



Creaform R-Series Integrator Manual MetraSCAN3D-R™

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About this manual

This manual is intended for robotic system integrators and targets the design and installation of an R-Series Automated Quality Control solution. It requires to be familiar with basic mechanical and electrical knowledge and the programming language of the robot.

For documentation on the operation of the R-Series Automated Quality Control Inspection solution, refer to the R-Series User Manual and Training Scripts.

All dimensions and measurements are for information use only.

This manual follows the use of the International System of Units (SI)¹. Unless otherwise specified, length units are expressed in millimeters and angle are expressed in degrees. The convention used for the colors of coordinate systems axes is as follows:

red=X, green=Y, blue=Z.

Important Safety Notice

Any machine safety information provided in this manual must not be interpreted as a warranty of compliance to applicable safety laws and regulations. The integrator is responsible of conducting a risk assessment of the complete robot cell, and of ensuring that applicable safety laws and regulations are observed

¹ According to the National Institute of Standards and Technology Guide for the Use of the International System of Units (SI) available at <https://www.nist.gov/publications/guide-use-international-system-units-si>

Components

Here is an overview of the typical components used in an automated quality control solution. More details are available through the equipment training script and user manual provided onsite during training and through Creaform [Customer Center website](#).

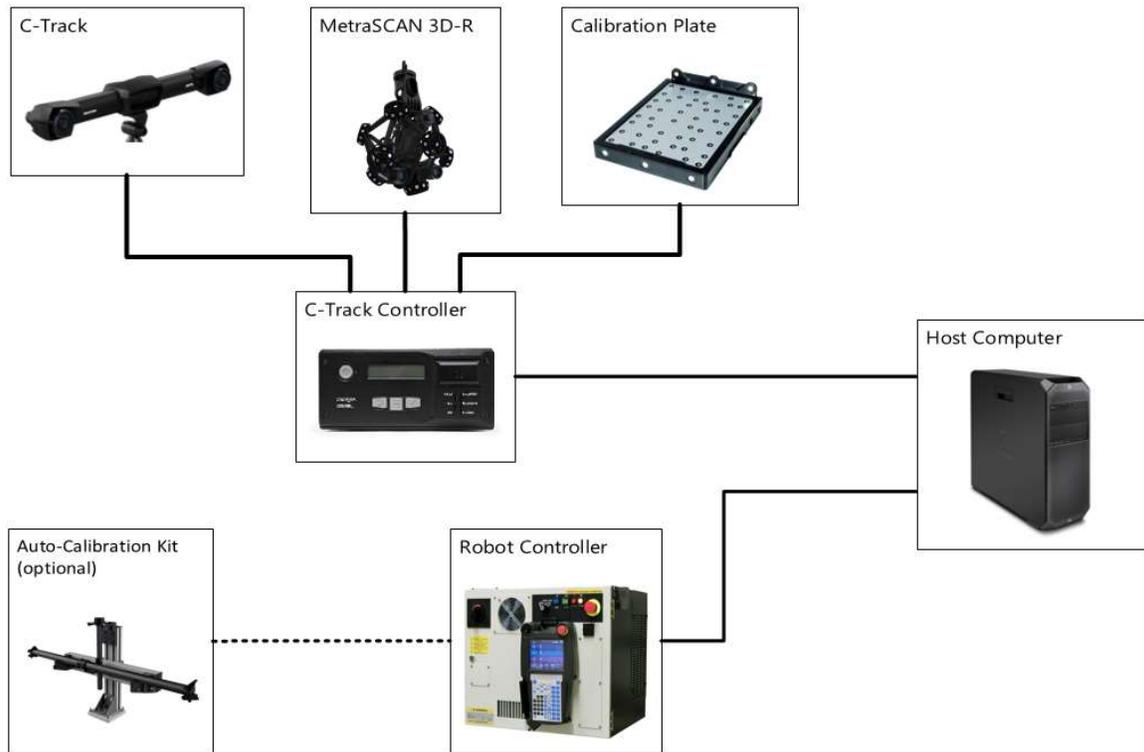


Figure 1 - R-Series Components Overview

C-Track

The C-Track is an optical tracker providing high-accuracy measurements. This device is used in conjunction with the MetraSCAN 3D-R. It accurately and efficiently measures the positions and orientations of reflectors and of the scanner in 3D space.

