USER MANUAL

GoPxL for G3 Sensors

Gocator 3210 & 3500 Series Sensors

Firmware version: 1.0.x.x

Document revision: B

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Introduction

This documentation describes how to connect, configure, and use a Gocator snapshot sensor ("G3 sensor" for short) using the GoPxL software.

> Before using a sensor, you should familiarize yourself with sensor safety and maintenance. For more information, see *Safety and Maintenance* on page 13.

For a breakdown of this documentation, see *Using the Manual* on page 15.

The documentation applies to the following:

- Gocator 3210
- Gocator 3500 series
- GoMax NX
- X64-based PC (Intel/AMD) running Windows 10 (for running GoPxL on a PC)

> GoPxL only supports GoMax NX, not the pre-NX version.

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.

For a description of the connector pins, see *Gocator I/O Connector* on page 796.

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 778.

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.

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
The sensor operating temperature range is 0 to 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.

⚠	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.

⚠	Sensors are high-accuracy devices, and the temperature of all of its components must therefore 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 in the sensor.

Using the Manual

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

Manual breakdown

Category	Description
Safety and Maintenance	Important safety and maintenance information (see *Sensor Management and Maintenance* on page 90).
Getting Started	Hardware overview and installation information (see *Getting Started* on page 17).
Key Concepts	Fundamental Gocator sensor concepts (see *Key Concepts* on page 41).
User Interface Overview	General overview of the GoPxL user interface (see *User Interface Overview* on page 58).
Data Viewer	Description of the data viewer and how to use it (see *Data Viewer* on page 62).
File Formats	Lists the formats used in GoPxL (see *File Formats* on page 83).
Working with Scan Data	Describes how to record scan data and how to play back recordings (see *Working with Scan Data* on page 85).
Creating, Saving and Loading Jobs	Describes how to work with jobs (see *Creating, Saving and Loading Jobs* on page 88).
Configuring Systems	Contains subsections describing how to do the following: • Perform general sensor maintenance • Create a sensor system • Align sensors • Configure acquisition • Configure inspection and processing tools • Configure control (including protocol and GoHMI) • Configure reporting For more information, see *Configuring Systems* on page 89.
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. For more information, see *Running GoPxL on a Windows PC* on page 656.
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 692).
GoHMI	Describes how to configure GoHMI in a PC instance of GoPxL. Also describes the GoHMI Designer (see *GoHMI and GoHMI Designer* on page 666).
Integrations	Describes the industrial protocols you can use in GoPxL (see See *Integrations* on page 703).
Specifications	Provides sensor specifications and drawings (see *Specifications* on page 777).

Gocator Overview

Gocator sensors are designed for 3D measurement and control applications.Sensors are configured using a web browser and can be connected to a variety of input and output devices. Sensors can also be configured using the provided development kits.

Before using sensors, see *Safety and Maintenance* on page 13.

For information on the physical installation and mounting of sensors, as well as a general hardware overview, see *Getting Started* on page 17.

For key concepts on how sensors acquire data and perform measurements, see *Key Concepts* on page 41.

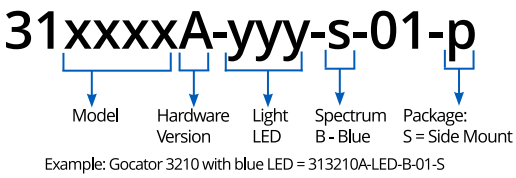
For information on using the PC-based interface (and the differences between running GoPxL on-sensor and on a PC), see *Running GoPxL on a Windows PC* on page 656.

Getting Started

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

Sensor Part Numbers

Use the following to understand sensor part numbers:



Example: Gocator 3210 with blue LED = 313210A-LED-B-01-S

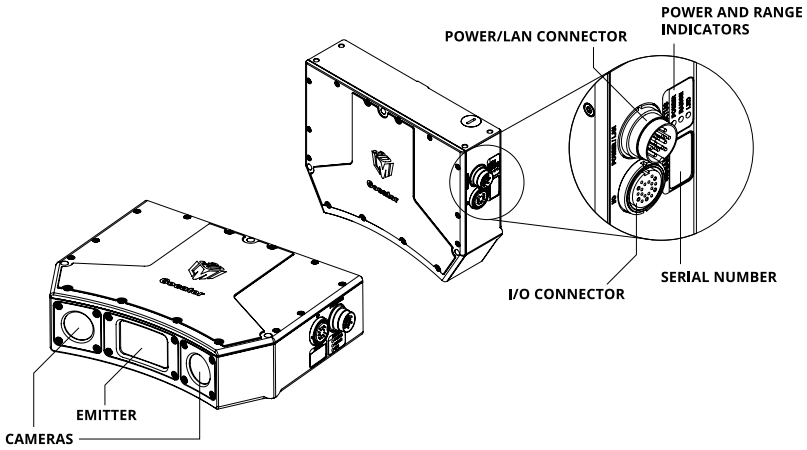
Upgrading from Gocator Firmware

If you are upgrading your sensor from Gocator firmware 6.2 or earlier to GoPxL, and you have created pattern files using Surface Pattern Matching or track files using Surface Track in the Gocator firmware, be sure to add instances of those tools and remove those files manually. These files can take up considerable space.

Hardware Overview

The following sections describe Gocator and its associated hardware.

Gocator Sensor



Gocator 3210

Item	Description
Camera	Observes light reflected from target surfaces.
Light Emitter	Emits structured light for 3D data acquisition.
I/O Connector	Accepts input/output signals.
Power/LAN Connector	Accepts power and connects to 1000 Mbit/s Ethernet network.
Power Indicator	Illuminates when power is applied (blue).
Range Indicator	Illuminates when the camera detects light that is within the sensor's measurement range (green).
LED Indicator	Illuminates when safety input is active (amber). Note that activating the safety input is *not* required to use Gocator snapshot sensors.
Serial Number	Unique sensor serial number.

Gocator 3x00 Cordsets

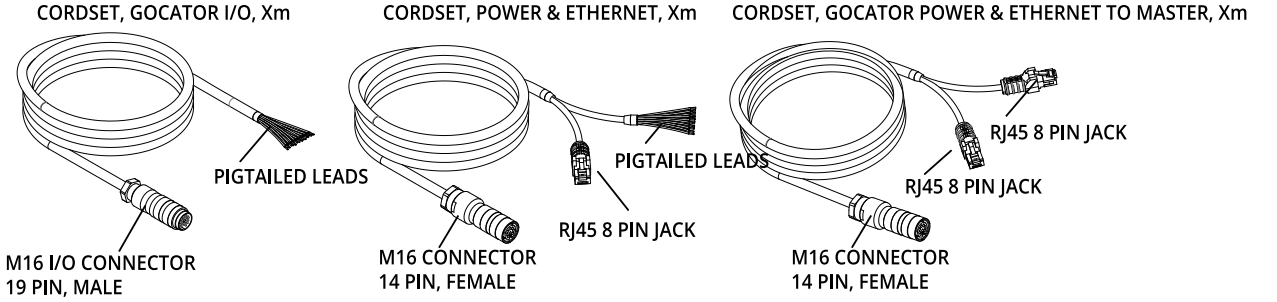
G3 sensors use two types of cordsets.

> When connecting cordset connectors to the sensor's connectors, do not exceed a torque of 2 Nm (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. It is also used for sensor communication via 1000 Mbit/s Ethernet with a standard RJ45 connector. The Master version of the Power & Ethernet cordset provides direct connection between the sensor and a Master network controller (excluding Master 100); for more information, see *Master Network Controllers* on page 801.

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

If you use a Master 100 with a sensor, you must use the latest version of the Master 100 with a metal-shielded Master Power Port and a Power & Ethernet cordset with a metal-shielded Power/Sync RJ45 plug.

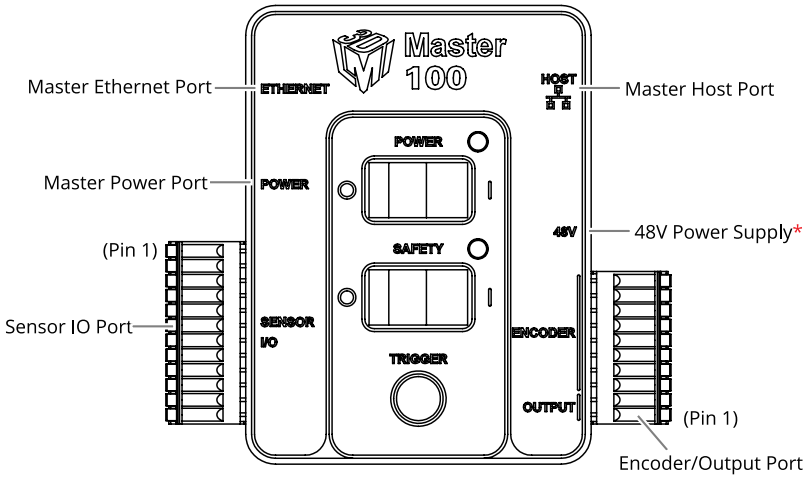


Cordsets are available with two types of cabling: standard and high flex. Use the high flex versions in applications where a tighter bend in the cordset is required, especially when the cordset must bend repeatedly. For more information, see *Cordset Bend Radius Limits* on page 26.

The maximum cordset length is 60 m. For pinout details, see *Gocator I/O Connector* on page 796 and *Gocator Power/LAN Connector* on page 794.

See *Accessories* on page 821 for cordset lengths and part numbers. Contact LMI for information on creating cordsets with customized lengths and connector orientations.

Master 100



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. Provides power to the sensor.
Sensor I/O Port	Connects to the I/O cordset.
Master Host Port	Connects to the host PC's Ethernet port.

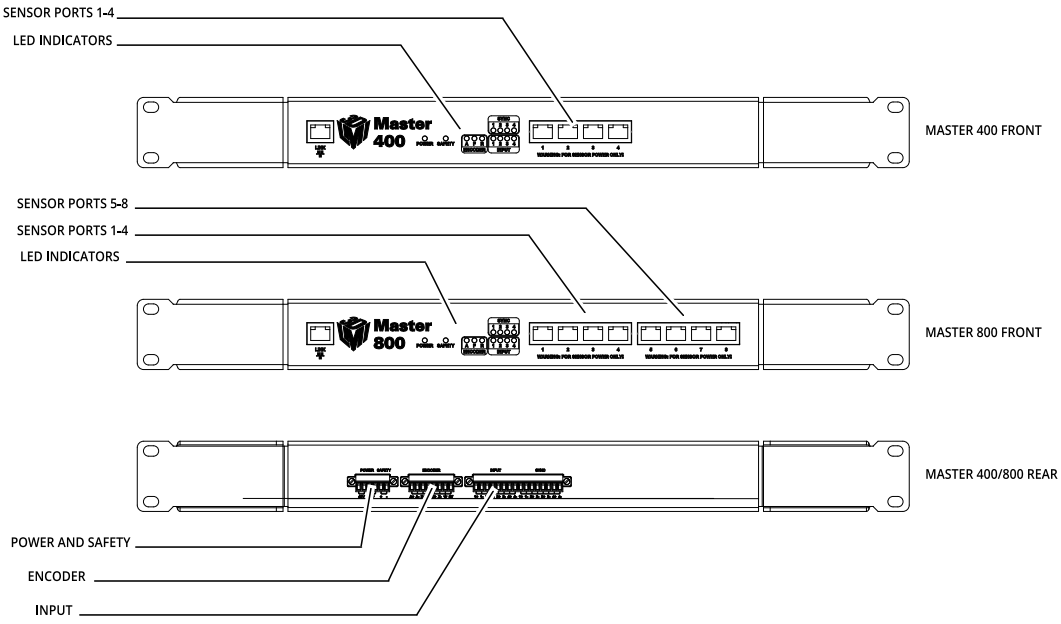
Item	Description
Power	Accepts power (+48 V).
Power Switch	Toggles sensor power.
Safety Switch	Toggles safety signal provided to the sensors [O= off, I= on]. Turning this switch on is *not* required with snapshot sensors.
Trigger	Signals a digital input trigger to the sensor.
Encoder	Accepts encoder A, B and Z signals.
Digital Output	Provides digital output.

See *Master 100* on page 801 for pinout details.

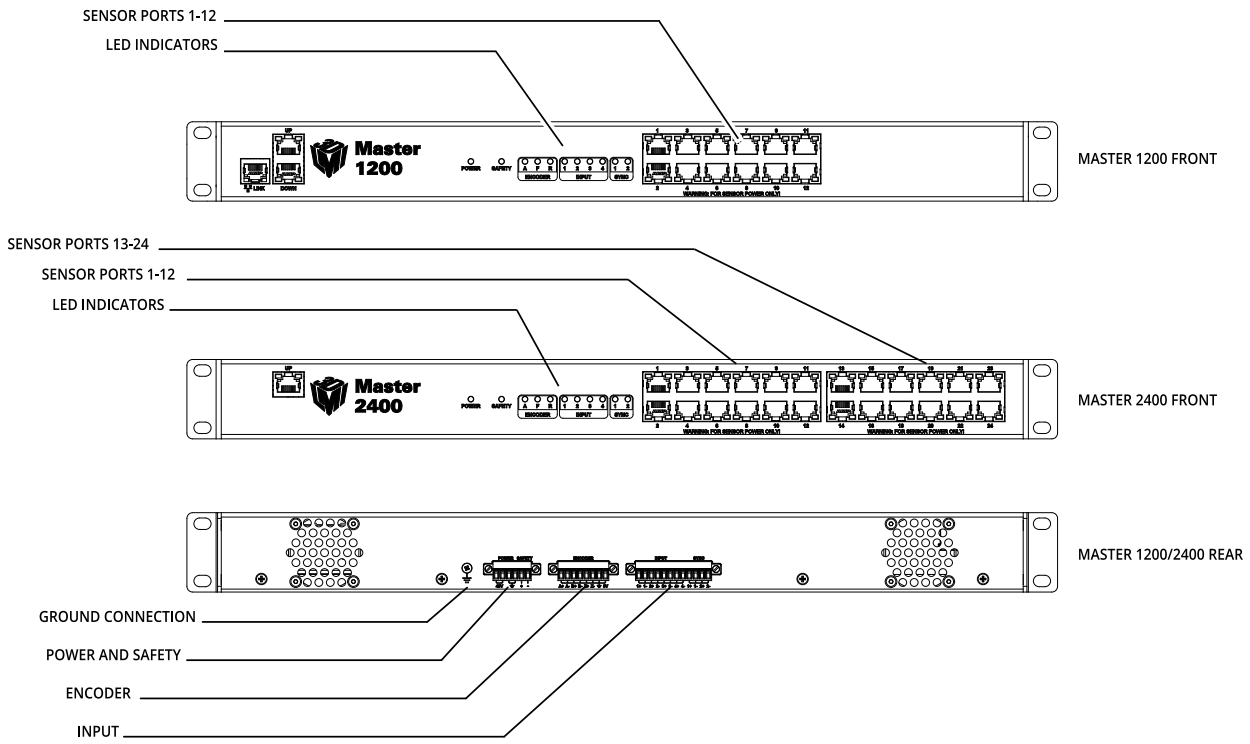
Master 400 / 800 / 1200 / 2400

The Master 400, 800, 1200, and 2400 network controllers let you connect more than two sensors:

- Master 400: accepts four sensors
- Master 800 accepts eight sensors
- Master 1200: accepts twelve sensors
- Master 2400: accepts twenty-four sensors



Master 400 and 800



Master 1200 and 2400

Item	Description
Sensor Ports	Master connection for sensors (no specific order required).
Ground Connection	Earth ground connection point.
Power and Safety	Power and safety connections. Safety input is *not* required with snapshot sensors.
Encoder	Accepts encoder signal.
Input	Accepts digital input.

For pinout details for Master 400 or 800, see *Master 400/800* on page 803.

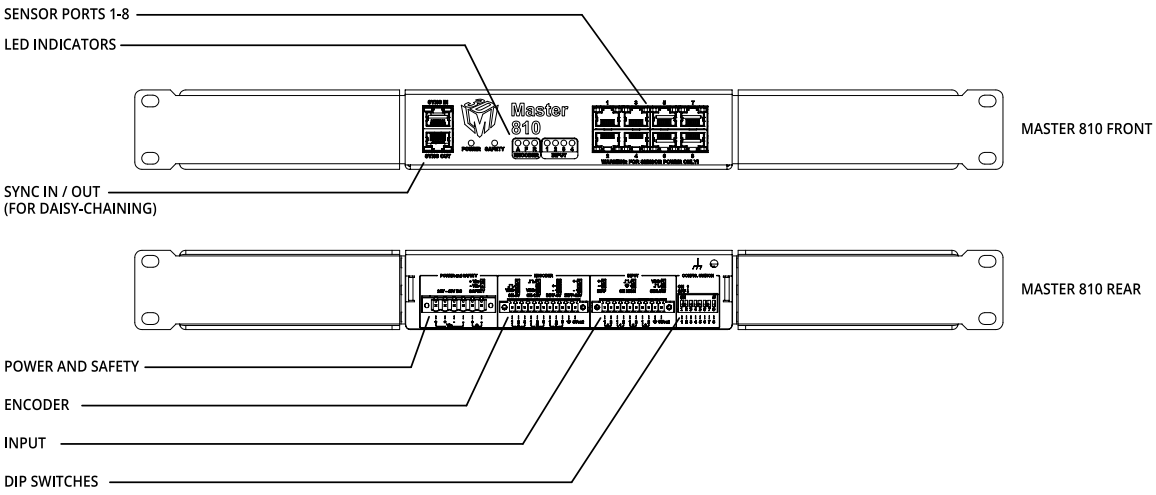
For pinout details for Master 1200 or 2400, see *Master 1200/2400* on page 818.

Master 810 / 2410

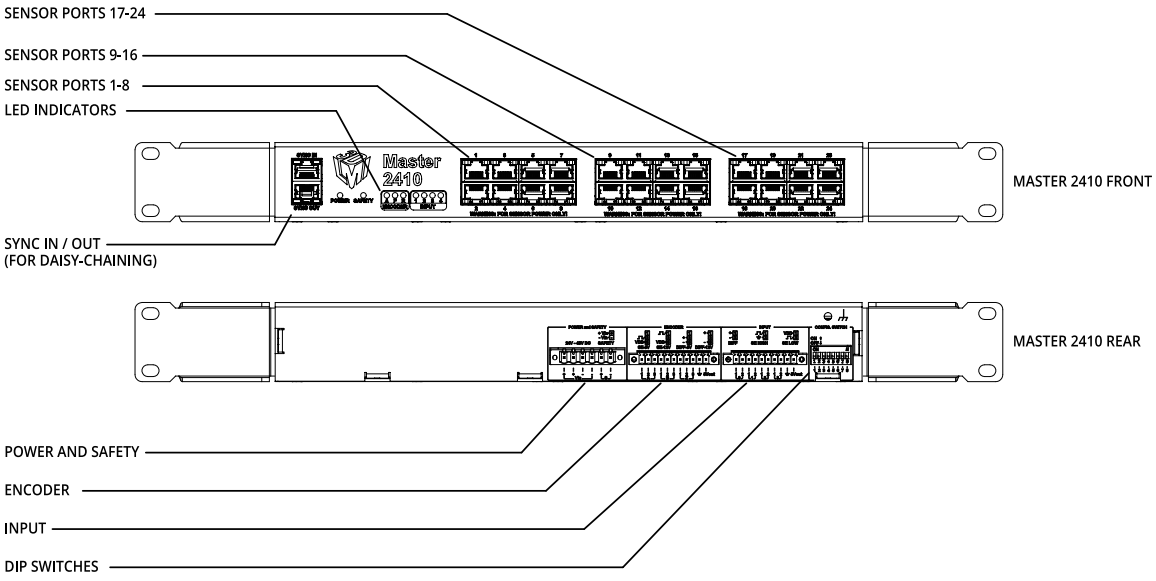
The Master 810 and 2410 network controllers let you connect multiple sensors to create a multi-sensor system:

- 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 32. (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. Safety input is *not* required with snapshot sensors.
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 32.
LED Indicators	For more information, see *Master 810/2410* on page 807.

For pinout details, see *Master 810/2410* on page 807.

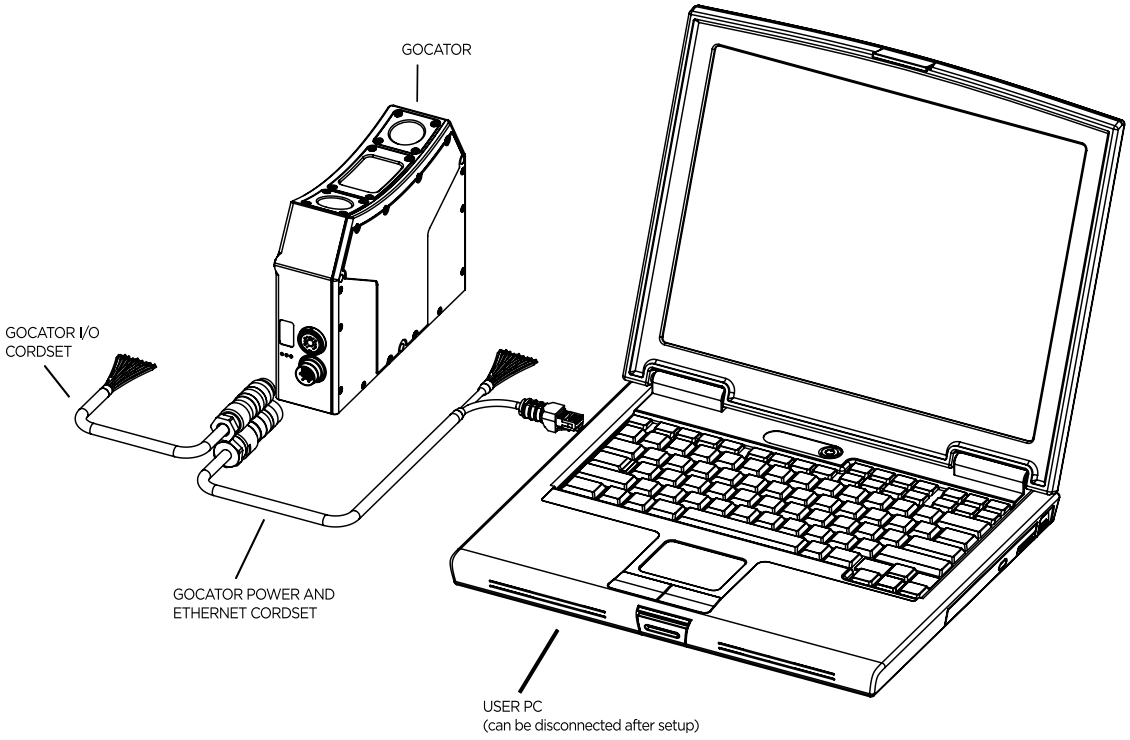
System Overview

Gocator sensors can be installed and used in scenarios where the target to be scanned is static in position relative to the sensor for the short duration of camera exposure. Sensors can be connected as standalone devices or in a multi-sensor system.

Standalone System

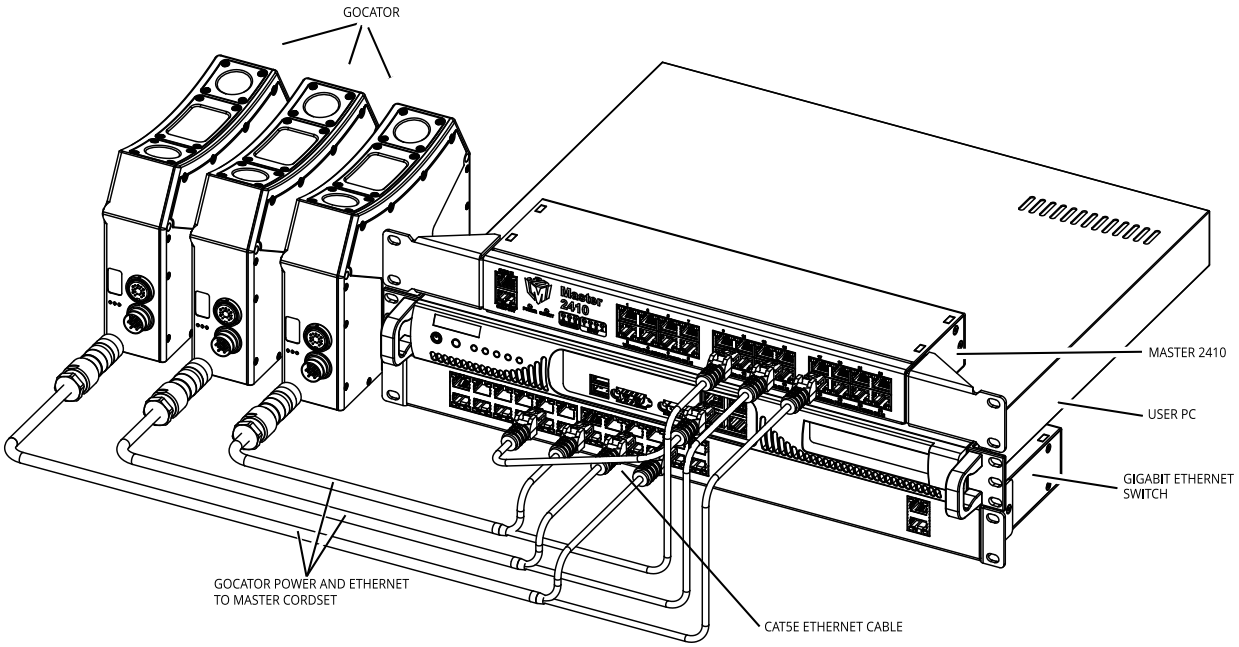
Standalone systems include only a single sensor. The device can be connected to a computer's Ethernet port for setup and can also be connected to devices such as encoders, photocells, or PLCs.

For information on physical installation, see *Installation* on page 25.



Multi-Sensor System

A Master network controller (excluding Master 100) can be used to connect two or more sensors into a multi-sensor system. Master cordsets are used to connect the sensors to a Master. The Master provides a single point of connection for power, safety, encoder, and digital inputs. A Master 400/800/810/1200/2400/2410 can be used to ensure that the scan timing is precisely synchronized across sensors. Sensors and client computers communicate via an Ethernet switch (1 Gigabit/s recommended).


GOCATOR
MASTER 2410
USER PC
GIGABIT ETHERNET SWITCH
GOCATOR POWER AND ETHERNET TO MASTER CORDSET
CAT5E ETHERNET CABLE

Installation

The following sections provide grounding, mounting, and orientation information.

> When connecting cordset connectors to the sensor's connectors, do not exceed a torque of 2 Nm (18 in-lbs). Ensure that you properly secure the cordset cabling to avoid stress loading on the sensor connectors.

Gocator 3210: 24 VDC Operation and Cordset Length **25**
Mounting **26**
Cordset Bend Radius Limits **26**
Grounding **28**
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Recommended Practices for Cordsets 29
Master Network Controllers 29
Grounding When Using a DIN Rail (Master 810/2410) 30
Additional Grounding Schemes 30
Installing DIN Rail Clips: Master 810 or 2410 ..... **31**
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Gocator 3210: 24 VDC Operation and Cordset Length

Although LMI recommends operating Gocator 3210 at 48 VDC to fully exploit the sensor's capabilities, starting with Gocator firmware 4.7, Gocator 3210 can operate when connected to a 24 VDC power supply. This may sometimes be necessary, for example, because of local regulations.

When running the sensor with a 24 VDC power supply, because of limitations in the sensor and in cordsets, the projector intensity is reduced. As a result, when running a 3210 sensor at 24 VDC, you may need to increase exposure time with darker targets to compensate for the reduced projector intensity. For information on setting exposure, as well as the impact of running the sensor at 24 VDC on projector intensity, see *Exposure* on page 120.

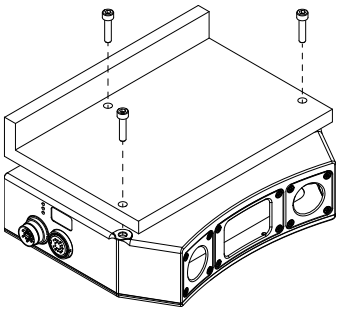
Note that because projector intensity decreases with longer cordsets (caused by the increased resistance and higher current), if limiting exposure time is important, try to limit the length of the cordset.

Note that if you run a 3210 sensor on 24 VDC, you must specify this voltage and the cordset length in the web interface. For more information, see *Settings* on page 90.

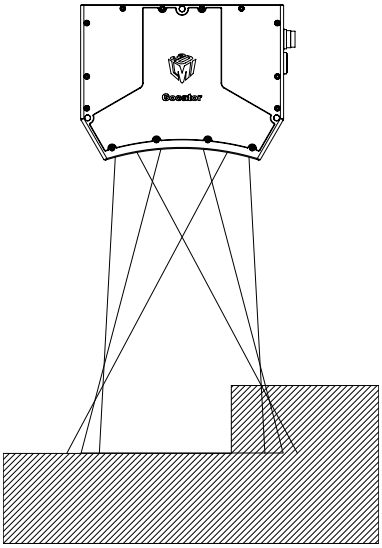
Mounting

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. Refer to the dimension drawings of the sensors in *Specifications* on page 777 for the appropriate screw diameter, pitch, and length, and bolt hole diameter.

⚠	Proper care should be taken in order to ensure that the internal threads are not damaged from cross-threading or improper insertion of screws.



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



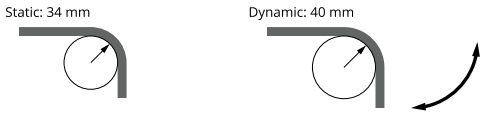
⚠	The sensor must be heat sunk through the frame it is mounted to. When a sensor is properly heat sunk, the difference between ambient temperature and the temperature reported in the sensor's health channel is less than 15° C.

⚠	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.

Cordset Bend Radius Limits

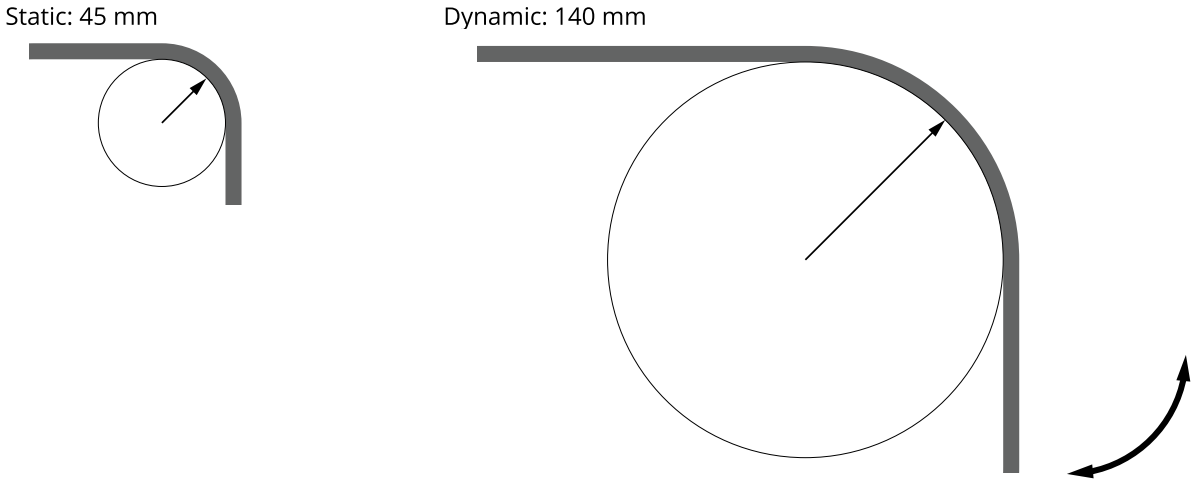
With high flex cordsets of lengths 25 meters and lower, limit bends as follows:

- 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.



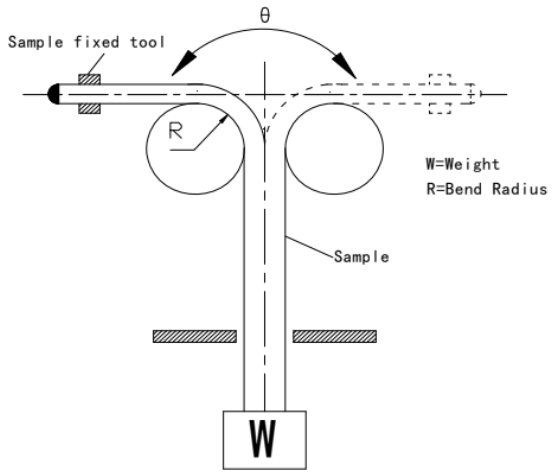
High flex cordset bend radius limits

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.

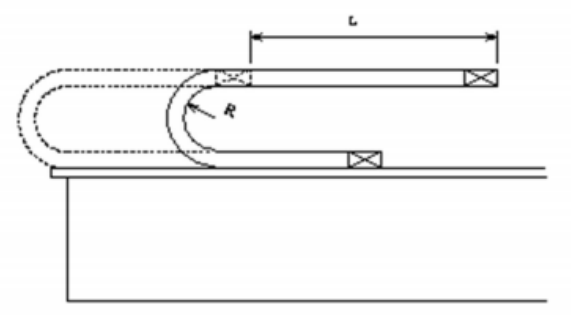


Standard cordset bend radius limits

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 821.

> 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.

For more information on cordsets, see *Gocator 3x00 Cordsets* on page 18.

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.

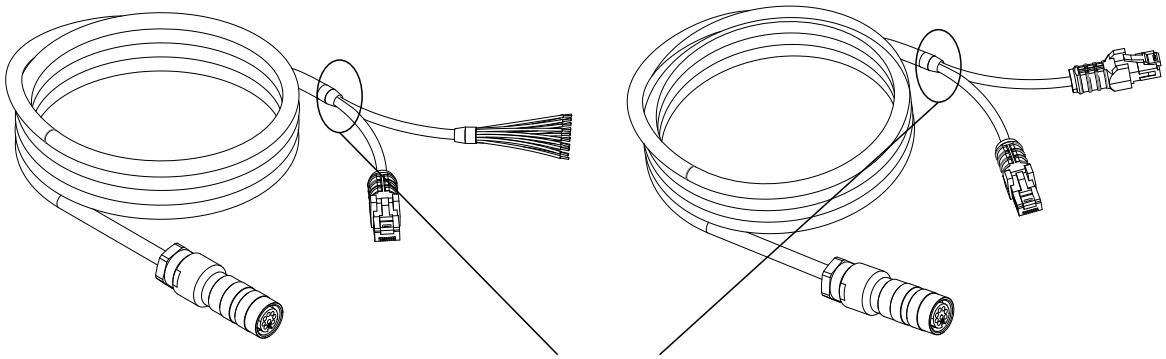
> The frame or electrical cabinet that the sensor is mounted to must be connected to earth ground.

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

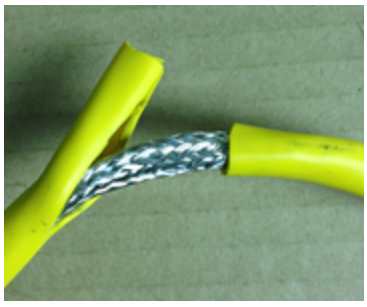
CORDSET, GOCATOR POWER & ETHERNET TO MASTER, Xm



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.

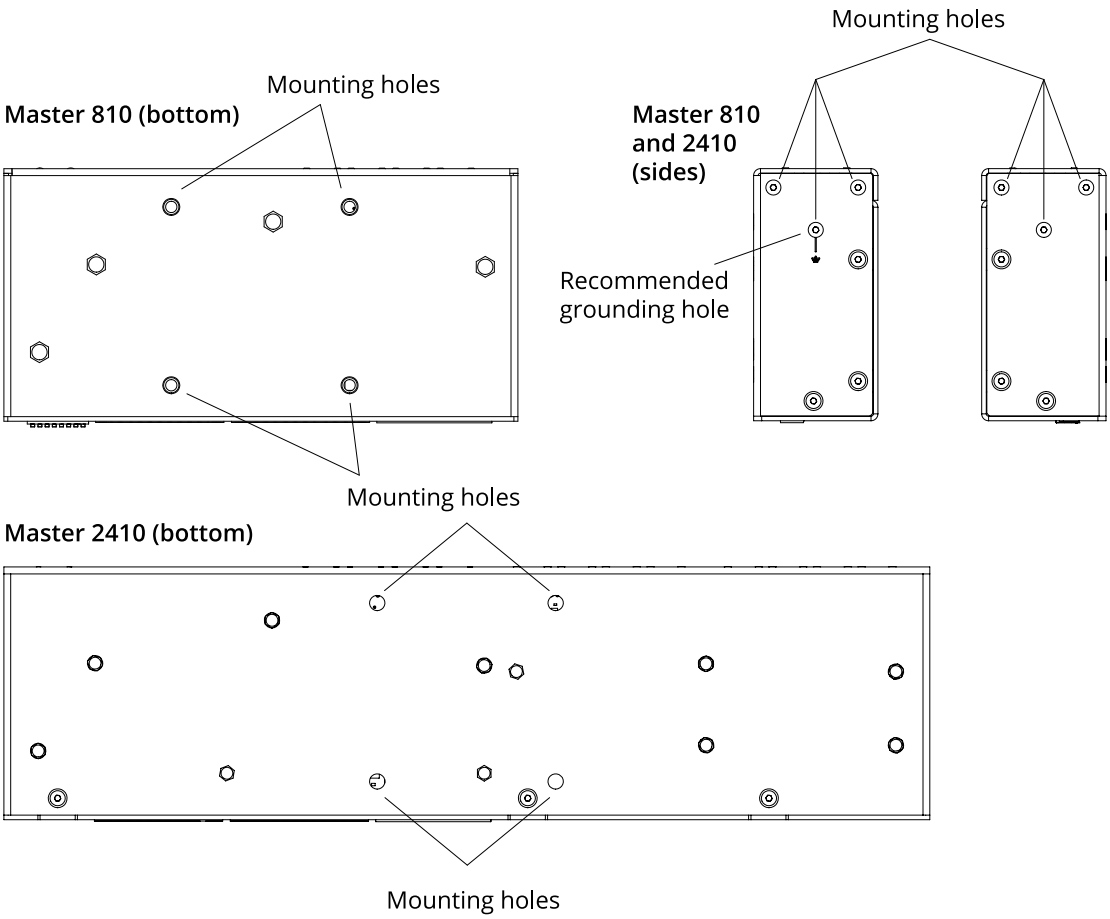
	You *must* check electrical continuity between the mounting frame and RJ45 connectors on the front using a multi-meter.

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)* below.

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:

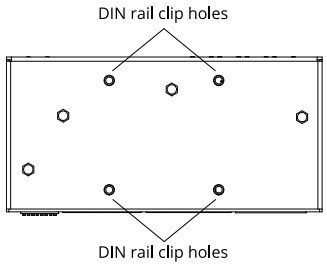


Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

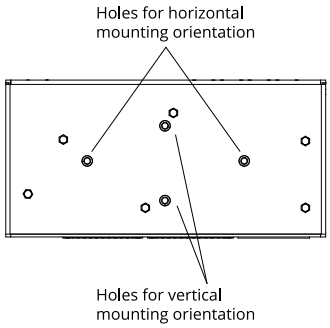
To install the DIN rail clips:

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

   Master 810:

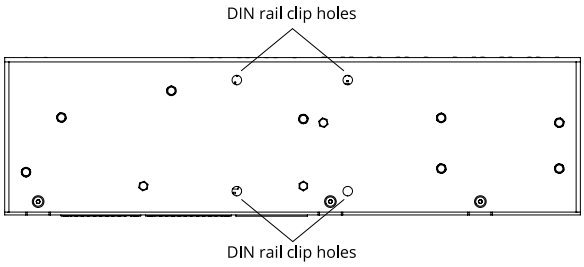


Current revision

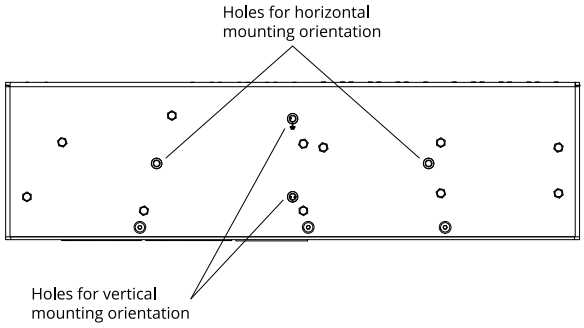


Older revision

   Master 2410:



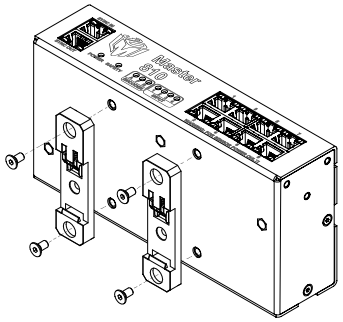
Current revision



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:



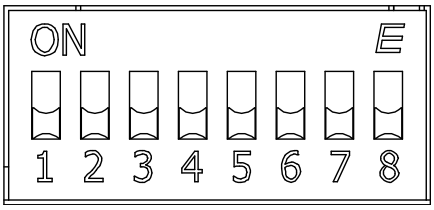
	Ensure that there is enough clearance around the Master for cabling.

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

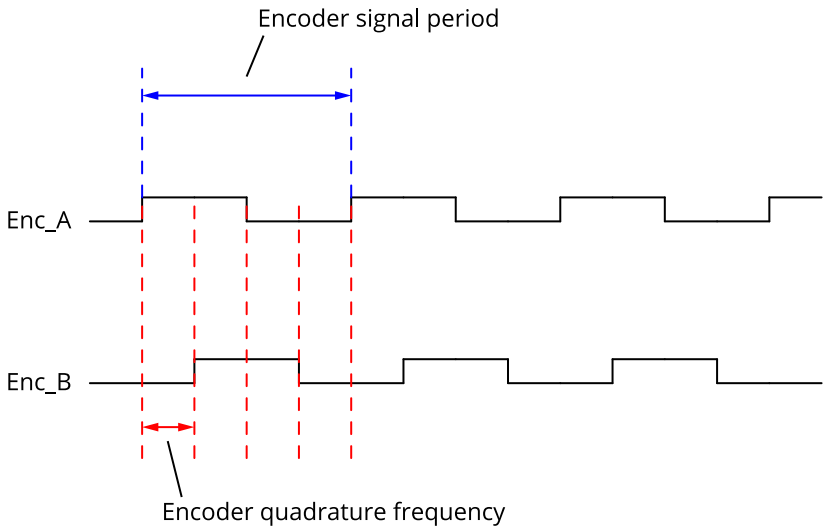
In the formula, use the *quadrature frequency* of the encoder (for more information, see *Encoder Quadrature Frequency* below) and a divider from the following table so that the Output Quadrature Frequency is no more than 300 kHz.

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

Network and Sensor Setup

The following sections provide procedures for client PC and sensor network setup.

> DHCP is not recommended for sensors. If you choose to use DHCP, the DHCP server should try to preserve IP addresses. Ideally, you should use static IP address assignment (by MAC address) to do this.

Client Setup

To connect to a sensor from a client PC (using a web browser), you must ensure the client's network card is properly configured. The network ID of the client PC's network card must match that of any sensors you want to connect to.

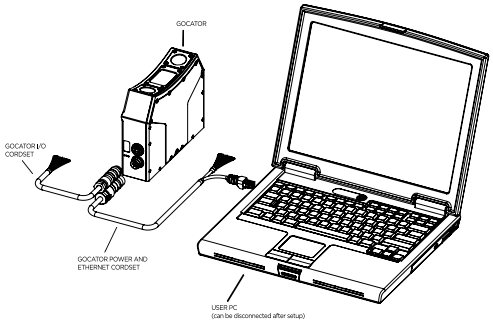
Sensors are shipped with the following default network configuration:

Setting	Default
DHCP	Disabled
IP Address	192.168.1.10
Subnet Mask	255.255.255.0
Gateway	0.0.0.0

> When connecting cordset connectors to the sensor's connectors, do not exceed a torque of 2 Nm (18 in-lbs). Ensure that you properly secure the cordset cabling to avoid stress loading on the sensor connectors.

To connect to a sensor for the first time

1. Connect cables and apply power.



   Sensor cabling is illustrated in *System Overview* on page 23.

2. Change the client PC's network settings.

   Windows 10

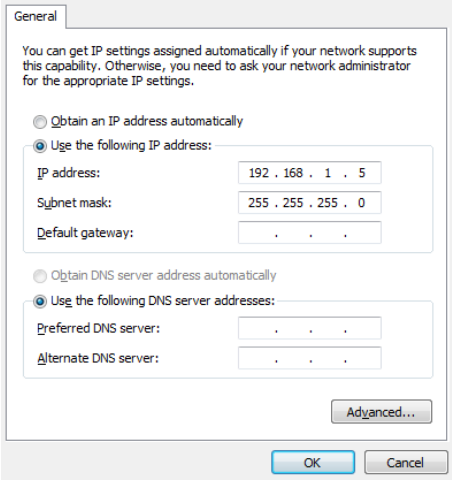
   a. From the **Start** menu, launch the Settings app and click **Network & Internet**.

   b. Under **Advanced network settings**, click **Change adapter options**.

   c. Right-click desired network connection, and then click **Properties**.

   d. On the **Networking** tab, click **Internet Protocol Version 4 (TCP/IPv4)**, and then click **Properties**.

   e. Select “Use the following IP address” option.



f. Enter IP Address “192.168.1.5” and Subnet Mask “255.255.255.0”, then click **OK**.

Mac OS 11

a. Click Apple menu > **System Preferences**, and then click **Network**.

b. In the list to the left, select **Ethernet**.

c. Click **Advanced**, click **Hardware**, click the **Configure** pop-up menu, and set it to “Manually”.

d. Enter IP Address “192.168.1.5” and Subnet Mask “255.255.255.0”, and then click **Apply**.

⚠ See *Troubleshooting* on page 823 if you experience any problems while attempting to establish a connection to the sensor.

Gocator Setup

Gocator sensors are shipped with a default configuration that will produce 3D data for most targets.

The following describes how to set up a sensor system for operations. After you have completed the setup, you can perform a scan to verify basic sensor operation.

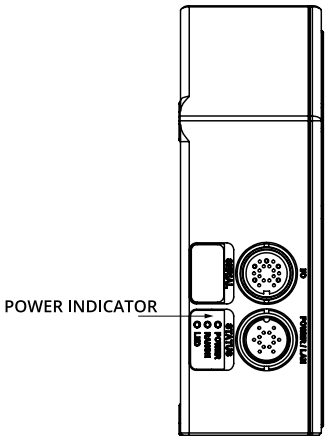
Standalone Sensor System

When connecting cordset connectors to the sensor's connectors, do not exceed a torque of 2 Nm (18 in-lbs). Ensure that you properly secure the cordset cabling to avoid stress loading on the sensor connectors.

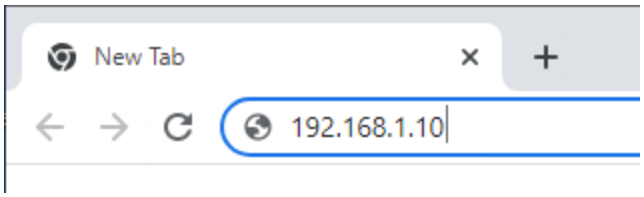
To configure a standalone sensor system

1. Power up the sensor.

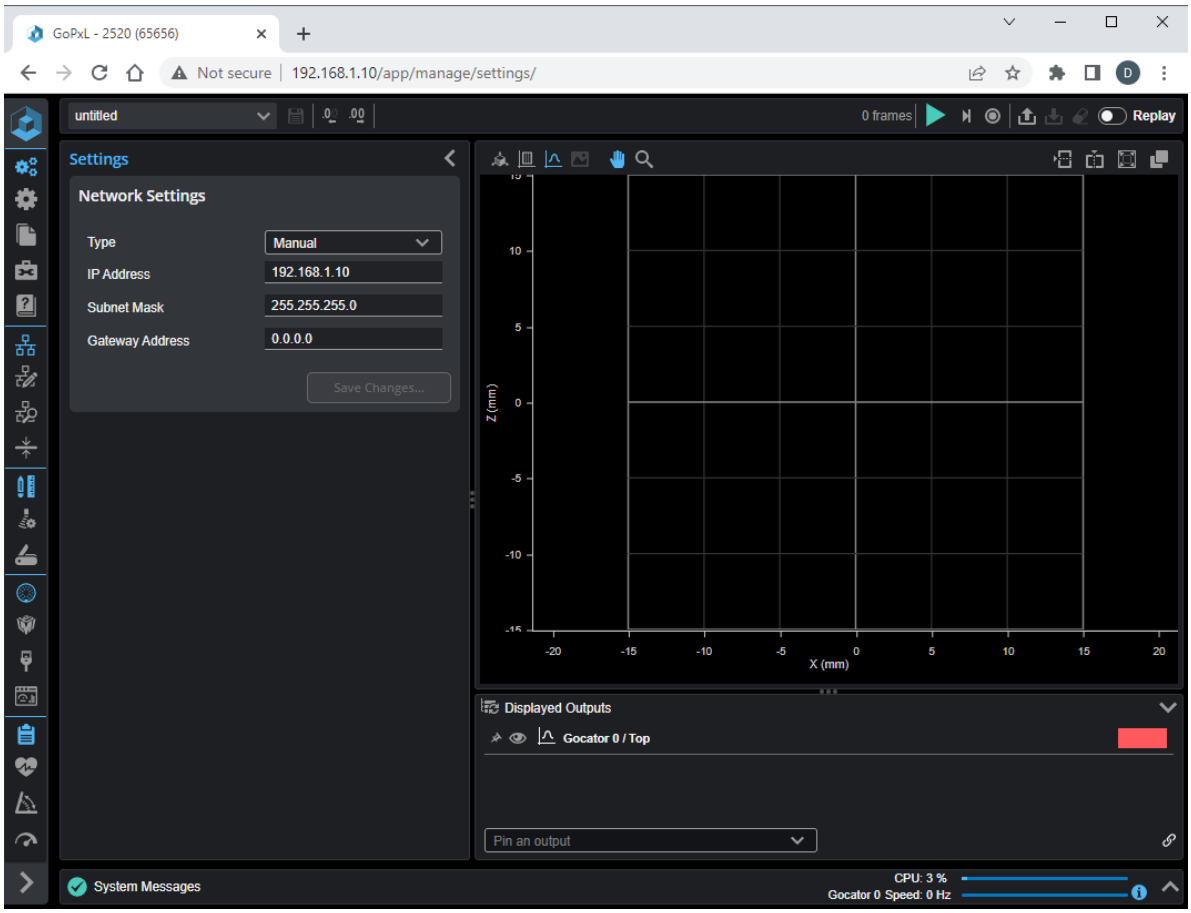
   The power indicator (blue) should turn on immediately.



2. Enter the sensor's default IP address (192.168.1.10) in a web browser.



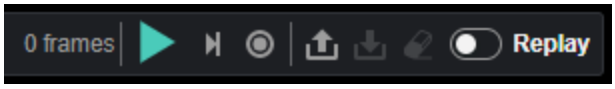
   The sensor interface loads.



If you can't connect to the sensor's interface, use the Discovery tool to find it on your network (for more information, see *GoPxL Discovery Tool* on page 750) and use the IP address of the sensor.

3. Ensure that Replay mode is off

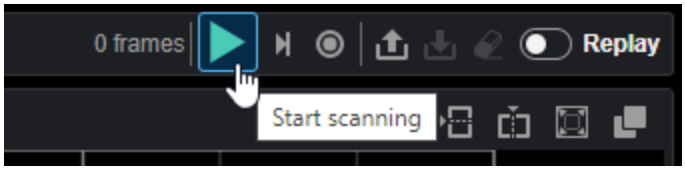
   Replay mode is off when the Replay toggle above the data viewer is to the left.



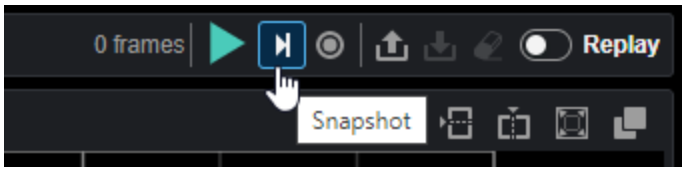
   For an overview of the user interface, see *User Interface Overview* on page 58.

4. Move a target under the sensor within its measurement range and field of view.
5. Press the Start button or the Snapshot on the Toolbar to start the sensor (FOV).

   The Start button is used to run a sensor continuously.



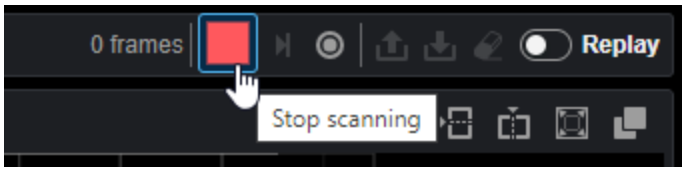
   The Snapshot button is used to trigger the capture of a single frame.



If a target object is within the sensor's measurement range and FOV, the data viewer will display scan data, and the sensor's range indicator will illuminate.

If no scan data is displayed in the data viewer, see *Troubleshooting* on page 823.

6. If you started the sensor using the Start scanning button, press the Stop button.



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. **Sensors and GoMax NX**: All devices use this port. **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. **Physical sensors and GoMax NX**: All devices use this port. **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

Port	Data Packet Protocol	Description
		GoPxL Manager. For more information, see *Running GoPxL on a Windows PC* on page 656.
3601	TCP	Gocator Data Protocol (GDP) port. **Physical sensors and GoMax NX**: All devices use this port. **GoPxL running on a PC**: This port is offset from the control port by +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.) 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 656.
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.

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 sensors 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, the scan data of the individual sensors in a sensor group is combined. So for example, in a multi-sensor G2 system, the profiles from the individual sensors are combined into a single, wider profile.

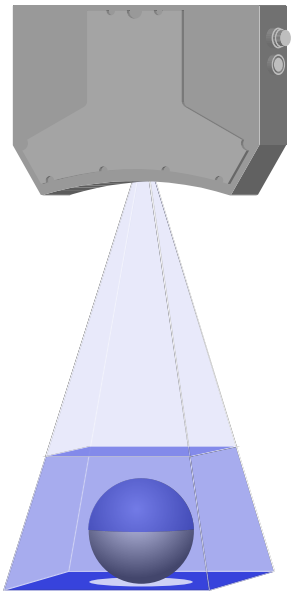
Sensors and sensor groups also have an associated "scan engine." For example, when designing a sensor system containing one or more G2 sensors, the associated scan engine is "Gocator Laser Profiler," with acquisition settings specific to that family of sensors.

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

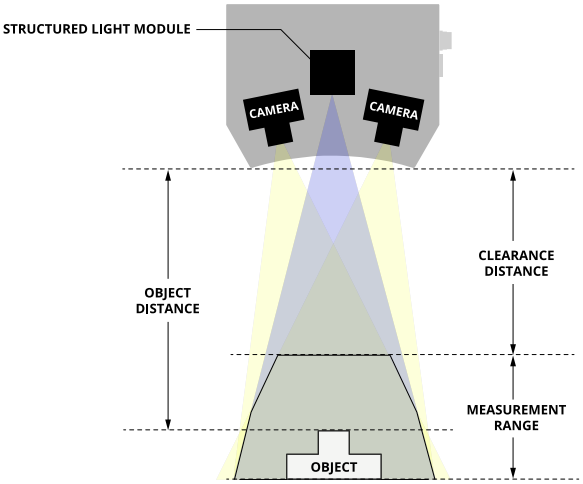
3D Acquisition

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

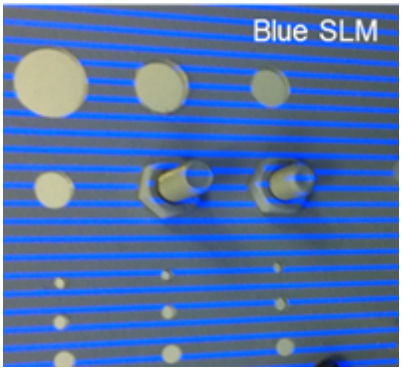
3x00 series sensors are 3D snapshot sensors, meaning they capture an entire surface in 3D in a single snapshot. These sensors project several structured light patterns in a rapid sequence onto the target. The reflection of the pattern off the target is captured by two cameras. The target must remain stationary during the camera exposure of the light patterns. The required exposure time depends on the shape, color, and reflectiveness of the target, but is often shorter than 1 second.



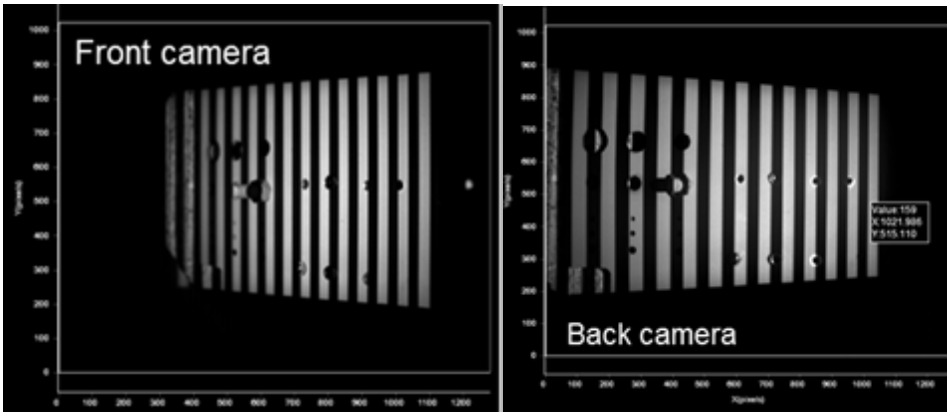
A Structured Light Modulator (SLM) produces a sequence of high resolution/high contrast light patterns using a blue LED. Two cameras capture the reflected light pattern from different viewing angles. The sensor can then use either stereo correlation or independent triangulation to generate 3D points from the light pattern.



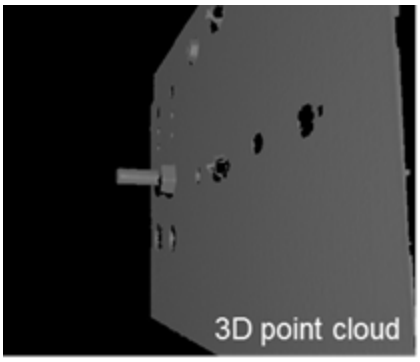
These are the steps of the acquisition of a 3D point cloud:



Step 1: Light pattern projected on target



Step 2: Reflected light captured by two cameras



Step 3: Use stereo correlation or independent triangulation to generate 3D point cloud

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

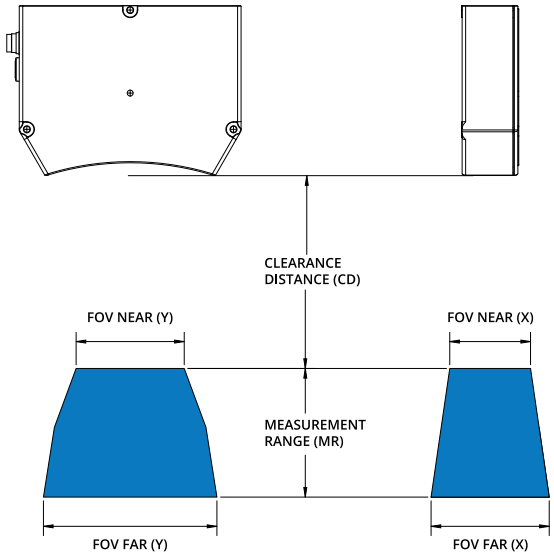
Clearance Distance, Field of View and Measurement Range

Clearance distance (CD), field of view (FOV), and measurement range (MR) are important concepts for understanding the setup of a sensor and for understanding results.

Clearance distance – The minimum distance from the sensor that a target can be scanned and measured. A target closer than this distance will result in invalid data.

Measurement range – The vertical distance, starting at the end of the clearance distance, in which targets can be scanned and measured. Targets beyond the measurement range will result in invalid data.

Field of view – The area on the XY plane along the measurement range. At the far end of the measurement range, the field of view is larger, but the resolution is lower. At the near end, the field of view is smaller, but the resolution is higher. When resolution is critical, if possible, place the target closer to the near end.



Stereo Correlation vs. Independent Triangulation

Stereo correlation means that the sensor locates the same point on the physical target in the two images captured at different viewing angles. Since the exact distance between the two cameras and the viewing angles are known, the distance to the point can be calculated. In order for stereo correlation to work and produce a 3D data point, the point on the target must be visible in both cameras. Stereo acquisition may produce more stable measurements on targets with a simple shape, but will be affected by occlusions on targets with complicated shapes and protruding features.

Independent triangulation means that each camera independently triangulates off the LED light pattern, based on the calibration process that takes place when the sensor is manufactured. Since a snapshot sensor has two cameras, a point on the physical target only needs to be visible to one of the cameras in order to generate a 3D point. Independent triangulation may improve performance on targets with complicated shapes that can cause occlusion, but it relies on the sensor's internal components being fully stable.

The **Reduce Occlusion** setting determines whether 3D data is acquired by using stereo correlation or both stereo correlation and independent triangulation. See *Reduce Occlusion* on page 110 for more details.

3D Data Output

Gocator measures the shape of the object calculated from either dual triangulation or stereo correlation. The sensor reports a series of 3D coordinates from the surface of the target in the sensor's field of view.

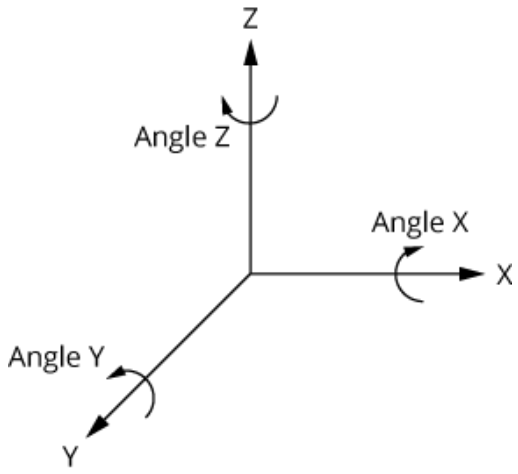
Coordinate Systems

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.

Gocator 3x00 sensors use Cartesian left-hand notation for defining 3D coordinates.



The Z axis represents the sensor's measurement range (MR), where the values increase toward the sensor. The X axis and Y axis represent the sensor's field of view (FOV).

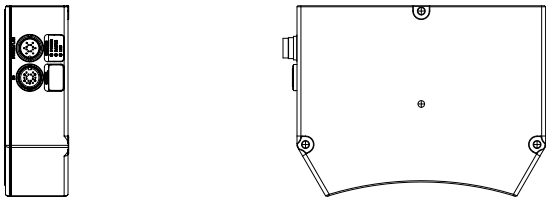
X offset, Y offset, and Z offset define the translations from the origin.

Rotations are specified based on rotating the target around the X axis (Angle X), followed by rotating around the Y axis (Angle Y), followed by rotating around the Z axis.

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. Most importantly, the origin is at the *center* of the measurement range and field of view, in other words, the center of the scan volume.

Before alignment, the origin of the sensor is at the center of the sensor's measurement range (MR) and field of view (FOV).





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 97.

The adjustments resulting from alignment are called *transformations* (offsets along the axes and rotations around the axes). Transformations are displayed in the **System** > **Alignment** page. 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 104.

X angle is positive when rotating from positive Y to positive Z. Z angle is positive when rotating from positive X to positive Y.

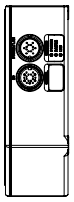
Alignment can be used to establish a transformed coordinate system according to the user's needs. Alignment determines the adjustments to X, Y, and Z, as well as rotation angle around each axis. Transformed coordinate systems can be associated with specific sensor jobs. For details, see *Aligning Sensors* on page 97.

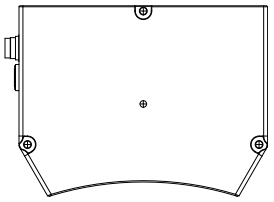
When applying the transformations, the data is first rotated around X (clockwise, with the X axis toward the viewer), then Y (counterclockwise), and then Z (clockwise), and then the offsets are applied.

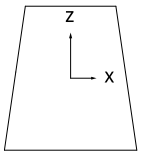
Sensor Coordinates

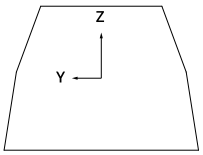
Unaligned sensors use *sensor* coordinates. The measurement range (MR) is along the Z axis. Most importantly, the origin is at the *center* of the measurement range and field of view, in other words, the center of the scan volume.

Before alignment, the origin of the sensor is at the center of the sensor's measurement range (MR) and field of view (FOV).









System Coordinates

Understanding system 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.

Performing the built-in alignment procedure on sensors adjusts the coordinate system in relation to sensor coordinates, resulting in *system coordinates* (for more information on sensor coordinates, see *Sensor Coordinates* on the previous page). For more information on aligning sensors, see *Aligning Sensors* on page 97.

The adjustments resulting from alignment are called *transformations* (offsets along the axes and rotations around the axes). Transformations are displayed in the **Sensor** panel on the **Scan** page. For more information on transformations in the web interface, see *Transformations* on page 104.

Alignment is used with a single sensor to compensate for mounting misalignment and to set a zero reference, such as a conveyor belt surface.

Y angle is positive when rotating from positive X to positive Z axis.

X angle is positive when rotating from positive Y to positive Z. Z angle is positive when rotating from positive X to positive Y.

Alignment can be used to establish a transformed coordinate system according to the user's needs. Alignment determines the adjustments to X, Y, and Z, as well as rotation angle around each axis. Transformed coordinate systems can be associated with specific sensor jobs. For details, see *Aligning Sensors* on page 97.

When applying the transformations, the data is first rotated around X (clockwise, with the X axis toward the viewer), then Y (counterclockwise), and then Z (clockwise), and then the offsets are applied.

Part and Section Coordinates

When you work with parts or sections extracted from scan data, a different coordinate system is available.

Part data can be expressed in aligned system coordinates or unaligned sensor coordinates. But part data can also be represented in *part coordinates*: data and measurement results are in a coordinate system that places the X and Y origins at the center of the part. The Z origin is at the surface surrounding the alignment target (if the sensor or system has been aligned) or in the center of the center of the measurement range (if the sensor or system has not been aligned).

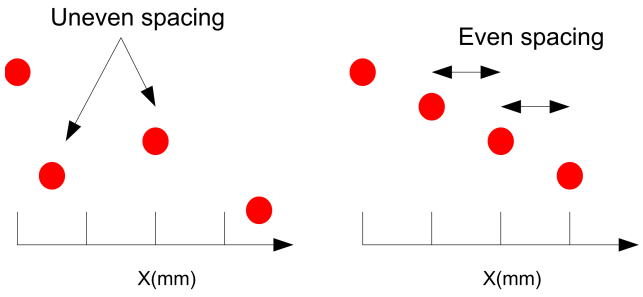
> The **Frame of Reference** setting, in the **Part Detection** panel on the **Scan** page, controls whether part data is recorded using sensor/system coordinates or part coordinates.

Sections are *always* represented in a coordinate system similar to part coordinates: the X origin is always at the center of the extracted profile, and the Z origin is at the bottom of the alignment target (or in the center of the measurement range if the sensor is unaligned).

Resampling

The internal acquisition engine in the sensor produces a random 3D point cloud, where each individual point is a coordinate triplet (X, Y, Z). When the sensor's **Uniform Spacing** setting is disabled, the sensor returns this point cloud.

When the sensor's uniform spacing setting is enabled, the random 3D point cloud is resampled to an even grid in the XY plane. The resampling divides the XY plane into fixed-size square "bins." 3D points are projected along the Z axis, perpendicular to the XY plane, and points that fall into the same bin will be combined into a single Z value. The size of the resampling bins can be set with the **X/Y Spacing Interval** setting; for details, see *Triggers* on page 112. The XY resampling plane is established through the sensor's built-in alignment routine. That is, the resampling plane is set to match the plane described by the calibration plate; for more information, see *System Coordinates* on the previous page.



In the Ethernet data channel, only the Z values are reported, and the X and Y positions can be reconstructed through the 2D-array index at the receiving end (the client). Resampling reduces the complexity for the algorithms in the sensor's built-in measurement tools, allowing them to run on the embedded processors. All built-in measurement tools in the sensor operate on resampled data in Surface mode.

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:

- Part detection
- Sectioning

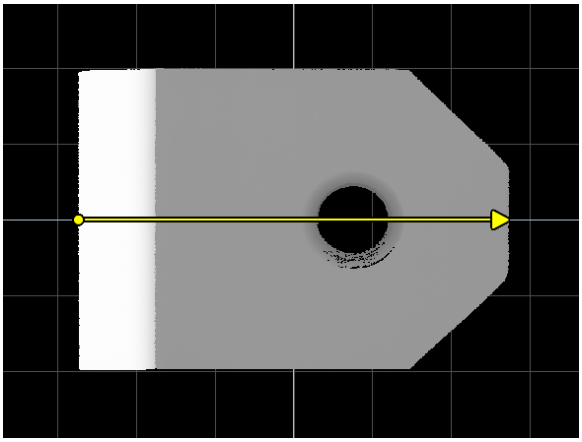
Part Detection

A sensor can isolate discrete parts on a surface into separate scans representing parts. For more information, see *Surface Part Detection* on page 450.

Gocator can then perform measurements on these isolated parts.

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 482.

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 455) or to the dimensions of a fitted bounding box that encapsulates the part data (for more information see *Surface Bounding Box* on page 332). 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 532). 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 several 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 *Configuring Inspection and Processing Tools* on page 127.

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 176.

Tool Chaining

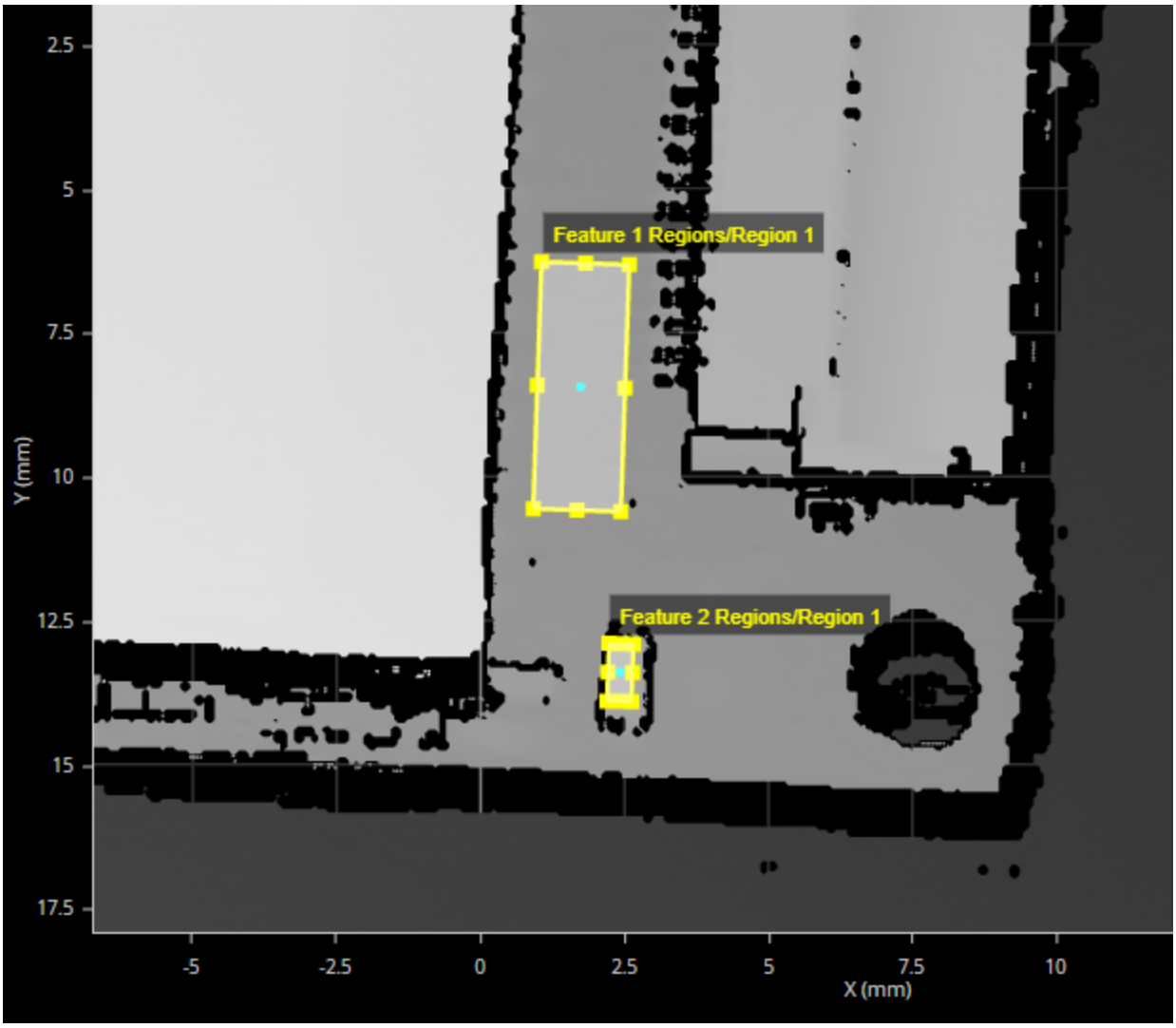
GoPxL's measurement and processing tools can be linked together: one tool uses another tool's output as input. This gives you a great deal of control and flexibility when it comes to implementing your application.

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

Anchoring Measurements

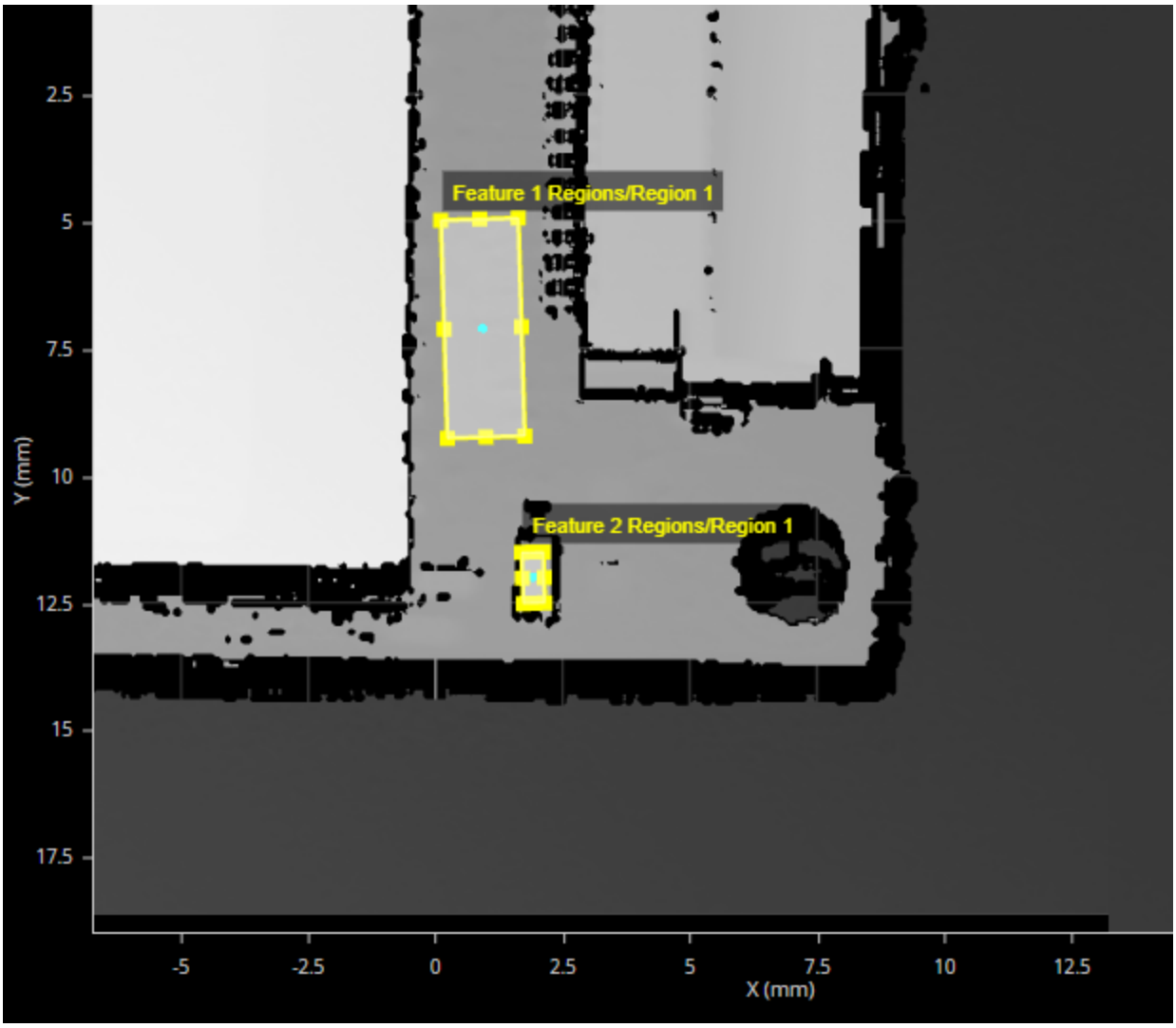
Tools can use the positional measurements (X, Y, or Z) of other tools as anchors to compensate for minor shifts of parts: anchored tools are "locked" to the positional measurements of the anchoring tool's measurements. Some tools can also use a Z Angle measurement as an anchor. Typically, you will use 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.

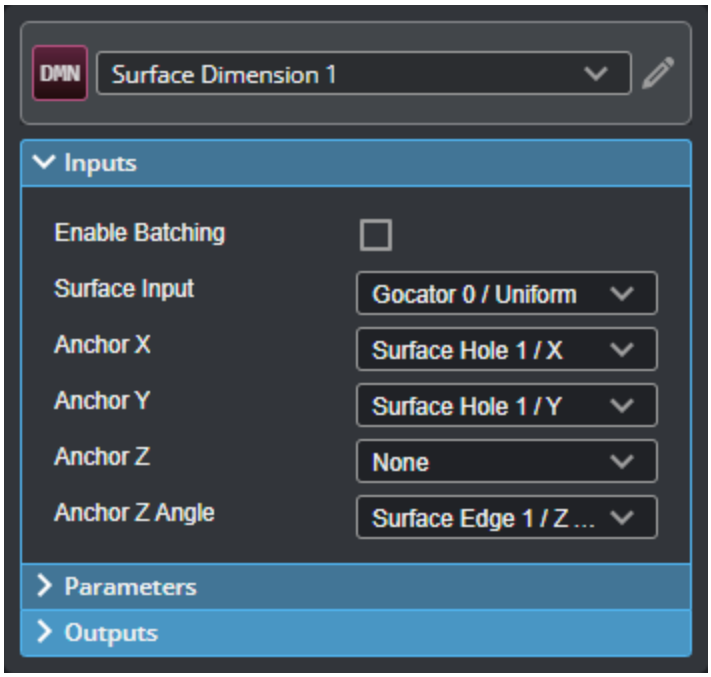


The height of a small PCB component (Feature 2) relative to nearby surface (Feature 1), anchored to positional (X and Y) measurements of the hole (lower right) and to the Z angle of the edge of a larger component to the left.

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



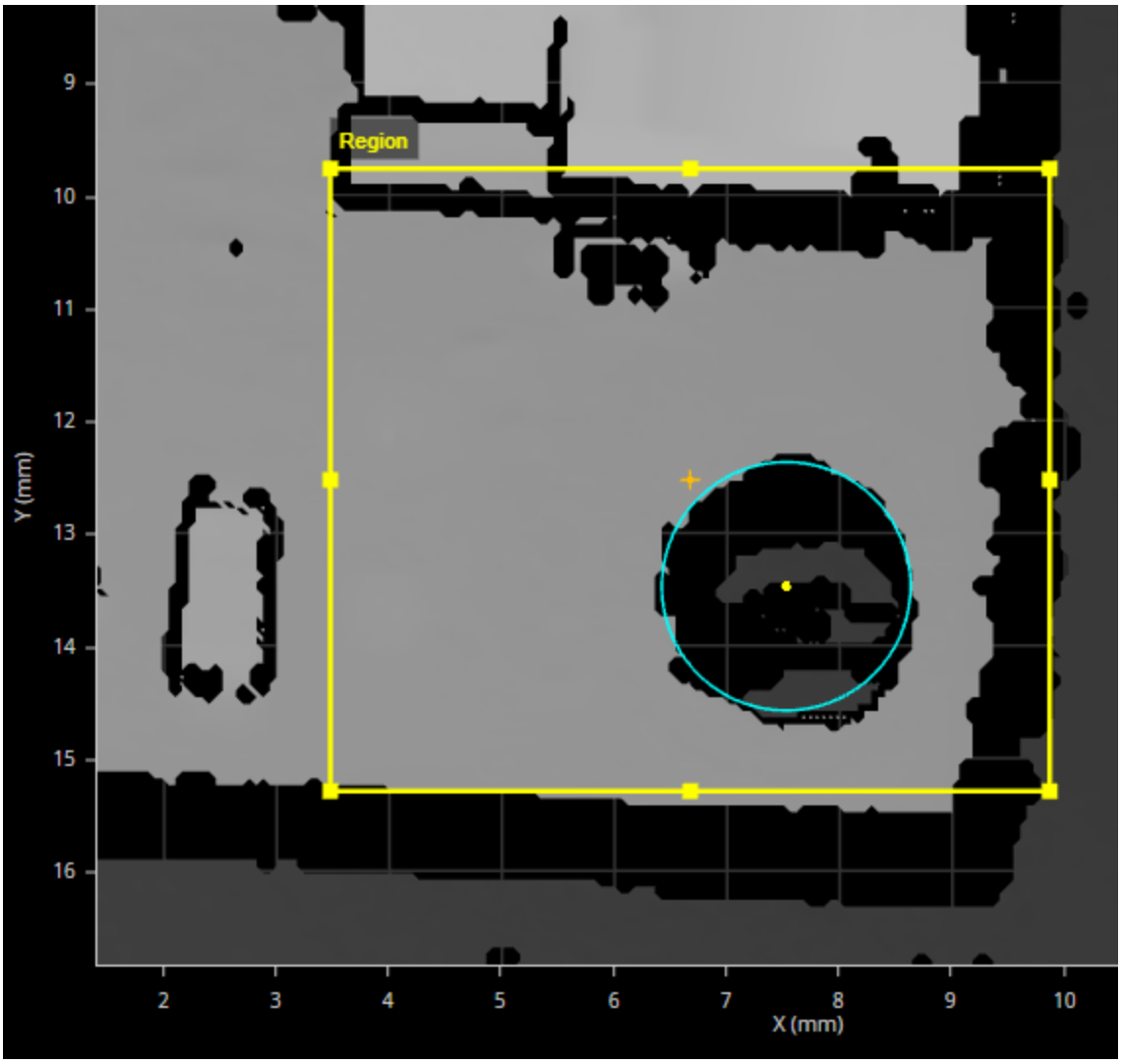
You enable anchoring in the expandable **Inputs** section of a tool:



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.

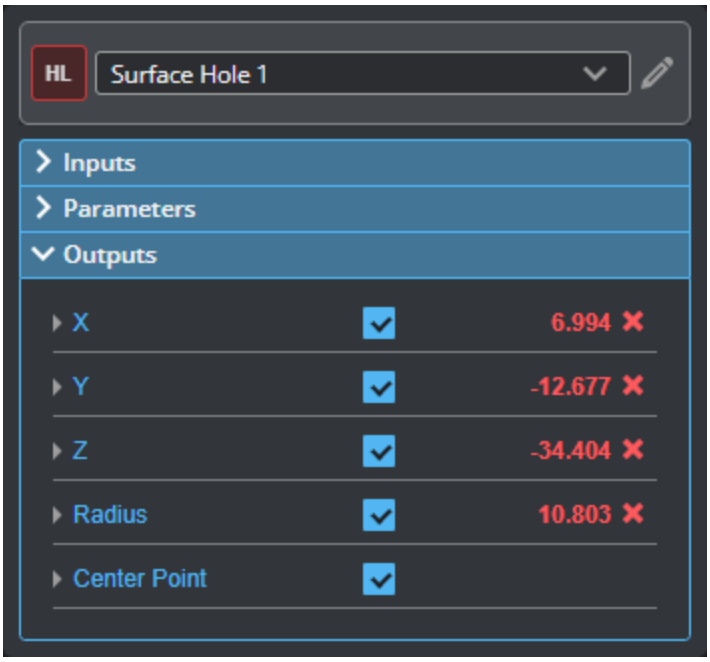
Geometric features are rendered as overlays on a tool's input data.



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

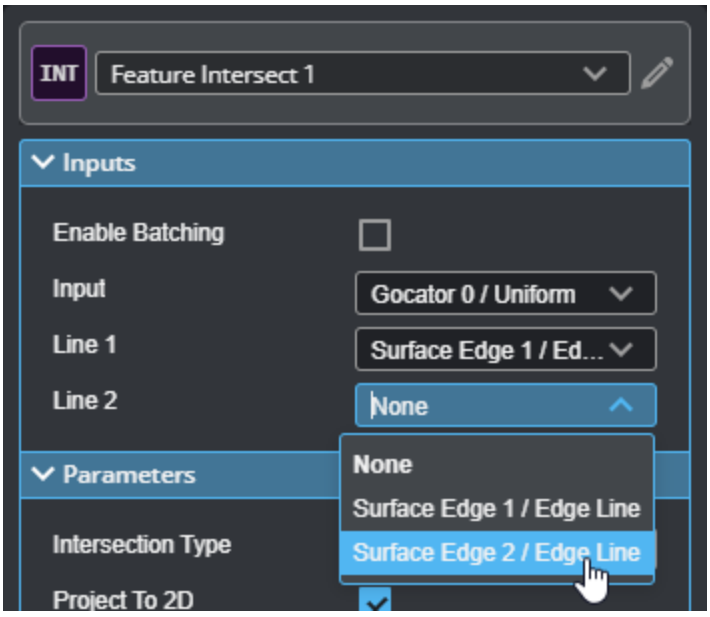
Gocator's "Feature" tools (such as Feature Dimension and Feature Intersect) use geometric features as inputs. For example, because the point geometric feature representing the center of a hole has X, Y, and Z components, you can perform dimensional measurements between it and another geometric feature, 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 552.

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



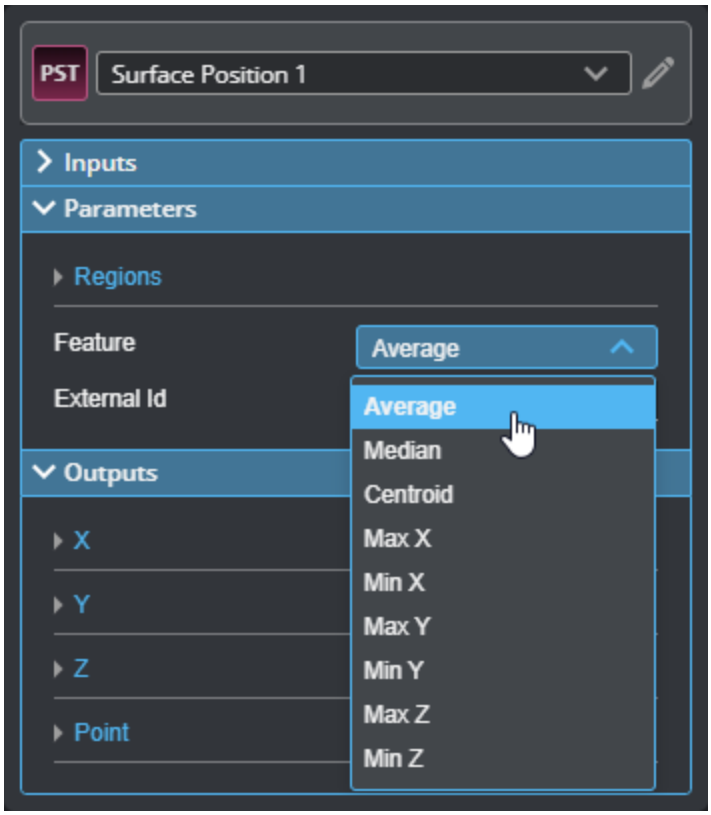
Center Point geometric feature of a Surface Hole tool enabled on Features tab

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 172.

Tool Data

Some measurement and processing tools can output more complex data, which can be used as input by other tools or SDK applications. The following types of data are available: Profile, Surface, and Generic.

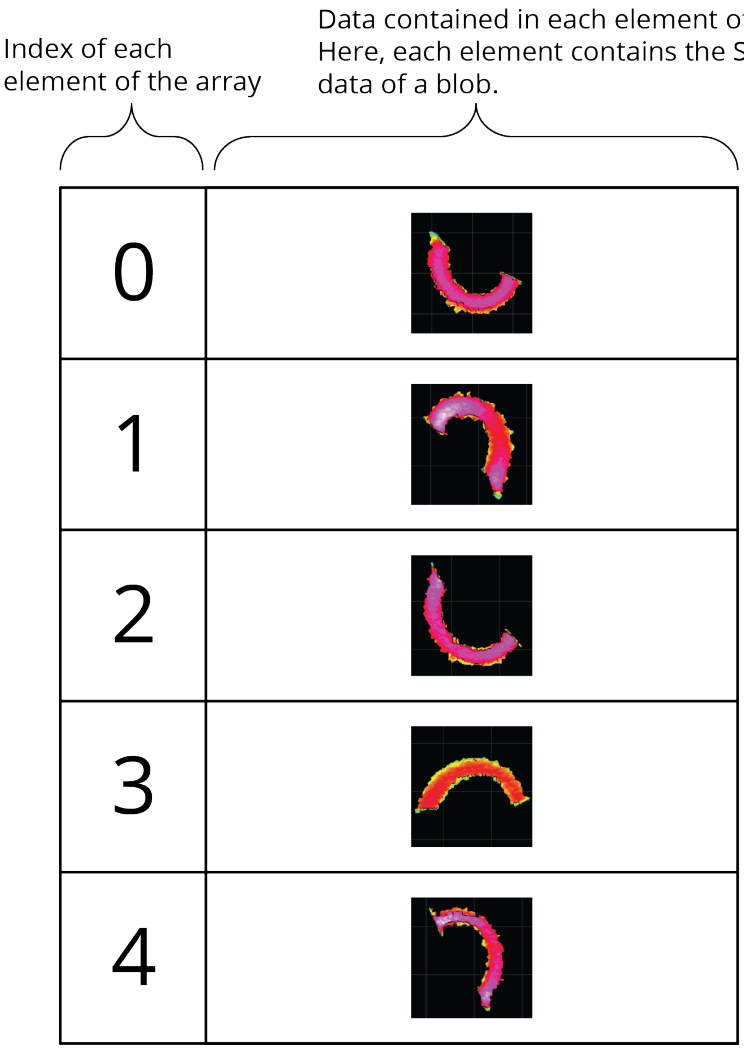
Profile and Surface data produced by a tool is identical in nature to the data produced by a sensor scan, except that they are the processed result from a tool. This kind of data can be used as input in compatible tools. Examples of this kind of this kind of data are the Stitched Surface output from 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 532.

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 155.

User Interface Overview

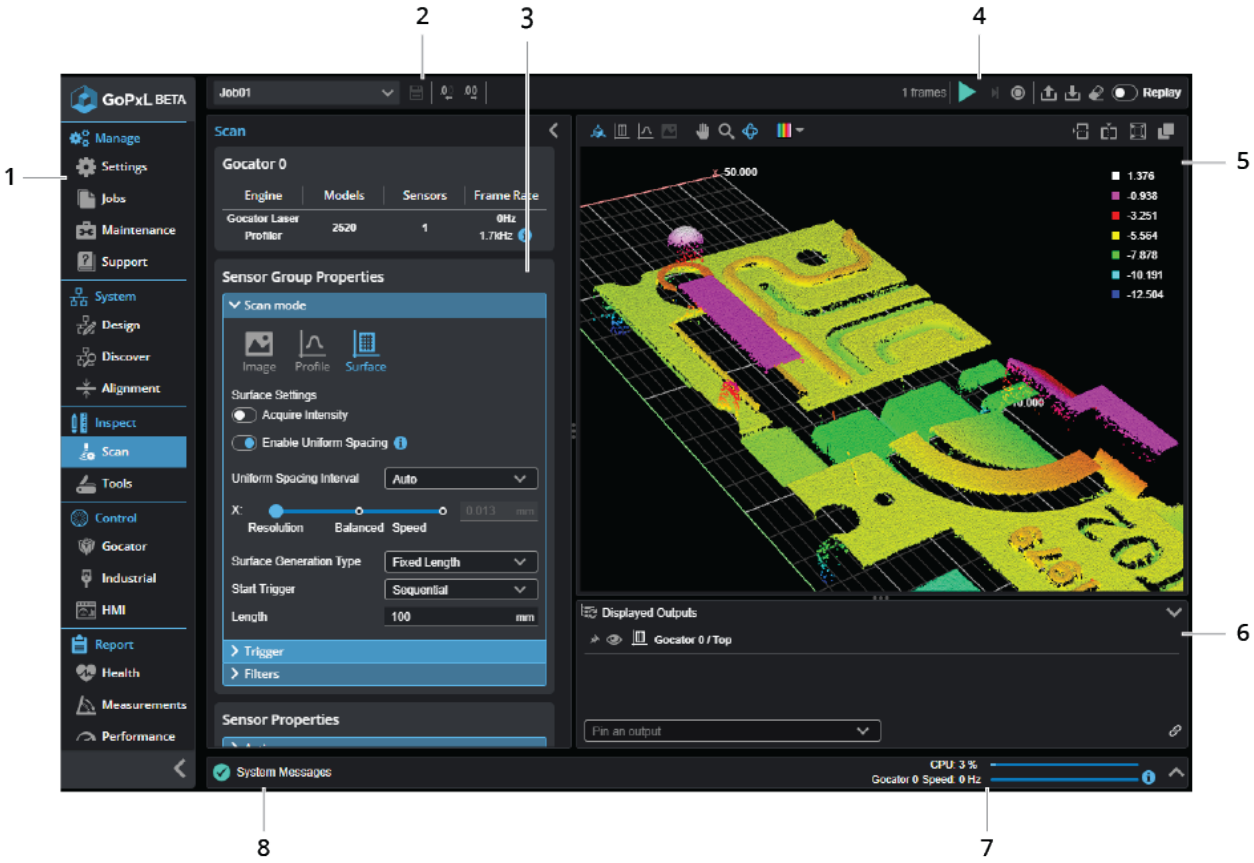
You configure sensors using GoPxL by connecting to an IP address with a web browser.

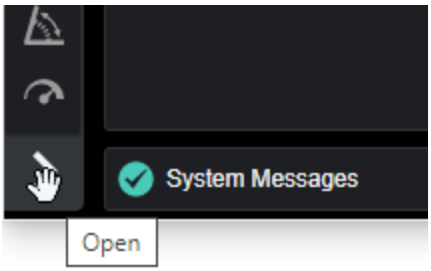
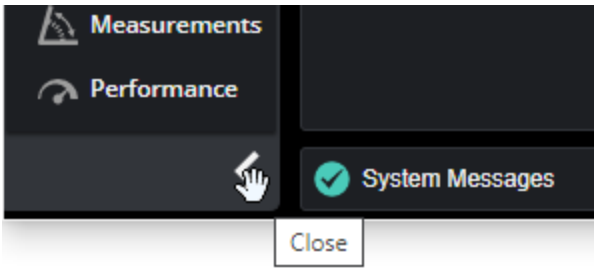
If you are running GoPxL on-sensor, in the browser, you connect to the IP address of the sensor. By default, the IP address of Gocator sensors is 192.168.1.10.

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 656.

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, **Manage**, **System**, **Inspect**, and so on), which contain one or more configuration 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. In this manual, we often use a shorthand convention to describe the location of a page, such as "**Inspect** > **Tools** page." By default, the navigation bar is collapsed and only shows the category and page icons. When you move the mouse pointer over the navigation bar, it expands temporarily to show the category and page names. To pin the navigation bar open, click the Open button at the lower left of the interface:  To unpin the navigation bar, click the Close button at the lower left of the interface.  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 91.
3	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.
4	Scan controls	These controls let you start and stop scanning, and also work with replay data. For information on starting and stopping scanning, see *Starting, Stopping, and Recording* on page 86. For information on working with replay data, see *Playing Back Recorded Data* on page 86.
5	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. For more information, see *Data Viewer* on page 62.
6	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 *Pinning Outputs* on page 78.
7	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.
8	System messages	This area provides log messages, error alerts and warnings. For more information, see *System Messages* on the next page.

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
Manage	Lets you configure network settings, manage jobs, upgrade sensors or perform a factory restore, and so on. For more information, see *Sensor Management and Maintenance* on page 90.
System	Lets you design and align sensor systems. For more information system design, see *Creating a Sensor System* on page 96.
Inspect	Lets you do the following: • Configure a sensor's data acquisition. For more information, see *Configuring Acquisition* on page 107. • Add and configure measurement and processing tools. For more information on tools, see *Configuring Inspection and Processing Tools* on page 127.
Control	Lets you enable and configure the Gocator communication protocol and industrial protocols. Also lets you configure GoHMI. For more information, see *Configuring Control* on page 622. For information on the protocols, see *Integrations* on page 703.
Report	Lets you monitor measurements, as well as sensor health and performance. For more information, see *Reporting* on page 650.

Status Bar

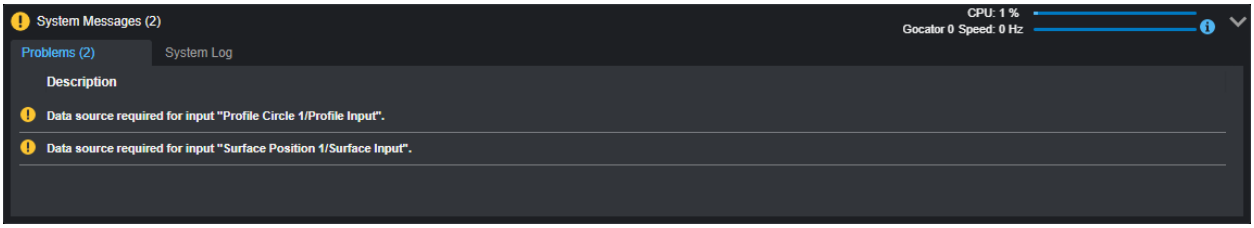
The status bar lets you do the following:

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

System Messages

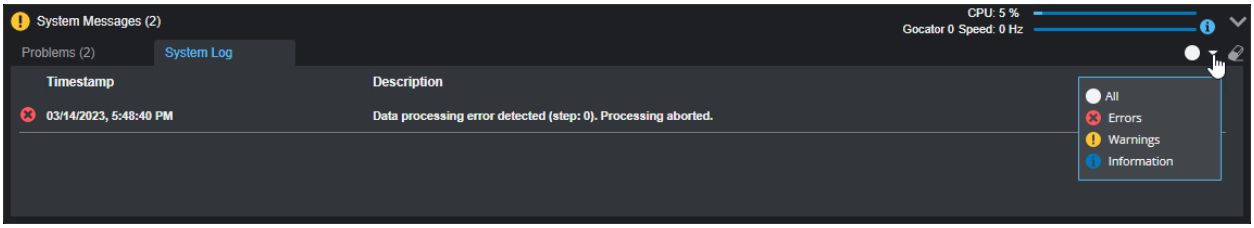
The **System Messages** panel displays current problems and a system log containing errors, warnings, and general information, in two tabs.

The **Problems** tab lists the *current* problems. 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 **System Log** tab displays a complete list of system-level problems.



You can filter the log entry types using the filter drop-down to the right of the **System Log** tab, and clear the entries using the eraser button.

Metrics Area

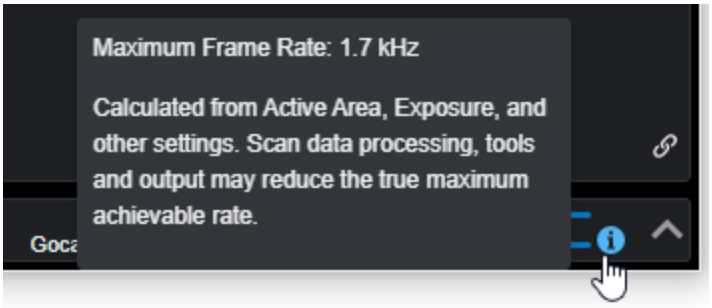
The Metrics area on the right side of the status bar displays two important performance metrics: CPU load and sensor speed (current frame rate).



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

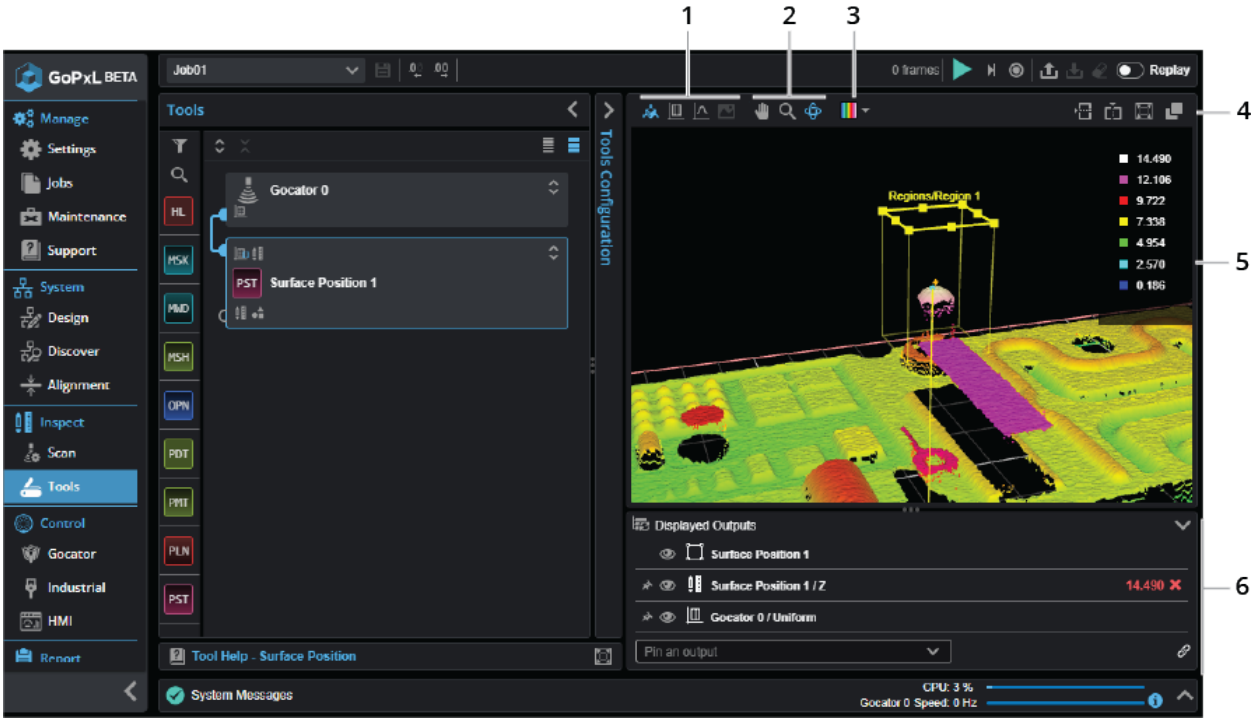
The **Speed** bar displays the frame rate of the sensor.

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

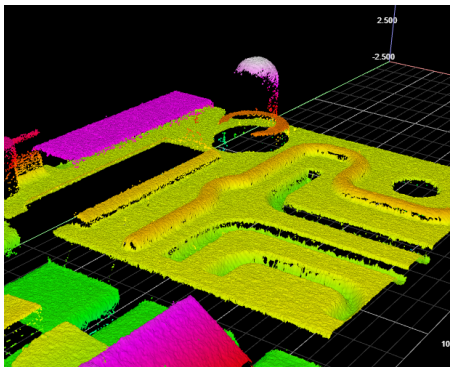
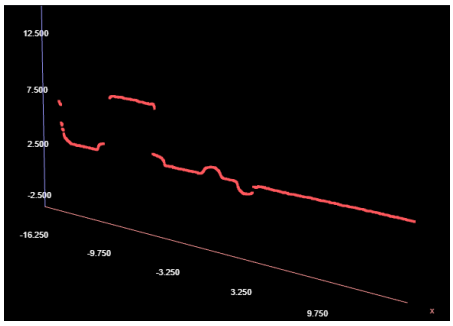
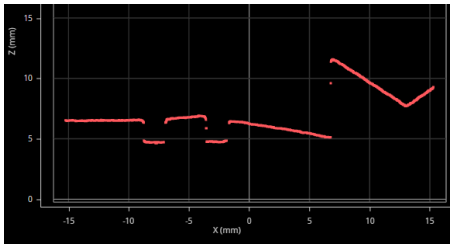


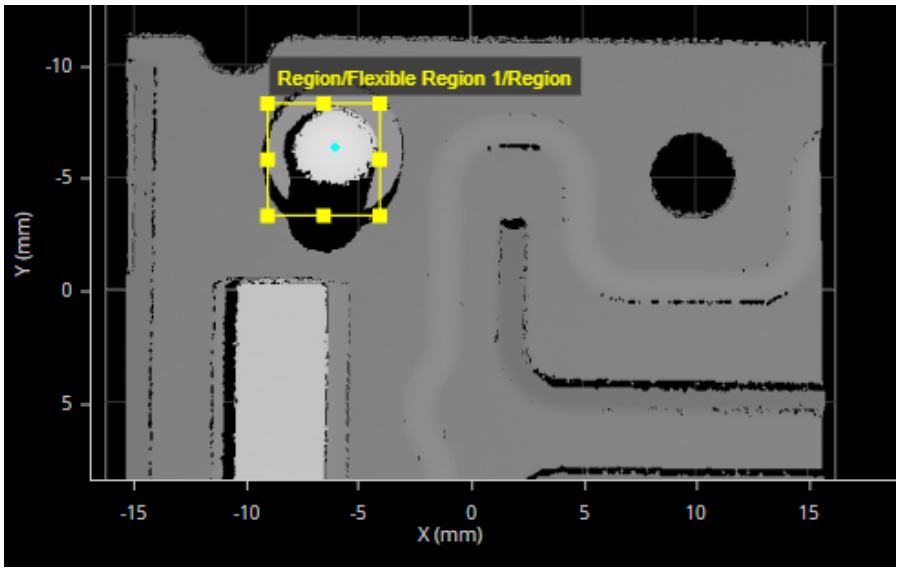
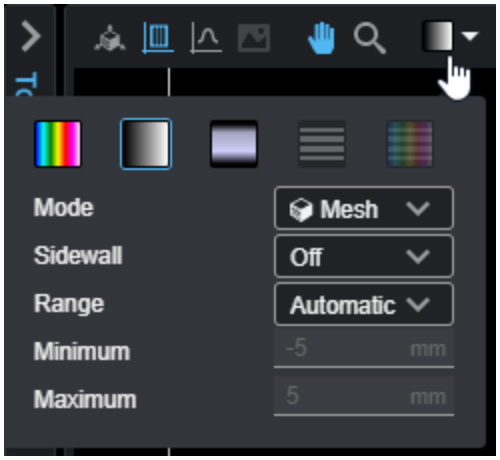
Data Viewer

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 *Configuring Inspection and Processing Tools* on page 127) and a sensor's active area (see *Active Area* on page 118). 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: **Perspective** 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 71.

Element	Description
	  **Profile / Front** Profile / Front mode ( ) displays profiles in a 2D representation when Profile data is available.  **Surface / Top** Surface / Top mode ( ) lets you display surface data in a 2D representation when Surface data is available. For information on controlling how the data viewer displays Surface data in Perspective mode, see *Surface and Perspective Display Options* on page 71.

	Element	Description
		 **Image** Image mode ( ) lets you view pixel data that the system has acquired in Image mode. Useful for adjusting exposure and diagnostics.
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.)
3	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, or the color of a profile. For information on changing how the data viewer displays Surface data, see *Surface and Perspective Display Options* on page 71. For information on how the data viewer displays Profile data, see *Profile Mode* on page 69. 
4	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.

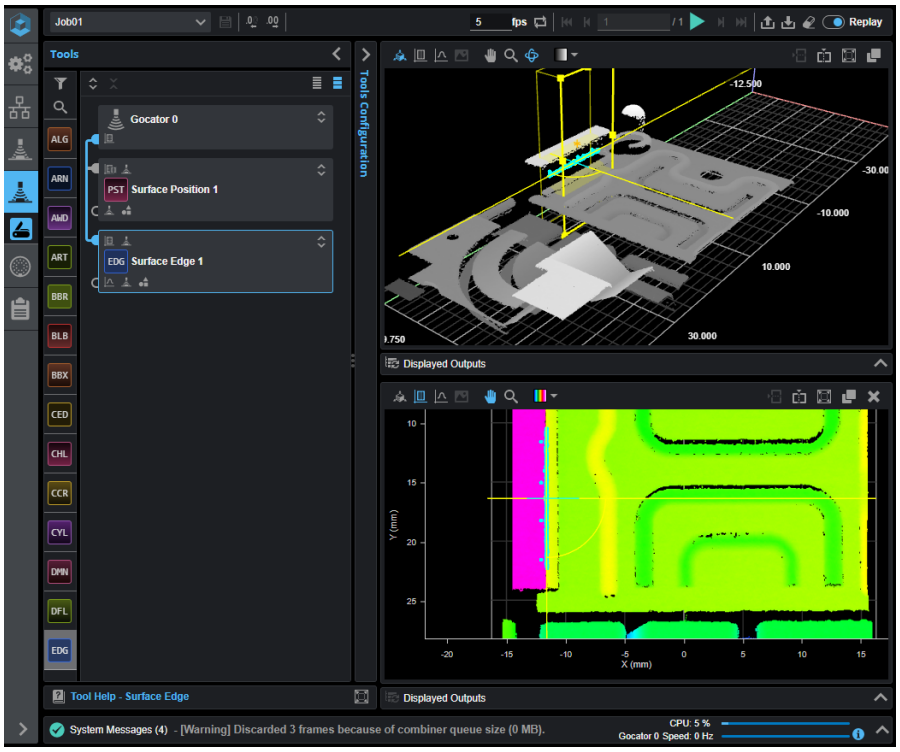
	Element	Description
		 Use the Pop-out button ( ) to create a new window with a single data viewer. For more information, see *Using Multiple Data Viewer Windows* on page 77. Use the Zoom to fit button ( ) to zoom the scan data so that it fits in the data viewer window.
5	Data viewer window	This is the 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.
6	Displayed Outputs pane	Lets you pin and hide outputs. For more information, see *Pinning Outputs* on page 78. 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 *Adding a Data Viewer to an HMI* on page 687.

Image Mode

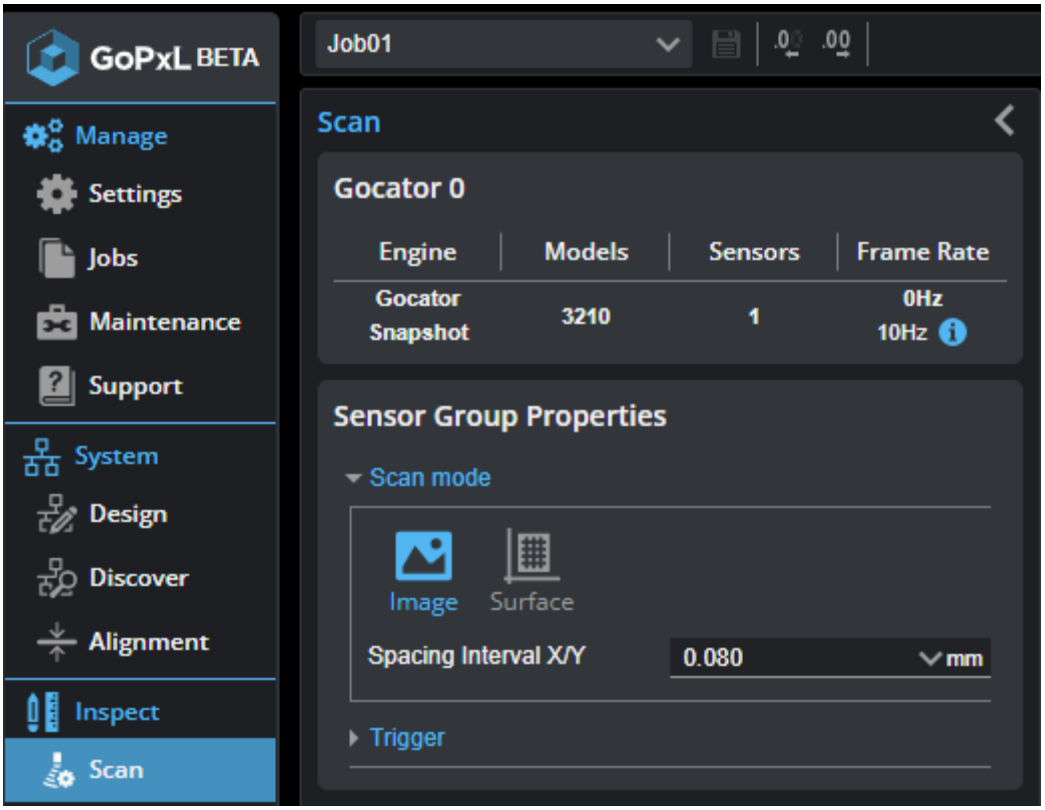
In Image mode, the data viewer displays images and spots directly from a sensor's camera or cameras.

In this mode, depending on the model, you can use the data viewer to display exposure information (see *Exposure Information* on page 67) 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 without red areas appearing in the image, the **Multiple** exposure feature should be enabled. Use the drop-down selection box 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.

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** page > **Scan Mode** section.



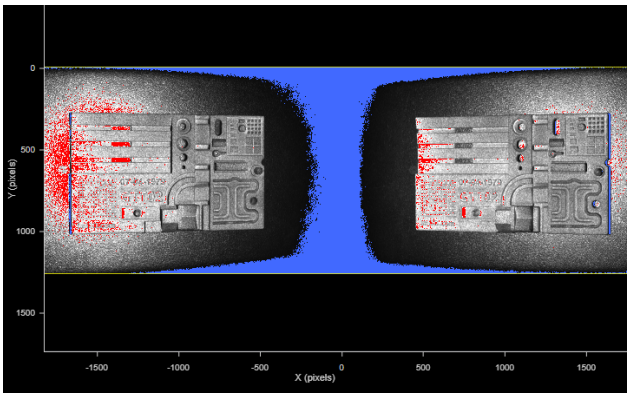


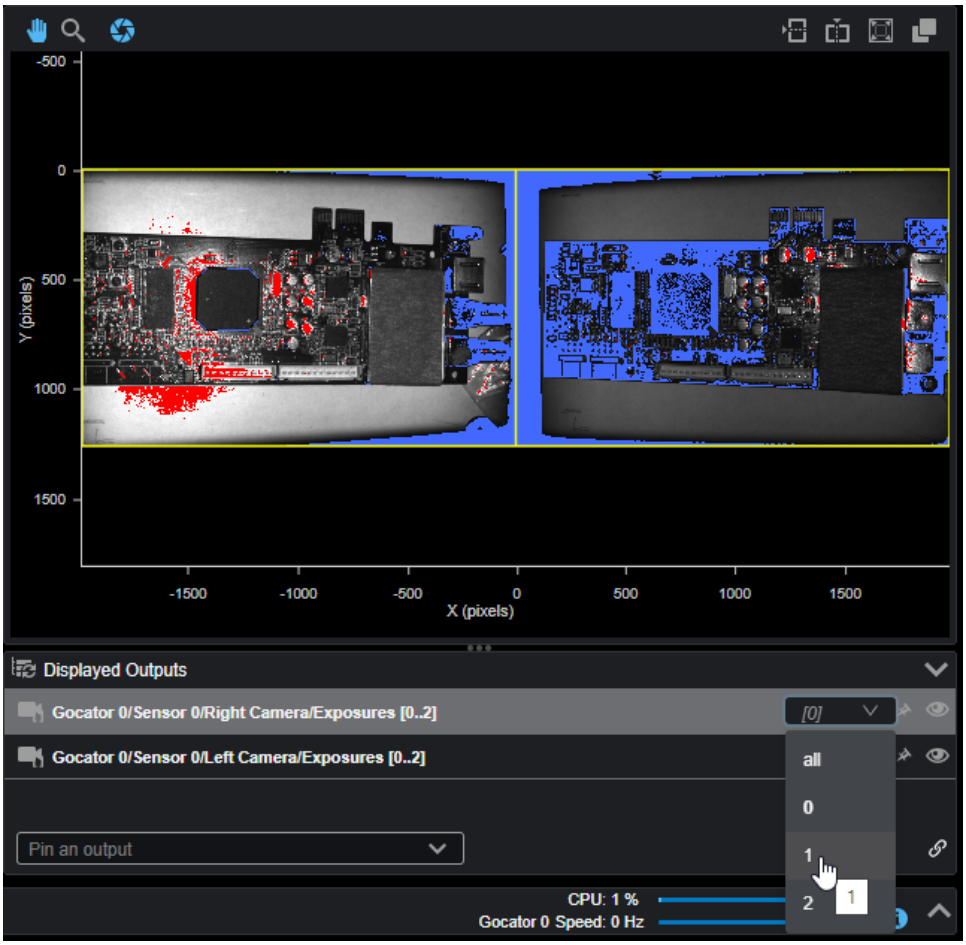
Image data showing left and right camera views. The grayscale dots represent camera pixels. Red pixels are overexposed. Blue pixels are underexposed. The yellow outline indicates the boundaries of the sensor camera.

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* on page 120.)

Exposures

Exposures are 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 > Scan** page, and have set more than one exposure, each exposure is listed individually (G2) or as an element available in a drop-down (G3 and G5).

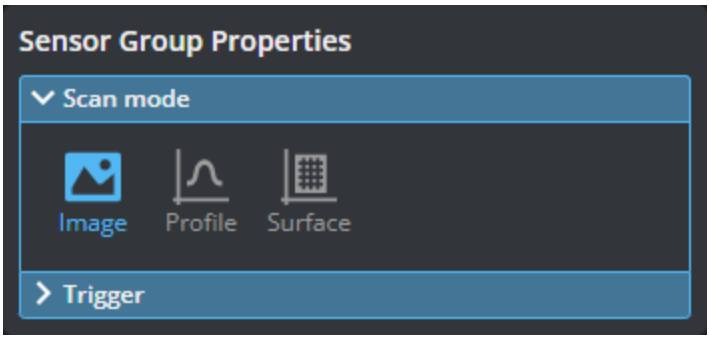


Incorrect Exposure

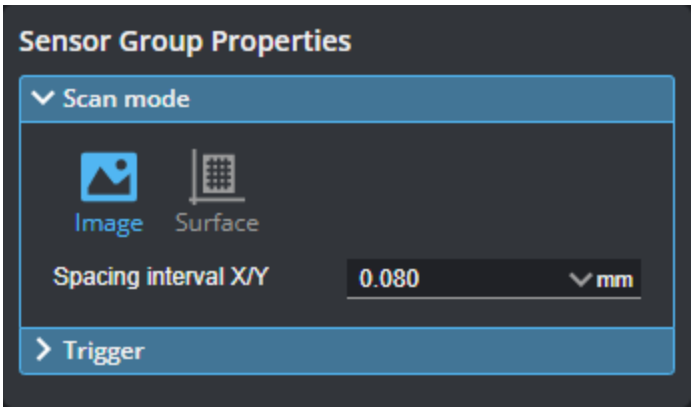
You can display a color overlay on the video image to help set the correct exposure. Underexposed pixels are displayed in blue. Overexposed (saturated) pixels are displayed in red. Black, grey, and white pixels represent the intensity of a pixel that isn't underexposed or overexposed.

To display exposure information, make sure you are in Image scan modes:

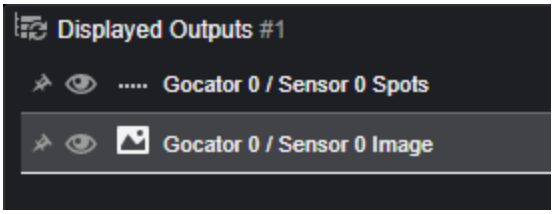
G2 and G5



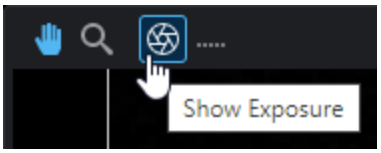
G3



Also make sure the Image output is not disabled ( ) in the Displayed Outputs pane.

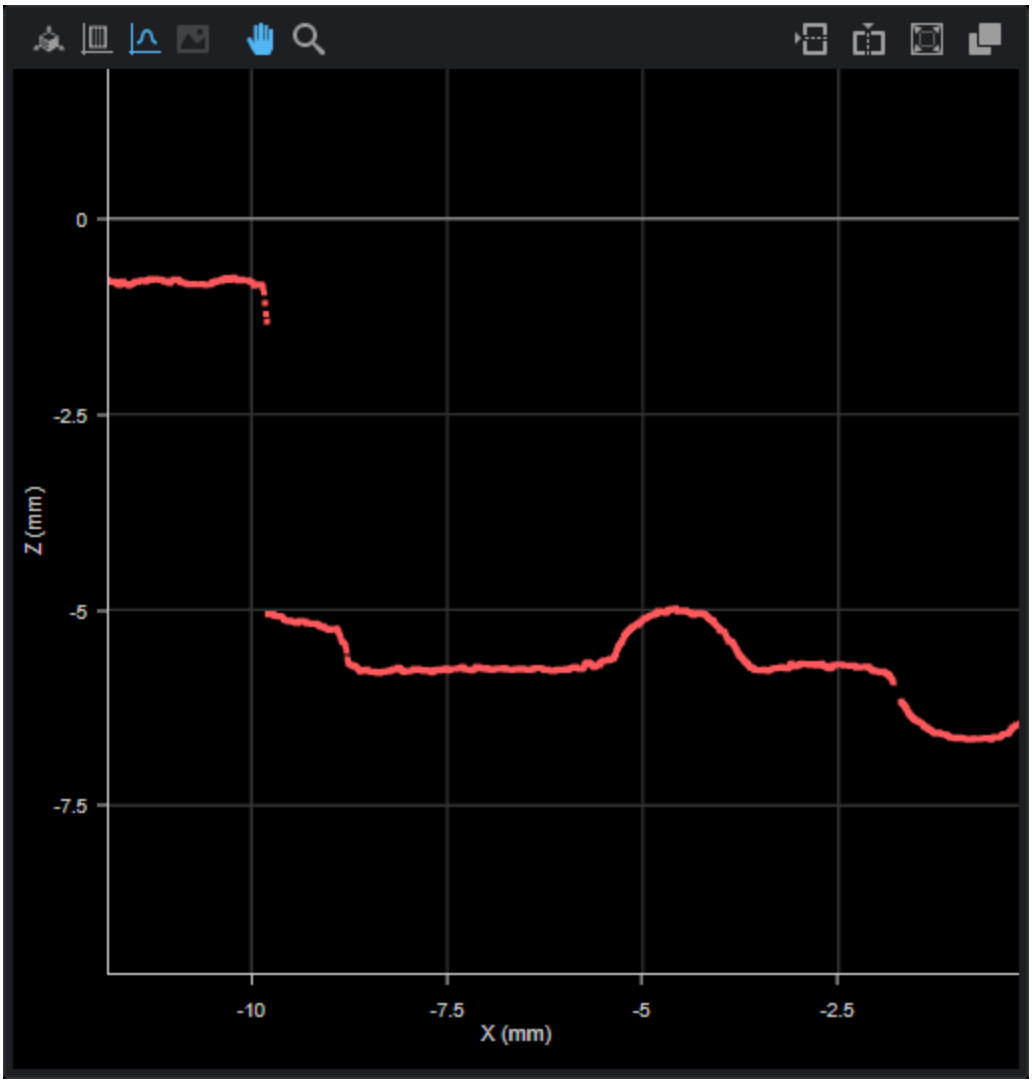


Then click the **Show Exposure** button at the top left of the data viewer.

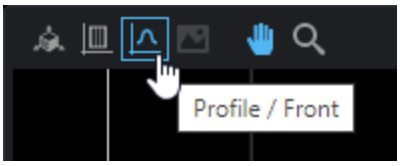


Profile Mode

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

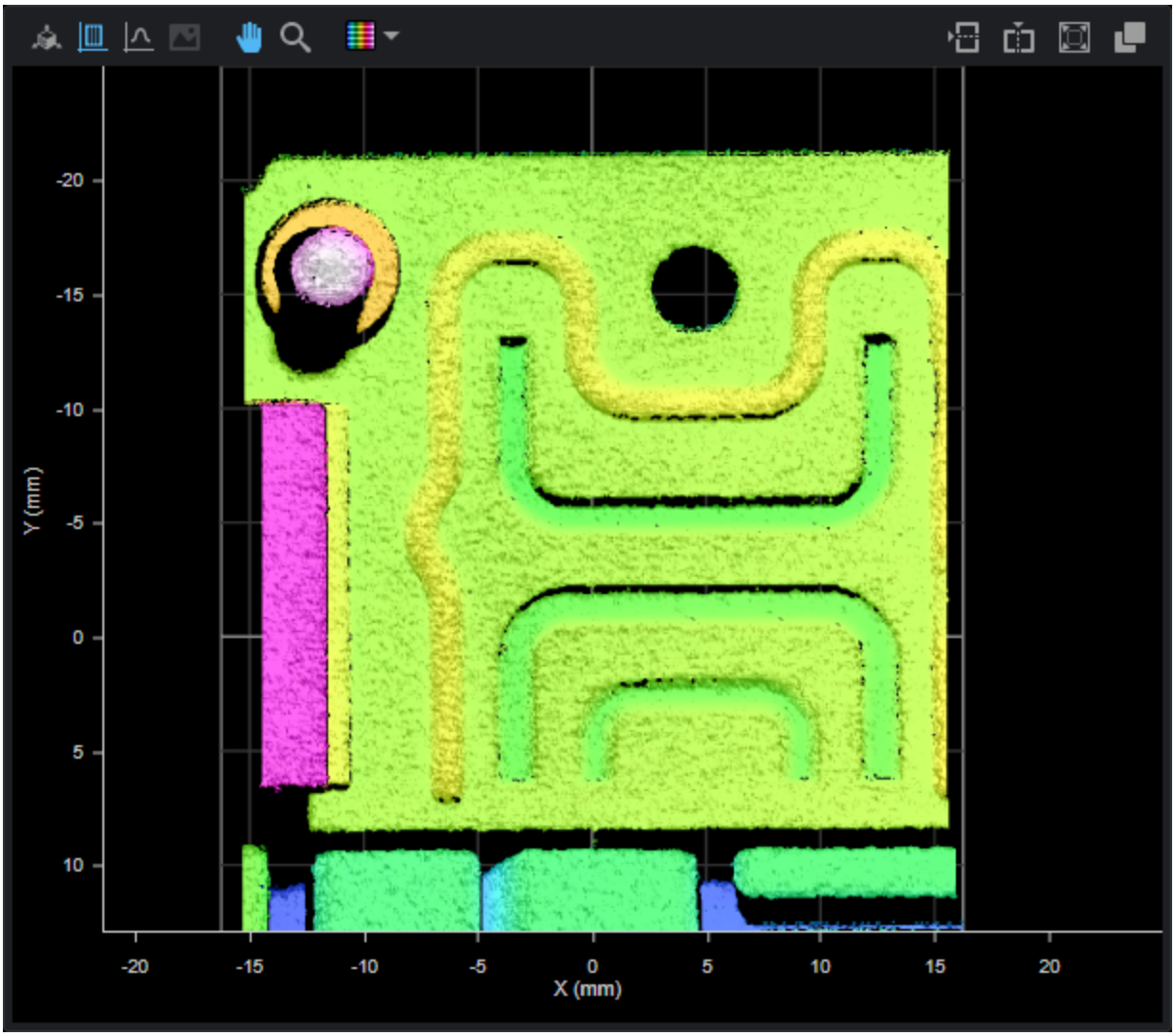


To set the data viewer to Profile mode, click the Profile mode button above the data viewer window:

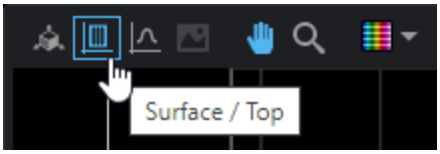


Surface Mode

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



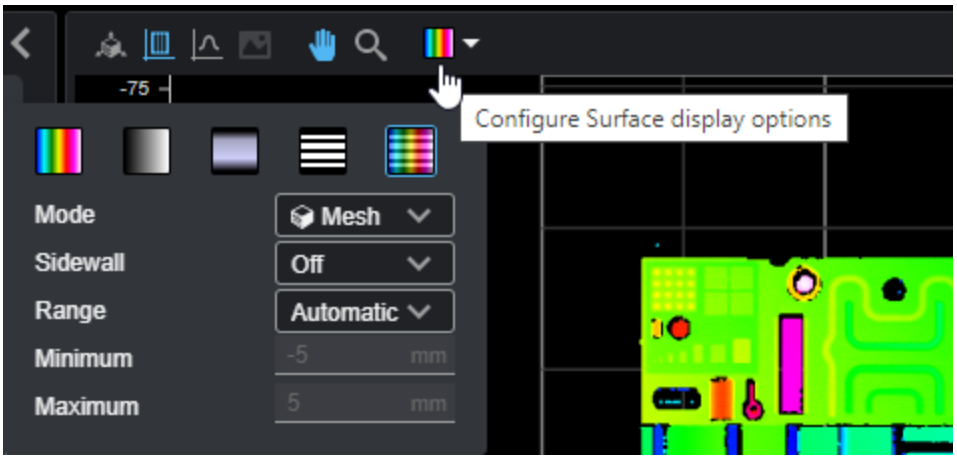
To set the data viewer to Surface / Top mode, click the mode button above the data viewer window:



You can control how Surface data is displayed. For more information, see *Surface and Perspective Display Options* below.

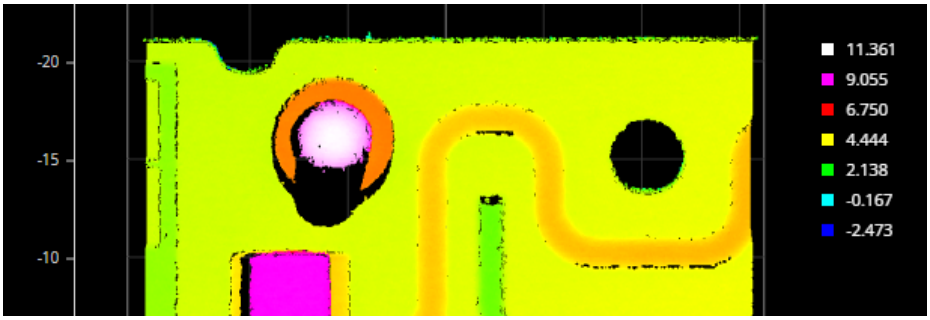
Surface and Perspective Display Options

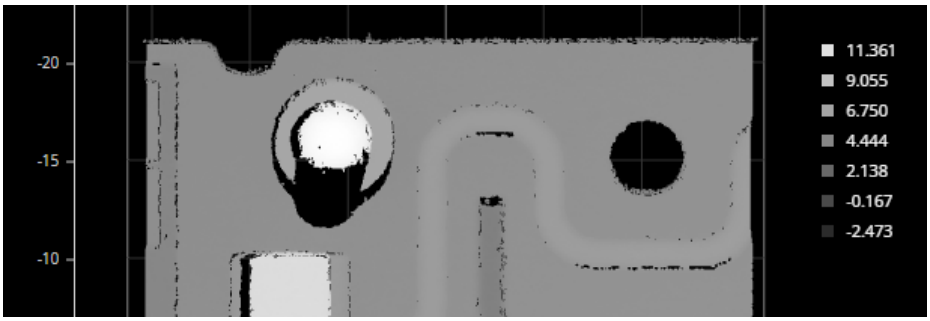
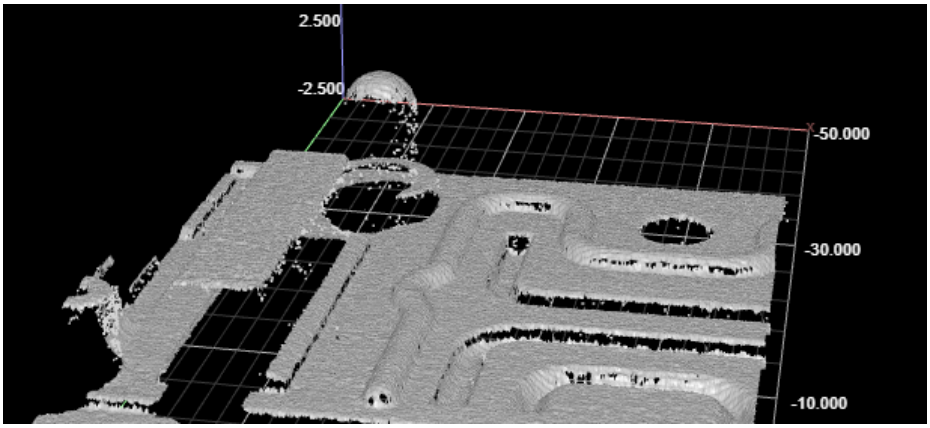
You control how Surface data displays when the data viewer is in Surface or Perspective mode using the display options available in the Display Outputs panel. To access the display options, open the **Display Outputs** panel and click the rightmost icon of the output you are working with.

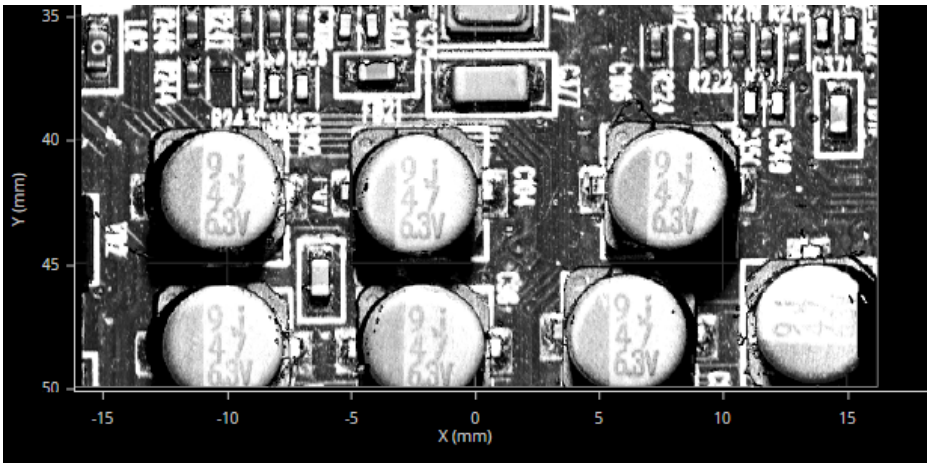
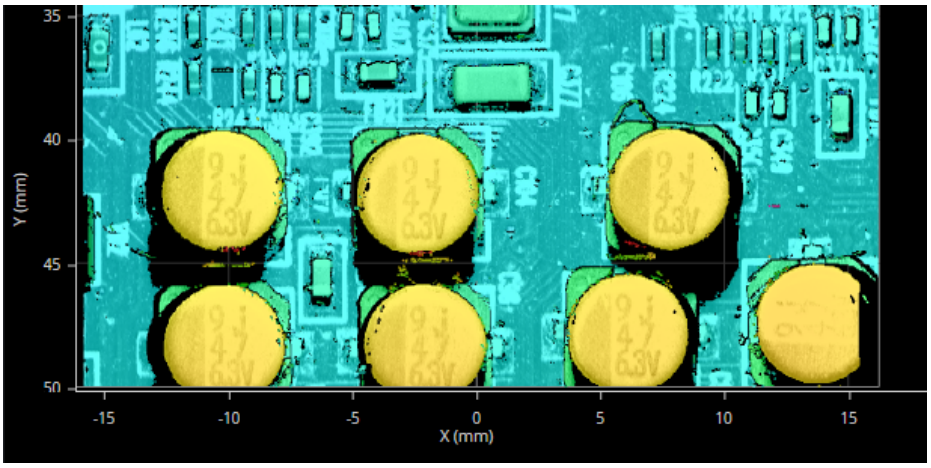


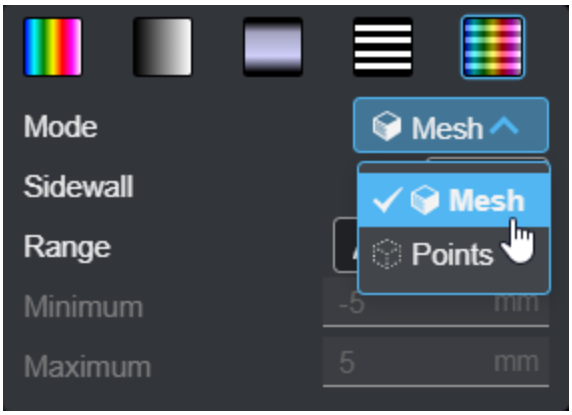
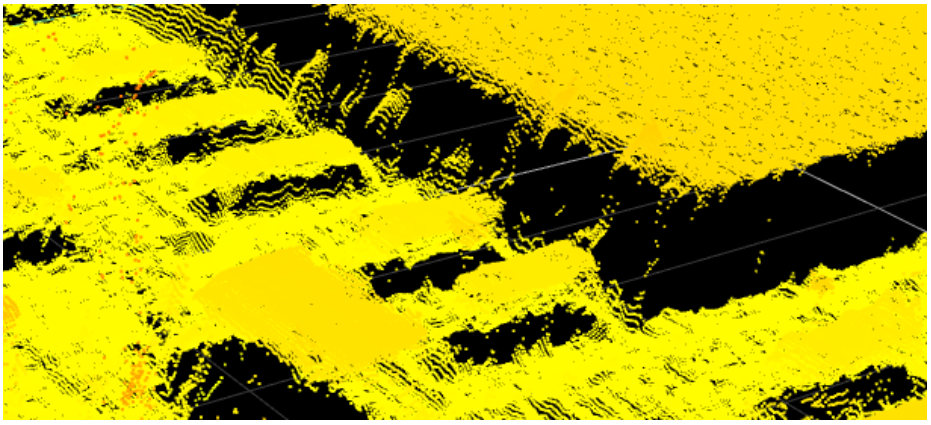
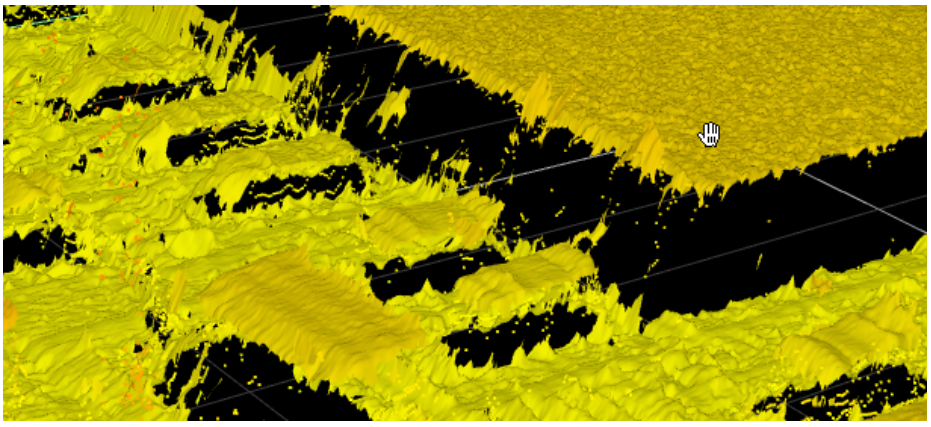
Surface display options.

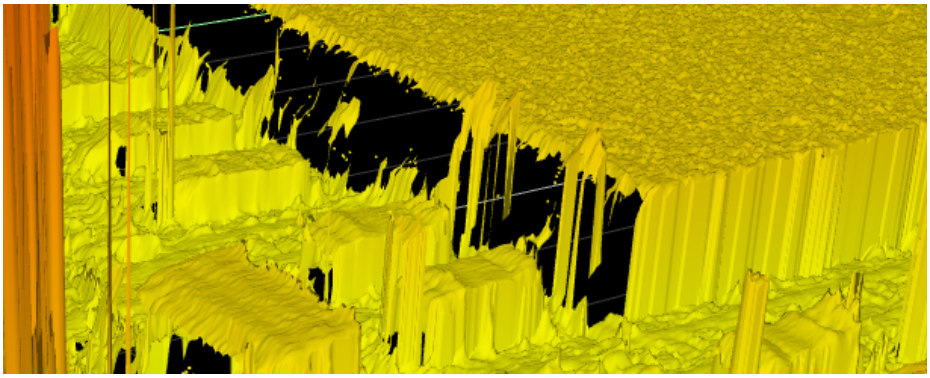
Display options

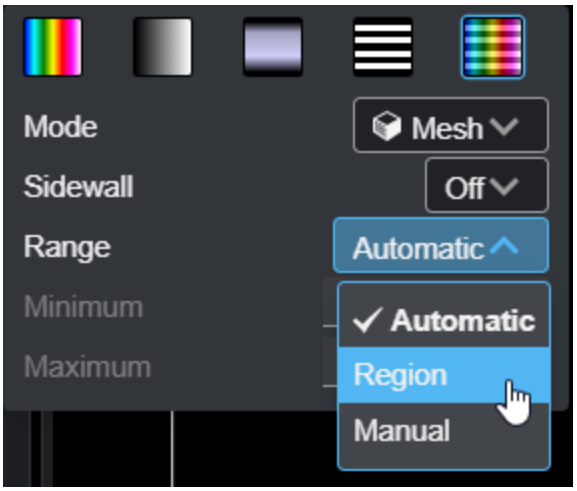
Option	Description
Display options	The output display modes let you choose how GoPxL shades the Surface data when the data viewer is in Surface mode or in Perspective mode.  The following output display modes are available: **Heightmap** Heightmap mode ( ) displays a color heightmap over the Surface data. A heightmap legend is displayed in the data viewer. You can set the range values that map to the heightmap colors to make features easier to see.  **Grayscale** 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. You can set the range values that map to the heightmap colors to make features easier to see.

Option	Description
	 **Uniform** 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.  **Intensity** Intensity mode ( ) displays intensity data over the Surface data if it is available. When intensity data is enabled on the **Acquire** > **Scan** page, 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 107.

Option	Description
	 **Heightmap + Intensity** 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 107. 
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 598.)

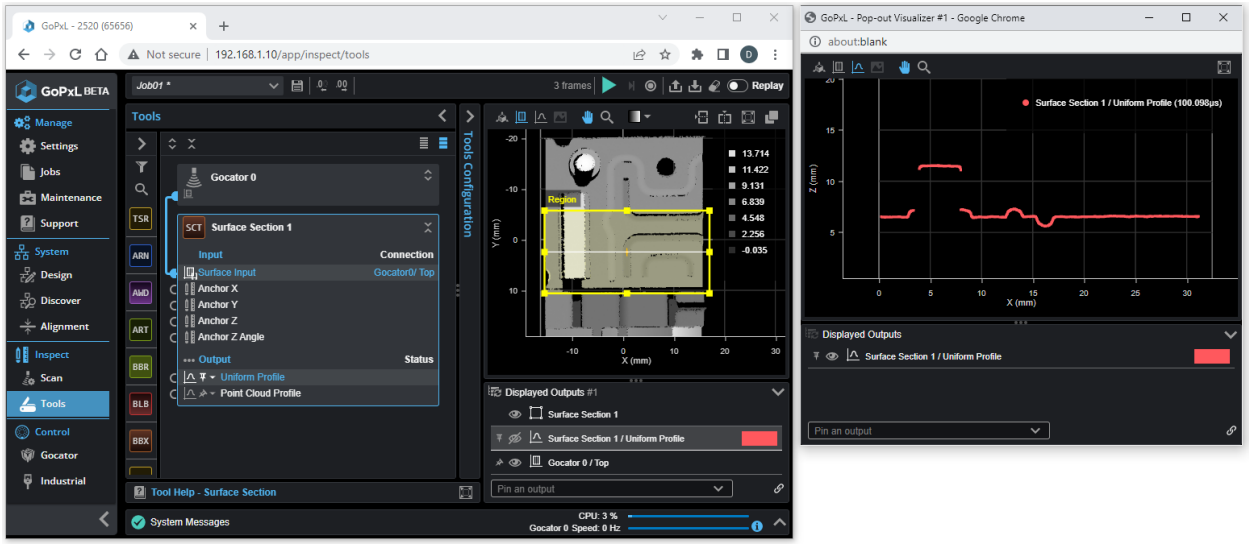
Option	Description
	 Points mode displays the data as discrete data points. This mode is useful in scan data that contains noise around edges, and can show hidden structure.  Mesh mode displays Surface data by connecting the data points with polygons. 
Sidewall mode	You can toggle the data viewer between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

Option	Description
	 For example, in the following, the sidewalls are enabled, resulting in the lines shown at the edges of the PCB components.  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 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. To change the scaling, choose an option from **Range**.

Option	Description
	 Do one of the following: • To automatically set the scale, choose **Automatic** in the **Range** drop-down. • To automatically set the scale based on a user-selected sub-region of the heightmap, choose **Region** in the **Range** drop-down and adjust the yellow region box in the data viewer to the desired location and size. • 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.

Using Multiple Data Viewer Windows

You can pop out multiple data viewers outside of the main browser window. You can configure data viewers to different views, different display modes, and different sets of pinned outputs. This lets you more easily monitor or set up complex applications, for example placing one or more data viewer windows in one computer monitor, and others in a different monitor.



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 *Pinning Outputs* below.

To open a new external data viewer window

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



A new window opens containing a separate data viewer.

Use the tool bar at the top of the new data viewer to choose and modify the view (Surface vs. section data, color heightmap vs. intensity, 2D vs. 3D, etc.). For more information, see *Data Viewer* on page 62.

Pin outputs to the new data viewer as in the main view data viewer. For more information, see *Pinning Outputs* below. 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.

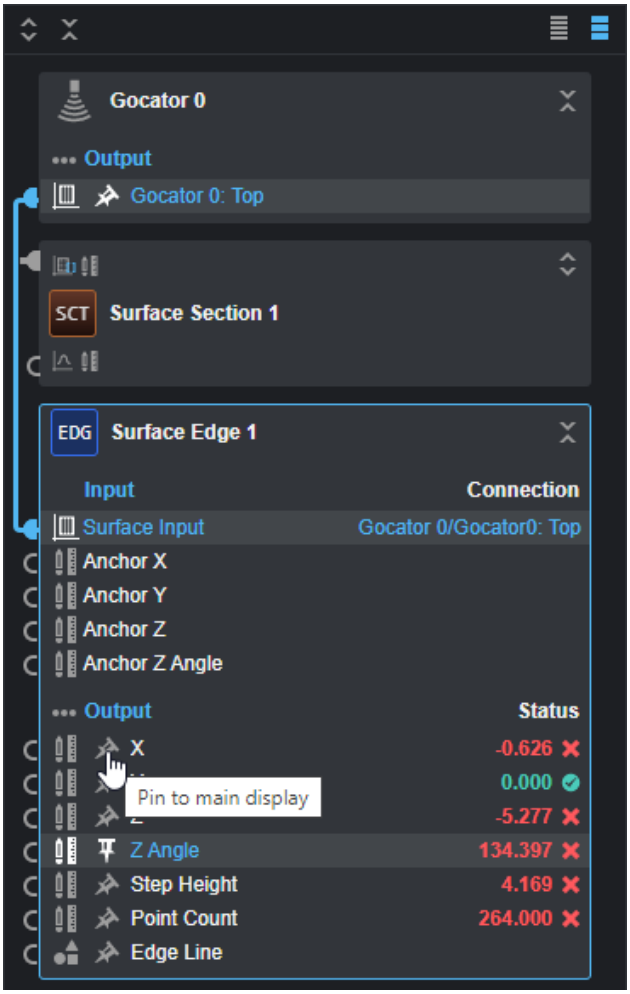
Pinning Outputs

You can “pin” one or more tool outputs (measurements and geometric features) to a data viewer. When these outputs are pinned, they remain visible in a data viewer at all times, even when you click on a different tool, measurement, or feature in one of the outputs listed in either the data viewer's

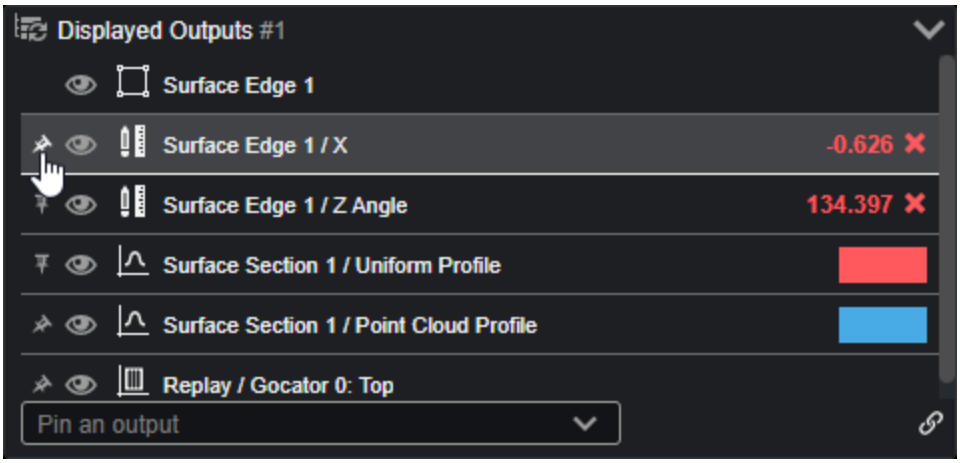
Displayed Outputs panel or in the Tools Diagram. When no tool outputs are pinned, only the currently selected tool output is displayed in the data viewer. Pin information (for the main data viewer) is stored in job files.

Pinning outputs is useful if you want to monitor multiple, independent measurements while the Gocator 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 modification has on another tool later in the chain. This minimizes toggling and clicking between tools and measurements. Pins are automatically stored as measurements in job files.

You can pin outputs in the Tools Diagram or in a data viewer's Displayed Outputs pane.

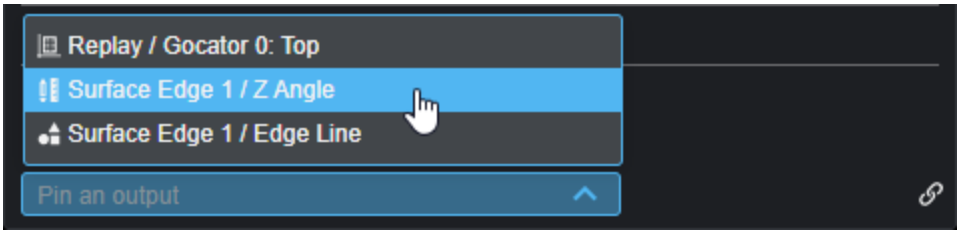


Pinning an output in the Tools Diagram. A pinned output's pin state is reflected in the Tools Diagram list.

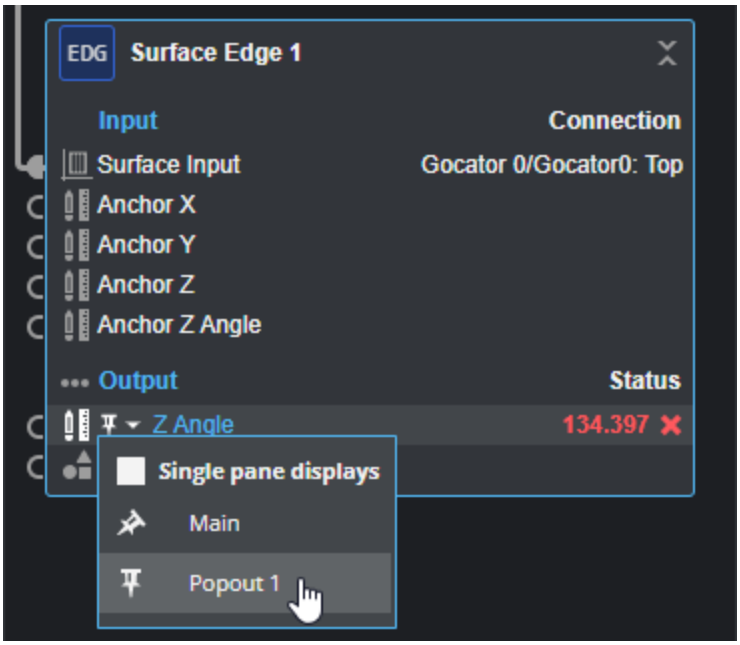


Pinning an output in a data viewer's Displayed Outputs panel.

You can also choose an output from the Pin an output dropdown.



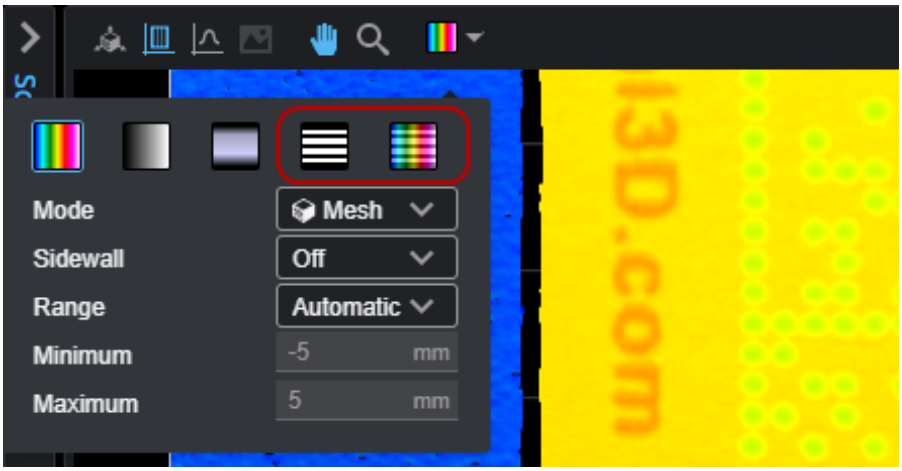
If you have created multiple data viewers, either by splitting a data viewer in the main browser window, or by popping out a new data viewer, you can choose which data viewer to pin an output to.



Intensity Output

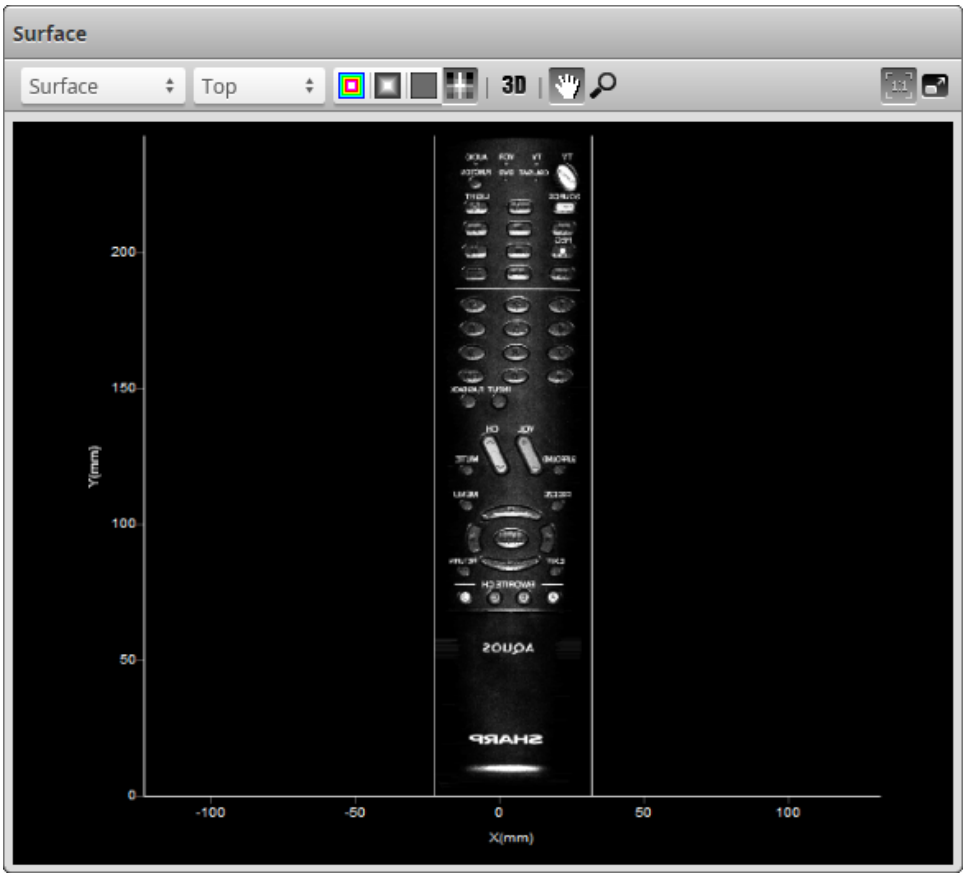
Sensors can produce intensity images that measure the amount of light reflected by an object. An 8-bit intensity value is output for each data point in the scan data. GoPxL uses the same coordinate system as the data points.

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 enabled **Acquire Intensity** in the **Scan Mode** panel.


Surface
Surface
Top
3D
200
150
100
50
0
Y(mm)
-100
-50
0
50
100
X(mm)

File Formats

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

File formats

Format	GoPxL extension	Gocator firmware 6.x and earlier	Content	Description
Job	.gpjob	.job	• Scan settings • Tool settings • Control/output settings	Quickly change a set of settings by switching from one job to another. For more information, see *Jobs* on page 91.
Recording	.gprec	.rec	• Current job settings (see above) • Recorded data Note that sensor settings are not necessarily visible after loading a recording.	Quickly save and load recorded data for development and diagnostic purposes. For more information on recording and on loading recorded data, see *Working with Scan Data* on page 85. You can use the replay converter, provided in the utilities package, to convert .gprec files to and from various formats. For more information, see *Replay Converter Tool* on page 753.
Backup	.gpbak	.bak	• All jobs • Layout and transformation • Current recorded data • Global settings	Allows restoring a sensor to a previous state in case undesired changes were made. You back up and restore sensors on the **Maintenance** page. For more information, see *Backup and Restore* on page 94.
Support	.gpsup	.gs	• Everything the Backup file contains • Additional diagnostic information	For supporting development and diagnosing issues. You download and upload support files on the **Support** page. For more information, see *Support* on page 95.

The following formats can be converted using the replay converter. For more information, see *Replay Converter Tool* on page 753.

File formats

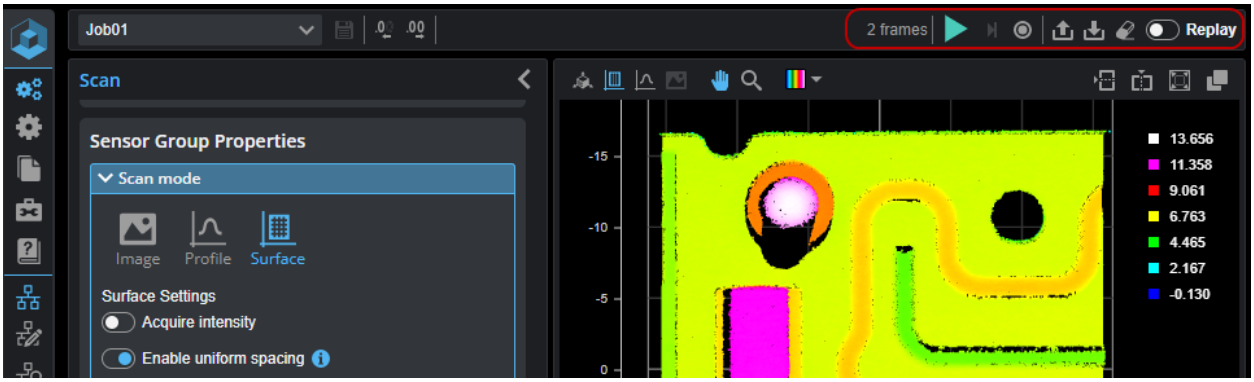
Format	GoPxL extension	Gocator firmware 6.x and earlier	Content	Description
CSV	n/a	.csv	Scan data in CSV format	First download replay data in GoPxL, and then use the Replay Converter tool to convert to the CSV format, for use with third-party tools.
.pcd / .sur / .srf	n/a	n/a	Scan data in various formats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

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 scanning
- record replay data
- enable replay mode and play data
- upload, download, and clear replay data

> 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 (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)

	Element	Description
1	Frames per second and looping	Lets you set the number of frames per second during playback, and also enable or disable looping.
2	Data controls	These controls let you start and stop scanning, start recording and also work with replay data. The number of frames is also indicated. The controls that are available depends on whether Replay mode is disabled or enabled.

	Element	Description
		For information on starting and stopping scans, see *Starting, Stopping, and Recording* below. For information on data playback, see *Playing Back Recorded Data* below.
3	Replay actions	Lets you upload, download, and clear recorded data. Note that replay data contains The file type of replay data is .gprec.
4	Replay toggle	Lets you toggle between data acquisition (toggle is to the left) and data playback (toggle is to the right).

Starting, Stopping, and Recording

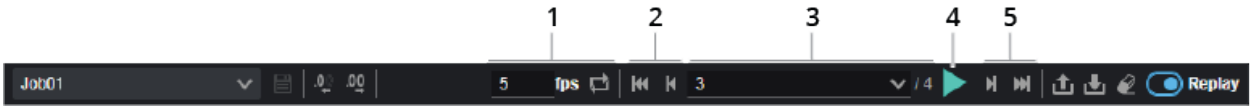
You start and stop data acquisition using the data control buttons when Replay is disabled.



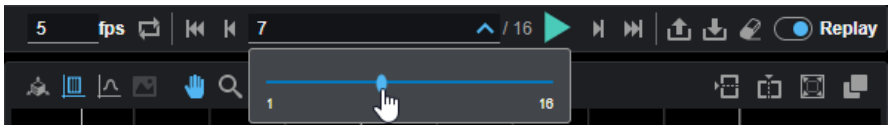
	Element	Description
1	Start scanning	The sensor starts scanning continually.
2	Single frame (Snapshot)	The sensor acquires a single frame of data. For laser line sensors and line confocal sensors, you can't acquire a single frame of data if the sensor is in Surface mode, only in Profile or Image mode.
3	Record data	The sensor records scan data as it is acquired. The number of frames is displayed next to the Start button.

Playing Back Recorded Data

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



	Element	Description
1	Playback rate and continuous loop	When continuous loop ( ) is enabled, scan data is played back in a loop. Useful for demos, and when inspecting data or configuring tools using recorded data.
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.

	Element	Description
		
4	Start playback	Starts playing back frames of the recorded data.
5	Go to next / last frame	Displays the next frame or jumps to the last frame of the recorded data.

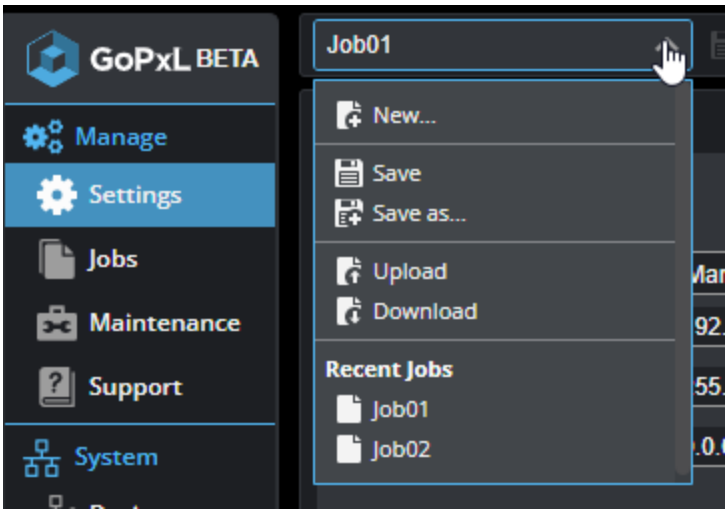
Creating, Saving and Loading Jobs

Jobs contain sensor, tool, and control configurations for a particular inspection or quality control application. (For more information, see *Configuring Systems* on page 89.)

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 can be changed in the sensor's web interface are temporary until saved in a job file. If there is a job file that is designated as the default, it will be loaded automatically when the sensor is reset.

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 91.

Configuring Systems

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

GoPxL can run on a sensor, or you can run GoPxL on a Windows PC and connect to a sensor 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 5500 series sensors, LMI *strongly* recommends using the PC version of GoPxL.

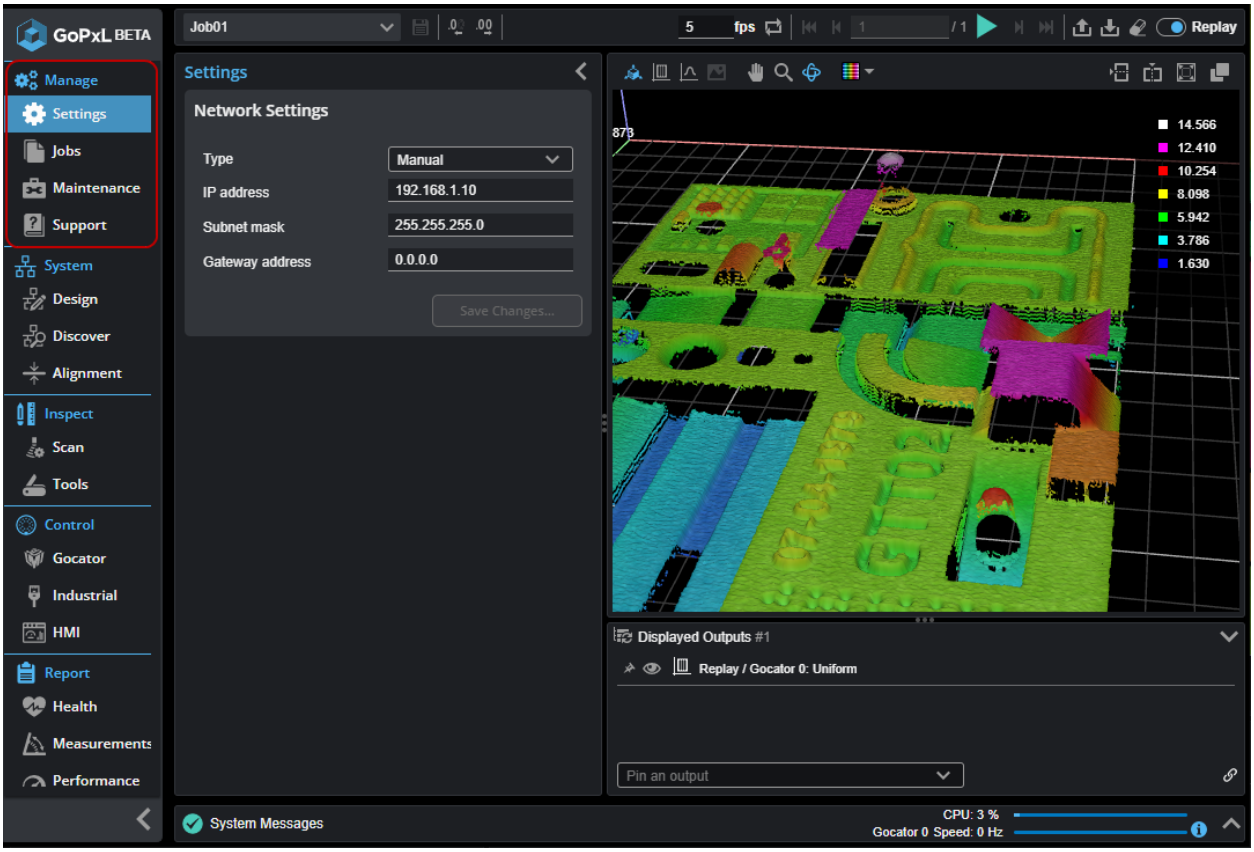
To configure GoPxL when it is running on-sensor, you connect directly to the sensor's IP address (by default, 192.168.1.10.). To configure GoPxL when it is running on a PC, you connect to the IP address of the PC instance. If you can't connect to your sensor or the PC instance of GoPxL, use the GoPxL Discovery tool to find it and launch the GoPxL interface (for more information, see *GoPxL Discovery Tool* on page 750).

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 656 first.

For information on configuring sensors programmatically, see See *GoPxL SDK and REST API* on page 692.

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).

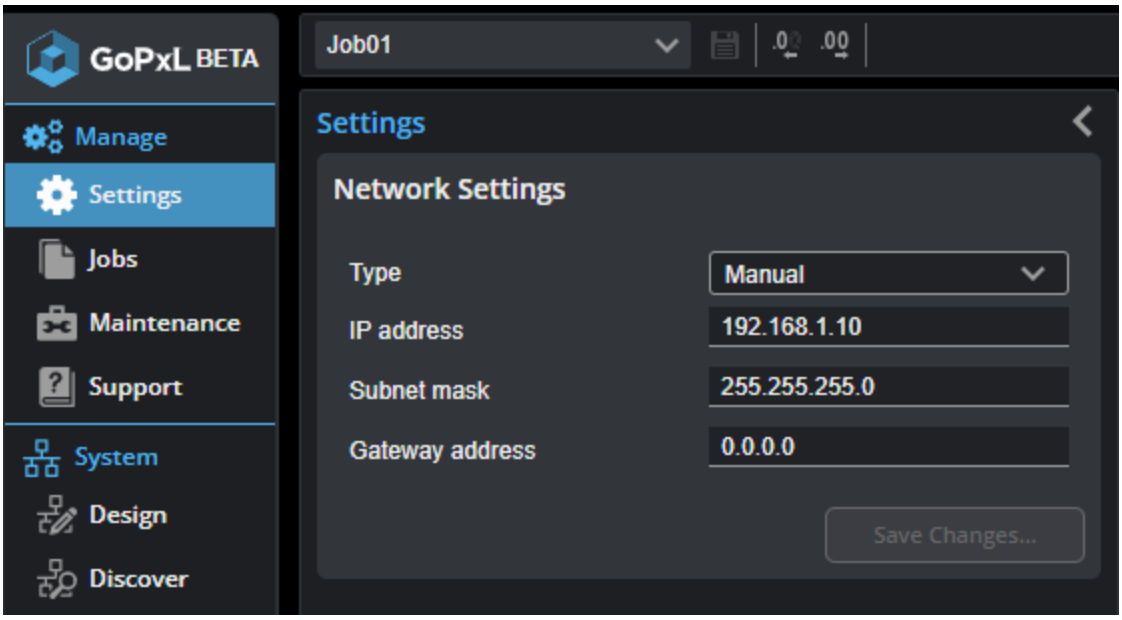


Settings page selected, displaying the panels available on that page. The selected page is highlighted.

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 manage jobs. For more information, see *Jobs* on the next page.
Maintenance	The **Maintenance** page lets you upgrade a device's software, perform a backup or restore of a device, or perform a factory restore of a device. For more information, see *Maintenance* on page 93.
Support	The **Support** page provides software version information and lets you download a support file for troubleshooting. For more information, see *Support* on page 95.

Settings

The **Settings** page in the **Manage** category provides network settings. Settings must be configured to match the network to which the sensors are connected.

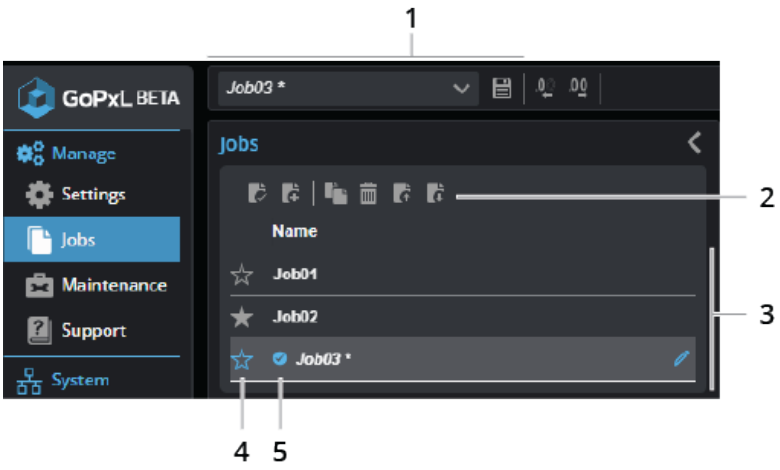


To configure the network settings:

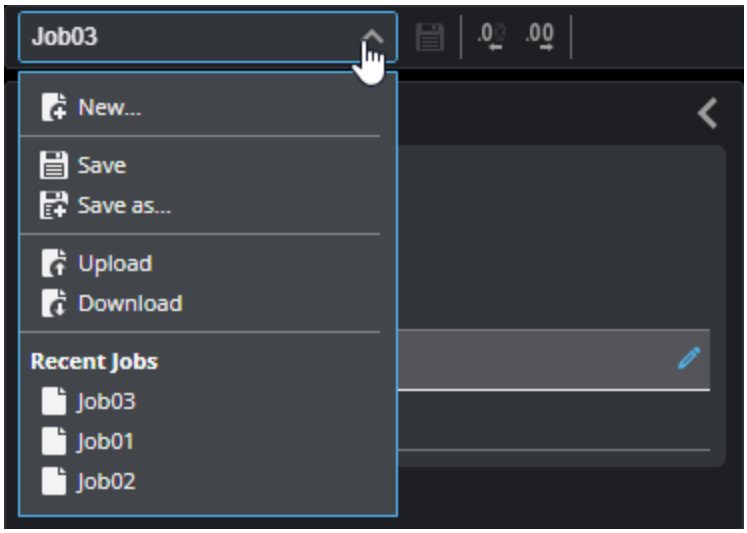
1. Go to the **Manage** > **Settings** page.
2. Specify the type (Manual or DHCP), IP, subnet mask, and gateway settings.
   The sensor can be configured to use DHCP or assigned a static IP address by selecting the appropriate option in the **Type** drop-down.
3. Click **Save Changes...**.
   You will be prompted to confirm your selection.

Jobs

The **Jobs** page in the **Manage** category lets you manage jobs.



	Element	Description
1	Job-related operations on global toolbar	Job menu and Save button. Use the job menu to create new jobs, save jobs, and load recent jobs.

	Element	Description
		
2	Job-related operations	These controls let you work with jobs, for example, creating and saving jobs. For explanations of the job related operations, see *Job-related operations* below.
3	Job list	The list of available jobs.
4	Default job indicator	Clicking on the default job indicator ( ) sets the job as the default.
5	Loaded job indicator	The loaded job indicator ( ) shows which job is currently loaded. Note that "untitled" is the default name of a new job file.

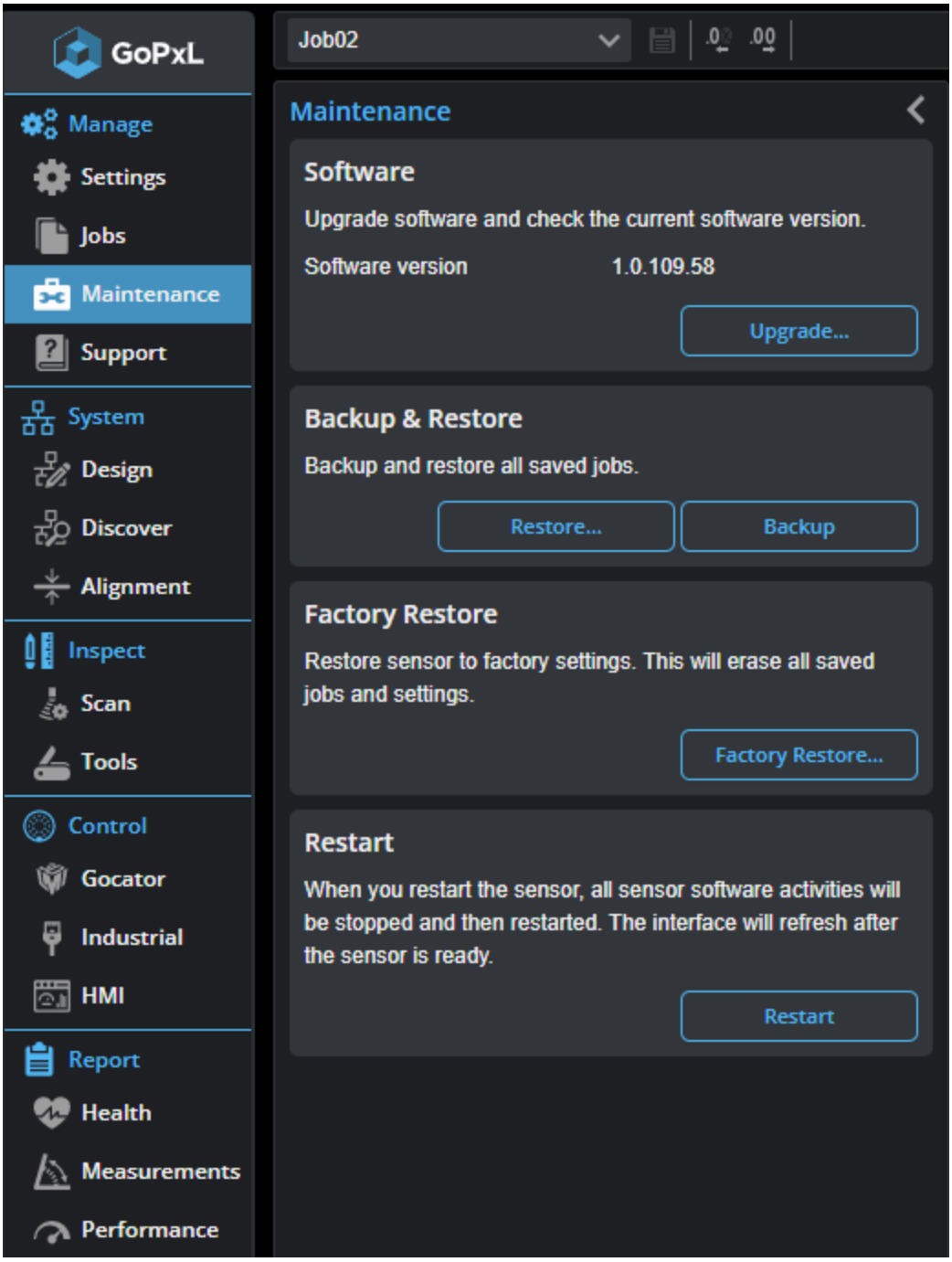
The following table describes the job-related operations.

Job-related operations

Operation	Description
	Loads the job selected in the job list.
	Creates a new job.
	Duplicates the job selected in the job list.
	Uploads a job from the client computer.
	Downloads a job to the client computer.
	Deletes the selected job.
	Lets you edit the job name. You can also double-click on the job's name to stat editing it.

Maintenance

You use the **Maintenance** page in the **Manage** category to perform basic maintenance.



The **Maintenance** panel lets you do the following:

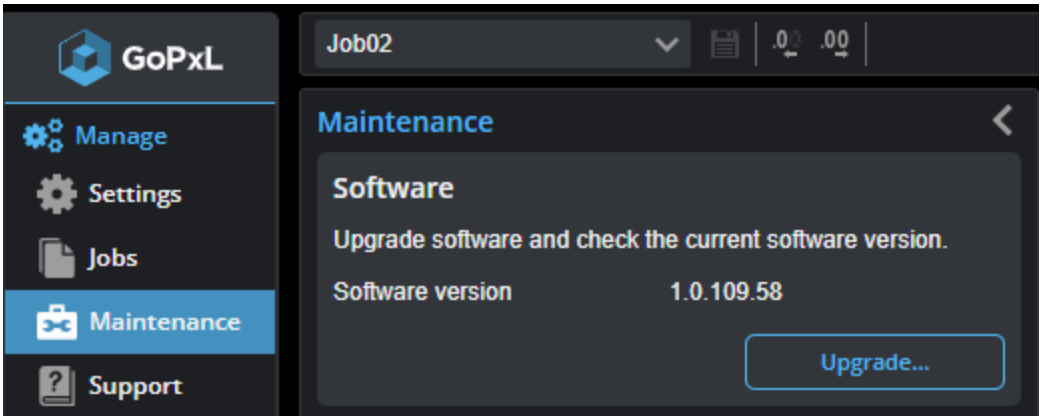
- Upgrade the device's software. Note that you can't upgrade a sensor if you are running it through a PC instance of GoPxL. For more information on upgrading a sensor's software, see *Software Upgrade* on the next page.

- 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* below.
- Restore the sensor to factory defaults. This erases *all* saved jobs and settings, as well as files created by Surface Pattern Matching and Surface Track. Note that performing a factory restore on a PC instance of GoPxL connected to a sensor *only* affects the PC instance, not the sensor.
- Restart the sensor. Note that you can't restart a sensor if you are running it through a PC instance of GoPxL To do this, you must remove the sensor from the PC instance.

Software Upgrade

LMI recommends routinely updating software to ensure that sensors always have the latest features and fixes.

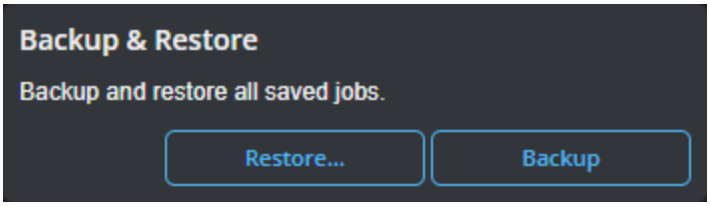
Note that if you are running a sensor through a PC instance of GoPxL, you can't upgrade its software. To do this, you must temporarily remove it from the sensor group in the PC instance of GoPxL, access the sensor directly at its IP address, and perform the upgrade. You can then add it back to the sensor group on the PC instance of GoPxL. For more information, see *Stopping Acceleration* on page 661.



Backup and Restore

Sensor backups let you 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
- Layout and transformation
- Current recorded data
- Global settings

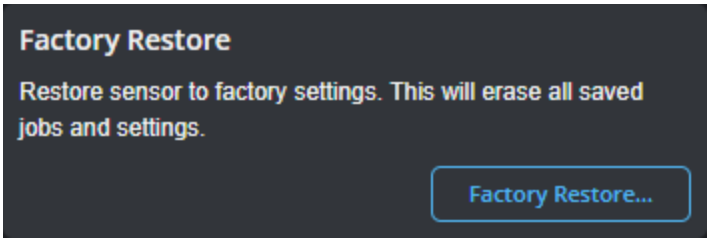


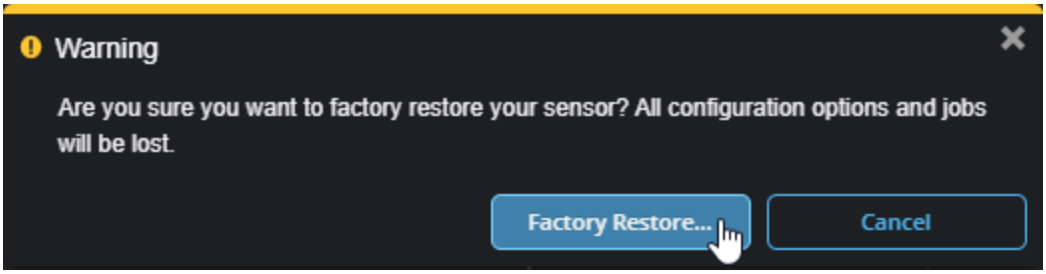
> You should always create a sensor backup file in the unlikely event that a sensor fails and a replacement sensor is needed. If this happens, the new sensor can be restored with the backup file.

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 configuration options, as well as the files created by Surface Pattern Matching and Surface Track.

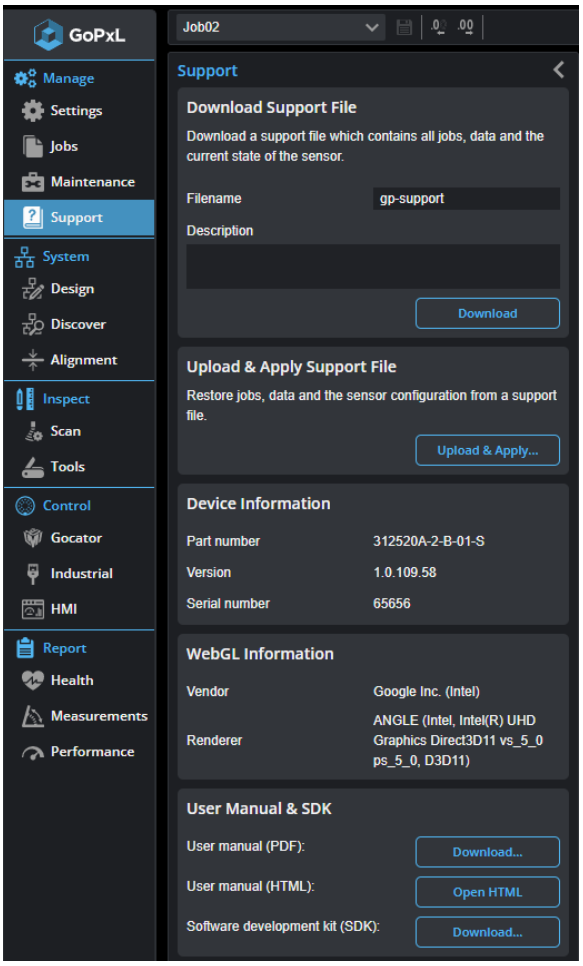




> You should create a backup file of your sensor in case of unwanted changes and in the unlikely event that a sensor fails and a replacement sensor is needed. If this happens, the new sensor can be restored with the backup file.

Support

The **Support** page in the **Manage** category lets you download or upload a support file and get software version information. You can also access the user manual and download the SDK. Use support files for troubleshooting.



Support files contain everything in backup files, but contain additional diagnostic information:

- All jobs
- Layout and transformation
- Current recorded data
- Global settings
- Additional diagnostic information

Support files are useful for supporting development and diagnosing issues.

Creating a Sensor System

You use the **Design** page in the **System** category to create a sensor system containing two or more sensors.

	GoPxL does not currently support G3 multi-sensor systems.

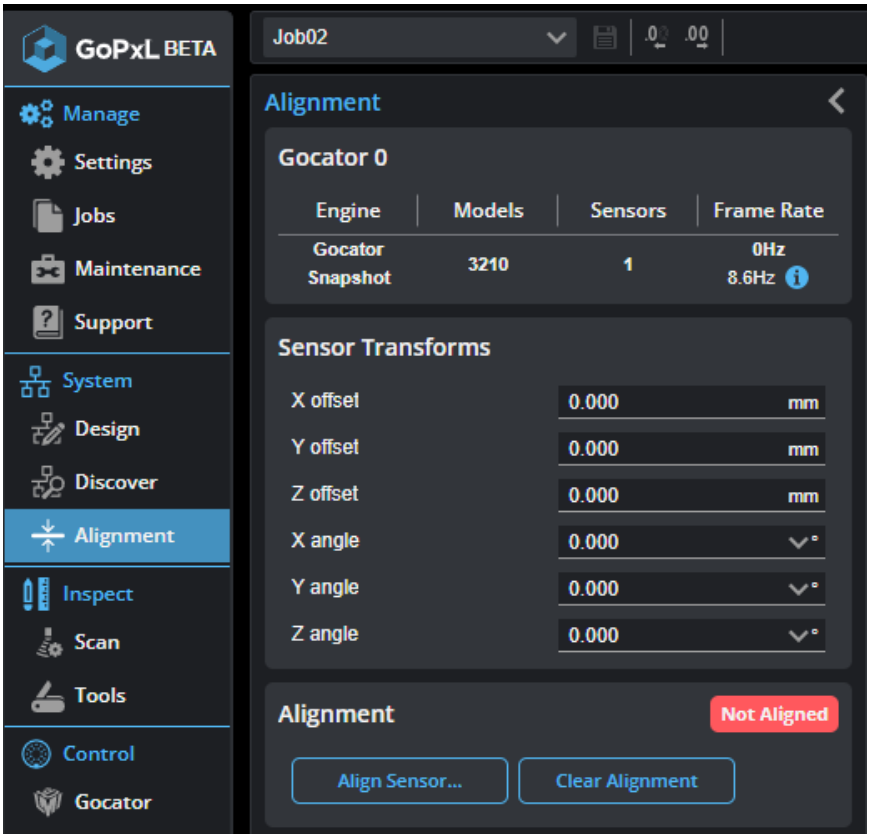
	GoPxL does not currently support mixed-model multi-sensor systems.

The **System** > **Discover** page lets you see all sensors, including those that are unavailable (either because the on-sensor version of GoPxL doesn't match the version of GoPxL running on a PC, 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 656.

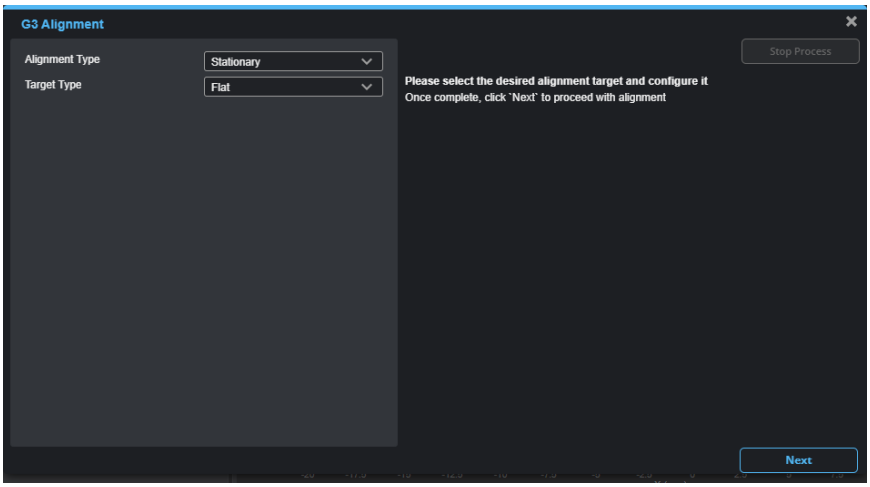
Aligning Sensors

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 flat surface or an alignment target.
- To accommodate intentional rotation of sensors.



Once you click the **Align Sensors** 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.

Performing the Alignment

Currently, GoPxL only supports up to 5 degrees of freedom using the alignment routines on the **System** > **Alignment** page.

Alignment is configured and performed using the **System** > **Alignment** page. If you use a plate alignment target with two holes, alignment will include all 6 degrees of freedom; otherwise, sensors are aligned to only 5 degrees of freedom.

For information on coordinate systems, see *Coordinate Systems* on page 45.

Snapshot sensors only support Stationary alignment.

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 45.

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

Alignment State

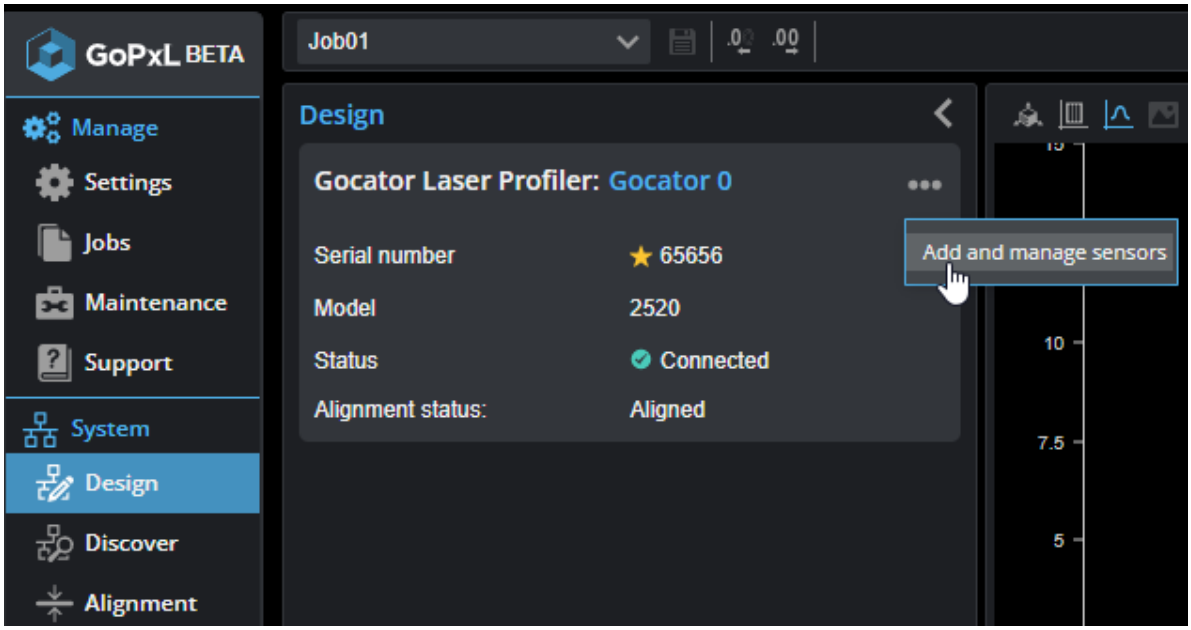
State	Explanation
Unaligned	The sensor or sensor system is not aligned. Data points are reported in sensor coordinates.
Aligned	The sensor is aligned using the alignment procedure (described below) or by manually modifying the values under **Sensor Transforms** on the **System** > **Alignment** page (for more information, see *Transformations* on page 104). Data points are reported in system coordinates.

Once you have performed the alignment procedure on the **Alignment** page, the calculated transformation values are displayed under **Transformations** in the **Sensor Transforms** panel on the **Alignment** page. For more information on transformations, see *Transformations* on page 104.

To prepare for alignment

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

   On the **System** > **Design** page, add sensors to the system. For information, see *Creating a Sensor System* on page 96.



   Configure the system's layout, if necessary. For more information, see *Creating a Sensor System* on page 96 and *Creating a Sensor System* on page 96.

   If the laser lines of the sensors overlap, make sure to check the **Exposure Multiplexing** option. Otherwise, the laser line from one sensor will be detected by other sensors and cause the alignment procedure to fail or be inaccurate; for more information, see *Creating a Sensor System* on page 96.

2. Go to the **System** > **Alignment** page.
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, on the **Inspect** > **Scan** page, adjust the sensor settings 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 122.
   - Active area. For more information, see *Active Area* on page 118.

- Spacing: Make sure to use the sensor's full X resolution (spacing interval is set to full resolution). For more information, see *Uniform Spacing* on page 109.

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 112.

6. Perform the steps in *Performing Stationary Alignment* below.

Performing Stationary Alignment

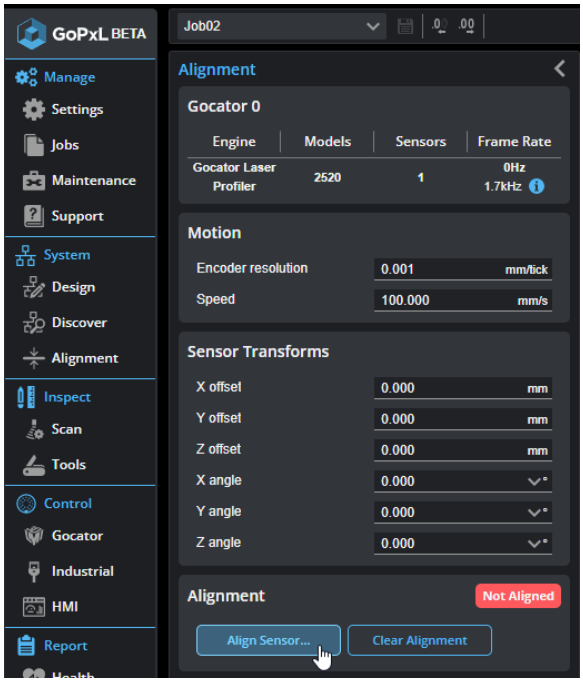
To perform stationary alignment

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.

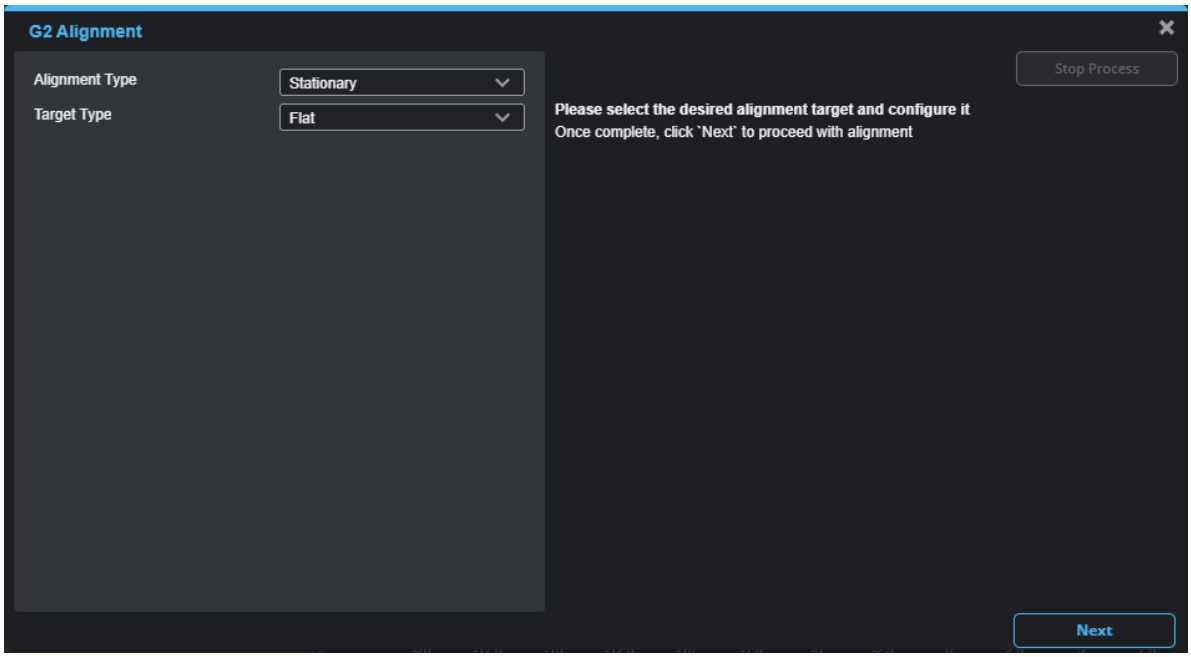
   To determine this, in the sensor's web interface, click **Start** and observe whether the Range LED on the sensor is illuminated. If you have set the trigger source to Encoder under **Inspect** > **Scan** > **Trigger**, temporarily set it to Time for this. Be sure to stop the sensor after confirming 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 778), and measuring the physical distance between the scan surface and the sensor.

2. Go to the **System** > **Alignment** 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. On the **System** > **Alignment** page, click **Align Sensors**.



The Alignment dialog appears.



6. Set **Alignment type** to Stationary.
7. Choose an alignment type in **Alignment type**.
   - **Flat Surface**: Use this to align to a simple flat surface. For more information, see *Stationary Flat Surface* below.
   - **Stationary Plate**: Use this to align to an alignment plate you have manufactured. For more information, see *Stationary Plate* below.
8. Click the **Next** button.

   If the alignment fails, check the settings described in *To prepare for alignment* on page 99 and repeat the steps described here.
9. Inspect alignment results.

   Check the alignment results under **Sensor Transforms**.

   For information on how alignment affects the coordinate system used by sensors, see *Coordinate Systems* on page 45.

Stationary Flat Surface

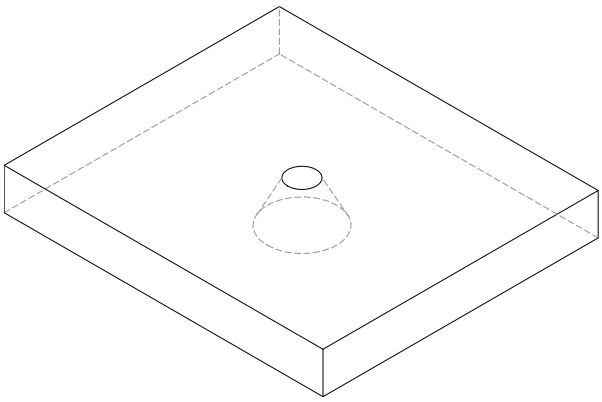
No additional settings are required for this alignment method. Note however that this type of alignment expects to receive flat scan data. Therefore, if the surface is curved, the alignment will be inaccurate. The surface should also be clear of debris and damage. The alignment results in 5 degrees of freedom (it excludes Z angle corrections).

Stationary Plate

You can align a G3 sensor using an alignment plate using one or two holes. The table below describes the transformations resulting from aligning using each kind of target.

Target Specifications

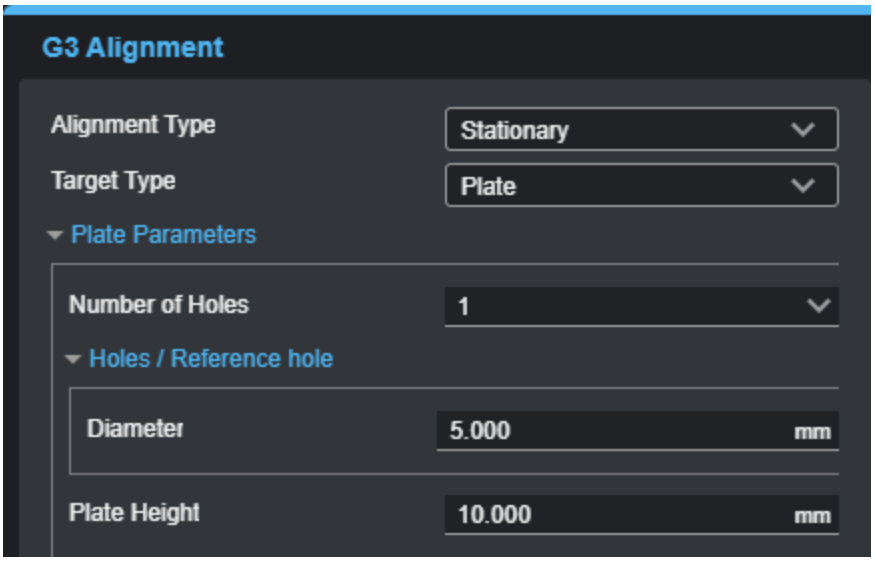
Make sure of the following when manufacturing an alignment plate:



- Holes must be as sharp as possible: avoid bevels.
- The size of the holes should be more than 10 times the XY resolution of the sensor; for the XY resolution of your sensor, see specifications of the sensor in *Sensors* on page 778.
- Sensors must capture as little data from the inside of a hole as possible. Either countersink holes from the opposite side of the plate, 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 alignment 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 778.
- It is not necessary to machine the plate height to a high tolerance. Height can instead be controlled during measuring rather than at manufacture. Only flatness is 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.
- Plates 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).

Configuring GoPxL for Plate Alignment

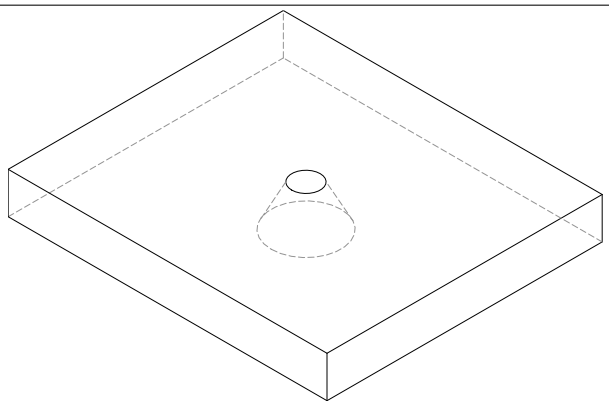
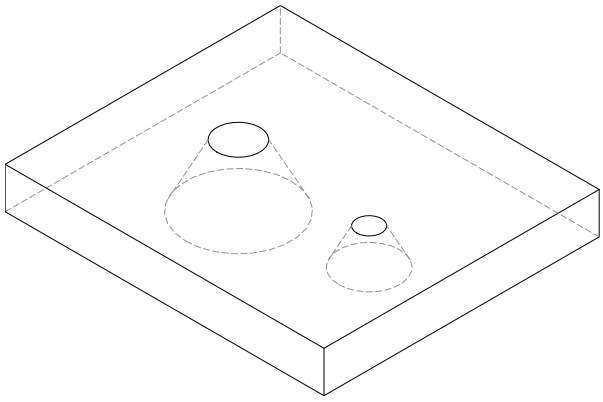
Configure the characteristics of the target; for more information on these settings, see below.



- **Height**: The alignment procedure determines the average Z height of the alignment target'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).
- **Hole Count** is the number of holes in the alignment plate. For information on the transformations resulting from different types of plates, see *Transformations resulting from plates* below.
- **Reference Hole Diameter** and **Secondary Hole Diameter** are the diameters of the holes. If you are using a plate with two holes, they must be of different sizes.

Transformations resulting from plates

Target	Resulting Transformations	Explanation
Plate	X offset Y offset Z offset X angle Y angle	The orientation of the surface surrounding the hole determines the X angle and Y angle transformations. Z angle is not calculated. X and Y offsets are calculated from the X and Y angles.
Plate (single reference hole)	X offset Y offset Z offset X angle Y angle	The center of the hole defines the location of the X, Y and Z origins (the offsets). The orientation of the surface surrounding the hole determines the X angle and Y angle transformations. Z angle is not calculated.

