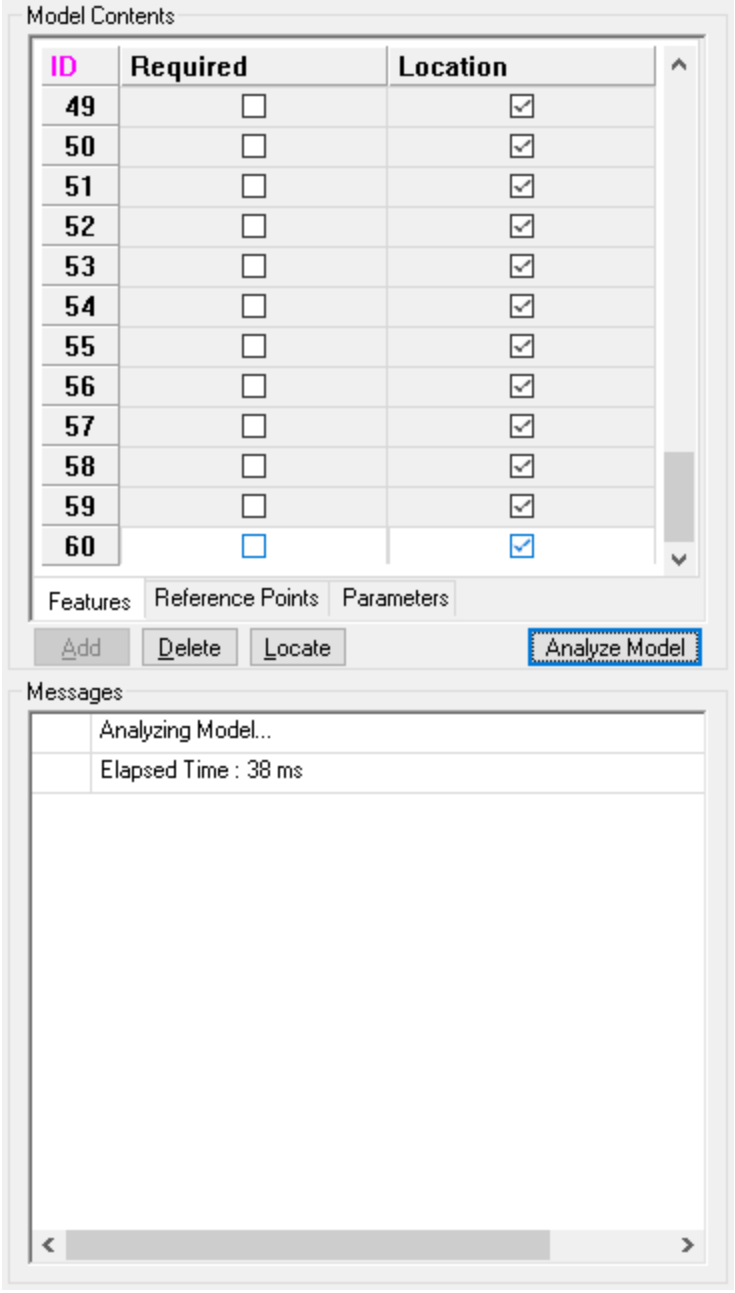
Clicking **Add** or pressing the Insert key on your keyboard adds the segment of the contour as a feature to the model.



After adding a feature, it is added to the list of features on the **Feature** tab in the **Model Contents** panel. Do not press the build button after adding or removing features, or you will lose the modifications that were just made. You must however save the changes; for more information, see *Saving and Discarding Changes* on page 949.

To remove a feature, click a magenta or green path in the editor to select it and click **Delete** or press the Delete key on your keyboard. After removing a feature, it is removed from the list of features on the Feature tab in the Model Contents panel. You do not need to build the model, but must save the changes; for more information, see *Saving and Discarding Changes* on page 949.

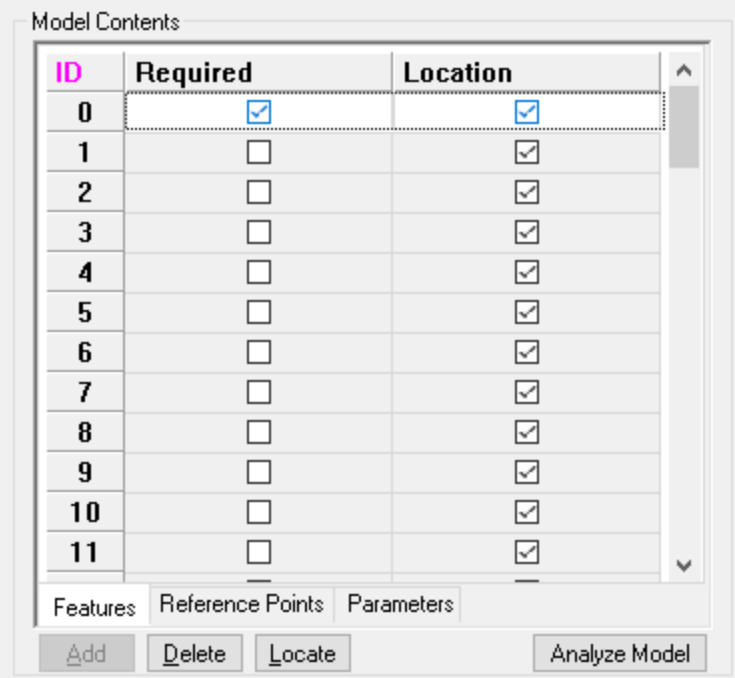
After adding a feature to a model or removing a feature from a model, you should analyze the model by clicking **Analyze Model**. Make note of any errors in the **Messages** panel.




*No error messages after clicking Analyze Model.*

## Setting Required and Locating Features

In the list of features in the **Model Contents** pane, you can indicate that a feature is “required” or that it is used to calculate the location of an instance by checking the appropriate checkbox next to the feature.



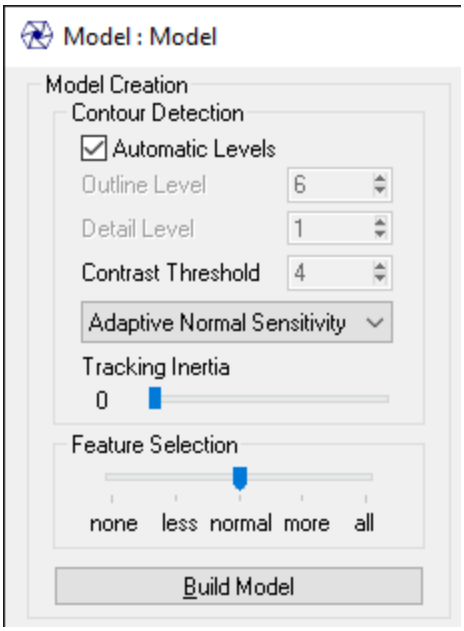

When Required is checked for a feature, it *must* be found by the Surface Pattern Matching tool in order for an instance to be identified.

When Location is checked for a feature, the Surface Pattern Matching tool uses the feature to calculate the location of instances. If a feature's location is not checked, it is only used for instance recognition. An example of the latter is a tag or label glued to an object. Although the label's contours (it's shape or what is written on it) might be unique enough to help recognize an instance, it's position *on* the object (that is, relative to the other features) might vary in its position from frame to frame. For this reason, it might be useful for instance recognition, but not for determining the location of the object.

## Model Creation Settings and Rebuilding

The Surface Pattern Matching tool uses internally fixed settings to detect contours in the scan data and then select features from those source contours. In the pattern editor, you can increase or decrease the contour detection levels, change the contrast threshold, and so on, and then rebuild the model. This can be useful if the Surface Pattern Matching tool's internal settings do no produce the right amount of source contours and subsequently features.

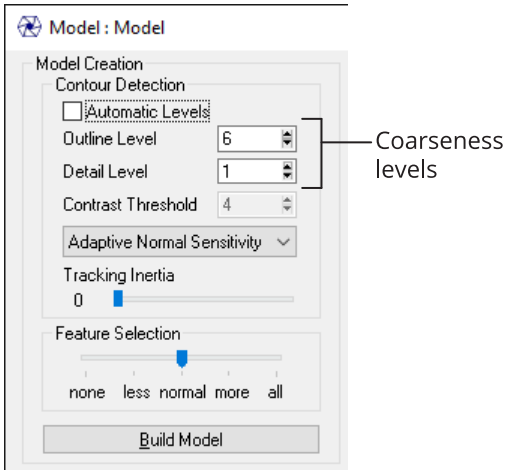
The settings described here are found in the **Model Creation** section of the model editor.




After making changes to any of these settings, you must rebuild the model by clicking **Build Model**, and then save the changes. You should also click **Analyze Model** after rebuilding a model. Pay special attention to messages in the **Messages** pane at the bottom of the editor to make sure there are no errors. For more information on saving changes, see *Saving and Discarding Changes* on page 949.

## Coarseness Levels

By default, the pattern editor uses automatically determined contour coarseness values (at both the Outline and Detail levels) to detect contours in the scan data image. If you uncheck **Automatic Levels**, you can change the **Outline Level** and **Detail Level** values to generate more or fewer contours, from which you can then select features that more reliably represent your target.

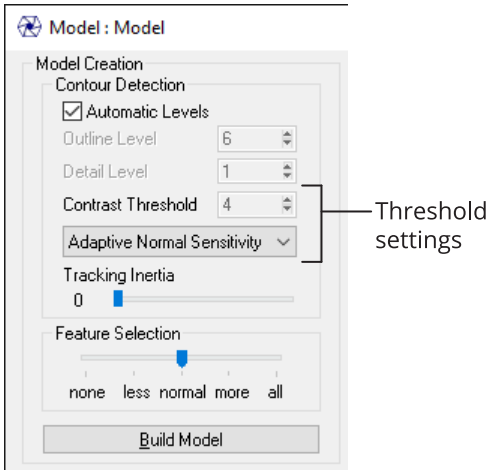



The **Outline Level** and **Detail Level** values range from 1 to 16. At the lowest value, contours are detected in a full-resolution version of the image based on the scan data, which results in more contours from which to choose features. At higher values, contours are detected in a reduced-

resolution version of the image based on the scan data: the resolution is reduced by the setting's value, which results in fewer contours being detected. Note that **Detail Level** must be less than or equal to **Outline Level**.

## Thresholds

You can adjust the level of sensitivity the pattern editor uses to detect contours in the scan data image.




By default, the sensitivity is set to Adaptive Normal Sensitivity, but you can set it to one of the following adaptive sensitivity levels, or to a fixed threshold value (see below).

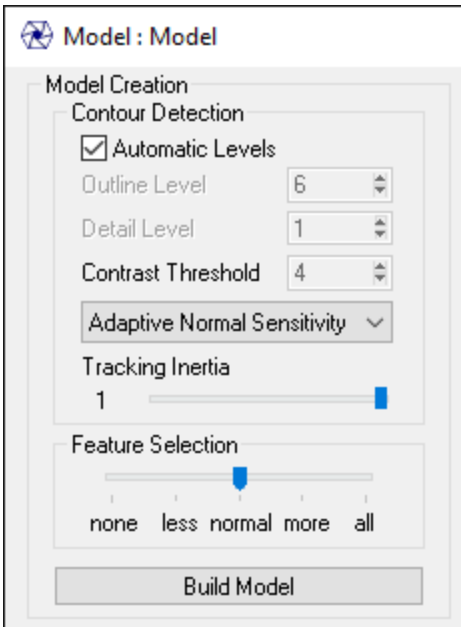
**Adaptive High Sensitivity**: Results in more low-contrast contours, but also noise.

**Adaptive Low Sensitivity**: Results in strongly defined contours and eliminates noise, but may miss important contour segments.

If you set the dropdown to Fixed Value, you can then set a fixed threshold in **Contrast Threshold**. The **Contrast Threshold** value corresponds to the minimum step required to detect corners. A lower value generates more contours when you rebuild the model, but may also result in noise.

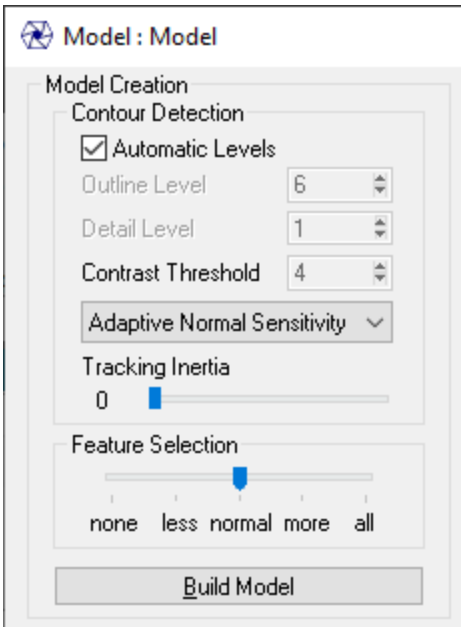
## Tracking Inertia

Setting the Tracking Inertia slider to 1 closes small gaps in the source contours, connecting contours that might otherwise be broken into smaller sections.




## Feature Selection

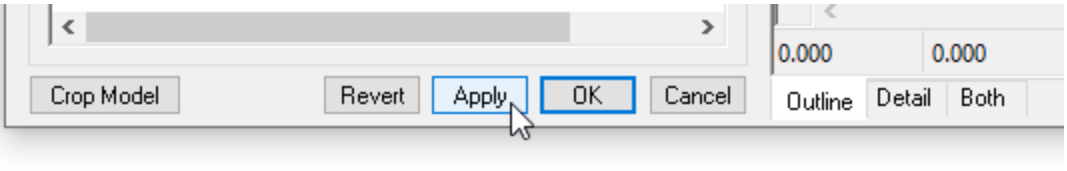
This setting ranges from **none** to **all**, which determines which features the pattern editor selects from the detected contours and adds to the model when you rebuild it. You should use **none** (which adds no features to the model) if you want to manually add features to the model from the detected contours. The **normal** setting tries to add the most appropriate features to the model; use this setting with simple to moderately complex parts. The **all** setting adds all detected contours as features to the model; only use this with very complex parts, such as electronic parts.



## Saving and Discarding Changes

After making changes to a model (either adding or removing features, or re-detecting contours by clicking **Build Model**), you *must* do the following:

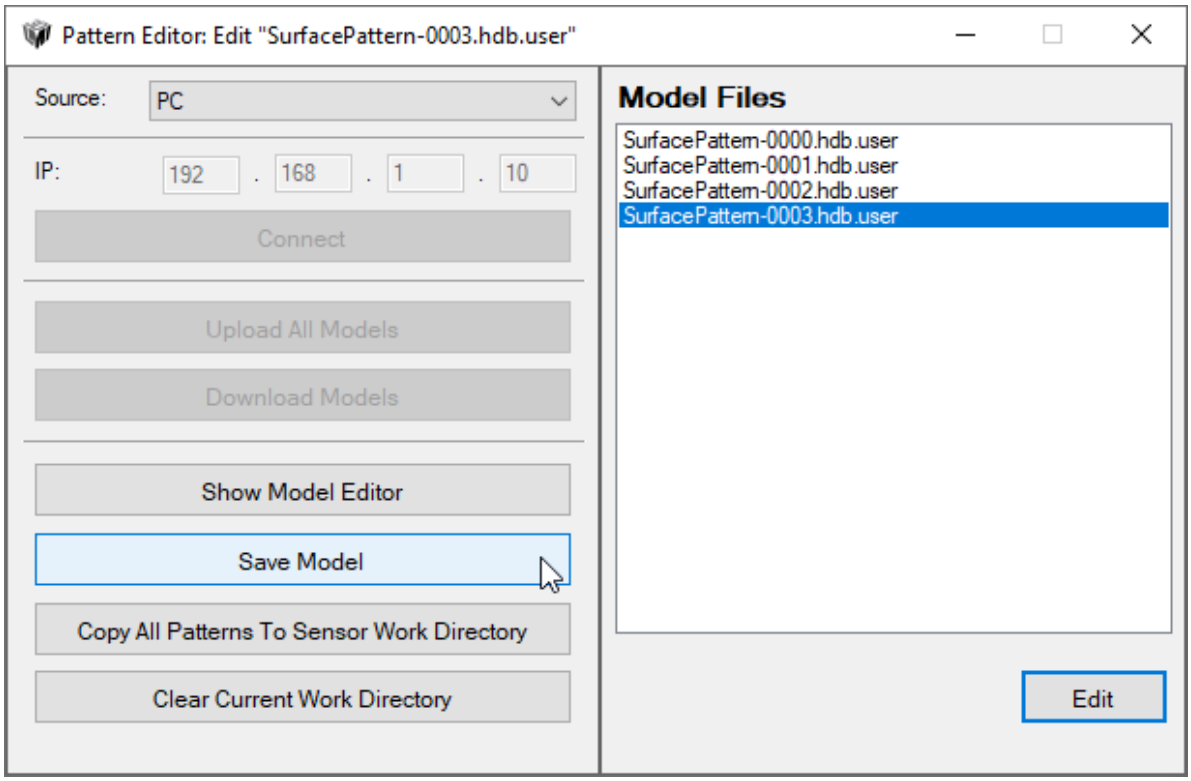
1. In the model editor, at the bottom of the window, click **Apply** or **OK**.




   Clicking **Apply** leaves the model editor open. Do this if you want to continue working on a model (for example, if you want to test the model in Gocator before closing the model).

   Clicking **OK** closes the model editor.

2. In the pattern editor helper application, click the model you were working on, and click **Save Model**.




   The model is saved to the working folder.