MetraSCAN 3D-R

The MetraSCAN 3D-R is a powerful robot-mounted optical 3D scanner that can be integrated into factory automation projects.

C-Track Controller

The C-Track system uses a dedicated controller. This hardware will be used as the interface between the software running on the host computer and the equipment itself through an Ethernet connection.

Working Environment

Creaform R-Series systems are rated IP50 (per ANSI/IEC 60529-2004 - Degrees of Protection Provided by Enclosures – IP Code). Therefore, ingress of dust is not entirely prevented; it must not enter in large enough quantity to interfere with the satisfactory operation of the equipment. The systems are not protected from liquids.

Always operate in an environment suited to this IP rating.

Creaform R-Series systems must be operated within specific conditions, as follow:

Operating Temperature Range	15–40°C
Operating Humidity Range (non-condensing)	10–90%

During calibration, the maximum permitted temperature variation is +/- 2°C. A variation above this value will require the calibration process to be restarted.

During measurements, the maximum permitted temperature variation is +/- 10°C. A variation above this value will require a C-Track recalibration.

C-Track

Throughout this document, unless otherwise specified, all positions will be expressed to the C-Track Coordinate System. It is in front of the center section and based on the camera positions.

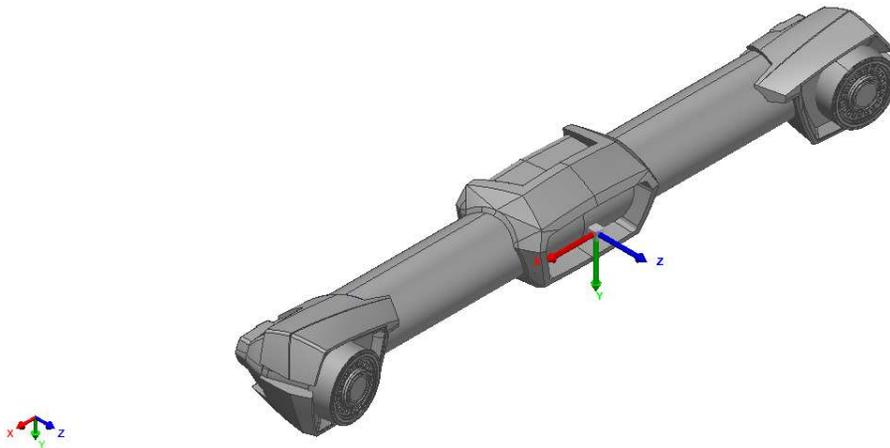


Figure 2 - C-Track Coordinate System

The cell design must account for the following:

- The provided mounting interface must be used to anchor the C-Track in the cell (see *Mechanical* Interface)
- No external force must be applied to the body of the C-Track.
- No direct airflow should be directed at the lens bodies.
- Avoid positioning the camera to be facing direct sunlight or equipment generating bright lights such as welding equipment.
- The C-Track self-regulates its temperature for optimal working conditions. A normal temperature stabilization time for the C-Track is around 20-25 minutes at start-up.

The following information can be used for preliminary layout. Refer to the 3D Model for more details.

Table 1 - Bounding box dimensions and weight

Property	Value
Length (X)	1050
Height (Y)	150
Depth (Z – w/o cables)	200
Weight	5.7 kg

Working Volume

The volumetric accuracy performance of the MetraSCAN 3D-R is dependent on the working volume in which measurements are made: 9.1 m³ or 16.6 m³. Refer to the Technical Specification for details.