Target	Resulting Transformations	Explanation
		
Plate (with two reference holes)	X offset Y offset Z offset X angle Y angle Z angle	The sizes of the primary and the secondary holes must be different. The center of the primary hole defines the location of the X, Y, and Z origins (the offsets). The orientation of the surface determines X Angle and Y Angle. The angular position of the secondary hole on the XY plane, relative to the primary hole, determines Z Angle. 

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 45). Transformation values are set automatically when you align a sensor using an alignment routine on the **System** > **Alignment** page.



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

When applying the transformations, the data is first rotated around X (clockwise, with the X axis toward the viewer), then Y (counterclockwise), and then Z (clockwise), and then the offsets are applied.

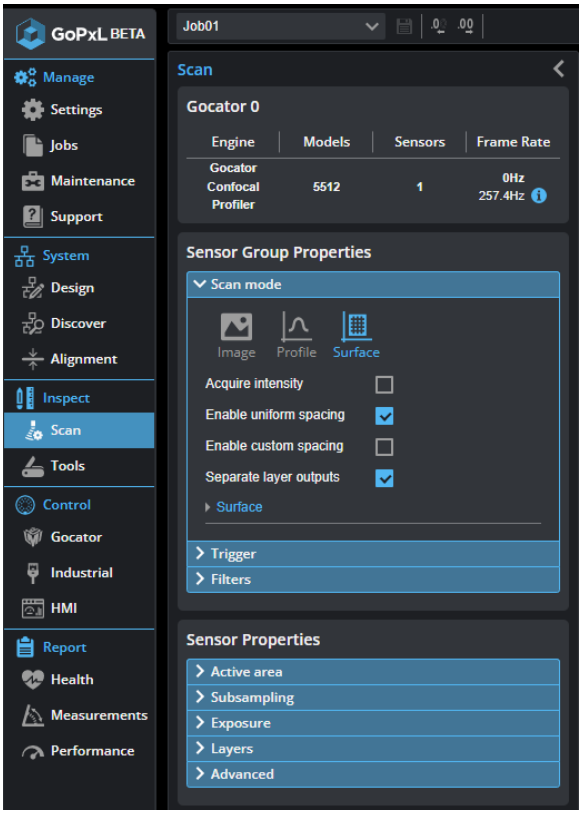
Setting **Angle X** or **Angle Z**, and to a lesser extent **Y Offset**, to a non-zero value increases CPU usage when scanning, which reduces the maximum scan speed.

Artifacts may appear in scan data when **Angle Z** or **Angle X** is set to a non-zero value

if encoder trigger spacing is set too high (resulting in a low sampling rate). For more information on trigger spacing, see *Trigger Settings* on page 115.

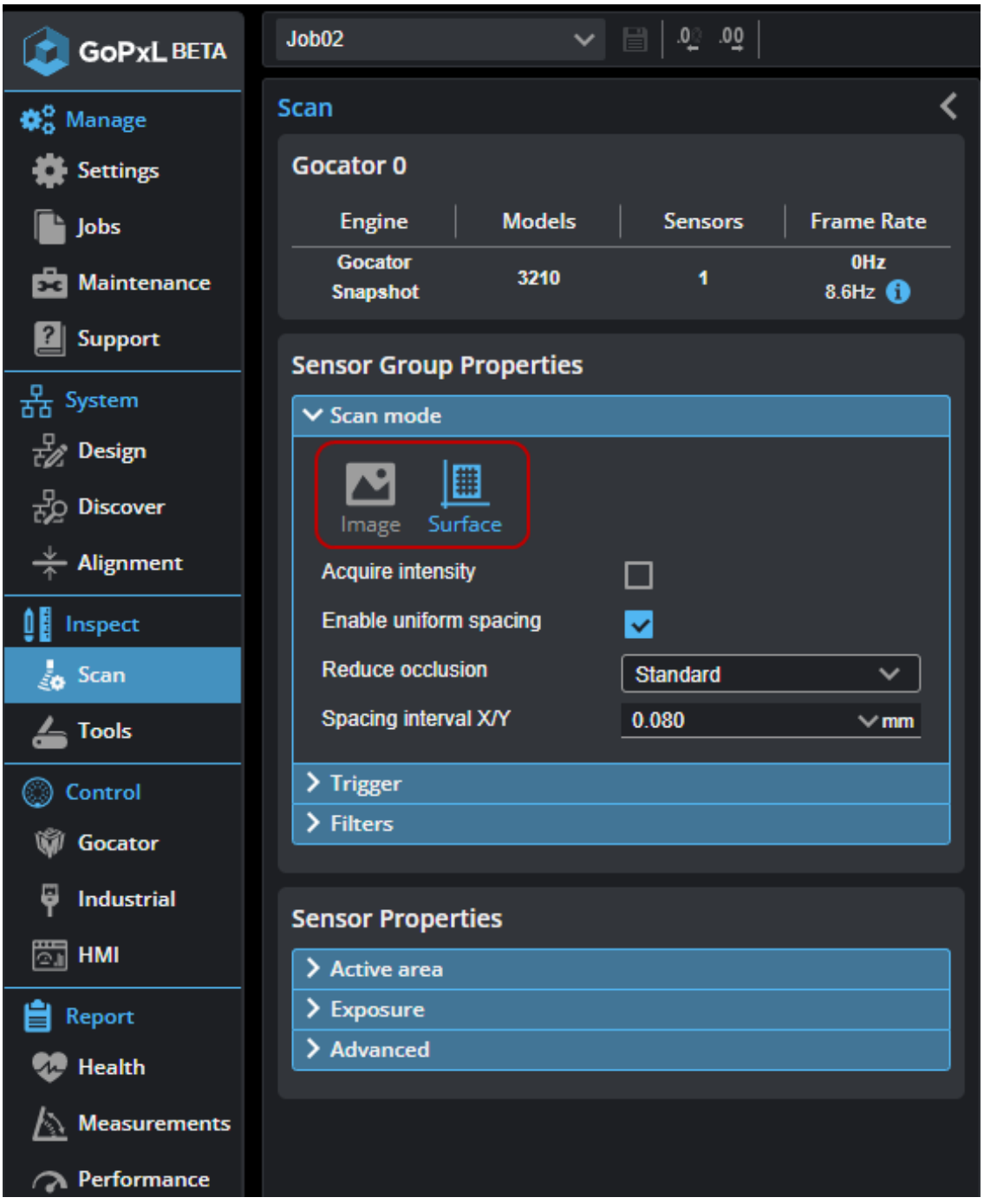
Configuring Acquisition

You configure acquisition in the **Scan** page under the **Inspect** category.

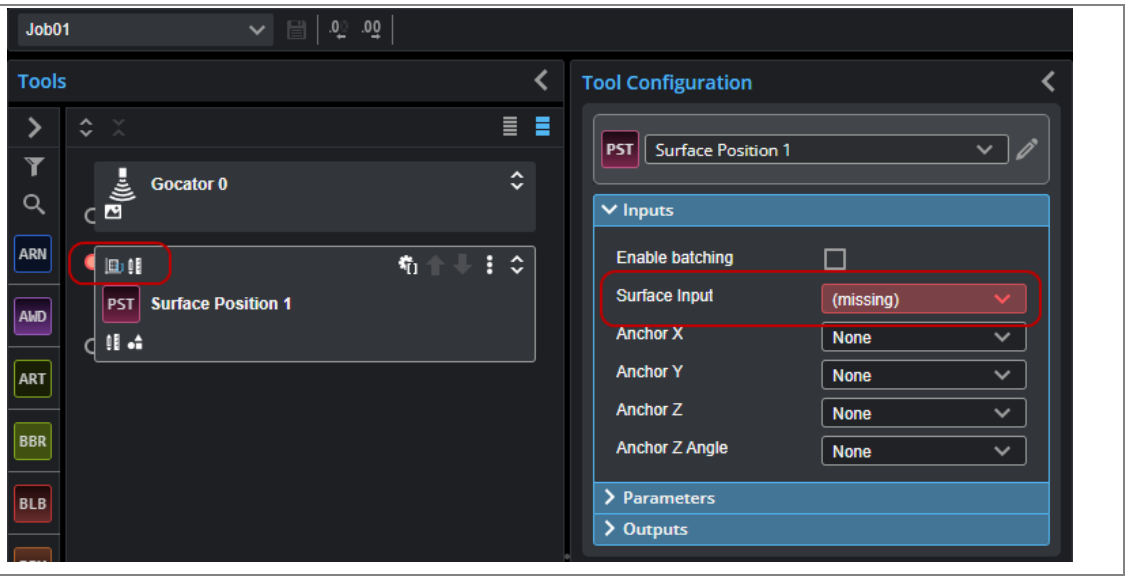


Scan Modes and Intensity

Sensors supports one or more data acquisition modes, in addition to an image mode. You choose the scan mode on the **Acquire** > **Scan** 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. GoPxL also indicates this in the interface:



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.
Surface	Outputs Surface data.
Enable uniform spacing	When this option is enabled, data points are resampled to a uniform spacing . Set the size of the spacing with the Uniform spacing interval settings; for more information, see *Uniform Spacing* below. 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 81.

Uniform Spacing

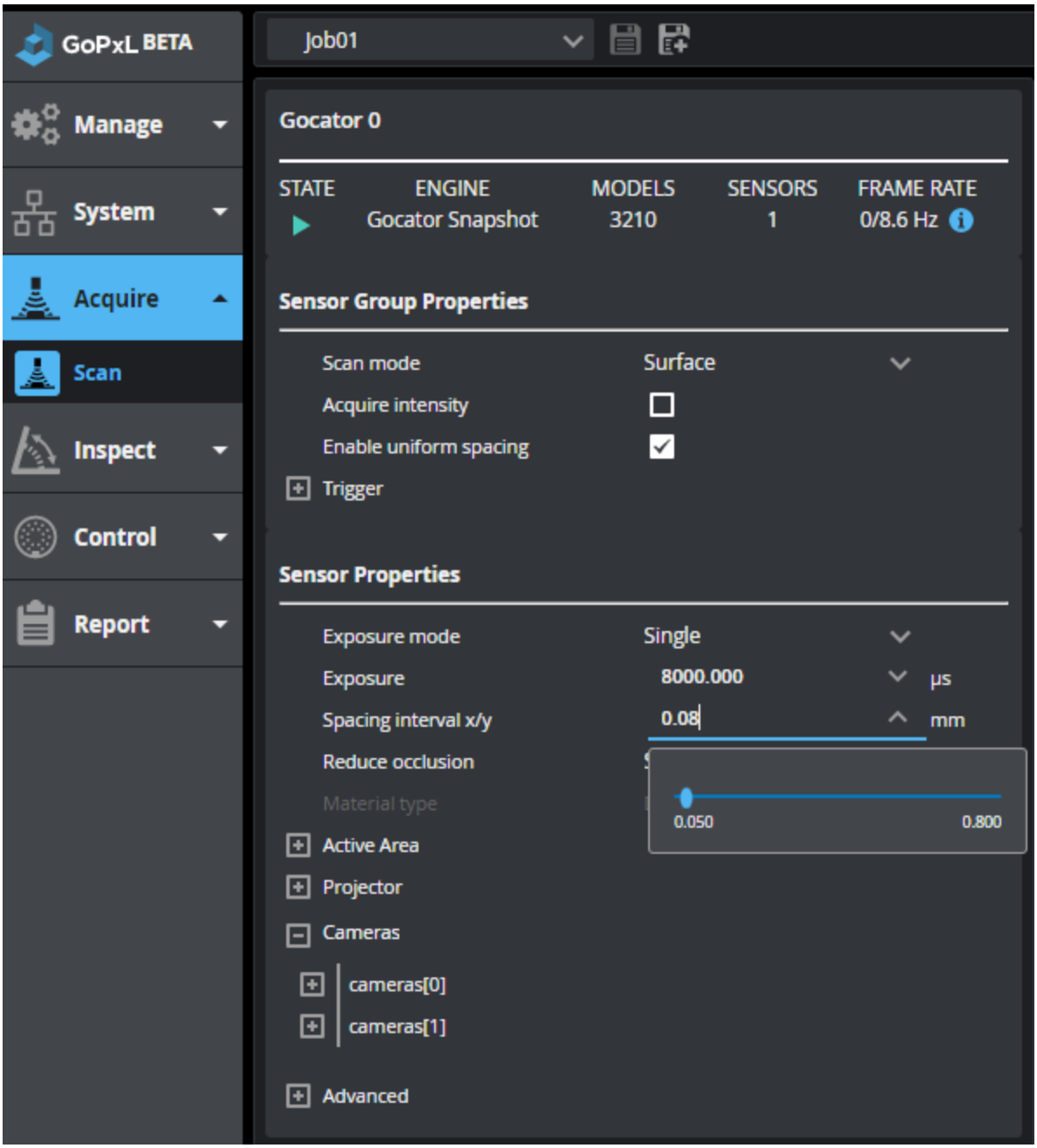
When **Enable uniform spacing** is checked, data points are resampled to a uniform spacing. Set the size of the spacing using the **Spacing interval x/y** parameter in the Sensor Properties section (see below).

When uniform spacing is disabled, the sensor outputs unprocessed data. The sensor reports data points in (x, y, z) coordinate tuples. No measurement tools are available when the option is disabled.

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 creates scans with lower X/Y resolution, reduces CPU usage, and potentially increases the maximum frame rate. A larger interval also reduces the data output rate.

You can set the spacing interval in the **Spacing interval x/y** parameter, under **Sensor Properties**.



Reduce Occlusion

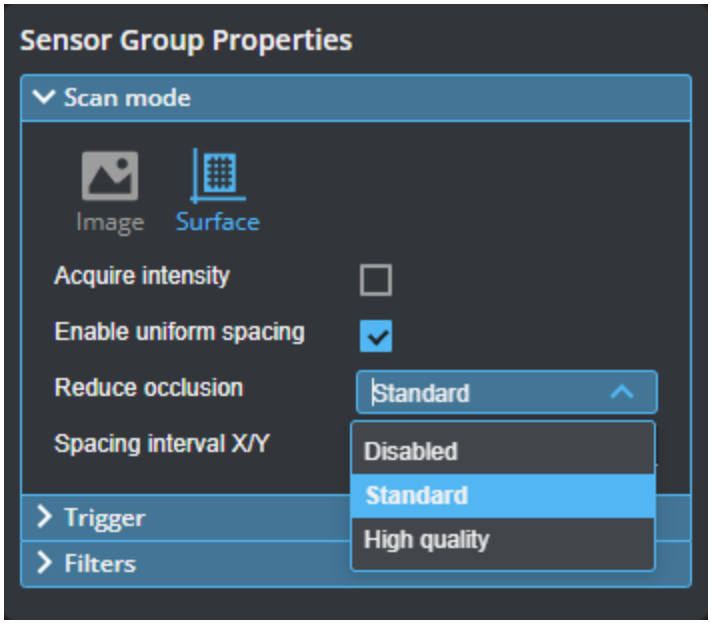
When this option is enabled (by default, set to Standard), in addition to stereo correlation, each camera independently triangulates off the LED light pattern, which may improve performance on targets with complicated shapes that can cause occlusions. The following options are available

Standard: The standard algorithm for merging images from each camera is used.

High Quality: An enhanced algorithm is used to merge images from each camera, which reduces the seam where images merge. Processing time may be increased.

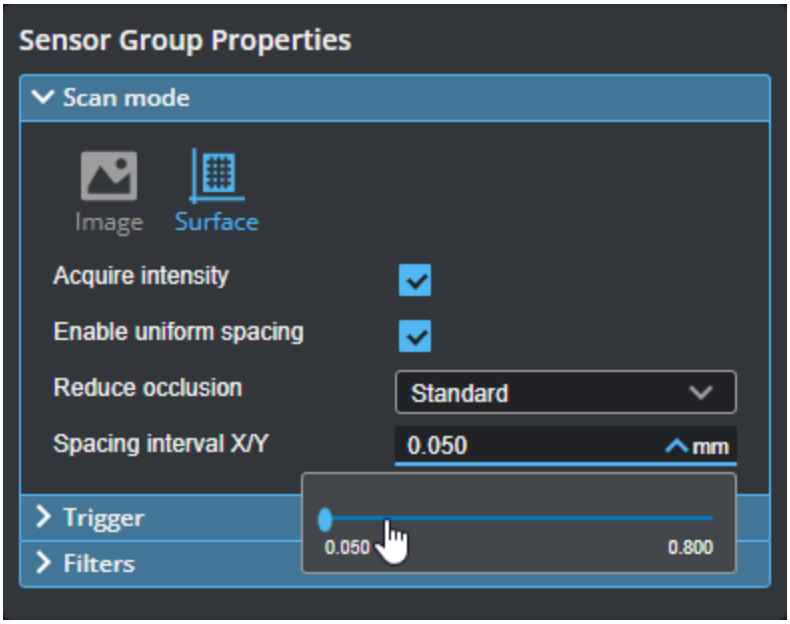
When the **Reduce Occlusion** option is disabled, 3D data is acquired using *only* stereo correlation between the two cameras, meaning that a point on the target must be visible in both cameras to produce a data point.

For more information, see *Stereo Correlation vs. Independent Triangulation* on page 44.



Spacing Interval

Spacing interval is the spacing between data points in resampled data. A larger interval creates scans with lower X/Y resolution, reduces CPU usage, and potentially increases the maximum frame rate. A larger interval also reduces the data output rate. For more information on resampled data, see *Resampling* on page 48.



To configure the spacing interval:

1. Go to the **Scan** page.
2. Choose Surface mode in the **Scan Mode** panel.

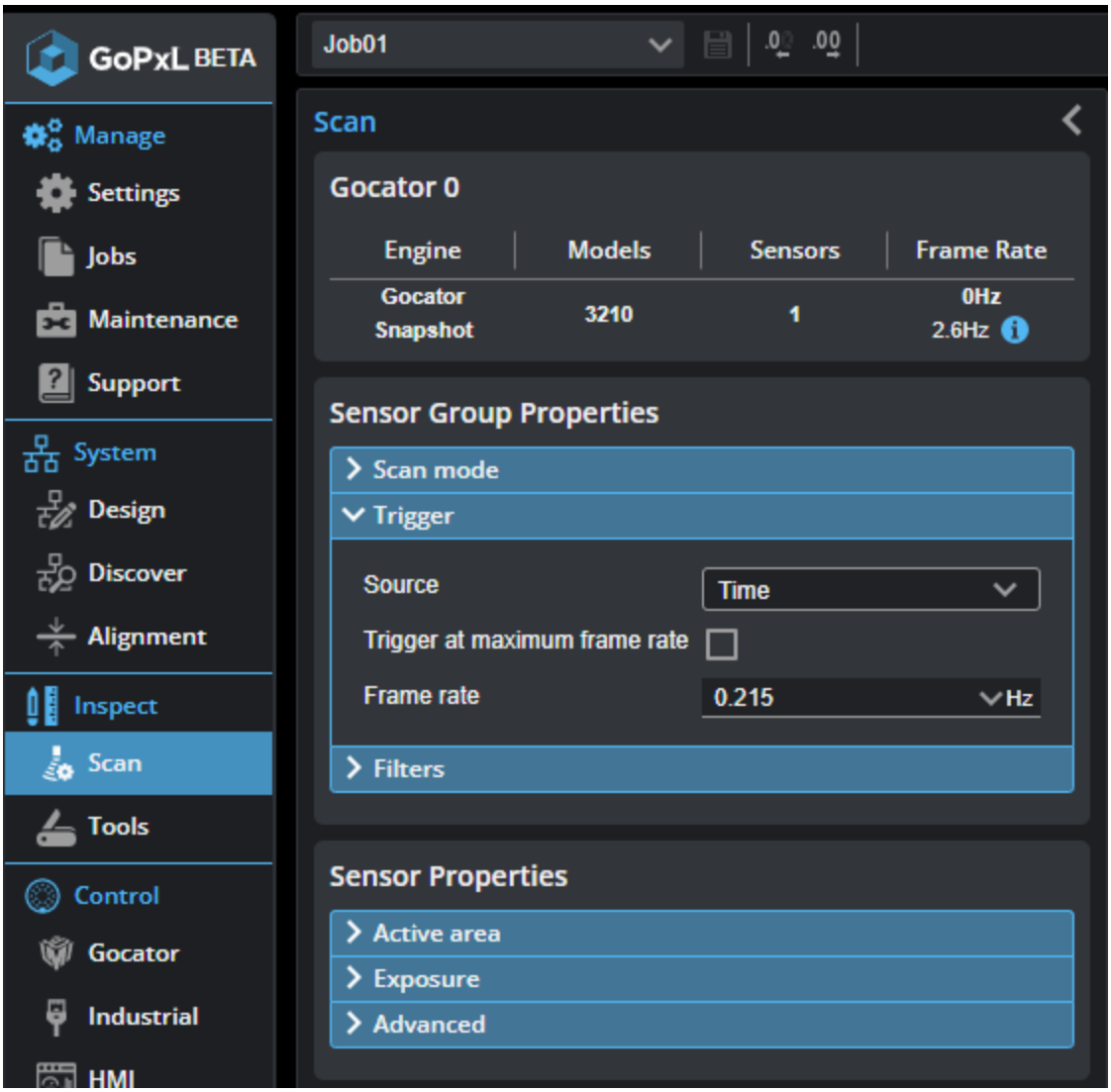
   If this mode is not selected, you will not be able to configure the spacing interval.
3. Expand the **Sensor** panel by clicking on the panel header or the ⊕ button.
4. Click the button corresponding to the sensor you want to configure.

   The button is labeled **Top**, **Bottom**, **Top-Left**, or **Top-Right**, depending on the system.

   Spacing is configured separately for each sensor.
5. Click the **Spacing** tab.
6. Do one of the following:
7. Select a spacing interval level.
8. Save the job in the **Toolbar** by clicking the **Save** button 💾.

Triggers

A trigger is an event that causes a sensor to take a single 3D snapshot. You configure triggers on the **Acquire** > **Scan** page.



When a trigger is processed, the LED light pattern is strobed and the cameras expose to produce images. The resulting images are processed inside the sensor to yield a 3D point cloud. The data can then be used for measurement.

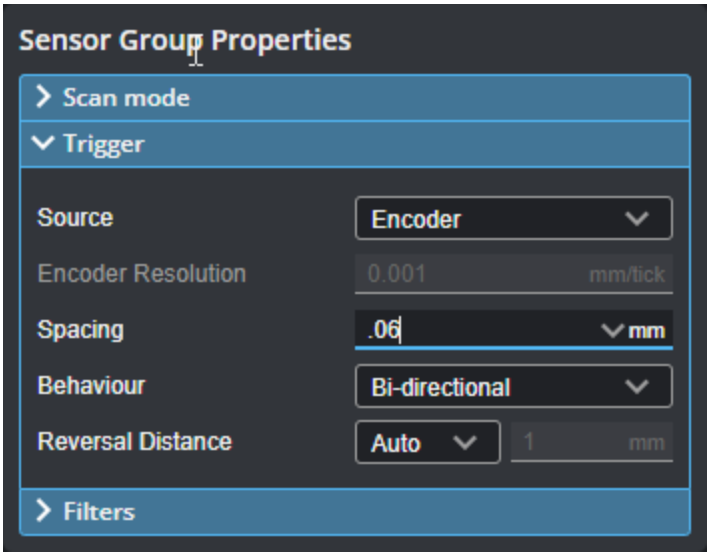
At the top-right of the **Scan** page, the maximum frame rate is displayed, based on the exposure values, active area, the number of projection patterns required, and so on.

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

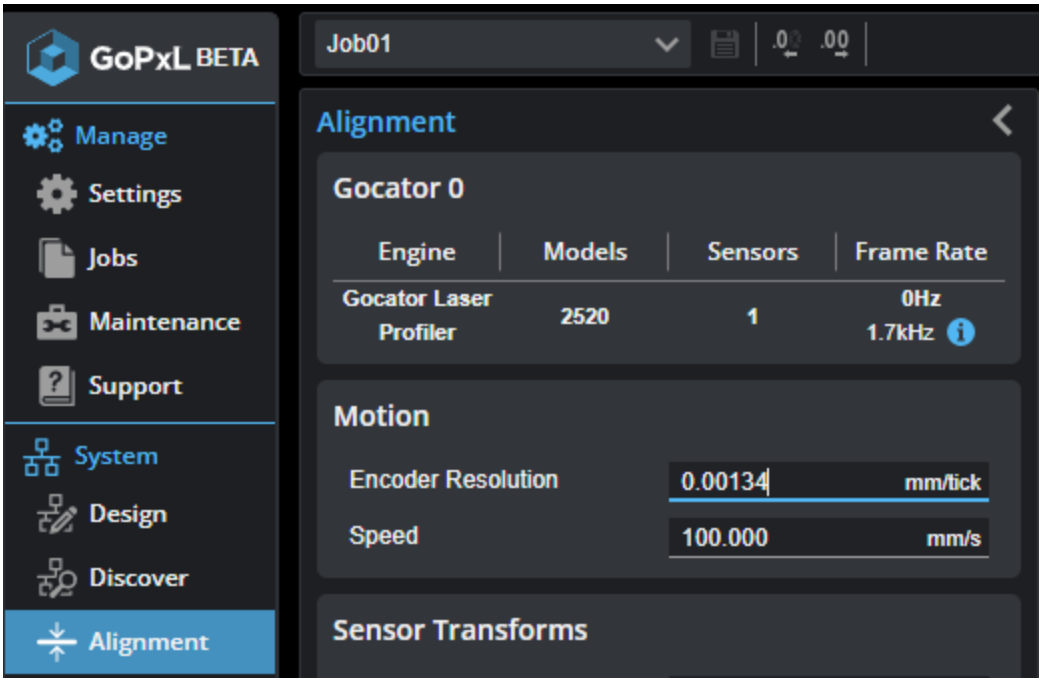
	If the sensor is connected to a Master 400 or higher, encoder and digital (external) input signals over the IO cordset are *ignored*. The sensor instead receives these signals from the Master; for encoder and digital input pinouts on Masters, see the section corresponding to your Master in *Master Network Controllers* on page 801. If the sensor is connected to a Master 100 (or no Master is used), the sensor receives signals over the IO cordset. For information on connecting encoder and digital input signals to a sensor in these cases, see *Encoder Input* on page 798 and *Digital Input* on page 797, respectively.

G2 and G5

When using encoder triggering (G2 and G5), the current encoder resolution is displayed under the **Source** drop-down as a reference when setting trigger spacing.



To set the encoder resolution, go to the **System** > **Alignment** page 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.
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. 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 *Reporting* on page 650. For information on the maximum input trigger rate, see *Maximum Input Trigger Rate* on the next page.
Software	A network command can be used to send a software trigger. For more information, *Protocols (PLCs and other hardware)* on page 703.

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

For examples of typical real-world scenarios, see *Trigger Examples* on the next page.

Trigger Settings

After you choose the trigger source, the **Scan** page shows the trigger parameters you can configure.

Parameter	Trigger Source	Description
Source	All	Selects the trigger source (Time, External Input, or Software).
Trigger at maximum frame rate	Time	When this is enabled, the frame rate locks to the maximum 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. Choose one of the following: **Trigger at maximum frame rate**: The sensor triggers at the maximum available frame rate. The frame rate is displayed after this option and also toward the top of the configuration area on the **Scan** page. **Manually configure**: Lets you provide a custom frame rate.
Units	External Input	Specifies whether the trigger delay, output delay, and output scheduled command operate in the time domain. The unit is implicitly set to microseconds with Time trigger source. .
Trigger Delay	External Input	Controls 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, photocells) and the sensor.

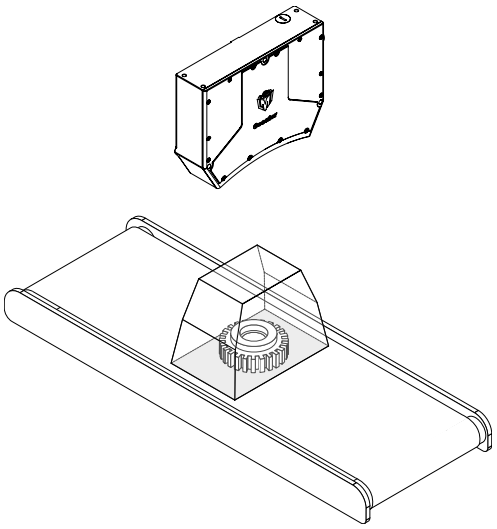
Trigger Examples

Example: External Input + Conveyor

External input triggering can be used to produce a snapshot for 3D measurement.

For example, a photocell can be connected as an external input to generate a trigger pulse when a target object has moved into position.

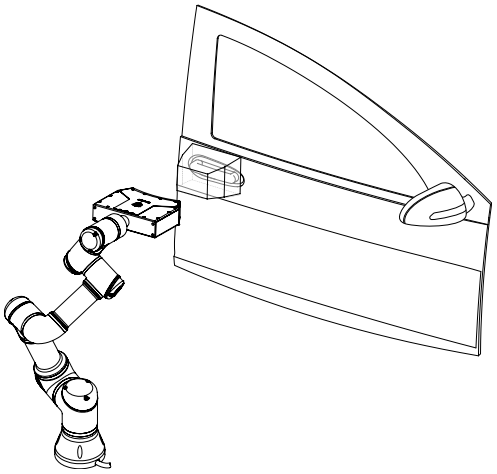
An external input can also be used to gate the trigger signals when time or encoder triggering is used. For example, a photocell could generate a series of trigger pulses as long as there is a target in position.



Example: Software Trigger + Robot Arm

Software triggering can be used to produce a snapshot for 3D measurement.

A software trigger can be used in systems that use external software to control the activities of system components.



Maximum Input Trigger Rate

The maximum external input trigger rate in a system including Master 400 or higher 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

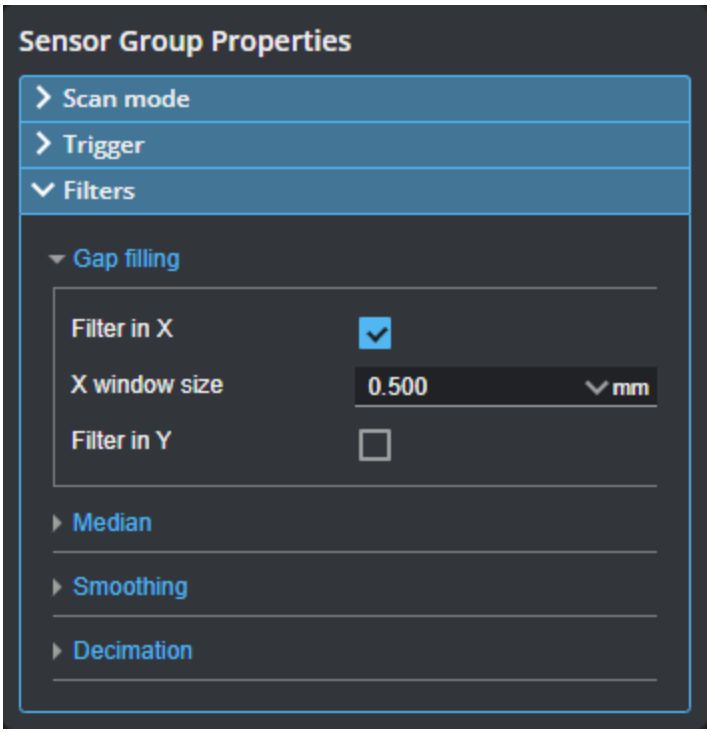
Maximum Encoder Rate

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 400 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.



Tool-based filtering is also available on the **Tools** page. Using tool-based filtering provides various advantages:

- Additional filters not available in the **Filters** panel. (This mostly applies to Surface filters.)
- Choosing between millimeters and data points for the kernel units. (This mostly applies to Surface filters.)
- Filtering based on intensity and not just 3D height data.

- 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.

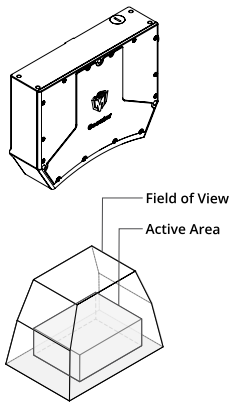
For more information on tool-based filters, see *Surface Filter* on page 418 (Surface-based) and *Profile Filter* on page 227 (Profile-based).

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 field of view. By reducing the active area, the sensor can operate at higher speeds. You can also reduce the active area to exclude areas that are affected by ambient light.

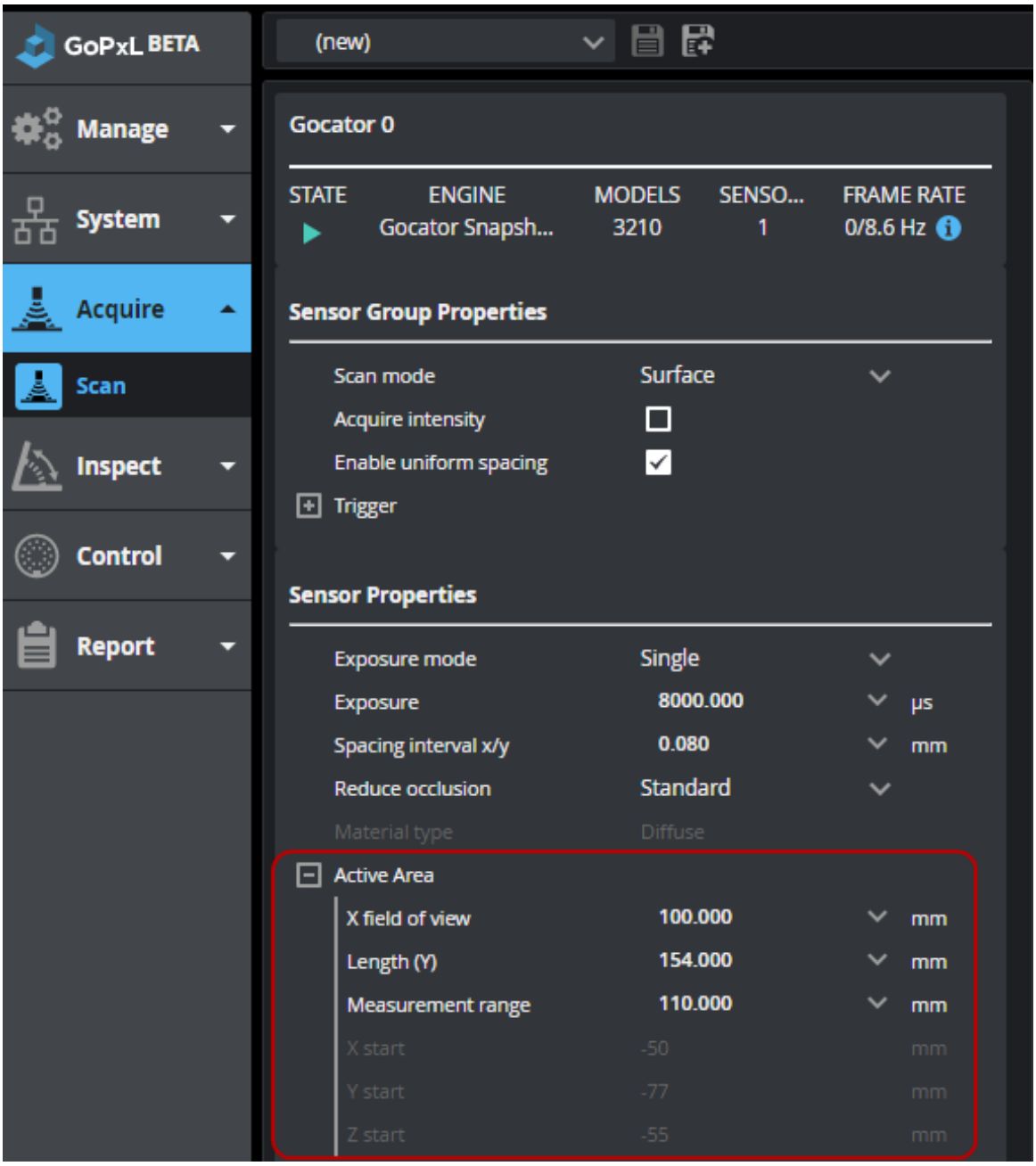
You can choose the active area configuration method, which can be either Point / Size, or Minimum / Maximum.



G3 sensor capturing data within the active area. In an unaligned sensor, the X, Y, and Z origins are in the centre of the field of view.

You set the active area in the **Inspect** > **Scan** page, in the **Active area** section under **Sensor Properties**.

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* on the next page.



To set a sensor's active area

1. Go to **Inspect** > **Scan** 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* below.

   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) Y FOV (mm)	The width of the active area along the X and Y 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) Y center (mm) Z center (mm)	The X, Y, 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 Max X	The minimum and maximum X values.
Min Y Max Y	The minimum and maximum Y values.
Min Z Max Z	The minimum and maximum Z values.

Scanning devices are usually more accurate at the near end of their measurement range. If your application requires a measurement range that is small compared to the maximum measurement range of the sensor, mount the sensor so that the active area can be defined at the near end of the measurement range.

Exposure

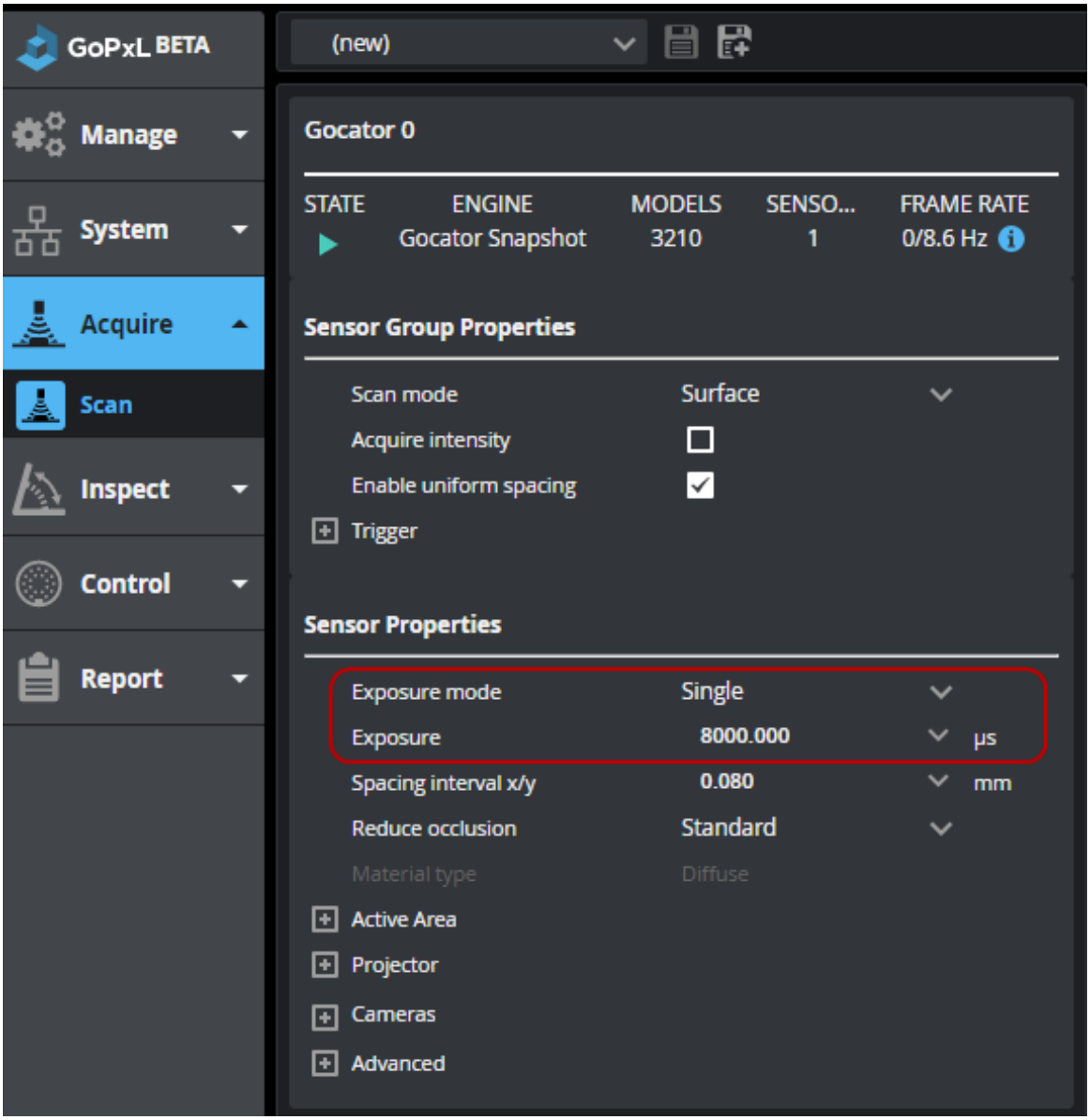
Exposure determines the duration of camera and light-source on-time (or pulse width), given in microseconds (µs). Longer exposures can be helpful to detect light on dark or distant surfaces, but

increasing exposure time decreases the maximum speed. 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.

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 examine the resulting image to confirm whether the features or flaws you need to measure will be well presented in the scan data. For more information on Image mode and the information it provides for configuring exposure, see *Image Mode* on page 65.

You configure exposure in the **Exposure** panel on the **Inspect** > **Scan** page, in the **Sensor Properties** section.

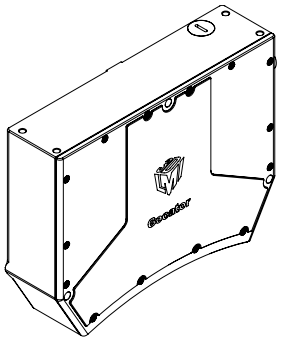


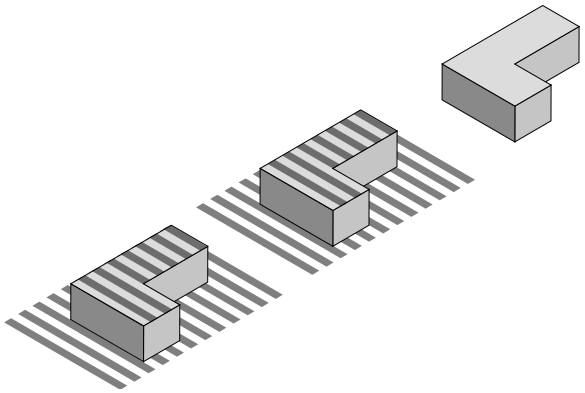
When exposure is set to Dynamic or Multiple, additional parameters are displayed.

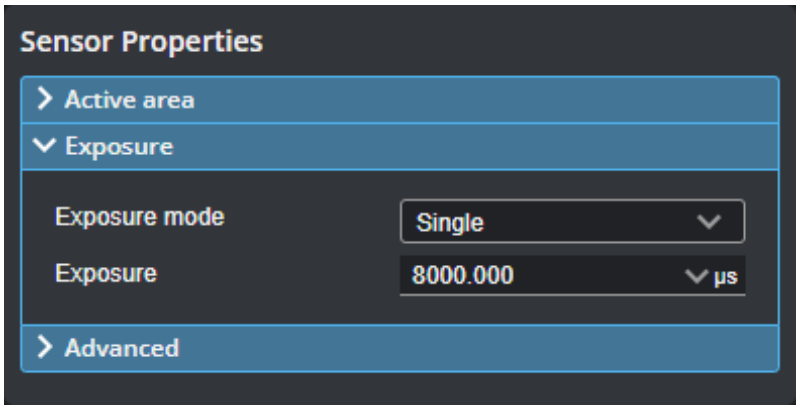
Exposure Mode	Description
Single	Uses a single exposure duration for each frame. Use this when the surface is uniform and is the same for all targets. For more information, see *Single Exposure* below.
Multiple	Uses multiple exposures to create a single scan. Used when the target surface has a varying reflectance within a single scan (e.g., white and black). For more information, see *Multiple Exposure* on the next page.

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	Single or Multiple.
Exposure	The length of the lighter emitter's on-time.

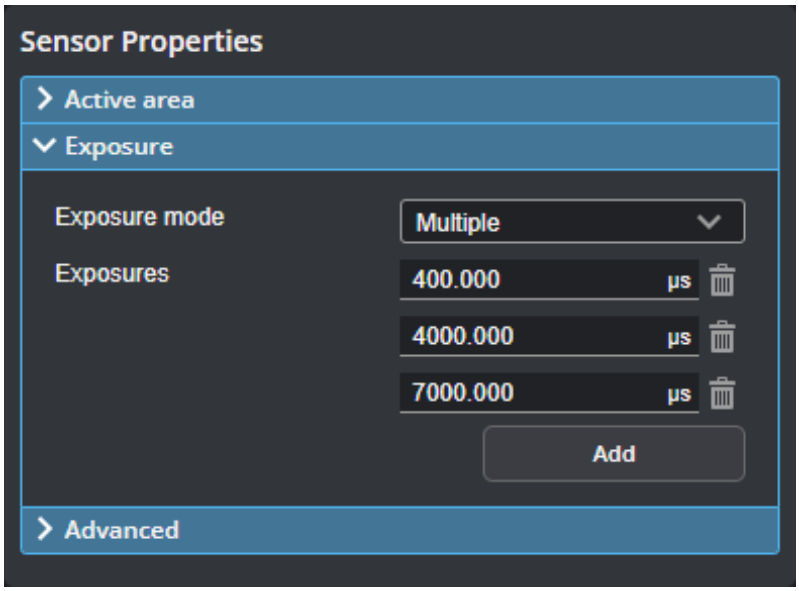
Multiple Exposure

The sensor can combine data from multiple exposures to create a single profile (G2 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.

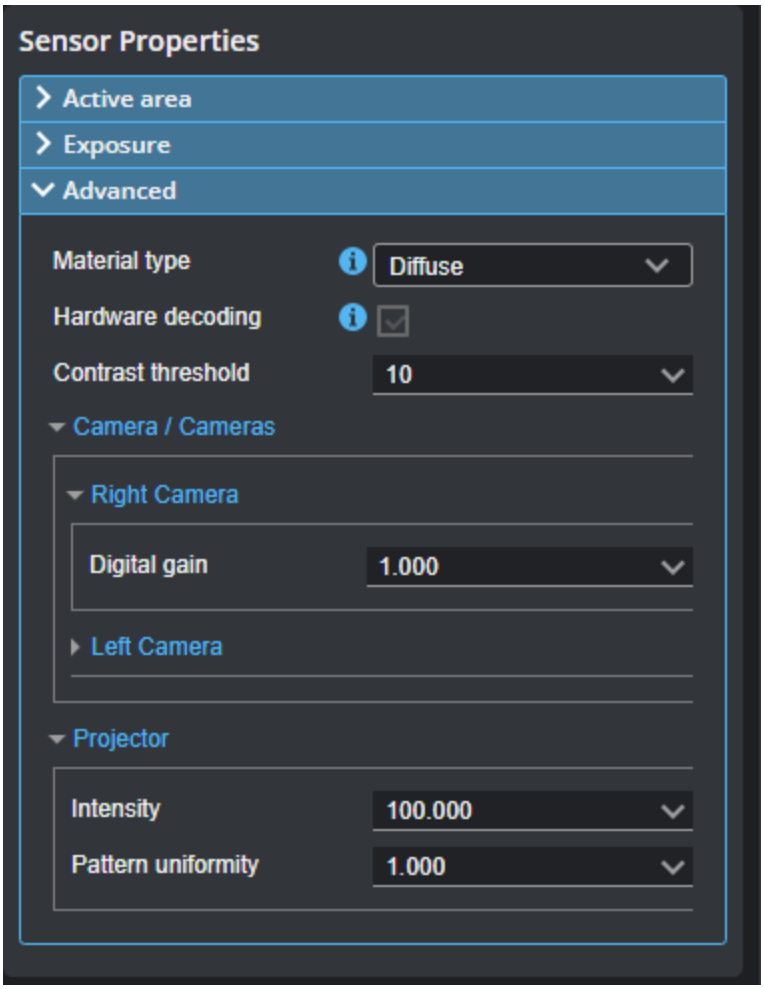
The resulting scan data is a composite created by combing data collected with different exposures.



Setting	Description
Exposure Mode	Single or Multiple. Set to Multiple.

Advanced Settings

The settings in the **Advanced** section on the **Inspect** > **Scan** page let you configure camera gain, material characteristics, and projector.



Material Type

You can configure data acquisition to suit different types of target materials. 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** panel on the **Inspect** > **Scan** page. The **Diffuse** material option is suitable for most materials. The **Interreflective** material option is useful with targets whose surface may show reflections from other surfaces in the scanned area, for example inside a countersunk hole or on surfaces with concave features.

	Currently, choosing **Custom** under the **Material** setting displays options identical to the **Interreflective** and **Diffuse** options under **Material**. Further customizations will be provided in the future.

	A special G3 firmware that optimizes the on-sensor performance of the interreflective scan engine is available for download on LMI's Download center (https://lmi3d.com/product-downloads/). This firmware results in faster takt time for challenging targets. Note that the **Diffuse** material option (see above) will not be available: only Interreflective material will be available.

In order to use the optimized engine, you must install the firmware on the sensor; for more information, see *Software Upgrade* on page 94.

Spot Detection

When adjusting the spot detection parameters, it's best to set the sensor to Profile mode and set the data viewer to Profile view to see the effect of changes you make. You can only adjust spot detection parameters when **Material type** is set to Custom.

Camera Gain

Setting	Description
Camera Gain	
	Digital camera gain can be used when the application is severely exposure limited, yet dynamic range is not a critical factor.

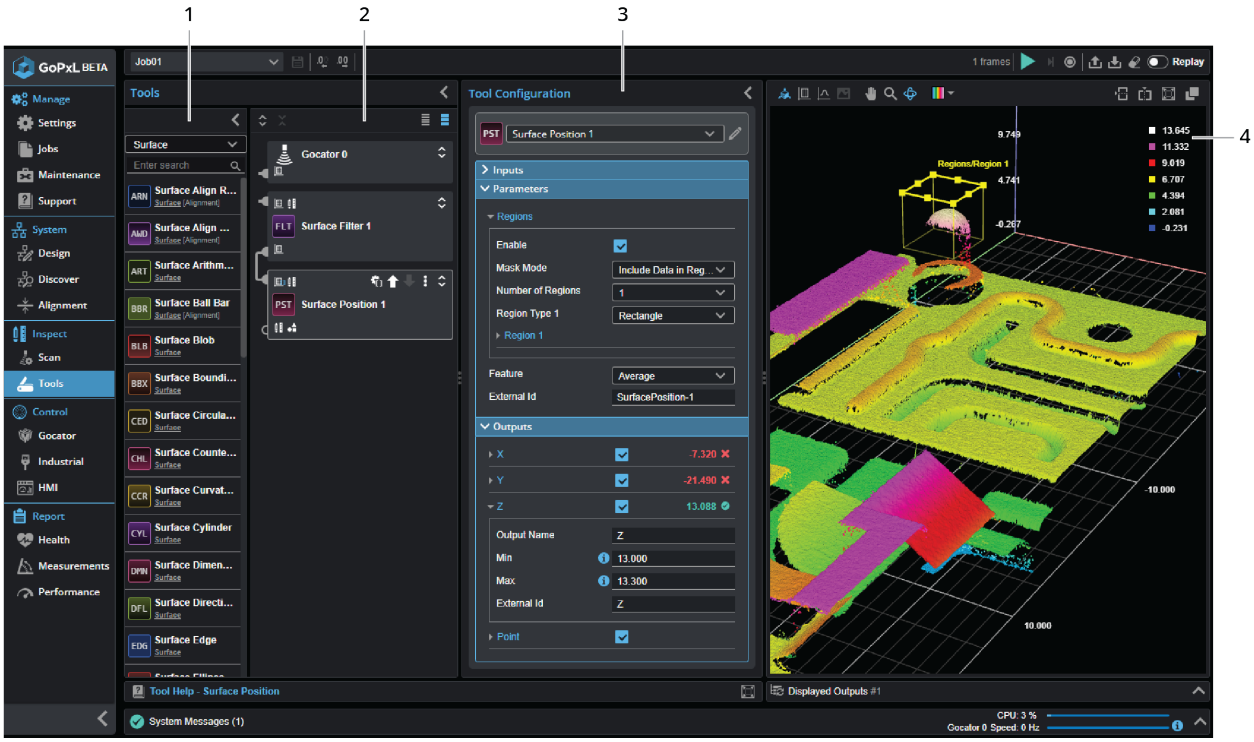
Setting	Description

Other Advanced Settings

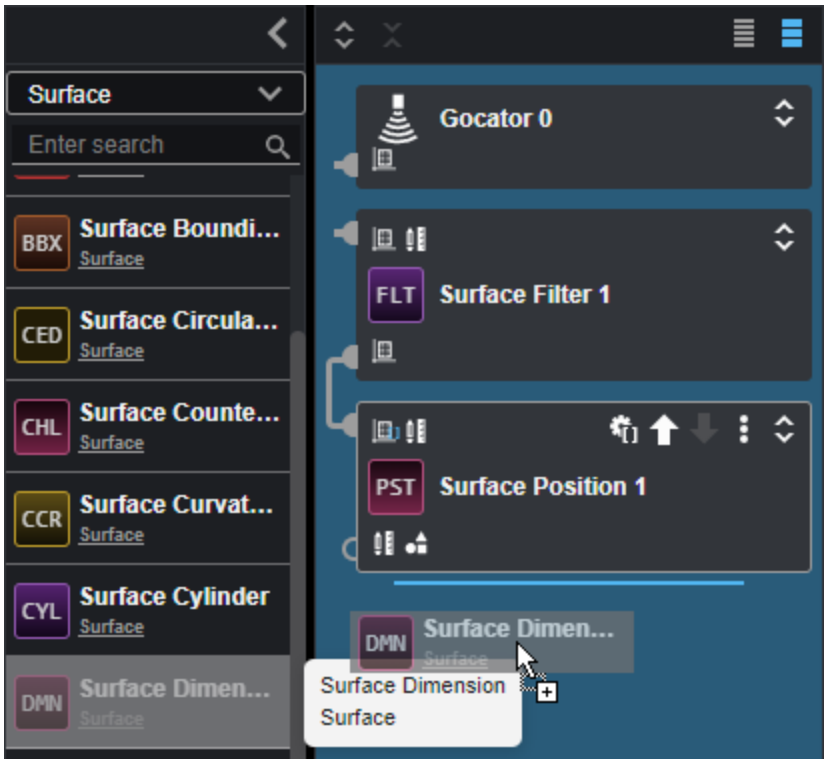
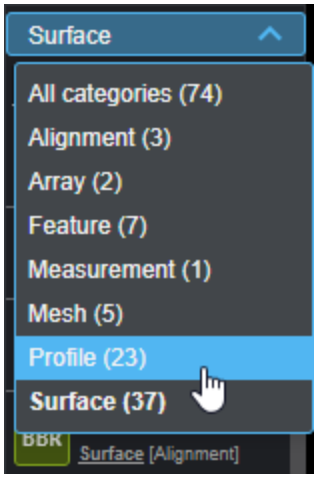
Setting	Description
Hardware decoding	Not settable.
Contrast Threshold	Controls the contrast threshold. Allows tuning the detection of points based on the intensities observed in Image mode.
Projector	Contains projector settings.
	Intensity Current projector intensity as a percentage.
	Pattern uniformity Pattern uniformity coefficient. Balances the center and sides of the projected image by lowering center intensity. Default = 1.0 no effect Min = 0.01 minimal center intensity Max = 1.0 full center intensity

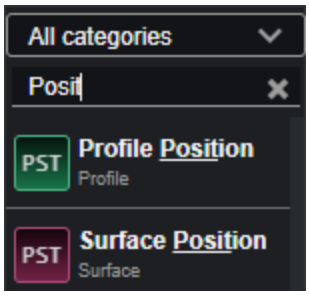
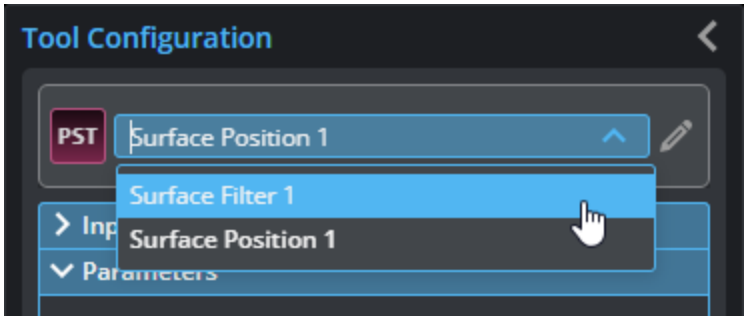
Configuring Inspection and Processing Tools

You add and configure measurement and processing tools on the **Tools** page, in the **Inspect** category.



	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 Tools Diagram panel to the right of the list.

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

	Element	Description
		
2	Tools Diagram	Lists the tools that you have added. The Tools Diagram lets you better visualize the workflow in complex tools chains. For more information, see *Working with Tool Chains* on page 134.
3	Tool configuration	You configure a tool using the **Inputs**, **Parameters**, and **Outputs** sections in the **Tool Configuration** panel. You can select which tool you want to configure from the tool selector drop-down, or by selecting the tool in the Tools Diagram to the left.  For information on parameters common to most tools, see *Tool Configuration* on page 153. For information on the different types of tools, see their topics in the following sections. Profile tools: See *Profile Measurement* on page 181. Surface tools: See *Surface Measurement* on page 310. Feature tools: See *Feature Measurement* on page 552. Mesh tools: See *Mesh Measurement* on page 598. Array tools: See *Array Tools* on page 593. Measurement Formula tool: See *Measurement Formula Tool* on page 618.
4	Data viewer	When configuring tools, you can graphically configure regions of interest. The data viewer's toolbar lets you change the display mode (for more information, see *Data Viewer* on page 62) 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 Tools Diagram or by double-clicking the tool.

GoPxL automatically sets the added tool's input to an appropriate output. 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 Tools Diagram shows where the tool will be added when you drop it.



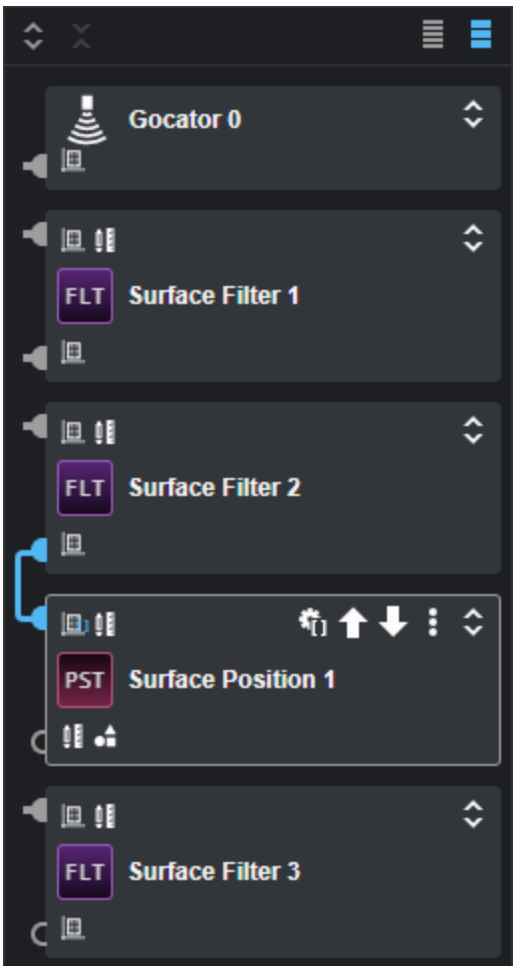
When double-clicking a tool in the tool list, the new tool is added after the currently selected tool in the Tools Diagram. If no tool is selected (or if a sensor or sensor group is selected), the tool is added to the bottom of the list of tools in the Tools Diagram.

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 Tools Diagram panel). 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.

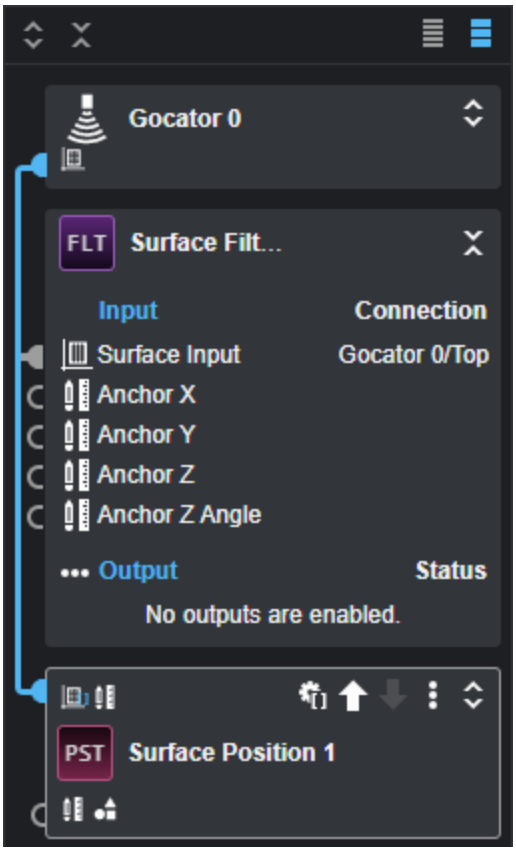
Note that you can also manually connect tools.

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.

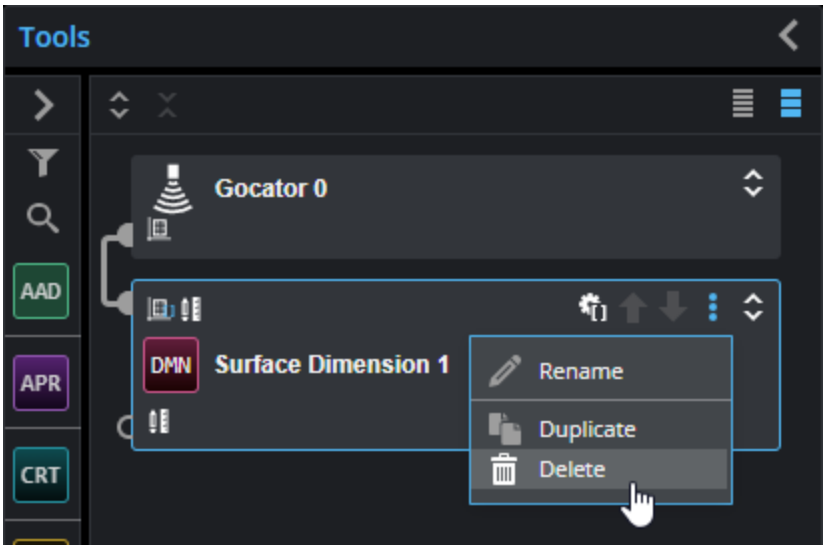


For information on other operations you can perform in the Tools Diagram, see *Working with Tool Chains* on page 134.

Removing a Tool

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

To remove a tool, select it in the Tools Diagram and press Delete on your keyboard. You can also open the tool's drop-down menu and choose **Delete**.

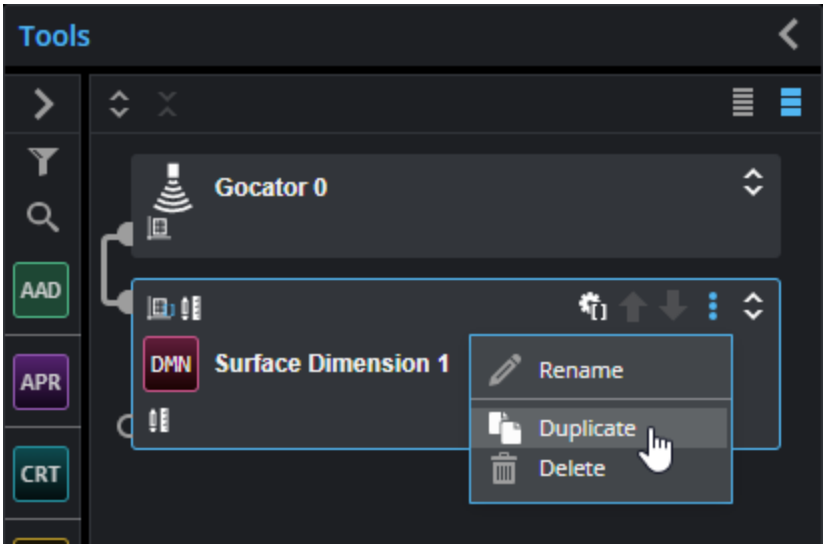


For information on other operations you can perform in the Tools Diagram, see *Working with Tool Chains* on the next page.

Duplicating a Tool

You can quickly create a copy of a tool you have previously added in GoPxL in the Tools Diagram panel. Tool inputs and parameter settings of the original are copied, but outputs are not. 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 Tools Diagram panel, you duplicate a tool using the Action menu of an individual tool.



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

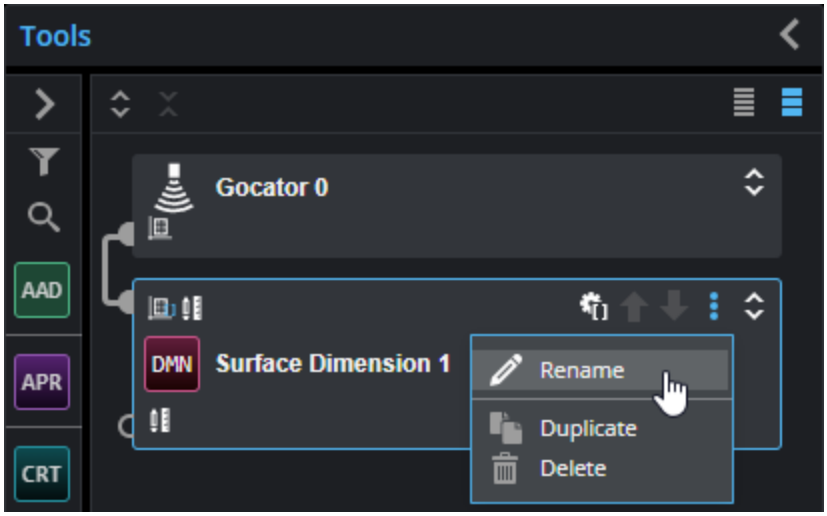
Renaming a Tool

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

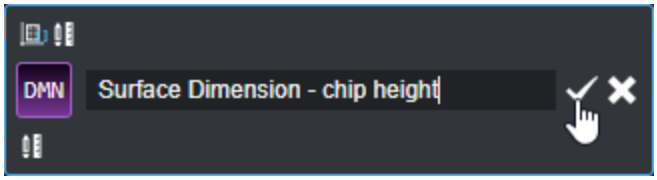
To rename a tool in the Tools Diagram panel

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 the check icon (see above).

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

Working with Tool Chains

The Tools 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 and other mouse operations, letting you quickly and easily implement and maintain applications requiring multiple, interconnected tools.

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)

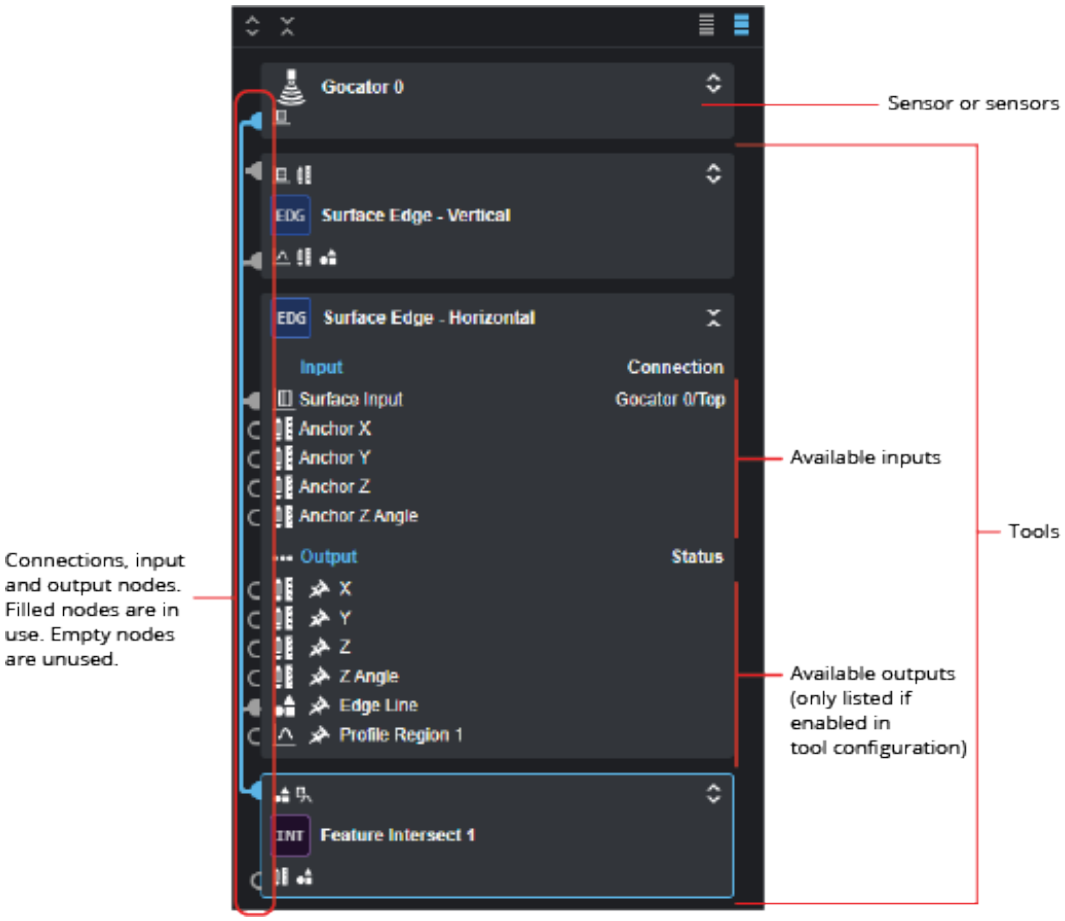
- Geometric features
- Tool data (some data outputs are intended to be consumed only by SDK applications and can't be used as part of a tool chain)

For details on how the Tools Diagram panel displays information, see *Understanding the Data Flow in Tool Chains* on page 140.

For details on how to connect and disconnect, see *Connecting Tools* on page 146 and *Disconnecting Tools* on page 151.

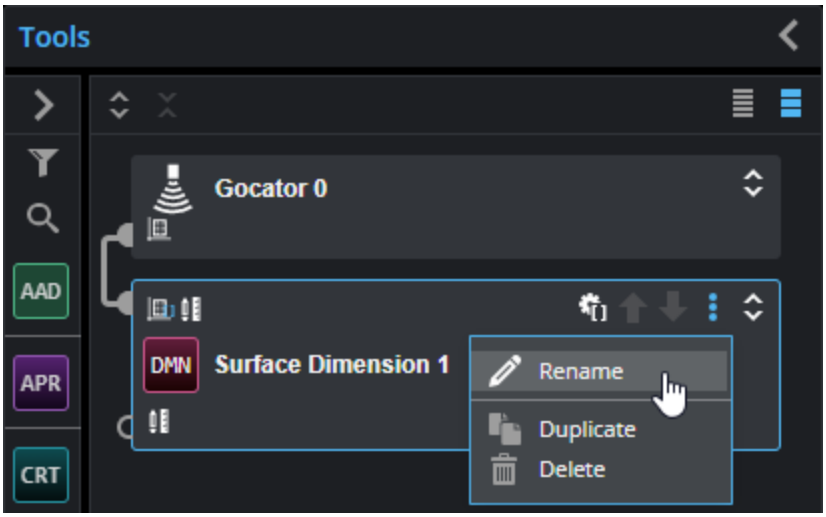
The Tools Diagram panel is open by default. The inputs, parameters, and outputs of the tool selected in the Tools Diagram panel are displayed to the right of the Tools Diagram panel.

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



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

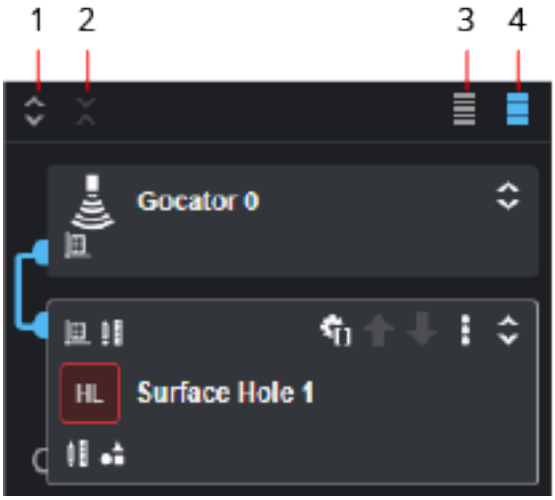
At the top of a tool, an action menu provides functions to rename, duplicate, and delete the current tool.



Action menu (collapsed tool)

Changing Tool Display Options

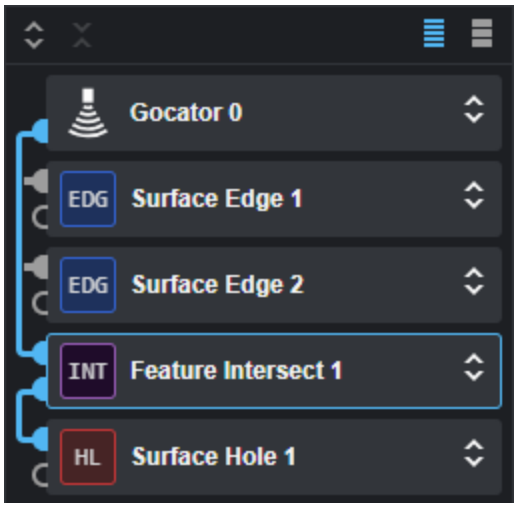
The buttons at the top of the Tools Diagram panel let you control how the panel displays sensor groups, tools, and the data flow (tool chain). Buttons at the top of individual tools let you organize the tools in the list, as well as name, duplicate, and delete them.



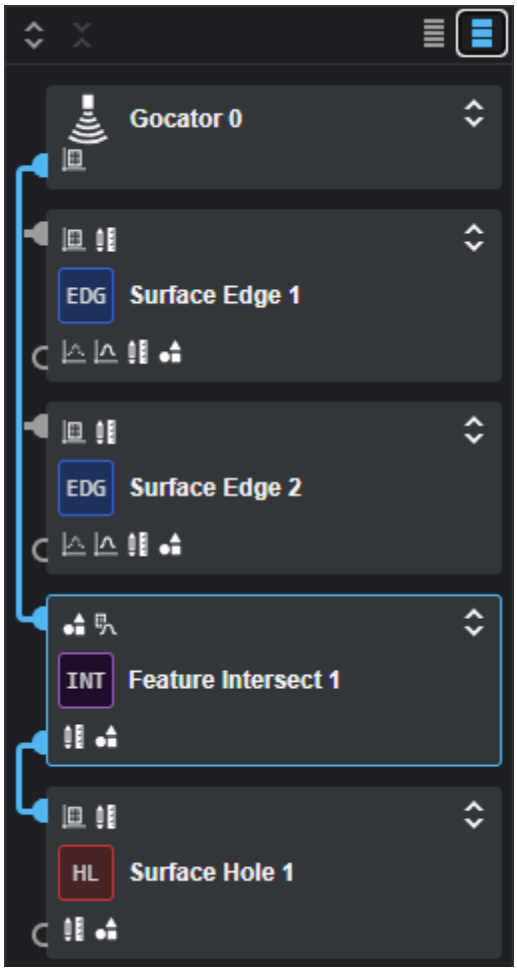
The following describes the toolbar's functions:

1. Open All: Expands sensor group and all tools in the Tools Diagram panel, displaying a list of available inputs and enabled outputs for each one.
2. Close All: Collapses all items in the Tools 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 Tools 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.

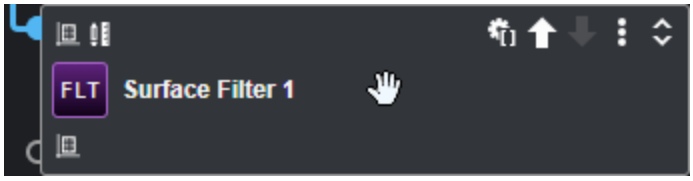
Note that the order of tools in the Tools Diagram panel does not affect the flow. Also, note that tools are added after the currently selected tool in the tool list.

You can reorder tools you have added by dragging and dropping them to the position you want in the list of tools, or by using the up and down arrows.



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

If you hover the mouse pointer over a tool in the Tools Diagram panel, you can use the up / down buttons next to the action menu to move the tool up or down in the panel.



Data Types

GoPxL represents the data types of inputs and outputs in the Tools Diagram panel with an icon.

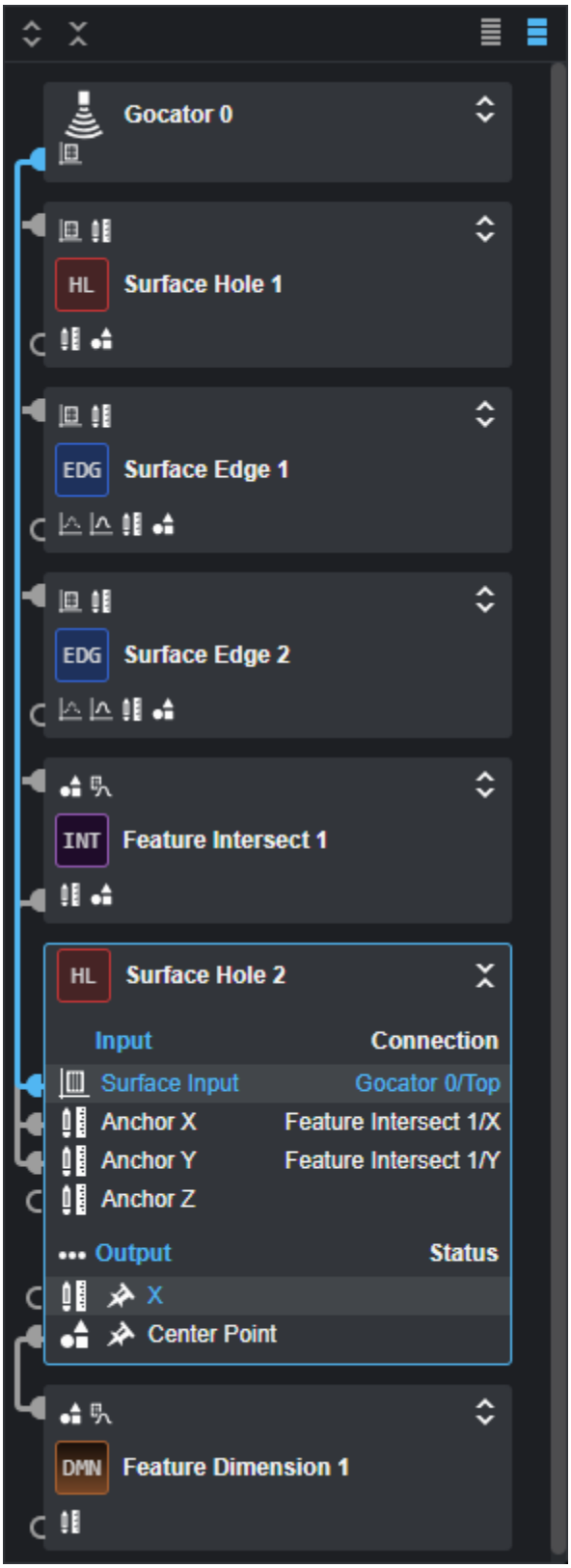
Icon	Description

	Surface data
	Profile data
	Measurement
	Geometric feature
	Tool data

Understanding the Data Flow in Tool Chains

The rectangular elements displayed in the Tools Diagram represent a sensor group 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.

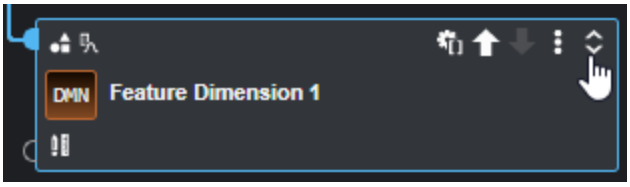
The appearance of nodes changes depending on whether they are connected and whether they are selected. Connections that are used are filled. Connections that are not used are empty. When a sensor or tool is expanded, you can see which specific inputs or outputs are used and part of the tool chain. For 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.


Gocator 0
HL
Surface Hole 1
EDG
Surface Edge 1
EDG
Surface Edge 2
INT
Feature Intersect 1
HL
Surface Hole 2
Input
Connection
Surface Input
Gocator 0/Top
Anchor X
Feature Intersect 1/X
Anchor Y
Feature Intersect 1/Y
Anchor Z
Output
Status
X
Center Point
DMN
Feature Dimension 1

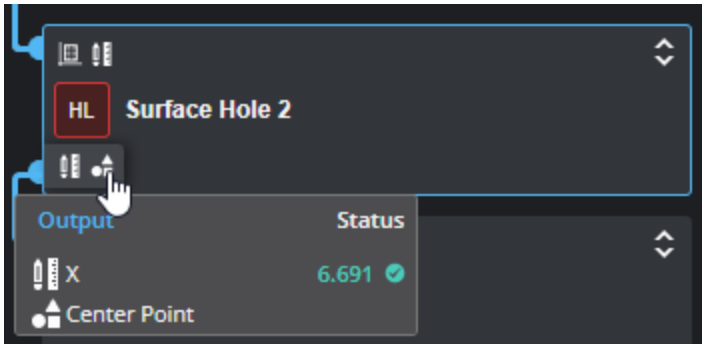
When a tool is collapsed, however, you only know that at least one input or output is used (or none at all). For example, looking at the collapsed Feature Dimension tool at the bottom, we know that at least one input (the connection node at the top) is used, and that none of the tool's outputs are used. 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 not), the data flow of the selected item is indicated by blue connection lines. For more information, see below.

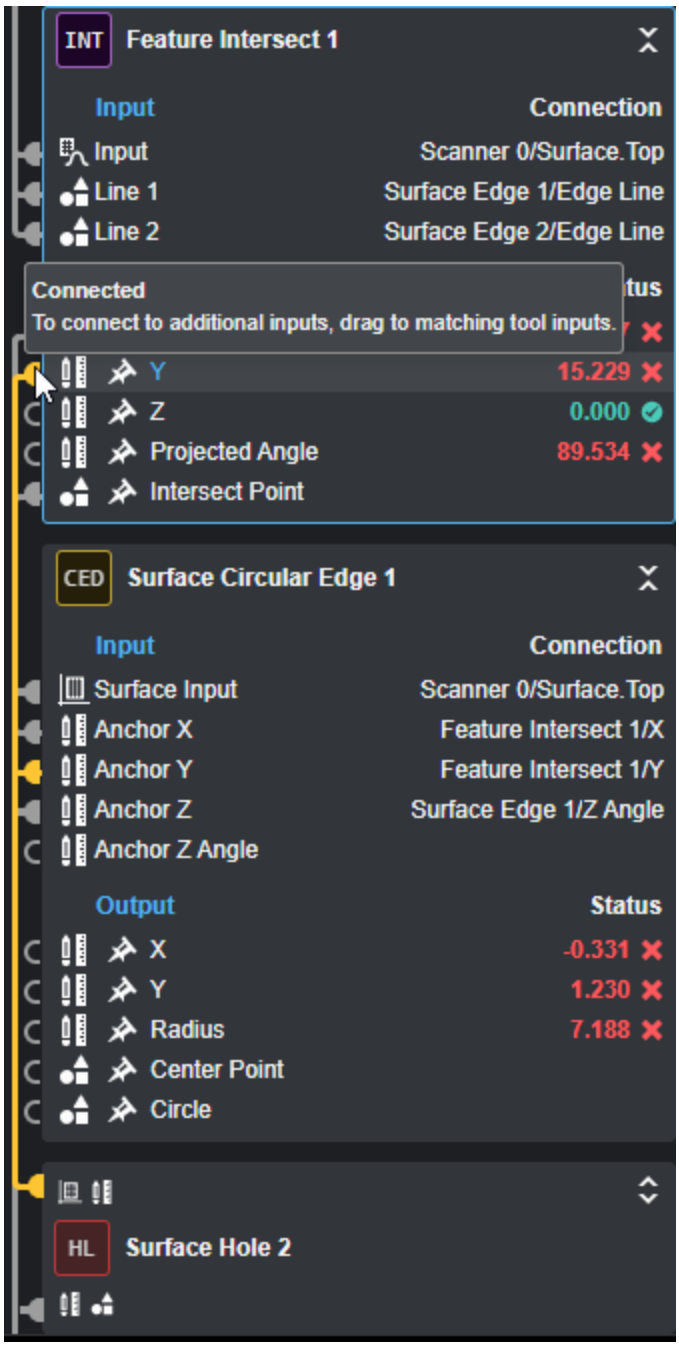
By default, sensors and tools are collapsed, but you can expand them individually by clicking the expand / collapse button at the top right of a tool to display the complete list of available inputs and outputs. Note that for an output to be listed in the Outputs section, it must be enabled in the tool's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



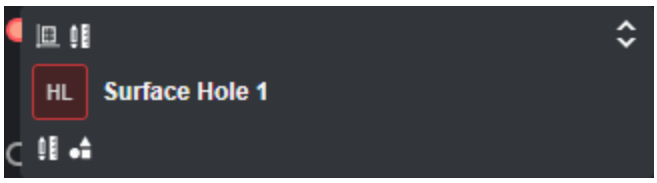
When a tool is collapsed, you can "peek" the available inputs or the enabled outputs by clicking one of the horizontal lists of small icons (Standard view only). Clicking an item selects it for display in the Displayed Outputs panel below the data viewer.



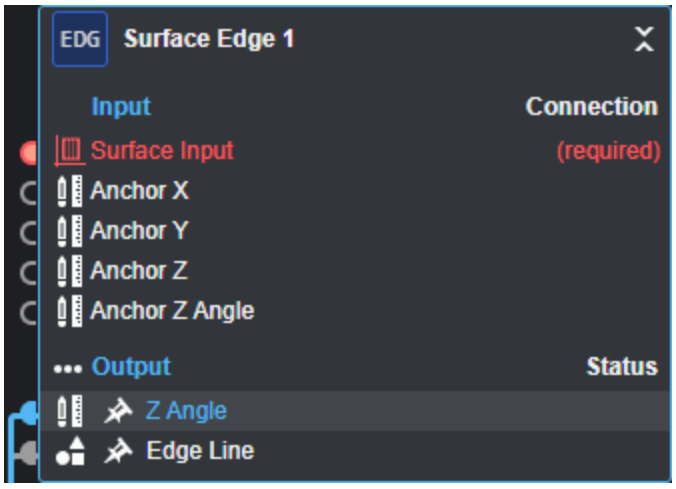
If you hover the mouse pointer over a blue connected node, a part of the blue connection line is highlighted to indicate what it is connected to. In the image below, you can see that by hovering over an output (the Y measurement of the Feature Intersect tool at the top) is used as an input (the Y anchor)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



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

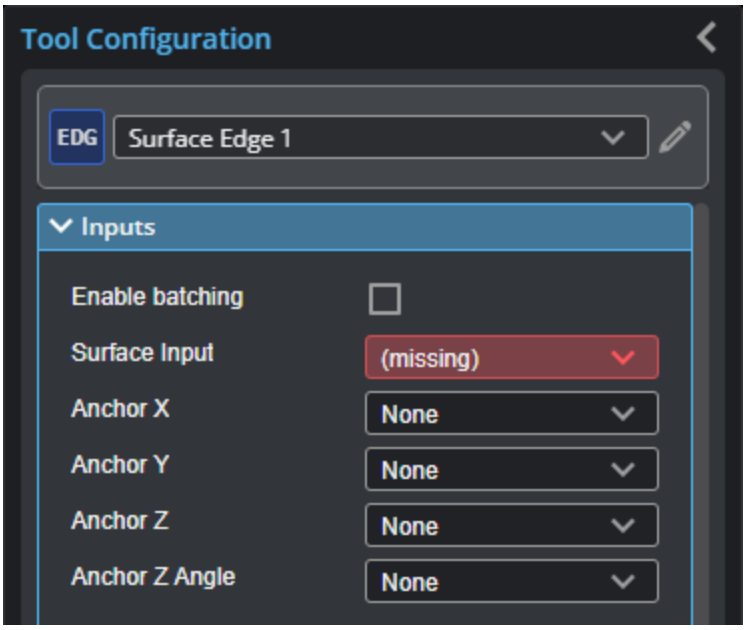


Collapsed tool with a missing input



Expanded tool with a missing input

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

In the following, we connect a geometric feature output from one tool to the input of another tool. However, the same procedure applies when connecting other kinds of outputs to inputs, such as connecting a measurement from one tool to one of the anchors available in another tool, or when connecting Surface output (such as the output from the Surface Filter tool) to the input of another tool (which is initially set to the direct output of a sensor).

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.

   For information on adding tools, see *Understanding the Data Flow in Tool Chains* on page 140.

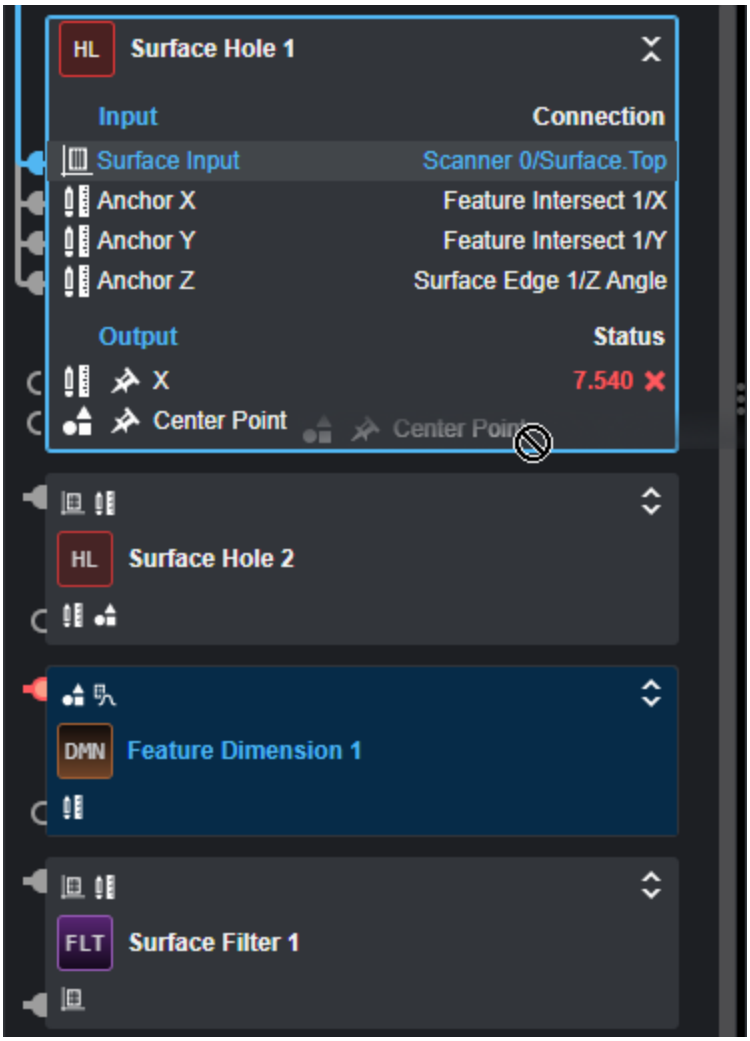
2. Locate the tool whose output you want to use (the "source" tool).

3. Do one of the following:

   From an expanded tool

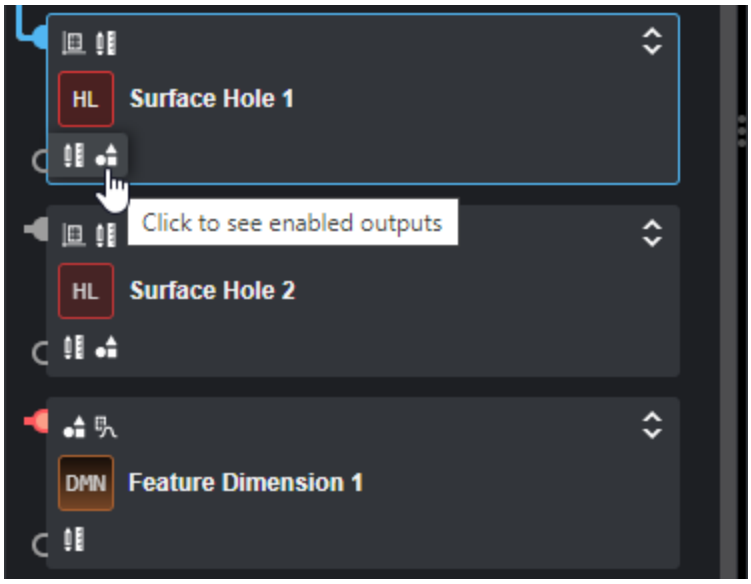
   a. Click and hold the output you want to connect to the other tool's input and drag it to the input.

      Here, we are dragging the Center Point output. Tools with compatible inputs (here, the Feature Dimension tool), are highlighted with a dark color.

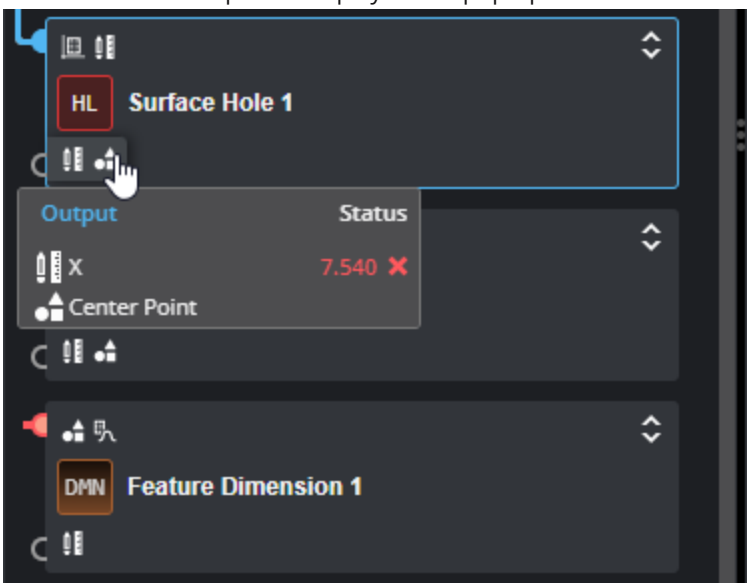


From a collapsed tool

a. Click the small output types at the bottom of the tool to expand the list of

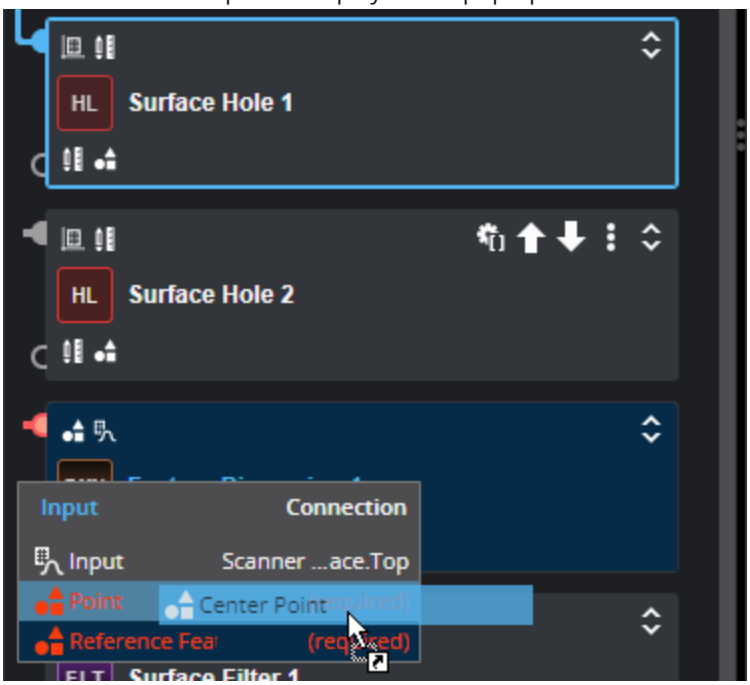


A list of enabled outputs is displayed in a pop-up list.

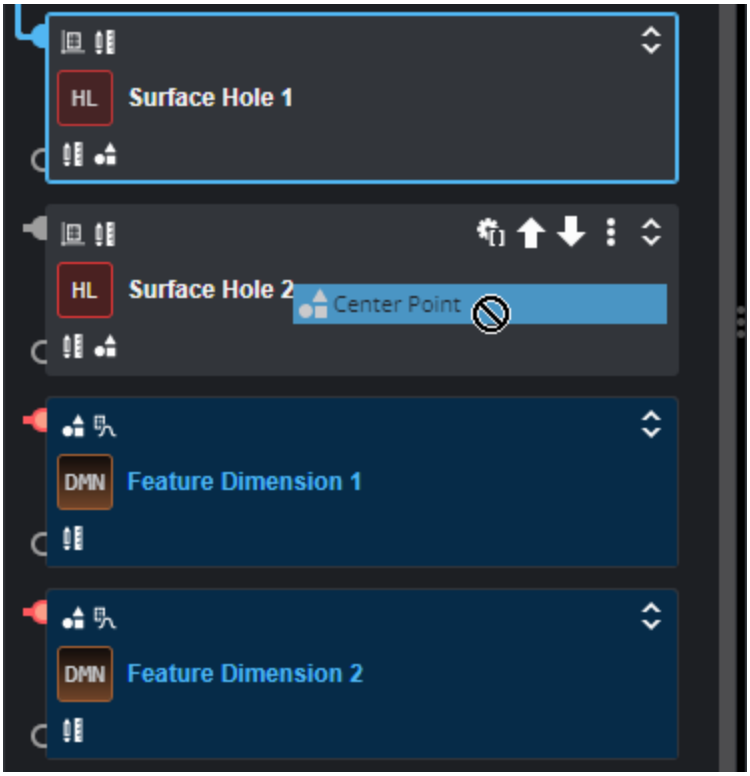


b. In the pop-up list, click and hold the output you want to connect to the other tool's input and drag it to the input.

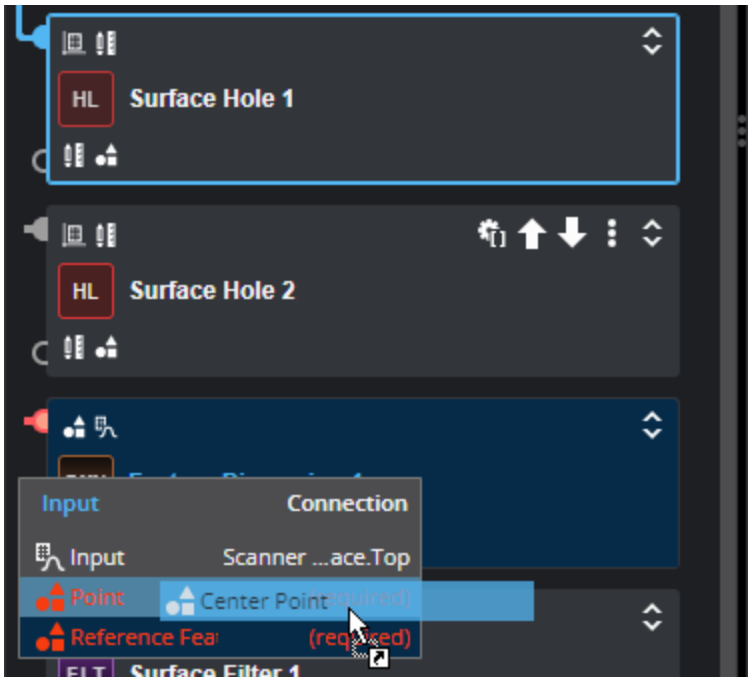
A list of enabled outputs is displayed in a pop-up list.



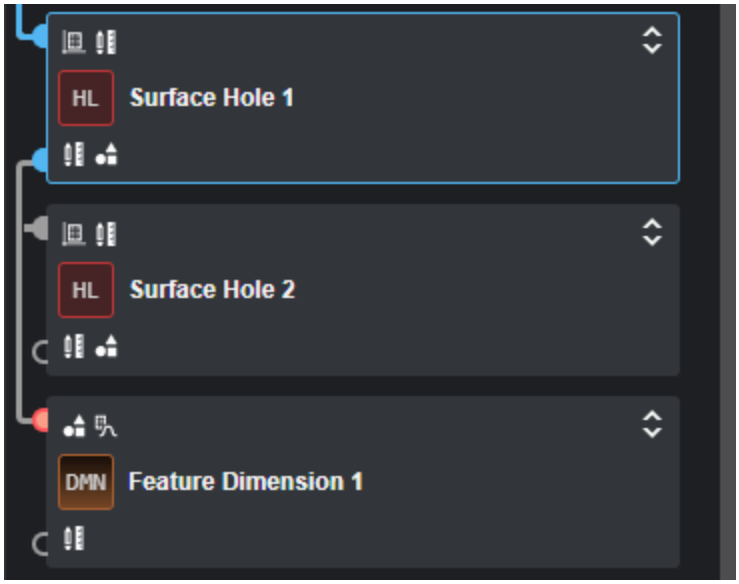
Tools with compatible inputs are highlighted with a dark color. Here, the two Feature Dimension tools have compatible inputs.



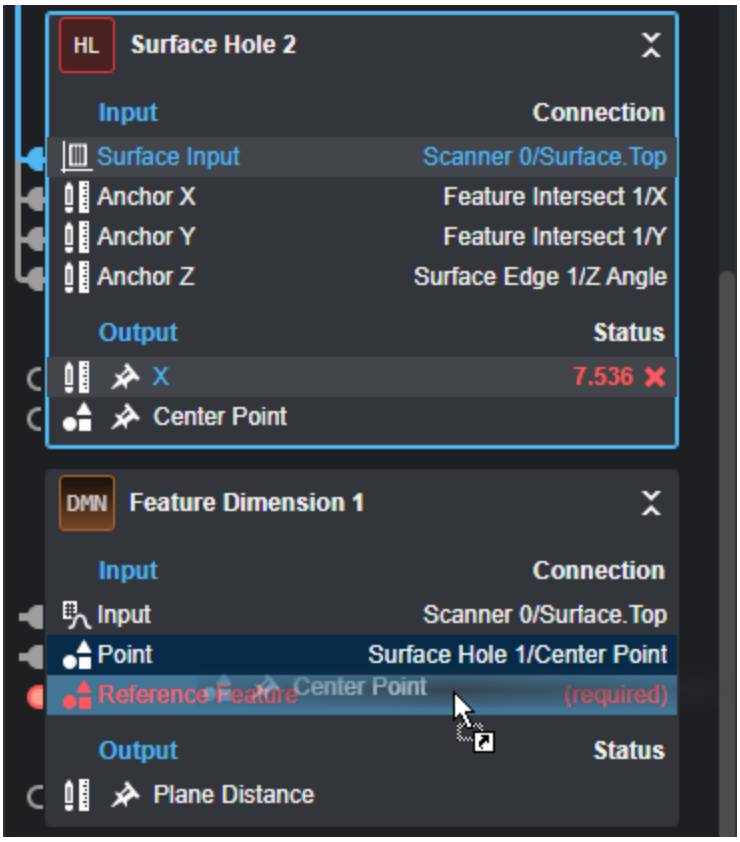
4. Drop the output on the desired input.



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).



You can also drag-and-drop outputs when one or both tool blocks is expanded.

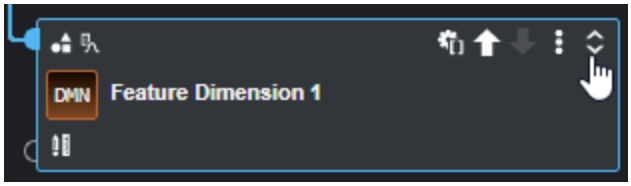


Disconnecting Tools

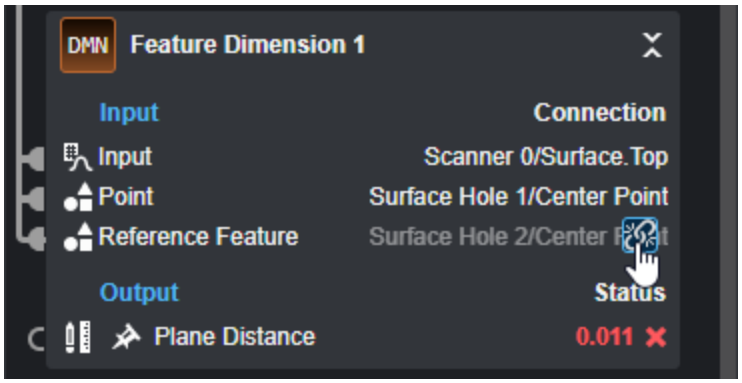
You can quickly disconnect an input in the Tools Diagram panel, but only if the tool containing the input is expanded.

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.

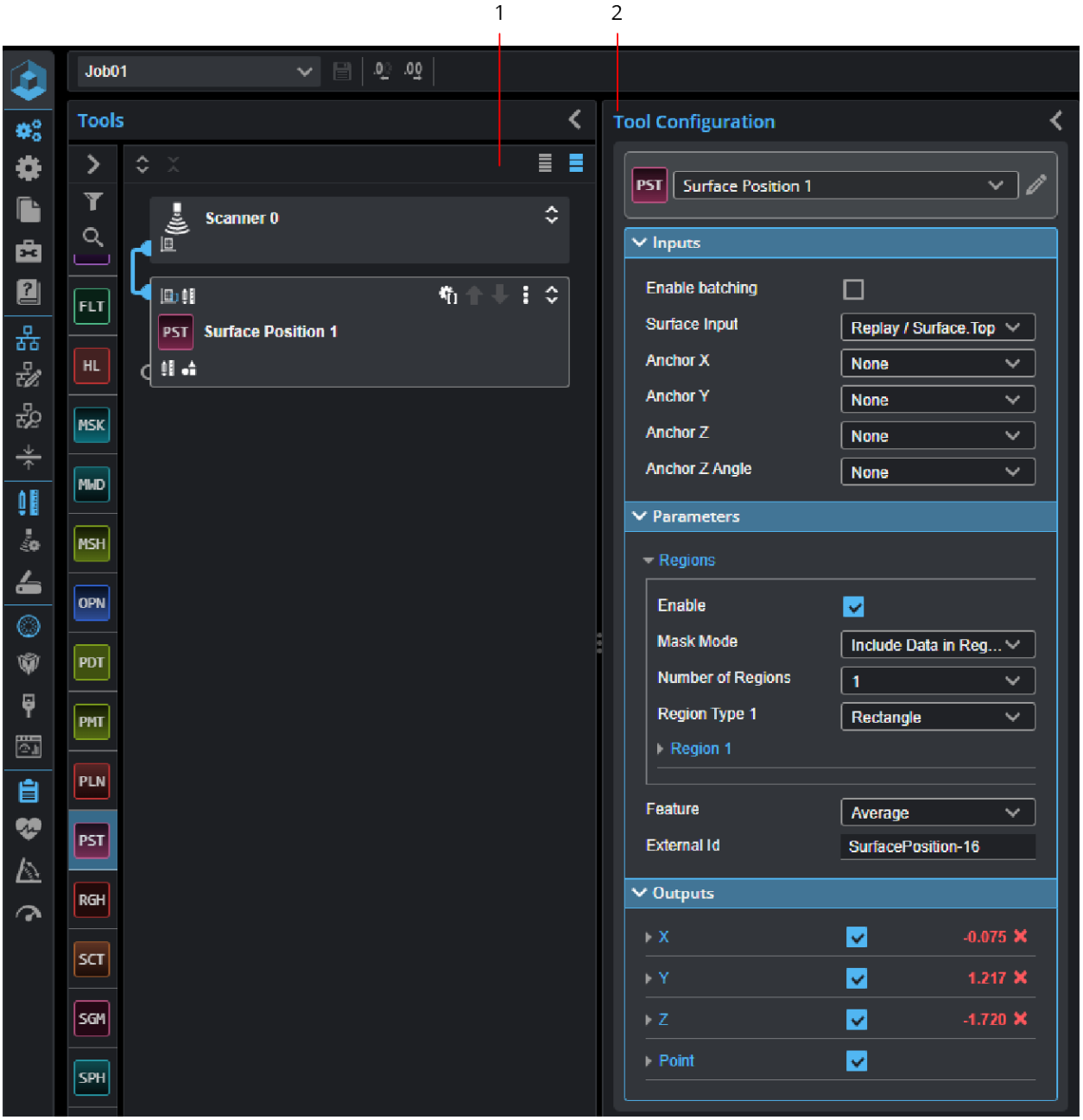


3. Click the Disconnect icon.

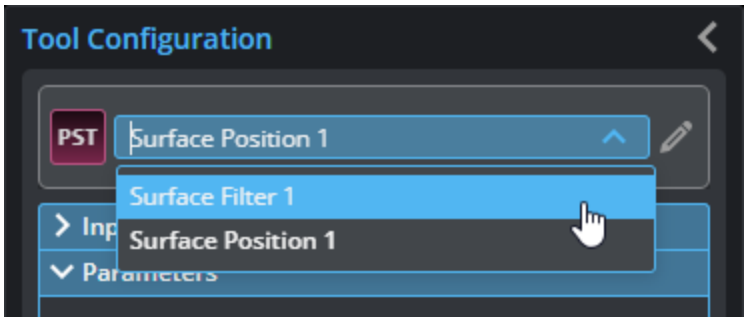
   The input is disconnected from the other tool's output.

Tool Configuration

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



	Element	Description
1	Tools Diagram	Lists the tools that you have added. The Tools Diagram lets you better visualize the workflow in complex tools chains. For more information, see *Working with Tool Chains* on page 134.

	Element	Description
2	Tool configuration	You configure a tool using the Inputs, Parameters, and Outputs sections in this area. You can select which tool you want to configure from the tool selector drop-down, in addition to selecting the tool in the Tools Diagram. 

The following sections describe the parameters common to most tools.

Inputs and Outputs **154**
Arrays, Batching, and Aggregation **155**
Arrays from Multi-instance Tools 156
Arrays from Multi-layer Output 157
G2 Multi-sensor Output 158
Batching 159
Aggregating 161
Regions **163**
Standard Regions 163
Flexible Regions 164
Working with Circular and Elliptical Regions 168
Region Rotation 170
Feature Points **172**
Geometric Features **175**
Fit Lines **175**
Decisions **176**
Measurement Anchoring **176**

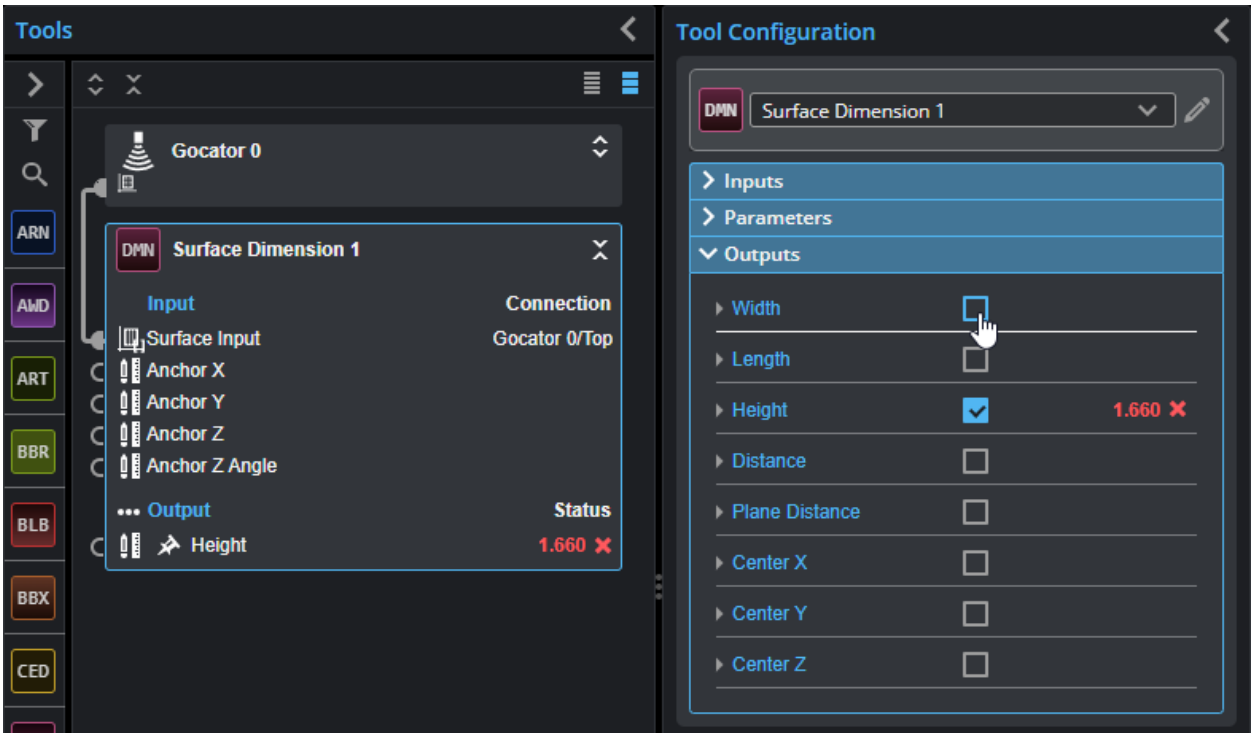
Inputs and Outputs

All tools take one or more inputs, either directly from a sensor 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 (G2 or G5 sensors only) or surface data. In these cases, the tool performs measurements on the data it receives, or processes it, and makes the them available as outputs.

Most measurement 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 data) available in a tool are listed in the **Outputs** section of the tool in the **Tool Configuration** panel after a tool has been added. 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 Tools Diagram.

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. 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 separately. For more information, see *Batching* on page 159.
- 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 161.

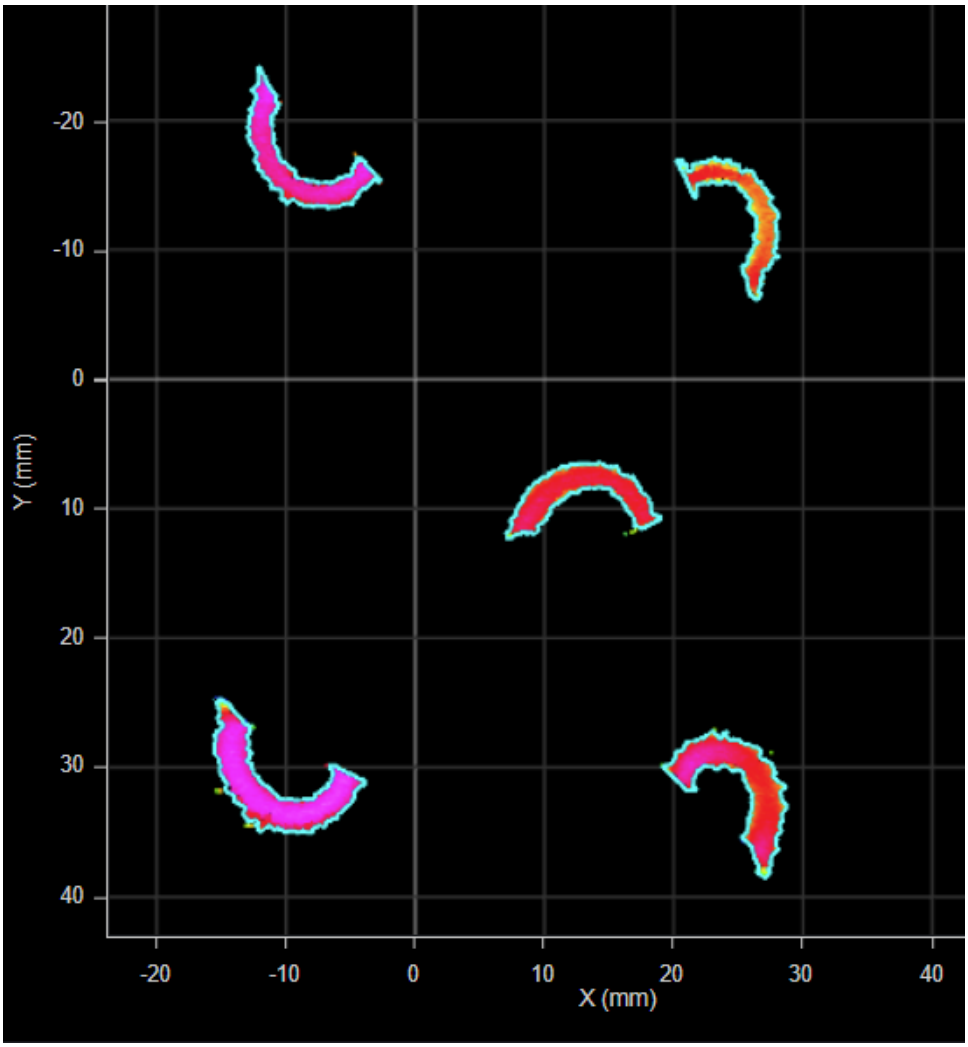
Most tools support the batching of array elements. Some tools support both batching and aggregating.

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.
- G5 (single- and multi-sensor) multi-layer output. For more information, see *Arrays from Multi-layer Output* on the next page.
- G2 multi-sensor output. For more information, see *G2 Multi-sensor Output* on page 158.
- The Array Create tool. For more information, see *Array Create* on page 594.

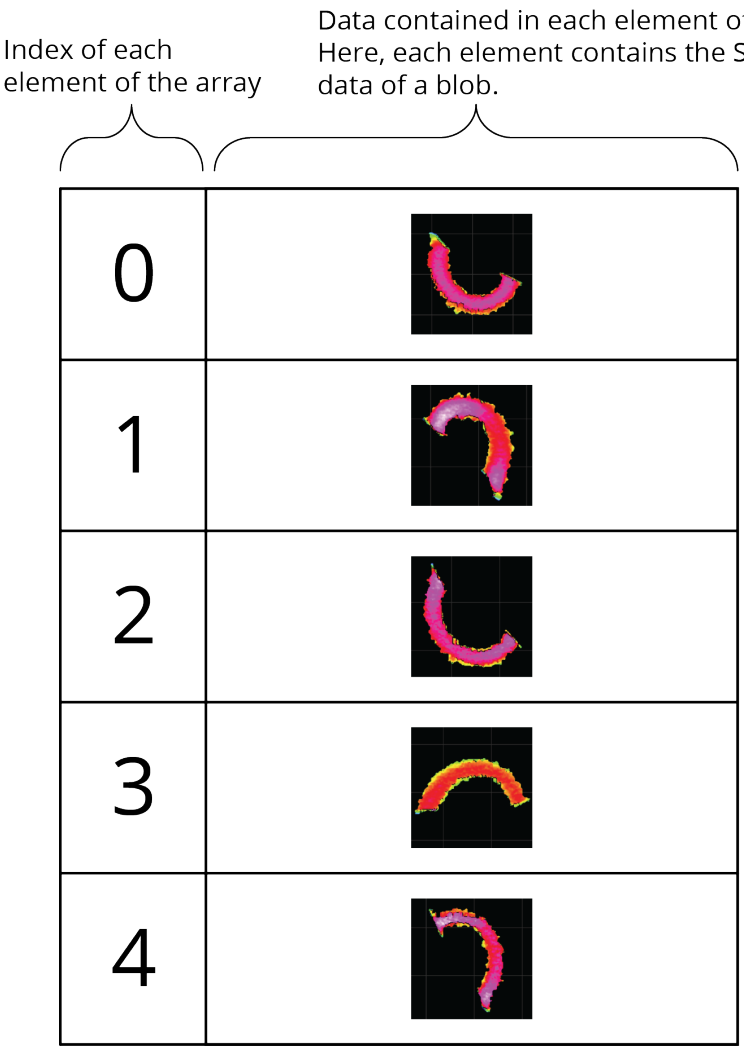
Arrays from Multi-instance Tools

The Surface Blob, Surface Segmentation, and Surface Pattern Matching tools can identify 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 **Enable Array Output** is checked, the Surface Blob tool outputs an array containing all of the blobs it identifies. An array containing the blobs identified above could be represented in the following way.

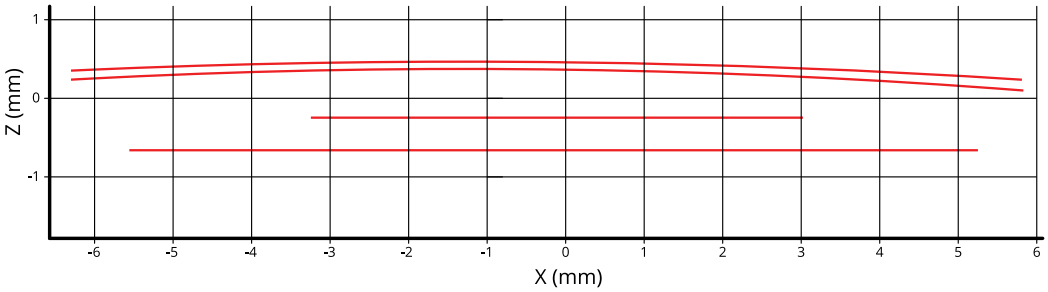


Other tools can then take this array as input. For more information, see *Batching* on page 159 or *Aggregating* on page 161.

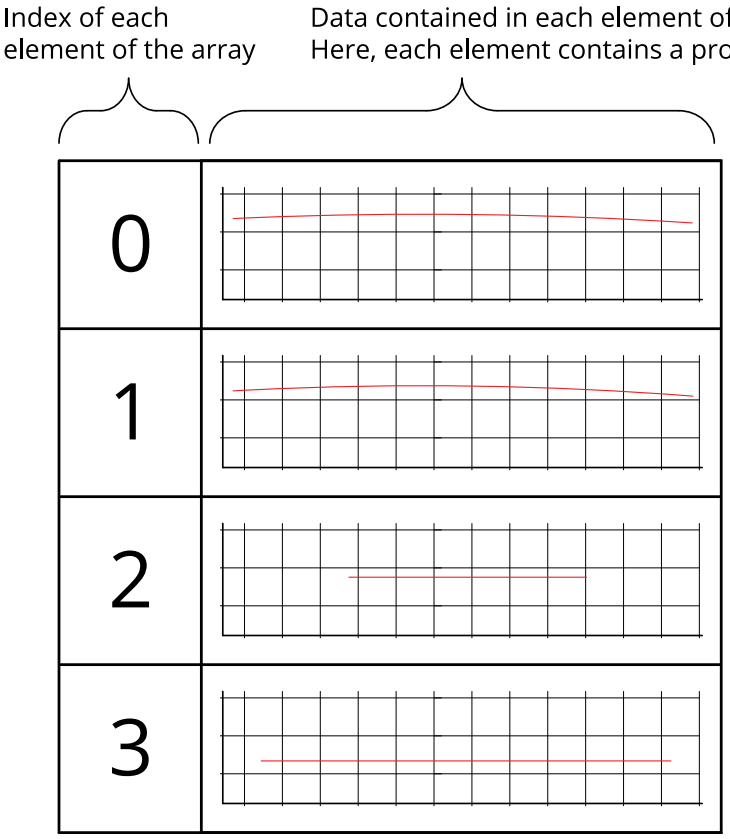
Arrays from Multi-layer Output

When configured for multi-layer scanning, G5 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**.)

The following illustration is a representation of multilayer Profile scan data from a G5 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 161.

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.

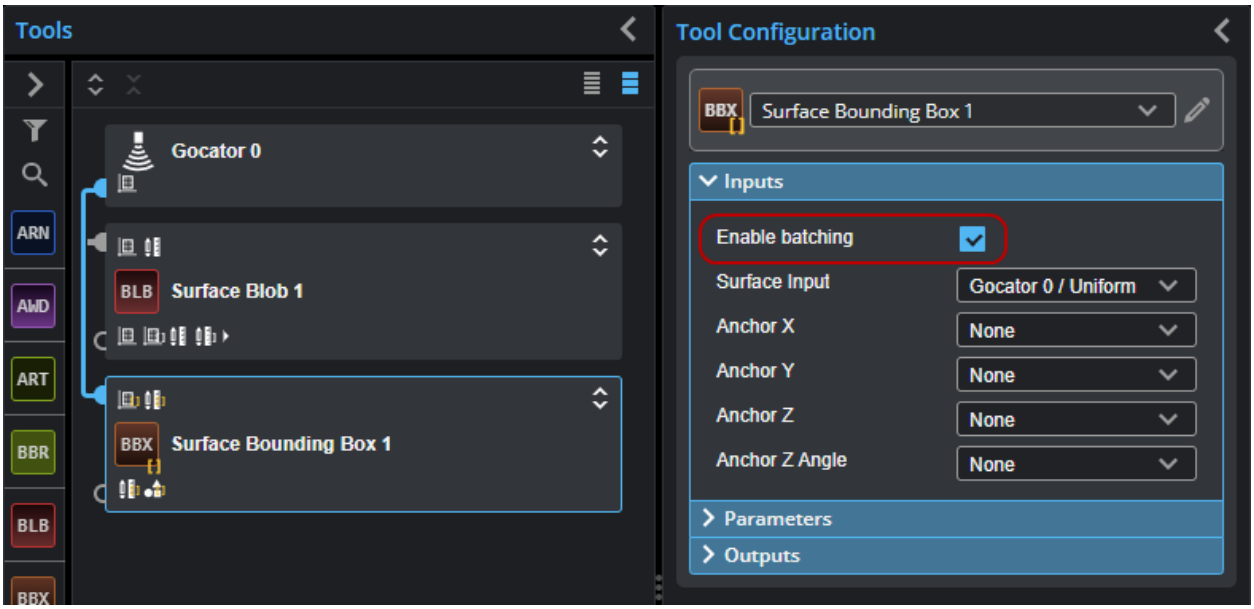
Other tools can then take this array as input. For more information, see *Batching* on the next page or *Aggregating* on page 161.

Batching

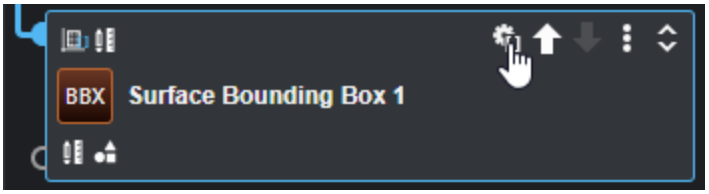
When a tool is in *batching* mode, it takes an array as input and processes each item in the input array *individually*. A tool in batching mode also outputs one or more arrays (such as measurements, Profile or Surface data, geometric features, and so on), where each element of the output arrays corresponds 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 explicitly in tools, by checking the **Enable Batching** parameter in the tool's Input section.

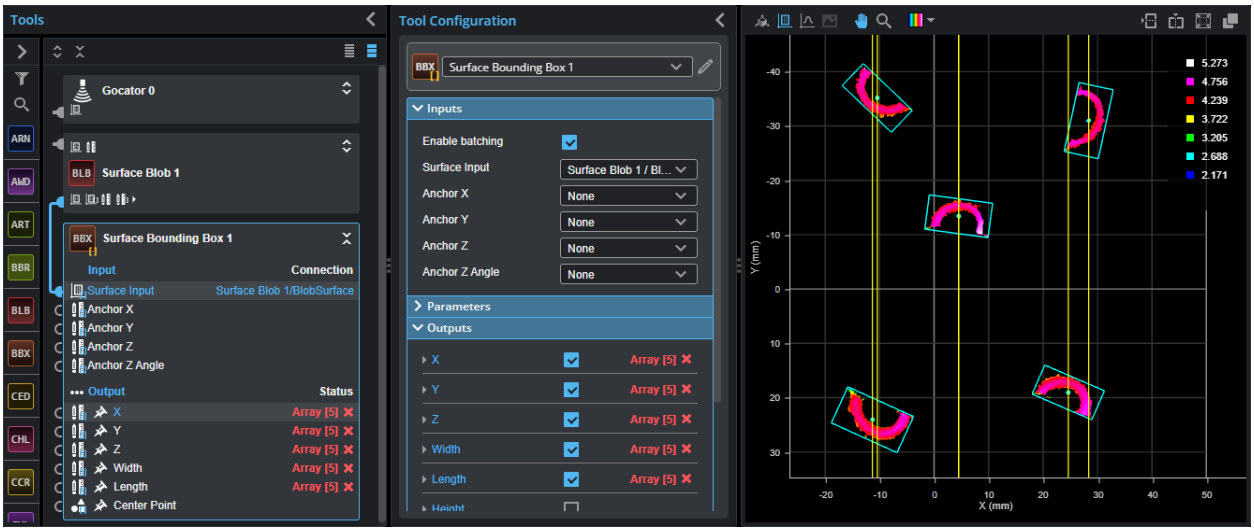


In the Tools Diagram, you can also hover over a tool's block and click the Batching icon ( ).

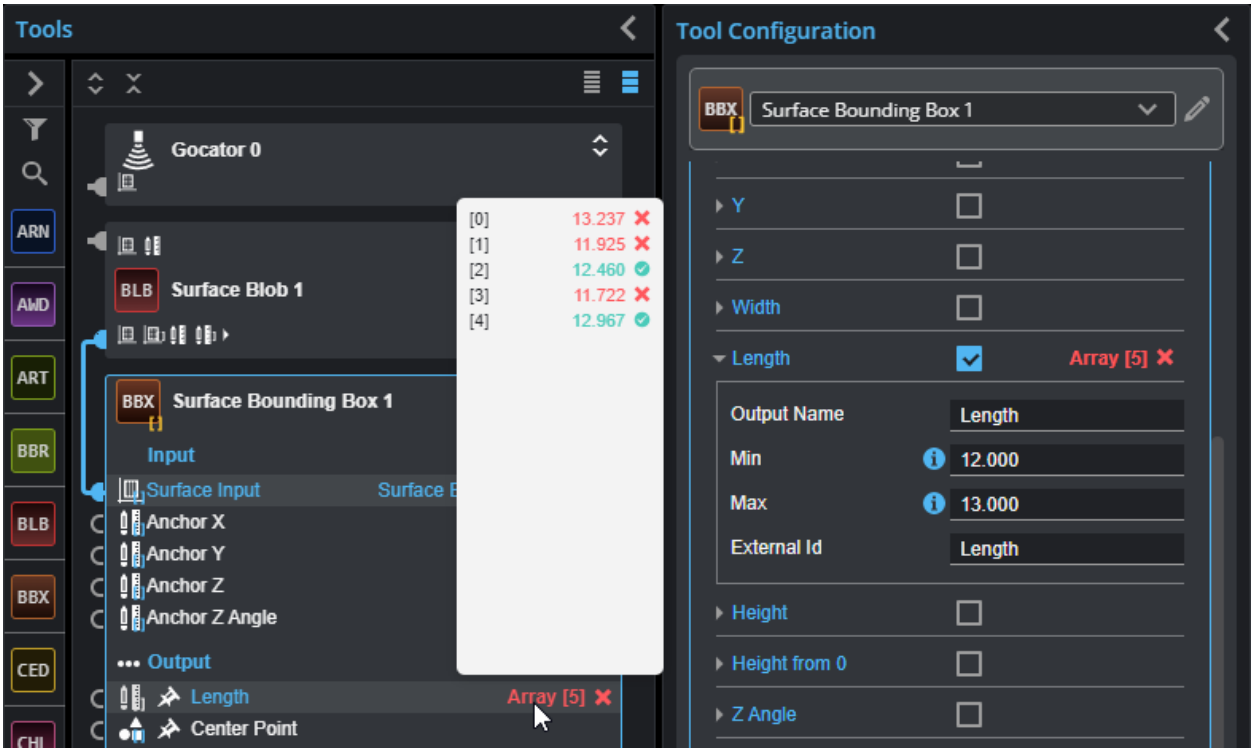


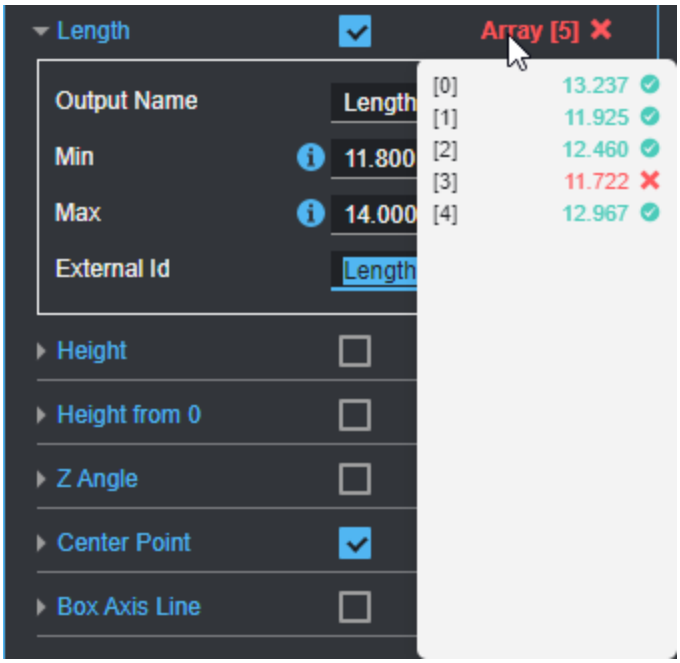
Batching mode is indicated by square bracket ("[]") overlays in the tool list and in the Tools Diagram.

The following shows the Surface Bounding Box tool in batching mode. The tool calculates the bounding box for each element in the input array, and returns the enabled measurements as arrays.



Hovering over batched outputs in the Tools Diagram or in the Tools 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.

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.

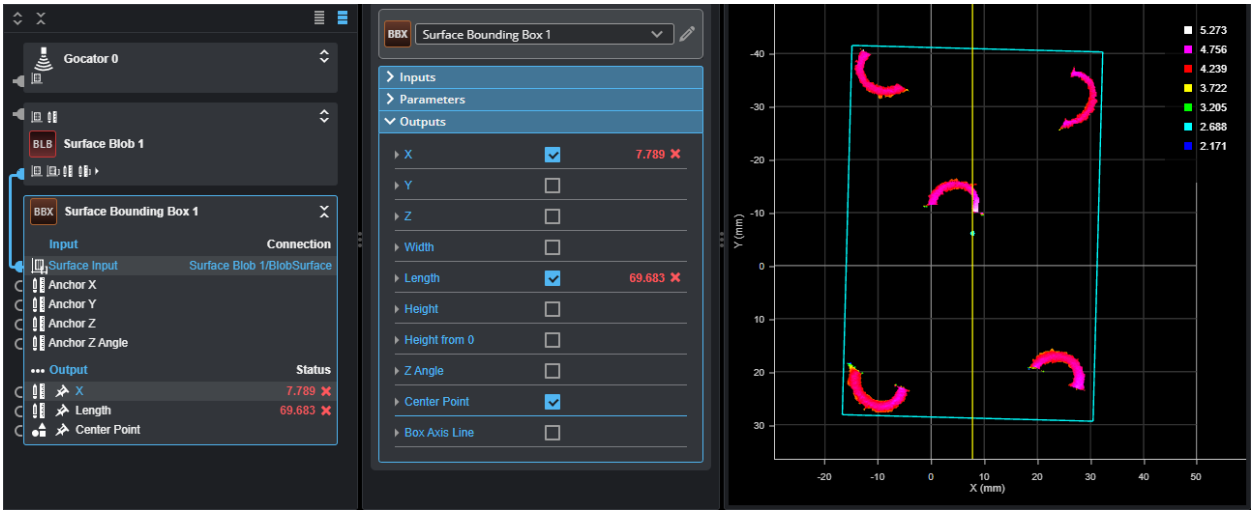
> Remember to uncheck **Enable Batching** if you want a tool to aggregate array inputs.

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		✓

	Number of array elements supported for aggregation	
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		✓
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.



As with other tools, you set a measurement's Min and Max values to produce pass/fail results.

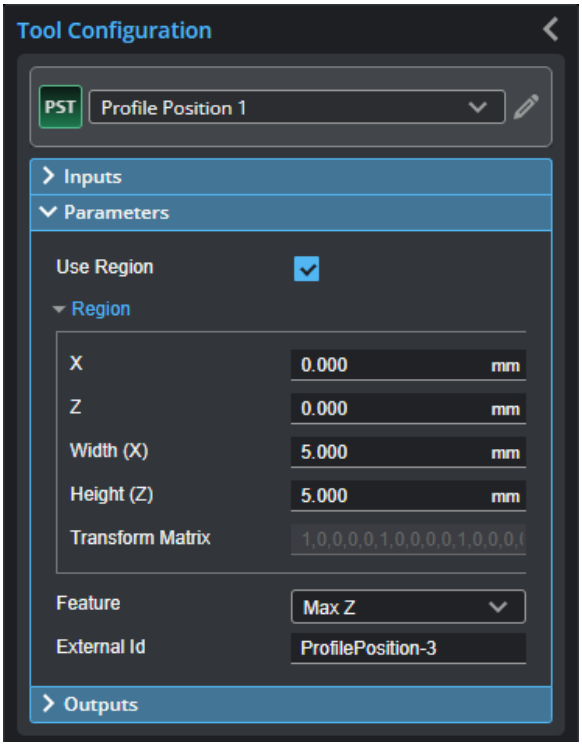
Regions

Some tools provide "flexible" regions, which in addition to rectangular regions let you create circular and elliptical regions (which can optionally be annular), and in some tools, polygon regions. 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. However, you can get "flexible regions" in a tool that doesn't directly support them by adding and configuring a Surface Mask tool, and using that tool's output as the other tool's input. (For information on masks, see *Surface Mask* on page 434.)

Standard Regions

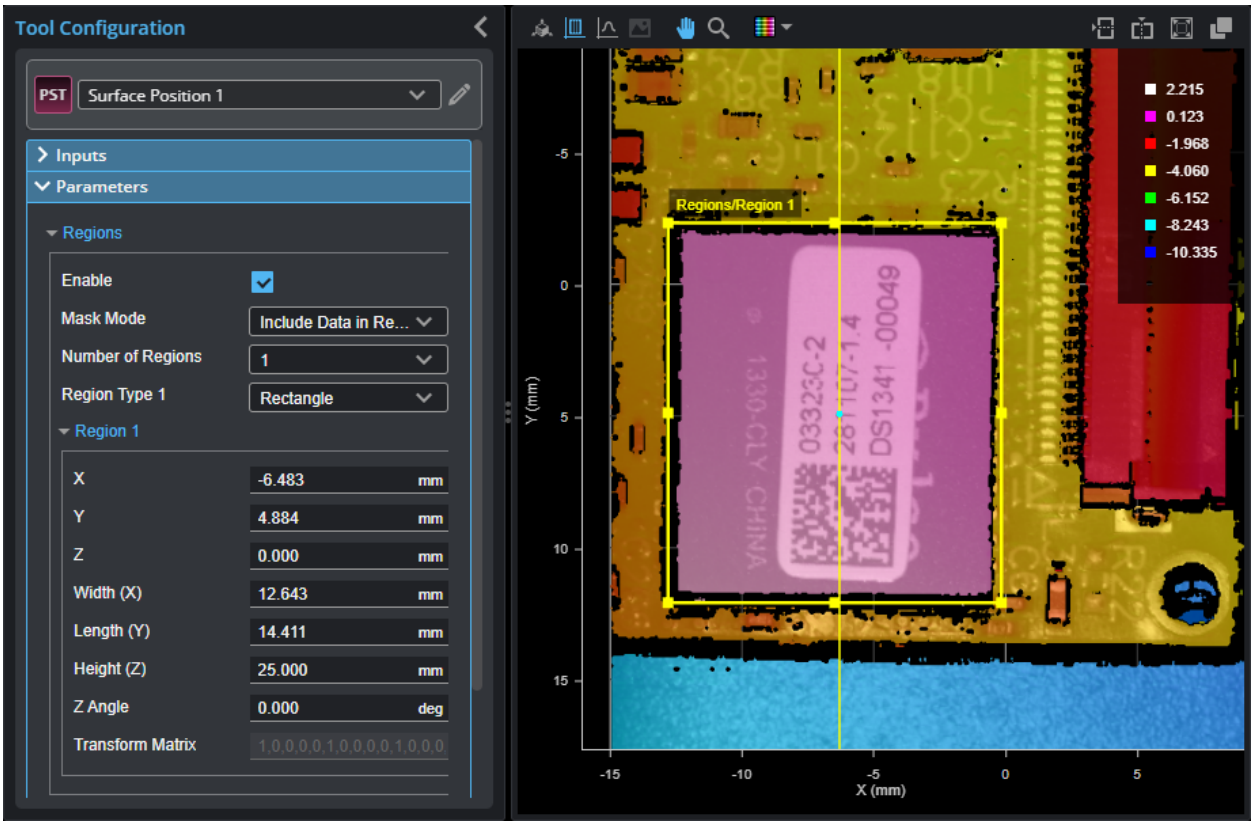
Some tools provide regions limited to boxes/rectangles.

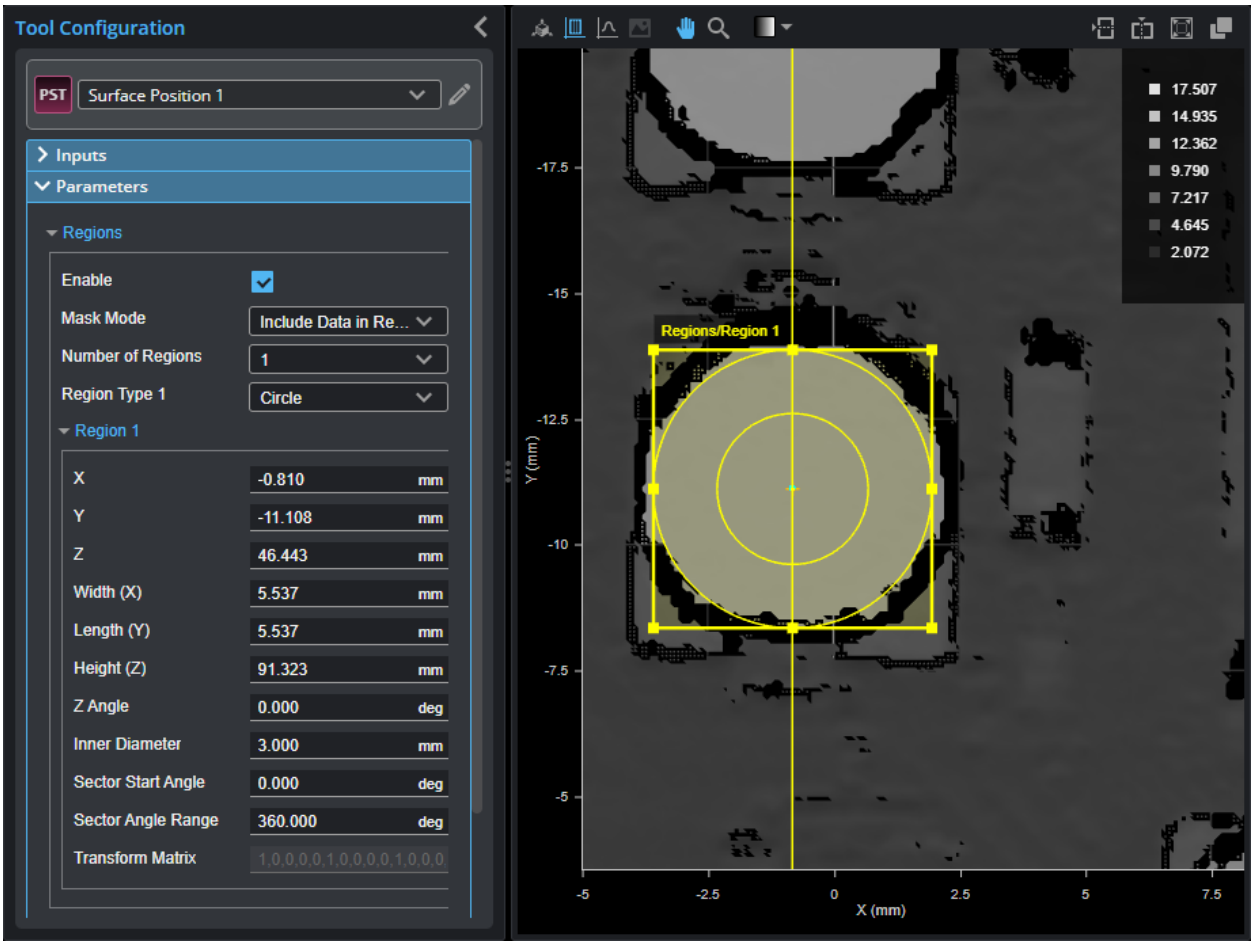


The **Transform Matrix** setting is not currently used.

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* on the next page.

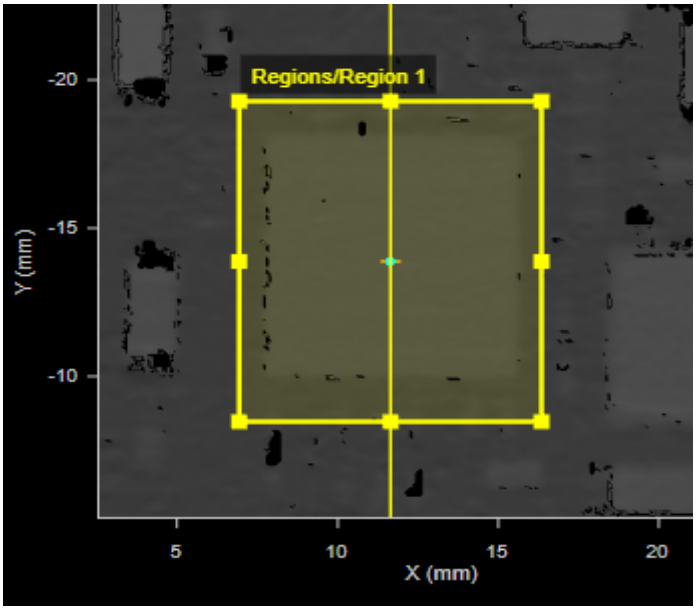
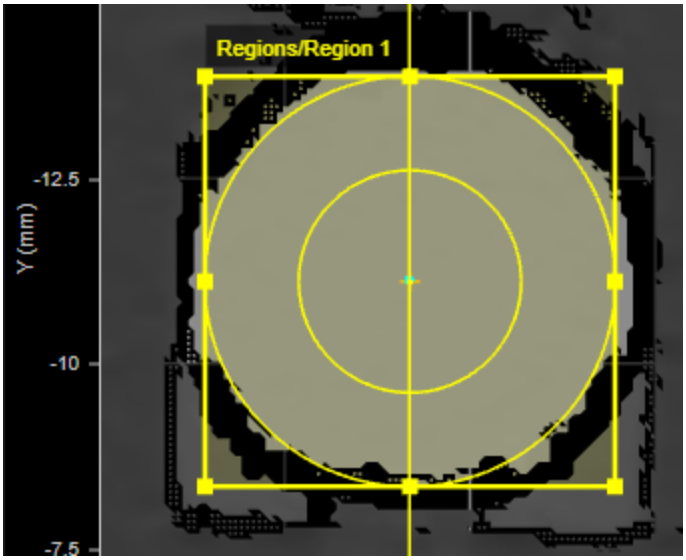


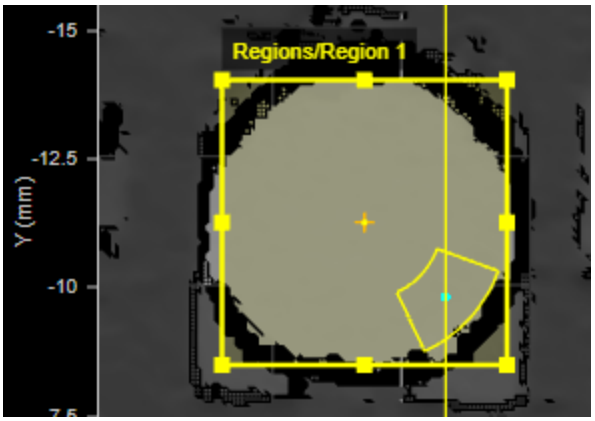
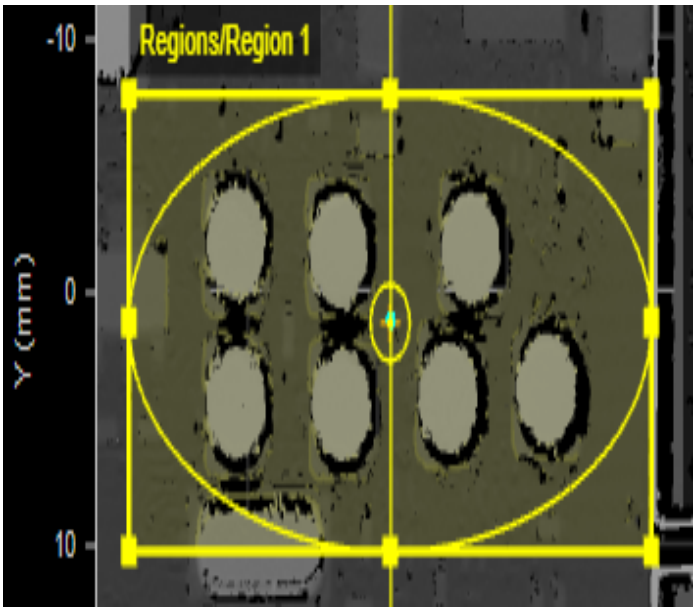


The following parameters are available in tools that support flexible regions.

Flexible Region Parameters

Parameter	Description
Mask Mode	One of the following: **Include Data in Region**: The tool uses only the data inside the region or regions. **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 surface data. You can define up to 15 or 16 regions. This parameter is not available in some tools. When you specify more than one region, the regions are initially stacked on top of one another, in the same location.
Region Type {n}	The type of each region. Regions can overlap. (For more information on the settings you use with the Circle and Ellipse types, see *Working with Circular and Elliptical Regions* on page 168.) One of the following:

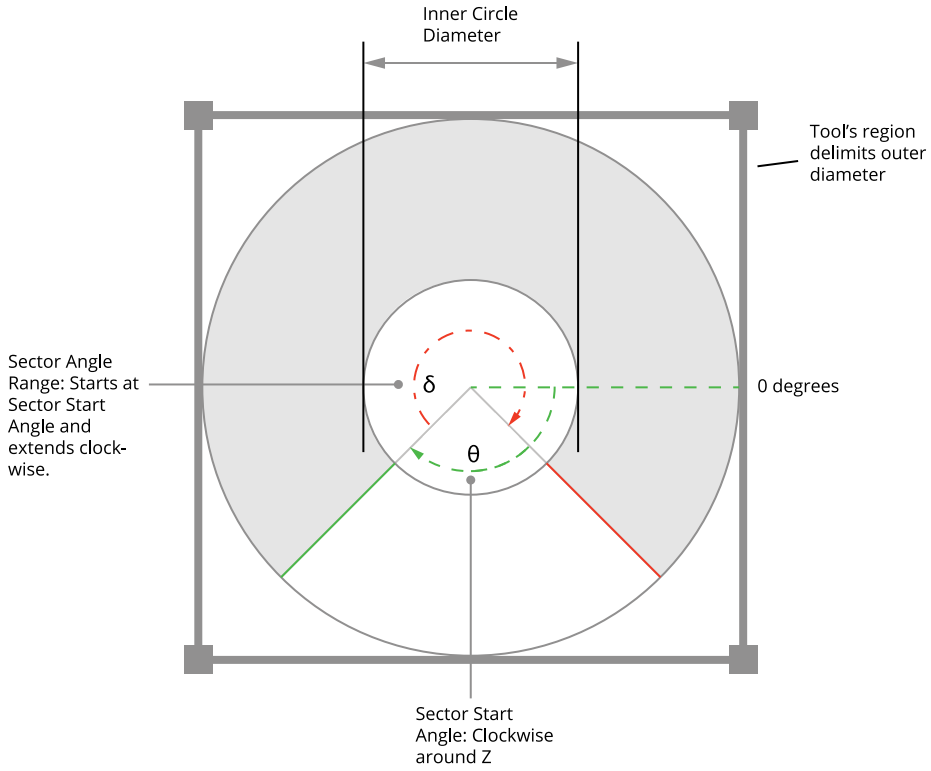
Parameter	Description
	Rectangle Extracts a rectangular region from the surface data.  **Circle** Extracts a circular region from the surface data, constrained by a square region. Set the region's inner circle using the **Inner Diameter** parameter to extract annular data.  Use the **Sector Start Angle** and **Sector Angle Range** parameters to extract a partial circular or elliptical region.

Parameter	Description
	 **Ellipse** Extracts an elliptical region from the surface data, constrained by a square or rectangular region. Set the region's inner ellipse (inner cyan ellipse below) using the **Inner Major Axis** and **Inner Minor Axis** parameters to extract annular data.  Use the **Sector Start Angle** and **Sector Angle Range** settings to extract a partial circular or elliptical region. **Surface** Uses the Surface data you select in **Mask Source {n}**, in the **Inputs** panel, to create a mask.

Parameter	Description
	Surface Intensity Uses the intensity data you select in **Mask Source {n}**, in the **Inputs** panel, to create a mask. Set the **Low Threshold** and **High Threshold** parameters as required.
X, Y, Z Width (X), Length (Y), Height (Z) 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 **Surface** or **Surface Intensity**.
Inner Diameter	Only available when **Region Type {n}** is set to **Circle**. Defines the diameter of the inner circle. 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 Inner Minor Axis	Only available when **Region Type {n}** is set to **Ellipse**. These parameters define the major and minor axes of the inner ellipse, respectively 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 Sector Angle Range	Only available when **Region Type {n}** is set to **Circle** or **Ellipse** 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. Note that the angles and ranges in these parameters are measured clockwise around Z, where 0 degrees is along the positive X axis. For more information on how these settings work together, see *Working with Circular and Elliptical Regions* below.
High Threshold Low Threshold	The high and low thresholds the tool uses in combination with the intensity mask. Only available when **Region Type {n}** is set to **Surface Intensity**.

Working with Circular and Elliptical Regions

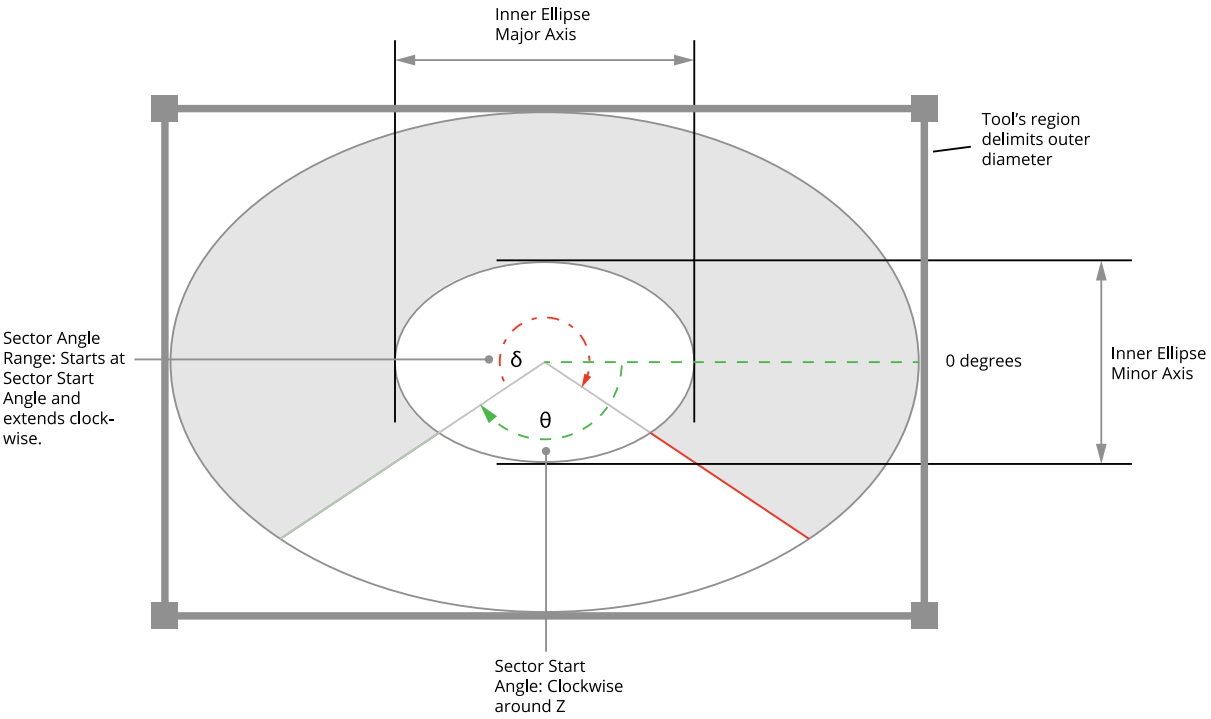
When you set a region's type to Circle or Ellipse, the tool displays several additional settings that work together to define the region. **Sector Start Angle** and **Sector Angle Range** work together to define the start and end of a partial circular/elliptical region (solid or annular). A region will 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.

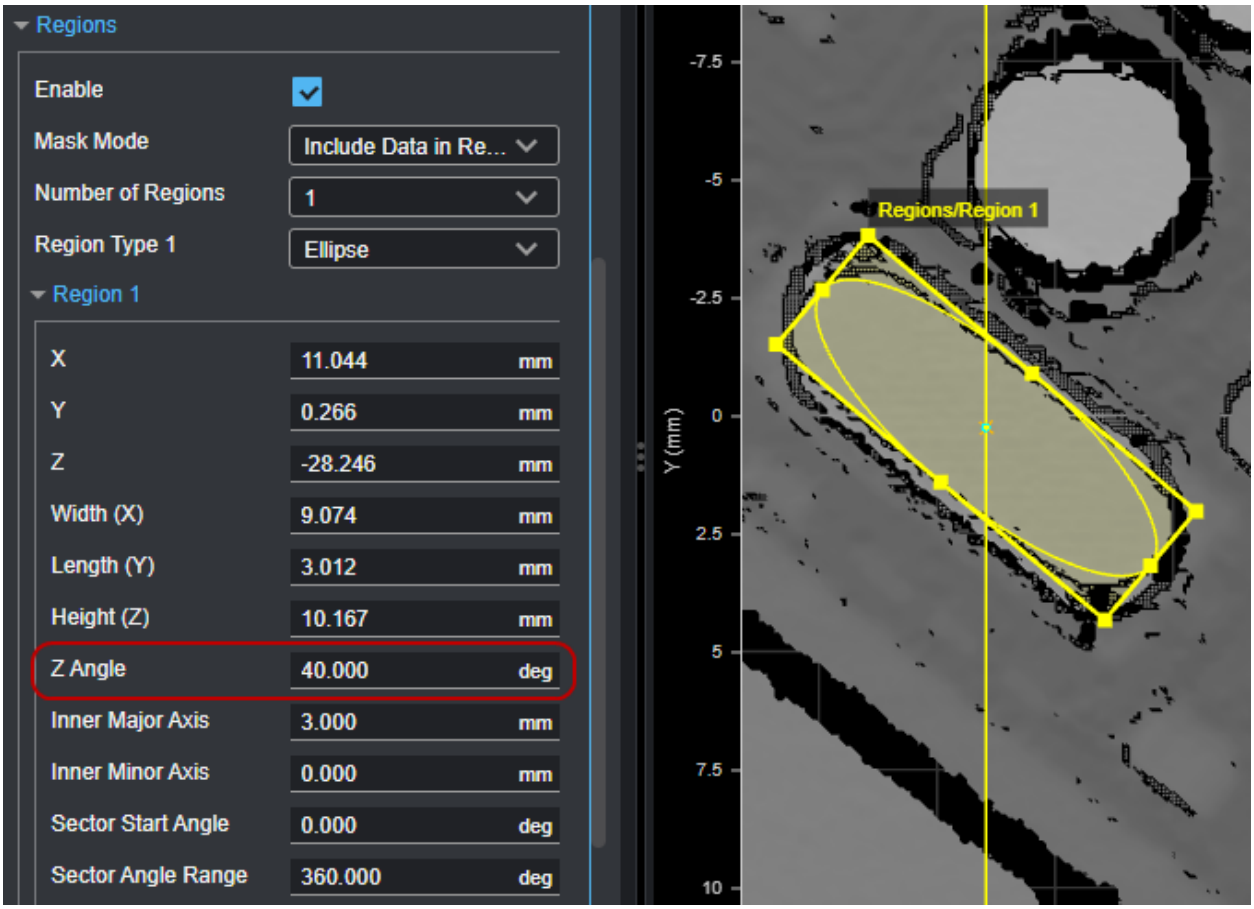
Note that the angles defining a partial circular/elliptical region are relative to the *region*, and not the sensor's coordinate system. So a region rotated 30 degrees using its **Z Angle** setting rotates the start angle and angle range by 30 degrees.

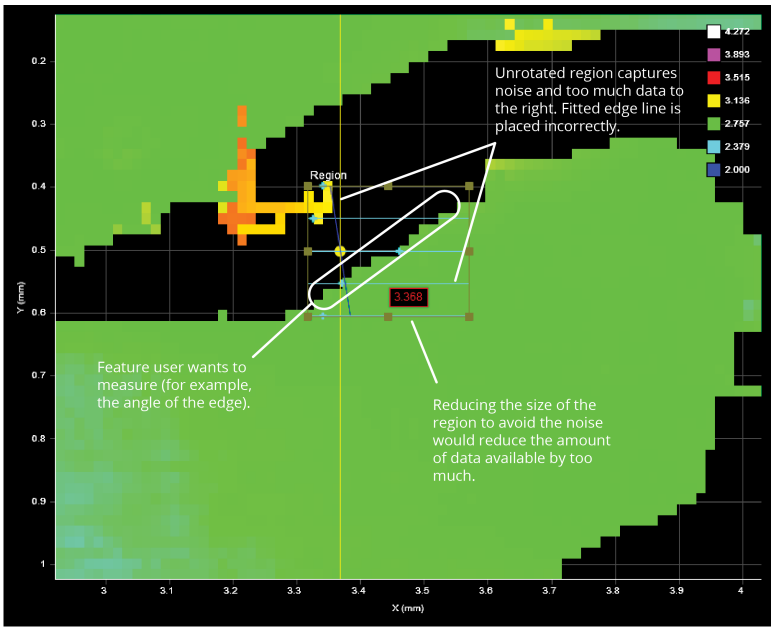
When you set a region type to Ellipse, instead of the inner circle diameter, you must set the major and minor axes of the inner ellipse.



Region Rotation

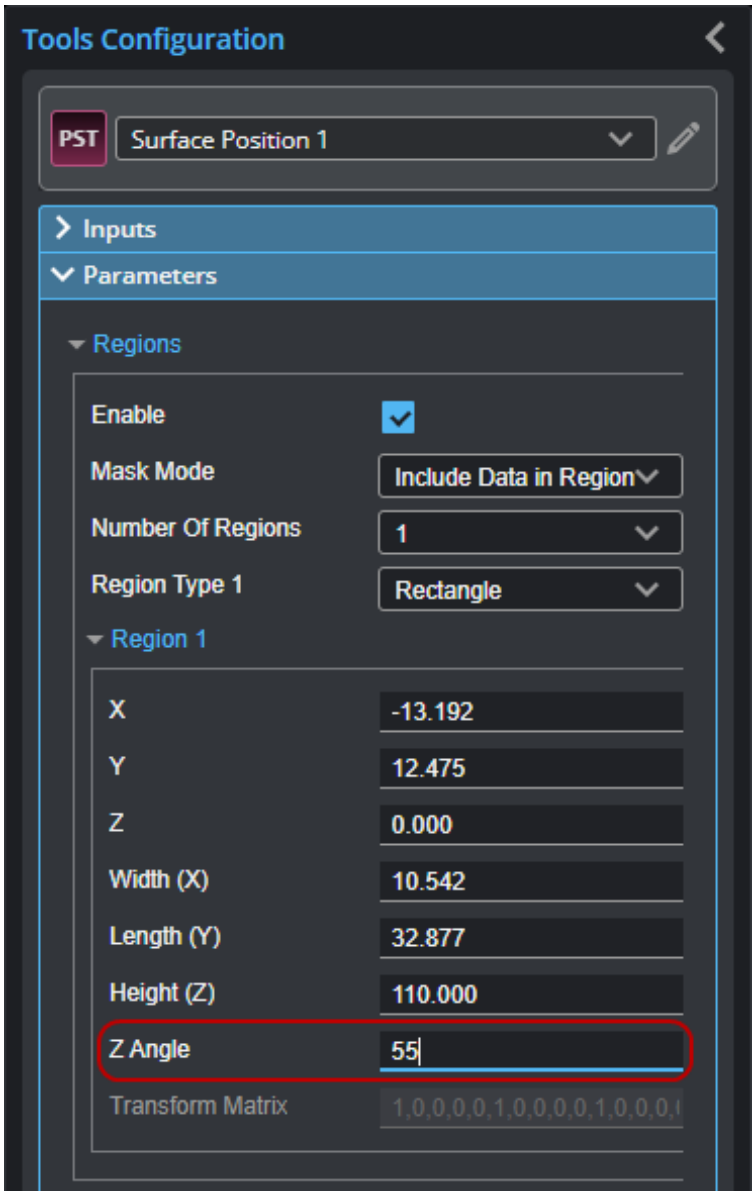
The measurement region of some tools can be rotated by setting the region's **Z Angle** to better accommodate features that are on an angle on a target. By rotating the measurement region, data not related to the feature can often be excluded, improving accuracy of measurements. You can modify the size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





To rotate measurement regions:

1. Determine the length and width of the region that will be required once it is rotated.
2. Expand the region section in the Tools Configuration panel and set a value in **Z Angle**.



The region rotates clockwise around the Z axis relative to the X axis.

Once the region has been rotated, you can modify its size and location in the data viewer using the mouse. You can also modify its dimensions and its location manually by changing the region's values in the Tools Configuration panel.

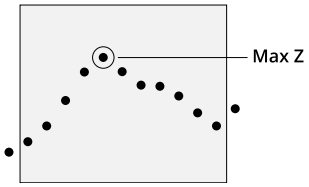
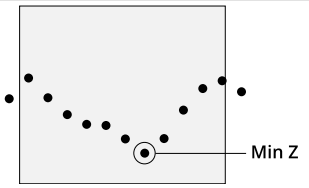
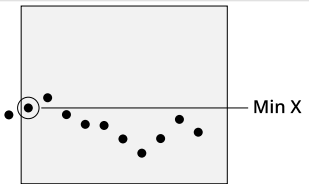
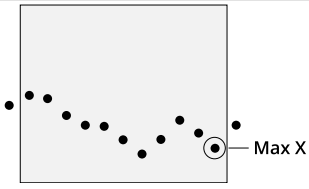
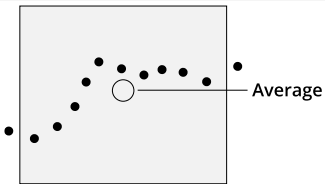
Feature Points

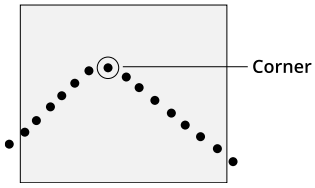
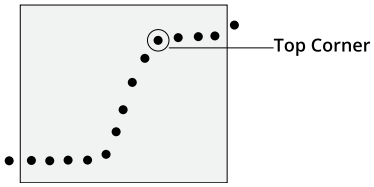
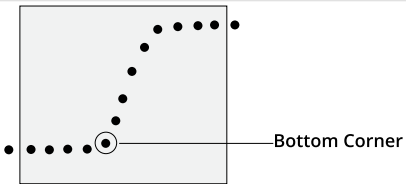
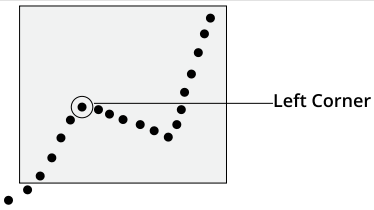
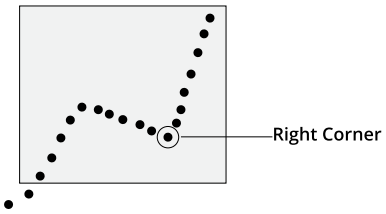
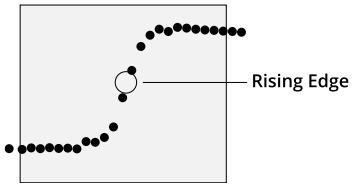
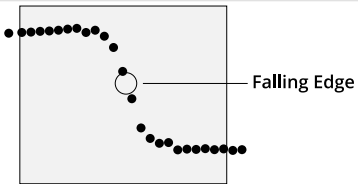
Dimensional and positional measurements detect *feature points* found within the defined region (whether it's a measurement region, feature region, reference region, and so on) and then compare measurement values taken at the selected point with minimum and maximum thresholds to produce a pass / fail 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.

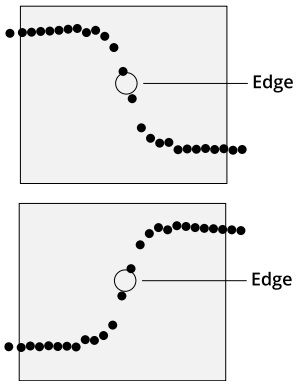
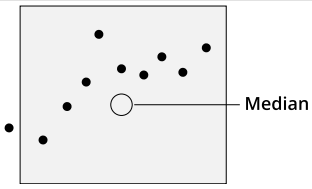
It is important to note that the feature points described here are distinct from the geometric features generated by some tools, and which can be taken as inputs by other tools. Feature points are simply the location in the scan data at which a measurement tool performs a measurement. So, for example, 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 175.)

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 Finds the point with the maximum Z value in the region of interest.	
Min Z Finds the point with the minimum Z value in the region of interest.	
Min X Finds the point with the minimum X value in the region of interest.	
Max X Finds the point with the maximum X value in the region of interest.	
Average Determines the average location of points in the region of interest.	

Point Type	Examples
Corner Finds a dominant corner in the region of interest, where corner is defined as a change in profile slope.	
Top Corner Finds the top-most corner in the region of interest, where corner is defined as a change in profile shape.	
Bottom Corner Finds the bottom-most corner in the region of interest, where corner is defined as a change in profile shape.	
Left Corner Finds the left-most corner in the region of interest, where corner is defined as a change in profile shape.	
Right Corner Finds the right-most corner in the region of interest, where corner is defined as a change in profile shape.	
Rising Edge Finds a rising edge in the region of interest (moving from left to right).	
Falling Edge Finds a falling edge in the region of interest (moving from left to right).	

Point Type	Examples
Any Edge Finds a rising or falling edge in the region of interest.	
Median 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 552.)

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

Points: A 2D or 3D point. Can be used for point-to-point or point-to-line measurements.

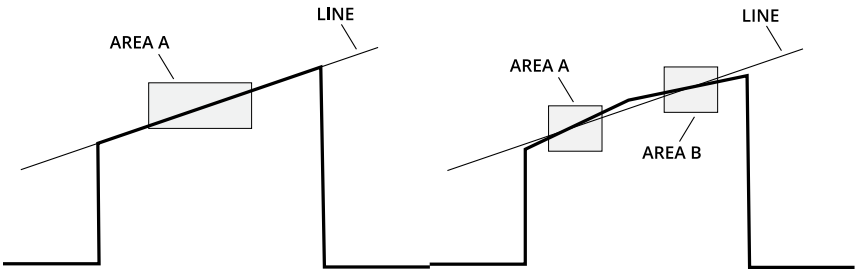
Lines: A straight line that is infinitely long. Useful for locating the orientation of an enclosure or part, or to intersect with another line to form a reference point that can be consumed by a Feature tool.

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

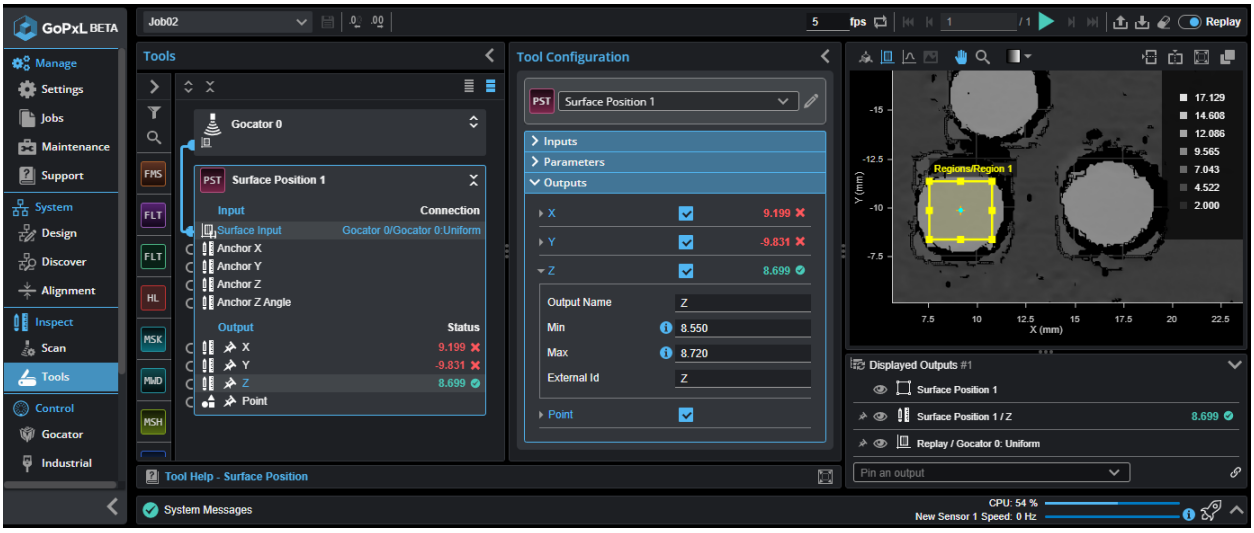
Some measurements involve estimating lines in order to measure angles or intersection points. A fit line can be calculated using data from either one or two fit areas.



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 to generate *pass* / *fail* decisions. The decision state is *pass* if a measurement value is within the minimum / maximum range; the range is inclusive. Output values that pass are green in the lists of outputs. Output values that fail are red in the lists of outputs.



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.

Along with measurement values, decisions can be sent to external programs and devices. In particular, decisions are often used with digital outputs to trigger an external event in response to a measurement. For more information on sending values and decisions as output, see *Configuring Control* on page 622.

Measurement Anchoring

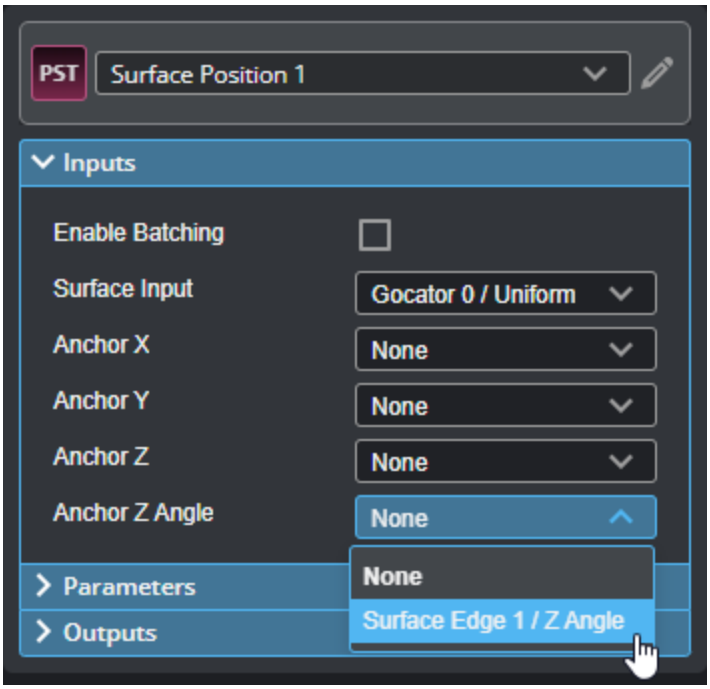
When parts that a sensor is scanning move on a transport mechanism such as a conveyor, their position typically changes from part to part in one or both of the following ways:

- along the X, Y, and Z axes (that is, horizontally and vertically)
- around the Z axis (orientation angle)

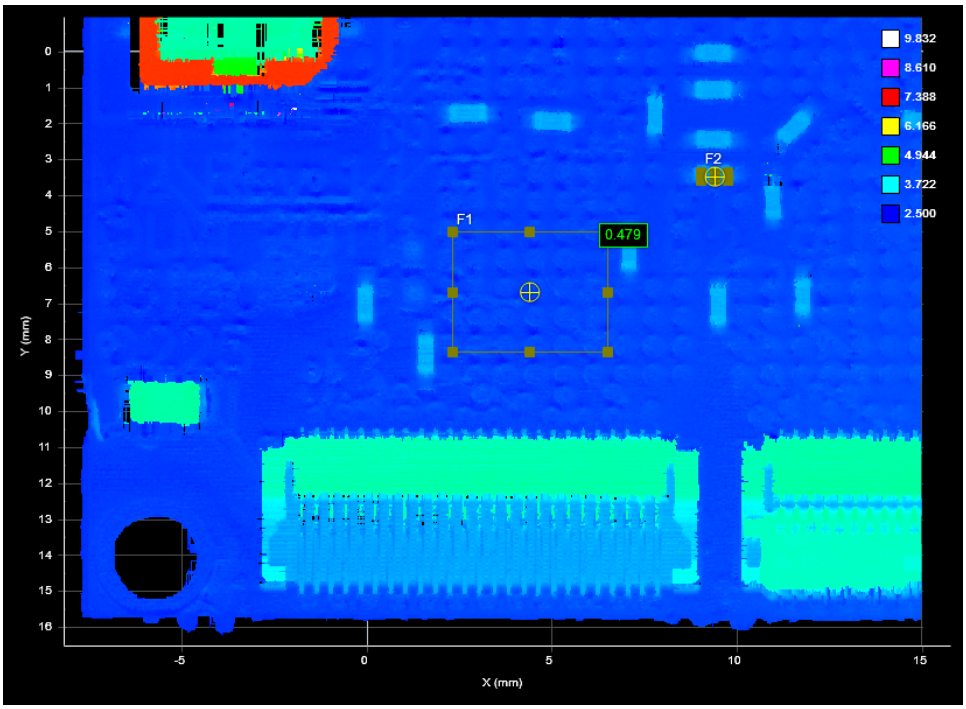
When the position and angle variation between parts is minor—for example, when scanning electronic parts in trays—you can anchor one tool to one or more measurements from another tool to compensate for these minor shifts. As a result, GoPxL can correctly place the anchored tool's measurement regions 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 455.

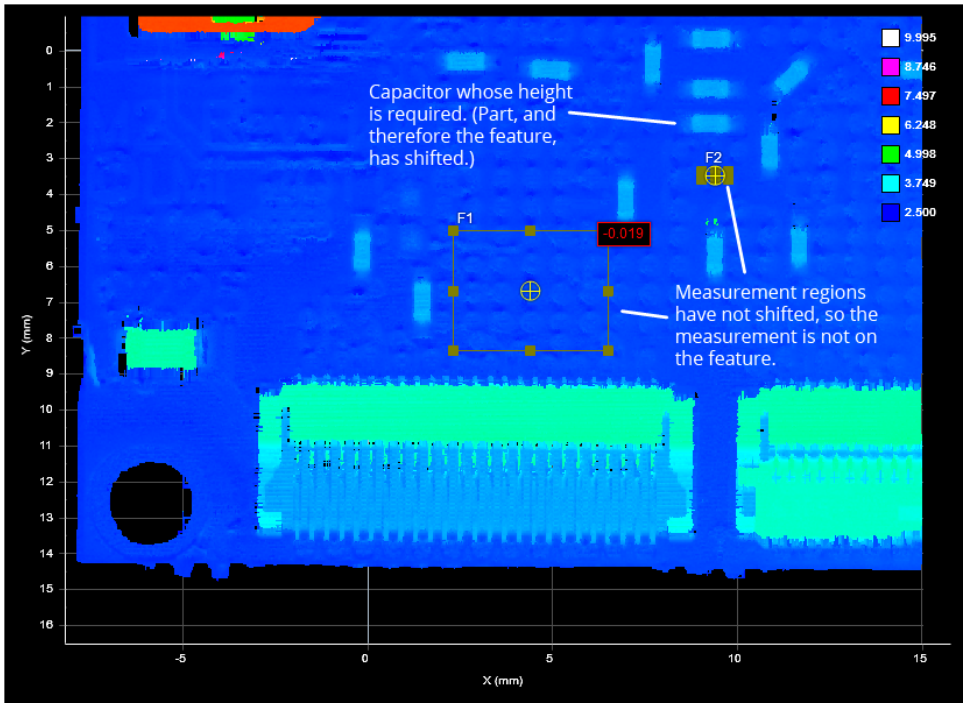
You set a tool's anchors in its **Inputs** section, by setting **Anchor X**, **Anchor Y**, **Anchor Z**, or **Anchor Z Angle** to the appropriate measurement from another tool:



For example, the following shows a surface scan of a PCB. A Surface Dimension height measurement returns the height of a surface-mount capacitor in the measurement region relative to a nearby reference region.

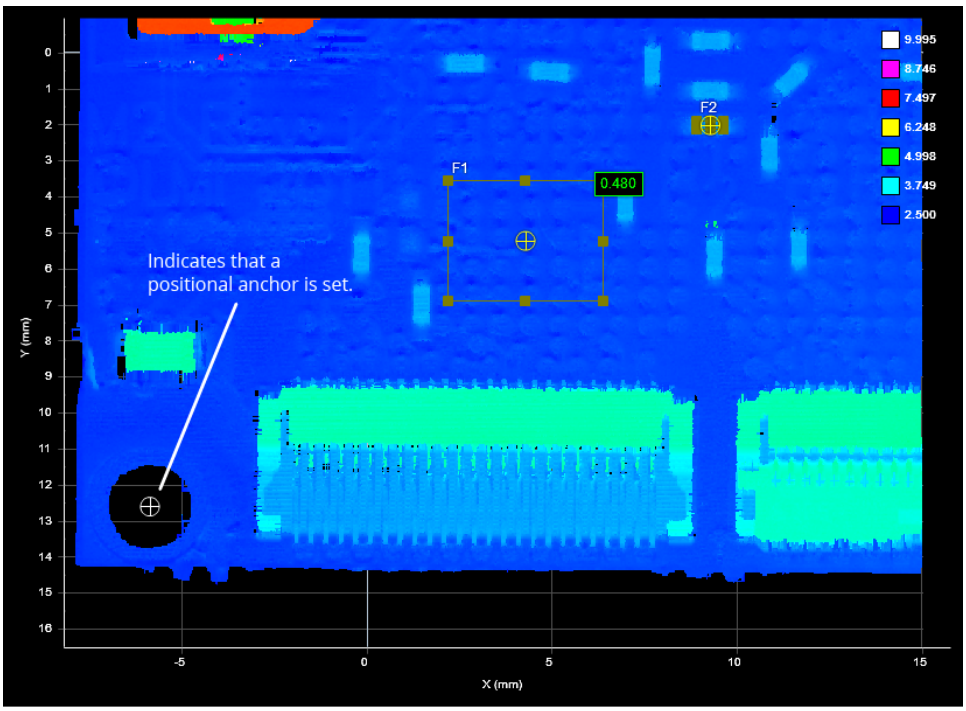


In the following scan, the part has shifted, but the measurement regions remain where they were originally configured, in relation to the sensor or system coordinate system, so the measurement returned is incorrect:

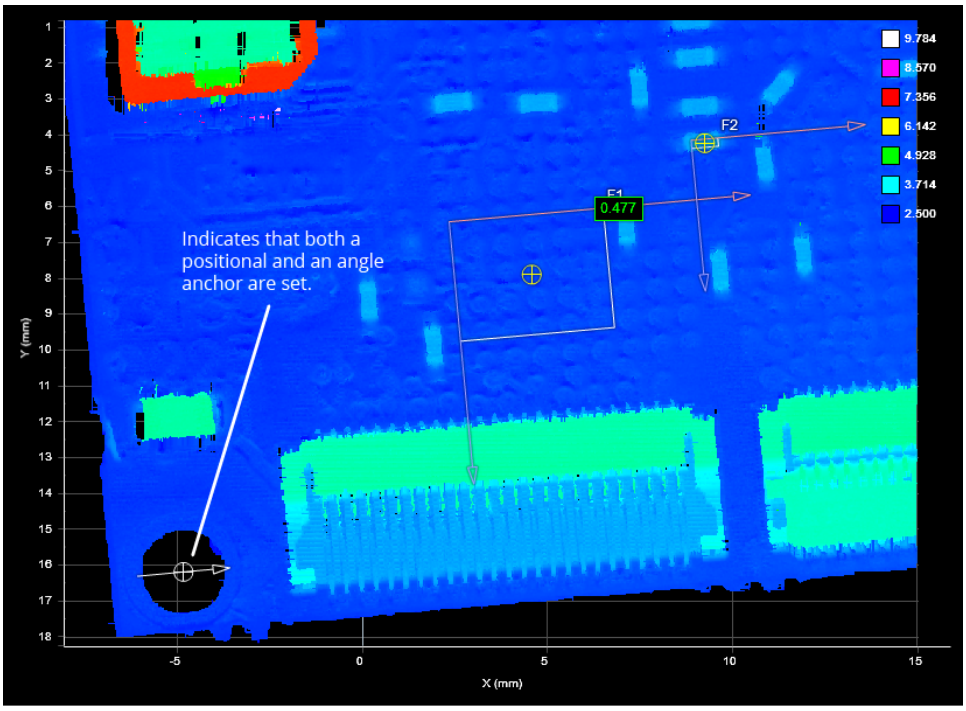


When you set a tool's anchor source, an offset is calculated between the anchored tool and the anchor source. This offset is used for each frame of scanned data: the anchored tool's measurement region is placed in relation to the anchor source, at the calculated offset.

In the following image, after the Surface Dimension tool is anchored to the X and Y measurements from a Surface Hole tool (placed over the hole to the lower left), GoPxL compensates for the shift—mostly along the Y axis in this case—and returns a correct measurement, despite the shift.



You can combine the positional anchors (X, Y, or Z measurements) with an angle anchor (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 (placed on the lower edge in this case) compensates for the rotation, and the anchored tool returns a correct measurement.



If Z Angle anchoring is used with both X and Y anchoring, the X and Y anchors should come from the same tool.

If Z 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 482.

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).

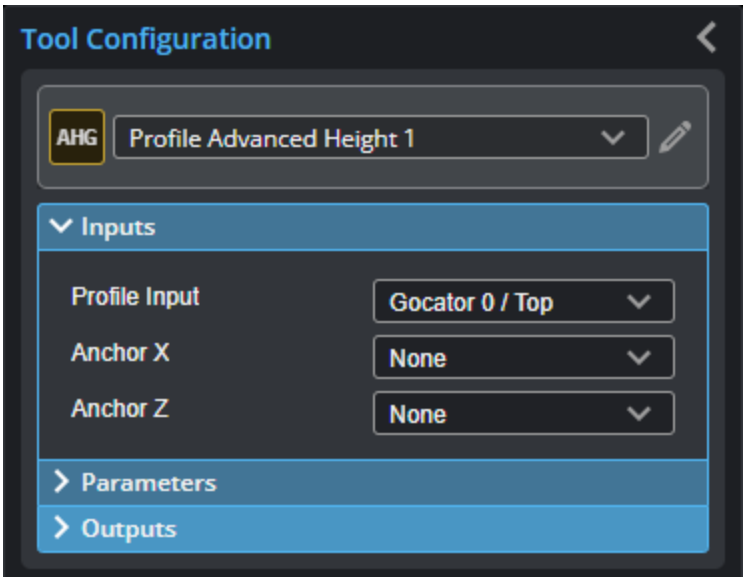
> All instances of the Advanced Height tool share the same template file set in **File**. For this reason, you must be careful when editing or removing template files shared by another instance of the tool.

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 153.

Inputs

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



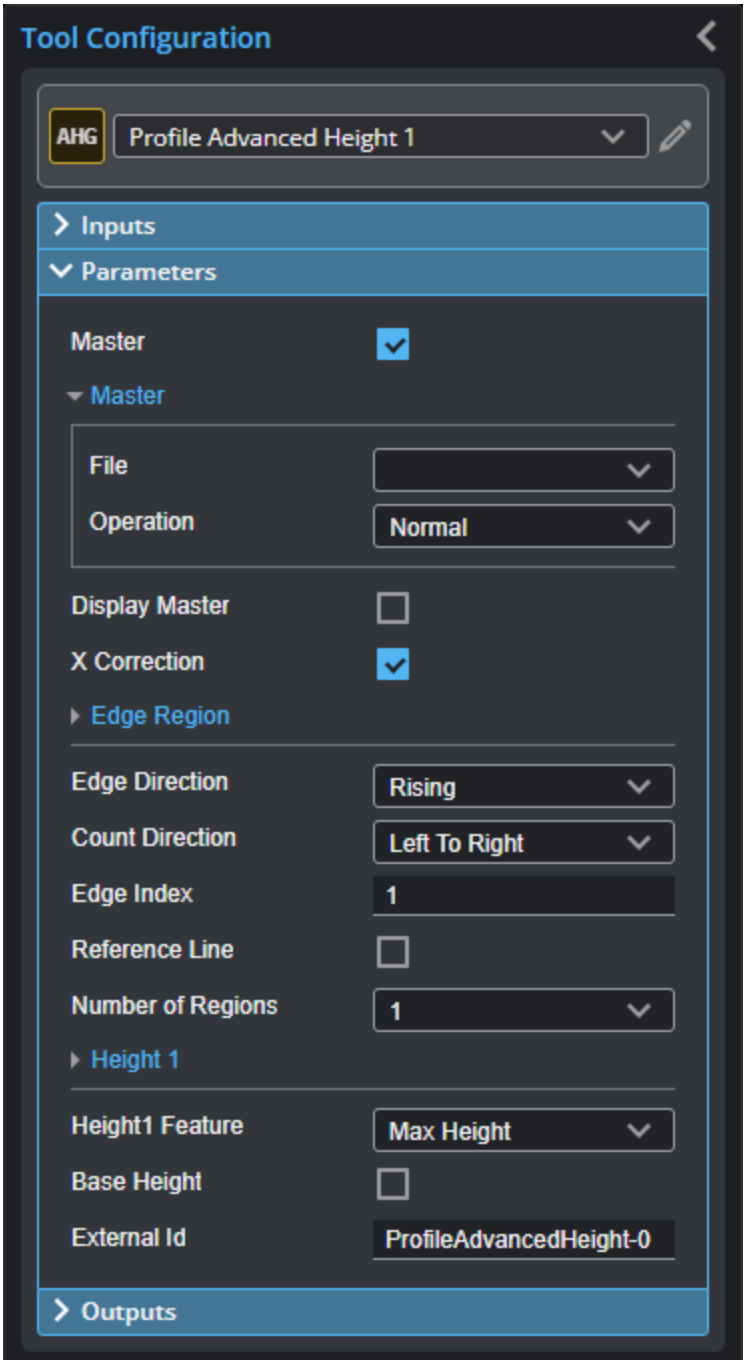
> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

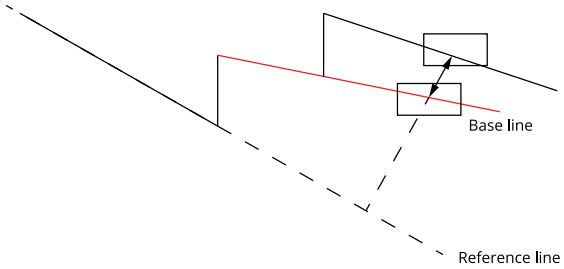
Name	Description
Profile Input	The data the tool applies measurements to or processes.
Anchor X or Anchor Z	The X or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

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.  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 666.

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: • **Normal**: Selected by the tool after you perform another file operation. • **Create**: Saves the *current profile* as the master. Use this when the master does not exist. • **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. • **Delete**: Deletes the master file selected in **File**. • **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

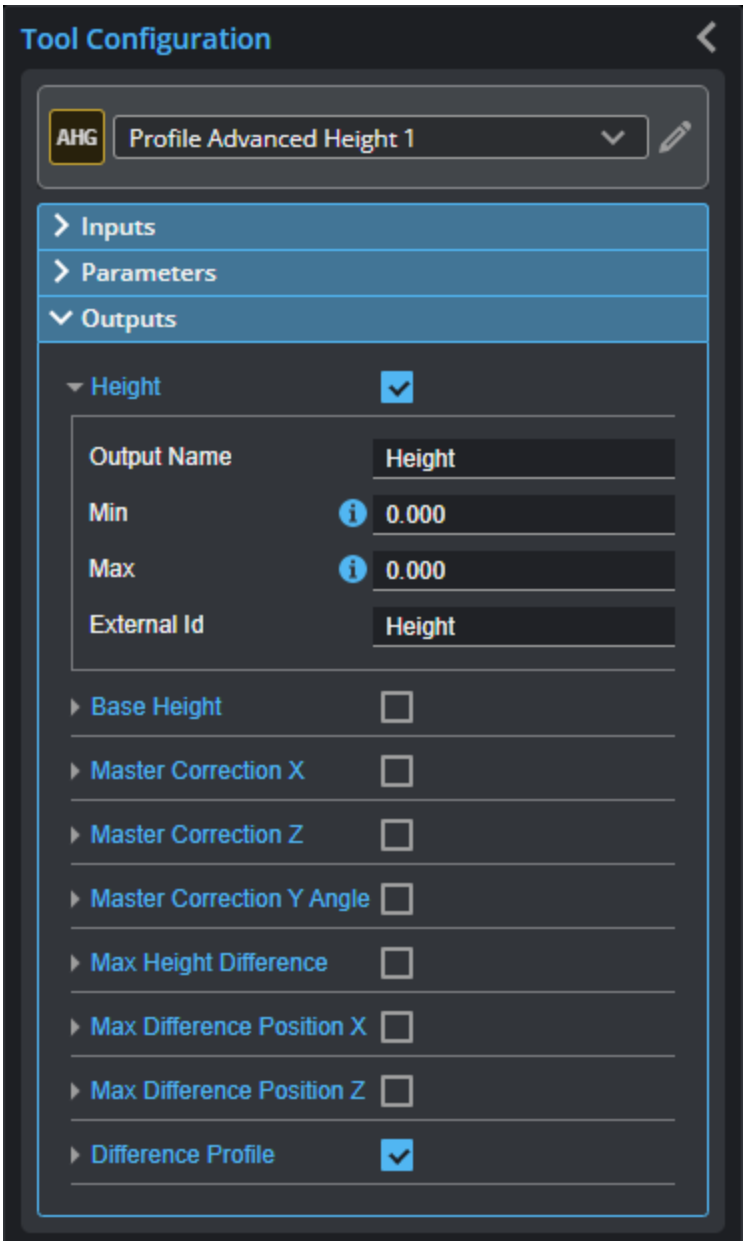
When you enable **Reference Line**, the tool displays several additional settings. The reference line is used to set the measurement direction (perpendicular to the reference line).

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

All 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} The height measured in height region {n}. Height is measured perpendicular Will be Invalid if the appropriate number of height regions has not been set in **Height Region**.

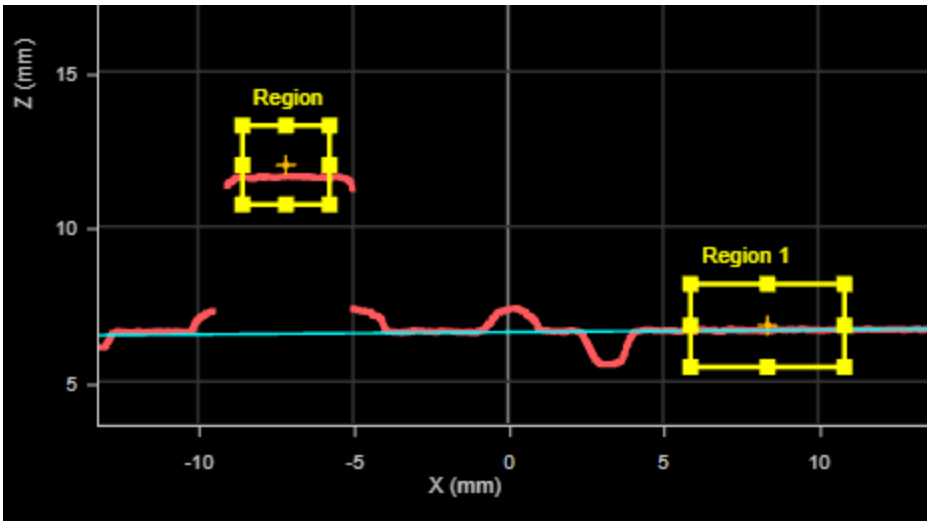
Measurement
Master Correction X
Master Correction Z
Master Correction Y Angle
The amount of correction applied to the profile with respect to the master.
Max Height Difference
The maximum height difference.
Max Difference Position X
Max Difference Position Z
The X and Z positions of the maximum height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

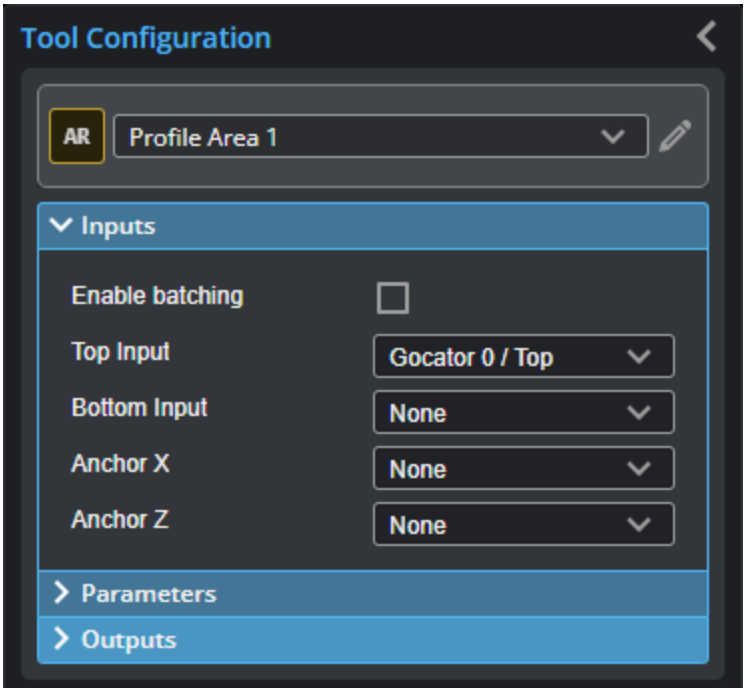


Profile Area tool with baseline set to the best-fitted line in Region 1

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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

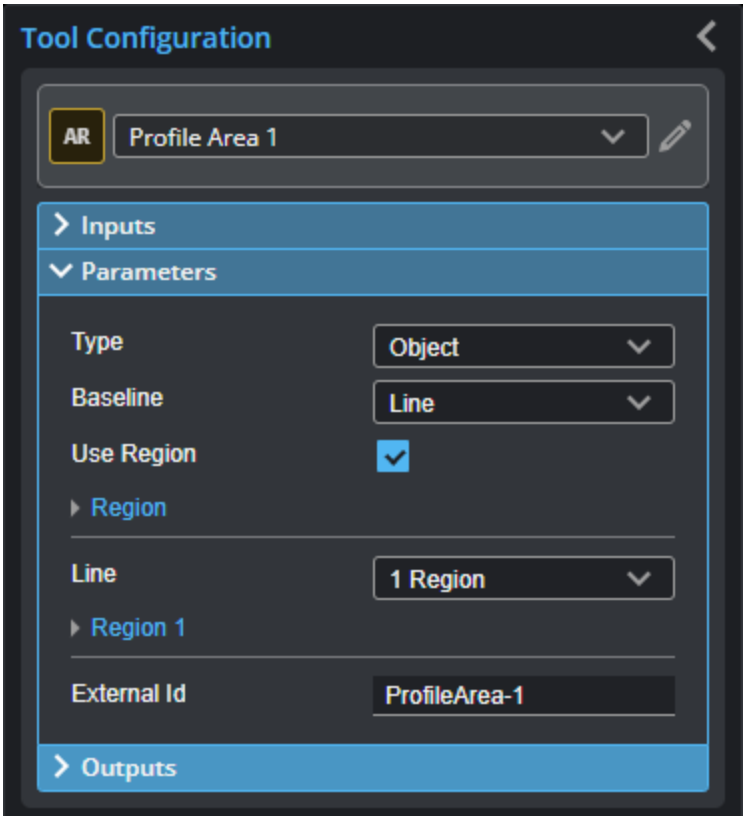
providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.



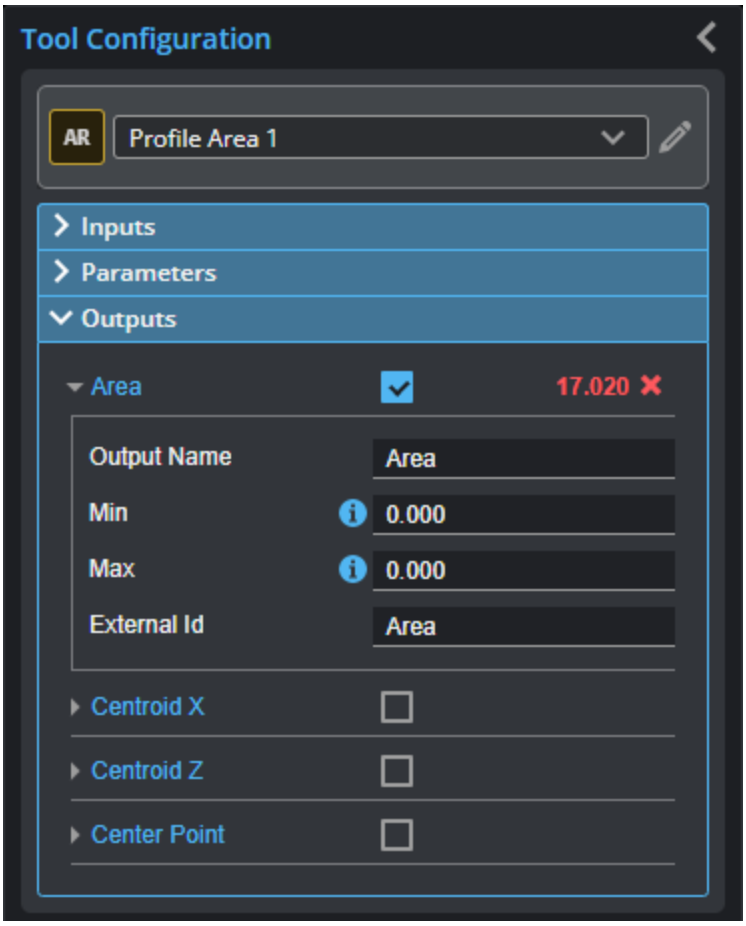
Parameters

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

Parameter	Description
	baseline are ignored. **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. When this parameter is set to **Line**, you must define a line in the Line parameter. See *Fit Lines* on page 175 for more information on fit lines. 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 163.
Line	When **Baseline** (see above) is set to **Line**, set this to one of the following: **1 Region** or **2 Regions**: Lets you set one or two regions. The tool uses the data in those regions to fit a line. **All Data**: The tool uses all of the data in the scan data. For more information on regions, see *Regions* on page 163). For more information on fit lines, see *Fit Lines* on page 175.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

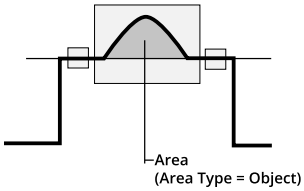
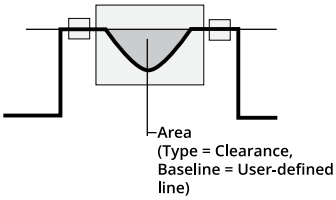
All tools provide measurements, geometric features, or data as outputs.

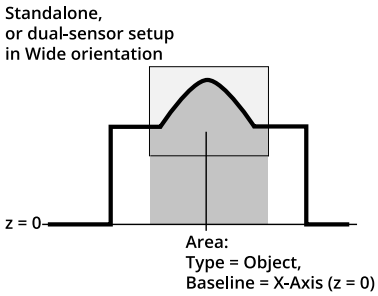
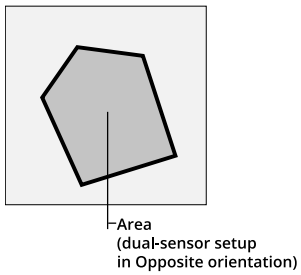
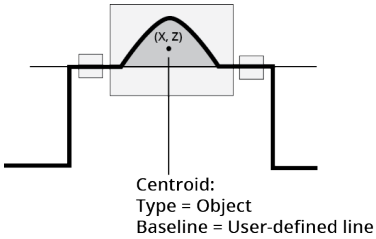


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Measures the cross-sectional area within a region that is above or below a fitted baseline.	 

Measurement	Illustration
	
	
Centroid X Determines the X position of the centroid of the area. **Centroid Z** Determines the Z position of the centroid of the area.	