> After making changes to a model, you must re-load the pattern in the instance of Surface Pattern Matching to see the changes.

*Before* saving changes (either by clicking **Apply** or **OK**), you can revert the model to its initial state by clicking **Revert**.

## Miscellaneous

Reference points, which you can create in the pattern editor on the **Reference Points** tab in the **Model Contents** panel, are not currently supported by the Surface Pattern Matching tool.

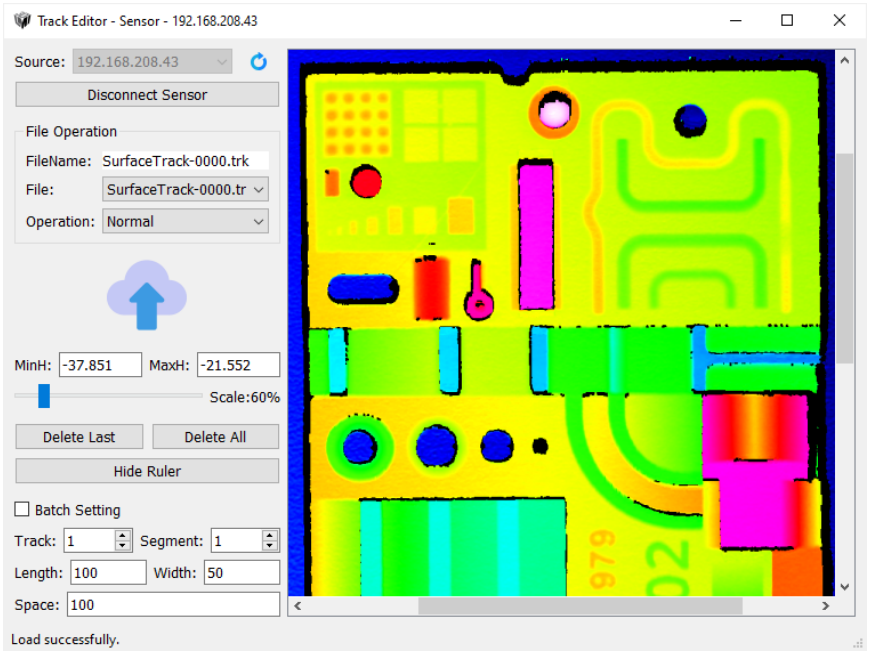
The Surface Pattern Matching tool does not currently support the custom shading area (on the **Parameters** tab in the **Model Contents** panel).

You can change the region of the model by resizing the green bounding box (or setting its dimensions in the **Bounding Area** section in the model editor) and rebuilding the model. After resizing and rebuilding the model to the desired region, you can use the **Crop Model** button to reduce the size of the final model surface, and reduce the pattern file size.

In the Show section in the model editor, you can hide the scan data to see only the contours and features by unchecking **Image**. Note that the Dim / Normal / Bright options below **Image** only apply to intensity data.

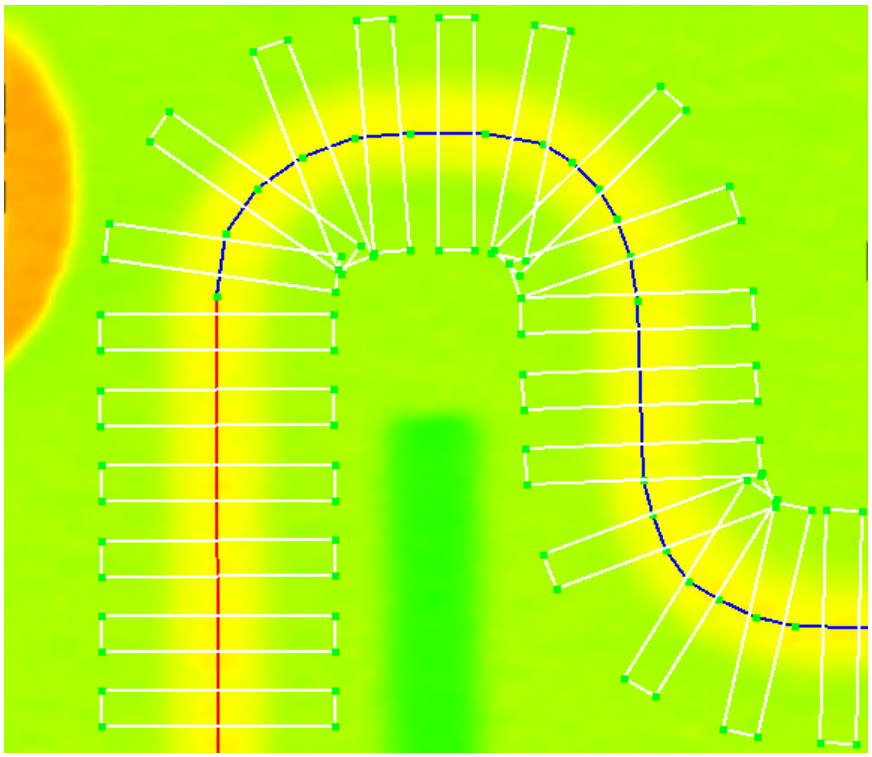
# Track Editor

You use the track editor in conjunction with the Surface Track tool. The track editor lets you configure "path" and "ruler" information on a frame of scan data from a sensor or GoMax NX device, a PC instance of GoPxL, or a GoPxL backup file. The Surface Track tool uses this information to inspect targets along the defined path. For more information on paths, rulers, and other concepts related to the Surface Track tool, see *Surface Track* on page 595.




*The track editor*

In the track editor, you define one or more paths, and configure rulers along these paths.

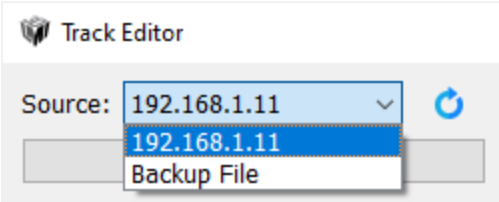


*Closeup of the track editor window, showing a track of material on a surface (yellow on green), path points (green dots), a path (blue segments; red segment for the currently selected segment), and rulers (white rectangles).*

> The following assumes that you have already scanned a representative target and created a track file from within the Track tool. For more information, see the first steps of *To configure the Track tool:* on page 599.

*To load and work with scan/track data:*

1. In the track editor, in the **Source** drop-down, choose one of the following:




- **An IP address**: Choose this option to edit a track file on a sensor or a GoMax NX device, or in a PC instance of GoPxL.
- **Backup File**: Choose this option to edit a track file in a backup file you have created from a sensor or a PC instance of GoPxL and saved in the PC's file system. For more information on backup files, see *Backup and Restore* on page 809.

> If you only see "Backup File" but expect to see an IP address, make sure the device or PC instance is running and is connected to your network, and then click the Reset button ( ).

2. If you have chosen an IP address, click **Connect Sensor**.

The track editor loads the data from the device or PC instance.

3. If you have chosen a backup file, click **Load Backup**, navigate to the location of the backup file, select it, and click **Open**.

   The track editor loads the data.

4. Under **File Operation**, in **File**, select the track file you have created in the Surface Track tool, and under **Operation**, choose Load.

> If you only see "External" under **File**, it means no track file has been defined on the device / PC instance or in the backup file. You can use "External" to load a .trk file from the PC's file system. Otherwise, create a track file in the Surface Track tool, and then disconnect and reconnect the source.

   The editor loads the specified track file.

   For a complete list of the file operations, see *File operations* below.

5. Do one or more of the following:
   - Move the slider to the left or right to zoom in or out in the editor's viewer.
   - Move the data in the track editor's window using the scrollbars or the mouse wheel.
   - Set **MinH** and **MaxH** and then reload the track data to assign a narrower height range to the height map colors. This may help make the track clearer in the editor. This does not change the height map data.

*File operations*

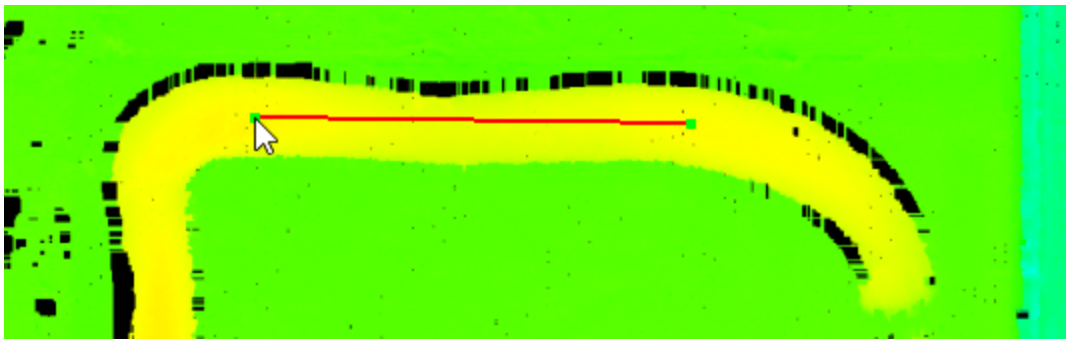
| Operation | Description |
|---|---|
| Normal | The utility defaults to this option after performing another operation. |
| Load | Loads the track file selected in the **File** list.<br>If you choose "External" in the **File** list, choosing Load displays a dialog that lets you load a file on the PC. |
| Save | Saves the currently loaded track file (as shown in **FileName**). |
| Save As | Saves the currently loaded track file (as shown in **FileName**) as a new file. |
| Delete | Deletes the file selected in the **File** list. |
| Refresh | Refreshes the **File** list. |

After you have loaded the data, you must add a path and configure its rulers.

*To add and configure a path and its rulers:*

1. In the track editor, click on the middle of the track somewhere in the scan data, move the mouse pointer to another location, and click again.

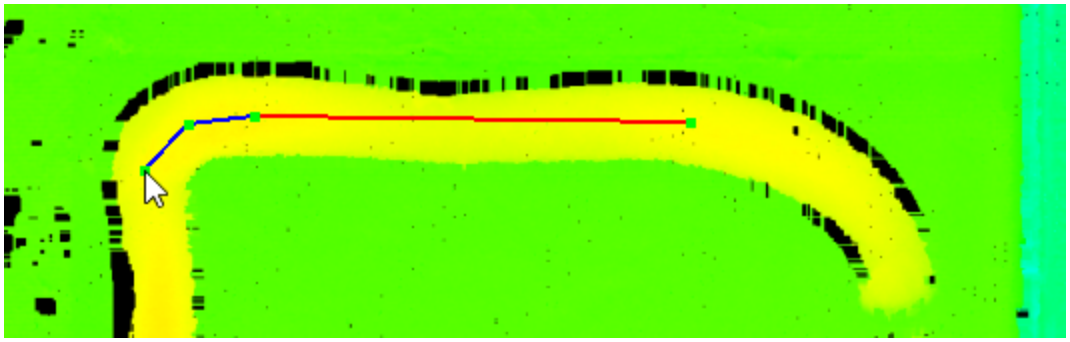
   A red segment between the first two green path points appears in the editor window.



You can move path points using the mouse at any time to adjust the path. You can also delete the last point by clicking **Delete Last**. To delete all path points, click **Delete All**.

2. Continue clicking along the track to add more path points, building up the path.

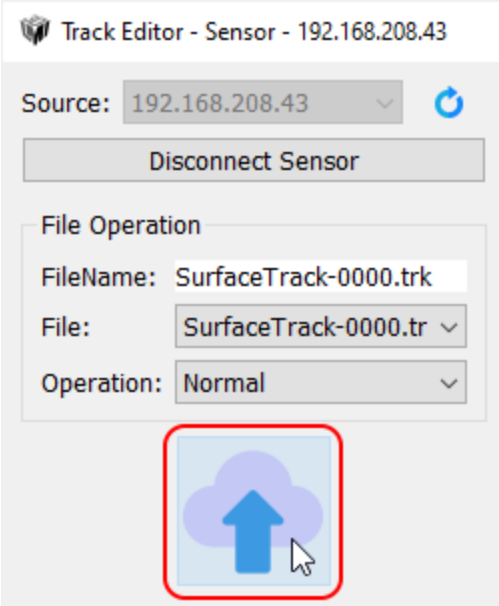
   When adding points on corners, add more points to follow the track more precisely.



3. Continue clicking until you complete the path along the track.
4. Modify the ruler settings.

   For more information, see *Ruler Settings* on the next page.
5. Under **Operation**, click **Save** to save the path information to the data.

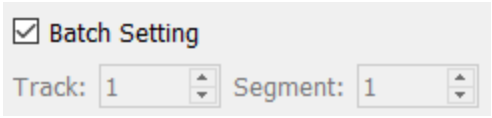
   For a complete list of the file operations, see *File operations* on the previous page.
6. Click the Sync button.



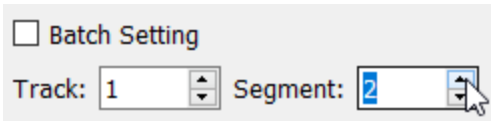

The changes are synchronized to the source (device or backup file).

## Ruler Settings

After you have finished adding a path, you can configure the rulers on the path (the dimensions and the spacing of the rulers). You can choose to apply dimensions/spacing to rulers in all segments at the same time by checking **Batch Setting**.




Otherwise, you must move through the individual path segments by clicking the spinner control in the **Segment** field and setting the ruler dimensions for each segment.




The following table lists the ruler settings available in the track editor:

*Track editor: ruler settings*

| Setting | Description |
|---|---|
| Length | The dimension of the ruler perpendicular to the path. Be sure to use a value large enough to cover the track from one side to another and to include enough surface on each side of the track (the surface to which the material is applied) for the Track tool to properly detect the track. |
| Width | The dimension of the ruler along the path. |
| Space | The space between rulers on the path. Because you will typically place path points closer together around corners, you may need to use smaller spacing around corners. |

# Specifications

The following sections describe the specifications of Gocator sensors and connectors, as well as Master hubs.


**Sensors** ..... **956**
Gocator 4000 Series ..... 957
Gocator 4010 / 4011 ..... 958
Gocator 4020 / 4021 ..... 961
Gocator 5500 Series ..... 964
Gocator 5504 ..... 966
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Power ..... 976
Gocator I/O Connector ..... 977
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Serial Output ..... 980
Analog Output ..... 980
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Master 2410 Dimensions ..... 994

# Sensors

The following sections provide the specifications of Gocator sensors.

## Gocator 4000 Series

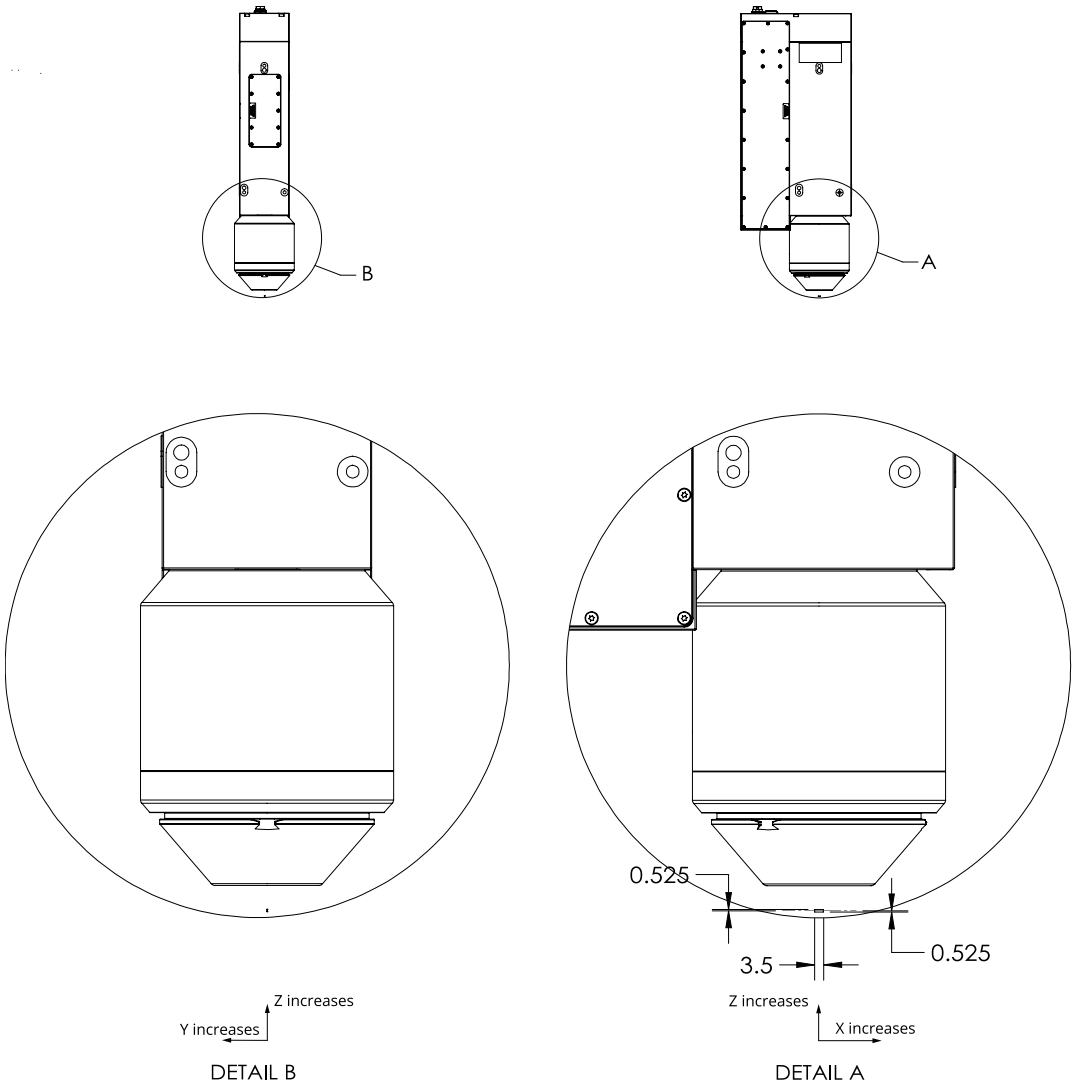
The Gocator 4000 series consists of the following models:

| MODEL | 4010 | 4011 | 4020 | 4021 |
|---|---|---|---|---|
| Scan Rate (Hz) | 4300 to 14,000 Hz | | 4500 to 16,000 | |
| Resolution X (µm) (Profile Data Interval) | 1.9 | | 2.6 | |
| Clearance Distance (CD) (mm) | 9.3 ±0.2 | | 27.8 ±0.3 | |
| Measurement Range (MR) (mm) | 1.05 | | 2.5 | |
| Field of View (mm) | 3.5 | | 5.0 | |
| Dimensions (mm) | 183 x 82 x 459 | | 183 x 82 x 428 | |
| Weight (kg) | 10.4 | | 9.6 | |
| Linearity Z (± % of MR) | 0.04 | | 0.02 | |
| Repeatability Z (µm) | 0.12 | 0.10 | 0.25 | 0.20 |
| Max Slope Angle (°) | ~ 45 - 85 | ~ 23 - 85 | ~ 30 - 85 | ~ 13 - 85 |
| Application Note | In most applications, the 4011 and 4021 provide superior data quality, repeatability, and linearity, and are the recommended sensors. In applications that require additional sensitivity (shorter exposure times for higher scan speeds) or increased detection angle on highly reflective targets, the 4010 and 4020 are typically more suitable. | | | |