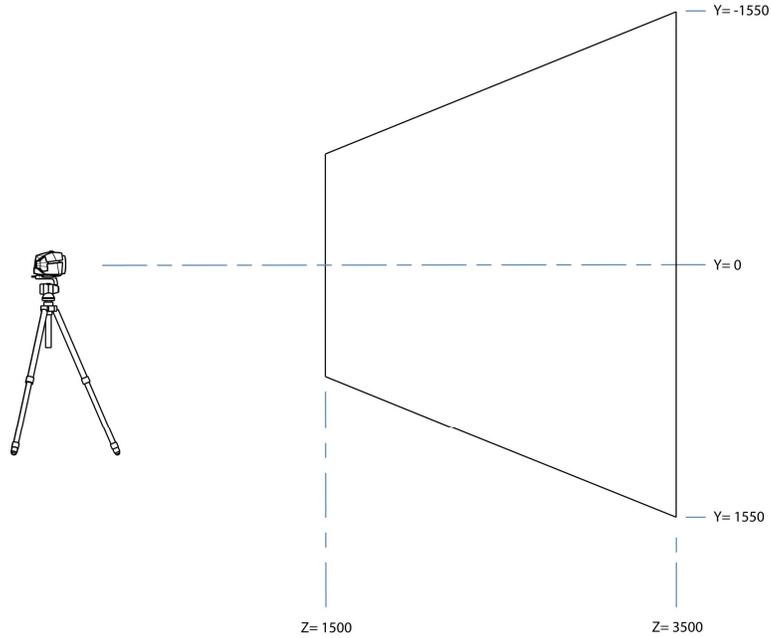


Figure 3 - C-Track 9.1m³ working volume - Side View

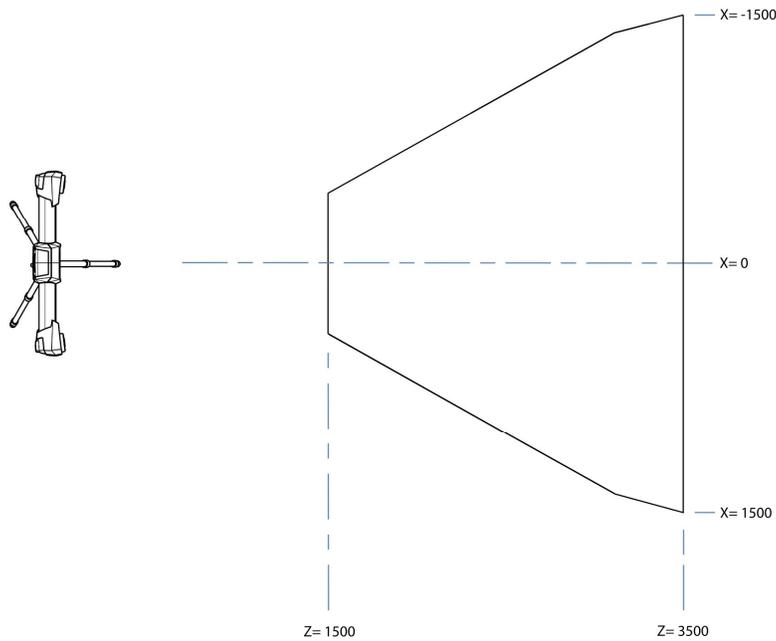


Figure 4 - C-Track 9.1m³ working volume - Top View

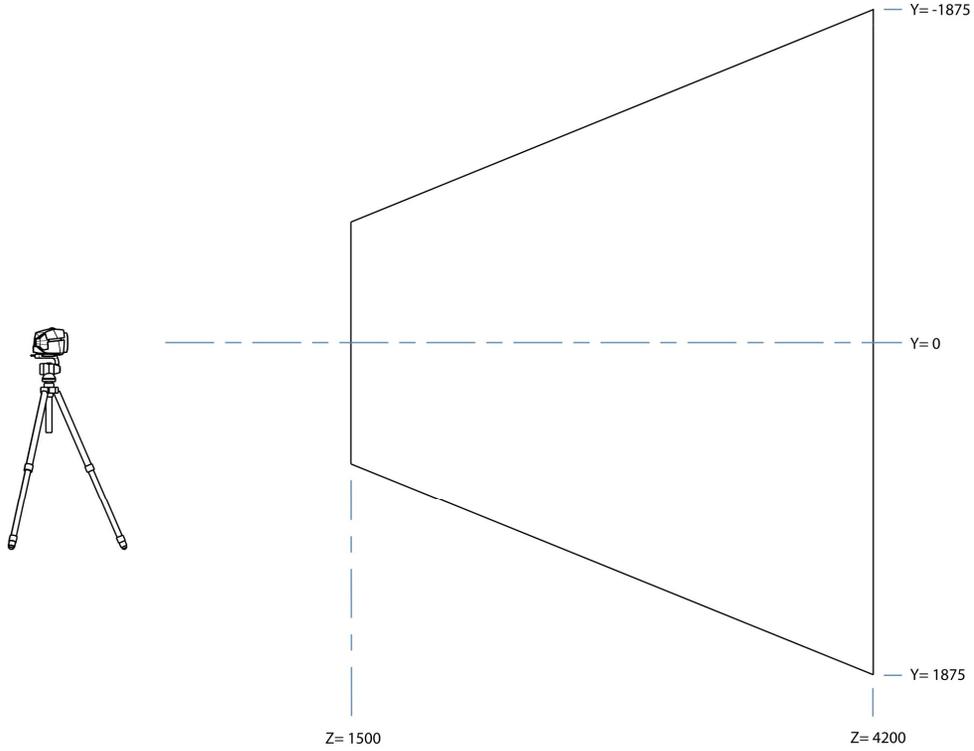


Figure 5 - C-Track 16.6m³ working volume - Side View

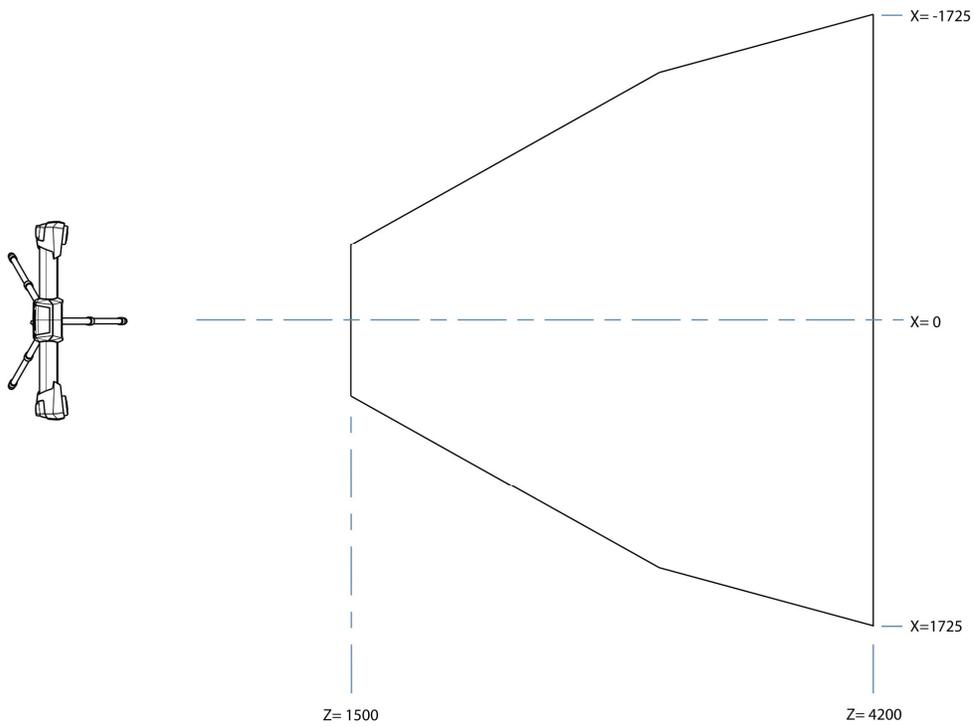


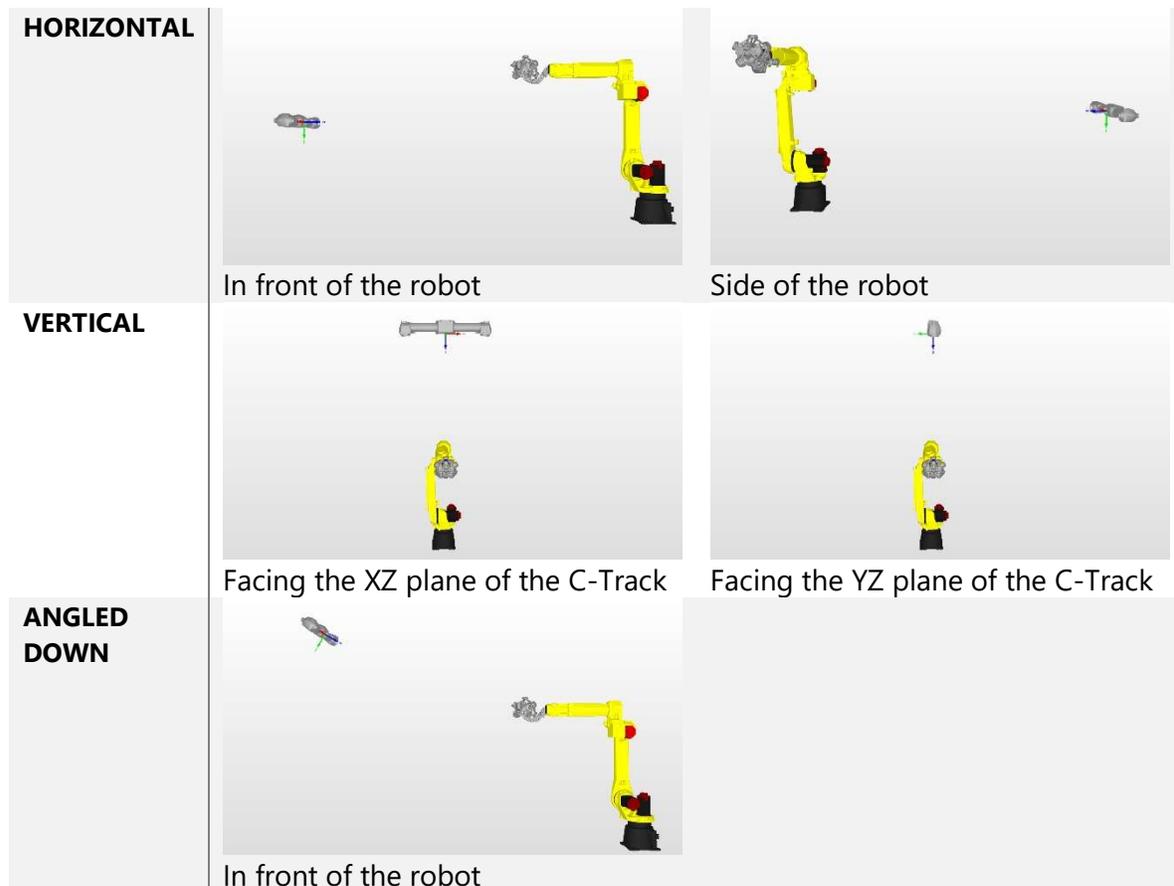
Figure 6 - C-Track 16.6m³ working volume - Top View

Position

The C-Track can be mounted in multiple orientations, given some constraints. Consult with Creaform for simulation assistance offer.

Parameter	Min	Max
Pitch (R_x)	+45°	-90°
Roll (R_z)	+45°	-45°

These are the suggested C-Track-robot configuration possible. Other configurations are possible but might negatively impact the C-Track line-of-sight to the scanner.



There is no restriction on the choice of the angle of C-Track (within allowed window) before calibration, it can be oriented as wished, however, some constraints apply:

- **All configurations**

C-Track rotations movement range (pitch and roll) is limited to $\pm 2^\circ$ during calibration.