Features

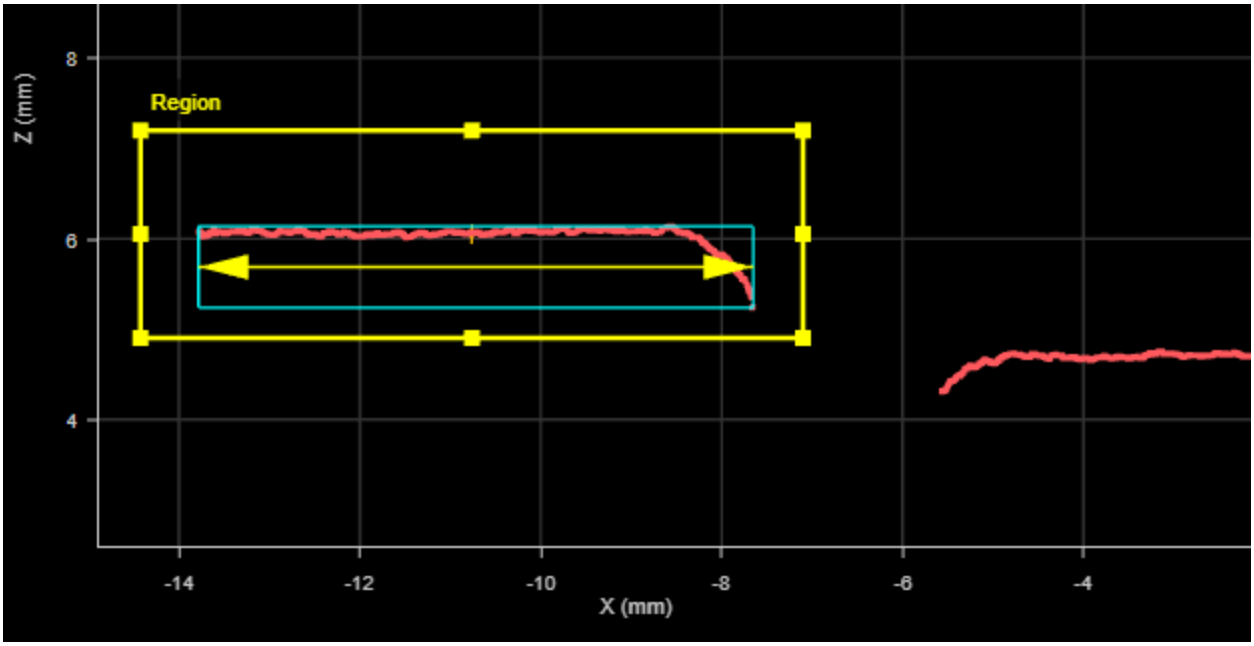
Type	Description
Center Point	The center point of the area.

For more information on geometric features, see *Geometric Features* on page 175.

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.).

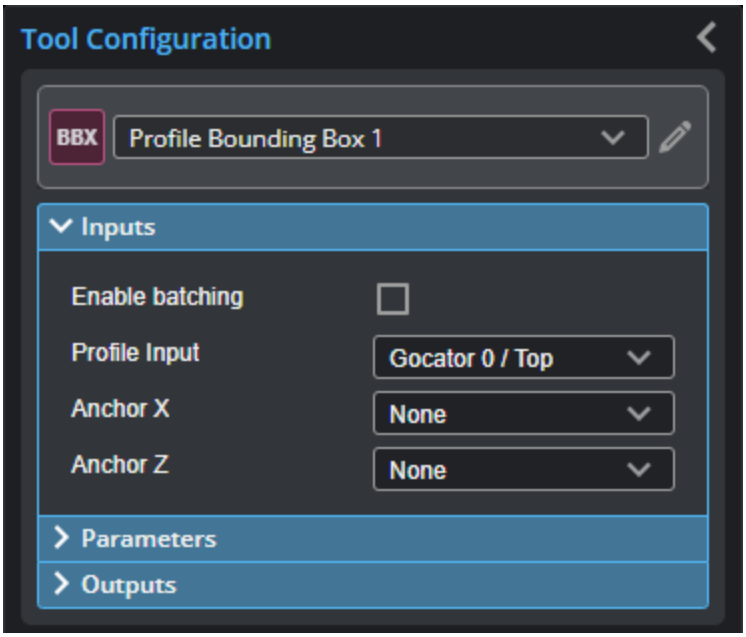
The bounding box provides the absolute position from which the Position centroids tools are referenced.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



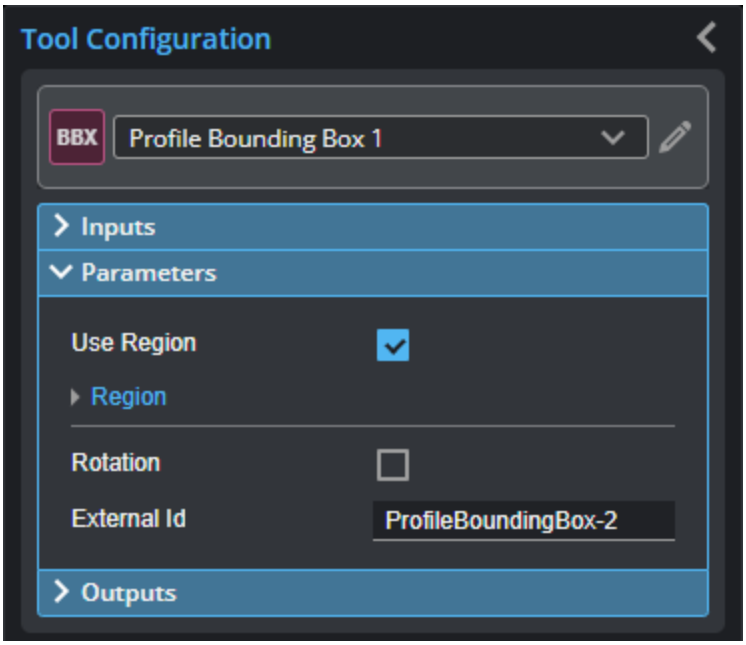
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
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.

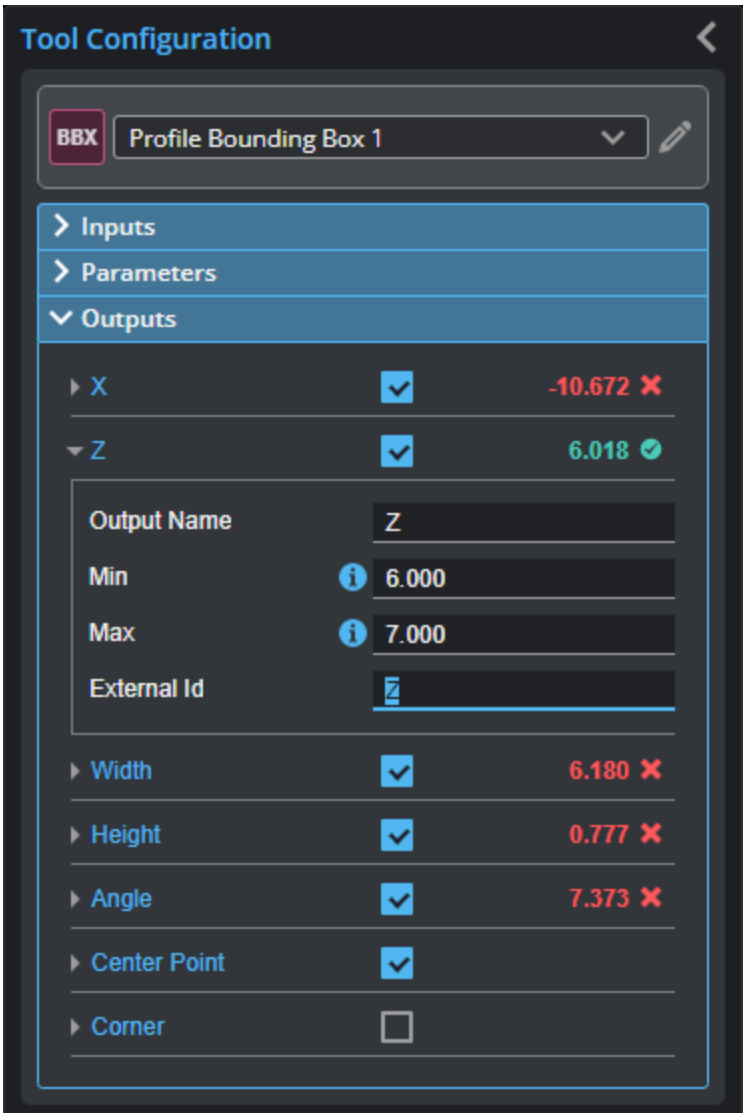


Parameters

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 163.
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. 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 666.

Outputs

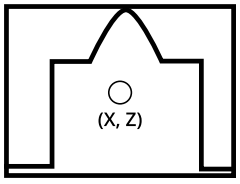
All tools provide measurements, geometric features, or data as outputs.

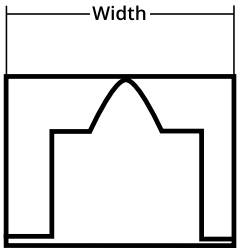
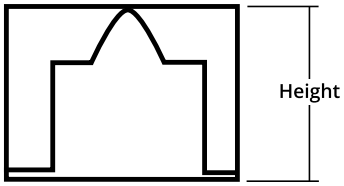


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the X position of the center of the bounding box that contains the profile. The value returned is relative to the profile.	
Z 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 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 Determines the height (thickness) of the bounding box that contains the profile.	
Angle Determines the angle of the longer side of the bounding box around the Y axis, relative to the X axis. This measurement is only available if the **Rotation** parameter is enabled.	

Features

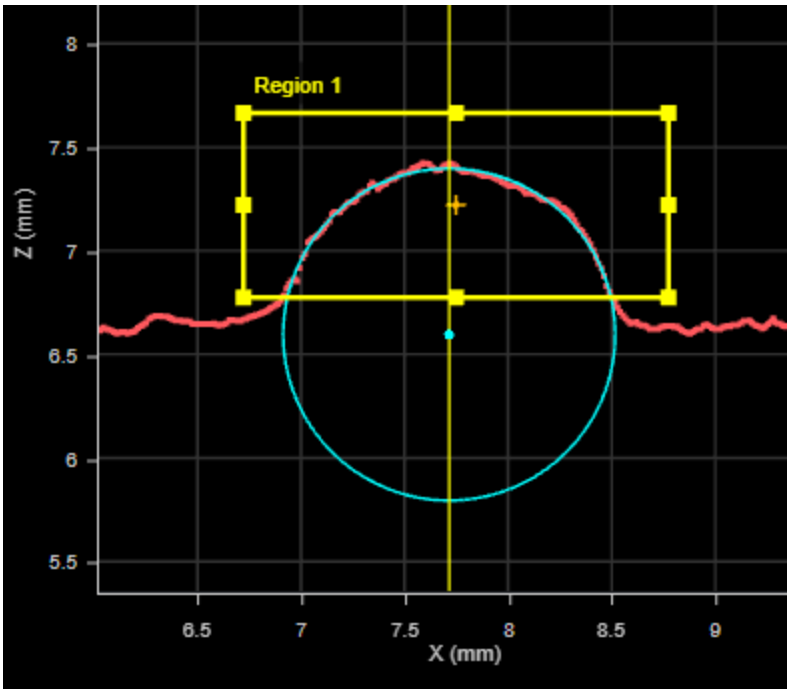
Type	Description
Center Point	The center point of the bounding box.
Corner Point	The lower left corner of the bounding box.

For more information on geometric features, see *Geometric Features* on page 175.

Profile Circle

The Circle tool provides measurements that find the best-fitted circle to a profile and measure various characteristics of the circle.

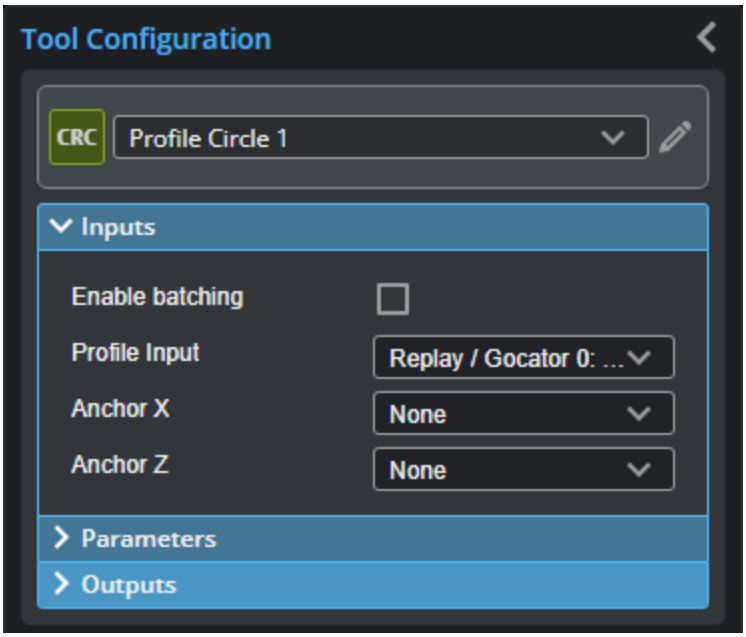
> The tool may be unable to fit a circle to the profile when attempting the fit on a small number of relatively collinear data points.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



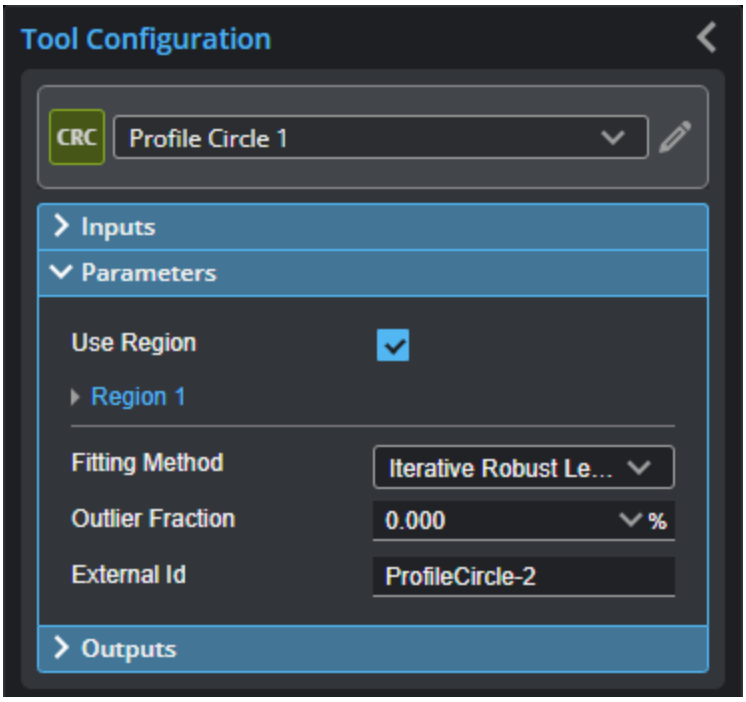
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
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.

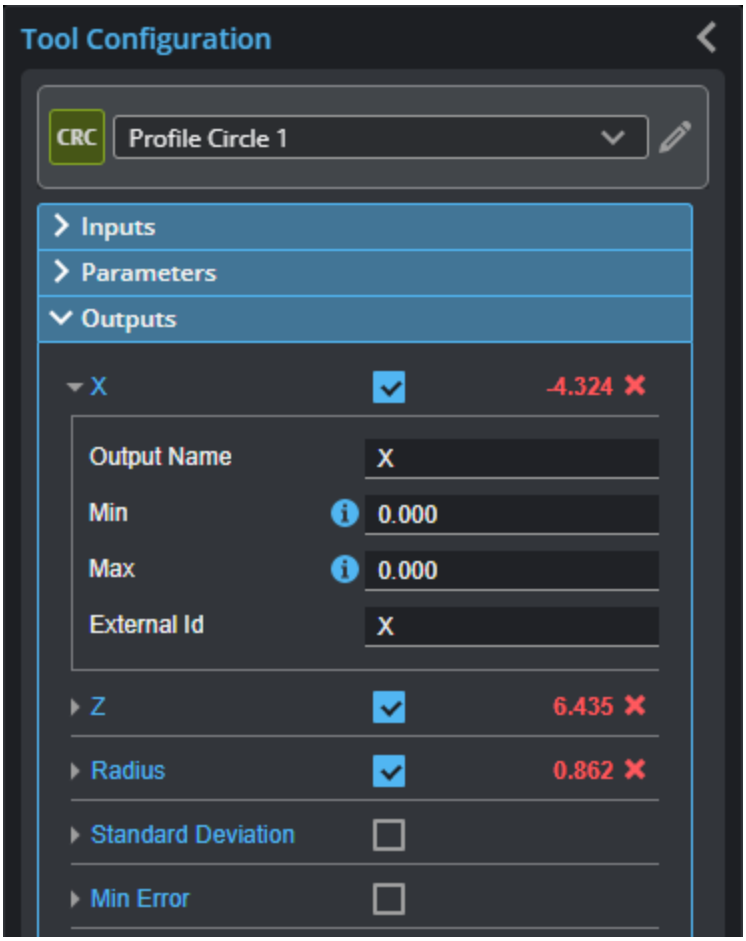


Parameters

Parameter	Description
Use Region	When enabled, displays Region parameters (see below). When disabled, the tool uses all data.
Region {n}	The region to which the tool's measurements will apply. For more information, see *Regions* on page 163.
Fitting Method	The tool supports two fitting methods: • Iterative Robust Least Squares: Set the **Outlier Fraction** parameter when you choose this method. • RANSAC: Set the **Iteration Count** and **Tolerance** parameters when you choose this method.
Outlier Fraction *(Used with Iterative Robust Least Squares fitting method)*	The percentage of the profile points that are considered noise. A range from 0% to 80%. 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.
Iteration Count *(used with RANSAC fitting method)*	Determines the number of iterations in the RANSAC algorithm.
Tolerance *(used with RANSAC fitting method)*	Used to determine the fitting accuracy in the RANSAC algorithm. This parameter can usually be set to the following: $\sqrt{XResolution^2 \cdot ZResolution^2}$
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

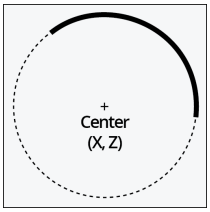
All tools provide measurements, geometric features, or data as outputs.

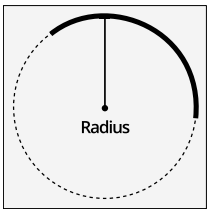


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Finds the circle center position in the X axis.	
Z Finds the circle center position in the Z axis.	

Measurement	Illustration
Radius Measures the radius of the circle.	
Standard Deviation Returns the standard deviation of the data points with respect to the fitted circle.	
Min Error **Max Error** The minimum and maximum error among the data points with respect to the fitted circle.	
Min Error X **Min Error Z** The X and Z position of the minimum error.	
Max Error X **Max Error Z** The X and Z position of the maximum error.	

Features

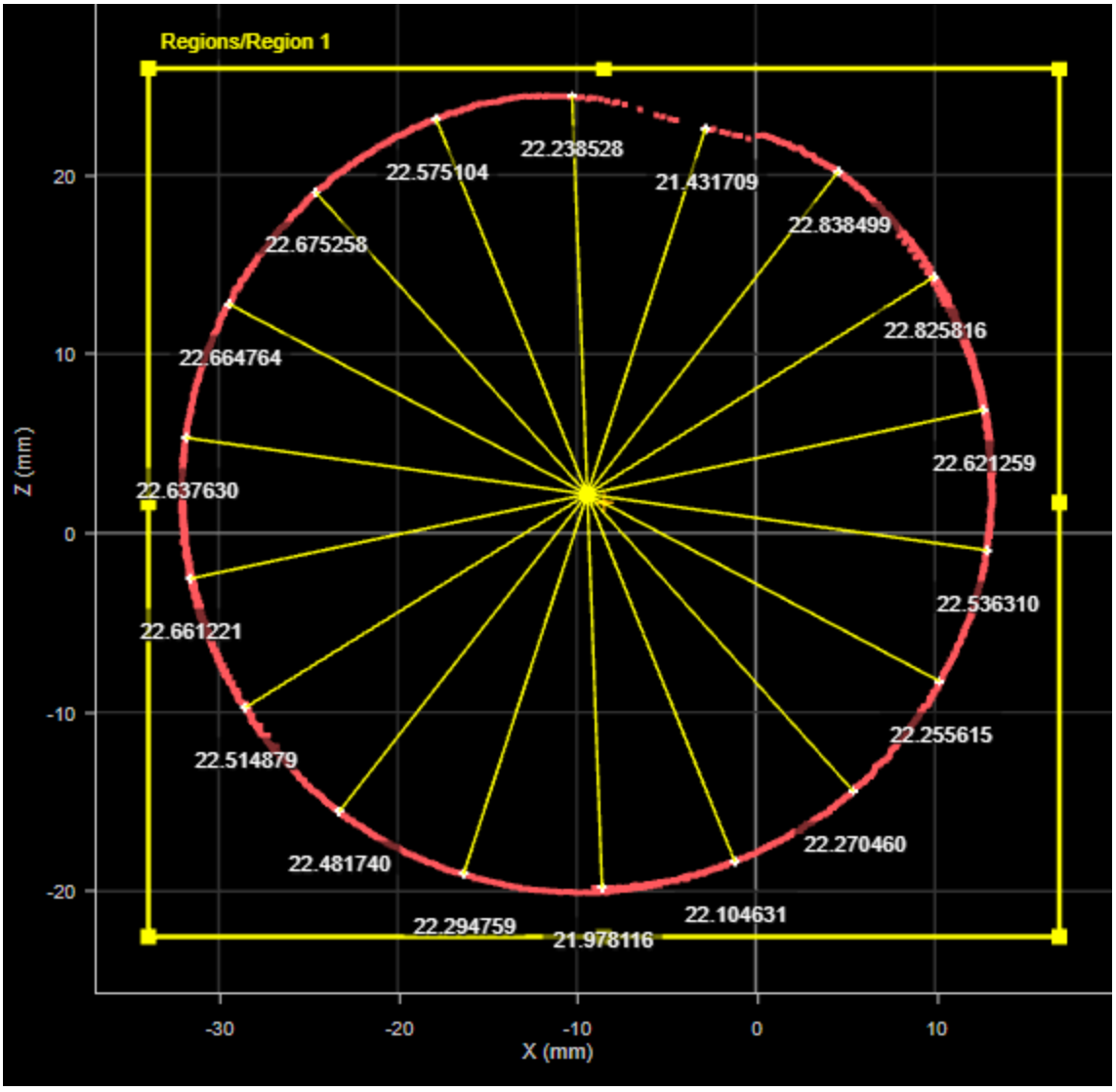
Type	Description
Point	The center point of the fitted circle.
Circle	The fitted circle.

For more information on geometric features, see *Geometric Features* on page 175.

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.

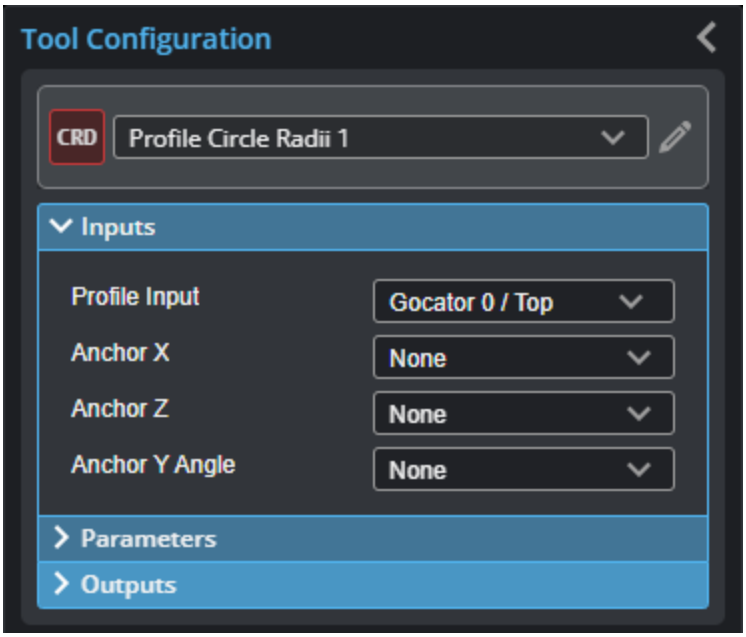
For example, in the following scan of an exhaust pipe by a four-sensor system, the tool is showing a shorter radius measurement at roughly 70 degrees that indicates a dent in the pipe.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



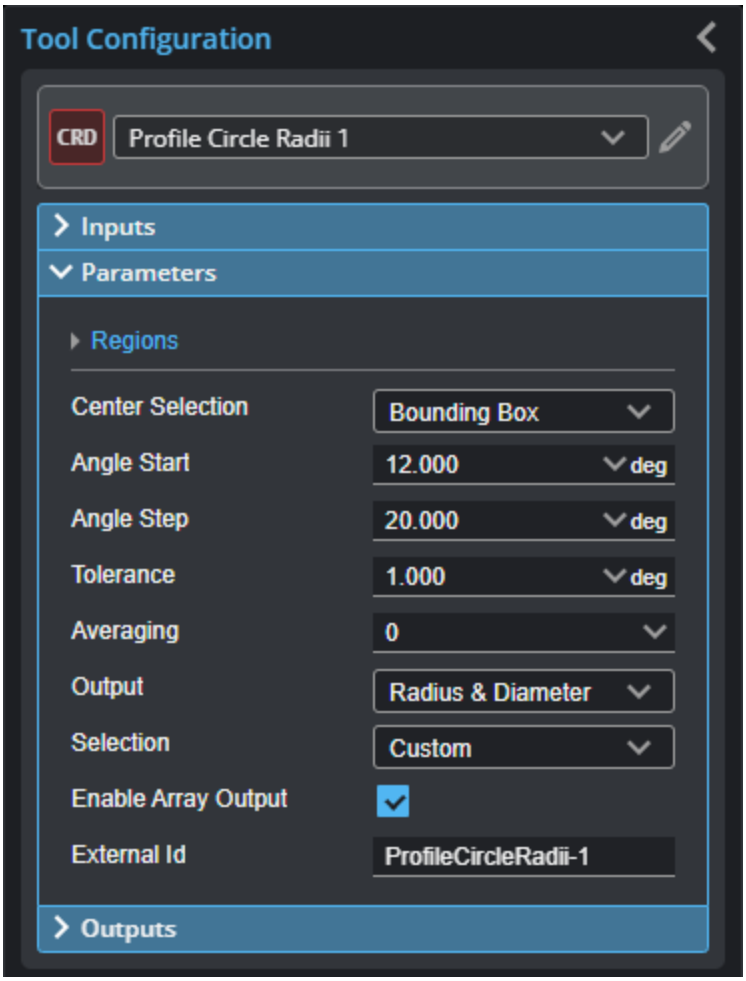
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

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**.

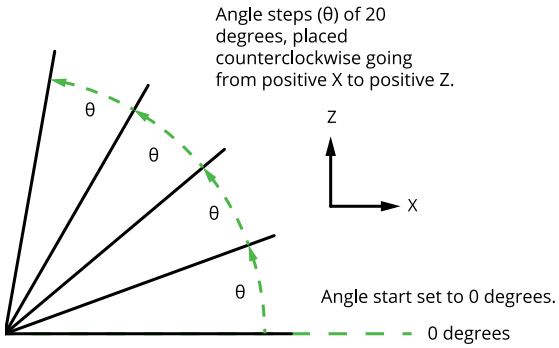
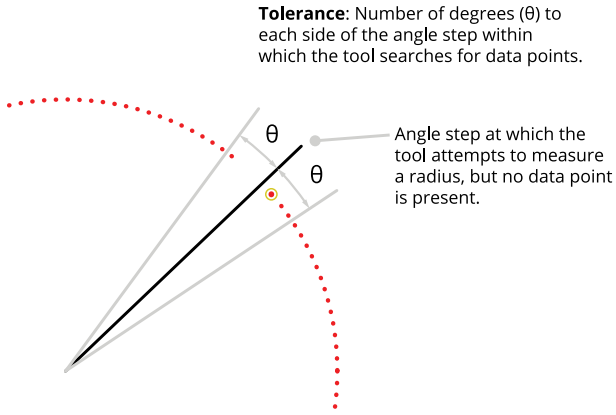
Parameters

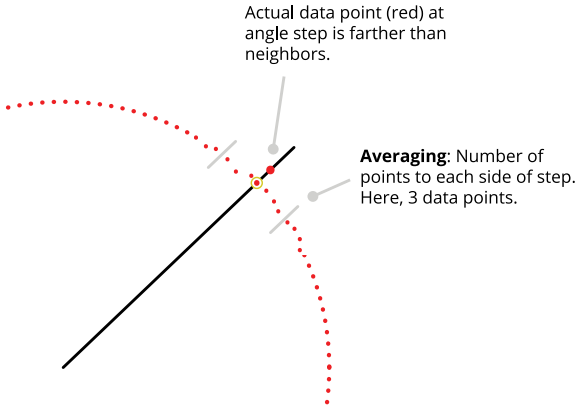
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

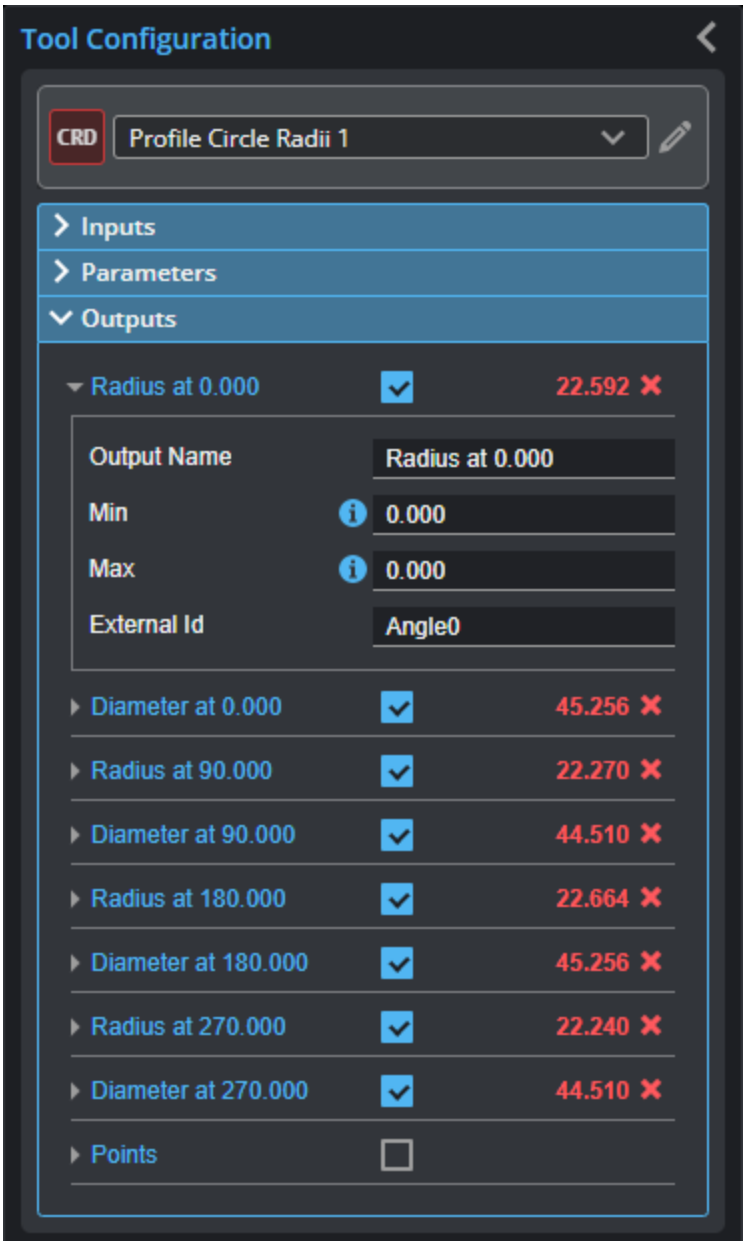
Parameter	Description
Regions	When expanded, displays the region- and mask-related settings.
Enable	Enables regions and displays the region- and mask-related settings (see below).
Mask Mode Number of Regions Region Type {n} Region {n}	When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Center Selection	The source for the point geometric feature the tool uses as a center point. One of the following: **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. **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. The following shows how these settings work together:  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.  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
	 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 666.

Outputs

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

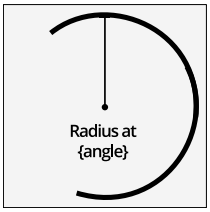
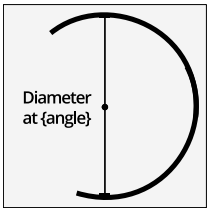


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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} Returns the radius at {angle}.	
Diameter at {angle} Returns the diameter at {angle}.	

Data

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

Profile Closed Area

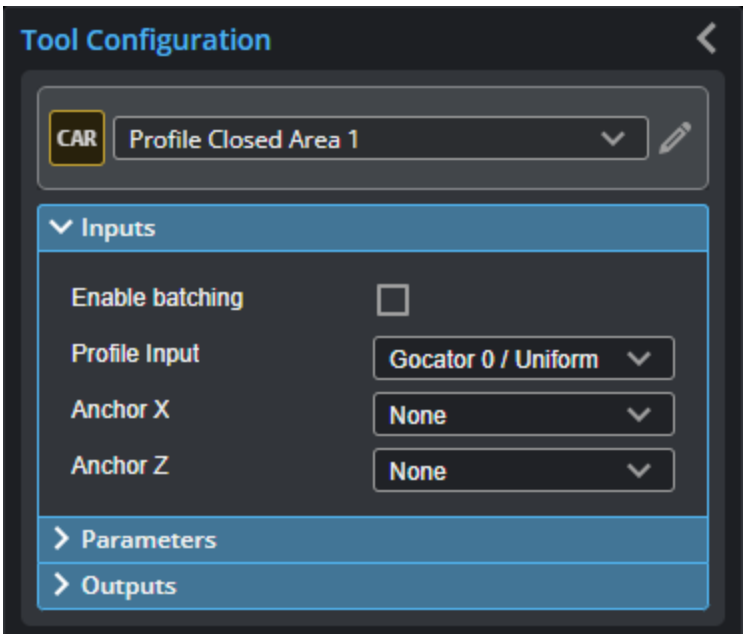
The Closed Area tool determines the cross-sectional area within a region using point cloud data (that is, with **Enable uniform spacing** disabled in the **Acquire** > **Scan** page > **Scan Mode** panel) from a dual- or multi-sensor system.

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.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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 176.

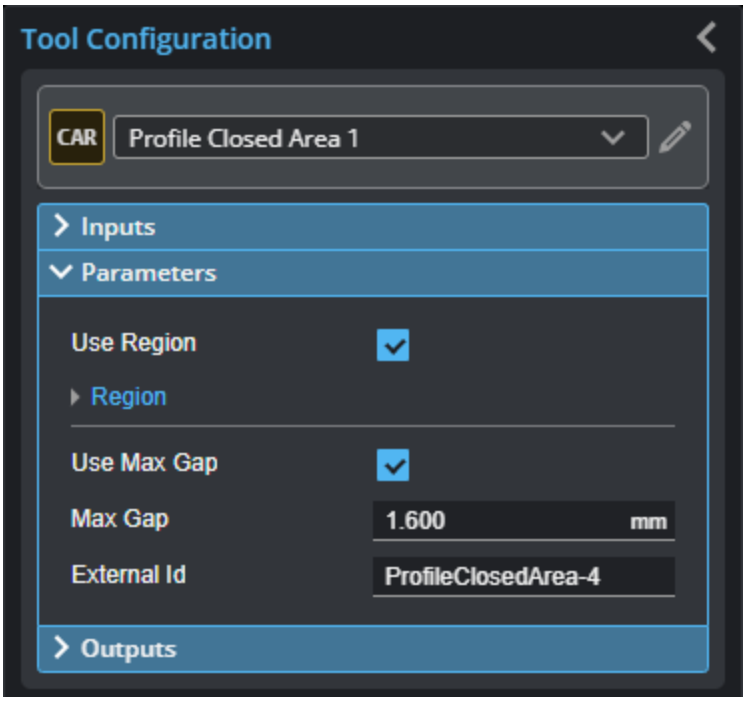
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching,*

Name	Description
	and Aggregation on page 155.
Profile Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
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.

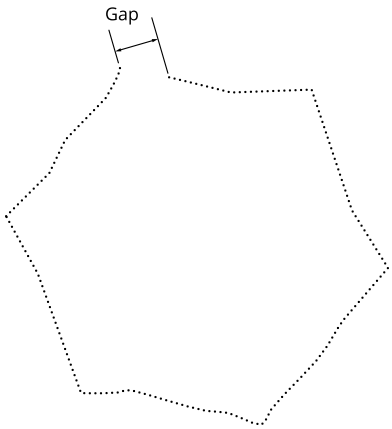
Parameters

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



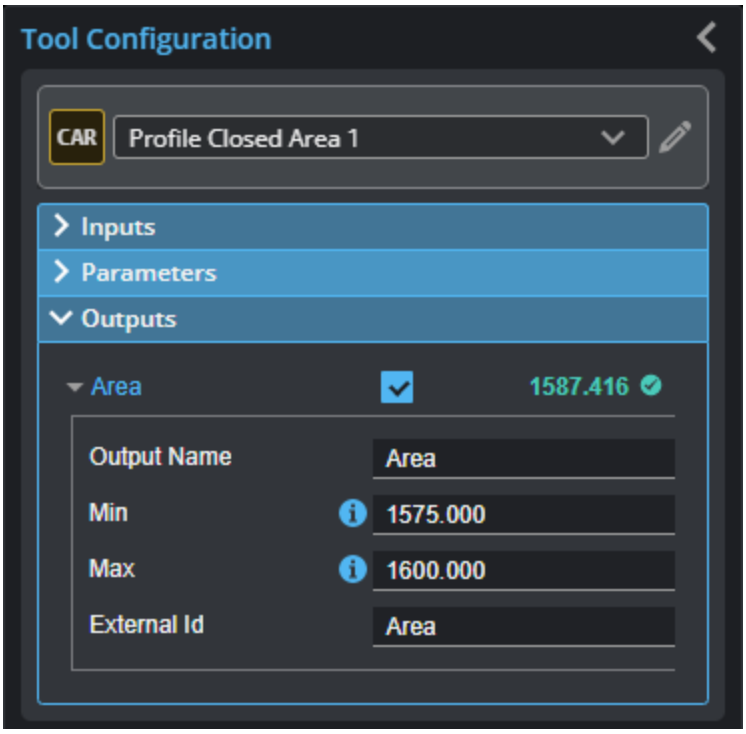
Parameters

Parameter	Description
Use Region	Indicates whether the tool uses a user-defined region. 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 163.
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.

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 666.

Outputs

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

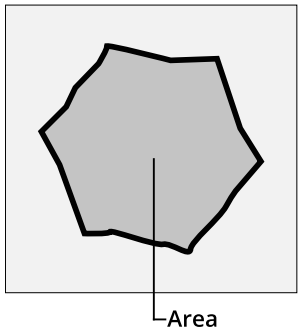


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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.

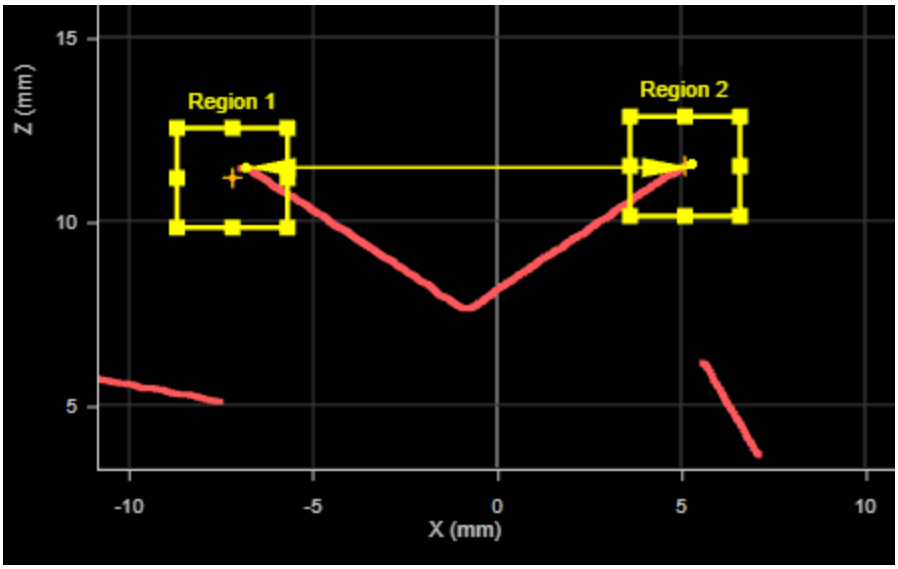
All outputs provide an external ID (available by expanding the output in the Outputs panel) for optional use in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Measurements

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

Profile Dimension

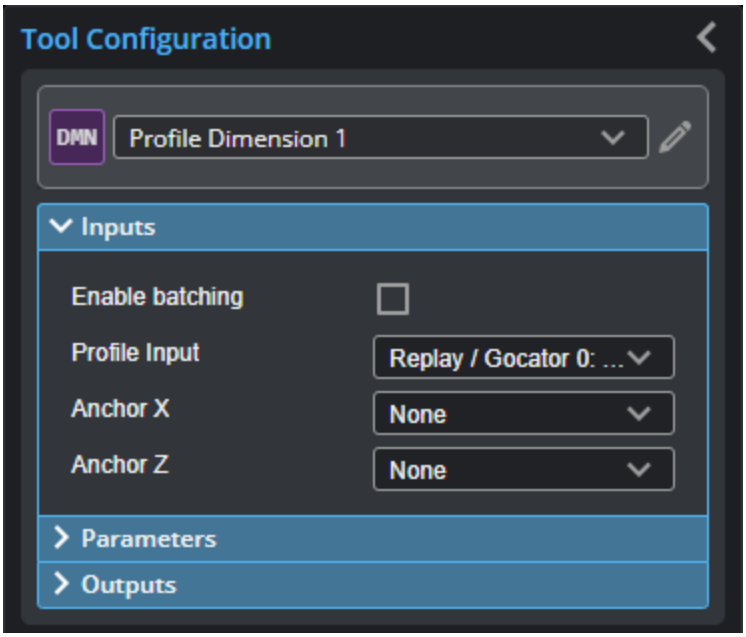
The Dimension tool provides Width, Height, Distance, Center X, and Center Z measurements.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



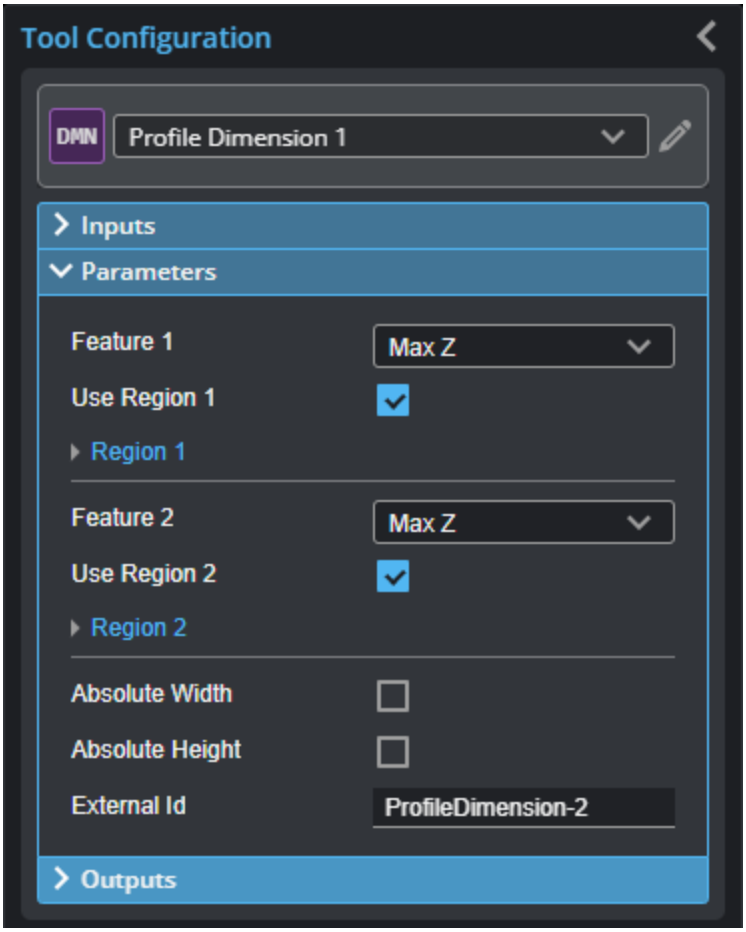
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.

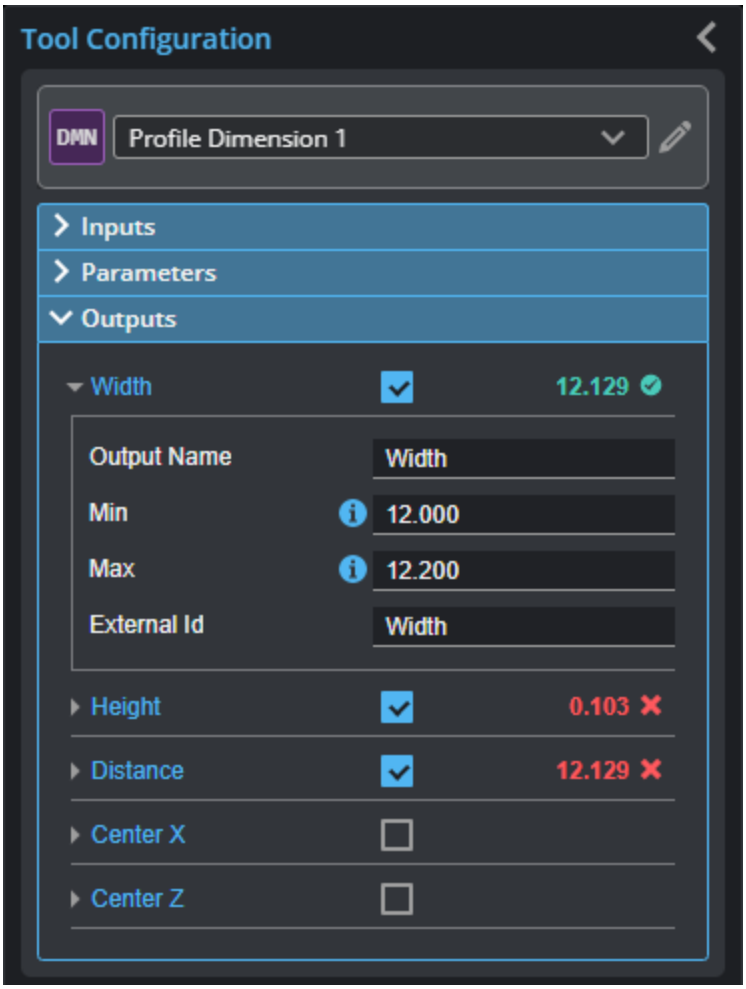


Parameters

Parameter	Description
Feature 1 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: • Max Z • Min Z • Max X • Min X • Corner • Average • Rising Edge • Falling Edge • Any Edge • Top Corner • Bottom Corner • Left Corner • Right Corner • Median For more information on feature points, see *Feature Points* on page 172.
Use Region 1 Use Region 2	When enabled, displays Region parameters (see below). When disabled, the tool uses all data.
Region 1 Region 2	The region to which the tool's measurements will apply. For more information, see *Regions* on page 163.
Absolute Width Absolute Height *(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 666.

Outputs

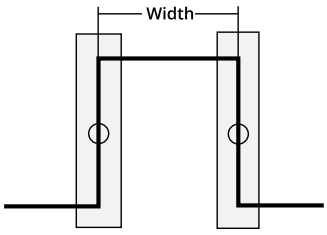
All tools provide measurements, geometric features, or data as outputs.

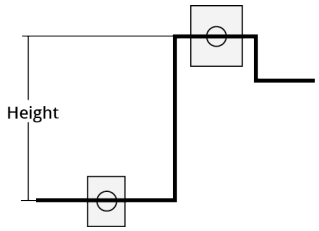
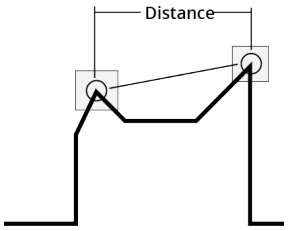
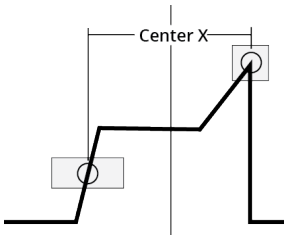
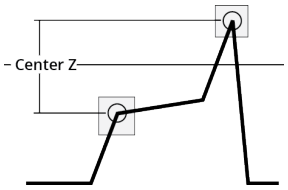


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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.

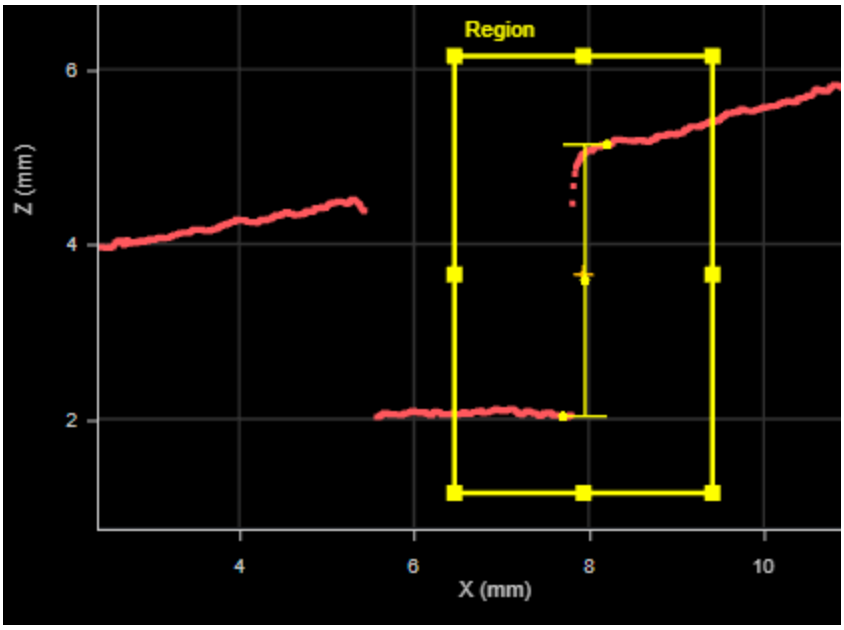
Measurements

Measurement	Illustration
Width Determines the difference along the X axis between two feature points. The difference can be calculated as an absolute or signed result. The difference is calculated by: $Width = Feature\ 2_{X\ position} - Feature\ 1_{X\ position}$	

Measurement	Illustration
Height Determines the difference along the Z axis between two feature points. The difference can be expressed as an absolute or signed result. The difference is calculated by: *Height = Feature $2_{Z\ position}$ – Feature $1_{Z\ position}$*	
Distance Determines the direct, Euclidean distance between two feature points.	
Center X Finds the average location of two features and measures the X axis position of the average location	
Center Z 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

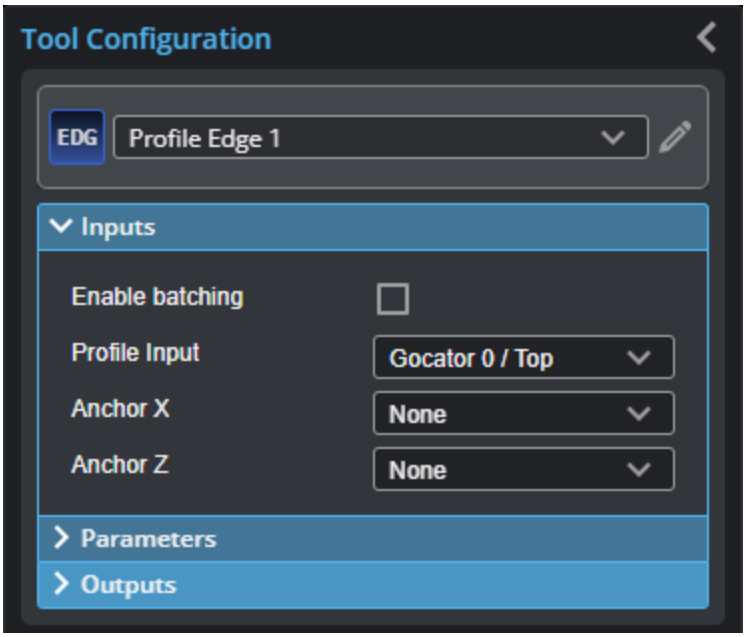
After the tool locates an edge, it returns the position (X and Z) of the edge. For steps, it also returns the step height.

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 552.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



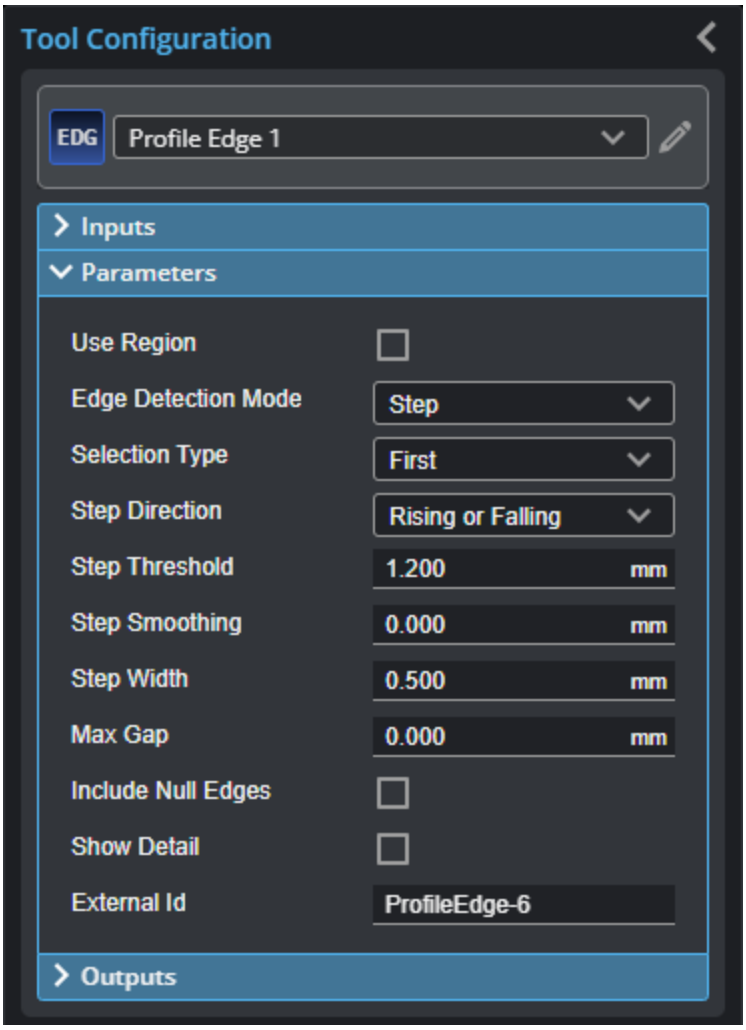
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.

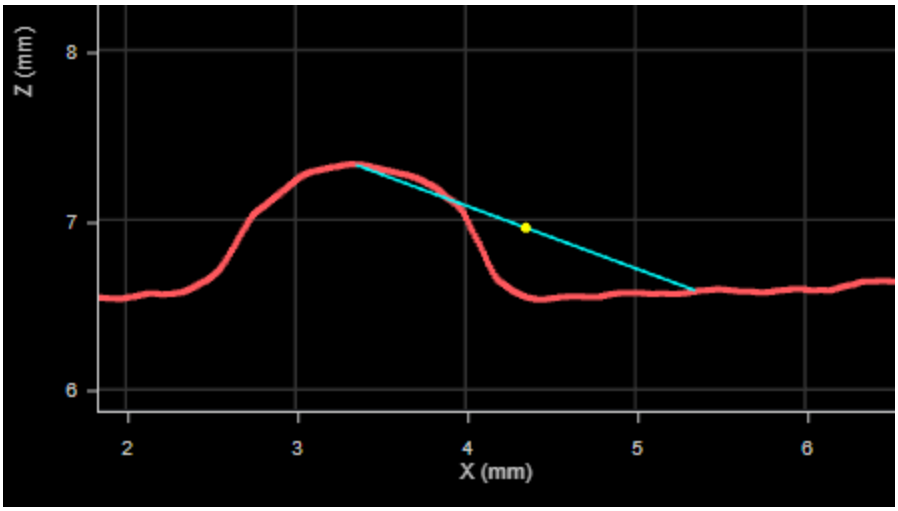
Parameters

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



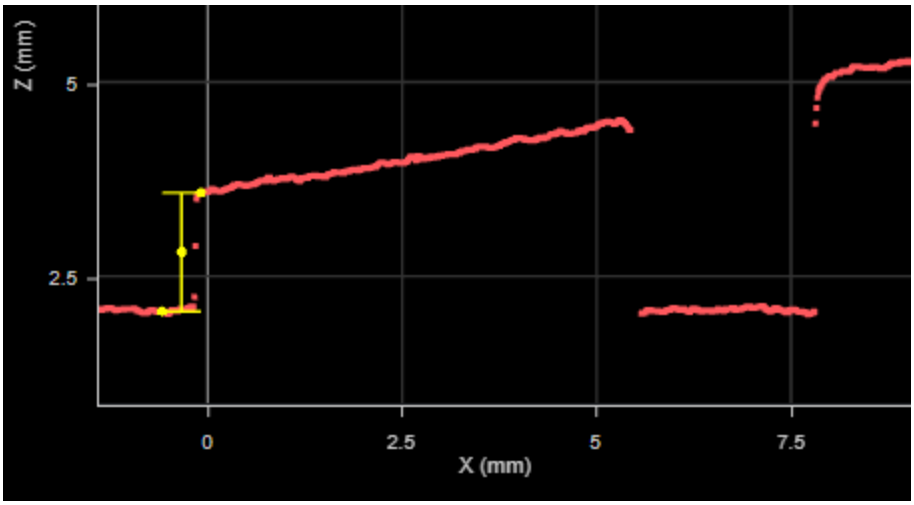
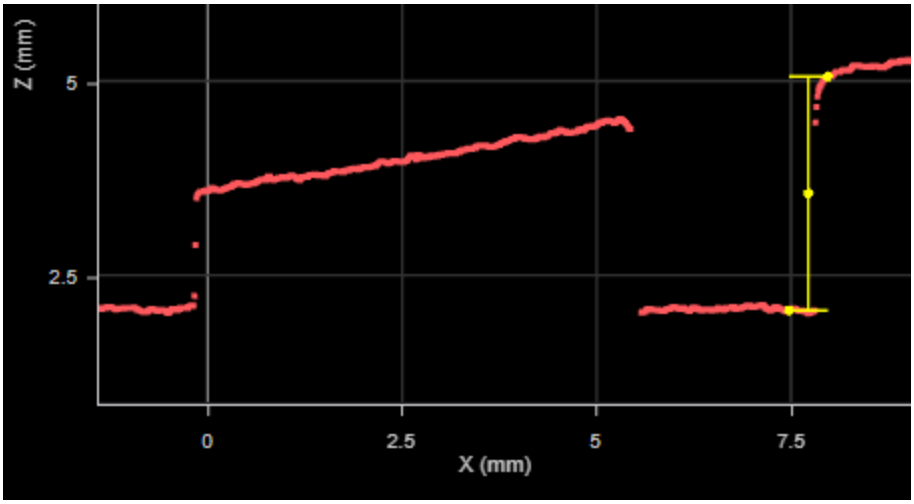
Parameters

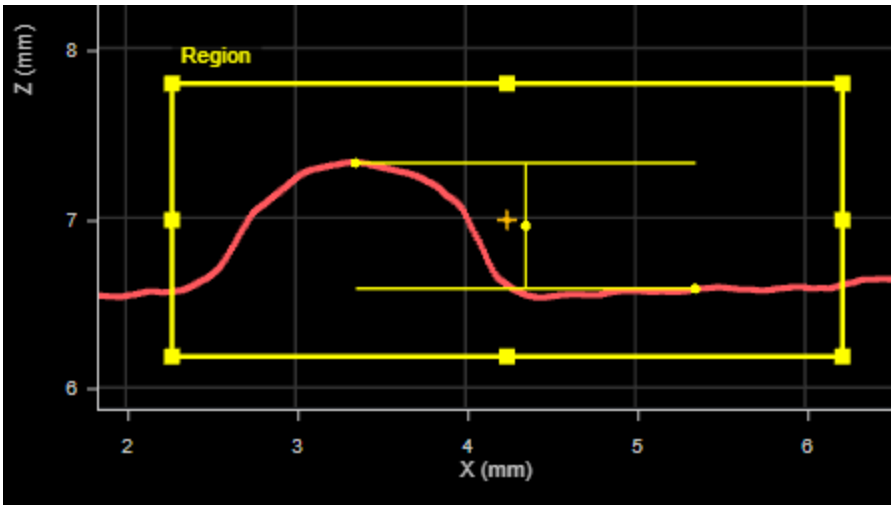
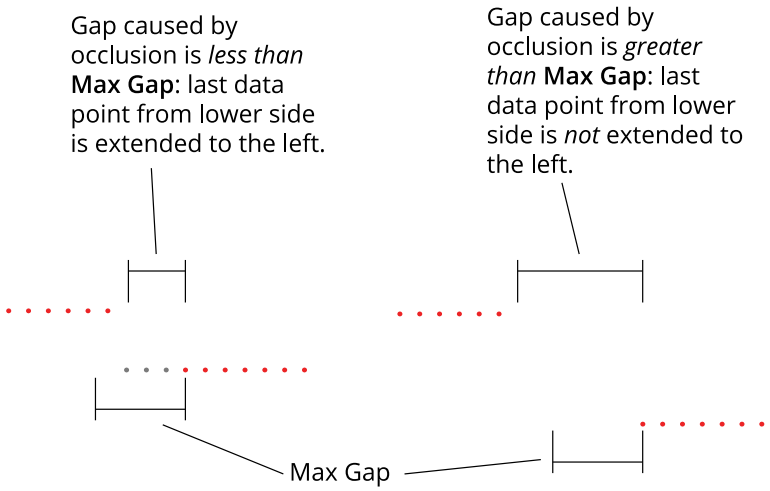
Parameter	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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 163.
Edge Detection Mode	One of the following: Step or Corner. **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.

Parameter	Description
	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 224.
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 step. Note that enabling this parameter can have an effect on processing. For high frequency scanning, be sure to disable it. 
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

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. **Best**: Selects the greatest step on the profile. **First**: Selects the first step on the profile. **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. 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
	 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. 
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. 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. 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
	 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. 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**.  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

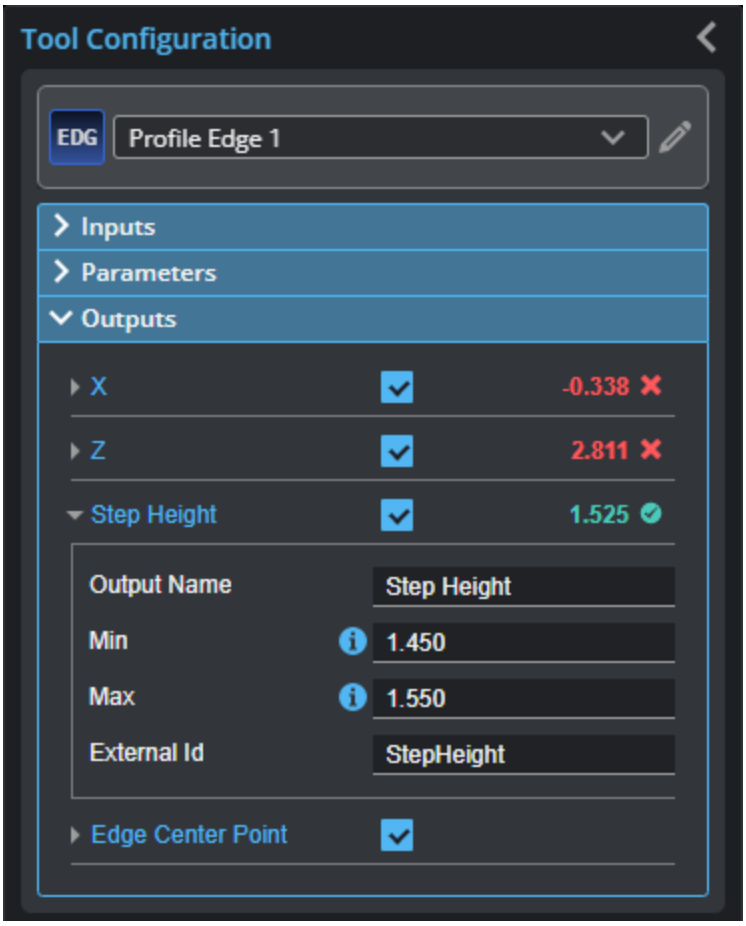
Parameter	Description
	dropouts or regions outside of the measurement range) are filled with the value in **Null Fill Value** as a general “background level.”
	To find an edges next null points, you must use either this option and an appropriate value in **Null Fill Value** or **Max Gap**. Otherwise, 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. 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: **Best**: Selects the greatest step in the profile data. **Left**: Selects the left-most step in the profile data. **Right**: Selects the right-most step in the profile data. **Top**: Selects the step that is the highest in the profile data. **Bottom**: Selects the step that is lowest in the profile.

Outputs

All 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 **Z** 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 Returns the height of the step on the profile. Only available if **Edge Detection Mode** is set to Step.

Features

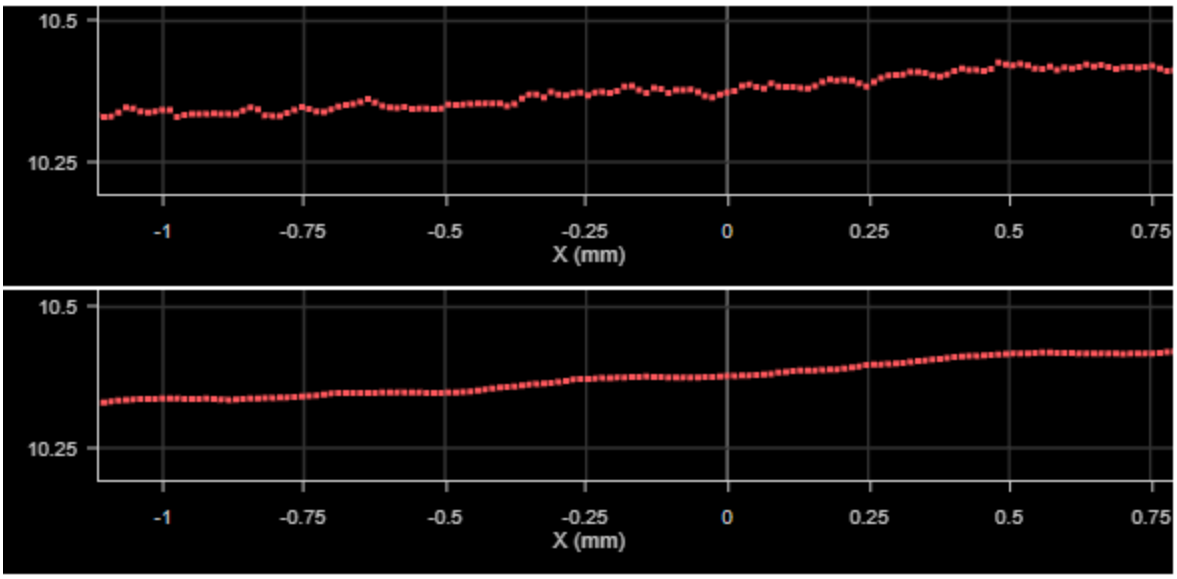
Type	**Description**
Edge Center Point	The edge point.

For more information on geometric features, see *Geometric Features* on page 175.

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 230.

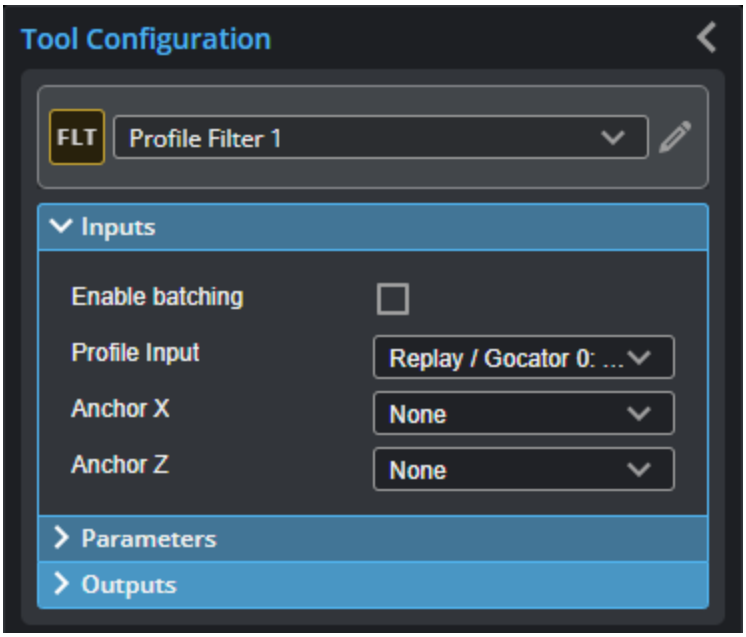
The Filter tool provides no measurements or decisions. It only outputs processed profile data.

> A limited set of filters is also available on the **Scan** page. 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 153.

Inputs

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



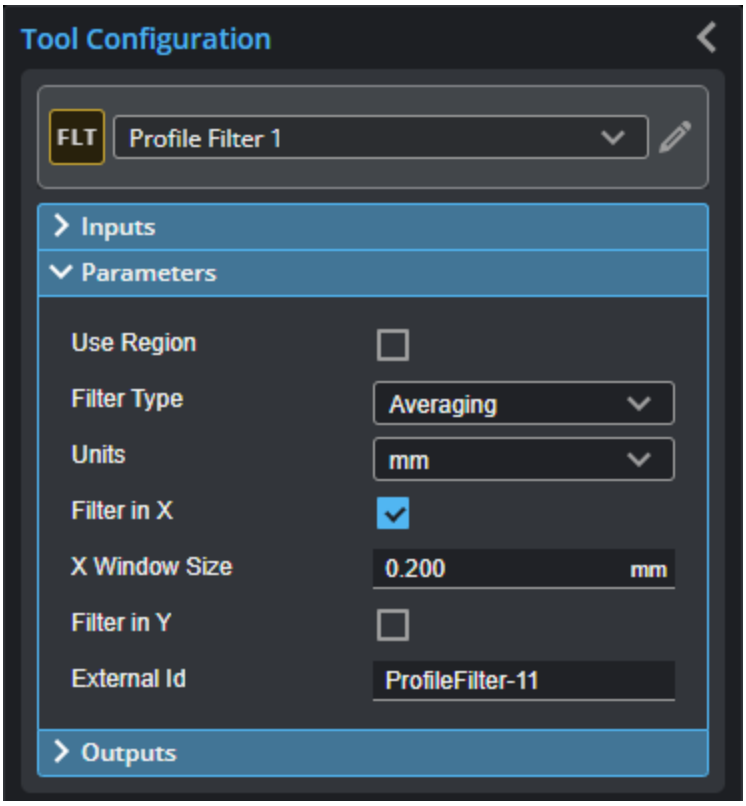
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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 Region {n}	Lets you set the number of regions, and for each region, the position and dimension. For more information on regions, see *Regions* on page 163.
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 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.)
Sigma	The Gaussian curve's sigma value. (Only displayed with the Gaussian filter and when **Filter in X** is enabled.)

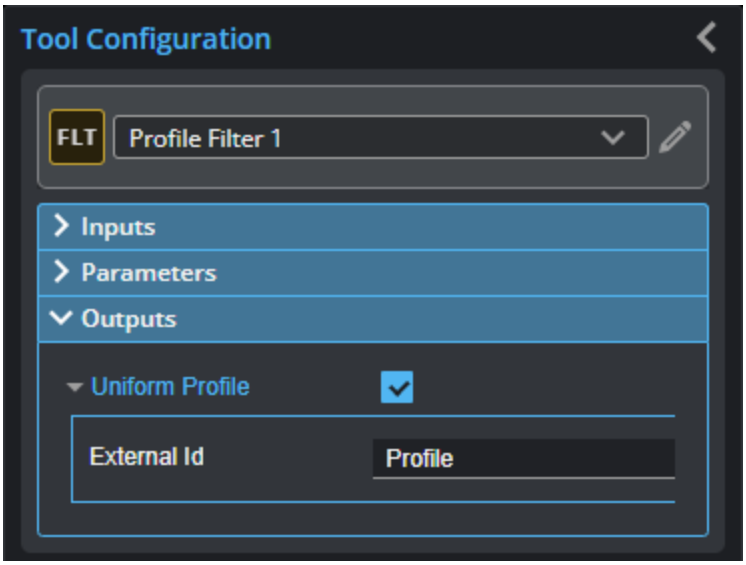
The following filters are available in the Profile Filter tool.

Filters

Name	Description
Gap Filling	Fills in missing data caused by occlusions using information from the nearest neighbors. Gap filling also fills gaps where no data is detected, which can be due to the surface reflectivity, for example dark or specular surface areas, or to actual gaps in the surface. The value in **X Window Size** represents the maximum gap width that the sensor will fill. Gaps wider than the maximum width will not be filled. 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.
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 median value is simply the value in the center of the sorted list of values. If the number of valid points is odd, the average of the two values in the center is used instead. Missing data points will not be filled with the median value calculated from data points in the neighbourhood. With an odd 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 along the X axis. Y smoothing works by calculating a moving average along the X axis. If both X and Y smoothing are enabled, the data is smoothed along X axis first, then along the Y axis. Missing data points will not be filled with the mean value calculated from data points in the neighbourhood.
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. Enables a **Sigma** parameter.

Outputs

The tool provides the following output.

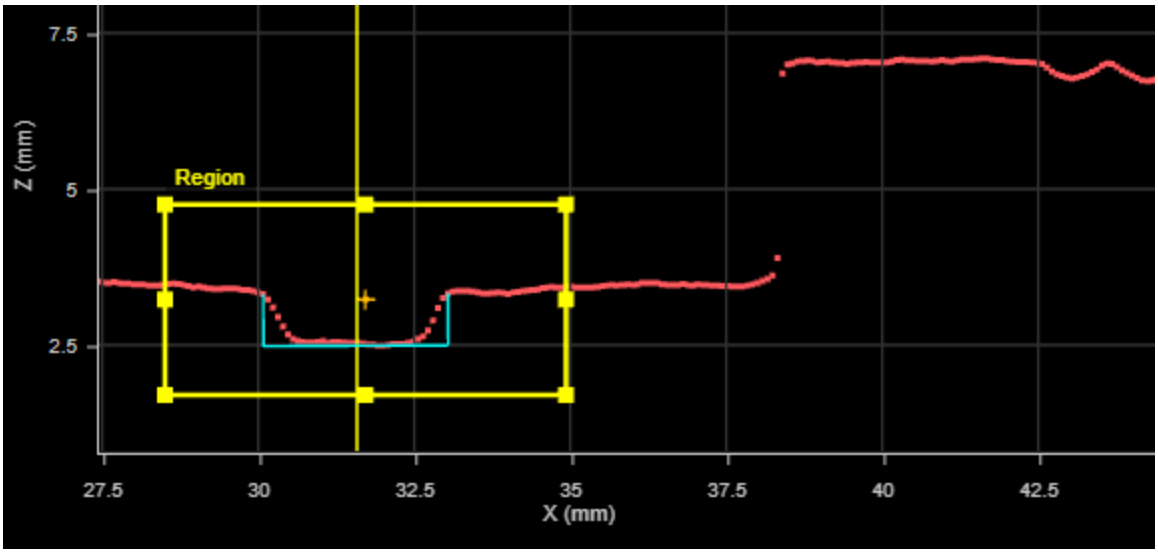


Data

Type	Description
Uniform Profile	The filtered uniform profile.

Profile Groove

The Groove tool provides measurements of V-shape, U-shape, or open-shape grooves.



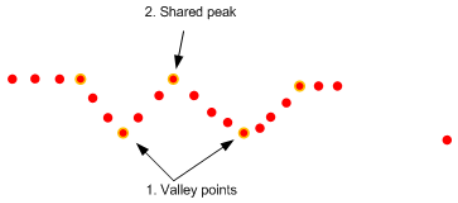
The tool lets you optionally set an index to return the measurements of a specific groove when more than one groove is visible in the region of interest. If you need to return multiple grooves from a profile, add a Profile Groove tool for each groove, configure it to represent the desired groove, and set its **Selection Index** parameter to the desired groove (0-based index).

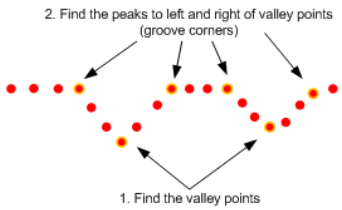
The Groove tool uses a complex feature-locating algorithm to find a groove and then return measurements. For a detailed explanation of the algorithm the tool uses, see *Groove Algorithm* below. The behavior of the algorithm can be adjusted by changing the tool's parameters.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

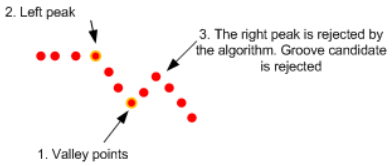
Groove Algorithm

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.

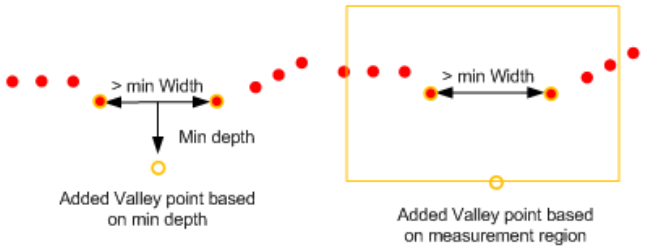




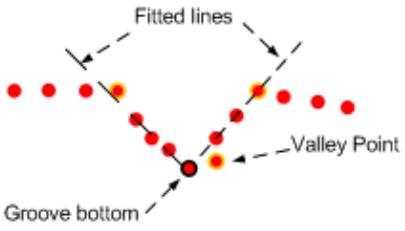
The algorithm derives search parameters from the user settings to prevent noise from triggering false detections. When detecting multiple grooves, an adaptive algorithm is used to ensure that candidate grooves are approximately the same scale.



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.

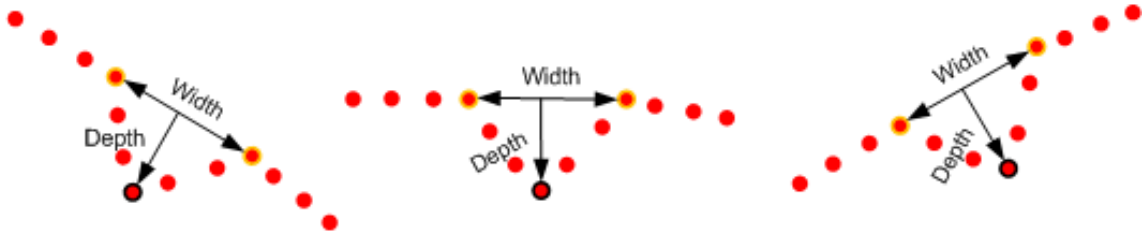


The actual groove bottom is calculated differently for different shapes. For a V-shaped groove, a line is fitted to the sides of the valley points starting from the corners, up to (but not including) the valley point. The groove bottom is the intersection of the left and right lines. Line fitting is used such that an accurate groove bottom can be found even when the real bottom is not visible (i.e., blocked by reflections).



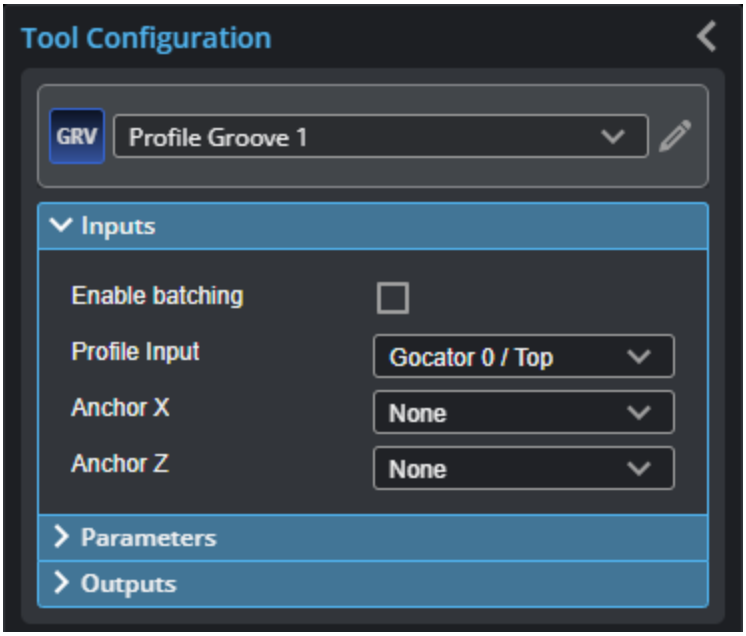
For U-shaped and open groove, the X and Z positions are at the bottom of the groove.

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 176.

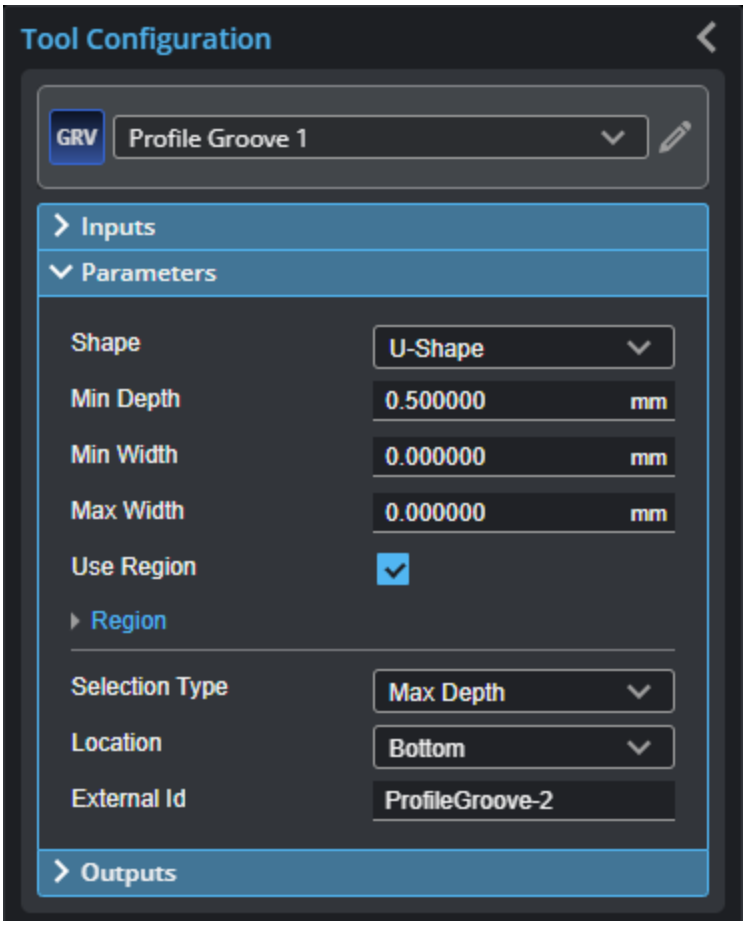
Inputs

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

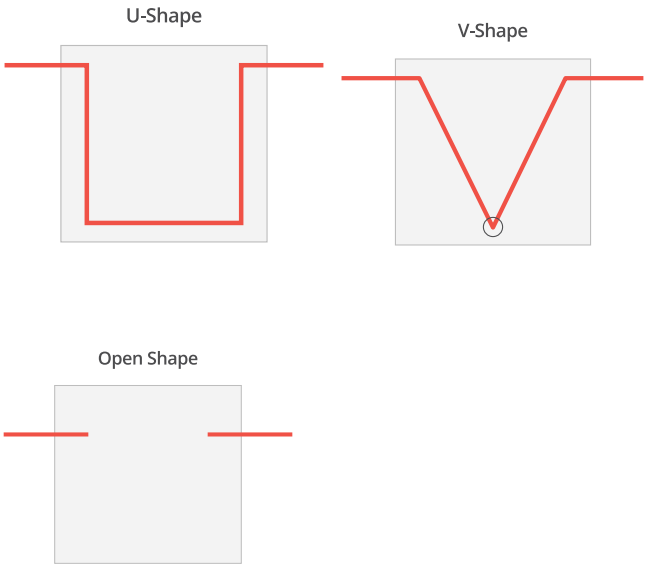
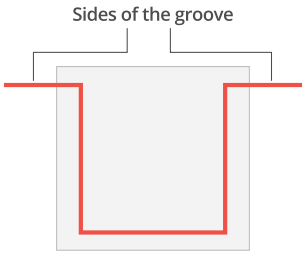
Name	Description
	When **Enable Batching** is unchecked, the tool takes either a single profile, or an array of profiles with a maximum of two elements. If the input is an array, the tool will aggregate the data in the array, and process that data as a whole. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.



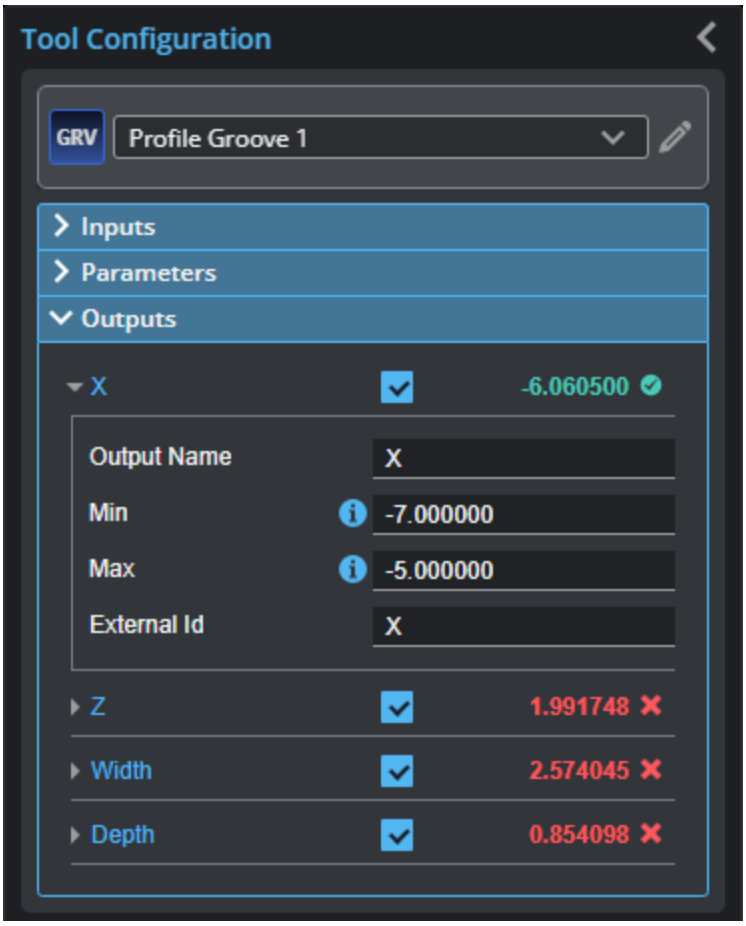
Parameters

Parameter	Description
Shape	One of the following: U-Shape, V-shape, or Open. 
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.  For more information on regions, see *Regions* on page 163.

Parameter	Description
Selection Type	Specifies how a groove is selected when there are multiple grooves the profile data. One of the following: **Maximum Depth**: The groove with the maximum depth. **Index from The Left**: A 0-based groove index, counting from left to right. **Index from the Right**: A 0-based groove index, counting from right to left. 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 *(For the X and Z measurements only)*	Specifies the location type to return. One of the following: **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 232. **Left Corner**: The groove's left corner. **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 666.

Outputs

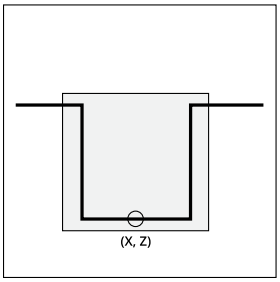
All tools provide measurements, geometric features, or data as outputs.

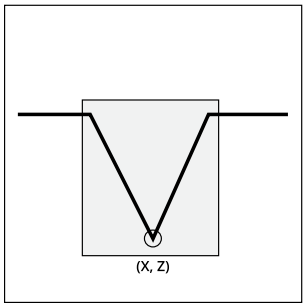
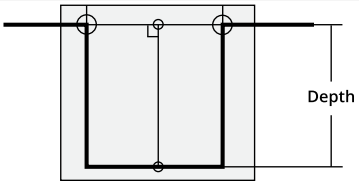
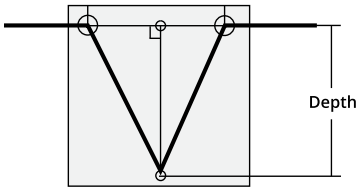


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Measures the X and Z position, respectively, of the bottom of a groove.	

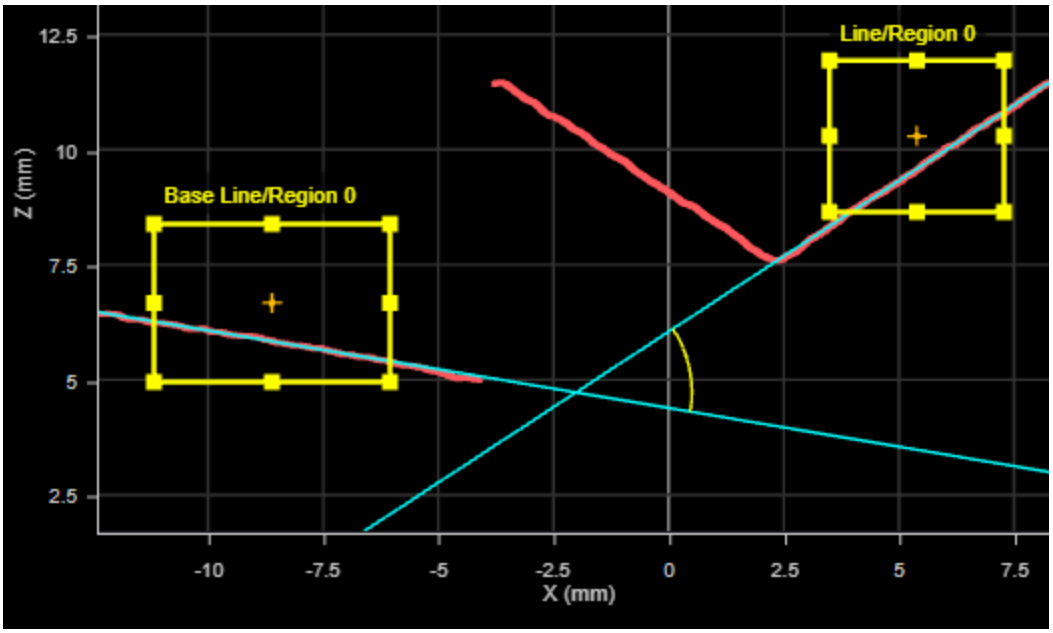
Measurement	Illustration
	
Width Measures the width of a groove.	 
Depth Measures the depth of a groove as the maximum perpendicular distance from a line connecting the edge points of the groove.	 

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:

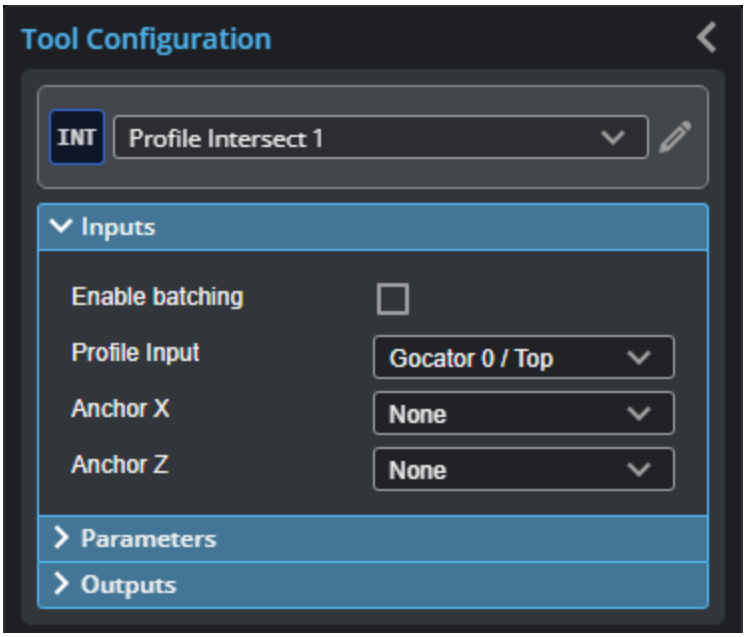
- the X axis (z = 0)
- the Z axis (x = 0)
- a user-defined line



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



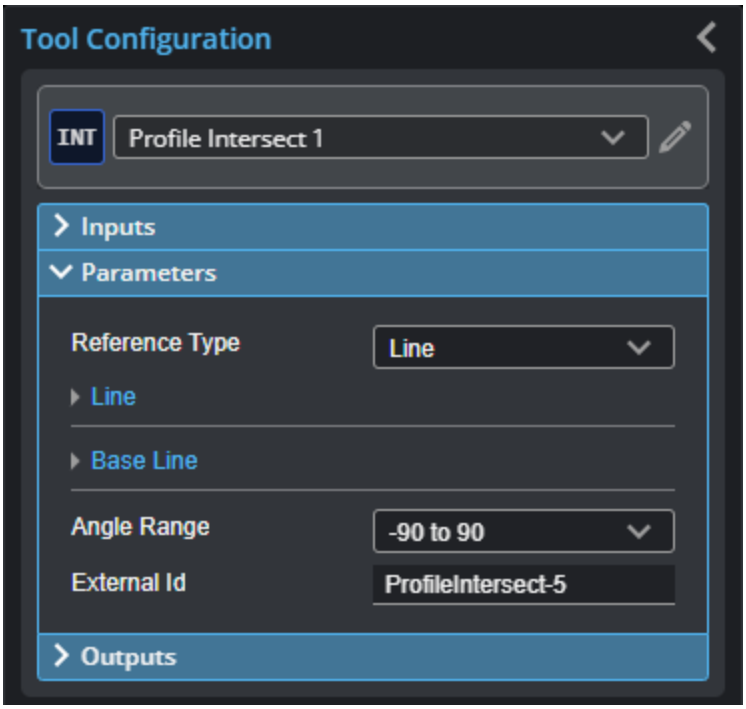
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.

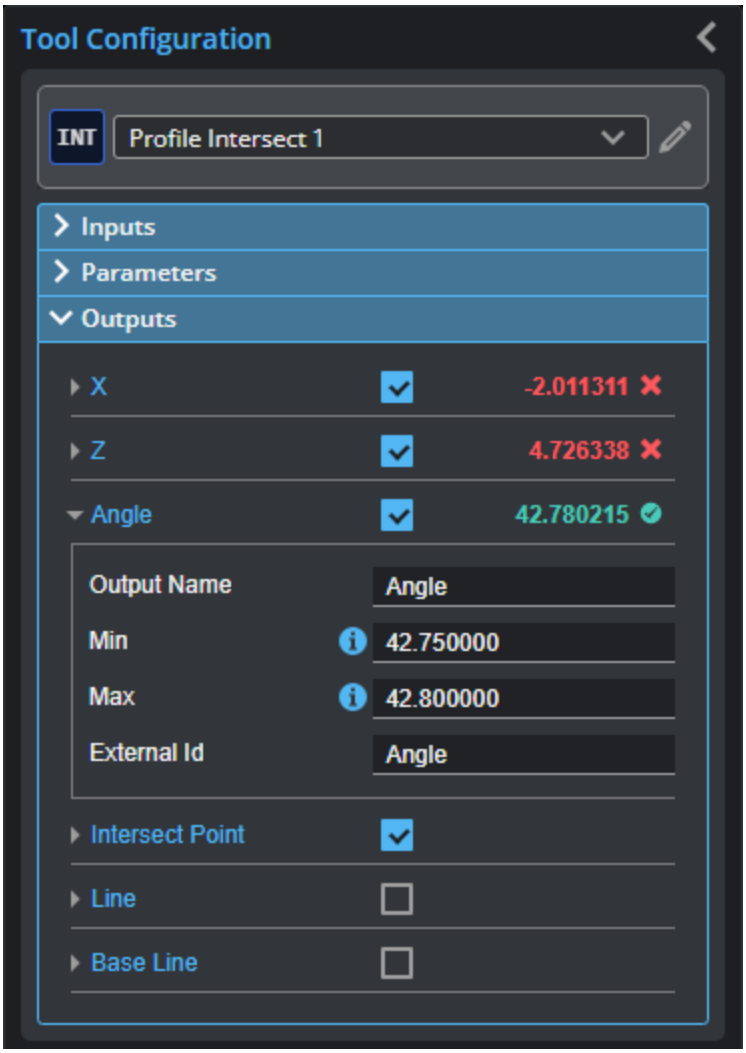


Parameters

Parameter	Description
Reference Type	Determines the type of the reference line. One of the following: X Axis, Z Axis, or Line. **X-Axis**The reference line is set to the X axis. **Z-Axis**: The reference line is set to the Z axis. **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 163. For more information on fit lines, see *Fit Lines* on page 175.
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 163. For more information on fit lines, see *Fit Lines* on page 175.
Angle Range	Determines the range returned by the Angle measurement. One of the following: **-90 – 90** **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 666.

Outputs

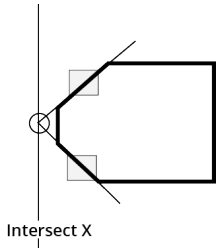
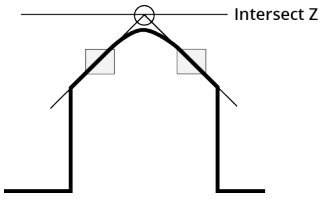
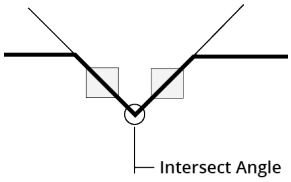
All tools provide measurements, geometric features, or data as outputs.



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 Finds the intersection between two fitted lines and measures the X axis position of the intersection point.	
Z Finds the intersection between two fitted lines and measures the Z axis position of the intersection point.	
Angle Finds the angle subtended by two fitted lines.	

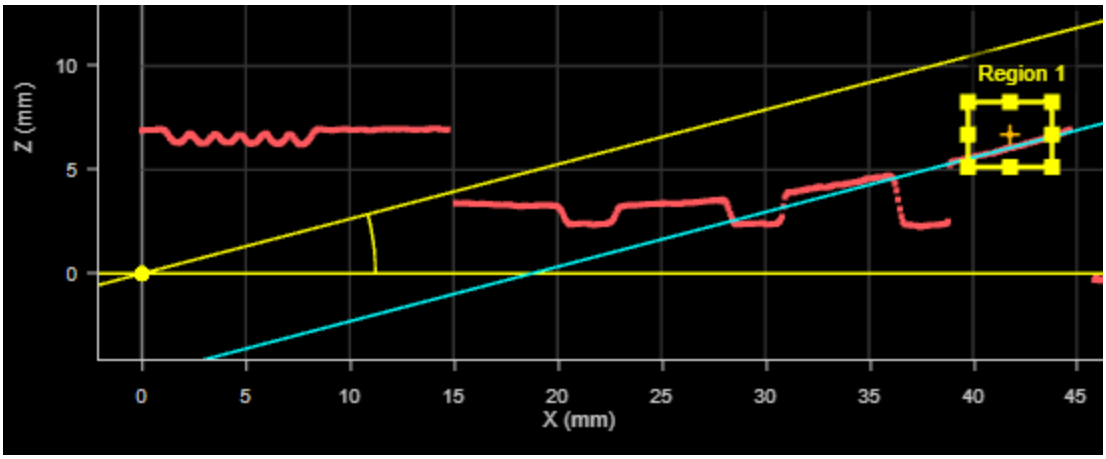
Features

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 175.

Profile Line

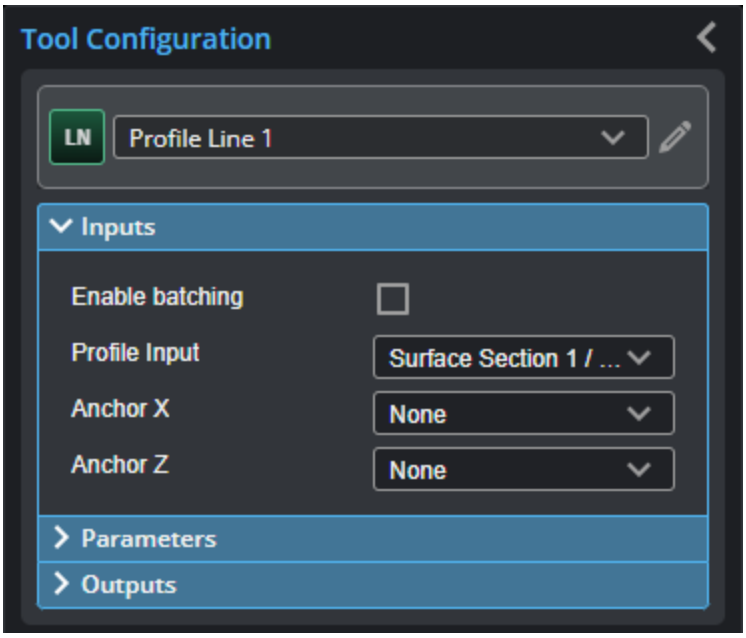
The Line tool fits a line to the profile and measures the deviations from the best-fitted line. The tool also provides two “roughness parameter” measurements: Arithmetic Average and Rz. For a complete list of the measurements the tool provides, see *Measurements* on page 249.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



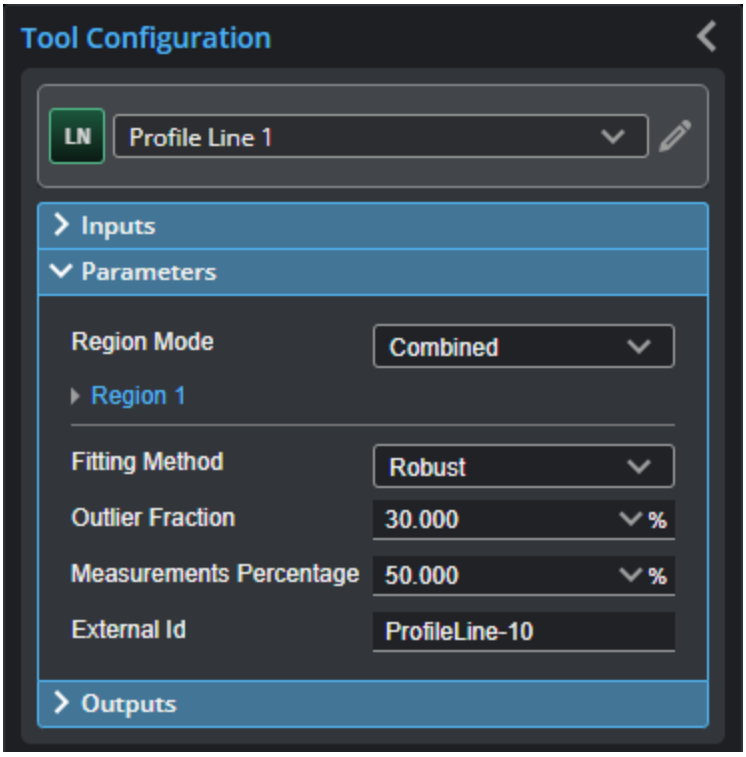
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
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.

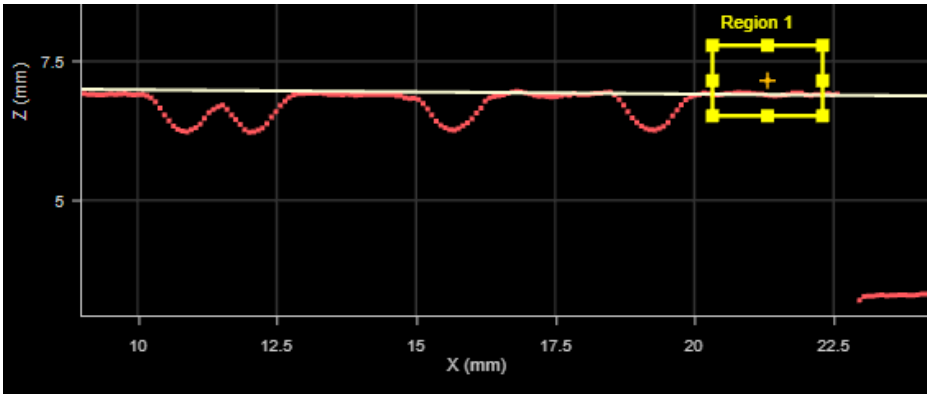
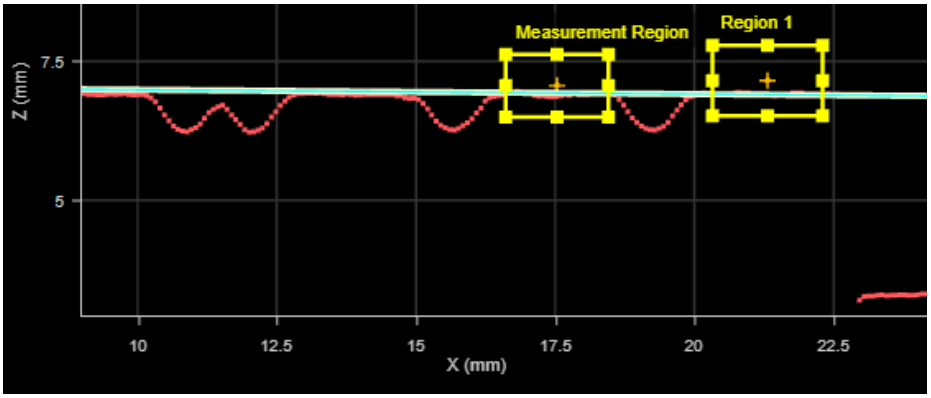
Parameters

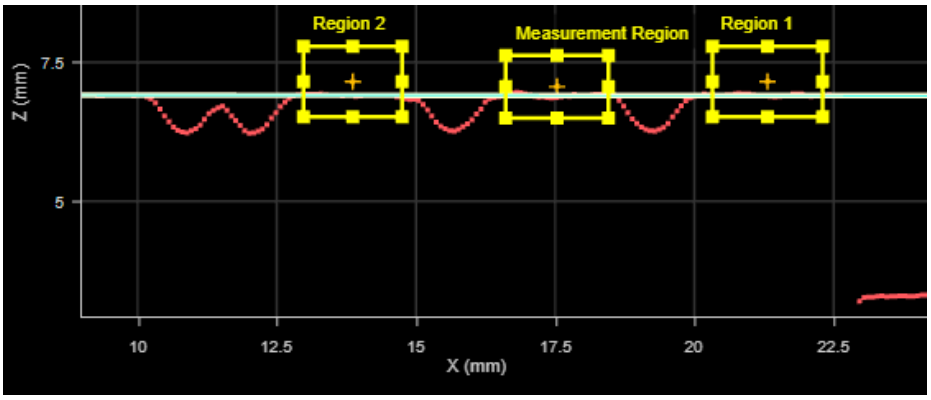
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

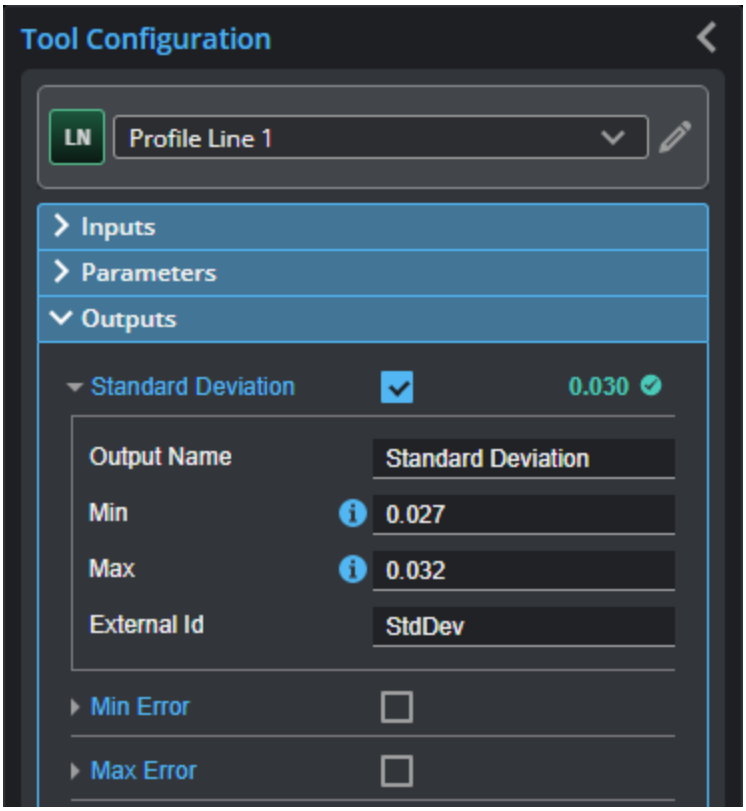
Name	Description
Region Mode	Whether the fitting and measurement regions are used, and whether they are combined or separate. One of the following:

Name	Description
	None The tool uses the entire profile both to fit the line and to perform measurements. **Combined** The tool uses a single, user-defined region to fit the line, in which it also performs measurements.  **Separated** 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.) 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:  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} 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.) 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: **Simple** Uses a less accurate but faster line-fitting method. **Robust** 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%. Only displayed when **Method** is set to **Robust**.
Measurements Percentage *(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 666.

Outputs

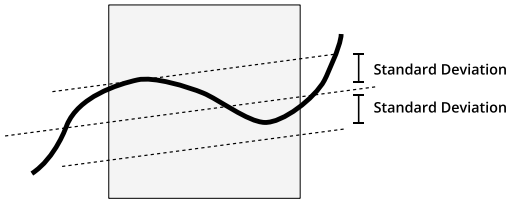
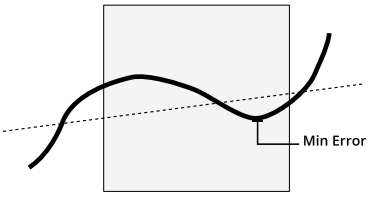
All tools provide measurements, geometric features, or data as outputs.

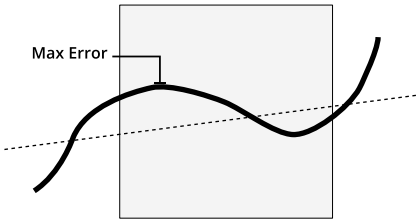
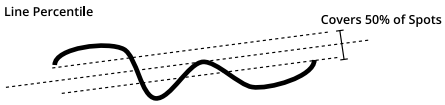
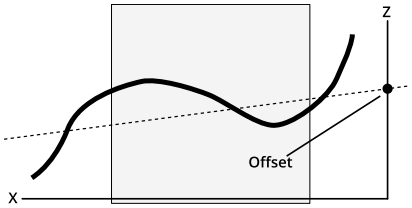
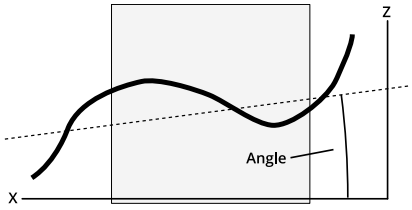
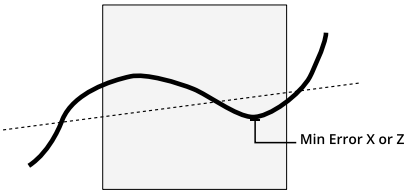
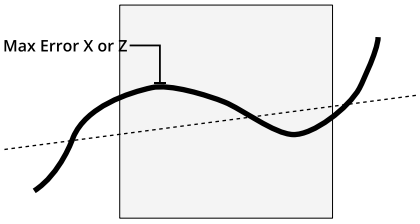
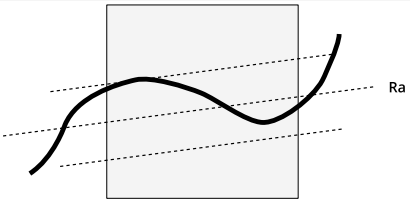


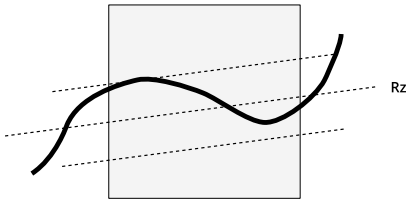
Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Finds the best-fitted line and measures the standard deviation of the data points from the line.	
Min Error Finds the best-fitted line and measures the minimum error from the line (the maximum distance below the line).	

Measurement	Illustration
Max Error Finds the best-fitted line and measures the maximum error from the line (the maximum distance above the line).	
Percentile Finds the best-fitted line and measures the range (in Z) that covers a percentage of points around the line.	
Offset Finds the best-fitted line and returns the intersection point between that line and the Z axis.	
Angle Finds the best-fitted line and returns the angle relative to the X axis.	
Min Error X **Min Error Z** 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 **Max Error Z** 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 Returns the roughness average of the profile data. Ra = SUM_N(abs(distance)) / (N) where N is the total number of non-outlier points, and the distance is from each point to the fitted line.	

Measurement	Illustration
Rz Returns the maximum height of the profile data. Rz = abs(smallest distance) + abs(biggest distance) 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.

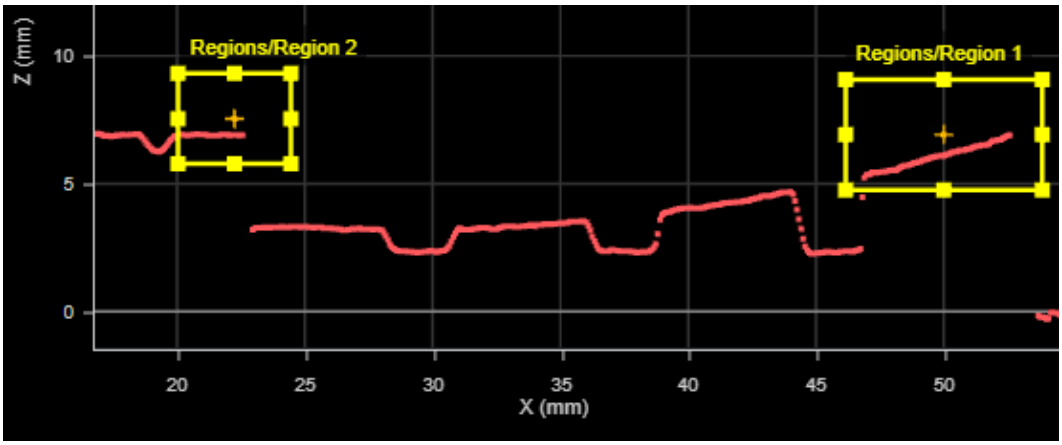
For more information on geometric features, see *Geometric Features* on page 175.

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.

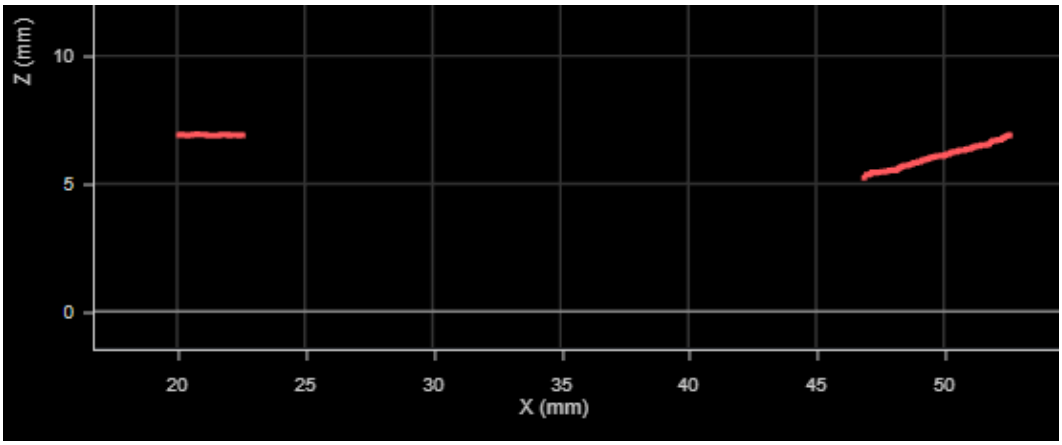
The resulting profile can then be further processed or measured by other tools.

For example, given the following scan data:



Two mask regions defined on a profile (original profile, all data included)

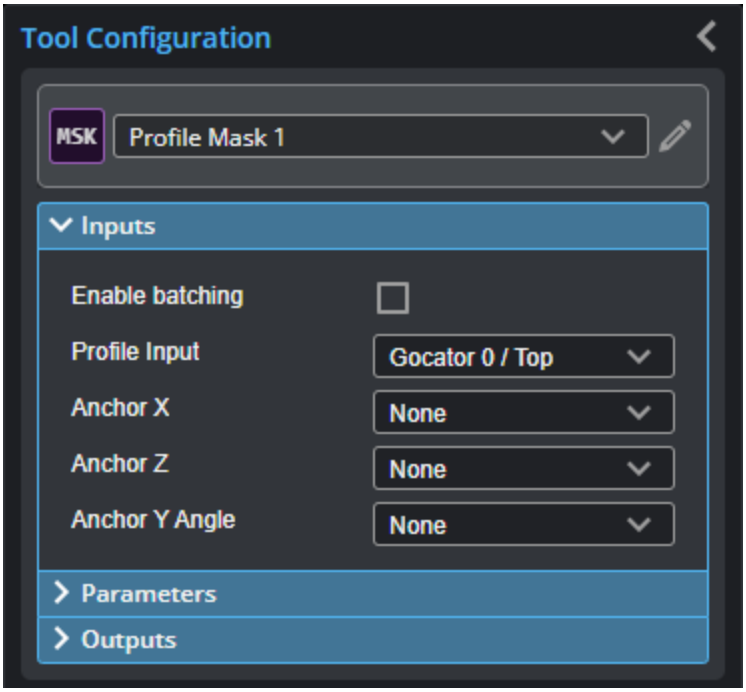
The image below shows the extracted data. The extracted profile data can then be further processed by other tools, or measurements can be applied to the surface data.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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 176.

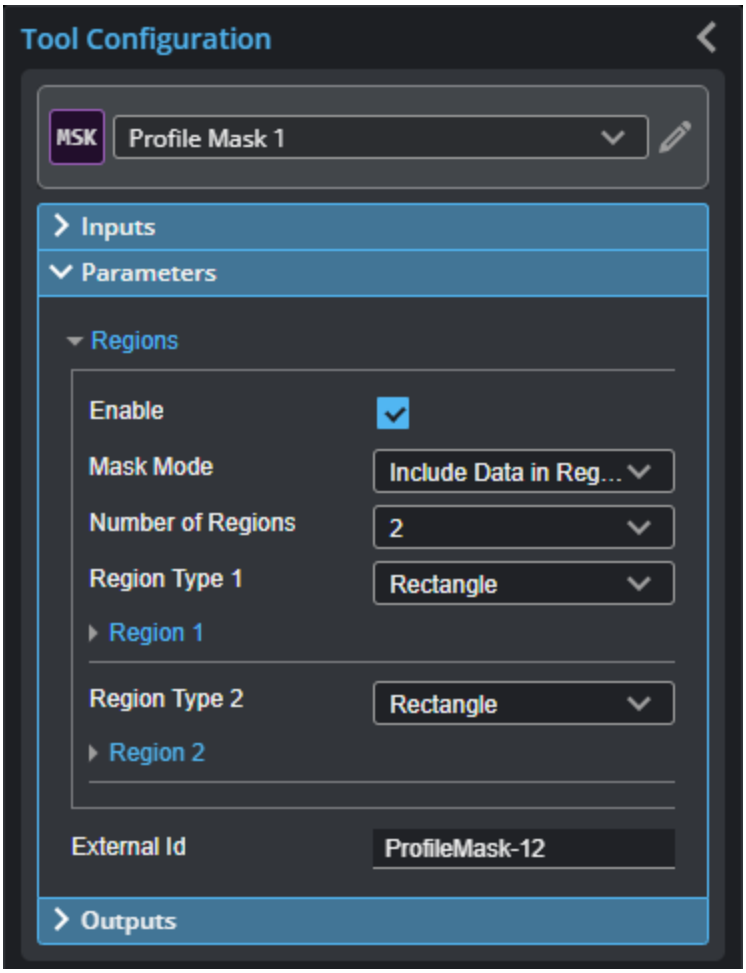
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other

Name	Description
	than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.



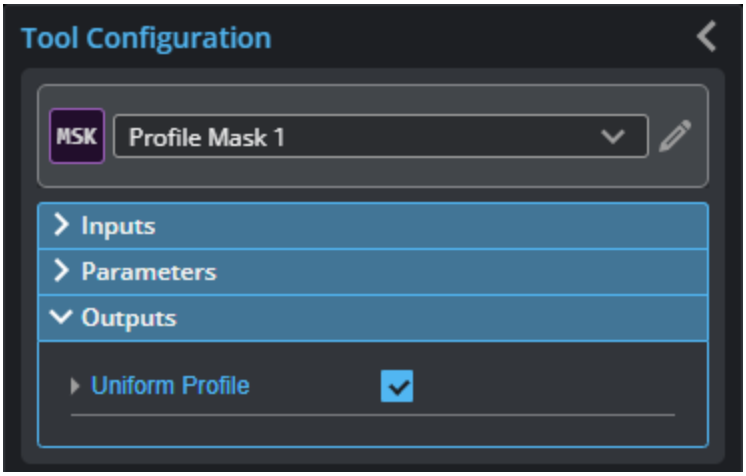
Parameters

Parameter	Description
Regions	When expanded, displays region-related settings. For details on the regions and their settings, see *Flexible Regions* on page 164.

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 666.

Outputs

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



Data

Type	Description
Uniform Profile Point Cloud Profile	The profile containing the extracted region or regions.

Profile Panel

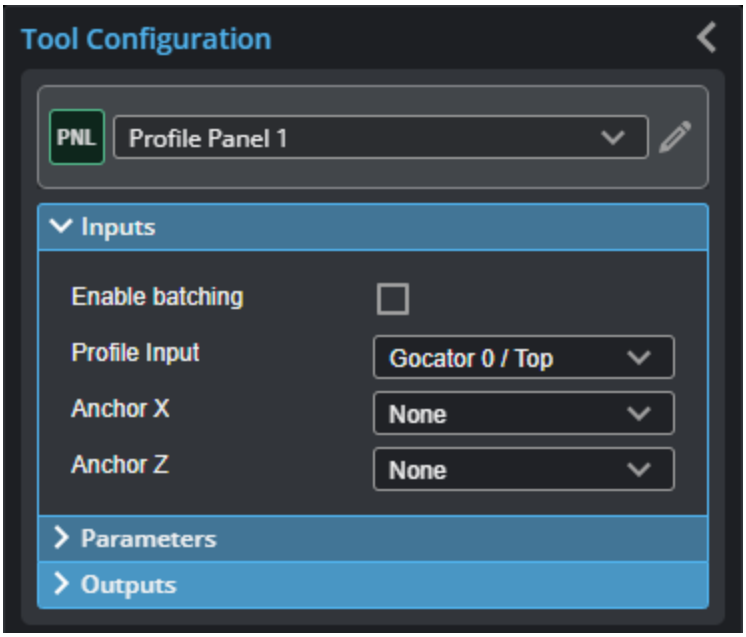
The Panel tool provides Gap and Flush measurements.

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 263.

> 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 153.

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 176.

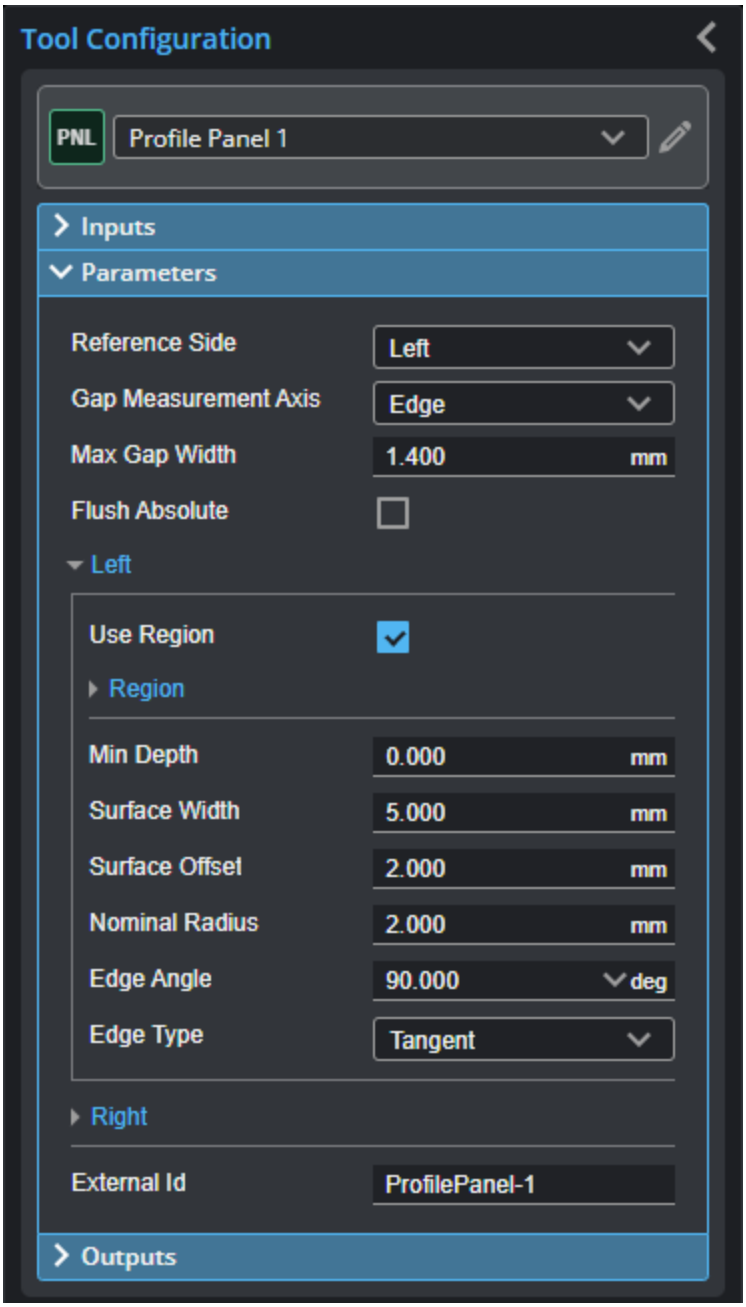
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

Name	Description
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.

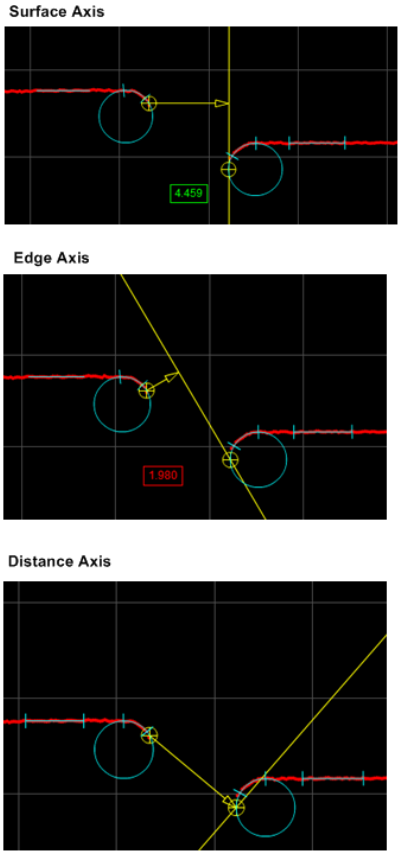
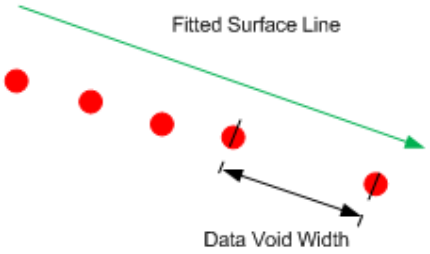
Parameters

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

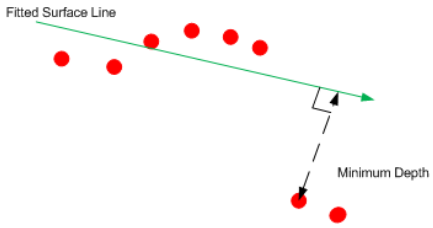
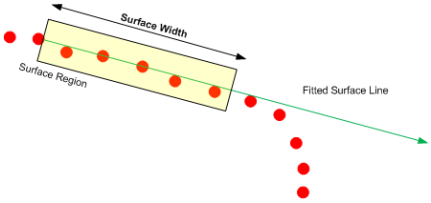
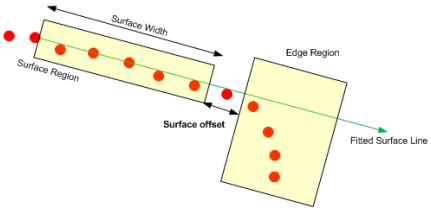
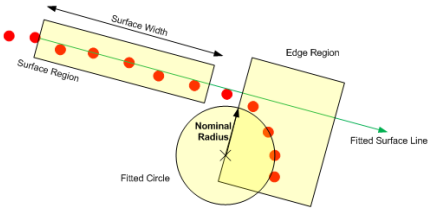


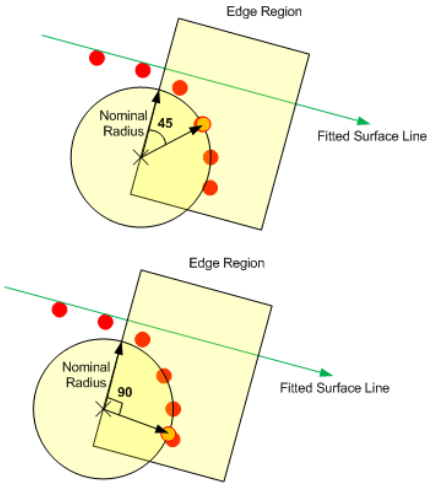
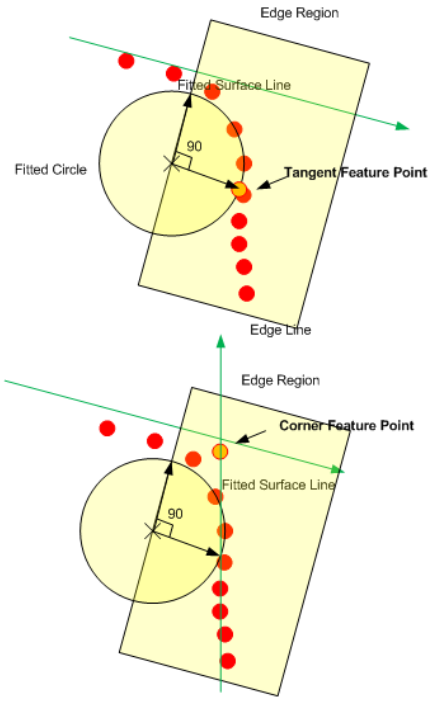
Parameters

Parameter	Description
Reference Side	Defines the side used to calculate the measurement axis (see below) rounded corner.
Gap Measurement Axis *Gap measurement only*	Defines the direction that the gap is calculated, in relation to the reference side (see above). **Surface**: In the direction of the fitted surface line of the reference surface. **Edge**: In the direction perpendicular to the edge of the reference surface.

Parameter	Description
	Distance: The Cartesian distance between the two feature locations. 
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. 
Flush Absolute *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 666.

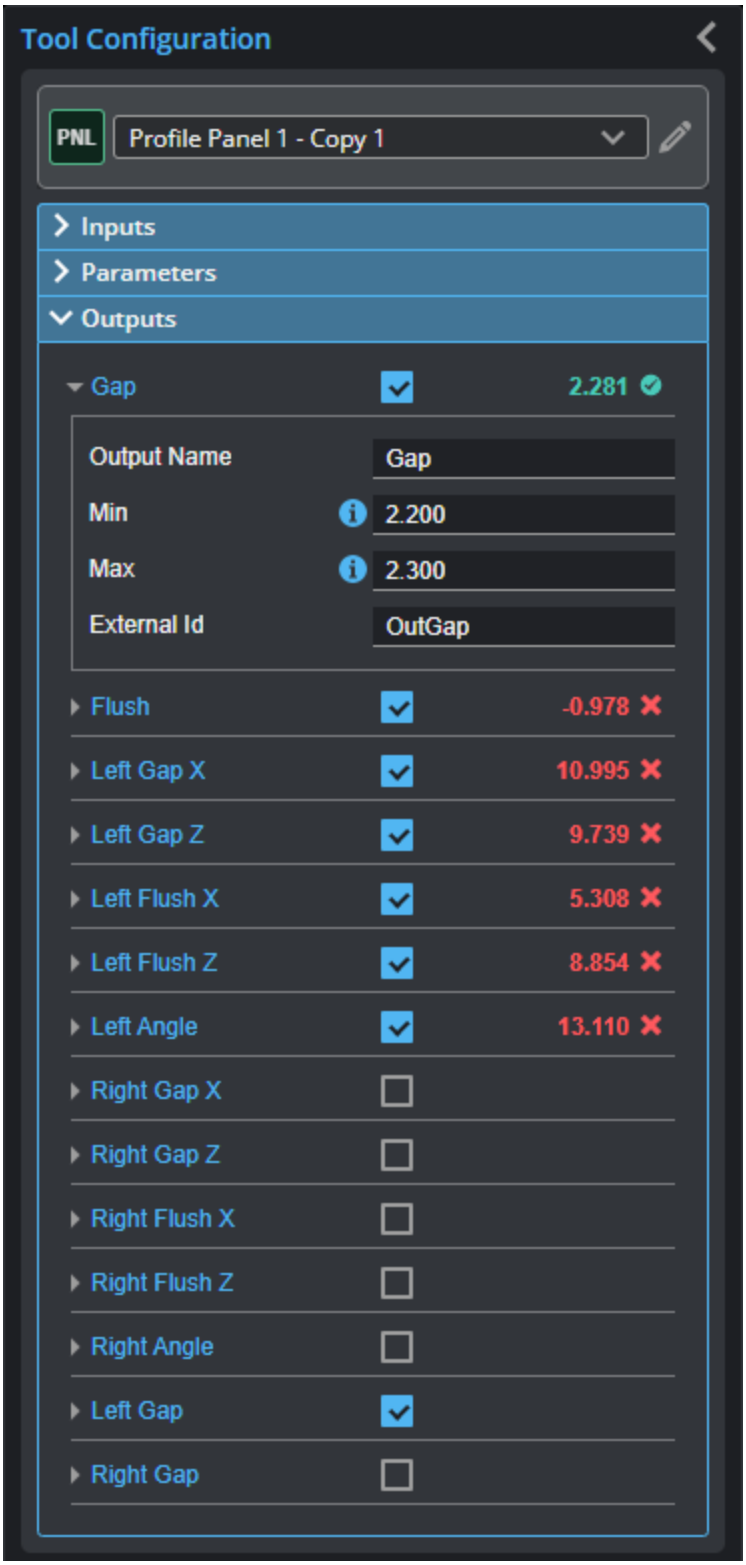
Left and Right Parameters

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. 
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). 
Surface Offset	The distance between the edge region and the surface region.  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. 
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.  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).  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

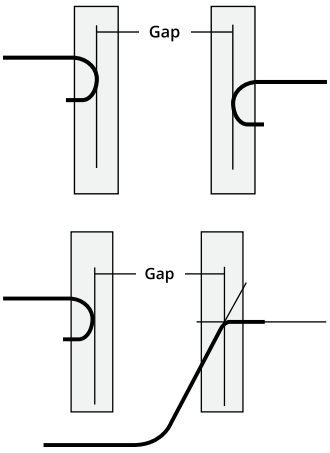
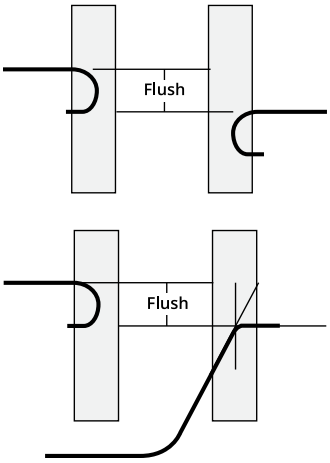
All tools provide measurements, geometric features, or data as outputs.



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 Measures the distance between two surfaces. The surface edges can be curved or sharp.	
Flush Measures the flushness between two surfaces. The surface edges can be curved or sharp.	
Left Gap X **Left Gap Z** The X and Z position of the edge feature on the left side used to measure the gap.	
Left Flush X **Left Flush Z** Returns the X and Z position of the feature on the left side used to measure flushness.	
Left Angle **Right Angle** The angle of the left and right side surface relative to the X axis.	

Measurement	Illustration
Right Gap X **Right Gap Z** Returns the X and Z position of the edge feature on the right side used to measure the gap.	
Right Flush X **Right Flush Z** Returns the X and Z position of the feature on the right side used to measure flushness.	

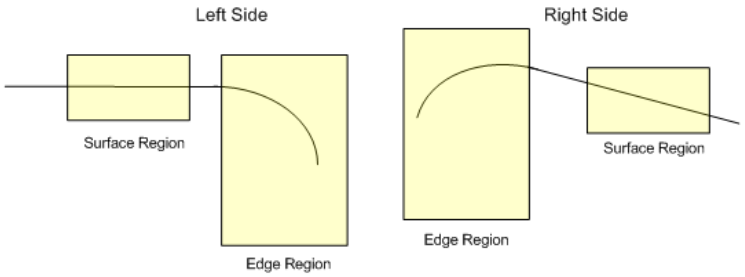
Data

Type	Description
Left Gap 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. 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.)

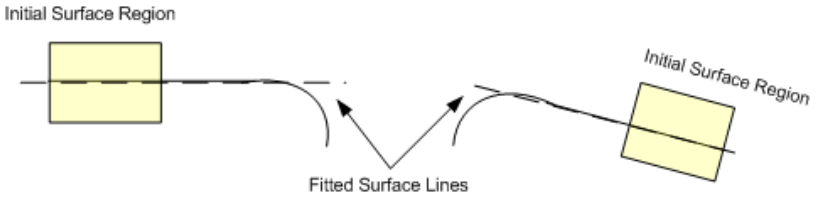


After the algorithm finds the regions, it places a feature point on the surface region based on a set of parameters. You can control the measurement regions, which contain the surface and the edge regions, for the left and the right side. A measurement region also defines the region in which the measurement tool will search for the feature points. Feature points are located on a side using the following algorithm.

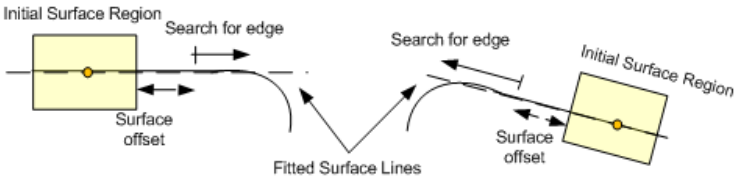
1. On the left side, search from left to right to find a surface region with data that covers at least the value specified in the **Surface Width** setting. For the right side, do the same, searching from right to left.



2. If a surface region is found, fit a line, called the surface line, using the data within the area.

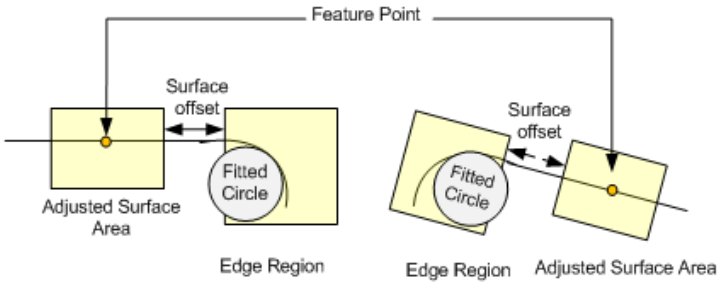


3. Search for a valid edge region that is located at least the distance specified in the **Surface Offset** setting from the end of the surface region. If a surface region is not found, move along the search direction and repeat step 1.



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.

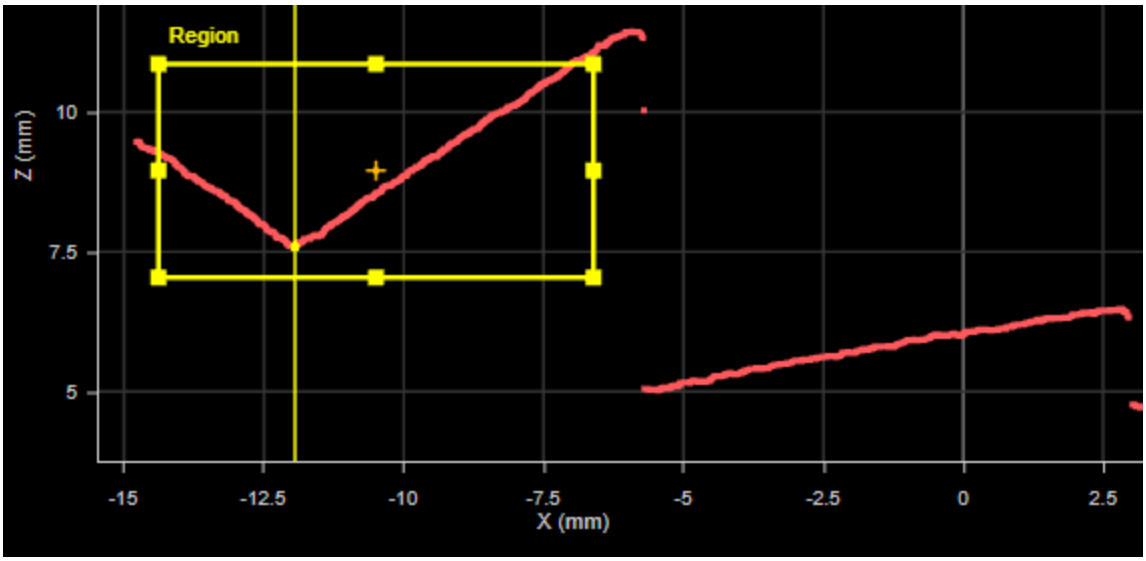


Profile Part Detection

This tool is not used on G3 sensors.

Profile Position

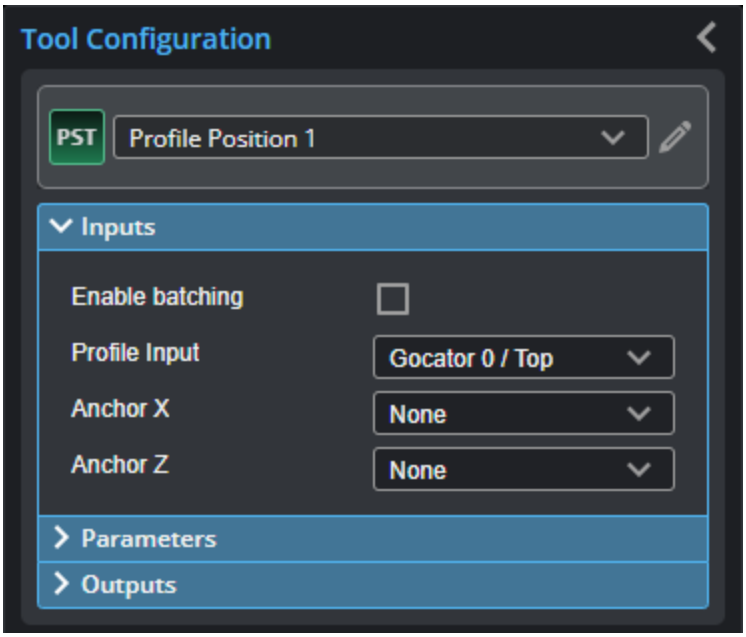
The Position tool finds the X or Z axis position of a feature point. The feature type must be specified (see below).



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



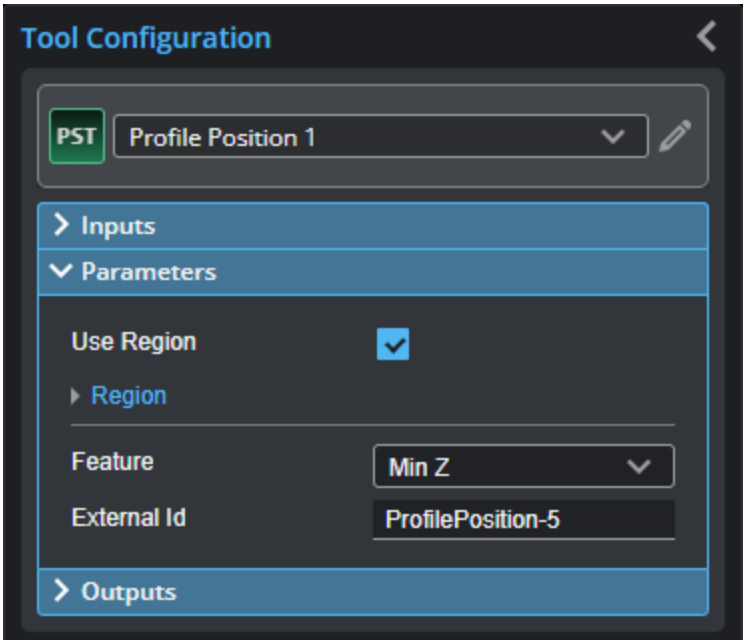
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.



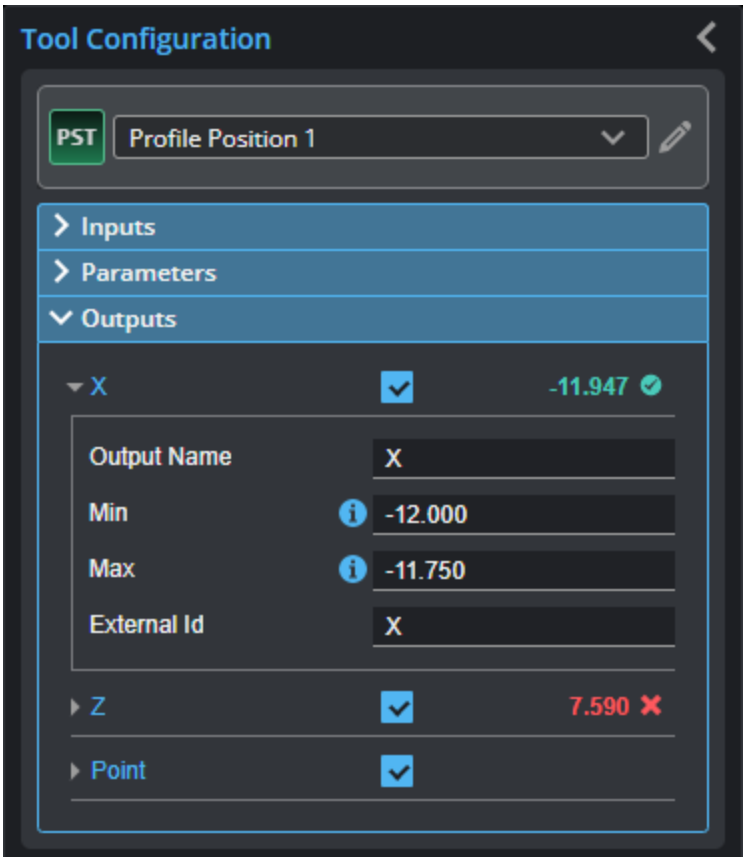
Parameters

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 163.

Parameter	Description
Feature	The feature the tool uses for its measurements. One of the following: • Max Z • Min Z • Max X • Min X • Corner • Average • Rising Edge • Falling Edge • Any Edge • Top Corner • Bottom Corner • Left Corner • Right Corner • Median 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 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

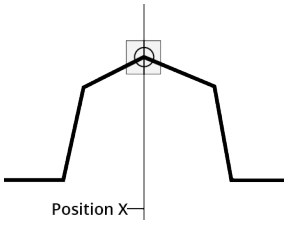
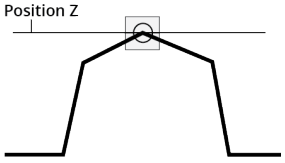
All tools provide measurements, geometric features, or data as outputs.



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 Finds the position of a feature on the X axis.	
Z Finds the position of a feature on the Z axis.	

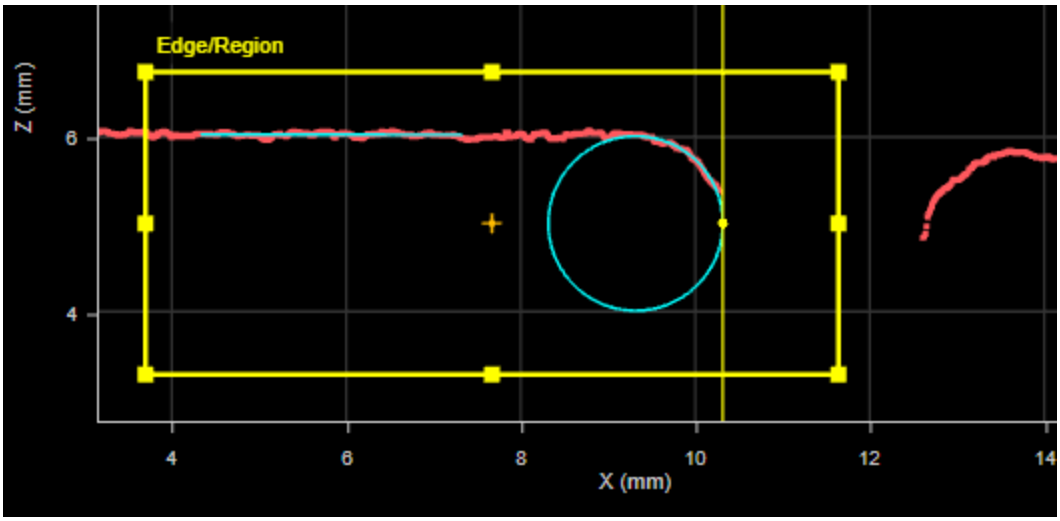
Features

Type	Description
Point	The returned position.

For more information on geometric features, see *Geometric Features* on page 175.

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.



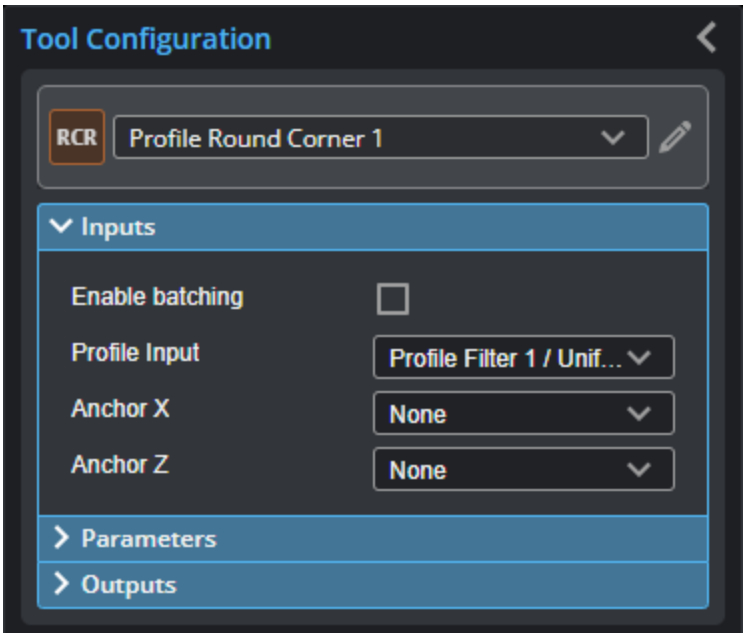
For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

The Round Corner tool uses a complex feature-locating algorithm to find the edge 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 263.

> 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.



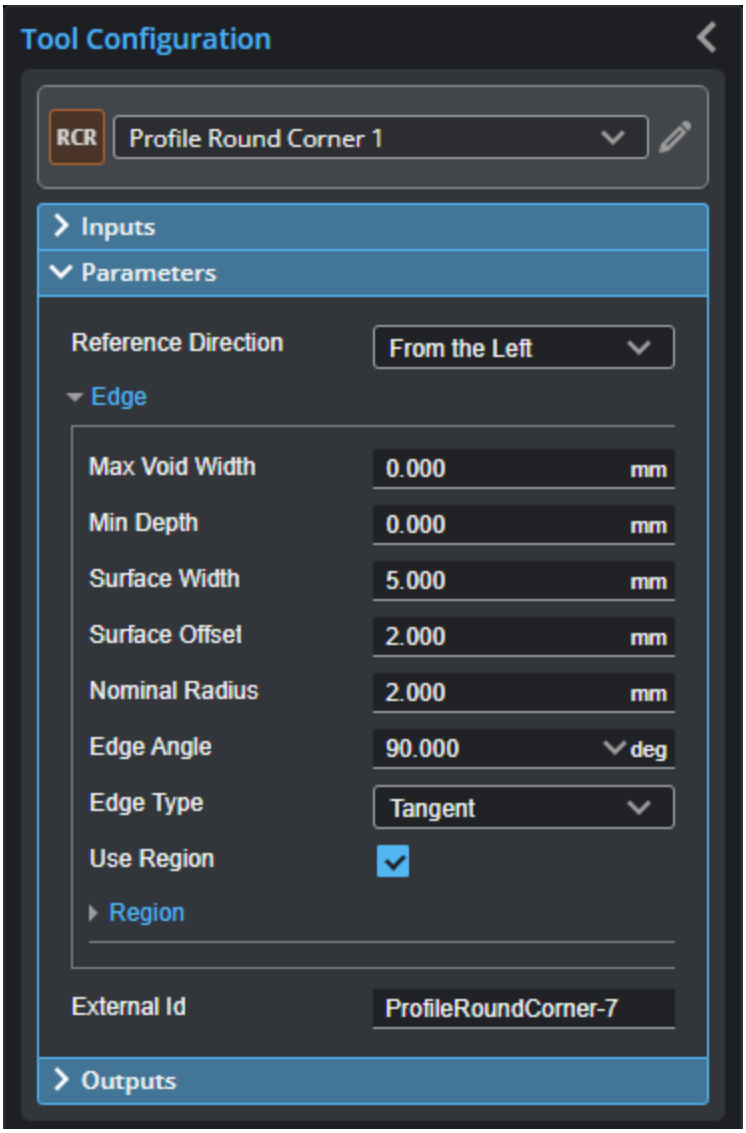
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Profile Input	The data the tool applies measurements to or processes. 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 155.
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.

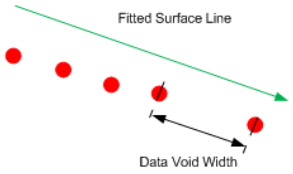
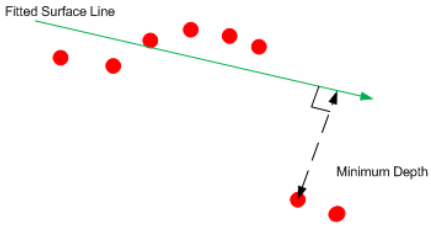
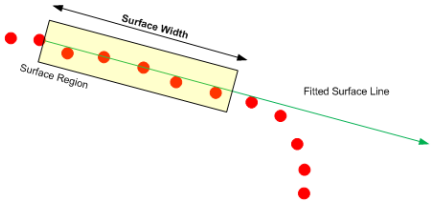
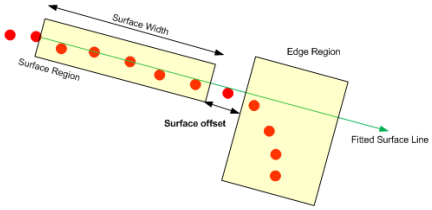
Parameters

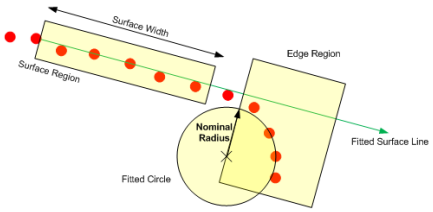
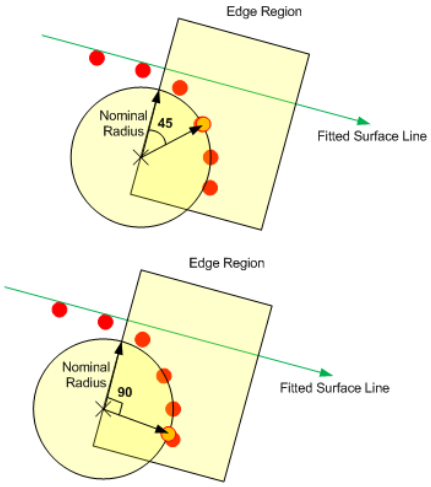
You configure the tool's parameters in the expandable **Parameters** section.

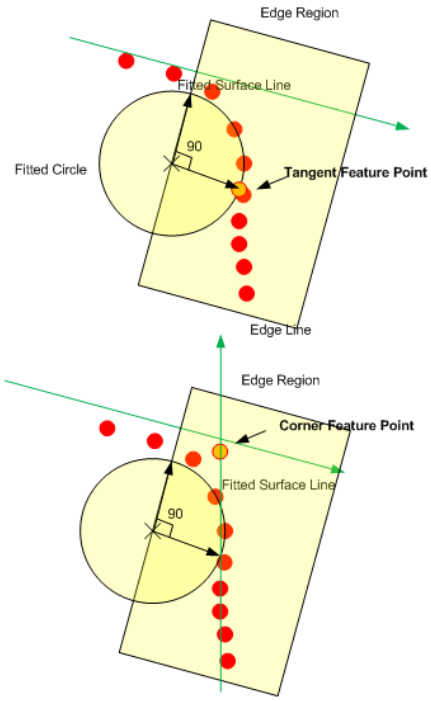


Parameters

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. A larger value prevents the algorithm from registering a section of missing data as an edge. Setting the value to 0 causes the algorithm to try to detect an edge in every missing data section.

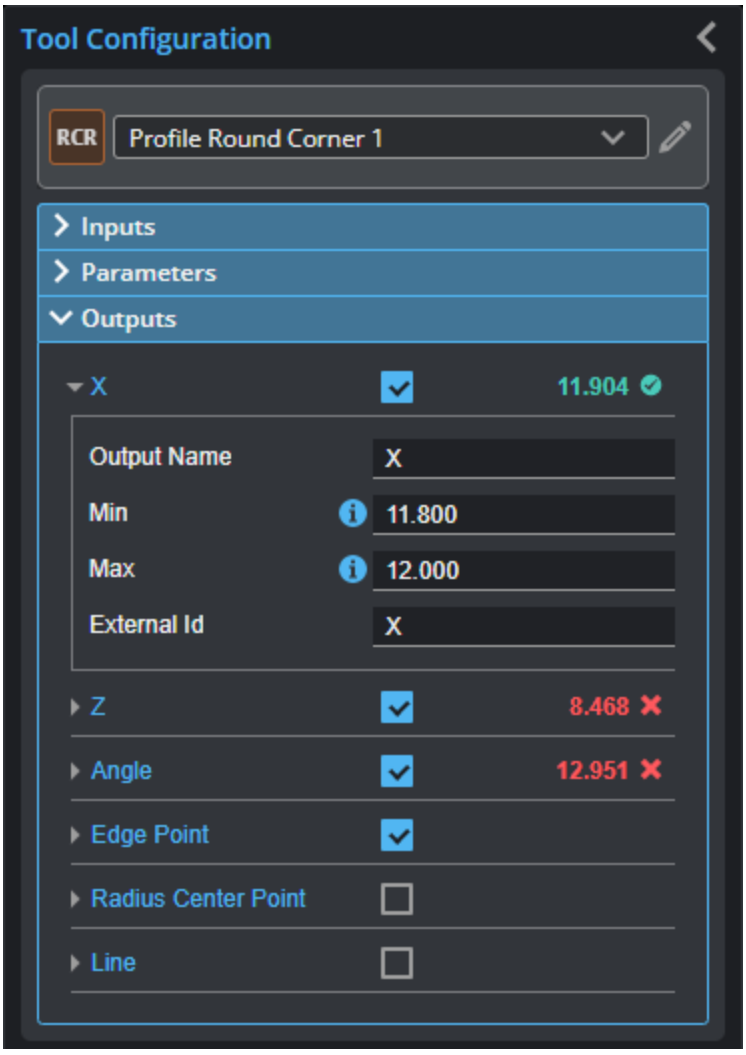
Parameter	Description
	
Min Depth	Defines the minimum depth before an opening could be considered to have a potential edge. The depth is the perpendicular distance from the fitted surface line. 
Surface Width	The width of the surface area in which data is used to form the fitted surface line. This value should be as large as the surface allows. 
Surface Offset	The distance between the edge region and the surface region. 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**. 
Nominal Radius	The radius of the curve edge that the tool uses to locate the edge region. 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. 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). 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 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

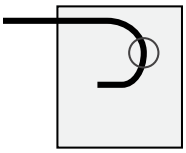
All tools provide measurements, geometric features, or data as outputs.

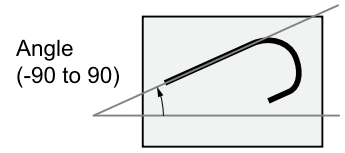
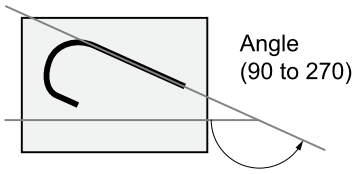


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 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 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 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.	
	

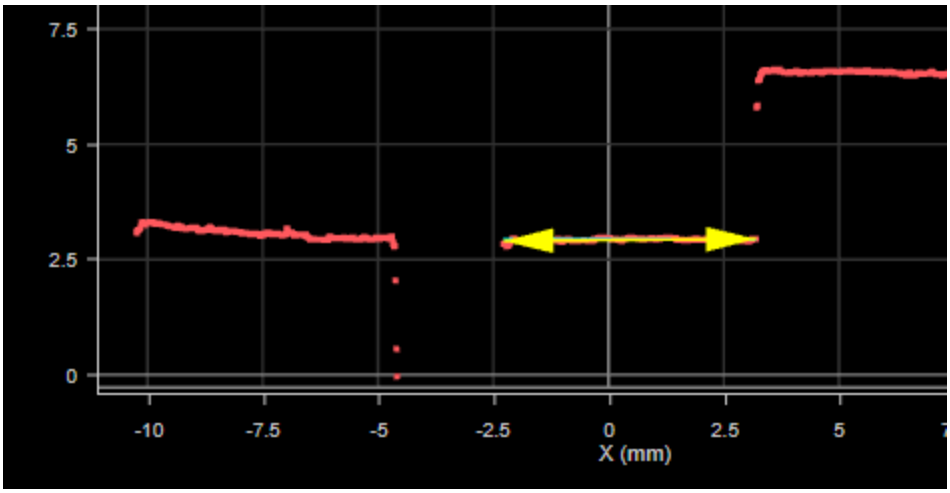
Features

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 175.

Profile Strip

The Strip tool returns various measurements related to a strip, such as its X and Z positions, width, and height.



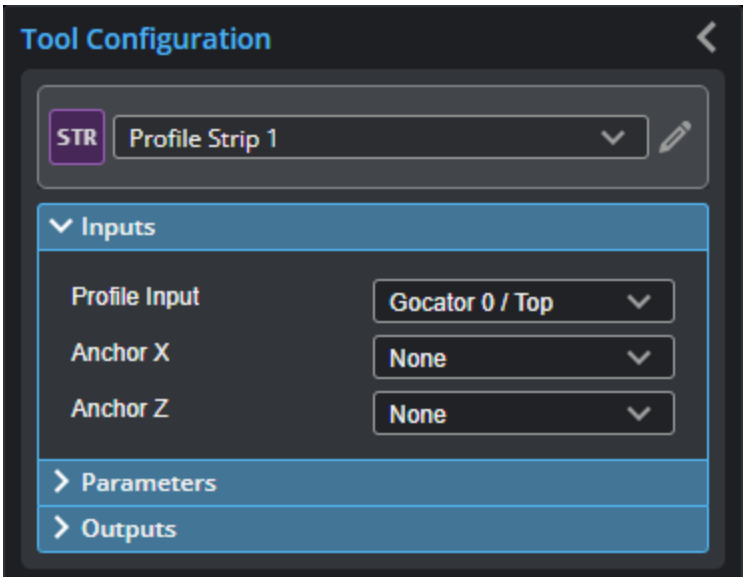
The tool lets you optionally set an index to return the measurements of a specific strip when more than one is visible in the region of interest. If you need to return multiple strips from a profile, add a Profile Strip tool for each strip, configure it to represent the desired strip, and set its **Selection 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 286. 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 153.

Inputs

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



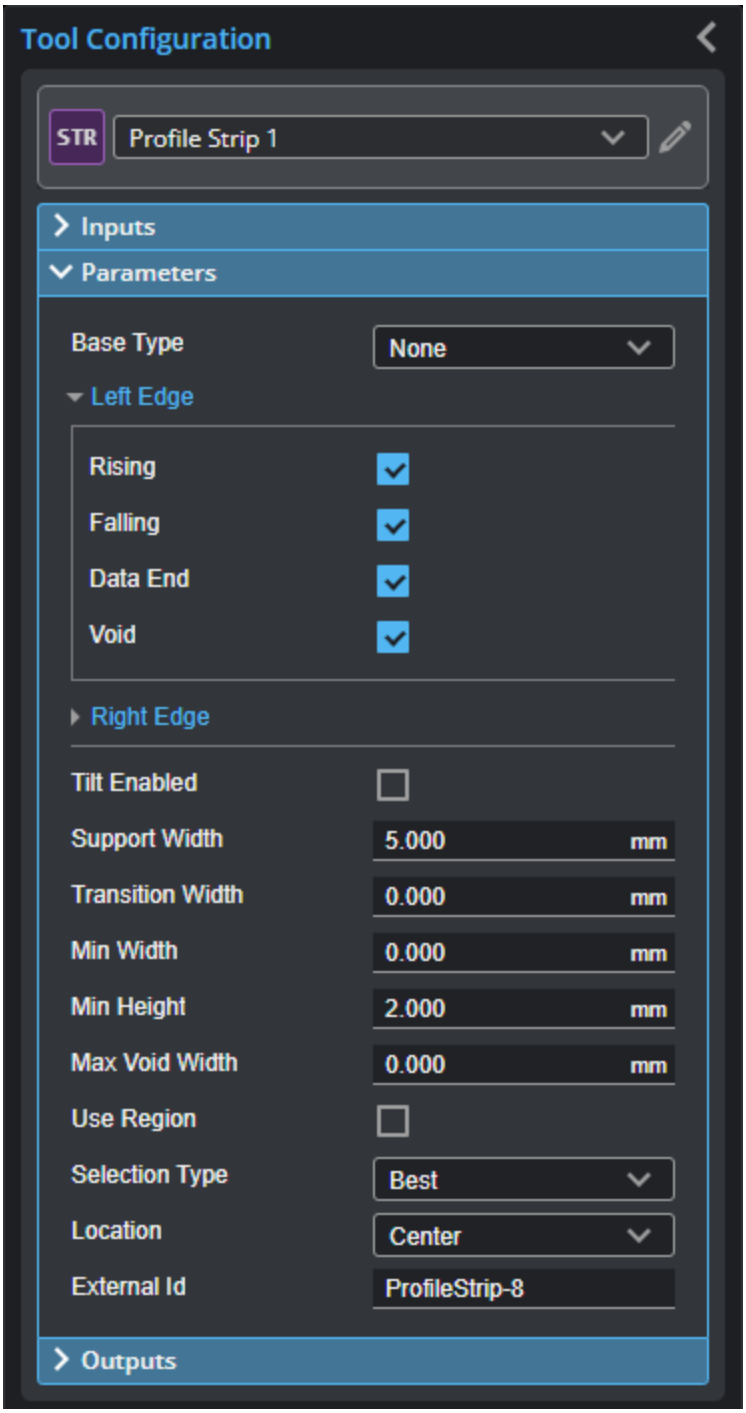
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

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.

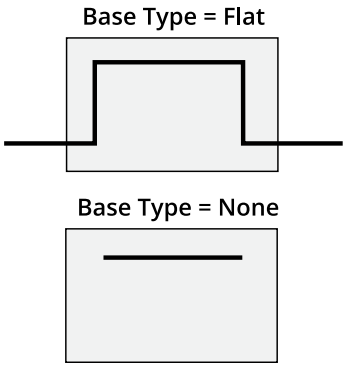
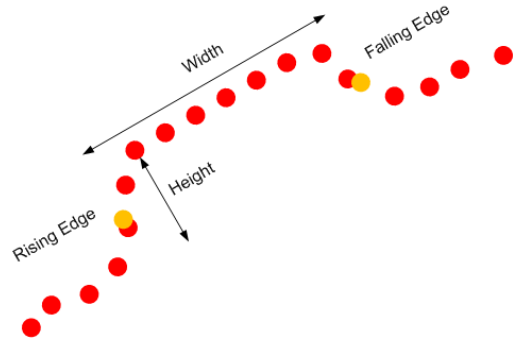
Parameters

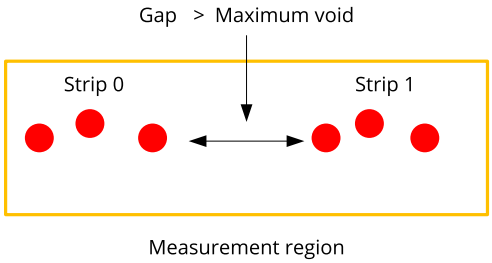
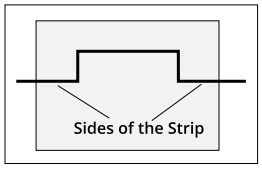
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

Parameter	Description
Base Type	Affects detection of rising and falling edges.

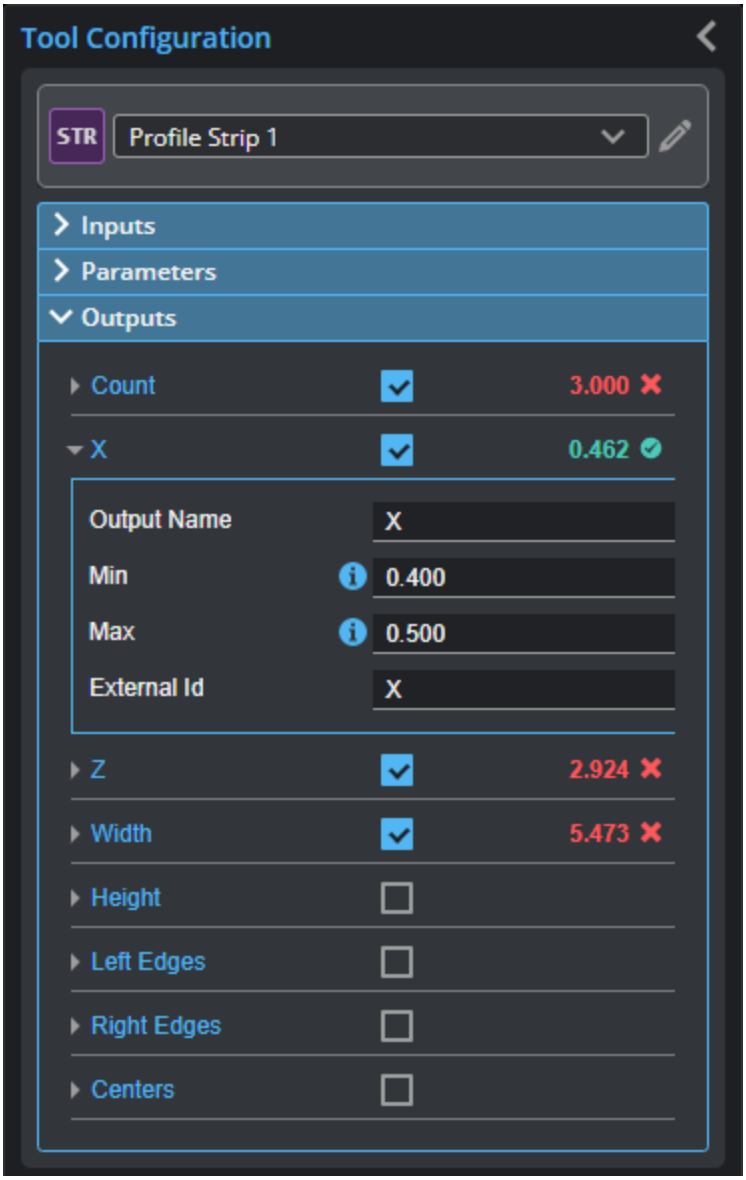
Parameter	Description
	 When **Base Type** is set to **Flat**, both strip (raised area) and base support regions are needed. When set to **None**, only a point that deviates from a smooth strip support region is needed to find a rising or falling edge.
Left Edge Right Edge	Specifies the features that will be considered as the strip's left and right edges. You can select more than one condition. **Rising** - Rising edge detected based on the strip edge parameters. **Falling** - Falling edge detected based on the strip edge parameters. **Data end** - First valid profile data point in the measurement region. **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. For the definitions of these conditions, see *Strip Start and Terminate Conditions* on page 286.
Tilt Enabled	Enables and disables tilt correction. 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. 
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 288.
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 288.
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 288.
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**.  When occlusion and exposure causes data drops, use a gap filling filter in a Profile Filter tool to fill the gaps; for more information, see *Profile Filter* on page 227.
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.  For more information, see *Regions* on page 163.
Location *(Strip Height, Strip X, and Strip Z measurements only)*	Specifies the strip position from which the measurements are performed. **Left** - Left edge of the strip. **Right** - Right edge of the strip. **Center** - Center of the strip.
Selection Type	Specifies how a strip is selected when there are multiple strips within the measurement area. **Best** - The widest strip. **Index Left** - 0-based strip index, counting from left to right. **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

Parameter	Description
	"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 666.

Outputs

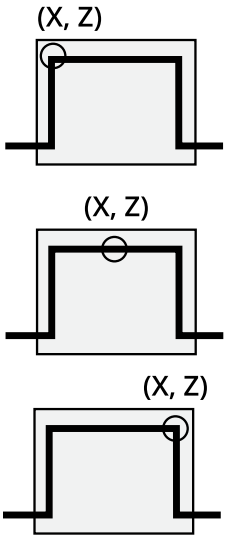
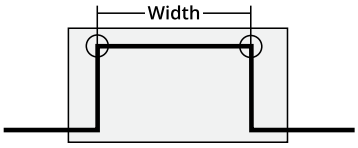
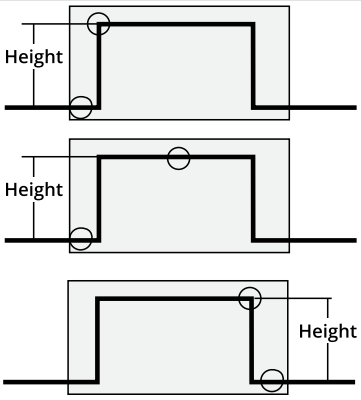
All tools provide measurements, geometric features, or data as outputs.



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

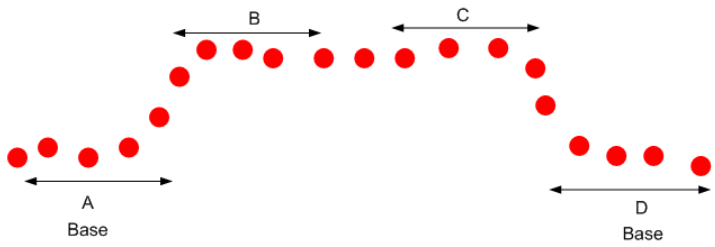
Measurement	Illustration
Count The number of strips.	
X, Z Measures the X and Z position, respectively, of a strip.	
Width Measures the width of a strip.	
Height Measures the height of a strip.	

Features

Type	Description
Left Edges Right Edges Centers	Arrays of Point geometric features representing the left edges, right edges, and centers of all strips, from left to right.

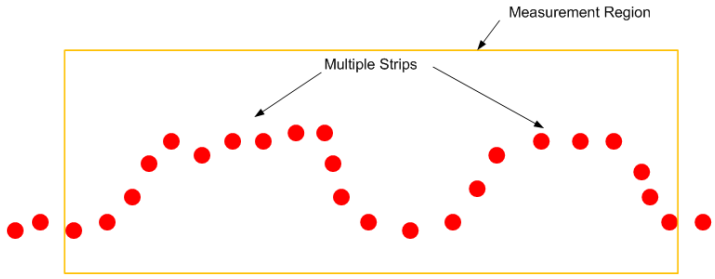
Strip Algorithm

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.

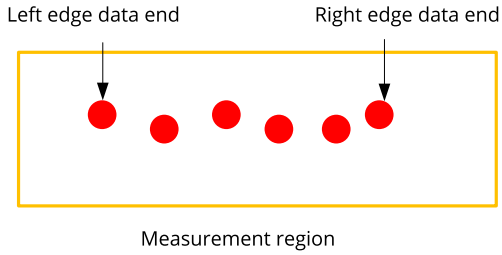
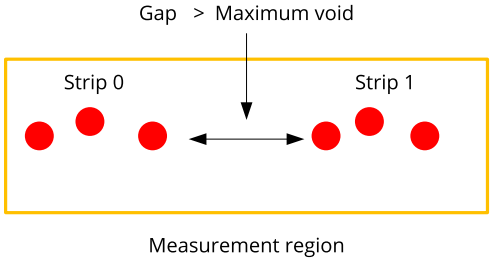
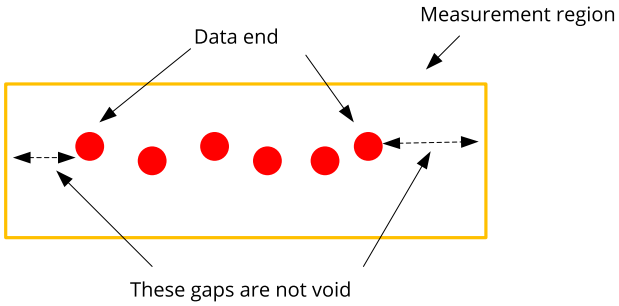


Strip Start and Terminate Conditions

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.

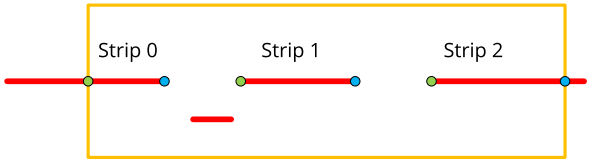
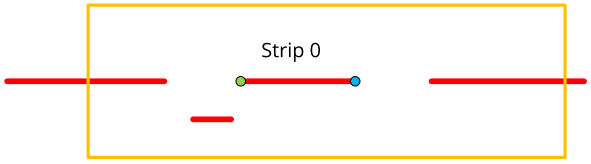
Start / terminate conditions

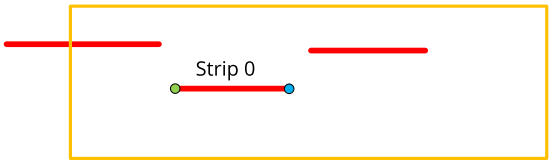
Condition	Description
Rising	Rising step edge detected based on the strip edge parameters. For details on how the step edge is detected, *Strip Step Edge Definitions* on page 288.
Falling	Falling step edge detected based on the strip edge parameters. For details on how the step edge is detected, *Strip Step Edge Definitions* on page 288.
Data end	The first (for the left edge) or the last (for the right edge) valid profile data point in the measurement region.

Condition	Description
	
Void	Gaps in the data that are larger than the maximum void threshold.  Gaps at the ends of the measurement region's boundary are not considered as a void. 

The following examples show how the parameters affect the strip detection in different scenarios.

Left and Right Edge conditions

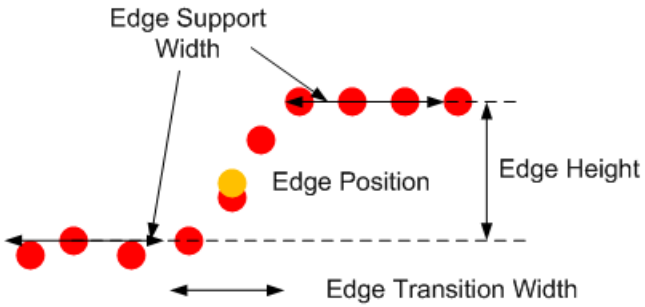
Condition	Example
Left: Rising, data end, void Right: Falling, data end, void	
Left: Rising, void Right: Falling, void	

Condition	Example
Left: Rising Right: Data end, void	
Left: Data end, void Right: Falling	
Left: Falling 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.

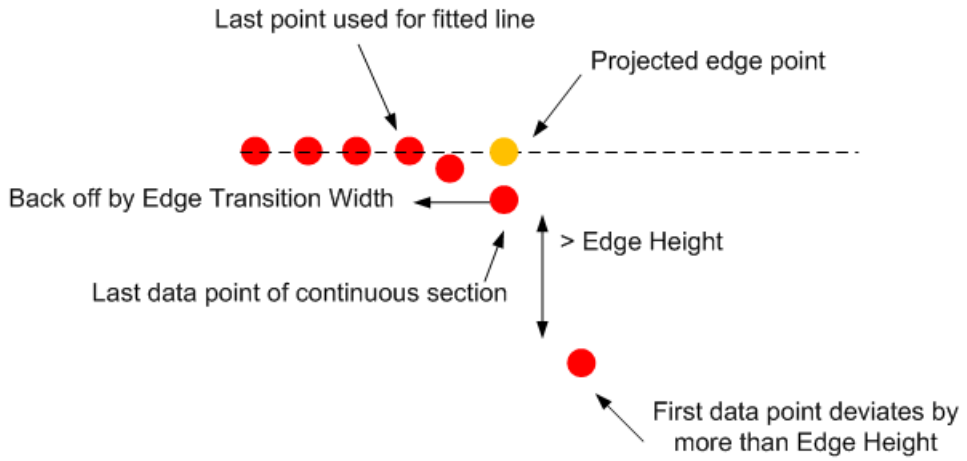
When Base Type is set to Flat, the regions around the edges are visible and the edge positions are between the base and the strip surface.



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.

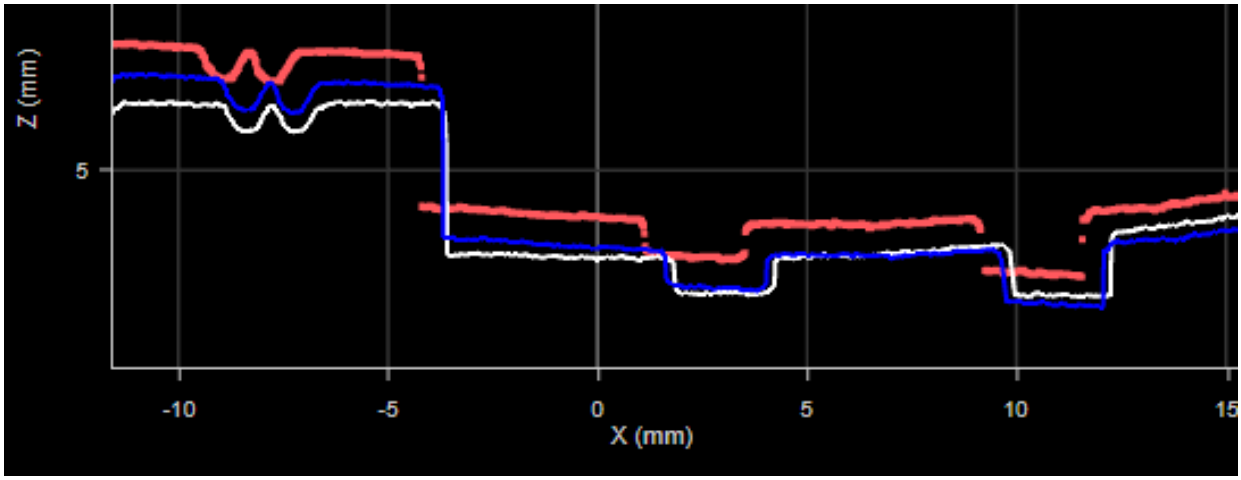
Profile Template Matching

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.

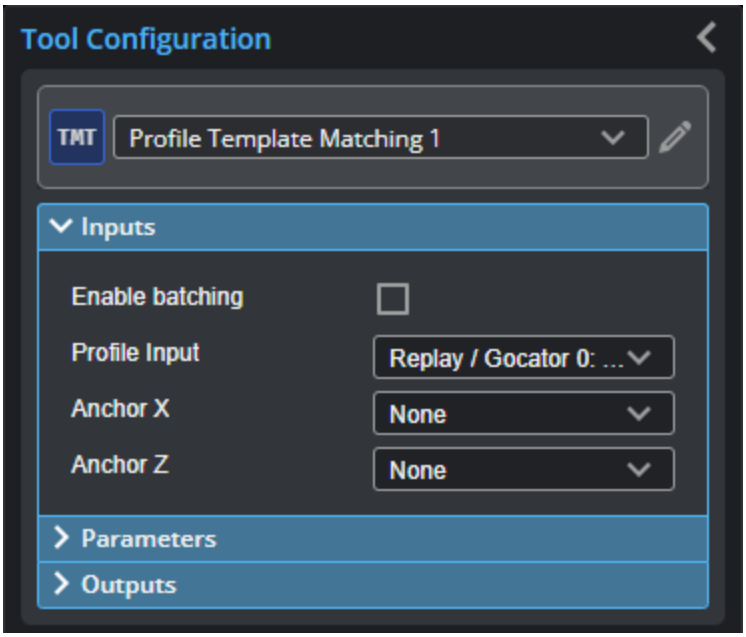
Note that in the image above, the tool is performing only a rough alignment to ensure that the different profiles are clearly visible. Typically, the aligned profile will be on top of the master profile.

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 153.

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 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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:

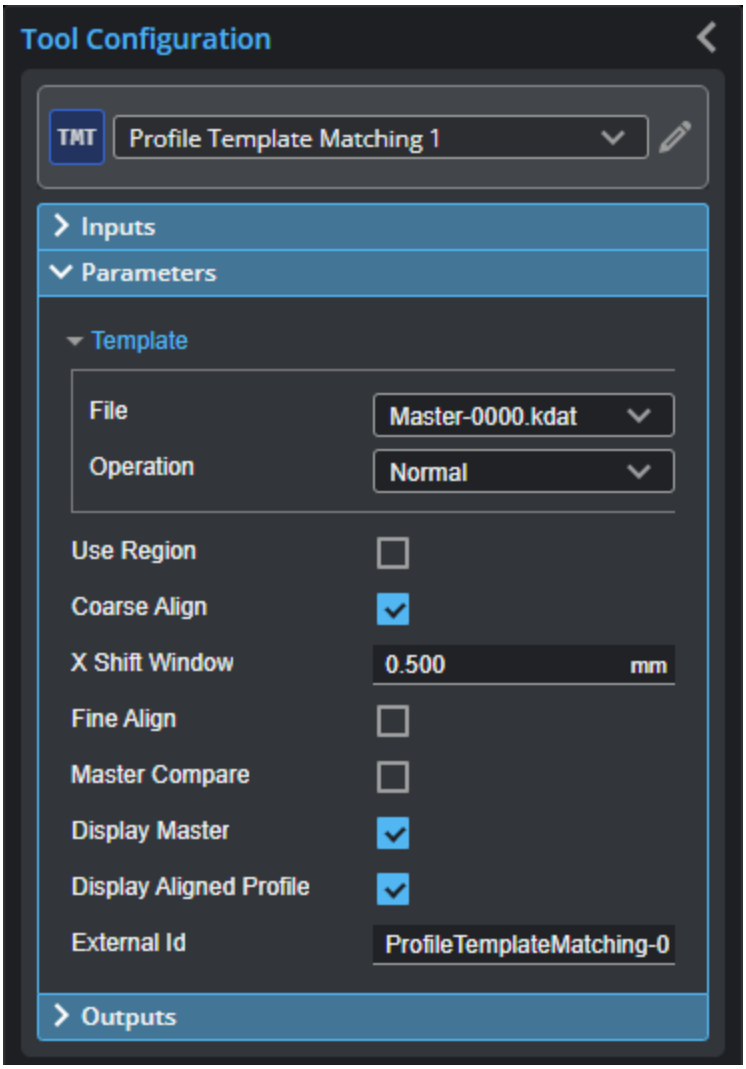
- Max Height Difference
- Max Difference Position X
- Max Difference Position Z

- Standard Deviation
- Difference Average
- Difference Sum
- Variance
- Matching Score

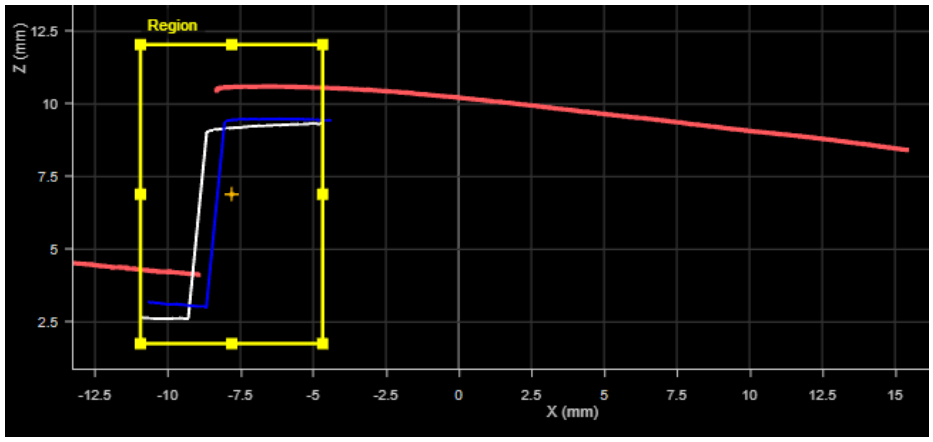
Also, for these “master compare” measurements, if the profile has been aligned to the master (either **Coarse Align** or **Fine Align** is enabled), the measurements compare the *aligned* profile and the master. If the profile has not been aligned (both alignment parameters are disabled), the measurement compares the *original* (unaligned) profile and the master.

Parameters

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



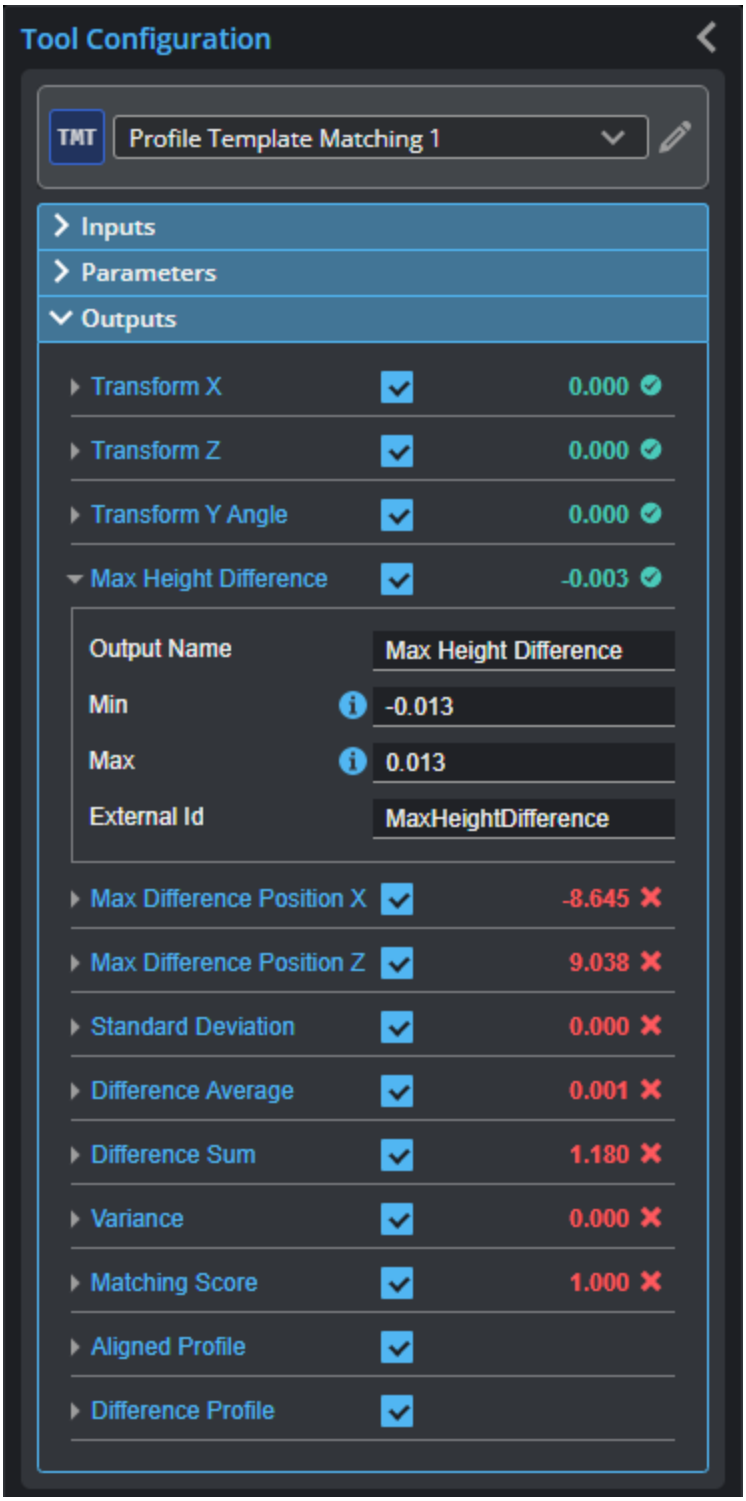
Parameters

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: • **Normal**: Selected by the tool after you perform another file operation. • **Create**: Creates a new template file. • **Load**: Loads the template selected in **File**. • **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. • **Delete**:Deletes the template file selected in **File**. • **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.) If this option is not checked, the tool performs matching using data from the entire active area. For more information on regions, see *Regions* on page 163.
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. 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. 
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.) 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 666.

Outputs

All 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 **Transform Z** The distance the profile has shifted on the X and Z axis after alignment to the master, respectively.
Transform Y Angle The rotation of the profile around the Y axis after alignment.
Max Height Difference The maximum height difference between the profile and the master.
Max Difference Position X **Max Difference Position Z** The X and Z positions of the maximum height difference between the profile and the master.
Standard Deviation The standard deviation between the profile and the master.
Difference Average The average difference on the Z axis between the profile and the master.
Difference Sum The sum of the differences on the Z axis between the profile and the master.
Variance Returns the variance of a difference profile calculated by subtracting the current profile from the master.
Matching Score 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. Z values in the difference profile above 0 represent data points higher in the profile than in the master. Z values in the difference profile below 0 represent data points lower in the profile than in the master. Z values in the difference profile at 0 represent data points that are the same in the profile and the master.

Raw Profile Matching

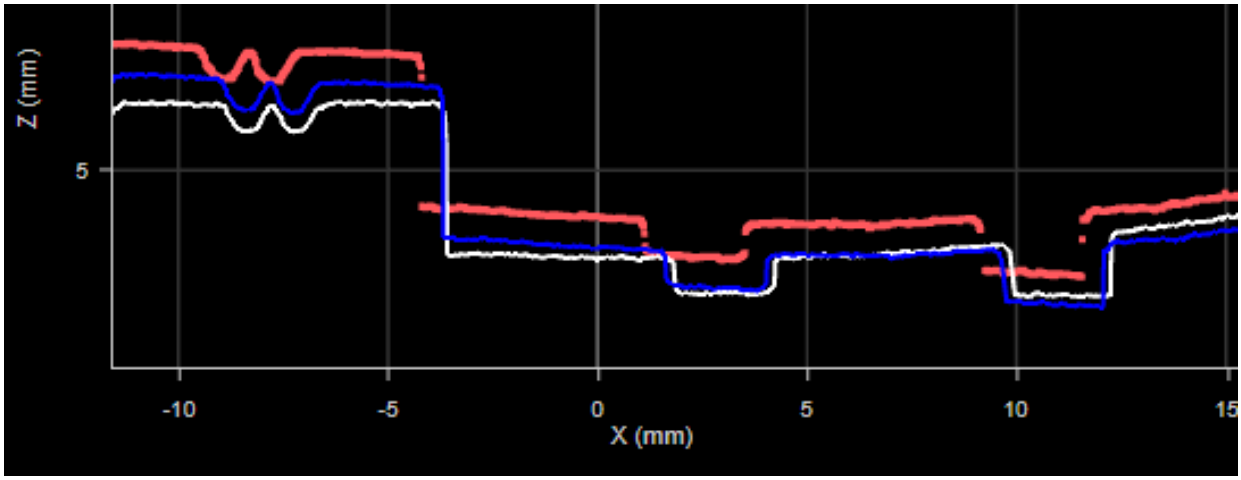
> The Raw Profile Matching tool takes unresampled profile data as input (the **Enable uniform spacing** setting is disabled on Acquire > Scanners).

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:



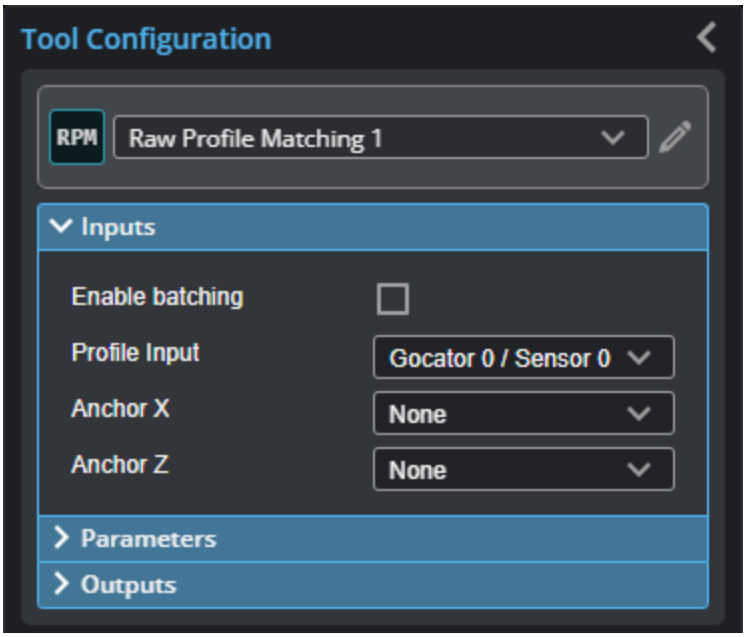
The master profile is rendered in white. The aligned profile is rendered in blue. The current profile is rendered in red.

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 153.

Inputs

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



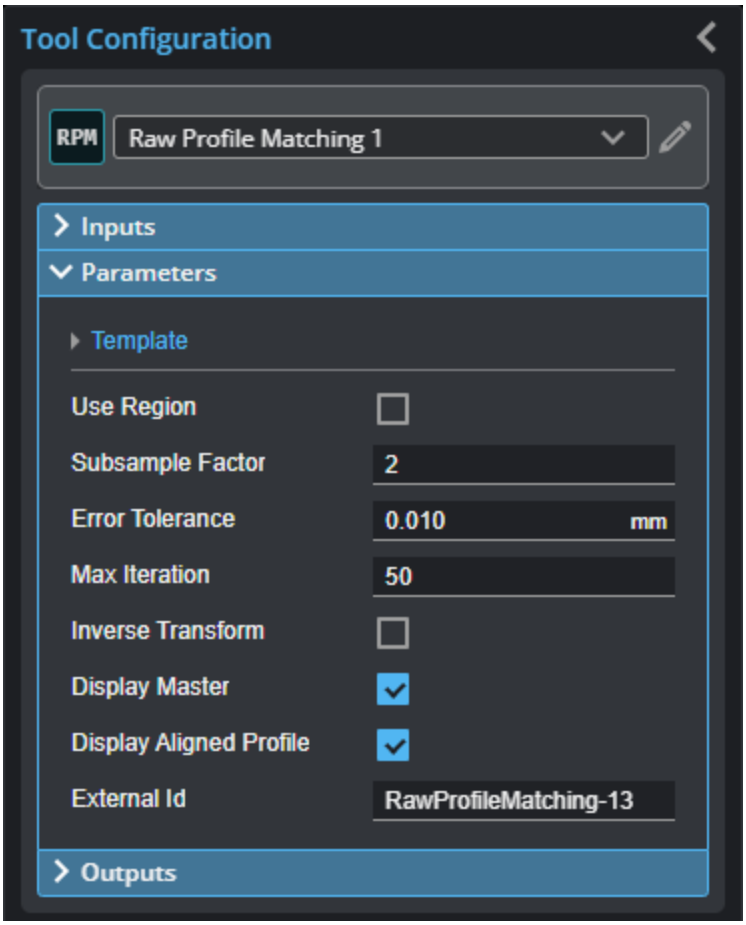
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.

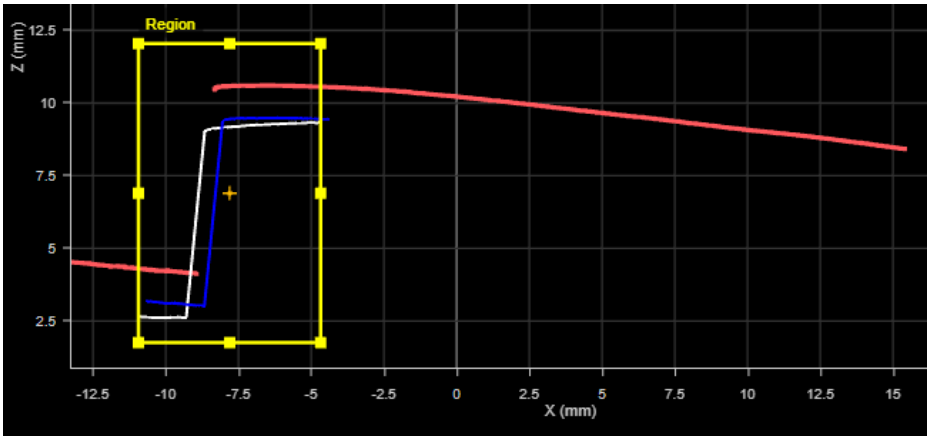
Parameters

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



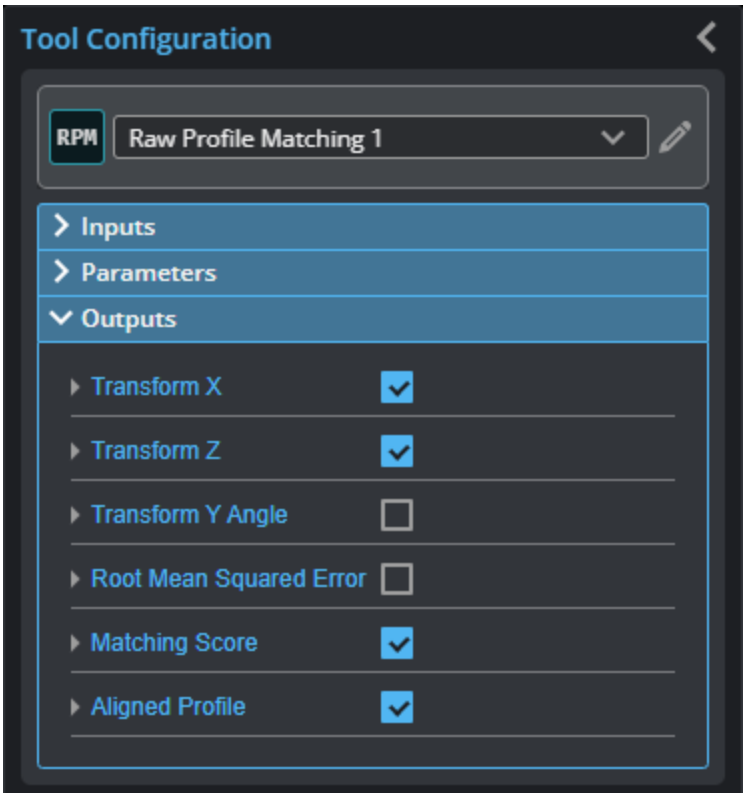
Parameters

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: • **Normal**: Selected by the tool after you perform another file operation. • **Create**: Creates a new template file. • **Load**: Loads the template selected in **File**. • **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. • **Delete**:Deletes the template file selected in **File**. • **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. For more information on regions, see *Regions* on page 163.
Match Region	When **Use Region** is enabled, provides settings for the size and position of the region in which the matching (alignment) is performed.. 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.  (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 666.