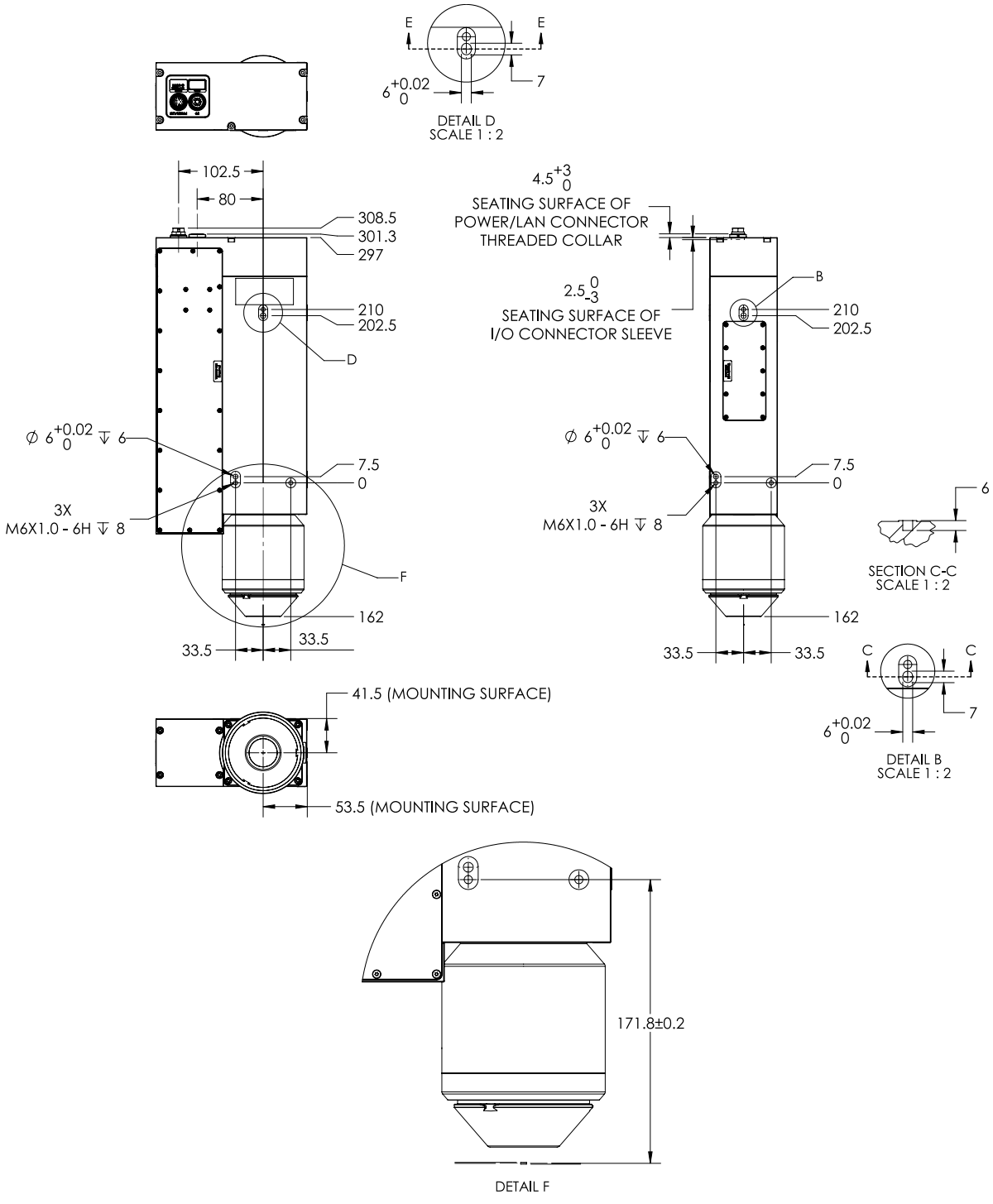
| ALL 4000 SERIES MODELS | |
|---|---|
| Data Points / Profile | 1920 |
| Interface | Gigabit Ethernet |
| Inputs | Differential / Single Ended Encoder, Trigger |
| Input Voltage (Power) | 24-48V (+-5%) @77W |
| Housing | Gasketed metal enclosure, IP50 |
| Operating Temp. | 15-35 °C (above 30 °C, maximum duty cycle is 50%) |
| Storage Temp. | -30 to 70 °C |
| Vibration Resistance | 10 to 55 Hz, 1.5 mm double amplitude in X, Y and Z directions, 2 hours per direction |
| Shock Resistance | 15 g, half sine wave, 11 ms, positive and negative for X, Y and Z directions |

Mechanical dimensions, CD/FOV/MR, and the envelope for each sensor model are illustrated on the following pages.

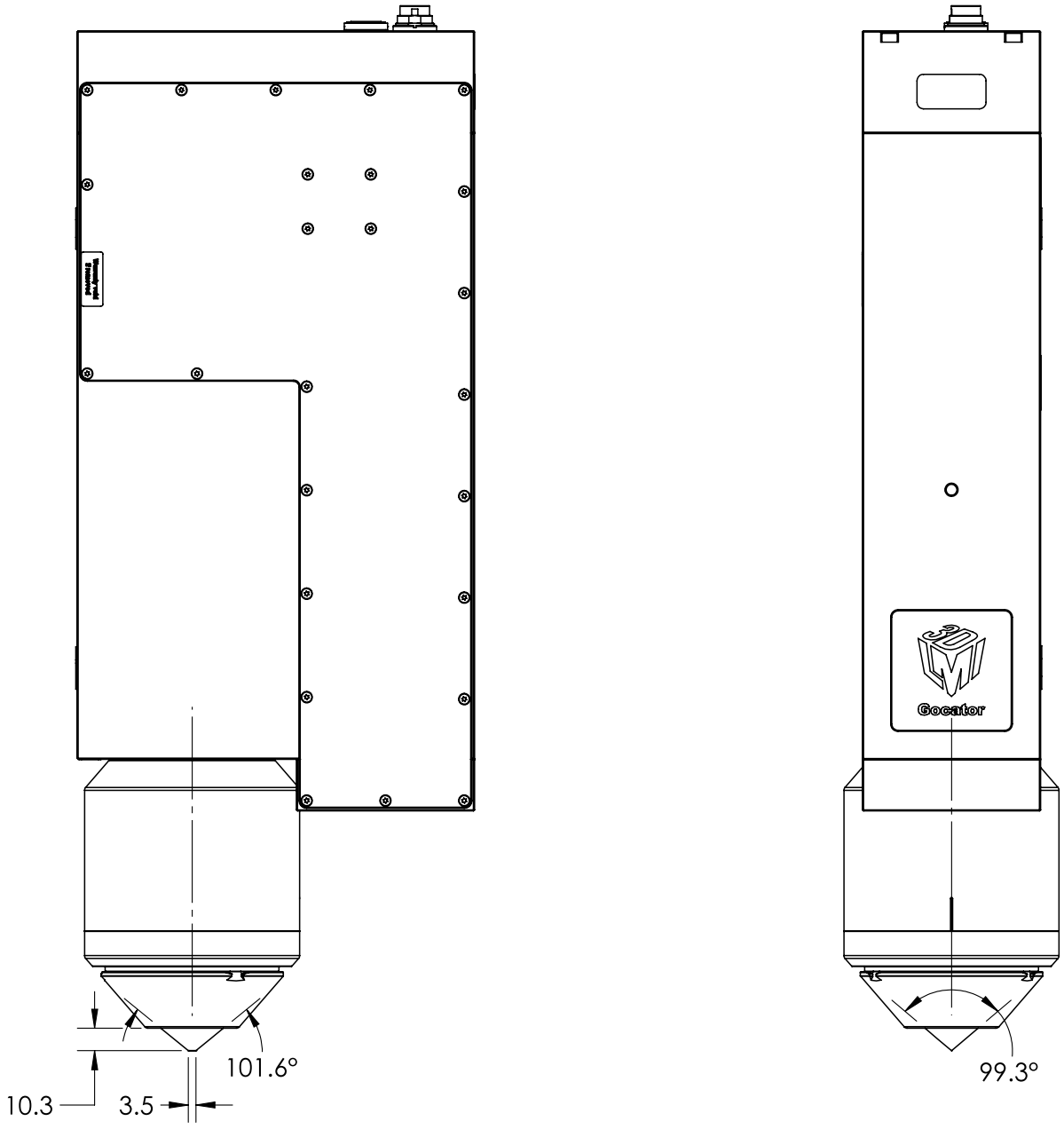
## Field of View / Measurement Range / Coordinate System Orientation



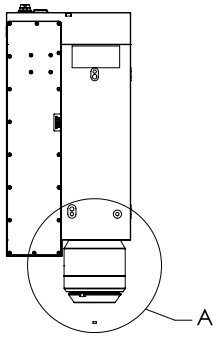
## Dimensions

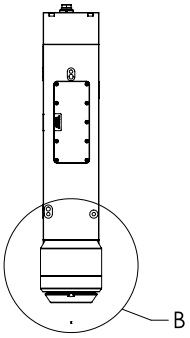

E
E
7
6 +0.02 0
DETAIL D
SCALE 1 : 2
102.5
80
308.5
301.3
297
210
202.5
D
∅ 6 +0.02 0 ↧ 6
7.5
0
3X
M6X1.0 - 6H ↧ 8
F
162
33.5
33.5
41.5 (MOUNTING SURFACE)
53.5 (MOUNTING SURFACE)
4.5 +3 0
SEATING SURFACE OF
POWER/LAN CONNECTOR
THREADED COLLAR
2.5 0 -3
SEATING SURFACE OF
I/O CONNECTOR SLEEVE
B
210
202.5
∅ 6 +0.02 0 ↧ 6
7.5
0
3X
M6X1.0 - 6H ↧ 8
162
33.5
33.5
6
SECTION C-C
SCALE 1 : 2
C
C
7
6 +0.02 0
DETAIL B
SCALE 1 : 2
171.8±0.2
DETAIL F

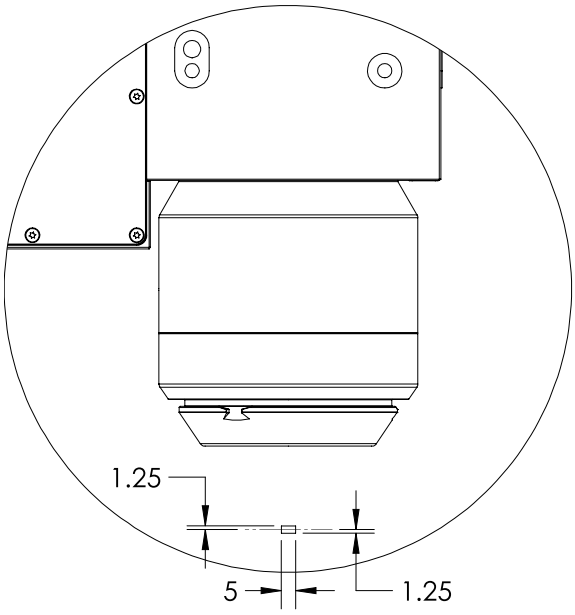
**Envelope**

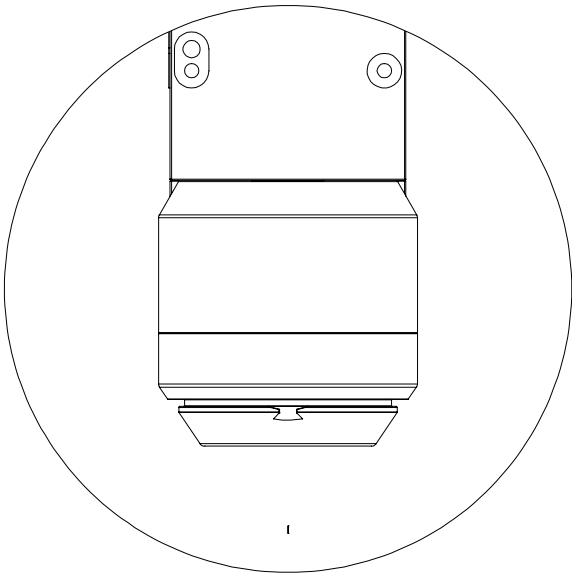


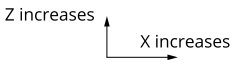
## Field of View / Measurement Range / Coordinate System Orientation