Outputs

All 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

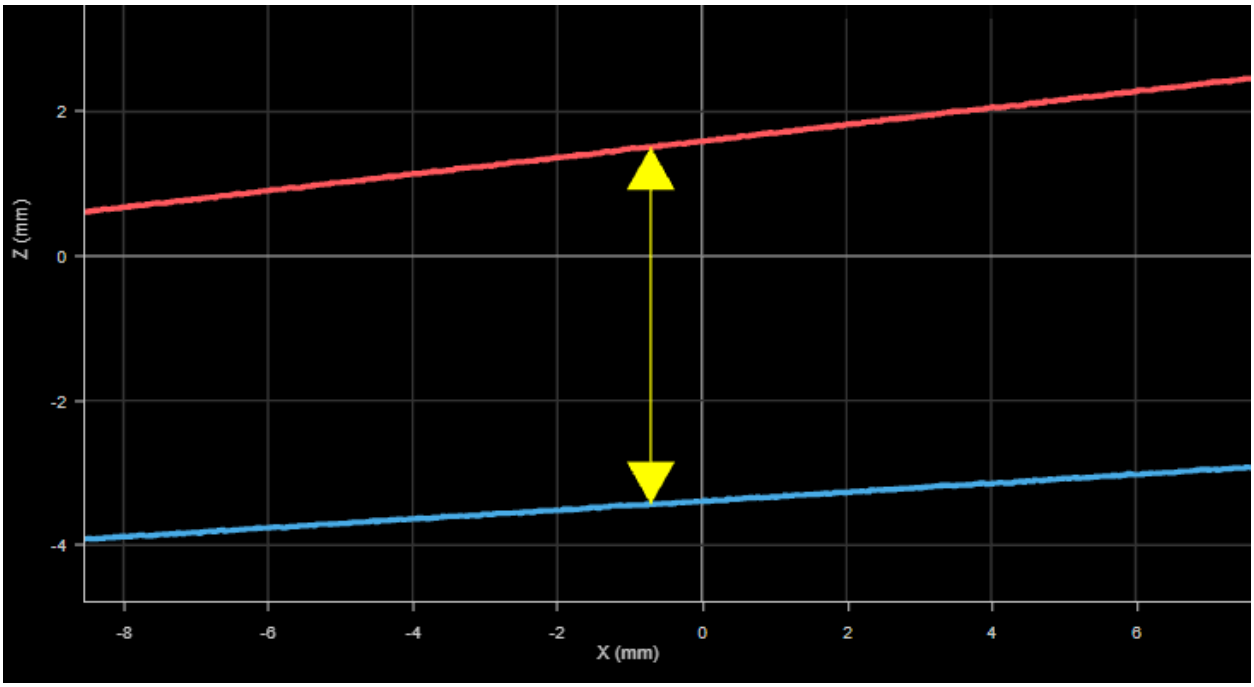
Measurement
Transform X **Transform Z** The distance the profile has shifted on the X and Z axis after alignment to the master, respectively.
Transform Y Angle The rotation of the profile around the Y axis after alignment.
Root Mean Squared Error The root mean squared error of the alignment.
Matching Score 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.

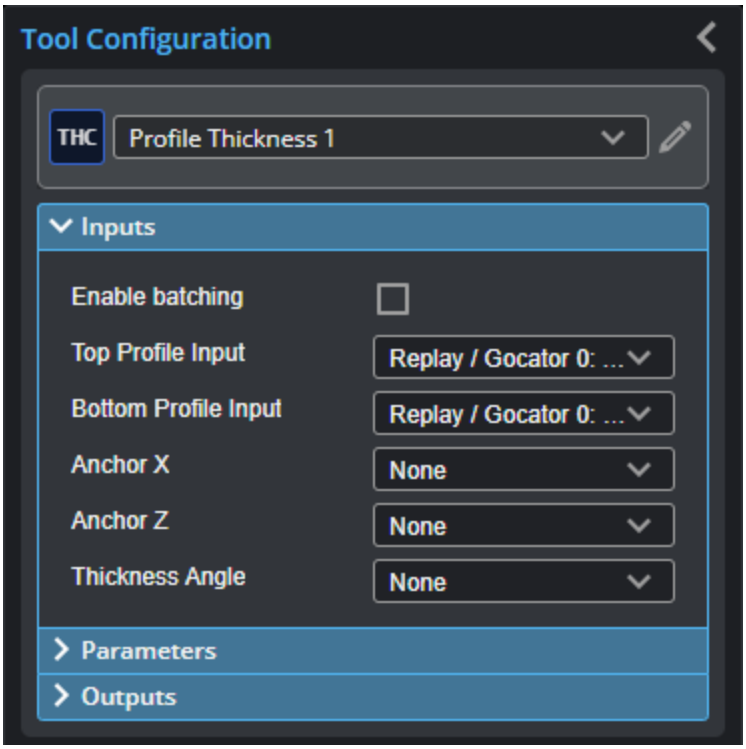


The tool also lets you specify an angle measurement relative to which the tool performs the thickness measurements, up to a maximum of 20 degrees, to compensate for minor tilt of the target. To get the compensation angle, you could first fit a straight line to the top profile using the Profile Line tool, and pass that tool's Angle measurement to Profile Thickness. (For information on Profile Line, see *Profile Line* on page 245.)

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

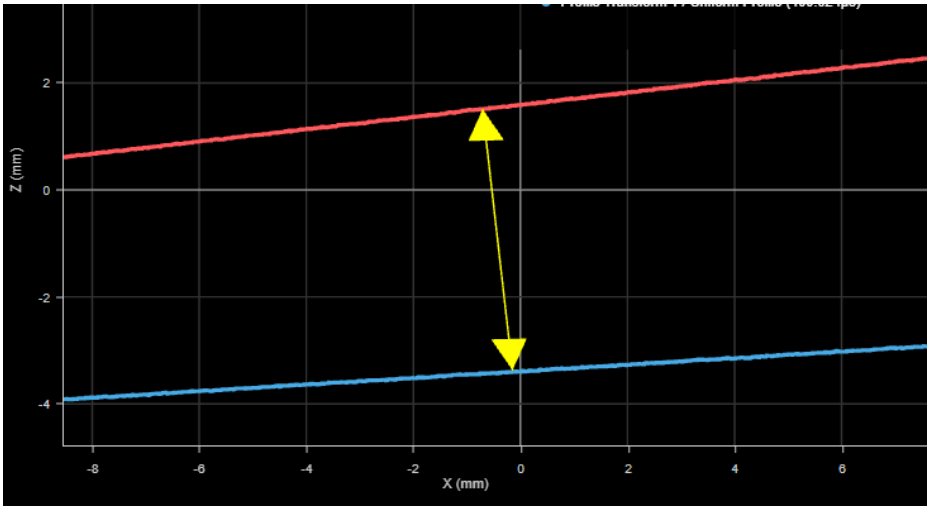
You configure the tool's inputs in the expandable **Inputs** section.



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 176.

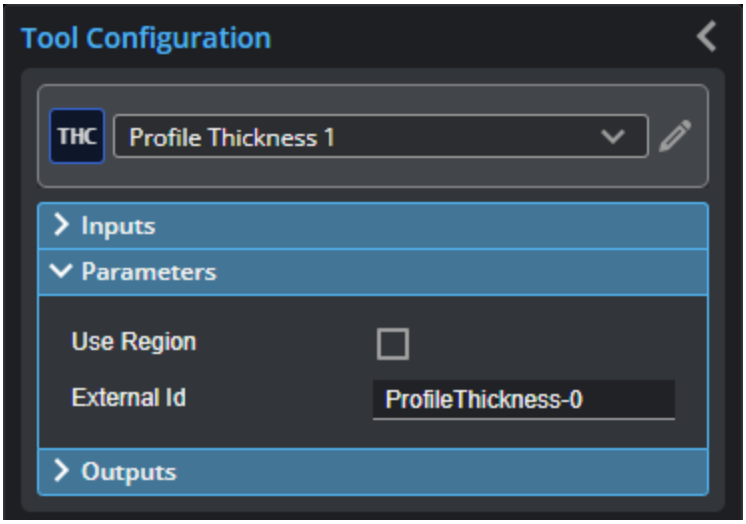
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.



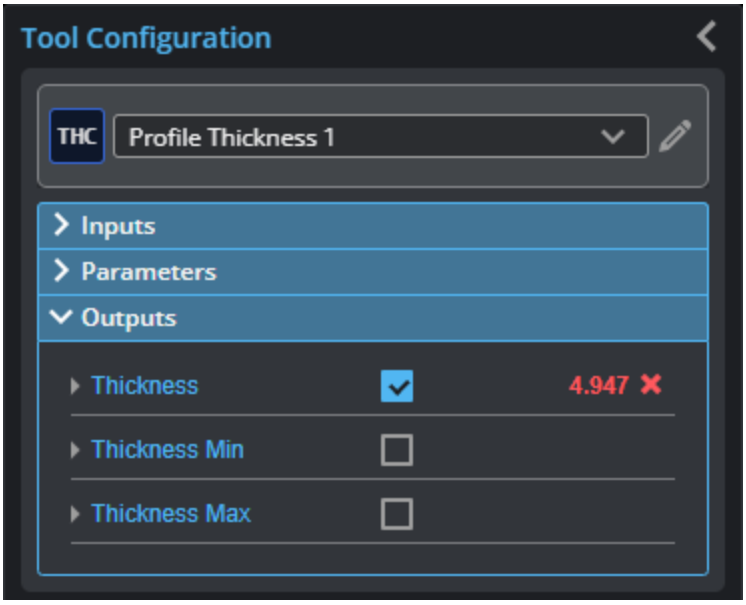
Parameters

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 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

All 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.

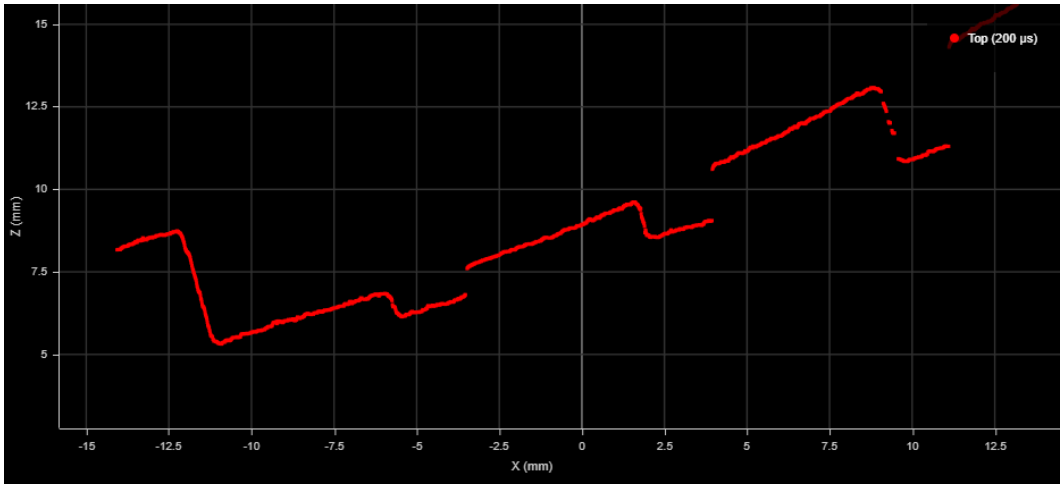
Measurements

Measurement
Thickness The thickness measured in the scan data.
Thickness Min The minimum thickness measured in the scan data.
Thickness Max The maximum thickness measured in the scan data.

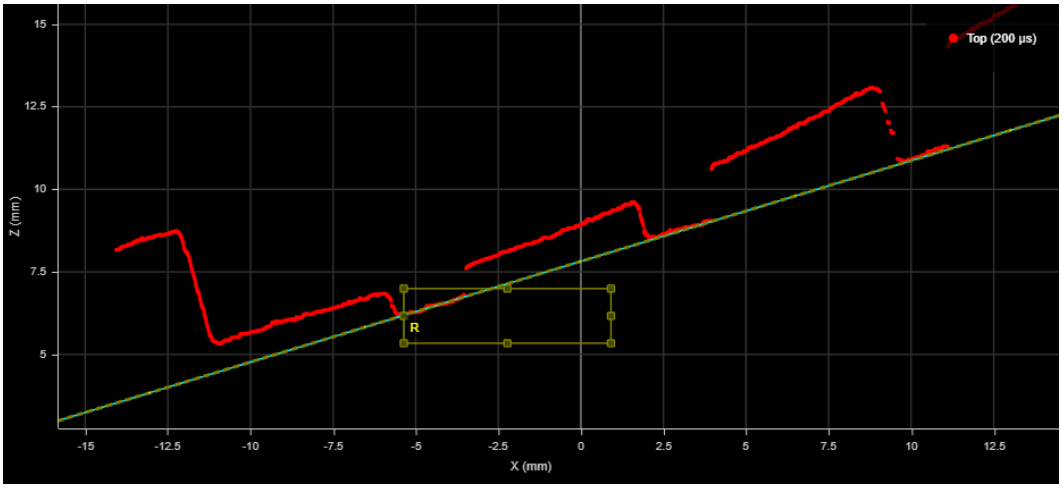
Profile Transform

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).

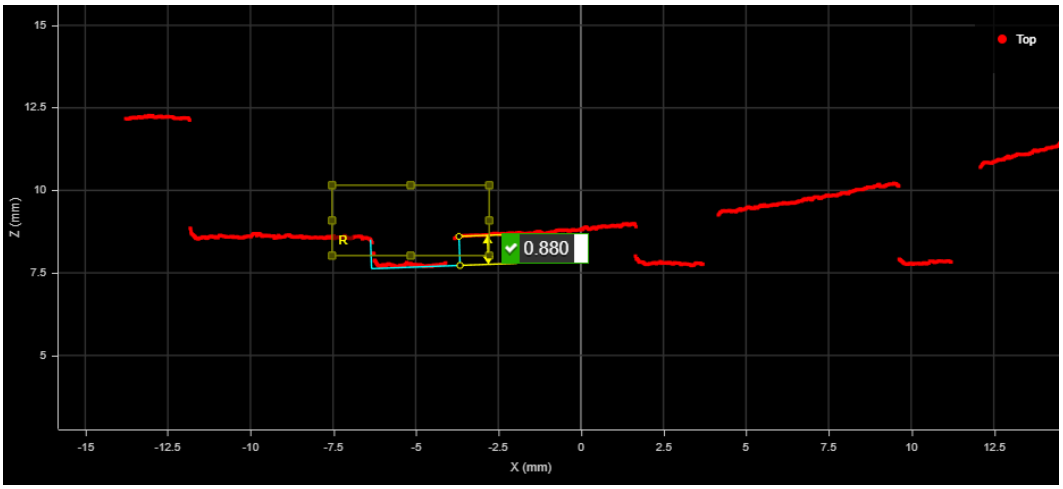
For example, in the following, if you want to measure the characteristics of the first groove on the left, you can use the tool to rotate the profile.



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.



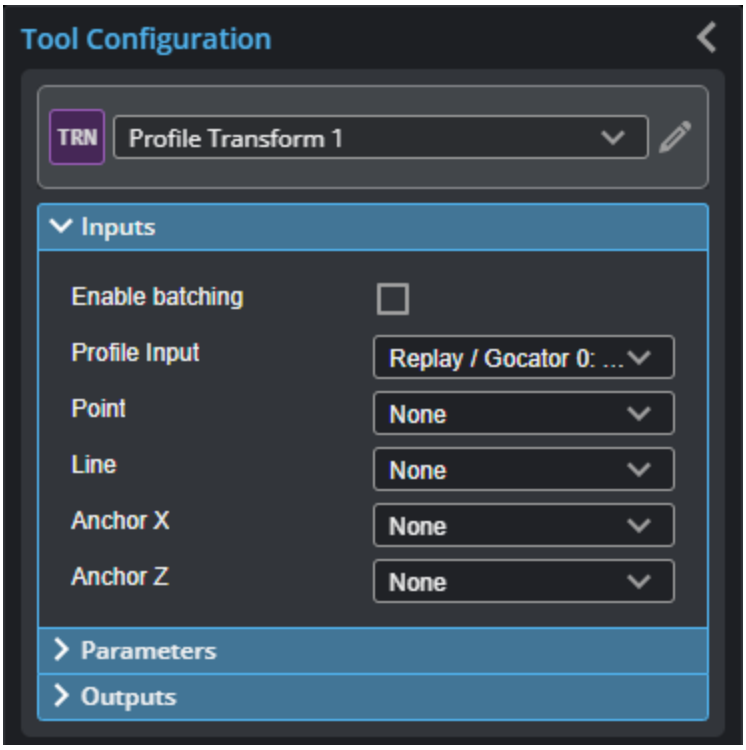
A Profile Transform tool takes the line geometric feature as input, and the transformed profile from that tool is used as input for a Profile Groove tool, which measures the groove's characteristics:



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



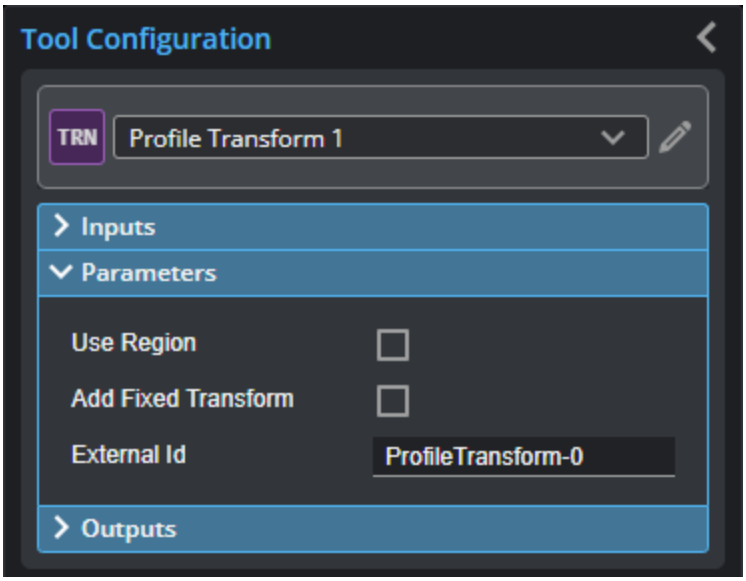
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each profile in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.



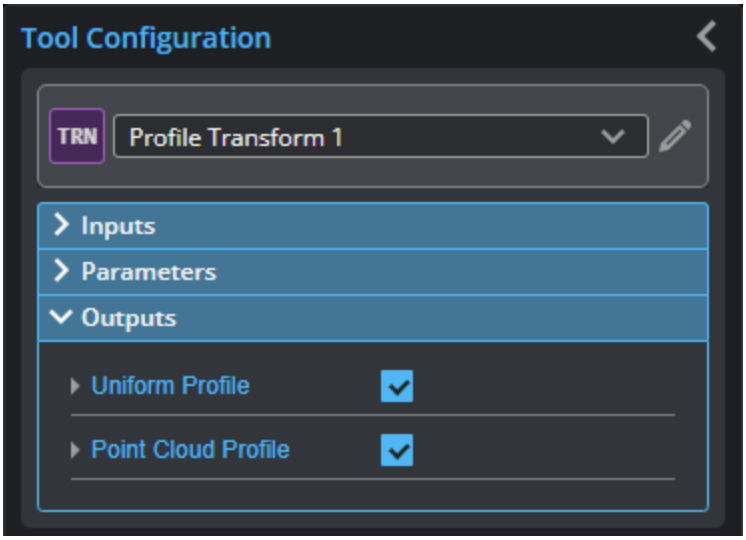
Parameters

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. 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 163.
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 666.

Outputs

All 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 G2 and G5 sensors, on the **Scan** page, by enabling continuous Surface generation and configuring the part detection settings.
- By using the Surface Blob or Surface Segmentation measurement tools (for more information, see *Surface Blob* on page 321 and *Surface Segmentation* on page 489).
- For G3 sensors (and G2 or G5 sensors when Surface generation is *not* set to Continuous), by using the Surface Part Detection tool.
- For G2 and G5 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 155.) 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 Through Open filter, some connections between parts can be separated, but the control is more limited than with Surface Segmentation.	Yes

	Part Detection	Surface Blob	Surface Segmentation
Supports background present	Yes Height threshold must be set above or below the background	Yes Height threshold must be set above or below the background	Yes
Supports background with significant tilt or intensity gradient	No Fixed height threshold is used	No Fixed height threshold is used	Yes 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 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.

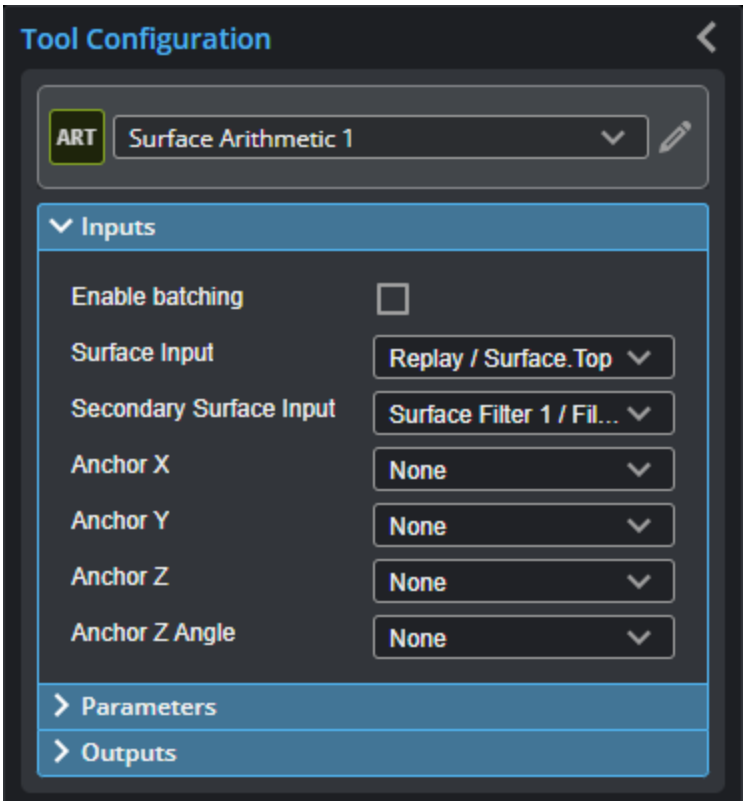
Surface Align Wide

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 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 176.

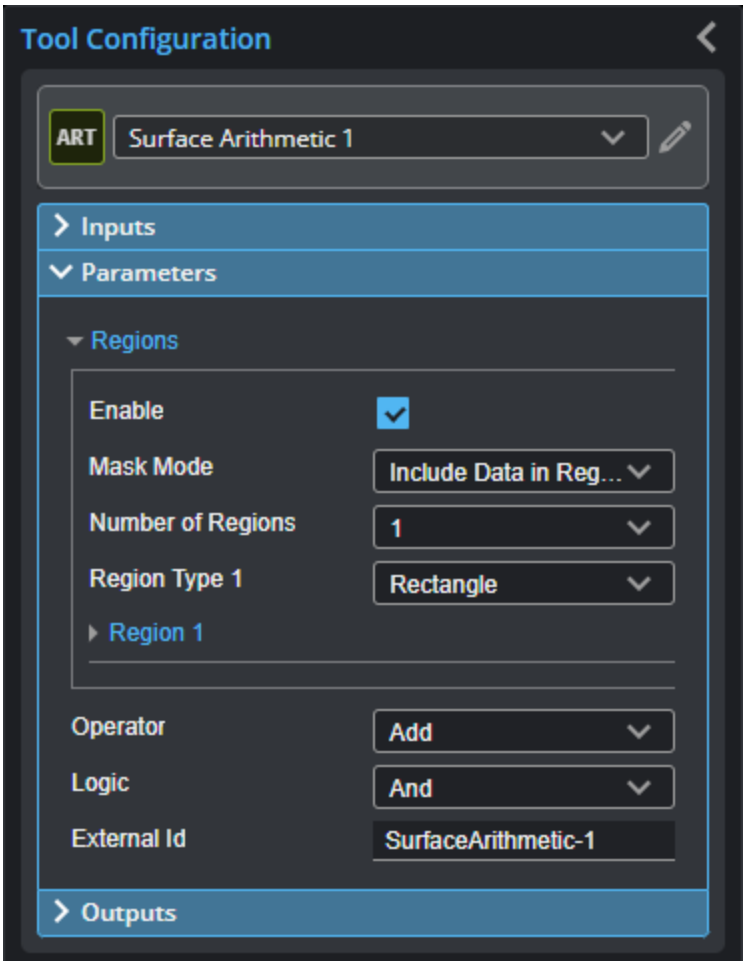
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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 Z 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.

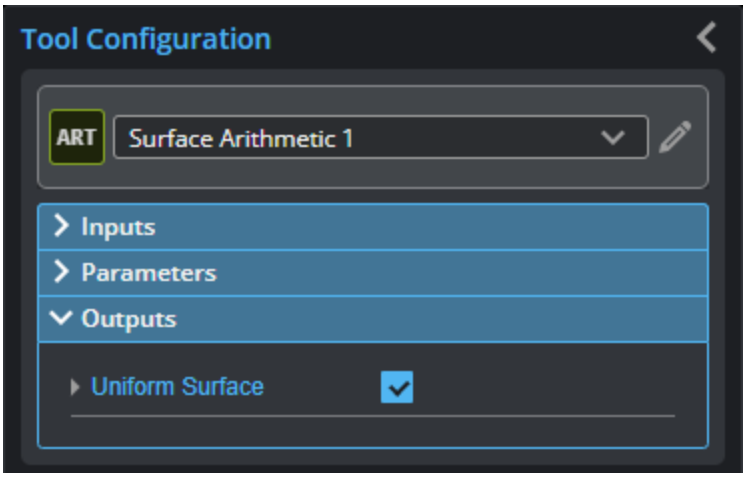


Parameters

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 Number of Regions 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 164. For general information on regions and the difference between standard and

Parameter	Description
Region {n}	"flexible" regions, see *Regions* on page 163.
Operator	One of the following: **Add**: Adds the height values of the corresponding data points in the two sources. **Subtract**: Subtracts the height values of the corresponding data points in the two sources. **Average**: Averages the height values of the corresponding data points in the two sources. **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 666.

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 666.

Data

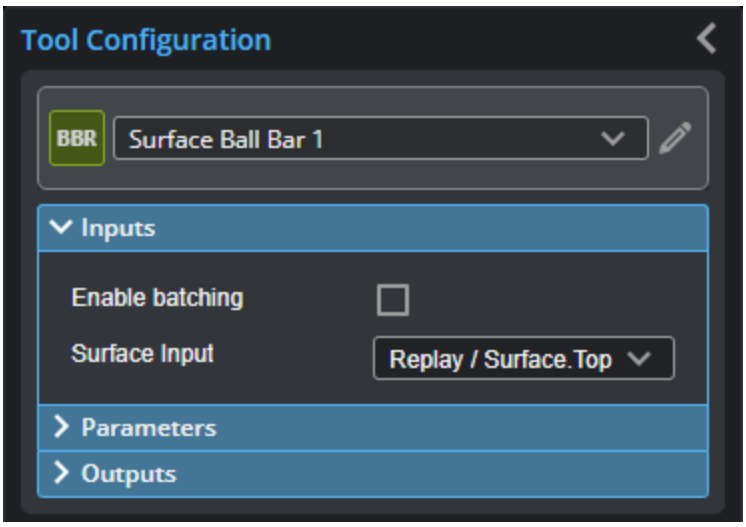
Type	Description
Uniform Surface	The processed surface data.

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.

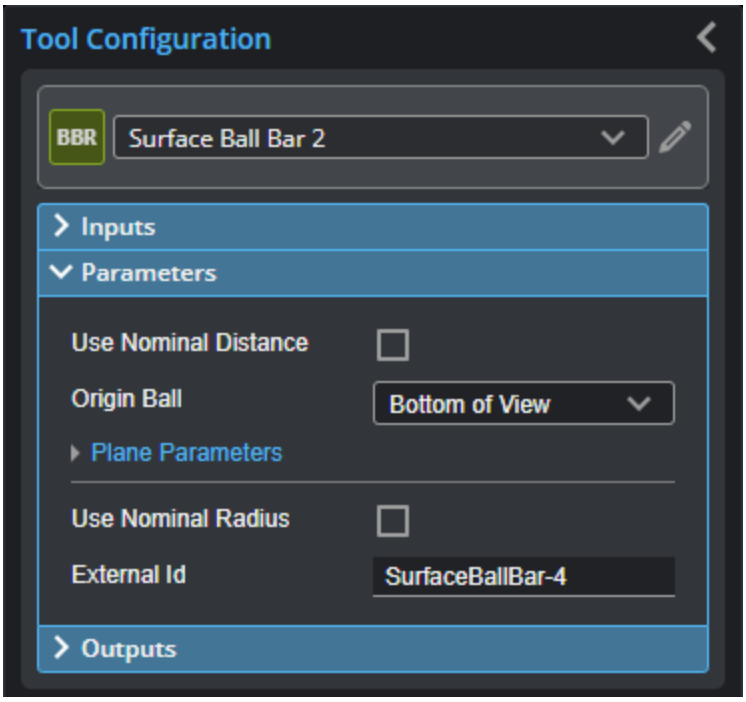


Inputs

Name	Description
Enable Batching	Leave this setting unchecked.
Surface Input	The data the tool applies measurements to or processes.

Parameters

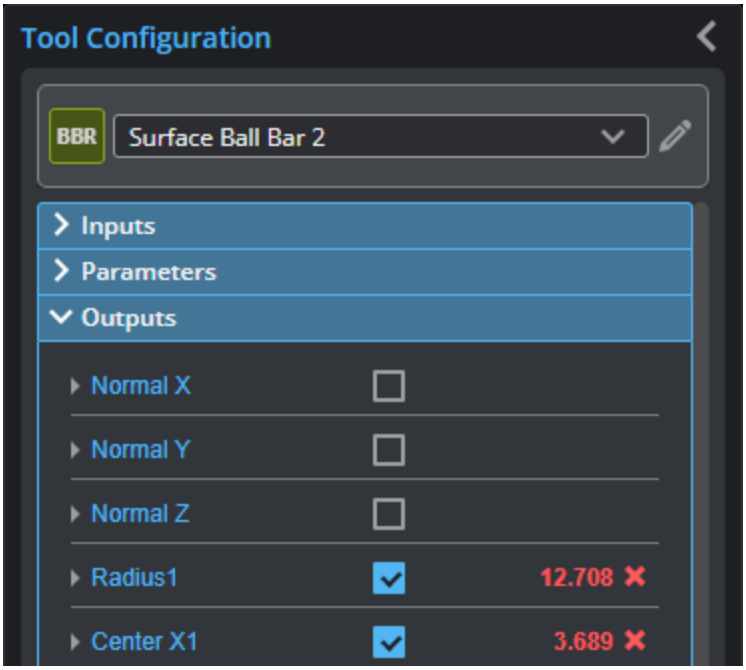
You configure the tool's parameters in the expandable **Parameters** section.



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 666.

Outputs



Measurements

Measurement
Normal X / Y / Z These measurements return the X, Y, and Z components of the normal vector of the surface surrounding the calibration target.
Radius1 **Radius2** These measurements return the radius of each ball.
Center X1 / Y1 / Z1 **Center X2 / Y2 / Z2** These measurements return the X, Y, and Z positions of the centers of the spheres fitted to the balls. Ball 1 (Center X1 / Y1 / Z1) is always used as the origin. (Corresponds to the values returned in Tx / Ty / Tz.)
Distance 3D The direct distance between the centers of the spheres fitted to the balls.
Ix / Iy / Iz **Jx / Jy / Jz** **Kx / Ky / Kz** 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 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.

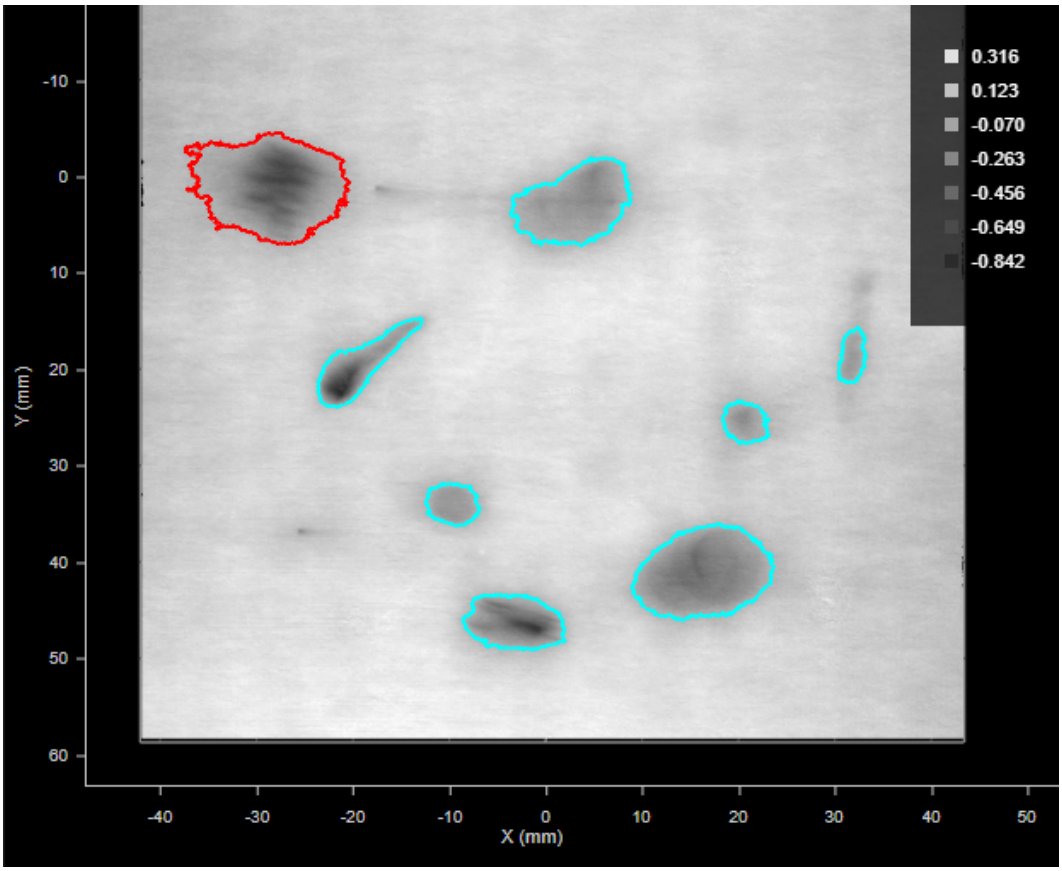


The Surface Blob tool provides functionality similar to the Surface Segmentation tool. For information on the Surface Segmentation tool, see *Surface Segmentation* on page 489.

For a comparison of these tools and the part detection capabilities you can configure on the **Scan** page, see *Isolating Parts from Surface Data* on page 310.

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.



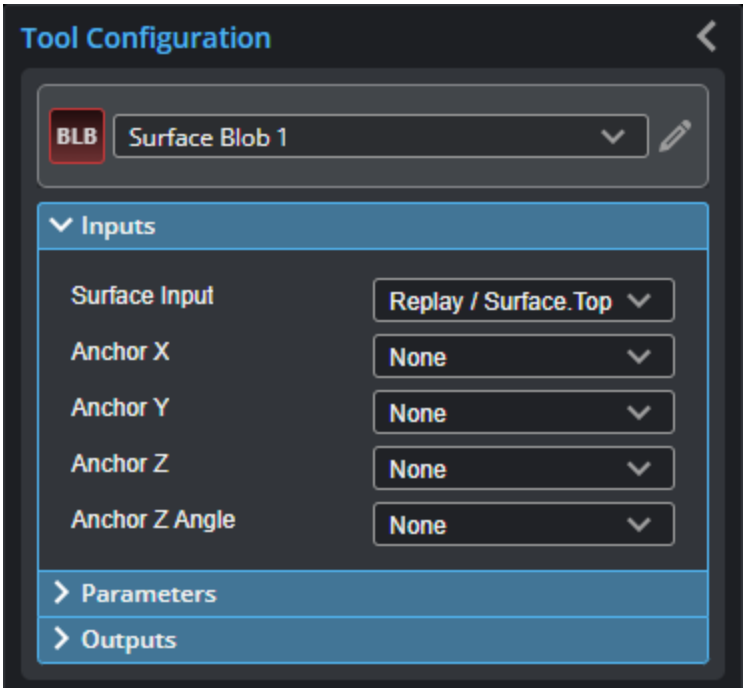
Several dents outlined by the tool on a surface in cyan. The currently selected blob is outlined in red. (Grayscale heightmap mode is used to better see the outlines.)

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 153.

Inputs



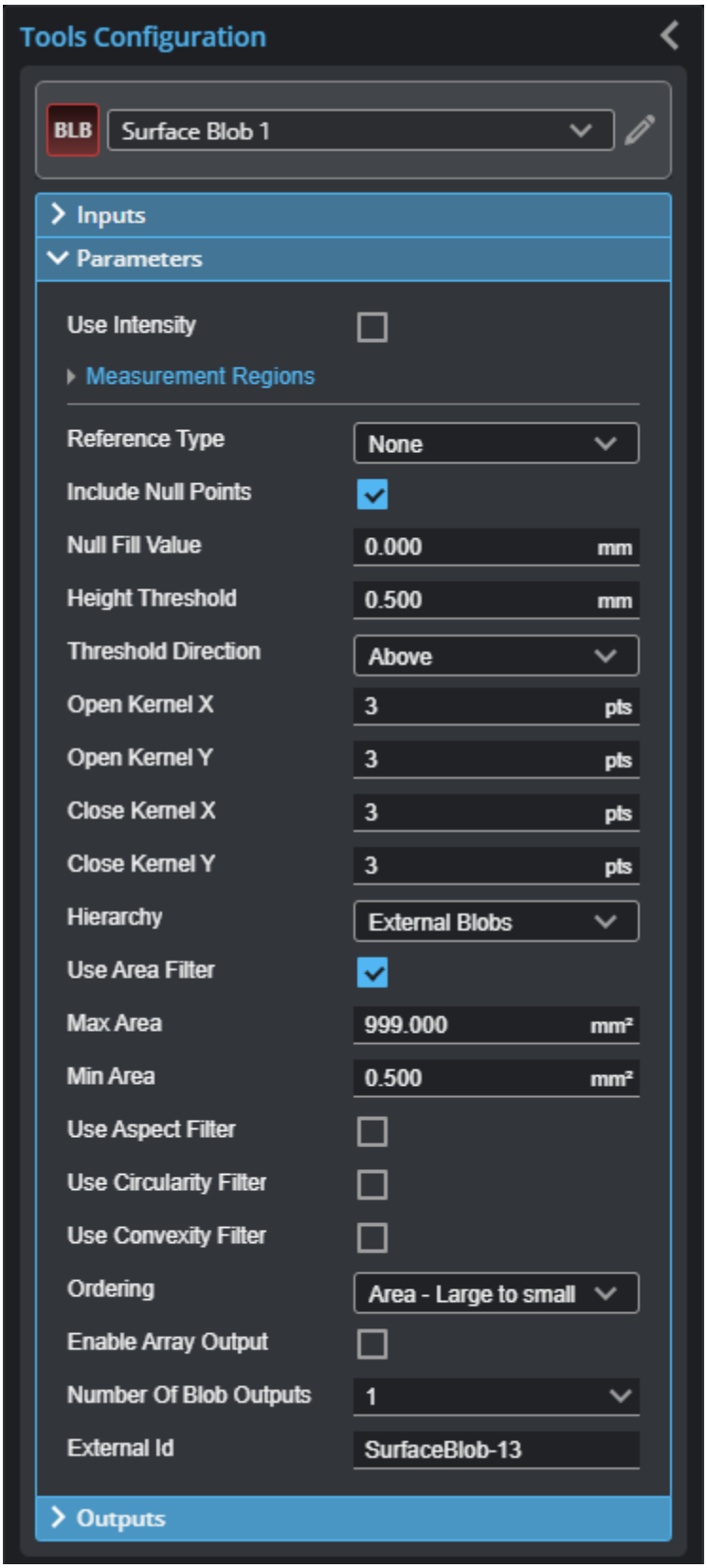
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

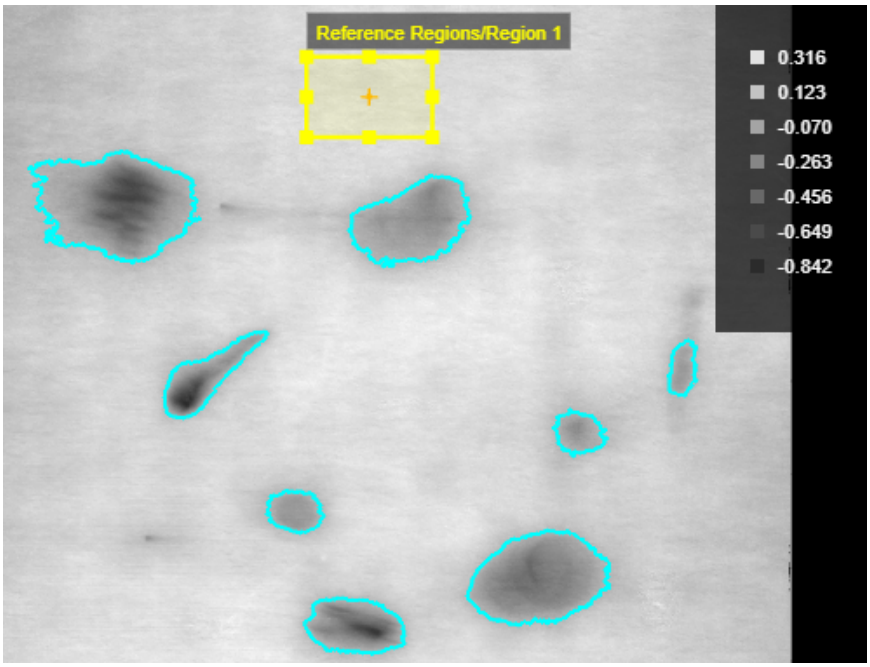
Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. This setting is hidden when the tool's **Enable Array Output** setting is checked. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z 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.

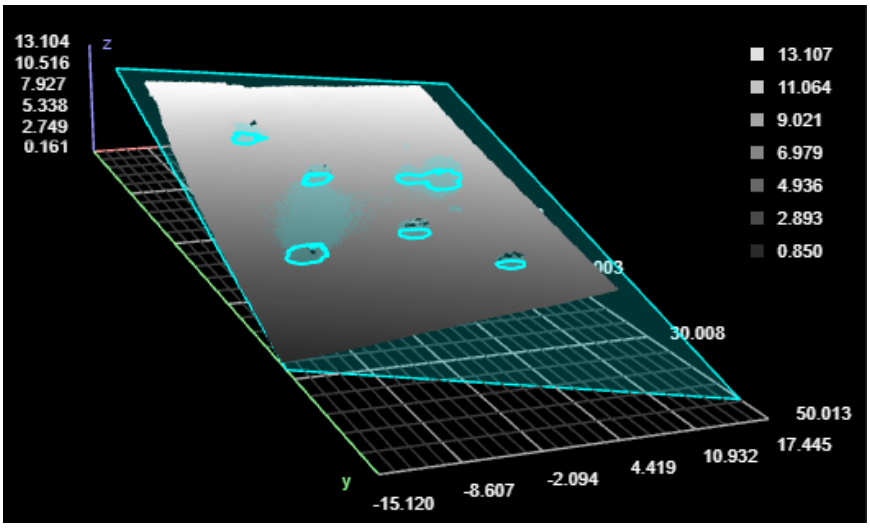
Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

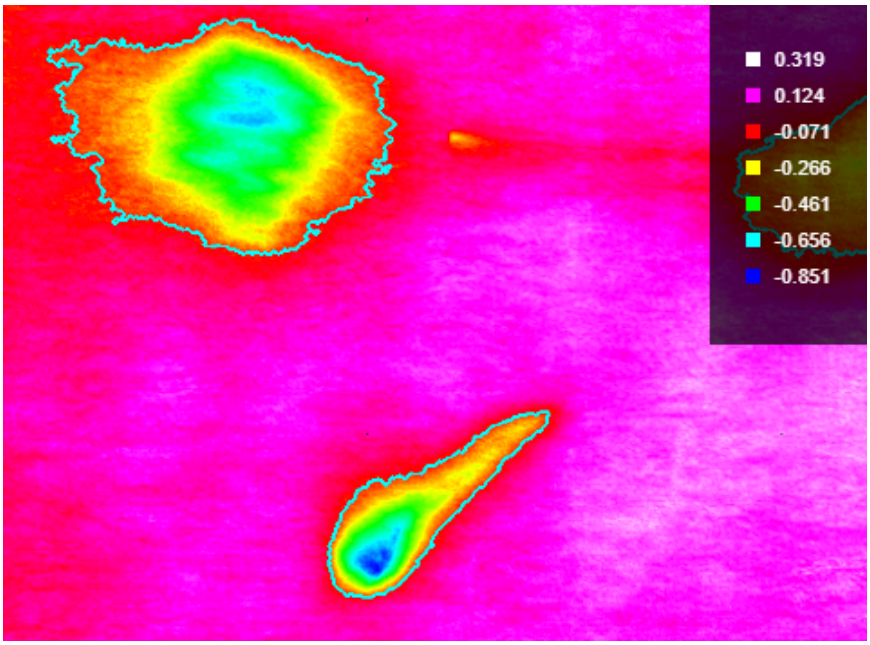
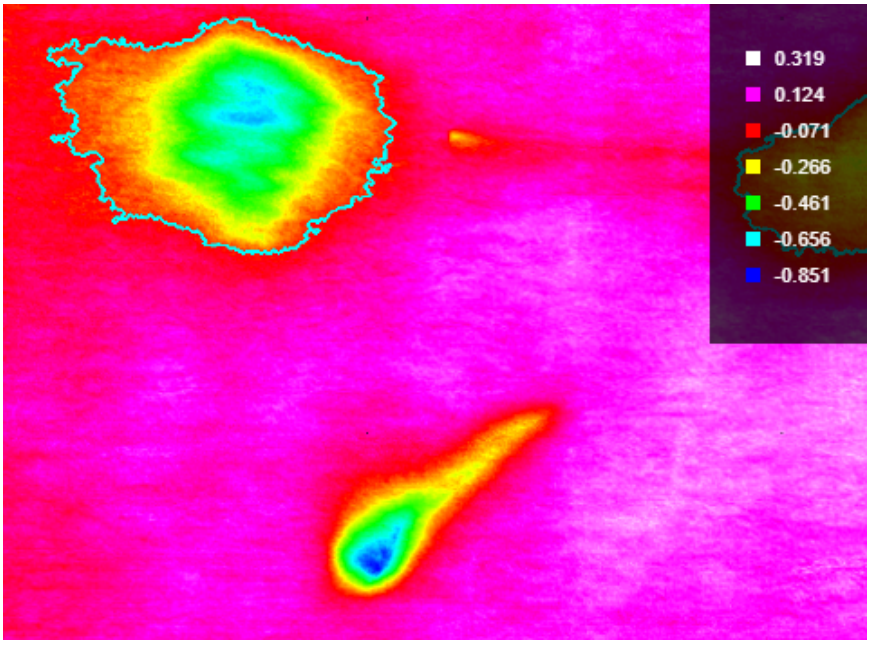

Tools Configuration
BLB
Surface Blob 1
Inputs
Parameters
Use Intensity
Measurement Regions
Reference Type
None
Include Null Points
Null Fill Value
0.000
mm
Height Threshold
0.500
mm
Threshold Direction
Above
Open Kernel X
3
pts
Open Kernel Y
3
pts
Close Kernel X
3
pts
Close Kernel Y
3
pts
Hierarchy
External Blobs
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
Number Of Blob Outputs
1
External Id
SurfaceBlob-13
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 **Inspect** > **Scan** page during scanning; for more information, see *Scan Modes and Intensity* on page 107.
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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
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 164.) The tool calculates an average height or intensity of the data in the reference region. **Height Threshold** is relative to this value. 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:  For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.

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 465). For information on geometric features, see *Geometric Features* on page 175. For applications where sheer distortion can't be tolerated, use Surface Transform to correct the tilt (see *Surface Transform* on page 532), and use the latter tool's output as the input for Surface Blob. 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.) 
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. If **Use Intensity** is enabled, the value in **Null Fill Value** is an intensity.
Height Threshold 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. 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

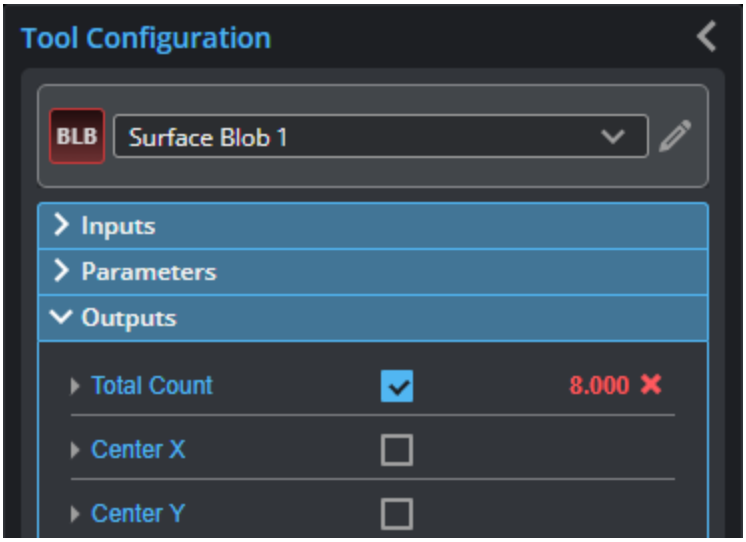
Parameter	Description
	blob. **Below**: The **Height Threshold** value is the maximum that will be considered as part of a blob (for example, a dent below the surrounding surface). **Above**: The **Height Threshold** value is the minimum that will be considered as part of a blob (so a raised feature).
Open Kernel X 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 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 blobs only or both external and internal blobs. **External Blobs** Use this option to ignore smaller blobs in larger blobs: only the outermost blob is returned. **External and Internal Blobs** Use this option to include smaller blobs in larger blobs.
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**. 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
	 In the following, the same dent is excluded if **Min Aspect** is set to a value greater than 0.354. 
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: • Position - X increasing • Position - X decreasing • Position - Y increasing • Position - Y decreasing • Area - Large to small • Area - Small to large
Enable Array Output	When **Enable Array Output** is unchecked, the tool outputs each blob as an individual Surface output. 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 155.
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.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

All 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 666.

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 Returns the total number of blobs identified, based on the tool's parameters.
Center X {n} / Center X **Center Y {n} / Center Y** The X and Y positions of the center of mass of a blob extracted from the surface.
Average Z {n} / Average Z The average Z positions of a blob extracted from the surface.
Min Z {n} / Min Z **Max Z {n} / Max Z** The minimum and maximum Z positions of a blob extracted from the surface.
Width {n} / Width **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 551.

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 175.

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. When the tool is configured to output arrays, the blob surfaces are in Blob Surface.

Surface Bounding Box

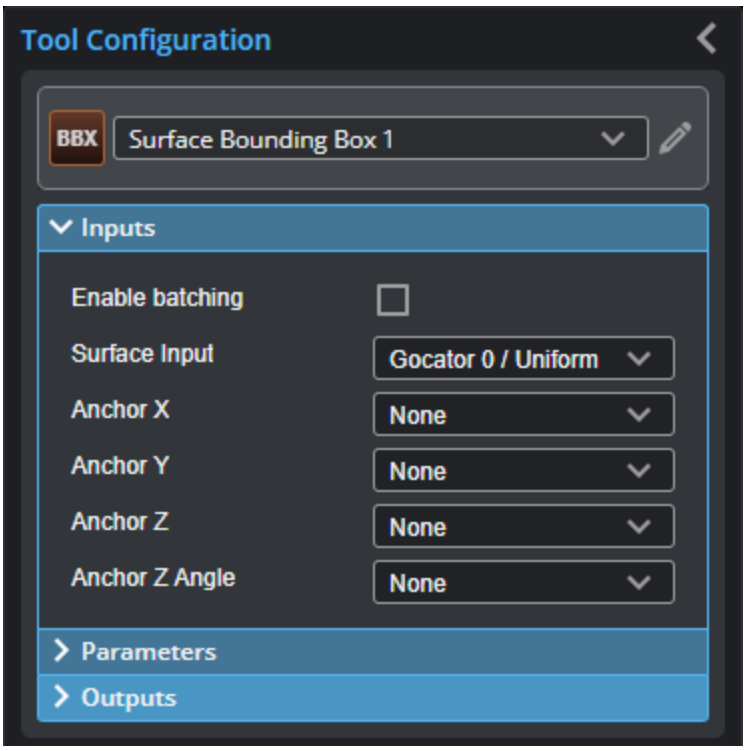
The Bounding Box tool provides measurements related to the smallest box that contains the *scan data* from a part (for example, X position, Y position, width, length, etc.). The tool also lets you get the height of bounding box relative to the Z origin (typically the conveyor on which the target is sitting). 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 153.

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 176.

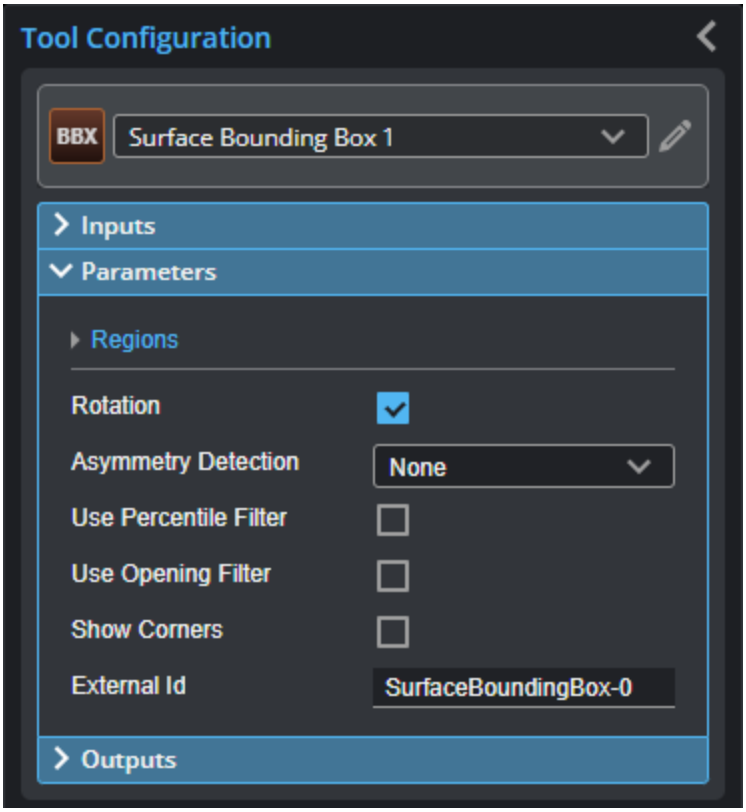
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array,

Name	Description
	other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

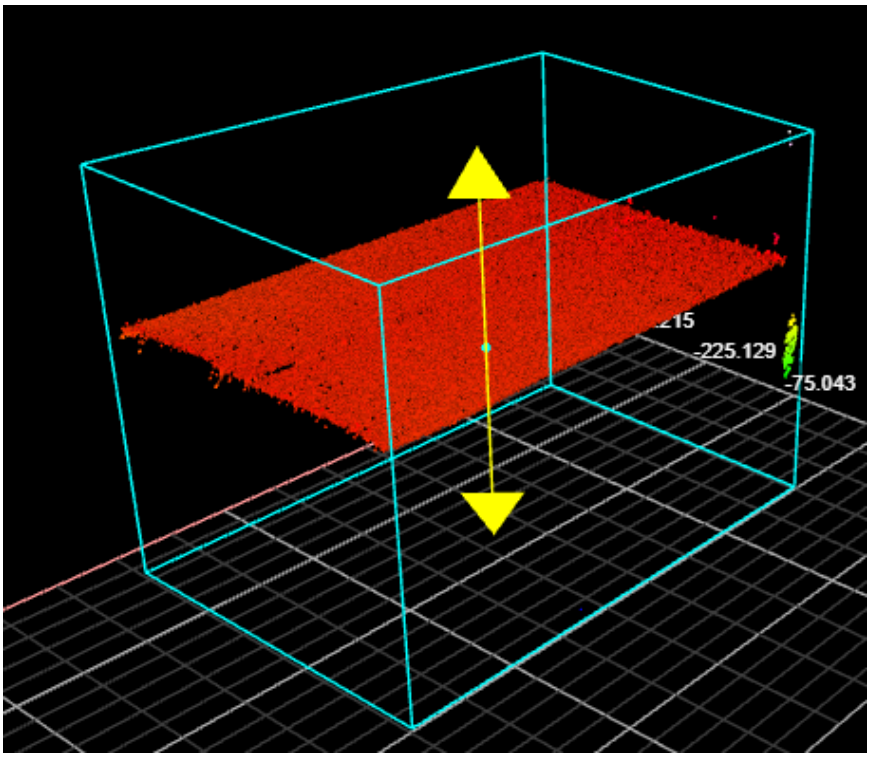
Parameters

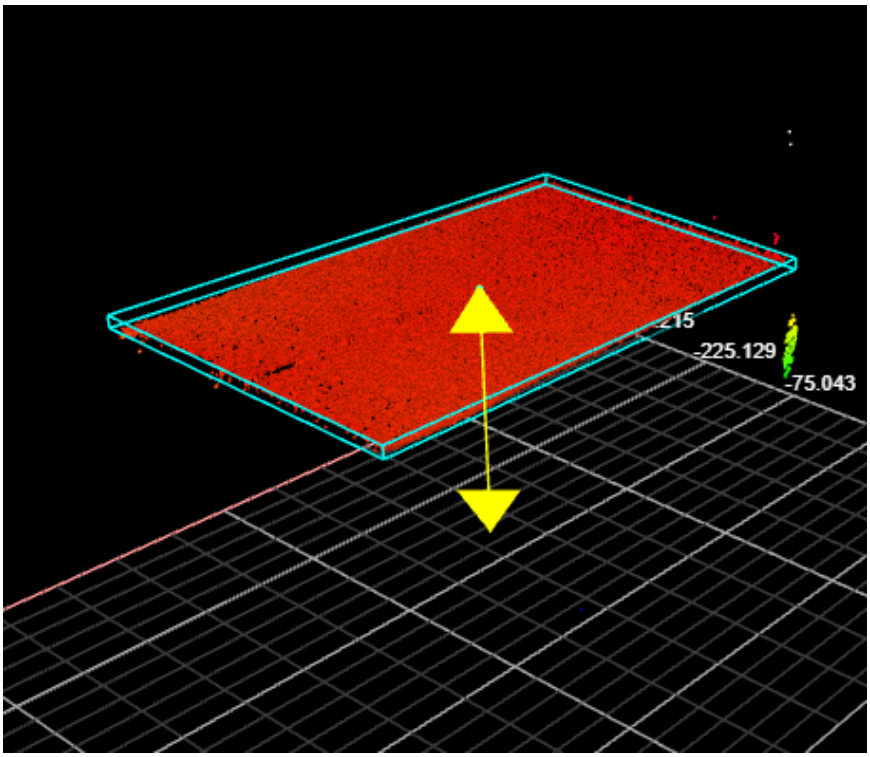
You configure the tool's parameters in the expandable **Parameters** section.

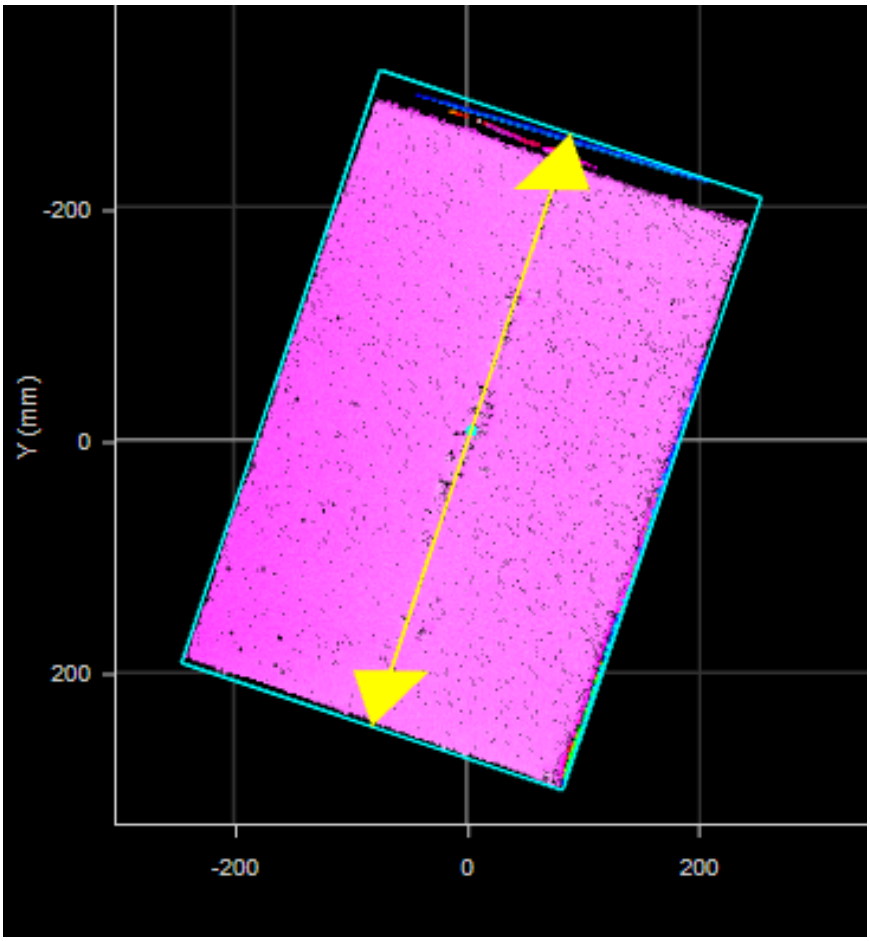


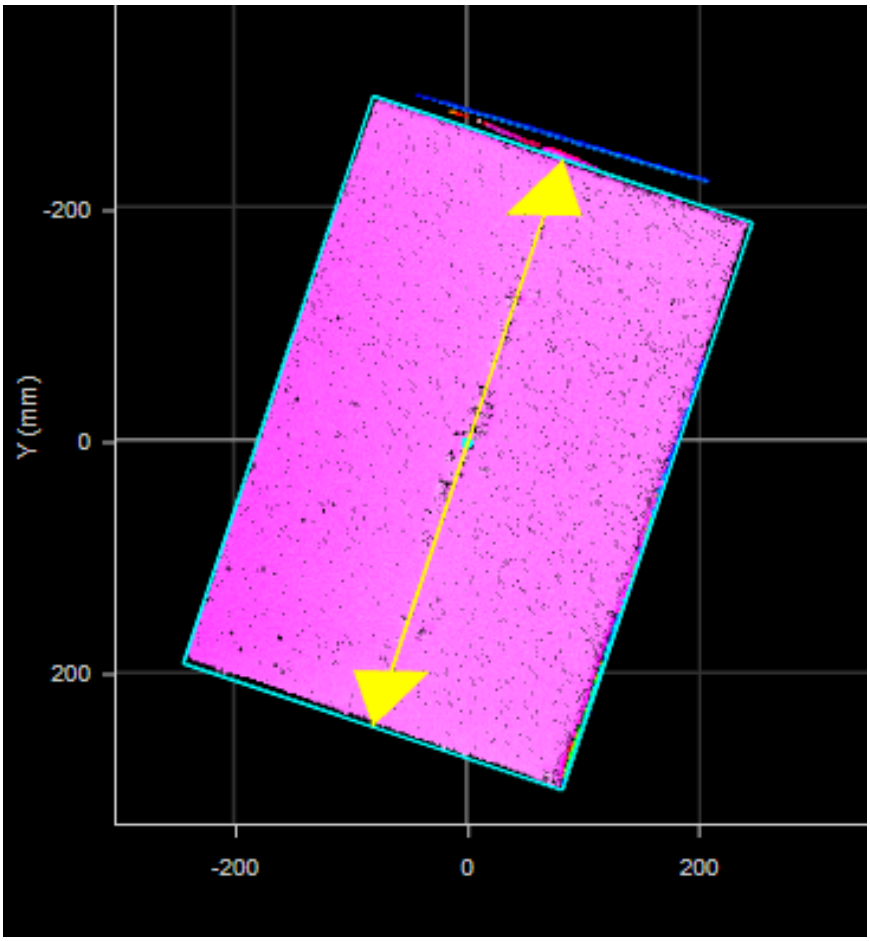
Parameters

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 Region Type 1 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
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: 0 – None 1 – Along Major Axis 2 – Along Minor Axis 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. 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. (The following screenshots are from a G2 sensor.)

Parameter	Description
	 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.

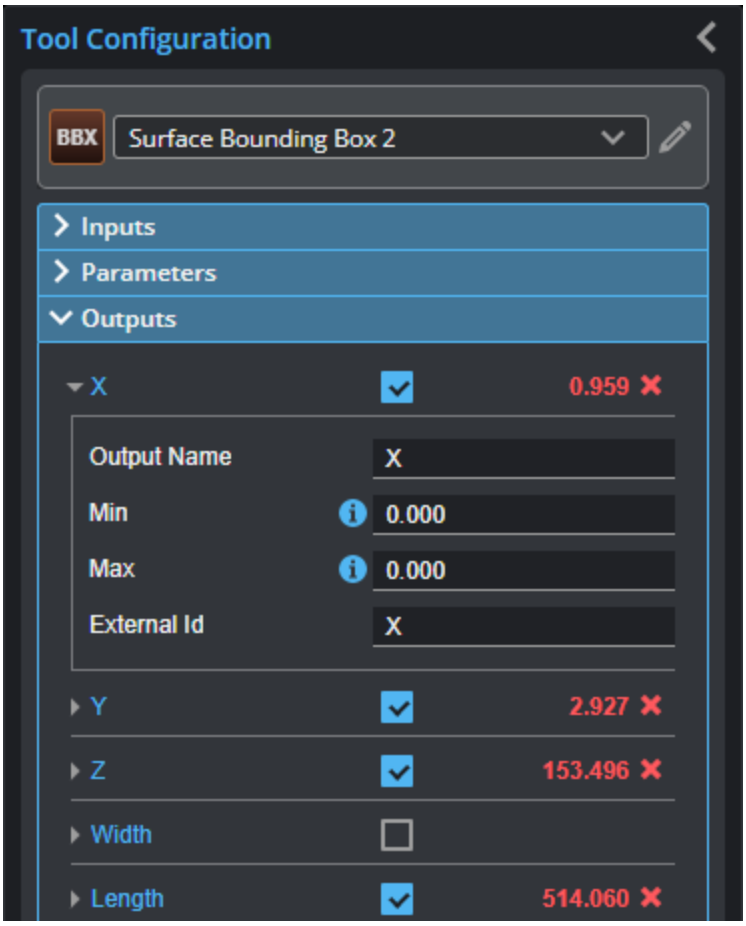
Parameter	Description
	
High Percentile Low Percentile	See **Use Percentile Filter** above.
Use Opening Filter	When enabled, this setting lets you set the value of **Kernel Size** for an *opening* morphological operation applied to the scan data on the XY plane, letting you achieve "robust" width and length measurements. 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. (The following screenshots are from a G2 sensor.)

Parameter	Description
	 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
	 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 666.

Outputs

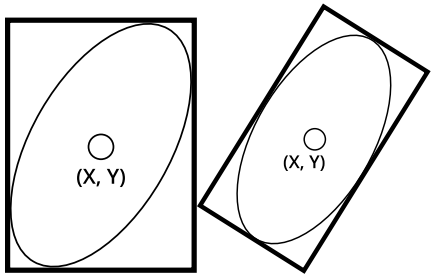
All tools provide measurements, geometric features, or data as outputs.

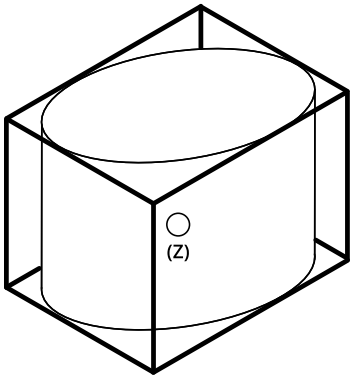
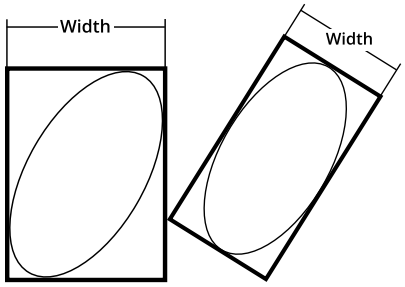
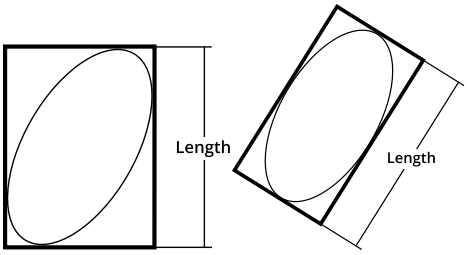
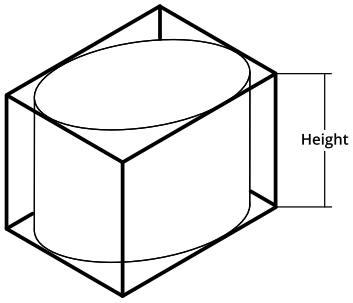


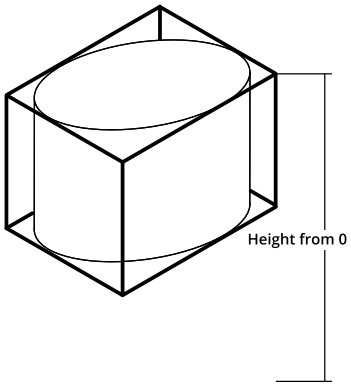
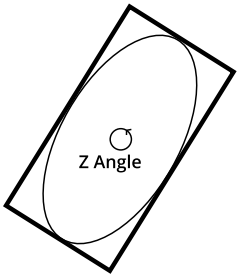
Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the X position of the center of the bounding box that contains the part. The value returned is relative to the *part*.	
Y Determines the Y position of the center of the bounding box that contains the part. The value returned is relative to the *part*.	

Measurement	Illustration
Z Determines the Z position of the center of the bounding box that contains the part. The value returned is relative to the *part*.	
Width Determines the width of the bounding box that contains the part. 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. When **Rotation** is enabled, the width is the smaller side dimension.	
Length Determines the length of the bounding box that contains the part. 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. When **Rotation** is enabled, the length is the longer side dimension.	
Height Determines the height of the bounding box that contains the part.	

Measurement	Illustration
Height from 0 Determines the distance from the top of the bounding box to the Z origin (Z = 0).	
Z Angle Determines the rotation around the Z axis and the angle of the longer side of the bounding box relative to the X axis. If **Rotation** is not enabled, the measurement returns 90.000 degrees. In order to use this measurement for angle anchoring, you must enable **Rotation**; for more information on anchoring, see *Measurement Anchoring* on page 176.	

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 175.

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)

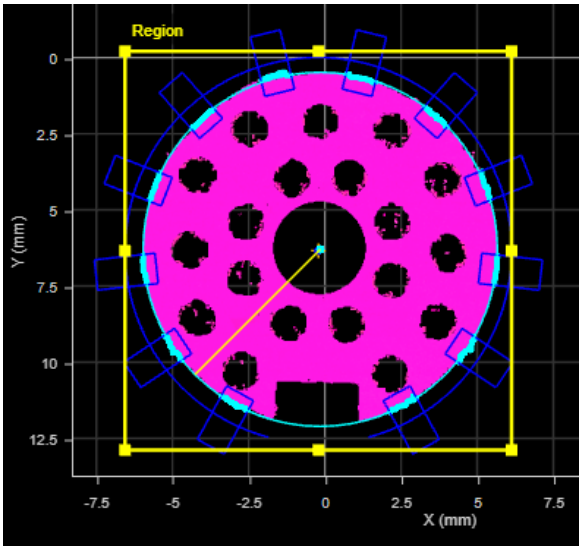
The tool can also generate circle and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see *Feature Measurement* on page 552.

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 153.

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

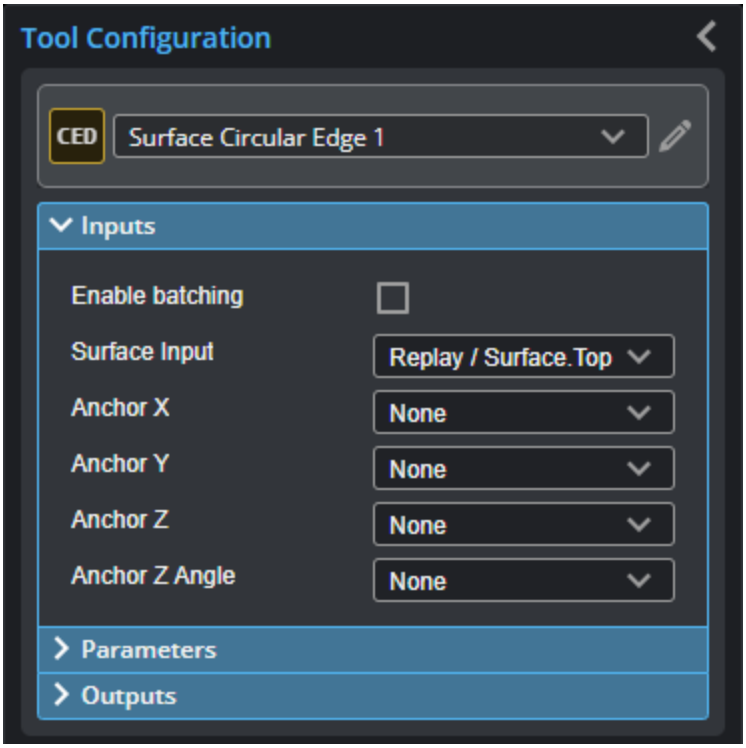
The circular path can optionally be partial, and starts at a defined orientation around the Z axis. The circular path can be as short as 1/4 of a circle, letting it work with rounded corners. Calipers extend vertically to fill the entire region of interest.

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 176.

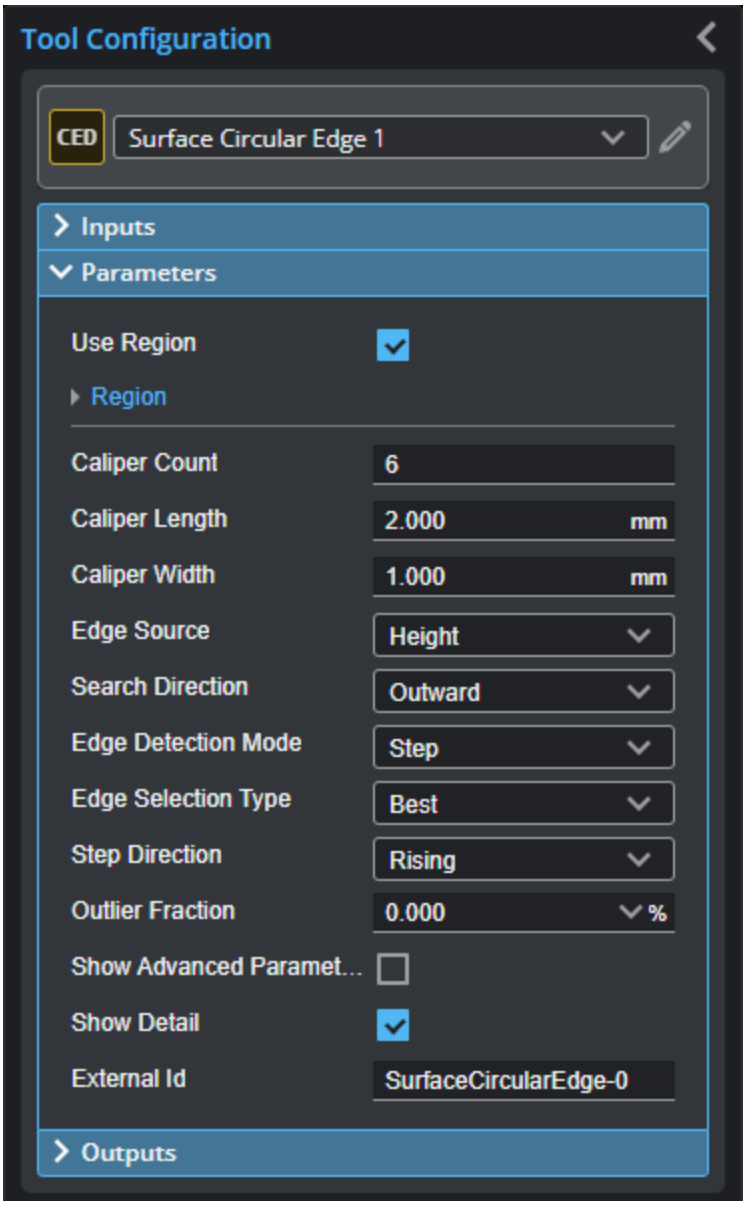
Inputs

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

Name	Description
	For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z 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.

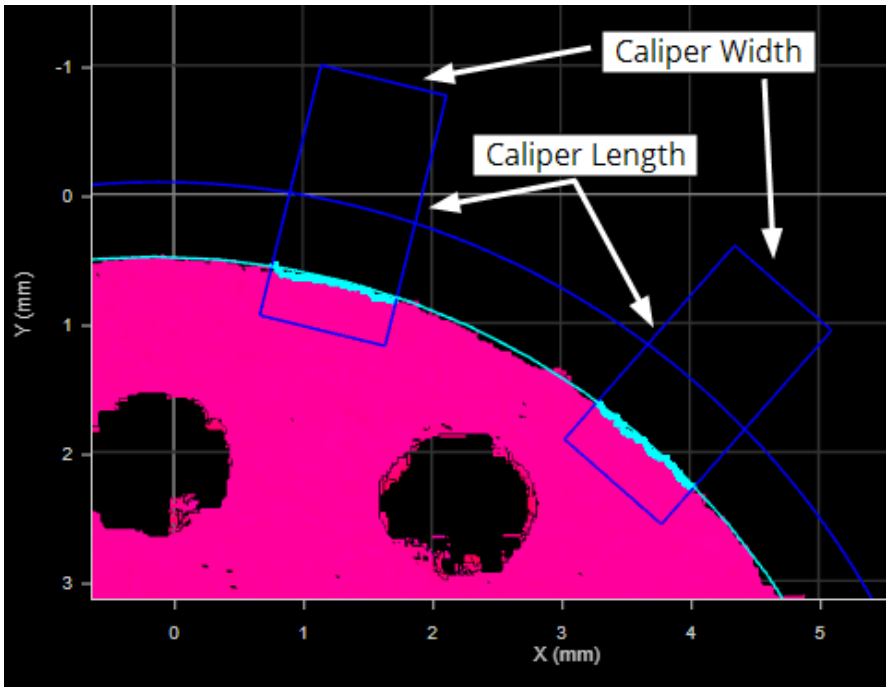
Parameters

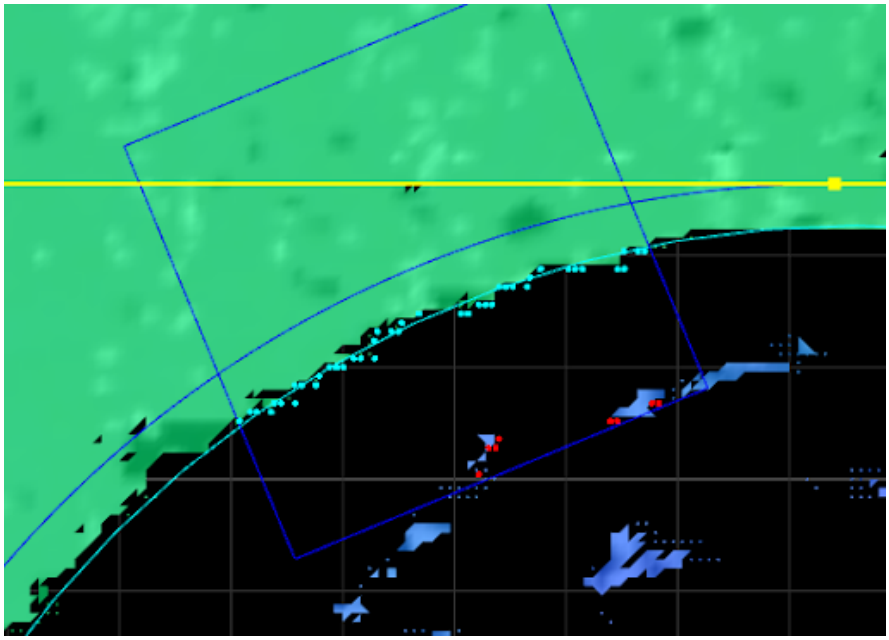
You configure the tool's parameters in the expandable **Parameters** section.



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 163.
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. 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.

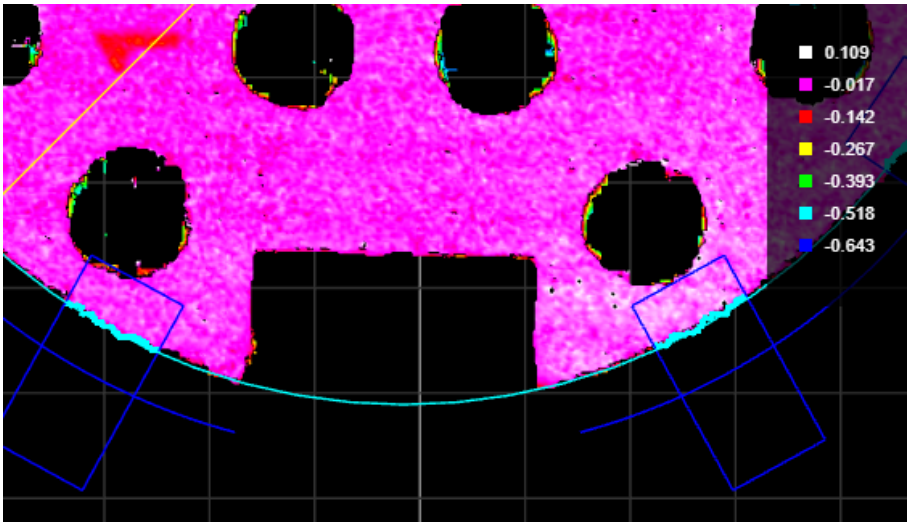
Parameter	Description
Caliper Length Caliper Width	**Caliper Length** is the length of the calipers (extending perpendicular to a tangent on the circular caliper path, centered on the path). The length of the calipers determines the length of the extracted profiles the tool examines for steps. Longer 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. **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. 
Edge Source	Specifies the type of data the tool uses. Either Height or Intensity. 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. **Step**: Searches for steps on each path profile. **Corner**: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden.

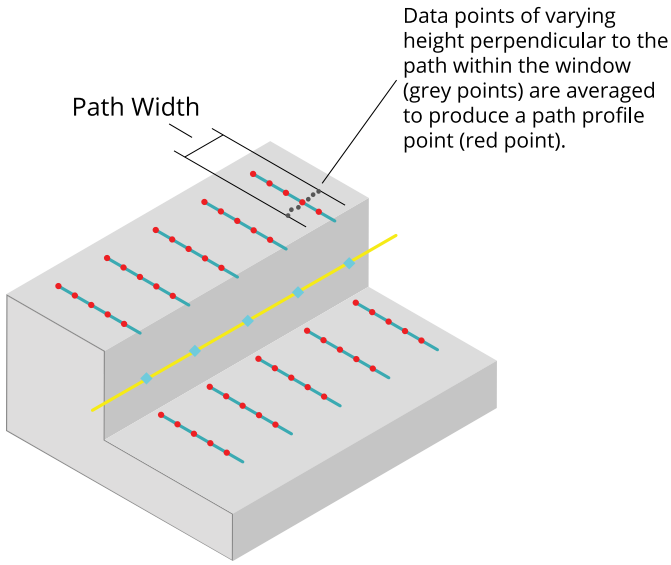
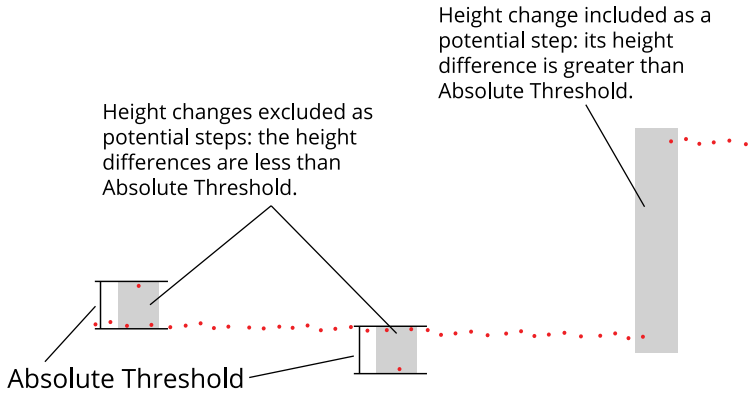
Parameter	Description
Edge Selection Type	Determines which step the tool uses on each of the profiles internally extracted from the calipers when there are multiple steps. An edge point is placed on each chosen step, and is used to fit the circle. Steps must pass the criteria of the tool's settings, such as threshold and outlier exclusion. **Best**: Selects the greatest step in the search direction on each profile. **First**: Selects the first step in the search direction on each profile. **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: **Best**: Selects the greatest corner. **First**: Selects the first corner. **Last**: Selects the last corner. **Top**: Selects the top corner. **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: **Rising & Falling**: Searches for edge points on rising or falling edges. **Rising**: Searches for edge points only on rising edges. **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. 

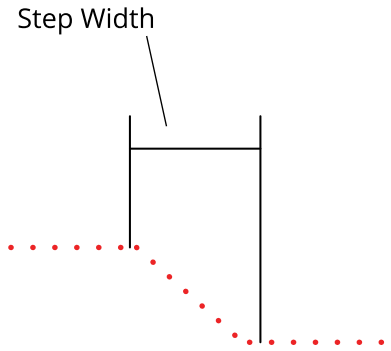
Parameter	Description
Show Advanced Parameters	When enabled, displays advanced settings. Note that most of these settings are applied *even when they are hidden*. For information on these settings, see *Advanced Parameters* below.
Show Detail	When disabled, hides the calipers and caliper path, as well 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 666.

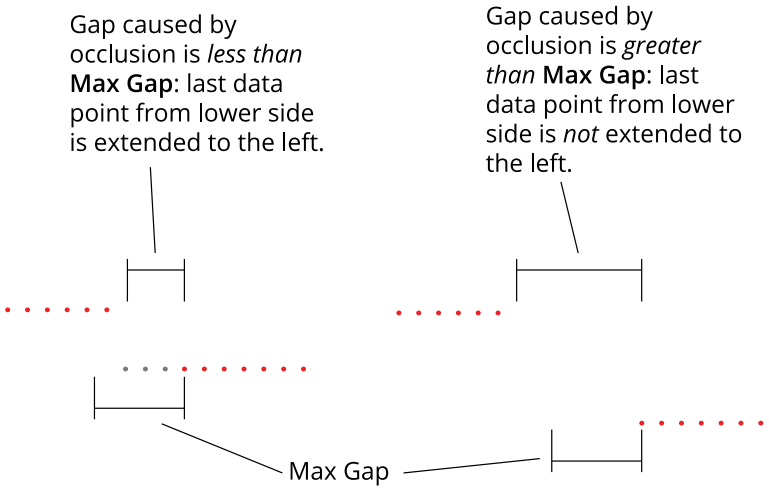
> The following parameters are hidden when **Show Advanced Parameters** is unchecked. All advanced parameters, *except***Reference Plane**, are applied when they are hidden. Mask regions are not rendered, even though they are applied.

Advanced Parameters

Parameter	Description
Angle Start 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.  **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. **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. 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.  If **Path Width** is set to 0, no averaging is performed (only the data point under the path is used). 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. 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.

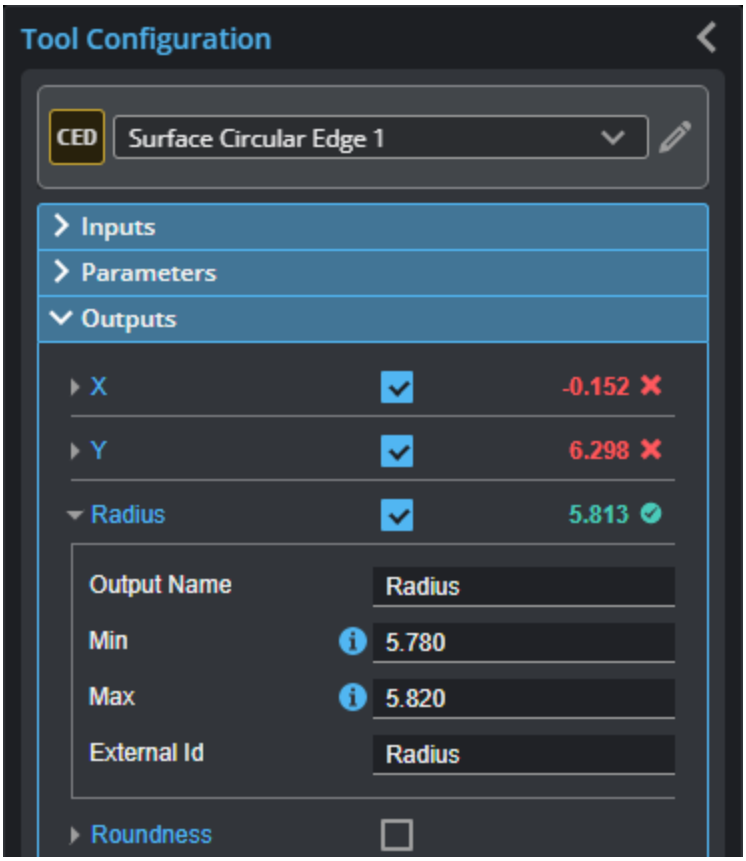
Parameter	Description
Relative Threshold	The value for the relative threshold. The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in **Relative Threshold**. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height. 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. If **Step Smoothing** is set to 0, no averaging is performed (only the data point under the path is used). 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.

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**. 
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 265). 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.

Parameter	Description
Mask Regions	Lets you enable up to five regions that you can use to mask data you want the tool to ignore. 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. 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. 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: **Least Square Circle (LSC)** **Minimum Zone Circle (MZC)**: If you choose this method, set the circle the tool uses with the **Which Circle** parameter. **Maximum Inscribed Circle (MIC)**: Typically used to measure the inner edge of a circular feature, such as a hole. **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

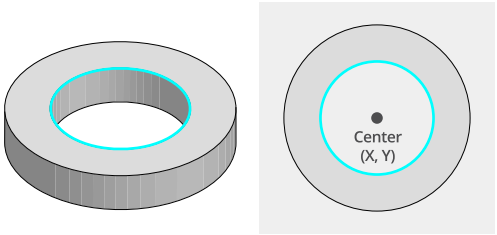
All tools provide measurements, geometric features, or data as outputs.

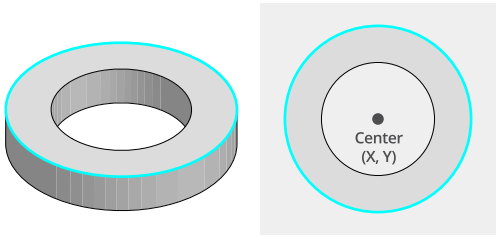
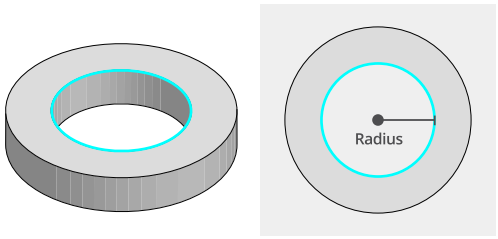
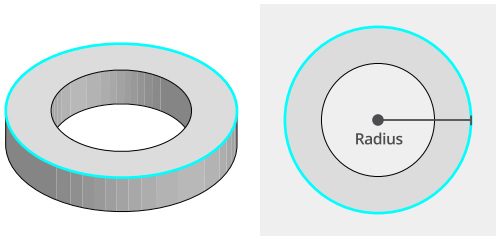
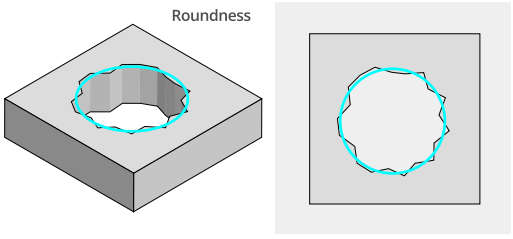
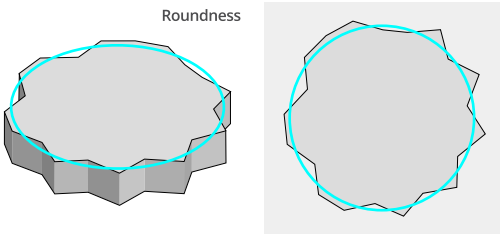


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 **Y** Returns the X and Y position of the center of the fitted circle, respectively.	

Measurement	Illustration
	
Radius Returns the radius of the fitted circle.	
	
Roundness 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 **Max Error** 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 175.

Surface Countersunk Hole

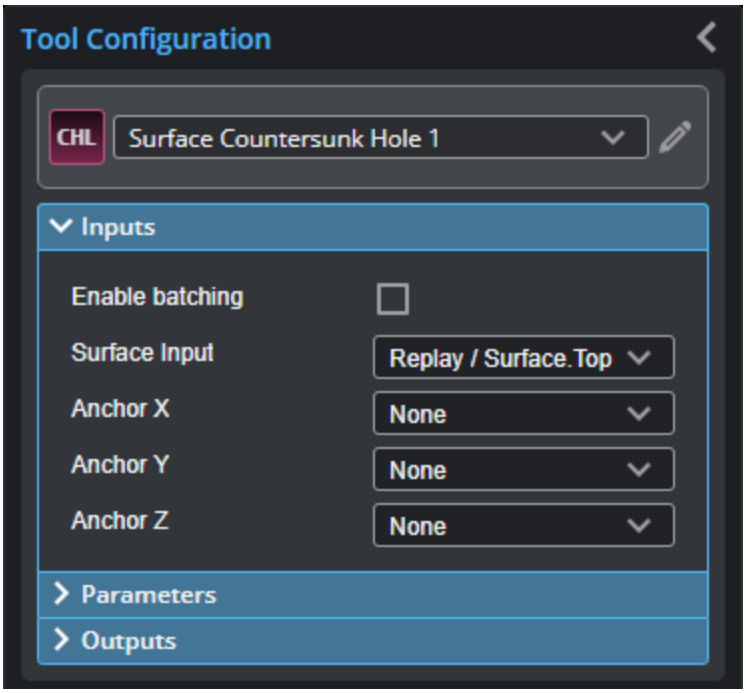
The Countersunk Hole tool locates a countersunk circular opening within a region of interest on the surface and provides measurements to evaluate characteristics of countersunk holes, including the position (X, Y, and Z) of the center of the hole, outside radius of the hole, hole bevel angle, and the 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 153.

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 176.

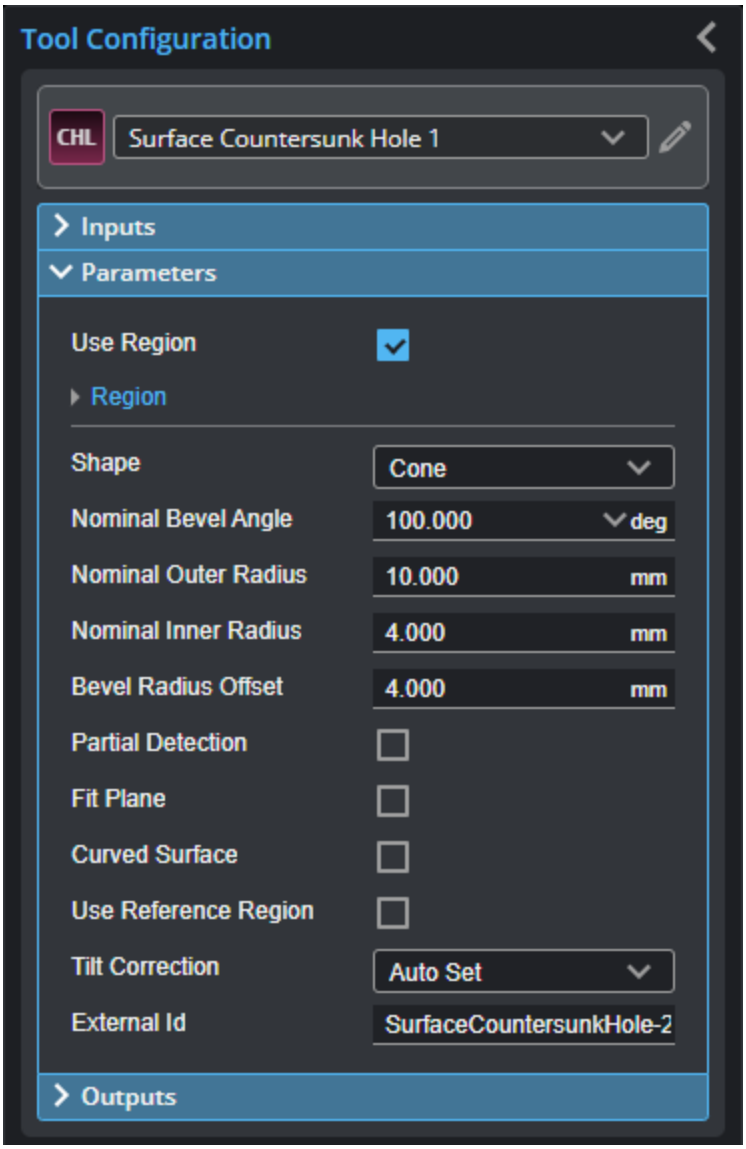
Inputs

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

Name	Description
	For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y Anchor Z	The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

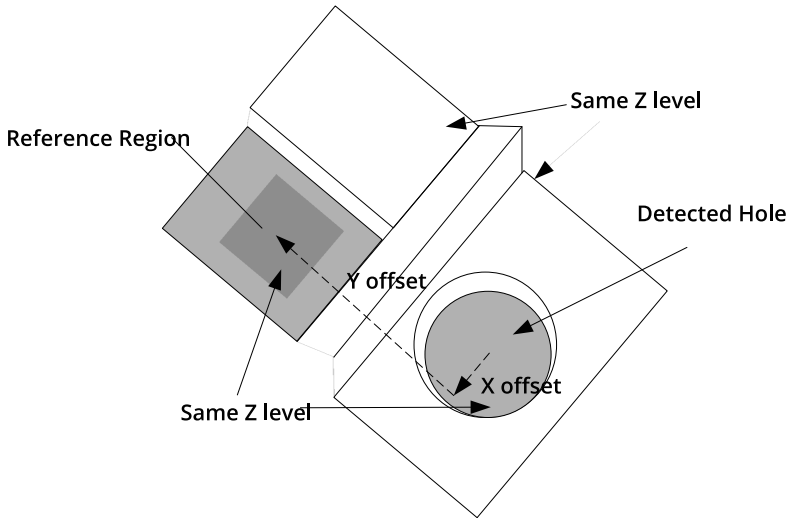
Parameters

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



Parameters

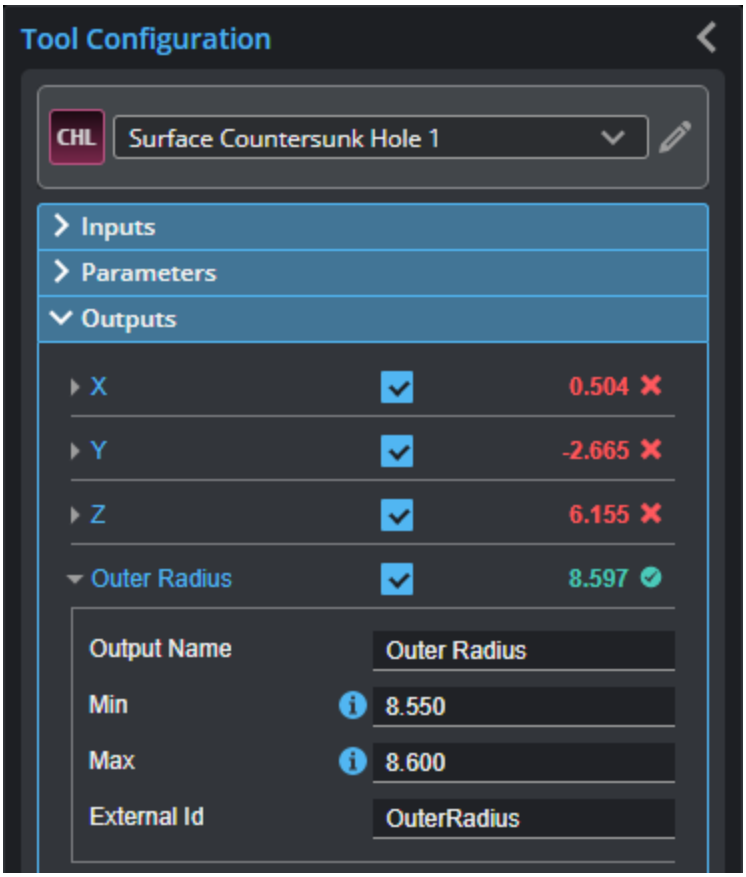
Parameter	Description
Use Region	When enabled, displays Region parameters (see below). When disabled, the tool uses all data.
Region	The region to which the tool's measurements will apply. For more information, see *Regions* on page 163.
Shape	The shape of the countersunk hole. (See illustrations below.) 0 – Cone 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.
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
	When this option is set to **Autoset**, the algorithm automatically determines the reference region. 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. 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. **Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. **Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
X Angle Y Angle	The X and Y angles you must specify when **Tilt Correction** is set to **Custom**. 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 666.

Outputs

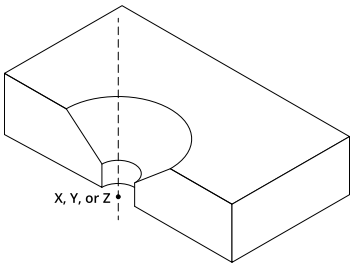
All tools provide measurements, geometric features, or data as outputs.

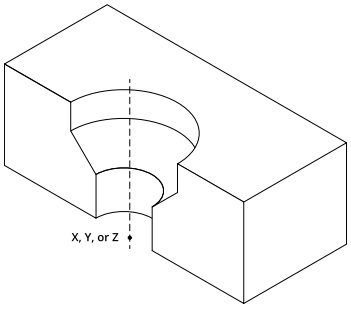
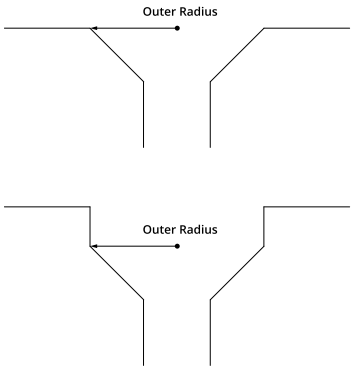
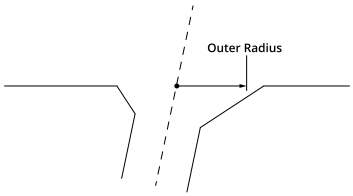
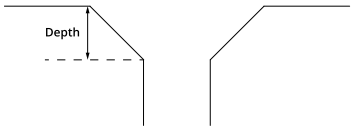
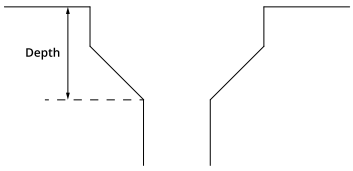


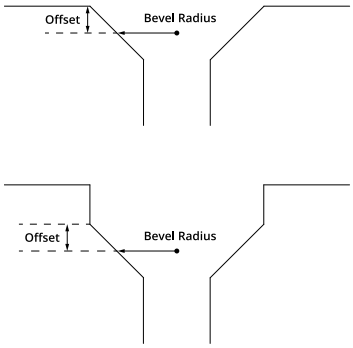
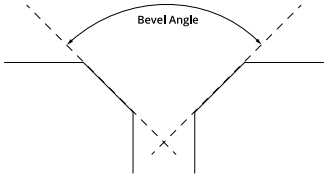
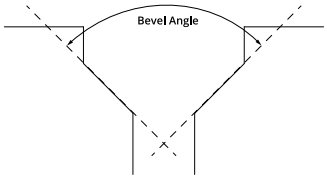
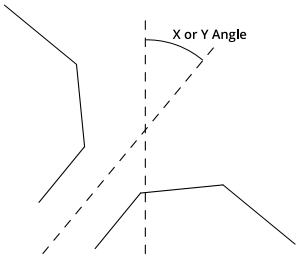
Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

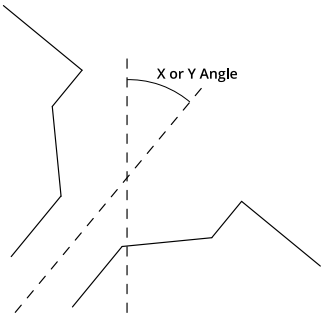
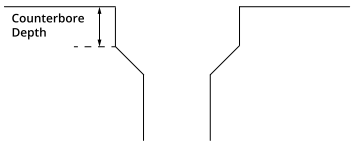
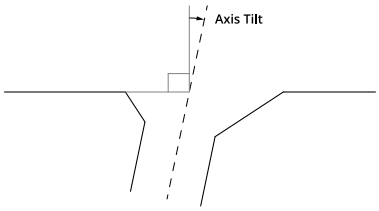
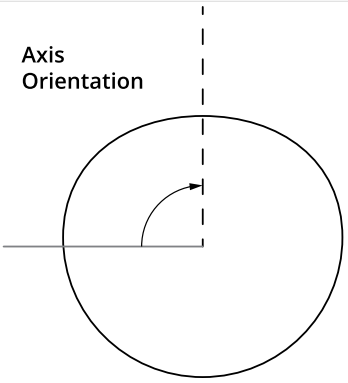
You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

Measurements

Measurement	Illustration
X Determines the X position of the center of the countersunk hole.	

Measurement	Illustration
Y Determines the Y position of the center of the countersunk hole. **Z** Determines the Z position of the center of the countersunk hole.	
Outer Radius Determines the outer radius of the countersunk hole. 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. 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 618.	 
Depth Determines the depth of the countersunk hole relative to the surface that the countersunk hole is on.	 

Measurement	Illustration
Bevel Radius Determines the radius at a user-defined offset (**Bevel Radius Offset** setting) relative to the surface that the countersunk hole is on. 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 618.	
Bevel Angle Determines the angle of the hole's bevel.	 *Cone*  *Counterbore*
X Angle Determines the angle the hole relative to the X axis.	 *Cone*

Measurement	Illustration
Y Angle Determines the angle of the hole relative to the Y axis.	 *Counterbore*
Counterbore Depth Determines the depth of a counterbore.	
Axis Tilt Measures the tilt of the axis of the hole relative to the surface surrounding the hole. This measurement is not supported when **Shape** is set to **Counterbore**.	
Axis Orientation Measures the angle of the axis of the hole around the normal of the surface surrounding the hole, relative to the X axis. 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.

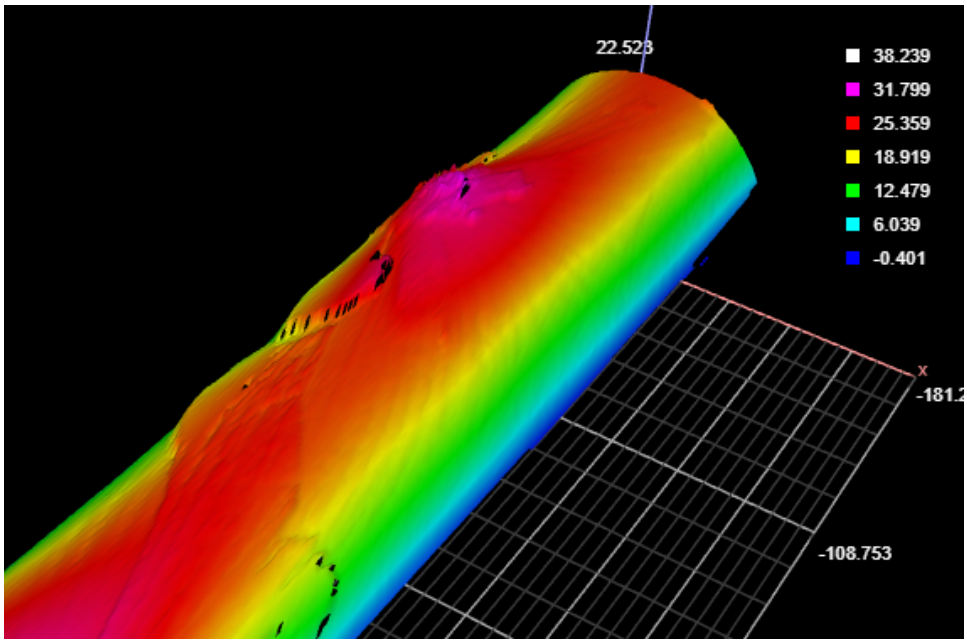
For more information on geometric features, see *Geometric Features* on page 175.

Surface Curvature Correction

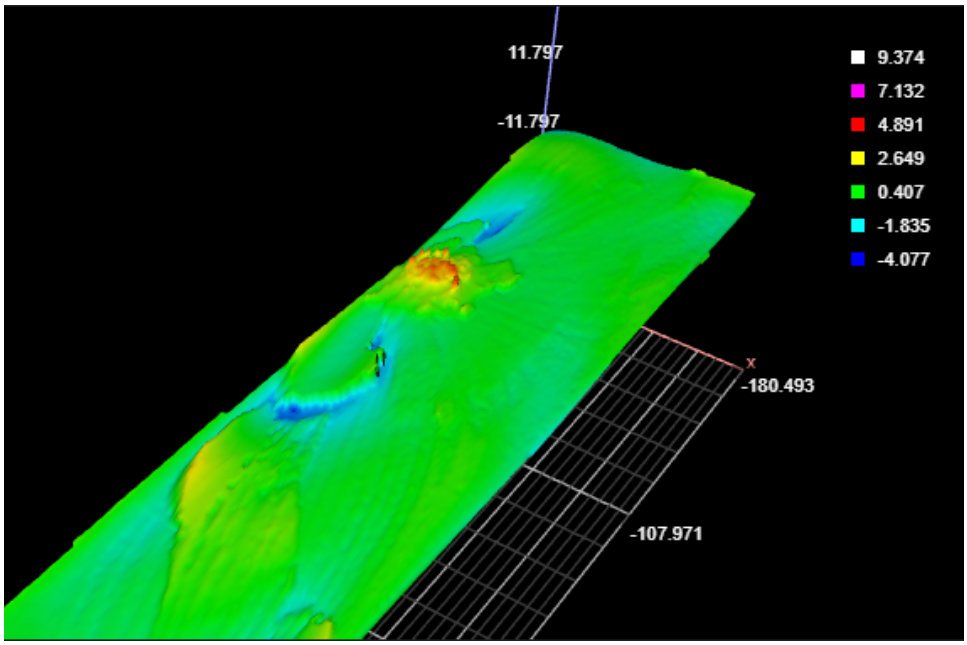
The Surface Curvature Correction tool removes curvature from curved surfaces while preserving surface features or defects, using a configurable polynomial order (the tool performs a 2D polynomial fit on X and Y to process surfaces). You can then use the tool's output as input to other measurement tools 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.

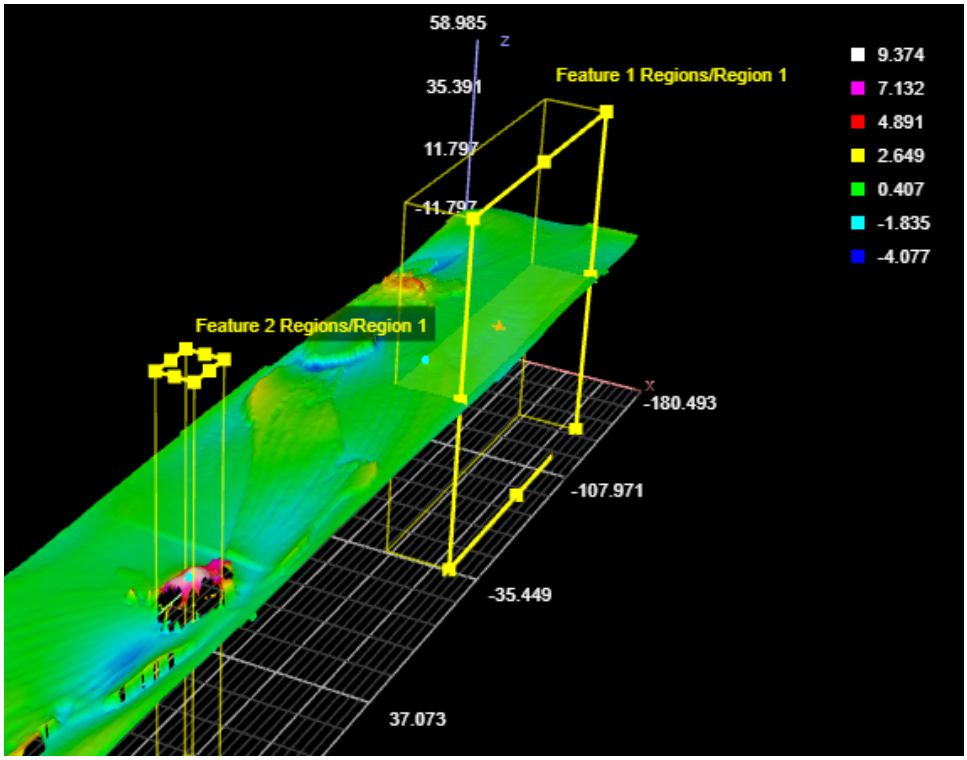


The original, curved scan of a target.



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:

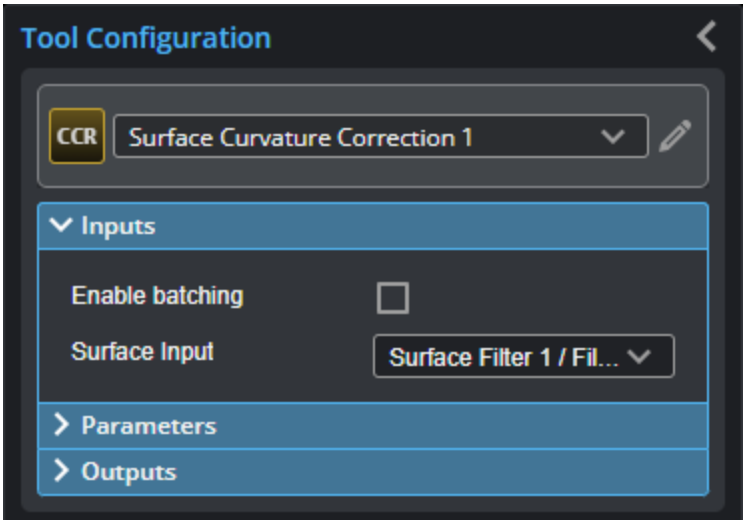


Height of a raised feature relative to the flattened surface.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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

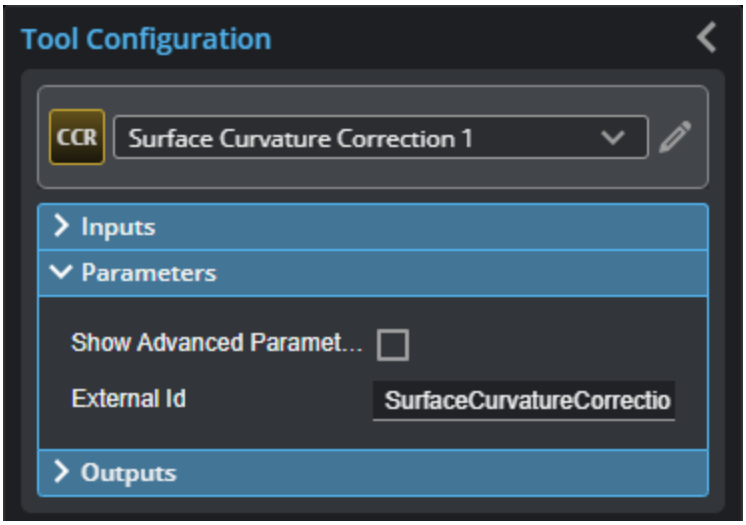


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.

Parameters

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

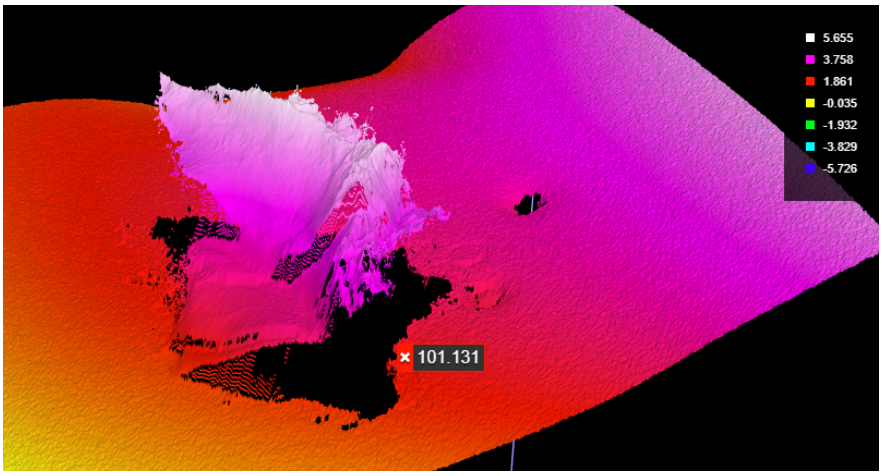
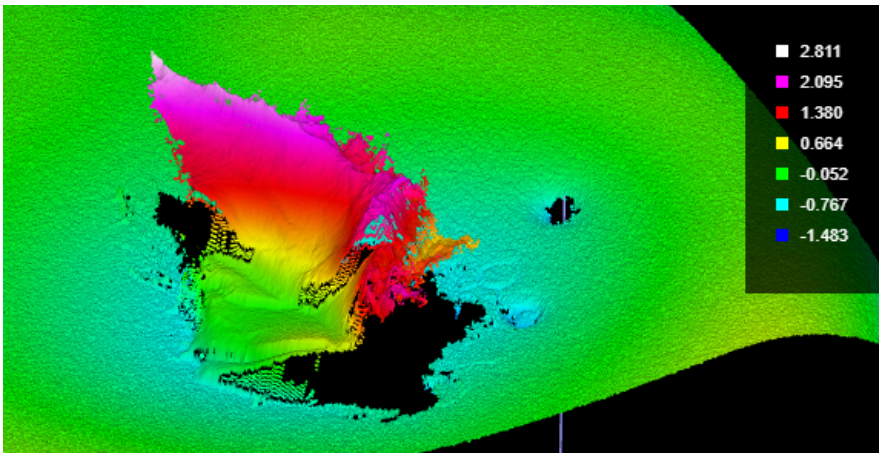


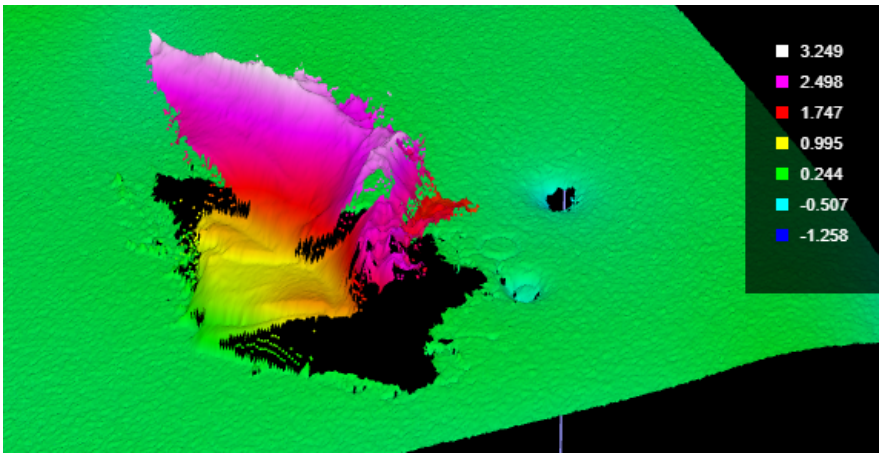
Parameters

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 666.

Advanced Parameters

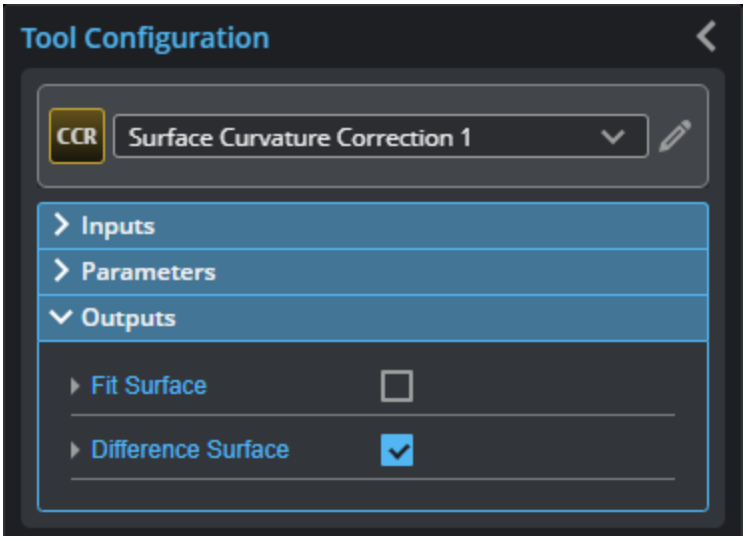
Parameter	Description
Number of Regions	Lets you specify and configure one or more regions the tool will process. Use this parameter to limit the tool to specific areas on the target.
Exclude Features	Lets you exclude features or surface details from the polynomial fit. This can allow you to get a better fit on the surrounding surface. Checking this option enables the **Negative area**, **Positive area**, and **Iterative Steps** parameters. (See below.) For example, in the following scan data, we would like to accurately measure the circular divots and the small hole near the center of the data on the curved surface.

Parameter	Description
	 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:  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 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 666.

Outputs

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

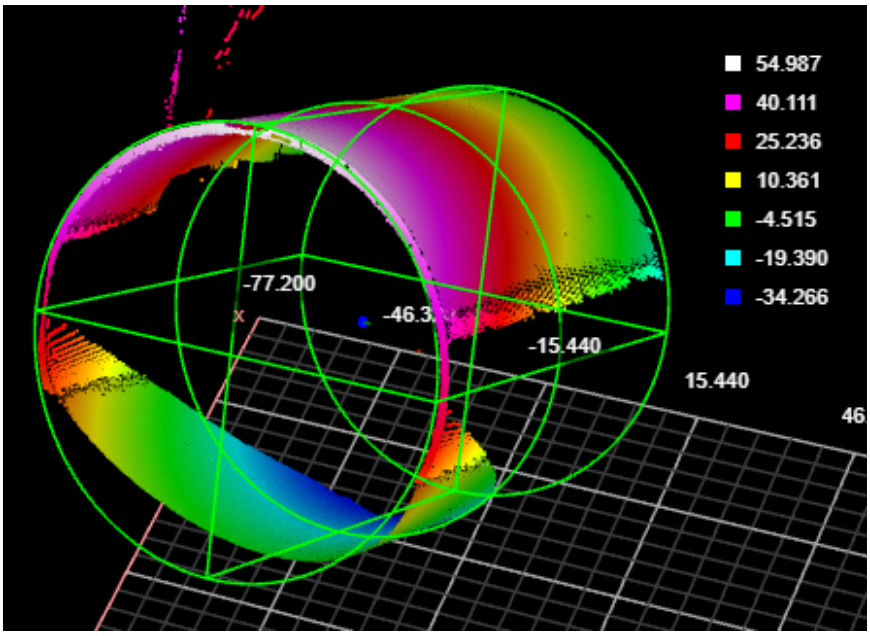


Data

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.

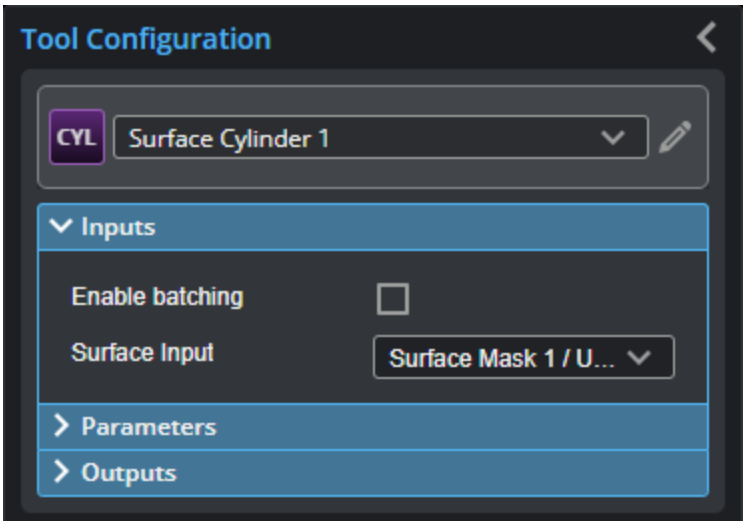
Surface Cylinder

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.



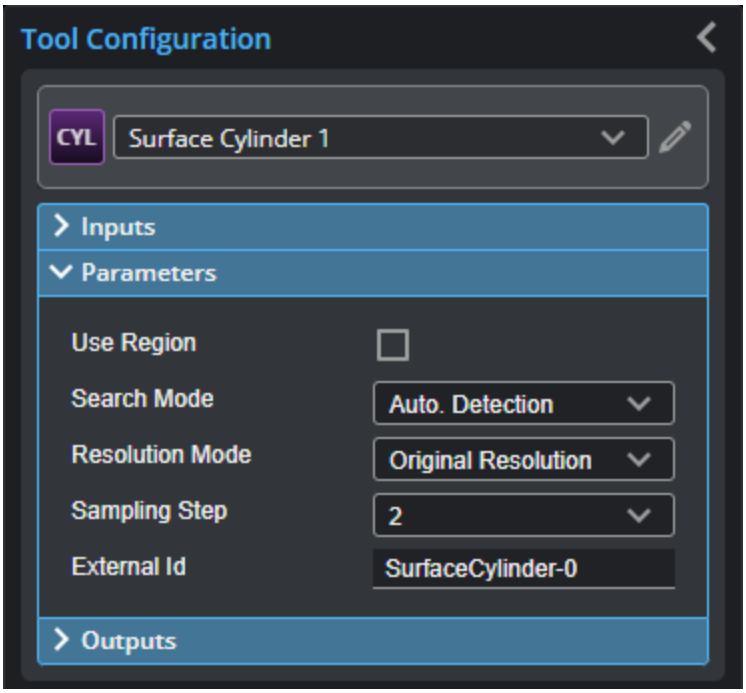
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array,

Name	Description
	other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.

Parameters

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

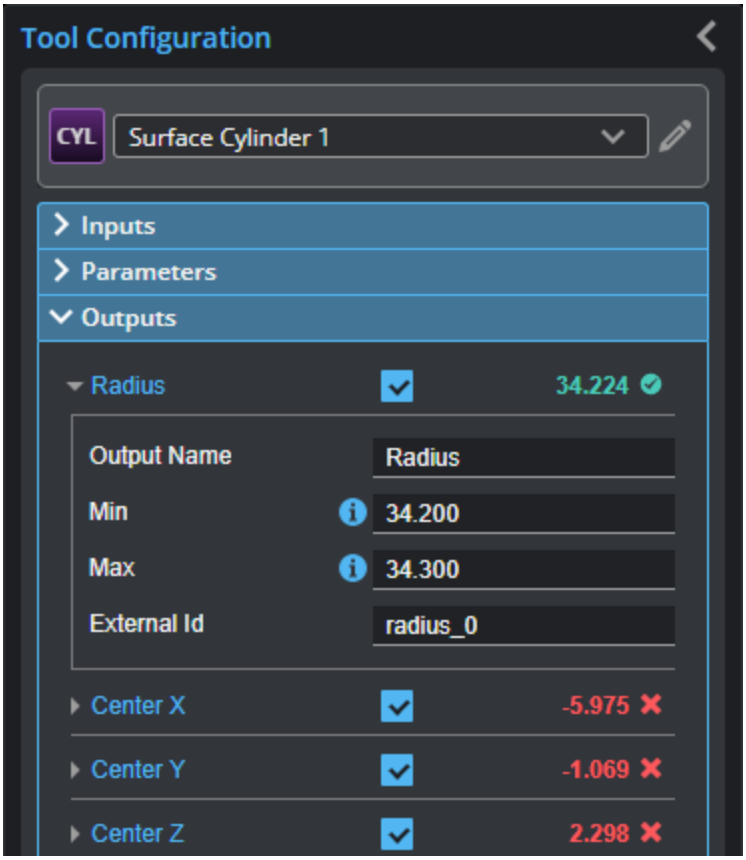


Parameters

Parameter	Description
Use 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 163.
Search Mode	Indicates the expected orientation of the cylindrical target's axis around the Z axis. One of the following: **Auto Detection** – The cylindrical target can be in any orientation. **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. **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

Parameter	Description
	mode.
Resolution Mode	On G3 sensors, leave this set to the default **Original Resolution**. 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. • **Optimal (uniform)** 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. • **High Oriented (uniform)** 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.) • **Low Oriented (uniform)** 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.) • **Original Resolution** 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 666.

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 Returns the radius of the fitted cylinder.
Center X **Center Y** **Center Z** The X, Y, and Z position of the center of a circle place in the middle of the fitted cylinder
Tilt Angle 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 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 175.

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.

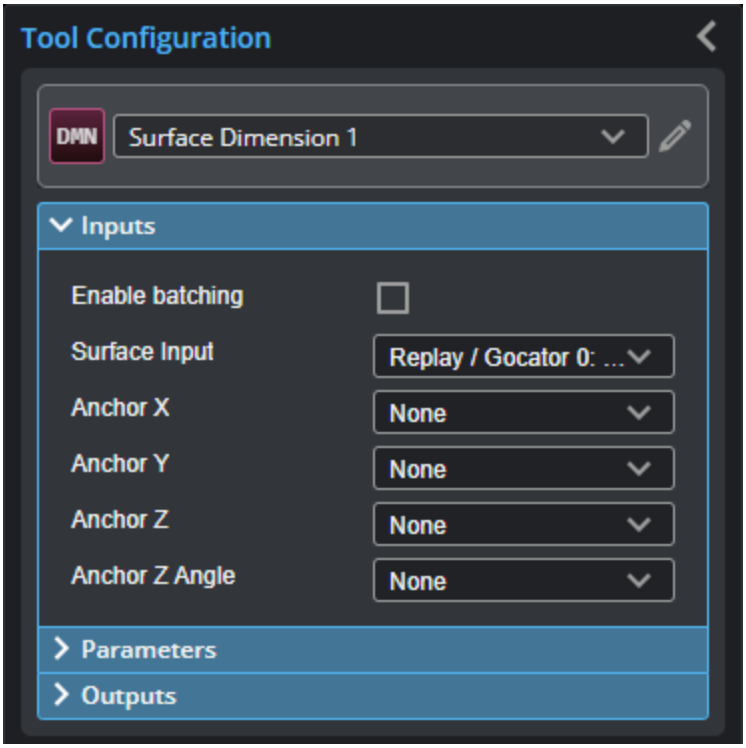
Surface Dimension

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 153.

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 176.

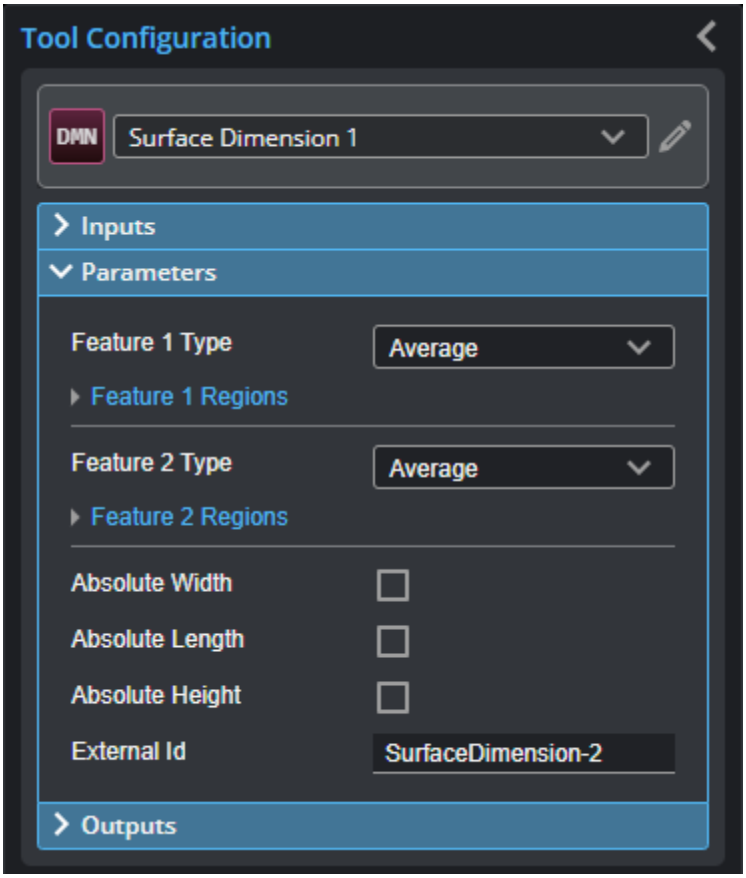
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X 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 Z 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.



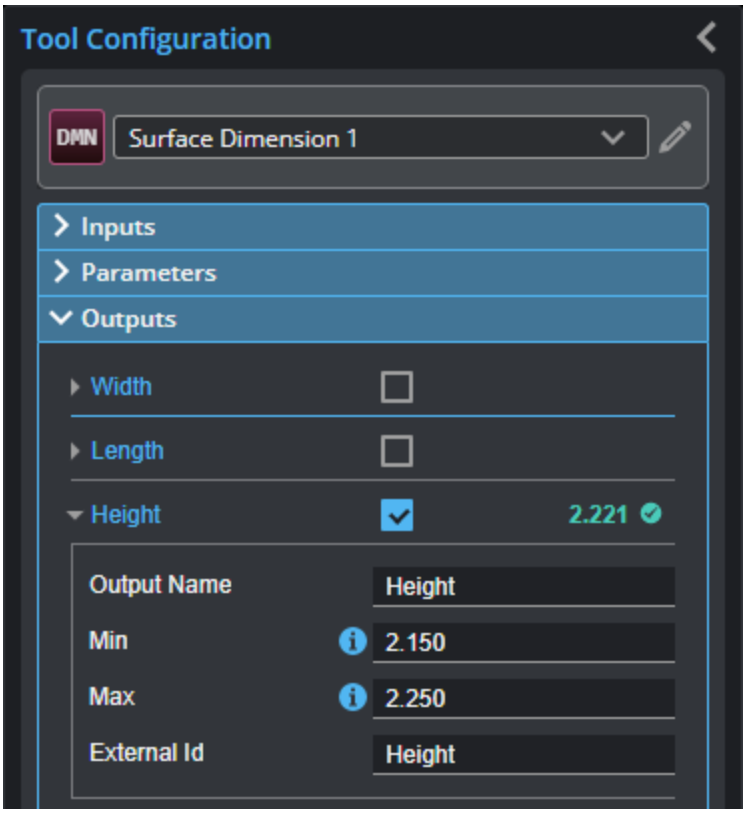
Parameters

Parameter	Description
Feature 1 Type Feature 2 Type	The feature point types the tool uses. For each, one of the following (for more information, see *Feature Points* on page 172): • Average • Median • Centroid • Max X • Min X • Max Y • Min Y • Max Z

Parameter	Description
	• Min Z 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. 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 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. 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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Absolute Width Absolute Length 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 666.

Outputs

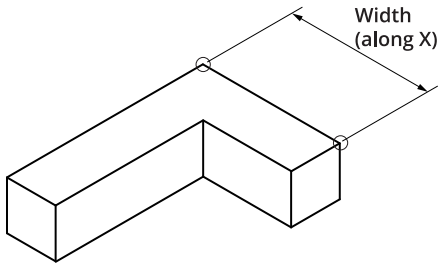
All tools provide measurements, geometric features, or data as outputs.

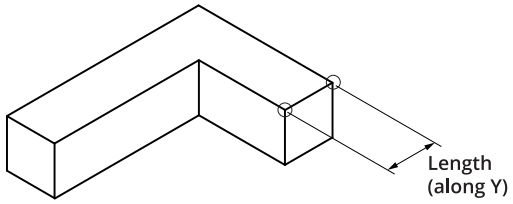
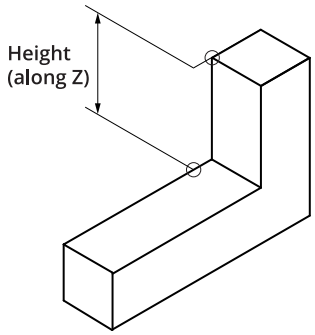
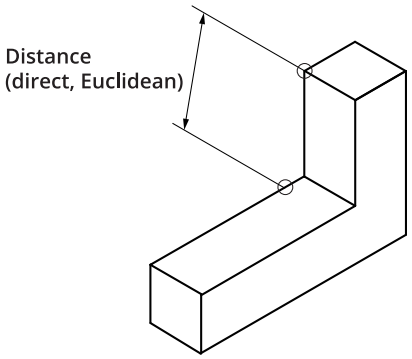


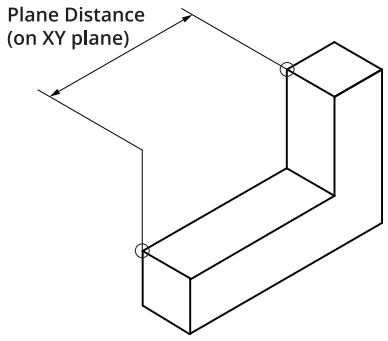
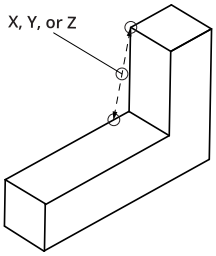
Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the distance between the selected features along the X axis.	

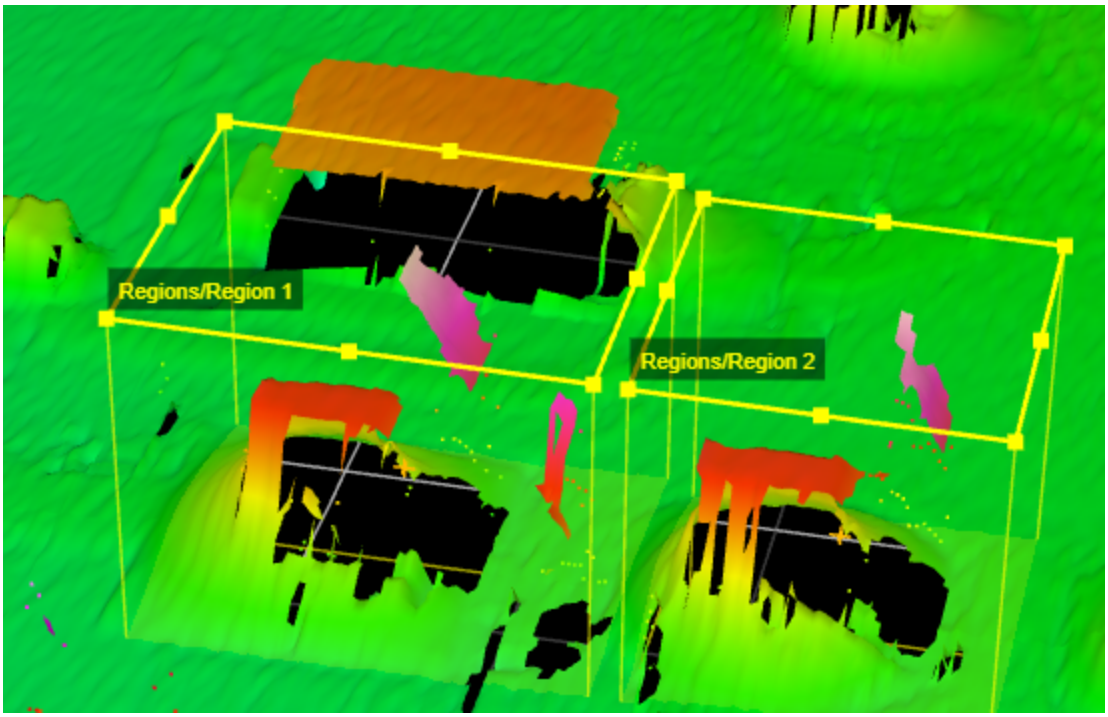
Measurement	Illustration
Length Determines the distance between the selected features along the Y axis.	
Height Determines the distance between the selected features along the Z axis.	
Distance Determines the direct, Euclidean distance between the selected features.	

Measurement	Illustration
Plane Distance 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 **Center Y** **Center Z** These measurements determine the X, Y, or Z position, respectively, of the center point between the selected features.	

Surface Direction Filter

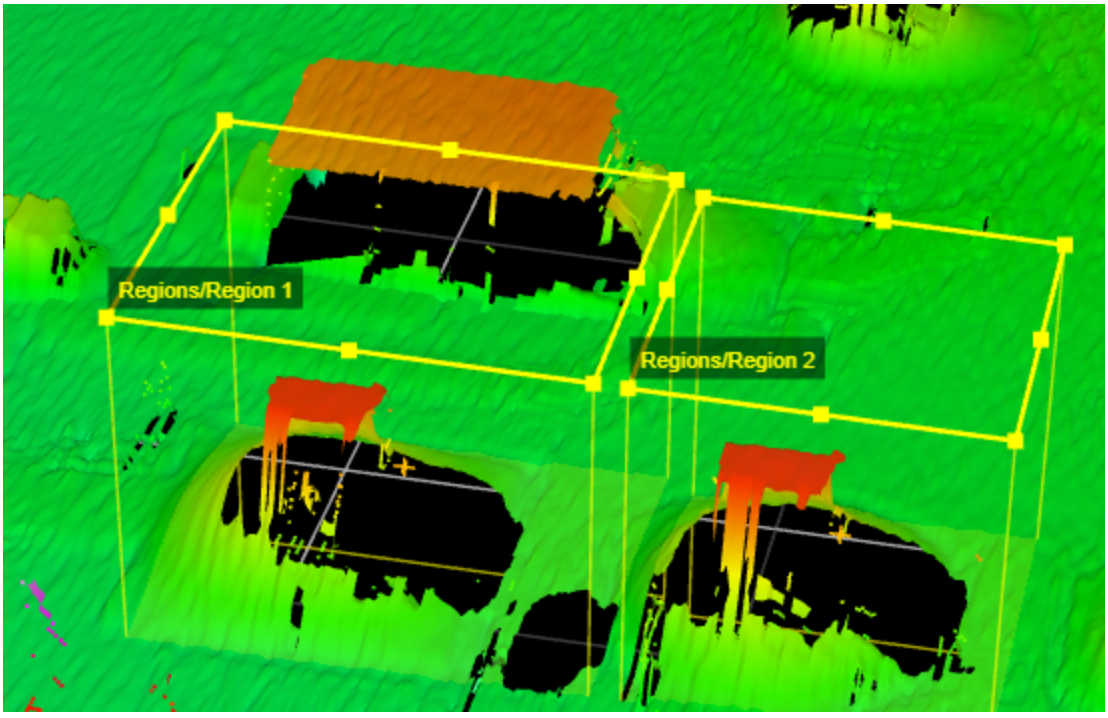
The Surface Direction Filter helps exclude unwanted data points based on their “orientation” (the polar angle relative to surrounding data points) in 3D space, for example, data points resulting from reflections. The tool can provide better results than median or height based filters. The tool lets you 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.



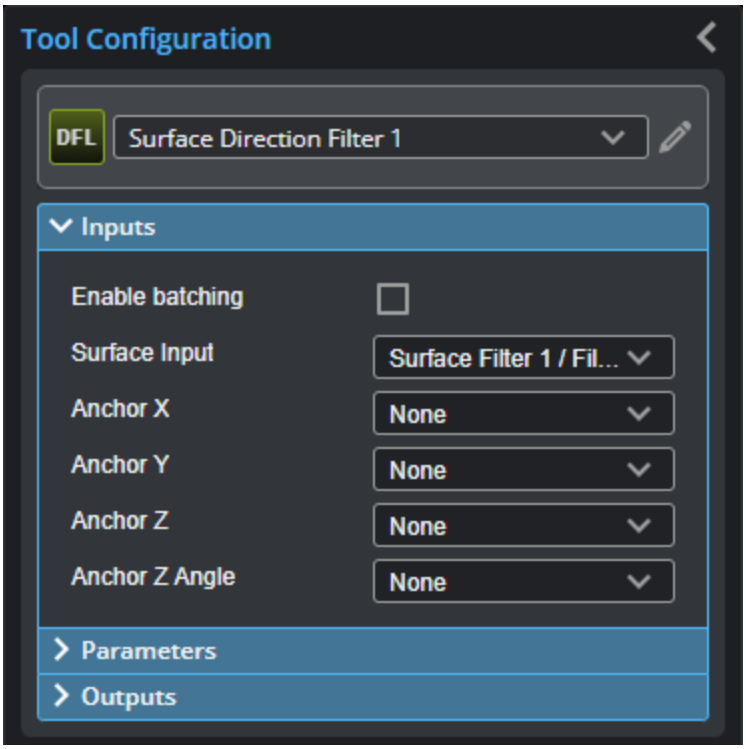
Surface after direction filtering.

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 153.

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 176.

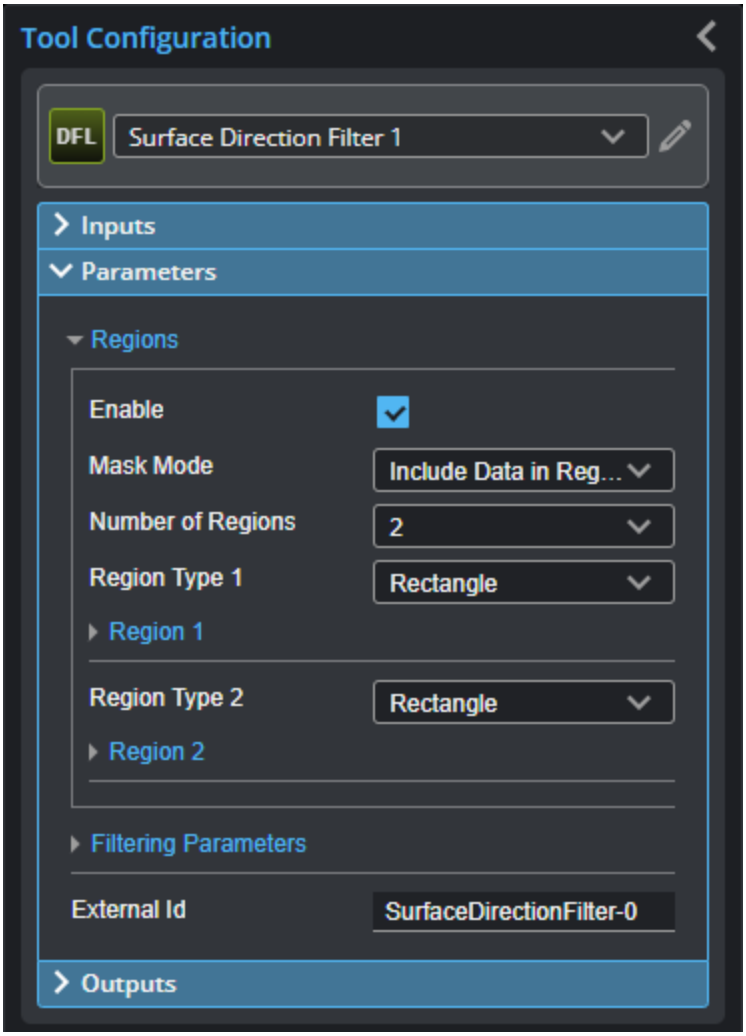
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y	The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

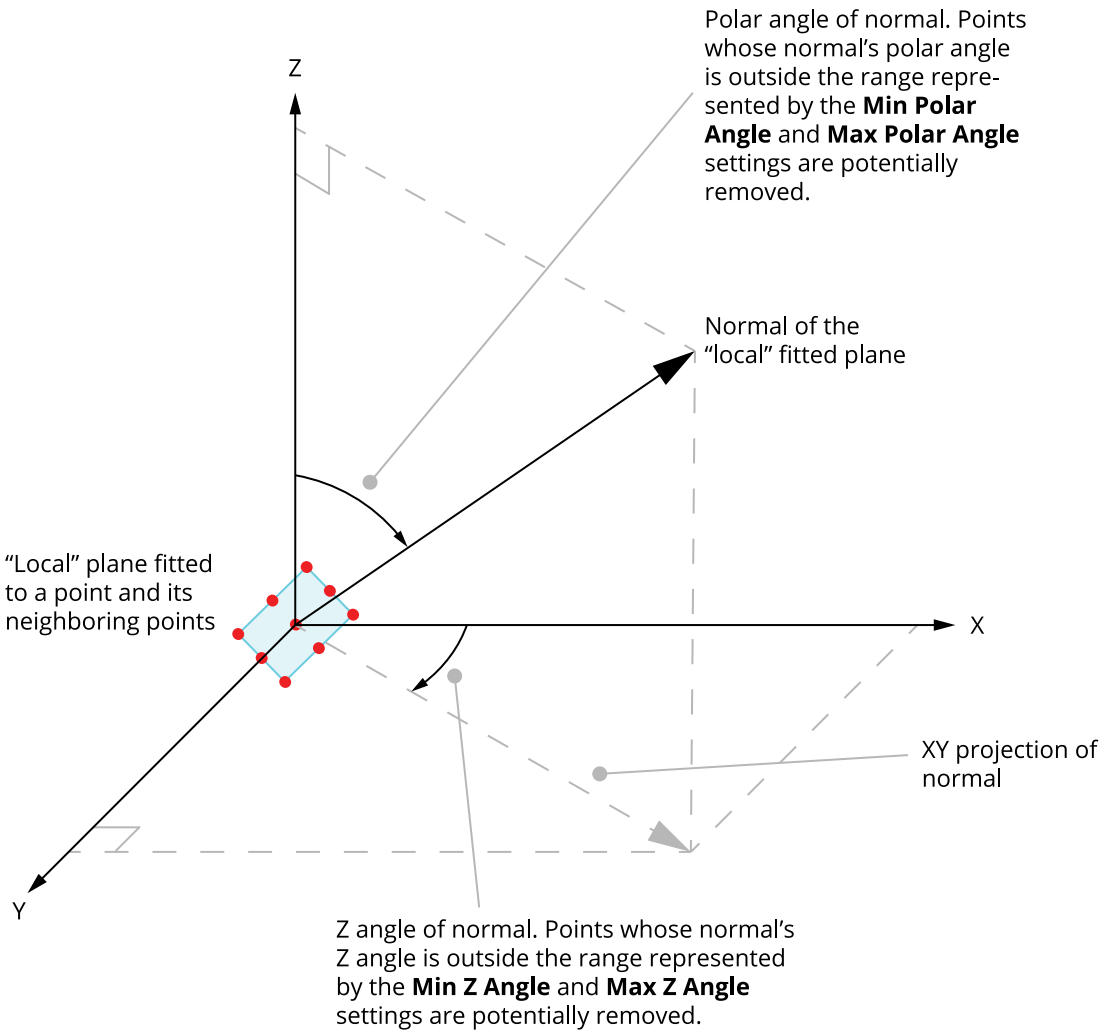
Name	Description
Anchor Z	
Anchor Z Angle	The Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

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.

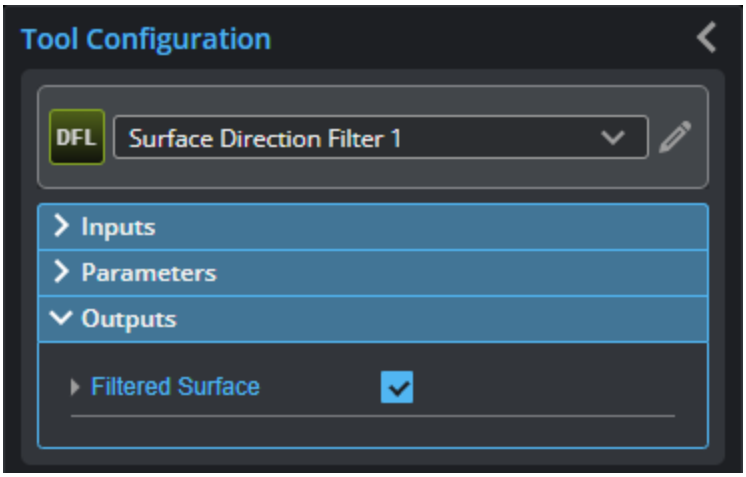
Parameters

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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Filtering Parameters	When expanded, displays the filtering parameters the tool uses.
Min Z Angle 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 666.

Outputs

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



Data

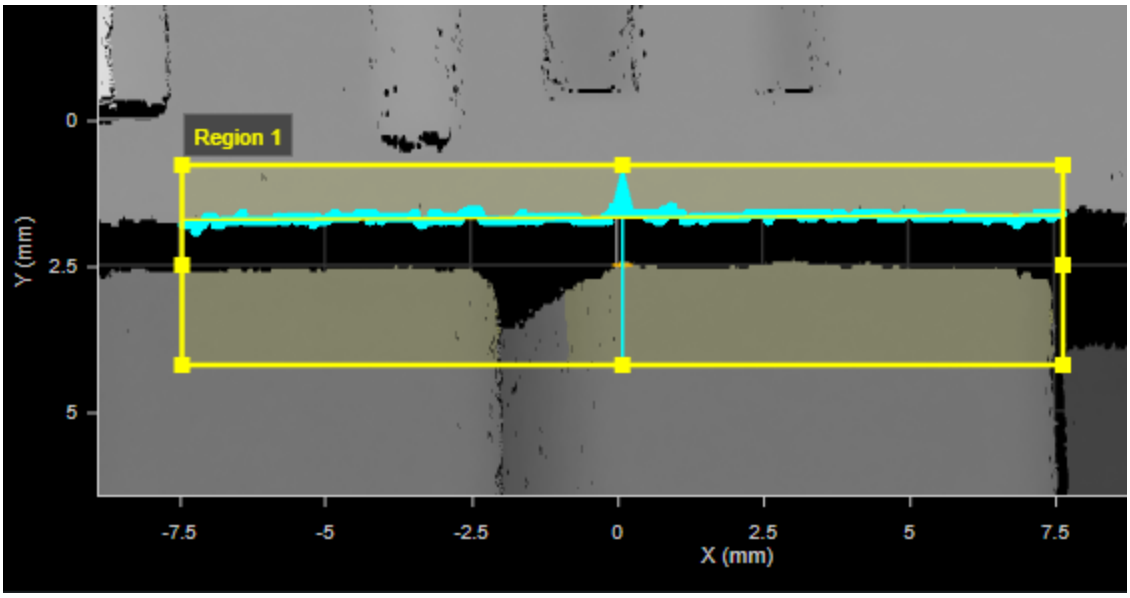
Type	Description
Filtered Surface	The surface after filtering.

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 176.

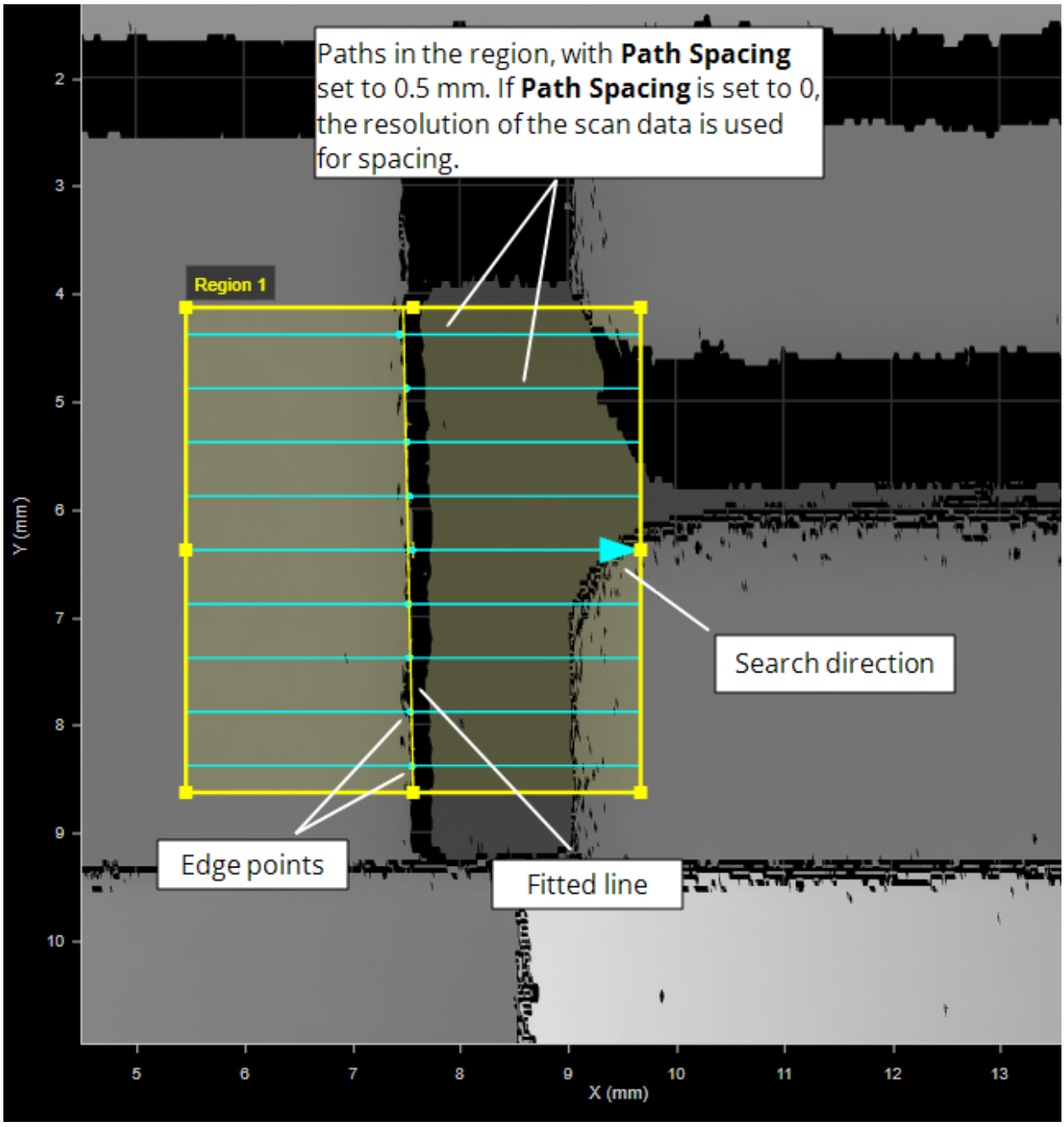
The tool can also generate edge line and center point geometric features that Feature tools can take as input for measurement. For more information on Feature tools, see *Feature Measurement* on page 552.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

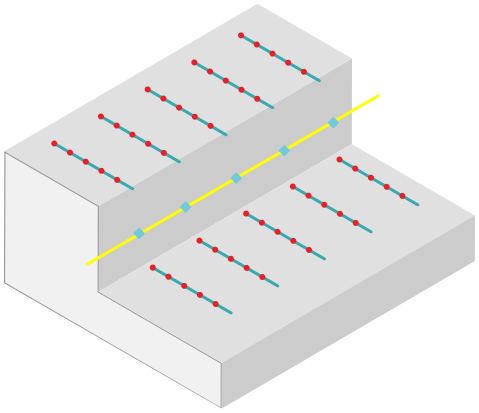
Paths and Path Profiles

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).



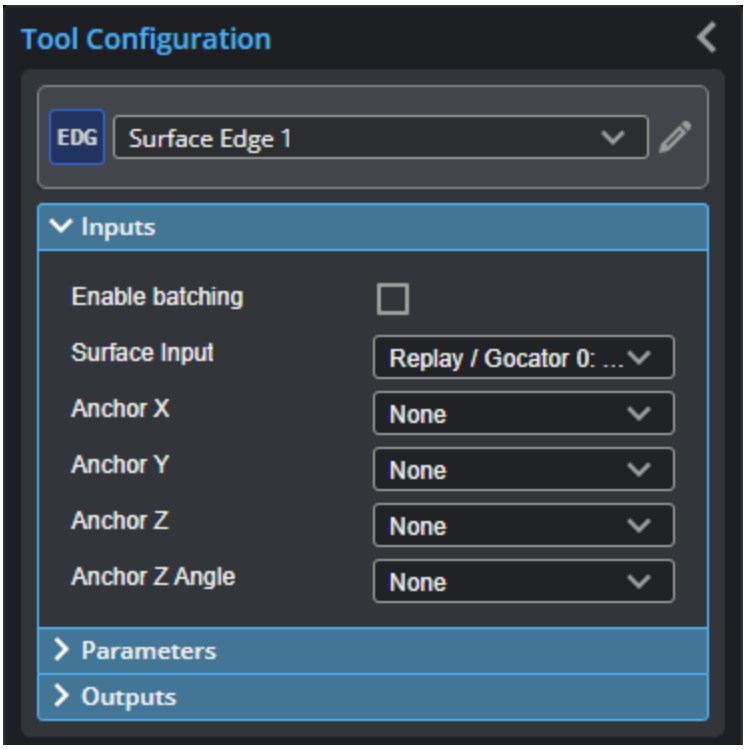
A single path profile extracted from a path.



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.



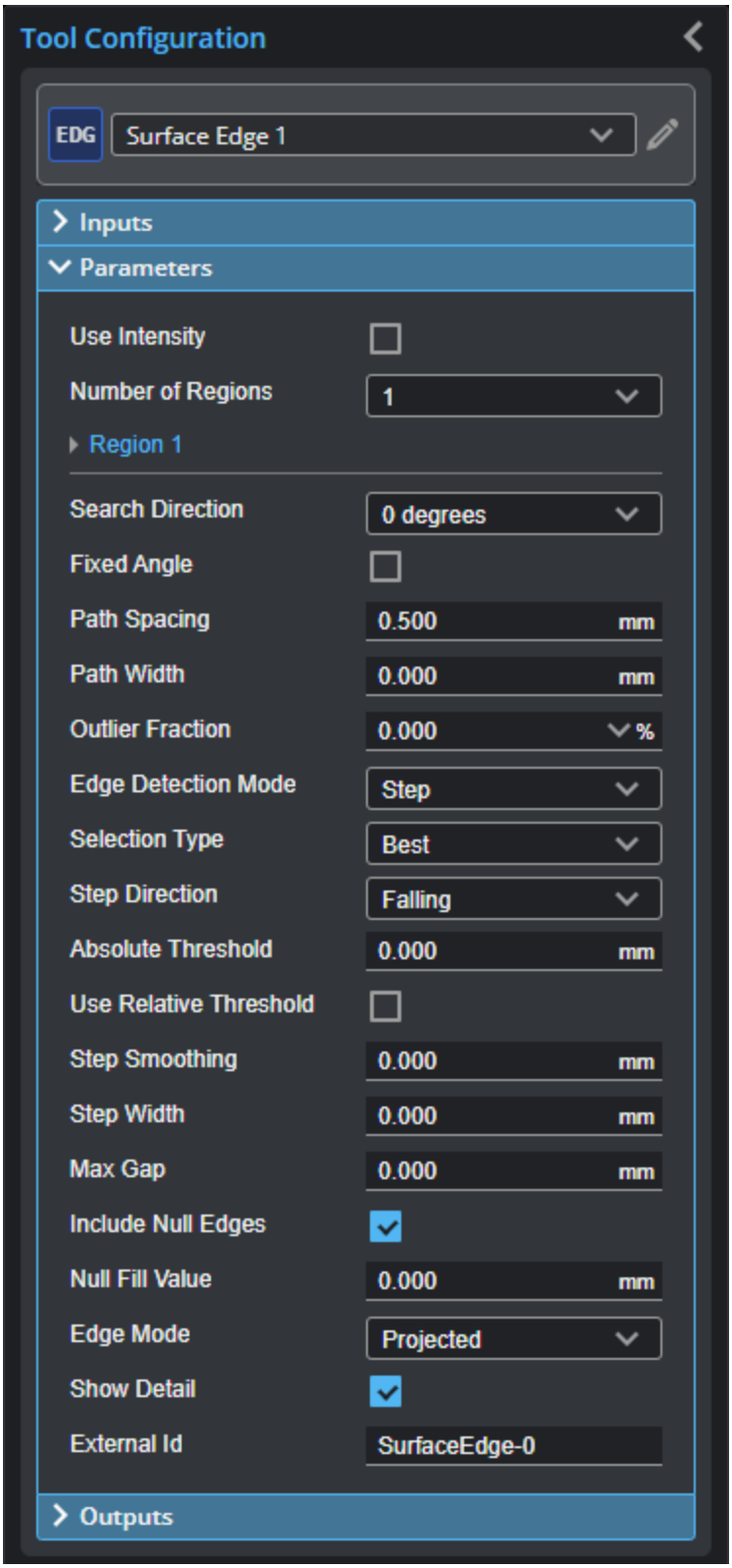
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

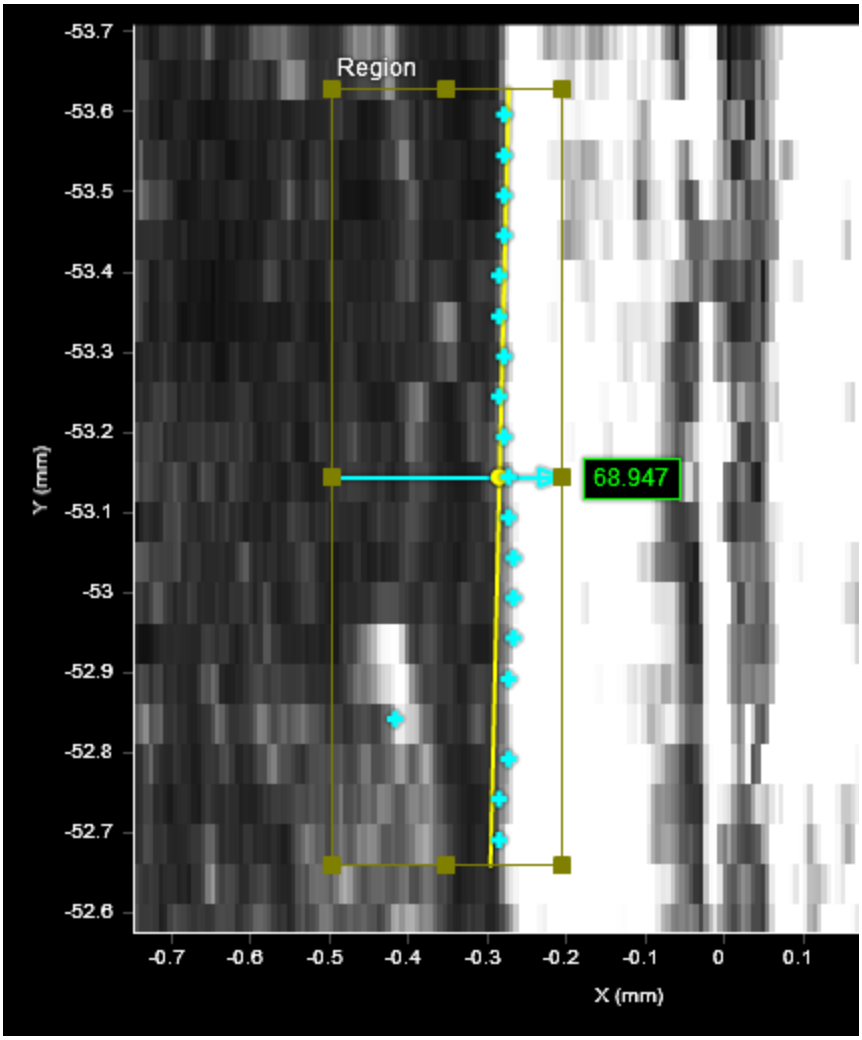
Parameters

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

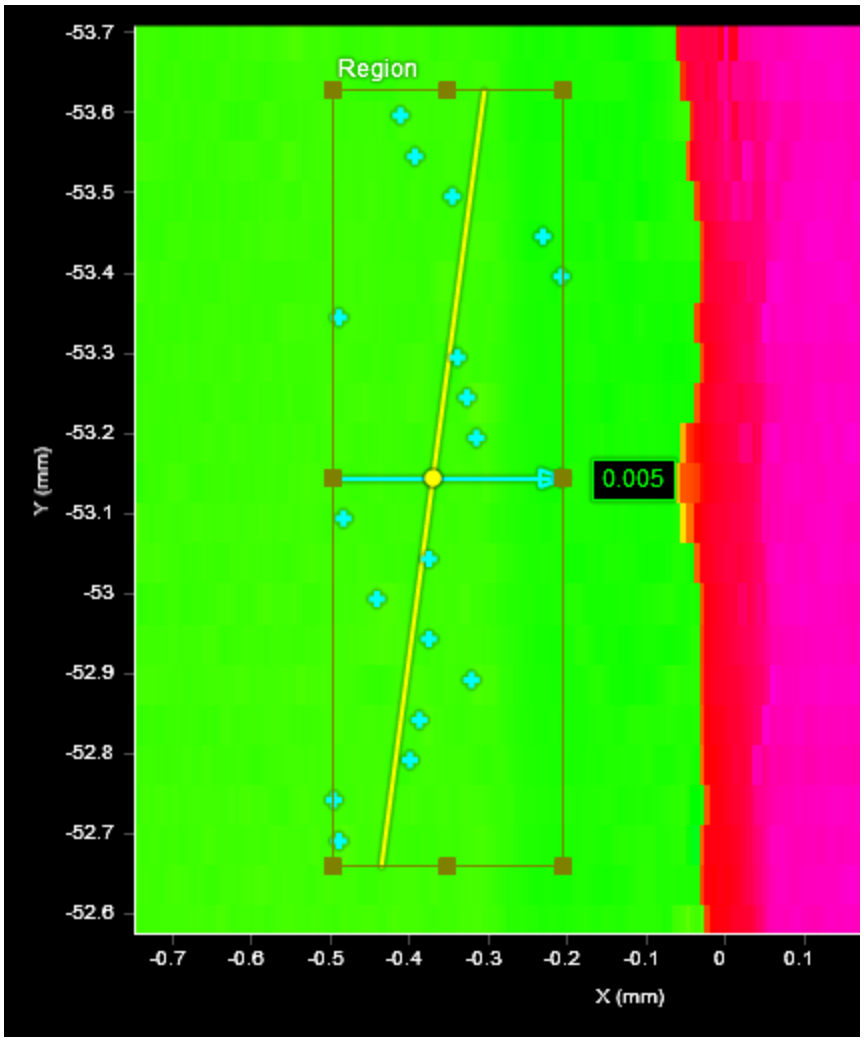

Tool Configuration
EDG
Surface Edge 1
Inputs
Parameters
Use Intensity
Number of Regions
1
Region 1
Search Direction
0 degrees
Fixed Angle
Path Spacing
0.500
mm
Path Width
0.000
mm
Outlier Fraction
0.000
%
Edge Detection Mode
Step
Selection Type
Best
Step Direction
Falling
Absolute Threshold
0.000
mm
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

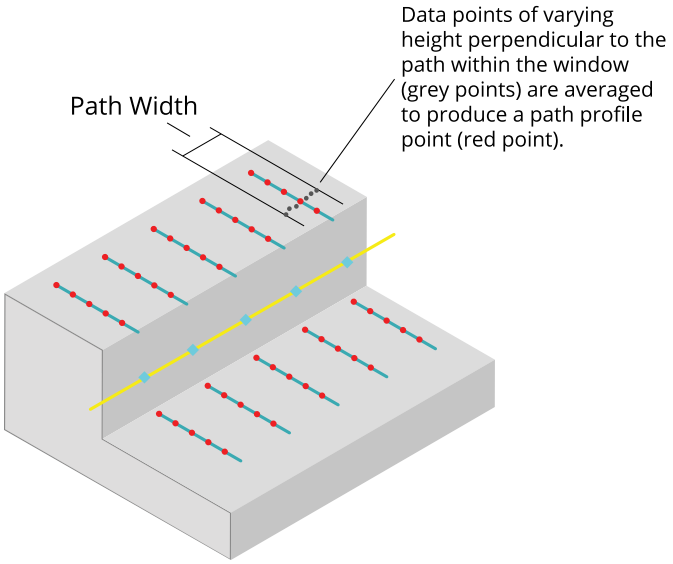
Parameters

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.*

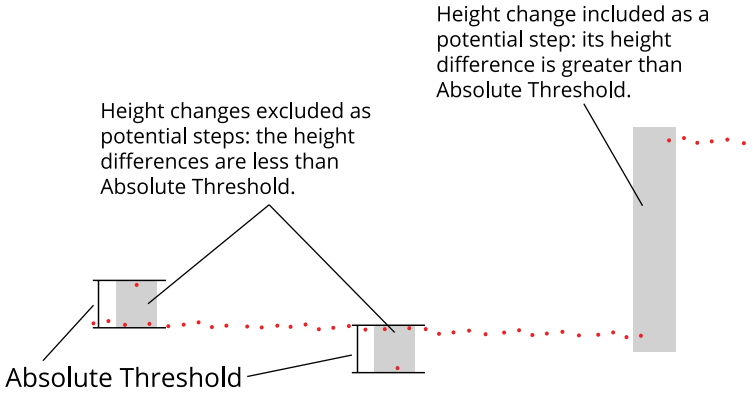
Parameter	Description
	 ***Use Intensity*** *disabled (heightmap view of the same area): Surface Edge tool unable to find edge using height data.*
Number of Regions	The number of regions the tool will use to fit the line. You must configure each region (see *Region {n}* below). Using multiple regions 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 163. The **Search Direction** setting applies to all of the regions. 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

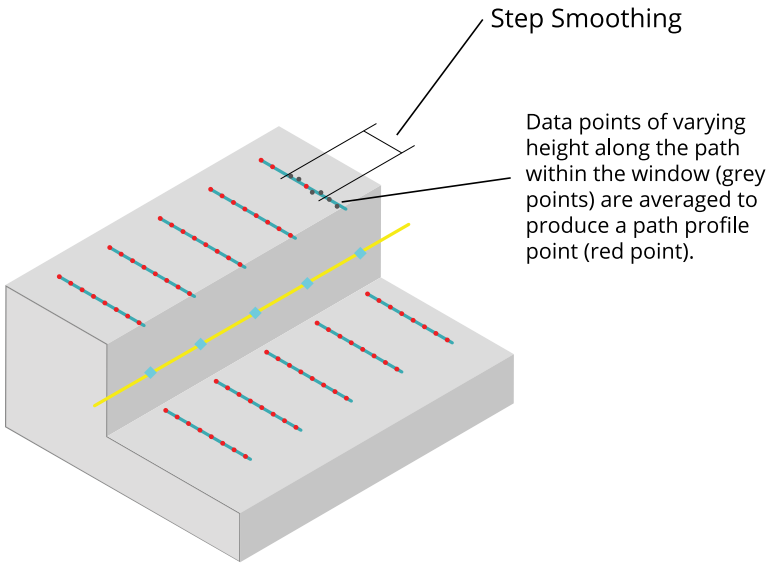
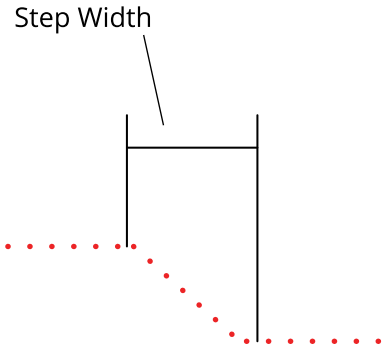
Parameter	Description
	roughly perpendicular to the edge on the target. The direction is indicated by a light blue arrow in the data viewer.
Fixed Angle *Dependent settings* Fixed Angle Value	When this option is enabled, the value in **Fixed Angle Value** replaces the value the Z Angle measurement returns. 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. 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.  If **Path Width** is set to 0, no averaging is performed (only the data point under the path is used). 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. **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. **Corner**: Searches for slopes on each path profile. When you choose this mode, several of the tool's parameters are hidden.

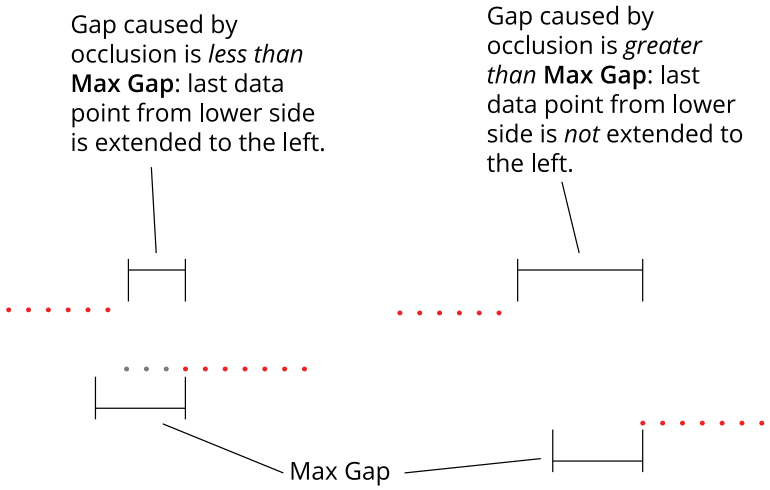
Parameter	Description
Selection Type Corner Type	Determines which step (when **Edge Detection Mode** is set to Step) or corner (when **Edge Detection Mode** is set to Corner) the tool uses on each path profile when there are multiple steps or corners in the profile. An edge point is placed on each chosen 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). **Best**: Selects the greatest step or corner on each path profile. **First**: Selects the first step or corner on each path profile. **Last**: Selects the last step or corner on each path profile. When **Edge Detection Mode** is set to Corner, the following additional options are available in Corner Type: **Top**: Selects the top-most corner on each path profile. **Bottom**: Selects the bottom-most corner on each path profile.
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 666.

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. 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.)

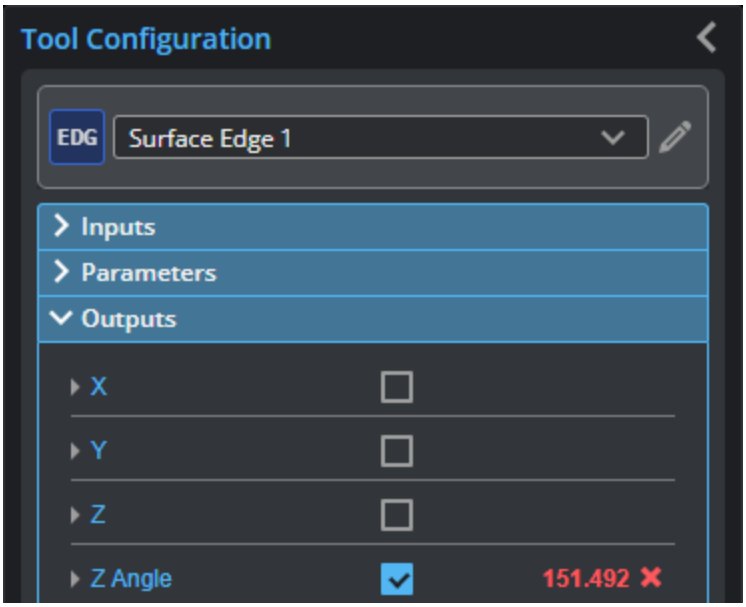
Use Relative Threshold	When this option is enabled, the **Relative Threshold** field is displayed.
Relative Threshold	The value for the relative threshold. The tool calculates a relative threshold by scaling the greatest height or intensity difference found on the path profiles by the percentage in **Relative Threshold**. This lets you configure the tool without knowing the actual step height in advance, and is useful for edges with varying step height. 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.  If **Step Smoothing** is set to 0, no averaging is performed (only the data point under the path is used). 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 265). 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: **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.

3D: The line fitted to the edge follows the slope of the edge. This mode is typically used with a sloped edge.

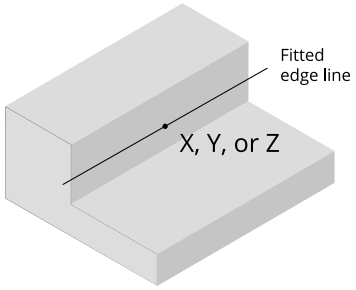
Outputs

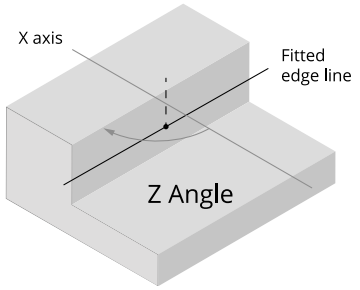
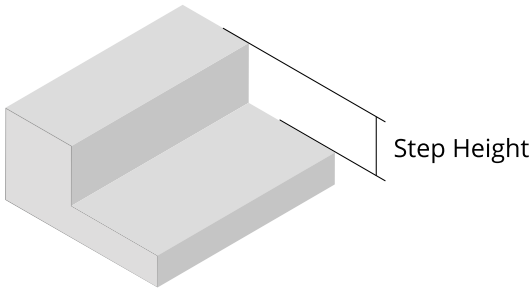
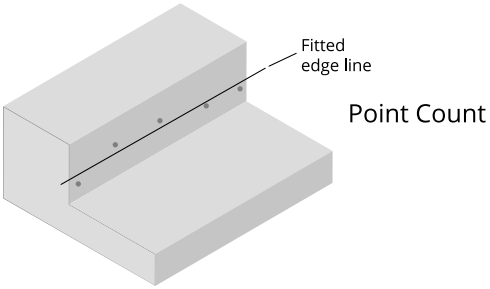
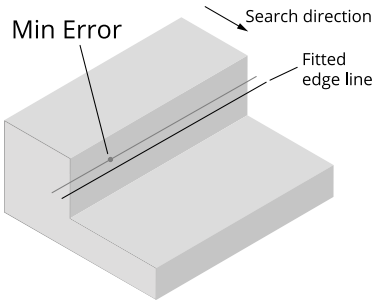
All tools provide measurements, geometric features, or data as outputs.

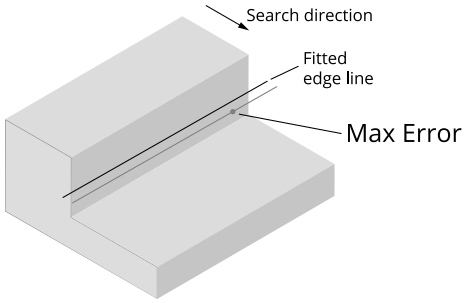


You configure the **Min** and **Max** parameters by expanding the measurement in the **Outputs** section. In order for a measurement to return a Pass decision, the measurement must be between maximum and minimum values; the range is inclusive.

Measurements

Measurement	Illustration
X Returns the X position of the center point of the fitted edge line.	
Y Returns the Y position of the center point of the fitted edge line.	
Z Returns the Z position of the center point of the fitted edge line.	

Measurement	Illustration
Z Angle 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. 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 176.	
Step Height Returns the height of the step, calculated by averaging the step heights of all of the path profiles. (When **Use Intensity** is enabled, the value returned is the difference in intensity.) This measurement returns Invalid when **Edge Detection Mode** is set to Corner.	
Point Count The number of points used to fit the line. Useful for determining if the number of points is above an acceptable minimum.	
Min Error **Max Error** 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. The measurements ignore points excluded using the **Outlier Fraction** parameter.	

Measurement	Illustration
	

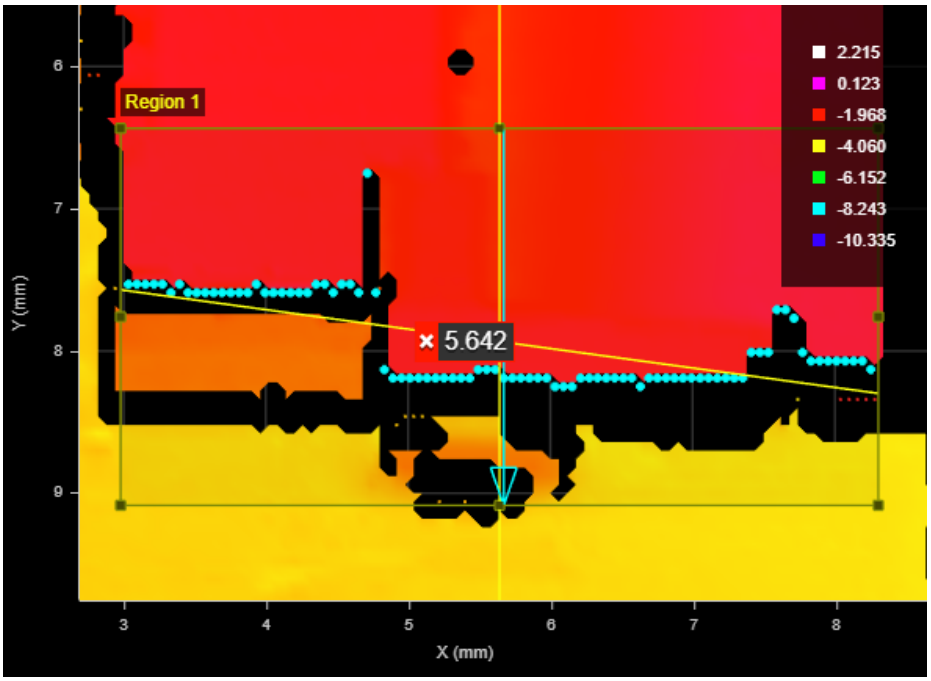
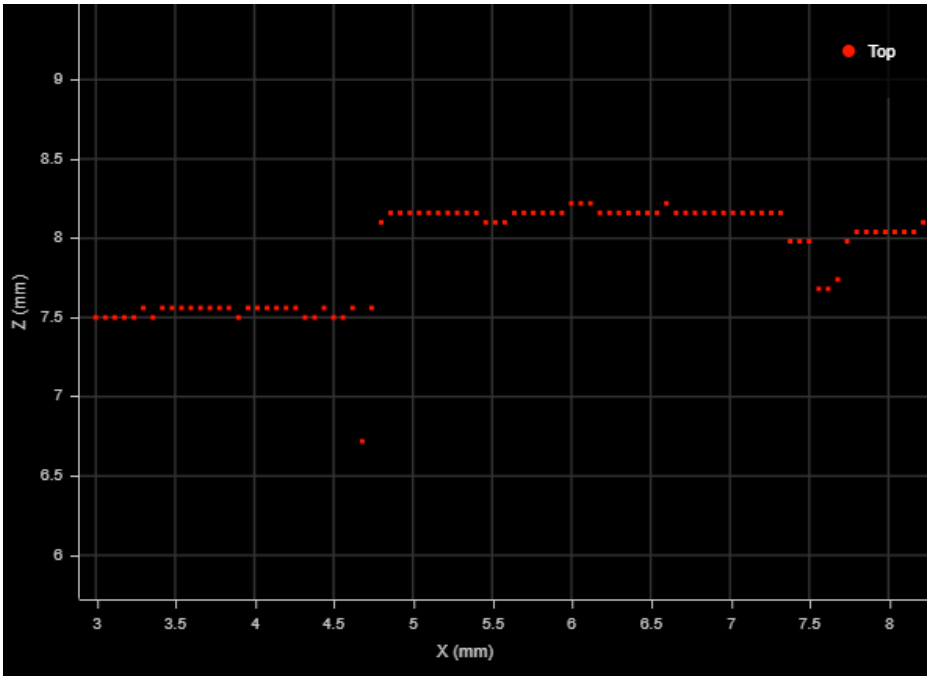
Features

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 175.

Data

Type	Description
Profile Point Cloud 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. Given the following edge, the resulting profile is shown further below:

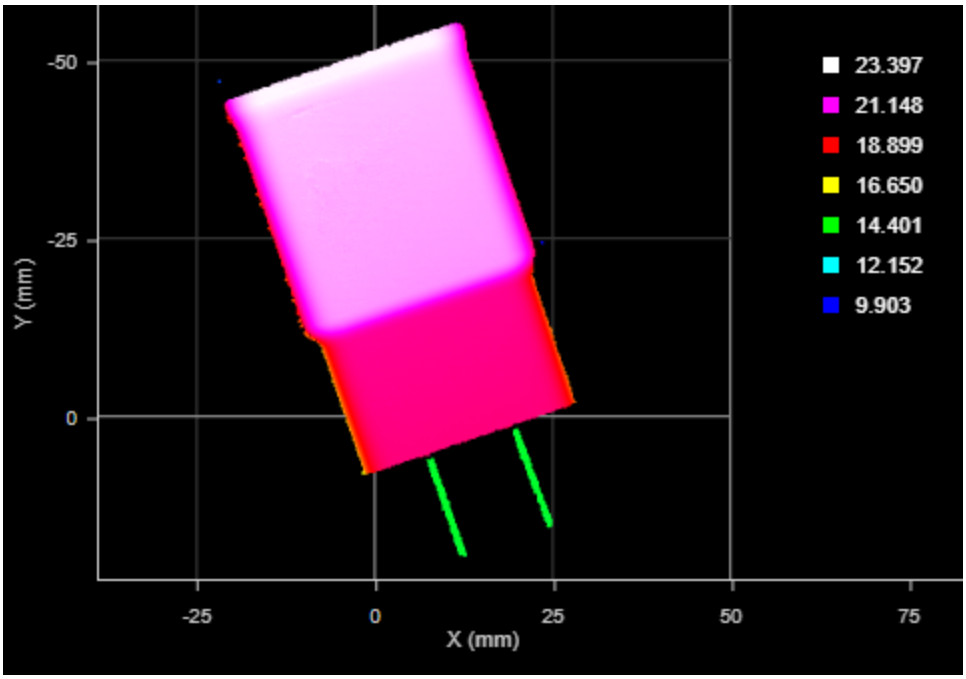
Type	Description
	 The profile is mirrored vertically when compared to the edge: Note how the single edge point toward the top of Region 1 in the surface data above is at the bottom of the extracted profile (below). 

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.

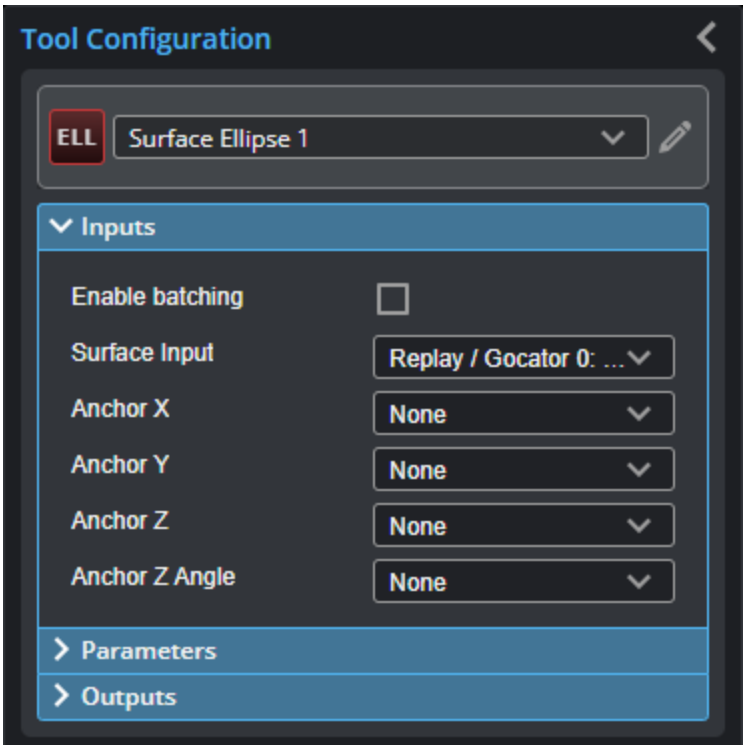
(The following screenshot is from a G2 sensor.)



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



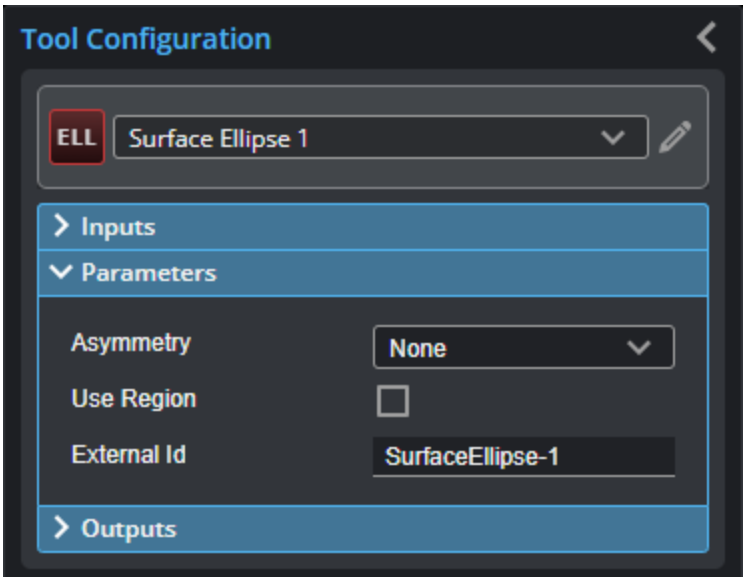
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z 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.

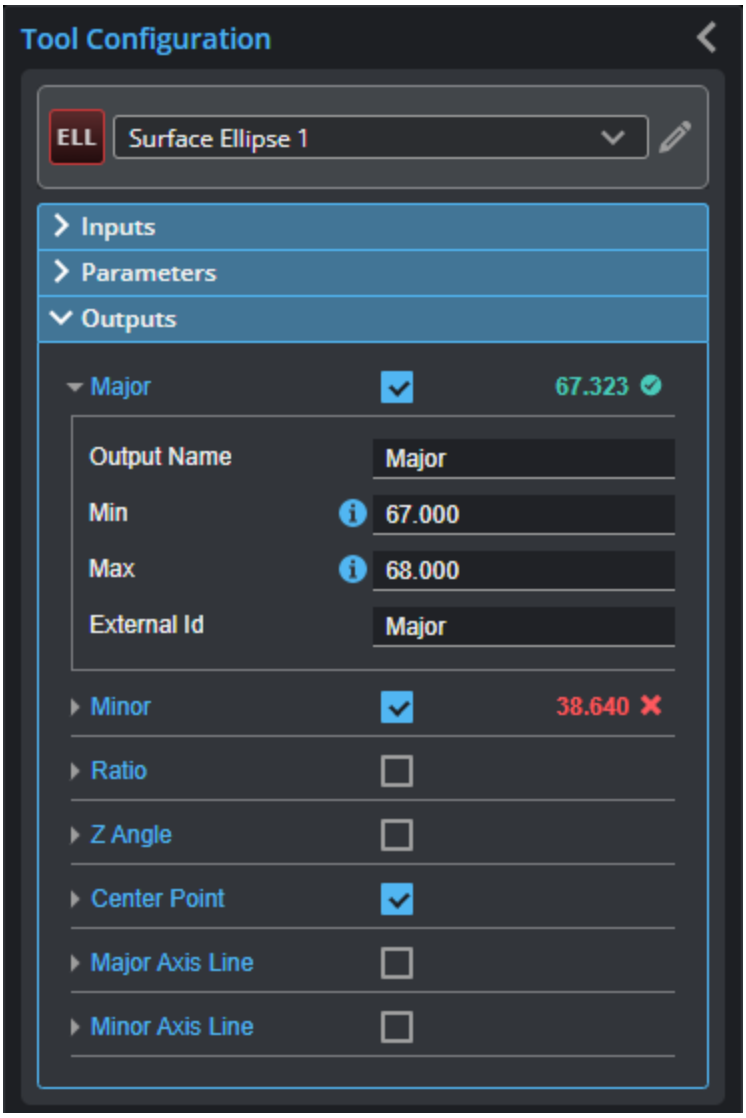


Parameters

Parameter	Description
Asymmetry	Resolves the orientation of an object over 360 degrees. The possible values are: 0 – None 1 – Along Major Axis 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 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

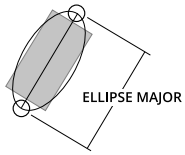
All tools provide measurements, geometric features, or data as outputs.

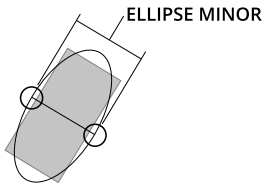
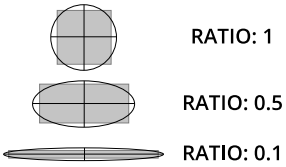
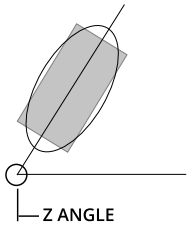


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the major axis length of an ellipse fitted to the part's area in the XY plane.	

Measurement	Illustration
Minor Determines the minor axis length of an ellipse fitted to the part's area in the XY plane.	
Ratio Determines the minor/major axis ratio of an ellipse fitted to the part's area in the XY plane.	
Z Angle Determines the orientation angle of an ellipse fitted to the part's area in the XY plane.	

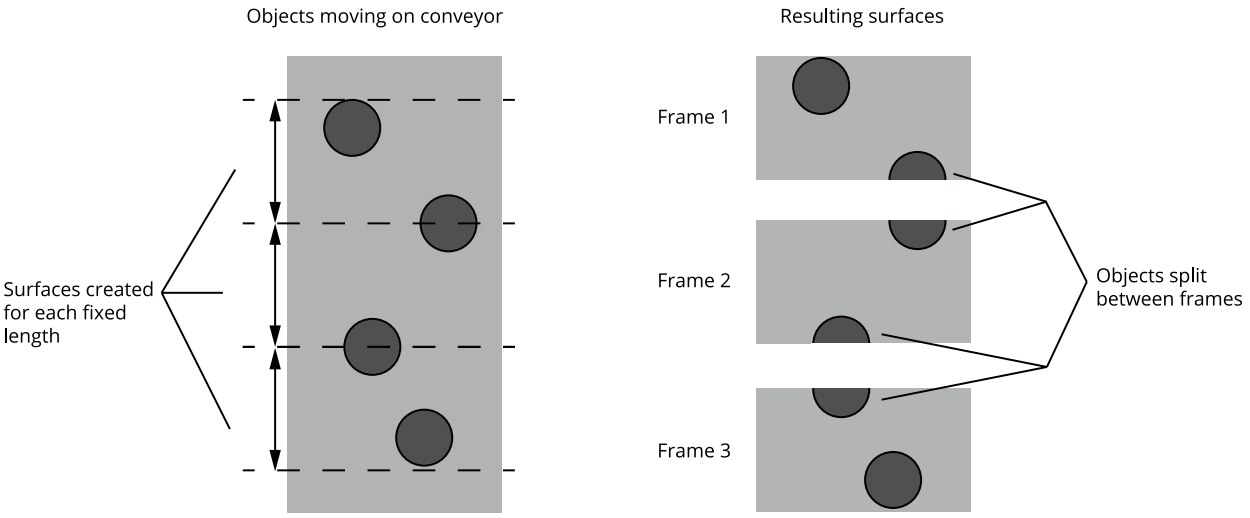
Features

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.

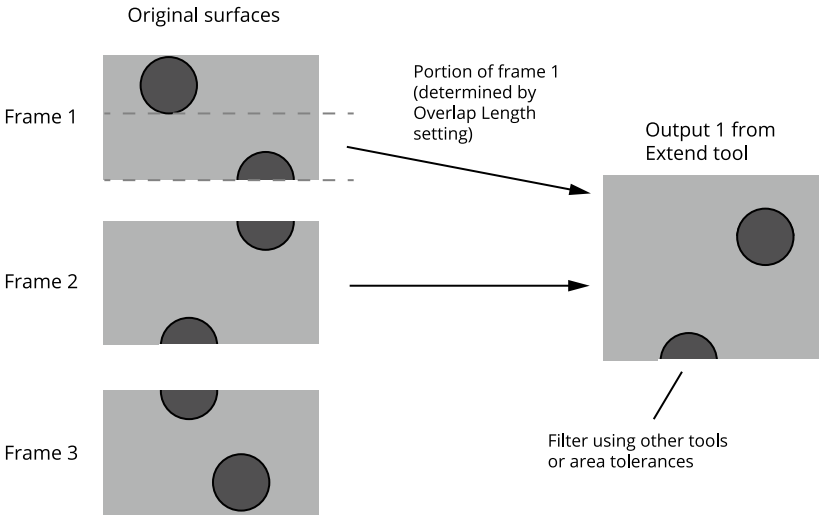
For more information on geometric features, see *Geometric Features* on page 175.

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:

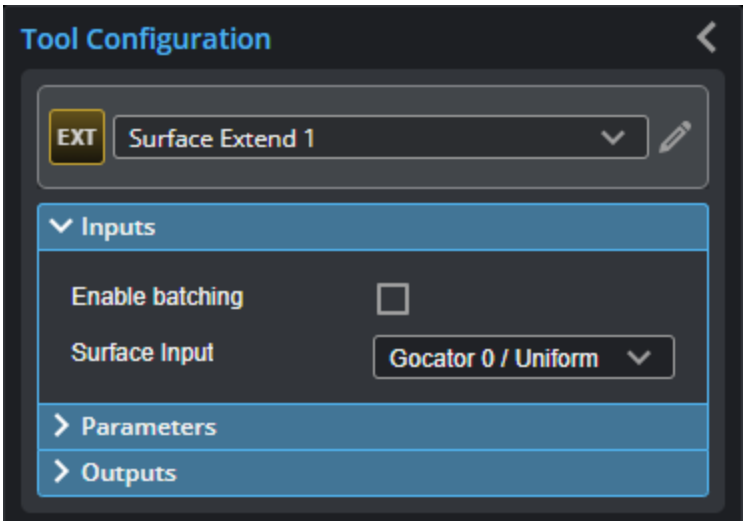


Data is only appended in one direction. Partial objects in the resulting surface output from the tool must be filtered out using downstream tools, for example, excluding them based on the expected area.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



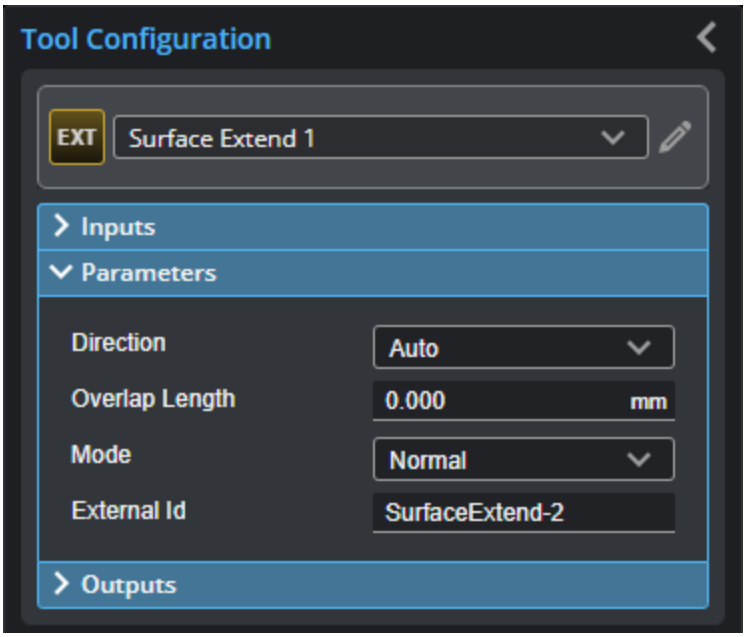
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

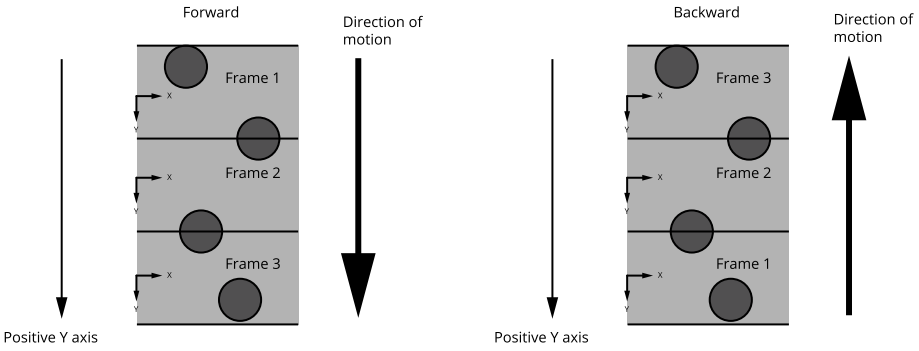
Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.

Parameters

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



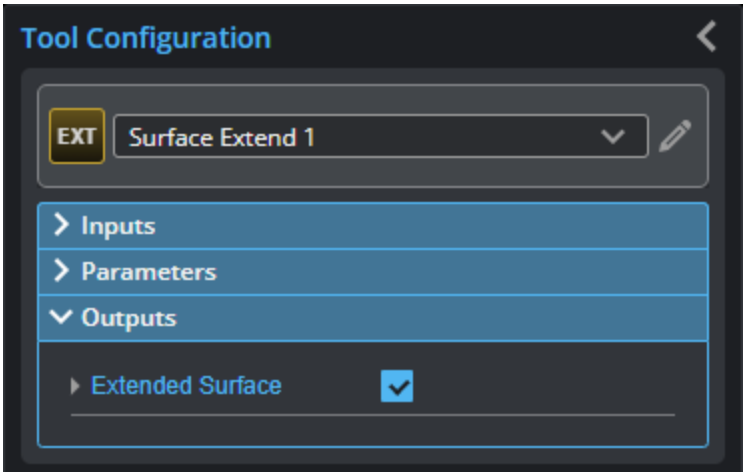
Parameters

Parameter	Description
Direction	Determines whether the previous frame's data is appended above or below the current frame's data.  One of the following. Note that these settings depend on whether the trigger source has been set to Encoder (see *Triggers* on page 112) and the orientation of the sensor. • **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. • **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. • **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: • **Normal**: The tool's output is unlocked and functions normally. • **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 666.

Outputs

All 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.

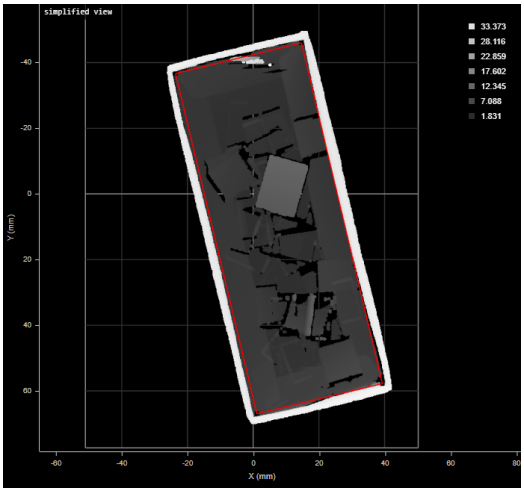
Surface Feature Mask

The Surface Feature Mask dynamically defines a polygon or circle mask using multiple 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.

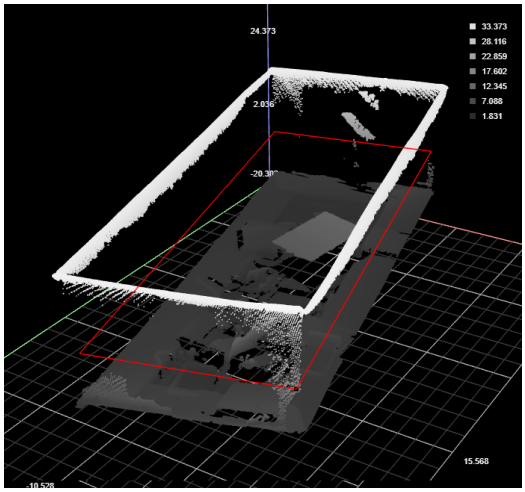
The following is a possible tool chain for calculating the fill volume of rectangular bin using Surface Feature Mask:

- 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

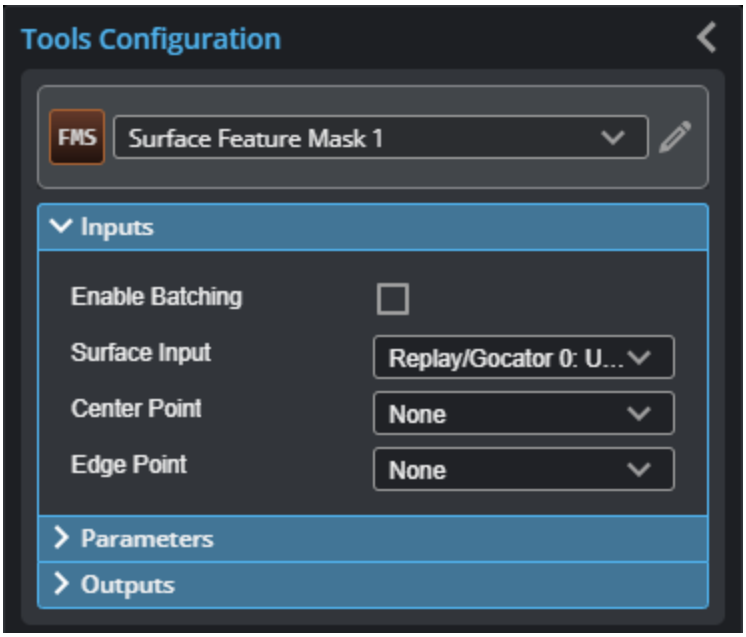


3D View

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



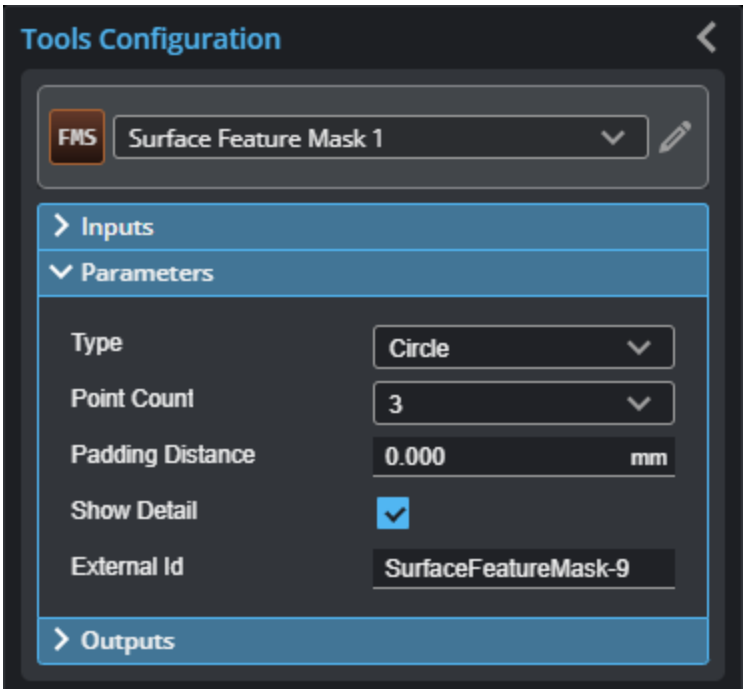
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Point {n}	The nth Point geometric feature. Only displayed if you set **Point Count** to 3 or higher.
Center Point	The center Point geometric feature of the circle. Only displayed if you set **Type** to Circle and **Point Count** to 2.
Edge Point	The Point geometric feature on the circle. 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 175.

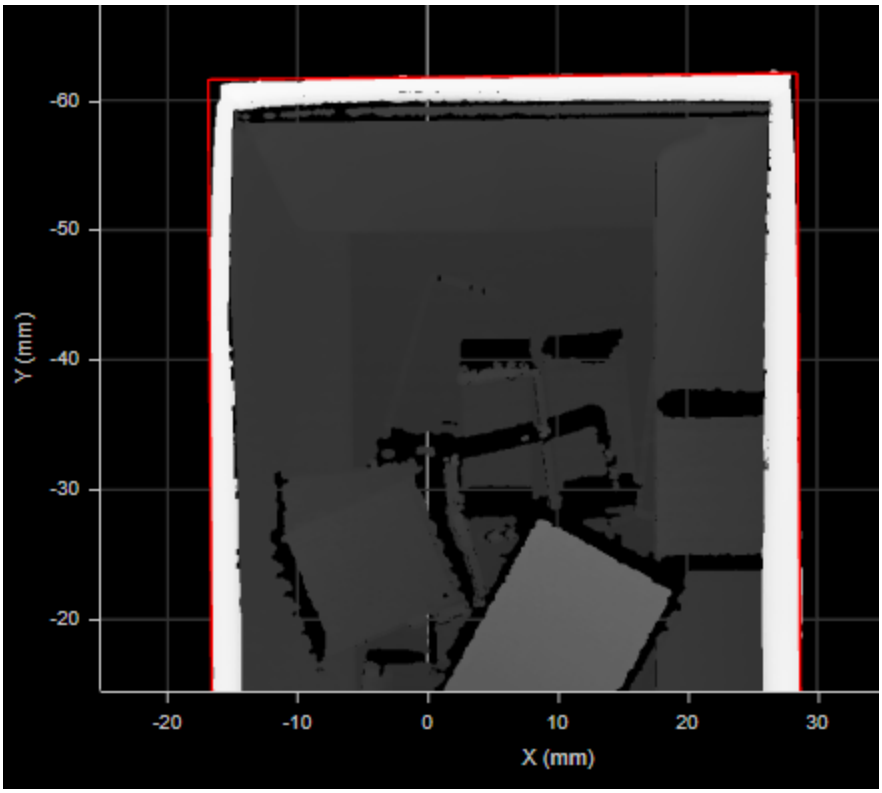
Parameters

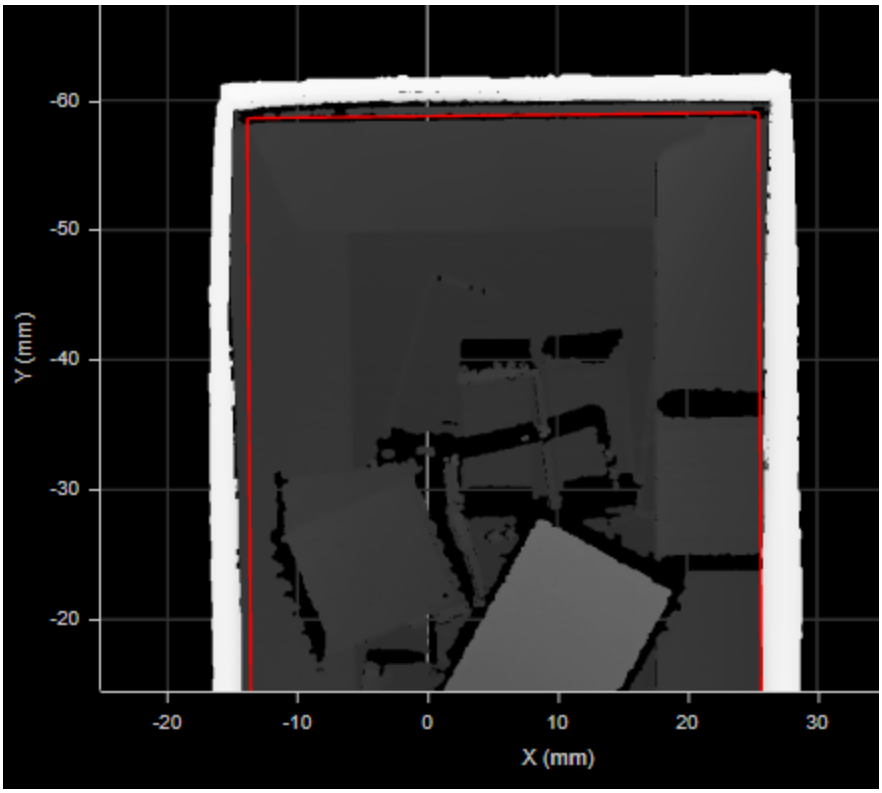
You configure the tool's parameters in the expandable **Parameters** section.

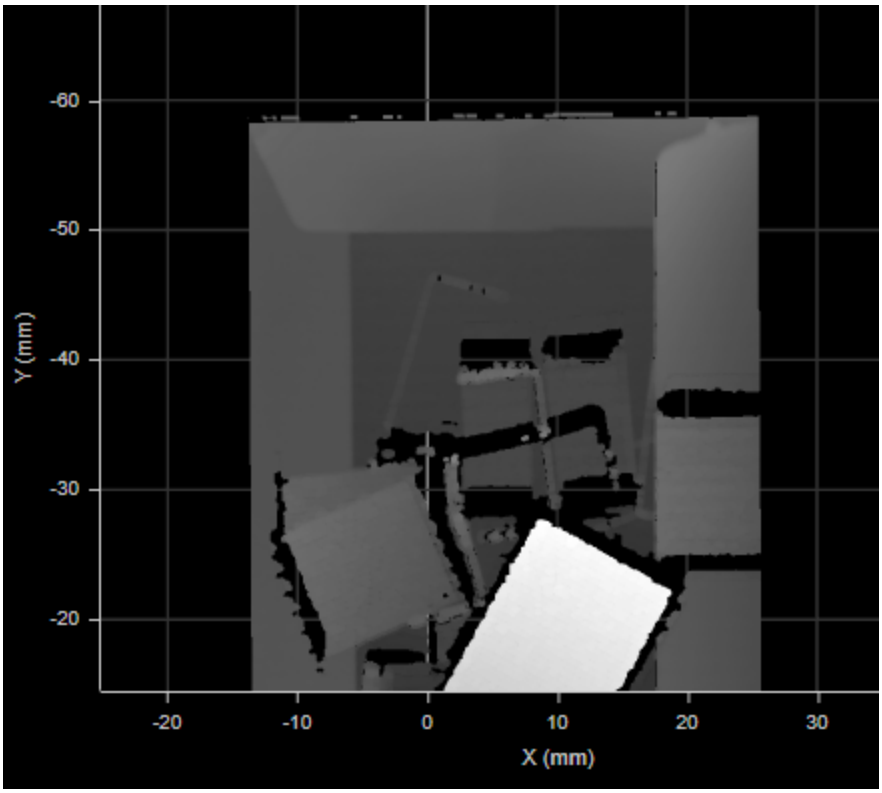


Parameters

Parameter	Description
Type	The shape type of the mask. It supports two options: **Polygon** - The tool needs at least 3 Point geometric features. **Circle** - The tool needs 2 or 3 point geometric features.
Point Count	The count of the input point features. For the Polygon **Type** option, the tool supports integers in the range of 3 to 10. For the Circle **Type** option, the tool supports integers of 2 or 3. 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. When the value is greater than 0, the offset is outward. When the value is less than 0, the offset is inward. 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.

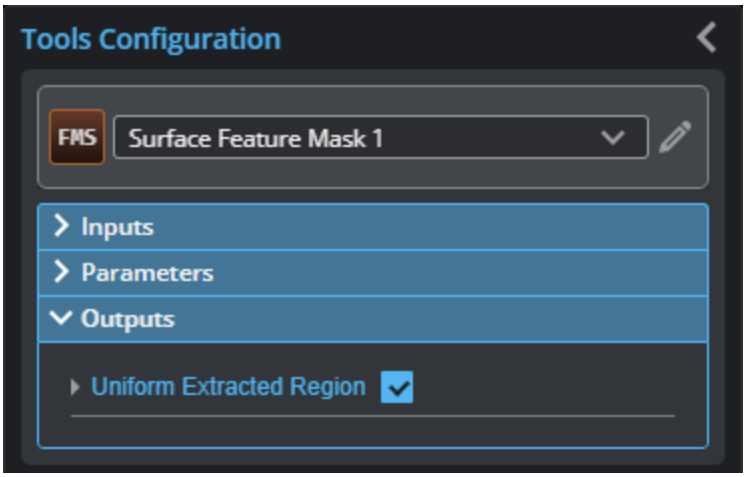
Parameter	Description
	 In the following, padding has been set to -3, which moves the mask "inward," excluding the bin.

Parameter	Description
	 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 666.

Outputs

All 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 666.

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 a 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 420.

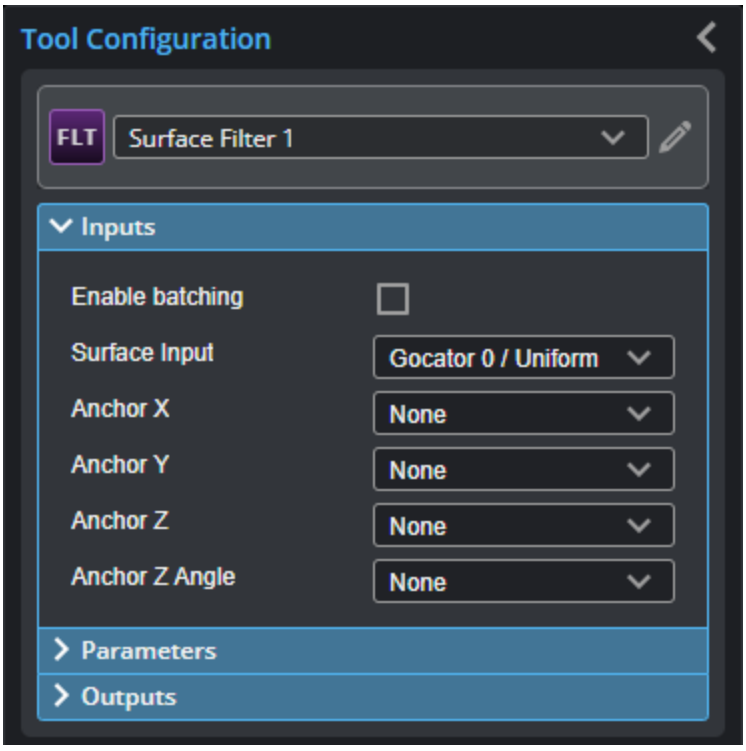
The Filter tool provides no measurements or decisions, as its only purpose is to output processed surface data.

> A limited set of filters is also available on the **Scan** page. 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 153.

Inputs

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



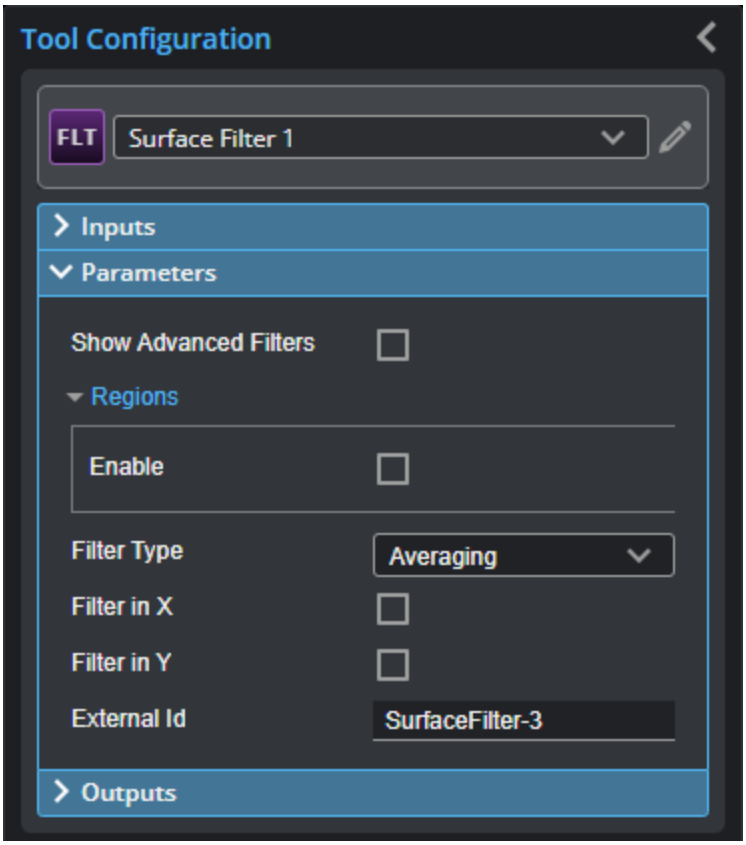
> To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z 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

Parameter	Description
	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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Use Intensity	If enabled, the tool uses intensity data *instead of* Surface data. Only usable if **Acquire Intensity** is enabled on the **Acquire** > **Scan** page during scanning. Only available in the advanced filters (see above); for information on the available filters, see *Filters* below. If disabled, the tool filters using Surface data; intensity data corresponding to filtered heightmap data will also be removed. For more information on scan modes, see *Scan Modes and Intensity* on page 107.
Units	Specifies whether filters use data points (**pts**) or millimeters (**mm**). Not available with all filters.
Filter Type	The type of the filter. For information on the available filters, see *Filters* below.
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. 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 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**.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

The following filters are available in the Filter tool. Filters described below as advanced are only displayed if **Show Advanced Filters** is enabled.

Filters

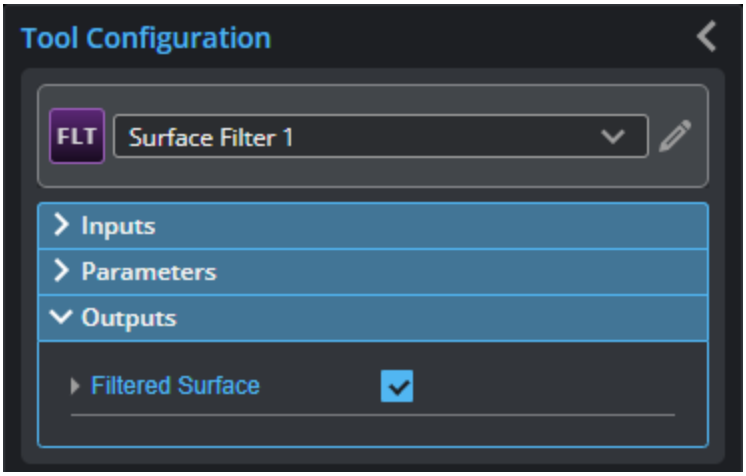
Name	Description
Gap Filling	Fills in missing data caused by occlusions using information from the nearest neighbors. Gap filling also fills gaps where no data is detected, which can be due to the surface reflectivity, for example dark or specular surface areas, or to actual

Name	Description
	gaps in the surface. The values in **Filter in X** and **Filter in Y** represent the maximum gaps the sensor will fill. Wider than gaps will not be filled. 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.
Median	A median filter.
Averaging	An averaging / mean / smoothing filter.
Decimation	A decimation filter.
Gaussian (advanced)	A Gaussian filter. Set the **Sigma** parameter as required.
Open (advanced)	Erosion followed by dilation.
Close (advanced)	Dilation followed by erosion.
Erode (advanced)	Applies an erosion filter. Lets you specify the direction of the erosion; one of the following: • Horizontal • Vertical • Symmetrical
Dilation (advanced)	Applies a dilation filter. Lets you specify the direction of the dilation; one of the following: • Horizontal • Vertical • Symmetrical
Morph Gradient (advanced)	Applies a morphological gradient. The difference between dilation and erosion.
Sobel Magnitude (advanced)	Applies a Sobel magnitude filter. Lets you specify the direction of the filter; one of the following: • Horizontal • Vertical • Symmetrical
Laplacian (advanced)	Applies a Laplacian filter. Useful for detecting areas of distinct edges. Uses the following kernel: 0 -1 0 -1 4 -1 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.

Name	Description
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. 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 based on user-specified minimum and a maximum heights. Use **Reference Region** to set the heights relative to a reference region.
Crop only (advanced)	Crops the scan data to the user-defined region.
Mask With Input	Uses the surface input into the tool as a mask on the data. Any points in the filtered data will be set to null if the input surface is null at the same location. For example, the Gaussian filter can extend data along the edges, adding data in areas that contain null values. This filter would remove data that the Gaussian filter introduces, preserving the null values. This filter should follow any filter that introduces this kind of unwanted data.

Outputs

All 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.

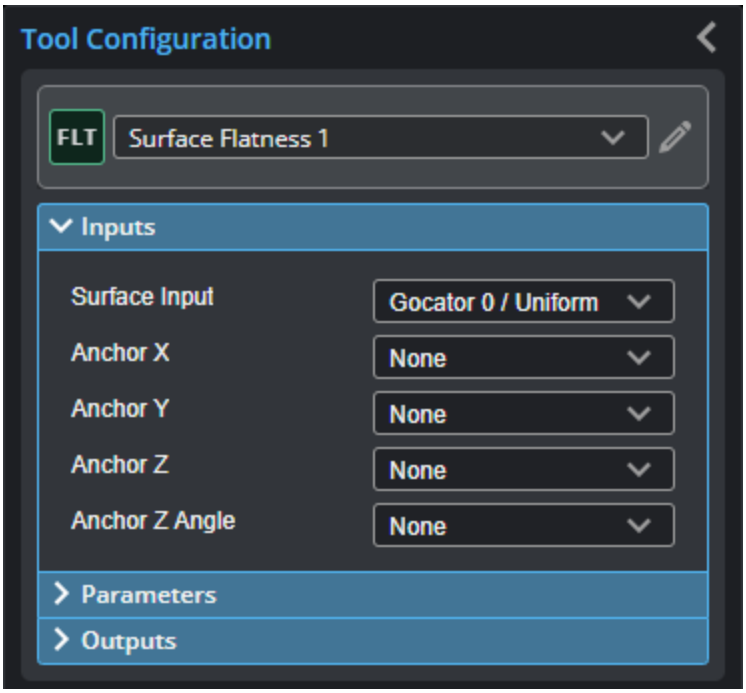
The tool lets you set a grid with user-defined cell sizes over a region, or more flexibly with multiple individual regions manually. In each case, "local" minimum and maximum heights, as well as flatness indicators (maximum - minimum), are returned. In addition, "global" minimum, maximum, and flatness 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 153.

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 176.

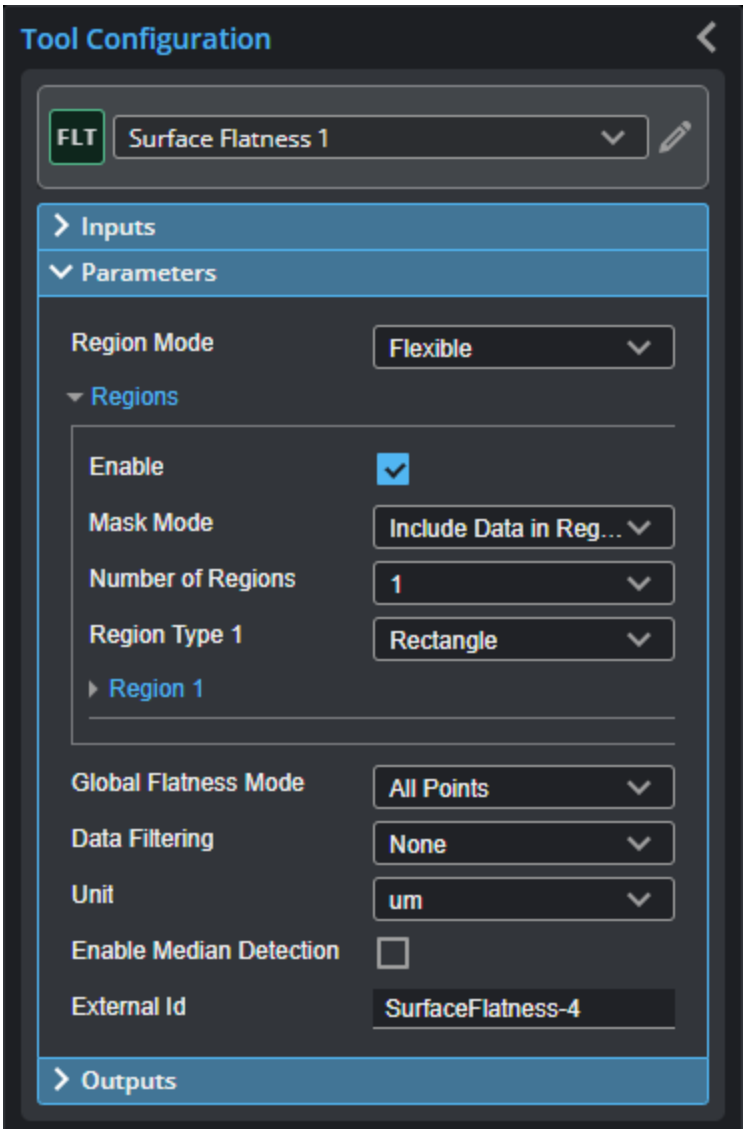
Inputs

Name	Description
Surface Input	The data the tool applies measurements to or processes.

Name	Description
Anchor X Anchor Y 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 Z 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

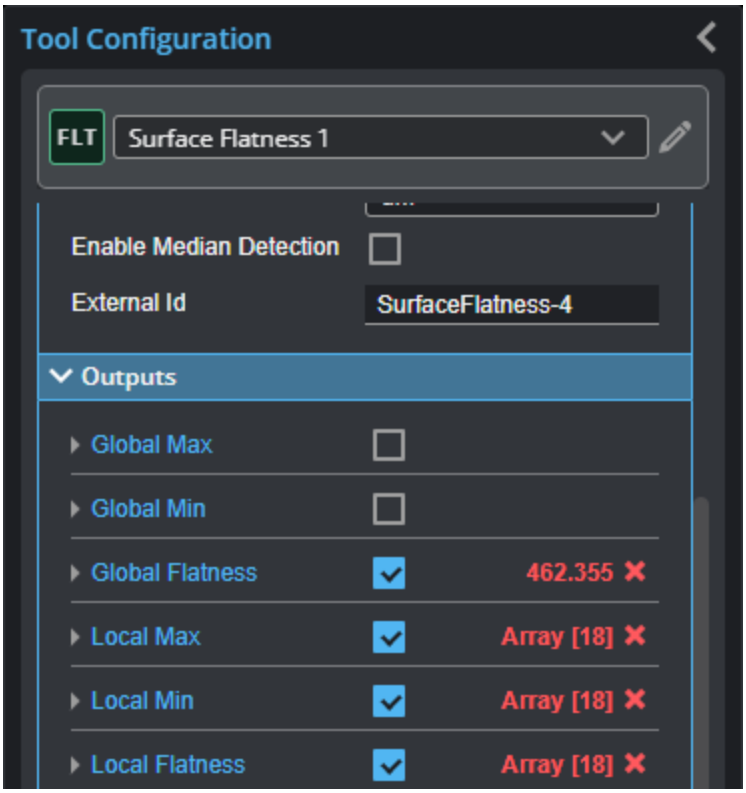
Parameter	Description
Region Mode	Determines how flatness measurement areas are set up on the target. One of the

Parameter	Description
	following: **Grid Pattern**: The tool determines flatness in a grid you define on the target. This 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. **Flexible**: The tool determines flatness using one or more regions that you define individually on the target.
Grid Region *(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) Grid Length (Y) *(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.
Enable	Enables regions and displays the region- and mask-related settings (see below).
Mask Mode Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Global Flatness Mode	Chooses which points the tool uses to calculate global flatness. One of the following: **All Points**: The tool uses all points in the measurement area (all flexible regions or the grid pattern in the region). **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. When you use Local Percentile or Global Percentile, you must set **High Percentile** and **Low Percentile**. **None** - The tool performs no filtering. **Local Percentile** - Applies the percentile filter to local masks first, and then merges to a global mask. **Global Percentile** - Merges to a global mask first, and then applies the percentile

Parameter	Description
	filter to the global mask.
Unit	Lets you choose which units the tool uses for measurement results. One of the following: • um (micrometers) • 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 666.

Outputs

All 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
Global Max
Global Min

Measurement
Global Flatness 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 155.

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 Global Max Point Global Min Point 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 Local Max Point Local Min Point 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

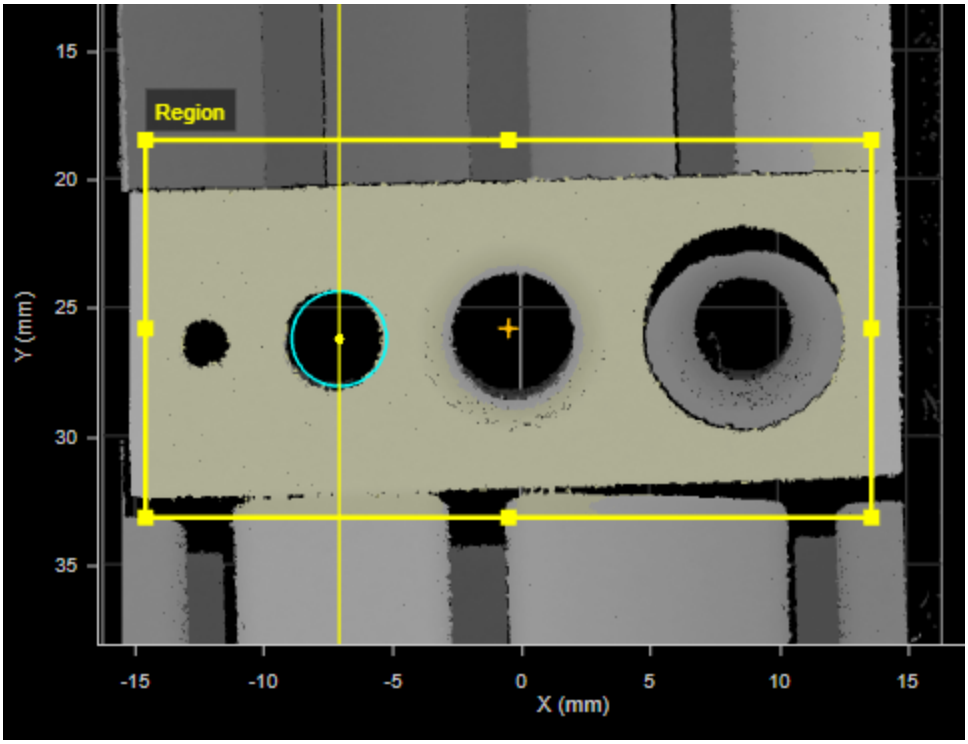
The Hole tool measures a circular opening within a region of interest on the surface and returns its position and radius.

> 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.

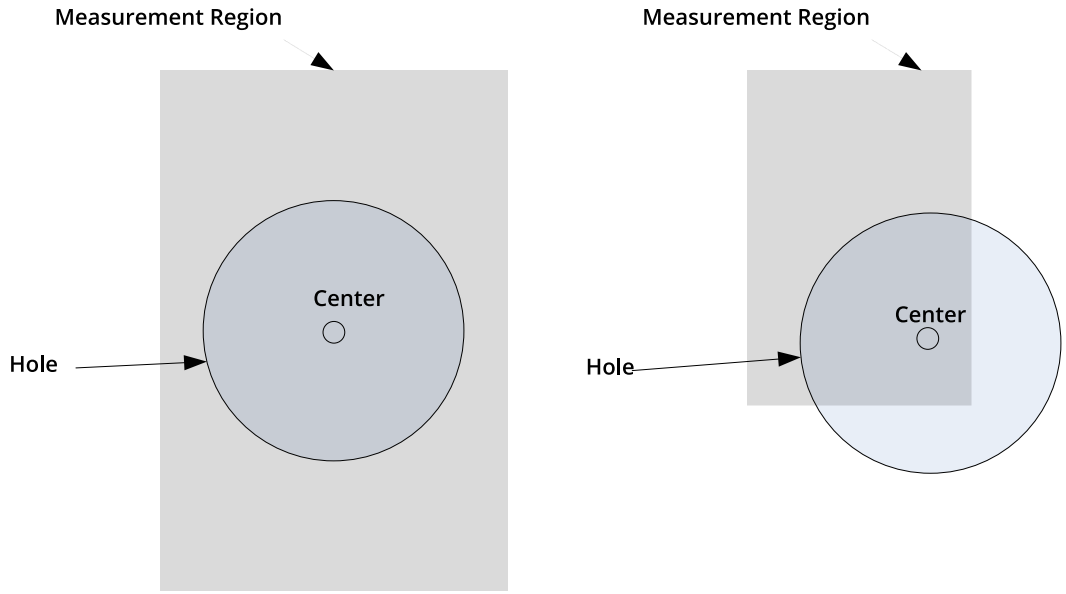
(The following screenshot is from a G2 sensor.)



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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.

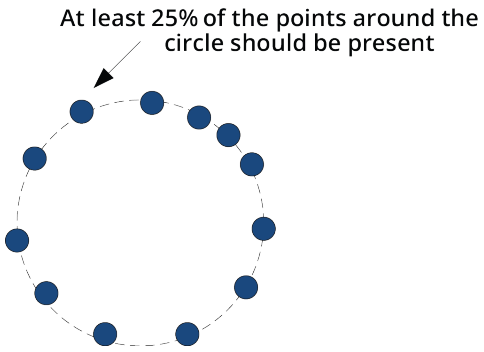
See the tool's parameters for an explanation of the options that affect the tool's algorithm.

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.

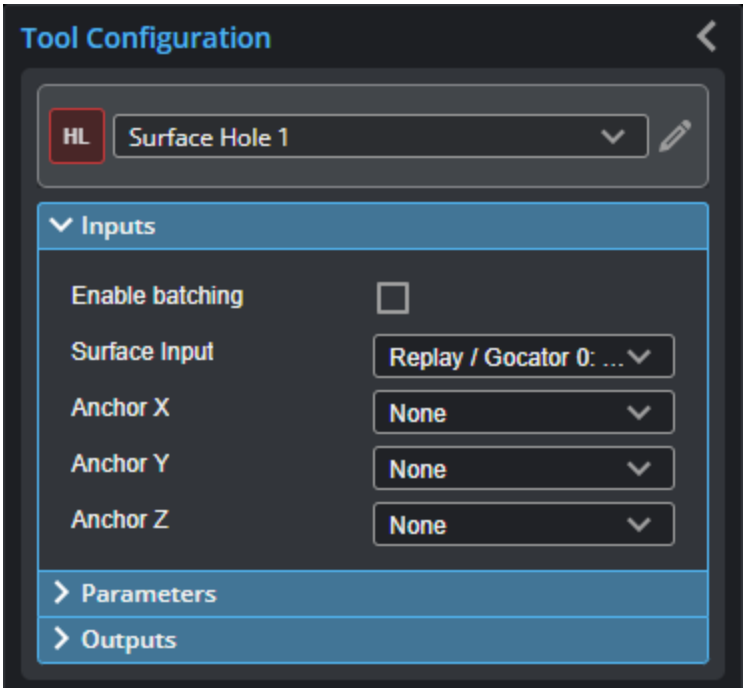
The set of refined edges is then used to locate and inspect the feature. If the Reference Regions option is enabled and set to AutoSet, the edges are also used to calculate the location of the reference regions.



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.



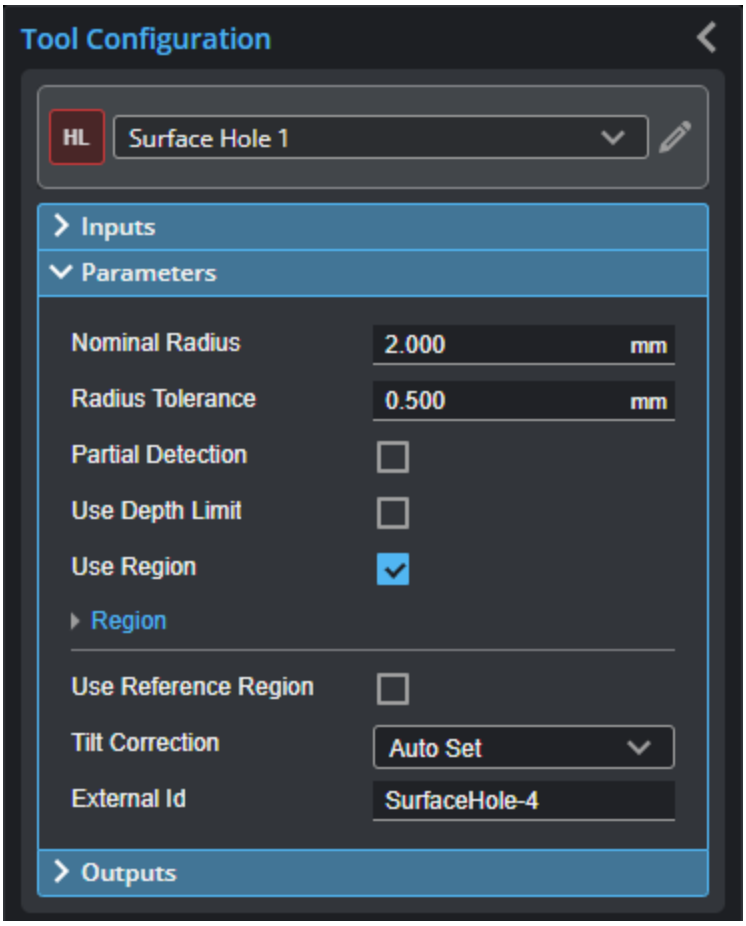
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y Anchor Z	The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

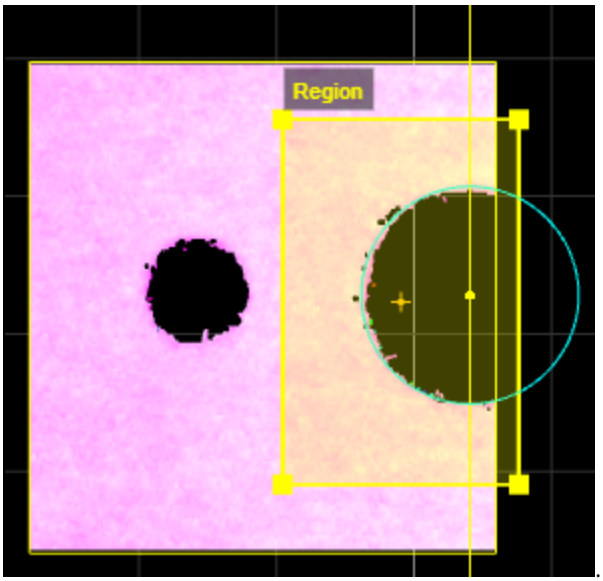
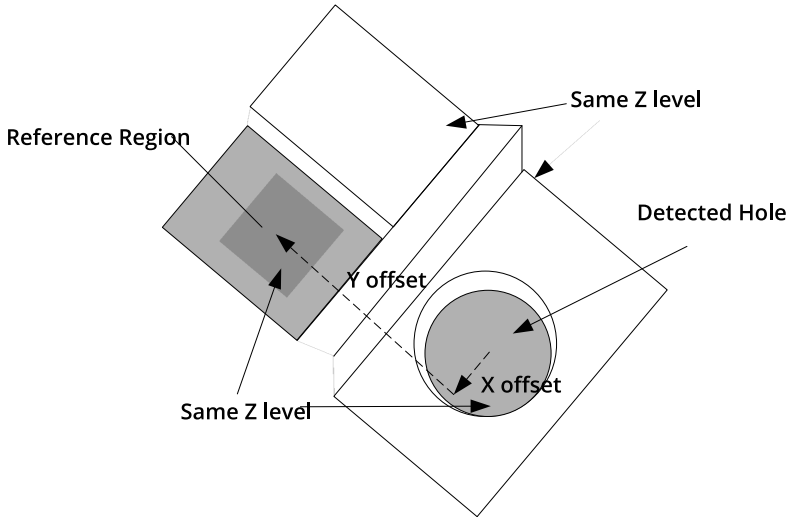
Parameters

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



Parameters

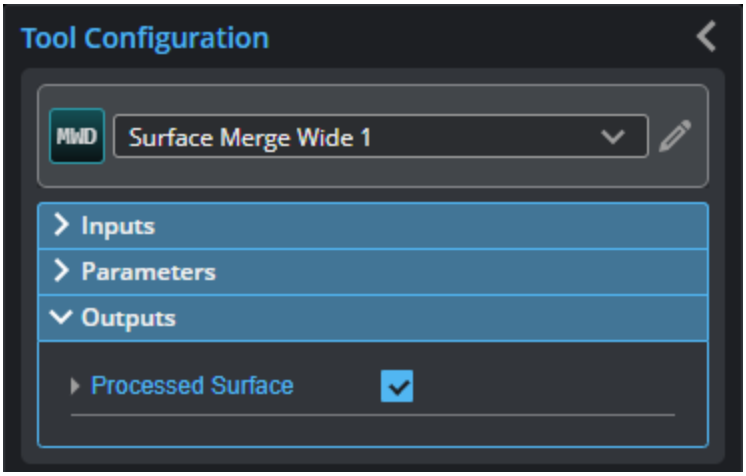
Parameter	Description
Nominal Radius	Expected radius of the hole.
Radius Tolerance	The maximum variation from the nominal radius (+/- from the nominal radius).
Partial Detection	Enable if only part of the hole is within the measurement region; the centre of the hole must be in the measurement region 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 163.
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.  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. 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. **Autoset**: The tool automatically detects the tilt. **Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
X Angle Y Angle	The X and Y angles you must specify when **Tilt Correction** is set to **Custom**. 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 666.

Outputs

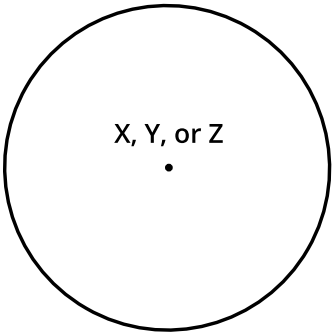
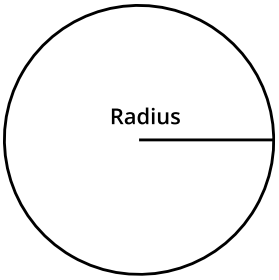
All tools provide measurements, geometric features, or data as outputs.



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 Determines the X position of the hole center.	
Y Determines the Y position of the hole center.	
Z Determines the Z position of the hole center.	
Radius 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.

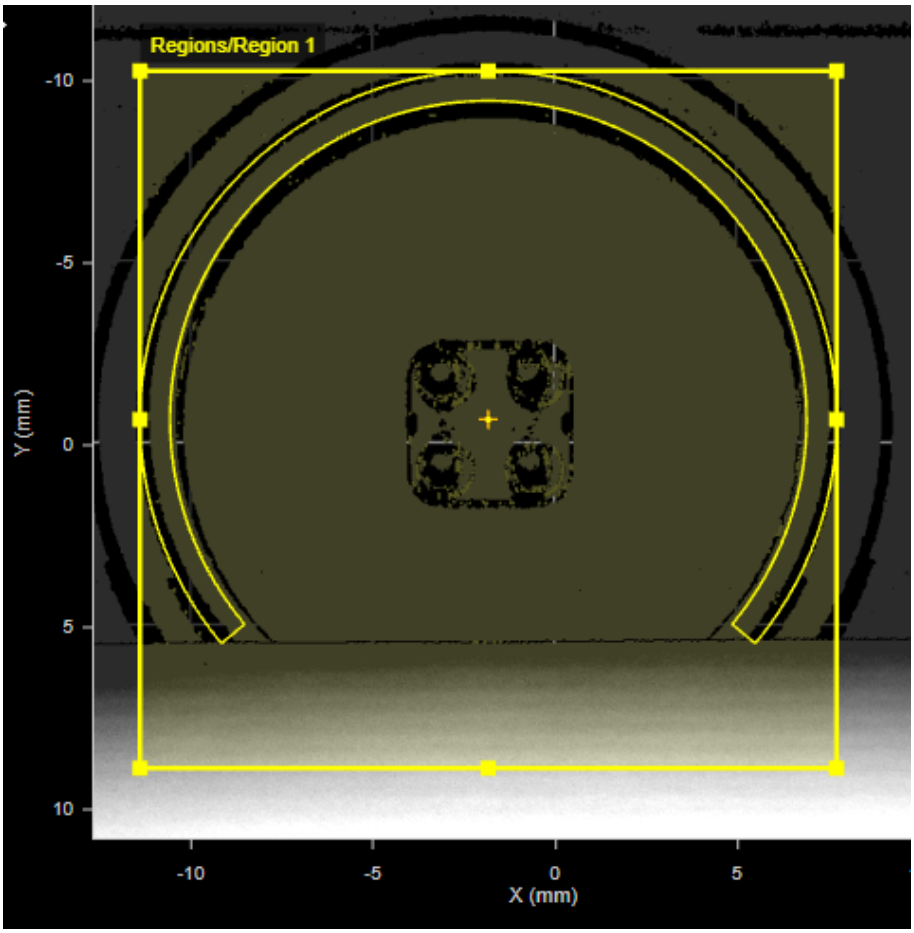
For more information on geometric features, see *Geometric Features* on page 175.

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.

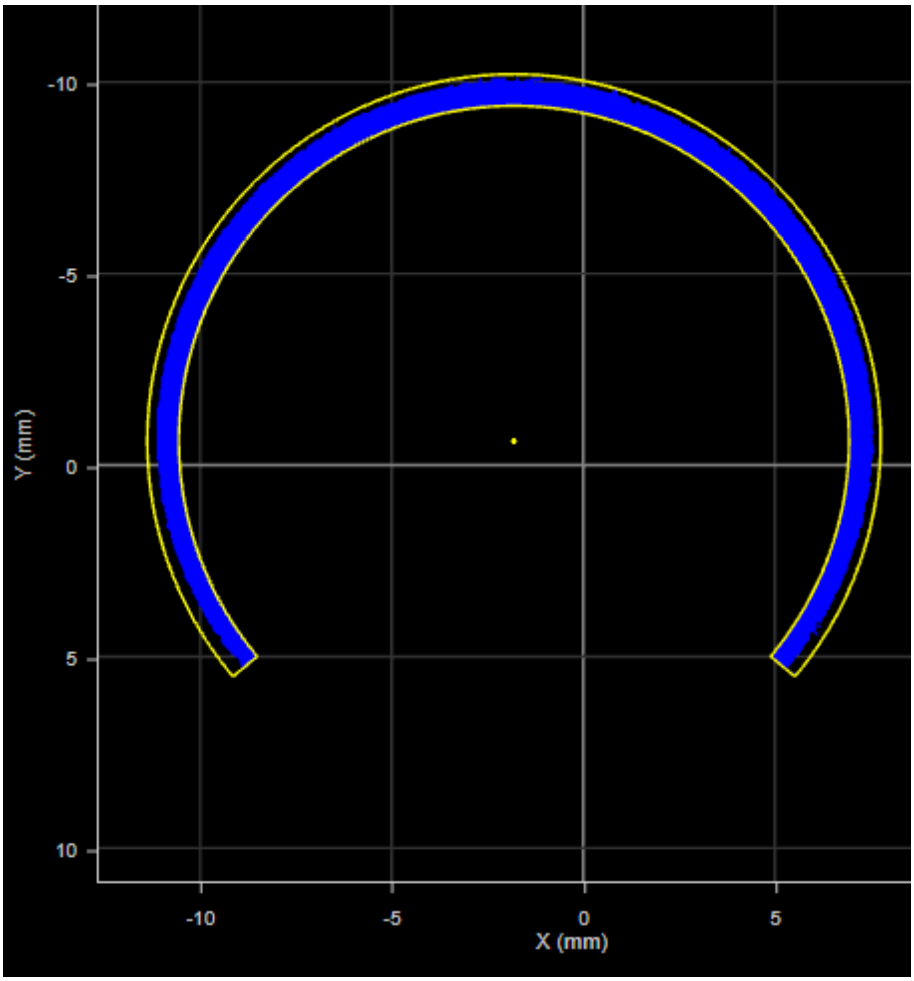
The resulting surface can then be further processed or measured by other tools.

For example, given the following scan data:



A circle region box containing a partial ring (cyan)

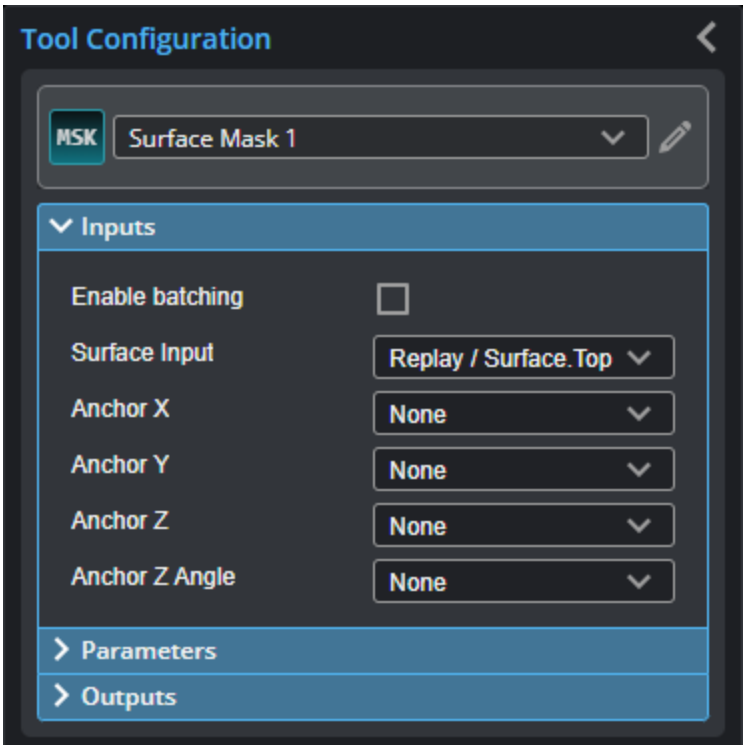
The image below shows the extracted data. The extracted surface data can then be further processed by other tools, or measurements can be applied to the surface data.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



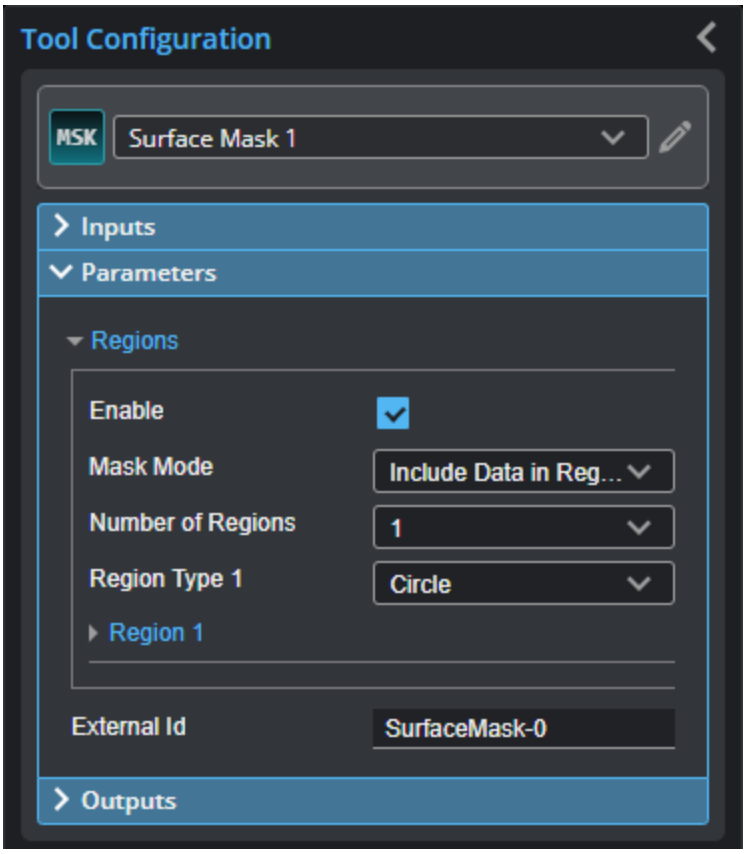
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z 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.

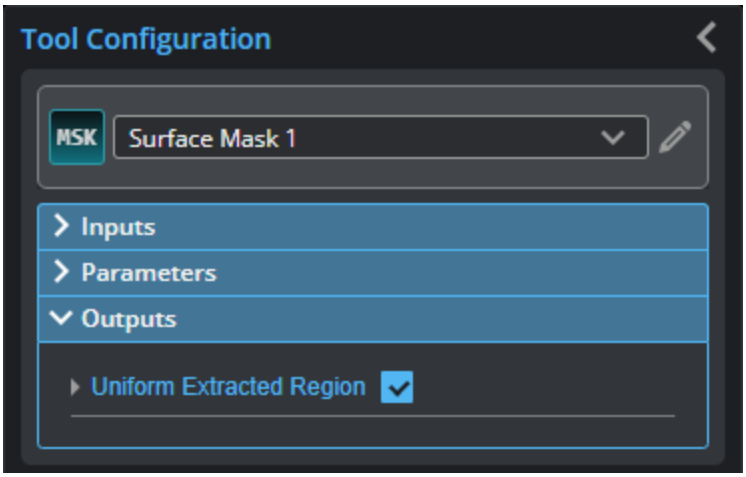


Parameters

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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

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



Data

Type	Description
Uniform Extracted Region 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.

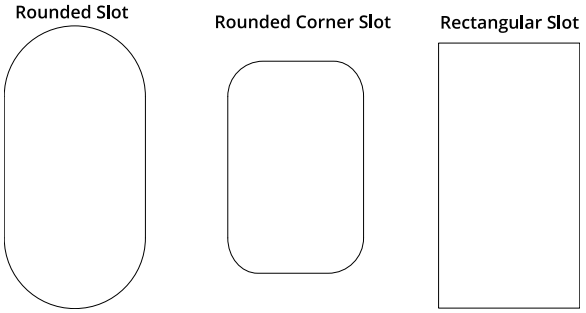
Surface Mesh

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.

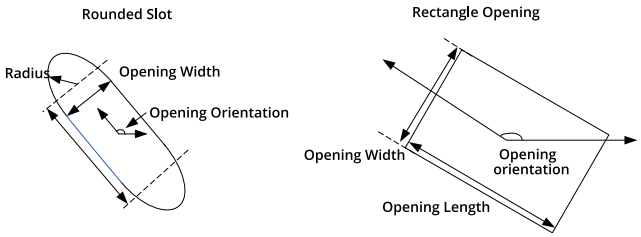


The tool uses a complex feature-locating algorithm to find a hold and then return measurements. For a detailed explanation of the algorithm the tool uses, see *Opening Algorithm* on the next page. The behavior of the algorithm can be adjusted by changing the tool's parameters.

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.

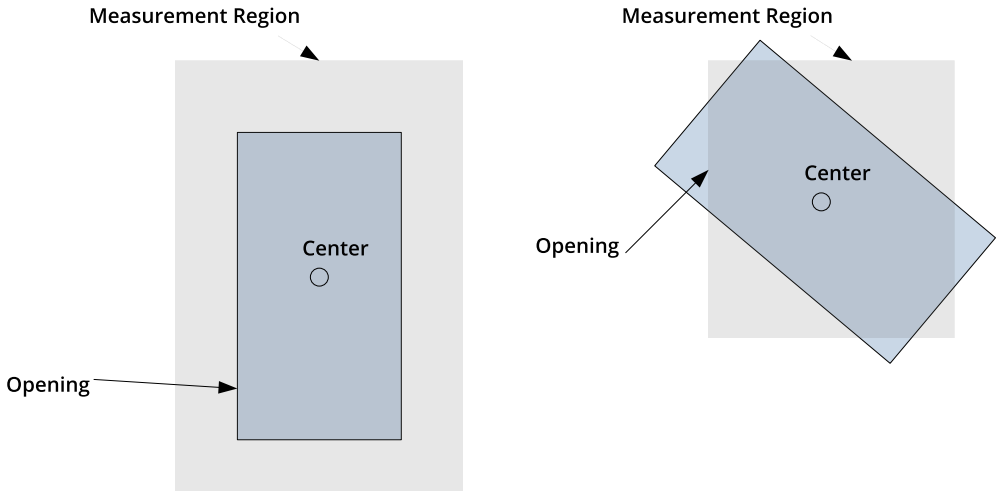


Measurement Panel

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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

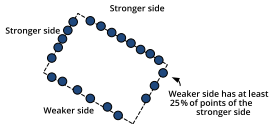
The Opening tool processes the data in three phases: Search, Measure, and Filter.

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.

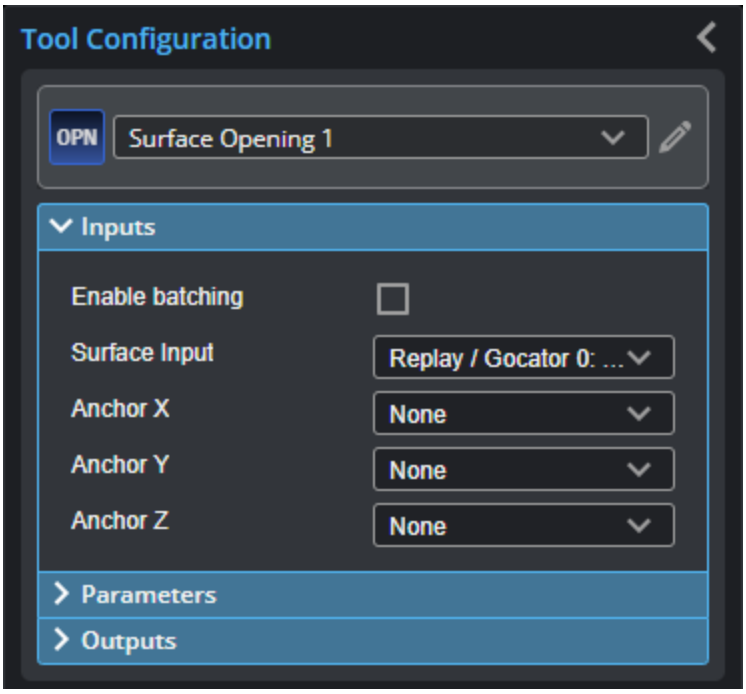
The set of refined edges is then used to locate and inspect the feature. If the **Reference Regions** setting is enabled, the edges are also used to calculate the location of the reference regions.



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.



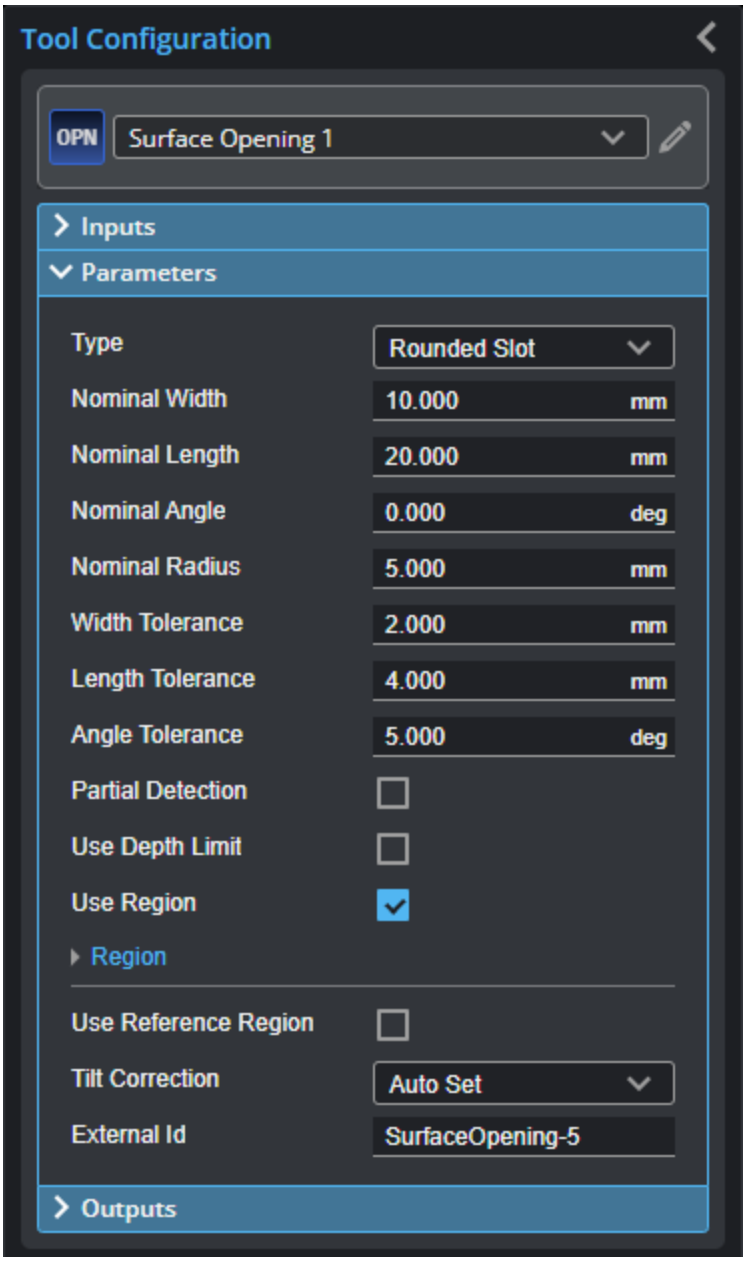
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y Anchor Z	The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

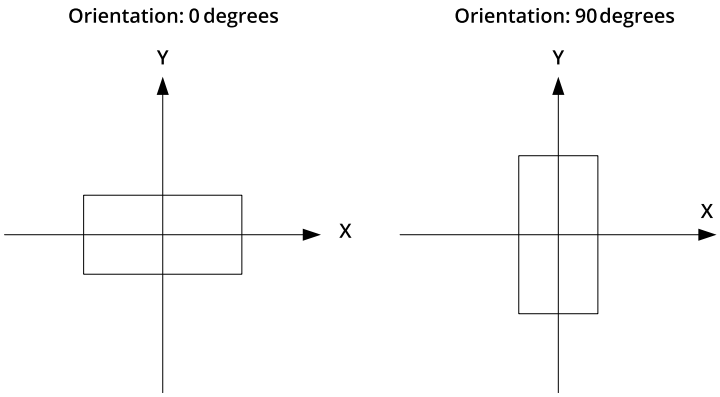
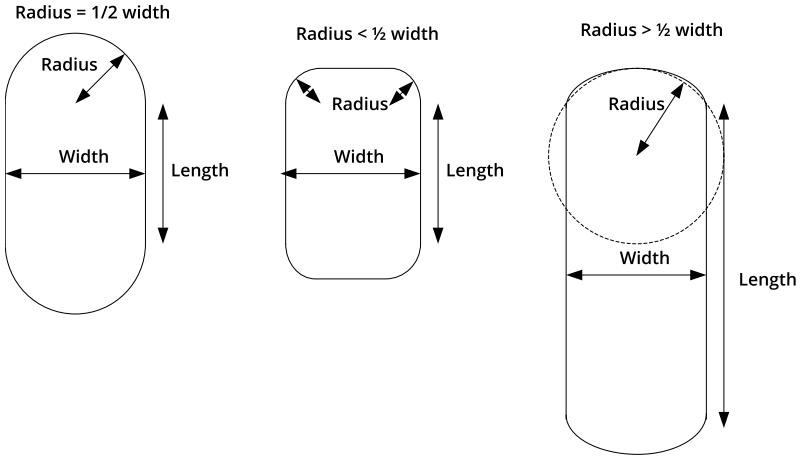
Parameters

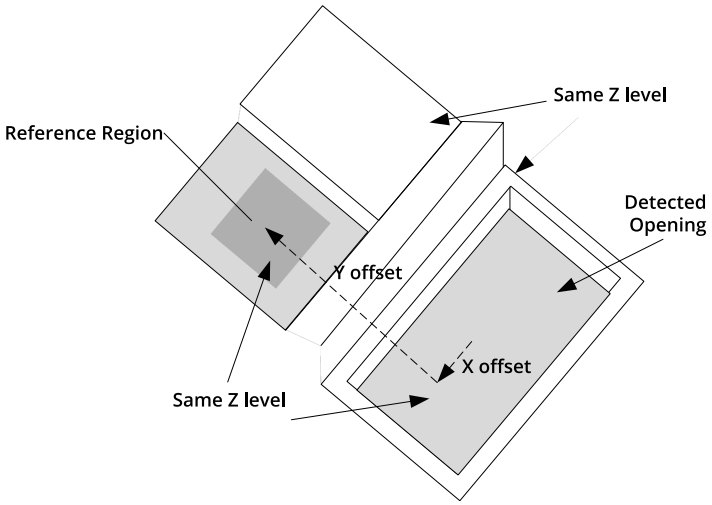
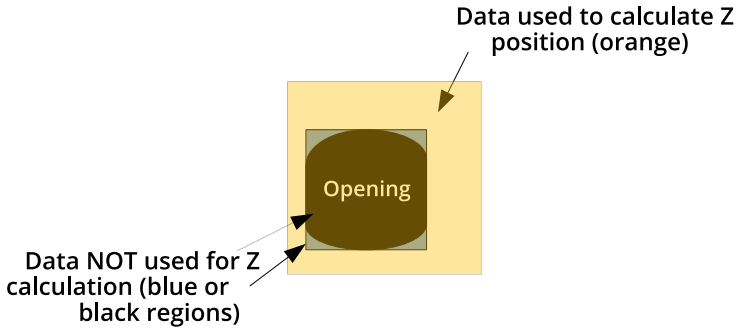
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

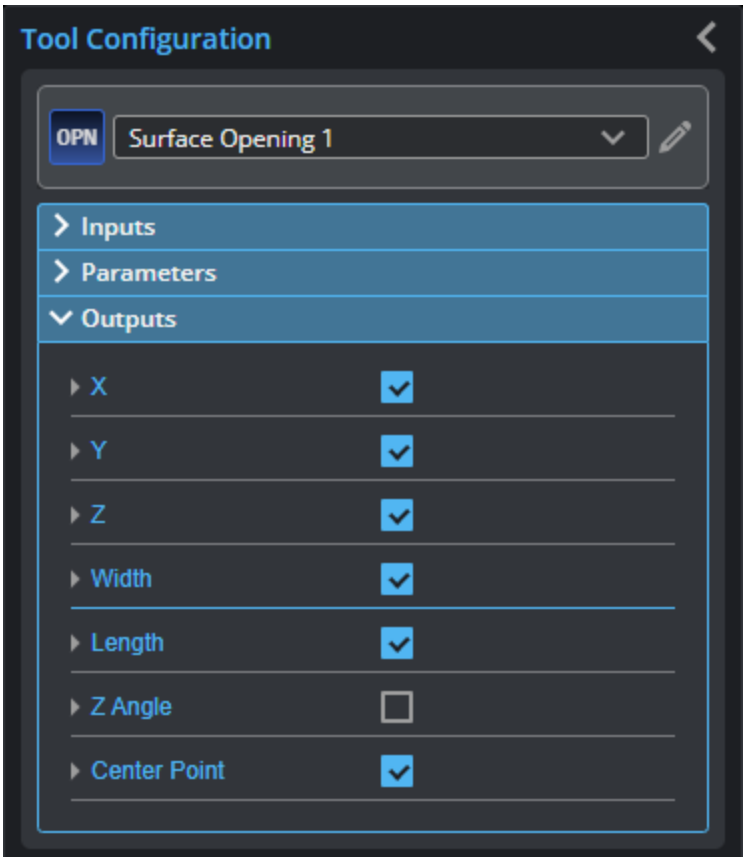
Parameter	Description
Type	One of the following: Rounded Slot, Rectangle.
Nominal Width	Nominal width of the opening.
Nominal Length	Nominal length of the opening.
Nominal Angle	Nominal angle of the opening. The default orientation is the length of the opening along the X axis.

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. 
Width Tolerance Length Tolerance 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 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 163.
Use Reference Region Reference Type 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.  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.  With one or more reference regions, the algorithm calculates the Z positions as the average values of the data within the regions. 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. **Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. **Custom**: You must enter the X and Y angles manually in the X Angle and Y Angle parameters (see below).
X Angle Y Angle	The X and Y angles you must specify when **Tilt Correction** is set to **Custom**. 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 666.

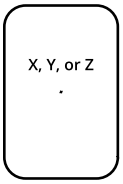
Outputs

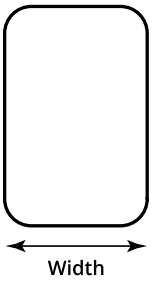
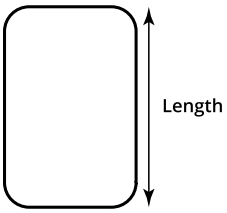
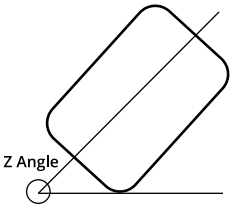


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the X position of the opening's center.	
Y Determines the Y position of the opening's center.	
Z Determines the Z position of the opening's center.	

Measurement	Illustration
Width Determines the width of the opening.	
Length Determines the length of the opening.	
Z Angle 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 175.

Surface Part Detection

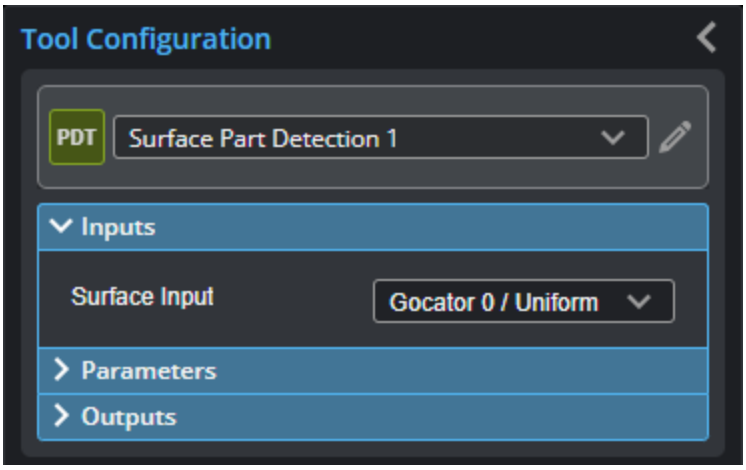
The Surface Part Detection tool identifies discrete objects in Surface data and then outputs them as Surface data. Surface measurements can then be performed on each object.

> You can isolate and then measure parts using Surface Blob and Surface Segmentation tools (for more information on these tools, see *Surface Blob* on page 321 and *Surface Segmentation* on page 489). For a comparison of part detection and these tools, see *Isolating Parts from Surface Data* on page 310.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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

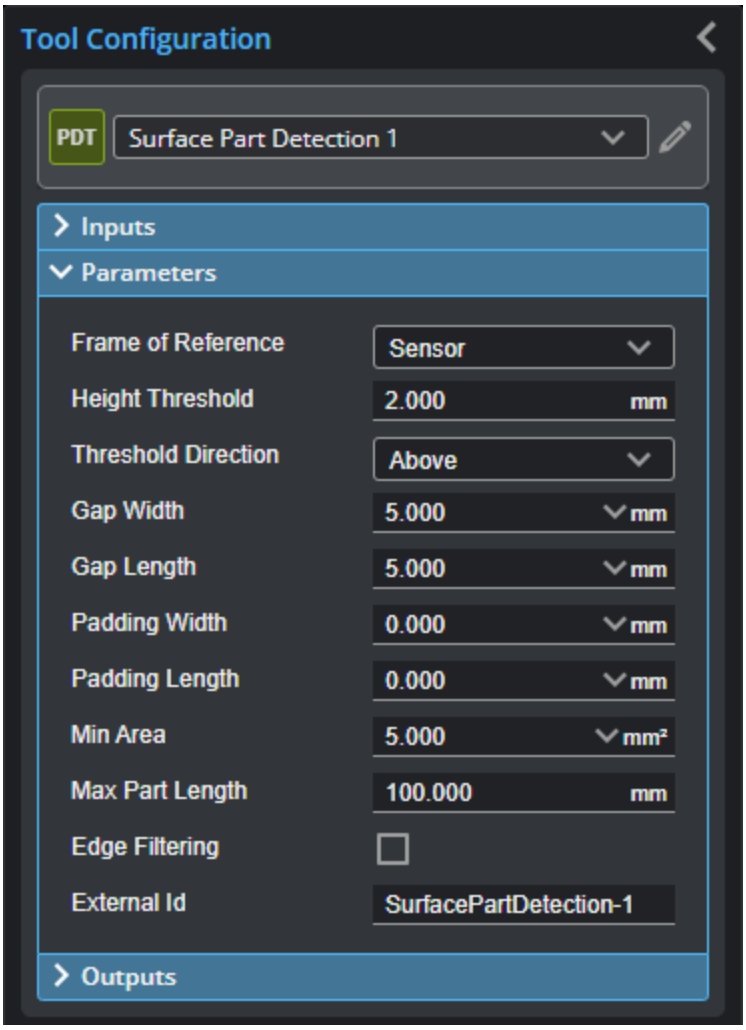


Inputs

Name	Description
Surface Input	The source of data for the tool.

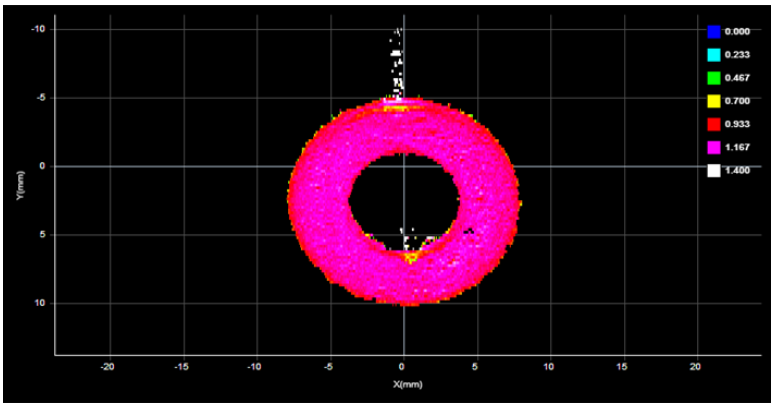
Parameters

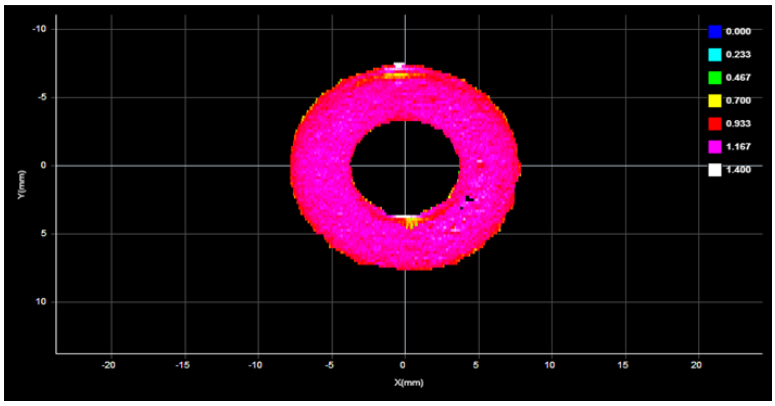
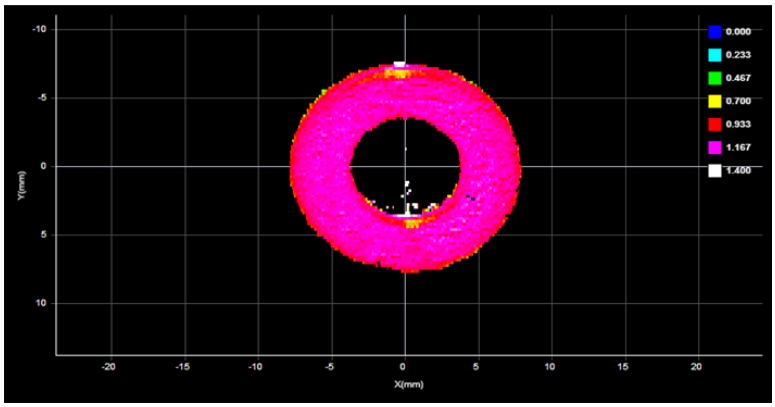
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

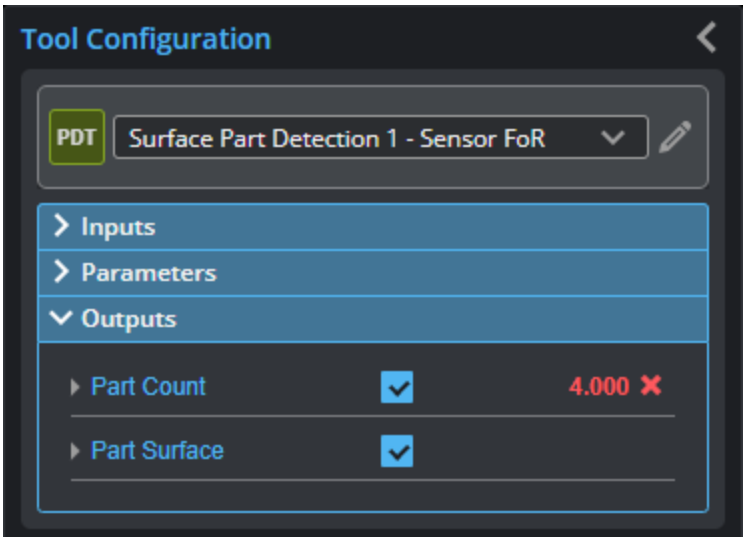
Parameter	Description
Frame of Reference	Determines the coordinate reference for surface measurements. **Sensor** When **Frame of Reference** is set to **Sensor**, the sensor's frame of reference is used. **Part** When **Frame of Reference** is set to **Part**, all measurements are relative to the center of the bounding box of the part. For Bounding Box X and Y, the measurement values are always relative to the sensor frame of reference (see *Surface Bounding Box* on page 332).
Threshold Type	Determines if parts should be detected above or below the height threshold.
Threshold	Determines the height threshold for part detection. The setting for **Threshold**

Parameter	Description
	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.
Gap Width 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.
Pad Width Pad Length	These parameters are useful when processing part data with third-party software such as HexSight, Halcon, etc. **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. 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. (The following screenshots are from a G2 sensor.)  *Edge Filter disabled (scan shows reflection noise)*

Parameter	Description
	 *Edge Filter enabled (reflection noise eliminated or reduced)*  *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 666.

Outputs

All 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

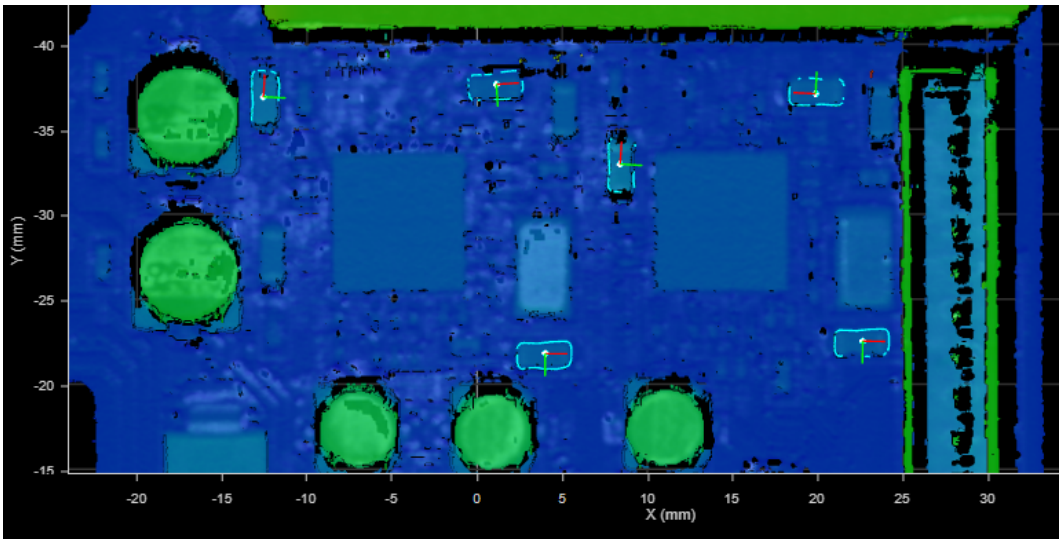
The Surface Pattern Matching tool locates parts and features by comparing 2D contours (on the XY plane) found in scan data to pattern models you have defined; note that the tool does not use height data in its algorithms. Models represent contour-based "golden parts" or "golden features." (Models can be modified in the provided standalone model editor; for more information, see *Pattern Editor* on page 760.)

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 176).

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.

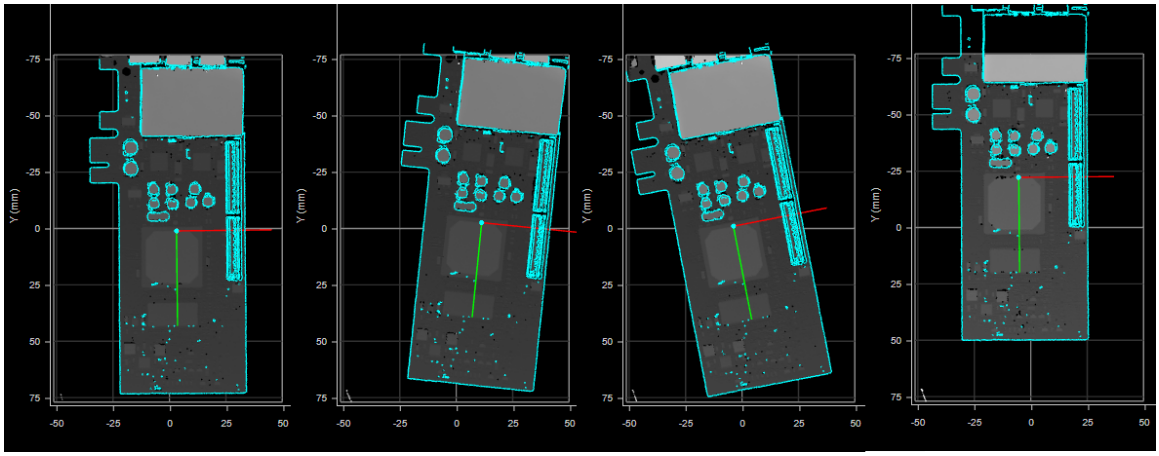
> In order to create a template for a *feature* on a target, you typically need to enable the **Use Region** checkbox to limit the tool to the contours related to that feature. After that, when running the tool to find instances of the feature, you should either modify the region to limit it to areas 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 153.

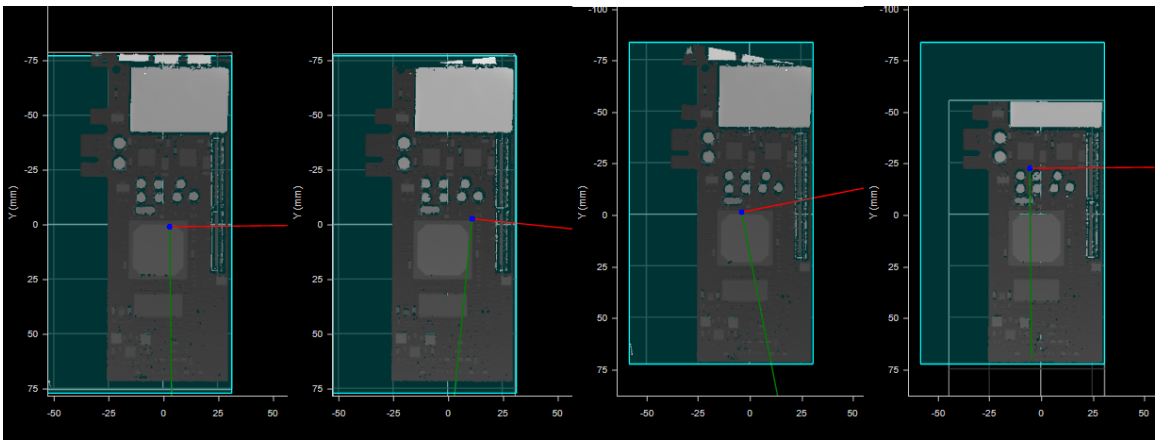
Note that when you use the geometric features with a Surface Transform tool to transform the scan data from frame to frame, you can often avoid the need to anchor other measurements, because

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.



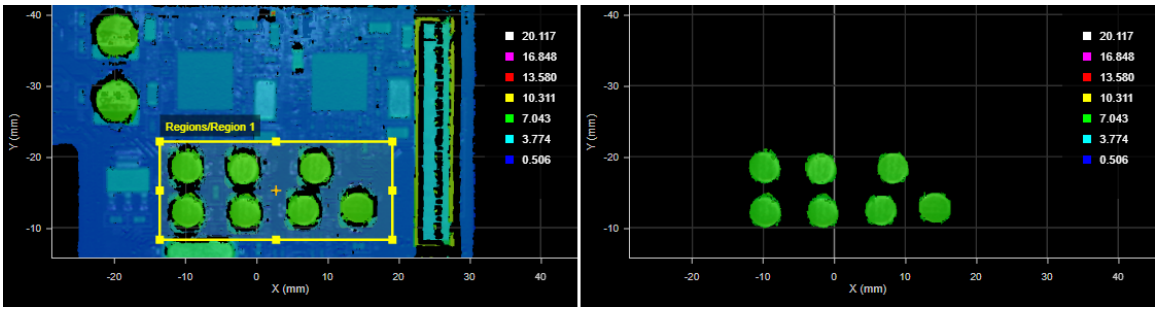
Four frames of scan data. Light blue outline represents the matching template. The first frame was used to create the template.

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.

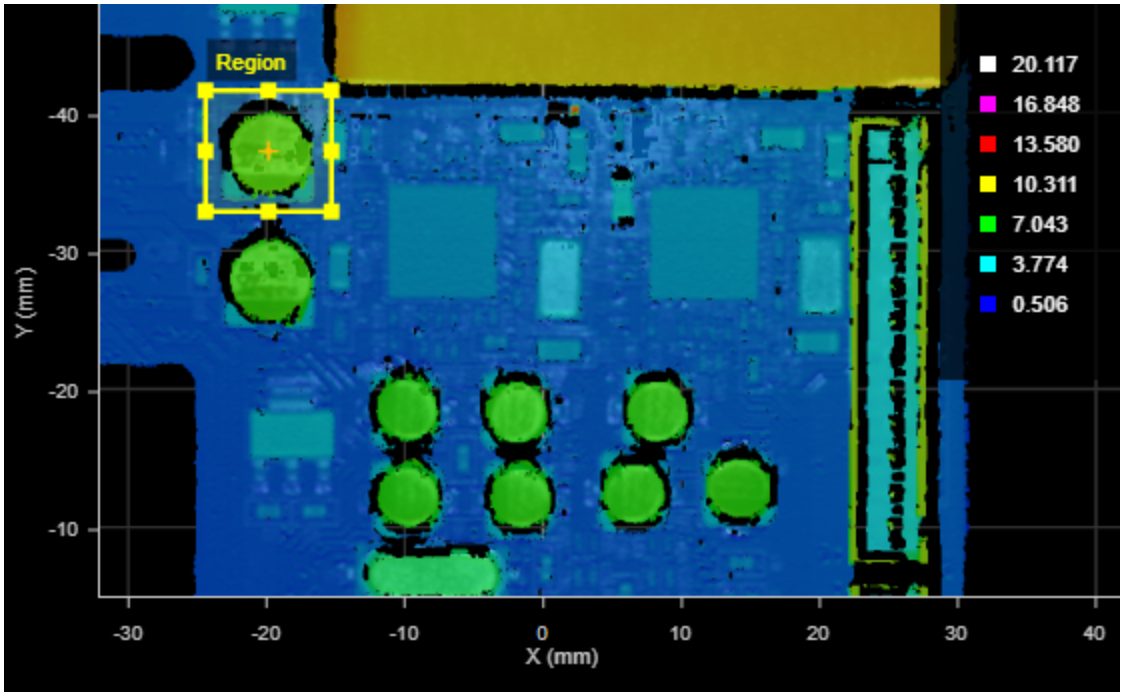


By adding multiple Surface Pattern Matching tools to a job and defining different templates for each, you can match multiple types of features or parts, for example, matching different parts moving on a conveyor, or different types of features on a single target.

Creating a Template

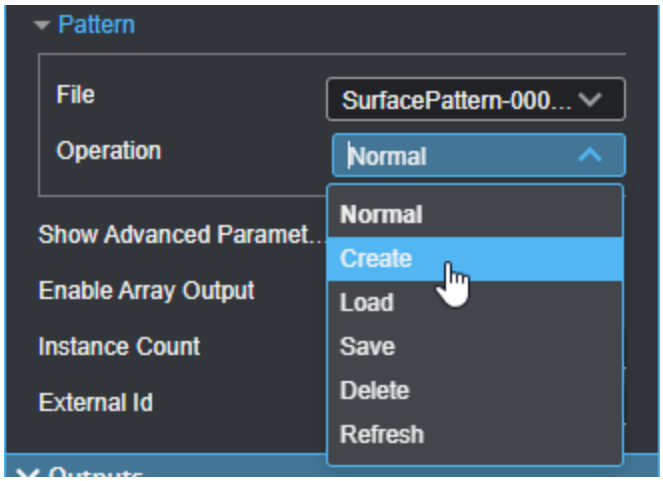
To create a template:

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.

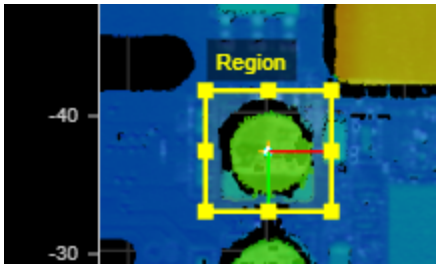


Otherwise, if you need to match the entire part, for example to orient parts from frame to frame, leave **Use Region** disabled to perform pattern matching on all of the scan data. This only works if no unwanted data is in the frame, such as the conveyor.

4. In the **Operation** drop-down, choose **Create**.



The tool creates a model and saves it either to the PC (to C:\GoTools\SurfacePatternMatching) or to the sensor. The tool also "matches" the pattern.

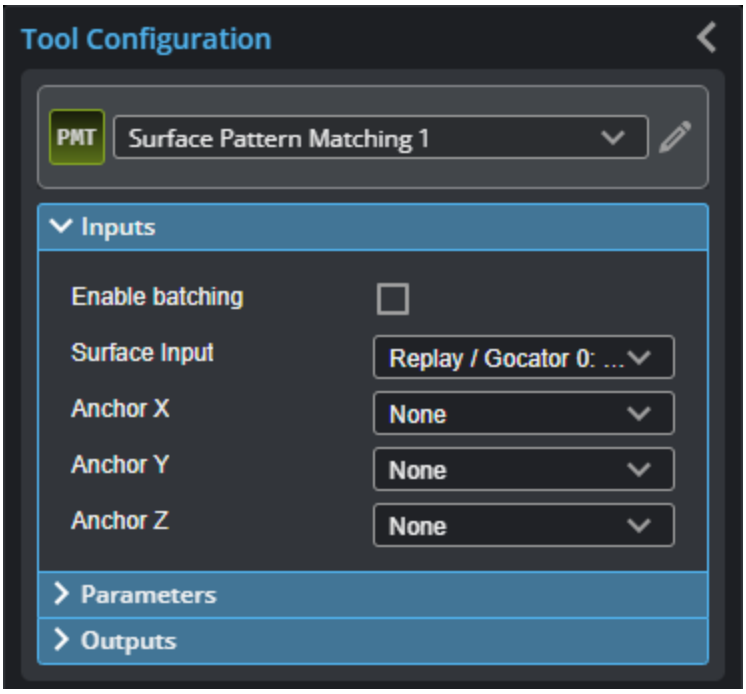


5. Disable, resize, or reposition the region as necessary to match the pattern in parts you will be scanning in production.

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.



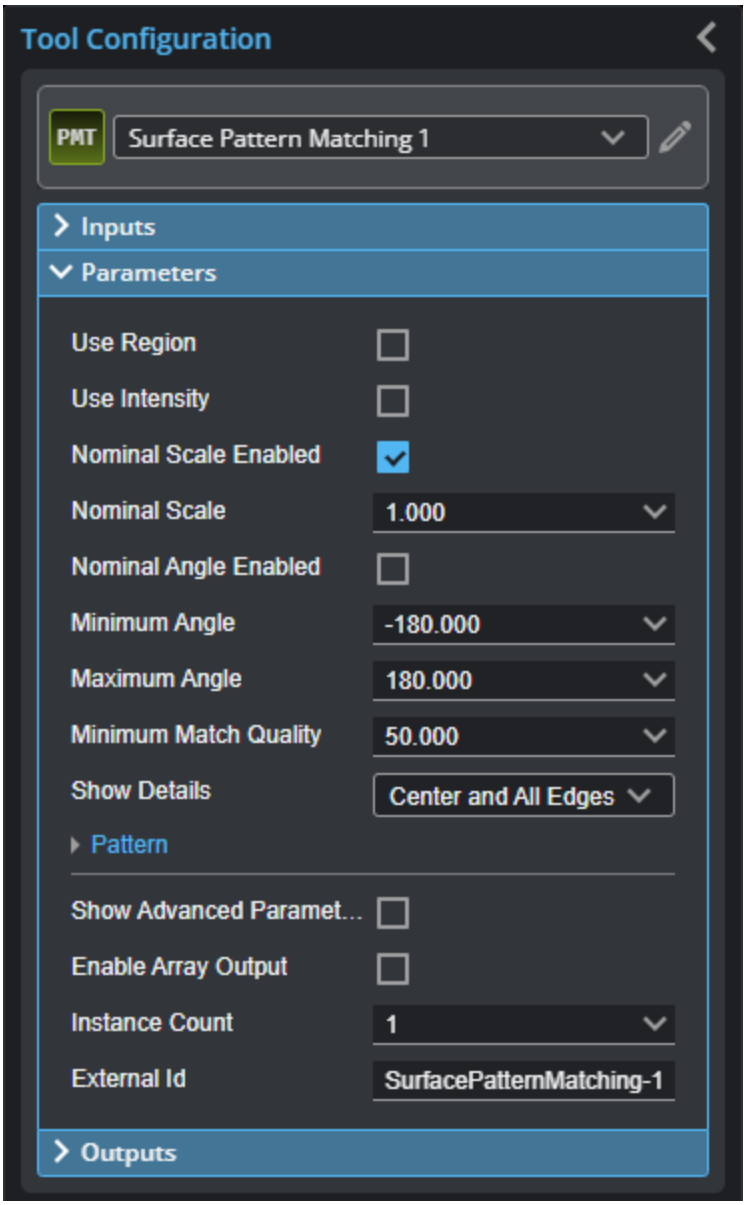
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 163.
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.

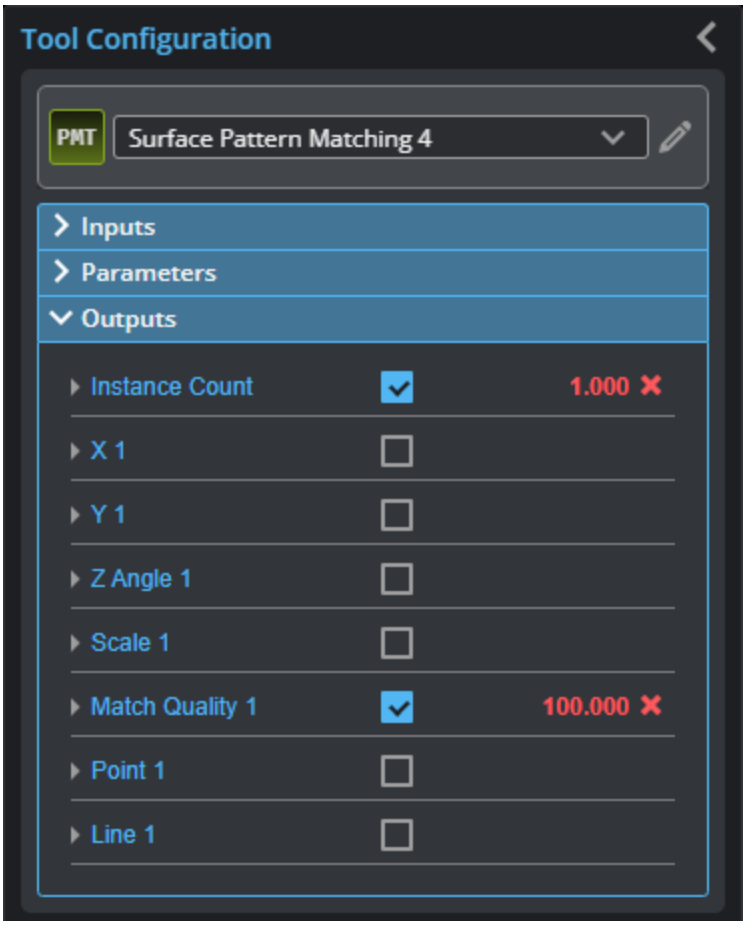
Parameter	Description
Nominal Scale	The scale factor the tool requires to recognize an instance. Displayed when **Nominal Scale Enabled** is enabled.
Minimum Scale Maximum Scale	The minimum and maximum scale factors set the acceptable scaling range of an instance. Displayed when **Nominal Scale Enabled** 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. Displayed when **Nominal Angle Enabled** is enabled.
Minimum Angle Maximum Angle	The minimum and maximum angles allowed for the tool to recognize an instance, respectively. 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. **Center only**: The center of the found pattern and its XYZ axes. **Center and All Edges**: The center of the found pattern and its XYZ axes, as well as the outline of the full pattern template. **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. **File** A drop-down containing the currently available templates. **Operation** The operation to perform on the currently selected template in the File drop-down. One of the following: **Normal**: The default value after having performed another operation. **Create**: Creates a new template based on the current frame of scan data. Limited to the region if **Use Region** is enabled. **Load**: Loads the currently selected template. **Save**: Saves contour data to the currently selected template, overwriting its contour data. **Delete**: Deletes the currently selected template. **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. **Sorting** The sort order of instances the tool uses. One of the following: • Evidence: The instances are ordered according to their hypothesis strength. • 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. • Position - X increasing • Position - X decreasing • Position - Y increasing • Position - Y decreasing **Recognition Level** 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). **Positioning Level** 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). **Match Tolerance Mode** 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. Note that the resolution-based mode results in a much tighter tolerance with high resolution scan data. **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.) 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 155.
Instance Count	The maximum number of instances the tool will locate. If **Enable Array Output** is checked, this parameter is hidden.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

All 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 Returns the number of parts or features matching the loaded template up to the value set in the Instance Count parameter.
X {n} **Y {n}** The X and Y position of the center of matched instance {n}.
Z Angle {n} The angle of matched instance {n} relative to the sensor's coordinate system.
Scale {n} The scale of matched object {n} relative to the loaded template.
Match Quality {n} 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.

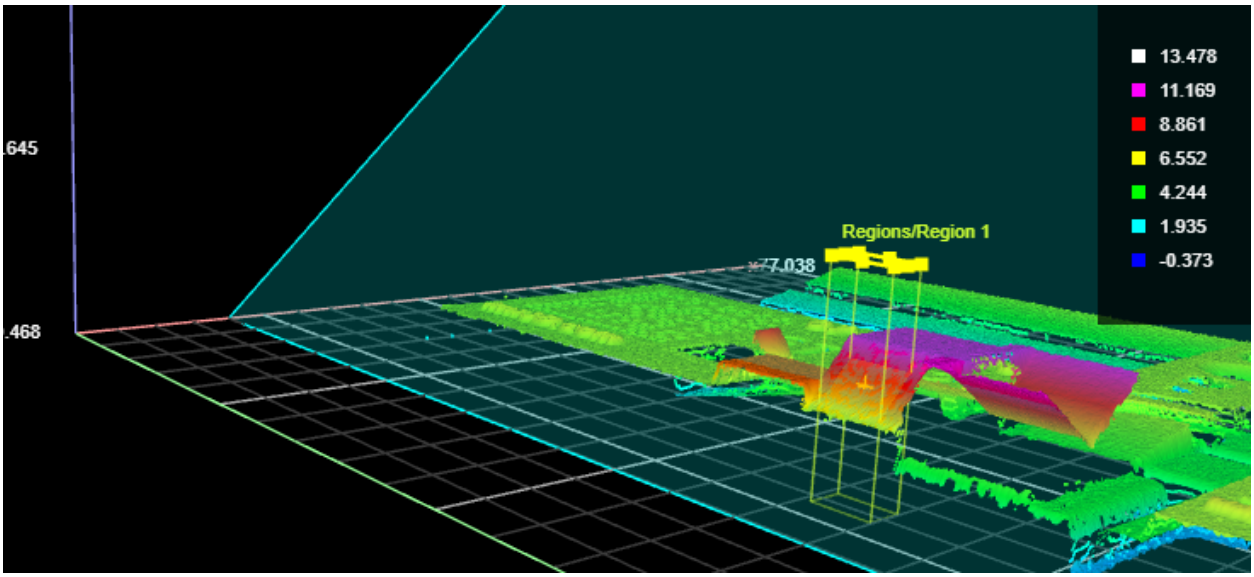
Features

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 175.

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.



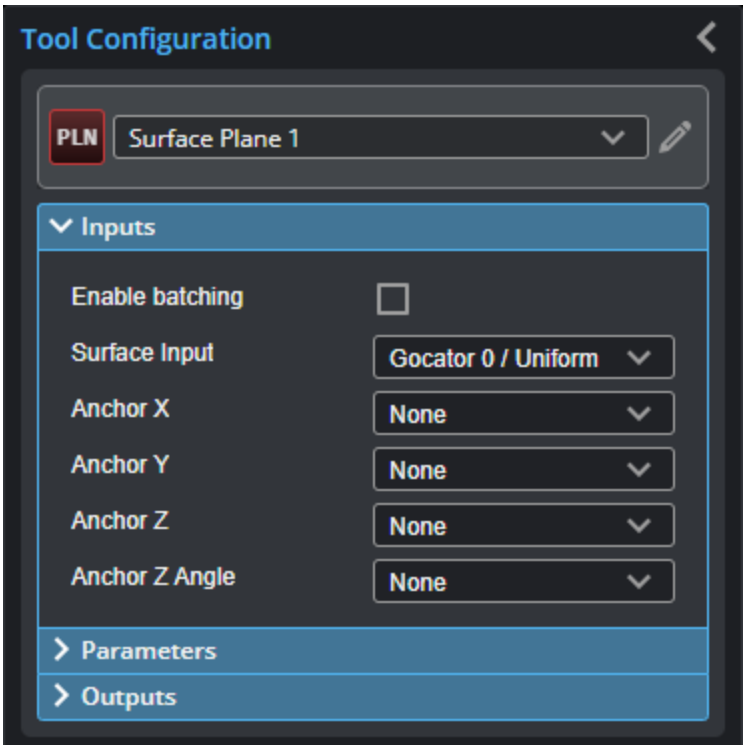
The Z offset reported is the Z position at zero position on the X axis and the Y axis.

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 153.

Inputs

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



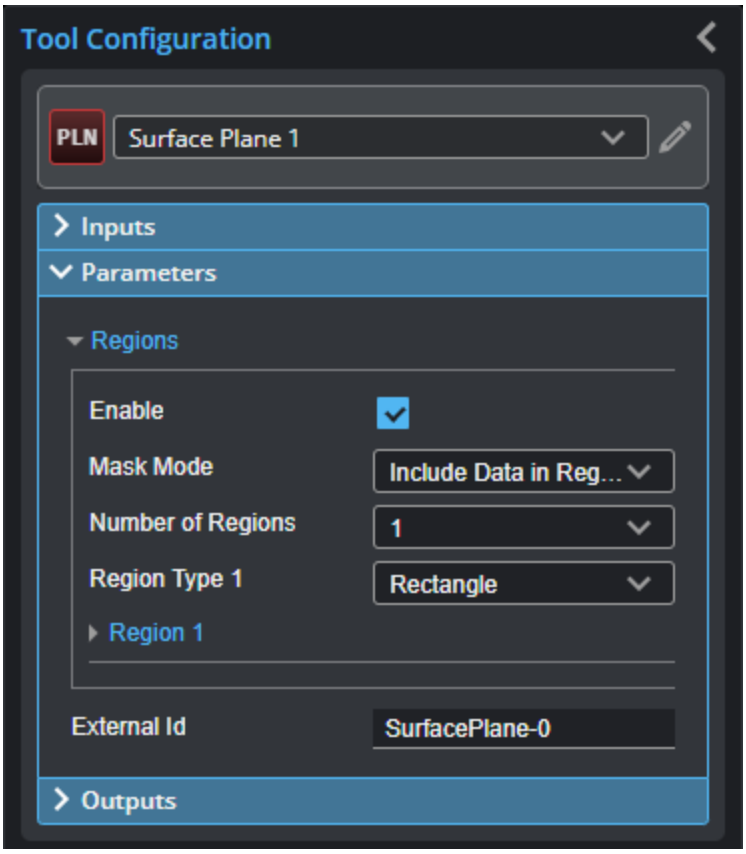
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

Parameters

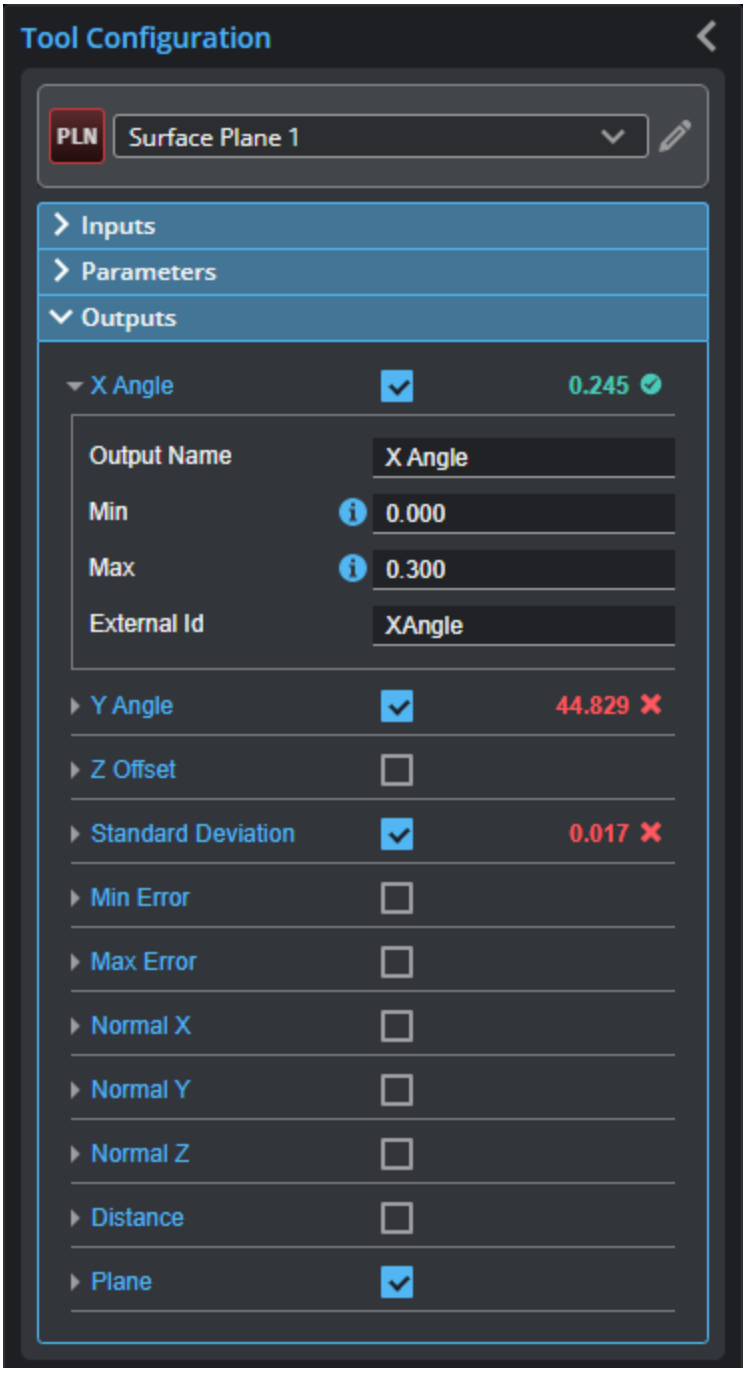
The following parameters are in the expandable **Parameters** section in the tool's configuration.



Parameters

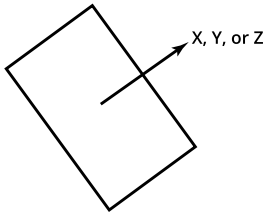
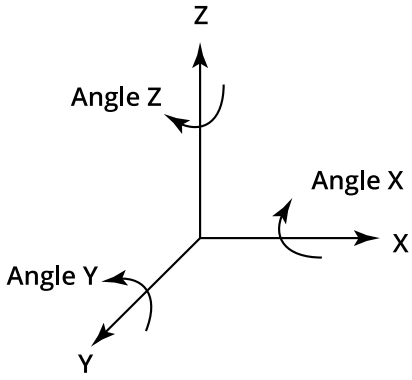
Parameter	Description
Regions	When expanded, displays the region- and mask-related settings.
Enable	Enables regions and displays the region- and mask-related settings (see below).
Mask Mode Number of Regions Region Type {n} Region {n}	When you enable regions (see above), the tool displays additional settings related to the region type. For details on the regions supported by this tool and their settings, see *Flexible Regions* on page 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

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 Determines the X angle of the surface with respect to the alignment target.	
Y Angle Determines the Y angle of the surface with respect to the alignment target.	
Z Offset Determines the Z value of intersection of the plane and the Z axis.	
Standard Deviation Measures the standard deviation of the points of the surface from the detected plane within the specified region or regions.	
Min Error 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 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 Returns the X component of the surface normal vector.	
Normal Y Returns the Y component of the surface normal vector.	
Normal Z Returns the Z component of the surface normal vector.	

Measurement	Illustration
Distance Distance from the origin to the plane.	

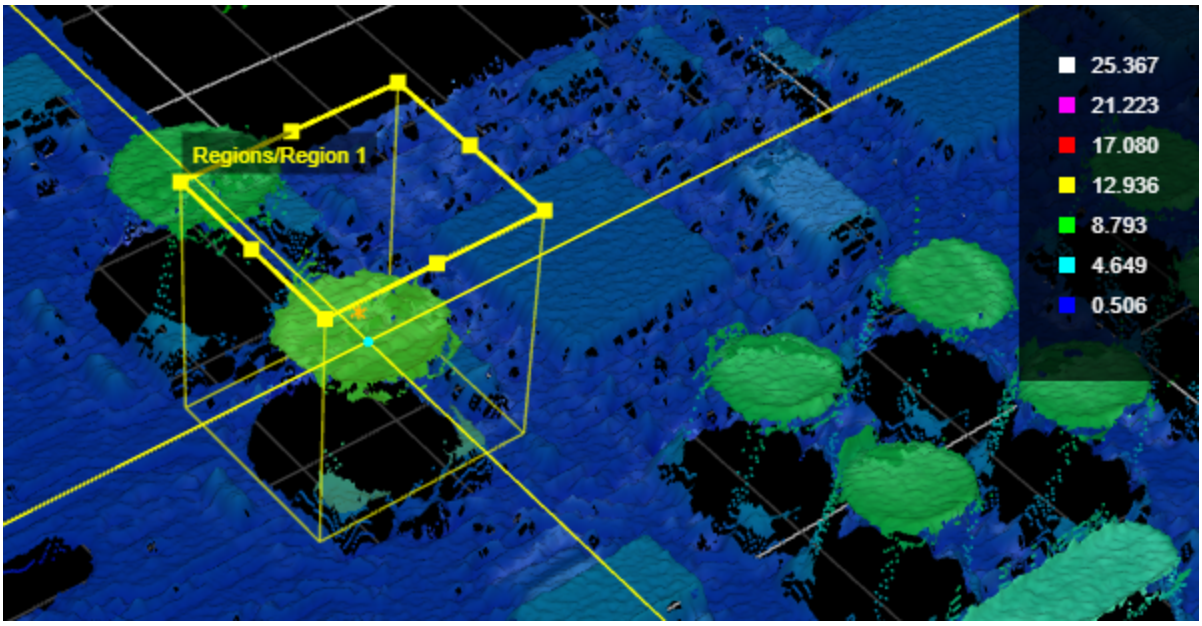
Features

Type	Description
Plane	The fitted plane.

For more information on geometric features, see *Geometric Features* on page 175.

Surface Position

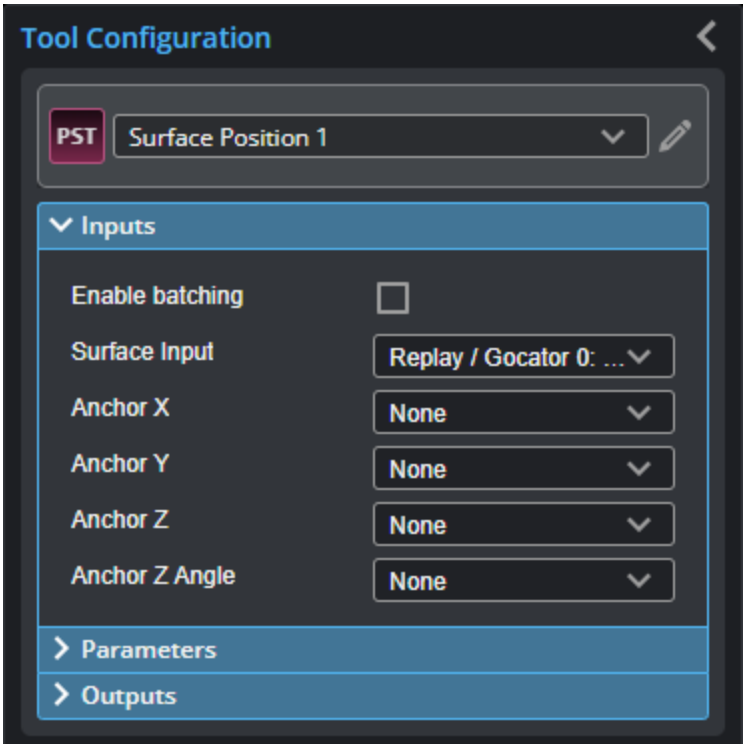
The Position tool reports the X, Y, or Z position of a part. You must specify the feature type specified and is one of the following: Average (the mean X, Y, and Z of the data points), Median (median X, Y, and Z of the data points), Centroid (the centroid of the data considered as a volume with respect 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 153.

Inputs



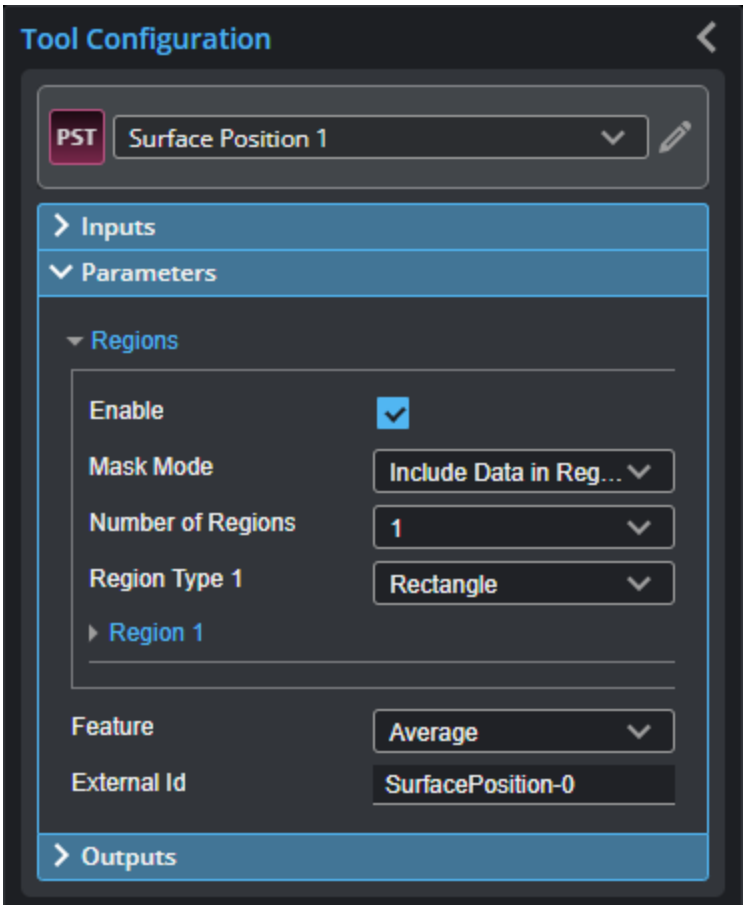
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
Anchor X Anchor Y 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 Z 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.

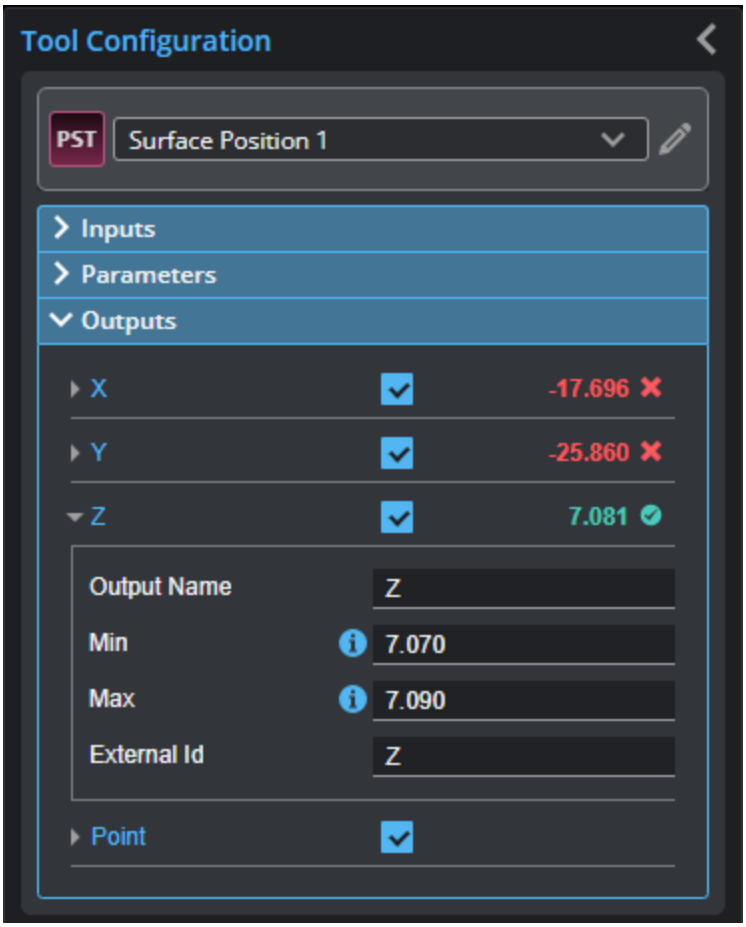


Parameters

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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Feature	The feature point types the tool uses. For each, one of the following (for more information, see *Feature Points* on page 172): • Average • Median • Centroid • Max X • Min X

Parameter	Description
	• Max Y • Min Y • Max Z • Min Z 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 666.

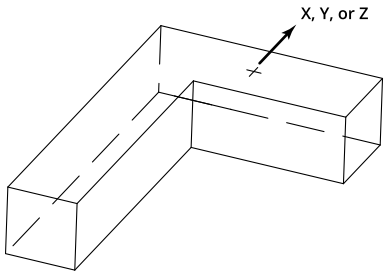
Outputs



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 Determines the X position of the selected feature type.	
Y Determines the Y position of the selected feature type.	
Z 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 175.

Surface Roughness

The Surface Roughness tool generates measurements of surface roughness. The following measurements are available:

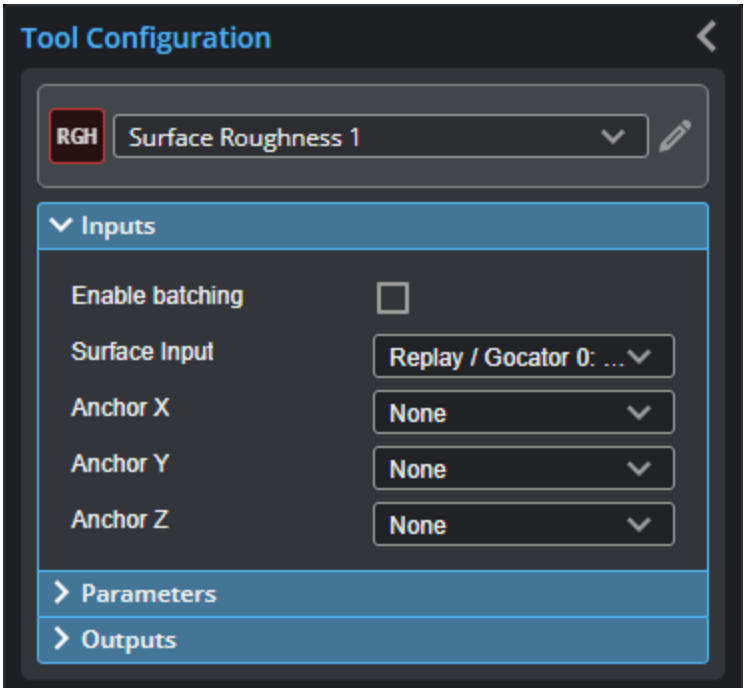
- Sa
- Sq
- Sp
- Sv
- Sz
- Ssk
- Sku

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 153.

Inputs



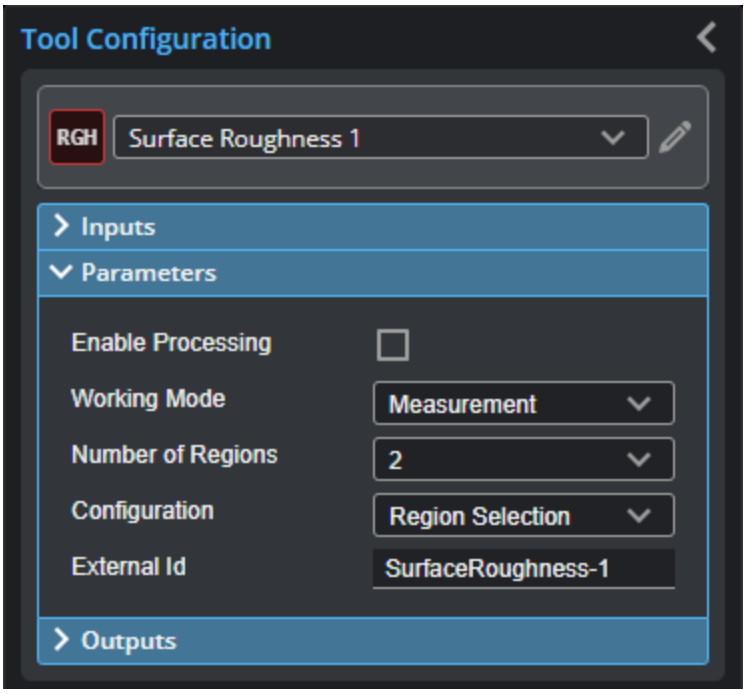
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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.

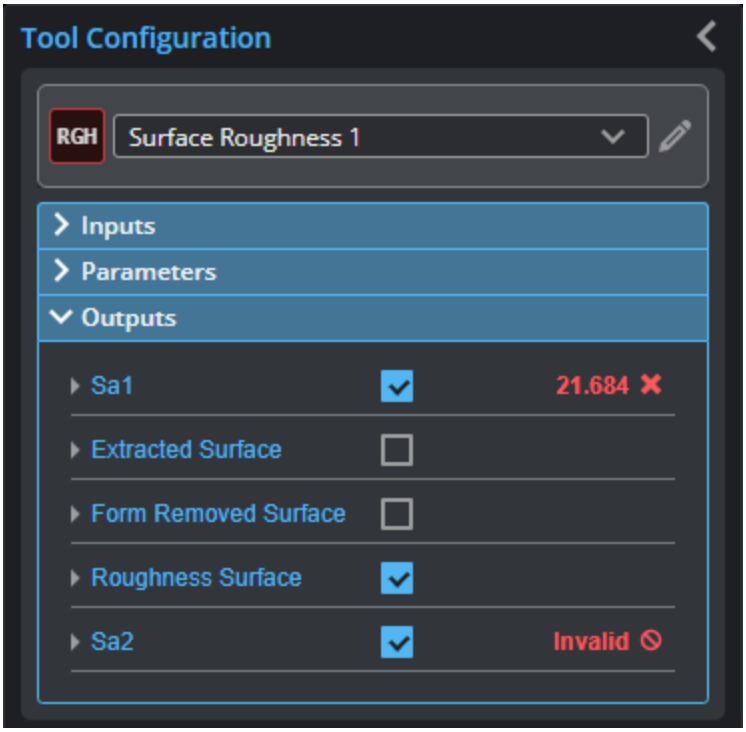


Parameters

Parameter	Description
Enable Processing	When enabled, the tool starts performing measurements.
Working Mode	The tool's working mode. One of the following: • Measurement • 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. • Reset Parameters: If the calibration parameters are no longer used or a new calibration is carried out, select **Reset parameters** once. • Roughness Calibration: See *Roughness Calculation Procedure* on page 482. See *Calibration Procedure* on page 481.
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**. The tool gives the summed mean values and the recorded sample number after each measurement. For mirror calibration, the mean values of the background noise of Sa and Sq and the number of measurements are returned. 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. 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: • Zero Padding criterion (ZPA) • Linear Extrapolation (LEX) • Line Symmetric Reflection (LSR) • Point Symmetrical Reflection (PSR)
Use Low Pass Filter 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 666.

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	Formula
Sa {n} Arithmetical mean height, 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} Maximum height, 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} Root mean square height, which is equivalent to the standard deviation of heights.	$Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$

Measurement	Formula
Sv {n} Maximum pit Height, 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} Height of the highest peak within the defined area.	$Sp = \max_A z(x,y)$
Sku {n} Kurtosis, which is a measure of the sharpness of the roughness profile.	$Sku = \frac{1}{Sq^4}\frac{1}{A}\iint_A z^4(x,y)dxdy.$
Ssk {n} Skewness, which represents the degree of bias of the roughness shape (asperity).	$Ssk = \frac{1}{Sq^3}\frac{1}{A}\iint_A z^3(x,y)dxdy.$

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.s

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

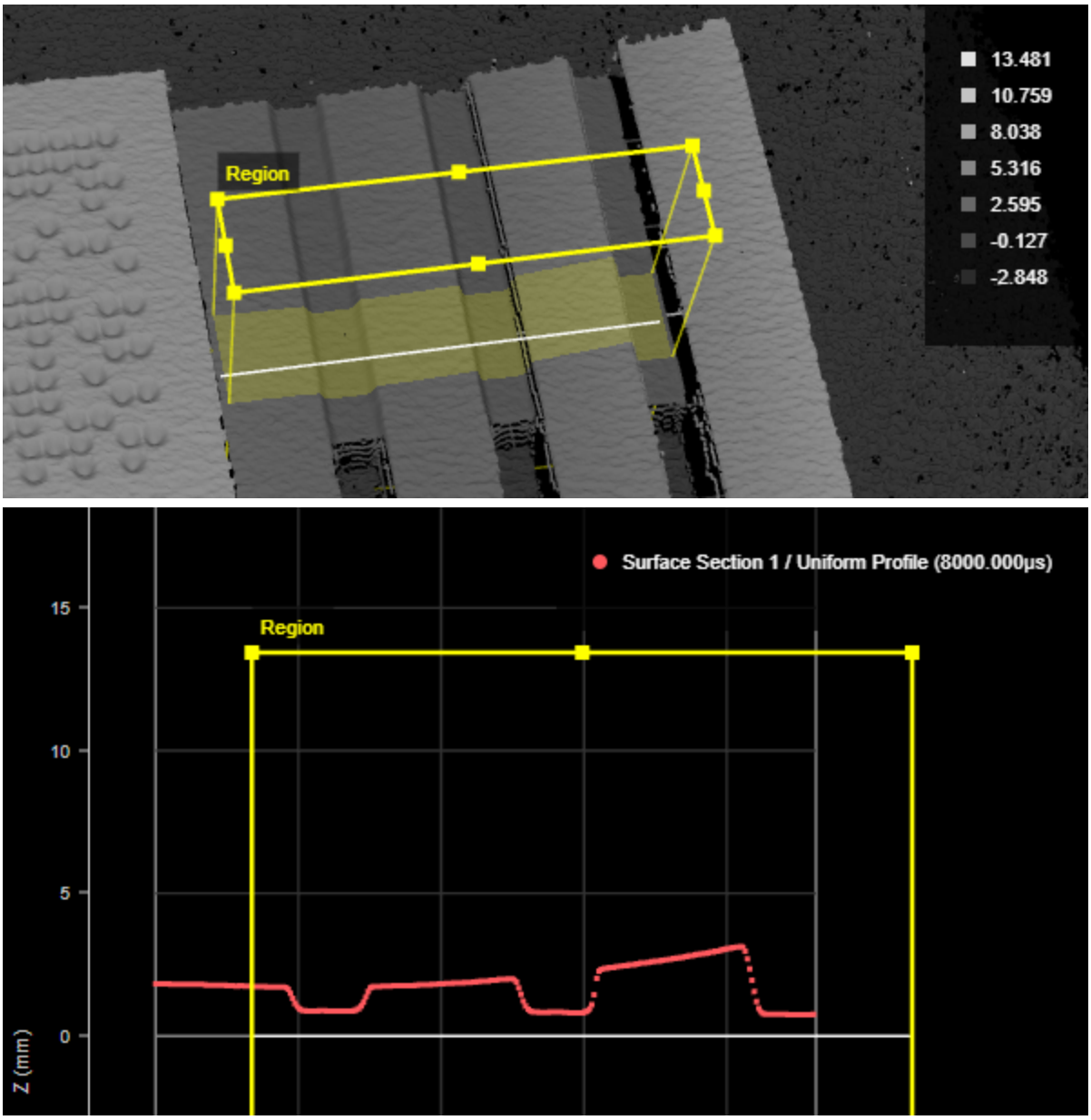
1. Deactivate "Enabled Processing" to get into the editing mode.
2. Select the number of regions to be calculated, currently up to 20 - 2 regions are available for selection (the last 2 are reserved for calibration).
3. Configure individual regions. The default settings correspond roughly to the settings 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 181). 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



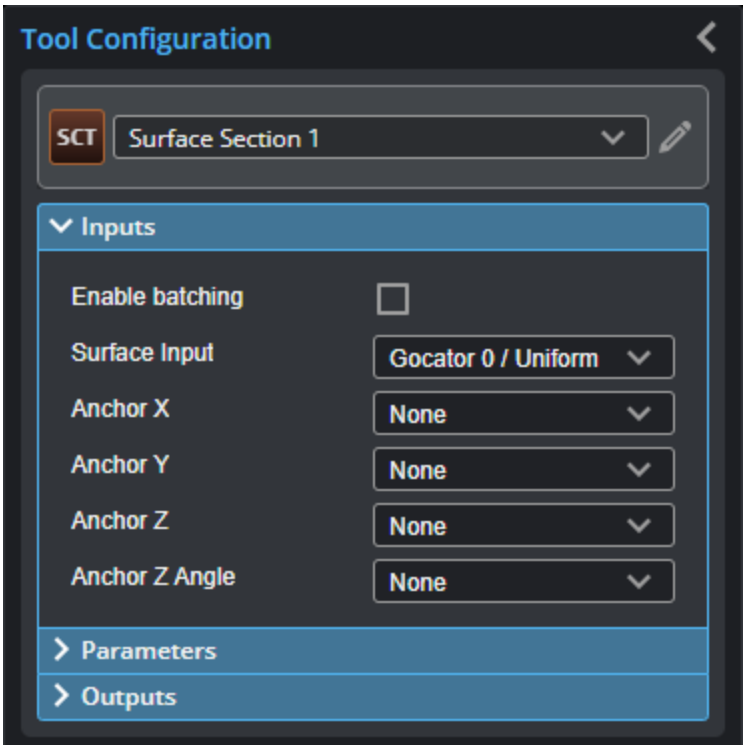
The resulting profile. The leftmost point of the profile is at the X origin. The region is positioned showing the X and Z position of the center of the region on the surface.

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 176.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

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 176.

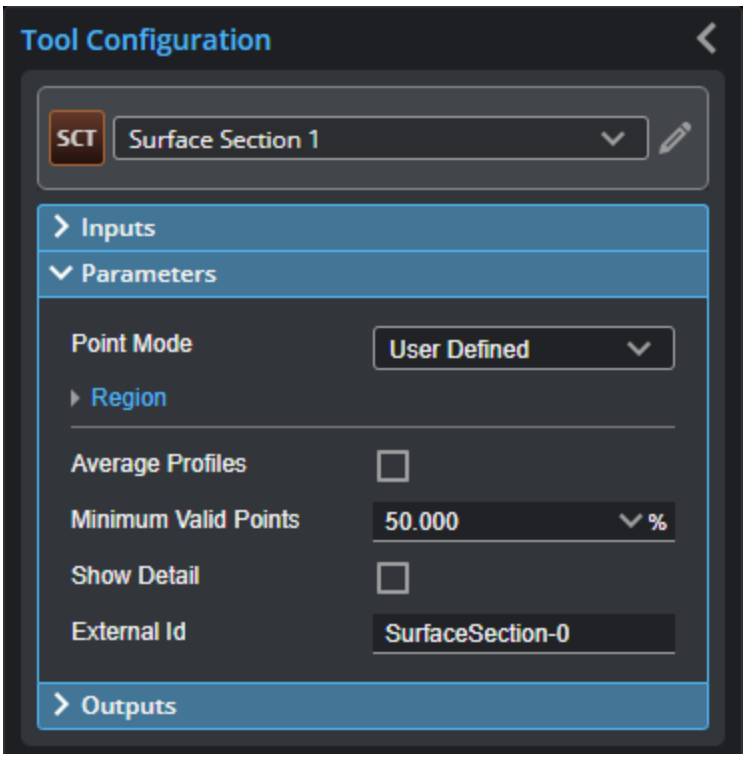
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

Name	Description
Point 1 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.

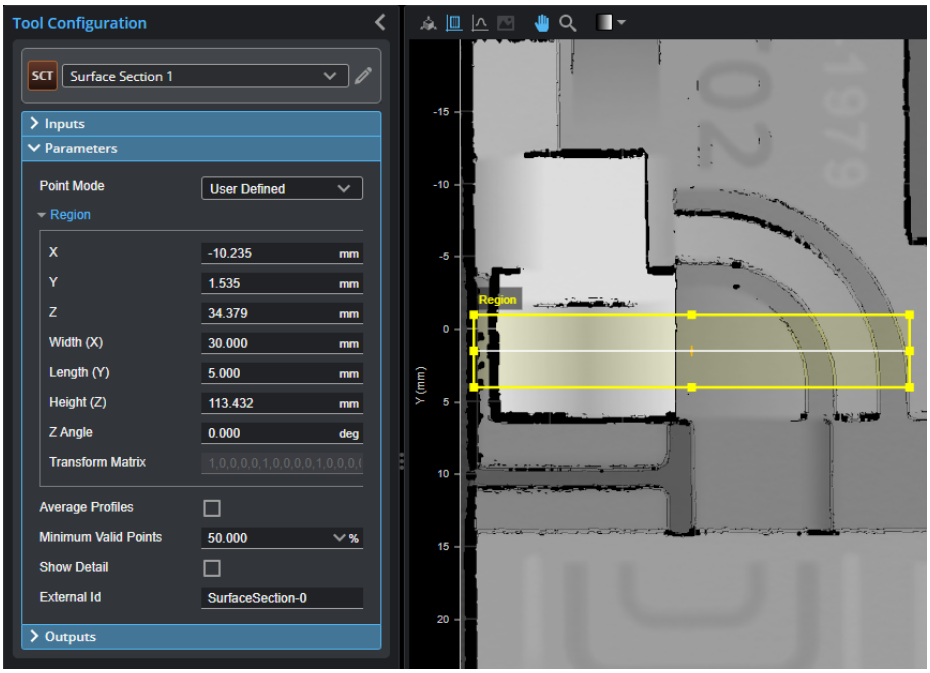
Parameters

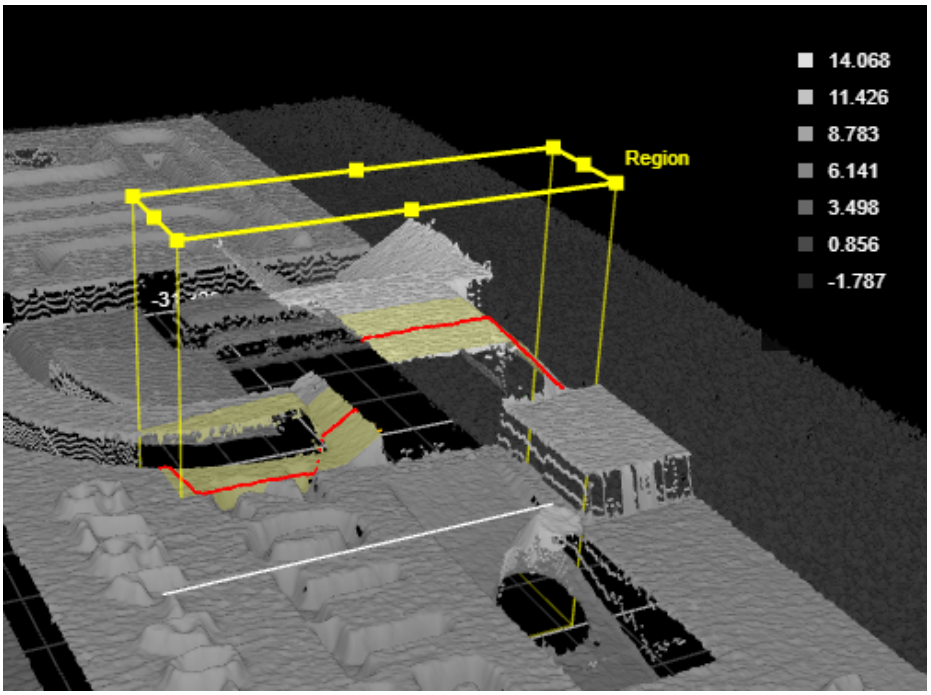
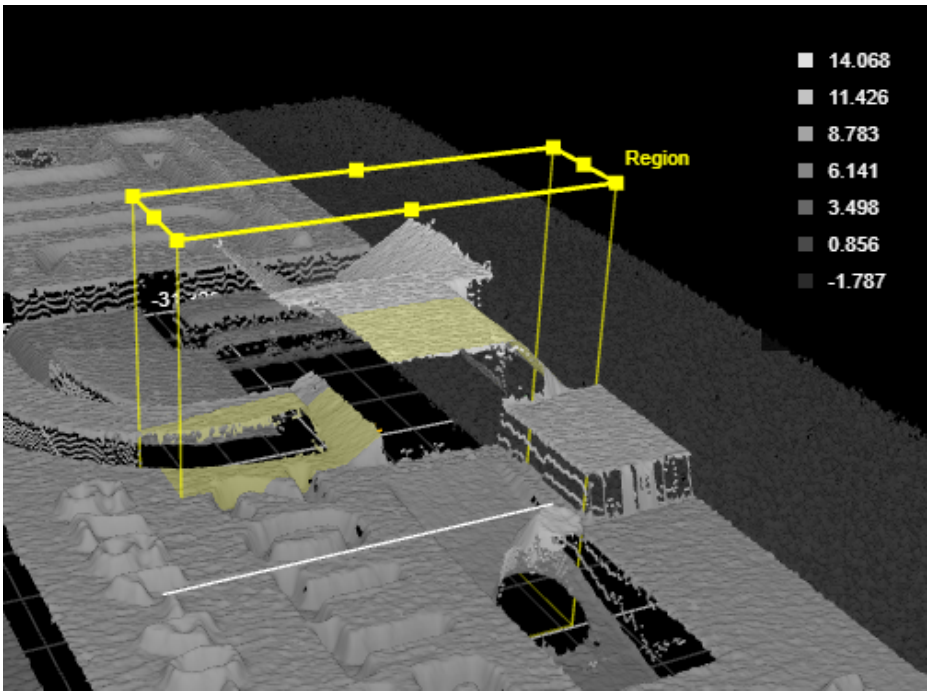
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

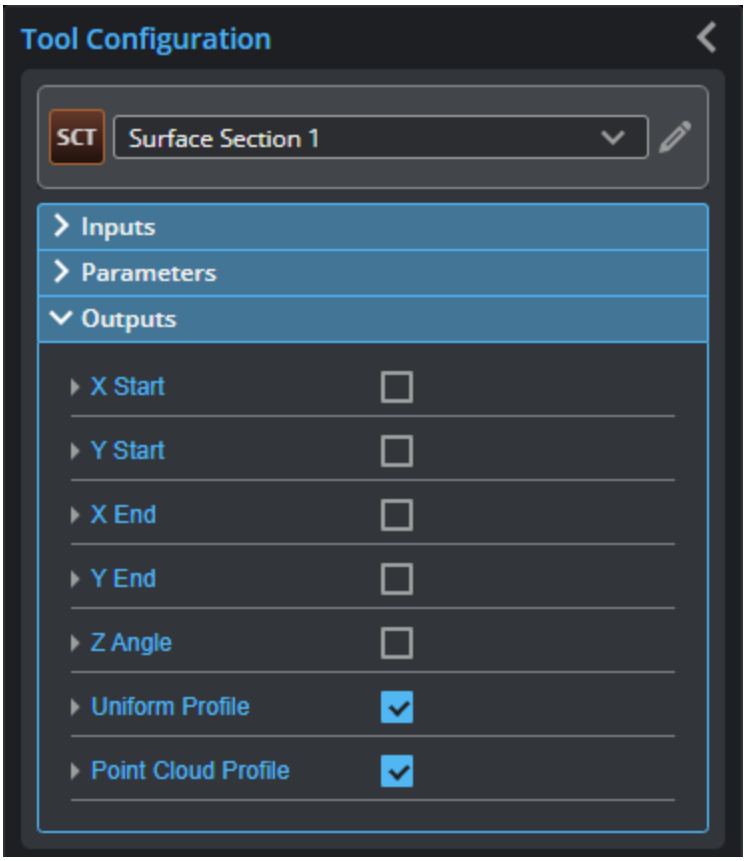
Parameter	Description
Point Mode	Selects how the tool defines the end points of the section. One of the following: **User-Defined**: Enables a region (see **Region** below) whose size, position, and rotation you define. The section is placed along the X axis in the middle of the region. **Feature Points**: 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. The length of the region (along the Y axis) is the averaging width for the section. 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.  For more information, see *Regions* on page 163.
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. **Show Details** enabled:

Parameter	Description
	 **Show Details** disabled: 
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

All 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

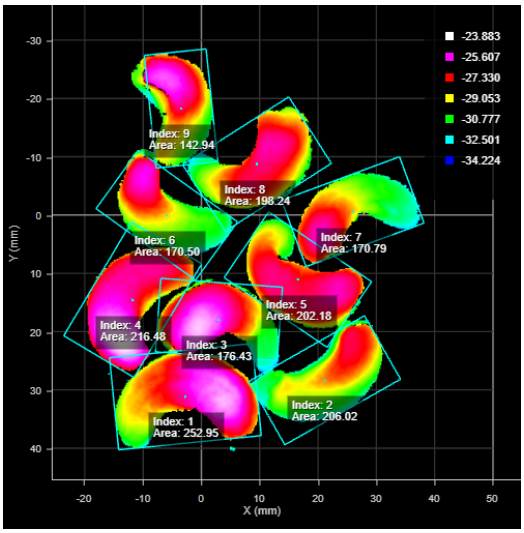
Measurement
X Start **Y Start** These measurements return the X and Y position of the start of the section, respectively.
X End **Y End** These measurements return the X and Y position of the end of the section, respectively.
Z Angle Returns the rotation of the section around the Z axis.

Data

Type	**Description**
Uniform Profile 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 265.

	The Segmentation tool cannot handle large overlaps.

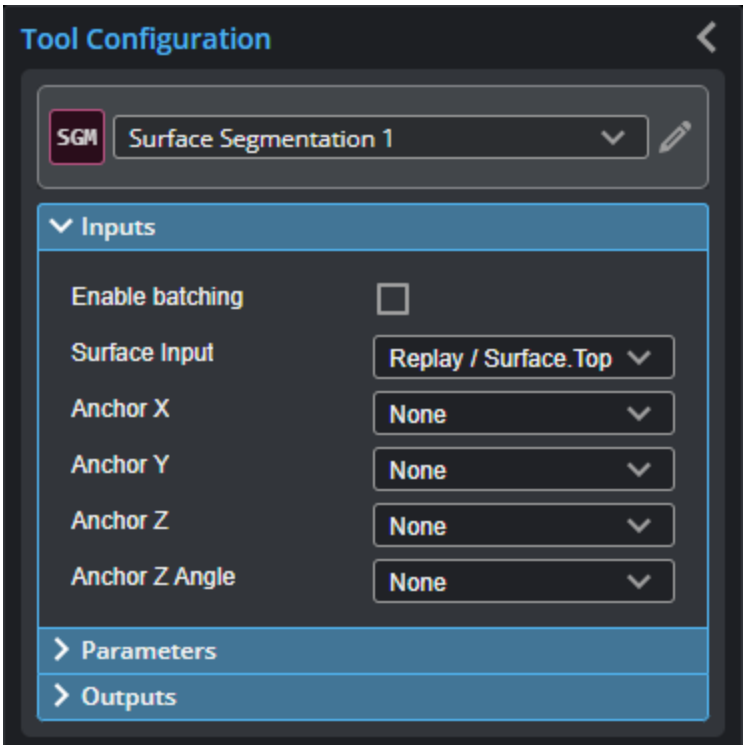
	The Segmentation tool does not perform template matching.

	To reduce processing time, consider using the decimation filter. For more information on this filter, see *Surface Filter* on page 418.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



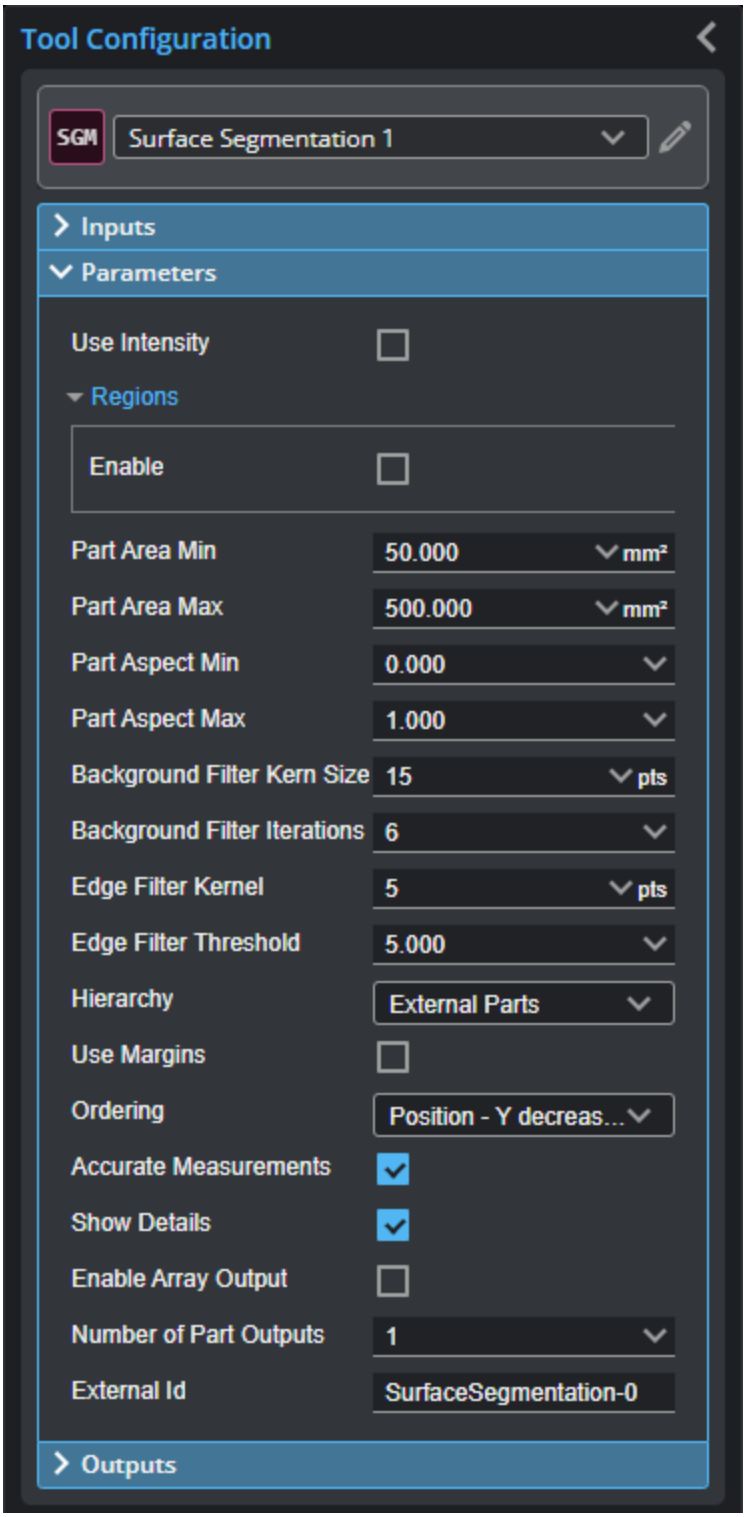
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

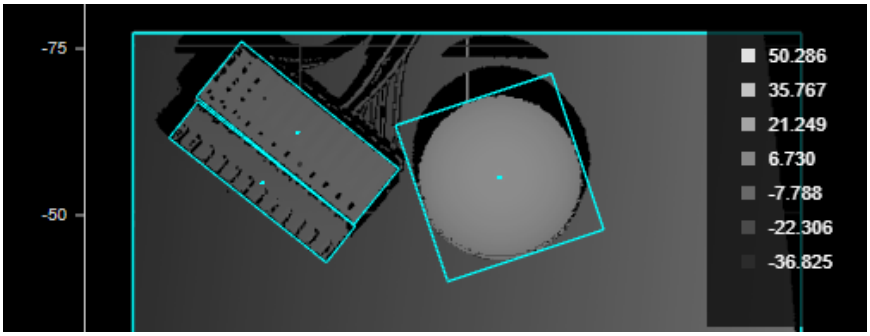
Parameters

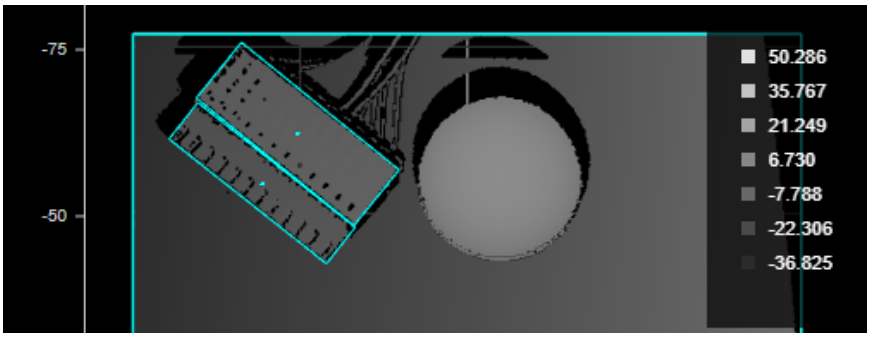
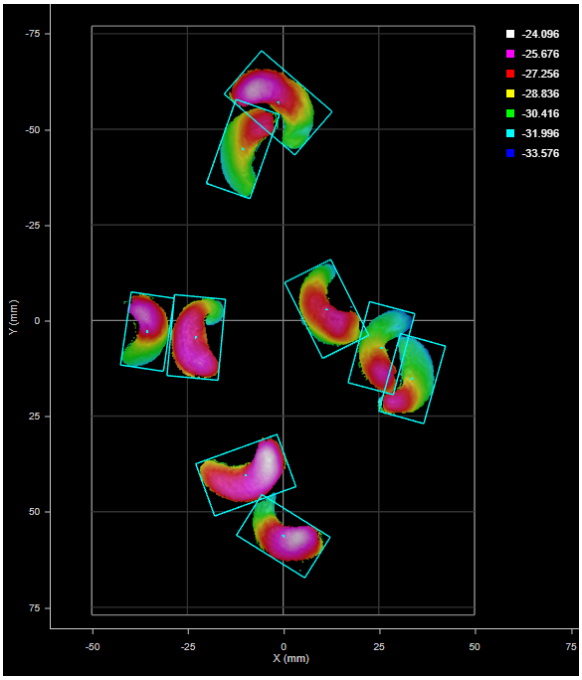
You configure the tool's parameters in the expandable **Parameters** section.

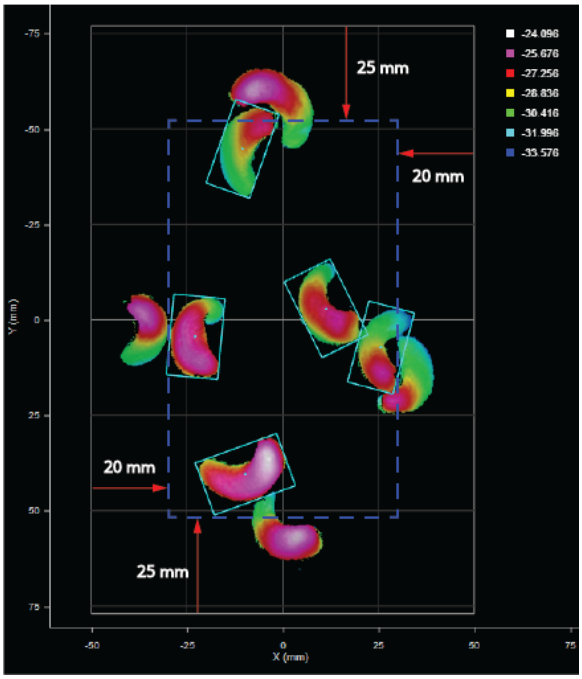


Parameters

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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Part Area Min 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 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 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 Parts**. **All Parts** This option lets you segment parts with surrounding background data. For example, in the following image, with **All Parts** selected, the sphere is correctly segmented from the surrounding background.  Note that this option may result in "over-segmentation": the tool may segment a part into two segments. **External Parts** In the following image, the sphere is not identified as a segment because of the

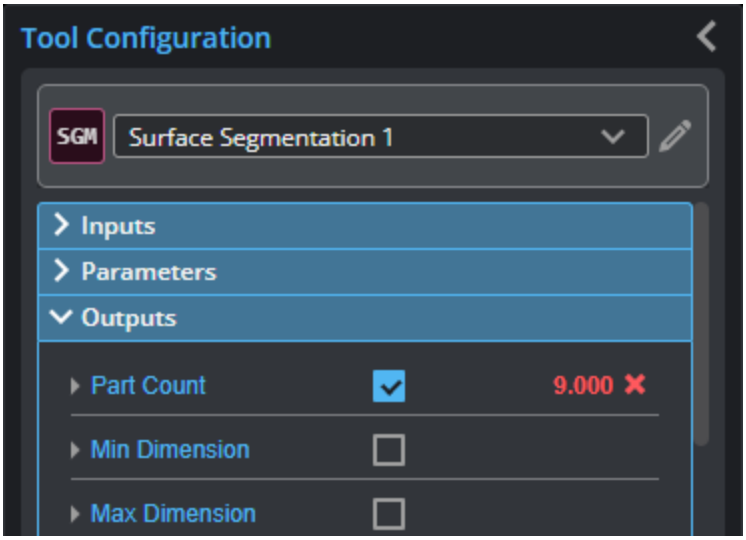
Parameter	Description
	surrounding background. It is treated as part of a large segment that includes all of the scan data. 
Use Margins Margins Left Right Top Bottom	When **Use Margins** is enabled, the tool discards parts whose center point is within the margins defined in the expandable Margins section. Margins extend inwards from the outer edges of the sensor's FOV (XY scan area) and are positive. In the following, with margins set to 0, nine parts are detected  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.)

Parameter	Description
	
Ordering	Orders the measurements, features, and surface data of the individual parts output by the tool. Choose one of the following: • Area - Large to small • Area - Small to large • Position - X increasing • Position - X decreasing • Position - Y increasing • Position - Y decreasing • Position - Z increasing • 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. 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 Aggregation* on page 155.
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**

Parameter	Description
	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 666.

Outputs

All 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 Returns the total number of segments identified, based on the tool's parameters.
Min Dimension **Max Dimension** The minimum and maximum dimensions among all of the identified segments, respectively.
Mean Width **Mean Length** The mean width and length of the segments, respectively.
Min Area

Measurement
Max Area The minimum and maximum area among all of the identified segments, respectively.
Sum Area The sum of the areas of the segments.
Mean Area The mean area of the segments.
Min Height **Max Height** **Mean Height** The minimum, maximum, and mean heights among all of the identified segments, respecitvely.
X Center {n} **Y Center {n}** The X and Y positions of the center of a part segmented from the surface.
Width {n} **Length {n}** 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} The area of a part segmented from the surface. 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 551.

Features

Type	Description
Center {n}	The point representing the center of a segmented part.

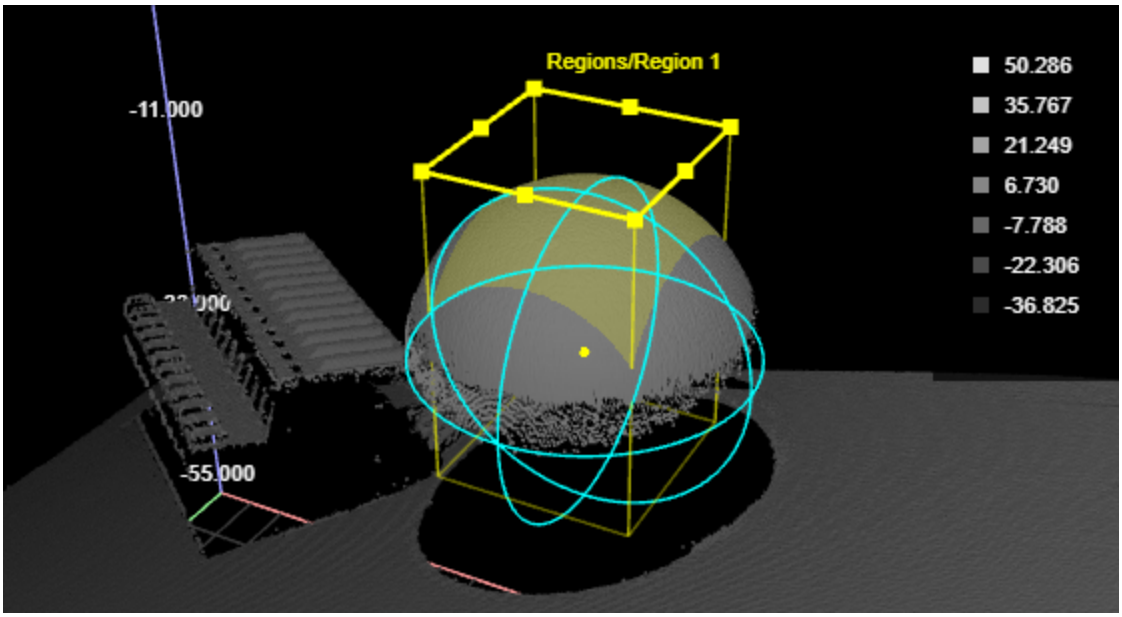
Data

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.

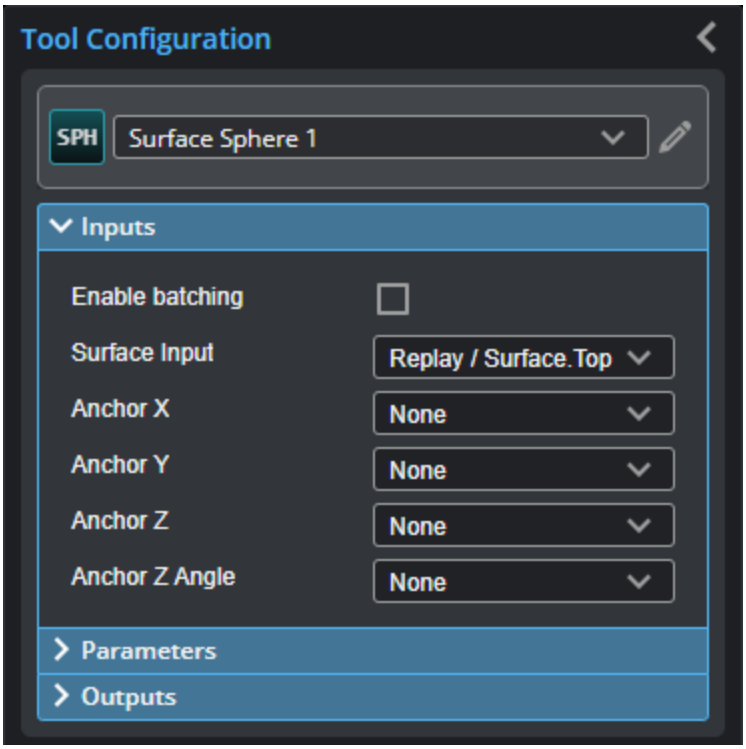
> For the tool to work properly, the tool's region must usually be enabled and properly placed to include only the sphere's scan data.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

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



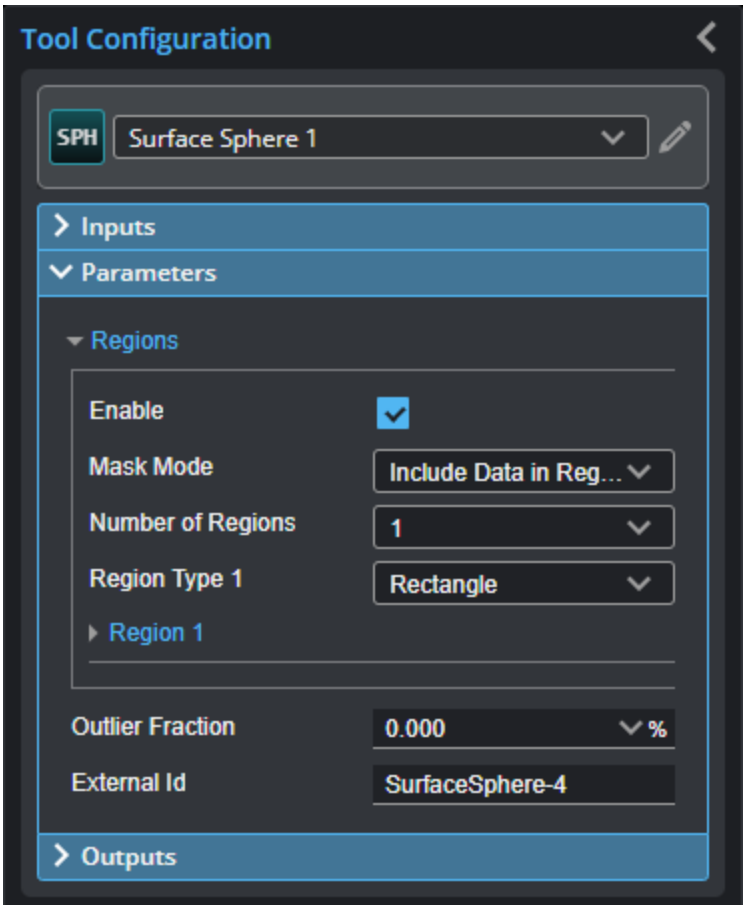
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes. This tool can optionally take an array as input. For more information, see *Arrays, Batching, and Aggregation* on page 155.
Anchor X Anchor Y 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 Z Angle measurement of another tool to use as a rotational anchor for this tool. Rotational anchors are optional.

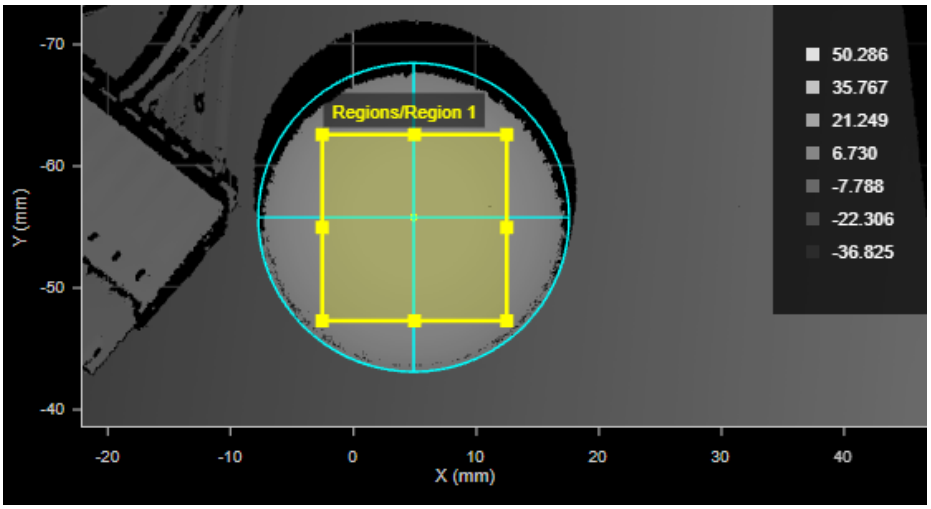
Parameters

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



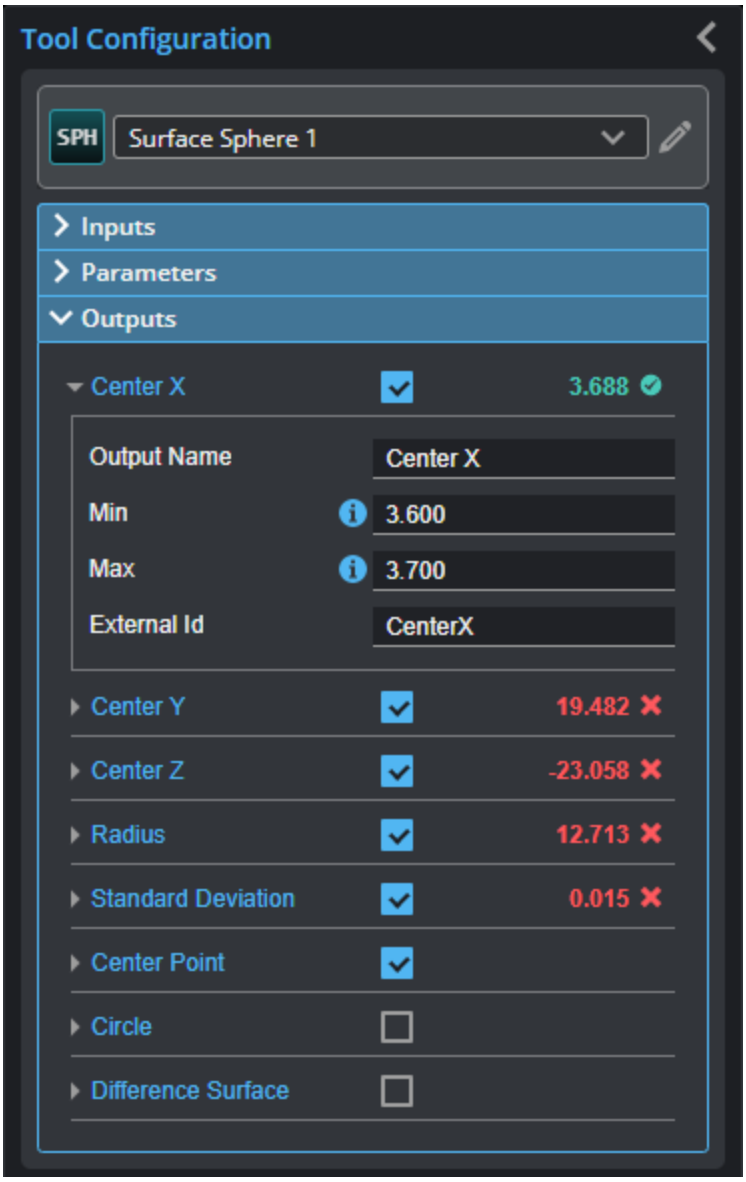
Parameters

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 Number of Regions Region Type {n} 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163. 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 666.

Outputs

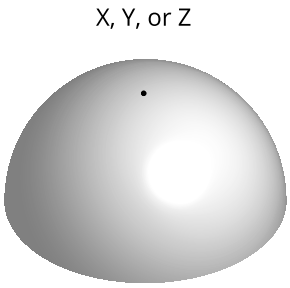
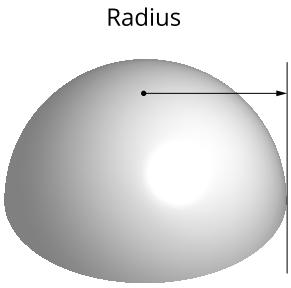
All tools provide measurements, geometric features, or data as outputs.



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** These measurements determine the X, Y, Z position of the center of the sphere, respectively.	
Radius Determines the radius of the sphere.	
Standard Deviation 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.	

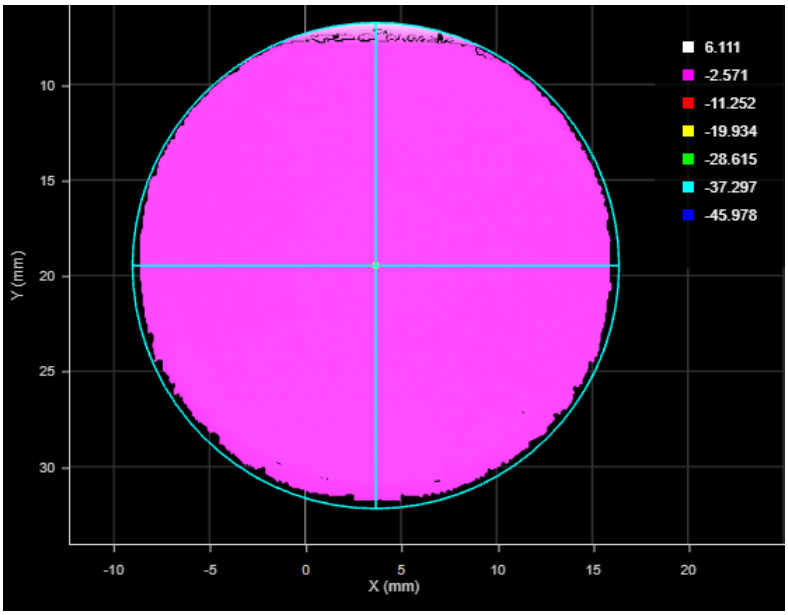
Features

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 175.

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.

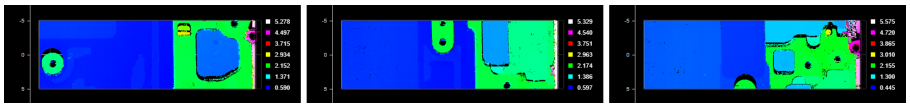
	Results are only as accurate as the motion system.

	Seams are often seen in combined data in stitching performed in anything other than along the Y axis.

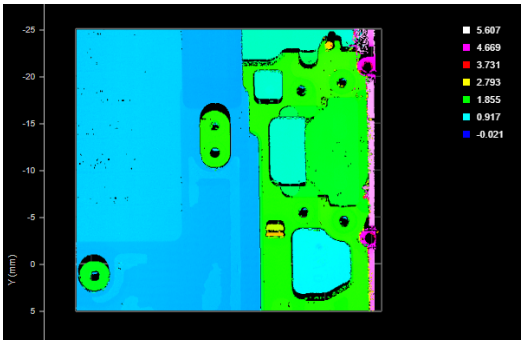
The tool returns one measurement, which simply indicates the number of scans successfully added to the combined scan data.

The following shows three individual frames.

(The following screenshots are from a G2 sensor.)

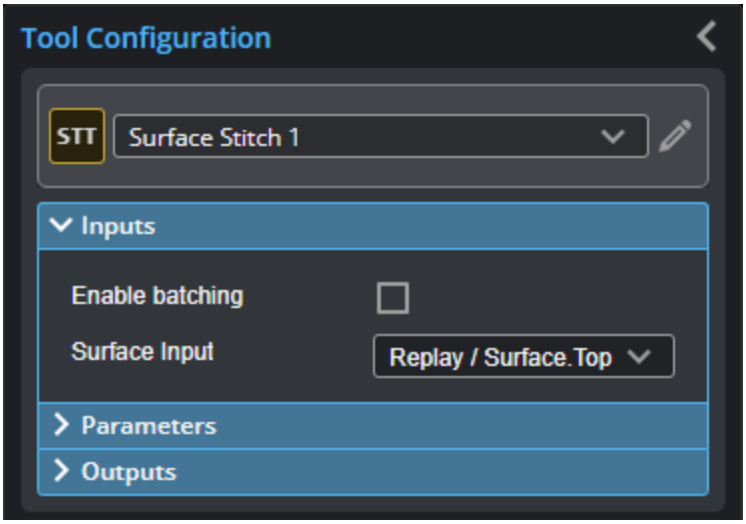


In the following, the tool has combined the frames into a single surface.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

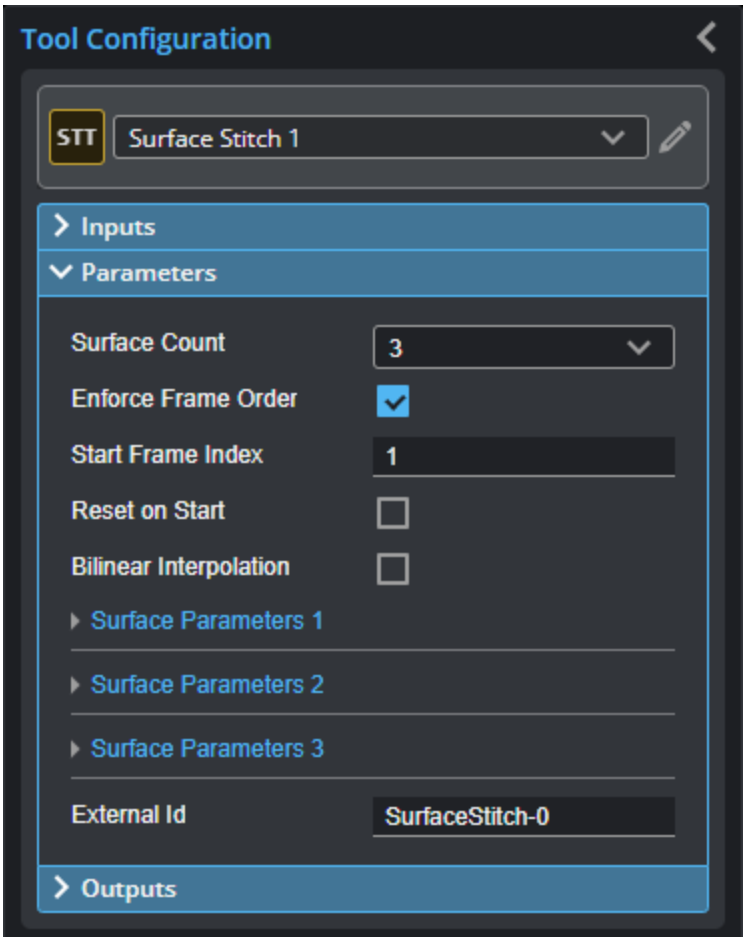


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.

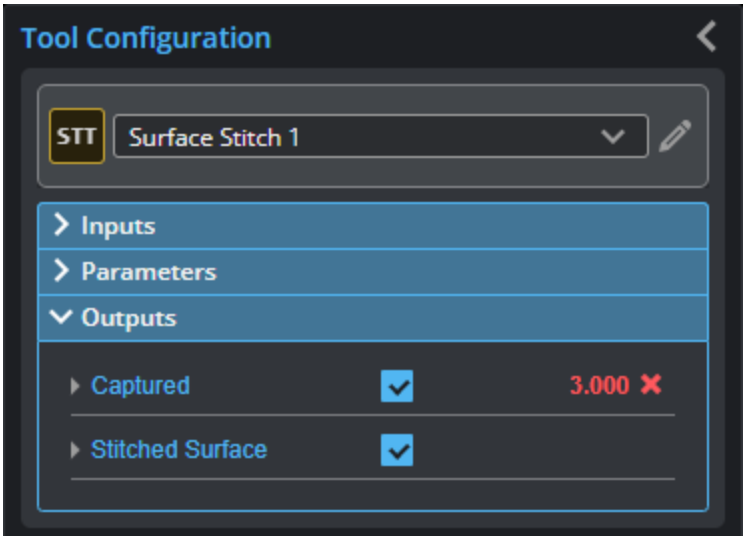


Parameters

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. 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: • **Normal**: The tool automatically chooses this operation after you have chosen another operation. • **Reset buffers**: Resets the buffers used to stitch frames. • **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.
Bilinear Interpolation	Evaluates the height of each transformed point (through translation or rotation) based on its neighbors. More precise, but has an impact on performance.
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: • X, Y, and Z Offset • X, Y, and Z Angle • 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 666.

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 107.

Data

Type	Description
Stitched Surface	The stitched surface scan.
Stitched Raw Surface	

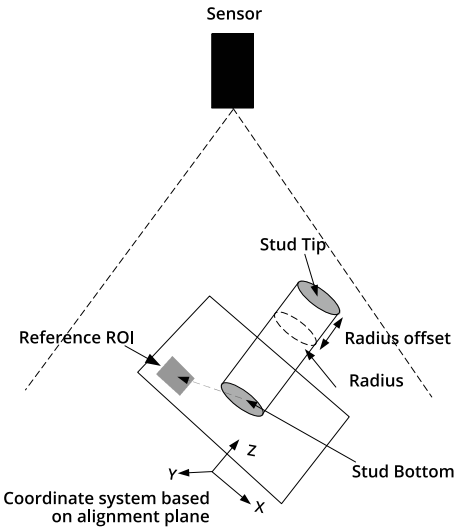
Surface Stud

The Stud tool measures the location and radius of a stud.

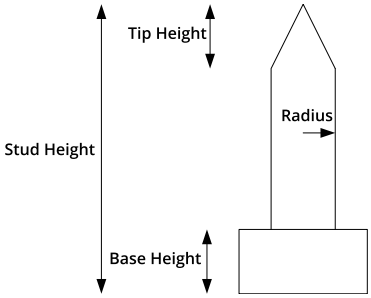
> The tool does not search for or detect the feature. The tool expects that the feature, conforming reasonably well to the defined parameters, is present and that it is on a sufficiently uniform background.

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 153.

Stud Algorithm

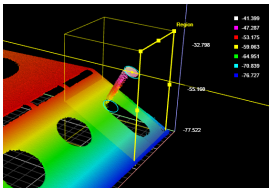
The Stud algorithm measures the stud in three steps: searching for the tip, finding the reference plane, and shaft fitting. Note that the tip and the side of the stud must be within the measurement region.

See the tool's parameters for an explanation of the options that affect the tool's algorithm.

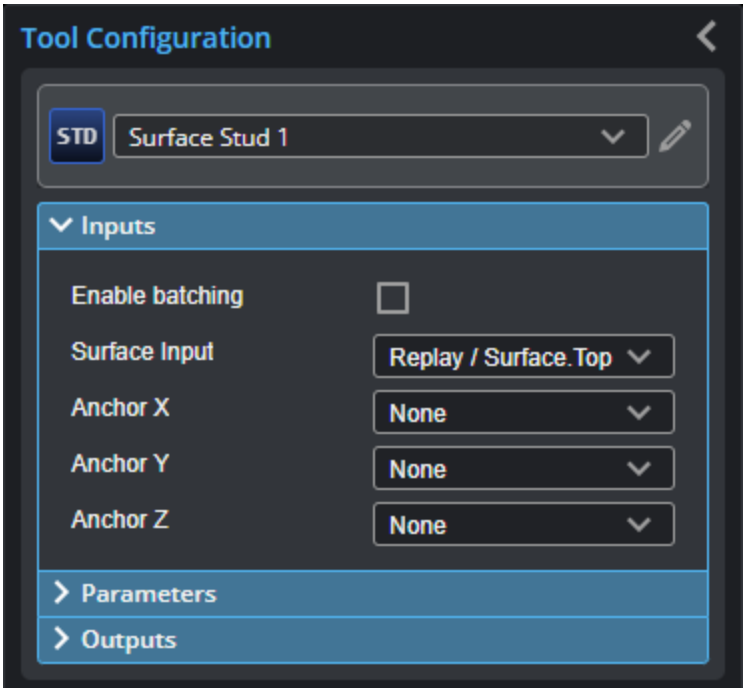
Searching for the tip - The algorithm looks for the approximate location of the tip. If Auto-Tilt is enabled, the algorithm uses the flat surface around the tip to estimate the orientations of the part. The approximate tip is the location of the highest (maximum Z) pixel after correction for the nominal 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



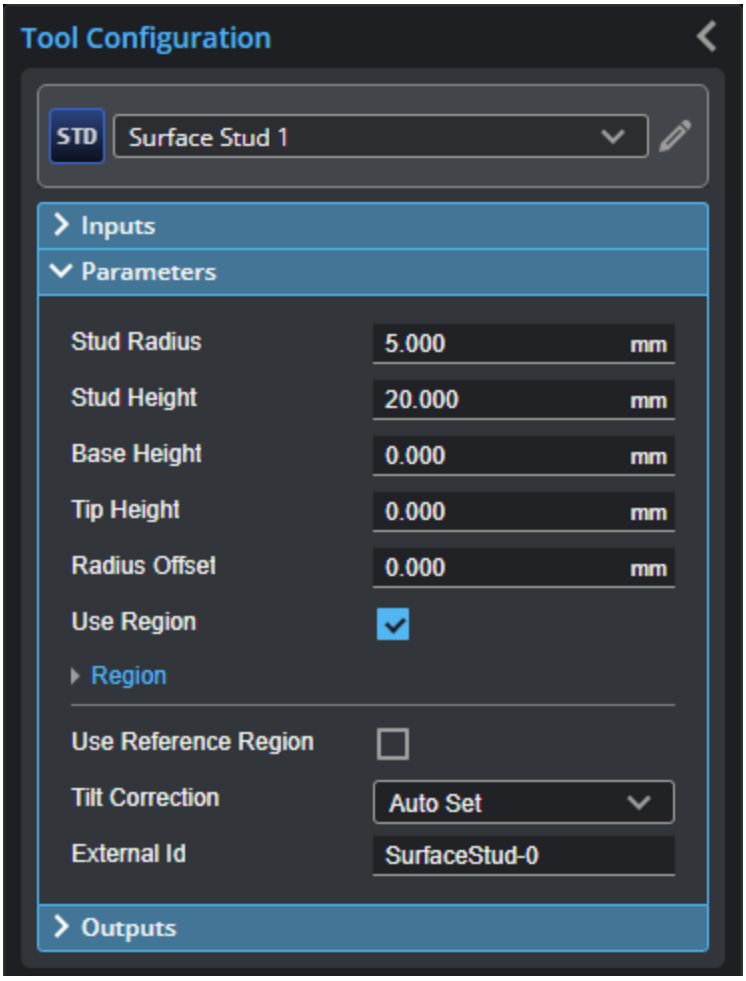
To use a measurement as an anchor, it must be enabled and properly configured in the tool providing the anchor. For more information on anchoring, see *Measurement Anchoring* on page 176.

Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Anchor X Anchor Y Anchor Z	The X, Y, or Z measurement of another tool that this tool uses as a positional anchor. Positional anchors are optional.

Parameters

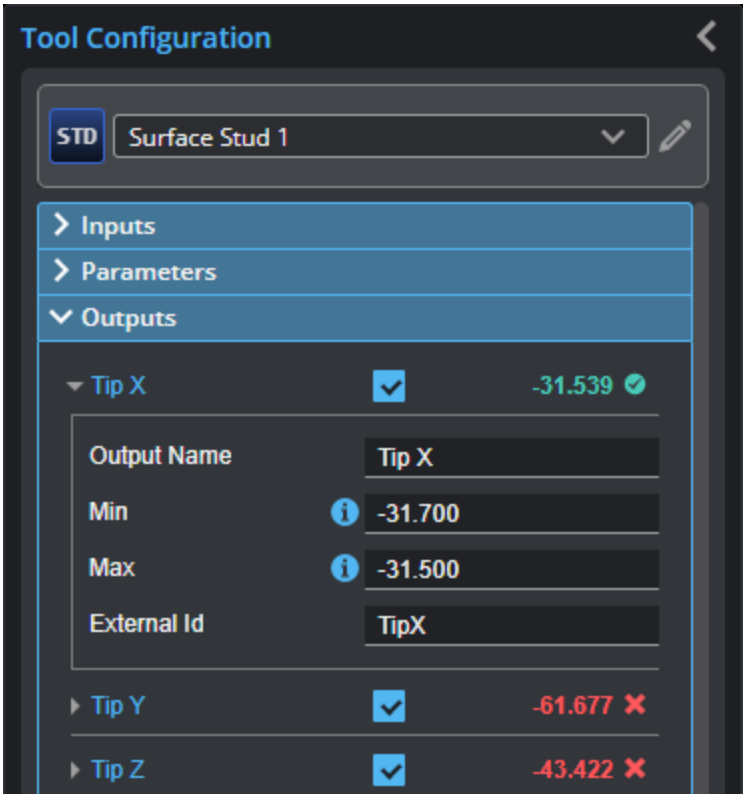
The following parameters are in the expandable **Parameters** section in the tool's configuration.



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 *(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 163.
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. **Autoset**: The tool automatically detects the tilt. The measurement region to cover more areas on the surface plane than other planes. **Custom**: You must enter the X and Y angles manually in the **X Angle** and **Y Angle** parameters (see below).
X Angle Y Angle	The X and Y angles you must specify when **Tilt Correction** is set to **Custom**. 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 666.

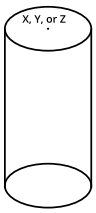
Outputs

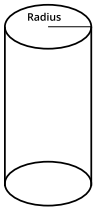


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 Determines the X position of the stud tip.	
Tip Y Determines the Y position of the stud tip.	
Tip Z Determines the Z position of the stud tip.	
Shaft X Determines the X position of the stud shaft. The position is defined with the parameter Radius Offset.	
Shaft Y 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 Determines the X position of the stud base.	
Base Y Determines the Y position of the stud base.	
Base Z Determines the Z position of the stud base.	
Radius Determines the radius of the stud.	

Features

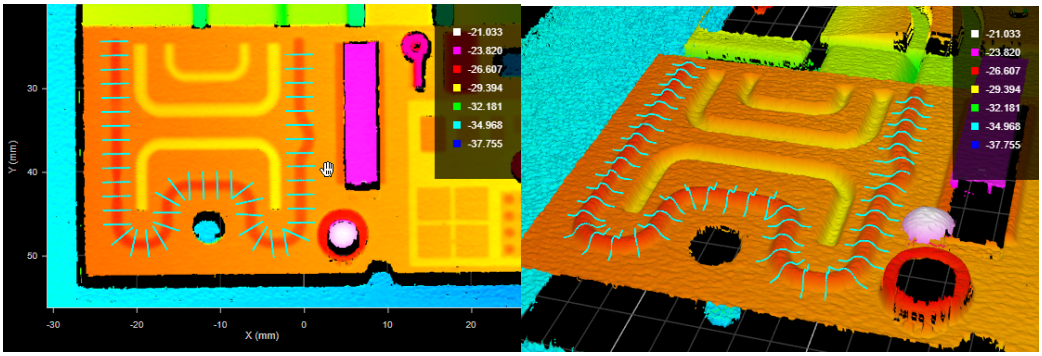
Type	Description
Tip Point	The center point of the stud tip.
Shaft Point	The center point of the stud shaft.
Base Point	The center point of the stud base.

For more information on geometric features, see *Geometric Features* on page 175.

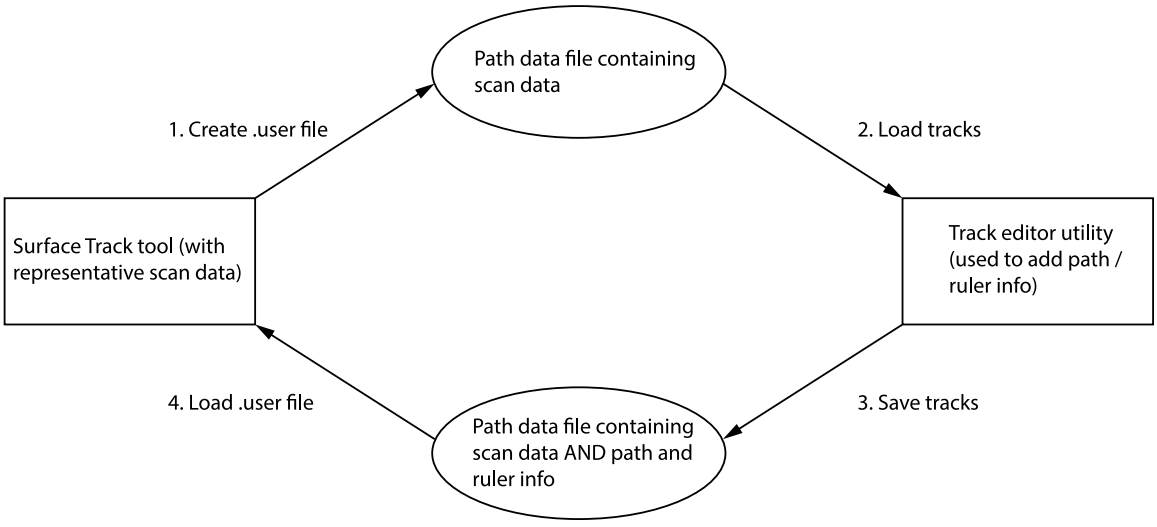
Surface Track

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 175).

> 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 656.



You define the path along which the tool performs its internal measurements using a separate, PC-based utility (the "track editor"). The following shows the relationship between the Track tool and the track editor.



For more information on the track editor, see *Using the Track Editor* on page 529.

> 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 153.

Key Concepts

The following are important concepts for using both the track editor (see *Using the Track Editor* on page 529) and the 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.

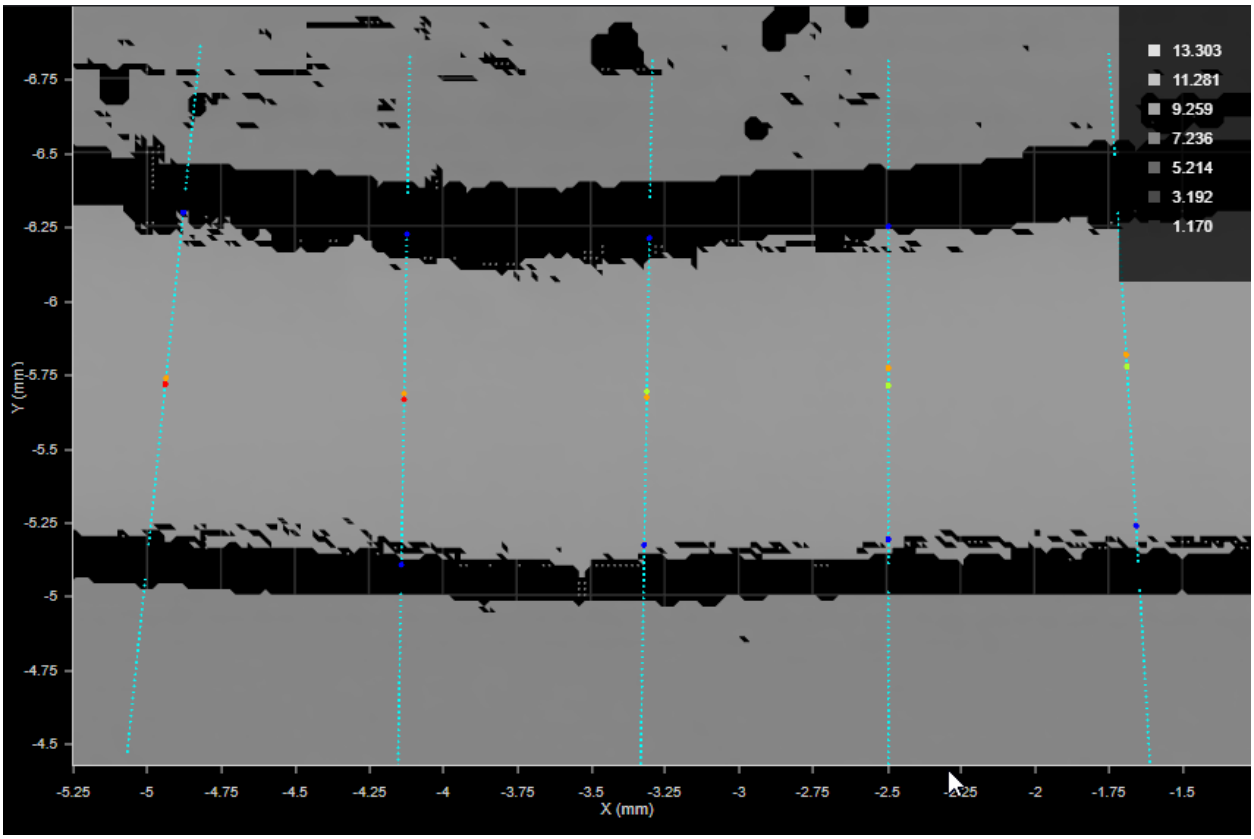
Path: The ideal centerline of the track. You define the path in the track editor. You can define more than one path for use on scanned targets, but the Track tool returns the combined results for all paths. For more information on the track editor, see *Using the Track Editor* on page 529.

Ruler: A ruler is one of the areas perpendicular to the path you define. You define the size (length and width) and spacing of the rulers in the track editor. The Track tool extracts a profile from the surface data beneath a ruler and performs internal measurements based on the values you set in the Track tool's parameters.

Ruler profiles: The profiles extracted from the surface data under a ruler. The tool's internal 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.

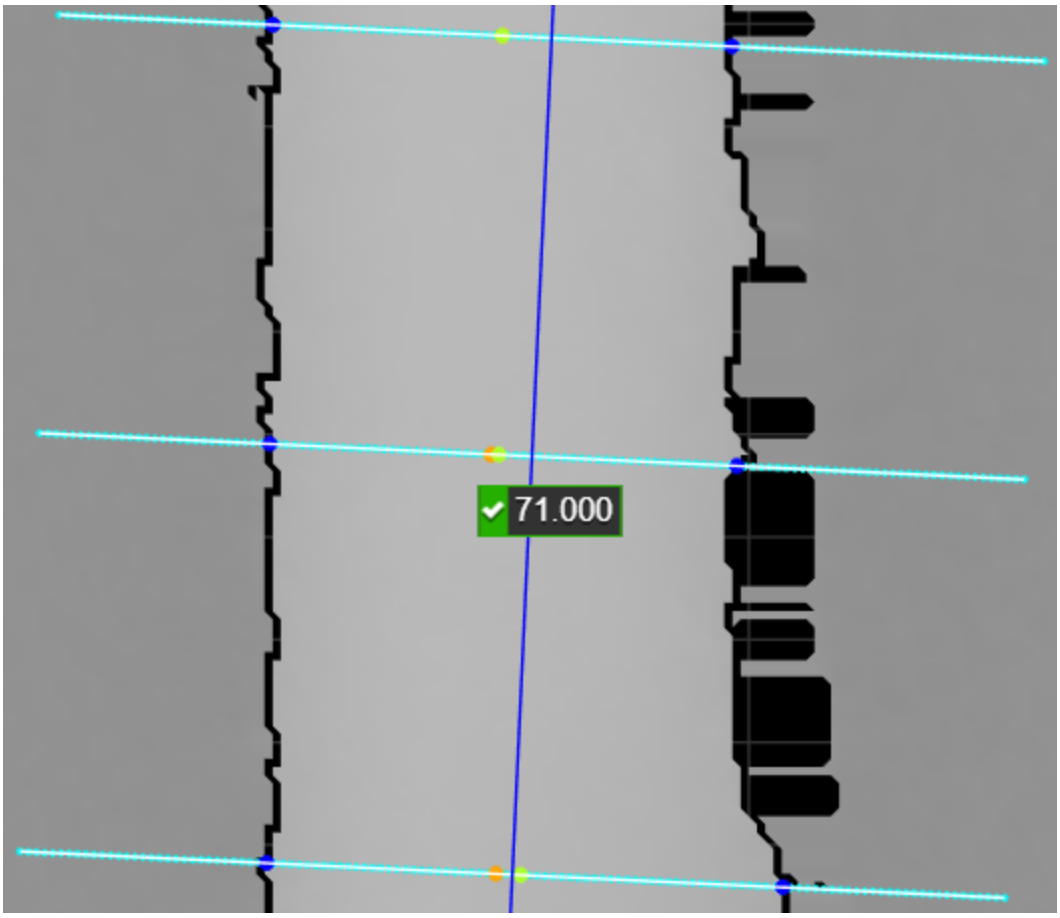
The following shows a track with rulers and measurement results:



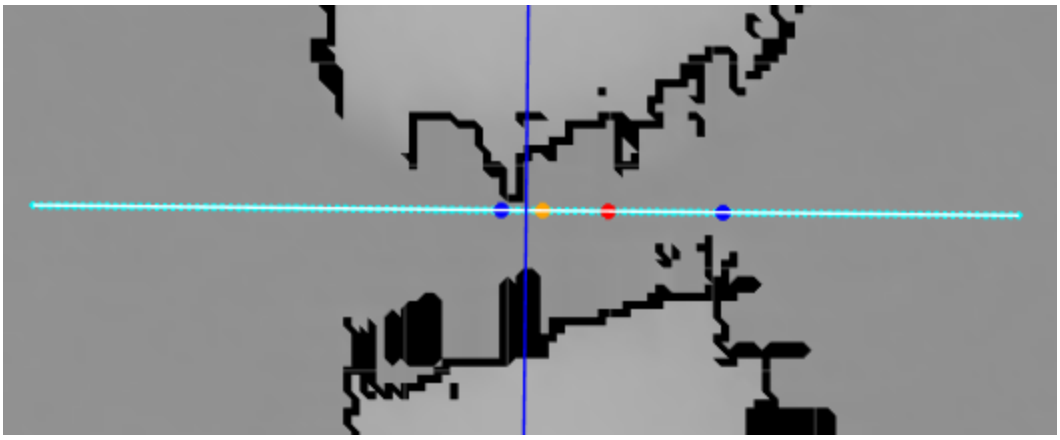
Track tool in data viewer, showing a track (lighter grey horizontal strip in the middle), rulers running perpendicular to the track (white lines centered on light blue dots).
Dots of other colors provide additional information (see below).

When you enable **Show Measurement Results**, the Track tool displays dots on the rulers to provide the following information (see also the images below):

- Light blue dots: The data points in the ruler profile. When you enable **Show Path and Rulers**, the tool displays a white line centered on these dots to indicate the location of the ruler.
- Dark blue dotes: The detected sides of the track. These represent the width of the track under that ruler.
- Green dots: Center points on rulers that pass the criteria set in the tool. These count toward the "OK Count" measurement.
- Red dots: Center points on rulers that fail at least one of the criteria set in the tool. These count toward the "NG Count" measurement.
- 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.



Three "OK" rulers, indicated by green center points. In the bottom two, the peak point (orange) is slightly to the left of the center point (green).



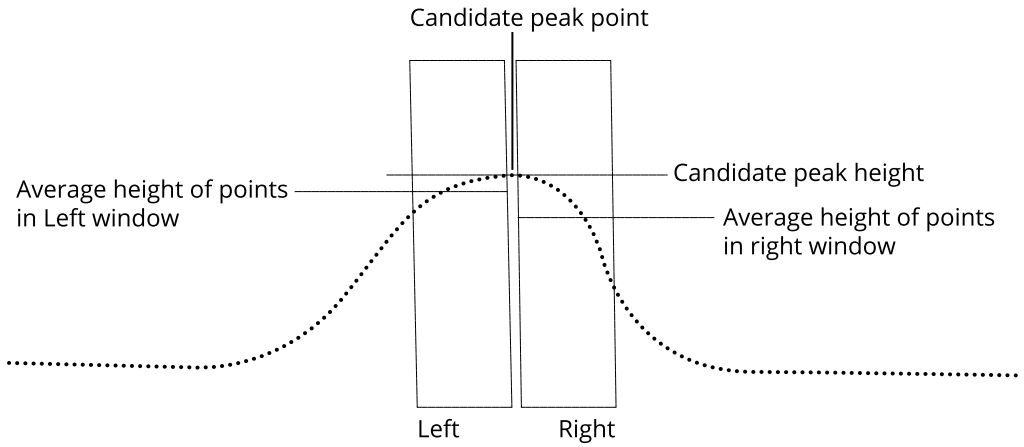
A "NG" ruler, indicated by the red center point.

Track Location

The tool attempts to locate the track using the profile data it extracts under each ruler, and does this by first locating the "peak" (the highest point on the ruler 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 ruler 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* average 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 ruler profile the tool searches for edge points. The tool uses this value to limit where the edge of the track might be detected. Set this to slightly larger than **Side Window Size**.

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 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 to 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 516.

To configure the Track tool:

1. Scan a representative target, or load previously scanned data.
2. Add a Surface Track tool.

   Gocator adds a Surface Track tool and creates a "C:\GoTools\SurfaceTrack" folder if it doesn't exist. Note that previous versions of this tool created and placed files in a "C:\LMI" folder. Files are still read from both locations but only written to C:\GoTools. Rename the existing C:\LMI folder to C:\GoTools for seamless transition.

   For more information on adding a tool, see *Adding a Tool* on page 130.
3. In the Surface Track tool, choose **Create** from the **Operation** drop-down.

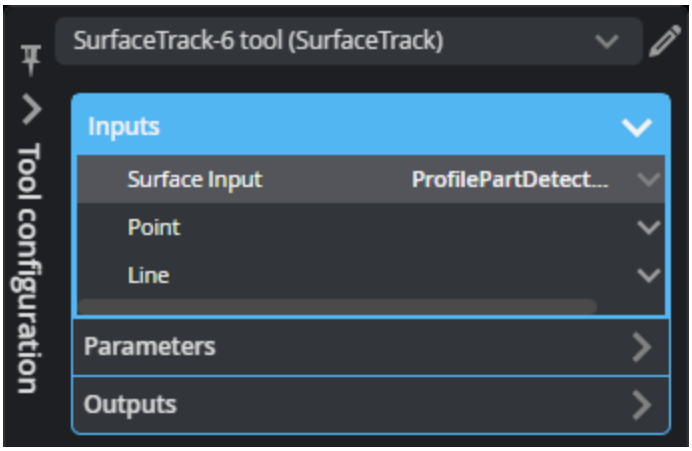
   The tool creates a file (for example, SurfaceTrack-0000.trk) containing scan data in "C:/GoTools/Surface Track". You will use the track editor to add path data to this file.
4. Launch the track editor and configure the path or paths.

   For information on using the track editor, see *Using the Track Editor* on page 529.
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.