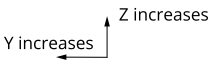



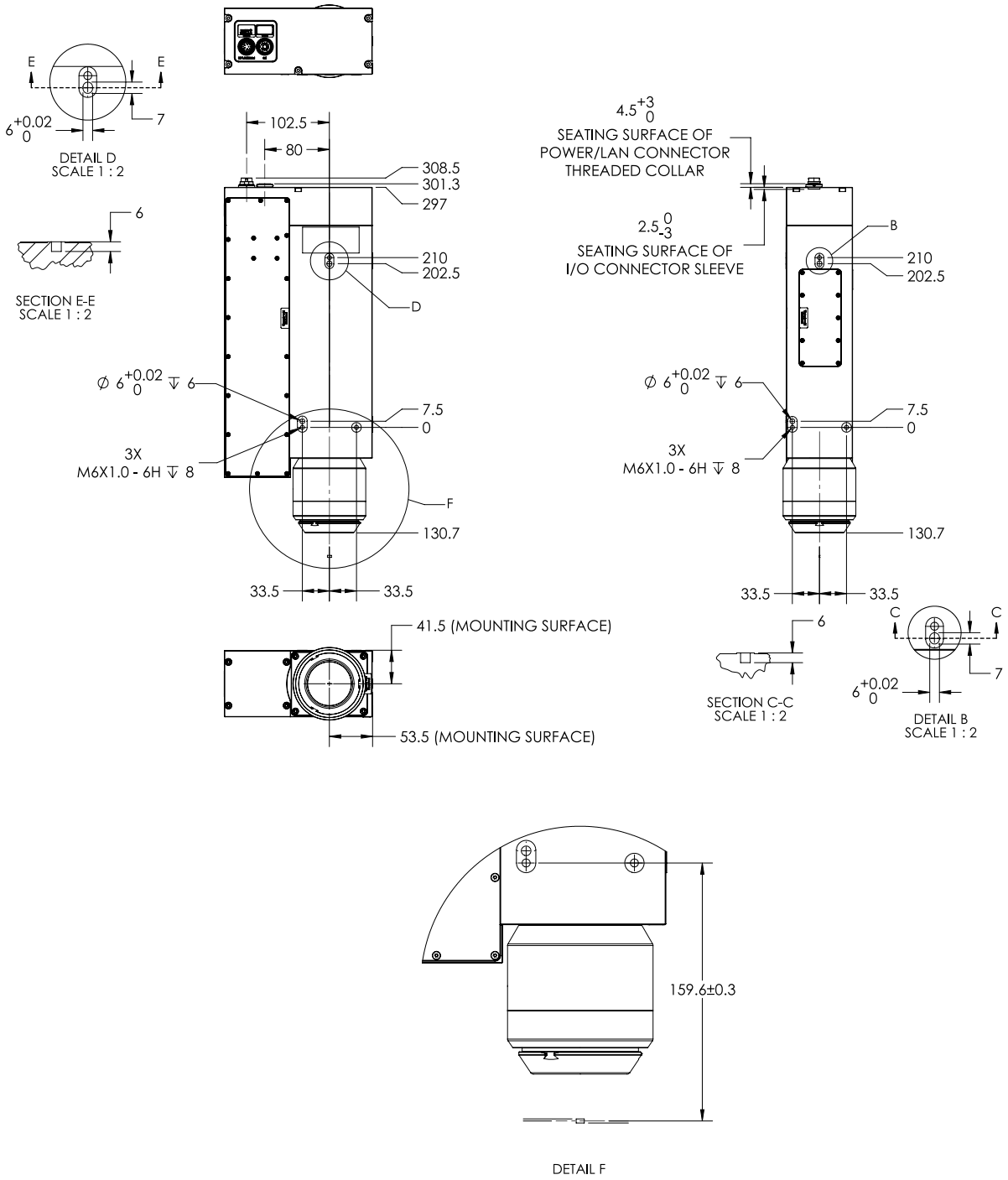



DETAIL A

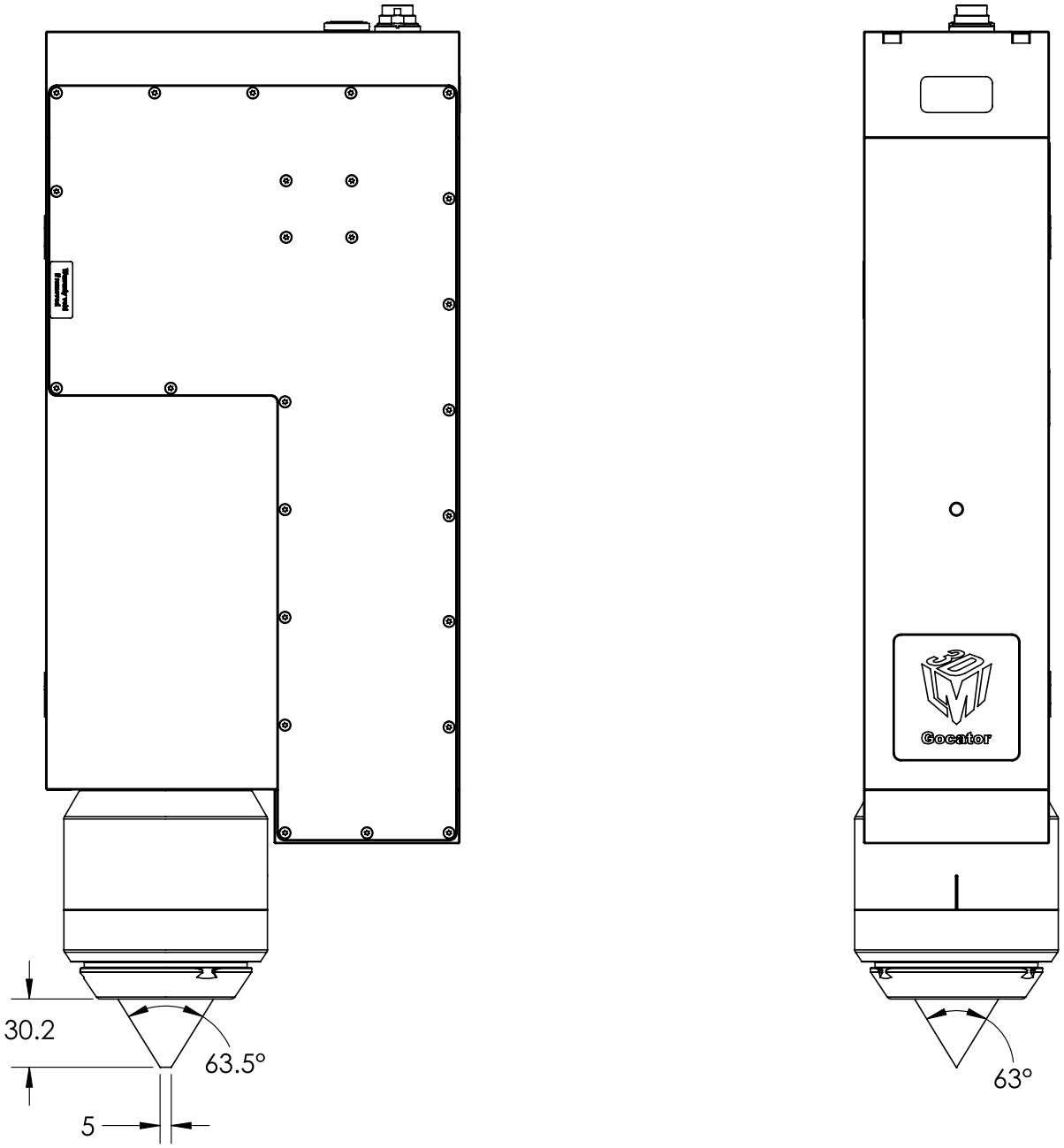



DETAIL B

## Dimensions


E
E
7
DETAIL D
SCALE 1 : 2
6
SECTION E-E
SCALE 1 : 2
102.5
80
308.5
301.3
297
210
202.5
D
7.5
0
3X
M6X1.0 - 6H ↧ 8
F
130.7
33.5
33.5
41.5 (MOUNTING SURFACE)
53.5 (MOUNTING SURFACE)
SEATING SURFACE OF
POWER/LAN CONNECTOR
THREADED COLLAR
SEATING SURFACE OF
I/O CONNECTOR SLEEVE
B
C
C
SECTION C-C
SCALE 1 : 2
DETAIL B
SCALE 1 : 2
159.6±0.3
DETAIL F

**Envelope**



## Gocator 5500 Series

The Gocator 5500 series consists of the following models:

| MODEL | 5504 | 5512 | 5516 |
|---|---|---|---|
| Scan Rate (Hz) [1] | 2100 - 39 000 | 4200 - 40 000 | 3800 - 38 000 |
| Data Points / Profile | 1792 | 1792 | 1792 |
| Resolution X (µm) (Profile Data Interval) | 2.5 | 6.5 | 9.9 |
| Resolution Z (µm) | 0.15 | 0.35 | 0.85 |
| Repeatability Z (µm) [2] | 0.07 | 0.17 | 0..42 |
| Clearance Distance (CD) (mm) | 7.8 | 19.1 | 61.3 |
| Measurement Range (MR) (mm) | 1.1 | 3 | 5.5 |
| Field of View (mm) | 4.3 | 11.6 | 17.0 |
| Max. surface slope on mirror (deg) | ±15.0 | ±20.0 | ±13.5 |
| Dimensions (mm) | 60 x 190 x 303 | 91 x 354 x 419 | 113 x 358 x 440 |
| Housing | IP67 | IP55 | IP50 |
| Weight (kg) | 5 | 19 | 21 |

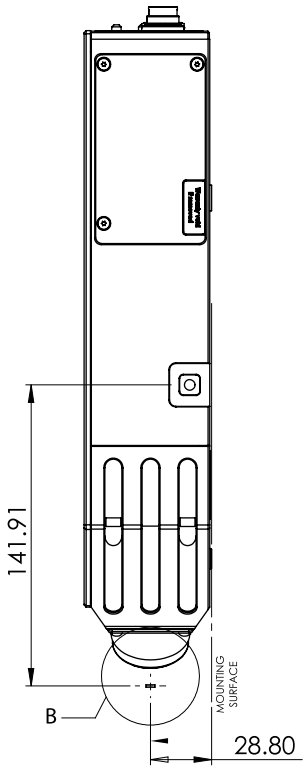
1. Speed ranges are from default configuration (full field of view and full measurement range) to high speed configuration (optimized imager readout, reduced field-of-view and measurement range).
2. These results are achieved with LMI standard target and optimized sensor configuration.

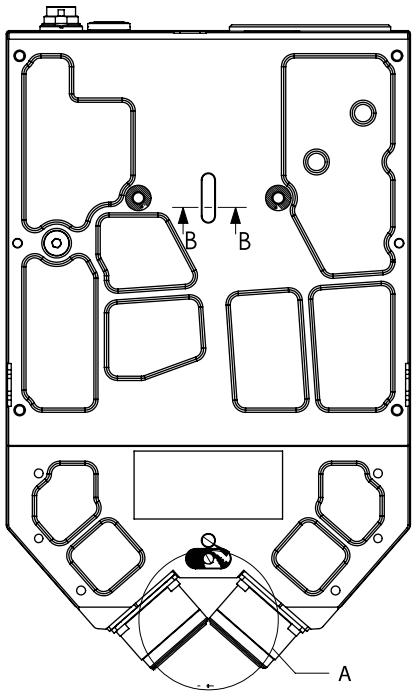
| ALL 5500 SERIES MODELS | |
|---|---|
| Scan Rate | > 16 kHz (when accelerated using PC, without acceleration 300 Hz)<br>(Full MR: G5504 2100 Hz, G5512 4200 Hz, G5516 3800 Hz) |
| Interface | Gigabit Ethernet |
| Inputs | Differential / Single Ended Encoder, Trigger |
| Input Voltage (Power) | Gocator 5512/5516: +24-48 VDC (+/- 5%) @ 62 W<br>Gocator 5504: +24-48 VDC (+/-5%) @ 48 W |
| Housing | 5504: IP67<br>5512: IP55<br>5516: IP50 |
| Operating Temp. | 0–35 °C |
| Storage Temp. | -30 to 70 °C |

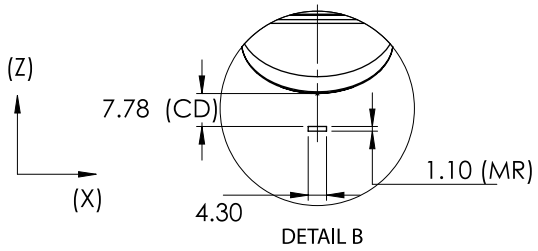
| ALL 5500 SERIES MODELS | |
|---|---|
| Vibration Resistance | 10 to 55 Hz, 1.5 mm double amplitude in X, Y and Z directions, 2 hours per direction |
| Shock Resistance | 15 g, half sine wave, 11 ms, positive and negative for X, Y and Z directions |

Mechanical dimensions, CD/FOV/MR, and the envelope for each sensor model are illustrated on the following pages.

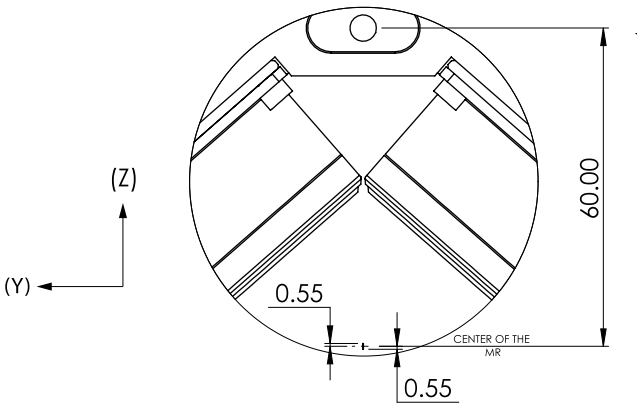
## Field of View / Measurement Range / Coordinate System Orientation



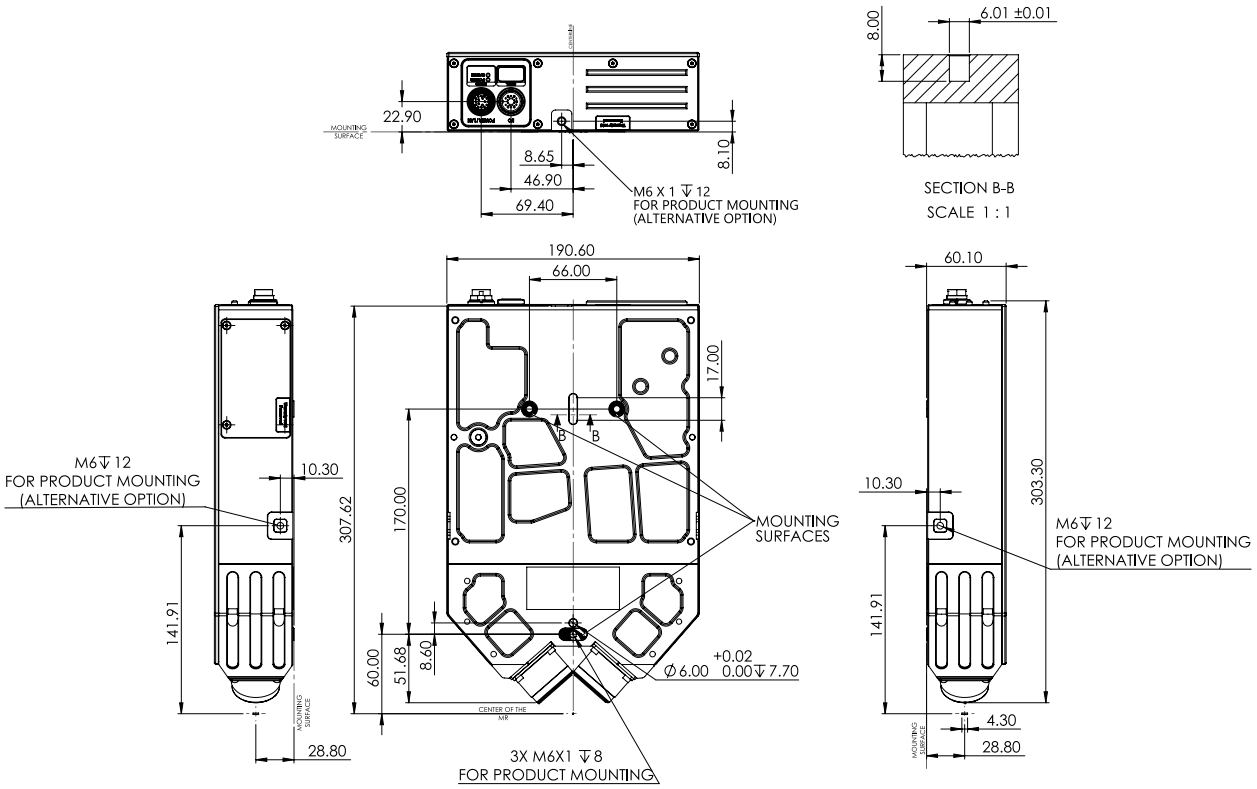




DETAIL B

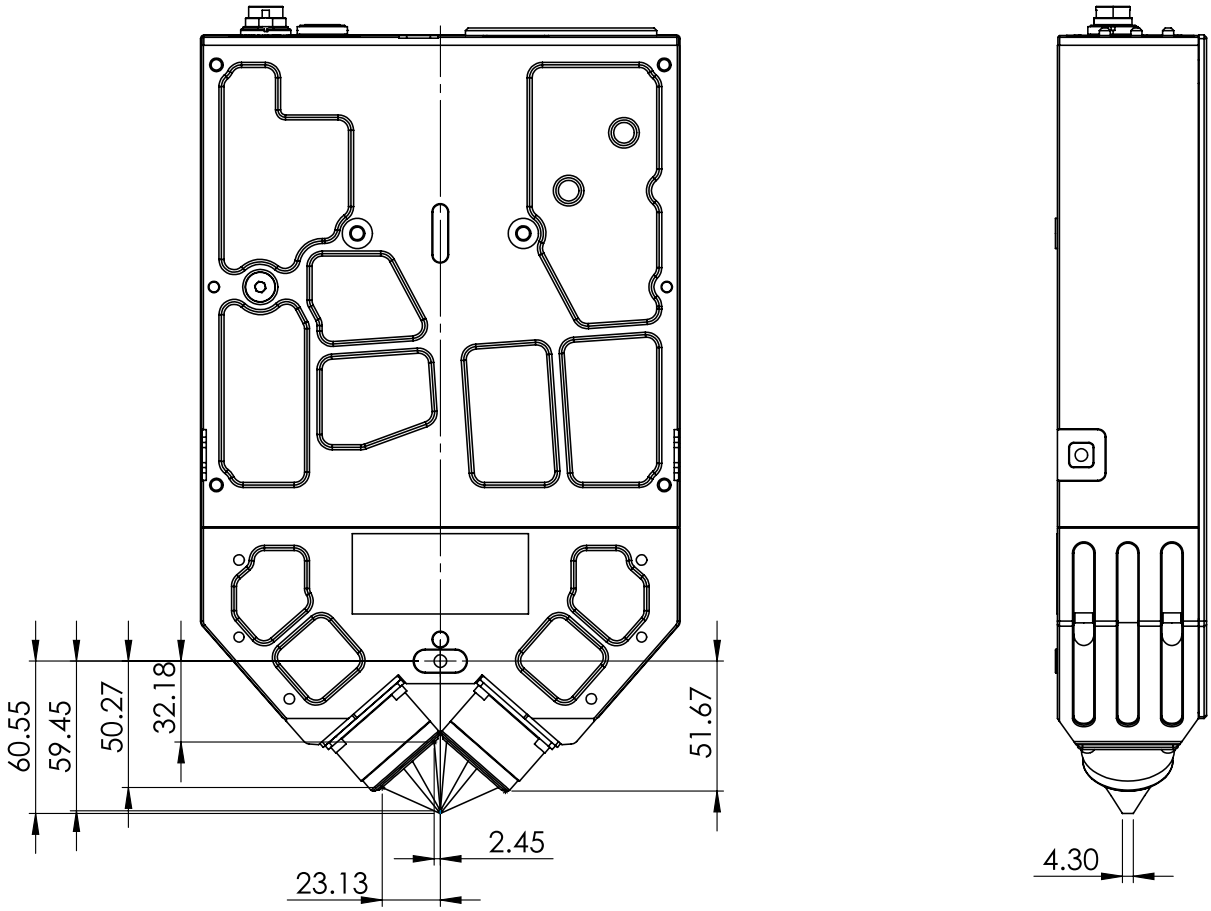



DETAIL A

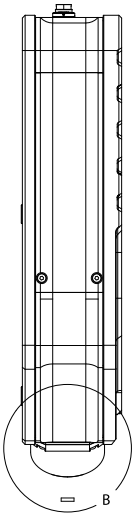
## Dimensions

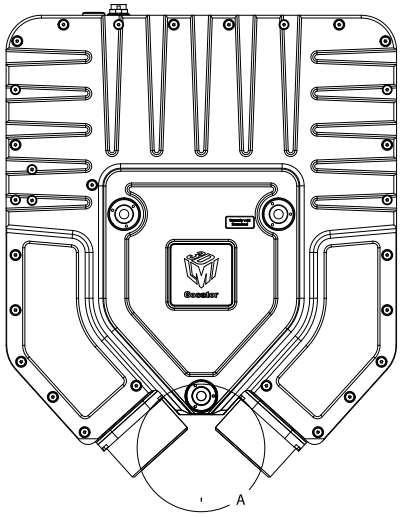

22.90
MOUNTING SURFACE
8.65
46.90
69.40
8.10
M6 X 1 ↧ 12
FOR PRODUCT MOUNTING
(ALTERNATIVE OPTION)
8.00
6.01 ±0.01
SECTION B-B
SCALE 1 : 1
190.60
66.00
17.00
B
B
M6↧12
FOR PRODUCT MOUNTING
(ALTERNATIVE OPTION)
10.30
307.62
170.00
MOUNTING
SURFACES
141.91
60.00
51.68
8.60
+0.02
Ø6.00 0.00↧7.70
CENTER OF THE
MF
MOUNTING
SURFACE
28.80
3X M6X1 ↧8
FOR PRODUCT MOUNTING
60.10
10.30
303.30
M6↧12
FOR PRODUCT MOUNTING
(ALTERNATIVE OPTION)
141.91
4.30
MOUNTING
SURFACE
28.80