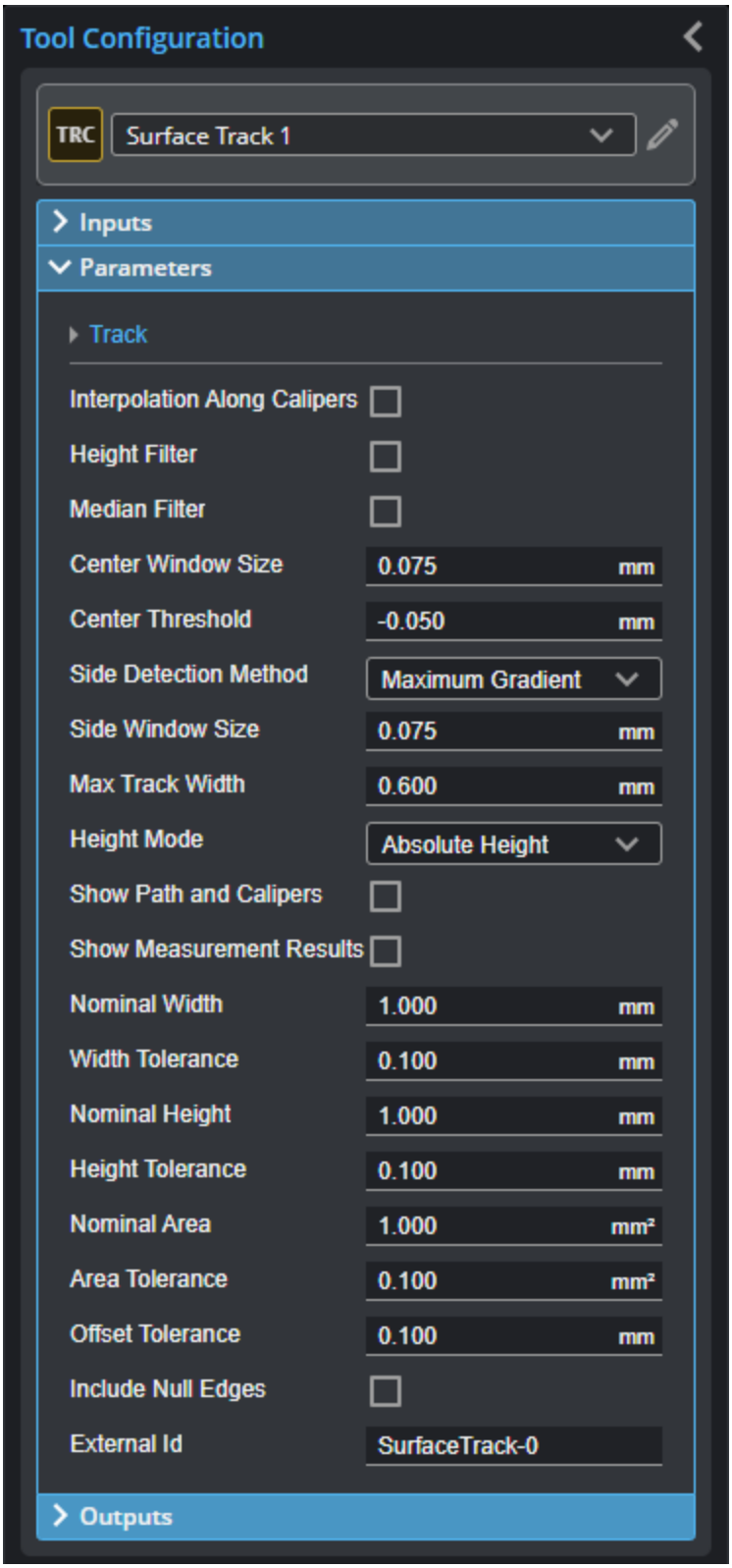


Inputs

Name	Description
Surface Input	The data the tool applies measurements to or processes.
Point 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 175.

Parameters

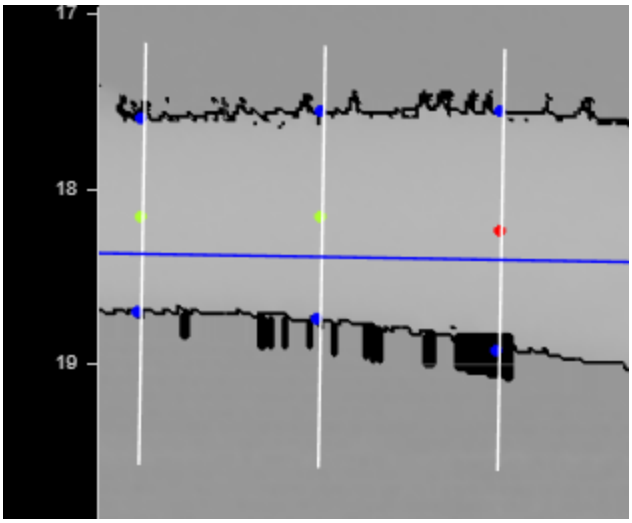
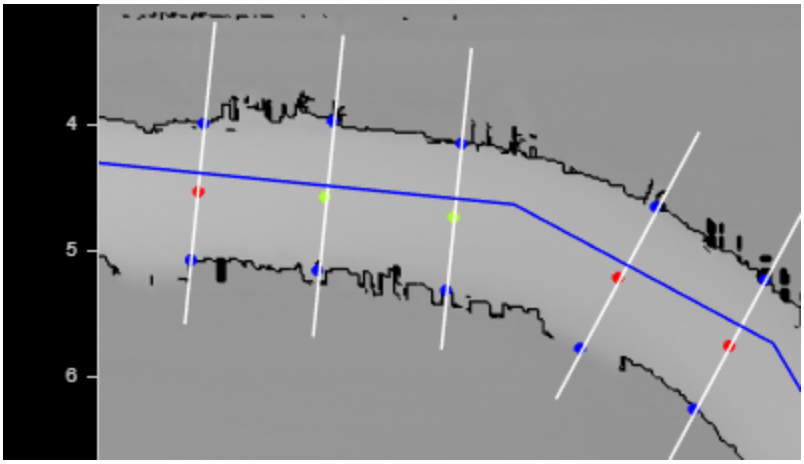
You configure the tool's parameters in the expandable **Parameters** section.

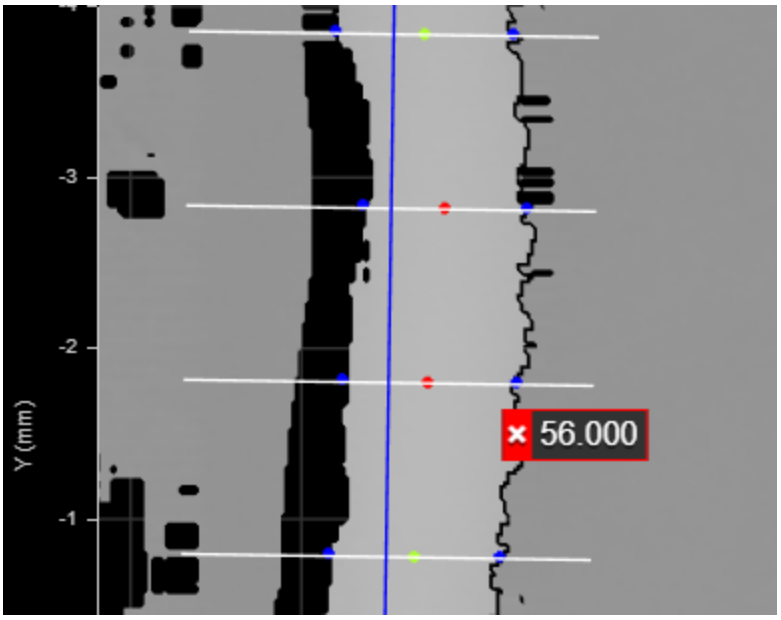

Tool Configuration
TRC
Surface Track 1
Inputs
Parameters
Track
Interpolation Along Calipers
Height Filter
Median Filter
Center Window Size
0.075
mm
Center Threshold
-0.050
mm
Side Detection Method
Maximum Gradient
Side Window Size
0.075
mm
Max Track Width
0.600
mm
Height Mode
Absolute Height
Show Path and Calipers
Show Measurement Results
Nominal Width
1.000
mm
Width Tolerance
0.100
mm
Nominal Height
1.000
mm
Height Tolerance
0.100
mm
Nominal Area
1.000
mm²
Area Tolerance
0.100
mm²
Offset Tolerance
0.100
mm
Include Null Edges
External Id
SurfaceTrack-0
Outputs

Main Parameters

Parameter	Description
Track	When expanded, displays file-related operations.
File	The track file that contains scan and path data. You add path data to the file using the track editor. For more information on the track editor, see *Using the Track Editor* on page 529.
Operation	Provides operations related to the track file. One of the following: • **Normal**: Selected by the tool after you perform another file operation. • **Create**: Creates a new track file for use with the track editor. • **Load**: Loads the path file selected in **File**. • **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**. • **Delete**: Deletes the path file selected in **File**. • **Refresh File List**: Refreshes the list of files.
Interpolation Along Rulers	Enables linear interpolation on the profile extracted from the rulers to achieve sub-pixel accuracy in the width and height measurements.
Height Filter *Dependent settings* Threshold High 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 ruler profiles.
Median Filter *Dependent settings* Window Size	When **Median Filter** is enabled, specify the window the tool will use to smooth the height values of the points in the ruler profiles in the **Window Size** setting.
Center Window Size	The size of the left and right windows the tool moves along the ruler profile to detect whether the point centered between the two is the highest point along a ruler (the center point). 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 ruler profile. At each point, the height value between the two windows is compared to the average height of the left and right windows. 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.

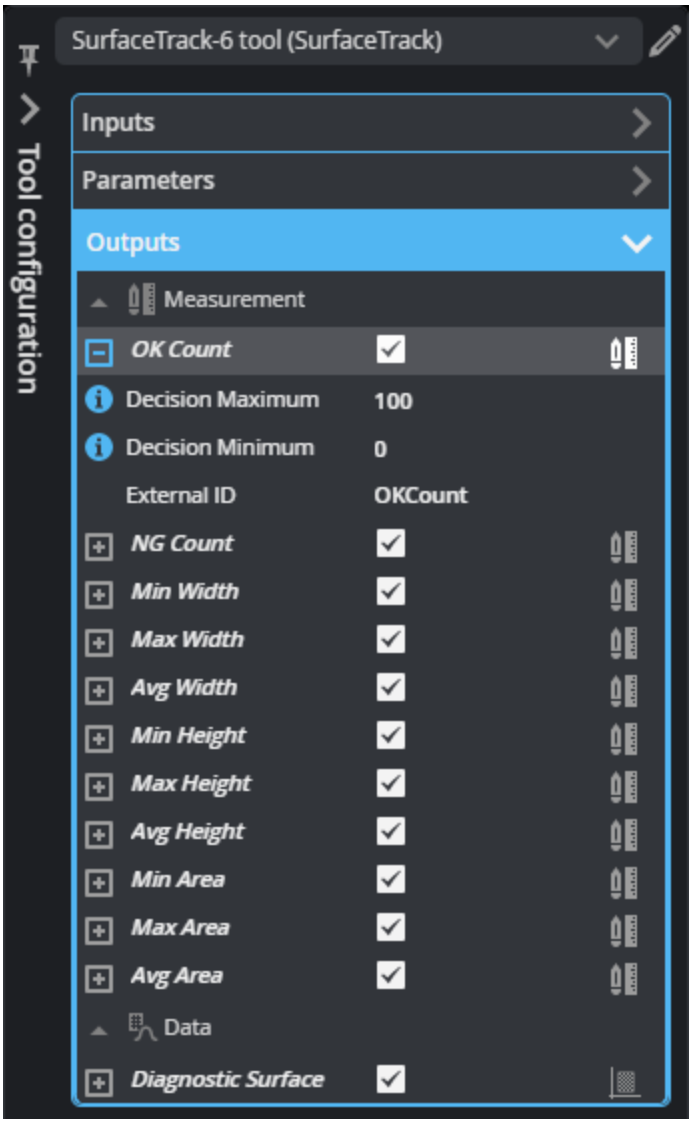
Parameter	Description
	It may be necessary to use a negative number in some cases. It may be necessary to use a negative value under some circumstances. For example, when the top point slightly dips below its surroundings.
Side Detection Method *Dependent settings* Side Window Size Max Track Width Side 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 519.
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: **Absolute Height** - Height values are interpreted globally (the entire scan data). **Step Height** - Height values are relative to the surrounding area of the track.
Show Path and Rulers	Displays the path and rulers (as defined in the track editor) on the scan data.
Show Measurement Result	Shows dots on each ruler representing the results of the internal measurements on the profile extracted from the surface data under the ruler. For more information, see *Key Concepts* on page 516.
Nominal Width	The expected width of the track.
Width Tolerance	The tolerance applied to the nominal width. In the following, the distance between the blue dots indicating the width of the track under the ruler to the right (white vertical line) is greater than the width tolerance; this is indicated by the red center point dot, and counts as a NG measurement. The widths of the track under the two rulers to the left are within tolerance; this is indicated by green center points, and count as OK measurements. The track is lighter grey than the surrounding surface.

Parameter	Description
	
Nominal Height	The expected height of the track. The expected height is the absolute height in the scan data, not relative to the surrounding area. 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. In the following, the red center points indicate that the height at that point is outside of the height tolerance. Green points indicate heights within tolerance. The track is lighter grey than the surrounding surface. 
Nominal Area	The expected cross-sectional area under the rulers 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. In the following, the top and bottom center points (green) are at an acceptable distance from the blue path. The red center points fail because they are too far

Parameter	Description
	from the path. The track is lighter grey than the surrounding surface. 
Include Null Edges	When enabled, displays a **Null Fill Value** parameter you can set to replace null values with the value.
Dependent settings Null Fill Value	
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs

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

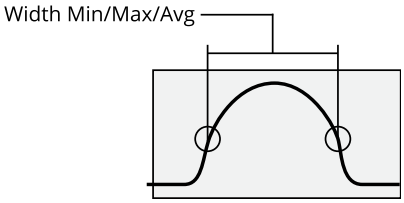
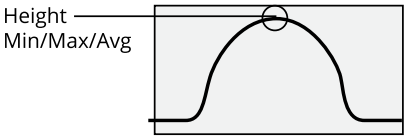
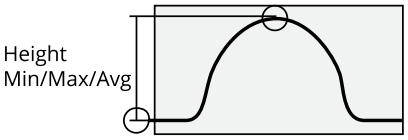
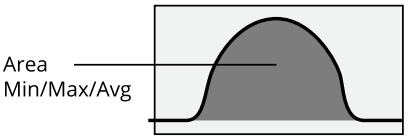


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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
OK Count Returns the number of rulers along the path that pass all of the criteria set in the tool's parameters.	
NG Count Returns the number of rulers along the track path that fail the criteria set in the tool's parameters. (They are "no good.")	

Measurement	Illustration
Min Width **Max Width** **Mean Width** These measurements return the minimum, maximum, and mean width of the track.	 *Width measurements on a ruler profile. The Track tool's settings determine the locations of the "sides" of the track.*
Min Height **Max Height** **Mean Height** These measurements return the minimum, maximum, and mean height of the track at the center point. 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.	 *Height measurements on a ruler profile with Height Mode set to Absolute Height.*  *Height measurements on a ruler profile with Height Mode set to Step Height.*
Min Area **Max Area** **Mean Area** These measurements return the minimum, maximum, and mean area under the rulers.	 *Area measurements under a ruler profile.*
Width **Peak Height** **Offset** 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.

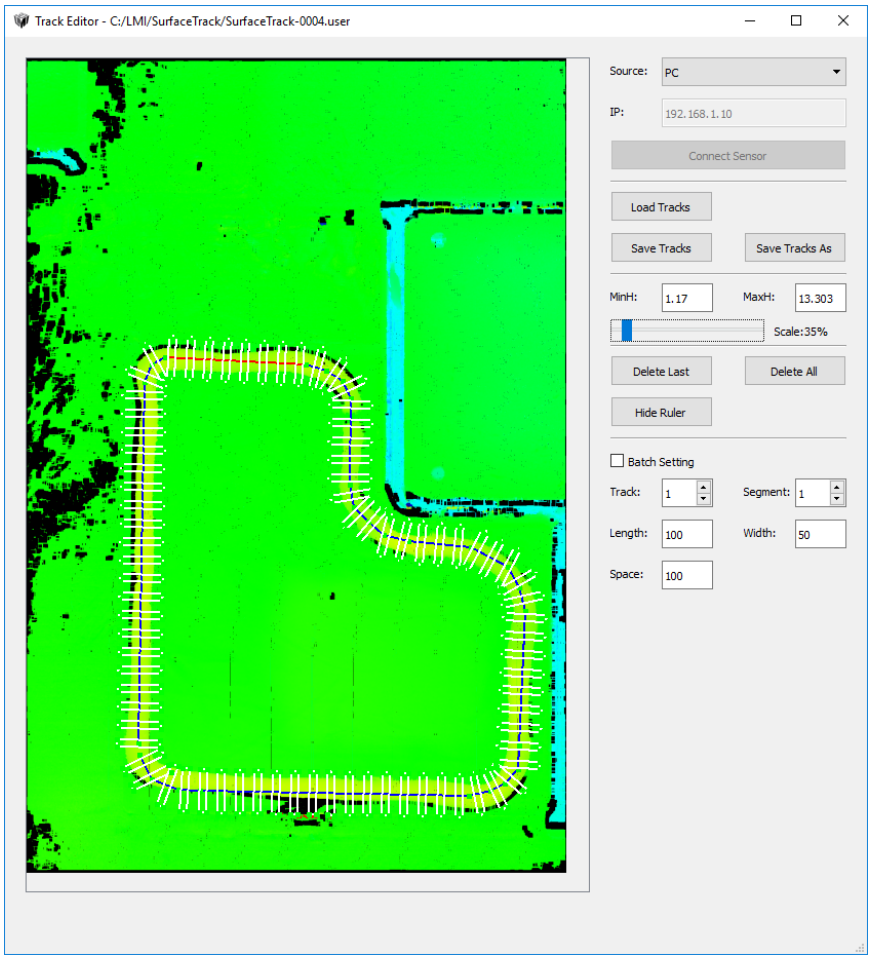
For more information on geometric features, see *Geometric Features* on page 175.

Data

Type	Description
Diagnostic Surface	Surface data created by combining the extracted profiles. Use for diagnostics.

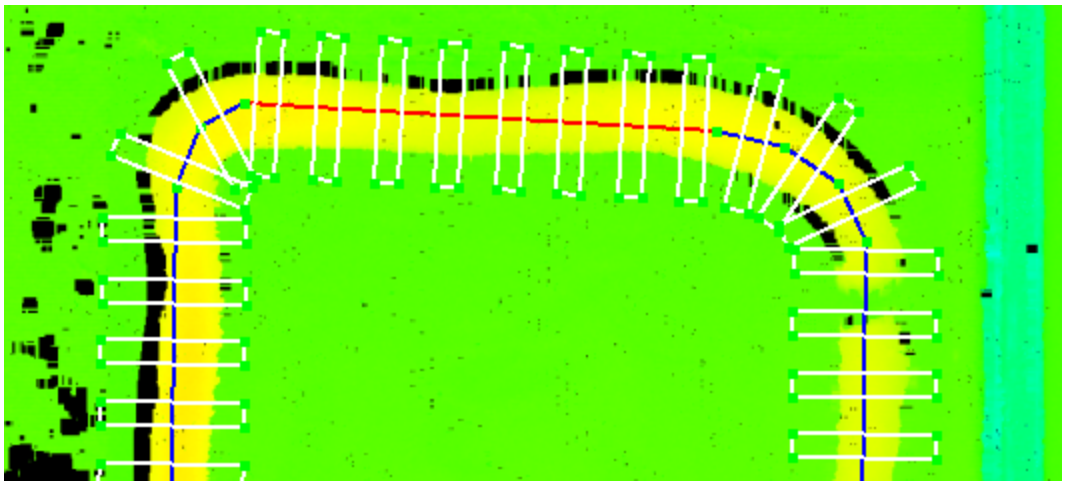
Using the Track Editor

You use the track editor to configure "path" and "ruler" information on a frame of scan data from a sensor, a PC instance of GoPxL, or a GoPxL backup file. The Surface Track tool uses this information to inspect targets along the defined path.



The track editor

In the track editor, you can 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), a path (blue segments; red segment for the currently selected segment), path points (green dots), and rulers (white rectangles).

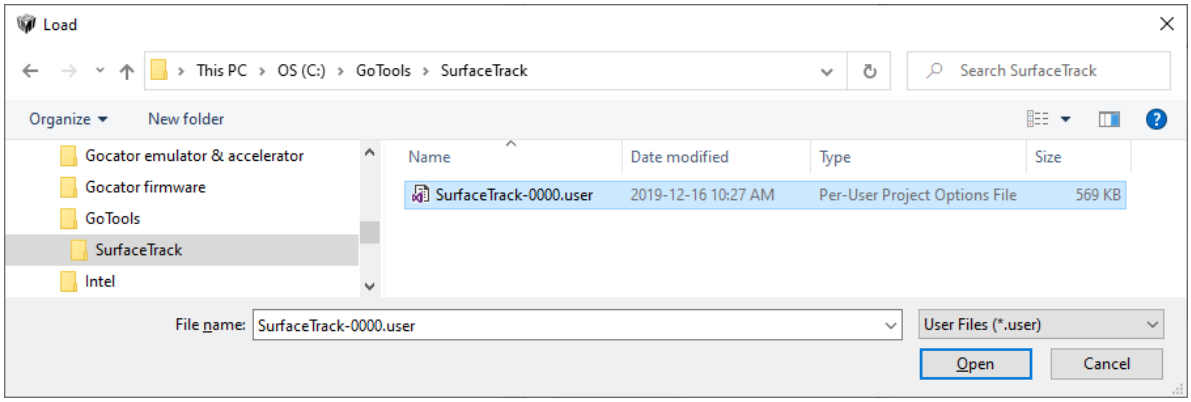
> The following assumes that you have already scanned a representative target and created a track file from within the Track tool. For more information, see the first steps of *To configure the Track tool:* on page 520.

Loading and working with scan/track data:

1. In the track editor, in the Source drop-down, choose one of the following:

- **PC**: Choose this option if you are using the Track tool through the accelerator. The track editor will retrieve the path data file from local (PC) storage and save changes there. (Choose the same if you are using the emulator).
- **Sensor**: Choose this option if you are not using the accelerator. The track editor will retrieve the path data file from the sensor at the IP address specified in the **IP** field. Because sensors have a limited amount of space to store path data, only use this option for simple paths.

2. Click **Load Tracks**, navigate to "C:\GoTools\SurfaceTrack" (if you have chosen PC as the source), and choose the .user file you created using the Surface Track tool.



The track editor loads the data. If paths have been previously defined, they are also loaded.

Note that previous versions of this tool created and placed files in a "C:\LMI" folder. Files are still read from both locations but only written to C:\GoTools. Rename the existing C:\LMI folder to C:\GoTools for seamless transition.

3. Do one or more of the following:

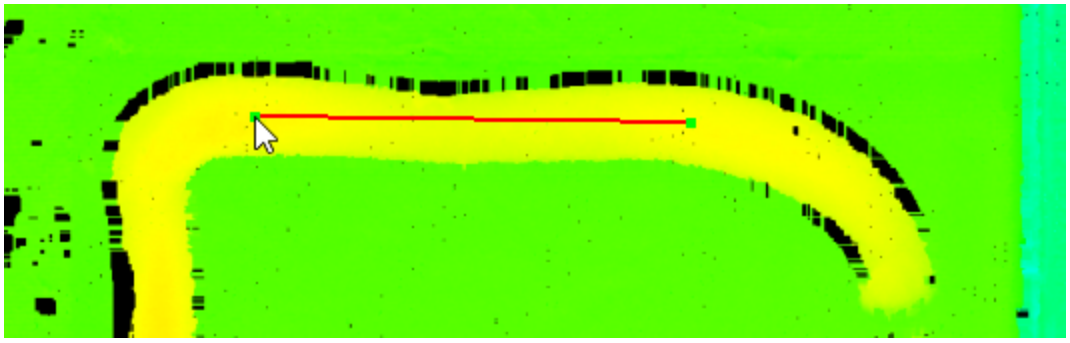
- Move the slider to the left or right to zoom in or out in the editor's viewer.
- Move the data in the track editor's window using the scrollbars or the mouse wheel.
- Set MinH and MaxH and then reload the track data to assign a narrower height range to the height map colors. This may help make the track clearer in the editor.

After you have loaded the data, you must add a path and configure its rulers.

To add a path:

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.

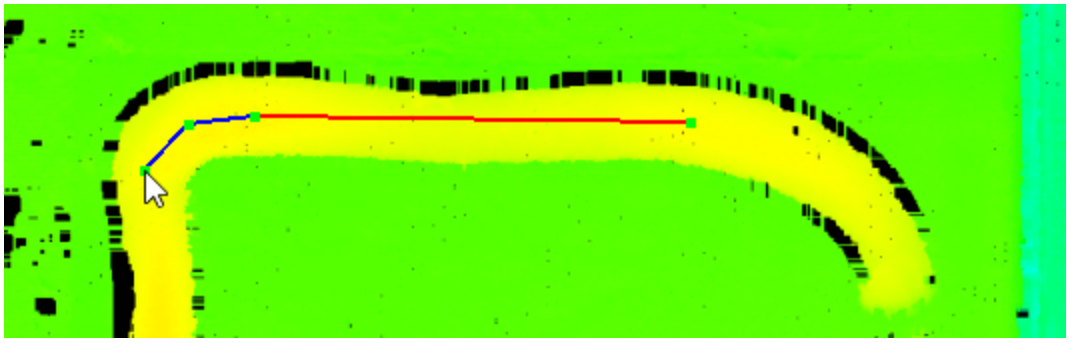
   A red segment between the first two green path points appears in the editor window.



   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.

   You cannot close the path: simply click close to the starting path point when you have finished.

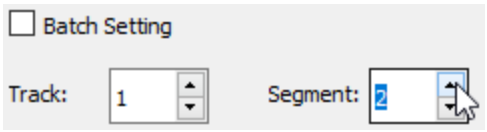
4. Click **Save Tracks** to save the path information to the data.

5. (Optional) You can add other paths if necessary by clicking somewhere in the scan data *after* you have saved the track data.

After you have finished adding a path, you must configure the rulers on the path (the dimensions and the spacing of the rulers). You can choose to apply dimensions/spacing to *all* rulers in all segments at the same time by checking **Batch Setting**. The settings also apply to all paths if you have defined more than one path.



Otherwise, you must move through the individual path segments by clicking the spinner control in the **Segment** field and set the ruler dimensions for each segment. If you have defined multiple paths, you will have to click through the paths too, using the **Track** spinner.



The following table lists the ruler settings available in the track editor:

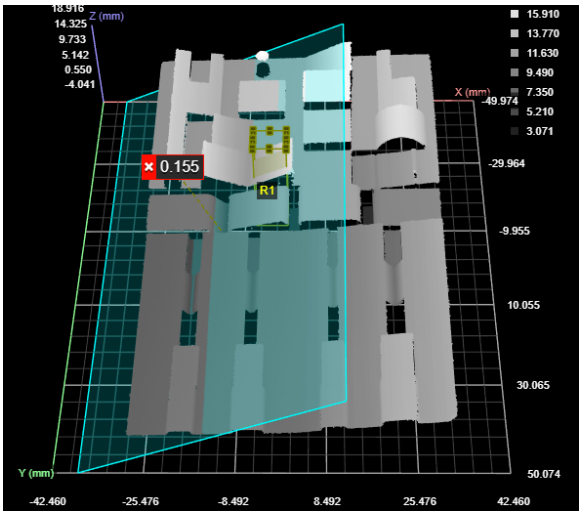
Track editor: ruler settings

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.

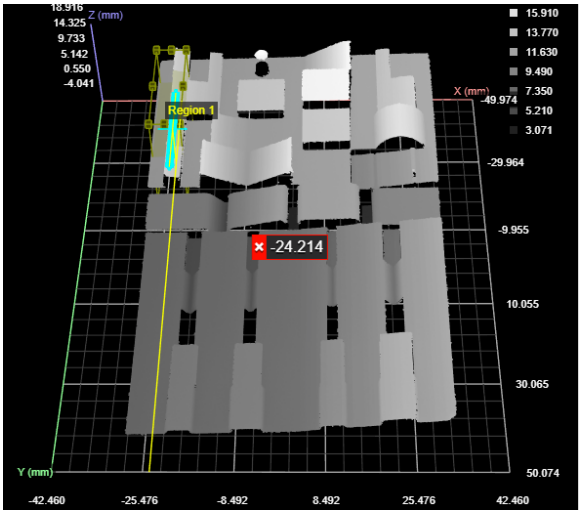
Surface Transform

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.

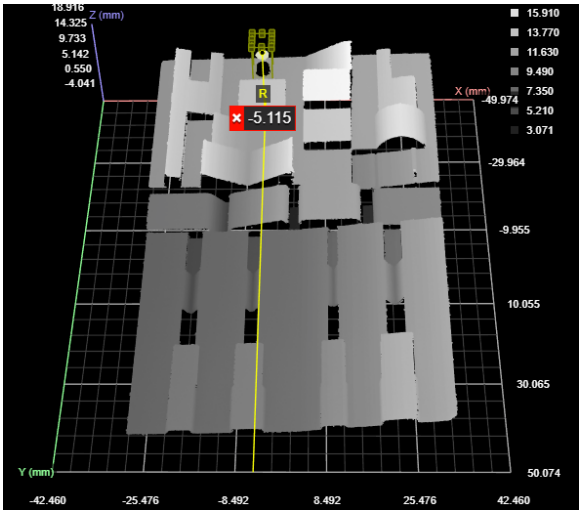
In *Combinations of geometric feature inputs and results* on page 535, the following geometric features are used by a Surface Transform tool in various combinations (a plane, a line, and a point).



A Surface Plane tool, with the region set to a small left-facing angled surface

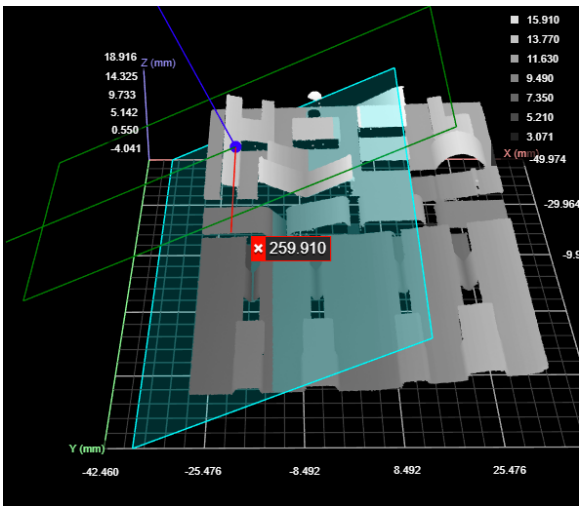


A Surface Edge tool, with the region set to the left edge of a raised surface (upper left of data viewer).



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

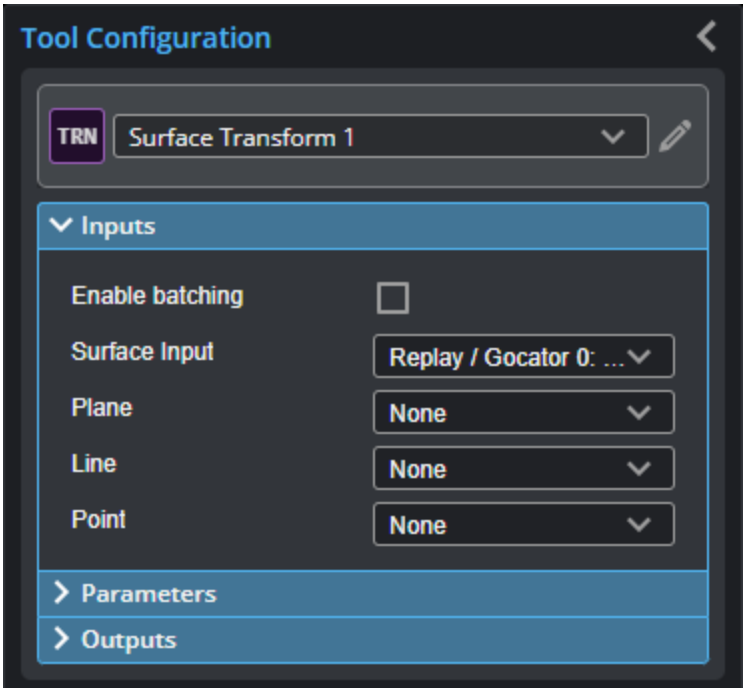
The new origin is represented by the dark blue dot at the intersection of the transformed axes.

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 surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.
Plane Line 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.

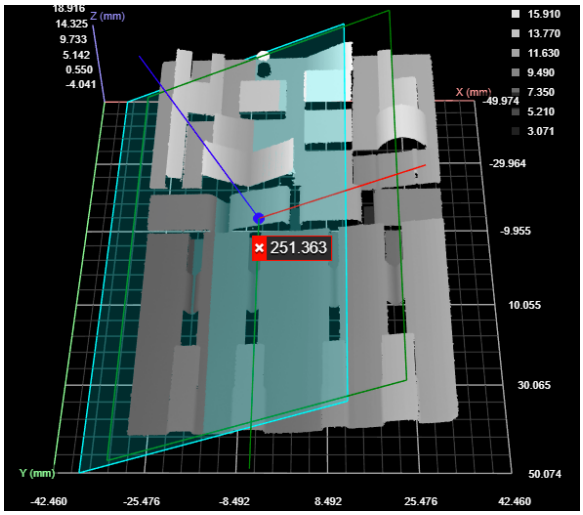
Combinations of geometric feature inputs and results

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.

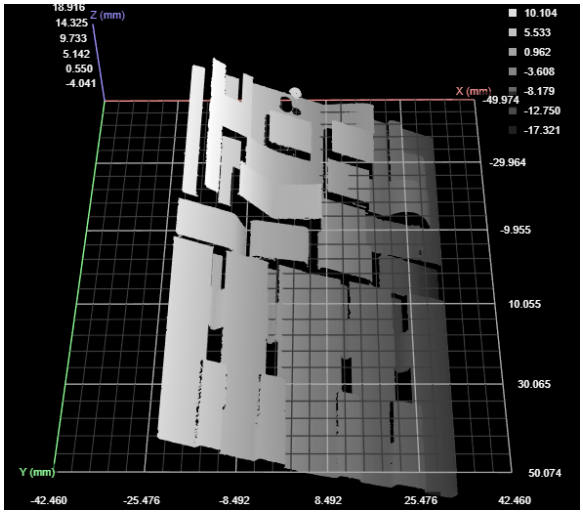
Plane

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



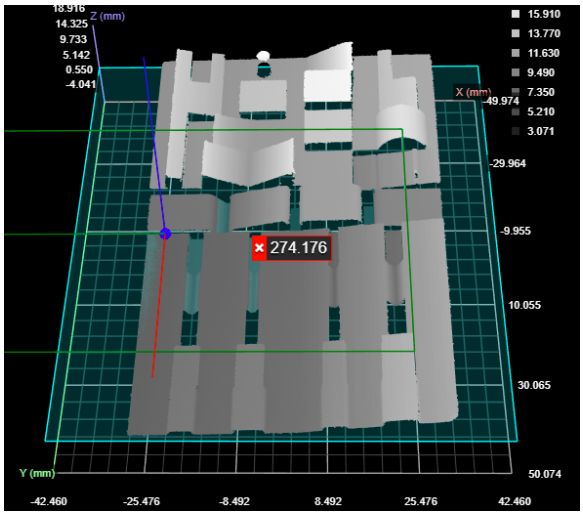
Transformed data



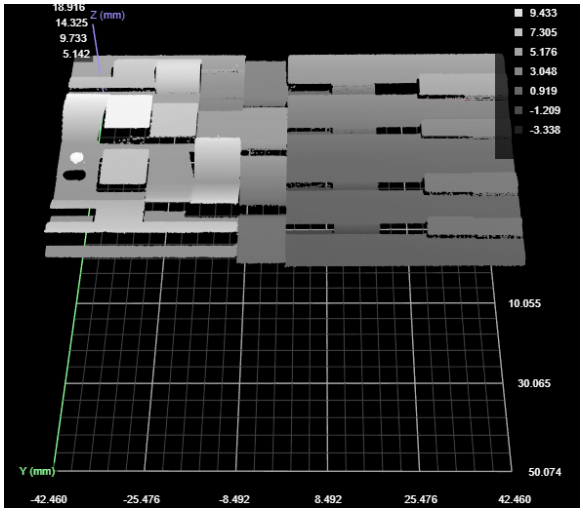
Line

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

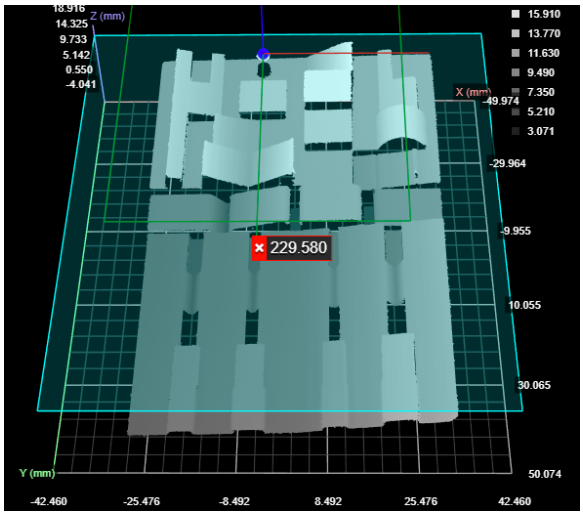


The direction of the X axis depends on the tool generating the line that Surface Transform takes as input. You may need to adjust the direction using the **Add Fixed Transform** settings.

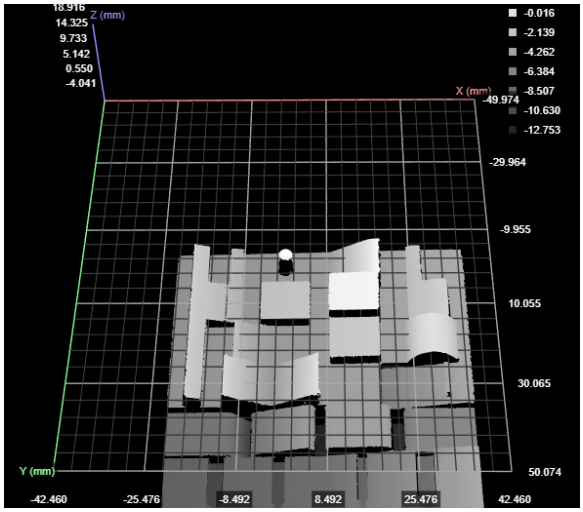
Point

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



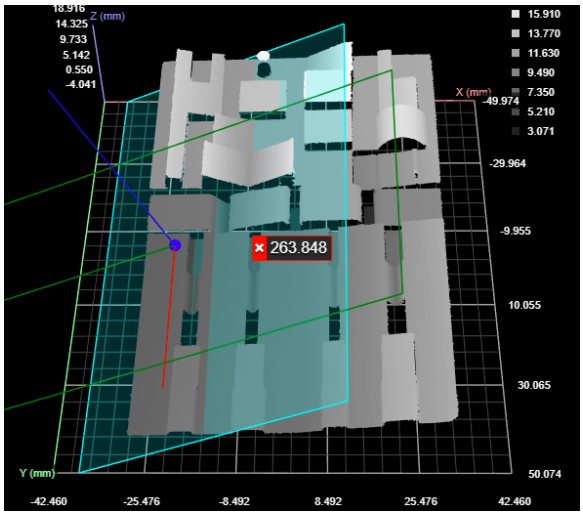
Transformed data



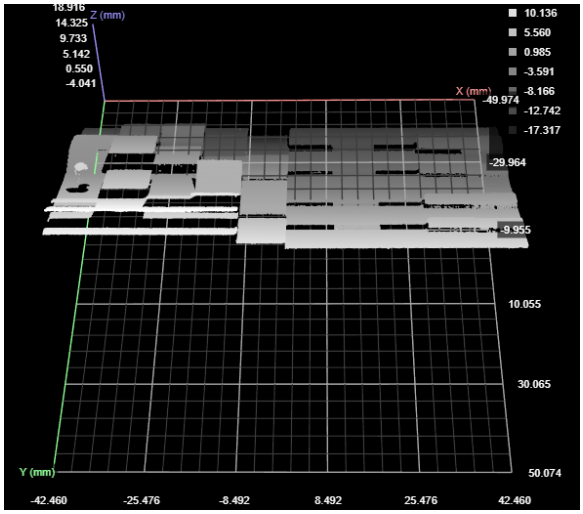
Plane + Line

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



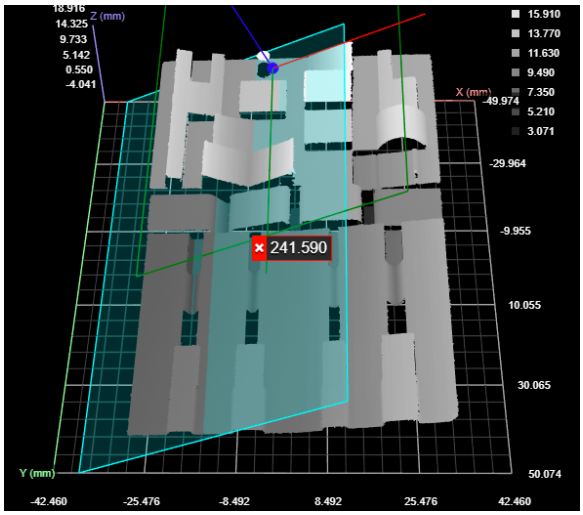
Transformed data



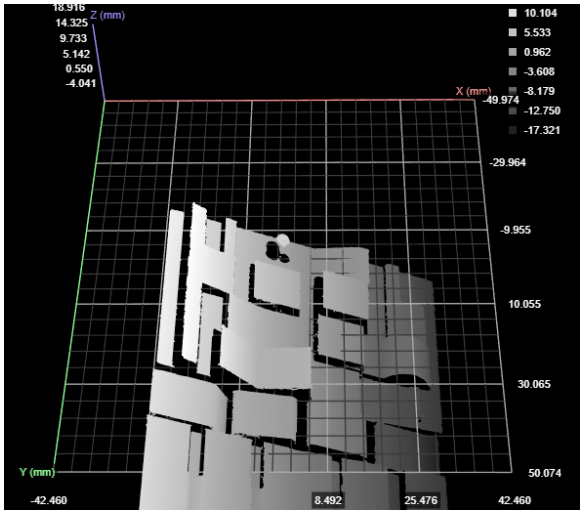
Plane + Point

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



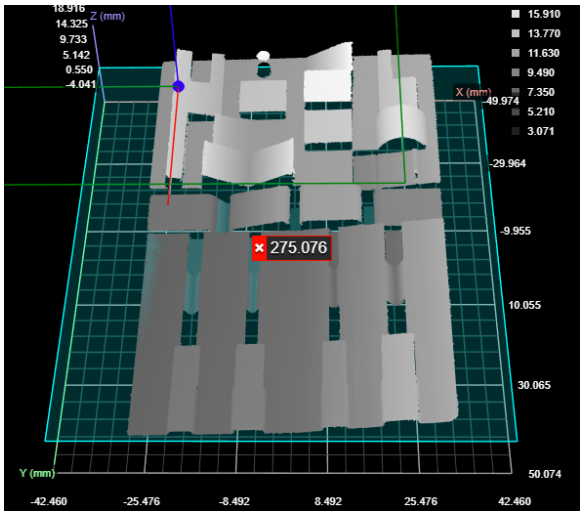
Transformed data



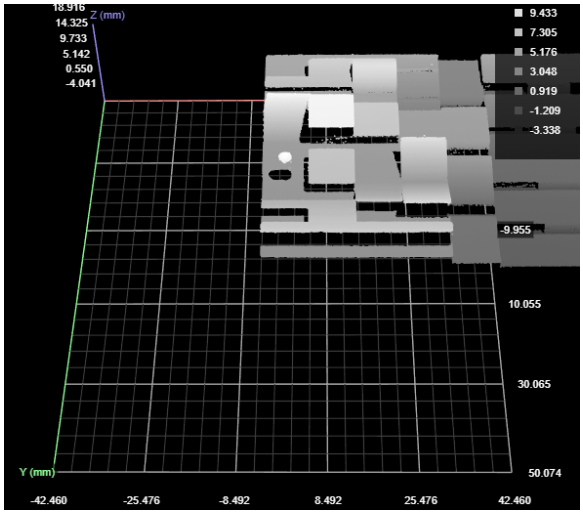
Line + Point

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



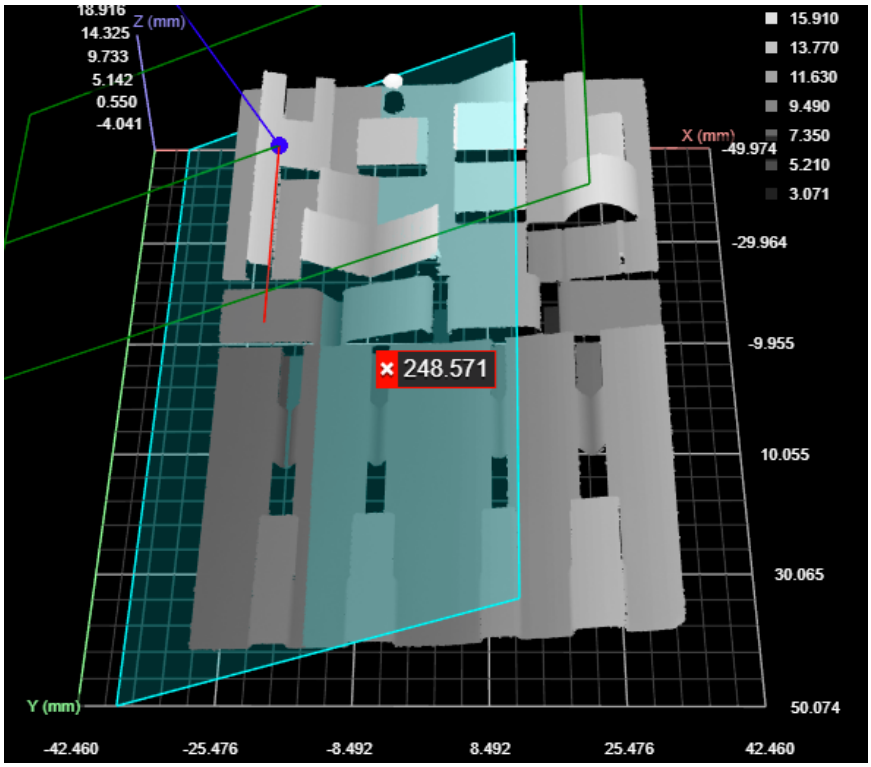
Transformed data



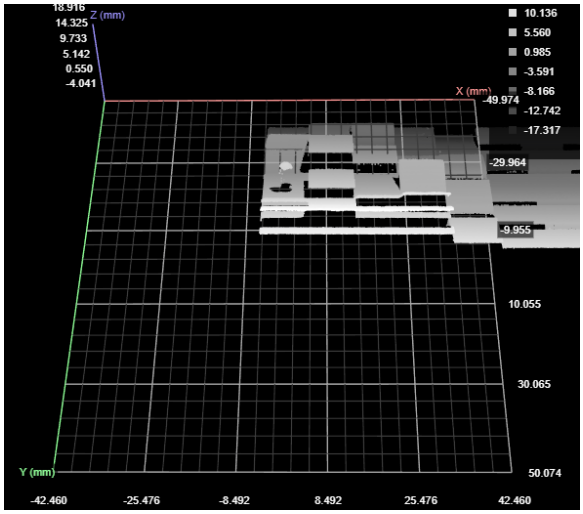
Plane + Line + Point

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



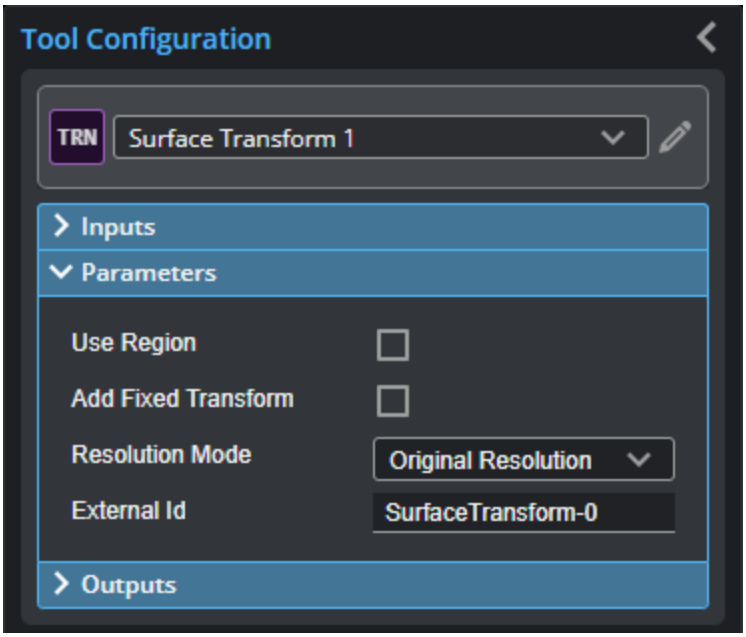
Transformed data



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Parameters

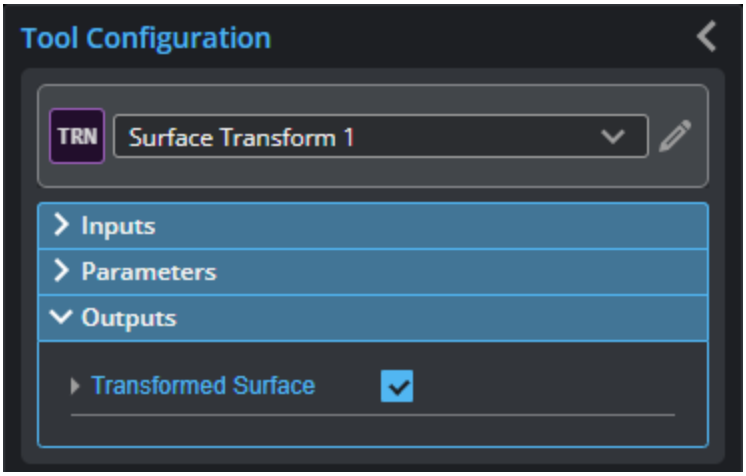
The following parameters are in the expandable **Parameters** section in the tool's configuration.



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 163.
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. 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	On G3 sensors, leave this set to the default **Original Resolution**.
Resolution Mode	

Outputs



Data

Type	Description
Transformed Surface	The transformed surface.

Surface Vibration Correction

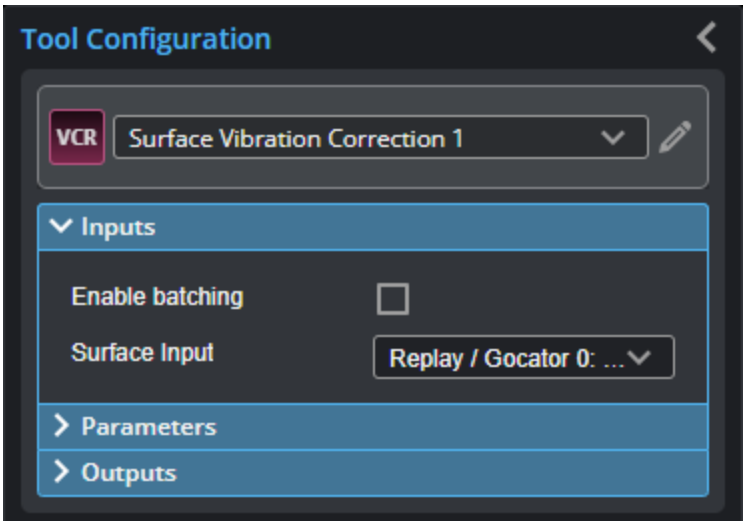
The Vibration Correction tool analyzes variation in surface data to remove high frequency noise in the data. The tool is useful for improving repeatability and accuracy of measurements when subtle vibrations in your transport system introduce height variations. The tool's intended use is to send corrected 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 153.

Inputs

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

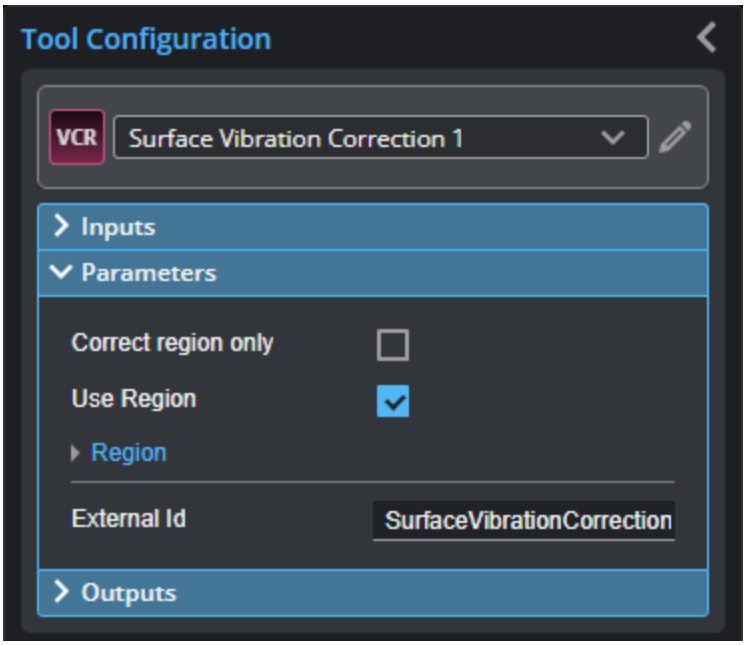


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Surface Input	The data the tool applies measurements to or processes.

Parameters

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

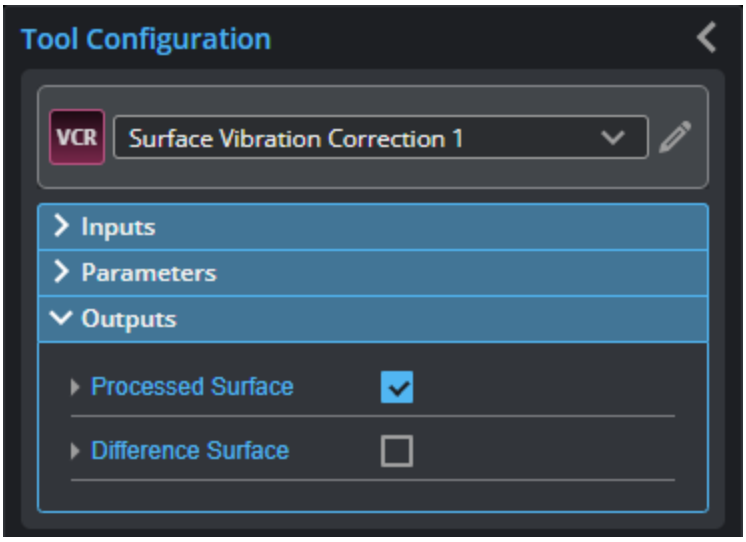


Parameters

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. When disabled, the tool applies correction to all of the scan data. 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. If **Correct Region Only** is enabled, the tool applies vibration correction *only* to the region. 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 666.

Outputs

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



Data

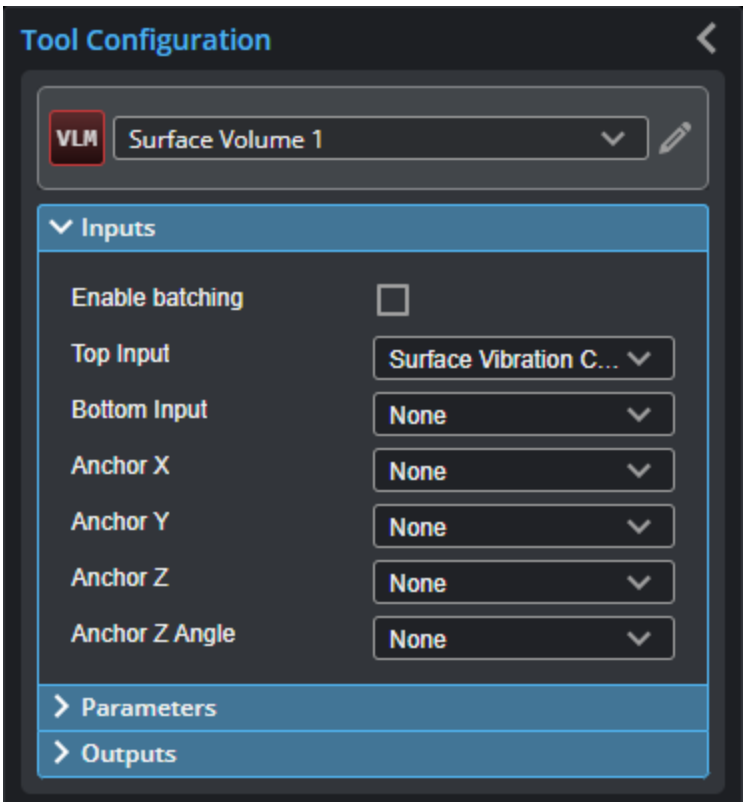
Type	Description
Processed Surface	Surface data corrected for vibration, available for use as input in other tools.
Difference Surface	Diagnostic Surface data showing the difference between the corrected surface and the original.

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 153.

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 176.

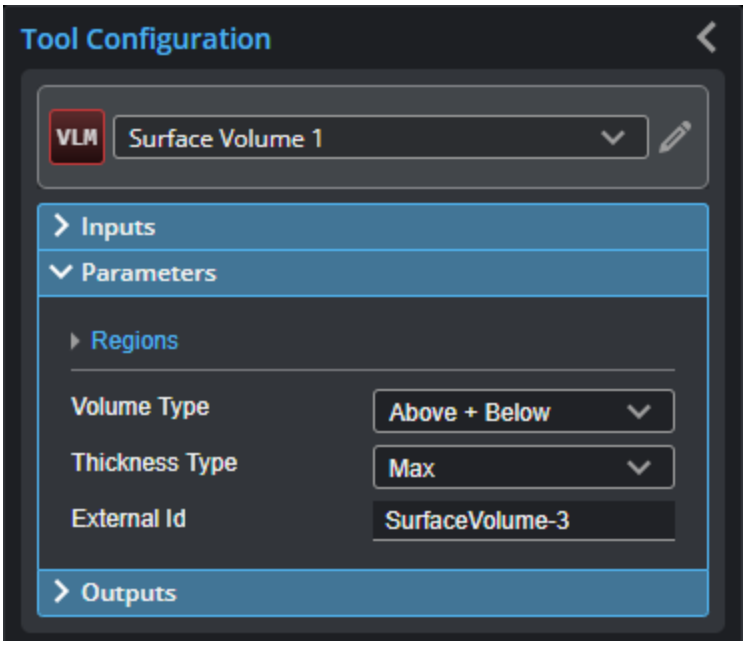
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each surface in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Top Input	The data the tool applies measurements to or processes.
Bottom Input	This tool can optionally take a second, bottom input. 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 Anchor Z	anchor. Positional anchors are optional.
Anchor Z Angle	The Z 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.



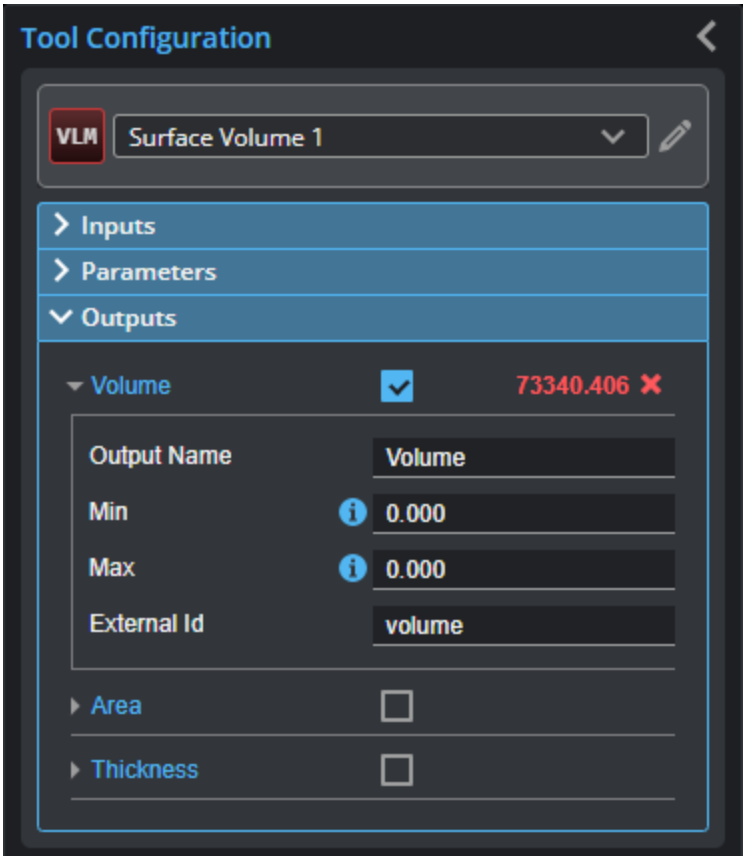
Parameters

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 Region Type 1 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 164. For general information on regions and the difference between standard and "flexible" regions, see *Regions* on page 163.
Volume Type	Used to compute different kinds of surface volumes. One of the following: • Above • Below • Above + Below (default) • Above - Below 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. Note that Above and Below can't be negative, but Above - Below can be negative if Below > Above.
Thickness Type *(Thickness measurement only)*	Determines which feature in the Surface data the tool uses to calculate thickness. One of the following: • Max • Min • Average • Median • Centroid 2D (height of the centroid in the XY plane) • 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 666.

Outputs

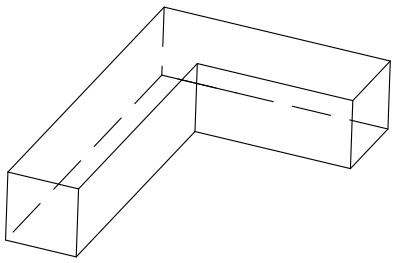
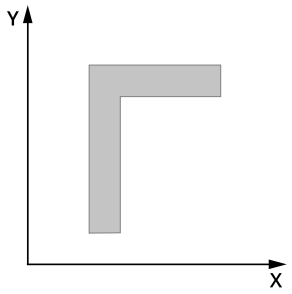
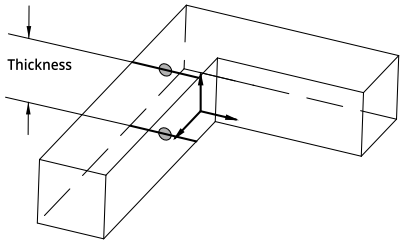
All tools provide measurements, geometric features, or data as outputs.



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 Measures volume in XYZ space.	
Area Measures area in the XY plane. 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 489 and *Surface Blob* on page 321.	
Thickness Measures thickness (height) of a part. 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 175. 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

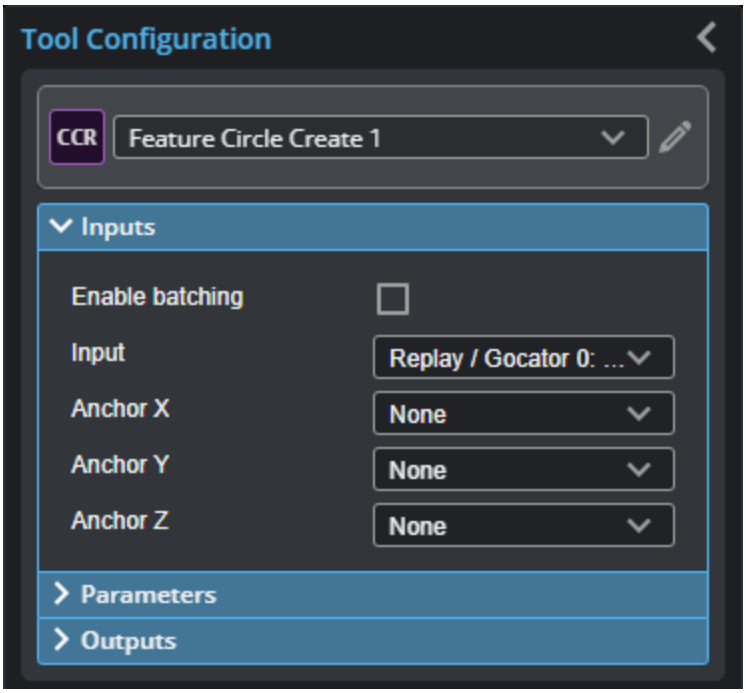
The Feature Circle Create tool lets you generate a Circle geometric features from geometric features generated by other tools. You can also generate a circle from an arbitrary position and radius. The following outputs are available (for more information, see *Output Types* on the next page):

- Constant circle
- Circle from points
- Circle from point and plane

For more information on geometric features, see *Geometric Features* on page 175.

Inputs

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

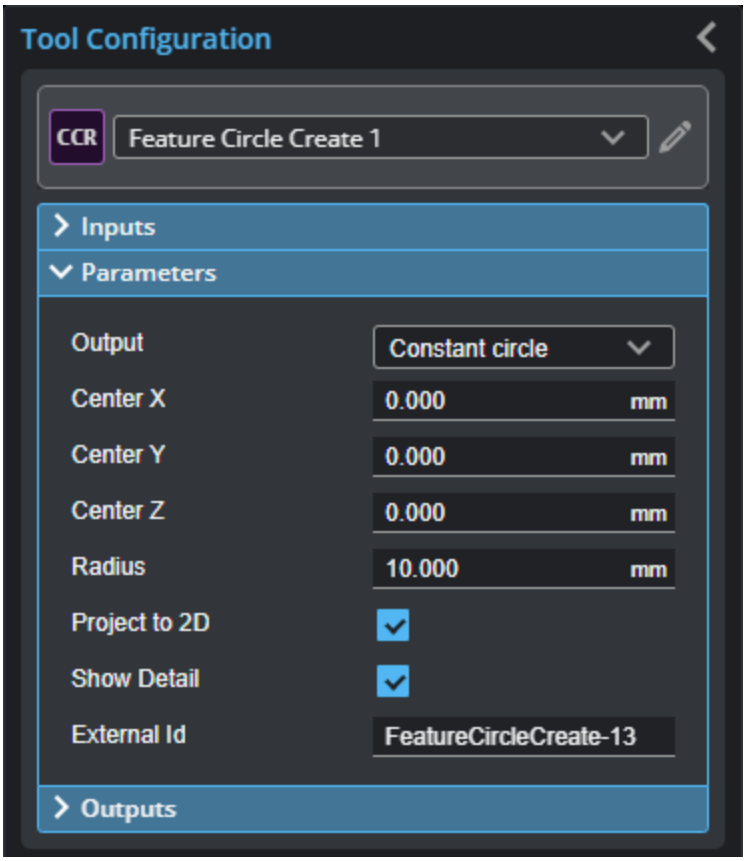


This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

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. 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. 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 666.

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.

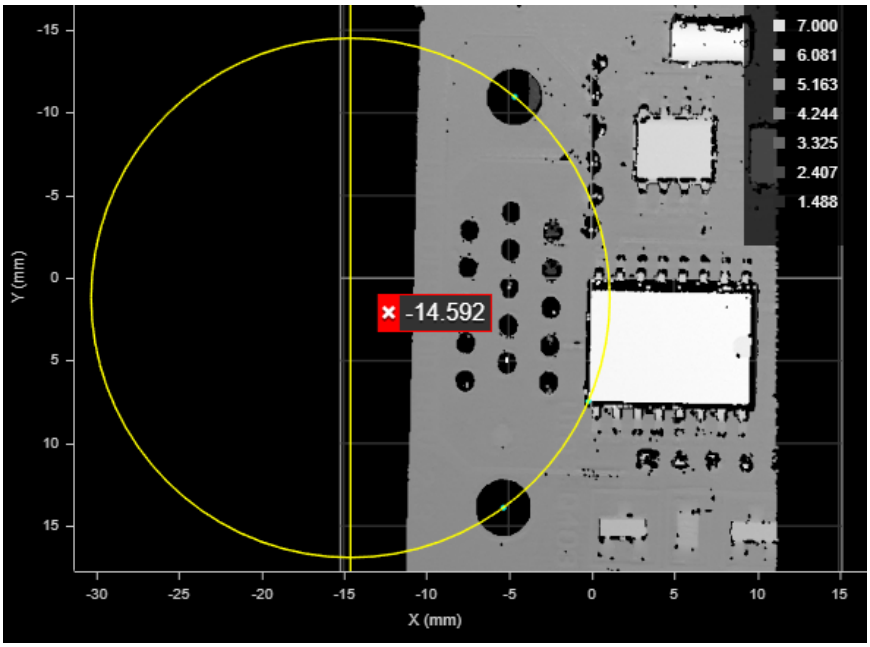
Constant Circle Output Type - Inputs and Parameters

Inputs	Type-Related Parameters
Input The Surface or Profile input.	**Center X**, **Center Y**, **Center Z** The X, Y, and Z position, respectively, of the center of the constant circle.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z offsets the tool will apply to the generated circle.	**Normal X**, **Normal Y**, **Normal Z** The X, Y, and Z for the normal vector. Only displayed when **Project To 2D** is disabled.
	Radius 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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z offsets the tool will apply to the generated circle.	
Point 1, **Point 2**, **Point 3** The three Point geometric features the tool uses as the center of the circle.	

Circle from point and plane

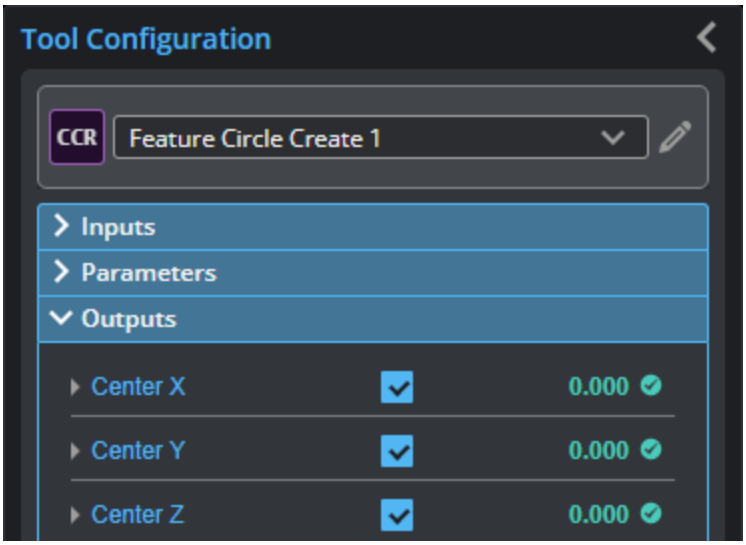
The **Circle from point and plane** output type generates a circle using Point and Plane geometric features and a user-defined radius. The circle is on the Plane received as input.

Circle from point and plane Output Type - Inputs and Parameters

Inputs	Type-Related Parameters
Input The Surface or Profile input.	**Radius** The radius of the circle.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z offsets the tool will apply to the generated circle.	
Point The Point geometric features the tool uses as the center of the circle.	
Plane The Point geometric features the tool uses as the center of the circle.	

Outputs

All 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 554.

Measurements

Measurement
Center X, **Center Y**, **Center Z** The X, Y, and Z positions of the center of the circle.
Radius The radius of the circle.
Z Offset The Z position of the intersection between the circle plane and the Z axis.
Distance The distance from the origin to the circle plane.
Normal X, **Normal Y**, **Normal Z** 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 554.

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 175.

Some examples:

- 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.

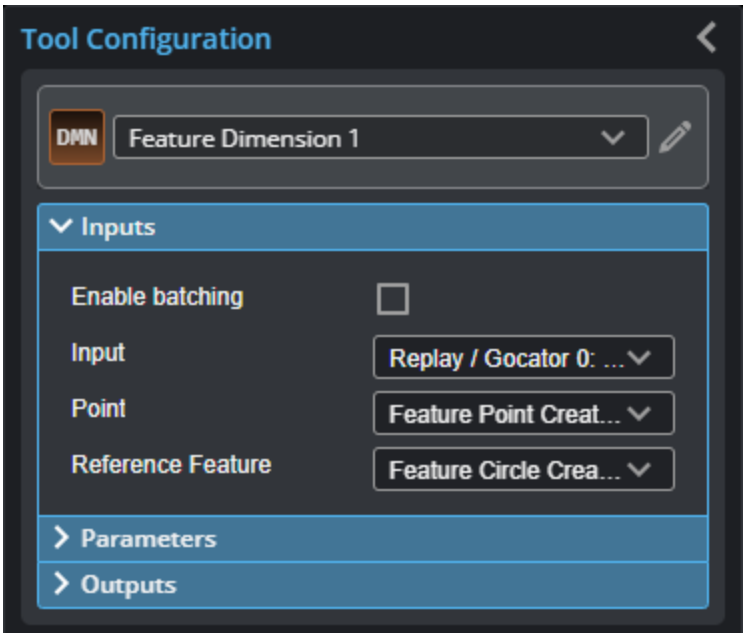
See *Adding a Tool* on page 130 for instructions on how to add measurement tools.

> 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.

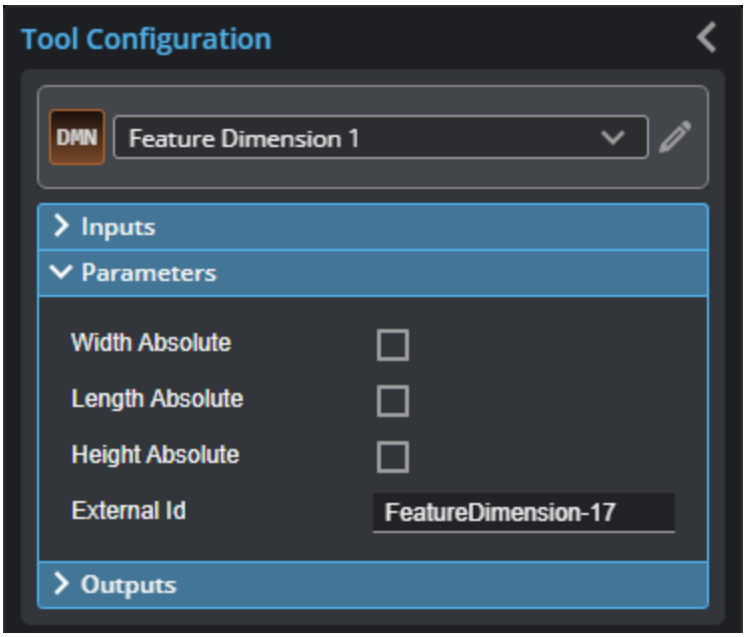


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.

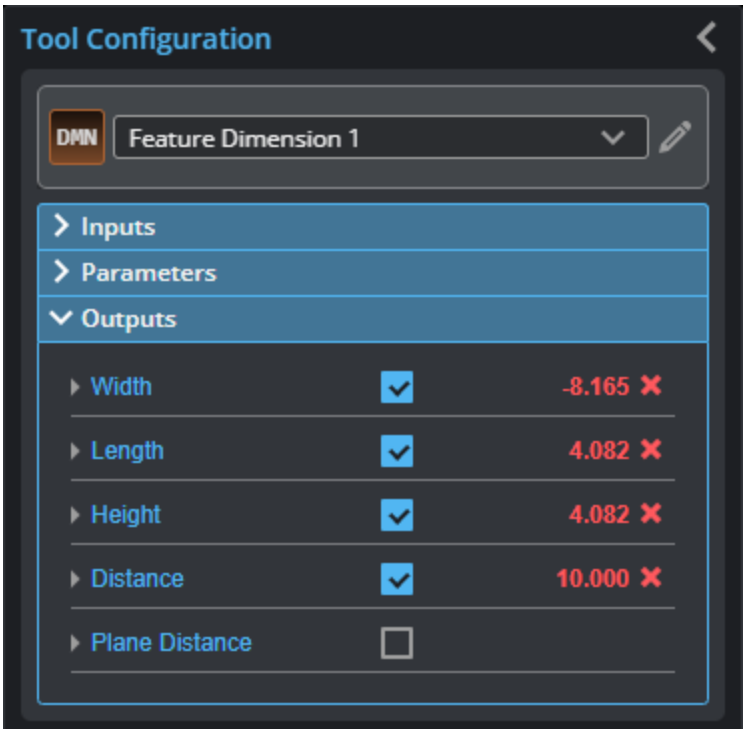


Parameters

Parameter	Description
Width Absolute Length Absolute 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 666.

Outputs

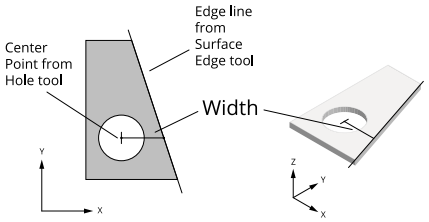
All tools provide measurements, geometric features, or data as outputs.

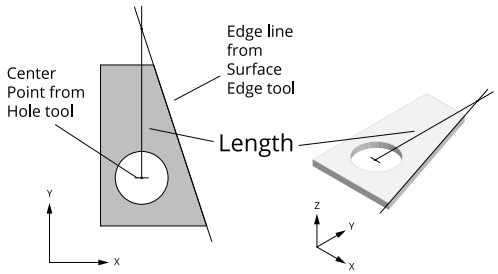
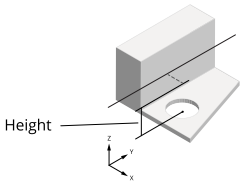
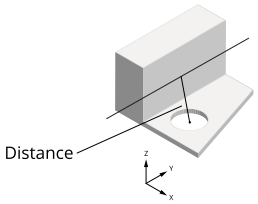
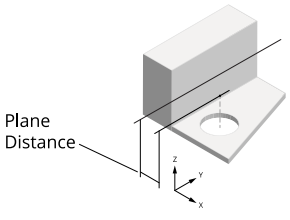


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 *Point-point*: The difference on the X axis between the points. *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. For surface data, the point on the line is at the same Y position. *Point-plane*: The difference on the X axis between a point and a point on the plane with the same Y and Z coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the X axis).	

Measurement	Illustration
Length *Point-point*: The difference on the Y axis between the points. *Point-line*: The difference on the Y axis between the point and, for profiles, the nearest point on the line; currently, always zero. For surface data, the point on the line is at the same X position as the first point. *Point-plane*: The difference on the Y axis between the point and a point on the plane with the same X and Z coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the Y axis).	
Height *Point-point*: The difference on the Z axis between the points. *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. For surface data, the point on the line is the one nearest to the first point. *Point-plane*: The difference on the Z axis between the point and a point on the plane with the same X and Y coordinates as the first point (or the intersection of the plane and a line from the first point, parallel to the Z axis).	
Distance *Point-point*: The direct, Euclidean distance between two point geometric features. *Point-line*: The direct, Euclidean distance between a point and the nearest point on the line. *Point-plane*: The direct, Euclidean distance between a point and the nearest point on the plane.	
Plane Distance *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). For surface data, the points are projected onto the XY plane. *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). For surface data, the distance is projected onto the XY plane.	

Measurement	Illustration
Point-plane: The distance between a point and a plane. For profiles, the distance is projected onto the XZ plane (always the same as the Distance measurement). For surface data, the distance is projected onto the XY plane.	

Feature Line Create

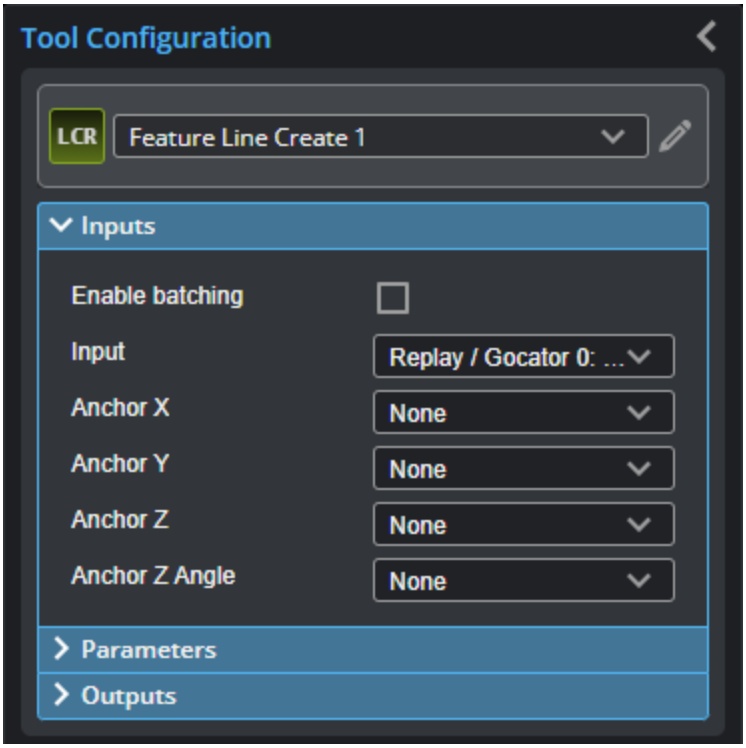
The Feature Line Create tool lets you generate a Line geometric features from geometric features generated by other tools. You can also generate a line from arbitrary positions you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- 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 175.

Inputs

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

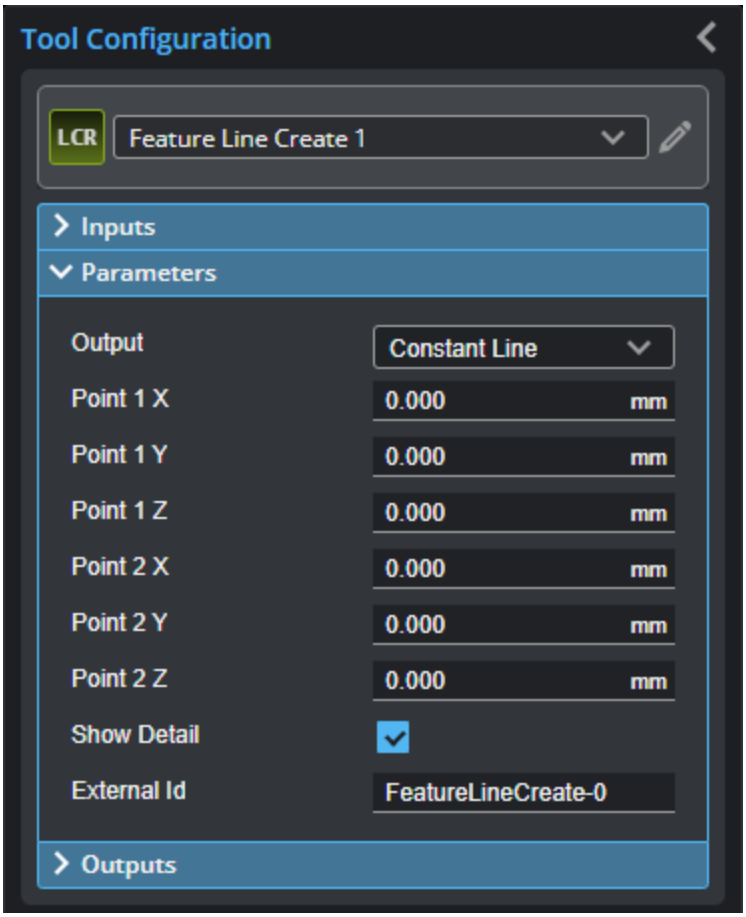


This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

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. 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 666.

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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Line The Line geometric feature the tool uses to create another Line geometric feature.	

Constant Line

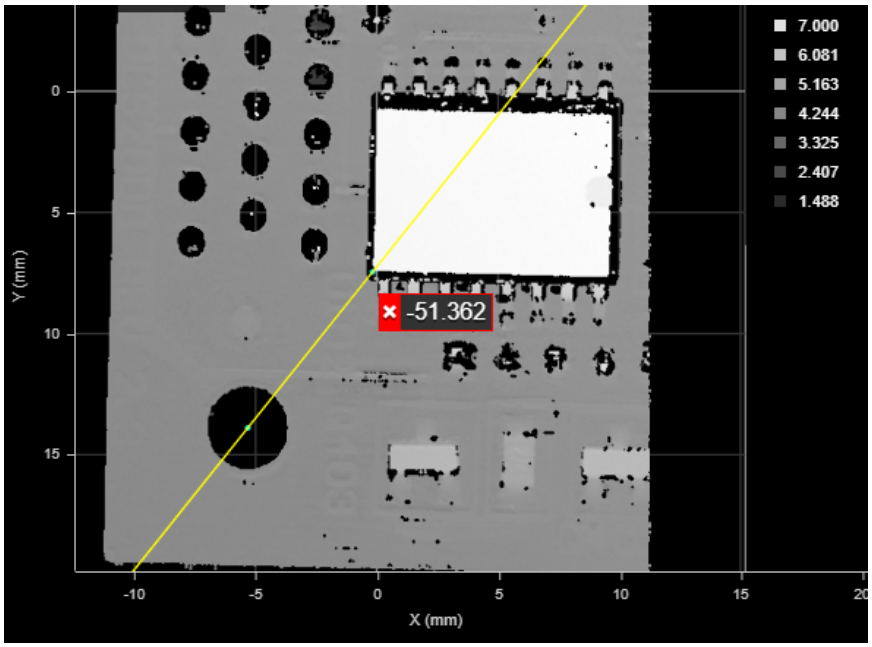
The **Constant line** output type displays parameters you can manually fill in to create a geometric feature. This output type is useful if the scan data from frame to frame is reliably fixed and you want to measure from an arbitrary line to another feature.

Line Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	**Point 1 X**, **Point 1 Y**, **Point 1 Z** The X, Y, and Z position, respectively, of the first end point of the constant line.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	**Point 2 X**, **Point 2 Y**, **Point 2 Z** The X, Y, and Z position, respectively, of the second end point of the constant line.

Line from Two Points

The **Line from two points** output type takes two Point geometric features as input.



A line between the center point of a hole and the corner of the chip.
(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 midpoint of the line. The X, Y, and Z Angle measurements return the angle of the line.

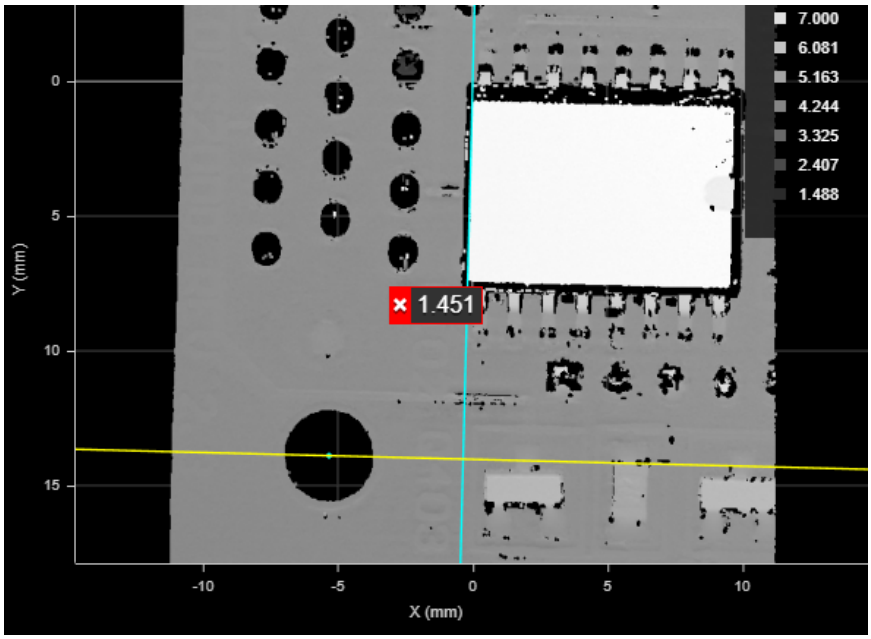
Line from two points Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Point 1, **Point 2** The two Point geometric features the tool uses as end points to create the line.	

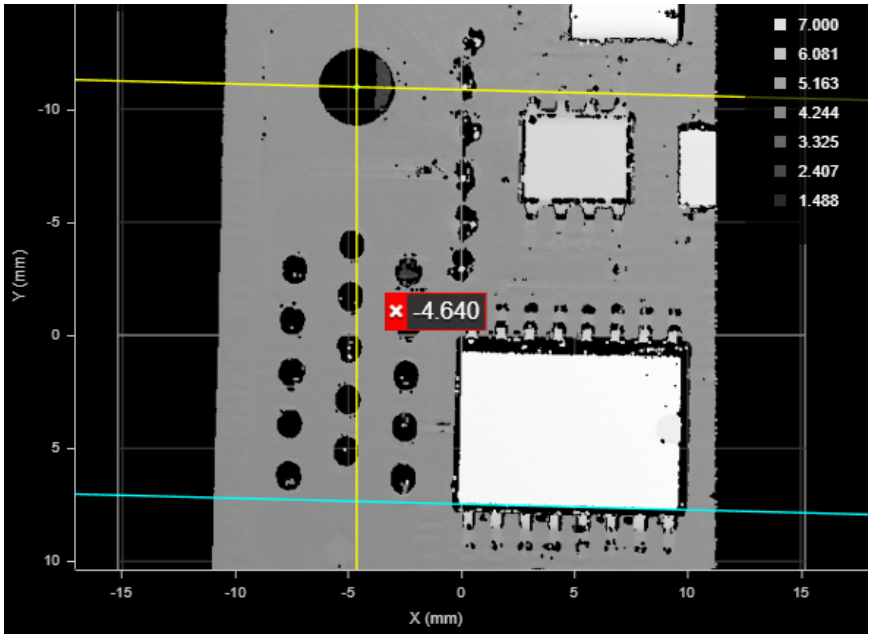
Perpendicular or Parallel Line from Point and Line

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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Point The Point geometric feature the tool uses to create the line.	
Line 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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Point The Point geometric feature the tool uses to create the line.	
Plane 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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Plane 1, **Plane 2** The two Plane geometric feature the tool uses to create the line.	

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 The Surface or Profile input.	**Projection Direction** One of the following: **Perpendicular to Plane** or **Along Z Axis**.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Line The Line geometric feature the tool uses to create the line.	
Plane The Plane geometric feature the tool uses to create the line.	

Bisect Projected Lines on Plane

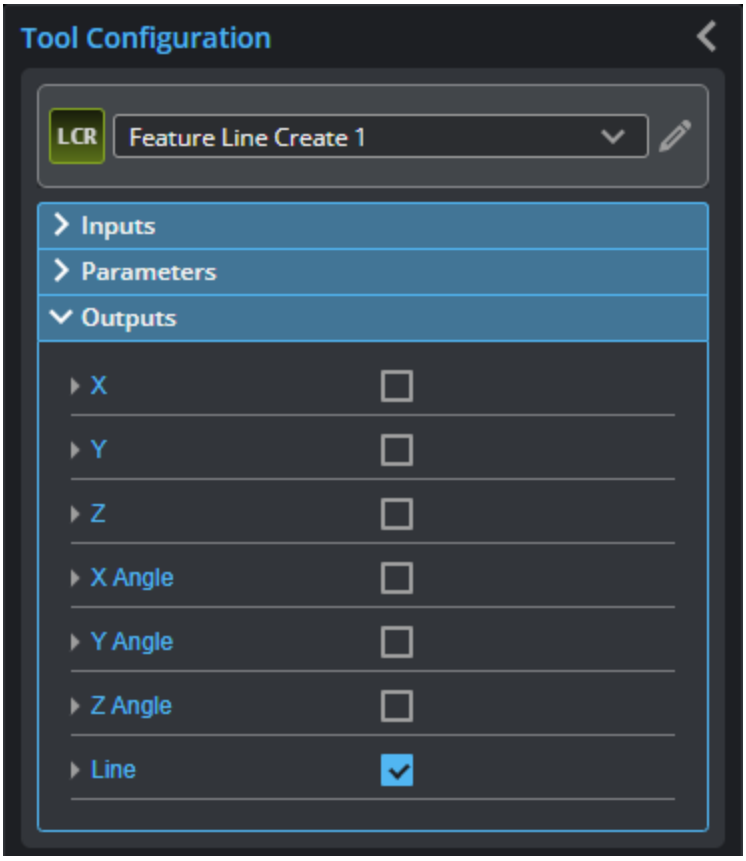
The **Bisect projected lines on plane** output type creates a Line and a Plane geometric feature as input and creates a line.

Bisect projected lines on plane Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z**, **Anchor Z Angle** The X, Y, and Z position measurements and the Z Angle measurement the tool uses as anchors.	
Line The Line geometric feature the tool uses to create the line.	
Plane The Plane geometric feature the tool uses to create the line.	

Outputs

All 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 564.

Measurements

Measurement
X, **Y**, **Z** 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** 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

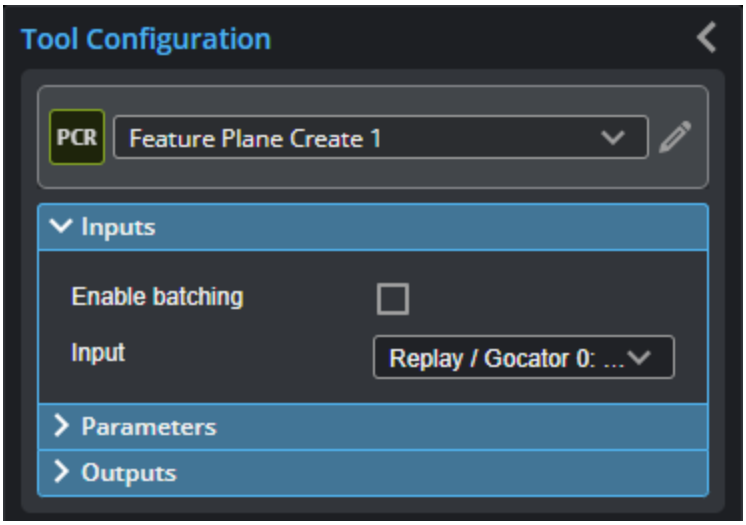
The Feature Plane Create tool lets you generate a Plane geometric features from geometric features generated by other tools. You can also generate a plane from arbitrary values you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- 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 175.

Inputs

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

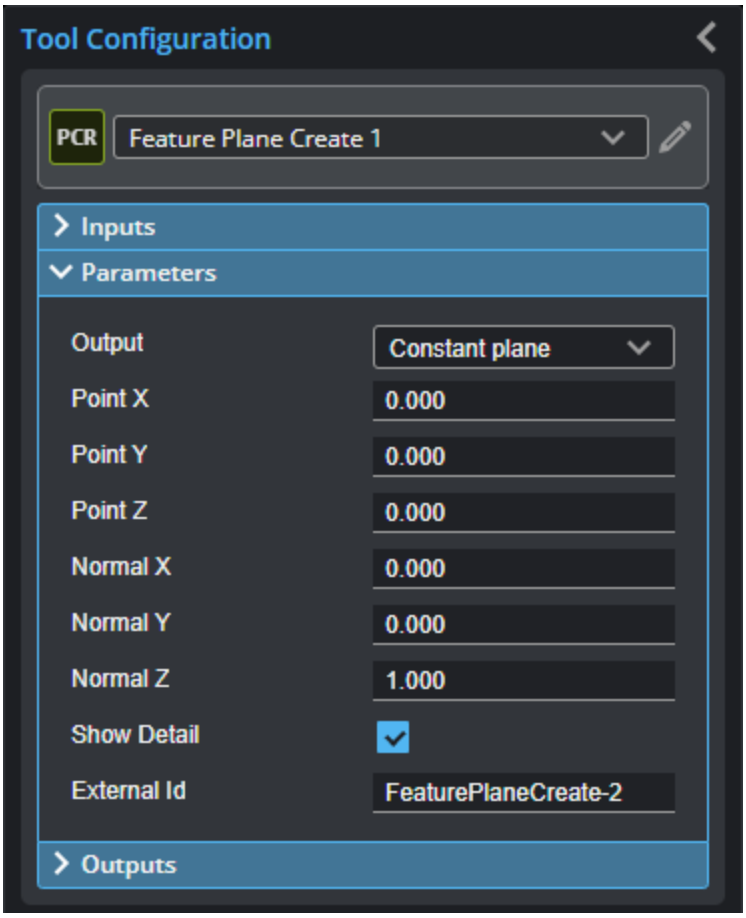


This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

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. 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 666.

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 The Surface or Profile input.	**Point X**, **Point Y**, **Point Z** The X, Y, and Z points that define the plane. **Normal X**, **Normal Y**, **Normal Z** 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 The Surface or Profile input. **Point** The Point geometric feature with which the plane intersects. **Line** 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 The Surface or Profile input. **Point** The Point geometric feature with which the plane intersects. **Line** 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 The Surface or Profile input.	None.
Point 1, **Point 2**, **Point 3** 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 The Surface or Profile input.	None.
Circle 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 The Surface or Profile input.	None.
Point The Point geometric feature with which the created plane intersects.	
Plane 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 The Surface or Profile input.	None.
Point 1, **Point 2** The Point geometric features with which the created plane intersects.	
Plane 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 The Surface or Profile input.	None.
Line The Line geometric feature that bisects the created plane.	
Plane 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

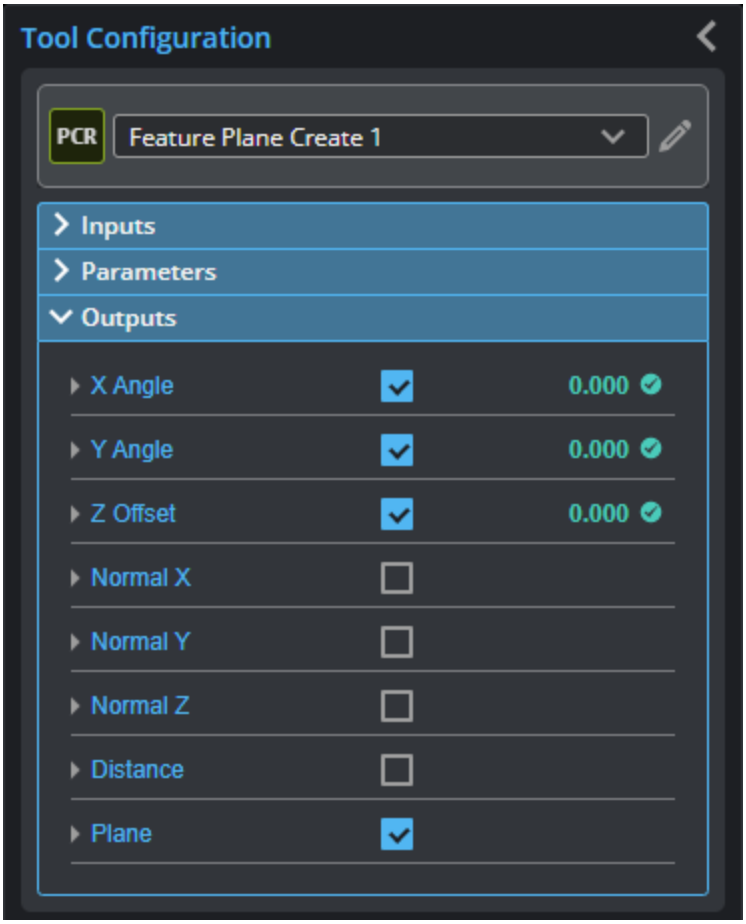
Inputs	Type-Related Parameters
Input The Surface or Profile input.	None.

Inputs	Type-Related Parameters
Plane 1, **Plane 2** The Plane geometric features the tool uses to create a bisecting plane	

See *Adding a Tool* on page 130 for instructions on how to add measurement tools.

Outputs

All 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 666.

For information specific to the different output types, see *Output Types* on page 573.

Measurements

Measurement
X Angle, **Y Angle** 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 The Z value of intersection of the plane and the Z axis.
Normal X, **Normal Y**, **Normal Z** The normal X, Y, and Z vectors of the plane.
Distance 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 573.

Feature Point Create

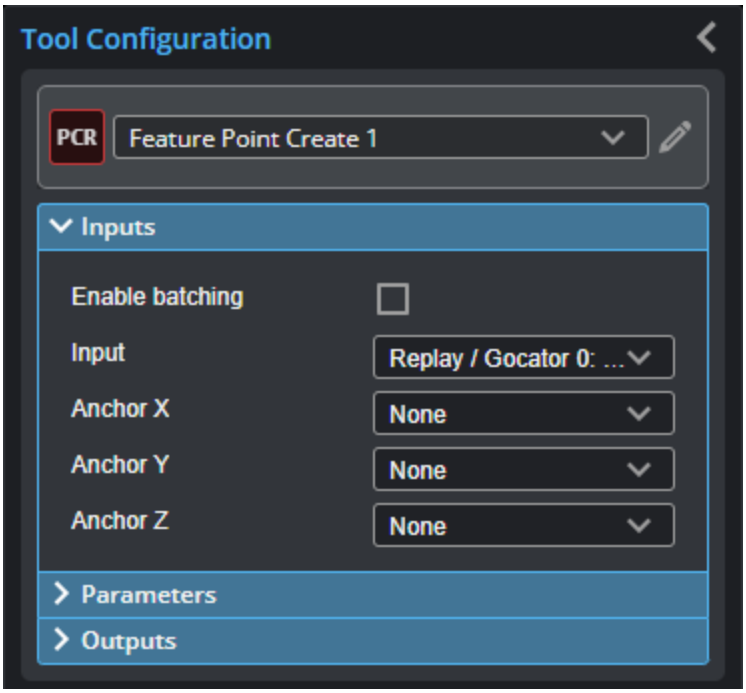
The Feature Point Create tool lets you generate a Point geometric features from geometric features generated by other tools. You can also generate a point from an arbitrary position you provide. The following outputs are available (for more information, see *Output Types* on the next page):

- 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 175.

Inputs

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

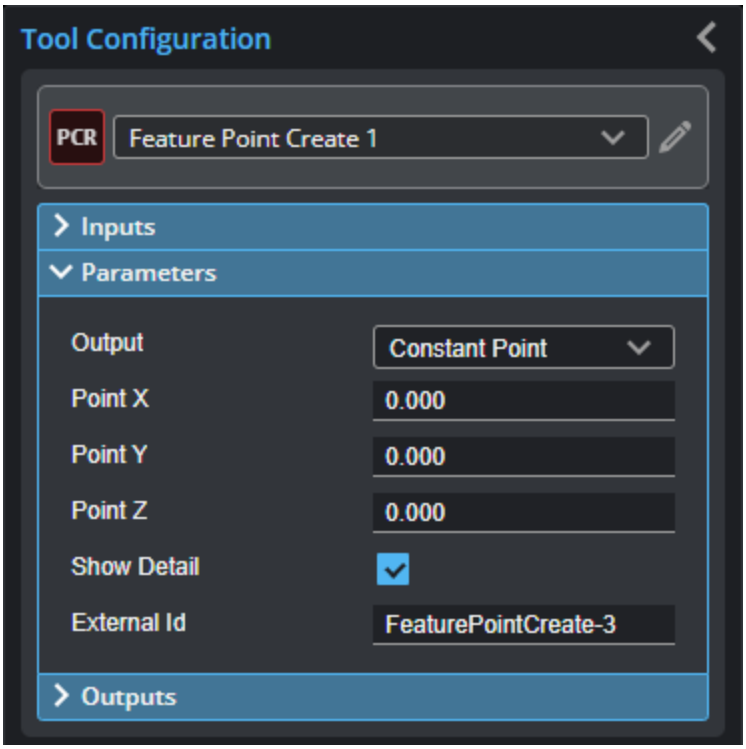


This tool can take an array as input. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

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. 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 666.

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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors.	
Point 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.

Line Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	**Point X**, **Point Y**, **Point Z** The X, Y, and Z position, respectively, of the first end point of the constant line.
Anchor X, **Anchor Y**, **Anchor Z** 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 to determine the line along which the generated point is offset, using the offset direction and distance you provide.

Point from Offset Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	**Offset Direction** The direction along the line running through the two input Point geometric features that the point is offset. One of two values: Forward or Backward. A Forward offset direction offsets the point along the line from moving from Point 1 to Point 2. A Backward offset direction offsets the point along the line moving from Point 2 to Point 1.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors.	
Point 1, **Point 2** The Point geometric features the tool uses to create	**Offset Distance**

Inputs	Parameters
another Point geometric feature.	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 The Surface or Profile input. **Anchor X**, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors. **Plane 1**, **Plane 2**, **Plane 3** 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 The Surface or Profile input. **Anchor X**, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors. **Line** The Line geometric feature the tool uses to generate the Point geometric feature. **Circle** The Circle geometric features the tool uses to generate	**Intersection Option** 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. **Upper**: The uppermost intersection point in the data visualizer. **Lower**: The lowermost intersection point in the data visualizer. **Middle**: The midpoint between the two intersection points.

Inputs	Parameters
the Point geometric feature.	

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 The Surface or Profile input.	**Angle Range** 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** The X, Y, and Z position measurements the tool uses as anchors.	
Line 1, **Line 2** 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 The Surface or Profile input.	**Angle Range** The range returned by the Angle measurement. One of the following: "-180 to 180" or "0 to 360".
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors.	
Line The Line geometric features the tool uses to generate the Point geometric feature.	
Plane The Plane geometric features the tool uses to generate 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 The Surface or Profile input.	None.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors.	
Point The Point geometric features the tool uses to generate the Point geometric feature.	
Line The Line geometric features the tool uses to generate the Point geometric feature.	

Projected Point on Plane

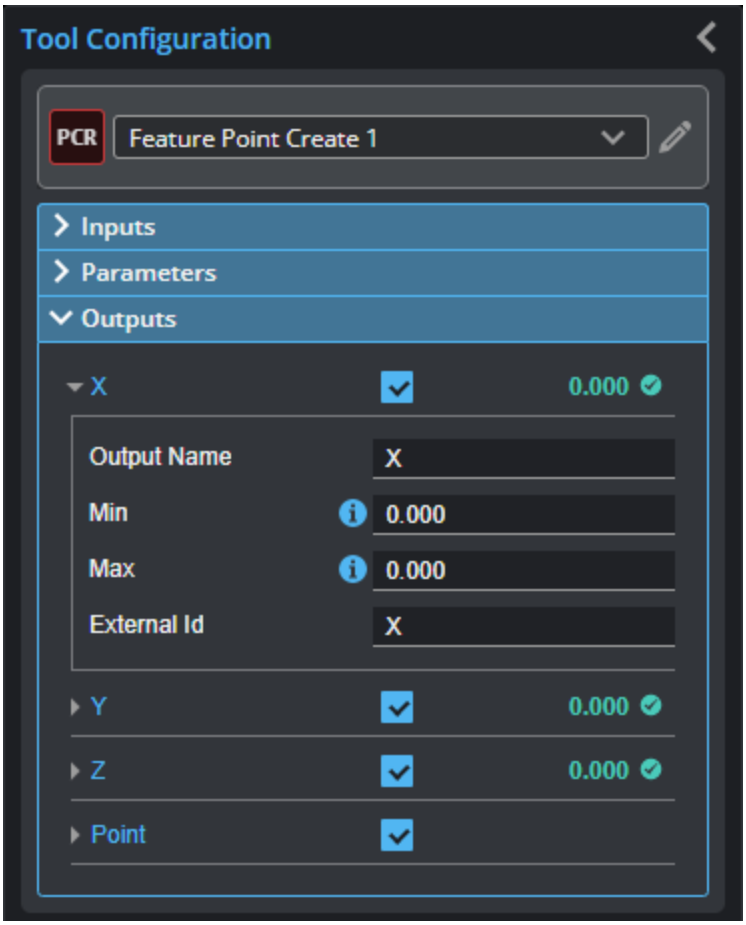
The **Projected point on plane** output type takes a Point and a Plane geometric feature as input and generates a Point geometric feature.

Projected Point on Plane Output Type - Inputs and Parameters

Inputs	Parameters
Input The Surface or Profile input.	**Projection Direction** The direction of the projection. One of the following: Perpendicular to Plane or Along Z Axis.
Anchor X, **Anchor Y**, **Anchor Z** The X, Y, and Z position measurements the tool uses as anchors.	
Point The Point geometric features the tool uses to generate the Point geometric feature.	
Plane The Plane geometric features the tool uses to generate the Point geometric feature.	

Outputs

All 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 580.

Measurements

Measurement
X, **Y**, **Z** The X, Y, and Z positions of the Point geometric feature. For more information, see the sections above.
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's positional measurements are particularly useful as anchor sources. For example, you can easily find a corner point on a part from two edges (produced by two Surface Edge tools) and using the X and Y positions as anchor sources.

When you use these positional anchors in combination with a Z Angle anchor from tools such as Surface Edge, you can achieve extremely robust, repeatable measurements.

For more information on anchoring, see *Measurement Anchoring* on page 176.

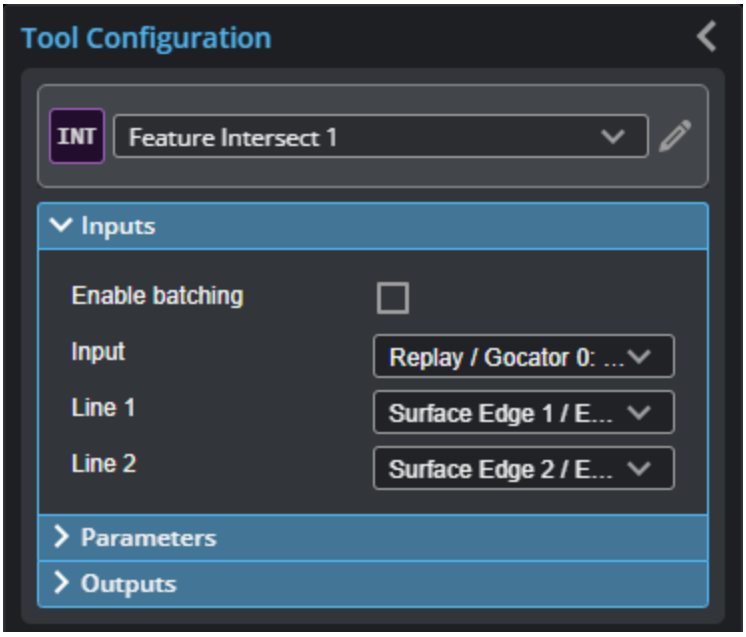
The Feature Intersect tool can also generate a point geometric feature representing the point of intersection of the lines that the Feature Dimension tool can use in measurements.

See *Adding a Tool* on page 130 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.

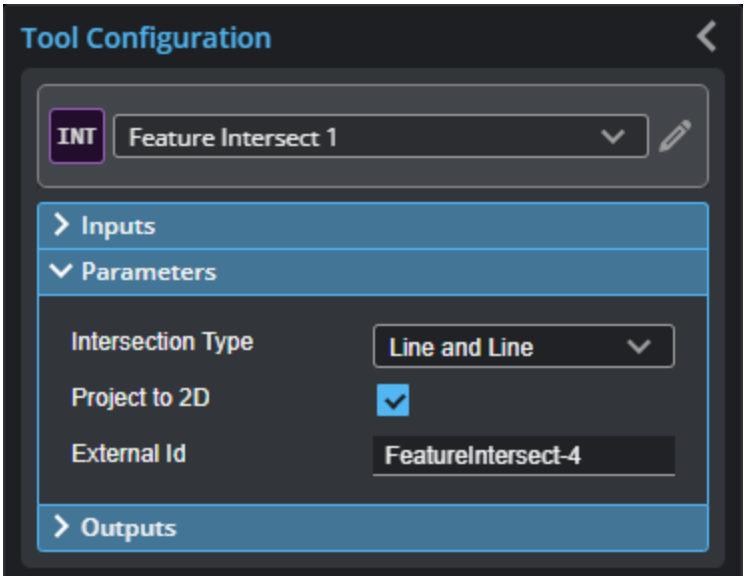


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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

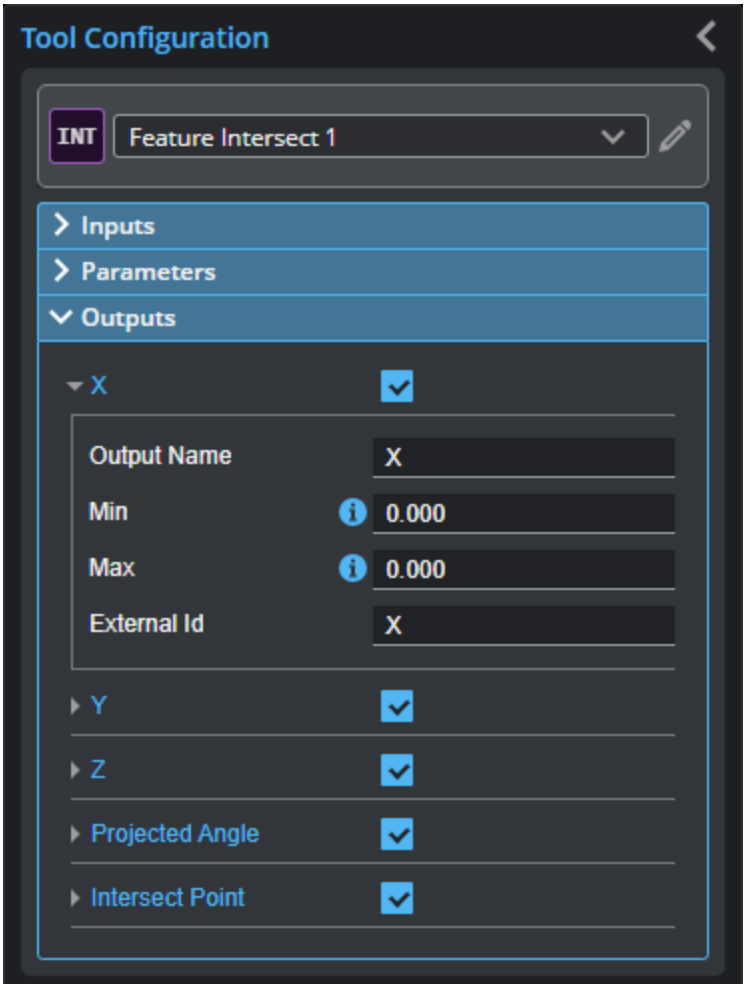
You configure the tool's parameters in the expandable **Parameters** section.



Parameters

Parameter	Description
Intersection Type	One of the following: • Line and Line • Line and Plane • Plane and Plane 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 666.

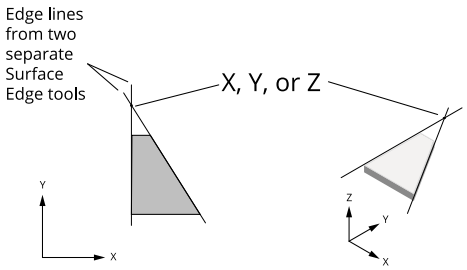
Outputs

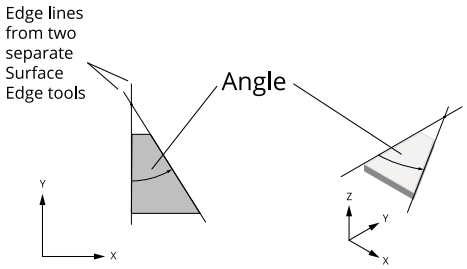
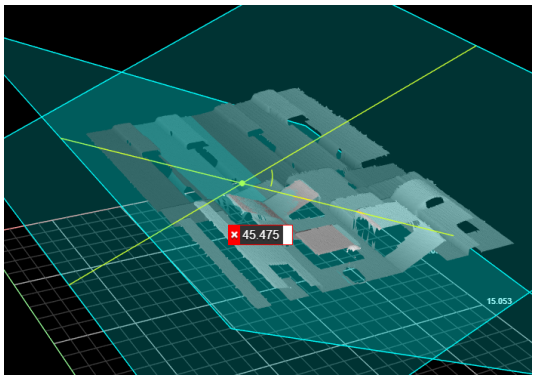


Outputs section with a measurement expanded to show user-configurable decision min/max fields and an external ID

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 *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	

Measurement	Illustration
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.	
Z *Line-Line*: The Z position of the intersect point between the lines. *Line-Plane*: The Z position of the intersect point between the line and the plane. *Plane-Plane*: The Z position of the center of the line intersecting the planes.	
Angle or **Projected Angle** (*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. *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**. *Plane-Plane*:The angle between the two planes, as measured from the plane geometric features selected in **Feature 1** and **Feature 2**.	 In the following image, the angle is measured between two planes (the small angled surfaces facing each other in the center of the image). 

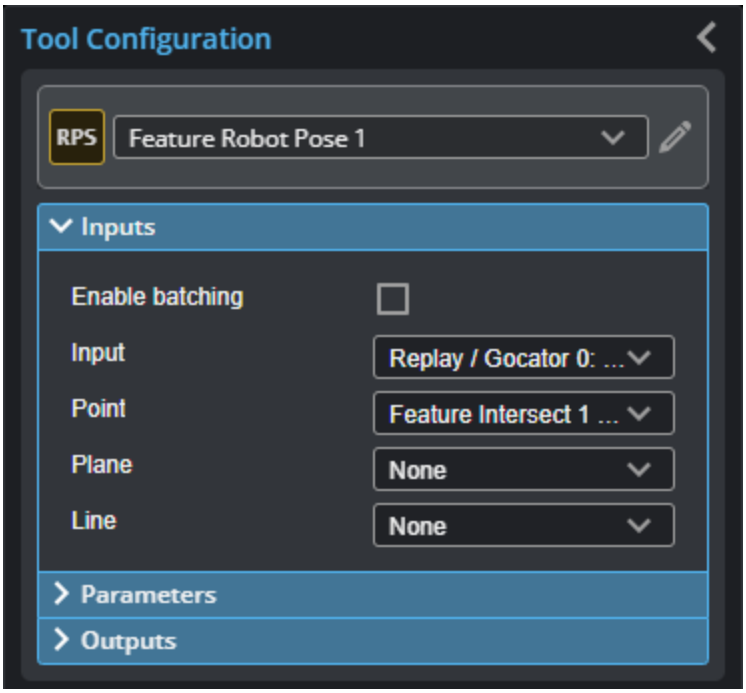
Features

Type	Description
Intersect Point	The intersect point of the two features.
Intersect Line	The line representing the intersection of two planes.

Feature Robot Pose

The Feature Robot Pose tool takes geometric features as input and outputs positional and rotational values. You can use these values in a robot system to control the robot. If you are using a Universal Robots robot in your system and have calibrated the robot with LMI's Gocator URCap plugin, you can use the plugin's Receive node to retrieve these values to quickly and easily get the pose of a part. The URCap can then use the pose to move the robot to the position of the part, to pick up the part, for example.

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 176.

Inputs

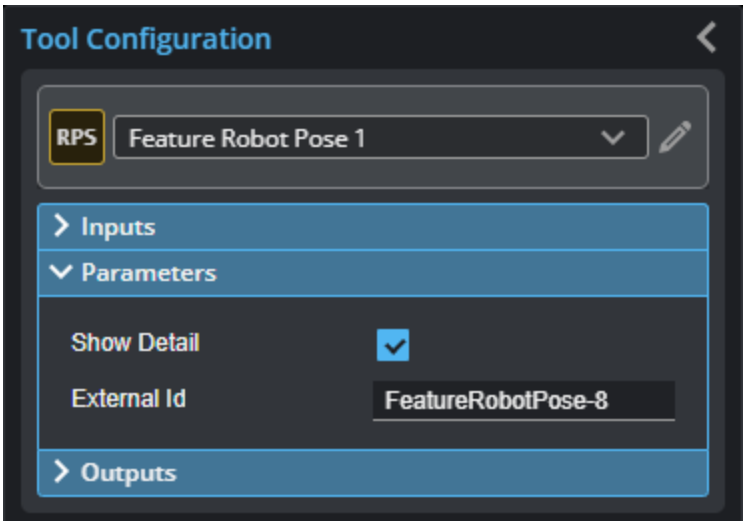
Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Input	The data the tool applies measurements to or processes.
Point	The Point geometric feature the tool extracts the X, Y, and Z measurements from. This input is required.
Plane	The Plane geometric feature the tool extracts the Roll and Pitch measurements from. This input is optional. If you omit it, the tools uses the XY plane for calculations.

Name	Description
Line	The Line geometric feature the tool extracts the Yaw measurement from. This input is optional. If you omit it, the tool uses the X axis for calculations.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Parameters

The following parameters are in the expandable **Parameters** section in the tool's configuration.

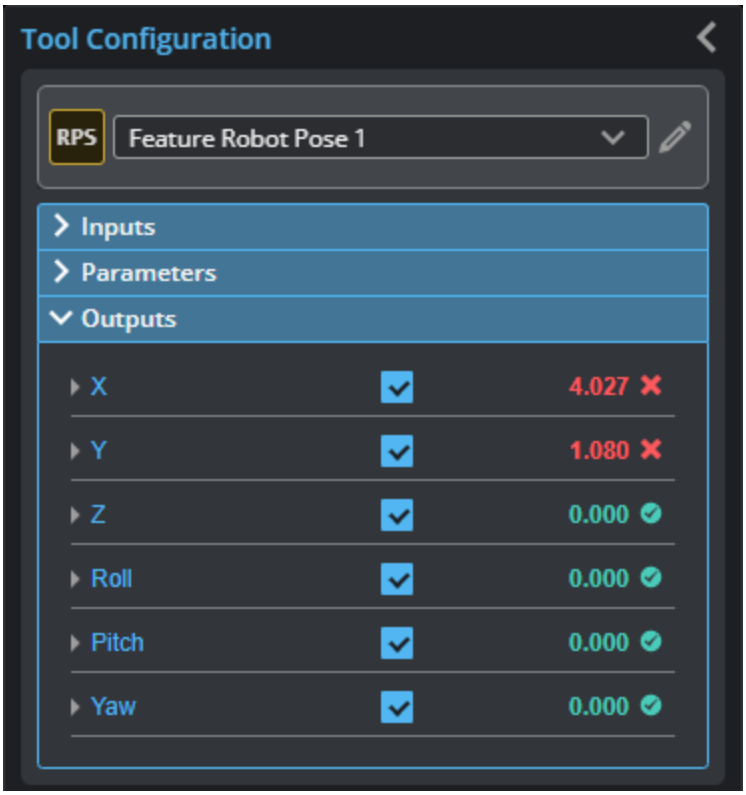


Parameters

Parameter	Description
Show Detail	Toggles the display of additional visualizations 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 666.

Outputs

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



Measurements

Measurement	Illustration
X, **Y**, **Z** The X, Y, and Z positions of the Point geometric feature.	
Roll, **Pitch**, **Yaw** The rotational angles of the Plane and Line geometric feature.	

Array Tools

Array tools let you create arrays from individual pieces of scan data (such as profiles or surfaces), or extract data from an array.

> Arrays can contain any type of data supported in GoPxL. For more information on this and on arrays in general, see *Arrays, Batching, and Aggregation* on page 155.

Two Array tools are available:

- Array Index: Takes an *array* of data (a group of data messages) as input and extracts a *single* piece of data at the user-provided index. You can then perform measurements on the individual profile or surface, 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 G5 sensor into individual profiles or surfaces.

  For more information on this tool, see *Array Index* on page 596.

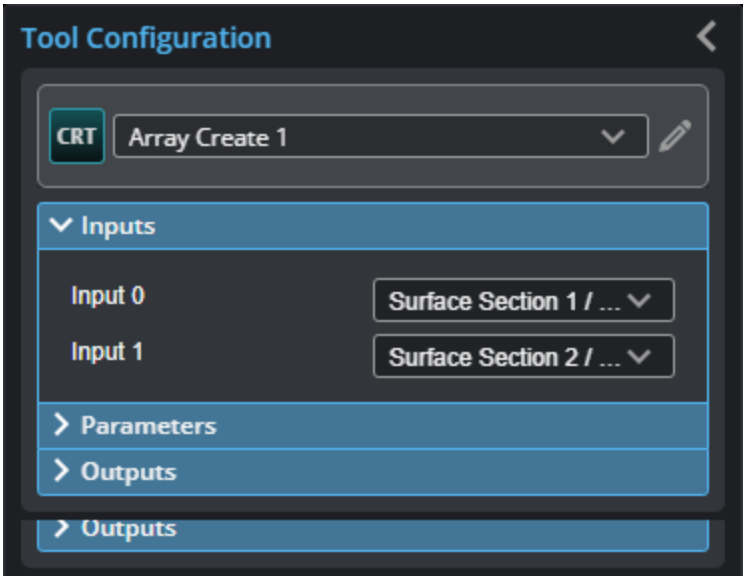
- Array Create: Takes one or more *individual* pieces of data (that is, *not* array data), created by other tools or separate sensors, as input and then creates an array containing those pieces of data as elements. For more information on this tool, see *Array Create* on the next page.

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 155.

For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs

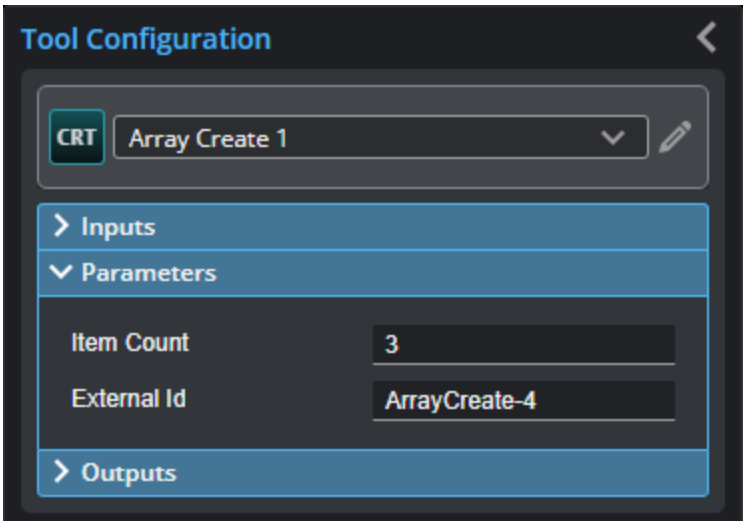


Inputs

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

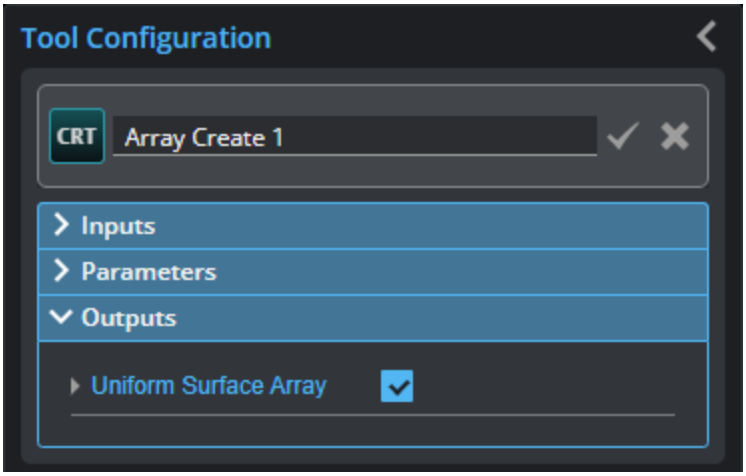
The following parameters are in the expandable **Parameters** section in the tool's configuration.



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 666.

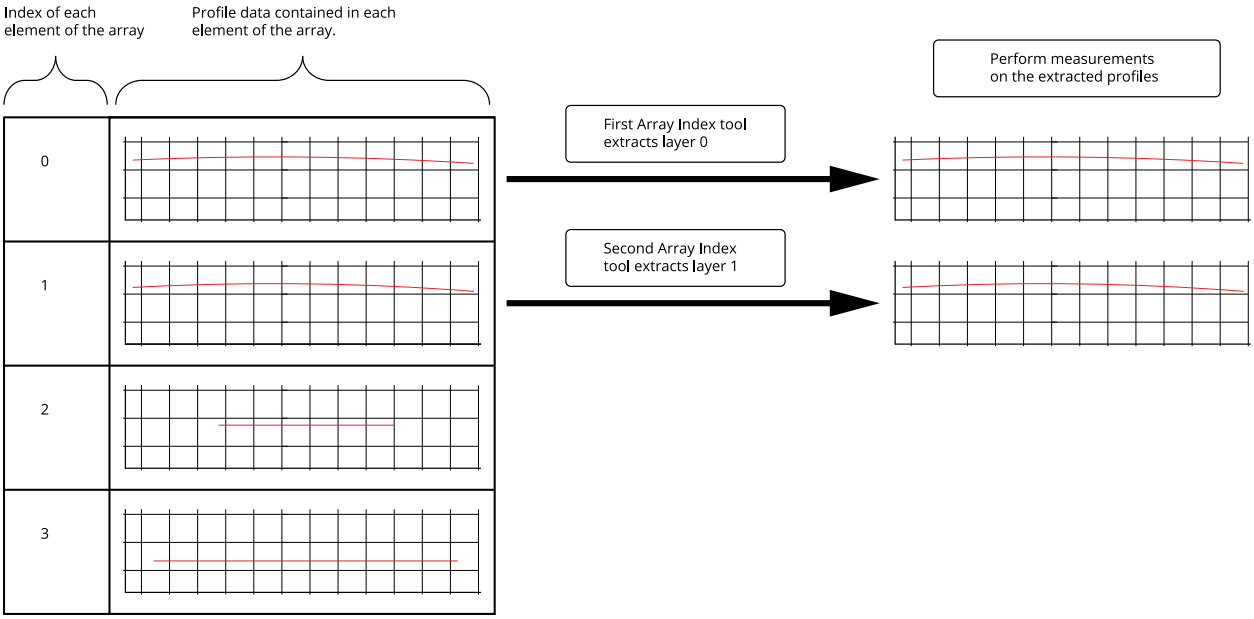
Outputs



The type of the output depends on the type of the inputs.

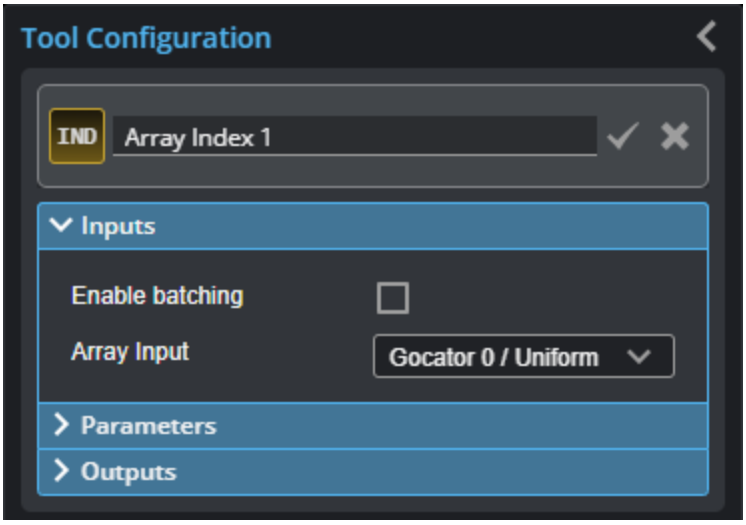
Array Index

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.



For information on adding, managing, and removing tools, as well as detailed descriptions of settings common to most tools, see *Tool Configuration* on page 153.

Inputs



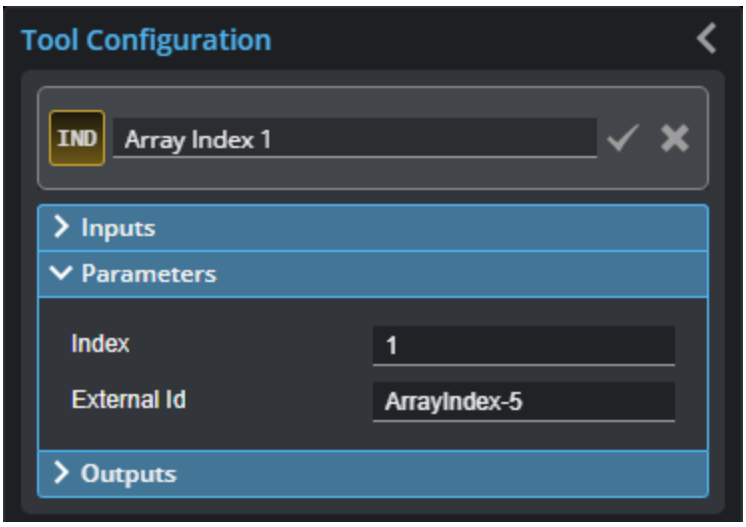
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually. For more information on arrays, batching, and aggregating, see *Arrays, Batching,*

Name	Description
	and Aggregation on page 155.
Array Input	The data the tool applies measurements to or processes.

Parameters

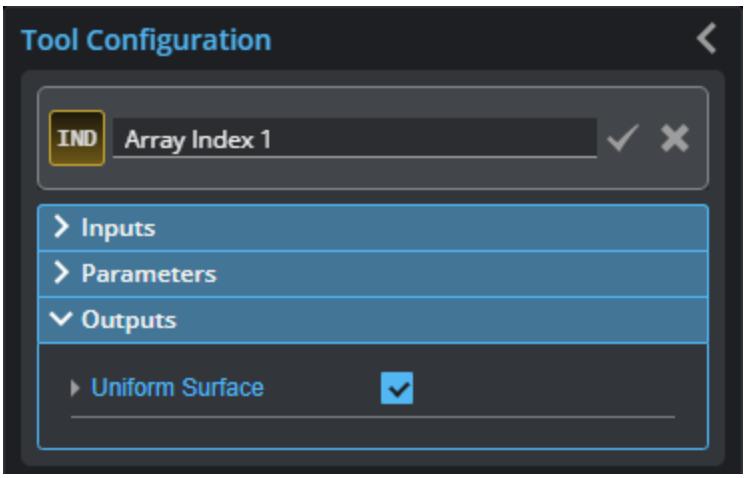
The following parameters are in the expandable **Parameters** section in the tool's configuration.



Parameters

Parameter	Description
Index	The position (the index) in the array at which the tool extracts and outputs.
External ID	The external ID of the tool that appears in GoHMI Designer. For more information, see *GoHMI and GoHMI Designer* on page 666.

Outputs



The type of the output depends on the type of the input array.

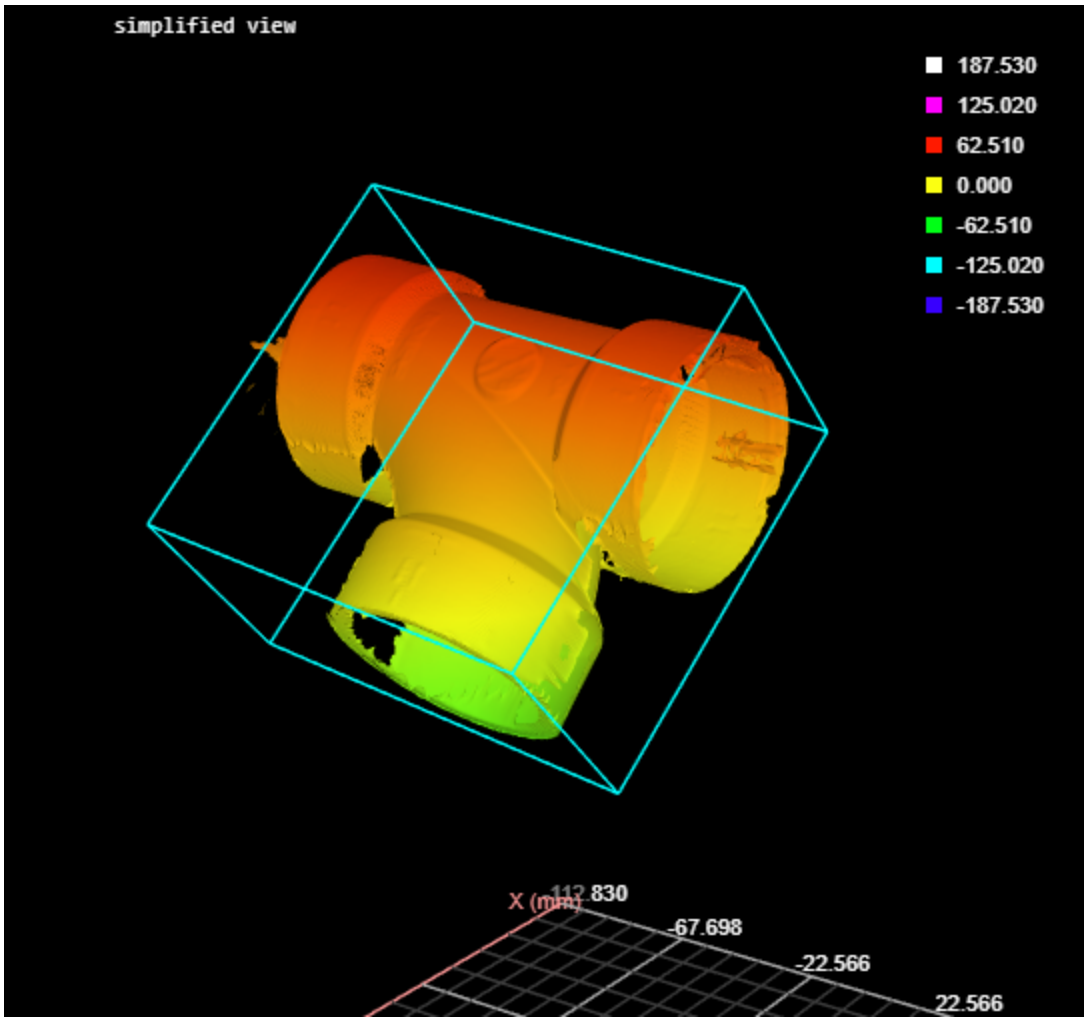
Mesh Measurement

The Mesh tools are only intended for use with G2 sensors.

Mesh Bounding Box

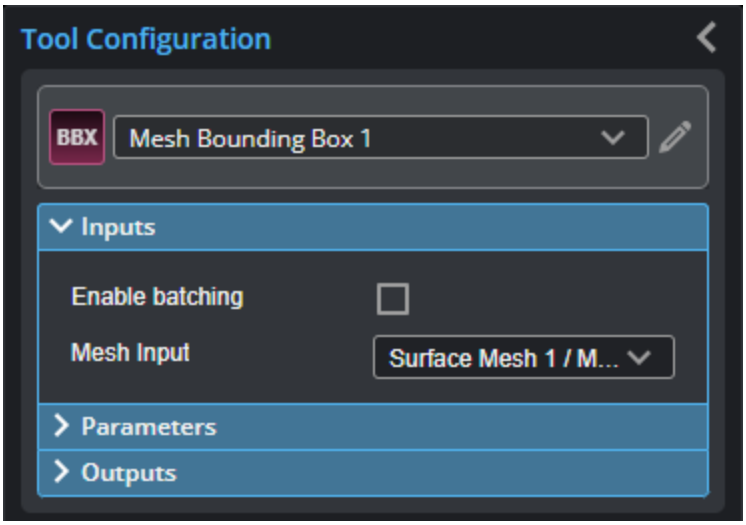
This tool is *only* intended for use with G2 sensors.

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.

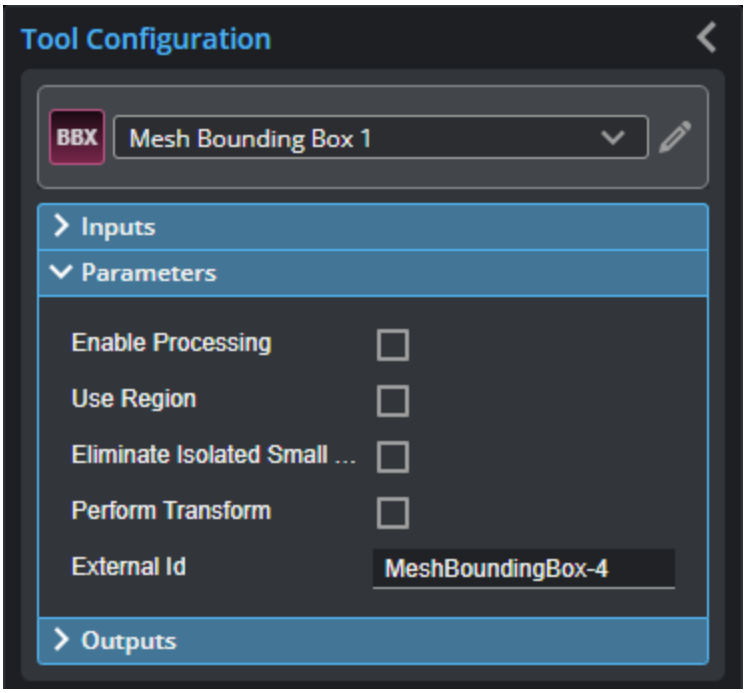


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each mesh in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Mesh Input	The data the tool applies measurements to or processes.

Parameters

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

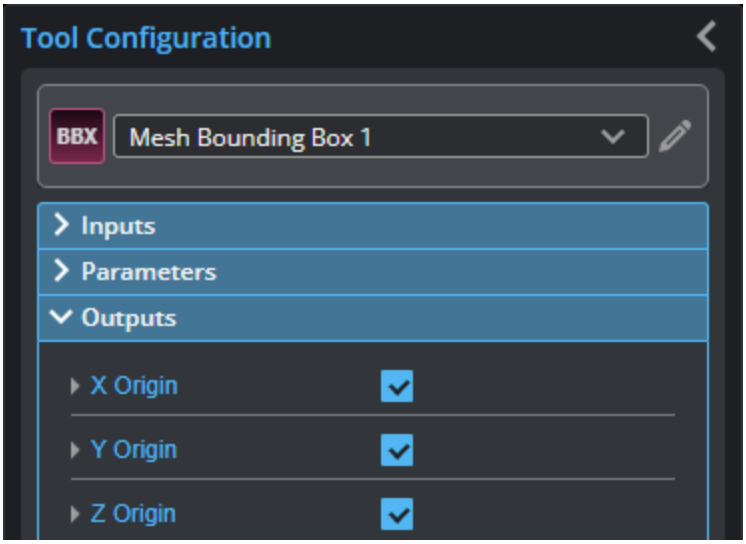


Parameters

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 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. **Transform Mode** is one of the following: • Minimal Alignment: The closest coordinate axes are arranged for alignment. • X > Y > Z Order • X > Z > Y Order • Y > X > Z Order • Y > Z > X Order • Z > X > Y Order • 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 666.

Outputs

All 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 666.

Measurements

Measurement
X Origin **Y Origin** **Z Origin** These measurements return the X, Y, and Z position of the center of the fitted bounding box, respectively.
X Angle **Y Angle** **Z Angle** The angle of the fitted bounding box around the X, Y, and Z axis, respectively.
Width **Length** **Height** 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 175.

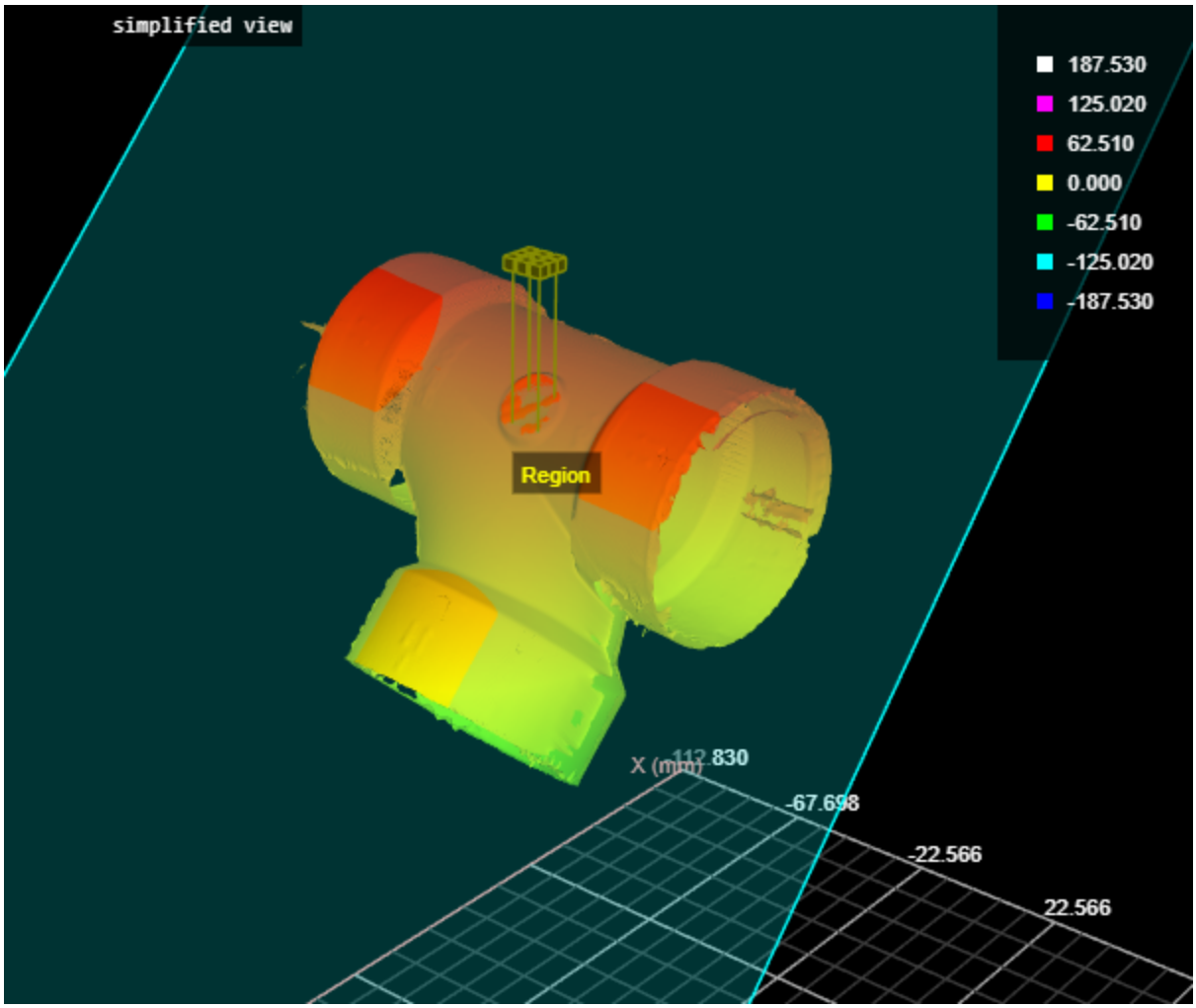
Data

Type	Description
Mesh	The Mesh data contained in the bounding box.

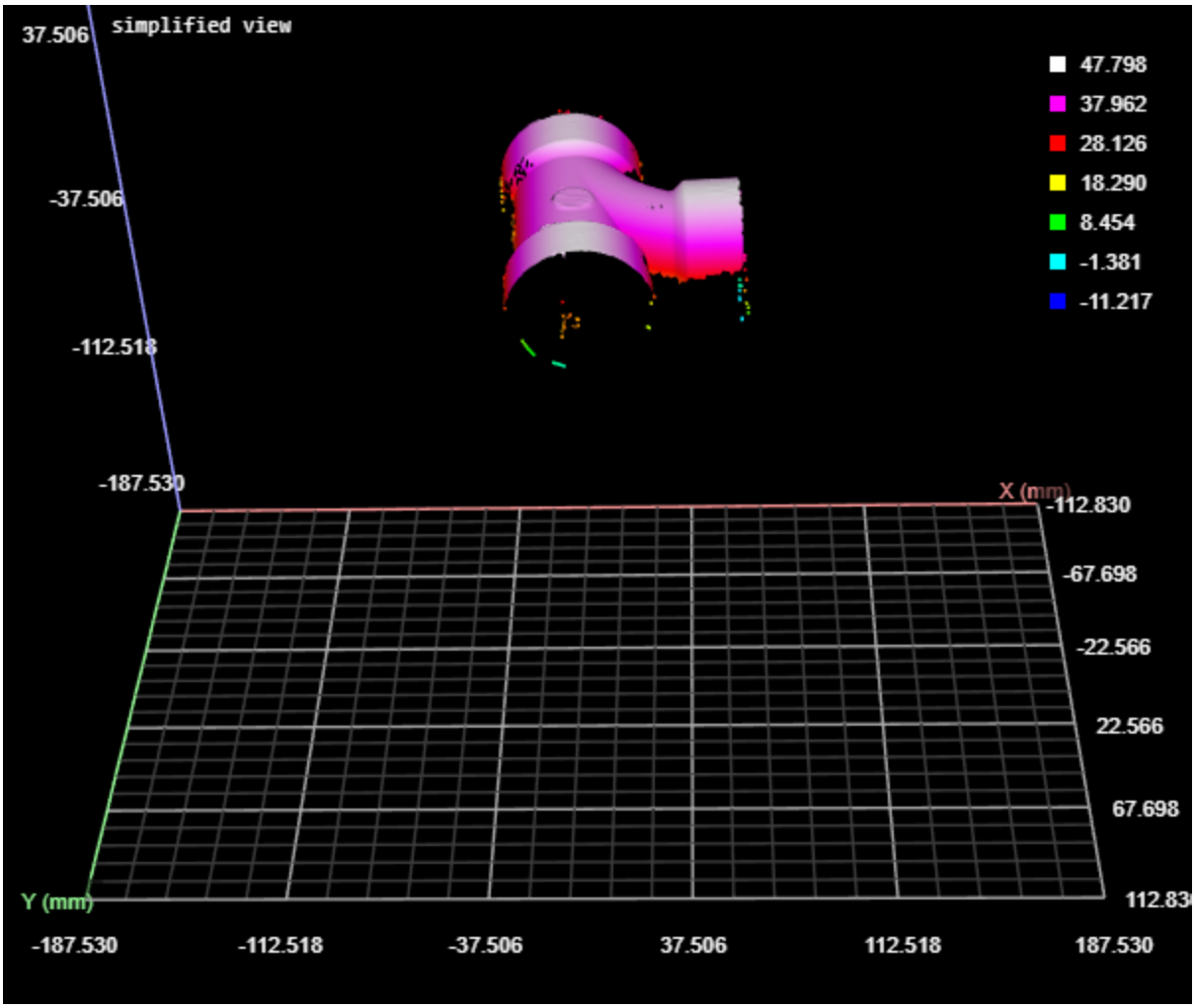
Mesh Plane

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 608). 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.



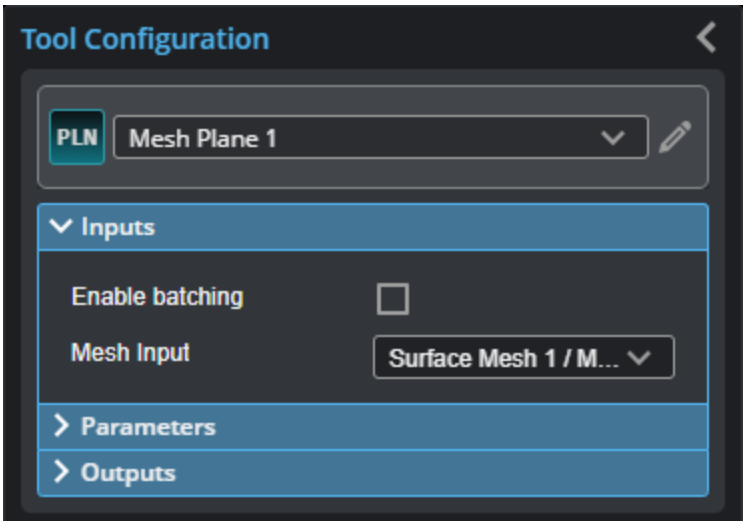
Mesh data with a region placed on a circular flat area. The plane fitted to the data in this region is shown in cyan.



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.

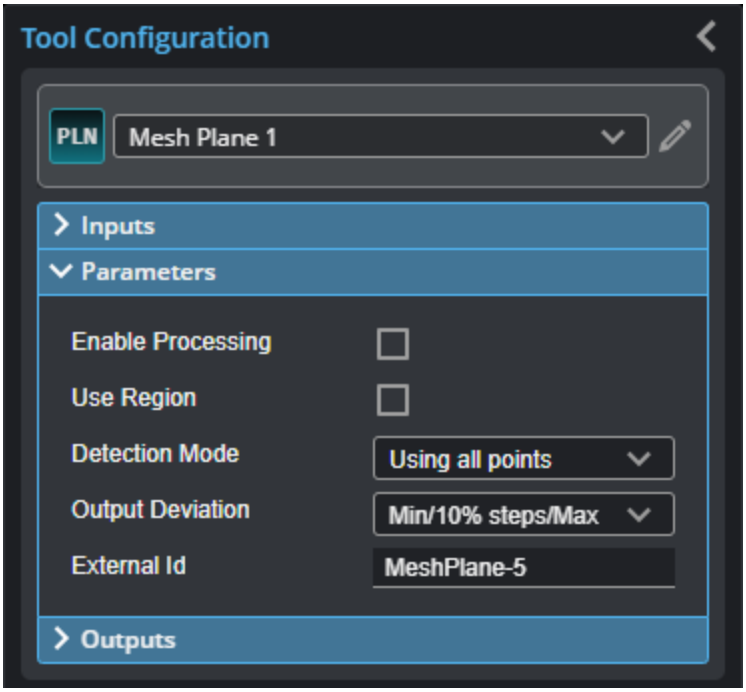


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each mesh in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Mesh Input	The data the tool applies measurements to or processes.

Parameters

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



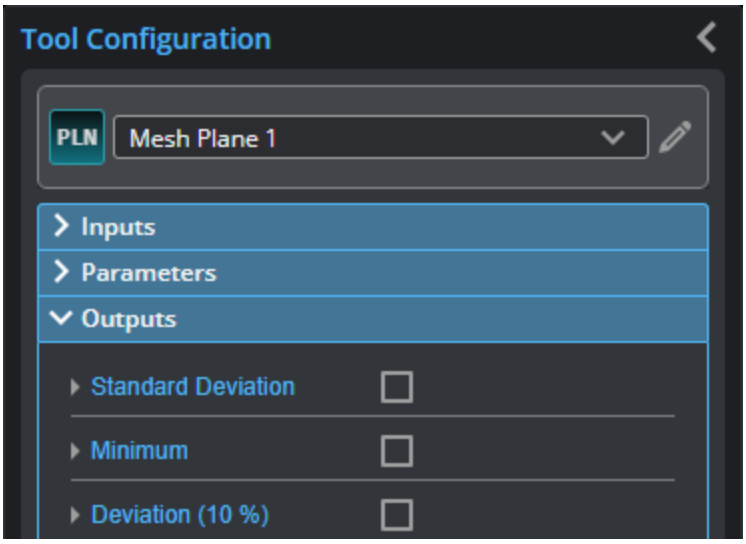
Parameters

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: **With Largest Area** **With Maximum Distance** **With Minimum Distance** 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 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. This parameter is only useful when **Plane Detection Mode** is set to one of the following: • With Largest Area • With Maximum Distance • With Minimum Distance 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. When **Search Direction** is set to **Input Direction**, the tool displays additional parameters: **Tilt Angle** and **Direction Angle**. **Tilt Angle** - The angle between the Z axis and the vector. **Direction Angle** - The vector is projected onto the XY plane and then rotated around the X axis. Specifically: X = sin(TiltAngle) * cos(DirectionAngle) Y = sin(TiltAngle) * sin(DirectionAngle) 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. 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 666.

Outputs

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



Measurements

Measurement
Standard Deviation The standard deviation of the data points from the fitted plane.
Minimum **Maximum** The minimum and maximum error of the data points from the fitted plane, respectively.
Deviation (x%) 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 175.

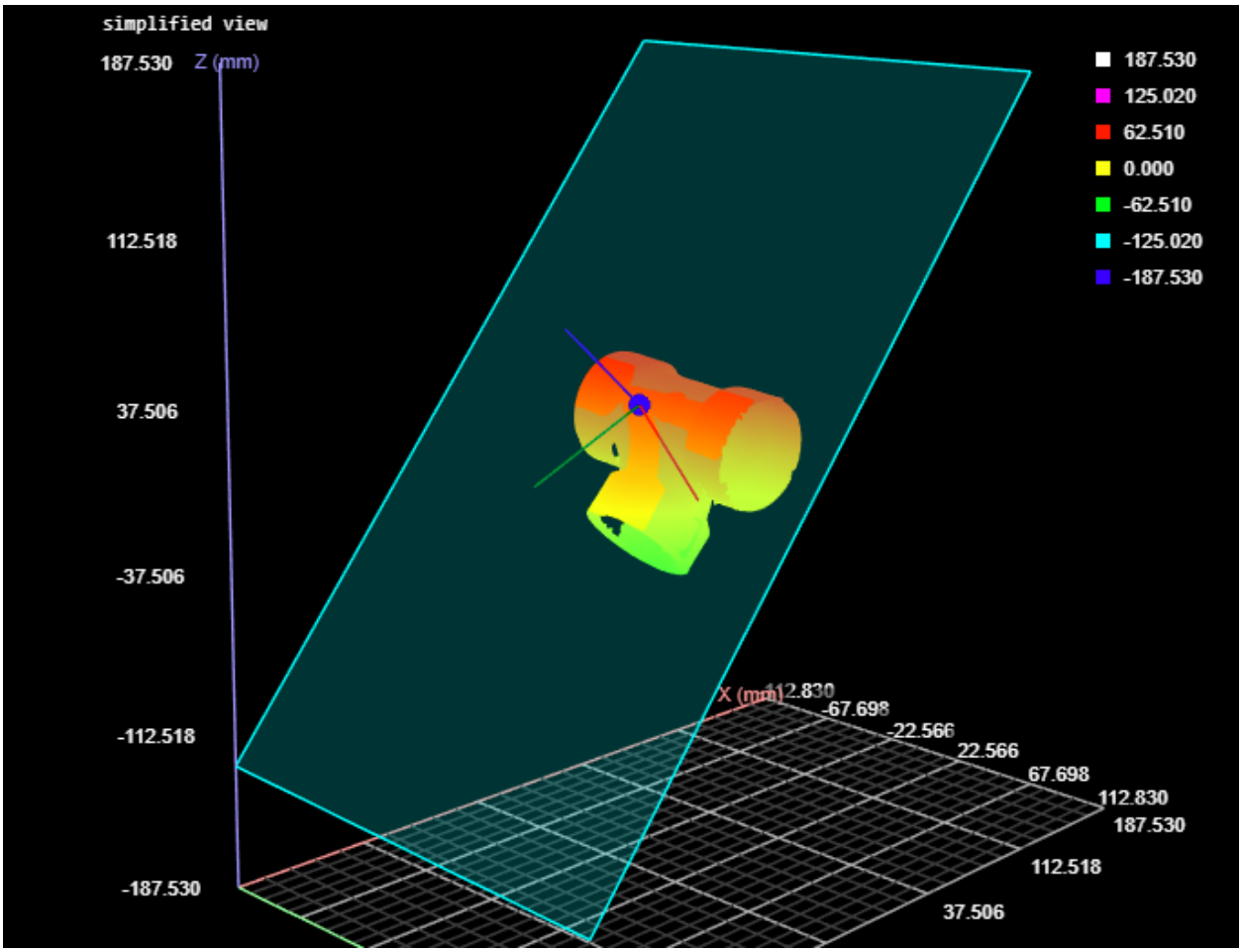
Data

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

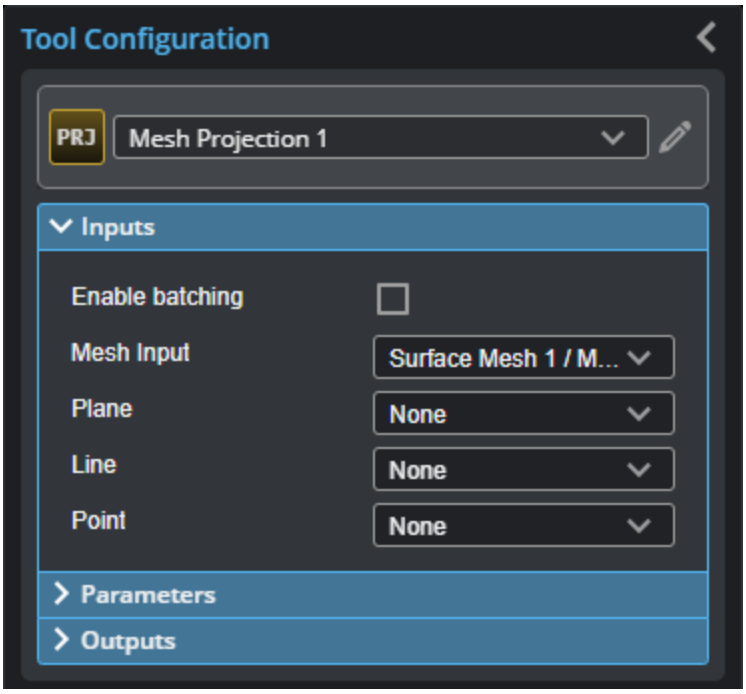
This tool is *only* intended for use with G2 sensors.

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 produced by other Mesh tools 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.

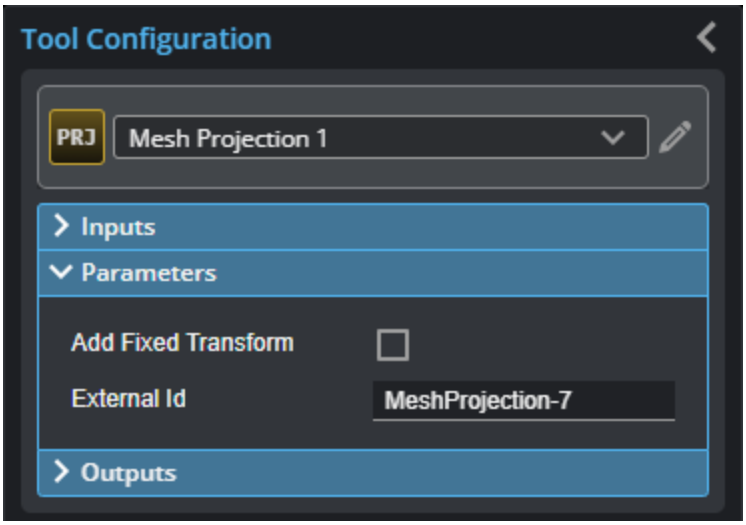


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each mesh in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. 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. 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. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
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.

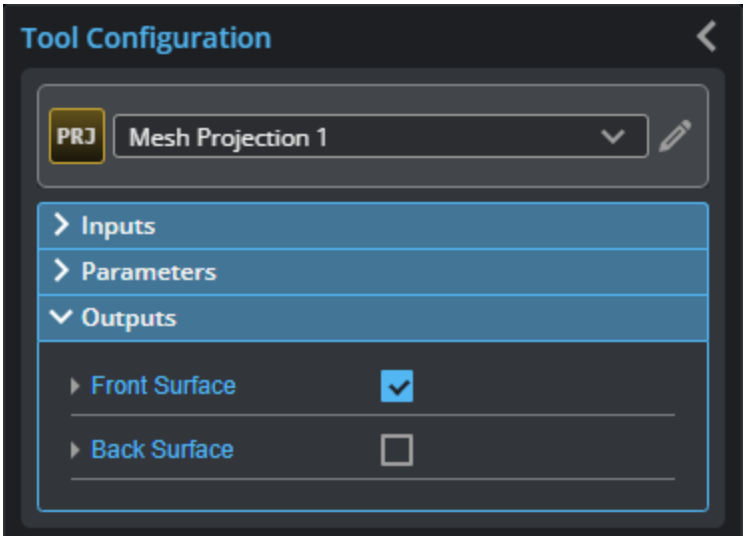


Parameters

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 666.

Outputs

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



Data

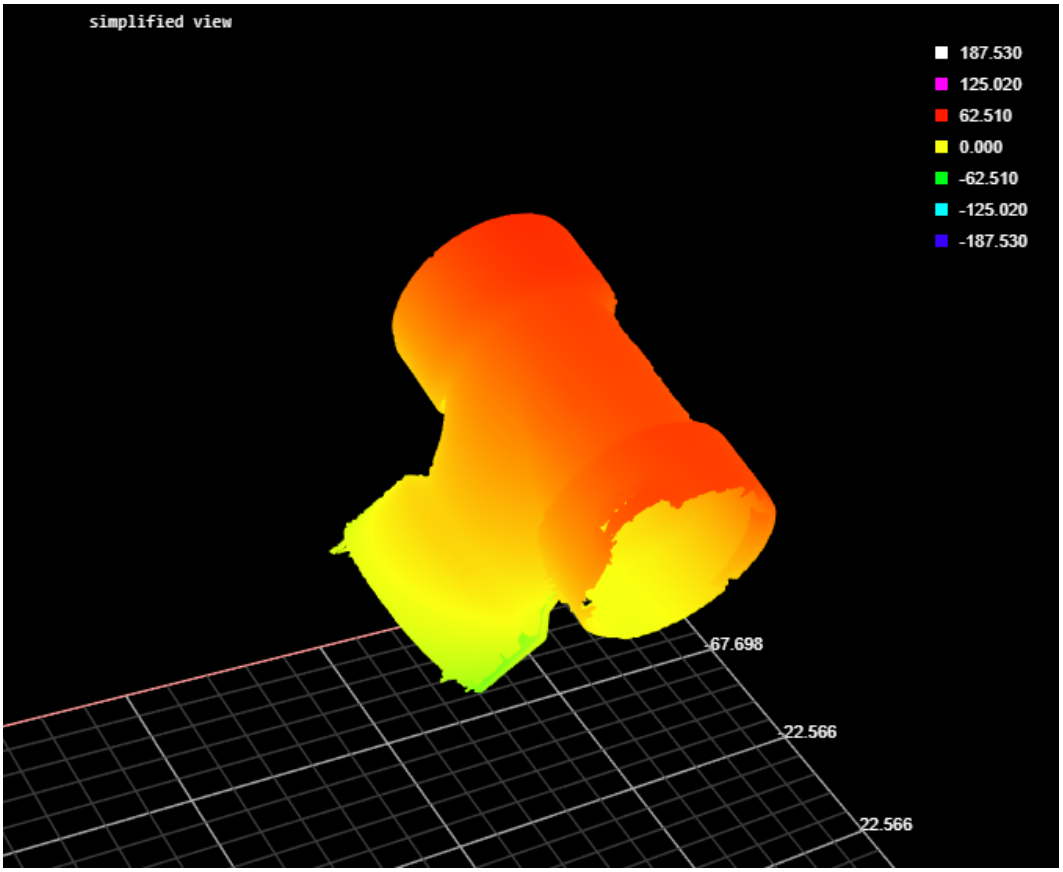
Type	Description
Front Surface	Surface data representing the front of the meshed target.
Back Surface	Surface data representing the back of the meshed target.

Mesh Template Matching

	This tool is *only* intended for use with G2 sensors.

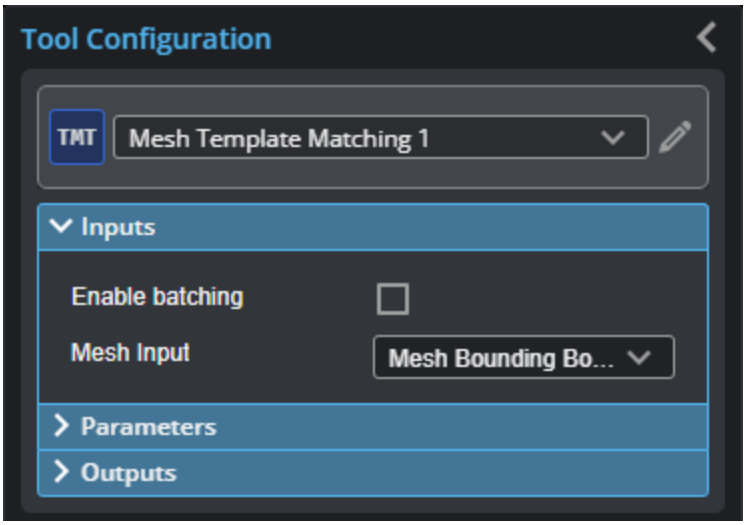
	This tool is not supported on A and B revision Gocator 2100 and 2300 sensors that are not accelerated (either by a PC-based application or by GoMax). The tool is supported in emulator scenarios.

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.

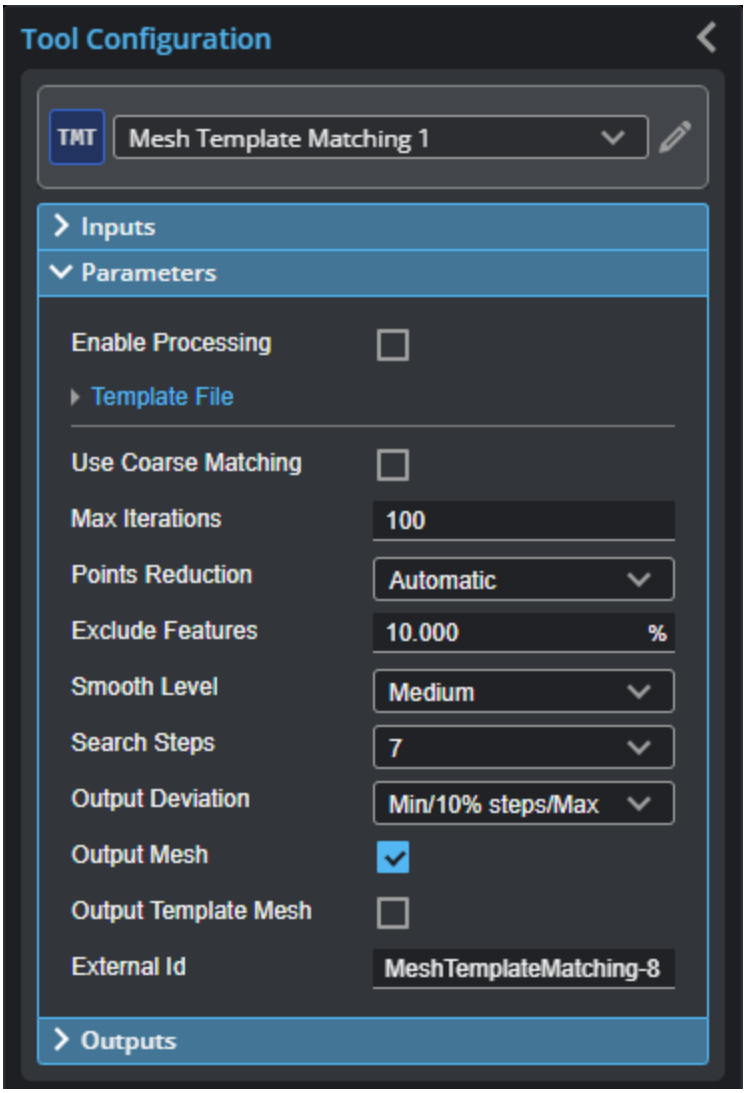


Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each mesh in the array individually. There is no limit to the size of the array, other than processing limitations of the sensor. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Mesh Input	The data the tool applies measurements to or processes.

Parameters

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



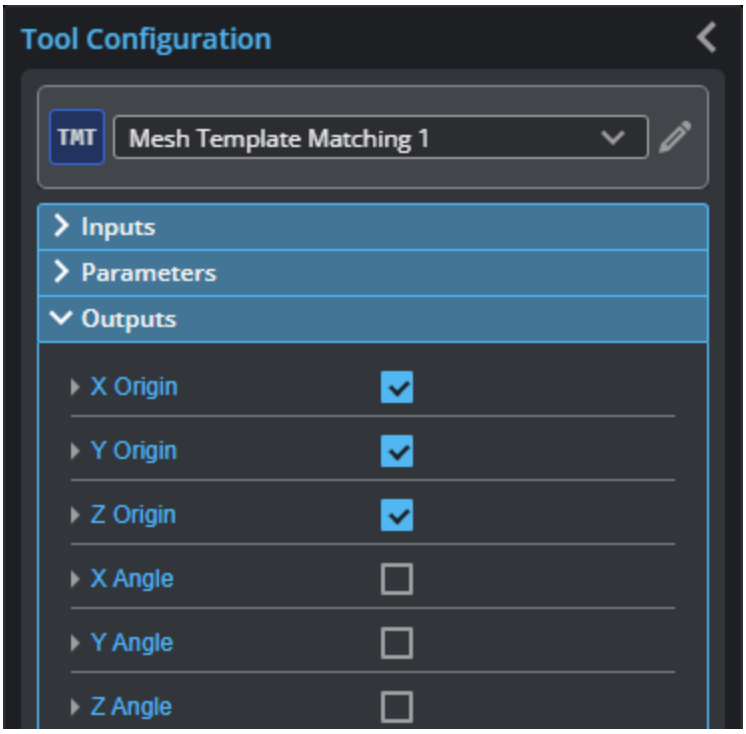
Parameters

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 Template Name Template File	The tool's operation mode. One of the following: **Normal**: When Enable Processing is enabled, the tool compares the Mesh scan data and the loaded template. **Load**: Displays a list of Mesh template files you can load (in the **Template File** drop-down). Supports the following three formats: • 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. • STL: A file format commonly used for 3D printing and computer-aided design (CAD). **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. **Delete**: Deletes the template file you select in the **Template File** field. **Refresh**: Refreshes the template file list. **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. 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 666.

Outputs

All 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 666.

Measurements

Measurement
X Origin **Y Origin** **Z Origin** **X Angle** **Y Angle** **Z Angle** These measurements represent the transform matrix that matches the input mesh against the template.
Standard Deviation The standard deviation of pairs of matching points.
Minimum **Maximum** The minimum and maximum deviation of pairs of matching points.
Deviation (x%) 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

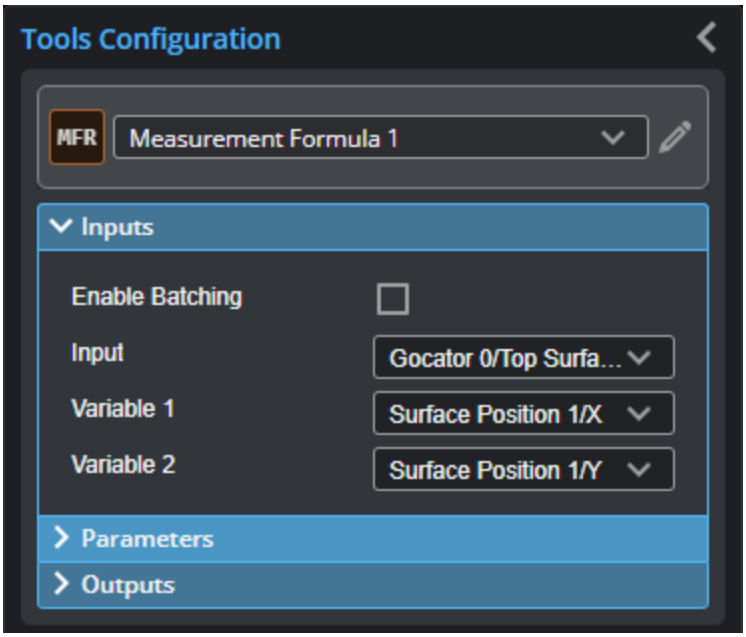
The Measurement Formula tool lets you create a mathematical expression containing one or more measurements from other measurement tools, up to a maximum of 20. The result of the calculation is returned in the tool's Result measurement.

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 153.

Inputs



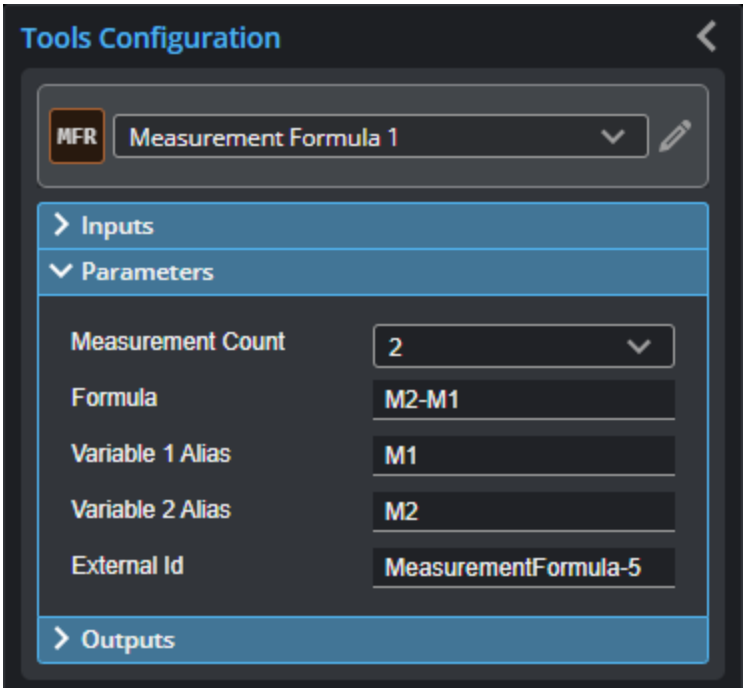
Inputs

Name	Description
Enable Batching	When **Enable Batching** is checked, the tool takes an array as input and processes each element in the array individually. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.
Input	If **Enable Batching** is disabled, set this parameter to any available input. The selected input has no effect on the tool's calculations. If **Enable Batching** is enabled, set this to an array source, such as arrayed output from a multi-sensor system or from multi-layer G5 output, or from the output of an Array Create tool. For more information on arrays, batching, and aggregating, see *Arrays, Batching, and Aggregation* on page 155.

Name	Description
Variable {n}	A measurement from another tool. 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

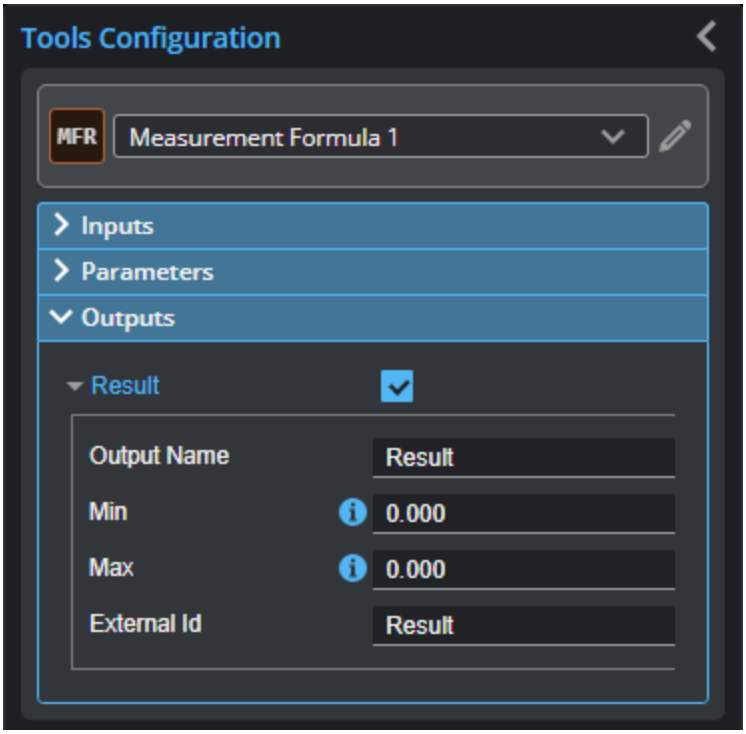
Parameter	Description
Measurement Count	Sets the number of variable inputs in the **Inputs** section. For each, a **Variable {n}** input and a **Variable {n} Alias** parameter is added, and for use in the expression.
Formula	The mathematical expression. Use the variable aliases from the **Variable {n} Alias** parameters in the expression. For example: • M1*3+M2/2+4 • tan(M1/180*pi) • max(M1, M2, M3) The tool supports complex mathematical formulas. For example, the following: $\sqrt{\frac{1-a\times e^{2t}+w^{\pi}}{sin(\frac{2x}{\pi})+cos(\frac{\pi}{y})}}$

Parameter	Description

	can be produced using this:
	`sqrt((1-a*exp(2t)+w^(pi))/(sin(2x/pi)+cos(pi/y)))`
	The following shows how to perform a *while* loop:
	`y:=0; while(x<10){y:=y+x;x+=1;};y`
	Note that ":=" is the assignment operator, and "=" is the equality operator.
	The following shows how to use an if-else structure:
	`if(x>2){x:=x+2;}else{x:=x-2;};x`

Variable {n} Alias	The alias of Variable {n}. 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 666.

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

Result

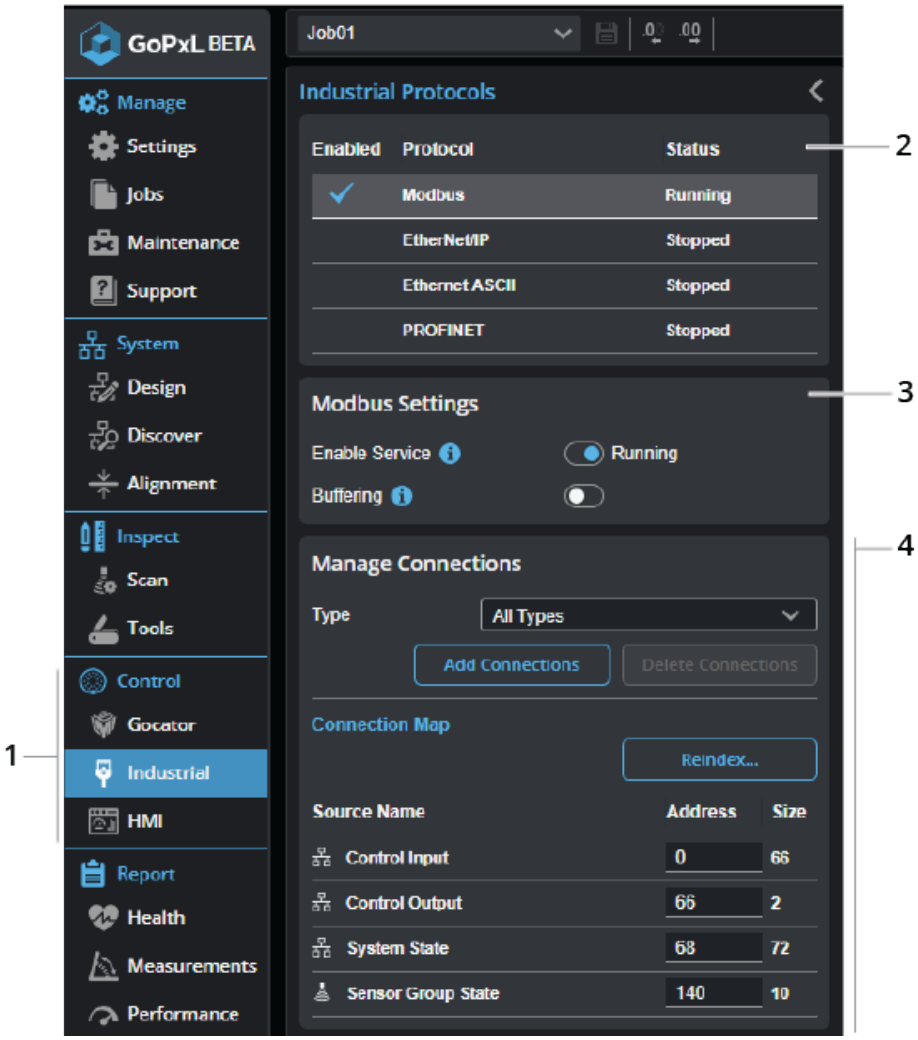
The result of the calculation in **Formula**.

Configuring Control

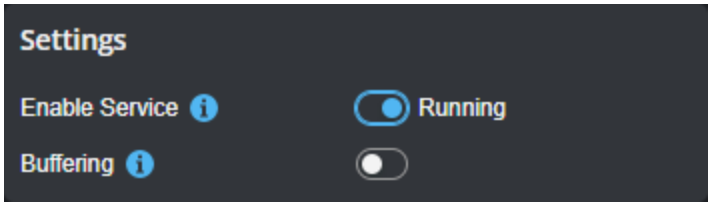
External devices such as PLCs (programmable logic controllers) can control Gocator sensors using various communication protocols and hardware interfaces. Sensors can also send scan data, measurement results, and measurement decisions to these devices. PLCs can in turn control other devices such as ejection chutes.

You can also use the Gocator communication protocol in conjunction with the GoPxL SDK and REST API to write software to control a sensor and receive data.

The following sections describe the **Control** category and the available protocols and interfaces.

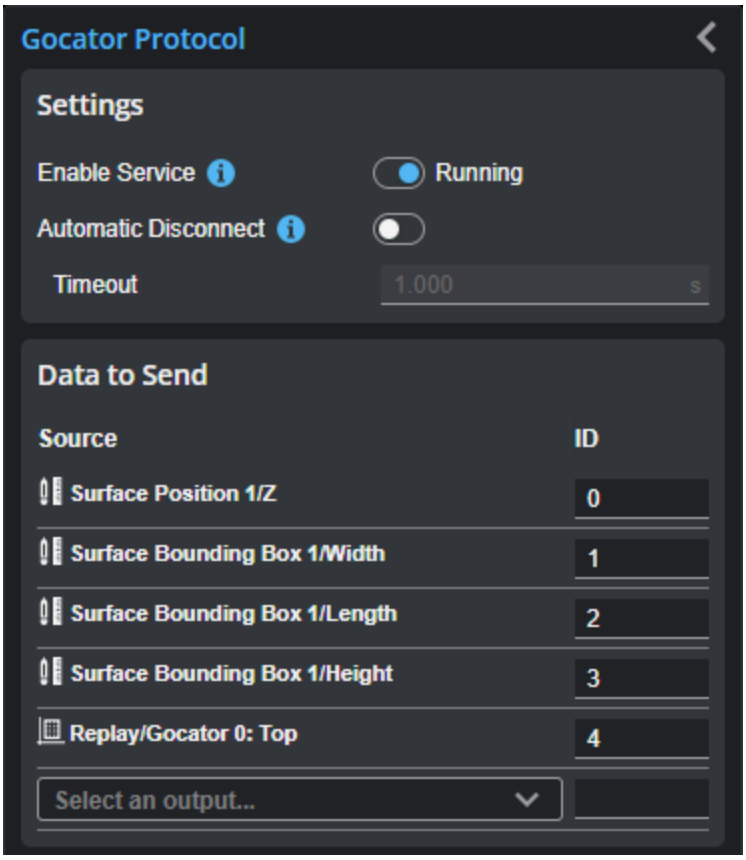


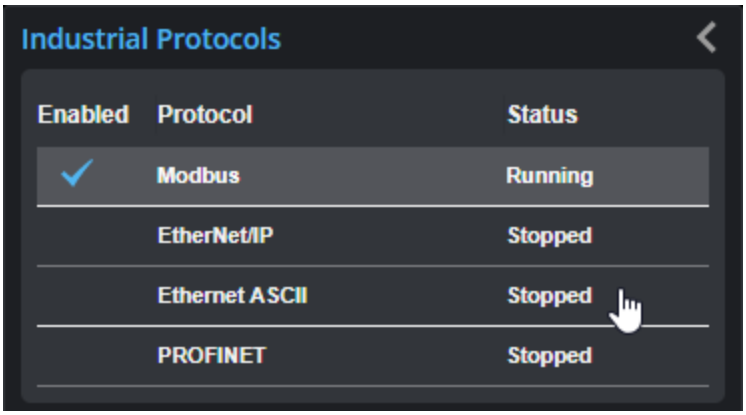
	Element	Description
1	Control pages	Control category and pages corresponding to the different control and data output methods available in GoPxL. For information on the available control methods, see *Control interfaces* on the next page.

	Element	Description
2	Protocol selector	Displays the available industrial protocols and whether a protocol is enabled. Click a protocol in the table and toggle **Enable Service** to Running.
3	Settings	Lets you enable, disable, and configure protocols. To enable a service, click the **Enable Service** toggle to Running. 
3	Connections	Lets you add and remove the connections to the connections map (industrial protocols) and outputs (Gocator protocol). For more information, see the table below.

Control interfaces

Interface	Description
Gocator	You use the Gocator communication protocol in conjunction with the GoPxL SDK and REST API. The protocol uses TCP messages to control the sensor or sensors and to transmit data and measurement results to a client computer. You can select which measurements and what type of scan data to send (image; range, profile, or surface, depending on sensor model; or intensity).

Interface	Description
	 For information on configuring the Gocator communication protocol in GoPxL, see *Gocator Communication Protocol* on page 626. For information on the SDK and REST API, see *GoPxL SDK and REST API* on page 692.
Industrial	The Industrial pages lets you enable and configure the following protocols over an Ethernet connection: • Modbus • EtherNet/IP • Ethernet ASCII • PROFINET

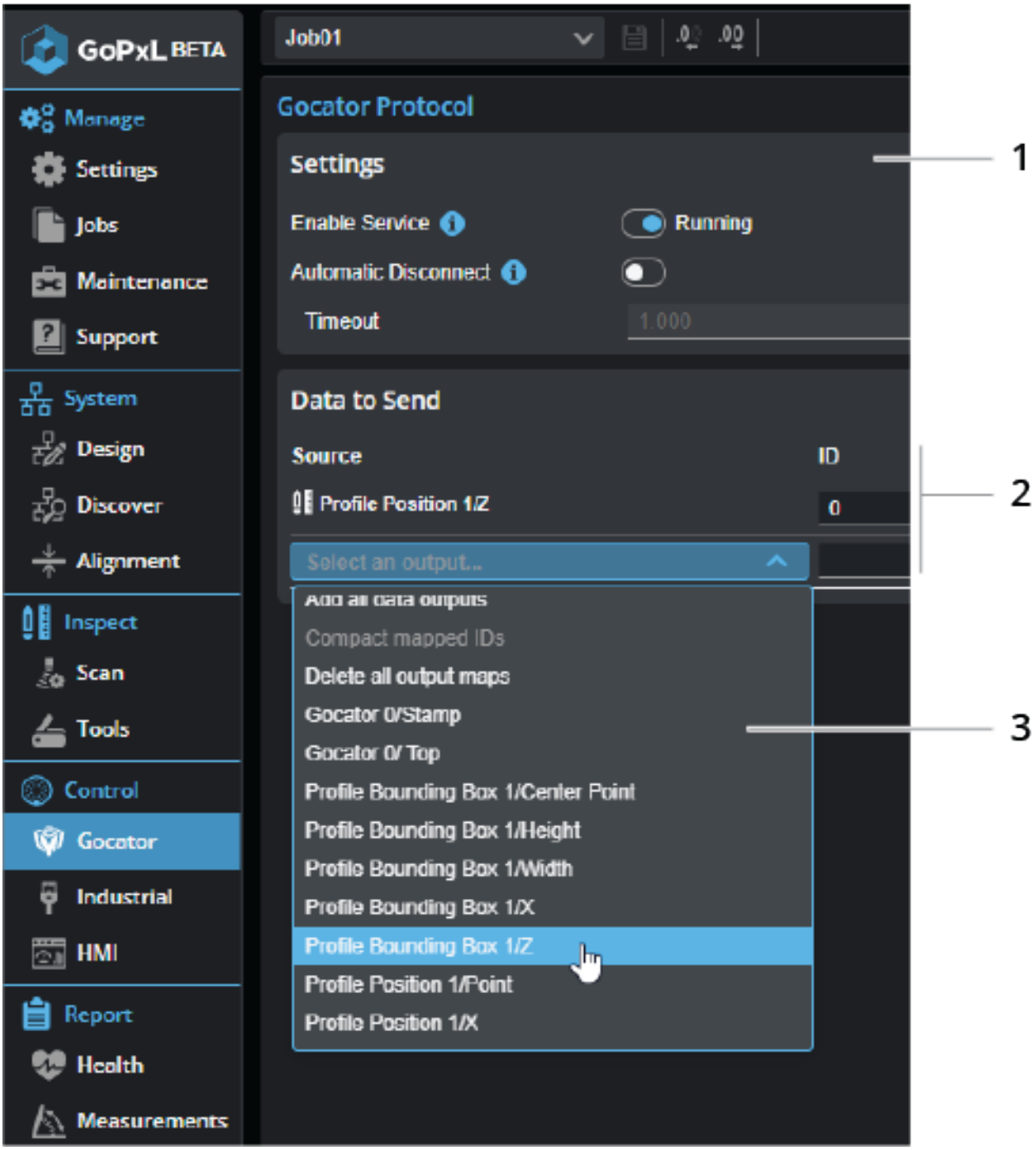
Interface	Description
	 **Modbus** The Modbus protocol lets you operate a sensor from a PLC that supports Modbus. For more information on configuring the Modbus protocol in GoPxL, see *Modbus Protocol* on page 628. For the Modbus protocol specification, see *Modbus Protocol* on page 704. **EtherNet/IP** The EtherNet/IP protocol lets you operate a sensor from a PLC that supports EtherNet/IP. For more information on configuring the EtherNet/IP protocol in the GoPxL UI, see *EtherNet/IP Protocol* on page 632. For the EtherNet/IP protocol specification, see *EtherNet/IP Protocol* on page 716. **Ethernet ASCII** The Ethernet ASCII protocol lets you communicate with a sensor using an ASCII format. For more information on configuring the ASCII protocol over Ethernet in the GoPxL interface, see *Ethernet ASCII Protocol* on page 637. For a list of the commands, see *Ethernet ASCII Protocol* on page 709. **PROFINET** The PROFINET protocol lets you operate a sensor from a PLC that supports PROFINET. For more information on configuring the PROFINET protocol in the GoPxL UI, see *PROFINET Protocol* on page 642. For the PROFINET protocol specification, see *PROFINET Protocol* on page 721.
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,

Interface	Description
	or a mobile device. For more information, see *GoHMI and GoHMI Designer* on page 666.

Gocator Communication Protocol

The Gocator communication protocol uses TCP messages to control sensors and to transmit data and measurement results to a client computer. You can select which measurements and what type of scan data to send (image; range, profile, or surface, depending on sensor model; or intensity).

All of the tasks that you can accomplish in the web interface can be accomplished programmatically by sending and receiving the protocol control commands, with the SDK or the REST API. For more information on the SDK and the REST API, see *GoPxL SDK and REST API* on page 692.



	Element	Description
1	Protocol settings	Lets you enable the protocol and configure automatic disconnect. For information on the settings available here, see *Configuration area parameters* on the next page.
2	Added outputs	Outputs that have been added from the output selection list.
3	Output selection list	You use the output selection list to choose the outputs you want to send over

Element	Description
	the protocol. The list also provides shortcut commands to add or remove outputs. For example, the **Add all measurement outputs** shortcut adds all available measurement outputs.

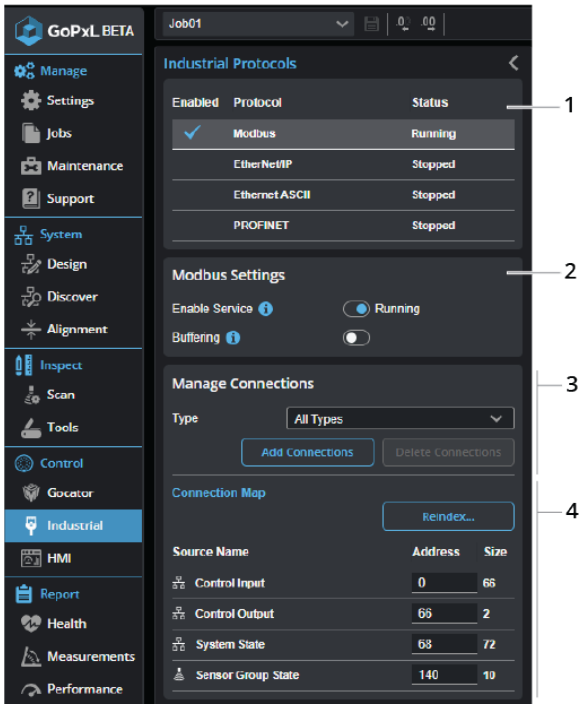
Configuration area parameters

Parameter	Description
Enable Service	Toggles whether the Gocator communication protocol is enabled.
Enable 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 **Enable Disconnect** is enabled.

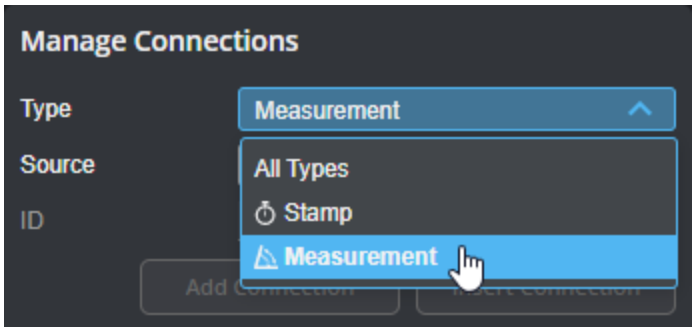
Modbus Protocol

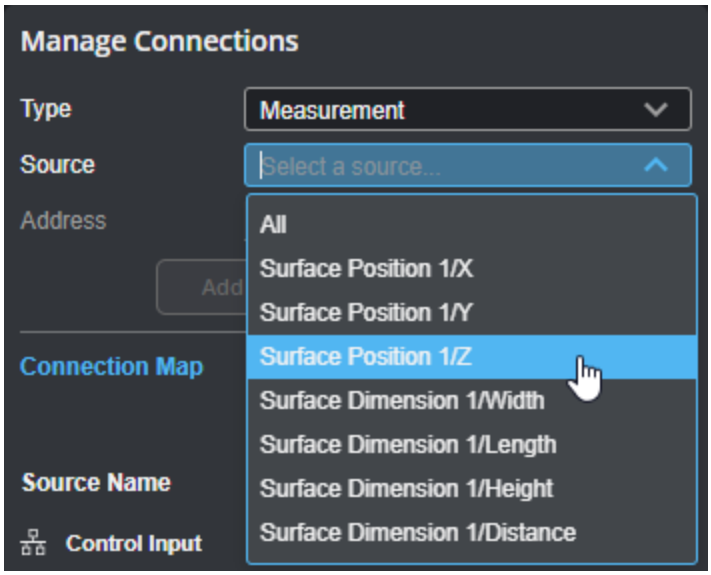
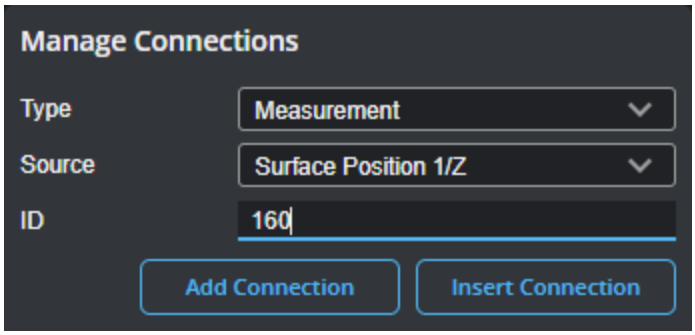
You can use a Modbus programmable logic controller (PLC) over Ethernet to operate a sensor and receive measurement values. Modbus only supports a subset of the tasks that can be accomplished in the web interface (for example, starting and stopping sensors, and switching jobs). Scan data can't be sent to the PLC.

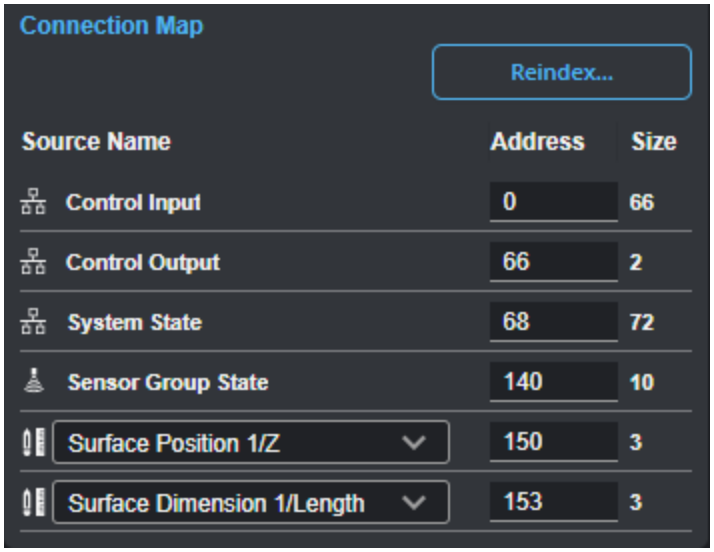
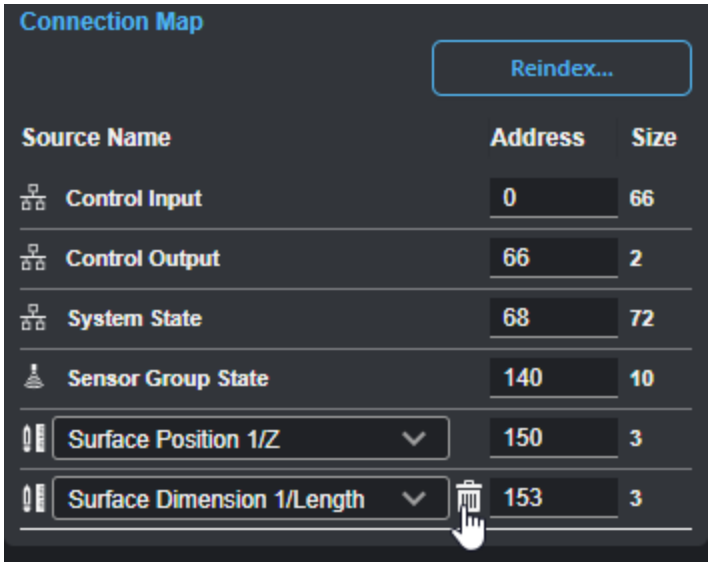
After configuring the Modbus protocol in GoPxL (see below), use the information in *Modbus Protocol* on page 704 to configure your PLC.

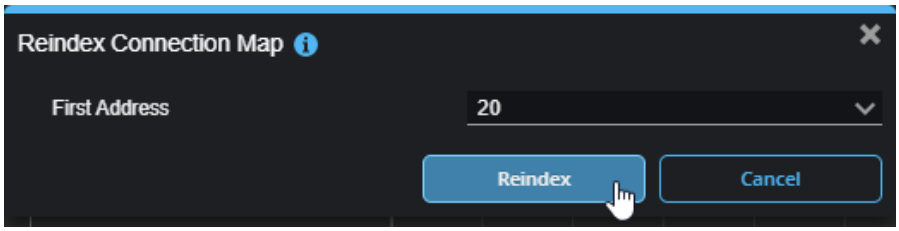


	Element	Description
1	Protocol selector	Click a row in the table to choose which protocol to configure.
2	Settings	Lets you enable the Modbus protocol and buffering.

	Element	Description
		Enable Service Toggle this to enable and disable the selected protocol. **Buffering** Used to enable/disable buffering of scan outputs. On G2 and G3 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 706.
3	Manage Connections	Lets you add, insert, and delete sources (such as stamps or measurements) in the connection map. Added connections appear in the connection map at the bottom of the panel. **Type** Use **Type** to optionally filter the connection types available to be added or inserted.  When **Type** is set to a type other than All Types, sources of that type are listed for selection in the **Source** drop-down. Choose All to add all sources of that type.

Element	Description
	 **Add Connections** Adds one or more connections to the connection map. If **Type** is set to All Types, all available sources are added. If **Type** is set to a specific type, the source selected in **Source** is added (or all sources of that type if All is selected). 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.  **Insert Connections** Set **Address** to the address of a previously added source and click **Insert Connection** to insert the selected source into the connection map at that address and shift others down. Inserting a source at an address not currently used adds it at that address. **Delete Connections**

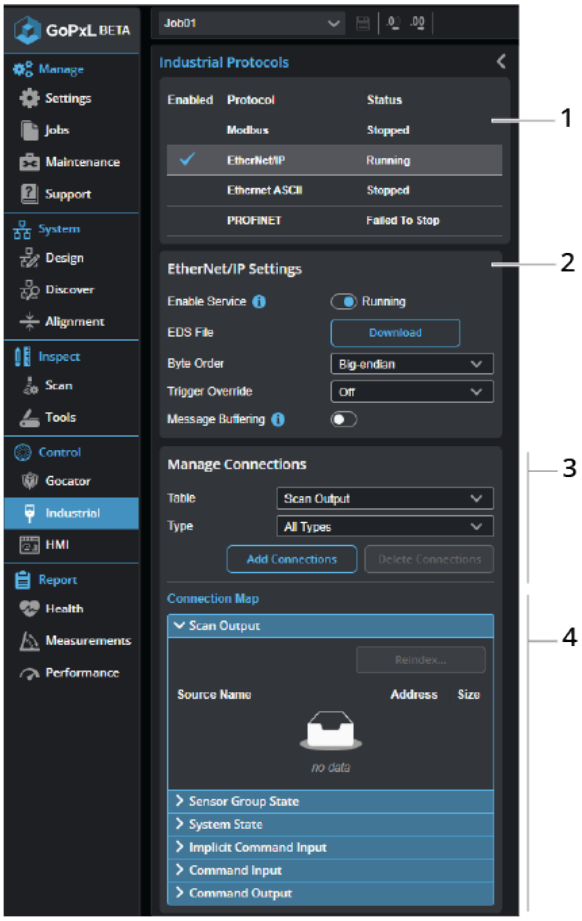
	Element	Description
		Removes all user-added connections.
4	Connection map	Lists the added connections. In the following, two measurements have been added.  You can change the address of a source by editing it and pressing Tab or clicking elsewhere in the interface. The sources are resorted after you change an address. To remove a source from the connections map, hover over the source and click the source's trashcan icon.  Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.

	Element	Description
		

EtherNet/IP Protocol

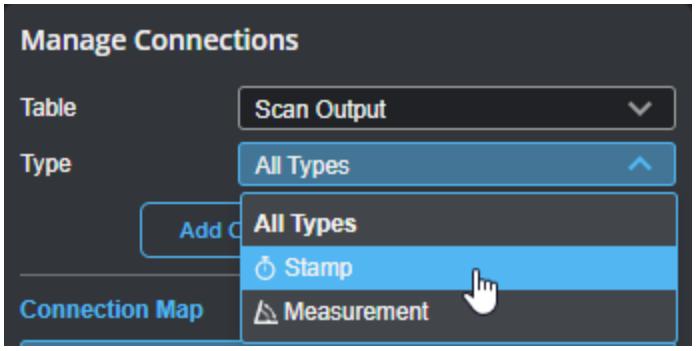
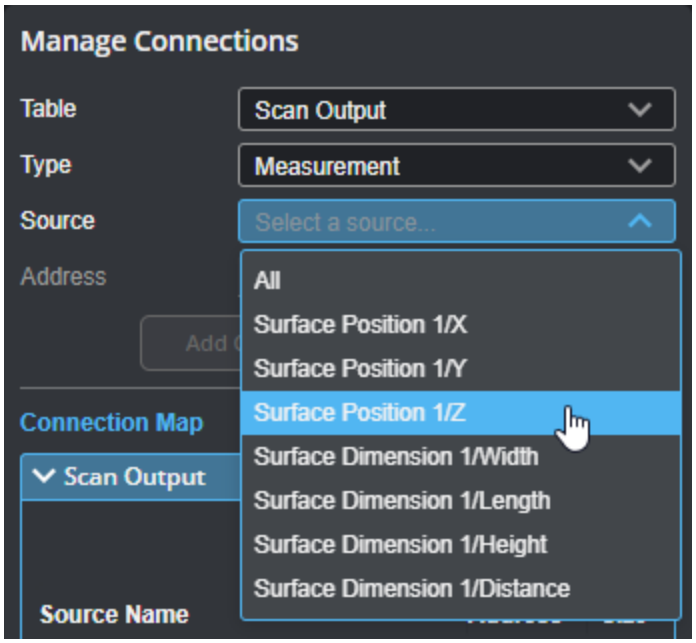
You can use an EtherNet/IP programmable logic controller (PLC) over Ethernet to operate a sensor and receive measurement values. EtherNet/IP only supports a subset of the tasks that can be accomplished in the web interface (for example, starting and stopping sensors, and switching jobs). Scan data can't be sent to the PLC.

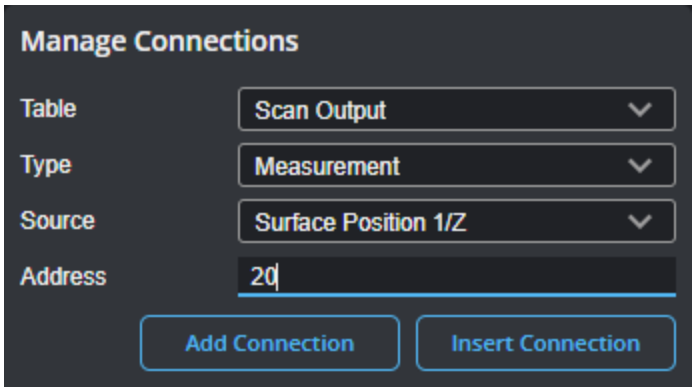
After configuring the EtherNet/IP protocol in GoPxL (see below), use the information in *EtherNet/IP Protocol* on page 716 to configure your PLC.



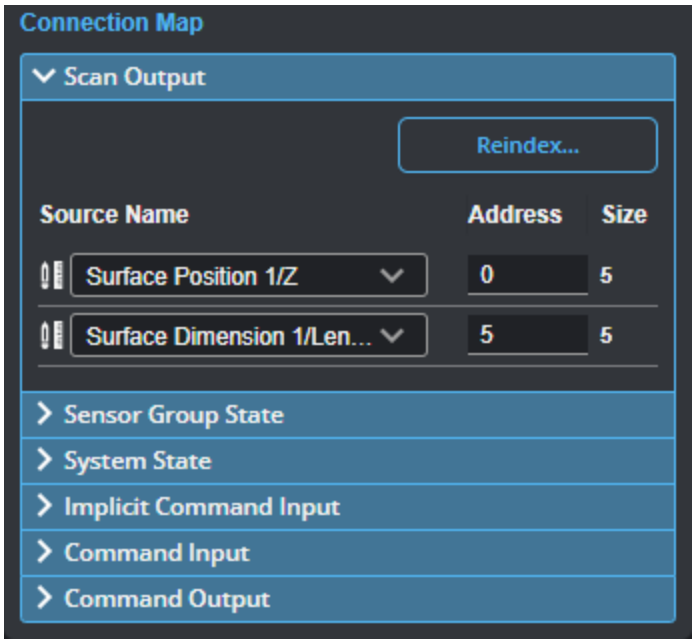
	Element	Description
1	Protocol selector	Click a row in the table to choose which protocol to configure.

	Element	Description
2	Settings	Lets you enable and configure the EtherNet/IP protocol. **Enable Service** Toggle this to enable and disable the selected protocol. **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 Byte Order**: 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. **Little Endian Byte Order**: 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. Most Allen-Bradley PLCs default to Little Endian addressing formats, but you should verify this when configuring the PLC. **Trigger Override** One of the following: **Off**, **Cyclic**, and **Change of State**. 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. **Message Buffering** 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. 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* on page 716). Message buffering only applies to tool outputs sent over explicit messaging.
3	Manage Connections	Lets you add, insert, and delete sources (such as stamps or measurements) in the connection map. Added connections appear in the connection map at the bottom of the panel.

Element	Description
	Table When GoPxL is running on a sensor, Table only contains one value (Scan Output) that represents a register assembly. When GoPxL is running on a PC or GoMax NX, **Table** contains an additional entry (Sensor Group State). Use this parameter to choose which register a source is added to. **Type** Use **Type** to optionally filter the connection types available to be added or inserted.  When **Type** is set to a type other than All Types, sources of that type are listed for selection in the **Source** drop-down. Choose All to add all sources of that type.  **Add Connections**

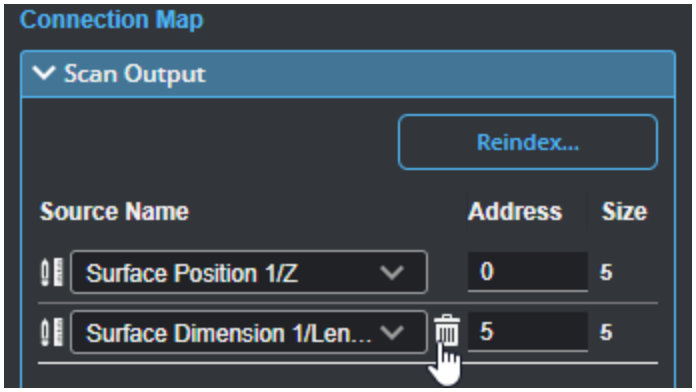
	Element	Description
		Adds one or more connections to the connection map. If **Type** is set to All Types, all available sources are added. If **Type** is set to a specific type, the source selected in **Source** is added (or all sources of that type if All is selected). By default, connections are added 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.  **Insert Connections** Set **Address** to the address of a previously added source and click **Insert Connection** to insert the selected source into the connection map at that address and shift others down. Inserting a source at an address not currently used adds it at that address. **Delete Connections** Removes all user-added connections.
4	Connection map	Lists the added connections. In the following, two measurements have been added.

Element	Description

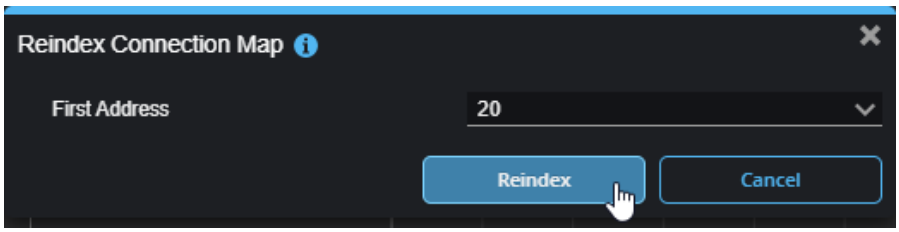


You can change the address of a source by editing it and pressing Tab or clicking elsewhere in the interface. The sources are resorted after you change an address.

To remove a source from the connections map, hover over the source and click the source's trashcan icon.



Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.

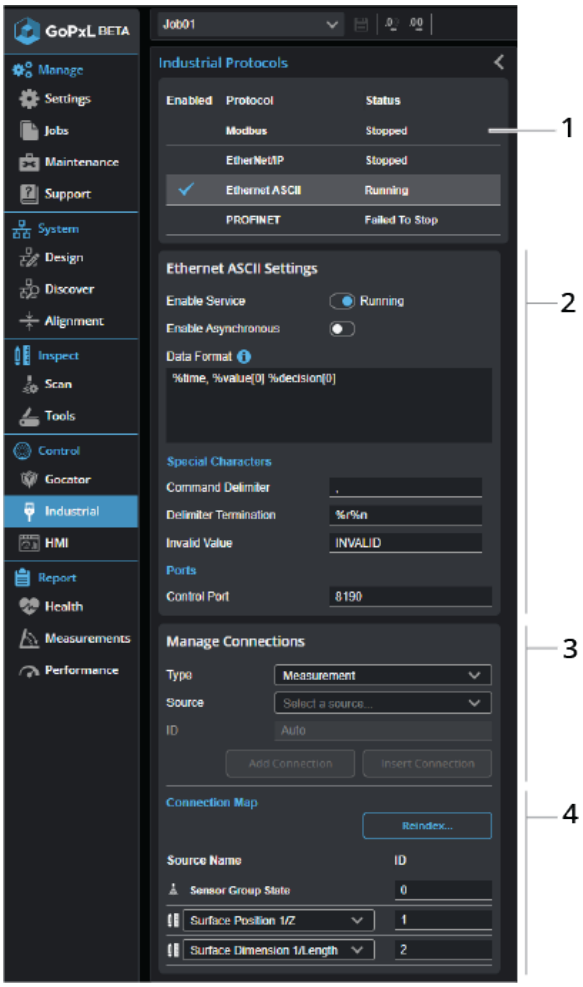


Ethernet ASCII Protocol

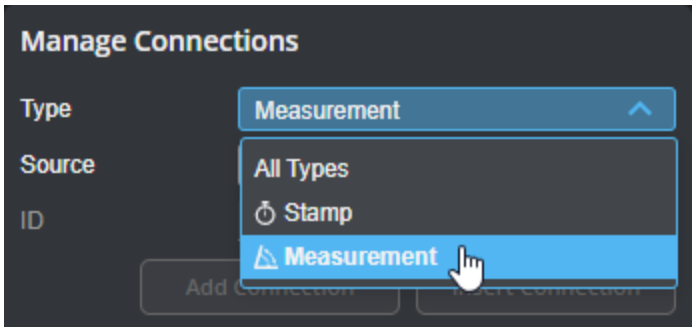
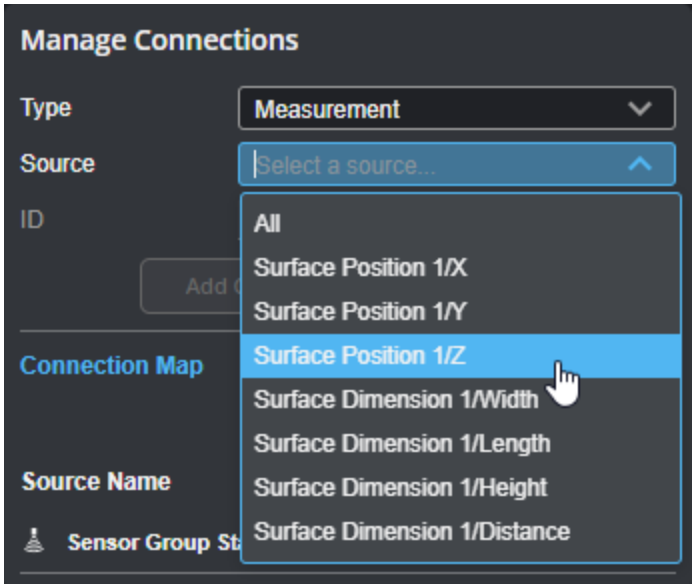
You can use a Programmable Logic Controller (PLC) that supports the Ethernet ASCII protocol to operate a sensor and receive values and decisions (together called results). Two modes are available: asynchronous and polling.

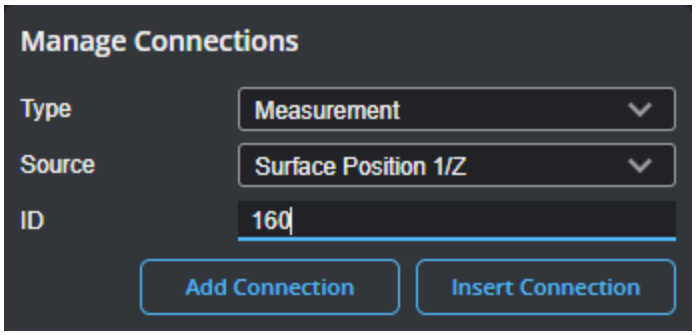
When the sensor is in asynchronous mode, results are sent automatically, as soon as they are available. No commands are required.

When the sensor is in polling mode, you 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). After configuring the ASCII protocol parameters in GoPxL (see below), see *Ethernet ASCII Protocol* on page 709 for information on the available polling commands.

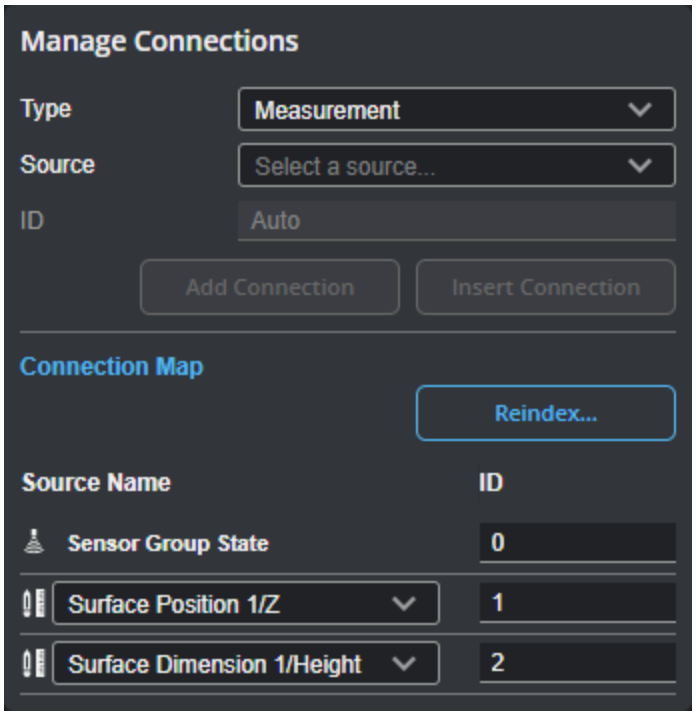


	Element	Description
1	Protocol selector	Click a row in the table to choose which protocol to configure.
2	Settings	Lets you enable and configure the Ethernet ASCII protocol.

	Element	Description
		For descriptions of the parameters, see *Configuration parameters* on page 641.
3	Manage Connections	Lets you add, insert, and delete sources (such as stamps or measurements) in the connection map. Added connections appear in the connection map at the bottom of the panel. **Type** Use **Type** to optionally filter the connection types available to be added or inserted.  When **Type** is set to a type other than All Types, sources of that type are listed for selection in the **Source** drop-down. Choose All to add all sources of that type.  **Add Connections** Adds one or more connections to the connection map. If **Type** is set to All Types, all available sources are added. If **Type** is set to a specific type, the source selected in **Source** is added (or all sources of that type if All is selected).

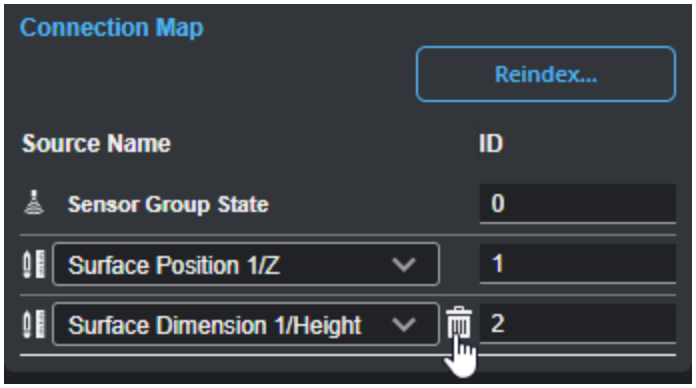
	Element	Description
		By default, connections are added directly after the last source in the connections map. You can optionally set the address at which a source is added using the **Address** parameter.  **Insert Connections** Set **Address** to the address of a previously added source and click **Insert Connection** to insert the selected source into the connection map at that address and shift others down. Inserting a source at an address not currently used adds it at that address. **Delete Connections** Removes all user-added connections.
4	Connection map	Lists the added connections. In the following, two measurements have been added.

Element	Description

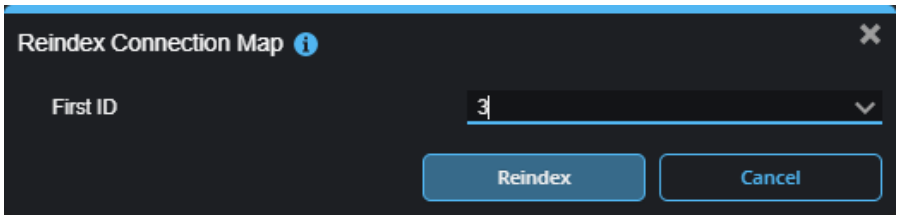


You can change the ID of a source by editing it and pressing Tab or clicking elsewhere in the interface. The sources are resorted after you change an address.

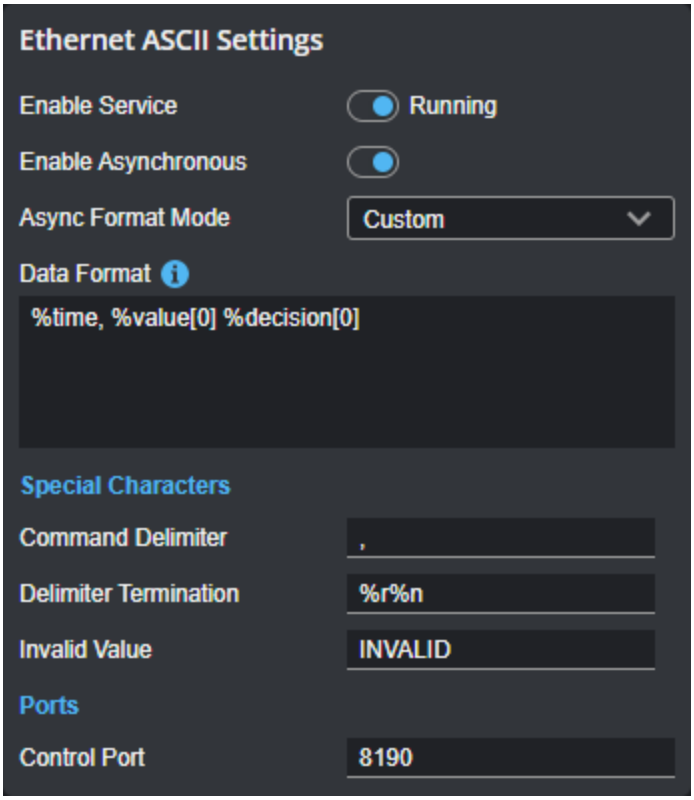
To remove a source from the connections map, hover over the source and click the source's trashcan icon.



Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.



Configuration parameters

Parameter	Description
Enable Service	Toggles whether the protocol is enabled.
Enable Asynchronous	Toggles asynchronous operation. In asynchronous mode, the data results are transmitted when they are available. Set the **Async Format Mode** and **Async Data Format** parameters as required. (These parameters are only displayed when asynchronous mode is enabled.) When this option is disabled, the protocol 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 710.
Async Format Mode	The formats used when asynchronous mode is enabled.
Data Format	One of the following Standard, Standard with Stamp, and Custom. Setting this parameter to Custom lets you edit the format in **Data Format**. Click the info icon for a list of replacement patterns. This format is used when you use the Result command without providing any arguments; for more information, see *Commands and Formats* on page 710. Otherwise, the built-in format is used. 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.

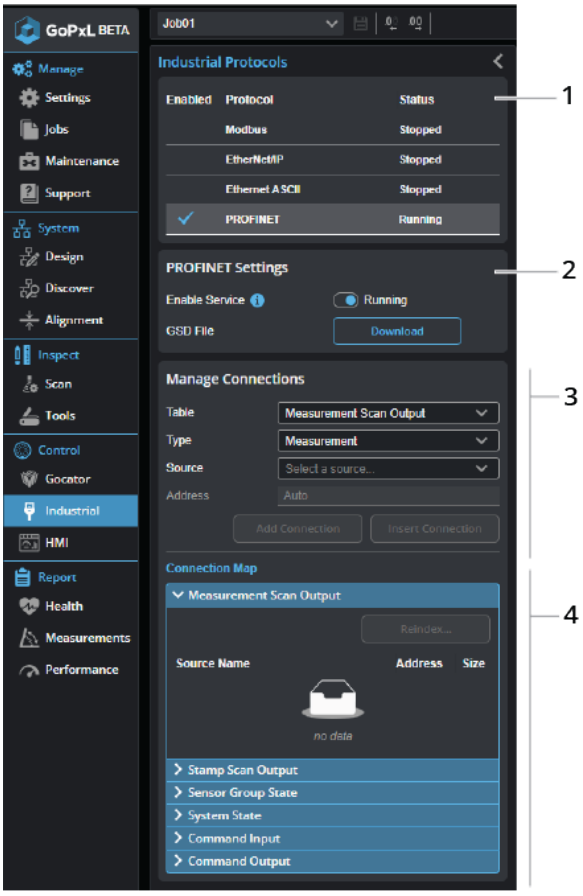
Parameter	Description
Delimiter Termination	Sets the command termination character.
Invalid Value	Sets the invalid value characters.
Control Port	Sets the control port. This is the port to which you must connect.

PROFINET Protocol

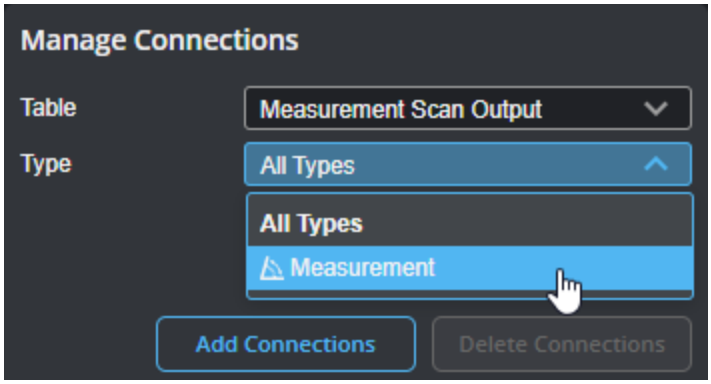
You can use a PROFINET Programmable Logic Controller (PLC) over Ethernet to operate a sensor and receive measurement values and decisions. Modbus only supports a subset of the tasks that can be accomplished in the web interface (for example, starting, stopping, and aligning sensors, and switching Jobs). Scan data can't be sent to the PLC.

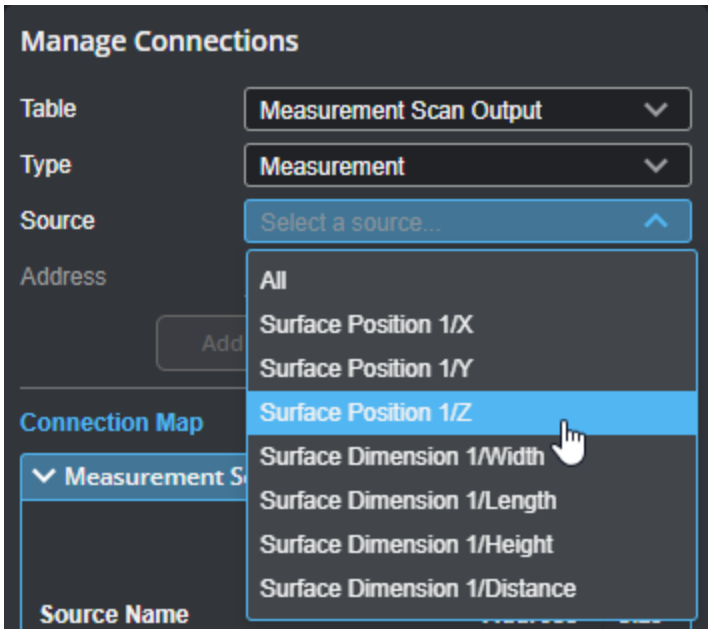
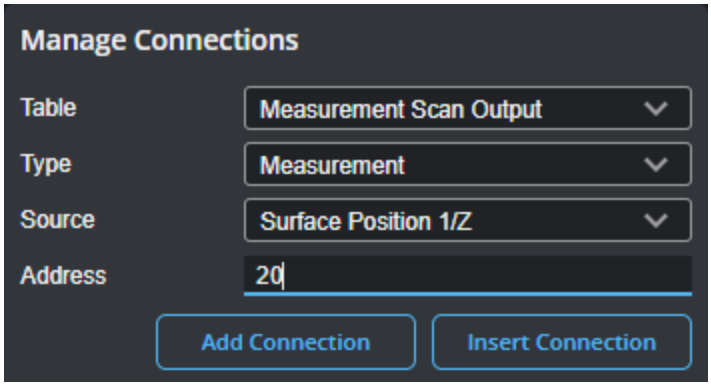
> GoPxL supports PROFINET on-sensor and on GoMax NX. PROFINET is not currently supported on PC instances of GoPxL. This functionality is planned for the near future.

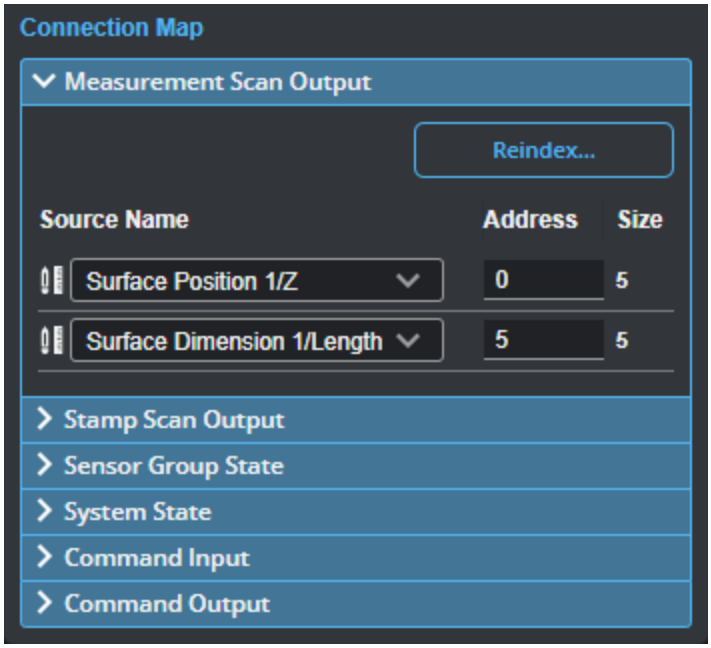
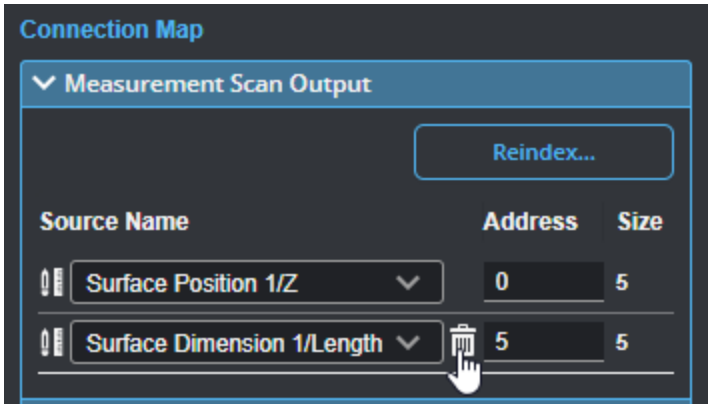
After configuring the PROFINET protocol in GoPxL (see below), use the information in *PROFINET Protocol* on page 721 for configuring your PLC.

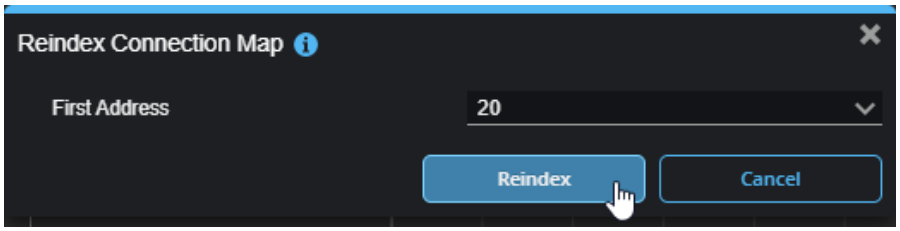


	Element	Description
1	Protocol selector	Click a row in the table to choose which protocol to configure.

	Element	Description
2	Settings	Lets you enable and configure the PROFINET protocol. **Enable Service** Toggle this to enable and disable the selected protocol. **GSD File** Click **Download** to save a GSD file to the client computer for later installation on the PLC.
3	Manage Connections	Lets you add, insert, and delete sources (such as stamps or measurements) in the connection map. Added connections appear in the connection map at the bottom of the panel. **Table** When GoPxL is running on a sensor, **Table** only contains two options (Measurement Scan Output and Stamp Scan Output), which represent register assemblies. When GoPxL is running on GoMax NX, **Table** contains an additional entry (Sensor Group State). Use this parameter to choose which register a source is added to. **Type** Use **Type** to optionally filter the connection types available to be added or inserted.  When **Type** is set to a type other than All Types, sources of that type are listed for selection in the **Source** drop-down. Choose All to add all sources of that type.

Element	Description
	 **Add Connections** Adds one or more connections to the connection map. If **Type** is set to All Types, all available sources are added. If **Type** is set to a specific type, the source selected in **Source** is added (or all sources of that type if All is selected). 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.  **Insert Connections** Set **Address** to the address of a previously added source and click **Insert Connection** to insert the selected source into the connection map at that address and shift others down. Inserting a source at an address not currently used adds it at that address.

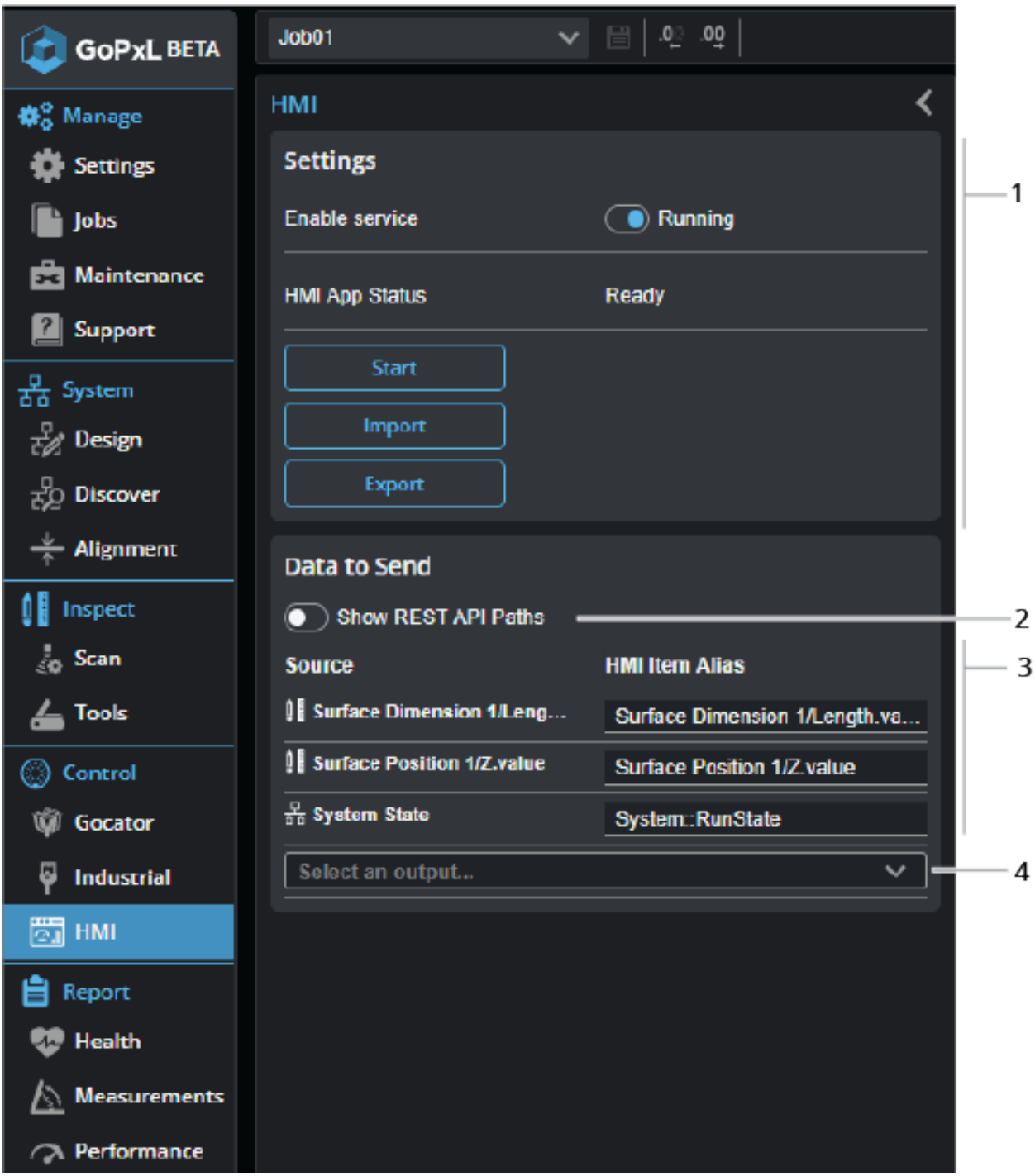
	Element	Description
		Delete Connections Removes all user-added connections.
4	Connection map	Lists the added connections. In the following, two measurements have been added.  You can change the address of a source by editing it and pressing Tab or clicking elsewhere in the interface. The sources are resorted after you change an address. To remove a source from the connections map, hover over the source and click the source's trashcan icon.  Use **Reindex...** to remove gaps of unused addresses between connections. You can also use **Reindex...** to set the value of the first index.

Element	Description
	

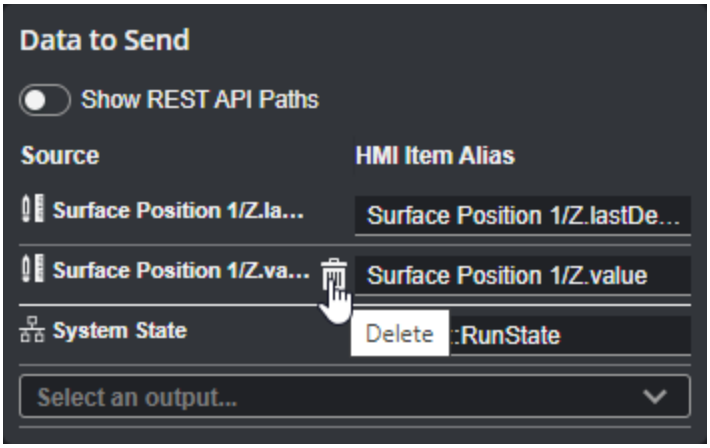
HMI

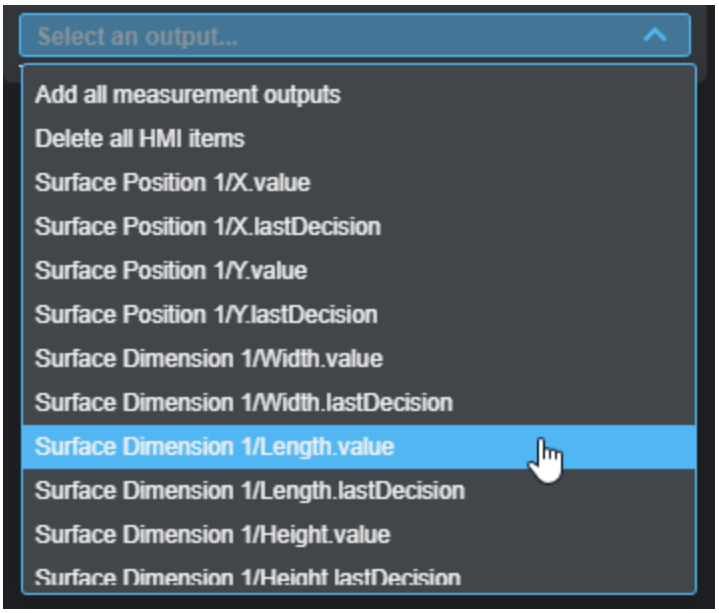
The HMI panel lets you enable GoHMI, choose which outputs you want to send to an HMI application, and start communication with the HMI.

For details, see *GoHMI and GoHMI Designer* on page 666.



	Element	Description
1	HMI	Lets you enable the HMI service. After you have enabled the service, the following functions are available: **Start / Stop**

	Element	Description
		Starts / stops the HMI application. After starting the application, a **View live** button is available, which lets you open the HMI in a browser tab. **View live** Opens the HMI in a browser tab. **Import / Export** 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.
2	Show REST API Paths	Toggles between showing the full internal path to an output and an alias, which is simplified.
3	Tool & Sensor Outputs	The list of outputs (scan data and tool outputs) that GoPxL will send to an HMI. You can remove an output from the list by hovering over it and clicking the trashcan icon. 
4	Output selector	Lists the available outputs. Click an output in the drop-down to add it to the outputs GoPxL will send to an HMI.

Element	Description
	

Reporting

The **Report** category summarizes sensor and system health information and provides tool and measurement statistics. It also provides tool performance statistics.

Available report pages

Report	Description
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* below.
Measurements	The Measurements page provides statistics for each enabled measurement. For more information, see *Measurements* on page 652.
Performance	The Performance page provides performance statistics. For more information, see *Performance* on page 654.

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 NX), the value reported in the System section comes from the accelerator. However, only the following metrics are appreciably different when accelerated: Uptime, CPU Usage, Memory Usage, and System/User Storage Usage.

System health

Name	Description
System state	Current system state.
Application version	System software version.
Uptime	Time since the system was power-cycled or reset. (If the sensor is accelerated by a

Name	Description
	PC, the PC's uptime.)
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 health

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.
Scanner drops	Number of sensor group (scanner) drops.
Trigger drops	Count of camera frames dropped due to excessive trigger speed.



For each sensor in a system, GoPxL displays a table 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. With snapshot sensors, enabling safety is not required in order to scan.
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 send rate	Rate at which data is being sent to the sensor over Ethernet (Mbps).
Ethernet receive rate	Rate at which data is being received by the sensor over Ethernet (Mbps).
Ethernet link speed	Speed of the Ethernet link.
Memory usage	Sensor memory usage (MB used / MB total available).
User storage usage	Sensor flash storage usage (MB used / MB total available). When

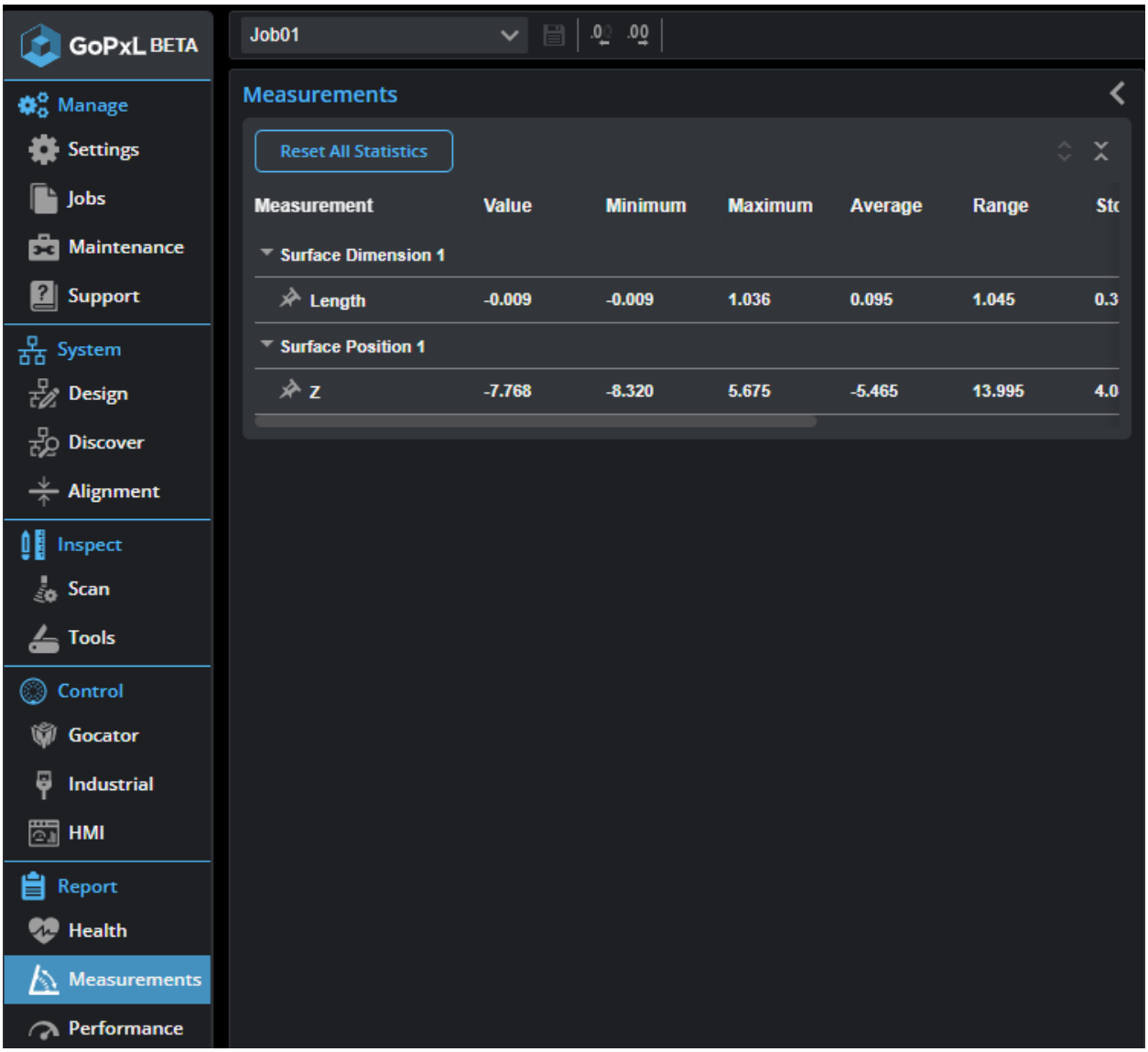
Name	Description
System storage usage	Non-volatile storage available (MB used / MB total available).
Max Spot Count	Maximum available spots, across all cameras. (G2)
Total exposure time	Total exposure time of laser light (G2), projector (G3), or light source (G5)
Internal temperature	Internal sensor temperature (degrees Celsius).
Laser driver temperature	Laser driver control temperature (degrees Celcius). (G2)
Light driver temperature	Light driver control temperature (degrees Celcius). (G5)
LED PCB temperature	LED PCB temperature (degrees Celcius). (G5)
External thermistor temp.	External thermistor temperature (degrees Celcius). (G5)
Projector illumination temp	Projector temperature (G3).
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.

Control

Name	Description
Gocator control drop	The number of Gocator protocol drops.

Measurements

The **Report** > **Measurements** page displays statistics for each measurement enabled in the **Inspect** > **Tools** 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 each measurement, the following information is available:

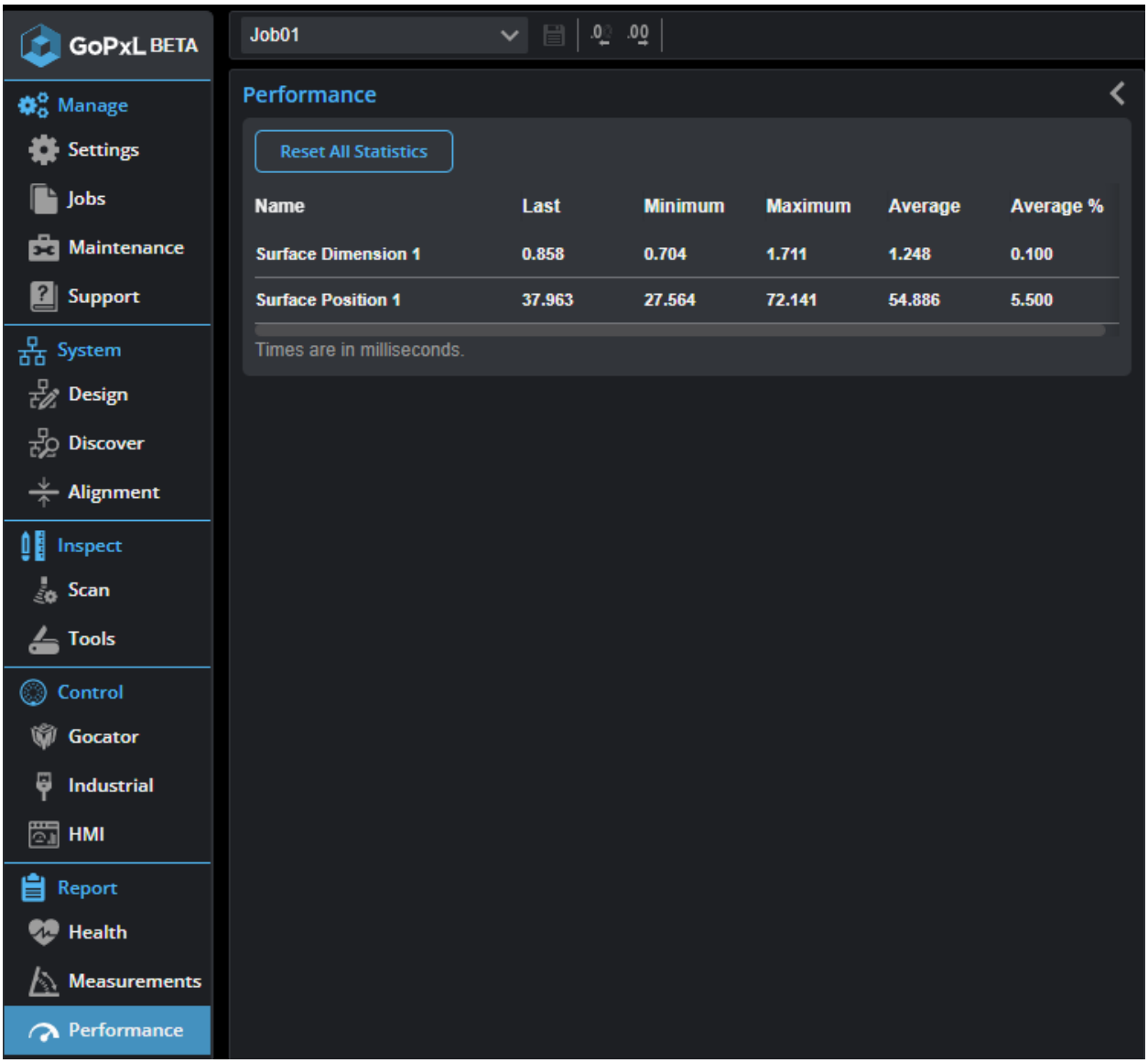
Measurement statistics

Name	Description
Value	The most recent measurement value.
Minimum	The minimum measurement value that has been observed.
Maximum	The maximum measurement value that has been observed.
Average	The average of all measurement values collected since the sensor was started.
Range	The difference between Max and Min.
Std Dev	The standard deviation of all measurement values collected since the sensor was started.

Name	Description
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.

Performance

The **Report** > **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

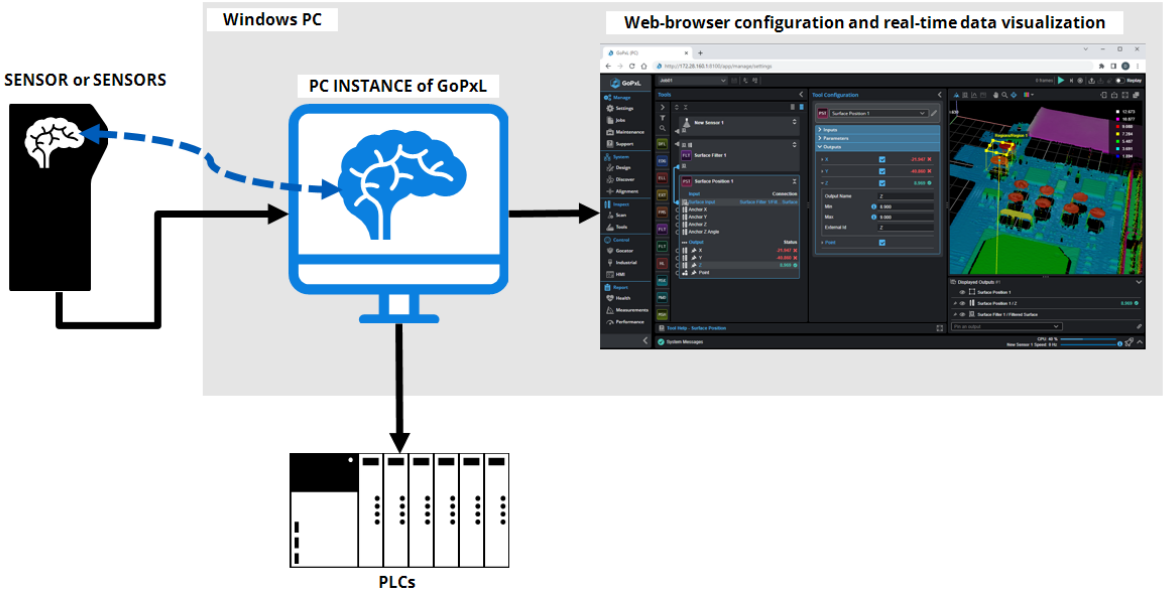
Name	Description
Last	The latest execution time of the tool.
Minimum	The minimum execution time of the tool.
Maximum	The maximum execution time of the tool.
Average	The average execution time of the tool.
Average %	The average percentage of the execution time of the tool.

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 750.)

You can also run GoPxL on a Windows PC. We call GoPxL running on a PC a "PC (or local) instance of GoPxL." 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 an PC instance of GoPxL, the PC 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.



- 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 663.

> 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 39.

The user interface of GoPxL running on a sensor and GoPxL running on a PC is largely the same, with the exception of the following:

- When you connect directly to a sensor, a sensor group containing the sensor is already created. When you launch GoPxL on a PC, no sensor group is created. You must do this yourself by adding a sensor to the PC instance. For more information on this, see *Accelerating a Sensor* on page 659. For information on sensors and sensor groups, see *Sensors, Sensor Groups, and Systems* on page 41.
- 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 sensor group (or delete the group) and connect to the sensor directly to perform these operations.

> Job files you create in a PC instance of GoPxL are separate from any jobs that are on the sensor. Be sure to back them up if ever you need to run them directly on the sensor.

System Requirements

The following are the 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 (32-bit and other OS are not supported)
- Display: 1366 x 768

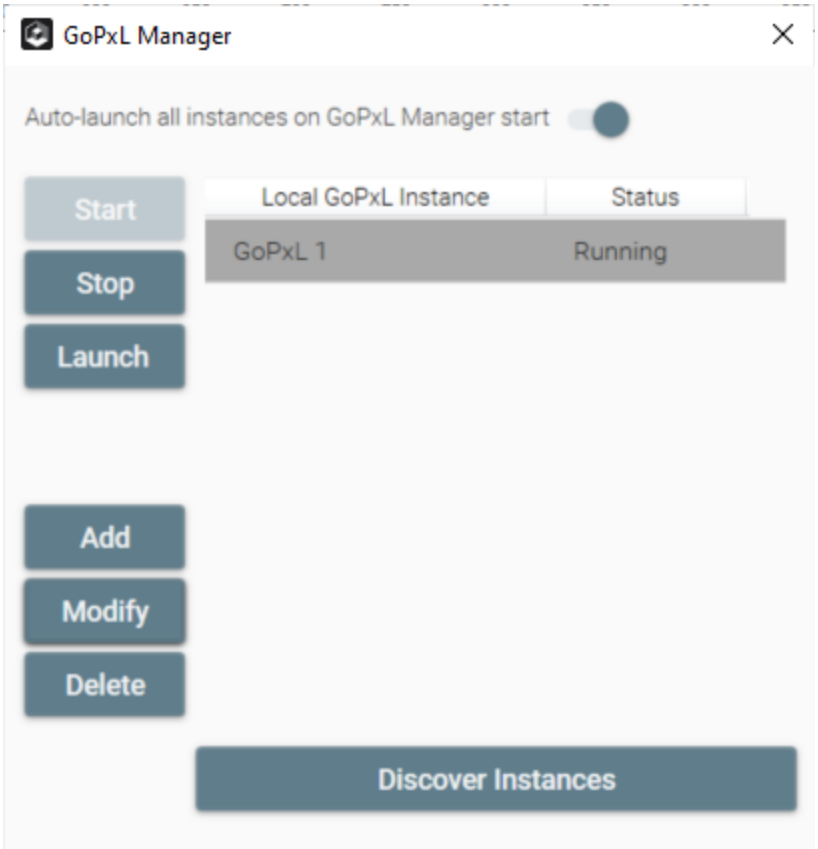
To accelerate more sensors or to run the system at higher speeds, use a computer with greater system resources.

When using GoPxL on a Windows PC to accelerate a G3, the PC instance can make use of a graphics card with CUDA support. However, the following requirements must be met:

- A CUDA compatible graphics card.
- A graphics card with a "Compute Capability" greater than 5.2. To determine whether a card fulfils this requirement, see NVIDIA's *CUDA GPUs* page.
- The latest NVIDIA graphics card driver version. LMI recommends downloading the driver directly from the NVIDIA website to get the driver, rather than using the Windows Device Manager.

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 for Windows) 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 a PC instance of GoPxL

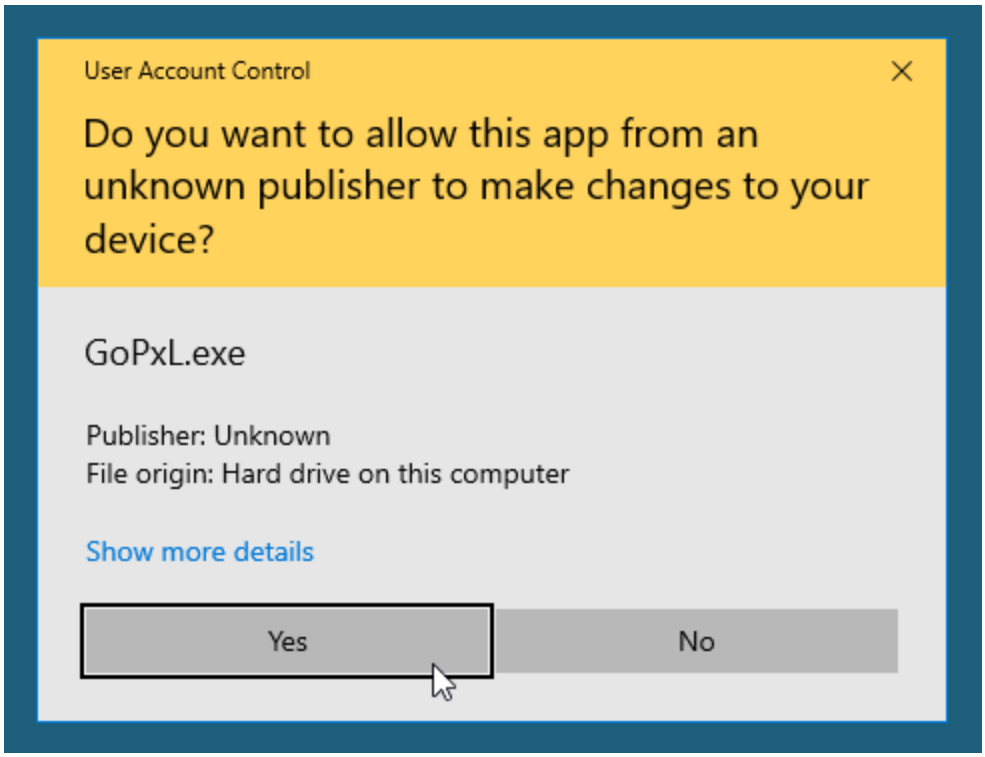
1. On the PC connected to the sensor, download and unzip the GoPxL Utilities package (`14631-x.x.x.x_SOFTWARE_GoPxL_Utilities.zip`).

   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 will display a User Account Control dialog. Click **Yes**.



Additionally, your firewall may ask if you want to allow the GoPxL Service Application to communicate over your network. The Windows firewall default is to only allow communications over Private networks. To avoid issues, LMI recommends allowing communication over both Public and Private networks.

At this point, you can do one of the following:

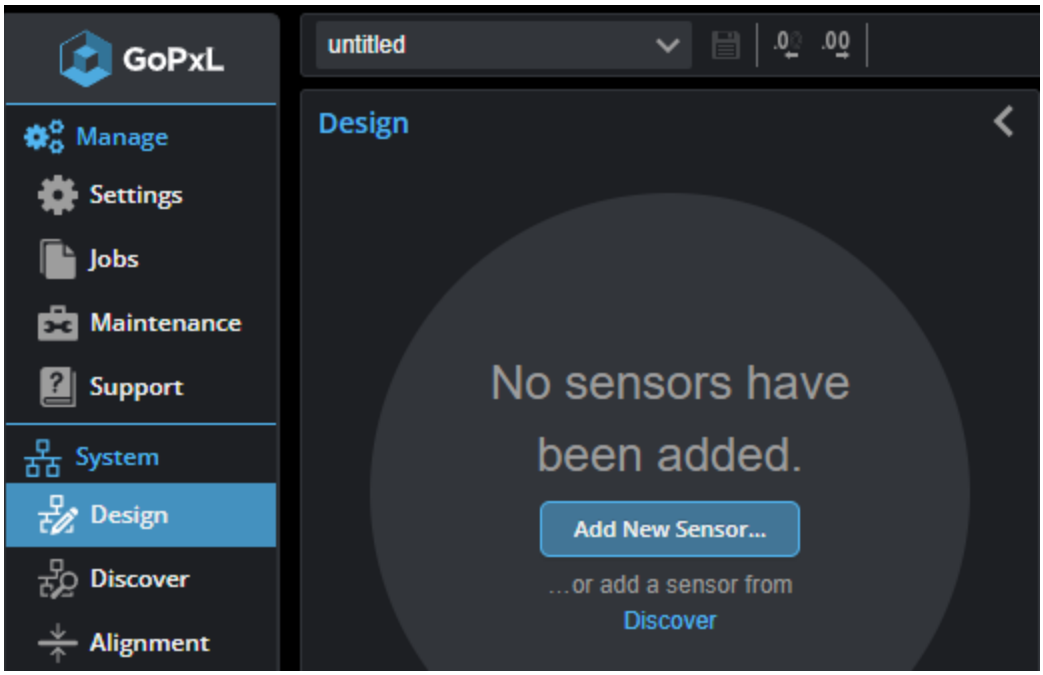
- Add one or more sensors to the PC instance to accelerate it. For information on adding a sensor to a sensor group, see *Accelerating a Sensor* below.
- Open scan data someone has previously recorded (in a .gprec file) and examine the data or use it to configure measurement tools without taking your sensor system offline. For more information, see *Loading Scan Data* on page 663. (For information on the file formats used with GoPxL, see *File Formats* on page 83.)

Accelerating a Sensor

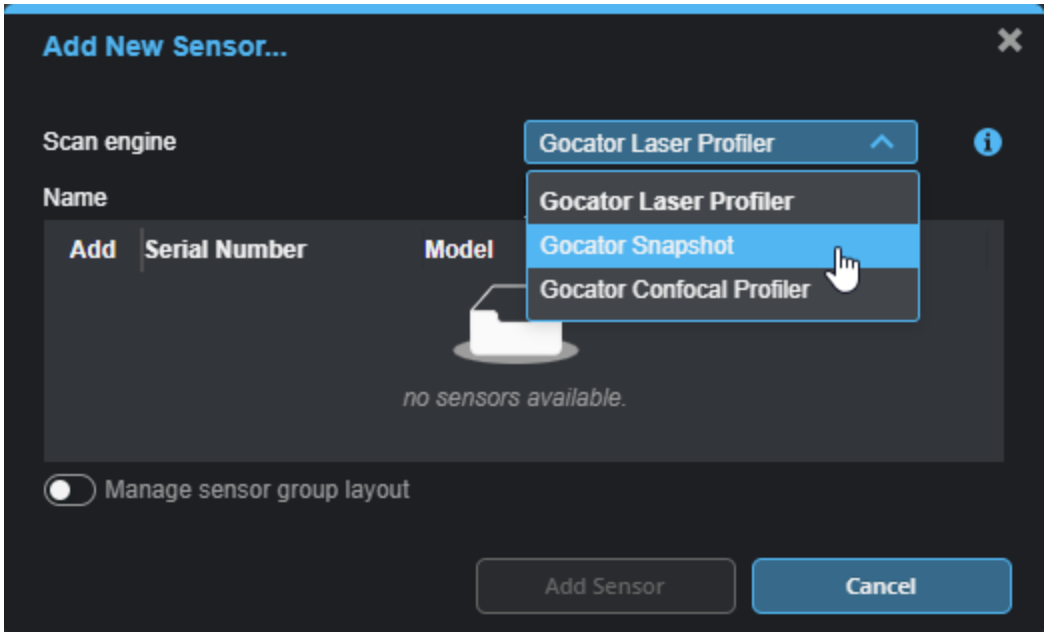
You can accelerate a sensor by connecting it to a PC instance of GoPxL.

To accelerate a sensor

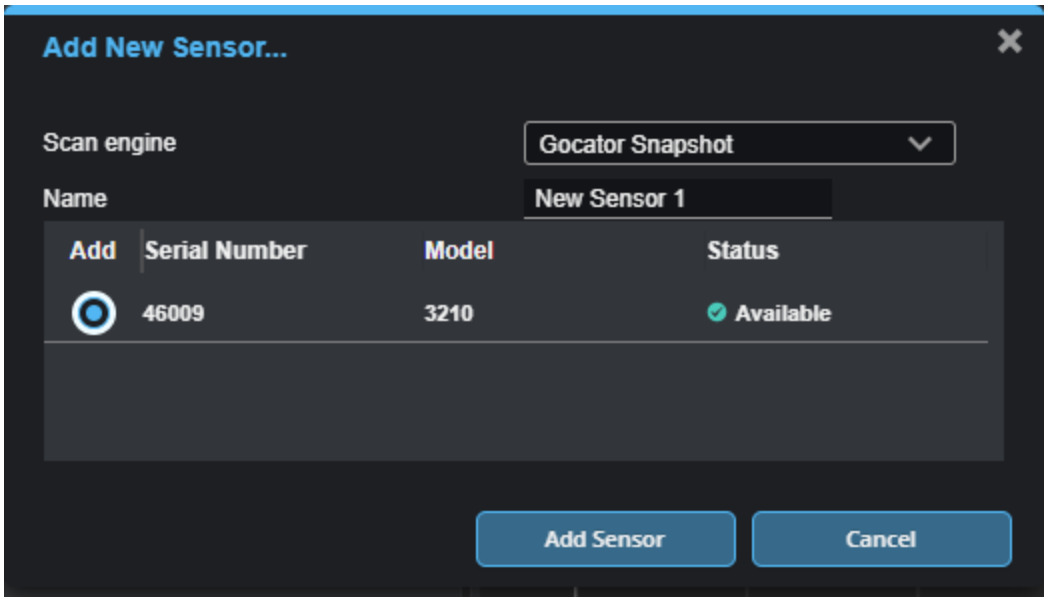
1. In the browser, go to the **System** > **Design** page and click **Add New Senor...**



2. In **Add New Sensor**, choose the scan engine appropriate for your device



3. Check the Add checkbox next to the device in the table, and click **Add Sensor**.



The physical sensor is now connected to the PC instance of GoPxL, and you control and configure it through the PC instance. The sensor is automatically accelerated.

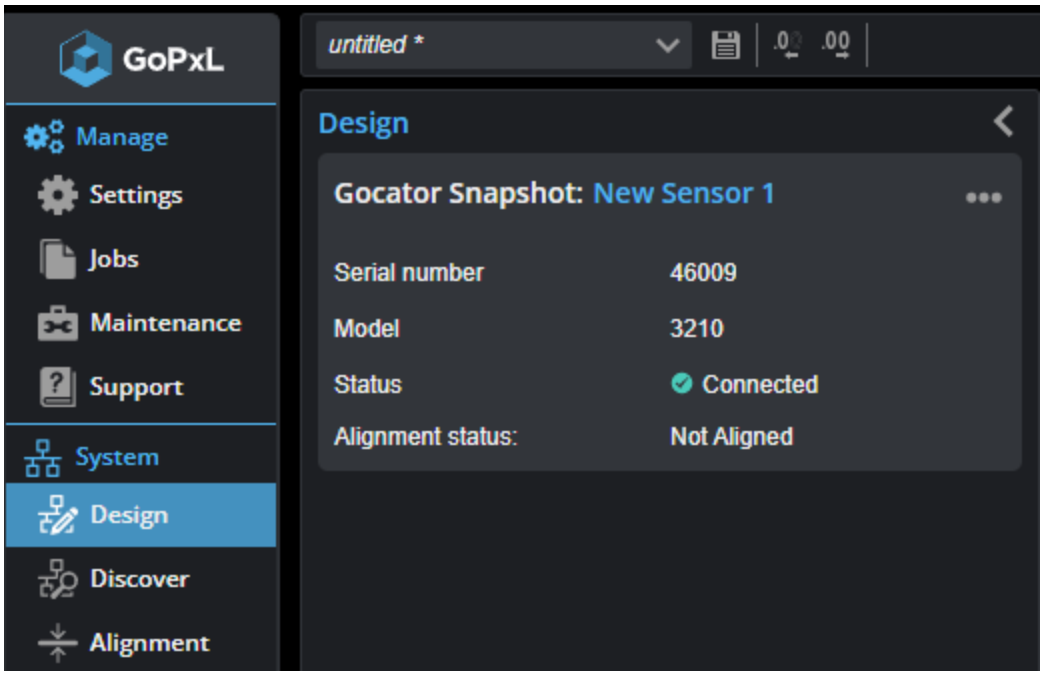
For information on enabling and configuring GoHMI, see *GoHMI and GoHMI Designer* on page 666.

Stopping Acceleration

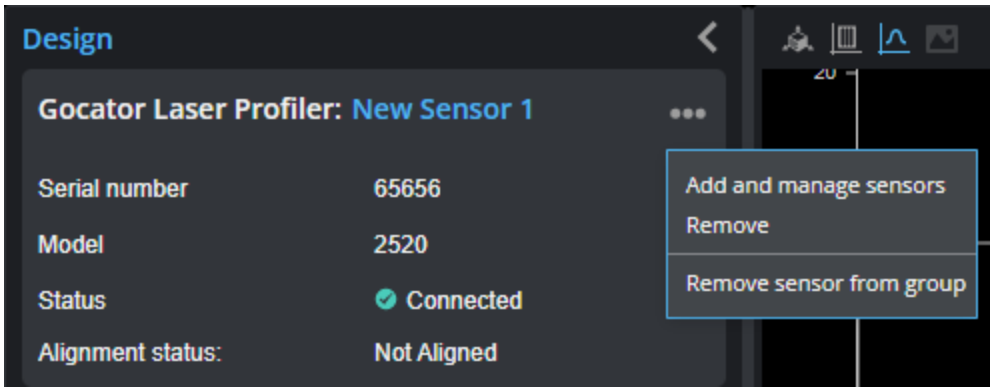
To stop accelerating a sensor, you remove it from the PC instance of GoPxL it's connected to.

To remove a sensor from a PC instance

1. In the GoPxL interface of the PC instance, go to the **System** > **Design** page.



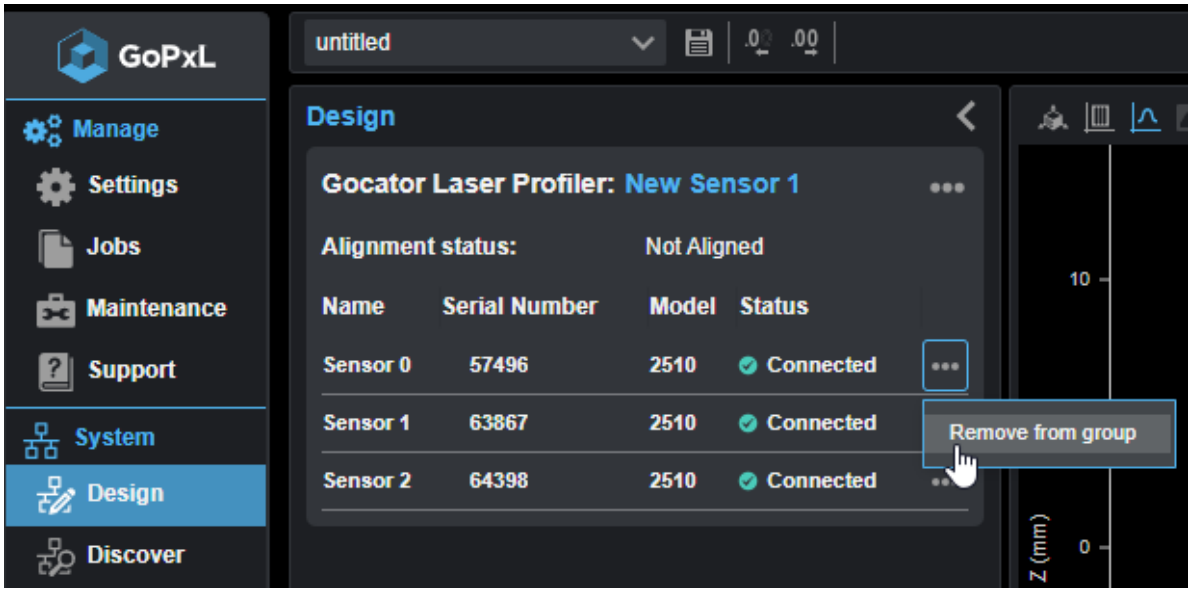
2. With single G2 sensors, click the three dots menu (•••) and click **Remove** or **Remove sensor from group**.



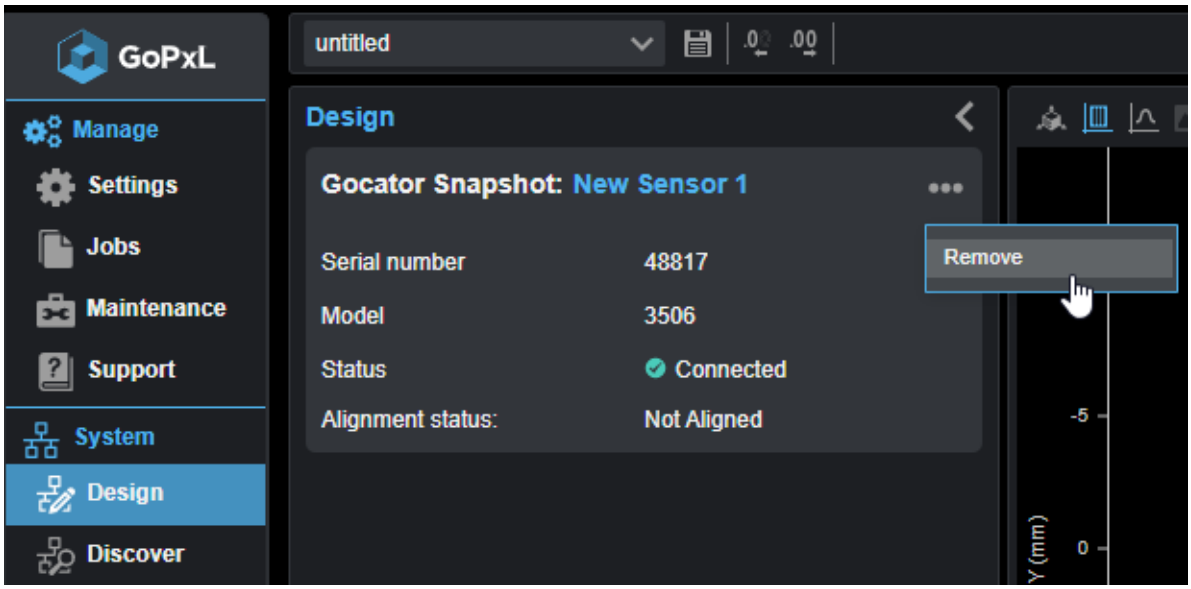
Remove: Choose this to remove the sensor and the sensor group containing it. If you have started configuring settings on the **Inspect** > **Scan** page, choose the next option instead.

Remove sensor from the group: Choose this if you have started configuring settings on the **Inspect** > **Scan** page and just need to add a different sensor to the sensor group.

3. With multi-sensor G2 systems, click the three dots menu (•••) in the row containing the sensor you want to remove, and click **Remove from group**.



4. With G3 sensors, click the three dots menu (•••), and choose **Remove**.

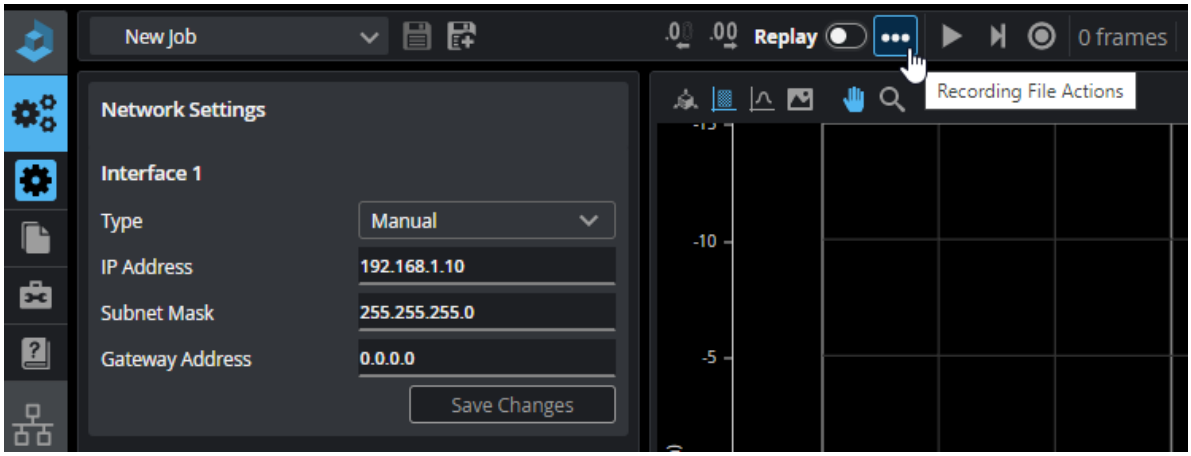


Loading Scan Data

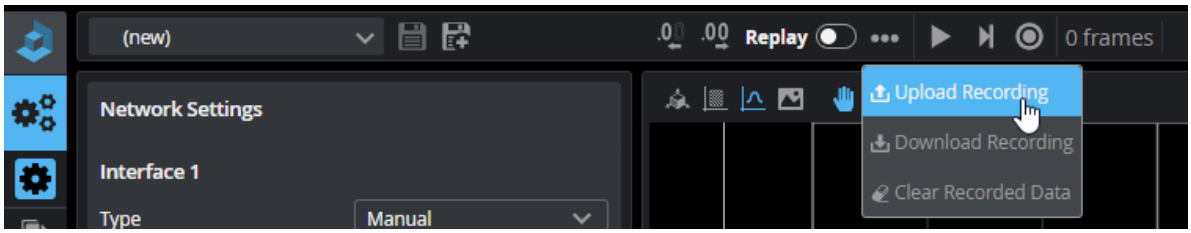
To examine previously recorded scan data offline, you load a .gprec file into the PC instance of GoPxL.

To load recorded data (.gprec)

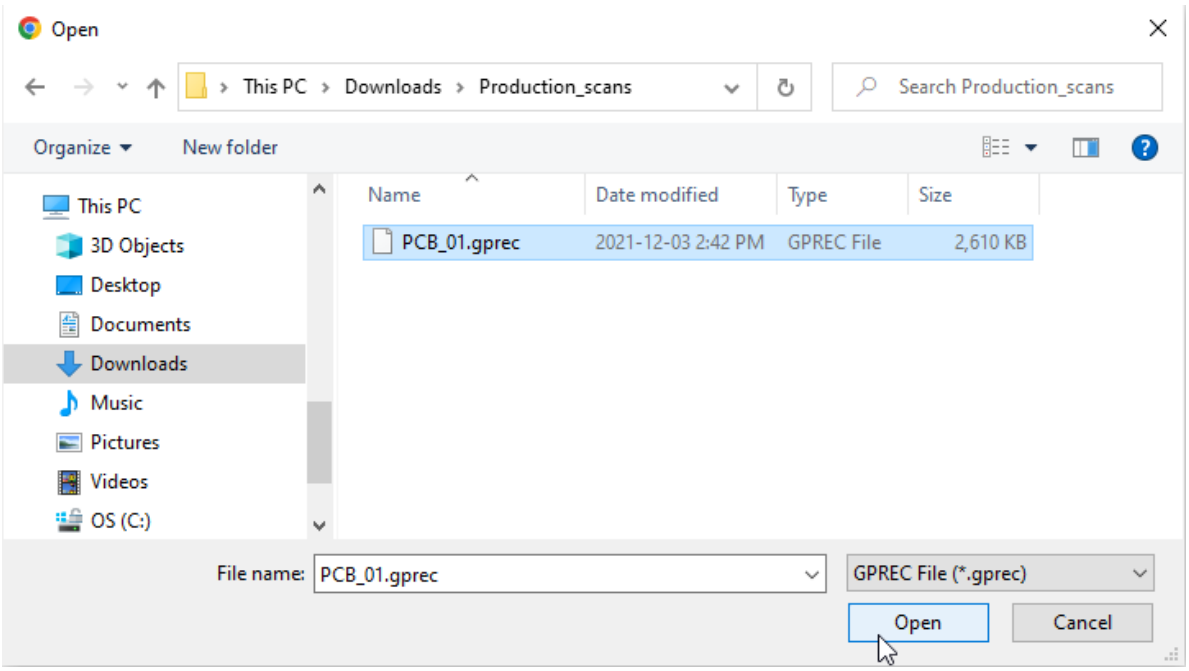
1. In the GoPxL interface above the data viewer, click the Recording File Actions button.



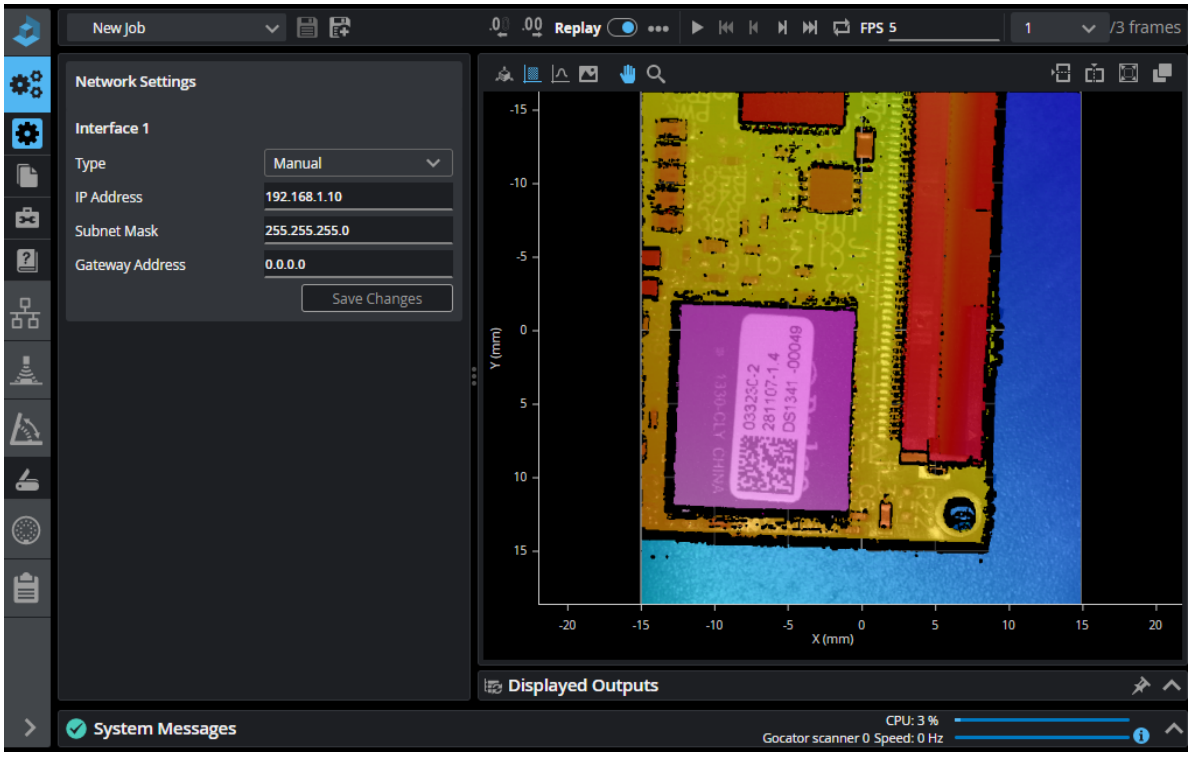
2. In the drop-down that appears, click



3. In the **Open** dialog, locate and select the recording (.gprec) you want to load, and click **Open**.



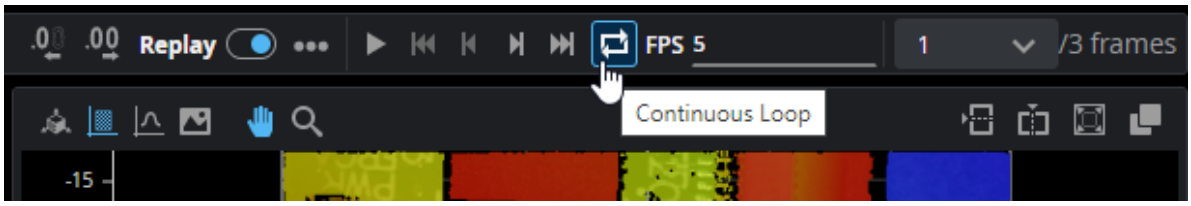
The recording loads in GoPxL, and GoPxL automatically switches to Replay mode.



You can now examine the recordings and configure tools using the data.

4. Use the replay controls above the data viewer to move through the frames, go to a specific frame, set continuous loop speed (FPS), and so on.

   Hover over the replay controls for tooltips describing their function.



Using continuous loop with a slow 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.

Continuous loop is also useful for demos.

GoHMI and GoHMI Designer

GoHMI lets you create flexible human-machine interfaces (HMIs), which lets you provide a custom GUI containing system and inspection metrics. Your HMI can be touch-enabled. You edit HMIs in GoHMI Designer.

	GoHMI and GoHMI Designer only support a single HMI app, called "GoHMI."

	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.

GoHMI application layout development involves the concept of containers. Containers contain widgets (user interface controls such as buttons) 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 alignment and adding widgets, you have complete control over your HMI app's 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, whereas 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 *Getting Started* on page 17.

2. Configure the sensor acquisition settings.

   For information on configuring acquisition settings, see *Configuring Acquisition* on page 107.

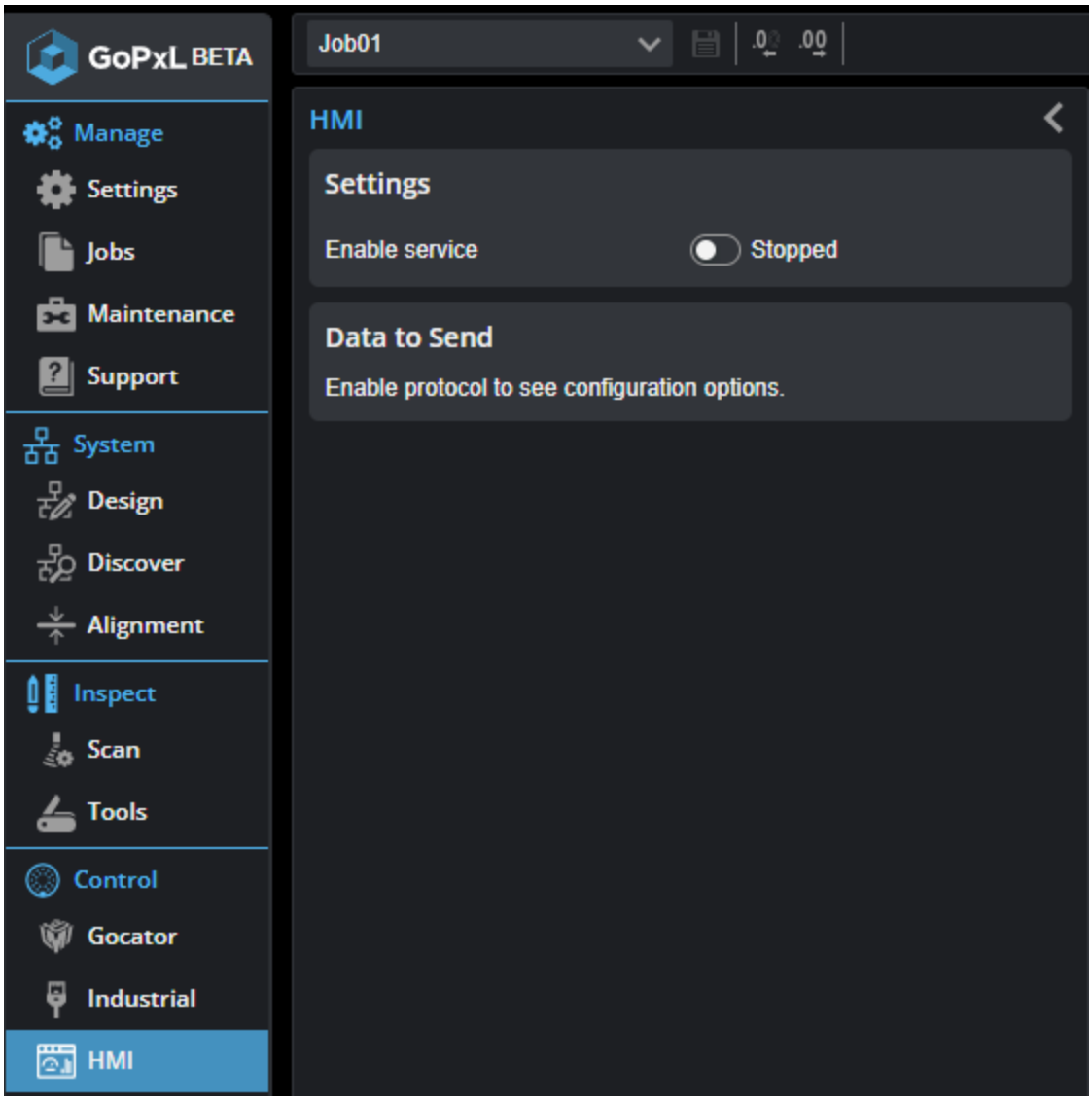
3. Add and configure measurement and processing tools.

   For more information, see *Configuring Inspection and Processing Tools* on page 127 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 703.

5. Enable the HMI control settings in the **Control** > **HMI** page using the toggle and configure GoHMI.



For more information, see *Enabling and Configuring GoHMI in GoPxL* below.

6. Launch GoHMI Designer.

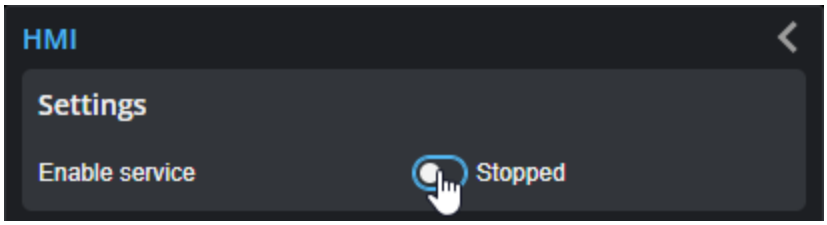
   For more information, see *Launching GoHMI Designer* on page 672.

Enabling and Configuring GoHMI in GoPxL

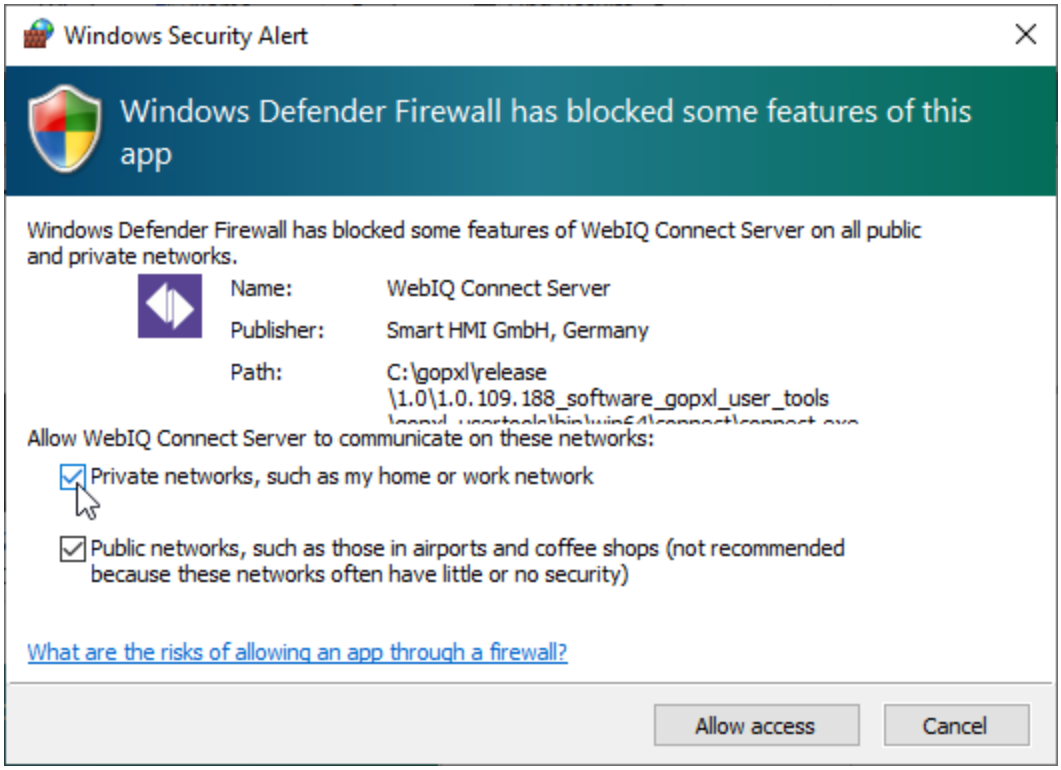
This section describes how to enable and configure GoHMI in the GoPxL interface. Before continuing, make sure you have created a sensor system, configured acquisition, added and enabled at least one measurement tool, and configured at least one measurement output. Later we use Surface Position.

To enable and configure GoHMI

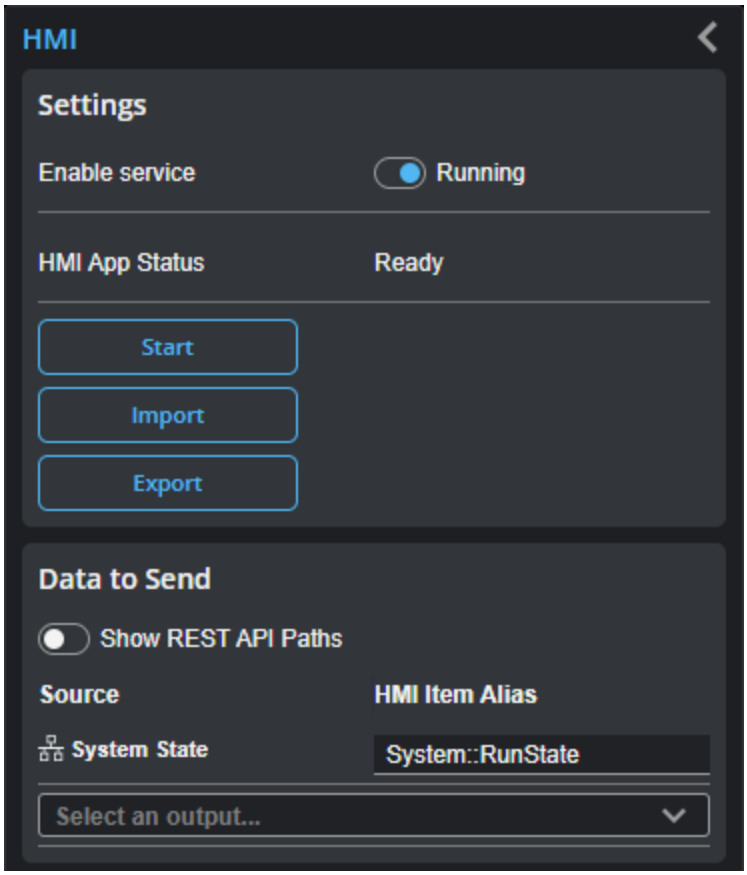
1. On the **Control** page, in the **HMI** panel, enable the HMI service.



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.



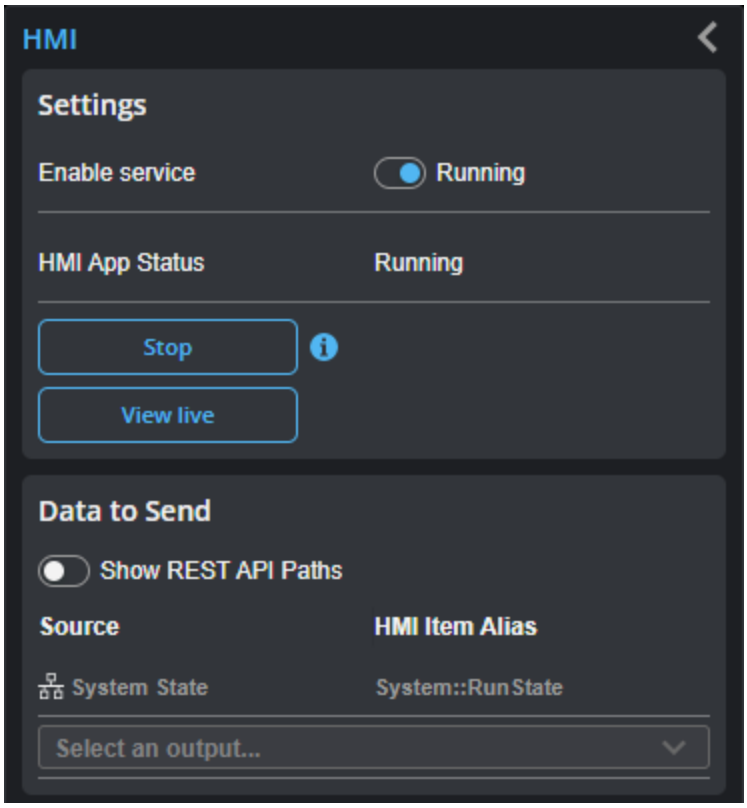
The HMI service launches, and the HMI panel displays the following:



The HMI panel provides three buttons.

Start lets you start the GoHMI application.

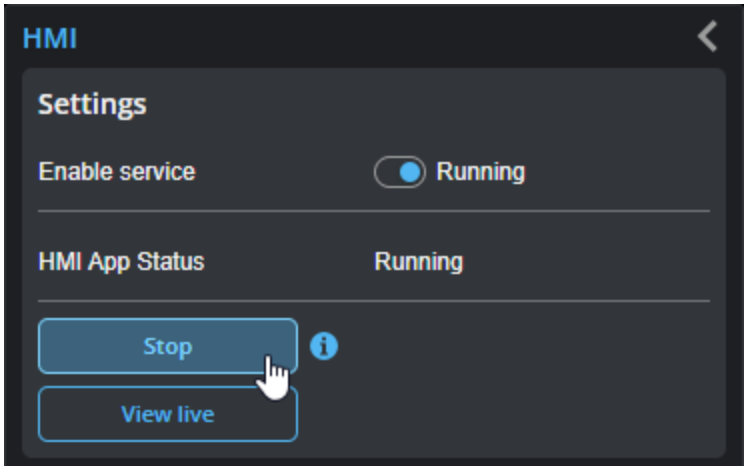
When the application is running, GoPxL displays a **View live** button that launches the application, in a new tab. Note that when the application is running, you can't add or remove outputs in the **Data to Send** panel.



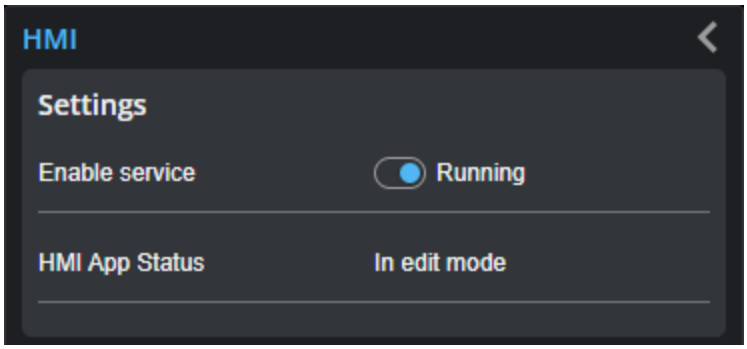
Import lets you import an HMI application.

Export lets you export the HMI application currently available on the sensor (or in the PC instance).

2. If the HMI app is already running, click **Stop** to stop it.



3. If you see **In edit mode** as the HMI status instead of **Ready**, you must clear the workspace in GoHMI Designer.



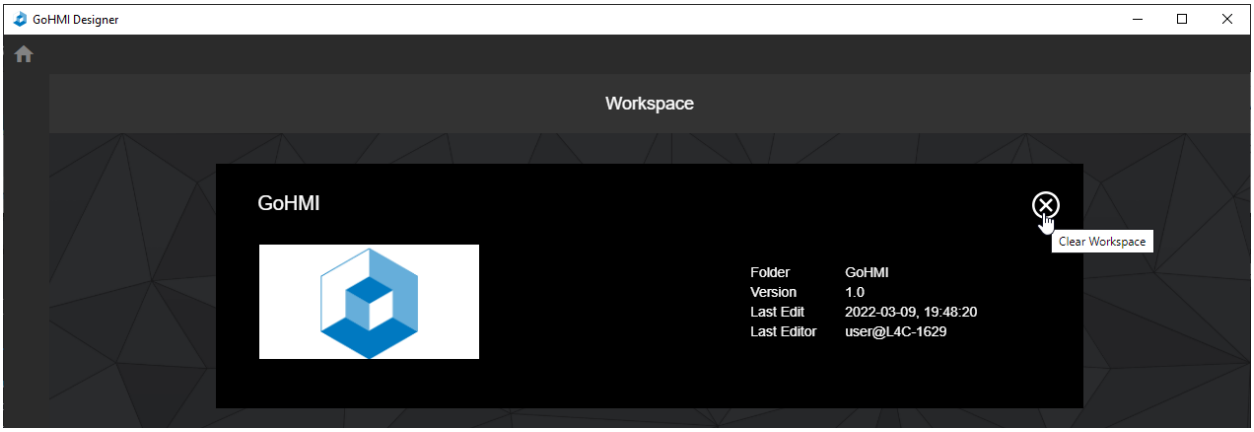
The status **In edit mode** means that someone has previously worked on the HMI app, and has not cleared it from the workspace in GoHMI Designer.

Do the following:

a. Launch GoHMI Designer.

   For more information, see *Launching GoHMI Designer* on the next page.

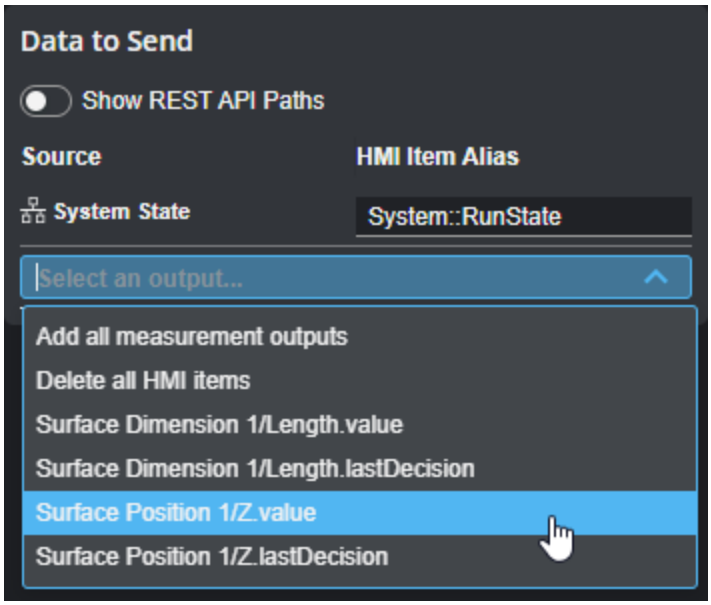
b. In GoHMI Designer, in the main screen, clear the workspace.



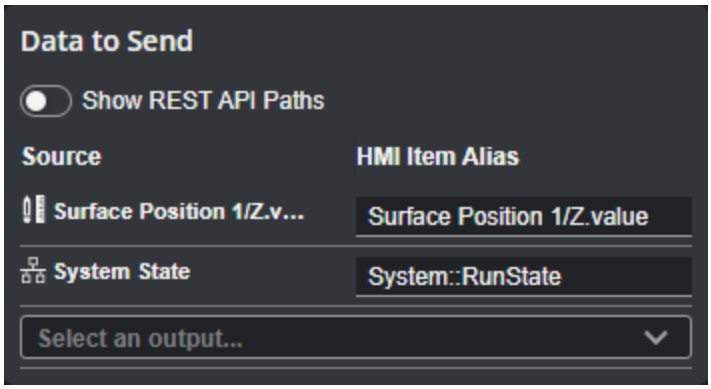
   If you have unsaved changes, you should publish them to the project directory to save them. In GoHMI Designer, this is called "publishing" the HMI. For more information, see *Publishing Changes* on page 683.

c. Return to the PC instance of GoPxL.

4. In the **Data to Send** panel below, expand the output drop-down and click the outputs 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.



You can toggle between showing HMI item aliases and HMI item paths of the outputs.

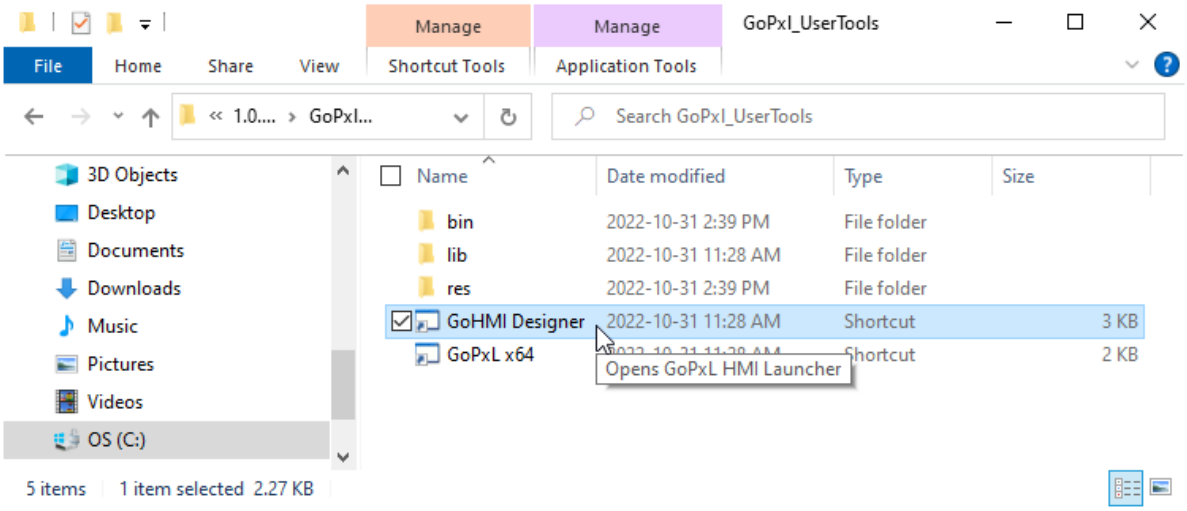
If you don't see the output you want to add, check that you have enabled it in the measurement tool, on the **Inspect** > **Tools** page.

Launching GoHMI Designer

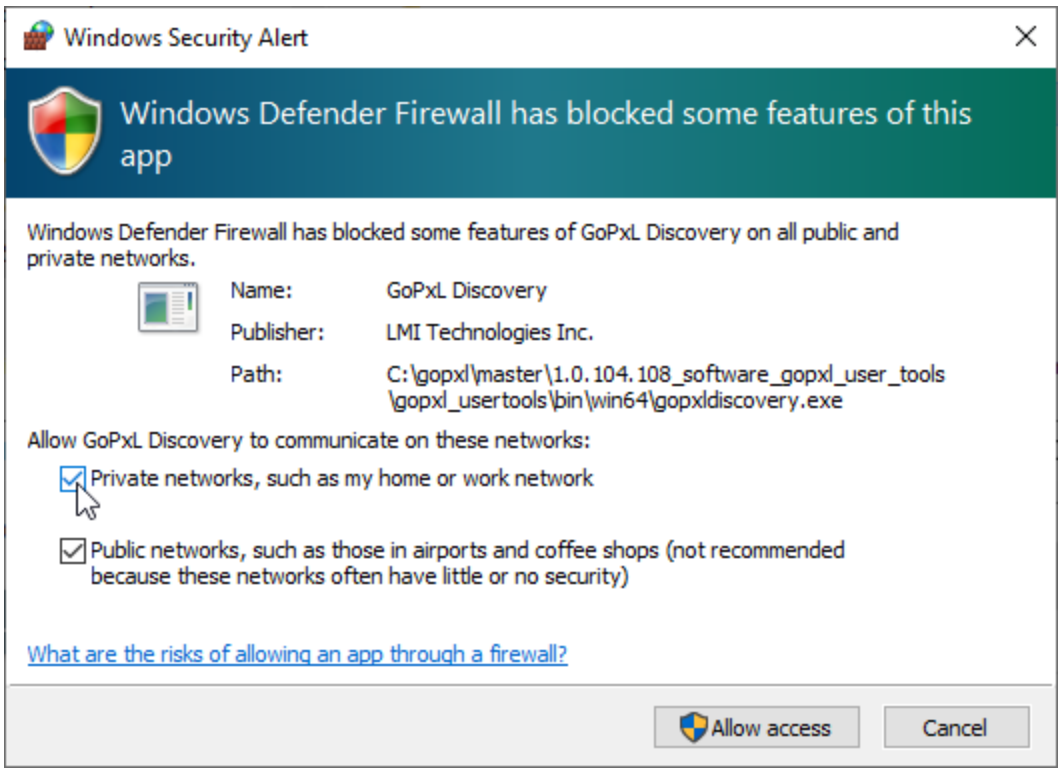
After you have enabled the HMI service and configured it by adding the outputs you want to send to the HMI, you can launch GoHMI Designer to create or edit an HMI.

To launch GoHMI Designer

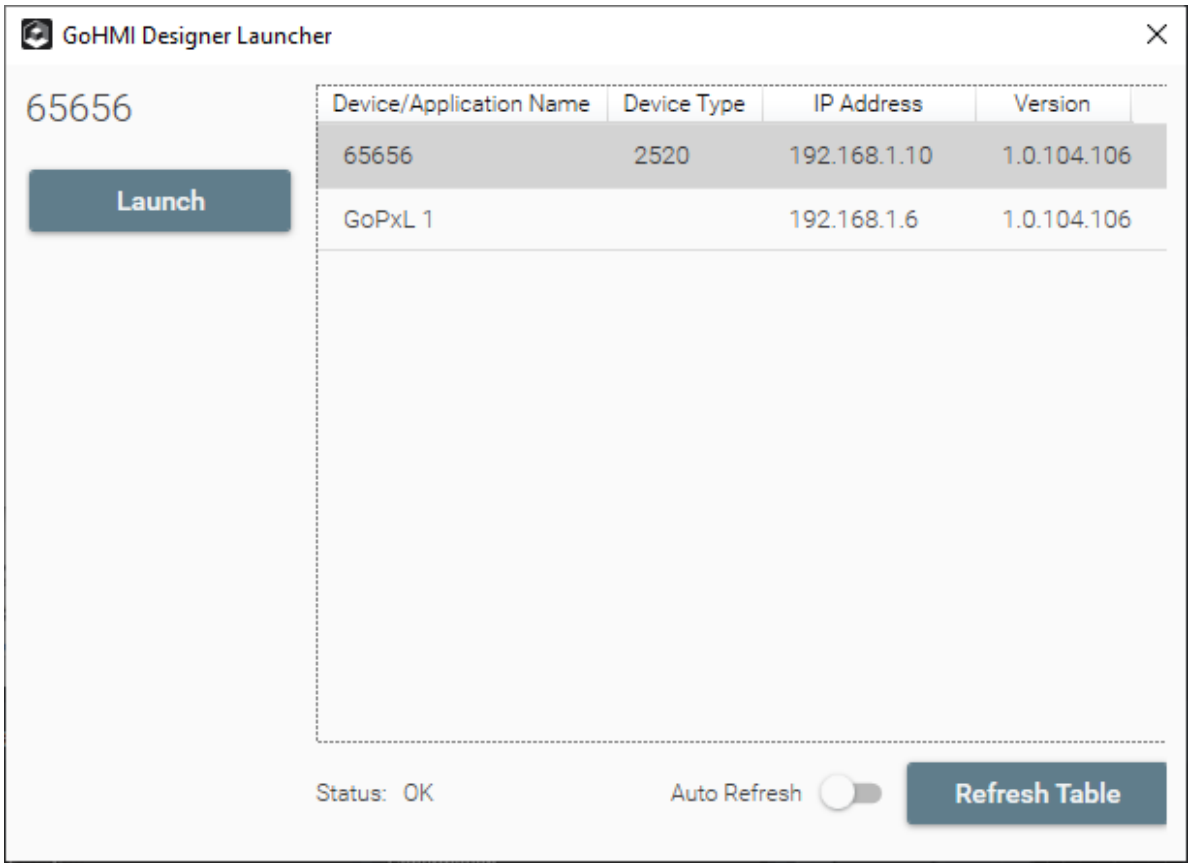
1. Go to where you extracted the GoPxL tools, and double-click the GoHMI Designer shortcut.



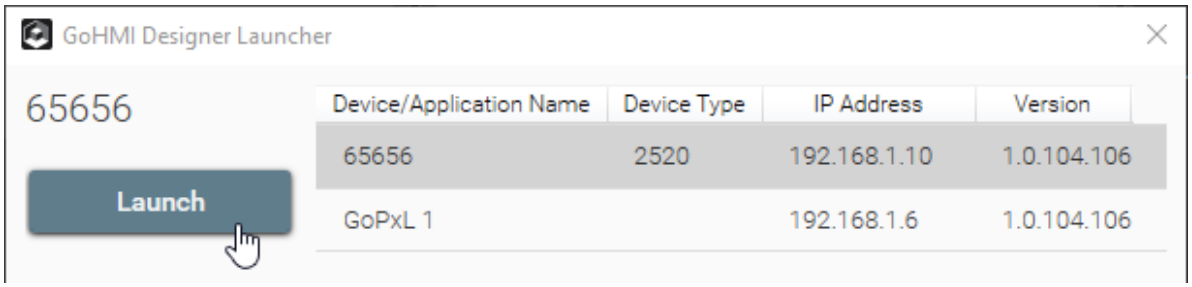
2. (Optional) If a Windows Security Alert opens, enable both networks and click **Allow access**.



GoHMI Designer Launcher opens and lists the available instances of GoPxL. The launcher lists sensors running GoPxL and any PC instances you have previously launched. In the following, we see a Gocator 2520 running GoPxL and a PC instance of GoPxL called "GoPxL 1."



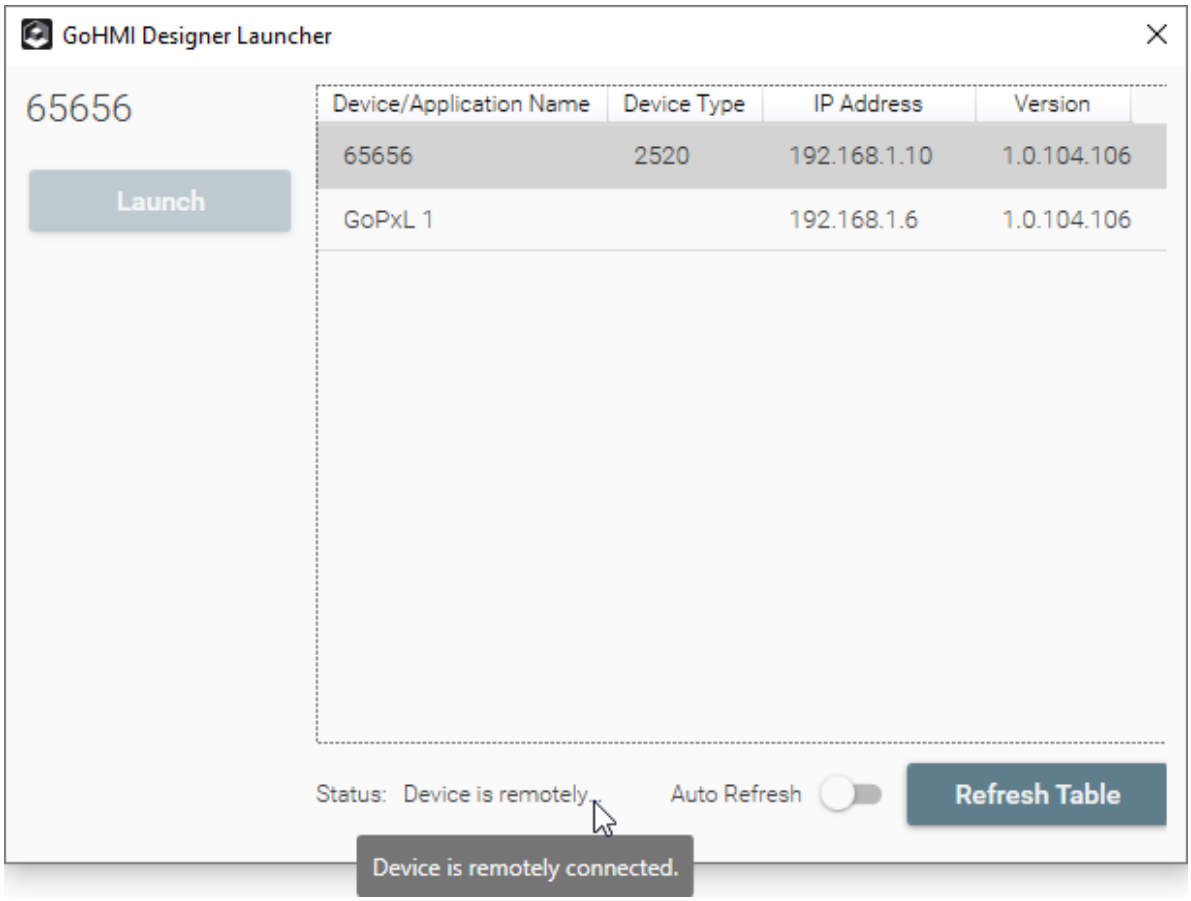
3. In the designer, select the row of the GoPxL instance for which you want to launch GoHMI Designer and click **Launch**.



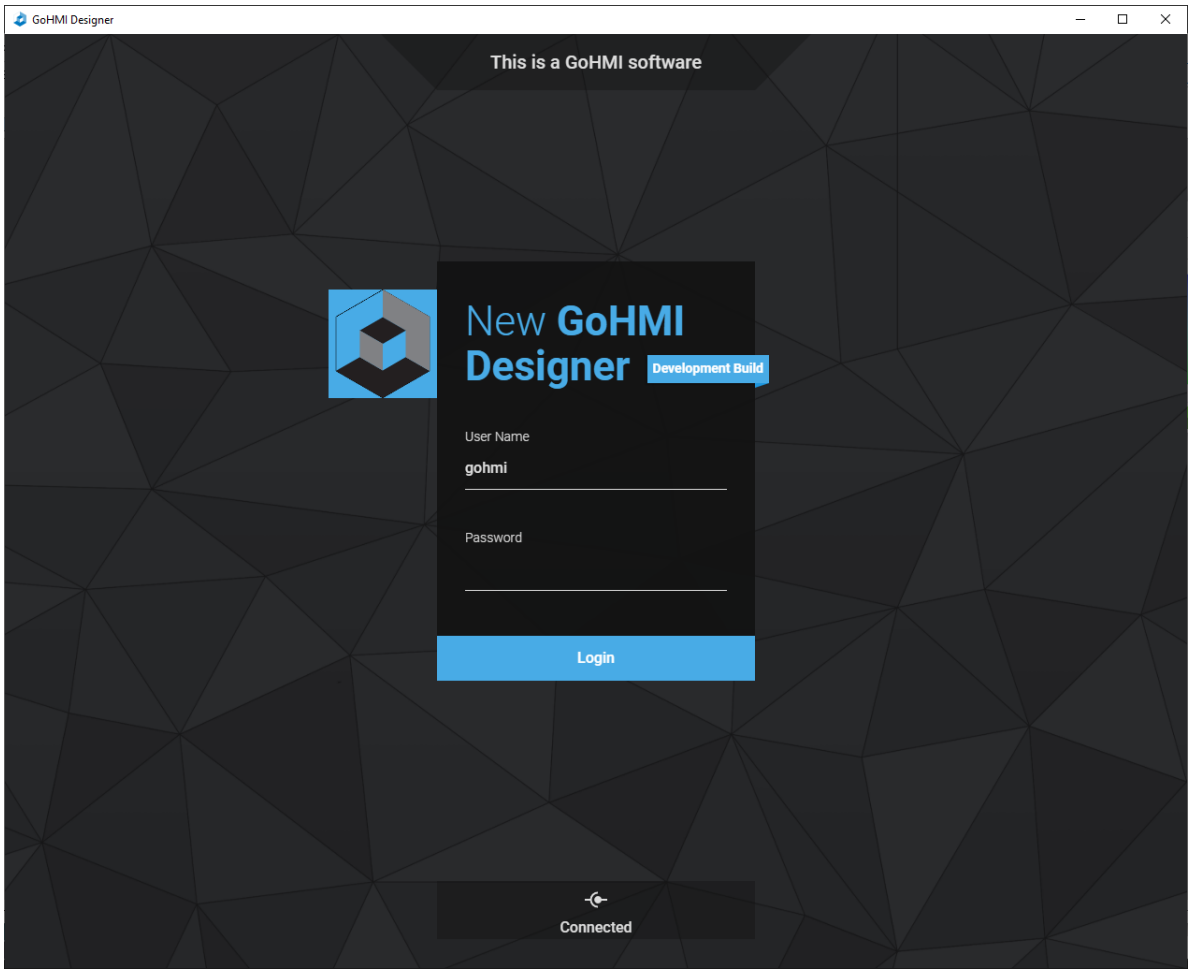
You may need to refresh the table to get the most up-to-date list by clicking **Refresh Table**. You can toggle **Auto Refresh** to have the table refresh automatically.

Note that you can only launch one instance of GoHMI Designer on a PC 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 the GoHMI Designer login screen appears.



4. Log in to the designer.

   By default, use "gohmi" for the user name and "gohmi" for the password.

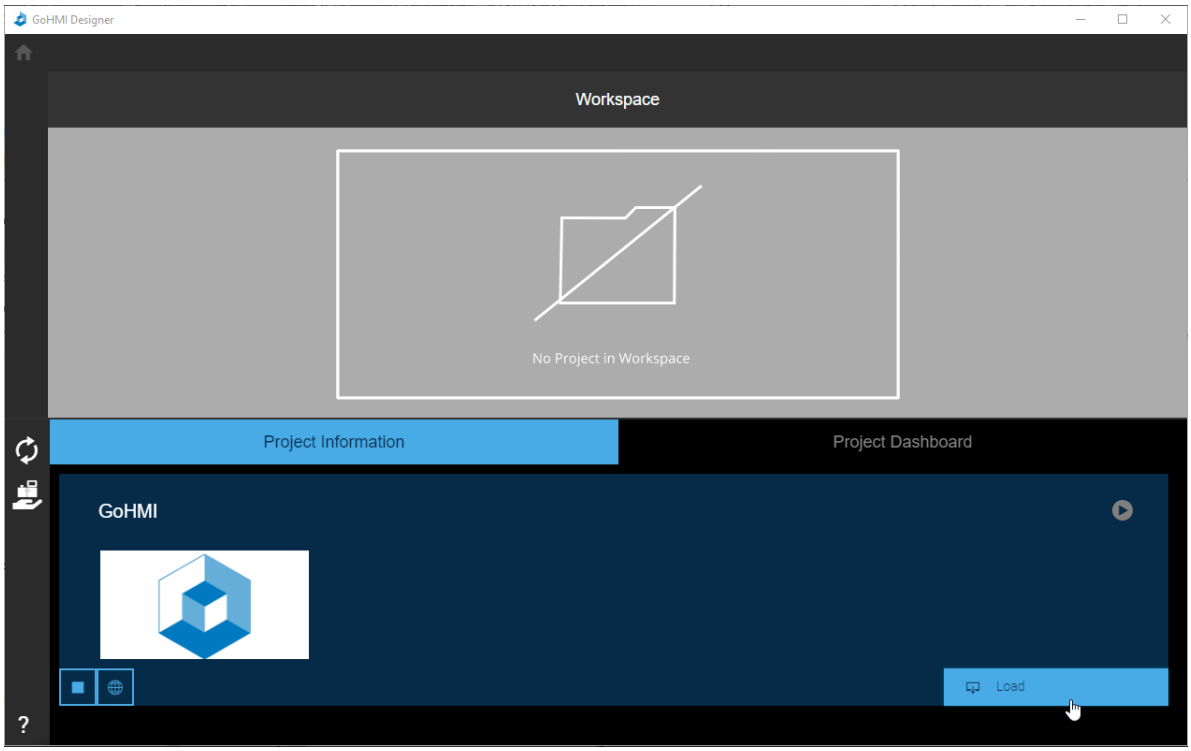
Opening, Editing, and Saving a Project

This section describes how to open the a GoHMI project (called GoHMI), modify it, and save it.

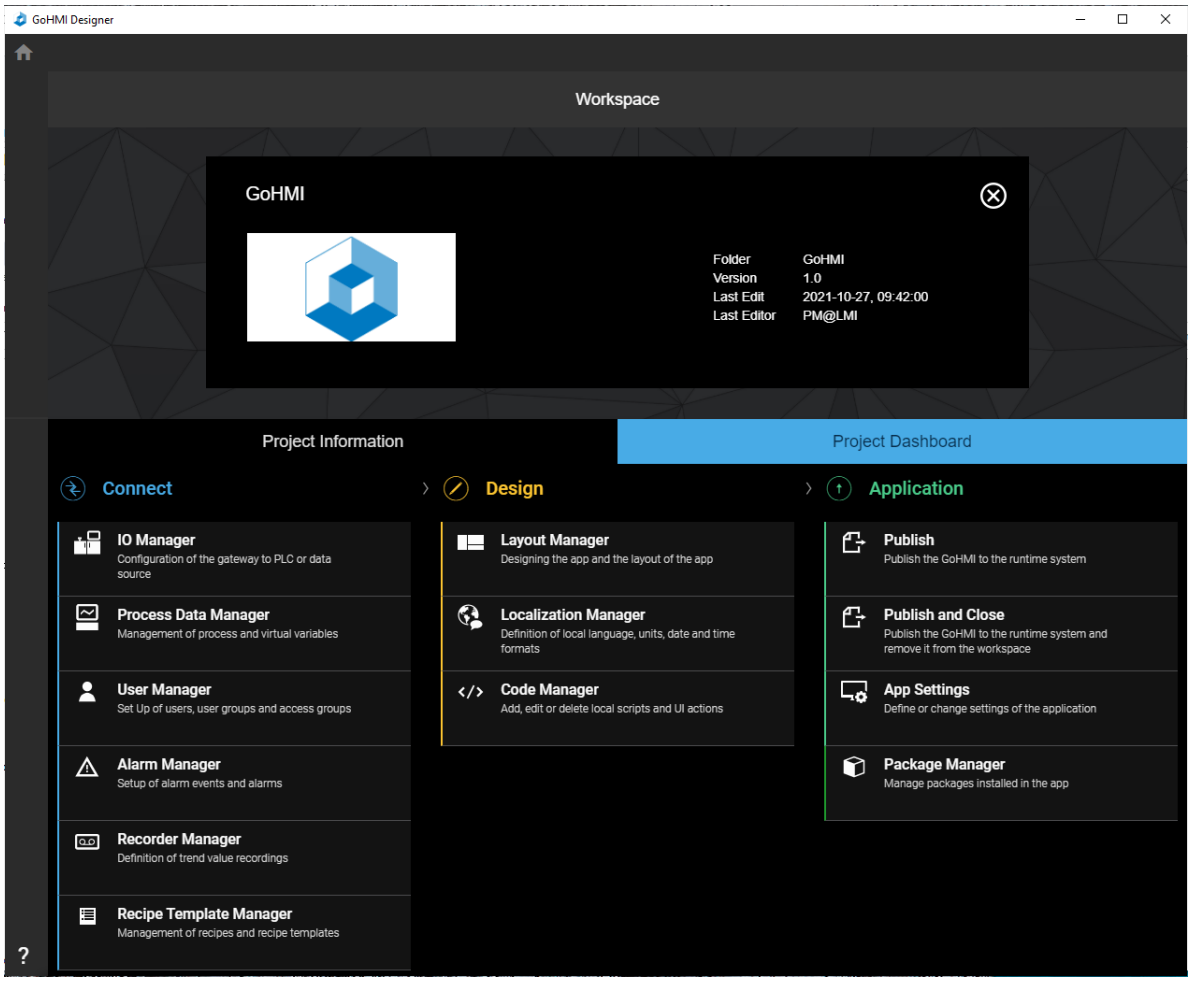
	GoHMI Designer only supports a single HMI application at a time.

To open a project

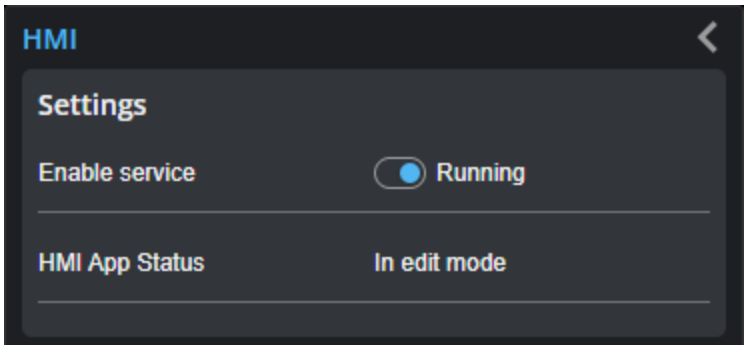
1. In the Project Information tab, hover the mouse over the GoHMI project and click **Load**.



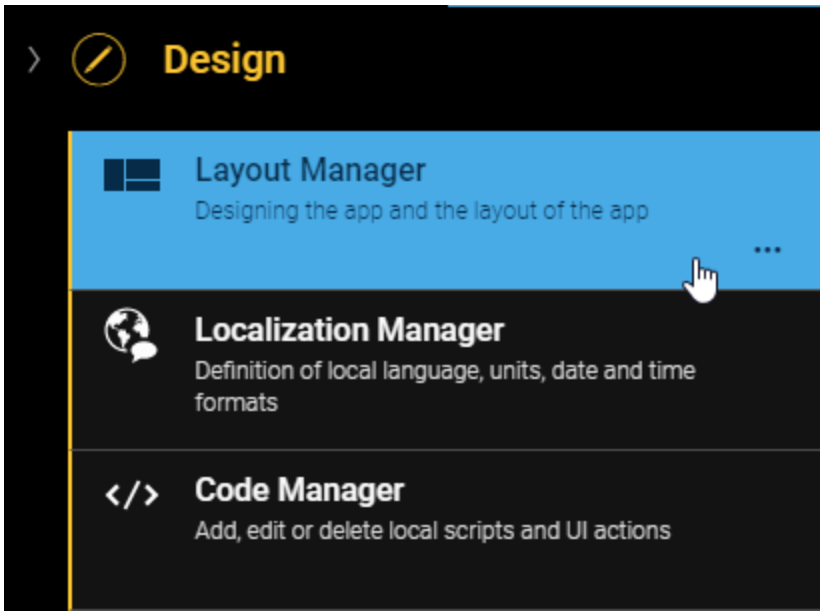
The designer loads the HMI into the workspace and switches to the Project Dashboard tab. When you click a manager in this tab, the HMI project opens in that manager.



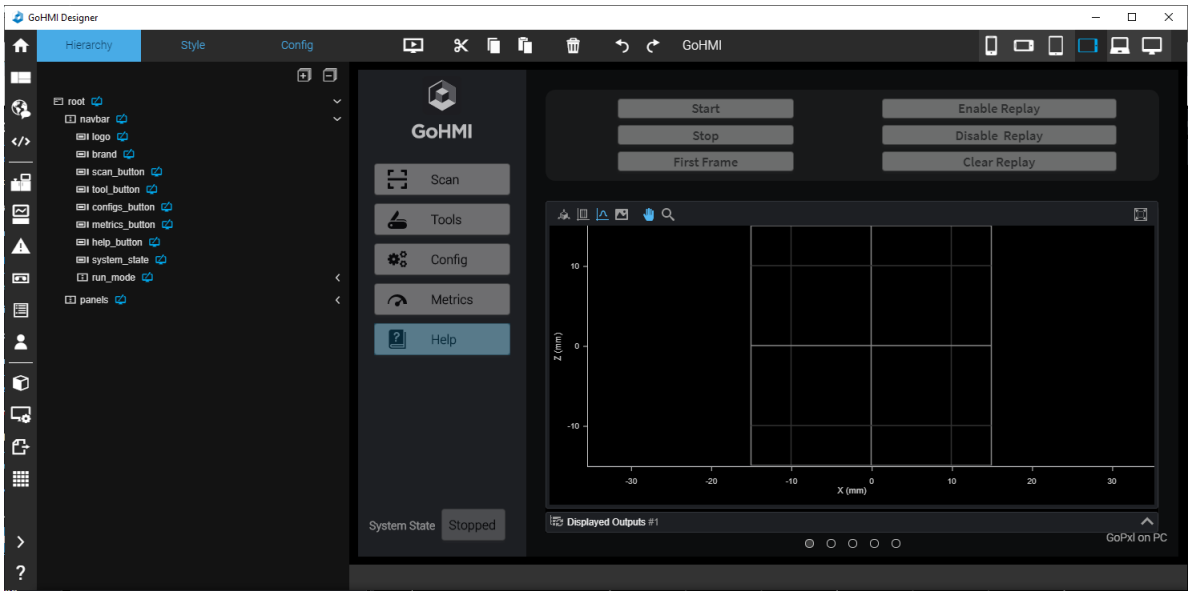
Note that in the GoPxL interface, the HMI app status becomes "In edit mode."



2. Click Layout Manager in the Project Dashboard tab.



The project opens in the Layout Manager.



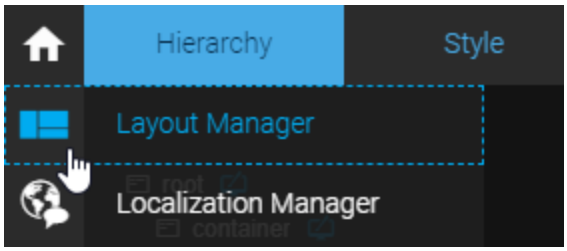
After you have loaded the HMI in the Layout Manager, we will add a label widget.

	Before modifying the demo HMI, you should export it for safe-keeping. For more information, see *Importing and Exporting an HMI* on page 685.

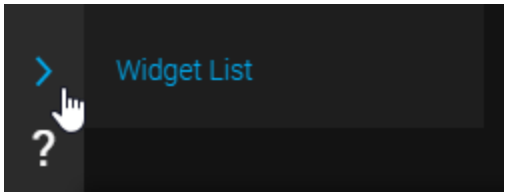
	The following uses an old version of the default app.

To add a widget

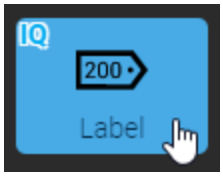
1. Move the mouse over side bar on the left and click Layout Manger to make sure you're in the Layout Manager.



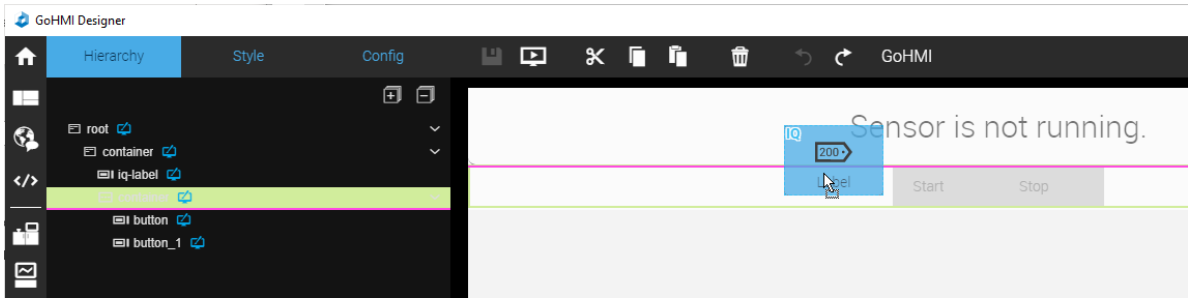
2. While still hovering over the side bar, move down to Widget List.



3. In the Widget List panel that opens, drag the Label widget toward the HMI in the Layout Manager.

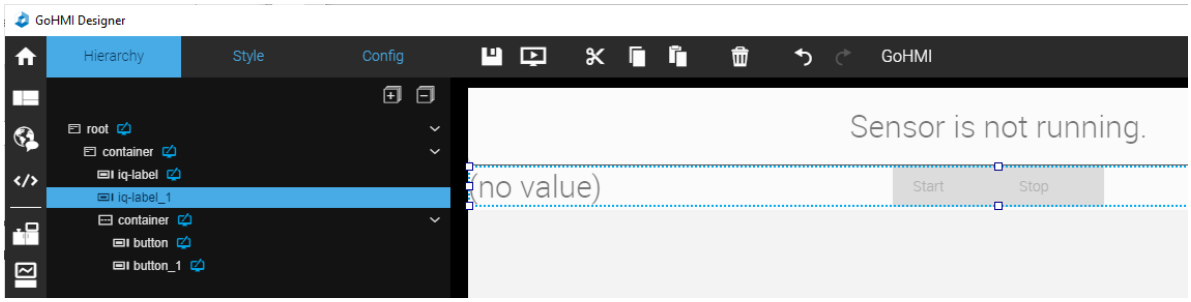


4. Drag the widget until you see a pink line, which shows where you can insert the widget.



5. Drop the widget.

   The widget is added to the HMI, and initially shows "(no value)".

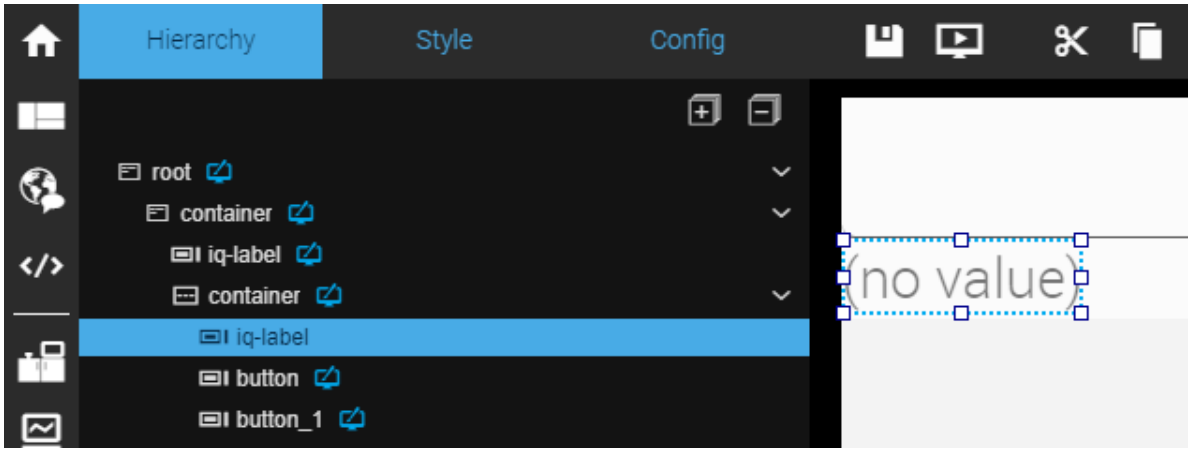


   Understanding where widgets will "land" involves understanding container types and their settings.

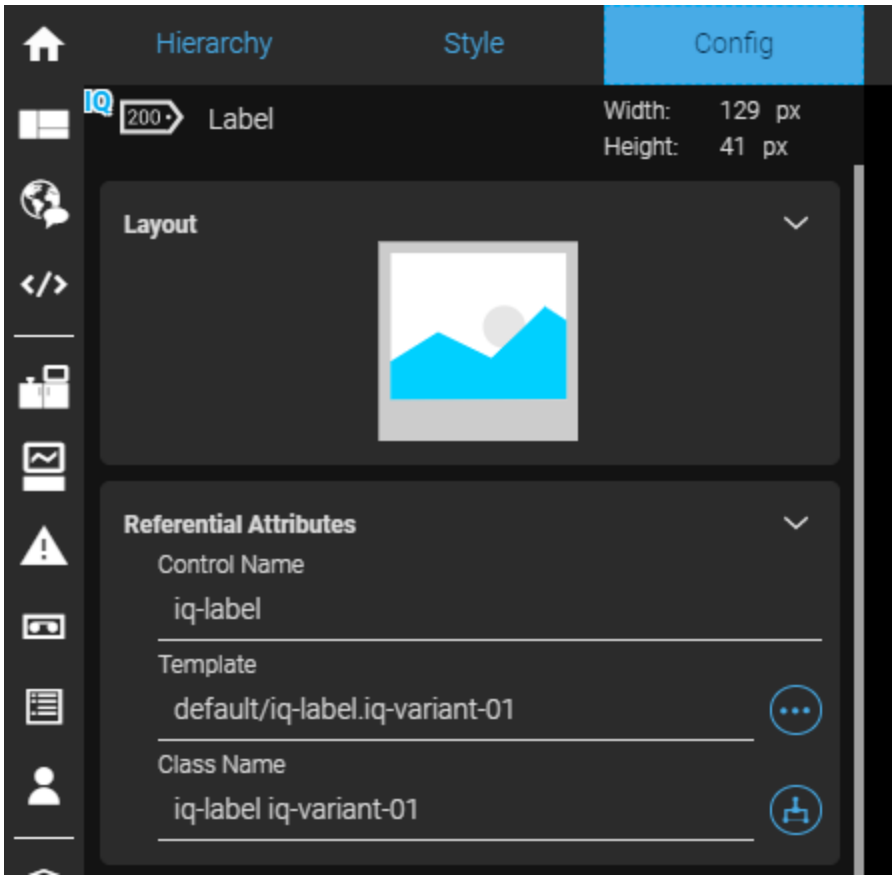
Next you will need to configure the widget's inputs.

To configure the label's input

1. Click the widget so that it is highlighted in blue.



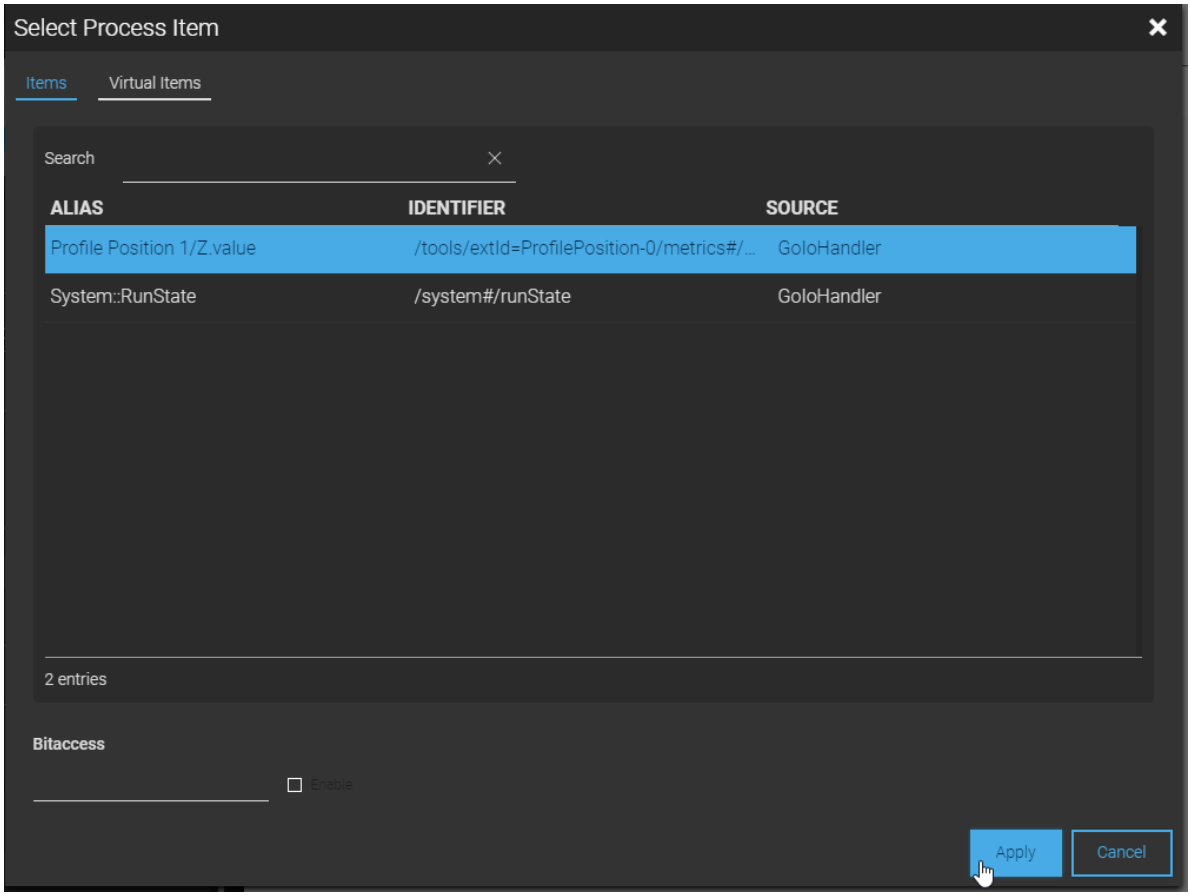
2. Switch from the **Hierarchy** tab to the **Config** tab.



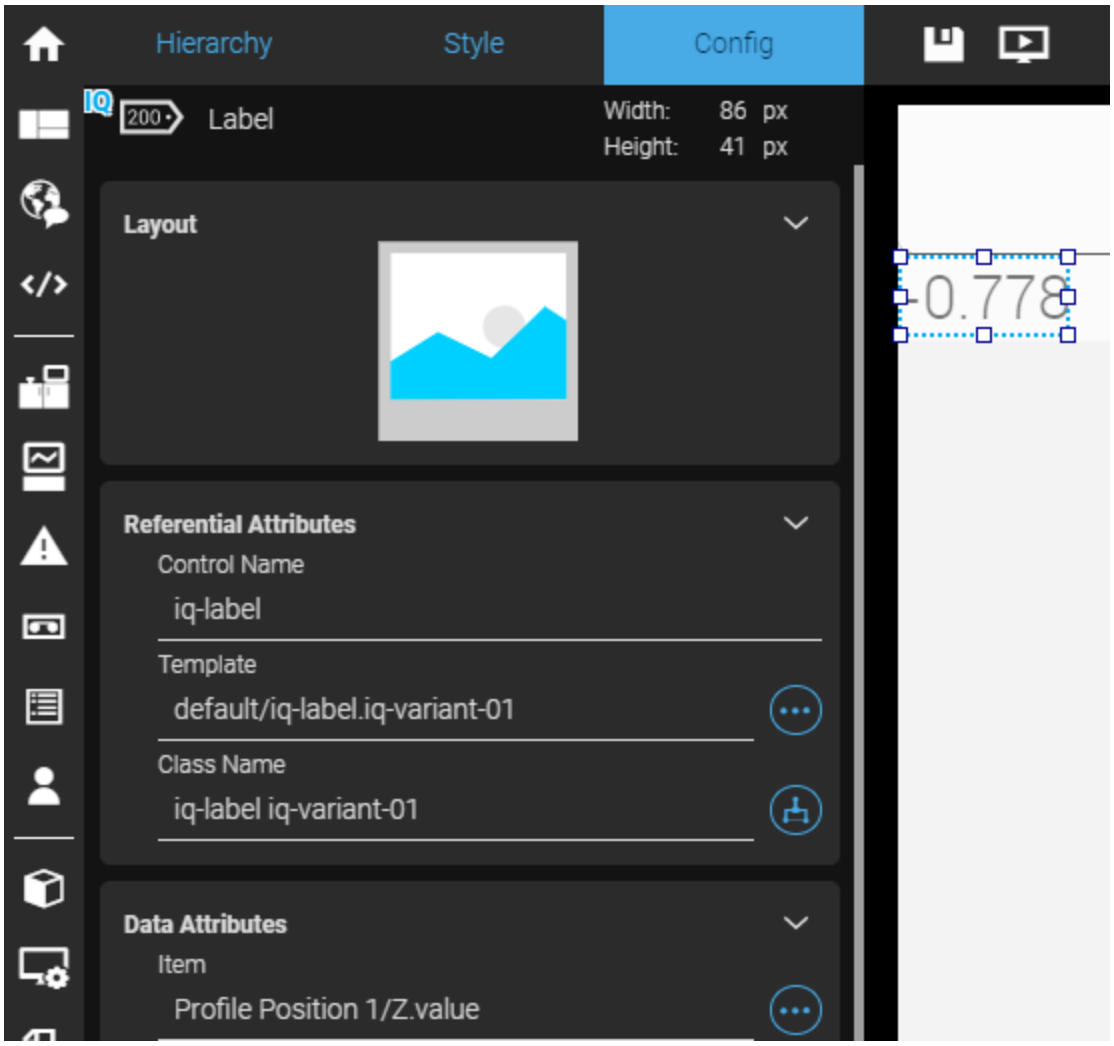
3. In the **Config** tab, in the **Data Attributes** section, click the Select Item icon ( ) next to **Item**.



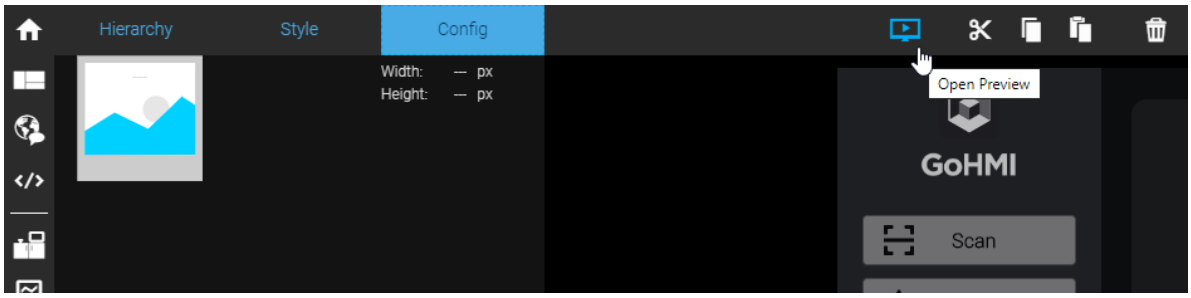
4. In the dialog that opens, choose the measurement tool output you want and click **Apply**.



The widget shows the value it receives from the measurement you chose. (The sensor must be actively scanning for a value to appear.)



Now you can preview the HMI to test it by clicking the preview icon above the Layout Manger's editor ( ). Doing this opens the HMI in the preview window. You can interact with it to test it.



You should save your work regularly by pressing Ctrl-S. Previewing an HMI also saves it.

Publishing Changes

After you have finished working on an HMI in GoHMI Designer, you should publish it. Publishing an HMI copies the project loaded in the workspace to the runtime. If you launched GoHMI Designer on a sensor in the GoHMI Designer launcher, the runtime is the sensor. If you launched it on a

PC instance of GoPxL, the runtime is the PC instance. Publishing also makes the HMI available in the GoPxL interface so that you can back it up or send it to someone (by exporting it).

Two publish options are available:

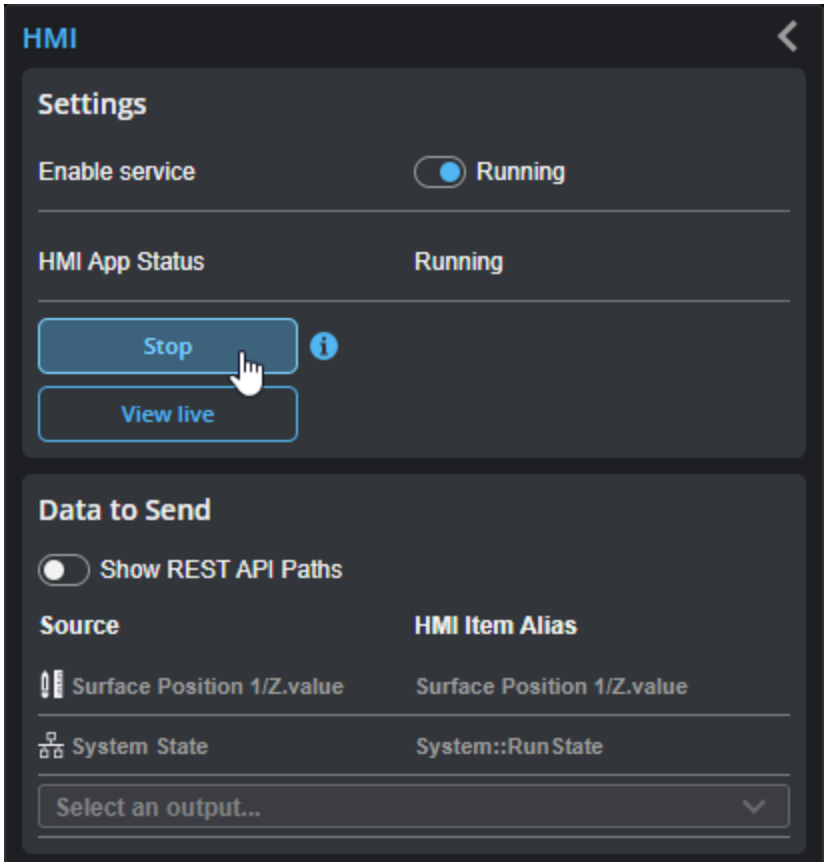
Publish: Copies the project from the workspace to the runtime. The project remains in the workspace. You can't view the HMI until you have published and closed the HMI (or until you clear it manually).

Publish and Close: Copies the project from the workspace to the runtime and also removes it from the workspace. You must do this to be able to start and then view the HMI from the GoPxL interface.

Changing Outputs in GoPxL

To add or remove measurements at a later date in the list of outputs that are sent to the HMI application, the **HMI Status** in GoPxL must say "Ready". If **HMI Status** shows "In edit mode" or "Running", you must perform the following to be able to make changes:

- **HMI Status** shows "In edit mode": Follow the steps in *Launching GoHMI Designer* on page 672 and then, in GoHMI Designer, close the workspace.
- **HMI Status** shows "Running": Stop the HMI.



Importing and Exporting an HMI

You can import an HMI app from the GoPxL interface. After importing an HMI app, you can then edit in GoHMI Designer. After you have imported an HMI you can also start it 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.

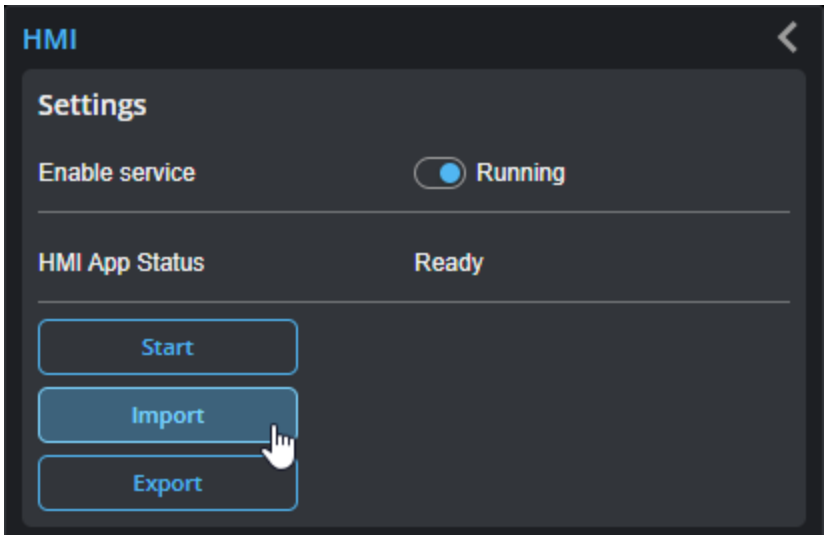
🗋	Imported and exported HMI apps are zip files.

To import an HMI app

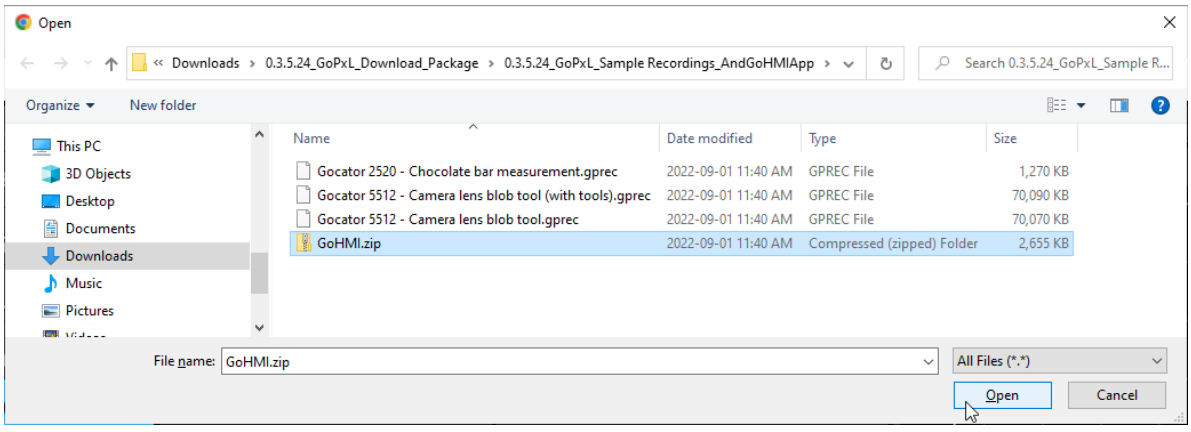
1. If an HMI app is currently in GoHMI Designer, make sure you have backed it up or that it is OK to overwrite it.

   Importing an HMI app overwrites the app in GoHMI Designer.

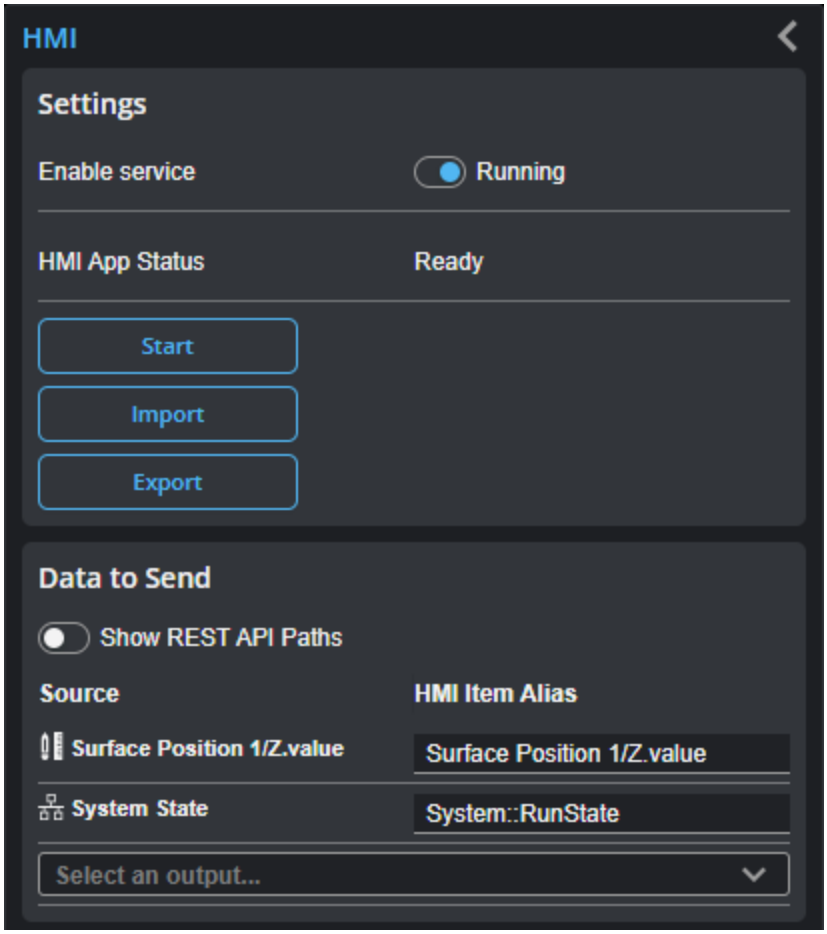
2. In the GoPxL interface, click **Import**.



3. In the Open dialog that displays, go to the location of the zipped HMI app project and click **Open**.

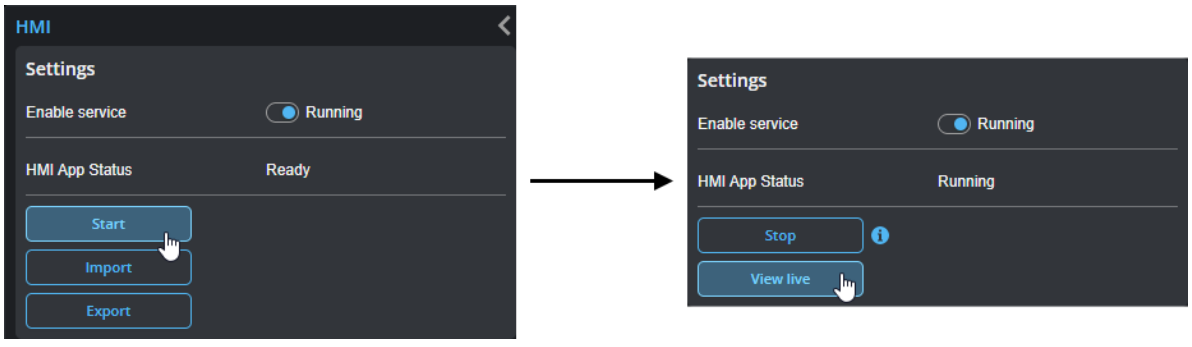


GoPxL imports the HMI app.



The app is now available for editing in GoHMI Designer (see See *Opening, Editing, and Saving a Project* on page 676).

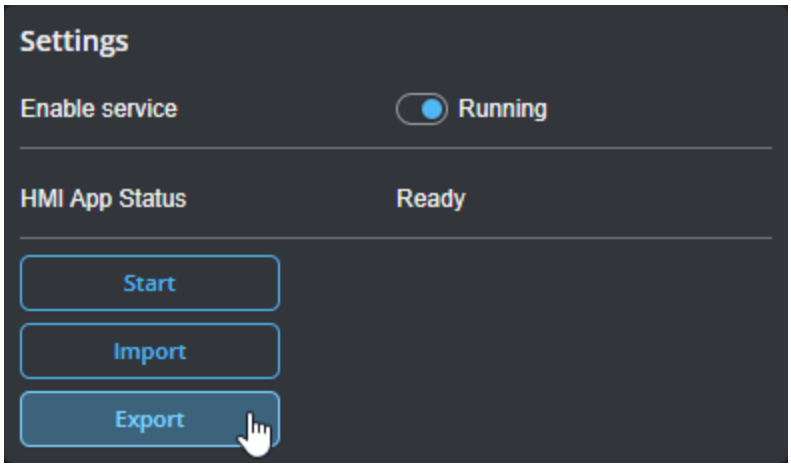
You can also start the app, and then view it live.



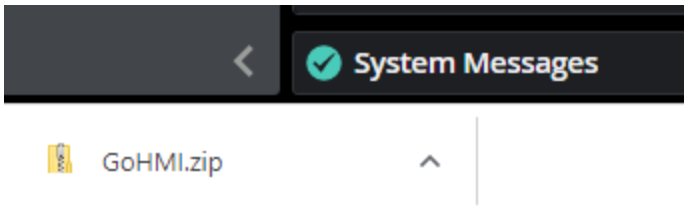
If you want to back up or send your HMI app to someone, you export it in GoPxL interface.

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).



Adding a Data Viewer to an HMI

You add a data viewer to an HMI by copying a link in the GoPxL web interface and pasting it into an IFrame widget in GoHMI Designer. The link tells the HMI the IP address of the sensor, as well as which sensor output and measurements it should display.

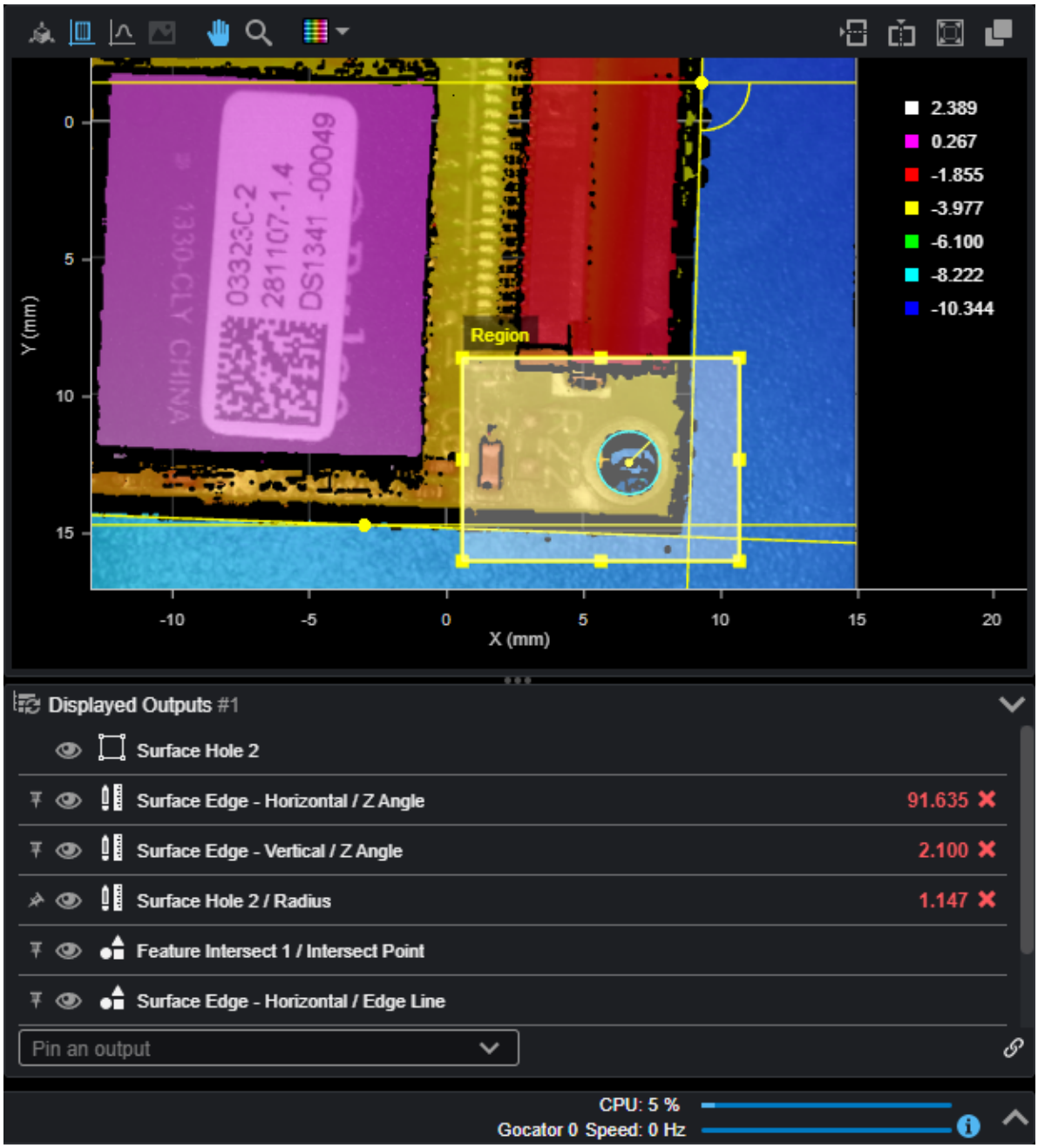
> The default HMI app includes an IFrame widget configured to display the data viewer. The IP address used in the link is 127.0.0.1:8100, which is valid for a PC instance of GoPxL (if one is running at that address and port).
>
> If you want to try out the default app with your sensor, follow the steps 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 9).

To add a data viewer to an HMI

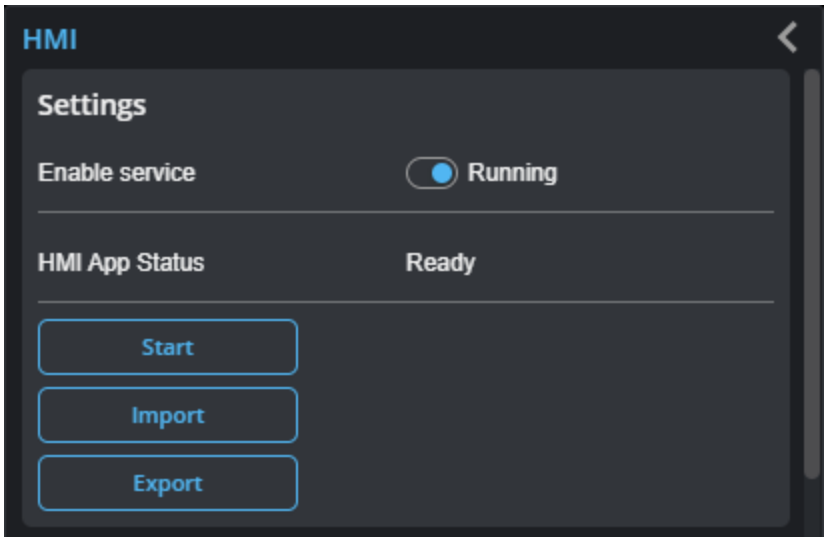
1. Set up a data viewer as required.

   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, configured, and started in the **Control** > **HMI** page.

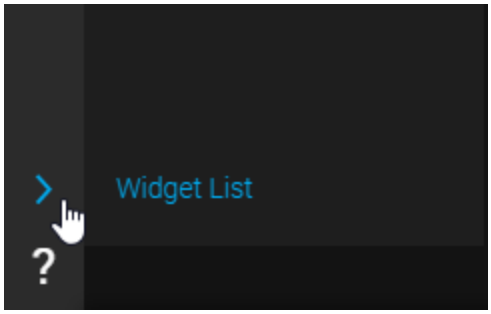


For more information, see *HMI* on page 646.

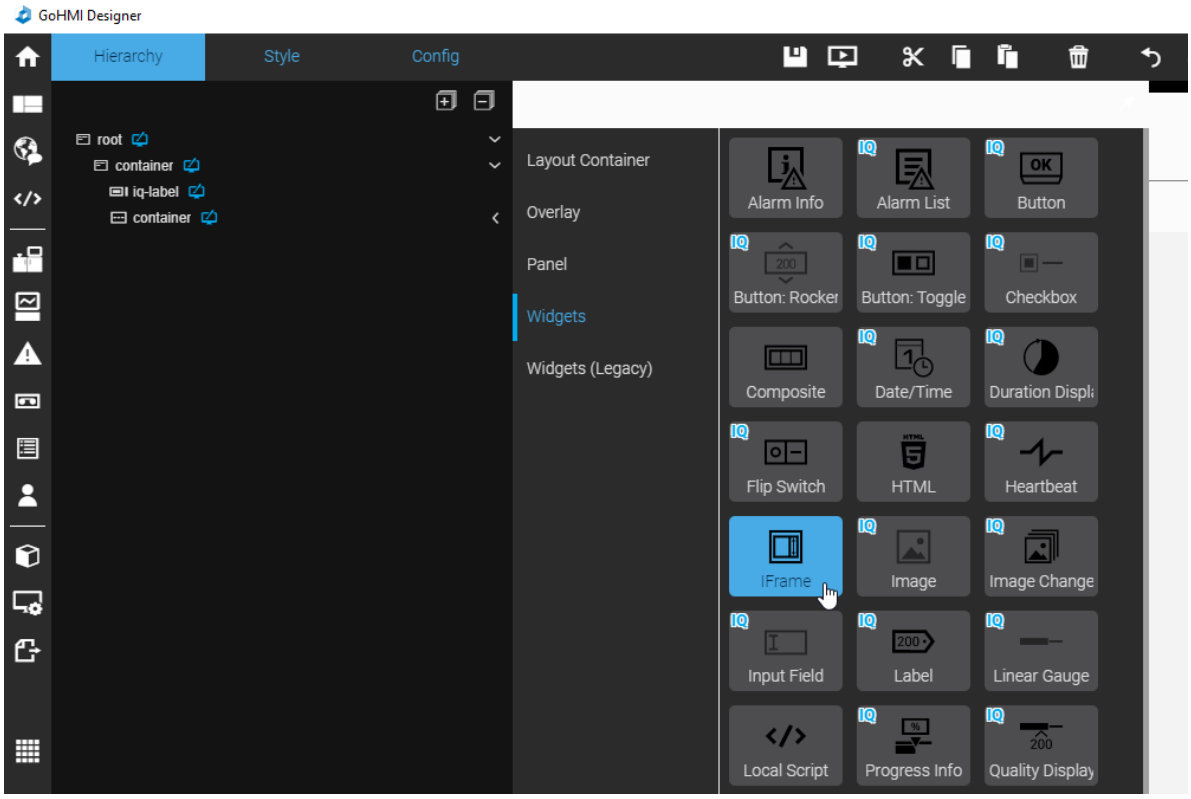
5. Launch GoHMI Designer.

   For information on launching GoHMI Designer, see *Launching GoHMI Designer* on page 672.

6. In GoHMI Designer, load the HMI project and open the Layout Manager.
7. In the Layout Manager, expand the widget list.

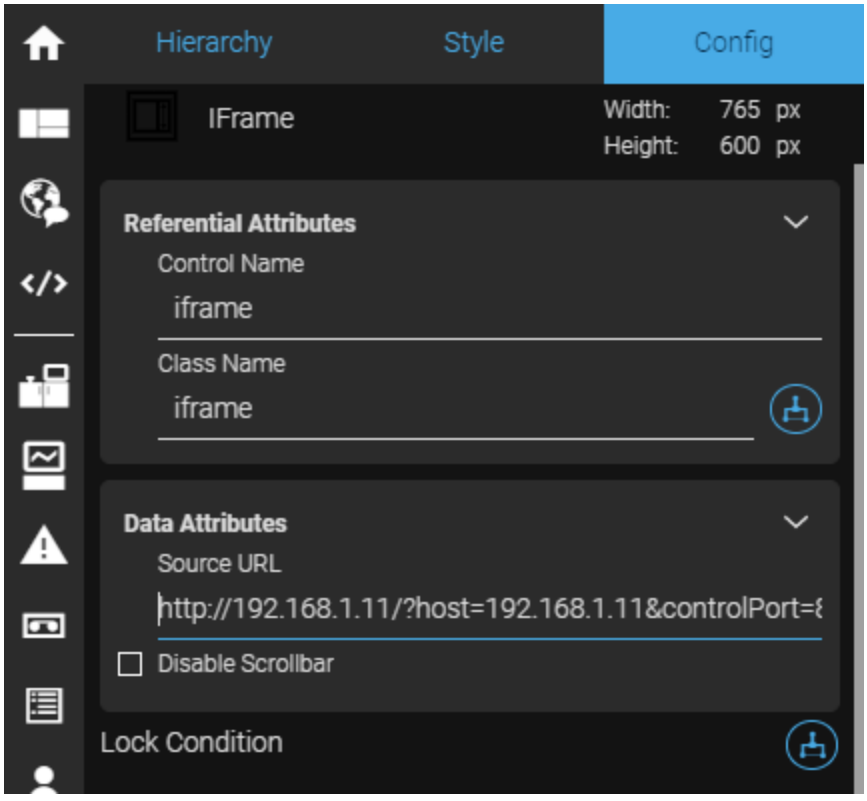


8. From the widget list, drag an IFrame widget into the HMI.



Resize the IFrame widget if necessary.

9. In the **Config** tab, paste the URL you copied in **Data Attributes** > **Source URL** in step 1.

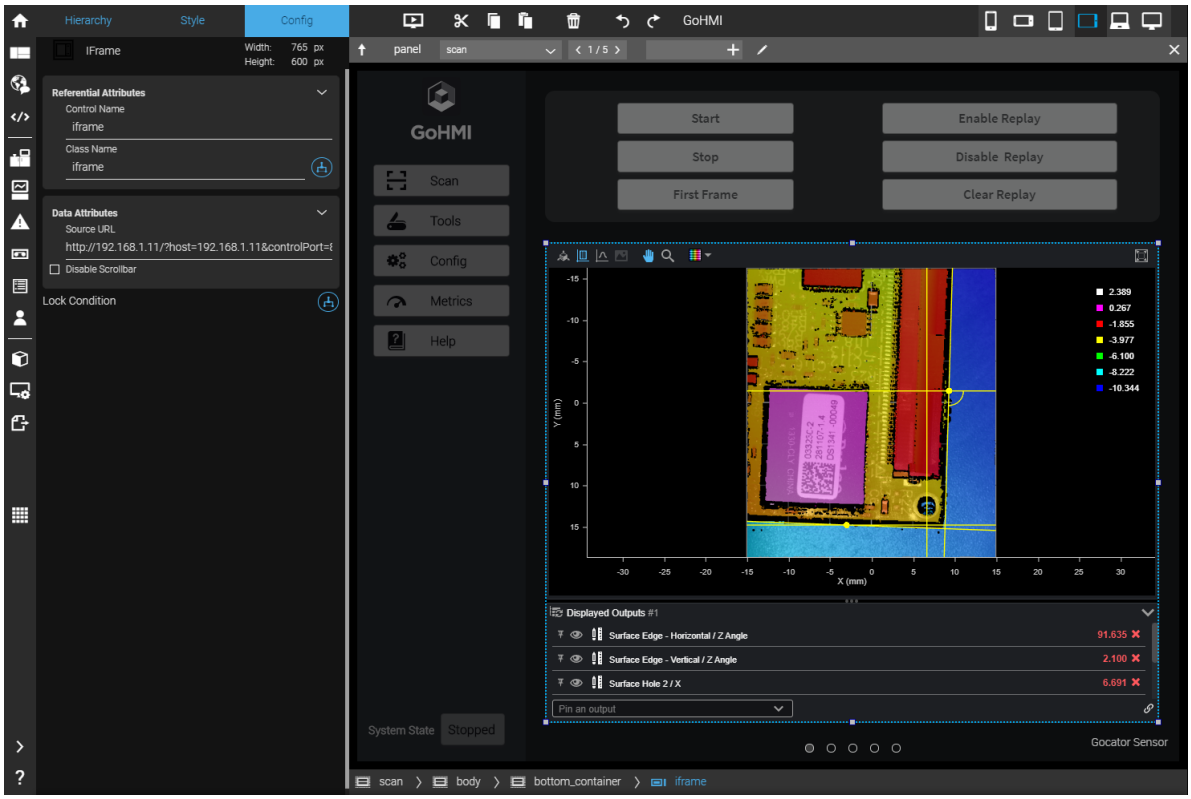


The URL will look something like this:

```
http://192.168.1.11/?host=192.168.1.11&controlPort=80&visualizerOnly=true&displayed
Outputs=Surface.Top,tools%3ASurfaceHole-1%3Aoutputs%3ARadius,tools%3ASurfaceEdge-
4%3Aoutputs%3AZAngle,
```

You *must* leave the comma at the end of the URL you paste.

After a few seconds, the data viewer from the connected instance of GoPxL appears in the IFrame widget.



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 following sections describe the Software Development Kit (GoPxL SDK).

> The GoPxL Development Kit (GDK) will be available in a later release.

Setup and Location of GoPxL SDK and REST API References

The GoPxL SDK, and the SDK and REST API references, are available in the `14630-1.0.x.x_SOFTWARE_GoPxL_SDK.zip` package.

The SDK zip file contains both a C++ and a .NET SDK. They are organized as follows:

- x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\
- x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_dotNet\

Please choose the type of SDK (C++ or .NET) that you will be working with. The directory paths in the documentation below will be relative to either x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\ (for C++ SDK) or x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_dotNet\ (for the .NET SDK), if the full path is not fully specified. The following references are availab;e:

- The full GoPxL SDK class reference is available in the following file: x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\doc\GoPxLSdk\GoPxLSdk.html.
- The full REST API reference is available in the following file: x.x.x.x_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\doc\rest-api-doc.html.

Visual Studio Solution Files and Linux Makefile

Visual Studio solution files are included for both the C++ and .NET SDKs.

- x.x.x.xx_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\Gocator
- x.x.x.xx_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_dotNet\Gocator

In Linux, first ensure that you have the g++ compiler package and then run the following command from `GoPxL_SDK_Cpp\Gocator\GoPxLSdk` directory:

```
> make -f GoPxL_SDK_Cpp/Gocator/GoPxLSdk/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, and click **OK**.

The compiled Linux output libraries can be found in the `GoPxL_SDK/lib/linux_x64` directory.

The GoPxL SDK can be compiled using the following environment requirements:

- Visual Studio 2017; with more recent versions, you must retarget the solution
- GCC X64 compiler, version: 7.5.0 (GccX64_7.5.0-p3)

The GoPxL SDK uses mm, mm^2, mm^3, hertz, microseconds, and degrees as standard units unless otherwise mentioned.

Header Files

Header files are referenced with `GoPxLSDK` as the source directory, for example: `#include <GoPxLSdk/GoRestClient.h>`.

The SDK header files also reference files from the `kApi` directory, for example, `#include <kApi/kApiDef.h>`.

Sample Projects

Sample projects showing how to perform various operations are provided, each one demonstrating a specific area. A makefile for Linux systems is also provided after running `generate.py`. Examples are located in the following folders:

- C++: x.x.x.xx_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\Gocator\GoPxLSdk\samples
- .NET: x.x.x.xx_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_dotNet\Gocator\GoPxLSdkNet\samples

Functional Hierarchy of Classes

GoPxL offers a simple programming API interface for connecting, configuring, and acquiring data from sensors and the GoMax vision accelerator.

> Example code shown below as examples are for C++ SDK programs.

All C++ GoPxL SDK programs should have the sequence described below, at the minimum. The .NET SDK programs may require less.

The following sequence assumes you know the IP address of the device. If you do not know the IP address or it's not static, 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 page 695.

1. For C++ SDK programs only, construct the SDK library by calling `GoApiLib_Construct`. (.NET SDK programs don't require `GoApiLib_Construct` to be called.)

```
// Constructs GoPxL API core framework.
                GoApiLib_Construct(&goApiLib)
```

You must call `GoApiLib_Construct` before any API functions are used.

2. Connect to the device at its known IP address

```
#define SENSOR_IP       "192.168.1.10"
                    kIpAddress ipAddress;
                    kIpAddress_Parse(&ipAddress, SENSOR_IP);
                    system = GoSystem(ipAddress);
                system.Connect();
```

3. Instantiate GoGdpClient to handle data received from the device. The following demonstrates an asynchronous data retrieval procedure.

```
gdpClient = std::make_unique<GoGdpClient>();
                    gdpClient->Connect(ipAddress)

                    // Callback function for ReceiveDataAsync()
                    void onData(const GoDataSet &receivedDataSet)
                    {
                    for (size_t i = 0; i < receivedDataSet.Count(); i++)
                    {
                    case GoPxLSdk::MessageType::MEASUREMENT:
                    {
                    const GoGdpMeasurement &MeasurementMsg = (const GoGdpMeasurement
&)receivedDataSet.GdpMsgAt(i);
                    std::cout << "Array count: " << std::endl;
                    std::cout << "Value: " << MeasurementMsg.Value() << std::endl;
                    break;
                    }
                    }
                    }

                    // Establish an asynchronous data transfer.
                    std::function<kStatus(GoDataSet* pDataSet)> func = onData;
                gdpClient->ReceiveDataAsync(func)
```

4. Start and stop the device.

```
// Start sensor
                    system.RunningState() != GoSystem::State::Running)
                    {
                    system.Start();
                    }

                    // Stop the sensor.
                system.Stop();
```

After the device starts running, data will be streamed to the `onData` function handler as it becomes available. For more information, see *Receive Device Data* on page 698.

If required, you can configure the device settings, such as changing exposure value, using `system.Client()`. For more information, see *Configure Device Settings* below.

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 by instantiating a `GoDiscoveryClient` class and calling the `BlockingDiscover` function.

```
// Discover GoPxL instances on the network.
                std::unique_ptr<GoDiscoveryClient> discovery = std::make_
unique<GoDiscoveryClient>();
            discovery->BlockingDiscover(10000);
```

After the discover function is completed, you can loop through the instances vector to get device information and IP addresses:

```
instances = discovery->InstanceList();
                for (size_t i = 0; i < instances.size(); i++)
                {
                const GoInstance& instance = discovery->InstanceList().at(i);
                kIpAddress_Format(instance.GetIpAddress(), ipAddress,
                std::cout << "IP Address: " << ipAddress << std::endl;
                ++instanceCount;
            }
```

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. `GoSystem` includes a client class instance you can use to read and write settings.

You use the system.Client().read and system.Client().write functions, among others, to access and modify a wide variety of parameters using the following format:

```
"command /path/to/callable/resource {'argument':'value'}"
```

For the full list of resources available, please see the *REST API Resources and User Guide* (`x.x.x.xx_SOFTWARE_DEV_GoPxL_SDK\GoPxL_SDK_Cpp\doc\rest-api-doc.html`).

The following sections describe the more common use cases.

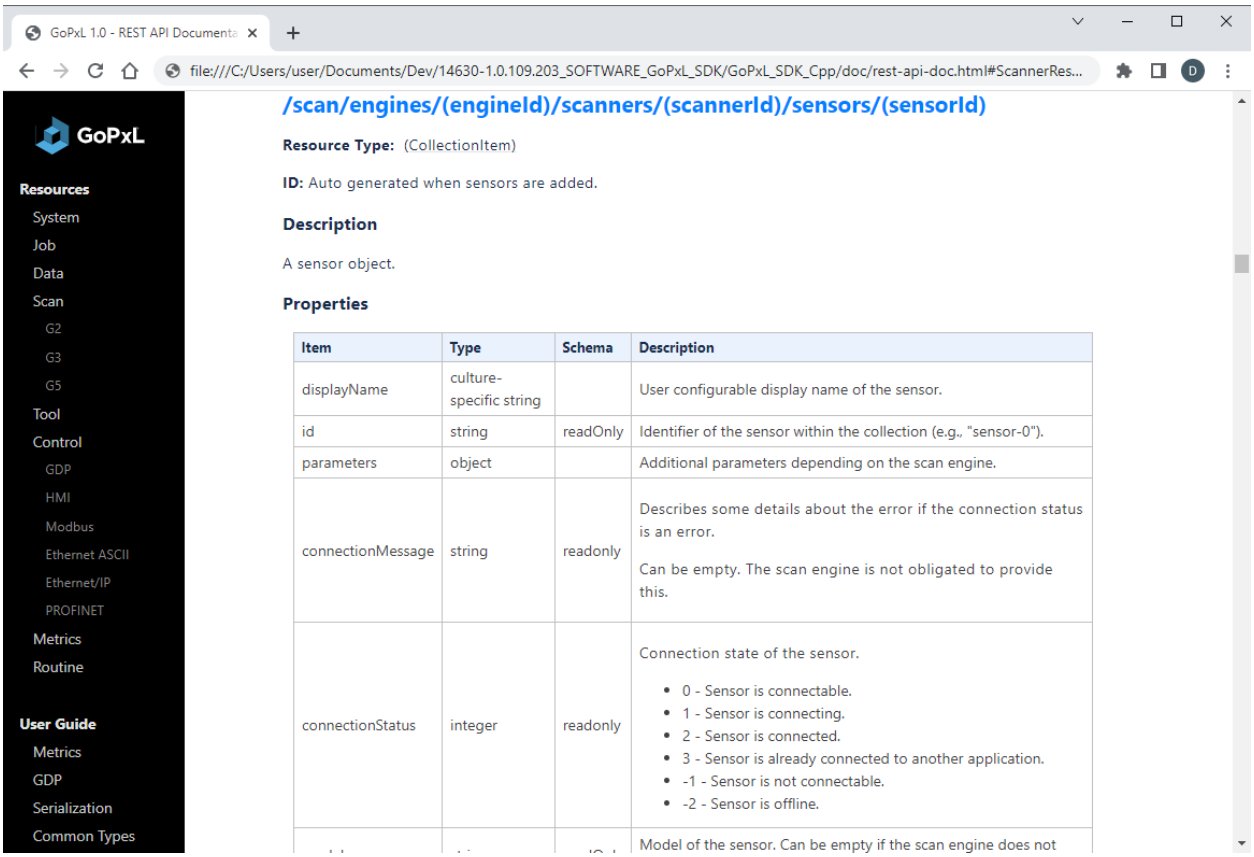
It's important to understand that GoPxL device settings are divided into two general types:

- 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.

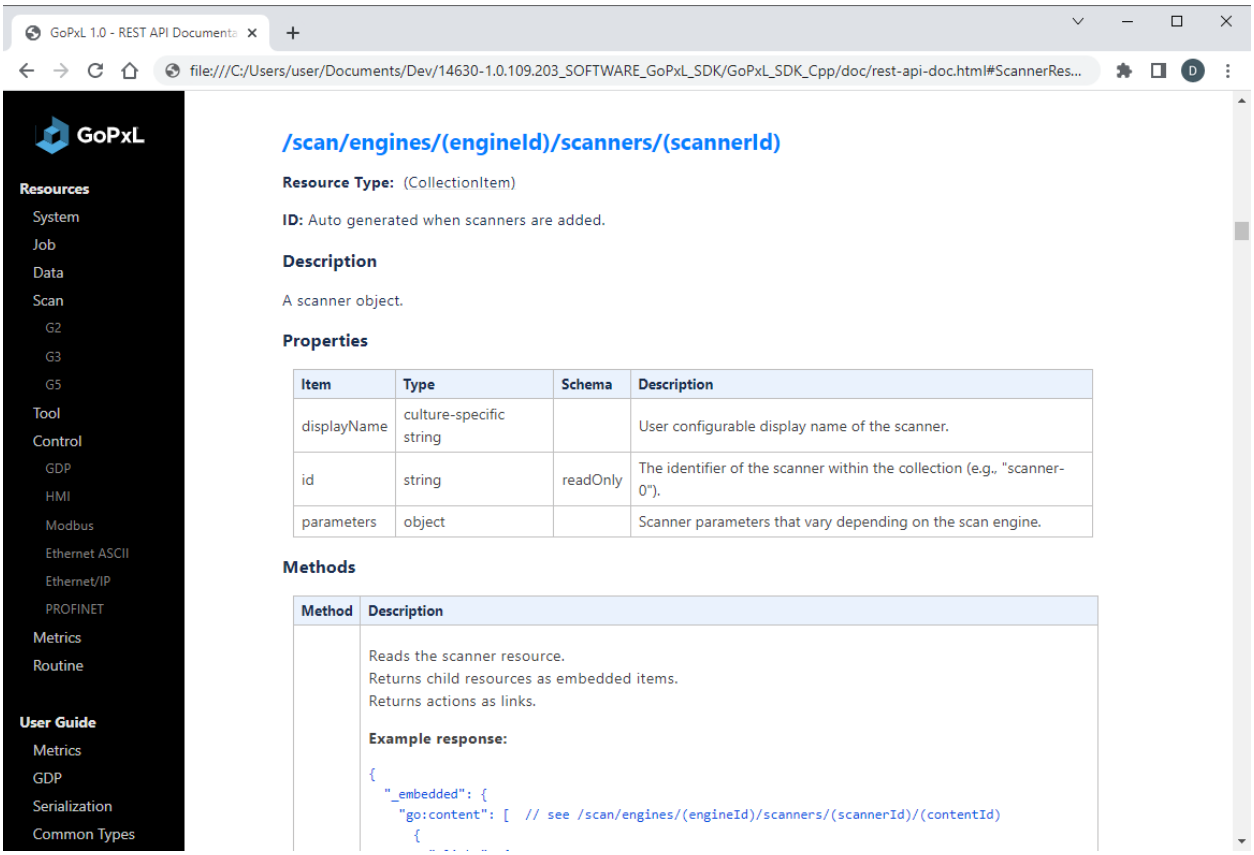
```
std::string sensorPath = system.SensorPath(sensorSerialNumber);
```

You can then access the settings under the `sensor` resources.

```
// Update Single Exposure:
SENSOR_PATH = "/scan/engines/g2xxx/scanners/scanner-0/sensors/sensor-0";
system = GoSystem(ipAddress);
payload = GoJson("{\"parameters\" : {\"exposureSettings\" : {\"exposureMode\" : 0,
\"singleExposure\" : 400} }}");
system.Client().Update(SENSOR_PATH, payload)
```

Accessing Scanner Resources

You access system-level settings (those that apply to a group of sensors) through the `scanner` resources.



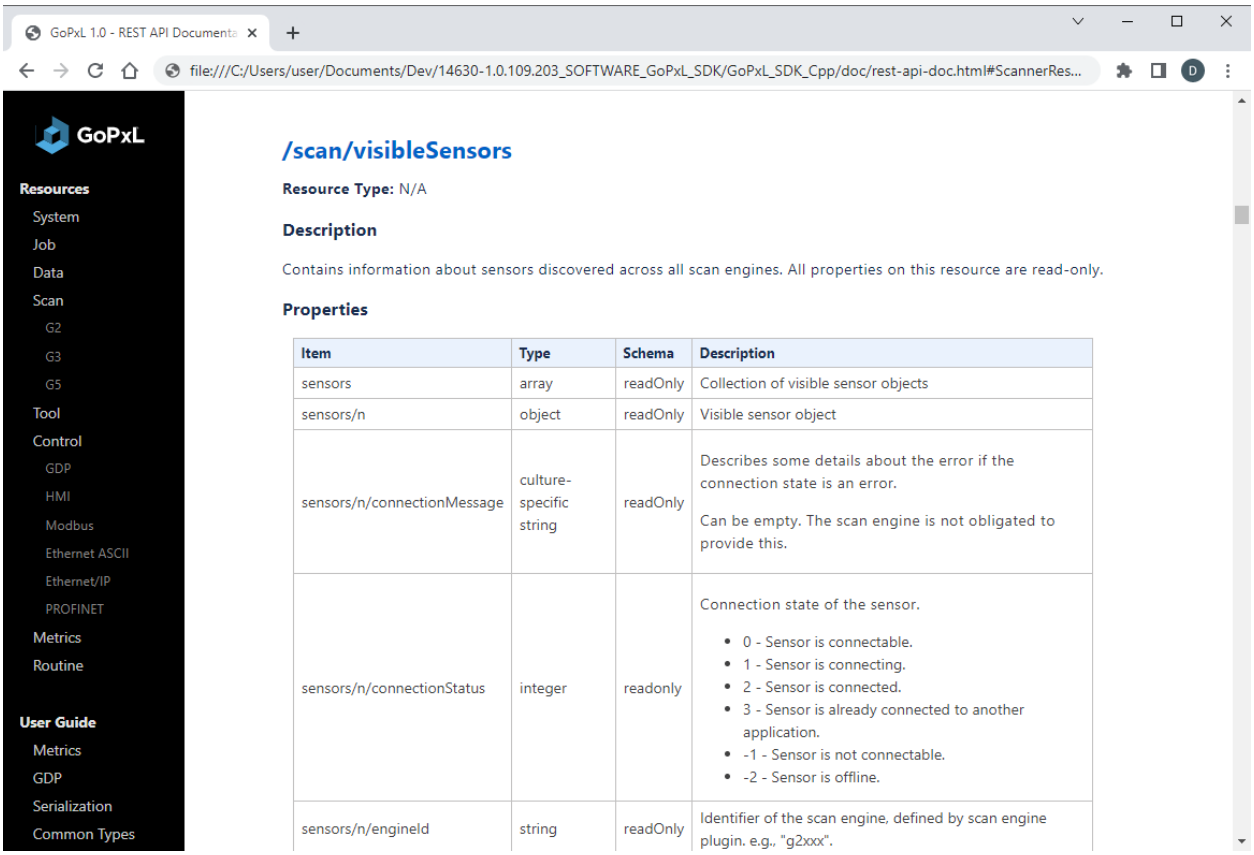
If you know the engine ID and scanner ID (available in the REST API reference documentation), you can use the following to access the scanner and modify the trigger setting:

```
SCANNER_PATH = "/scan/engines/g2xxx/scanners/scanner-0";
system = GoSystem(ipAddress);
payload = GoJson("{\"parameters\" : {\"triggerSettings\" : {\"source\" : 0} }}");
system.Client().Update(SCANNER_PATH, 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(VISIBLE_SENSORS_PATH).GetResponse().Content().At
("sensors");
```

You can then access elements of the returned array:

```
sensor = sensors.Begin();
std::string sensorSerialNumber = sensor.Value().At("/serialNumber").Get<std::string>
();
```

Instantiate a GoPxL Data Protocol Client (GoGdpClient) and connect it to the discovered device.

```
gdpClient = std::make_unique<GoGdpClient>();
gdpClient->Connect(instance.GetIpAddress())
```

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, first connecting it to the device. You can use `GoPxLSdk::MessageType` to identify the type of received data and the

associated stamp information. Stamps contain encoder, trigger timing information, current time, and the frame index, and are grouped into a dataset with their corresponding data.

```
auto gdpClient = std::make_unique<GoGdpClient>();
                auto ipAddress = instance.GetIpAddress();
                if ((status = gdpClient->Connect(ipAddress)) != kOK)
                {
                std::cout << "Error: " << status << " - Failed to connect to the GDP server. Make sure Ethernet output is available." << std::endl;
                return -1;
            }
```

Data can be received on the same thread used for controlling the sensors (that is, synchronously) or on a different thread (that is, asynchronously).

For synchronous data retrieval:

```
// Surfaces take longer to generate, so need to wait longer.
// Set to 3 seconds here.
gdpClient->ReceiveDataSync(3000000)) pDataSet = gdpClient->DataSet();
```

For more information, see the `ReceiveProfile` and `ReceiveSurface` samples.

For asynchronous data retrieval:

```
std::function<kStatus(GoDataSet* pDataSet)> func = onData;
dpClient->ReceiveDataAsync(callbackFunction)
```

Data is received in the `onData` function call:

```
kStatus onData(GoDataSet* pDataSet)
{
    std::cout << "Total number of messages in this data set: " << pDataSet->Count() << std::endl;
    …
}
```

For details, see the `ReceiveAsync` sample.

Note that data is received as the `GoDataSet` type. For more information on GoDataSet, see *GDP Data Types* on the next page.

Receive Health and Metrics Information

Health information is sent out using the REST client interface.

```
// Callback function for SetStreamHandler().
static void onMetrics(const std::shared_ptr<GoStreamResponse> &notification)
```

```
{
    GoJson content = notification->Payload();
    cout << "\nApplication Uptime: " << content.Get<int>("/appUpTime") << endl;
    cout << "CPU Cores Usage Average: " << content.Get<int>("/cpuCoresUsedAvg") <<
endl;
    cout << "Memory Capacity: " << content.Get<double>("/memCapacity") << endl;
}

// Running callback function to receive metrics
system.Client().SetStreamHandler(onMetrics);
system.Client().StartStream("/system/metrics");
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

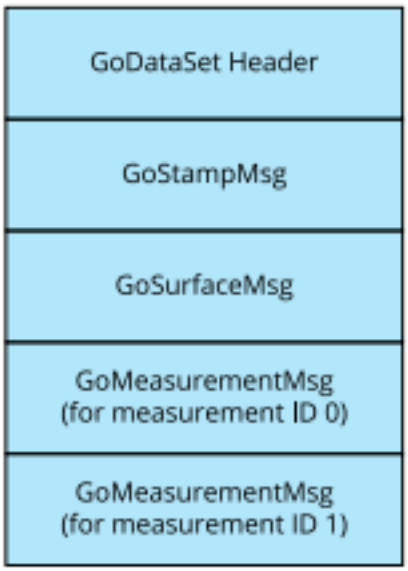
Type	Description
GoGdpBoundingBox	Bounding Box results output based on part matching results
GoGdpFeaturePoint	Feature point output
GoGdpFeaturePlane	Feature plane output
GoGdpFeatureLine	Feature line output
GoGdpFeatureCircle	Feature circle output
GoGdpImage	Video image
GoGdpMeasurement	Measurement 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.



Measurement Values and Decisions

There are two outputs for each measurement; value and 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. This is a pass decision.
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.

Integrations

GoPxL currently provides three types of integrations: Gocator (for use with the GoPxL SDK and API), industrial protocols, and GoHMI.

For information on the Gocator protocol, see *Gocator Protocol* below.

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 666.

Protocols (PLCs and other hardware)

GoPxL supports various protocols for communicating with sensors over Ethernet (TCP/IP).

The following protocols are available:

- Gocator
- Modbus
- EtherNet/IP
- PROFINET
- ASCII

The .

Gocator Protocol

For information on the SDK and the REST API, see *GoPxL SDK and REST API* on page 692.

Modbus Protocol

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 Protocol* on page 628), 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.

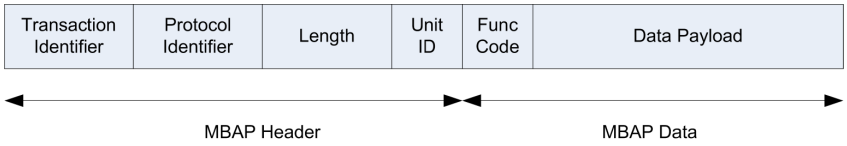
While the Modbus protocol includes several types of requests, the two basic operations are reading and writing registers. Commands are invoked by the PLC sending write-register requests. Data is requested by the PLC by sending read-register requests.

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 706). For more information on part detection, see *Profile Part Detection* on page 265.

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

Block Description	Supported Block Type	Read or Write only?	Size (number of Modbus registers)	Description
Control Input	"ControlInput"	WO	66	Command message set by the Modbus client.
Control Output	"ControlOutput"	RO	2	Result data corresponding to a command that was written to the Control Input block.
System State	"System"	RO	72	Information about the LMI device.
Sensor Group State	"Scanner"	RO	10	Information about a specific sensor group.
Stamp	"Stamp"	RO	17	Stamp message information.
Measurement	"Measurement"	RO	3	Measurement data of a scan output measurement data message.

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. 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. Supported actions: 0 = No Command 1 = Start Scanning 2 = Stop Scanning 3 = Align Sensor Group 4 = Clear Alignment 5 = Load Job File 6 = Software Trigger 7 = Buffer Advance
Command Arguments	16u	2	Arguments for commands that require arguments. For the Load Job File command, the command arguments

Field	Type	Address offset	Description
			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. This field takes up a maximum of 64 registers.
Reserved	16u	66	Not used. This field takes up 57 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. 0 = No Command Received 1 = In Progress 2 = Success 3 = Fail 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. 0 = System is stopped 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, including extension. Maximum length of job file name is 64 characters. Each register contains a single character. 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.

Field	Type	Address offset	Description
			A value of 1 indicates that overflow occurred and data is being lost. 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). 0 = Not Aligned 1 = Aligned 2 = Aligning
Laser Enabled	16u	9	Whether one or more devices under a scanner has its laser enabled to be able to turn on. 0 = All devices' lasers are disabled and cannot turn on 1 = One or more devices' lasers can be turned on 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	Time stamp, in microseconds, of last frame.
Frame Index	64u	12	The frame number of the last frame. This field takes up 4 registers.
Digital Input States	16u	16	Digital input states of last frame. Bit 0: State of digital input 1 on master or sensor 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. If the measurement value is invalid, the first register of the measurement value is set to 0x80000000. 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. Bit 0: 0 = Fail 1 = Pass Bit 1: 0 = Decision value is valid 1 = Decision value is invalid This field takes up 1 register.

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. 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 637.

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 637.

> 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.
result	-	Return the measurement data specified in the custom format string.
	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],... Example: result,0,1 Output: OK,M0,V-5000,D0,M1,V5000,D1
measurement	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],... Example: measurement,0,1 Output: OK,M0,V-5000,D0,M1,V5000,D1
value	One or more	Return the measurement value for each measurement id in the following format string: M[ID],V[VALUE],...

Command	Arguments	Description
	measurement ids, separated by command delimiter.	Example: value,0,1 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],... Example: decision,0,1 Output: OK,M0,D0,M1,D1
stamp	-	Return the time, encoder and frame index stamp values for the first stamp id found. Order of values returned is: Time, Encoder, Frame. Example: stamp Output: OK,Time,381497381349,Encoder,0,Frame,18,
	One or more of these arguments in any order, separated by the command delimiter: "time" "encoder" "frame"	Return the specified stamp value(s) in the order of the provided arguments. Example: stamp,time,frame Output: OK,381497381349,18
	A stamp ID.	Return the time, encoder, and frame index stamp values for the passed stamp ID. Example: stamp,1
time	One or more stamp ids, separated by command delimiter.	Return the time stamp value for each stamp id. Example: time,1 Output: OK,381497381349
encoder	One or more stamp ids, separated by command delimiter.	Return the encoder stamp value for each stamp id. Example: encoder,1 Output: OK,0
frame	One or more stamp ids, separated by command delimiter.	Return the frame index stamp value for each stamp id. Example: frame,1 Output: OK,18
align	-	Performs the alignment operation.

Command	Arguments	Description
clearalign	-	Clears sensor alignment.
readprop	One or more string representing a resource whose property to return, separated by command delimiter.	Return the resource JSON object specified by the resource path. It is possible to use JSON pointer to retrieve a specific value within the JSON document. Example #1: readprop,/system 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} Example #2: readprop,/system#/runState,/system#/autoStart Output: OK,1, true

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	Could not find a measurement data for specified ID.

Command	Arguments	Description
	measurement ID not found. Please verify your input	
	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.
	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.

Command	Arguments	Description
	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 not found	Could not find a measurement data for specified ID.
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	Resource may not exist.

Command	Arguments	Description
	property	

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 637. 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. 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: 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. This is a pre-defined format that cannot be changed: 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 637. Default format: %time, %value[0] %decision[0]

Measurement Output Format

Field	Type	Address offset	Description
Value	32s	0	Measurement value. This value is the actual measurement value multiplied by 1000. If the measurement value is invalid, the string "INVALID" is the output for the measurement value.
Decision	8u	4	Measurement decision. Bit 0: 0 = Fail1 = Pass Bit 1: 0 = Decision value is valid1 = Decision value is invalid

EtherNet/IP Protocol

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

> 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, sensor group, and scan output data to a PLC. Sensors also accept incoming 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 basic 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 as Big-Endian format or Little-Endian format based on the configuration selected in web interface.

Connections Map

The EtherNet/IP protocol supports the following objects. Except for mandatory objects, all objects are mapped to a register assembly.

Mandatory Objects

Mandatory objects are present in the EtherNet/IP service irrespective of the configured measurement objects.

- Identity object (Class 0X01)
- TCP/IP Object (Class 0XF5)
- Ethernet Link Object (Class 0XF6)

Assembly Objects

All assembly objects are modeled with class 4 and attribute 3. Only the instance ID changes between assembly objects.

A register assembly contains register blocks. This is a one-to-one mapping, which means each EtherNet/IP assembly object will have a corresponding control framework register assembly. These objects are added to GoPxL irrespective of the selection of register assembly, but the data is added to this EtherNet/IP object based on the selection of register assembly.

Assembly Objects

Object name	Register assembly	Supported Register Block Type	Service	Instance ID
Command input object	Control Input register assembly	"ControlInput"	SetAttributeSingle (0x10)	0x70
Command output object	Control Output register assembly	"ControlOutput"	GetAttributeSingle(0x0E)	0x71
Sensor Group State object	Sensor Group State register assembly	"Scanner"	GetAttributeSingle(0x0E)	0x72
System State object	System State register assembly	"System"	GetAttributeSingle(0x0E)	0x73
Sample State object	Sample State register assembly	"Stamp" "Measurement"	GetAttributeSingle(0x0E)	0x74
Implicit Messaging output object	Sample State register assembly	"Stamp" "Measurement"	GetAttributeSingle(0x0E)	0x65
Implicit Messaging input object	Implicit Control Input register assembly	"ControlInput"	SetAttributeSingle (0x10)	0x64

fThe EtherNet/IP protocol supports various blocks 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 EtherNet/IP client 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.

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	Read or Write only?	Size (number of EtherNet/IP registers)	Description
"ControlInput"	WO	67	Command message set by the Ethernet IP client.
"ControlOutput"	RO	3	Result data corresponding to a command that was written to the Control Input block.
"System"	RO	76	Information about the LMI device.
"Scanner"	RO	18	Information about a specific scanner.
"Stamp"	RO	33	Stamp message information.
"Measurement"	RO	5	Measurement data of a scan output measurement data message.