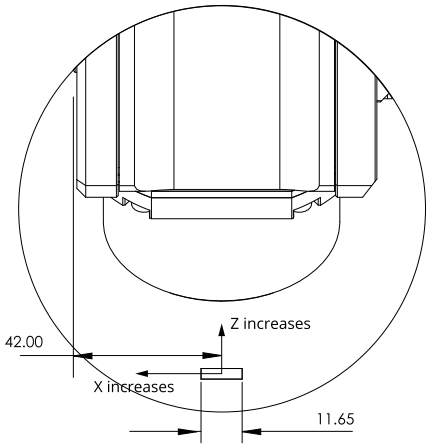
**Envelope**



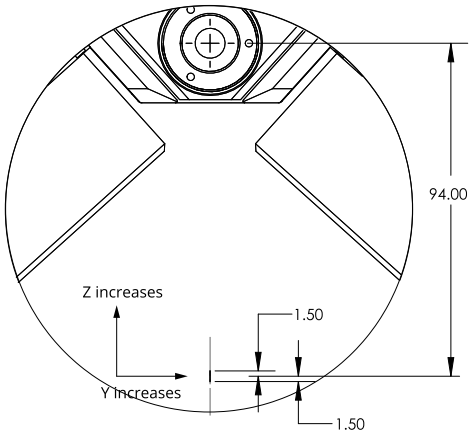
## Field of View / Measurement Range / Coordinate System Orientation



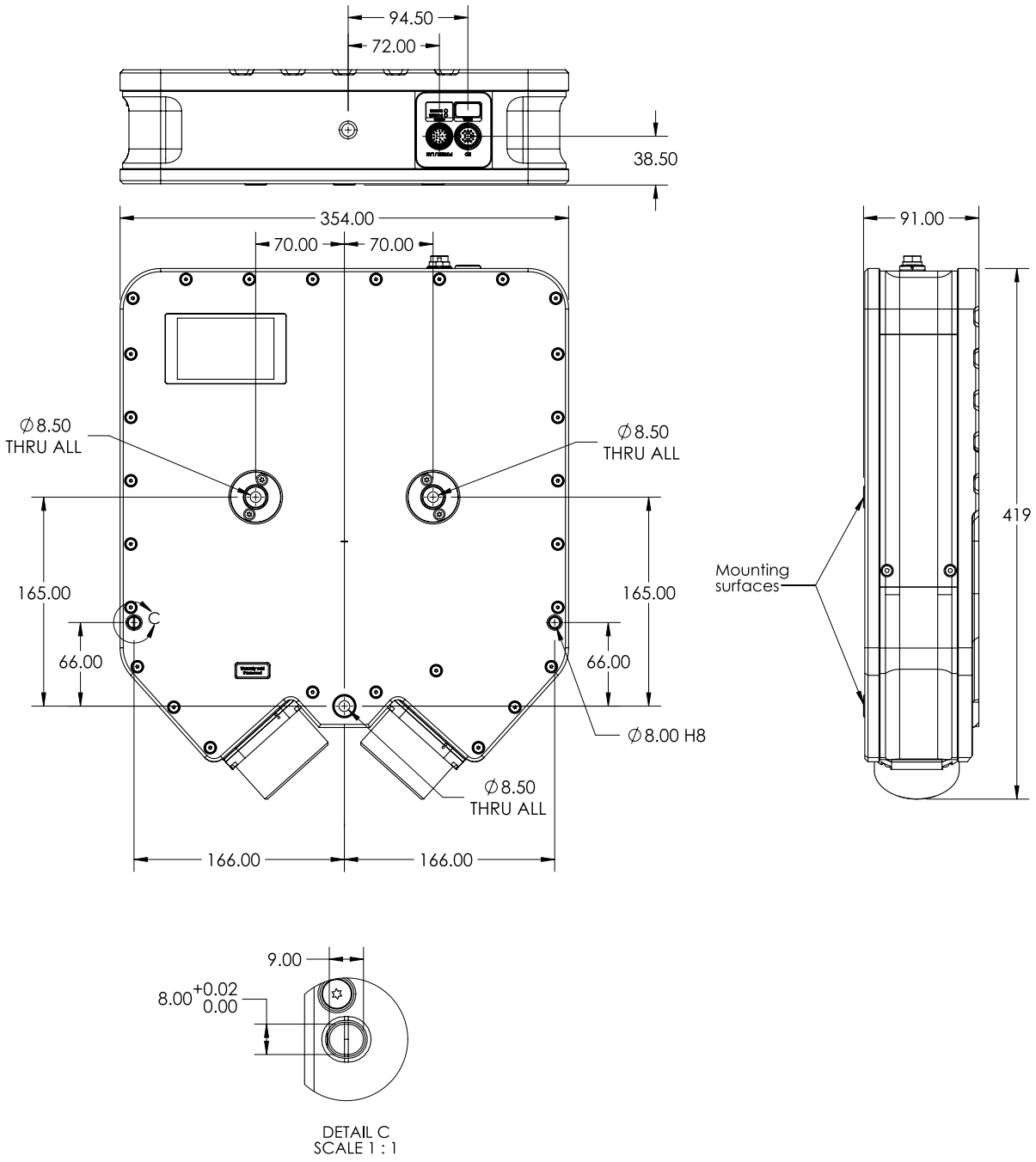




DETAIL B

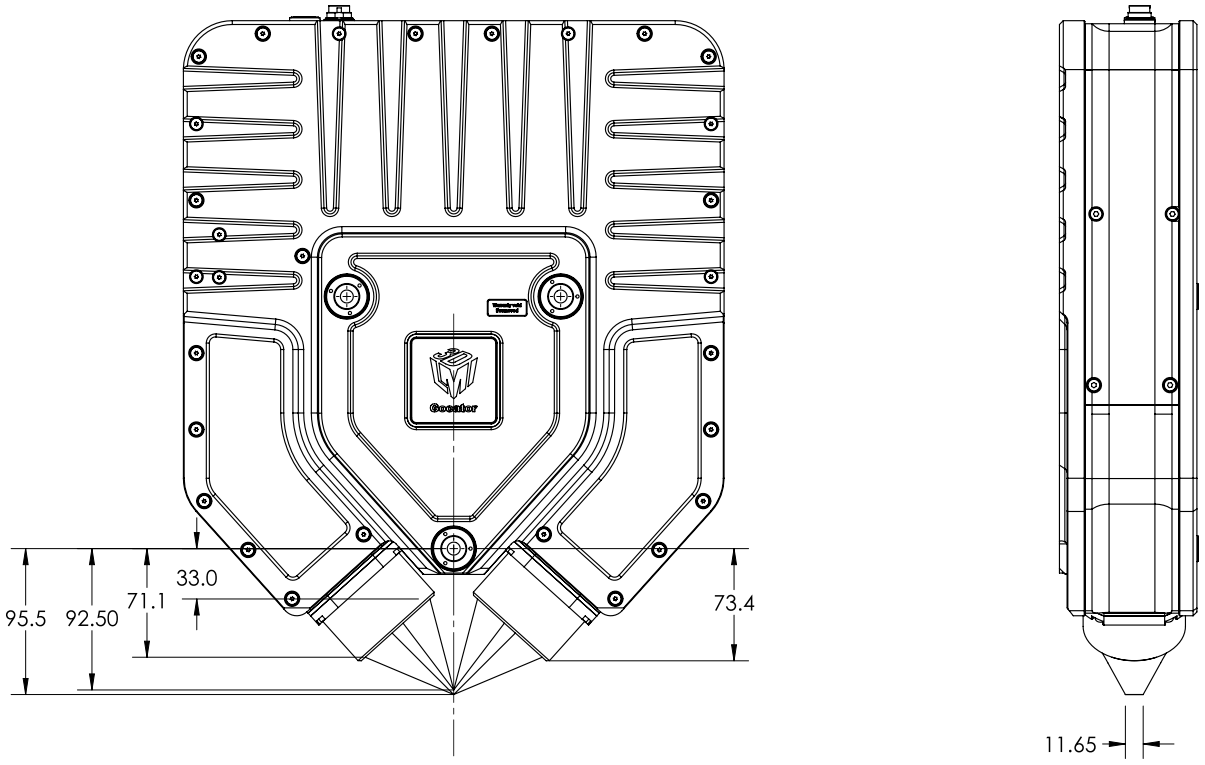



DETAIL A

## Dimensions

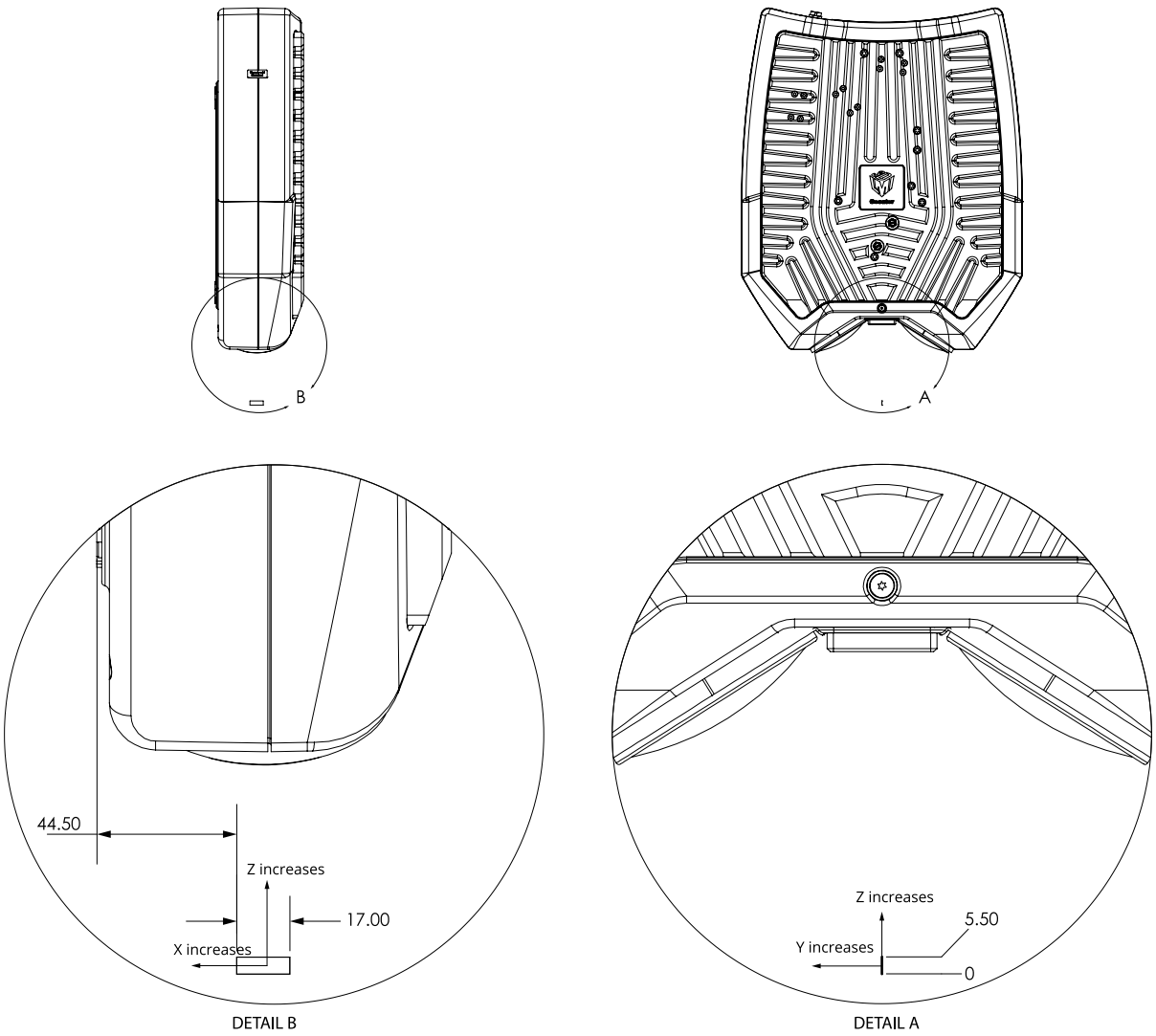

94.50
72.00
38.50
354.00
70.00
70.00
91.00
∅8.50
THRU ALL
∅8.50
THRU ALL
419
Mounting
surfaces
165.00
165.00
66.00
66.00
∅8.00 H8
∅8.50
THRU ALL
166.00
166.00
9.00
8.00 +0.02 0.00
DETAIL C
SCALE 1 : 1

## Envelope

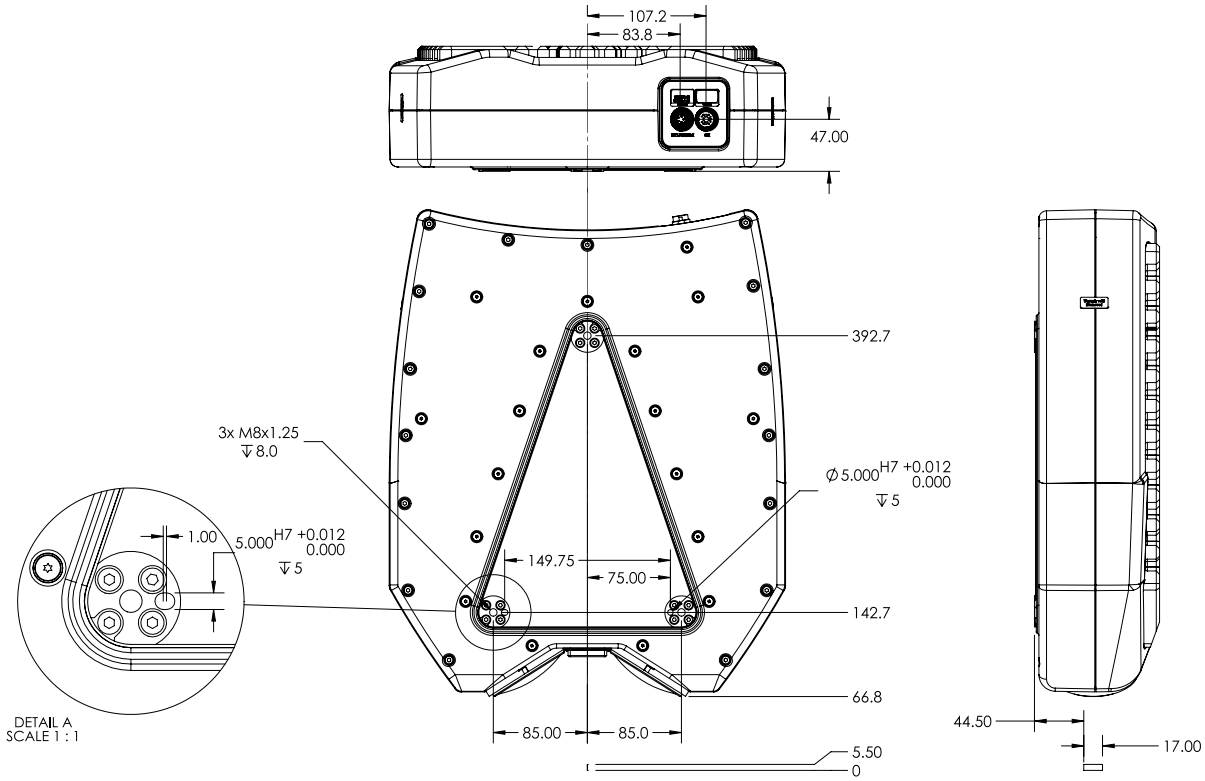


## Gocator 5516

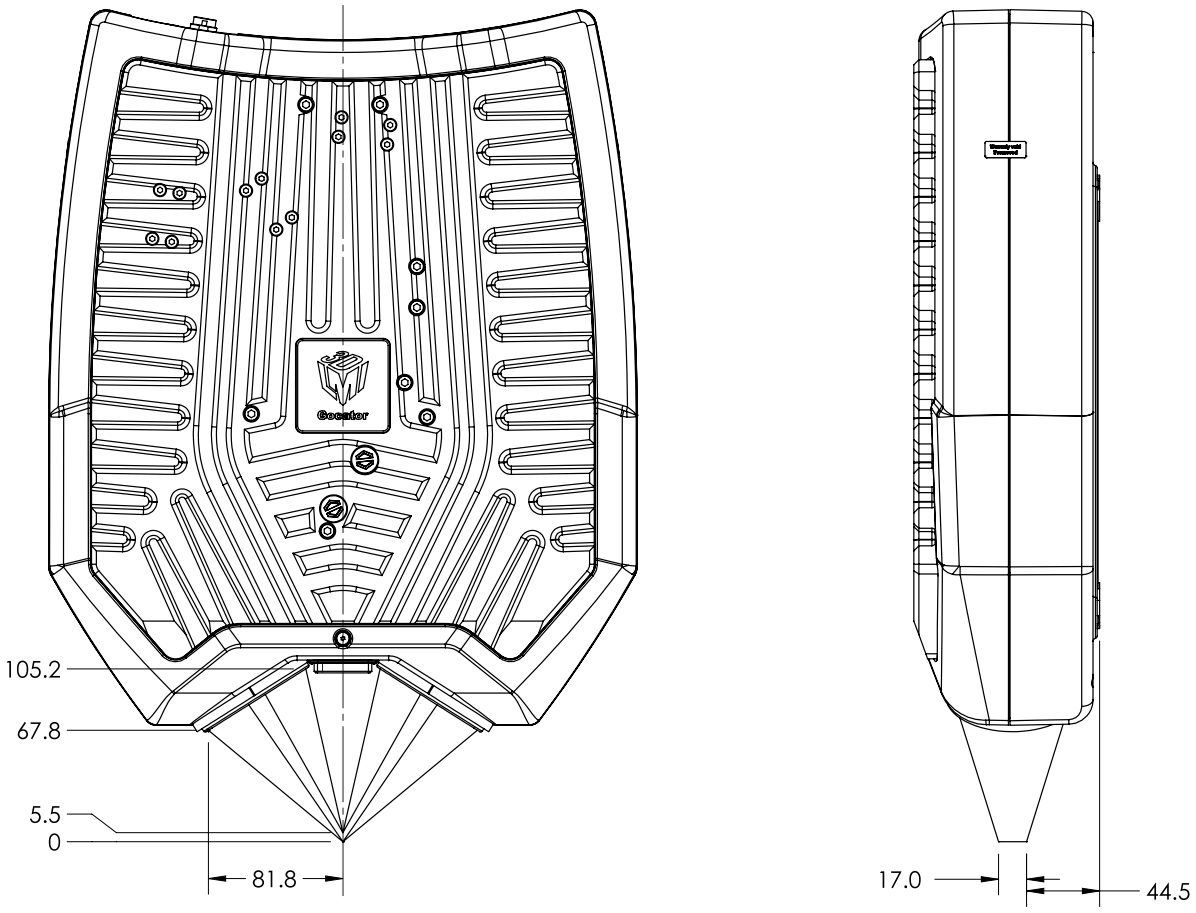
### Field of View / Measurement Range / Coordinate System Orientation




### Dimensions


107.2
83.8
47.00
392.7
3x M8x1.25
↧8.0
Ø5.000H7 +0.012 0.000
↧5
1.00
5.000H7 +0.012 0.000
↧5
149.75
75.00
142.7
66.8
85.00
85.0
5.50
0
DETAIL A
SCALE 1 : 1
44.50
17.00

## Envelope



# Sensor Connectors

The following sections provide the specifications of the connectors on Gocator sensors.

## Gocator Power/LAN Connector

The Gocator Power/LAN connector is a 16-pin, M16 style connector that provides power input, sync, and Ethernet.

> This connector is rated IP67 only when a cable is connected or when the protective cap is in place.

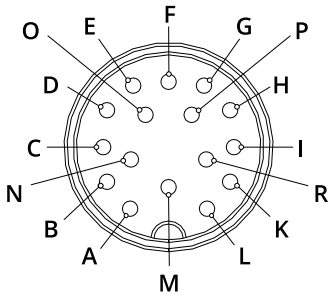
> Confocal profile sensors only support 48 VDC when connect to a Master network controllers. For more information on Masters, see *Master Network Controllers* on page 982.

*Both wires must be connected to the power supply. The leads are connected to the same connector pin, and both are required to support the maximum possible current draw.

**The Sync leads are not connected in the open wire versions of the Power/LAN cordsets.

*Gocator Power/LAN Connector Pins*

| Function | Pin | Lead Color on Cordsets |
|---|---|---|
| 24-48V (MAIN)* | L | Grey/Red |
| GND_24-48V (MAIN)** | M | Grey/Black |
| 24-48V (MAIN)* | L | Pink/Red |
| GND_24-48V (MAIN)** | M | Pink/Black |
| 24-48V (AUX)* | A | Red |
| GND_24-48V (AUX)** | N | Black |
| 24-48V (AUX)* | A | Orange/Red |
| GND_24-48V (AUX)** | N | Orange/Black |
| 24-48V (AUX)* | B | Yellow/Red |
| GND_24-48V (AUX)** | C | Yellow/Black |
| - | O | - |
| - | D | - |
| Ethernet MX1+ | E | Violet/Red |
| Ethernet MX1- | F | Violet/Black |
| Ethernet MX2+ | G | Green/Red |
| Ethernet MX2- | H | Green/Black |
| Ethernet MX3- | R | Blue/Red |
| Ethernet MX3+ | P | Blue/Black |
| Ethernet MX4+ | I | Brown/Red |
| Ethernet MX4- | K | Brown/Black |




*View: Looking into the connector **on** the sensor*

*All 24-48V wires (MAIN and AUX) are soldered together.

**All GND_24-48V (MAIN and AUX) wires are soldered together.

## Grounding Shield

The grounding shield should be mounted to the earth ground.

## Power

Apply positive voltage to DC_24-48V.

*Power requirements*

| Function | Pins | Min | Max |
|---|---|---|---|
| DC 24-48V* | L, A, and B | 24 V | 48 V |
| GND_24-48V (MAIN)** | M, N, and C | 0 V | 0 V |

* All 24-48V wires (MAIN and AUX) are soldered together.

** All GND_24-48V (MAIN and AUX) wires are soldered together.

## Gocator I/O Connector

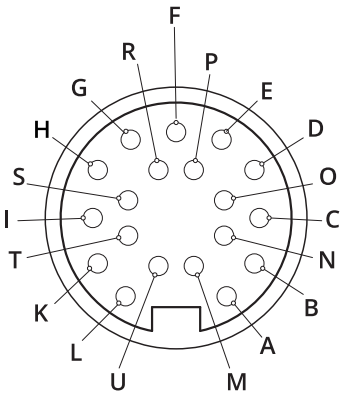
The Gocator I/O connector is a 19 pin, M16 style connector that provides encoder, digital input, digital outputs, serial output, and analog output signals.

> This connector is rated IP67 only when a cable is connected or when the protective cap is in place.

This section defines the electrical specifications for I/O connector pins, organized by function.

*Gocator I/O Connector Pins*

| Function | Pin | Lead Color on Standard Cordset | Lead Color on High Flex Cordset |
|---|---|---|---|
| Trigger_in+ | D | Grey | Blue / Red |
| Trigger_in- | H | Pink | Blue / Black |
| Out_1+ (Digital Output 0) | N | Red | Brown / Red |
| Out_1- (Digital Output 0) | O | Blue | Brown / Black |
| Out_2+ (Digital Output 1) | S | Tan | Green / Red |
| Out_2- (Digital Output 1) | T | Orange | Green / Black |
| Encoder_A+ | M | White / Brown & Black | Pink / Red |
| Encoder_A- | U | Brown / Black | Pink / Black |
| Encoder_B+ | I | Black | Yellow / Red |
| Encoder_B- | K | Violet | Yellow / Black |
| Encoder_Z+ | A | White / Green & Black | White / Red |
| Encoder_Z- | L | Green / Black | White / Black |
| Serial_out+ | B | White | Purple / Red |
| Serial_out- | C | Brown | Purple / Black |
| | E | Blue / Black | Red |
| | G | White / Blue & Black | Black |
| Reserved | P | Green | Gray / Red |
| Reserved | F | Yellow & Maroon / White | Gray / Black & Orange / Black |
| Reserved | R | Maroon (not connected) | Orange / Red (not connected) |




*View: Looking into the connector **on** the sensor*

### Grounding Shield

The grounding shield should be mounted to the earth ground.

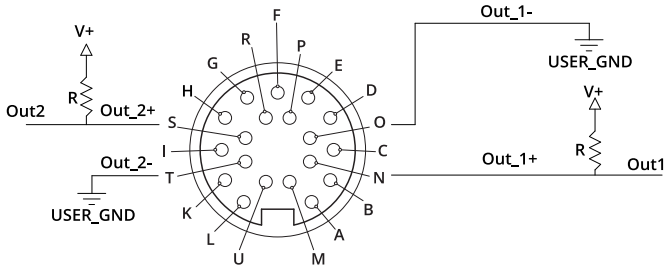
## Digital Outputs

Each sensor has two optically isolated outputs. Both outputs are open collector and open emitter, which allows a variety of power sources to be connected and a variety of signal configurations.

> Digital outputs cannot be used when taking scans using the Snapshot button, which takes a single scan and is typically used to test measurement tool settings. Digital outputs can only be used when a sensor is running, taking a continuous series of scans.

Out_1 (Collector – Pin N and Emitter – Pin O) and Out_2 (Collector – Pin S and Emitter – Pin T) are independent and therefore V+ and GND are not required to be the same.

| Function | Pins | Max Collector Current | Max Collector–Emitter Voltage | Min Pulse Width |
|---|---|---|---|---|
| Out_1 | N, O | 40 mA | 70 V | 20 µs |
| Out_2 | S, T | 40 mA | 70 V | 20 µs |

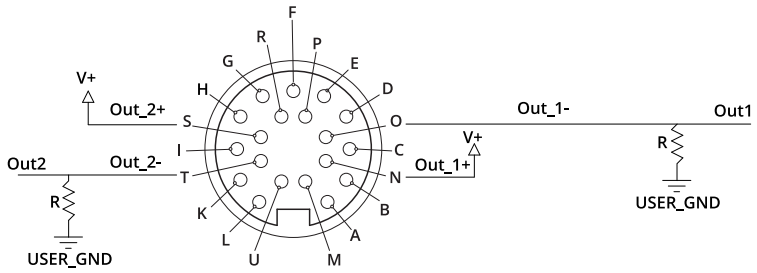



The resistors shown above are calculated by R = (V+) / 2.5 mA.

The size of the resistors is determined by power = (V+)^2 / R.

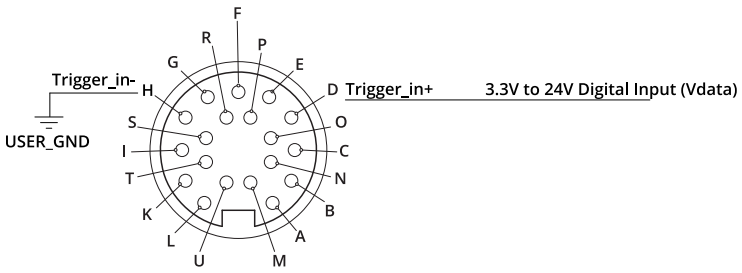
### Inverting Outputs

To invert an output, connect a resistor between ground and Out_1- or Out_2- and connect Out_1+ or Out_2+ to the supply voltage. Take the output at Out_1- or Out_2-. For resistor selection, see above.



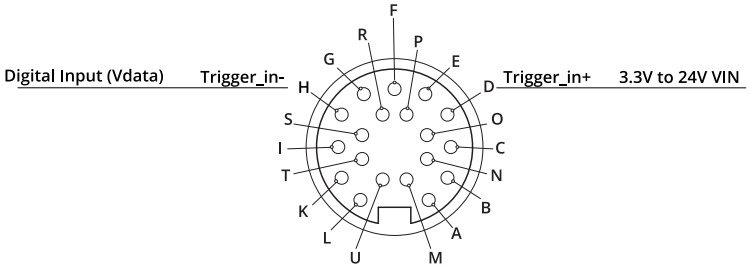

## Digital Input

Every sensor has a single optically isolated input. To use this input without an external resistor, supply 3.3 - 24 V to the positive pin and GND to the negative.




*Active High*

If the supplied voltage is greater than 24 V, connect an external resistor in series to the positive. The resistor value should be R = [(Vin-1.2V)/10mA]-680.



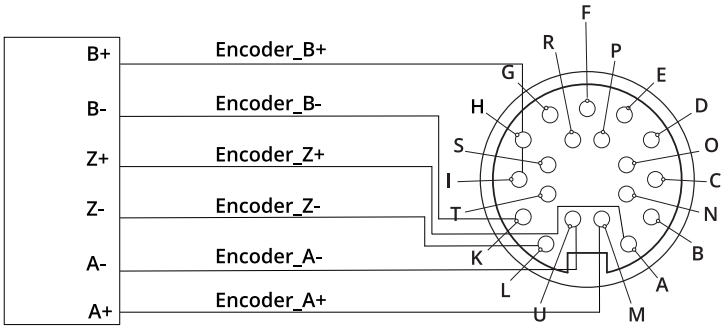

*Active Low*

To assert the signal, the digital input voltage should be set to draw a current of 3 mA to 40 mA from the positive pin. The current that passes through the positive pin is I = (Vin – 1.2 – Vdata) / 680. To reduce noise sensitivity, we recommend leaving a 20% margin for current variation (i.e., uses a digital input voltage that draws 4mA to 25mA).

| Function | Pins | Min Voltage | Max Voltage | Min Current | Max Current | Min Pulse Width |
|---|---|---|---|---|---|---|
| Trigger_in | D, H | 3.3 V | 24 V | 3 mA | 40 mA | 20 µs |

## Encoder Input

Encoder input is provided by an external encoder and consists of three RS-485 signals. These signals are connected to Encoder_A, Encoder_B, and Encoder_Z.



| Function | Pins | Common Mode Voltage | | Differential Threshold Voltage | | | Max Data Rate |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Typ | Max | |
| Encoder_A | M, U | -7 V | 12 V | -200 mV | -125 mV | -50 mV | 1 MHz |
| Encoder_B | I, K | -7 V | 12 V | -200 mV | -125 mV | -50 mV | 1 MHz |
| Encoder_Z | A, L | -7 V | 12 V | -200 mV | -125 mV | -50 mV | 1 MHz |

Gocator supports differential RS485 or RS422 signalling, as well as TTL. Both + and - signals must be connected.

Confocal profile sensors also support single ended encoder connections. These signals are connected to positive Encoder+ pins and encoder GND to the corresponding negative Encoder- pins.

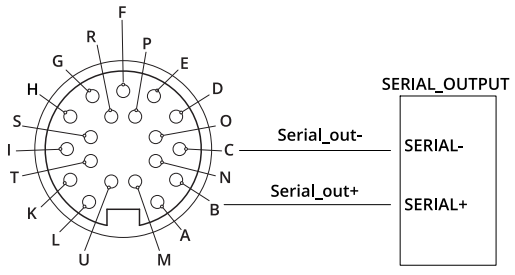
| Function | Pins | Single Ended Voltage | | | Max Data Rate |
|---|---|---|---|---|---|
| | | Min | Typ | Max | |
| Encoder_A+ | M | 2.65 V | 5 V | 5.7 V | 1 MHz |
| Encoder_B+ | I | 2.65 V | 5 V | 5.7 V | 1 MHz |
| Encoder_Z+ | A | 2.65 V | 5 V | 5.7 V | 1 MHz |

Encoders are normally specified in *pulses* per revolution, where each pulse is made up of the four quadrature *signals* (A+ / A- / B+ / B-). Because the sensor reads each of the four quadrature signals, you should choose an encoder accordingly, given the resolution required for your application.

## Serial Output

Serial RS-485 output is connected to Serial_out as shown below.

| Function | Pins |
|---|---|
| Serial_out | B, C |

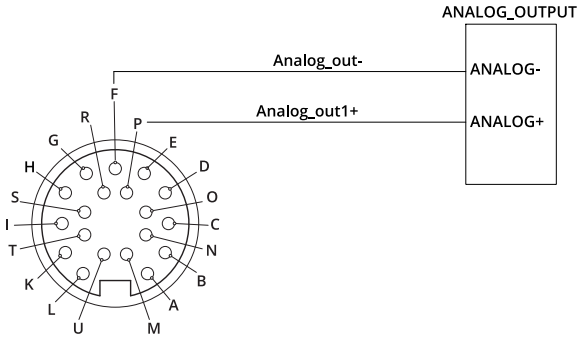



## Analog Output

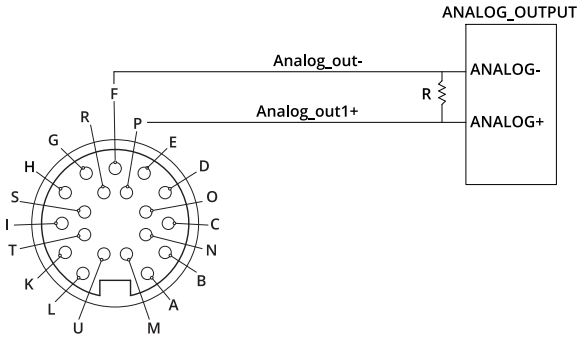
The Sensor I/O Connector defines one analog output interface: Analog_out.