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. This is an optional field but is recommended that Ethernet IP 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	8u	2	Identifies the requested action from the external client. Supported actions: 0 = No Command 1 = Start Scanning 2 = Stop Scanning 3 = Align Sensor Group 4 = Clear Alignment 5 = Load Job File 6 = Software Trigger
Command Arguments	Array[8u]	3	Arguments for commands that require arguments. 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 Ethernet IP server. 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 Outpu 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	8u	2	Status of the command, referenced by the Command Sequence Number. 0 = No Command Received 1 = In Progress 2 = Success

Field	Type	Address offset	Description
			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. 0 = System is stopped 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, including extension. Maximum length of job file name is 64 characters. Each register contains a single character. 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. A value of 1 indicates that overflow occurred and data is being lost.

Sensor Group State

The output of the Scanner (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	Indicator of whether all devices under the sensor group are aligned (that is, devices in the sensor group all have a non-identity transform matrix). 0 = Not Aligned 1 = Aligned 2 = Aligning
Laser Enabled	8u	17	Whether one or more devices under the sensor group has its laser enabled to be able to turn on.

Field	Type	Address offset	Description
			0 = All devices' lasers are disabled and cannot turn on 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	Time stamp, in microseconds, of last frame.
Frame Index	64u	24	The frame number of the last frame.
Digital Input States	8u	32	Digital input states of last frame. Bit 0: State of digital input 1 on master or sensor 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. If the measurement value is invalid, the 32-bit value is set to 0x80000000.
Decision	8u	4	Measurement decision. Bit 0: 0 = Fail 1 = Pass Bit 1: 0 = Decision value is valid 1 = Decision value is invalid

PROFINET Protocol

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.

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. 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-sensor and on GoMax NX. PROFINET is not currently supported on PC instances of GoPxL. This functionality is planned for the near future.

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 assembly	"Measurement "	Read	0x34	5
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.
"System"	RO	76	Information about the LMI device.
"Scanner"	RO	18	Information about a specific sensor group.
"Stamp"	RO	33	Stamp message information.
"Measurement"	RO	5	Measurement data of a scan output measurement data message.

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. 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. Supported actions: 0 = No Command 1 = Start Scanning 2 = Stop Scanning 3 = Align Sensor Group 4 = Clear Alignment 5 = Load Job File 6 = Software Trigger
Command Arguments	Array[8u]	3	Arguments for commands that require arguments.

Field	Type	Address offset	Description
			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. 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. 0 = No Command Received 1 = In Progress 2 = Success 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. 0 = System is stopped 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, including extension. Maximum length of job file name is 64 characters. Each register contains a single character. 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.

Field	Type	Address offset	Description
			A value of 1 indicates that overflow occurred and data is being lost.

Sensor Group State

The output of the Scanner (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). 0 = Not Aligned 1 = Aligned 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. 0 = All devices' lasers are disabled and cannot turn on 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	Time stamp, in microseconds, of last frame.
Frame Index	64u	24	The frame number of the last frame.
Digital Input States	8u	32	Digital input states of last frame. Bit 0: State of digital input 1 on master or sensor 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. If the measurement value is invalid, the 32-bit value is set to 0x80000000.
Decision	8u	4	Measurement decision. Bit 0: 0 = Fail 1 = Pass Bit 1: 0 = Decision value is valid 1 = Decision value is invalid

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 107.

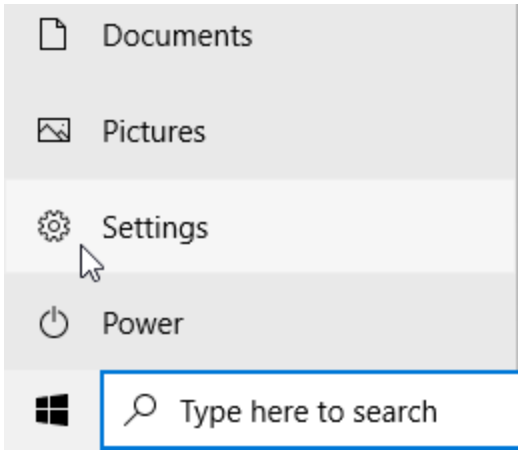
To use these third-party software applications, you *must* configure a system variable so the software can access the GenTL driver. For instructions, see *To configure system variables to use the driver in Windows 10*, below.

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.

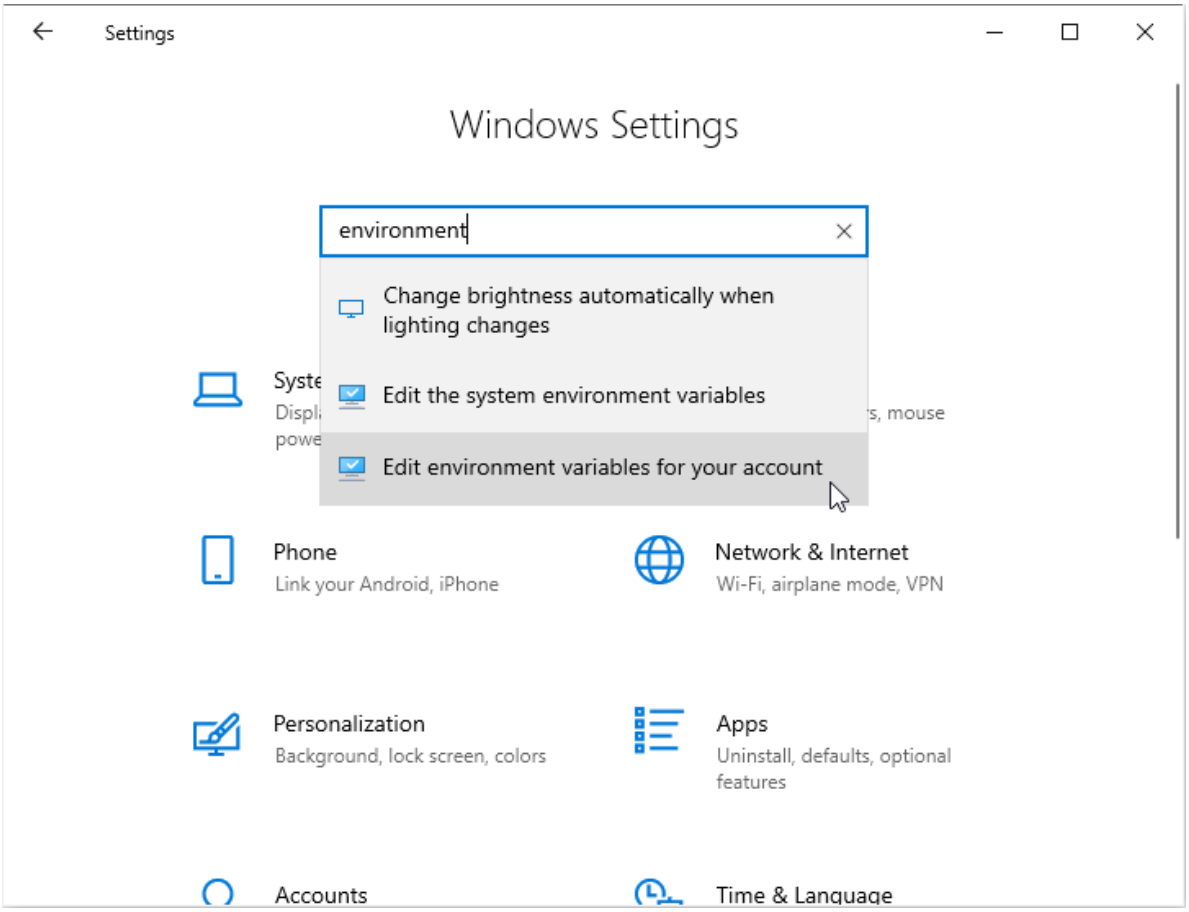
After downloading the package and unzipping the file to a location you will remember, you will find the driver in Integration\GenTL\x64 (you can move the GenTL folder to a more convenient location).

To configure system variables to use the driver in Windows 10

1. Click the Start menu and launch Settings.

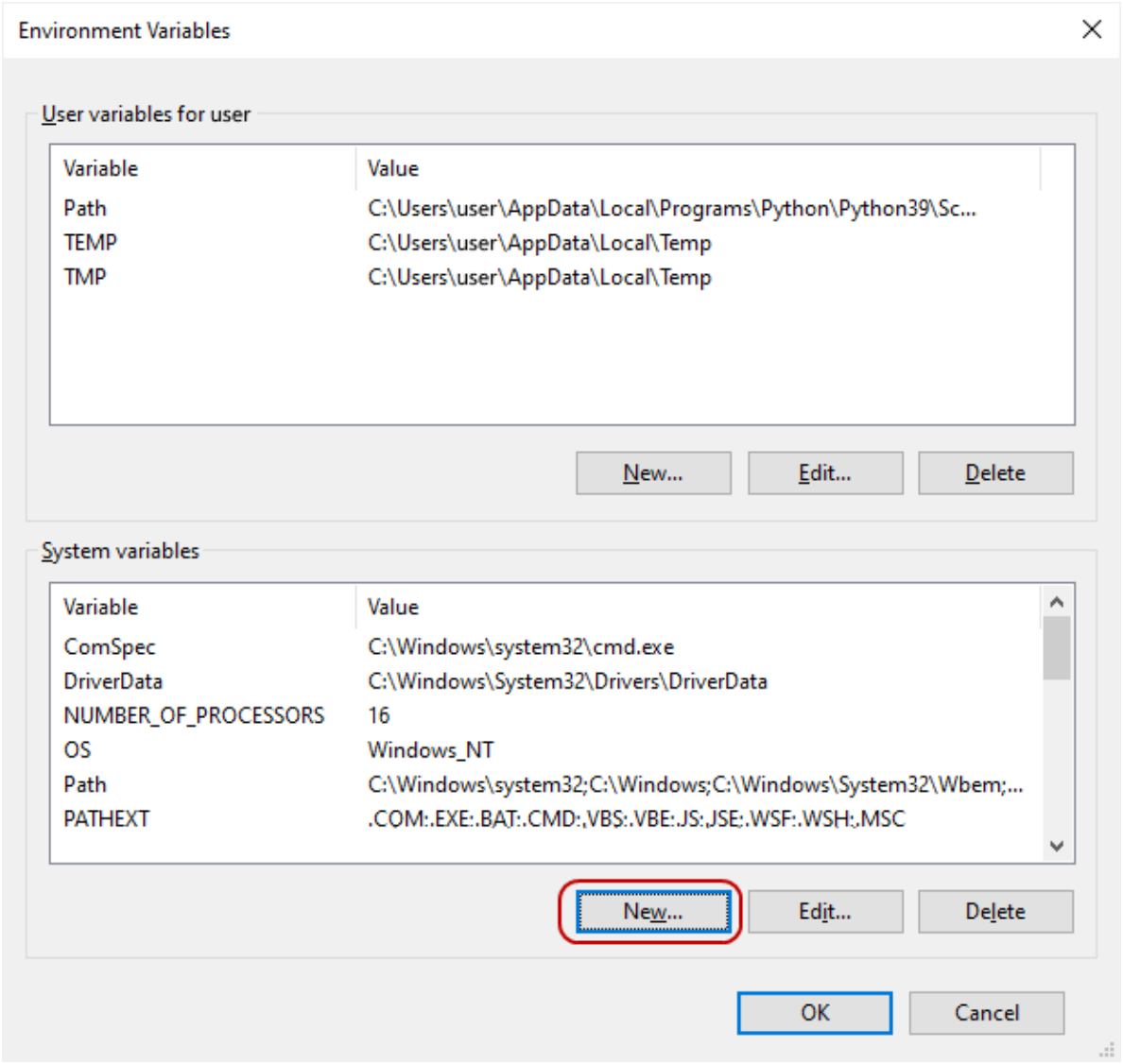


2. In the Settings application search field, type "environment".



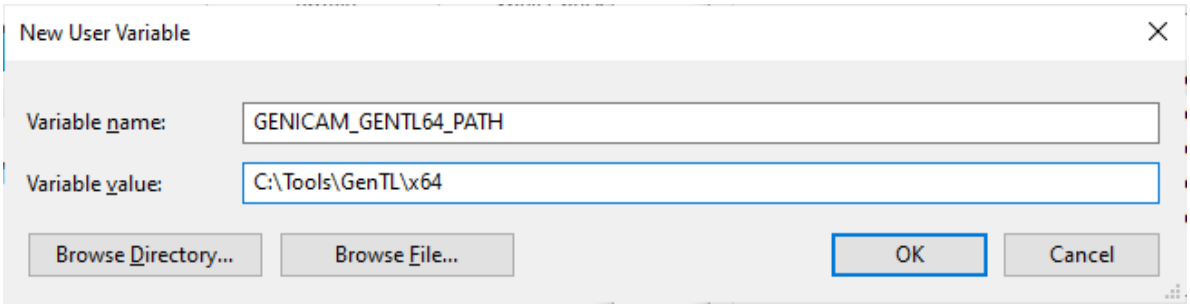
The Environment Variables dialog opens.

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 Gocator protocol and the desired outputs on the **Gocator** page. For more information on configuring the Gocator protocol, see *Gocator Communication Protocol* on page 626.

If you need intensity data, check **Acquire Intensity** in the **Scan Mode** panel on the **Scan** page and enable the intensity output on the **Gocator** page. For more information on enabling intensity, see *Scan Modes and Intensity* on page 107.

The GenTL driver packs the output, intensity, and stamps (e.g., time stamp, encoder index, etc.) into either a 16-bit RGB image or a 16-bit grey scale image. 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. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = Z offset + Pz * Z resolution 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. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz): X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = 16-bit intensity value 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.

Channel	Details
	Refer to the blue channel on how to retrieve the offset and resolution values.
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) 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. The following formula can be used to calculate the real-world coordinates (X, Y, Z) from pixel coordinates (Px, Py, Pz):

Rows	Details
	X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = Z offset + Pz * Z resolution 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) 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. 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. X = X offset + Px * X resolution Y = Y offset + Py * Y resolution Z = 16-bit intensity value 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. 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) 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)

Stamp Index	Column Position	Details
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

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 0 – Disable resampling 1 – Enable resampling 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). 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). 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 Address	Name	Read/Write	Length (bytes)	Description
				register causes the sensor to switch to the 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: 0 – Disable 1 – Enable 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: 0 – 16-bit RGB Image 1 – 16-bit grey scale Image The default value is 0.
OverrideImageWidth OverrideImageLength	32u	If you are using a multi-sensor system with Halcon, you must configure these settings as follows: OverrideImageWidth = image width / X resolution OverrideImageLength = image length / Y resolution Otherwise, leave the default of 0.
RawPartDetectionHeightThreshold 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. RawPartDetectionHeightThreshold: Detects the start and end of a part when scanning. When data points in the profile go over this threshold, the driver starts concatenating the profiles. As soon as

Element	Type	Description
		no data points are above this threshold, the driver stops concatenating profiles. RawPartDetectionMaxLength: The maximum length of a part. 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 3D data points and intensity data into Halcon in real-time. Halcon is supported in GoPxL 1.0 and higher.

> 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 726.

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.

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.

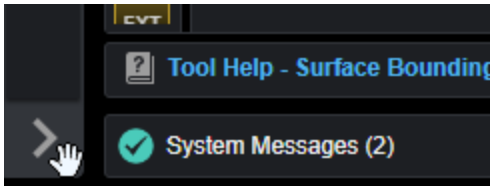
   You will need a Master hub to connect the sensor to the PC. For more information, see *Installation* on page 25 and *Network and Sensor Setup* on page 35.

2. Connect to GoPxL running either on a sensor or a PC using a web browser.

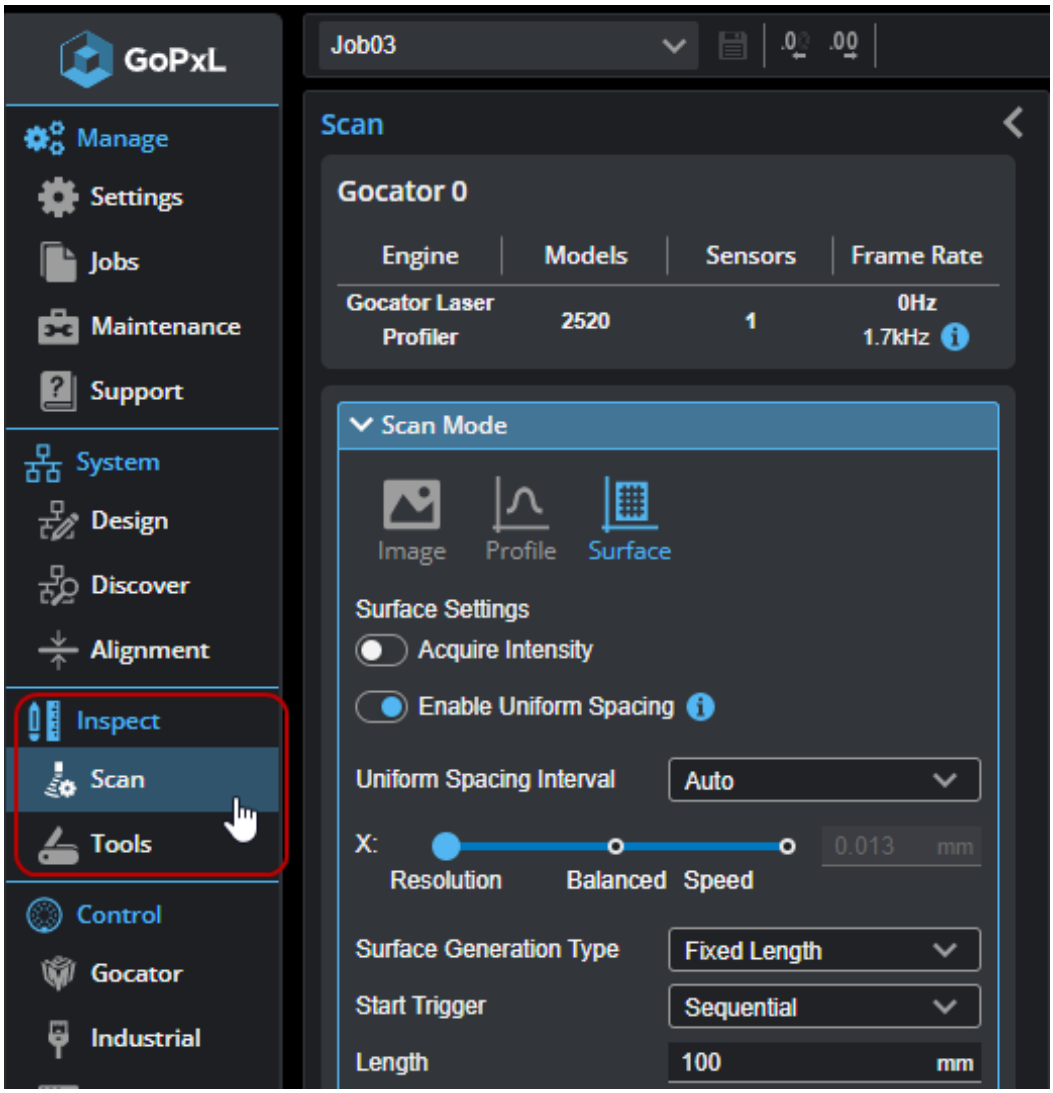
   By default, a sensor's IP is 192.168.1.10. If you have changed the sensor's IP, use that. If you can't find your sensor, see *GoPxL Discovery Tool* on page 750.

   For more information on running GoPxL on a PC, see *Running GoPxL on a Windows PC* on page 656.

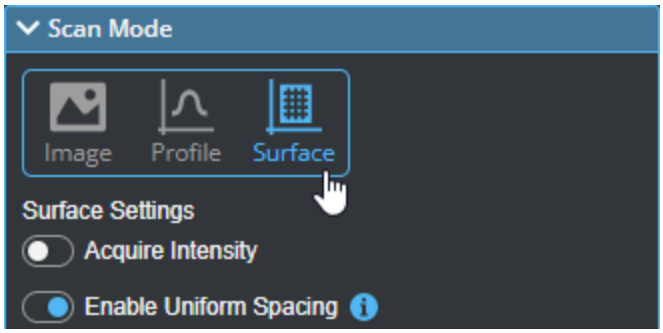
3. In the GoPxL interface, expand the navigation bar on the left side of the interface.

4. Click the **Scan** page icon in the navigation bar on the left.

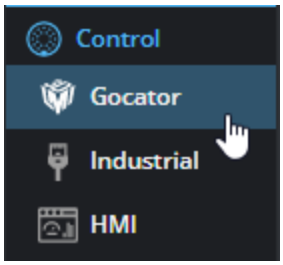


5. On the **Scan** page, click the **Surface** icon to switch to Surface mode.

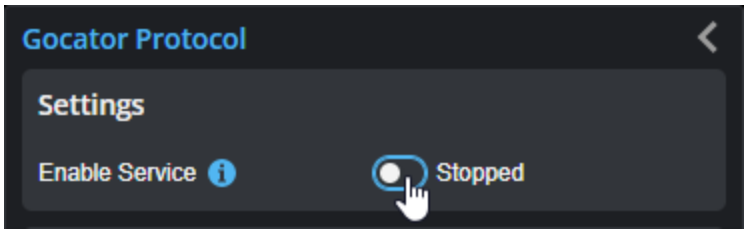


6. (Optional) If you need intensity data, enable **Acquire Intensity**.
7. Configure the sensor to produce the desired surface data.

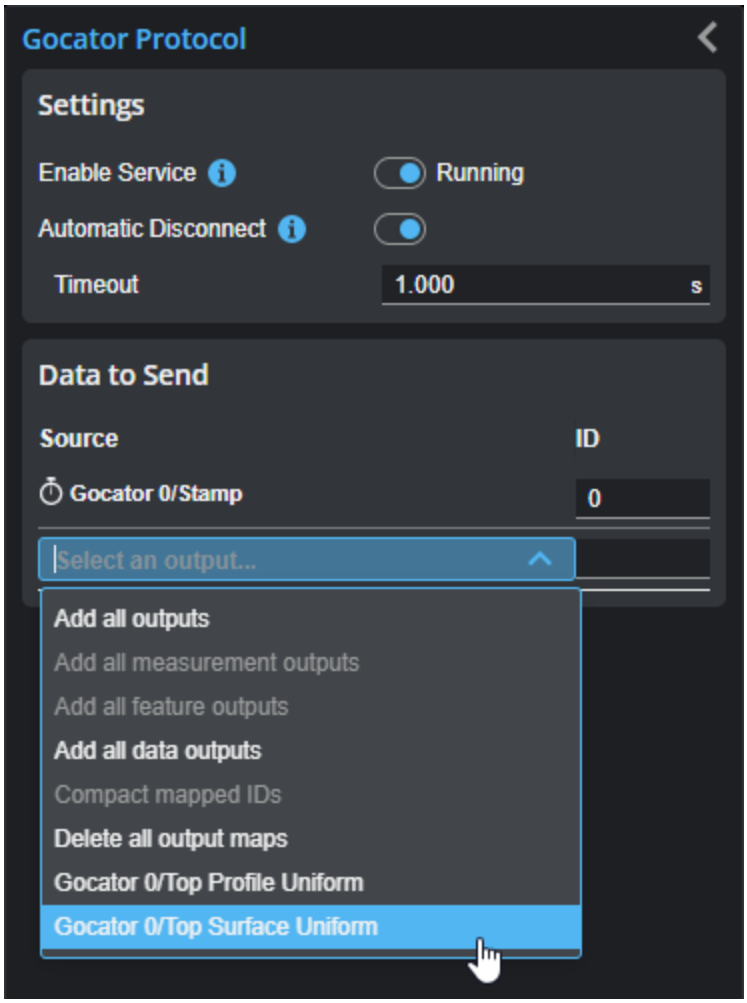
   For more information on configuring sensors, see *Configuring Acquisition* on page 107.
8. Click the **Gocator** page icon in the navigation bar.



9. On the **Gocator** page, enable the Gocator protocol.



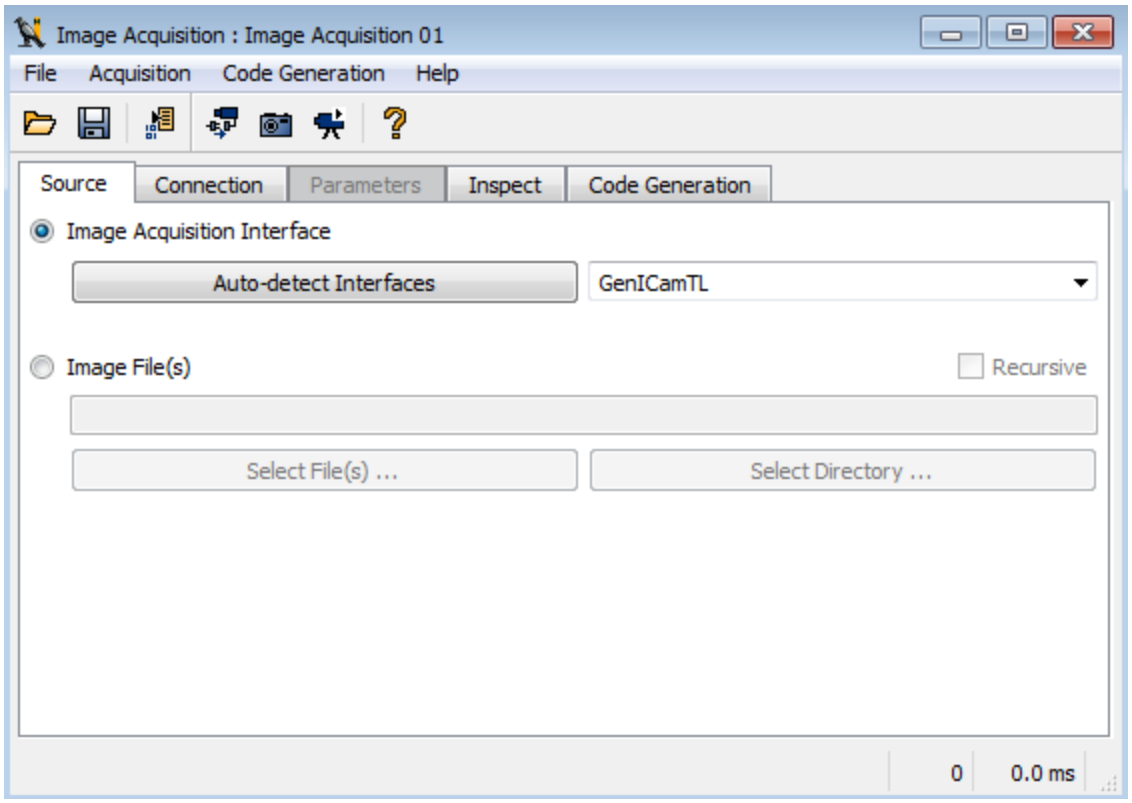
10. In the **Data to Send** section, choose the surface you want to send to Halcon.



For more information on configuring Gocator output, *Gocator Communication Protocol* on page 626.

11. Make sure the sensor is running.

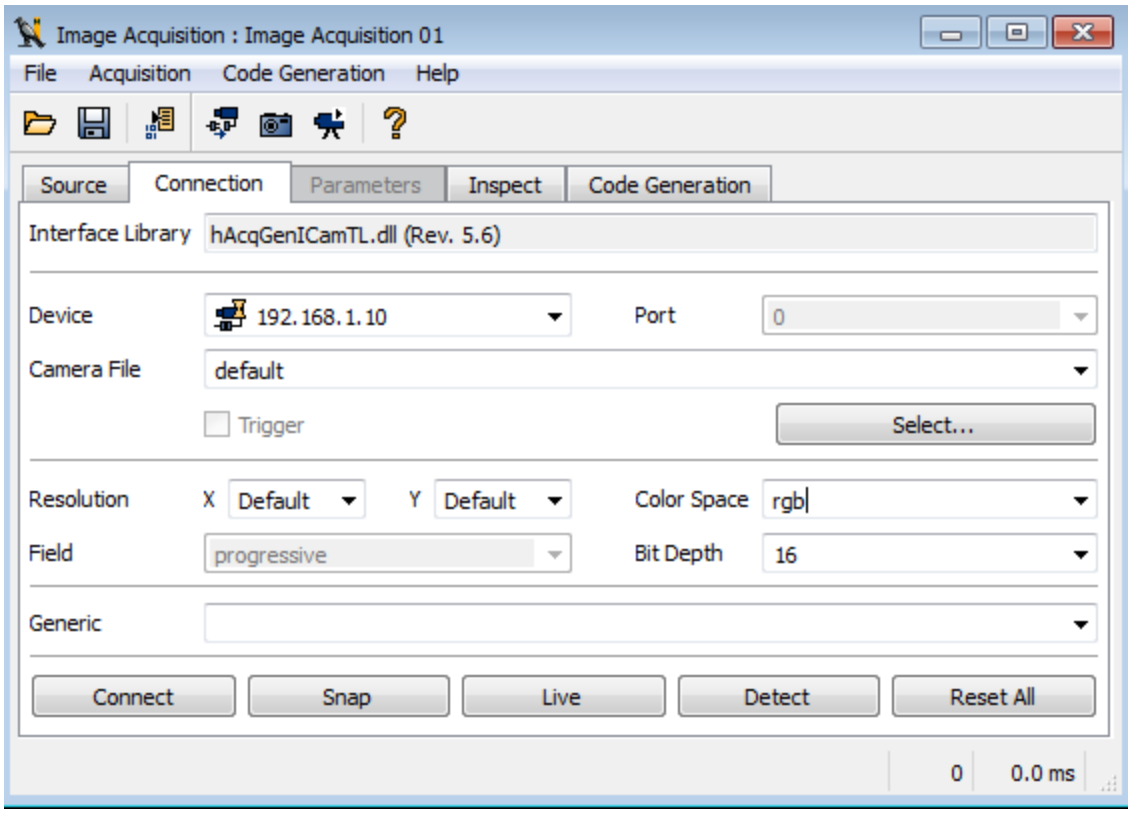
12. On the PC, launch Halcon.
13. In Halcon, in the **Assistants** menu, click **Open New Image Acquisition**.
14. In the dialog that opens, in the **Source** tab, check the **Image Acquisition Interface** option and choose `GenICamTL` in the drop-down.



> 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.

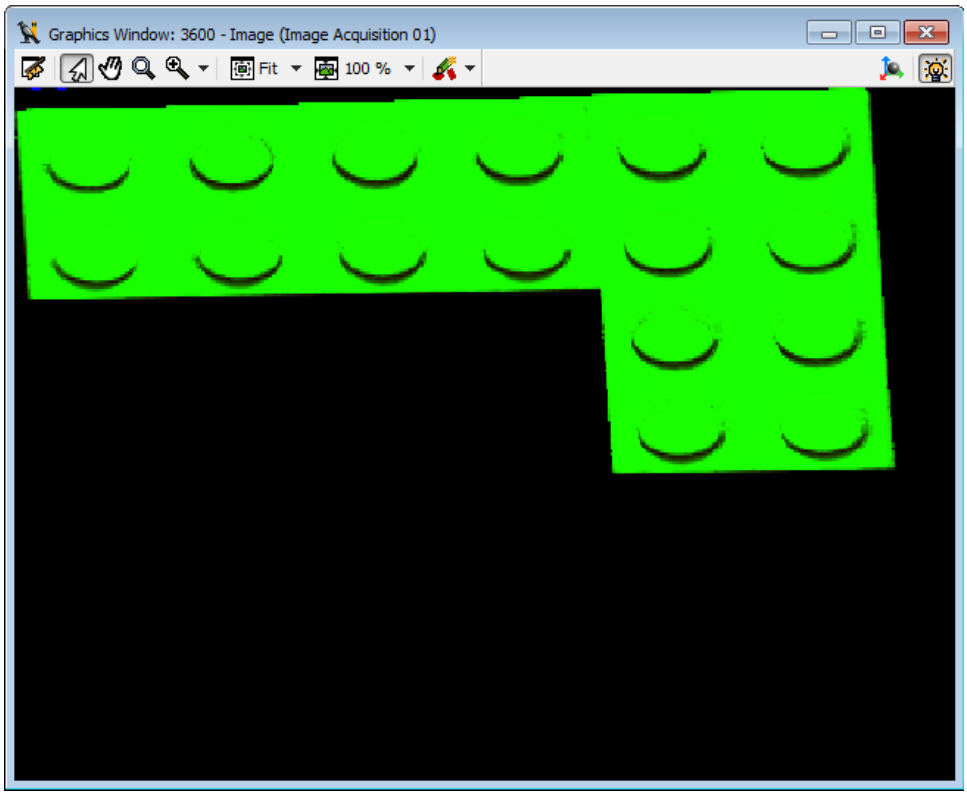
    If Halcon detects a sensor, the sensor's IP will be listed next to **Device**.



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: `set_framegrabber_param( AcqHandle, 'Name', 'Value')` *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. **Name**: The name of the parameter to set on the sensor. **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 743.
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: `get_framegrabber_param( AcqHandle, 'Name', 'Value')` *Parameters* **AcqHandle** (input): Acquisition handle created by `open_framegrabber`. **Name** (input): The name of the parameter to set on the sensor. **Value** (output): The variable where parameter's value will be stored. For full details on using this function, see *XmlSetting and XmlCommand Parameters* on page 743.
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. For details on how the information is packed in the data, see the sections under *GenICam GenTL Driver* on page 726. The function accepts the image acquired from `grab_image_async`, and returns the height map, intensity and stamps. ***Parameters*** **Image** (input): RGB Image acquired by using `grab_image_async`. **HeightMap** (output): The height map image. **Intensity** (output): The intensity image. **Stamps** (output): The stamps structure. **Index** (input): The index of the scan to extract. **NumScans** (output): The number of scans in the acquired image. Each output is returned as decimal value. ***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. For details on how the information is packed in the data, see the sections under *GenICam GenTL Driver* on page 726. The function accepts the stamp structure acquired from the Go2GenTL_ParseData function, and returns the various values encoded in the stamps. ***Parameters (Input)*** **Stamps**: The stamps structure acquired by using Go2GenTL_ParseData. ***Parameters (Output)*** **FrameCount**: The number of frames.

Procedures	Description
	Timestamp: The timestamp. **Encoder**: The encoder position. **EncoderIndex**: The last index of the encoder. **Inputs**: The digital input states. **xOffset**: The X offset in millimeters. **xResolution**: The X resolution in millimeters. **yOffset**: The Y offset in millimeters. **yResolution**: The Y resolution in millimeters. **zOffset**: The Z offset in millimeters. **zResolution**: The Y resolition in millimeters. **zOffset**: The Z offset in millimeters. **zResolution**: The Z resolution in millimeters. **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. **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. **HasIntensity**: Specifies if the intensity image is available. The intensity image is available if **Acquire Intensity** is enabled in the sensor's web interface. **NumScans**: The number of scans in the acquired image. **SyncTimestamp**: The PTP time stamp. **MeasurementIds**: Array of every measurement's ID. **MeasurementValues**: Array of every measurement's value. **MeasurementDecisions**: Array of every measurement's decision. **MeasurementDecisionCodes**: Array of every measurement's code. Each output is returned as decimal value. ***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. ***Parameters (Input)*** **AcqHandle**: Acquisition handle created by `open_framegrabber`.

Procedures	Description
	Parameters (Output) **ResampleMode**: No - Resample is disabled. Yes - Resample is enabled. 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. ***Example*** `Go2GenTL_ResampleMode (AcqHandle, ResampleMode)` 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. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. *Parameters (Output)* **ConfigFile**: The name of the job file. The file name includes the extension .job. *Example* `Go2GenTL_ConfigFileName (AcqHandle, ConfigFile)`
Go2GenTL_ SetConfigFileNam e	Sets the sensor live configuration. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. **ConfigFile**: The name of the job file. The file name should include the extension .job. *Example* `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. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. *Parameters (Output)* **EncoderValue**: The current encoder value. *Example* `Go2GenTL_Encoder(AcqHandle, EncoderValue)`
Go2GenTL_ ImageSize	Returns the size of the image returned by the GenTL driver. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. *Parameters (Output)* **Width**: The width of the image. **Height**: The height of the image. *Example* `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. The values of the offset and resolution input parameters can be retrieved using Go2GenTL_ ParseData. *Parameters (Input)* **HeightMap**: The height map image. **Row**: The row in the height map. **Column**: The column in the height map. **xOffset**: The X offset in millimeters. **xResolution**: The X resolution in millimeters. **yOffset**: The Y offset in millimeters. **yResoluion**: The Y resolution in millimeters. **zOffset**: The Z offset in millimeters. **zResolution**: The Z resolution in millimeters. *Parameters (Output)* **coordinateXYZ**: The real-world coordinates.
Go2GenTL_ Exposure	Returns the current exposure. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. *Parameters (Output)* **Exposure**: The current exposure value (in µs). The value is returned as an integer. Decimals are truncated. *Example* `Go2GenTL_Exposure(AcqHandle, exposure)`
Go2GenTL_ SetExposure	Sets the current exposure. *Parameters (Input)* **AcqHandle**: Acquisition handle created by `open_framegrabber`. **Exposure**: The current exposure value (in µs), as an integer. *Example* `Go2GenTL_SetExposure(AcqHandle, exposure)`

XmlSetting and XmlCommand Parameters

Sensor Settings

You use the `set_framegrabber_param` and `get_framegrabber_param` functions to set and retrieve 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 746.)

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 `set_framegrabber_param` repeatedly to set the XML path to the setting, by chunks of up to 30 characters, and retrieve the value into the passed variable in `set_framegrabber_param`. The following retrieves the value for the setting "Setup/Filters/XSmoothing/Window":

```
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Setup/Filters/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'XSmoothing/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Window')
get_framegrabber_param(AcqHandle, 'XmlSettingReturn', var)
```

To set a value, use `set_framegrabber_param` repeatedly to set the XML path to the setting, by chunks of up to 32 characters, add "=<value>", and end with an empty string.

The following sets the value of "Setup/Filters/XSmoothing/Window" to 5:

```
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Setup/Filters/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'XSmoothing/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Window=5')
set_framegrabber_param(AcqHandle, 'XmlSetting', '')
```

You can also optionally add the "\n" character to the end of the last line of the set operation:

```
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Setup/Filters/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'XSmoothing/')
set_framegrabber_param(AcqHandle, 'XmlSetting', 'Window=5\n')
```

To set or get an attribute, use the same format, but use a space to delimit the attribute ('Setup/Filters/XSmoothing/Window min="0.044"').

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 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/ScheduledStart" "GenTL/SystemScheduledStart" "GenTL/SensorScheduledStart"	Read-only. Schedule a start when the stamp (in the current domain, can be time or encoder mode) is reached. Applies for all three "GenTL/XScheduledStart" commands.
"GenTL/State" "GenTL/State(id)"	Read-only. By default, gets the state of the main sensor. If an ID is provided, the state of the connected sensor is returned. Use ID=0 for the main sensor. Any buddy starts at ID=1. For a system with a main and 2 buddies, the indices can be from 0 to 2.
"GenTL/BuddyState" "GenTL/BuddyState(id)"	Read-only. By default, gets the state of the first buddy sensor. If an ID is provided, the state of the connected sensor is returned. Use ID=0 for the first buddy sensor. For a system with a main and 2 buddies, the indices can be 0 or 1.
"GenTL/BuddyAt" "GenTL/BuddyAt(id)"	Read-only. By default, gets the serial number of the first buddy sensor. If an ID is provided, the serial number of the connected sensor is returned. Use ID=0 for the first buddy sensor. For a system with a main and 2 buddies, the indices can be 0 or 1.
"GenTL/BuddyCount"	Read-only. Returns the number of buddy sensors. For a system with a main and 2 buddies, the function will return 2.

Setting	Comment
"GenTL/Main"	Read-only. Returns the serial number of the main sensor.
"GenTL/AlignResult"	Read-only. Returns the alignment result of the last "GenTL/Align" command (see See *Driver-level commands* below).
"GenTL/LastResult"	Read-only. Returns the last result for any GenTL XmlCommand.
"GenTL/TransformX(id)" "GenTL/TransformY(id)" "GenTL/TransformZ(id)" "GenTL/TransformXAngle(id)" "GenTL/TransformYAngle(id)" "GenTL/TransformZAngle(id)"	Read-Write. Gets or sets the transformation value for a given transform of the specificed sensor ID.
"GenTL/TransformEncoderResolution"	Read-Write. Gets/Sets the encoder resolution for a sensor.

The following driver-level commands are available:

Driver-level commands

Setting	Comment
"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/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" "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', 'Setup/SurfaceGener')
* set_framegrabber_param(AcqHandle, 'XmlSetting', 'ation/FixedLength/')
* set_framegrabber_param(AcqHandle, 'XmlSetting', 'Length')
* get_framegrabber_param(AcqHandle, 'XmlSettingReturn', var1)
* *Set fixed length
* set_framegrabber_param(AcqHandle, 'XmlSetting', 'Setup/SurfaceGener')
* set_framegrabber_param(AcqHandle, 'XmlSetting', 'ation/FixedLength/')
* set_framegrabber_param(AcqHandle, 'XmlSetting', 'Length=400')
* set_framegrabber_param(AcqHandle, 'XmlSetting', '')

* 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)

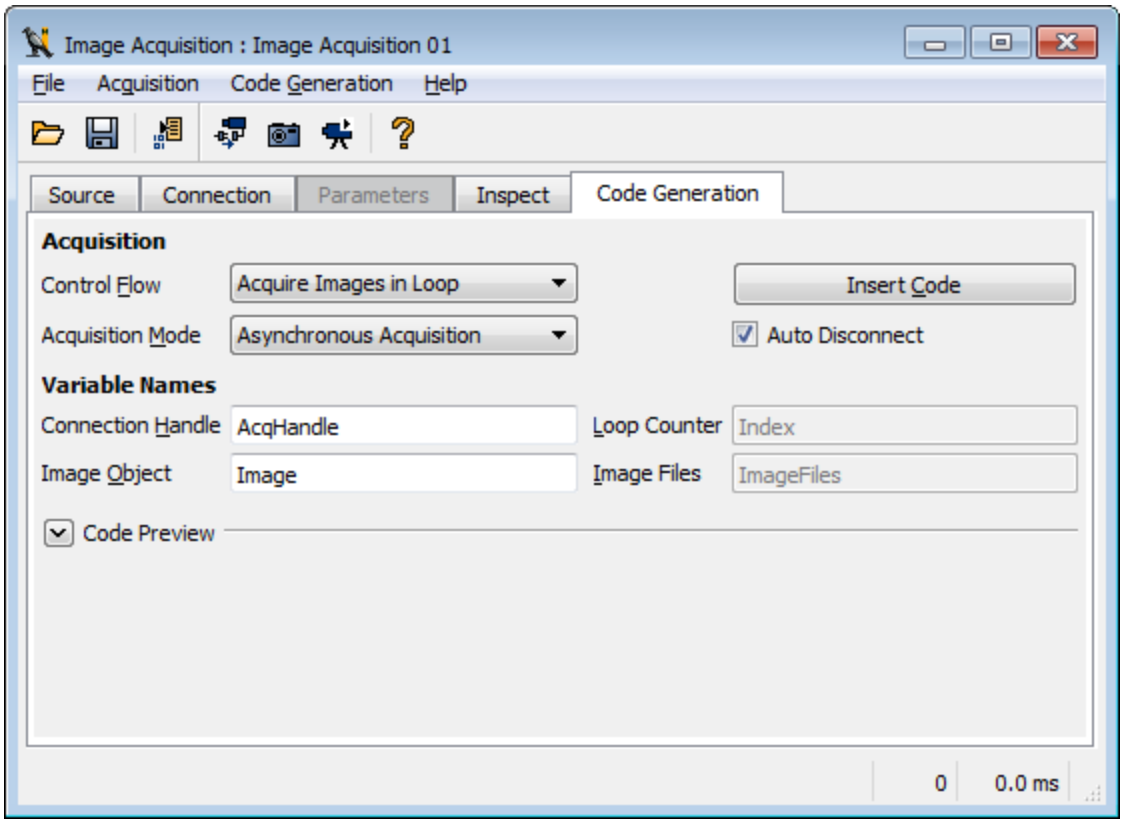

close_framegrabber (AcqHandle)
```

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.

Utilities

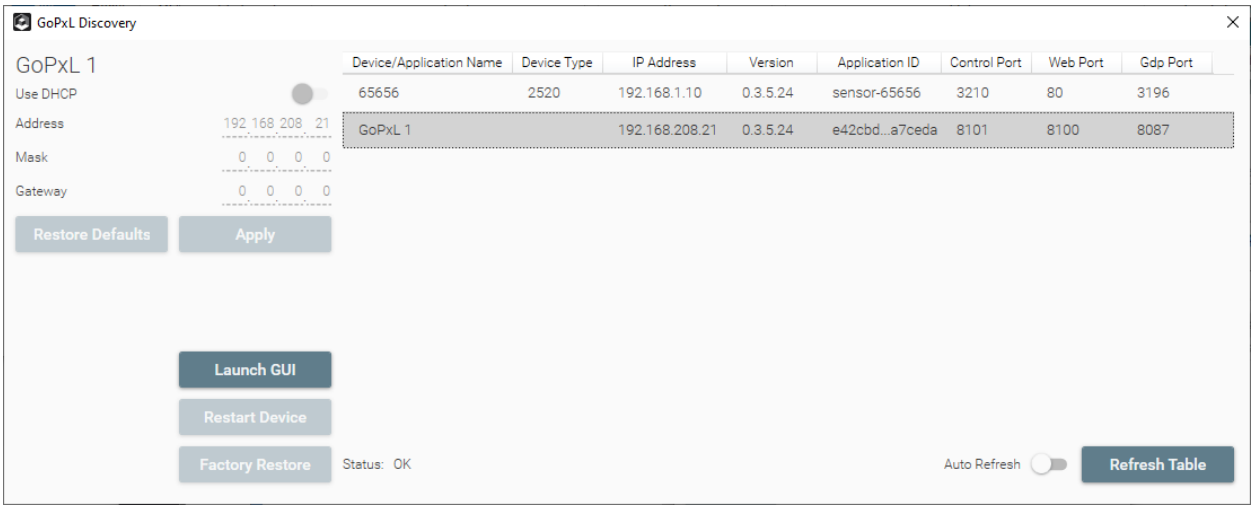
The following sections describe some of the utilities tools provided with a Gocator sensor, as well as the CSV format that a sensor can export. For information on the integrations available with a sensor, see *Integrations* on page 703.

You can get the tools 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/.

- 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 sensors on a network. See *GoPxL Discovery Tool* below.
- Replay Converter 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 Converter Tool* on page 753.
- Track Editor: Used with the Surface Track tool. For more information, see *Surface Track* on page 515.
- Pattern Editor: Used to edit patterns created in the Surface Pattern Matching tool. For more information, see *Pattern Editor* on page 760.

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:

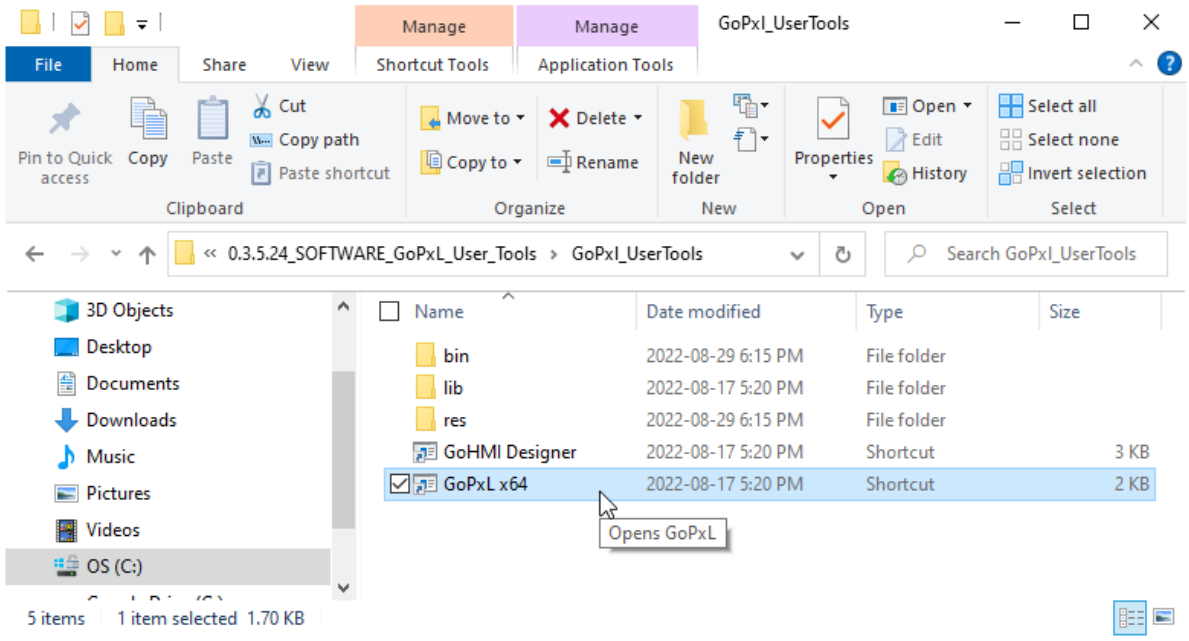
- Find a sensor if you have forgotten its IP address.
- View port information.
- Set the network configuration (IP address, mask, and so on) of a sensor, and also restore these values to the default.
- Launch the GUI of a sensor in your browser.
- Restart the sensor.
- Perform a factory restore on a 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.

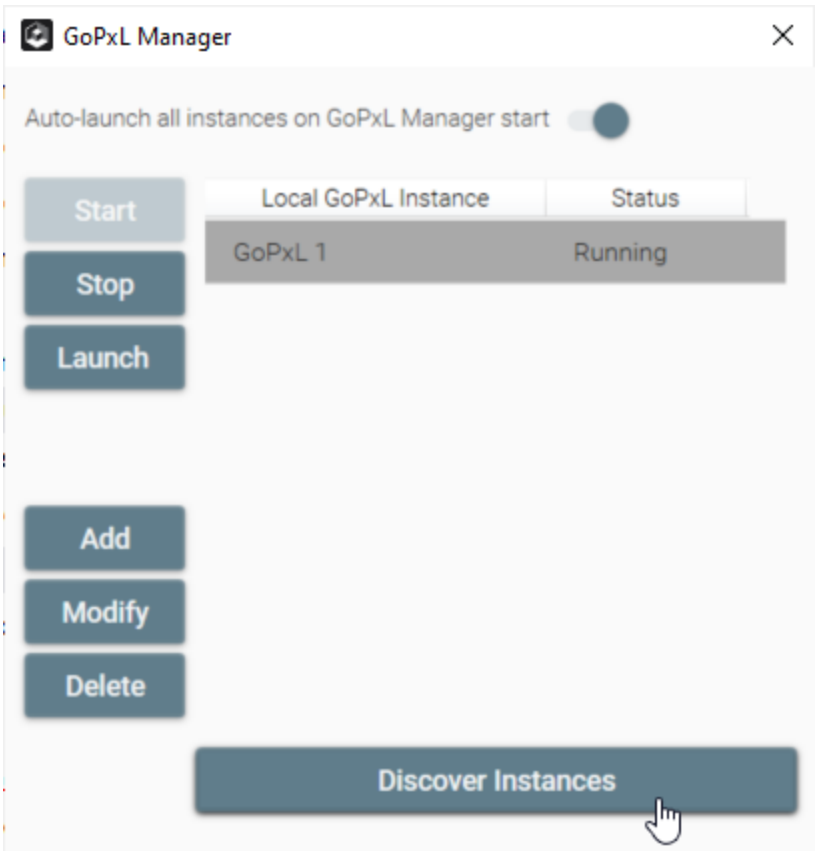
To run the GoPxL Discovery tool

1. If it isn't already running, start the Windows version of GoPxL.



   GoPxL Manager opens.

2. In the manager tool, click **Discover Instances**.



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 used when you connect to the GoPxL interface in a browser. 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 692.)

If a sensor or GoPxL instance is missing, click the **Refresh Table** button. Optionally, you can also enable the **Auto Refresh** toggle; note however that you can't perform operations when this setting is enabled.

To perform operations on a sensor or a GoPxL instance, click its row in the tool and then perform the operation.

Replay Converter Tool

The Replay Converter is a console application that lets you do the following conversions with Surface scan data:

.gprec <=> .srf/.sur/.pcd (Valid for Surface input data)

.gprec <=> .pro (Valid for Profile recording input data)

.gprec => .csv (Valid for Profile/Surface recording input 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 utility package, unzip the file and run ReplayConverter.exe (under Tools\ReplayConverter).

The tool provides the following parameters:

--help: Show the instructions for use

-i/--input: Specify the file name of the input file

-f/--frame: Specify the index of the exported frame in the recording data (Default is 0)

-w/--width: Specify the width of the exported surface (Only valid for the pcd file importing)

-h/--height: Specify the height of the exported surface (Only valid for the pcd file importing)

-s/--swap: Whether to swap the x and z coordinates (Only valid for the pcd file importing)

-z/--zoom: Specify the zooming factor of the exported surface (Only valid for the pcd file importing)

-r/--remove: Remove the specific point (Only valid for the pcd file importing)

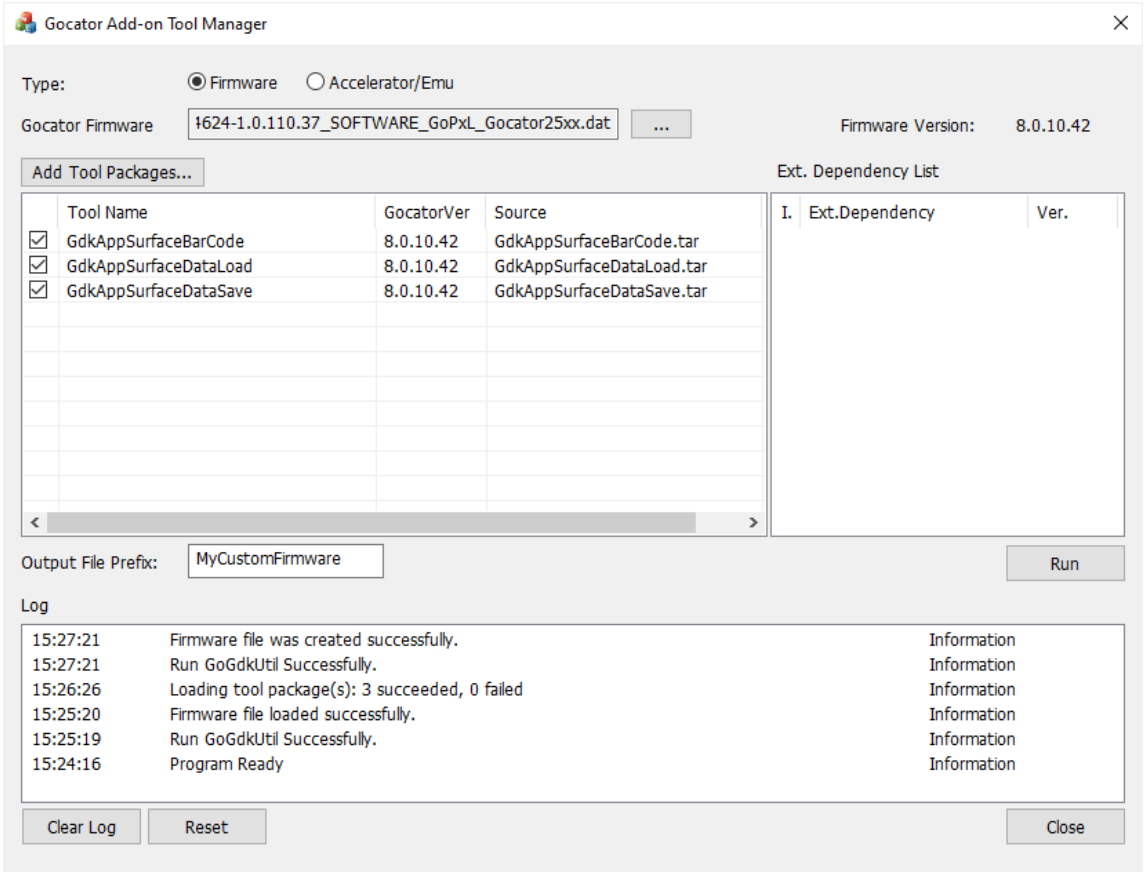
-a/--all: Export all the frames if the import is recording data

-o/--output: Specify the file name of the output file. For the case that the imported file isn't a recording data, if the exported file name isn't specified, it will use the imported file name as the exported file name

For example, 'ReplayConverter.exe xxx.gprec -f 0 -o xxx.sur'

Beta Add-on Tool Manager

The Beta Add-on Tool Manager lets you quickly and easily add LMI-provided beta tools to an existing firmware file. After updating the firmware, upload it to a compatible sensor; for more information, see *Software Upgrade* on page 94.



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 Gocator Add-on Tool Manager is as follows:

1. Load a .dat Gocator firmware file (or point the 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.
4. Run the tool manager on the firmware and tool packages.

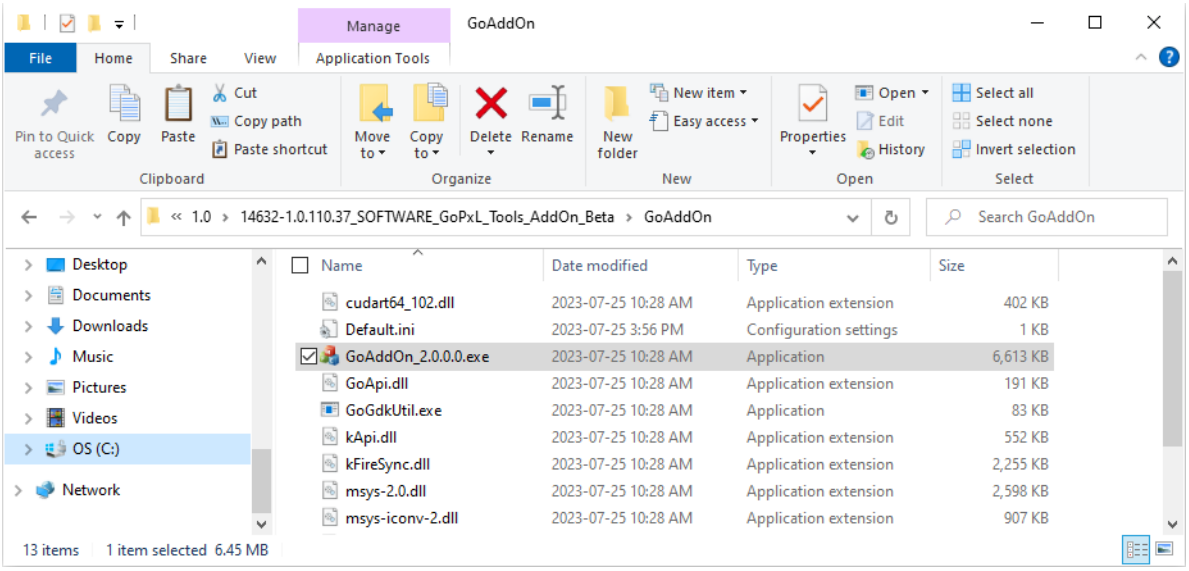
The result is a modified firmware file or GoPxL for PC that contains the tools you selected.

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 a Firmware

To add beta tools to a firmware:

1. If you haven't already done so, download and unzip the package containing the Gocator 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.

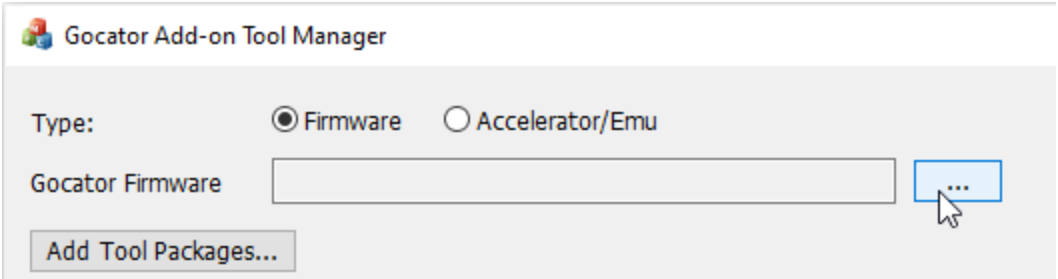


3. In the tool manager, set the type.

   Set the type to **Firmware** to create a custom firmware you will upload to a sensor.

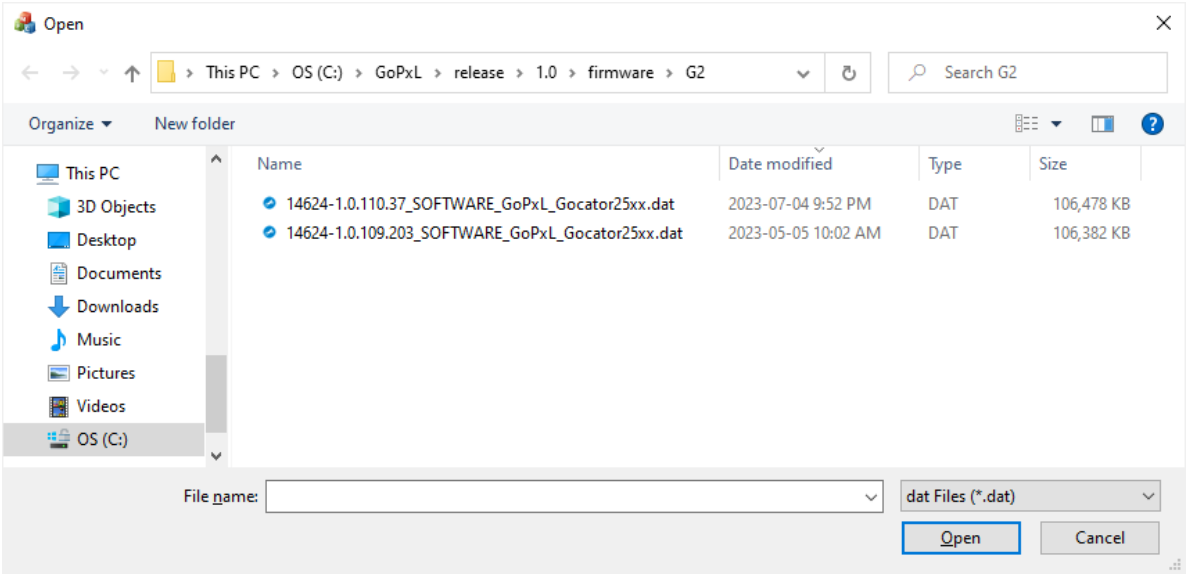
   Set the type to **Accelerator/Emu** to create a custom Windows version of GoPxL.

4. Below the type, click the ... button to choose the firmware or GoPxL folder.

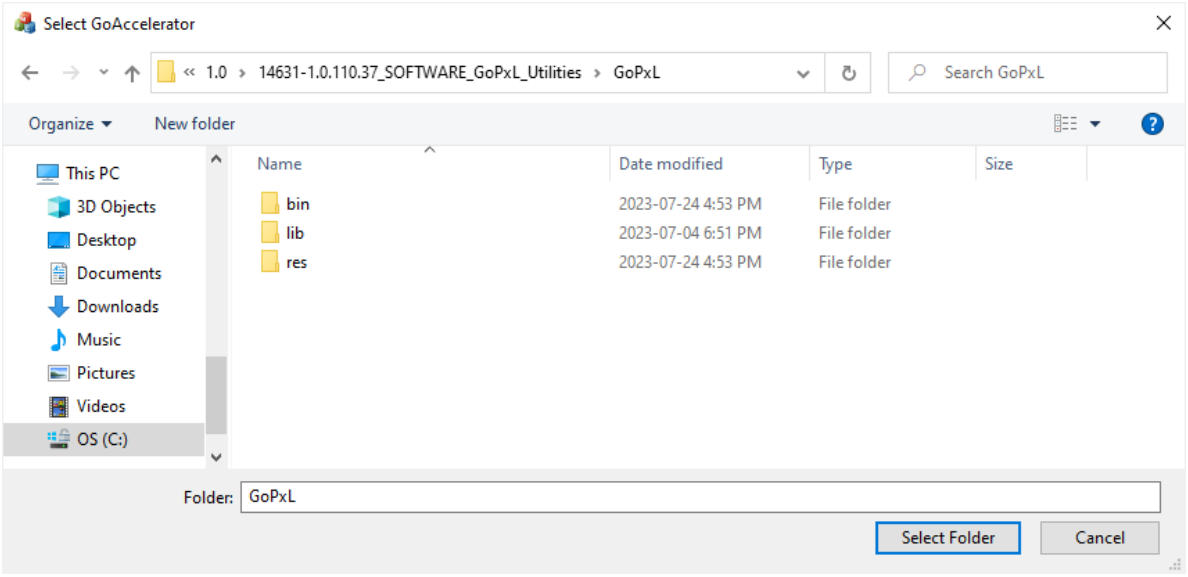


5. In the Open dialog that displays, navigate to the location of the .dat firmware file or the folder you want to use.

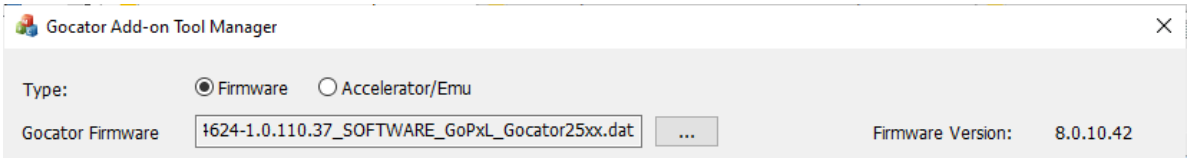
   Choosing a firmware:



Choosing a folder containing GoPxL for Windows:

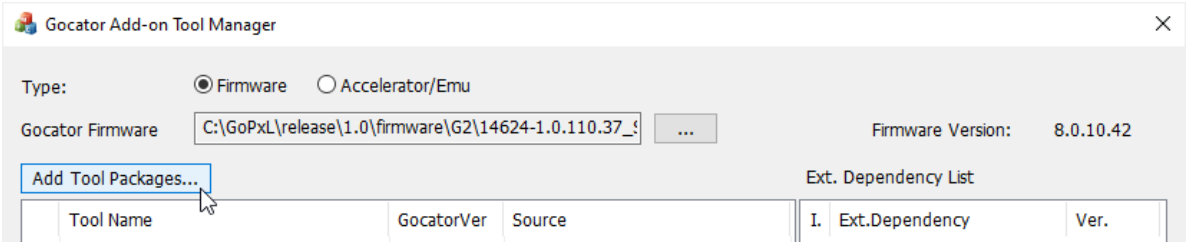


The tool manager loads the firmware.

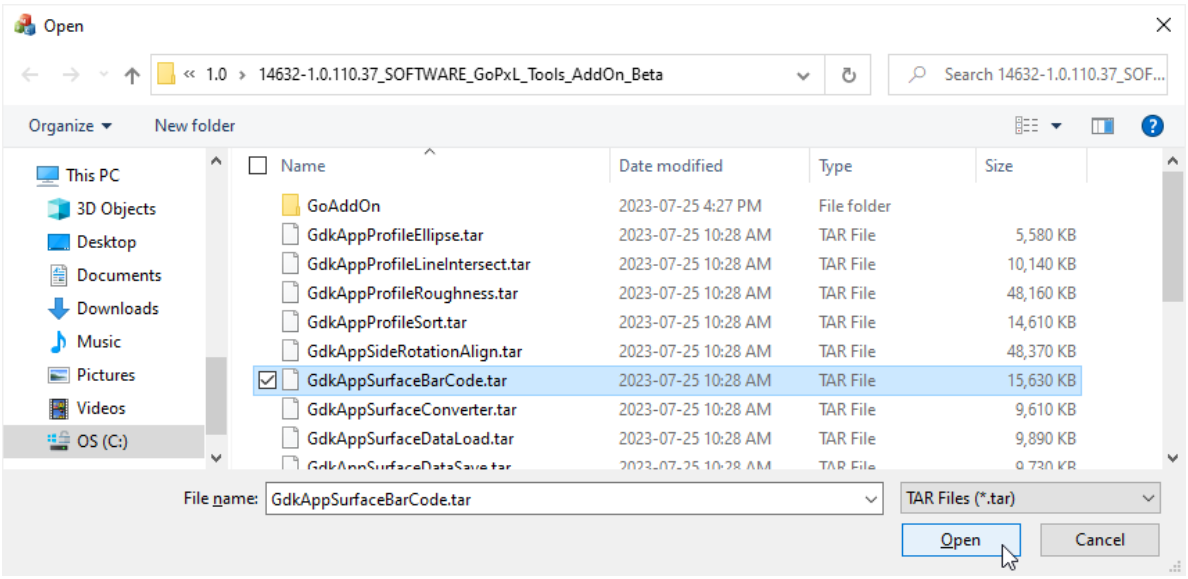


If the firmware was previously created using the tool manager, the tools will be listed in the tool window. For information on removing tools, see *Beta Add-on Tool Manager* on page 753.

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**.

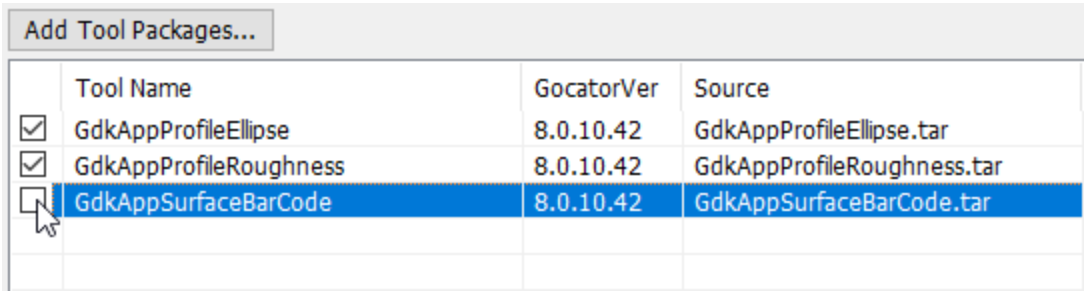


The tool manager adds the package to the tool list.

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.



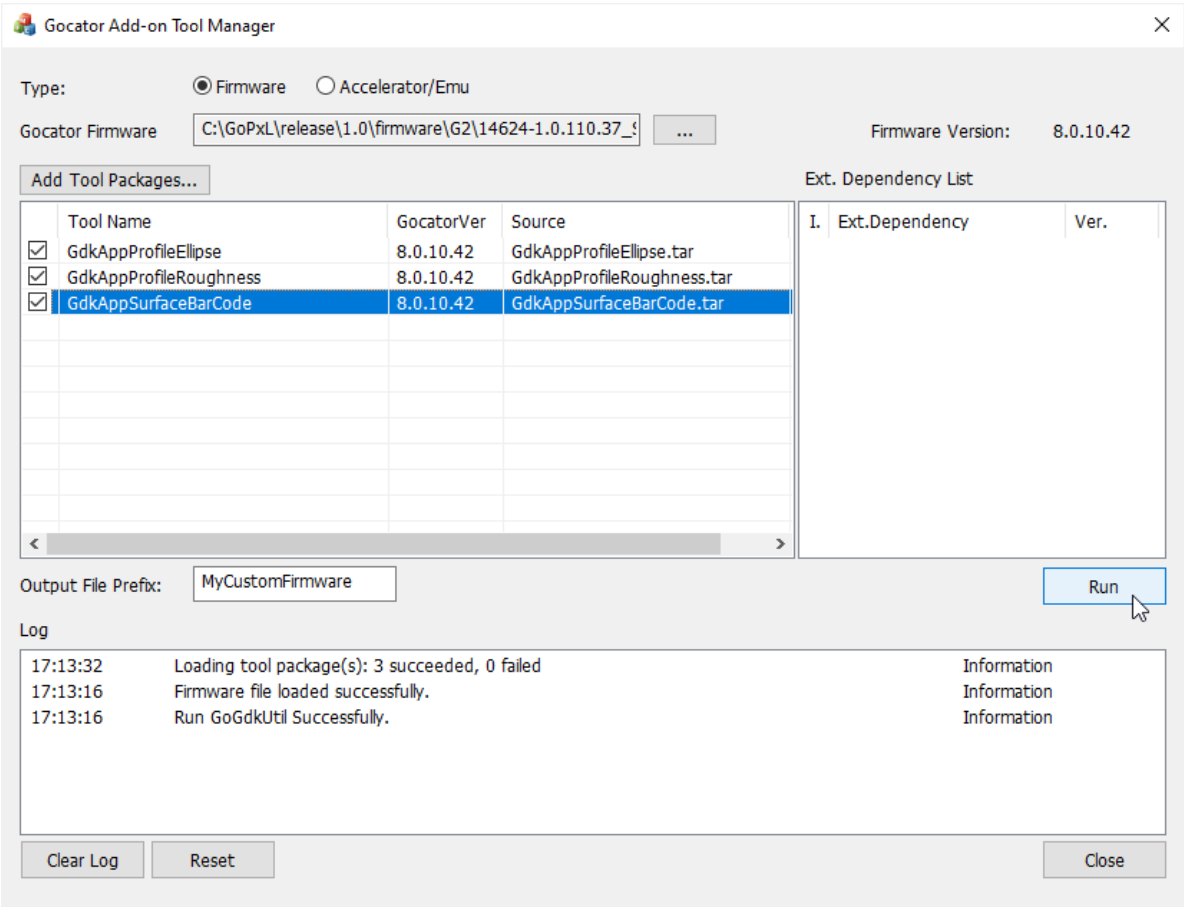
> Be sure to select at least one tool.

9. 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.

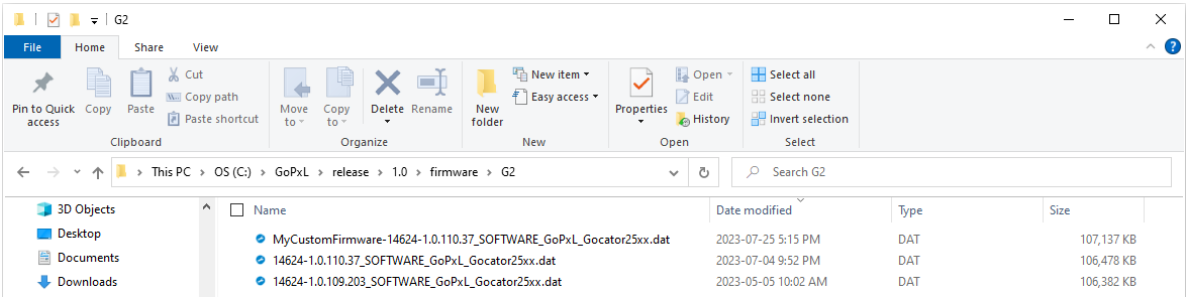


This field is hidden when you are adding tools to GoPxL for Windows folder.

10. Click **Run**.



If you are adding tools to a firmware, the tool manager creates a new firmware 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.

After you have successfully created the new firmware, you can upload it to any compatible sensor; for more information, see *Software Upgrade* on page 94.

Pattern Editor

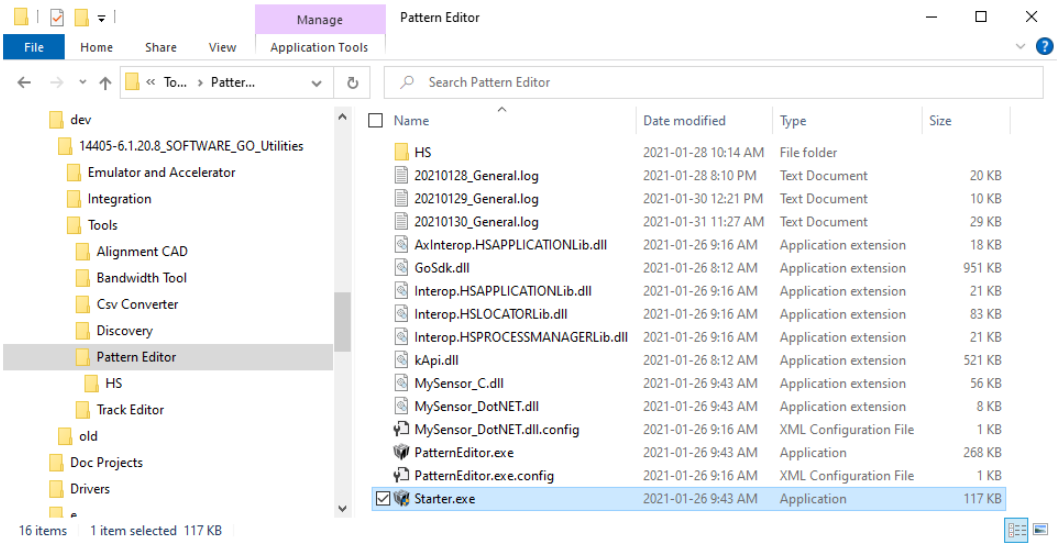
The pattern editor lets you modify patterns created in the Surface Pattern Matching tool (for more information on the tool, see *Surface Pattern Matching* on page 455). Although the patterns created in the Surface Pattern Matching tool will often result in good matches with your targets, you can use the pattern editor to improve the models, specifically by doing the following:

- Add or remove 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 working folder used to store pattern files (which end with a .hdb.user extension) depends on whether you are working with an accelerated sensor or an unaccelerated sensor. With an accelerated sensor, the working folder is C:\GoTools\SurfacePatternMatching. With an unaccelerated sensor, the working folder is C:\GoTools\SurfacePatternMatchingSensor; connecting to a sensor using the Pattern Editor downloads the models to this folder.

> When uploading a model to an unaccelerated sensor, an error will be displayed if there is not enough space on the sensor. Add an instance of Surface Pattern Matching (or any other tools that store models on-sensor, such as Surface Track), and delete unneeded models using the Delete operation under the Operation dropdown.

The pattern editor is available in the Utilities package (`14405-x.x.xx.xx_SOFTWARE_GO_Utilities.zip`, in the `Tools\Pattern Editor` folder.

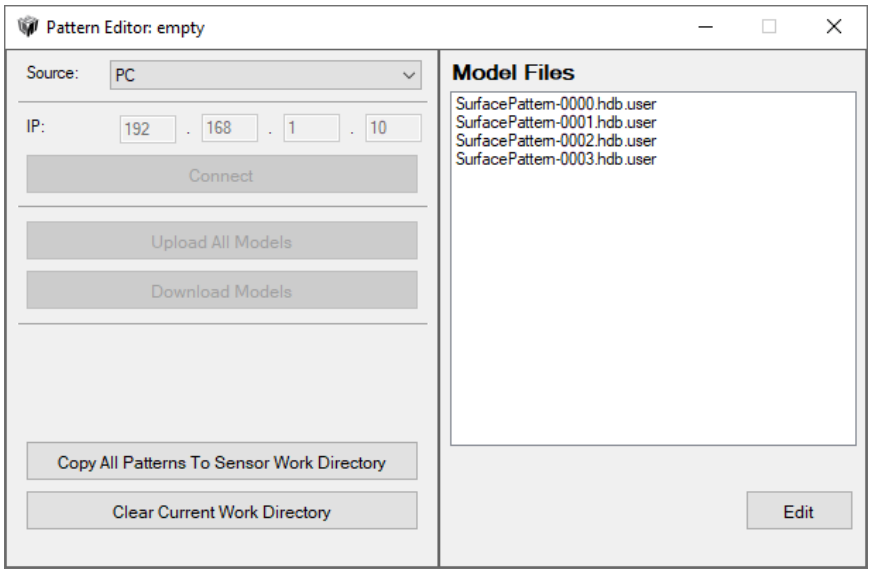


Launching the Pattern Editor

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 a sensor (accelerated or unaccelerated) or from the emulator. In all cases, files are accessed by the pattern editor in working folders in the local PC filesystem. When working with model files created with an unaccelerated sensor, you must use the helper application (see below) to transfer models between the PC and the sensor.

After you launch PatternEditor.exe, a helper application launches that lets you choose which model to edit, and also lets you connect to a sensor (accelerated or unaccelerated) and copy models to the working folder on the PC.



Source: When working with an accelerated sensor (recommended), choose **PC**; use this option also when working with the emulator. When working with an unaccelerated sensor, choose **Sensor**, set its IP in the **IP** field below, and click the Connect button to connect.

IP: The address of an *unaccelerated* sensor.

Connect: Connects to the *unaccelerated* sensor at the provided IP if **Source** is set to Sensor. Note that connecting to a sensor deletes all models in the unaccelerated 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.

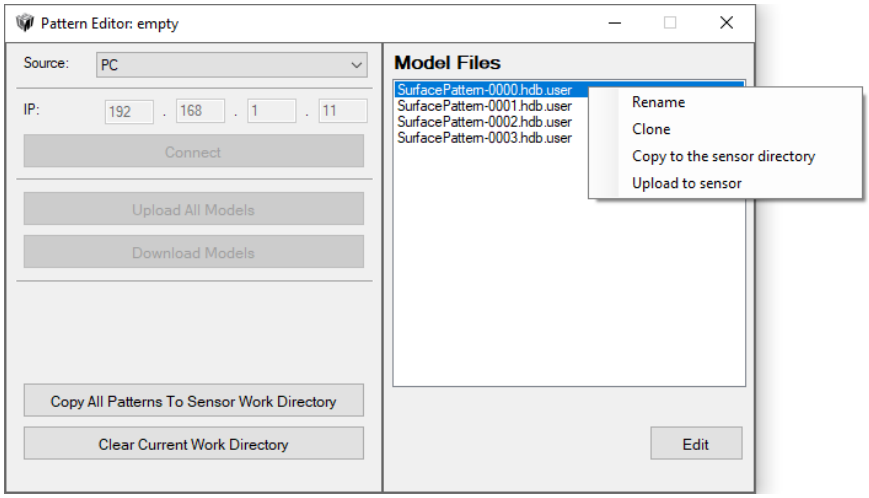
Upload All Models: Uploads the models from the working folder to the unaccelerated sensor.

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 Patterns To Sensor Work Directory / Copy all files to the sensor work directory: The name of this button depends on whether **Source** is set to **PC** (for an accelerated sensor) or **Sensor** (for an unaccelerated sensor). When set to PC, this button copies models to the unaccelerated sensor's work folder; use this to transfer patterns to an unaccelerated sensor. When Source is set to Sensor, this button copies models to the working folder used with accelerated sensors; use this if you created a model on an unaccelerated but will be using it with an accelerated sensor.

Clear Current Work Directory: Removes all models from the current working folder.

By right-clicking on a model in the list of models, you can perform the operations listed below.



Rename: Renames the model.

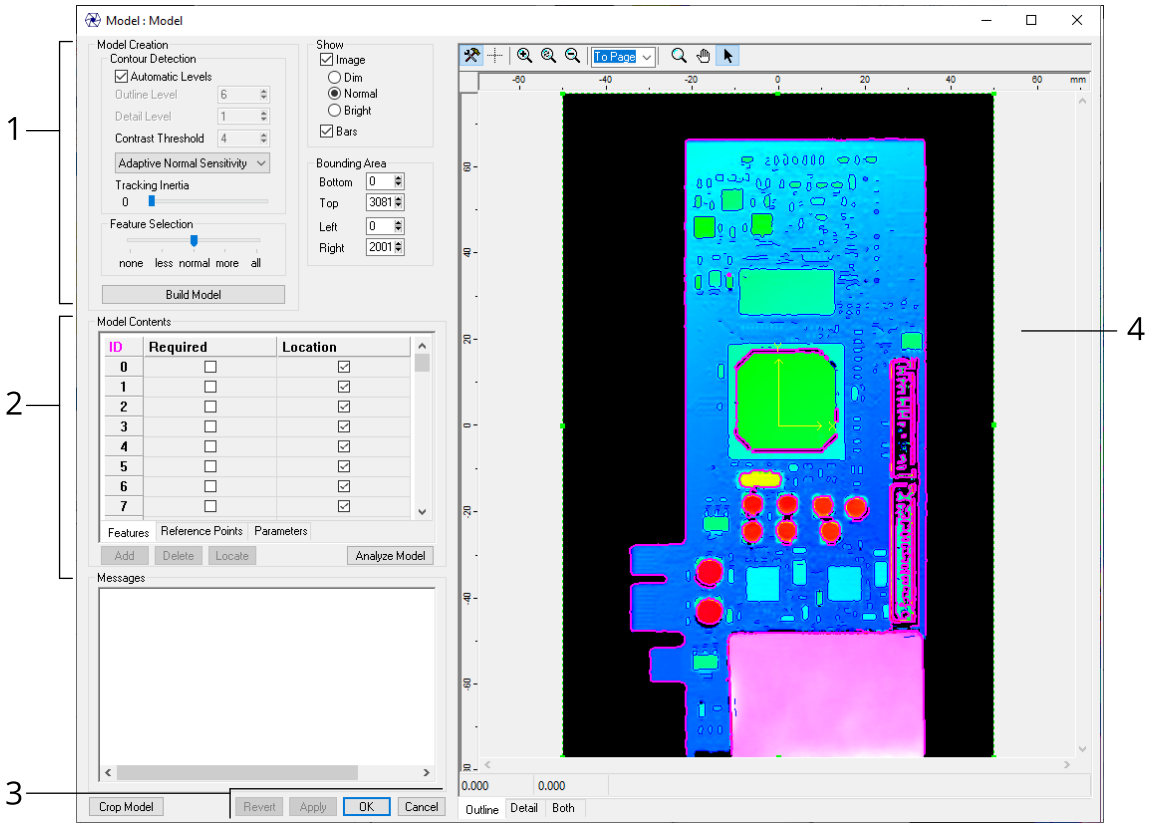
Clone: Makes a copy of the selected model using the name you provide.

Copy to the sensor directory: Copies the model to the sensor's working 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). 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.

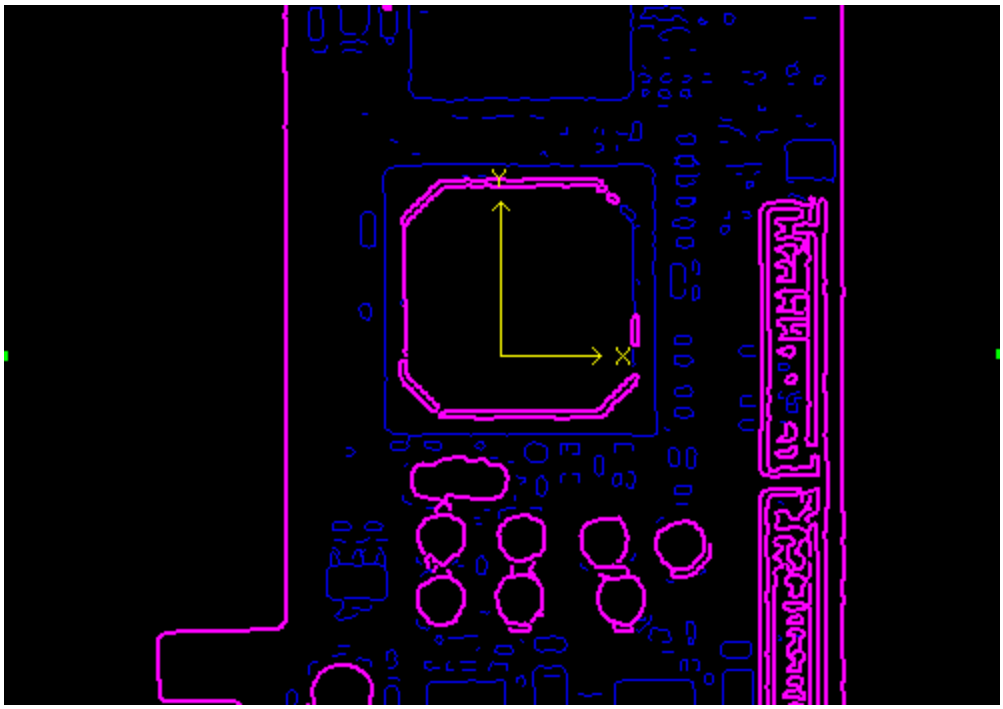
Outline: Used to quickly identify potential instances of a pattern in scan data. The Outline level is the "coarse" level of contours / features. The features at this level can be less stable, as they are not used to calculate the location of the instance. For example, a label whose position might change 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.

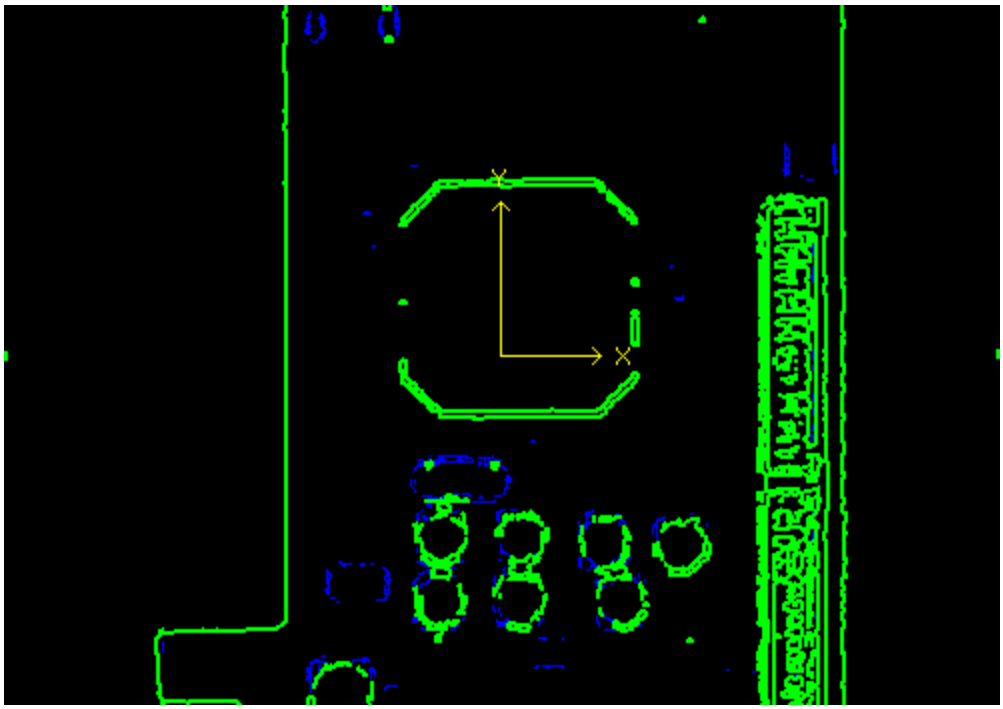
That said, the Outline and Detail levels will often be similar in terms of which features are included.

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.

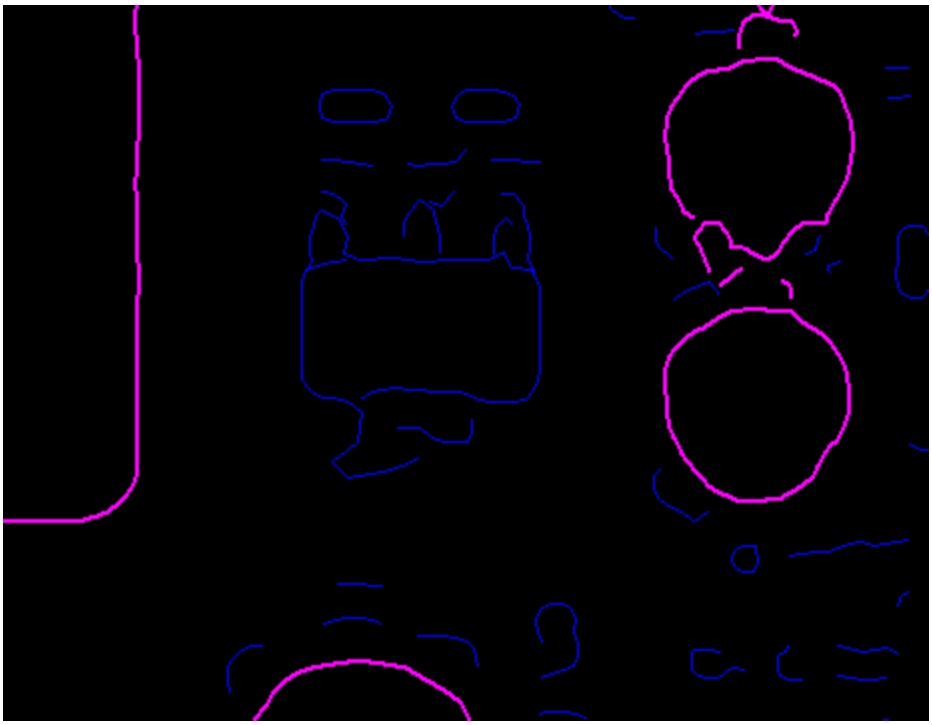
In the Surface Pattern Matching tool, only the Detail level of features is displayed.

Adding and Removing Features Manually

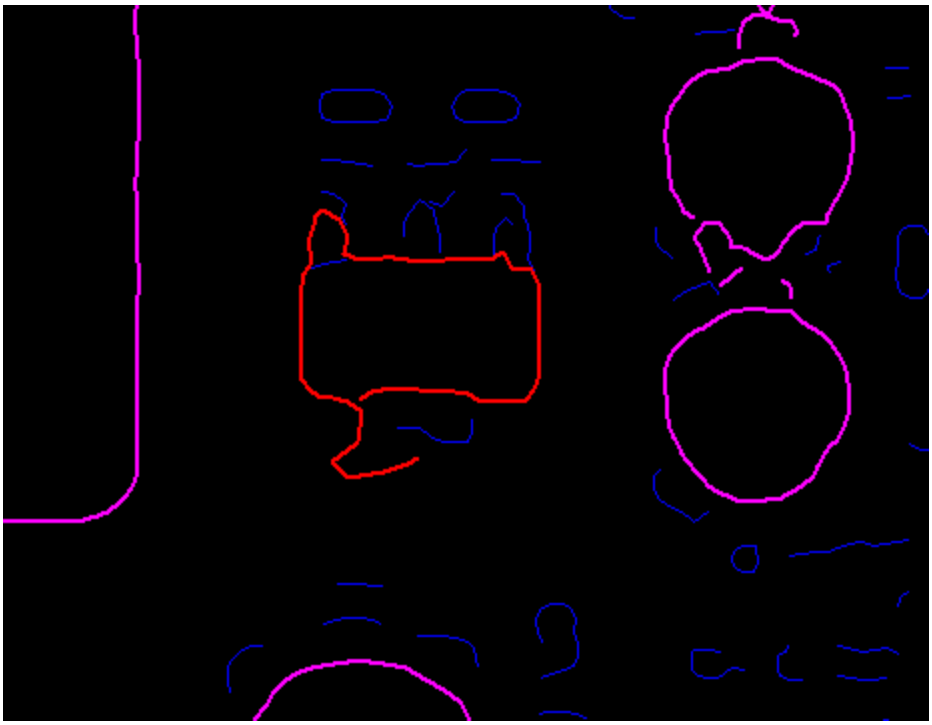
You can manually add features to a model from the source contours, or remove features currently in a model, at both the Outline and Detail levels. This can be useful if the model produced by the Surface Pattern Matching tool includes features related to parts of targets that could change or be present/absent 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.

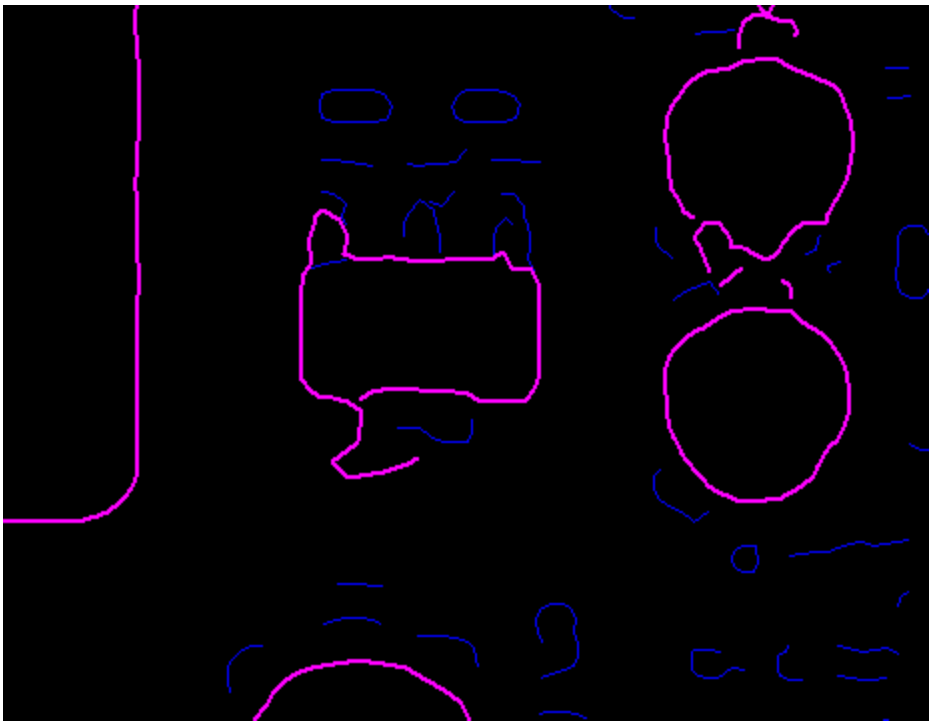
To add a feature from a source contour, double-click a dark blue contour in either the Outline or Detail tab and click Add or press the Insert key on your keyboard.



Dark blue unused contour (contours already added as features in the model are magenta).

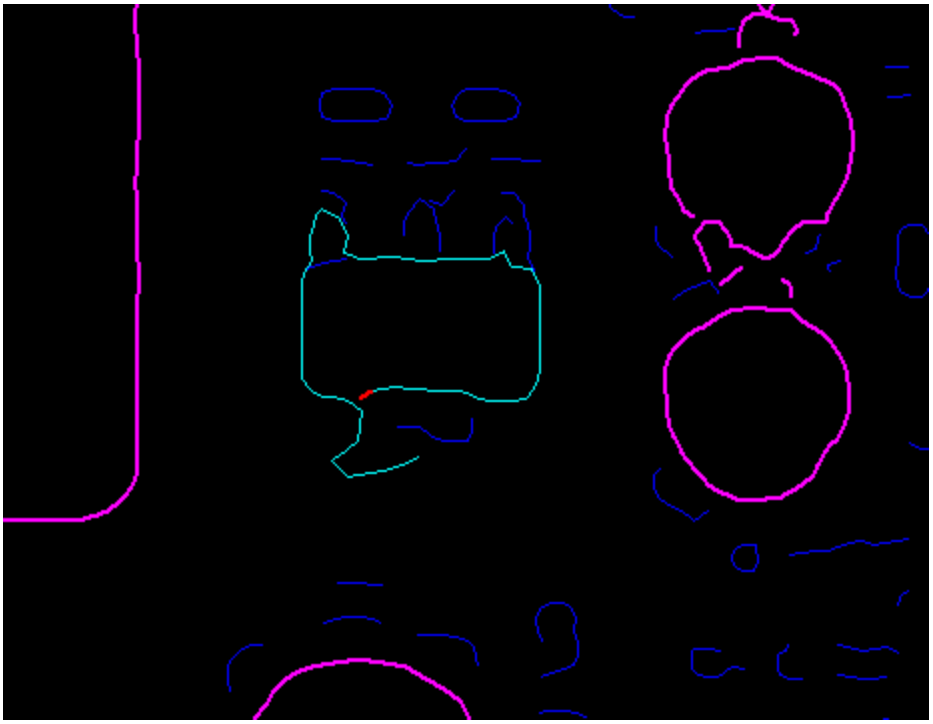


Contour selected by double-clicking it.



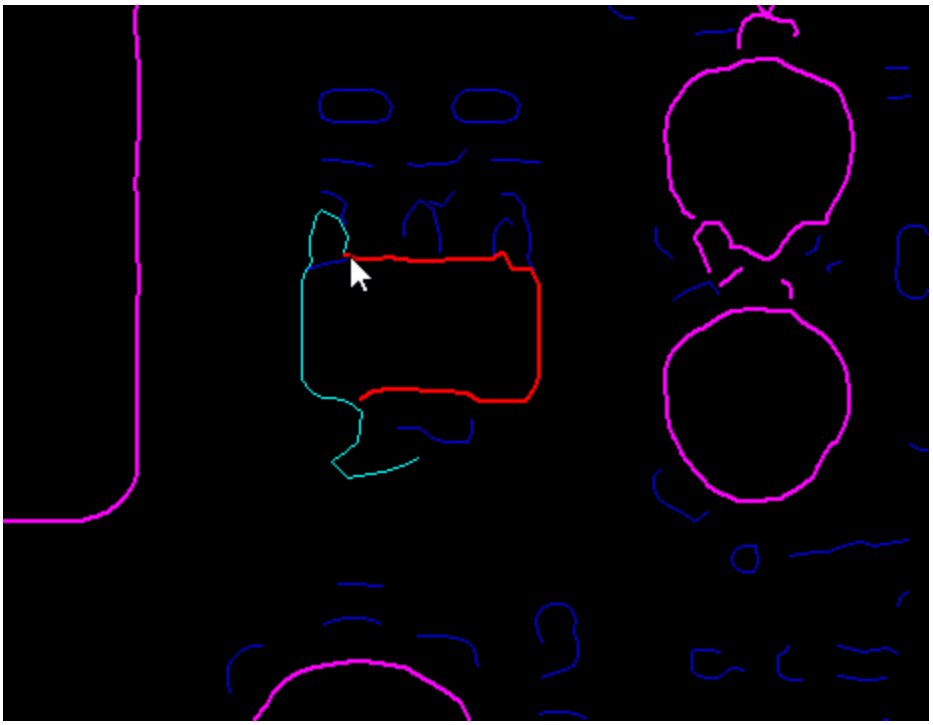
Contour added as a feature in the model (magenta).

If you single-click a dark blue unused contour, it turns cyan and lets you select segments of the contour.

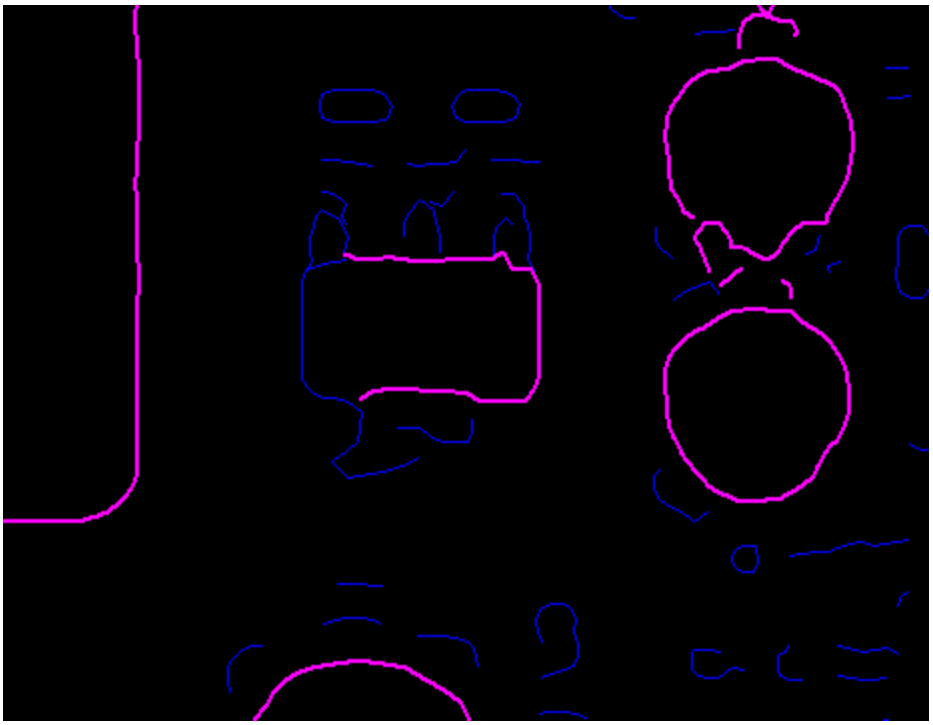


Contour highlighted in cyan with a selected segment (red).

Pressing the Ctrl key on your keyboard and clicking another segment selects a portion of the cyan path.



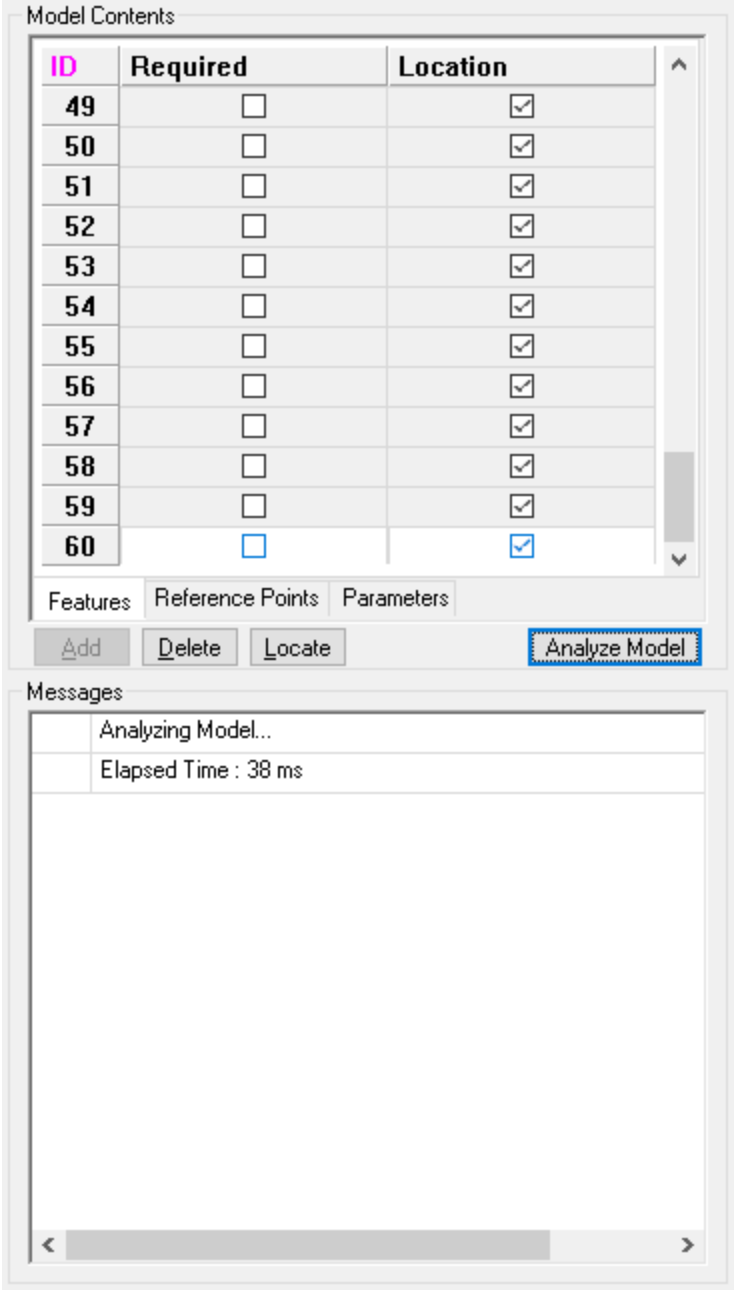
Clicking **Add** or pressing the Insert key on your keyboard adds the segment of the contour as a feature to the model.



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 775.

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 775.

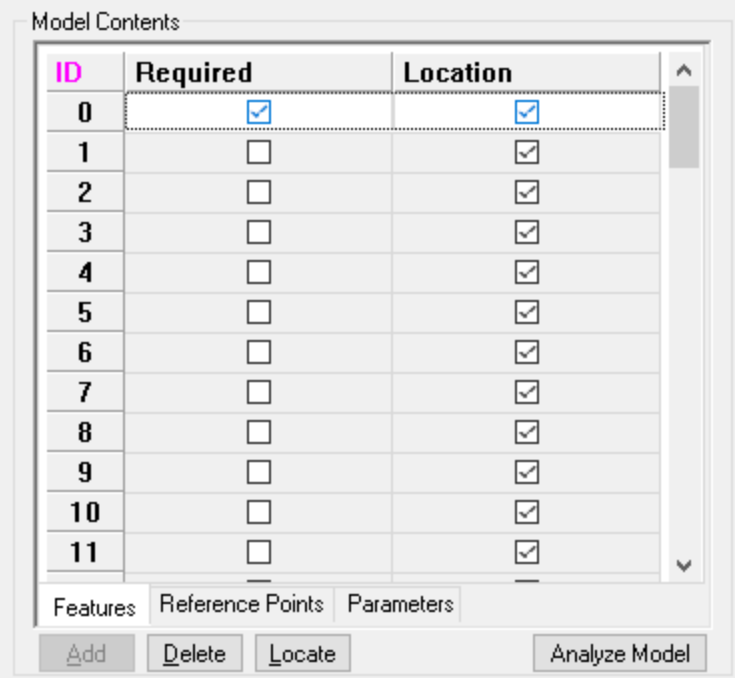
After adding a feature to a model or removing a feature from a model, you should analyze the model by clicking **Analyze Model**. Make note of any errors in the **Messages** panel.



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.



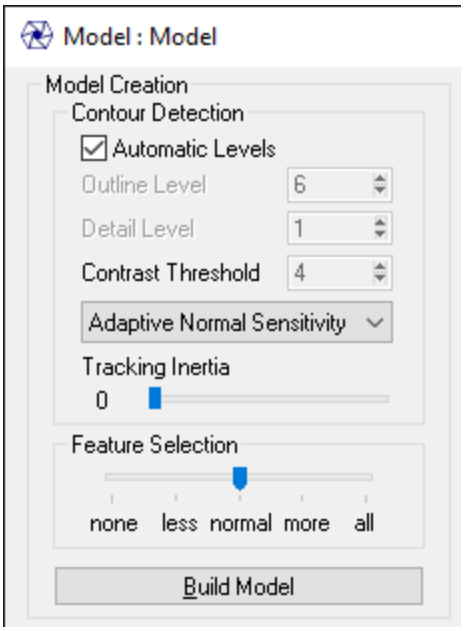
When Required is checked for a feature, it *must* be found by the Surface Pattern Matching tool in order for an instance to be identified.

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.

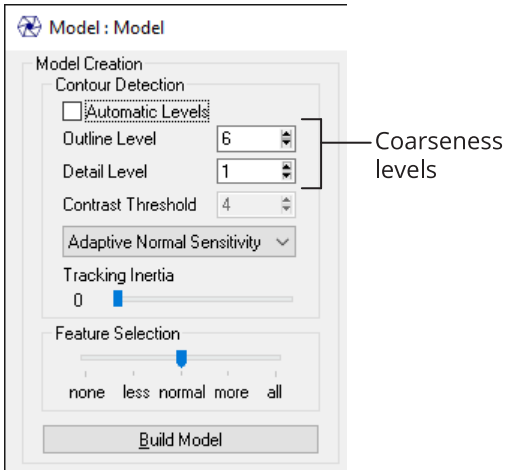
The settings described here are found in the **Model Creation** section of the model editor.



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 775.

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.

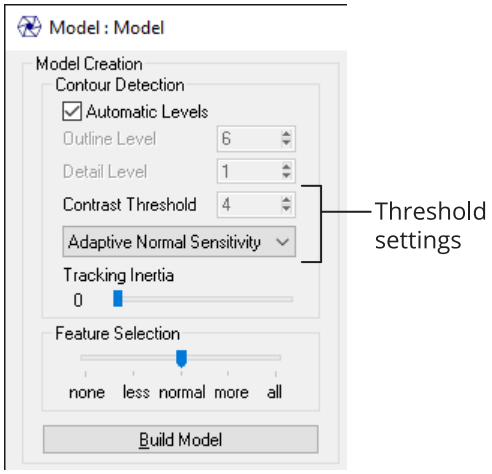


The **Outline Level** and **Detail Level** values range from 1 to 16. At the lowest value, contours are detected in a full-resolution version of the image based on the scan data, which results in more contours from which to choose features. At higher values, contours are detected in a reduced-

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).

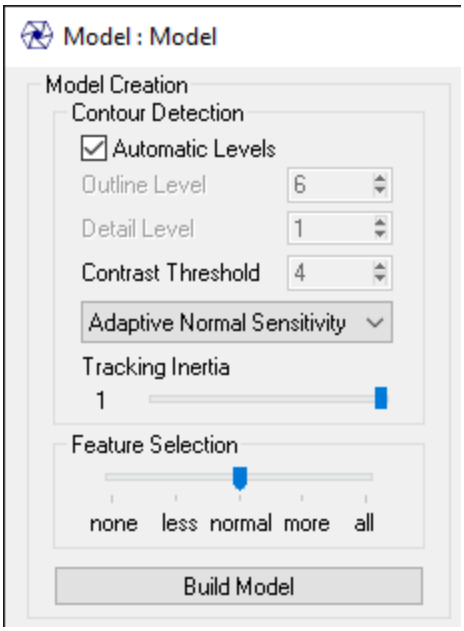
Adaptive High Sensitivity: Results in more low-contrast contours, but also noise.

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.

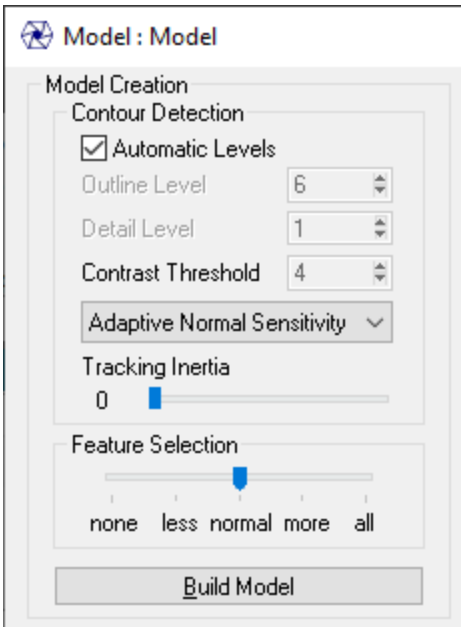
Tracking Inertia

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

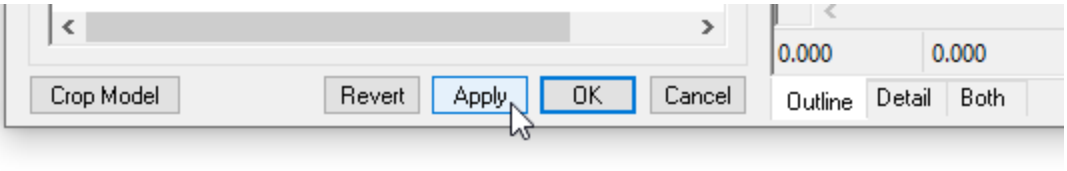
This setting ranges from **none** to **all**, which determines which features the pattern editor selects from the detected contours and adds to the model when you rebuild it. You should use **none** (which adds no features to the model) if you want to manually add features to the model from the detected 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:

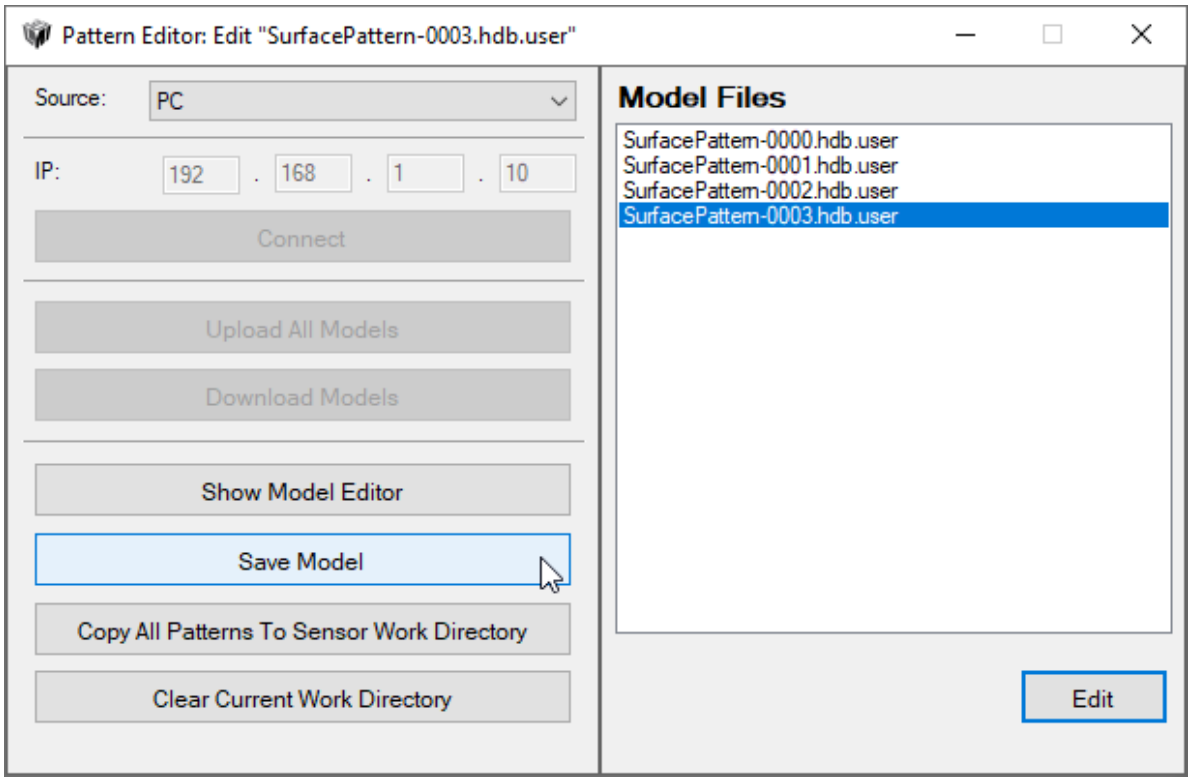
1. In the model editor, at the bottom of the window, click **Apply** or **OK**.



   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.

Specifications

The following sections describe the specifications of Gocator sensors and connectors, as well as Master hubs.

Sensors **778**
Gocator 3210 Sensor 779
Gocator 3210 781
Gocator 3500 Series 784
Gocator 3504 786
Gocator 3506 788
Gocator 3520 791
Sensor Connectors **794**
Gocator Power/LAN Connector 794
Grounding Shield 795
Power 795
Safety Input 795
Gocator I/O Connector 796
Grounding Shield 796
Digital Outputs 797
Inverting Outputs 797
Digital Input 797
Encoder Input 798
Serial Output 799
Analog Output 799
Master Network Controllers **801**
Master 100 801
Master 100 Dimensions 802
Master 400/800 803
Power and Safety 803
Encoder 804
Input 804
Master 400/800 Electrical Specifications 805

Master 400/800 Dimensions 806
Master 810/2410 807
Power and Safety 809
Encoder 810
Input 810
Electrical Specifications 811
Encoder 812
Input 814
Master 810 Dimensions 816
Master 2410 Dimensions 817
Master 1200/2400 818
Power and Safety 818
Encoder 819
Input 819
Master 1200/2400 Electrical Specifications 820
Master 1200/2400 Dimensions 820

Sensors

The following sections provide the specifications of Gocator sensors.

Gocator 3210 Sensor

The Gocator 3210 is defined below:

MODEL	3210
Scan Rate (Hz)	6
Imagers (megapixels)	2
Clearance Distance (CD) (mm)	164.0
Measurement Range (MR) (mm)	110.0
Field of View (mm)	71.0 x 98.0 - 100.0 x 154.0
Repeatability Z (µm)	4.7
Resolution XY (mm)	0.060 - 0.090
VDI/VDE Accuracy (mm)*	0.035
Dimensions (mm)	49 x 146 x 190
Weight (kg)	1.7
Light Source	Blue LED (465 nm)
Interface	Gigabit Ethernet
Inputs	Differential Encoder, Trigger
Outputs	2x Digital output, RS-485 Serial (115 kBaud) Analog Output (4 – 20 mA)
Input Voltage (Power)	+24 to +48 VDC (50 Watts); Ripple +/- 10%
Housing	Gasketed aluminum enclosure, IP67
Operating Temp.	0 to 45° C
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

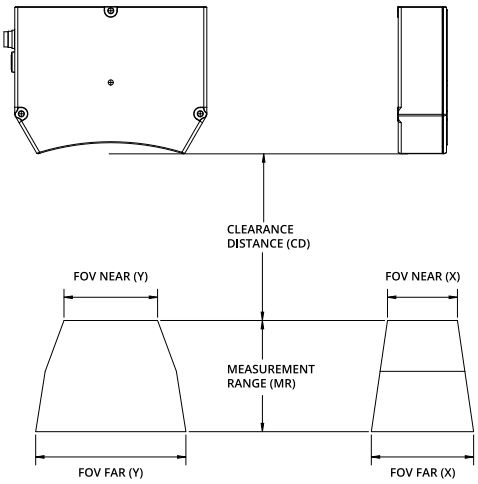
* Based on 2634, Part 2.

Linearity Z values and Resolution Z are typical values.

Field of View and Resolution XY are specified as [X] x [Y], near to far.

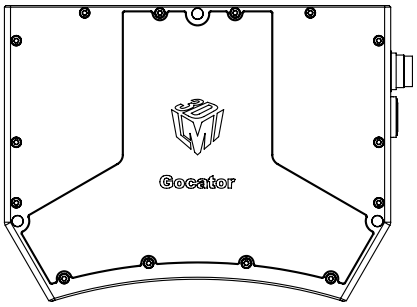
Differential encoder requires the use of Master 400/800/810/1200/2400/2410.

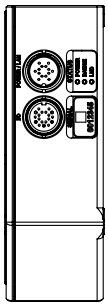
The following diagram illustrates some of the terms used in the table above.

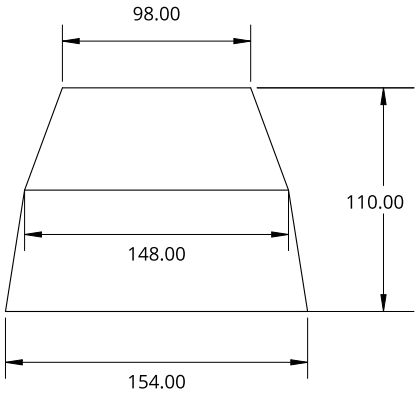


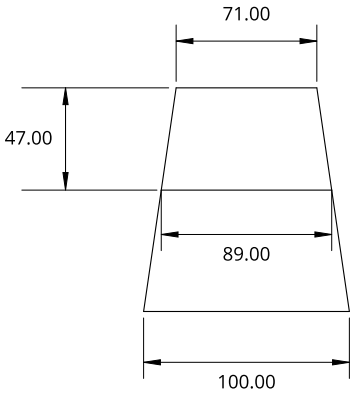
Mechanical dimensions, CD/FOV/MR, and the envelope for each sensor model are illustrated on the following pages.

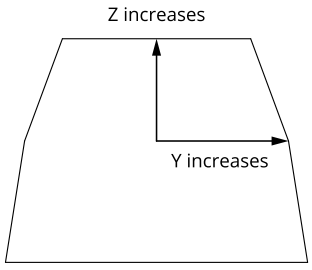
Field of View / Measurement Range / Coordinate System Orientation

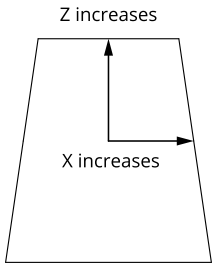






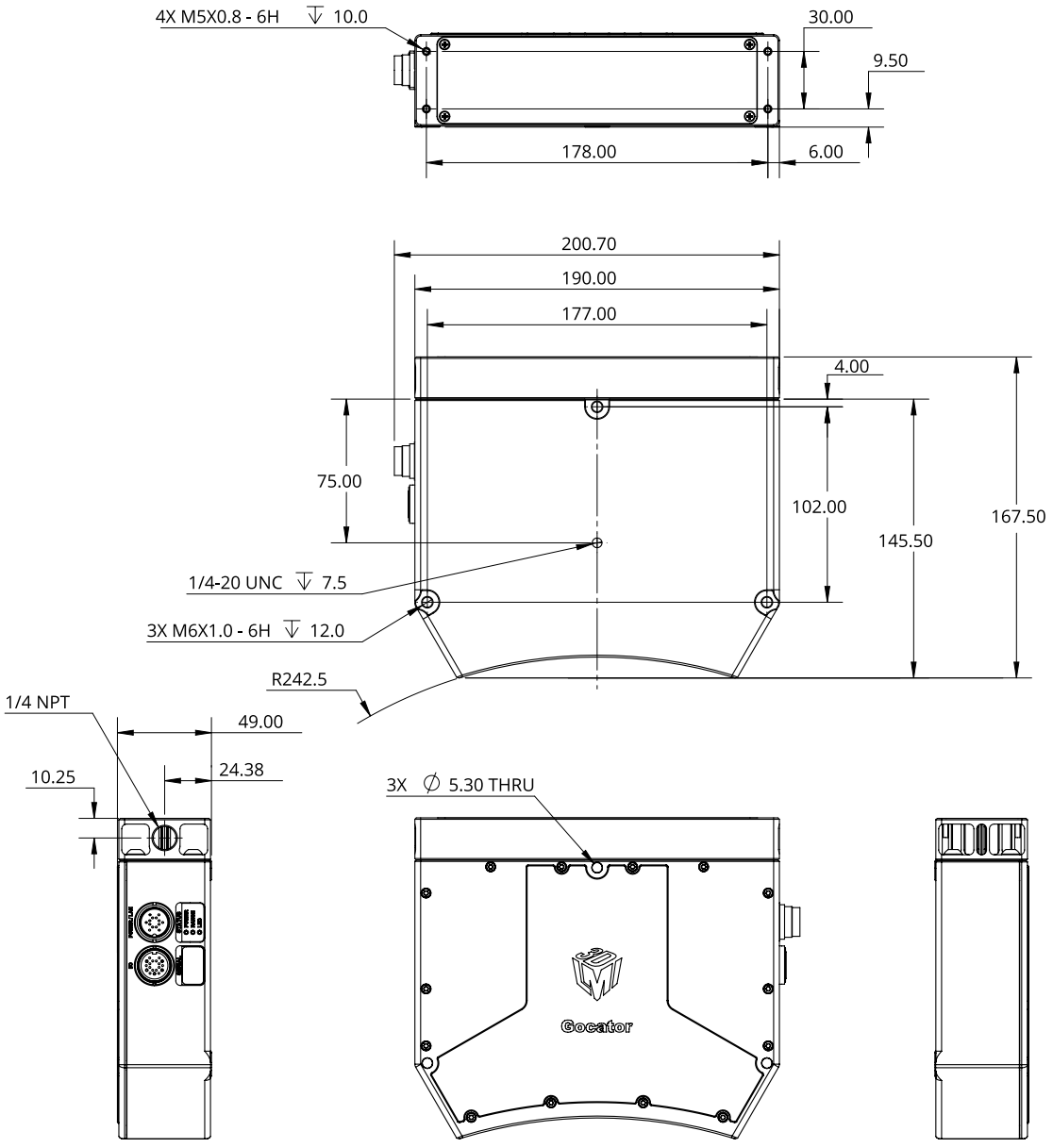




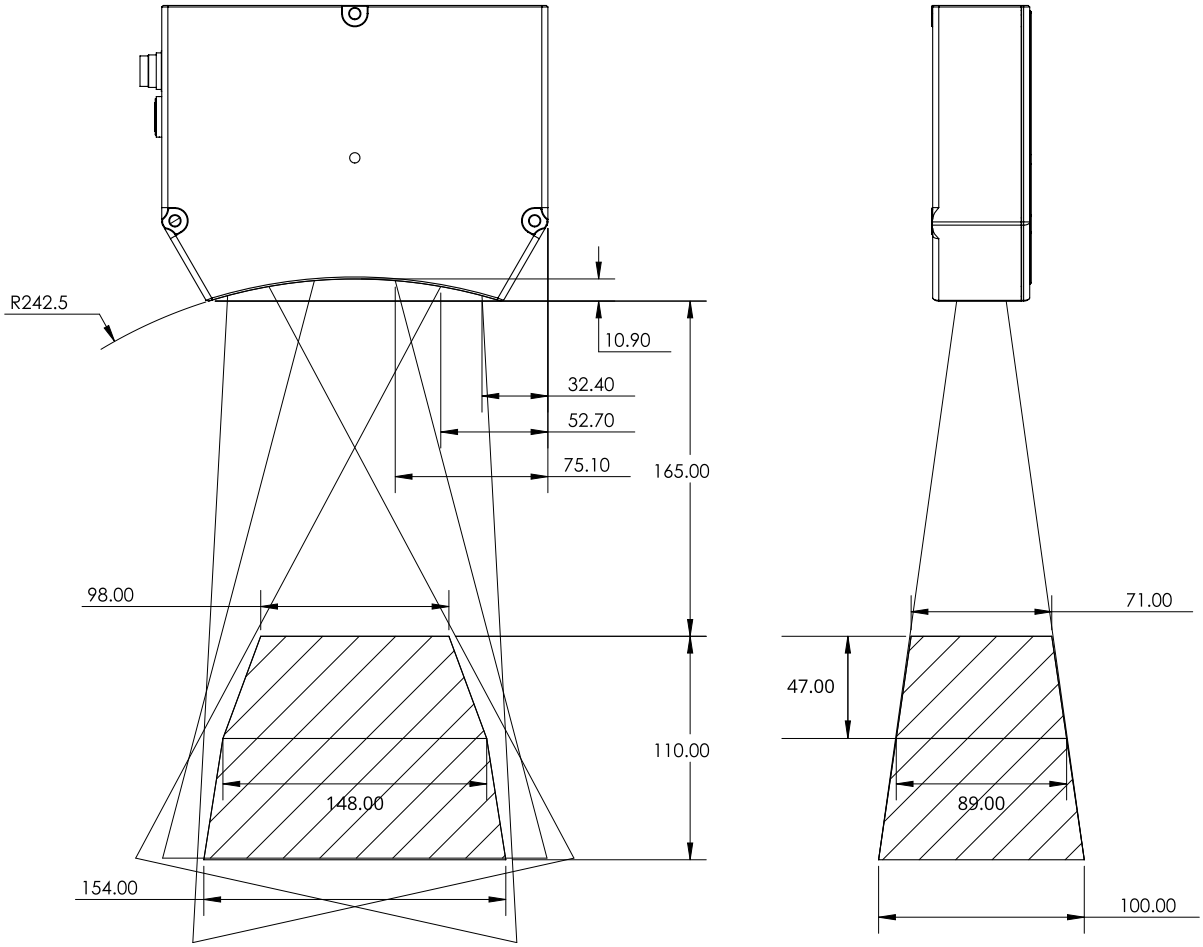


Dimensions

The following drawings include the optional shop air heat sink. For more information, see *APPNOTE_Gocator_3210_Heatsink.pdf*, available on LMI's website.


4X M5X0.8 - 6H ↧ 10.0
30.00
9.50
178.00
6.00
200.70
190.00
177.00
4.00
75.00
102.00
145.50
167.50
1/4-20 UNC ↧ 7.5
3X M6X1.0 - 6H ↧ 12.0
R242.5
1/4 NPT
49.00
24.38
10.25
3X ∅ 5.30 THRU
Gocator

Envelope


R242.5
10.90
32.40
52.70
75.10
165.00
98.00
110.00
148.00
154.00
71.00
47.00
89.00
100.00

Gocator 3500 Series

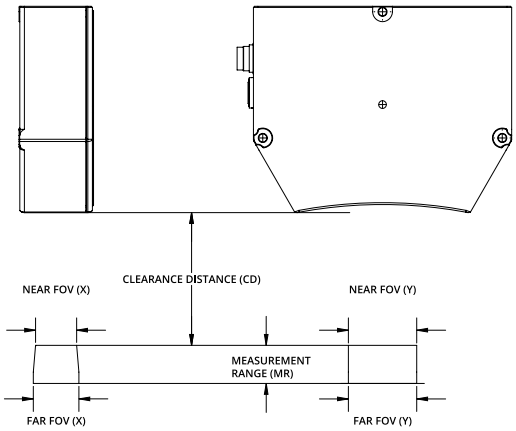
The Gocator 3500 series consists of the following models:

MODEL	3504	3506	3520
Scan Rate (Hz)	6	6	3
Imagers (megapixels)	5	5	5
Clearance Distance (CD) (mm)	52.5	87.0	203
Measurement Range (MR) (mm)	7	25.0	150
Field of View (mm)	12.1 x 13.2 (near) 12.7 x 16.4 (maxY) 13.0 x 15.0 (far)	27.0 x 45.0 (near) 30.0 x 45.0 (far)	179 x 115 (near) 282 x 175 (far)
Repeatability Z (µm)	0.2	2.0	4.6
Resolution XY (µm)	6.7 - 7.1	20 - 25	74 - 121
VDE Accuracy (mm)	n/a	0.012 mm(1)	0.090 mm(2) - 0.200 mm(3)
Accuracy XYZ (µm)4	6	n/a	n/a
Input Voltage (Power)	+24 to +48 VDC (25 Watts); Ripple +/- 10%		48 VDC (50 Watts); Ripple +/- 10%
Operating Temp.	0 to 50° C		0 to 40° C
Storage Temp.	-30 to 70° C		
Dimensions (mm)	49x152x177.5	49 x 136 x 170	55 x 167 x 260
Weight (kg)	1.77	1.52	2.6

1. Based on 2634, Part 2.
2. VDE within central 100 mm measurement range.
3. VDE within full 150 mm measurement range.
4. Based on sphere-fitting at various positions in the scan volume.

Field of View and Resolution XY are specified as [X] x [Y], near to far.

The following diagram illustrates some of the terms used in the table above.

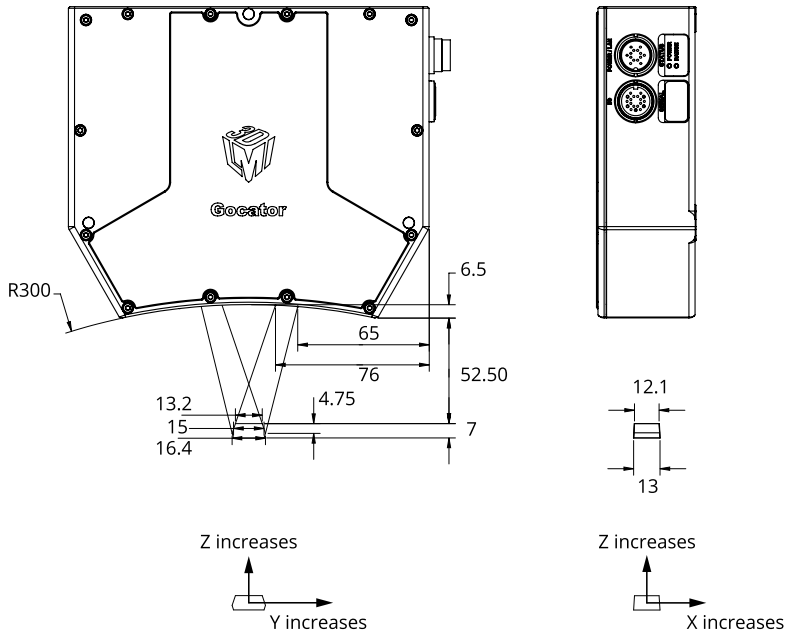


ALL 3500 SERIES MODELS	
Light Source	Blue LED (465 nm)
Interface	Gigabit Ethernet
Inputs	Differential Encoder, Trigger
Outputs	2x Digital output, RS-485 Serial (115 kBaud) Analog Output (4 – 20 mA)
Housing	Gasketed aluminum enclosure, IP67
Vibration Resistance	10 to 55 Hz, 1.5 mm double amplitude in 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

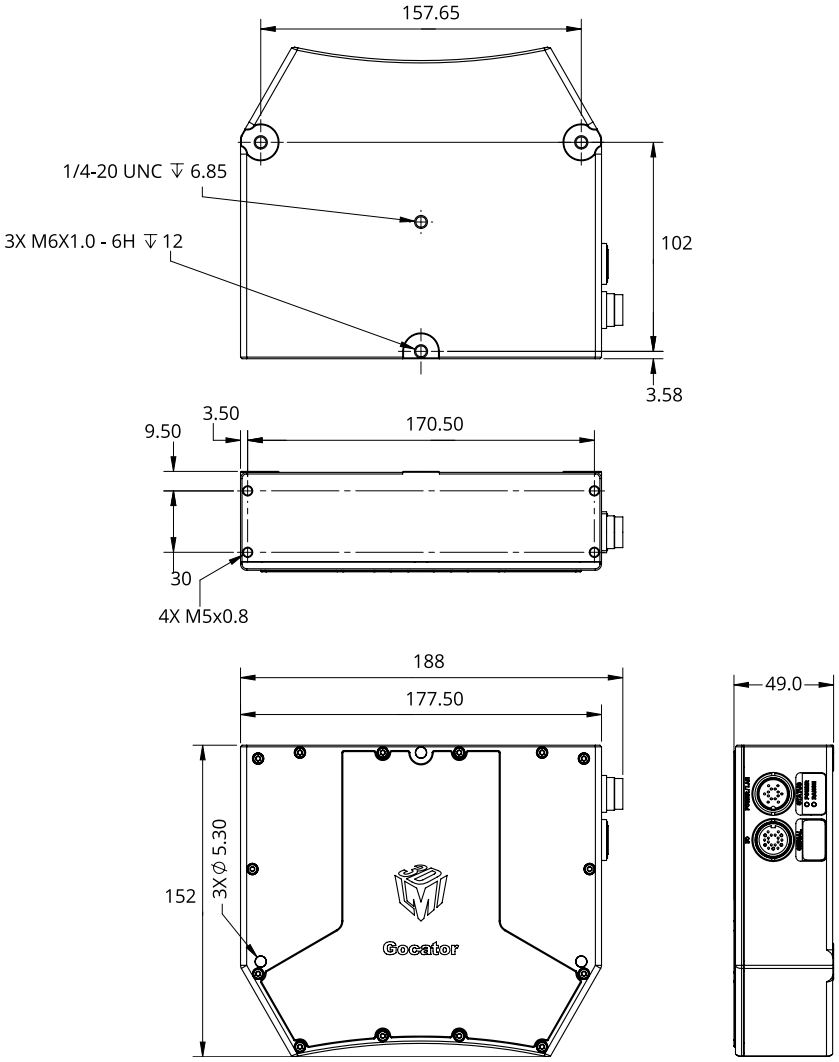
Mechanical dimensions, CD/FOV/MR, and the envelope for each sensor model are illustrated on the following pages.

Gocator 3504

Field of View / Envelope / Measurement Range / Coordinate System Orientation

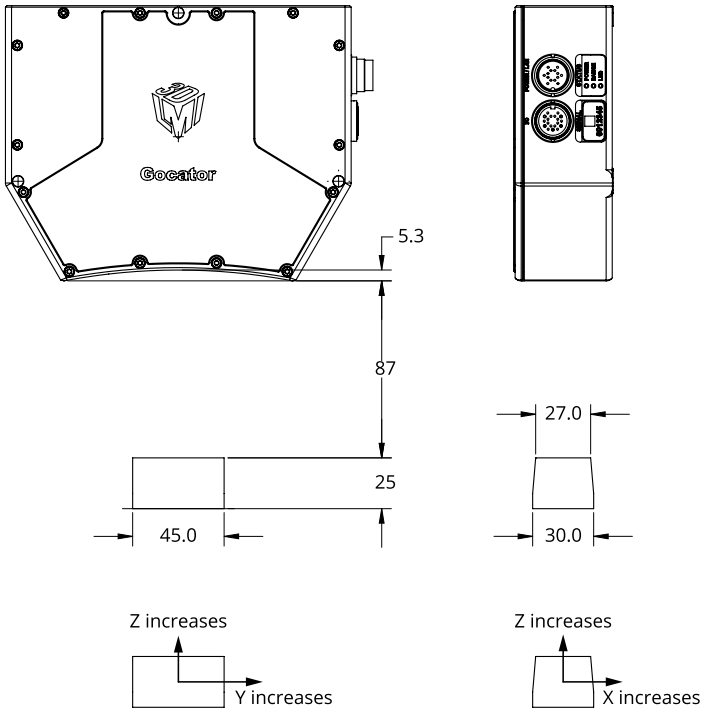


Dimensions

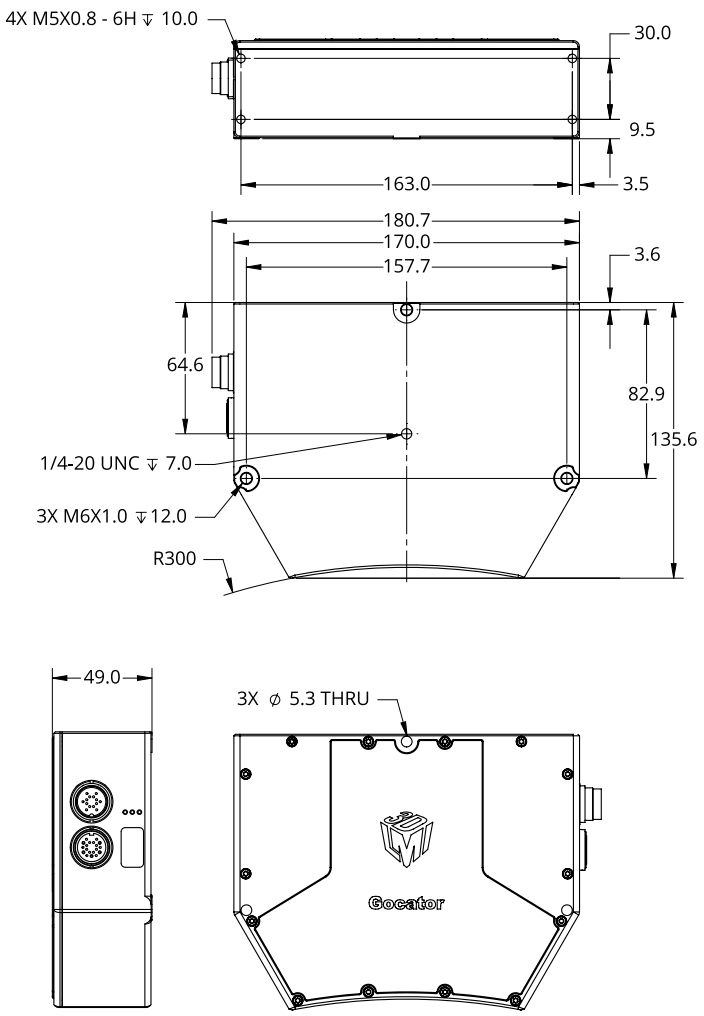

157.65
1/4-20 UNC ↧ 6.85
3X M6X1.0 - 6H ↧ 12
102
3.58
3.50
9.50
170.50
30
4X M5x0.8
188
177.50
49.0
152
3X ⌀ 5.30
Gocator

Gocator 3506

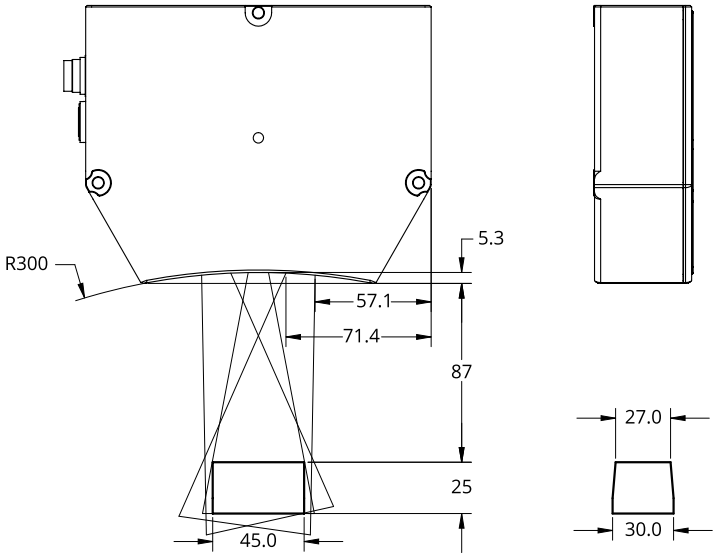
Field of View / Measurement Range / Coordinate System Orientation



Dimensions

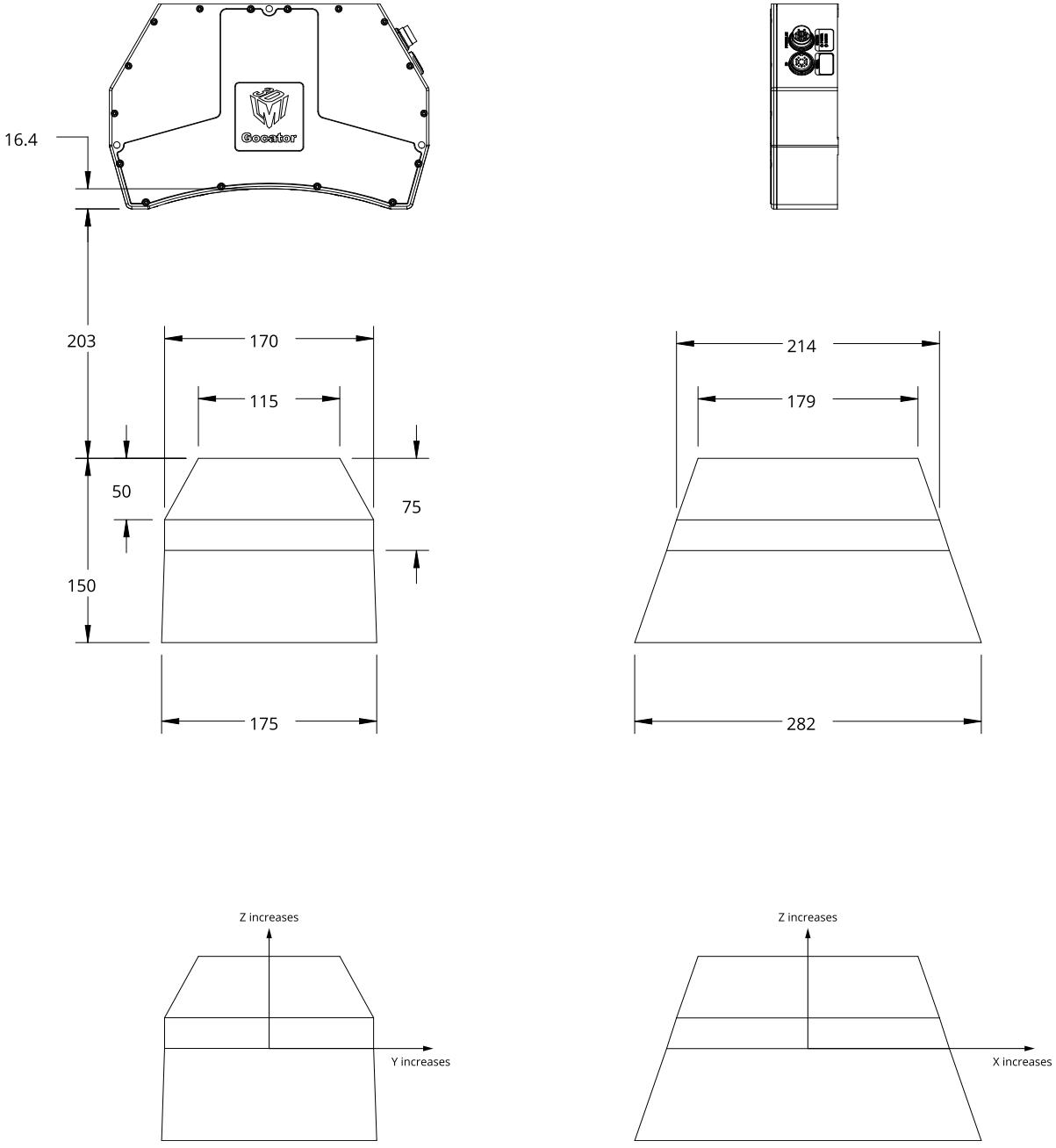

4X M5X0.8 - 6H ↧ 10.0
30.0
9.5
163.0
3.5
180.7
170.0
157.7
3.6
64.6
82.9
135.6
1/4-20 UNC ↧ 7.0
3X M6X1.0 ↧12.0
R300
49.0
3X ∅ 5.3 THRU
Gocator

Envelope

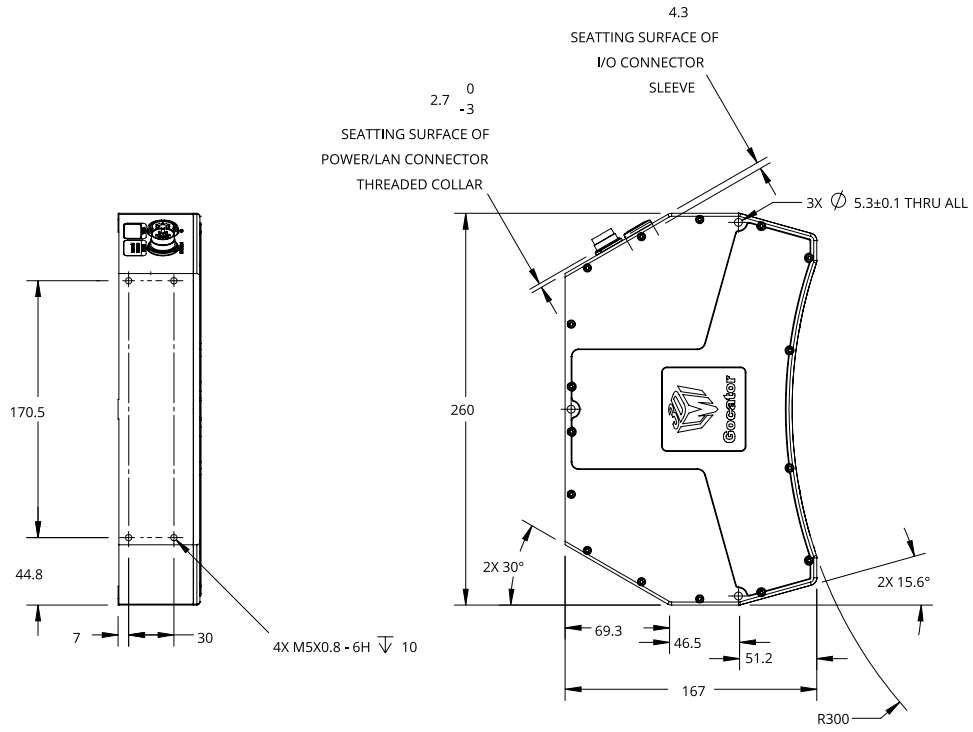


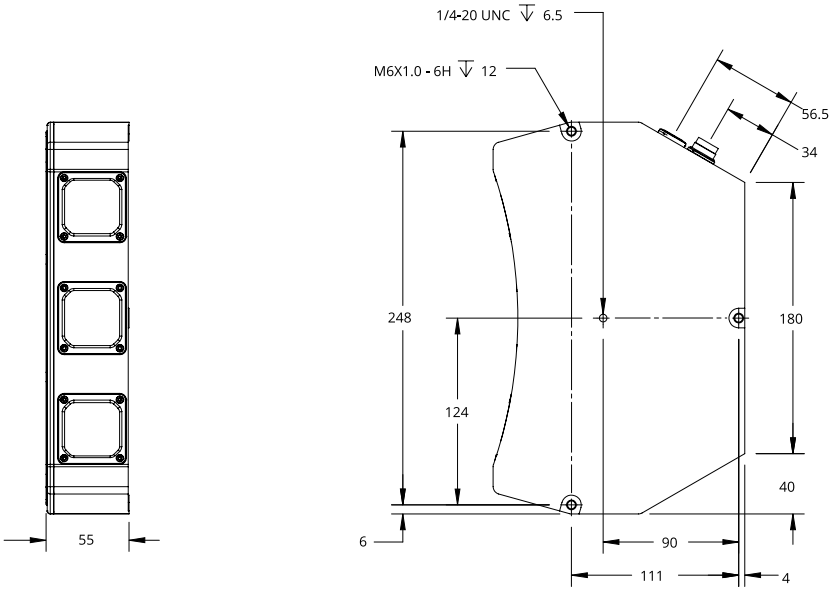
Gocator 3520

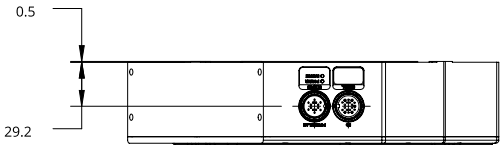
Field of View / Measurement Range / Coordinate System Orientation



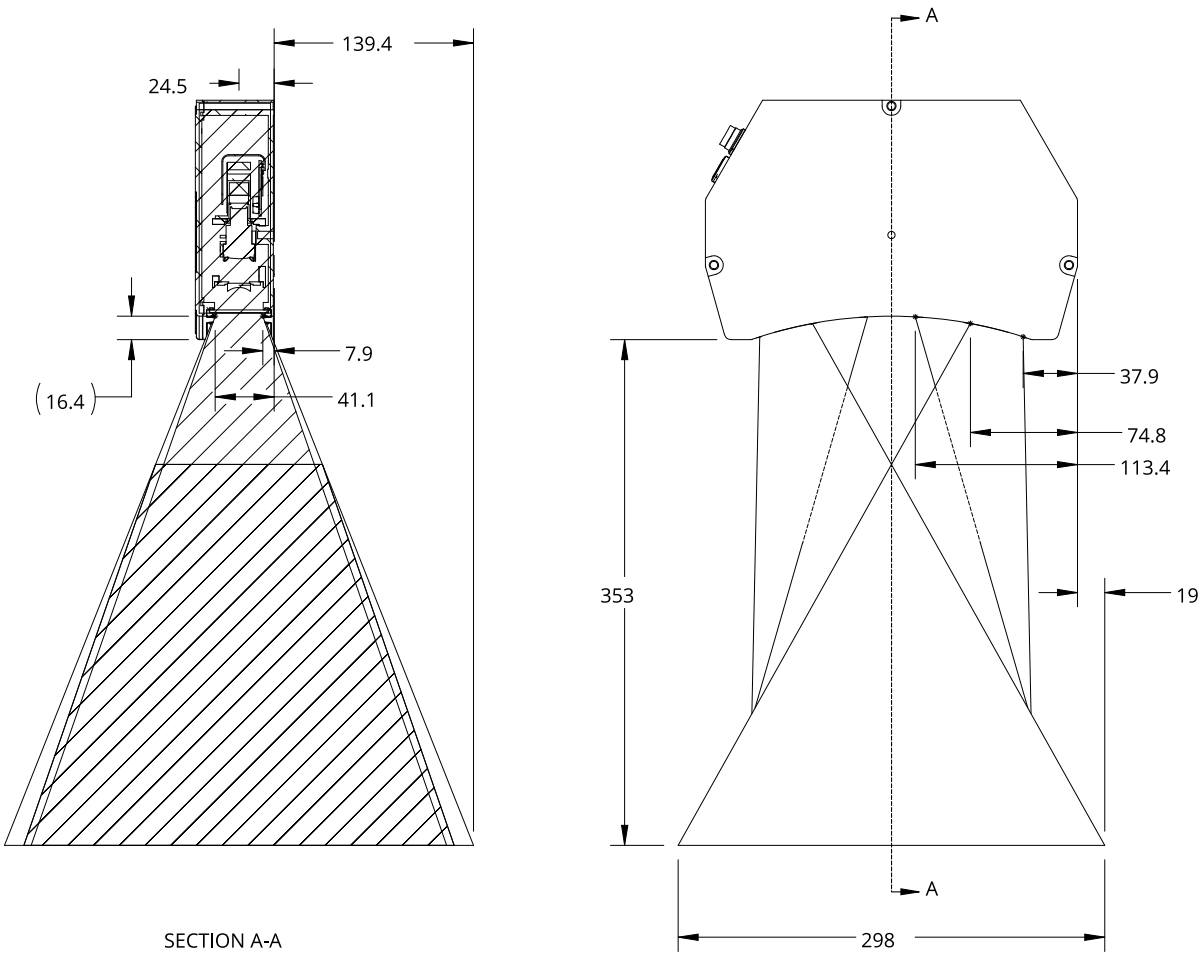
Dimensions


4.3
SEATTING SURFACE OF
I/O CONNECTOR
SLEEVE
2.7 0 -3
SEATTING SURFACE OF
POWER/LAN CONNECTOR
THREADED COLLAR
3X ∅ 5.3±0.1 THRU ALL
170.5
260
44.8
2X 30°
2X 15.6°
7
30
4X M5X0.8 - 6H ↧ 10
69.3
46.5
51.2
167
R300


1/4-20 UNC ↧ 6.5
M6X1.0 - 6H ↧ 12
56.5
34
248
180
124
40
55
6
90
111
4


0.5
29.2

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 14 pin, M16 style connector that provides power input and Ethernet.

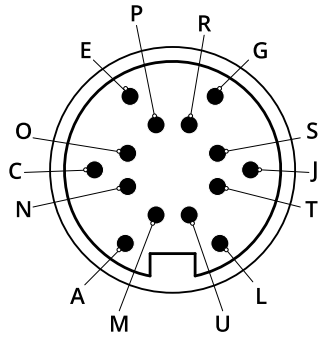
> This connector is rated IP67 only when a cable is connected or when a protective cap is used.

> 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 778.

This section defines the electrical specifications for Power/LAN Connector pins found on G1, G2, and G3 sensors, organized by function.

Gocator Power/LAN Connector Pins

Function	Pin	Lead Color on Standard Cordsets	Lead Color on High Flex Cordsets
GND_24-48V*	L	White/Orange & Black	Orange/Red
GND_24-48V*	L	Orange/Black	Orange/Black
DC_24-48V*	A	White/Green & Black	Green/Red
DC_24-48V*	A	Green/Black	Green/Black
Reserved	G	White/Blue & Black	Blue/Black
Reserved	J	Blue/Black	Blue/Red
Sync+**	E	White/Brown & Black	Brown/Red
Sync-**	C	Brown/Black	Brown/Black
Ethernet MX1+	M	White/Orange	White/Orange
Ethernet MX1-	N	Orange	Orange
Ethernet MX2+	O	White/Green	White/Green
Ethernet MX2-	P	Green	Green
Ethernet MX3-	S	White/Blue	White/Blue
Ethernet MX3+	R	Blue	Blue
Ethernet MX4+	T	White/Brown	White/Brown
Ethernet MX4-	U	Brown	Brown



*View: Looking into the connector **on** the sensor*

*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.

Grounding Shield

The grounding shield should be mounted to the earth ground.

Power

Apply positive voltage to DC_24-48V.

> 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 778.

Power requirements

Function	Pins	Min	Max
DC_24-48V	A	24 V (Some models require a minimum of 48 V.)	48 V
GND_24-48VDC	L	0 V	0 V

Safety Input

With snapshot sensors, the Safety_in+ and Safety_in- signals do not need to be connected (to a voltage source) in order to scan with these models.

Gocator I/O Connector

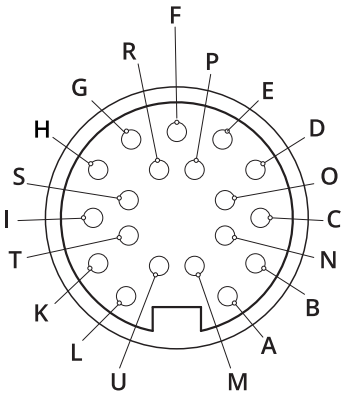
The Gocator I/O connector is a 19 pin, M16 style connector that provides encoder, digital input, digital outputs, serial output, and analog output signals.

> This connector is rated IP67 only when a cable is connected or when a protective cap is used.

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
Analog_out+	P	Green	Gray / Red
Analog_out-	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.

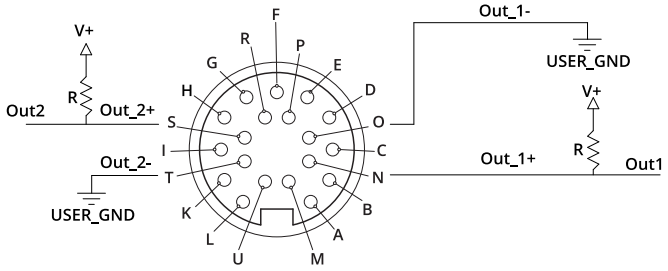
Digital Outputs

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

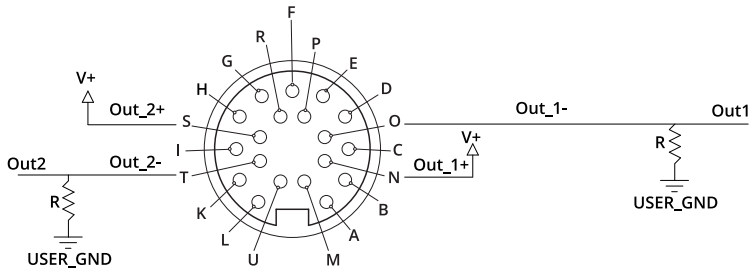


The resistors shown above are calculated by R = (V+) / 2.5 mA.

The size of the resistors is determined by power = (V+)^2 / R.

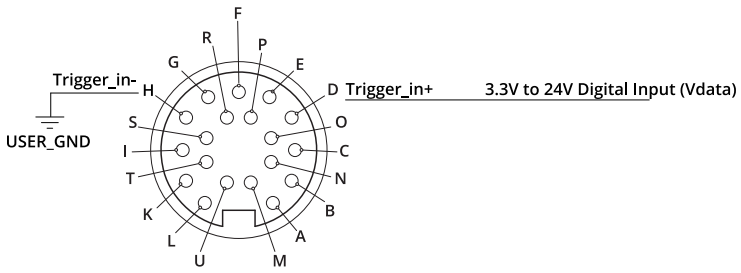
Inverting Outputs

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.



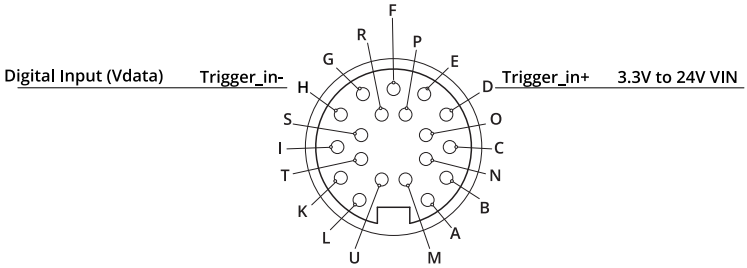
Digital Input

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.



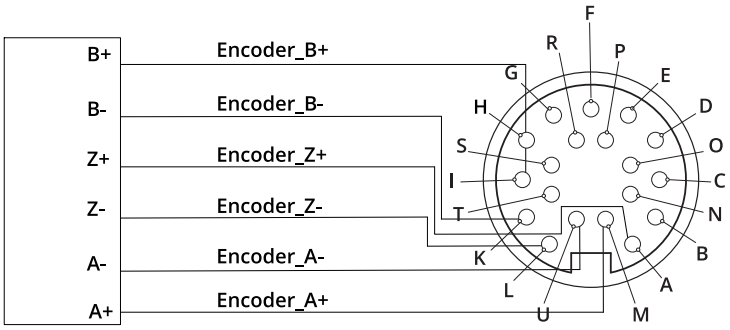
Active Low

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

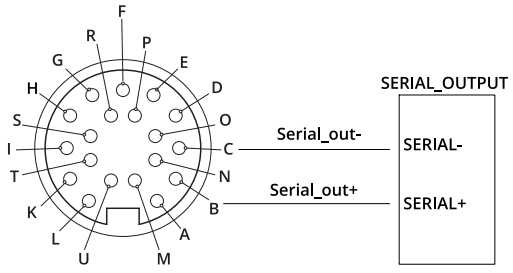
Gocator supports differential RS485 or RS422 signalling. Both + and - signals must be connected.

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

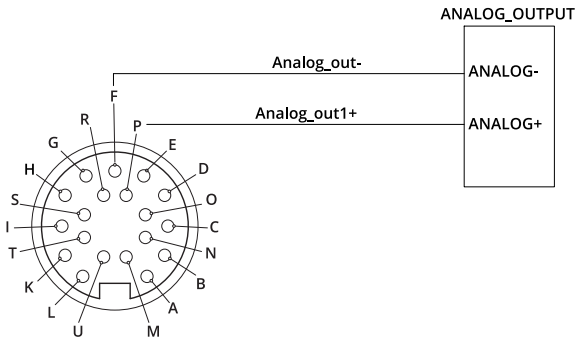


Analog Output

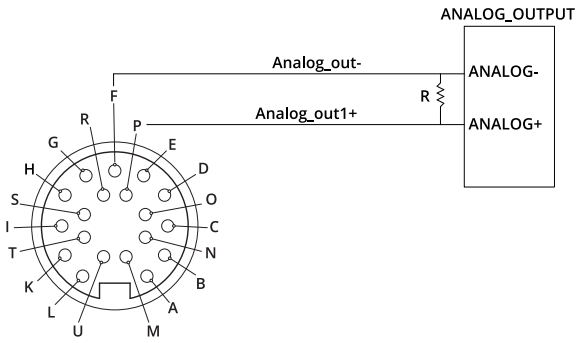
The Sensor I/O Connector defines one analog output interface: Analog_out.

You do not need to supply an external power source.

Function	Pins	Current Range
Analog_out	P, F	4 – 20 mA

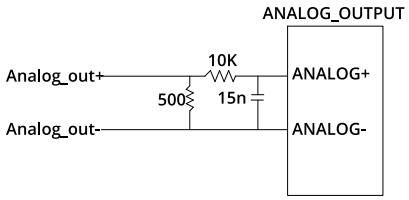


Current Mode



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.



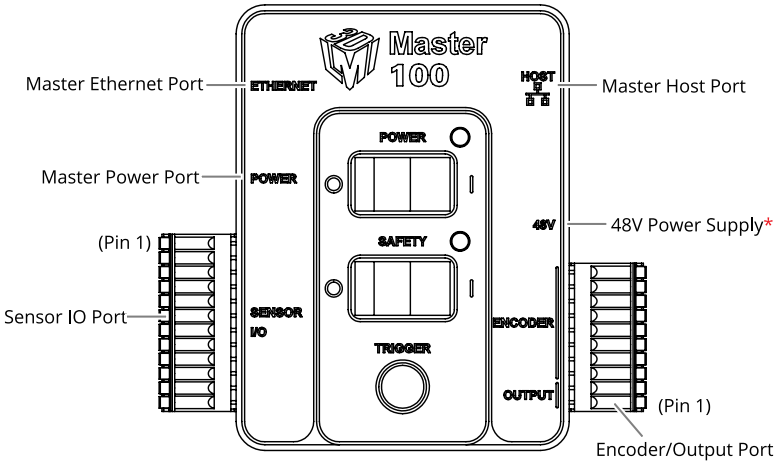
Master Network Controllers

The following sections provide the specifications of Master network controllers.

For information on maximum external input trigger rates, see *Maximum Input Trigger Rate* on page 116.

Master 100

The Master 100 accepts connections for power, safety (not supported by snapshot sensors), 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	White/Brown & Black
Encoder_A-	2	Brown/Black
Encoder_Z+	3	White/Green & Black
Encoder_Z-	4	Green/Black
Trigger_in+	5	Grey
Trigger_in-	6	Pink
Out_1-	7	Blue

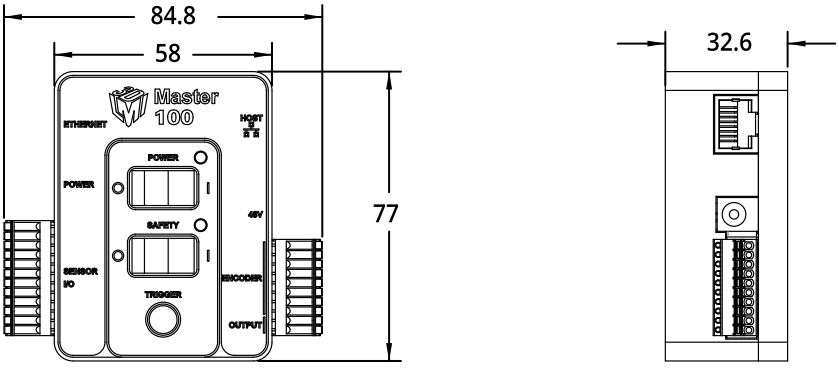
I/O Pin	Master Pin	Conductor Color
Out_1+	8	Red
Encoder_B+	11	Black
Encoder_B-	12	Violet

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



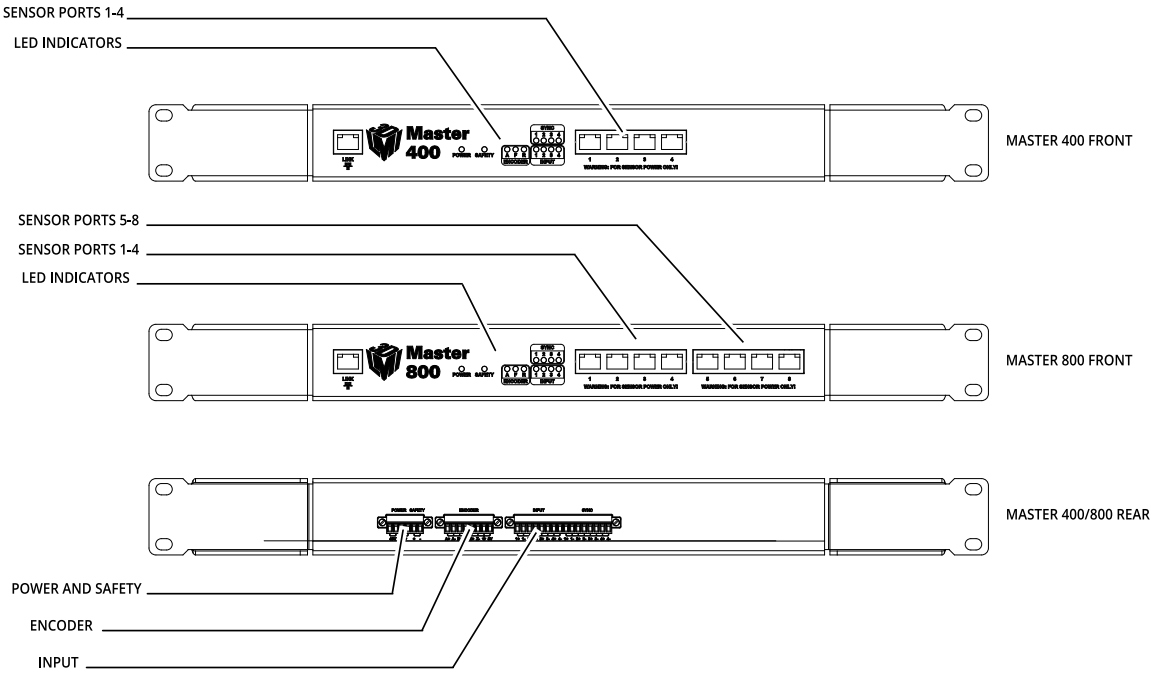
Master 400/800

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.")

> Laser safety is not supported by snapshot sensors.

> 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.



Power and Safety

Power and Safety (6 pin connector)

Function	Pin
+48VDC	1
+48VDC	2
GND (24-48VDC)	3
GND (24-48VDC)	4
Reserved	5
Reserved	6

The 6-pin Power and Safety connector's specifications are as follows:

- Manufacturer PN: 1847097
- Phoenix Contact MC 1,5/ 6-STF-3,5

> The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

Encoder

Encoder (8 pin connector)

Function	Pin
Encoder_A+	1
Encoder_A-	2
Encoder_B+	3
Encoder_B-	4
Encoder_Z+	5
Encoder_Z-	6
GND	7
+5VDC	8

The 8-pin Encoder connector's specifications are as follows:

- Manufacturer PN: 1847181
- Phoenix Contact MC 1,5/ 8-STF-3,5

Input

Input and Sync (16 pin connector)

Function	Pin
Input 1	1
Input 1 GND	2
Reserved	3
Reserved	4
Reserved	5
Reserved	6
Reserved	7
Reserved	8
Reserved	9
Reserved	10
Reserved	11
Reserved	12

Function	Pin
Reserved	13
Reserved	14
Reserved	15
Reserved	16

The 16-pin Input and Sync connector's specifications are as follows:

- Manufacturer PN: 1847262
- Phoenix Contact MC 1,5/ 16-STF-3,5

> The Input and Sync connector does not need to be wired up for proper operation.

Master 400/800 Electrical Specifications

Electrical Specifications

Specification	Value
Power Supply Voltage	+48 VDC
Power Supply Current (Max.)	10 A
Power Draw (Min.)	5.76 W
Encoder Signal Voltage	Differential (5 VDC)
Digital Input Voltage Range	Logical LOW: 0 to +0.1 VDC Logical HIGH: +3.3 to +24 VDC

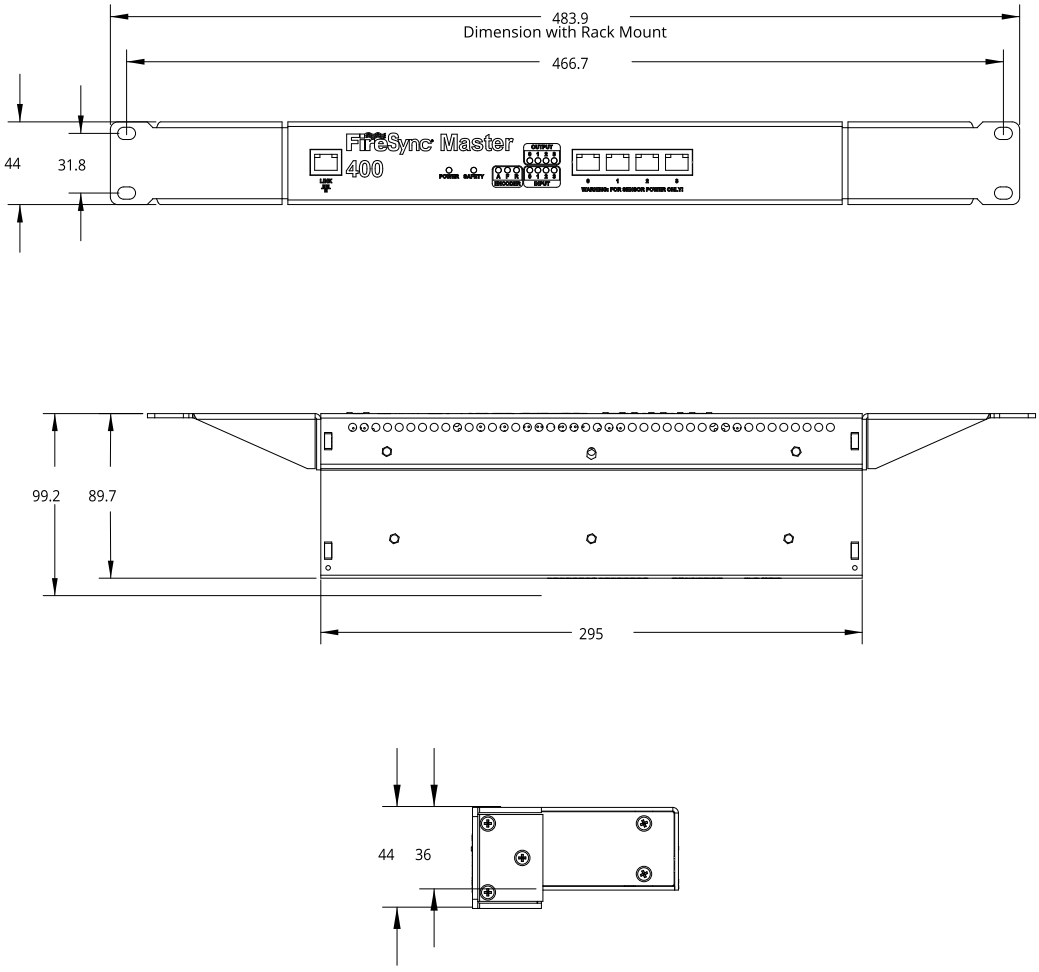
> ⚠ When using a Master hub, the chassis must be well grounded.

> The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

> 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..

Master 400/800 Dimensions

The dimensions of Master 400 and Master 800 are the same.



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.")

> Laser safety is not supported by snapshot sensors.

> 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 778.

The following table summarizes Master 810 and 2410:

Master 810 and 2410	
Input Voltage (Power)	+24-48 VDC (2 Watts)[1]
Total Power	Master 810 / 2410 input power + (sensor input power x number of sensors)
Capacity	Master 810: up to 8 sensors Master 2410: up to 24 sensors
I/O	4 digital inputs[2] Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC Differential HIGH: +3.3 to +24 VDC 10-pin Phoenix For more information, see *Electrical Specifications* on page 811.
Encoder	Differential (5 VDC, 12 VDC) Single-ended (5 VDC, 12 VDC)[3] For more information, see *Electrical Specifications* on page 811.
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 Master 2410: 0.9
Storage Temperature	-30 to 70 °C
Operation Temperature	0 to 50 °C

Notes

1. Refer to sensor datasheets for additional power required by sensors.
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

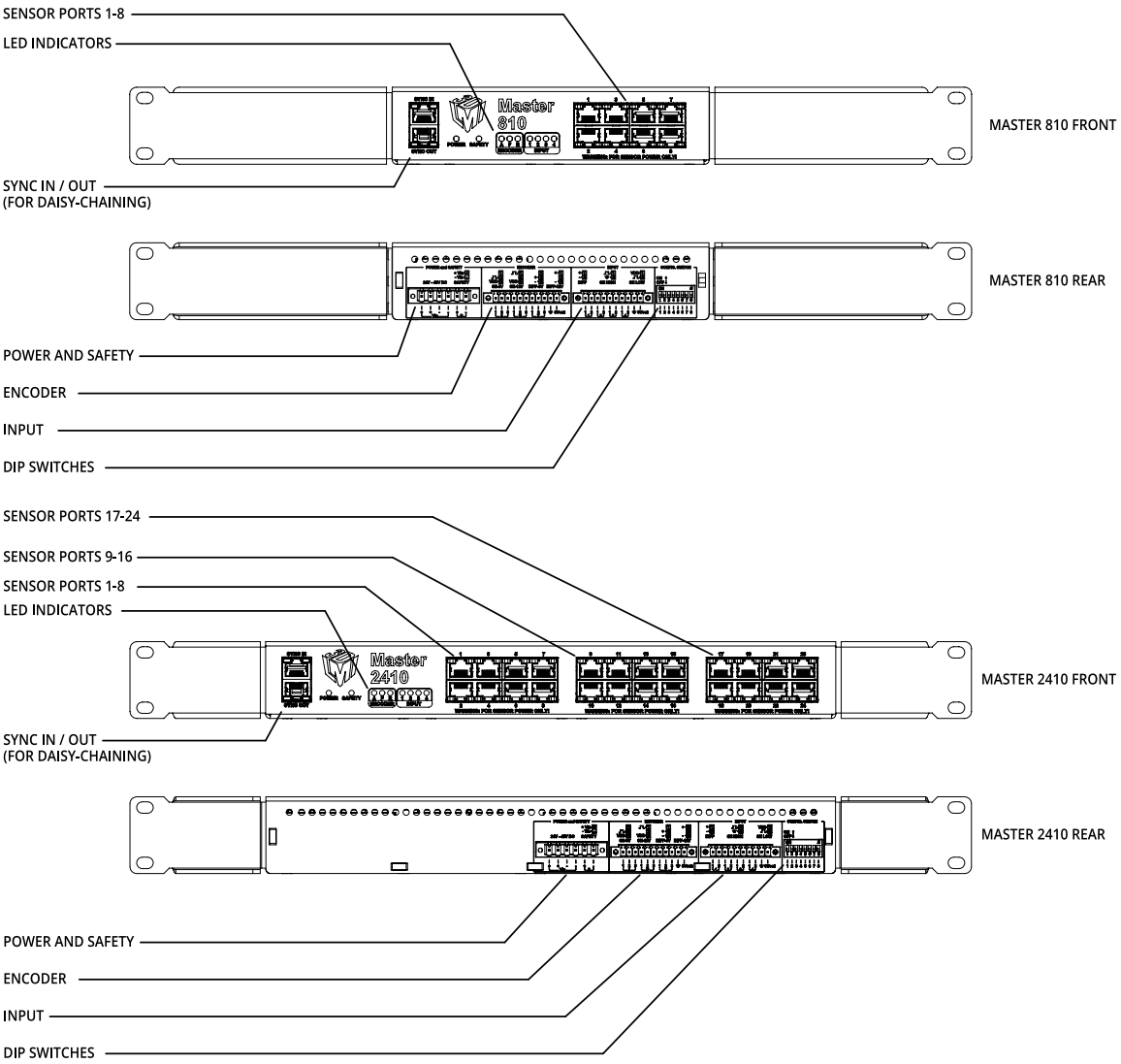
Indicator	Description
Power	Device is on.
Safety	Indicates the status of the Laser Safety circuitry. The "On" state indicates that all sensor light sources are active.
Encoder A	Reserved
Encoder F	**On continuously**: Forward motion with no indexing is detected. **Blinking**: Forward motion with indexing is detected.
Encoder R	**On continuously**: Reverse motion with no indexing is detected. **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 31). 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 32.



Power and Safety

Power and Safety (6 pin connector)

Function	Pin
Power In+	1
Power In+	2
Power In-	3
Power In-	4
Reserved	5
Reserved	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 812.

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
Input 2 Pin 1	3

Function	Pin
Input 2 Pin 2	4
Input 3 Pin 1	5
Input 3 Pin 2	6
Input 4 Pin 1	7
Input 4 Pin 2	8
GND (output for powering other devices)	9
+5VDC (output for powering other devices)	10

For Input connection wiring options, see *Input* on page 814.

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 778

Electrical Specifications

Specification	Value
Power Supply Voltage	+24 VDC to +48 VDC
Power Supply Current (Max.)*	Master 810: 9 A Master 2410: 25 A * Fully loaded with 1 A per sensor port.
Power Draw (Min.)	Master 810: 1.7 W Master 2410: 4.8 W
Encoder Signal Voltage	Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC Differential HIGH: +3.3 to +24 VDC For more information, see *Encoder* on the next page.
Digital Input Voltage Range	Single-Ended Active LOW: 0 to +0.8 VDC Single-Ended Active HIGH: +3.3 to +24 VDC Differential LOW: 0.8 to -24 VDC

Specification	Value
	Differential HIGH: +3.3 to +24 VDC For more information, see *Input* on page 814.

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).

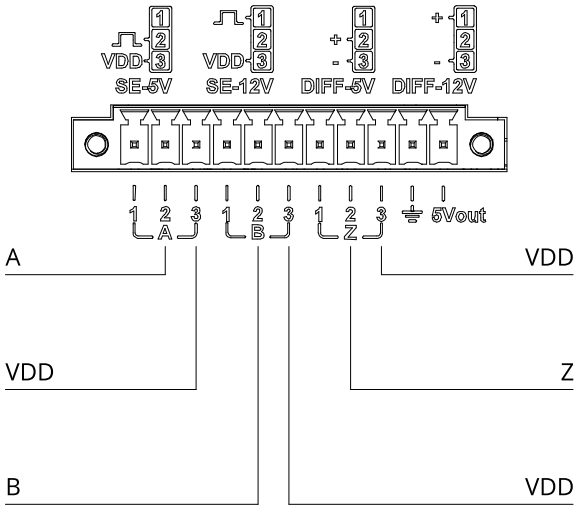
For 5 to 12 VDC operation, pins 2 and 3 of each channel are used.

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.

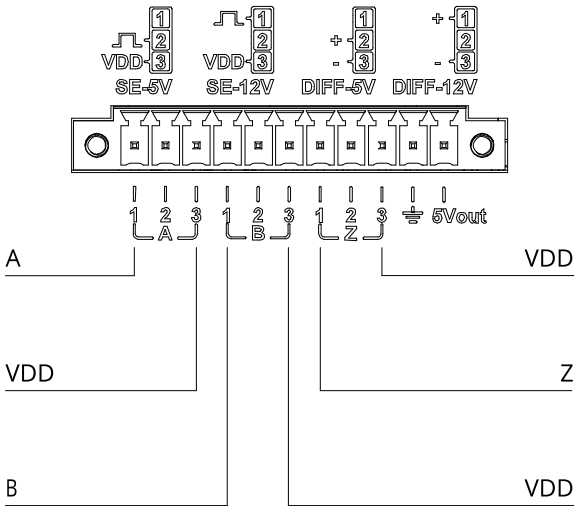
For 12 to 24 VDC operation, pins 1 and 3 of each channel are used.

Although Master 810 and 2410 are currently labeled as only supporting up to 12 VDC, they can support up to 24 VDC.

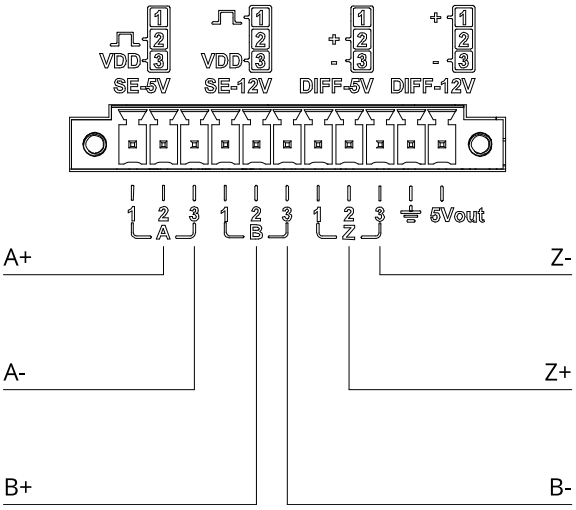
To determine how to wire a Master to an encoder, see the illustrations below.



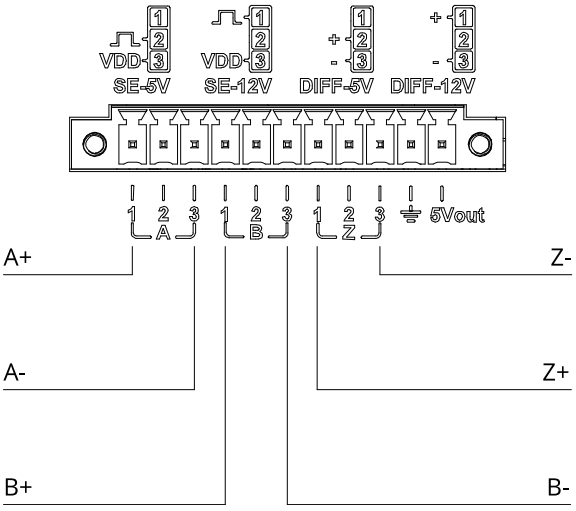
Single-Ended 5 VDC



Single-Ended 12 VDC



Differential 5 VDC



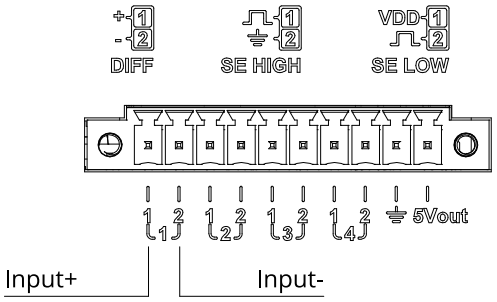
Differential 12 VDC

Input

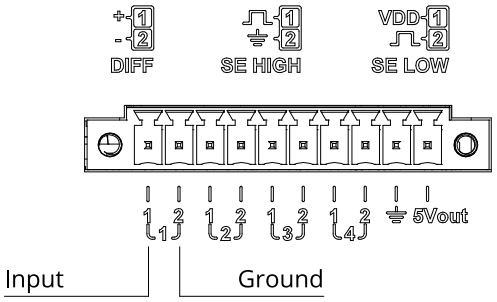
Master 810 and 2410 support the following types of input: Differential, Single-Ended High, and Single-Ended Low.

	Currently, Gocator only supports Input 0.

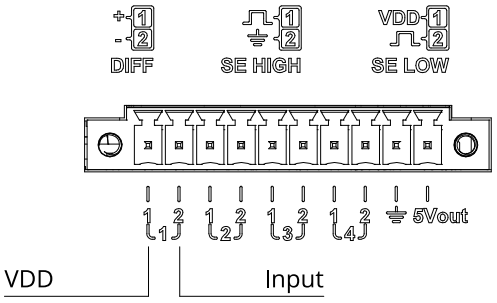
For digital input voltage ranges, see the table below.



Differential



Single-Ended Active High



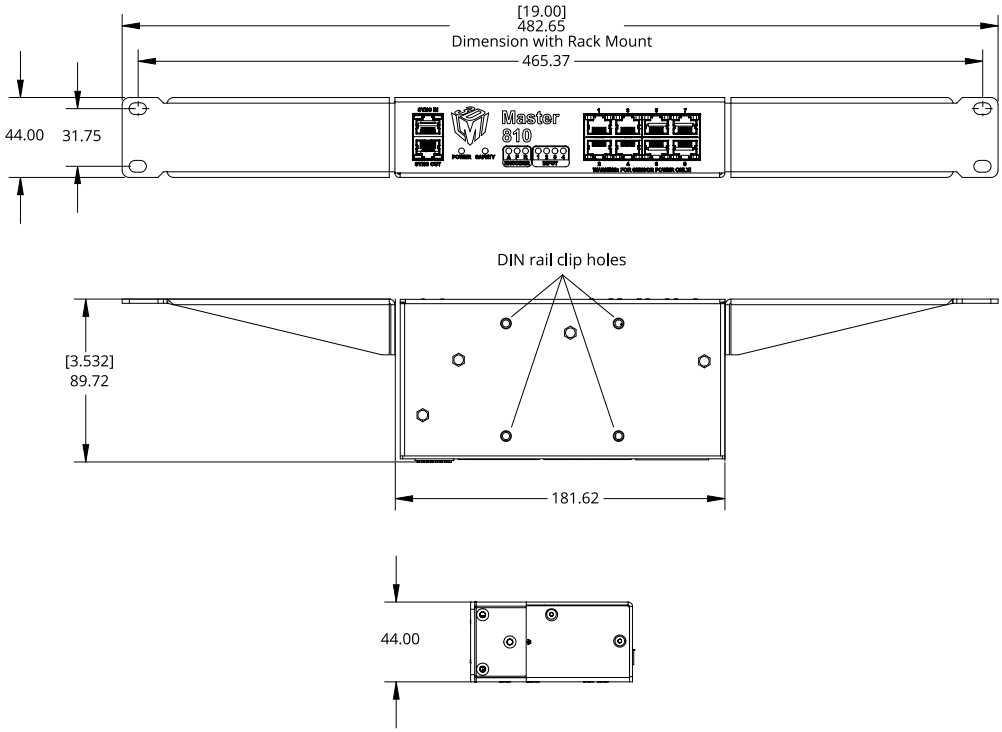
Single-Ended Active Low

Digital Input Voltage Ranges

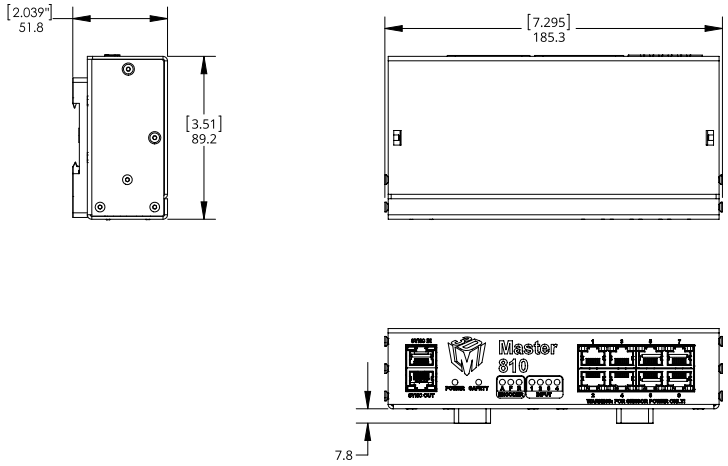
	Input Status	Min (VDC)	Max (VDC)
Single-ended Active High	Off	0	+0.8
	On	+3.3	+24
Single-ended Active Low	Off	(V_{DD} - 0.8)	V_{DD}
	On	0	(V_{DD} - 3.3)
Differential	Off	-24	+0.8
	On	+3.3	+24

Master 810 Dimensions

With 1U rack mount brackets:



With DIN rail mount clips:



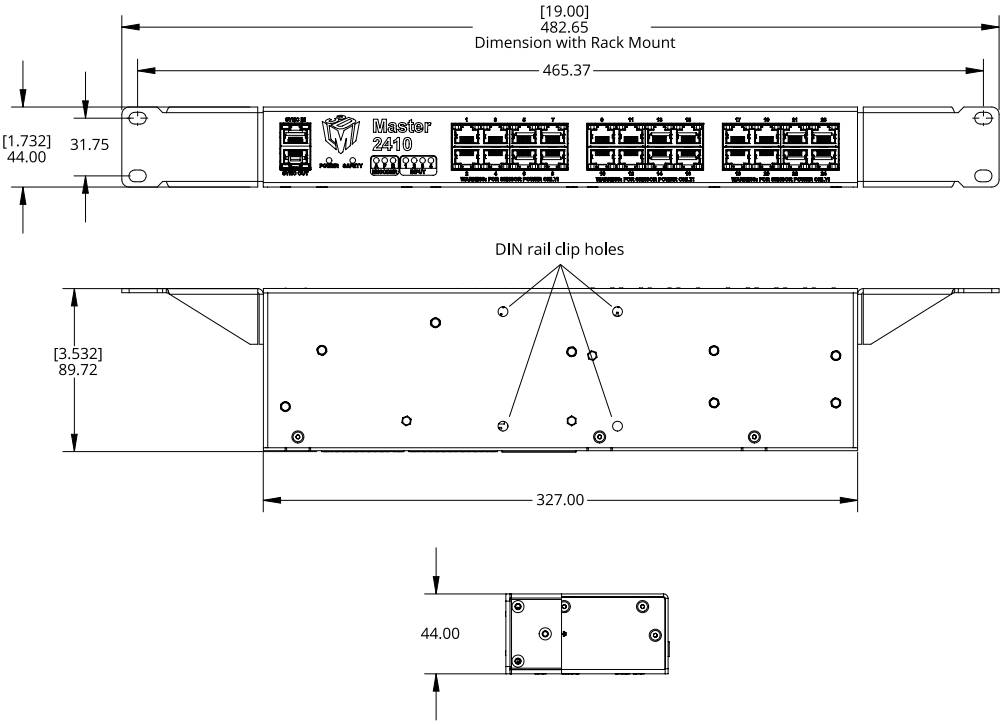
Older revisions of Master 810 and 2410 network controllers use a different configuration for the DIN rail clip holes.

For information on installing DIN rail clips, see *Installing DIN Rail Clips: Master 810 or 2410* on page 31.

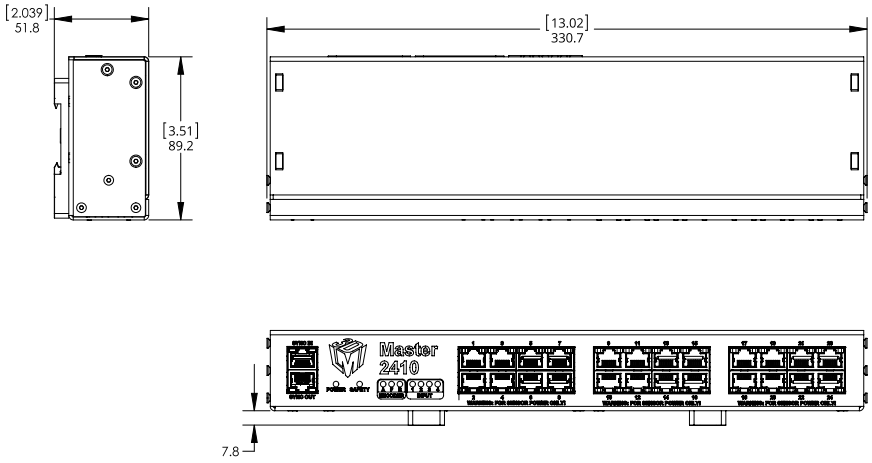
The CAD model of the DIN rail clip is available at https://www.winford.com/products/cad/dinm12-rc.igs.

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.

For information on installing DIN rail clips, see *Installing DIN Rail Clips: Master 810 or 2410* on page 31.

The CAD model of the DIN rail clip is available at https://www.winford.com/products/cad/dinm12-rc.igs.

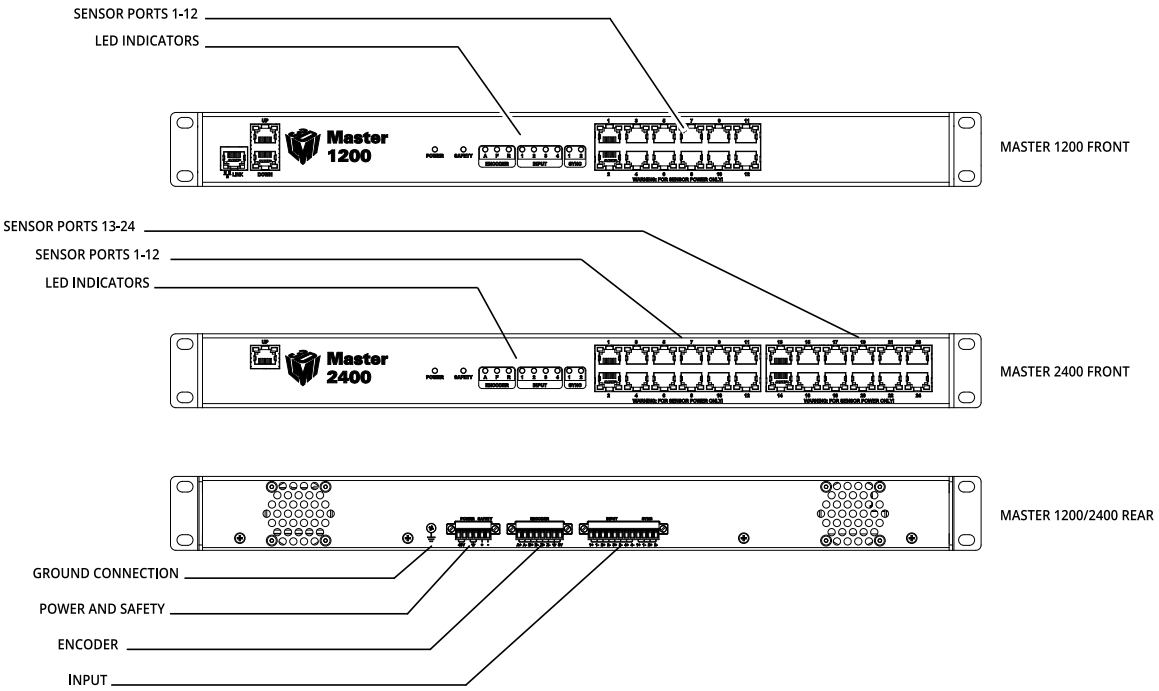
Master 1200/2400

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.")

> Laser safety is not supported by snapshot sensors.

> 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.



Power and Safety

Power and Safety (6 pin connector)

Function	Pin
+48VDC	1
+48VDC	2
GND (24-48VDC)	3
GND (24-48VDC)	4
Reserved	5
Reserved	6

The 6-pin Power and Safety connector's specifications are as follows:

- Manufacturer PN: 1847097
- Phoenix Contact MC 1,5/ 6-STF-3,5

> The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

Encoder

Encoder (8 pin connector)

Function	Pin
Encoder_A+	1
Encoder_A-	2
Encoder_B+	3
Encoder_B-	4
Encoder_Z+	5
Encoder_Z-	6
GND	7
+5VDC	8

The 8-pin Encoder connector's specifications are as follows:

- Manufacturer PN: 1847181
- Phoenix Contact MC 1,5/ 8-STF-3,5

Input

Input and Sync (12 pin connector)

Function	Pin
Input 1	1
Input 1 GND	2
Reserved	3
Reserved	4
Reserved	5
Reserved	6
Reserved	7
Reserved	8
Reserved	9
Reserved	10
Reserved	11
Reserved	12

The 12-pin Input and Sync connector's specifications are as follows:

- Manufacturer PN: 1847220
- Phoenix Contact MC 1,5/ 12-STF-3,5

🗋	The Input and Sync connector does not need to be wired up for proper operation.

Master 1200/2400 Electrical Specifications

Electrical Specifications

Specification	Value
Power Supply Voltage	+48 VDC
Power Supply Current (Max.)	10 A
Power Draw (Min.)	5.76 W
Encoder Signal Voltage	Differential (5 VDC)
Digital Input Voltage Range	Logical LOW: 0 to +0.1 VDC Logical HIGH: +3.5 to +6.5 VDC

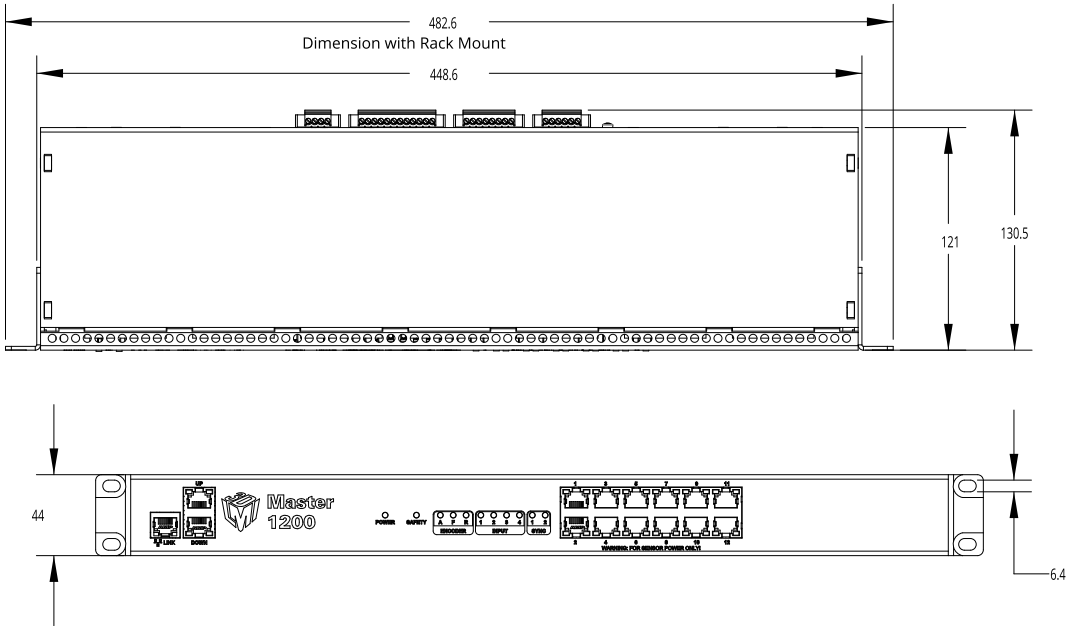
⚠	When using a Master hub, the chassis must be well grounded.

🗋	The power supply must be isolated from AC ground. This means that AC ground and DC ground are not connected.

🗋	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..

Master 1200/2400 Dimensions

The dimensions of Master 1200 and Master 2400 are the same.



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 - Straight Connectors

Description	Part Number
1.2m I/O cordset, open wire end	301175-1.2m
2m I/O cordset, open wire end	301175-2m
5m I/O cordset, open wire end	301175-5m
10m I/O cordset, open wire end	301175-10m
15m I/O cordset, open wire end	301175-15m
20m I/O cordset, open wire end	301175-20m
25m I/O cordset, open wire end	301175-25m
Custom length (< 25m) I/O cordset, open wire end	301175
2m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-2m
5m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-5m
10m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-10m
15m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-15m
20m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-20m
25m Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176-25m
Custom length (< 25m) Power and Ethernet cordset, 1x open wire end, 1x RJ45 end	301176
1.2m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-1.2m
2m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-2m
5m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-5m
10m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-10m
15m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-15m
20m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-20m
25m Power and Ethernet to Master cordset, 2x RJ45 ends	301165-25m
Custom length (< 25m) Power and Ethernet to Master cordset, 2x RJ45 ends	301165

High Flex Gocator Cordsets - 90-degree Connectors

Description	Part Number
2m I/O cordset, 90-deg, open wire end	301172-2m
5m I/O cordset, 90-deg, open wire end	301172-5m
10m I/O cordset, 90-deg, open wire end	301172-10m
15m I/O cordset, 90-deg, open wire end	301172-15m
20m I/O cordset, 90-deg, open wire end	301172-20m
25m I/O cordset, 90-deg, open wire end	301172-25m
Custom length (< 25m) I/O cordset, 90-deg, open wire end	301172
2m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-2m
5m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-5m
10m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-10m
15m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-15m
20m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-20m
25m Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171-25m
Custom length (<25m) Power and Ethernet cordset, 90-deg, 1x open wire end, 1x RJ45 end	301171
2m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-2m
5m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-5m
10m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-10m
15m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-15m
20m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-20m
25m Power and Ethernet to Master cordset, 90-deg, 2x RJ45 ends	301173-25m

Notes related to cordsets

For information on cordset bend radius limits, see *Cordset Bend Radius Limits* on page 26.

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 824.

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 750 for more information.

When attempting to log in, the password is not accepted.

- Use the Sensor Recovery tool. See *GoPxL Discovery Tool* on page 750 for steps to reset the password.

Performance

The sensor CPU level is near 100%.

- Consider reducing the speed. If you are using a time or encoder trigger source, see *Triggers* on page 112 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.
- Consider reducing the resolution.
  For more information on configuring resolution, see *Uniform Spacing* on page 109 and *Triggers* on page 112.
- 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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https://github.com/CLIUtils/CLI11

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xxhash

Website:

https://github.com/Cyan4973/xxHash

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xxhsum command line interface

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Website:

https://github.com/nlohmann/json

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https://github.com/EIPStackGroup/OpENer

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picoc

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https://github.com/jpoirier/picoc

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tar (binary only)

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ramda

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https://ramdajs.com/

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rc-menu

Website:

https://github.com/react-component/menu

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react

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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

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https://github.com/ReactiveX/rxjs

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