You do not need to supply an external power source.

| Function | Pins | Current Range |
|---|---|---|
| Analog_out | P, F | 4 – 20 mA |

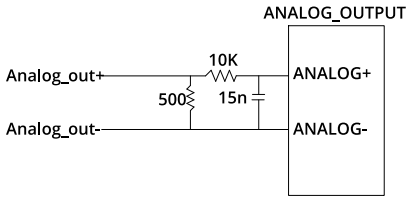



*Current Mode*




*Voltage Mode*

To configure for voltage output, connect a 500 Ohm ¼ Watt resistor between Analog_out+ and Analog_ out- and measure the voltage across the resistor. To reduce the noise in the output, we recommend using an RC filter as shown below.

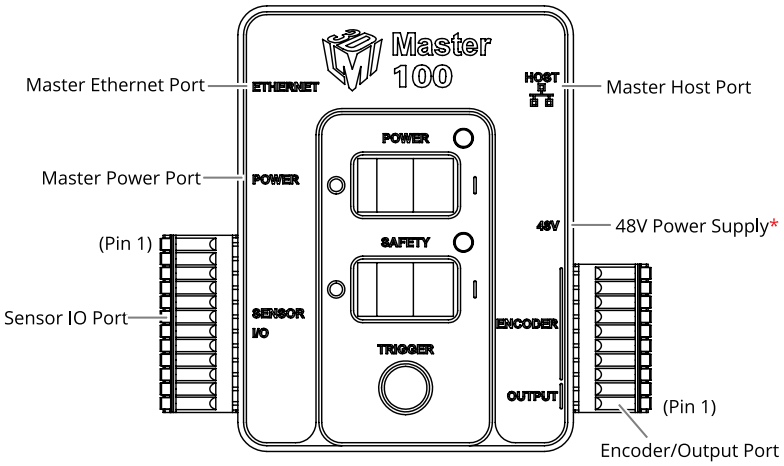


# Master Network Controllers

The following sections provide the specifications of Master network controllers.

## Master 100

The Master 100 accepts connections for power, safety, and encoder, and provides digital output.




*Contact LMI for information regarding this type of power supply.

Connect the Master Power port to the Gocator's Power/LAN connector using the Gocator Power/LAN to Master cordset. Connect power RJ45 end of the cordset to the Master Power port. The Ethernet RJ45 end of the cordset can be connected directly to the Ethernet switch, or connect to the Master Ethernet port. If the Master Ethernet port is used, connect the Master Host port to the Ethernet switch with a CAT5e Ethernet cable.

To use encoder and digital output, wire the Master's Gocator Sensor I/O port to the Gocator IO connector using the Gocator I/O cordset.

*Sensor I/O Port Pins*

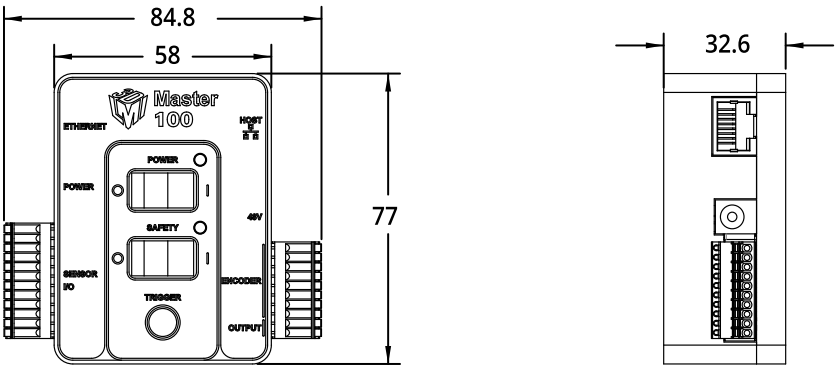
| I/O Pin | Master Pin | Conductor Color |
|---|---|---|
| Encoder_A+ | 1 | Pink / Red |
| Encoder_A- | 2 | Pink / Black |
| Encoder_Z+ | 3 | White / Red |
| Encoder_Z- | 4 | White / Black |
| Trigger_in+ | 5 | Blue / Red |
| Trigger_in- | 6 | Blue / Black |
| Out_1- | 7 | Brown / Black |
| Out_1+ | 8 | Brown / Red |
| Encoder_B+ | 11 | Yellow / Red |
| Encoder_B- | 12 | Yellow / Black |

The rest of the wires in the I/O cordset are not used.

*Encoder/Output Port Pins*

| Function | Pin |
|---|---|
| Output_1+ (Digital Output 0) | 1 |
| Output_1- (Digital Output 0) | 2 |
| Encoder_Z+ | 3 |
| Encoder_Z- | 4 |
| Encoder_A+ | 5 |
| Encoder_A- | 6 |
| Encoder_B+ | 7 |
| Encoder_B- | 8 |
| Encoder_GND | 9 |
| Encoder_5V | 10 |

## Master 100 Dimensions



## Master 810/2410

Master network controllers provide sensor power and laser safety, and broadcast system-wide synchronization information (i.e., time, encoder count, encoder index, and digital I/O states) to all devices on a sensor network.

> It is not necessary to power down a sensor's power source such as a Master before unplugging the sensor from the Master. (Sensors can be "hot-swapped.")

> Some sensors require a minimum input voltage of 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see *Sensors* on page 956.

The following table summarizes Master 810 and 2410:

| **Master 810 and 2410** | |
|---|---|
| Input Voltage (Power) | +24-48 VDC (2 Watts); ripple ± 10%[1] |
| Total Power | Master 810 / 2410 input power + (sensor input power x number of sensors) |
| Capacity | Master 810: up to 8 sensors<br>Master 2410: up to 24 sensors |
| I/O | 4 digital inputs[2]<br>Single-Ended Active LOW: 0 to +0.8 VDC<br>Single-Ended Active HIGH: +3.3 to +24 VDC<br>Differential LOW: 0.8 to -24 VDC<br>Differential HIGH: +3.3 to +24 VDC<br>10-pin Phoenix<br>For more information, see *Electrical Specifications* on page 988. |
| Encoder | Differential (5 VDC, 12 VDC)<br>Single-ended (5 VDC, 12 VDC)[3]<br>For more information, see *Electrical Specifications* on page 988. |
| LED Indicators | Safety, power, encoder, input. For more information, see *LED Indicators* on the next page. |
| Cable | Dual CAT5e cable for power / safety / synchronization / data |
| Weight (kg) | Master 810: 0.6<br>Master 2410: 0.9 |
| Storage Temperature | -30 to 70 °C |
| Operation Temperature | 0 to 50 °C |

### Notes

1. 48 VDC is recommended for multi-sensor systems and is required for G4000, G5000, and G200 systems. Refer to your sensor's "Input Voltage (Power)" specification on its datasheet to calculate the total power required.

2. Gocator only supports one digital input.
3. Supports open collector, pull-up resistor, line driver, push-pull, and TTL.

The following table describes the meanings of the encoder and sensor port LED indicators:

*LED Indicators*

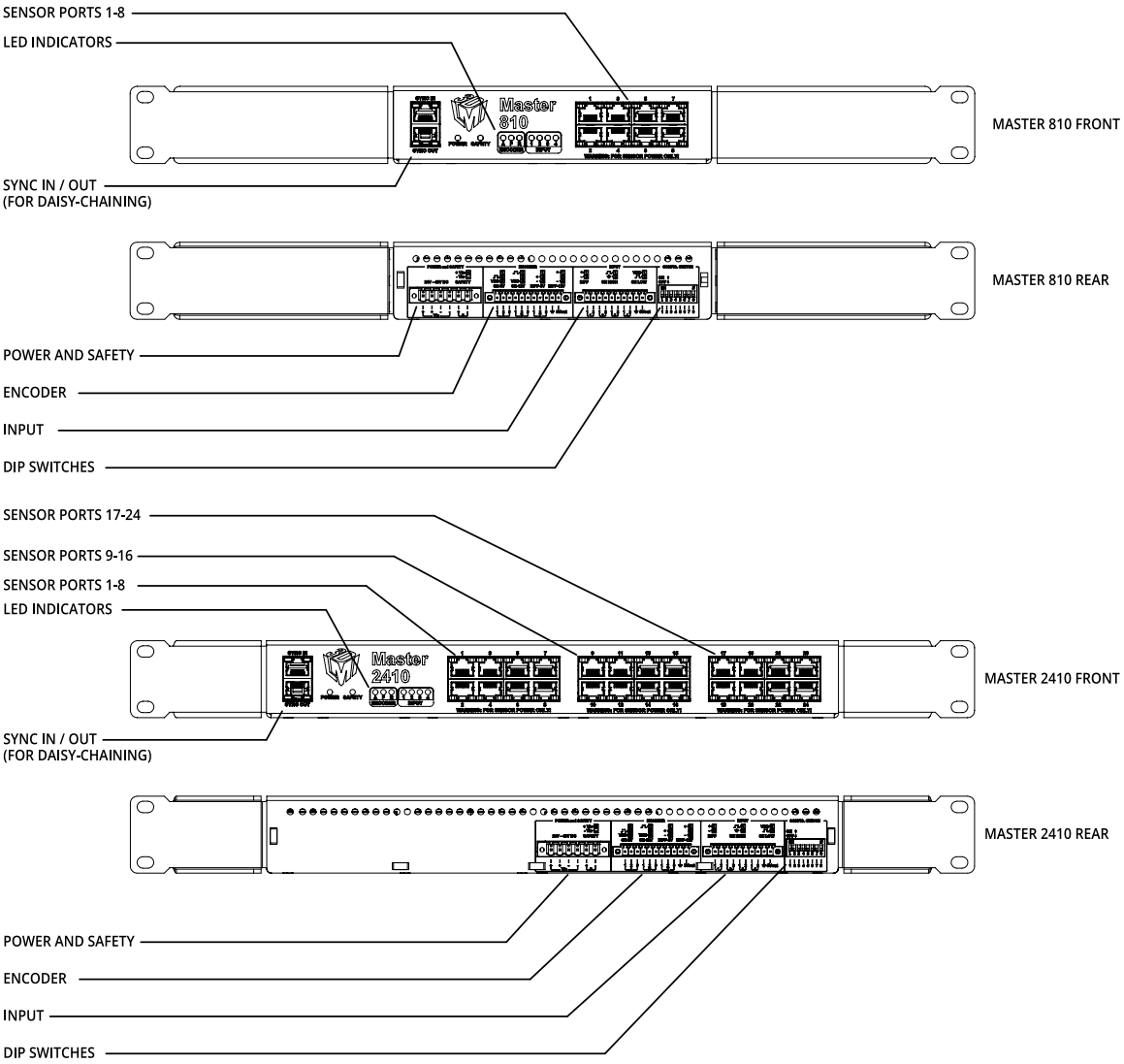
| Indicator | Description |
|---|---|
| Power | Device is on. |
| Safety | Indicates the status of the Laser Safety circuitry. The "On" state indicates that all sensor light sources are active. |
| Encoder A | Reserved |
| Encoder F | **On continuously**: Forward motion with no indexing is detected.<br>**Blinking**: Forward motion with indexing is detected. |
| Encoder R | **On continuously**: Reverse motion with no indexing is detected.<br>**Blinking**: Reverse motion with indexing is detected. |
| Input 1-4 | Digital input ports 1-4 active. |
| SYNC IN and SYNC OUT Ports (Green and Orange LEDs) | Reserved. |
| Sensor Port Green LED | Indicates that a sensor is connected to the port and is powered up. |
| Sensor Port Orange LED | Not used. |

Master 810 and 2410 can be mounted to DIN rails using the provided adapters (for more information, see *Installing DIN Rail Clips: Master 810 or 2410* on page 30). The units are also provided with removable adapters for 1U rack mounting; the mounting holes for this option are compatible with older Master models (400/800/1200/2400).

> The Phoenix connectors on Master 400/800/1200/2400 are not compatible with the connectors on Master 810/2410. For this reason, if you are switching models in your network, you must rewire the connections to the Master.

Master 2410 can currently be used with encoders with a maximum quadrature frequency of 300 kHz.

Master 810 can be configured to work with a maximum encoder quadrature frequency of 6.5 MHz. For more information, see *Configuring Master 810* on page 31.




## Power and Safety

*Power and Safety (6 pin connector)*

| Function | Pin |
|---|---|
| Power In+ | 1 |
| Power In+ | 2 |
| Power In- | 3 |
| Power In- | 4 |
| | 5 |
| | 6 |

The 6-pin Power and Safety connector's specifications are as follows:

- CONNECTOR, 6 Position Terminal Block Plug, Female Sockets 0.200" (5.08mm) 180° Free Hanging (In-Line)
- Manufacturer PN: 1912223
- Supplier Part Number 277-11017-ND
- Manufacturer: Phoenix Contact

> The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

## Encoder

*Encoder (11 pin connector)*

| Function | Pin |
|---|---|
| Encoder_A_Pin_1 | 1 |
| Encoder_A_Pin_2 | 2 |
| Encoder_A_Pin_3 | 3 |
| Encoder_B_Pin_1 | 4 |
| Encoder_B_Pin_2 | 5 |
| Encoder_B_Pin_3 | 6 |
| Encoder_Z_Pin_1 | 7 |
| Encoder_Z_Pin_2 | 8 |
| Encoder_Z_Pin_3 | 9 |
| GND (output for powering external devices) | 10 |
| +5VDC (output for powering external devices) | 11 |

> For Encoder connection wiring options, see *Encoder* on page 989.

The 11-pin Encoder connector's specifications are as follows:

- CONNECTOR, 11 Position Terminal Block Plug, Female Sockets 0.138" (3.50mm) 180° Free Hanging (In-Line)
- Manufacturer PN: 1847217
- Supplier Part Number 277-8897-ND
- Manufacturer: Phoenix Contact

## Input

> On earlier revisions of Master 810 and Master 2410, the inputs are labeled 0-3.

*Input (10 pin connector)*

| Function | Pin |
|---|---|
| Input 1 Pin 1 | 1 |
| Input 1 Pin 2 | 2 |
| Reserved | 3 |

| Function | Pin |
|---|---|
| Reserved | 4 |
| Reserved | 5 |
| Reserved | 6 |
| Reserved | 7 |
| Reserved | 8 |
| GND (output for powering other devices) | 9 |
| +5VDC (output for powering other devices) | 10 |

For Input connection wiring options, see *Input* on page 991.

The following are the 10-pin Input connector's specifications:

- CONNECTOR, 10 Position Terminal Block Plug, Female Sockets 0.138" (3.50mm) 180° Free Hanging (In-Line)
- Manufacturer PN: 1847204
- Supplier Part Number 277-6350-ND
- Manufacturer: Phoenix Contact

The Input connector does not need to be wired up for proper operation.

## Electrical Specifications

Some sensors require a minimum input voltage of 48 VDC. Verify the accepted input voltage for your sensor in the sensor's specifications; for specifications, see*Sensors* on page 956

*Electrical Specifications*

| Specification | Value |
|---|---|
| Power Supply Voltage | +24 VDC to +48 VDC; ripple ± 10%<br>48 VDC is recommended for multi-sensor systems and is required for G4000, G5000, and G200 systems. Refer to your sensor's "Input Voltage (Power)" specification on its datasheet to calculate the total power required. |
| Power Supply Current (Max.)* | Master 810: 9 A<br>Master 2410: 25 A<br>* Fully loaded with 1 A per sensor port. |
| Power Draw (Min.) | Master 810: 1.7 W<br>Master 2410: 4.8 W |
| Encoder Signal Voltage | Single-Ended Active LOW: 0 to +0.8 VDC<br>Single-Ended Active HIGH: +3.3 to +24 VDC<br>Differential LOW: 0.8 to -24 VDC<br>Differential HIGH: +3.3 to +24 VDC |

| Specification | Value |
|---|---|
| | For more information, see *Encoder* below. |
| Digital Input Voltage Range | Single-Ended Active LOW: 0 to +0.8 VDC<br>Single-Ended Active HIGH: +3.3 to +24 VDC<br>Differential LOW: 0.8 to -24 VDC<br>Differential HIGH: +3.3 to +24 VDC<br>For more information, see *Input* on page 991. |

If the input voltage is above 24 V, use an external resistor, using the following formula:

R = [(Vin - 1.2V) / 10mA] - 680

⚠ When using a Master hub, the chassis must be well grounded.

The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

24 VDC power supply is only supported if all connected sensors support an input voltage of 24 VDC.

The Power Draw specification is based on a Master with no sensors attached. Every sensor has its own power requirements that need to be considered when calculating total system power requirements..

**Encoder**

Master 810 and 2410 support the following types of encoder signals: Single-Ended (5 to 12 VDC, 12 to 24 VDC) and Differential (5 to 12 VDC, 12 to 24 VDC).

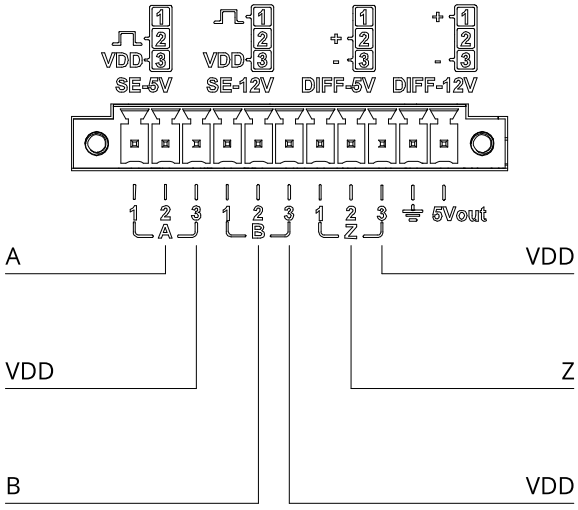
For 5 to 12 VDC operation, pins 2 and 3 of each channel are used.

The 5-volt encoder input supports up to 12 volts for compatibility with earlier Master network controllers. However, we strongly recommend connecting 12-volt output encoders to the appropriate 12-volt input to attain maximum tolerance.

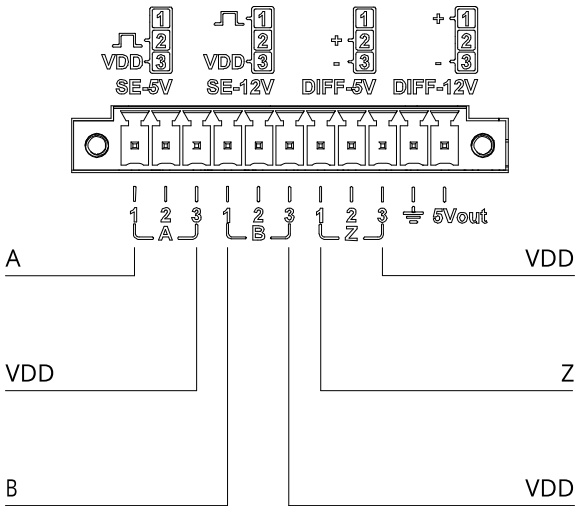
For 12 to 24 VDC operation, pins 1 and 3 of each channel are used.

Although Master 810 and 2410 are currently labeled as only supporting up to 12 VDC, they can support up to 24 VDC.

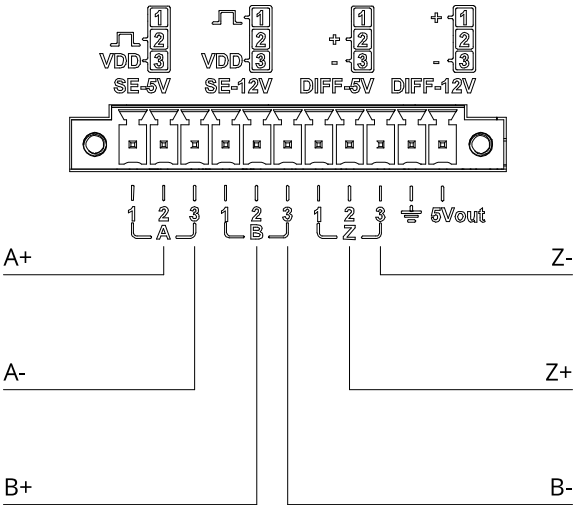
To determine how to wire a Master to an encoder, see the illustrations below.



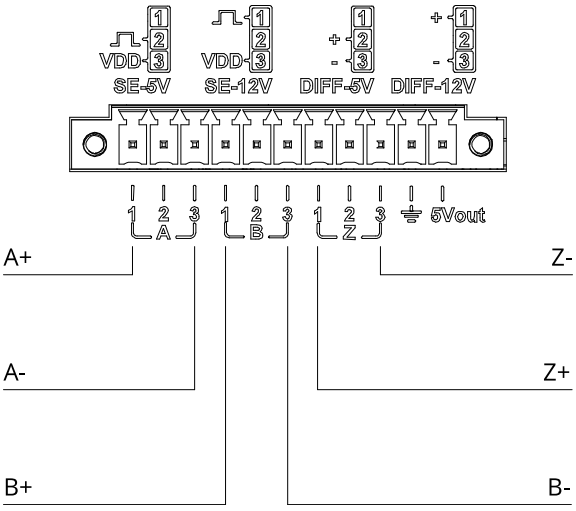

*Single-Ended 5 VDC*




*Single-Ended 12 VDC*




*Differential 5 VDC*



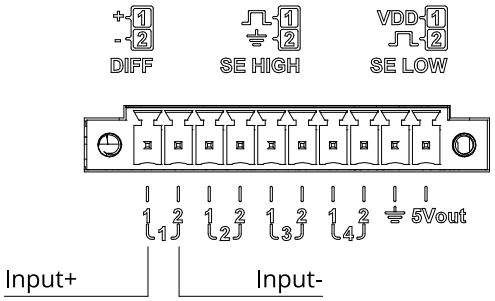

*Differential 12 VDC*

**Input**

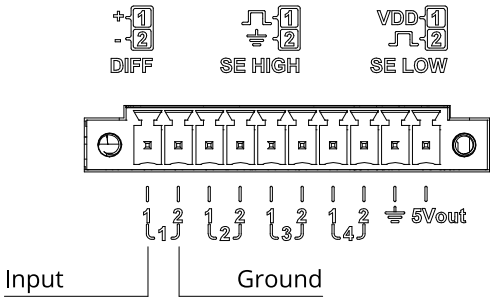
Master 810 and 2410 support the following types of input: Differential, Single-Ended High, and Single-Ended Low.

| | |
|---|---|
| | Currently, Gocator only supports Input 0. |

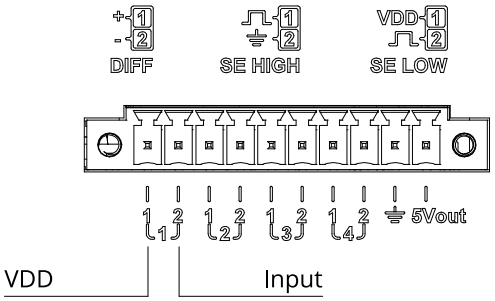
For digital input voltage ranges, see the table below.




*Differential*




*Single-Ended Active High*



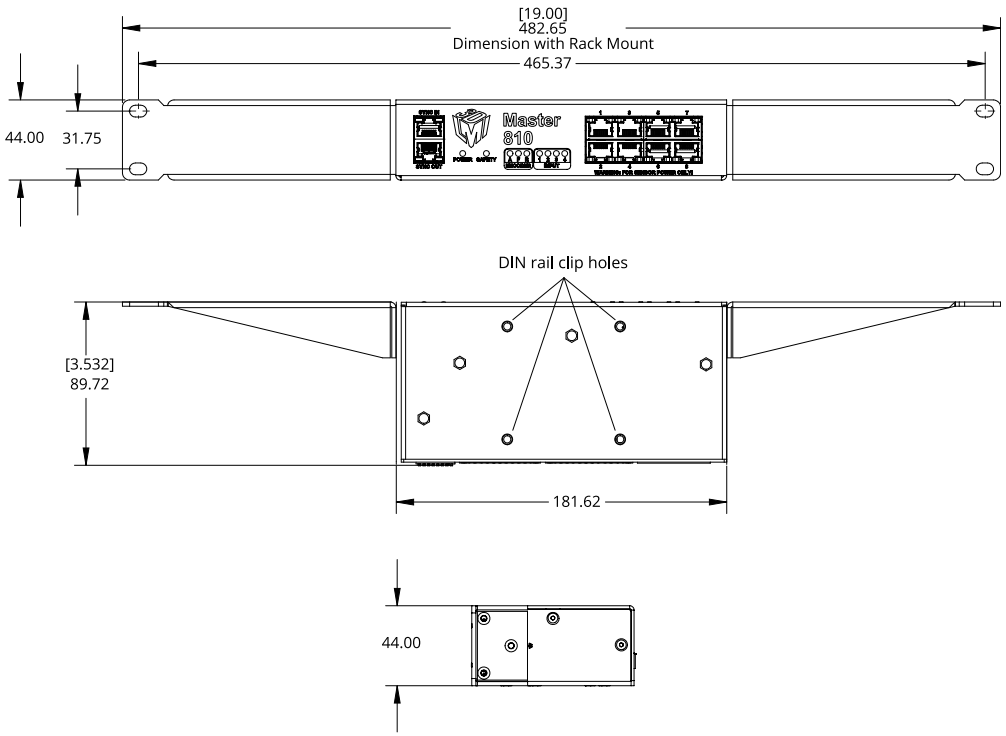

*Single-Ended Active Low*

*Digital Input Voltage Ranges*

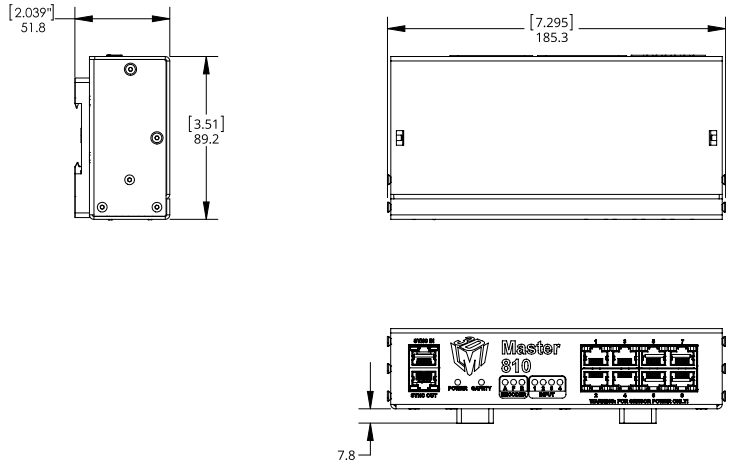
| | Input Status | Min (VDC) | Max (VDC) |
|---|---|---|---|
| Single-ended Active High | Off | 0 | +0.8 |
| | On | +3.3 | +24 |
| Single-ended Active Low | Off | ($V_{DD}$ - 0.8) | $V_{DD}$ |
| | On | 0 | ($V_{DD}$ - 3.3) |
| Differential | Off | -24 | +0.8 |
| | On | +3.3 | +24 |

## Master 810 Dimensions

With 1U rack mount brackets:



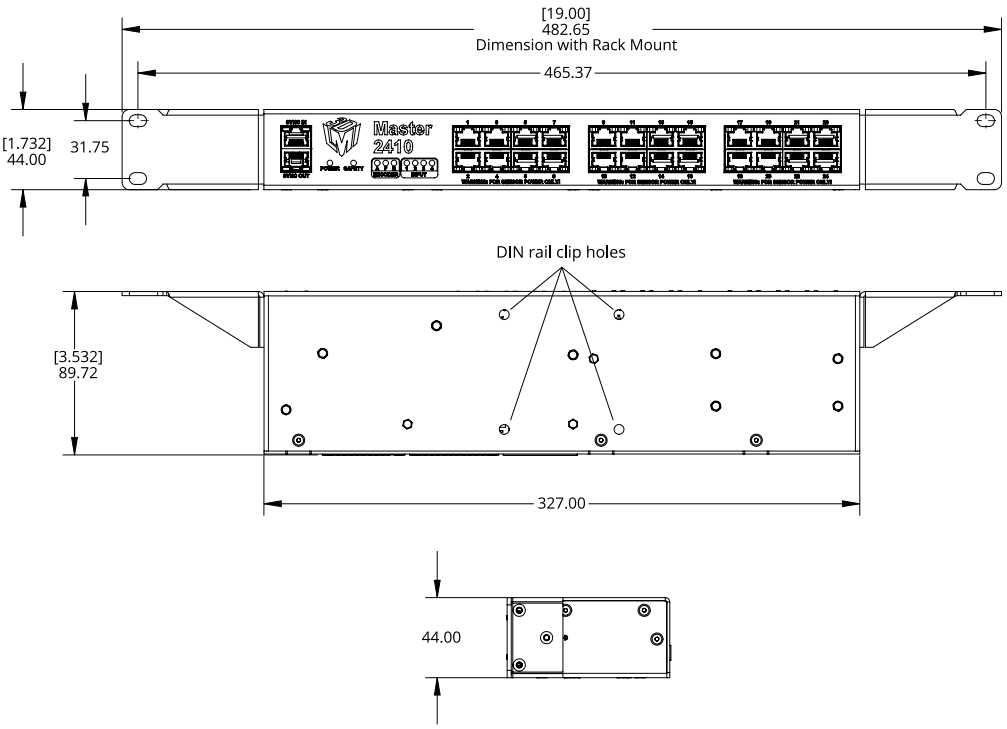

With DIN rail mount clips:



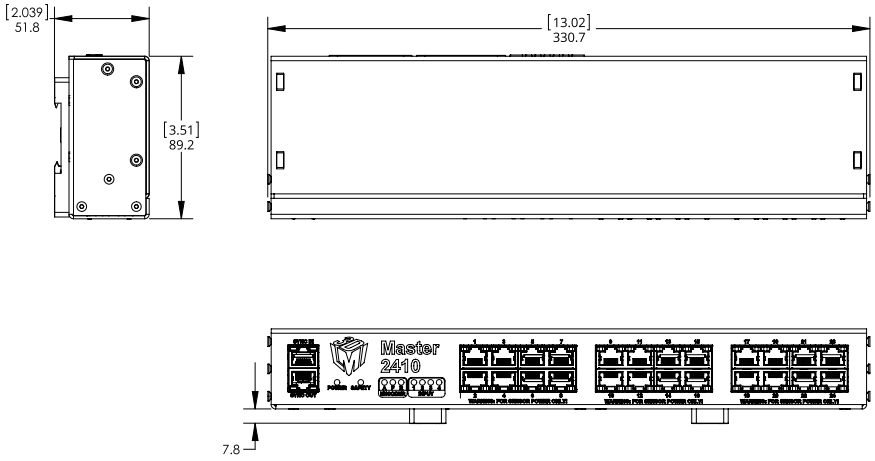

Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

## Master 2410 Dimensions

With 1U rack mount brackets:




With DIN rail mount clips:




Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

# Accessories

*Masters*

| Description | Part Number |
|---|---|
| Master 100 - for single sensor (development only) | 30705 |
| Master 810 - for networking up to 8 sensors | 301114 |
| Master 2410 - for networking up to 24 sensors | 301115 |

*High Flex Gocator Cordsets*

| Description | Part Number |
|---|---|
| 5m I/O cordset, open wire end | 301175-5m |
| 5m High Power and Ethernet cordset, 1x open wire end, 1x RJ45 end | 301203-5m |
| 10m High Power and Ethernet cordset, 1x open wire end, 1x RJ45 end | 301203-10m |
| 5m High Power and Ethernet to Master cordset, 90-deg, 2 x RJ45 ends (48V only) | 301237-5m |
| 5m I/O cordset, 90-deg, open wire end | 301172-5m |
| 5m High Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end | 301202-5m |
| 10m High Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end | 301202-10m |
| 5m High Power and Ethernet to Master cordset, 2 x RJ45 ends (48V only) | 301238-5m |

### Notes related to cordsets

For information on cordset bend radius limits, see *Cordset Bend Radius Limits* on page 33.

Custom cordset lengths between 25 m and 60 m (maximum) and connector orientations are available upon request. Prices depend on length and orientation requested. Extension cordsets with one male and one female Gocator connector are also available on request.

90-degree connectors can be adjusted one of four different orientations by opening the connector.

# Troubleshooting

Review the guidance in this chapter if you are experiencing difficulty with a sensor system.

If the problem that you are experiencing is not described in this section, see *Return Policy* on page 997.

**Mechanical/Environmental**

The sensor is warm.

- It is normal for a sensor to be warm when powered on. A sensor is typically 15° C warmer than the ambient temperature.

**Connection**

When attempting to connect to the sensor with a web browser, the sensor is not found (page does not load).

- Verify that the sensor is powered on and connected to the client computer network. The Power Indicator LED should illuminate when the sensor is powered.
- Check that the client computer's network settings are properly configured.
- Use the Sensor Recovery tool to verify that the sensor has the correct network settings. See *GoPxL Discovery Tool* on page 917 for more information.

When attempting to log in, the password is not accepted.

- Use the Sensor Recovery tool. See *GoPxL Discovery Tool* on page 917 for steps to reset the password.

**Performance**

The sensor CPU level is near 100%.

- LMI recommends running confocal profile sensors through the PC-based version of GoPxL. For more information, see *Running GoPxL on a Windows PC* on page 814.
- Consider reducing the speed. If you are using a time or encoder trigger source, see *Triggers* on page 120 for information on reducing the speed. If you are using an external input or software trigger, consider reducing the rate at which you apply triggers.
- Review the measurements that you have programmed and eliminate any unnecessary measurements.

# Return Policy

**Return Policy**
Before returning the product for repair (warranty or non-warranty) a Return Material Authorization (RMA) number must be obtained from LMI. Please call LMI to obtain this RMA number.

Carefully package the sensor in its original shipping materials (or equivalent) and ship the sensor prepaid to your designated LMI location. Please ensure that the RMA number is clearly written on the outside of the package. Inside the return shipment, include the address you wish the shipment returned to, the name, email and telephone number of a technical contact (should we need to discuss this repair), and details of the nature of the malfunction. For non-warranty repairs, a purchase order for the repair charges must accompany the returning sensor.

LMI Technologies Inc. is not responsible for damages to a sensor that are the result of improper packaging or damage during transit by the courier.

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**CLI11**

Website:

https://github.com/CLIUtils/CLI11

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**xxhash**

Website:

https://github.com/Cyan4973/xxHash

License:

xxHash Library

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xxhsum command line interface

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**JSON for C++**

Website:

https://github.com/nlohmann/json

License:

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**OpENer**

Website:

https://github.com/EIPStackGroup/OpENer

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https://github.com/jpoirier/picoc

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**tar (binary only)**

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**react**

Website:

https://reactjs.org/

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**react-dnd**

Website:

https://github.com/react-dnd/react-dnd/

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**react-router**

Website:

https://github.com/ReactTraining/react-router

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**rxjs**

Website:

https://github.com/ReactiveX/rxjs

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