- **Horizontal configuration**

Tilt and roll angles will be compensated by the C-Track up to $\pm 45^\circ$. This feature allows to compensate for the angles of inclination of C-Track and to notify when too large angles

are being used. When exceeding these angles, the C-Track angles must remain static between calibration and measurement.

- **Vertical configurations**

Tilt and roll angles are not compensated. The C-Track angles must remain static between calibration and measurement. Tolerance is $\pm 1^\circ$ during operation, vibrations could impact this measurement. This means, for example, that it is not possible to calibrate in Horizontal configuration and switch to Vertical for measurements.

Mechanical Interface

Mount the system on a sturdy, vibration-less surface that can withstand the weight of the system with an appropriate safety margin. A Design for Maintenance approach should be used where applicable. An equipment swap of all components should take a reasonable time.

The system provides three mounting options:

1. Direct attachment

The C-Track provides a mounting interface composed of two M5x0.5 X 5 threaded holes located under the center section of the system. The two holes are spaced symmetrically by 100.90mm center-to-center (see Figure 8).



Figure 7 - Mounting Interface (shown here with quick release plate attached)

2. Interface with quick release plate

The system is provided with a Quick Release plate attached to the C-Track mounting holes. It has compatibility with the optional tripod head.

It can also be used as a custom quick-release interface based on the following information:

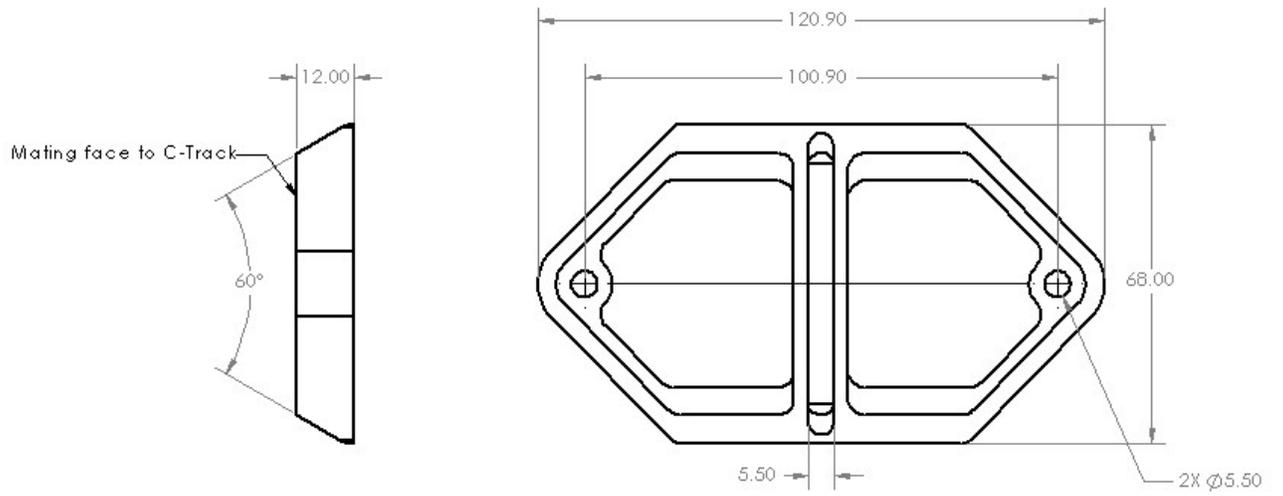


Figure 8 - Quick Release Interface plate

MetraSCAN 3D-R

The MetraSCAN 3D-R is a 3D scanner provided as a robotic End-Of-Arm tool (EOAT) with a hollow-wrist compatible adapter bracket. It is designed for direct compatibility with Fanuc M-20iA end-effector mounting flange. This hollow-wrist design is not compliant to ISO 9409. Consult with Creaform for adapter design, Tool Frame definition and payload (mass, center of gravity and inertia).

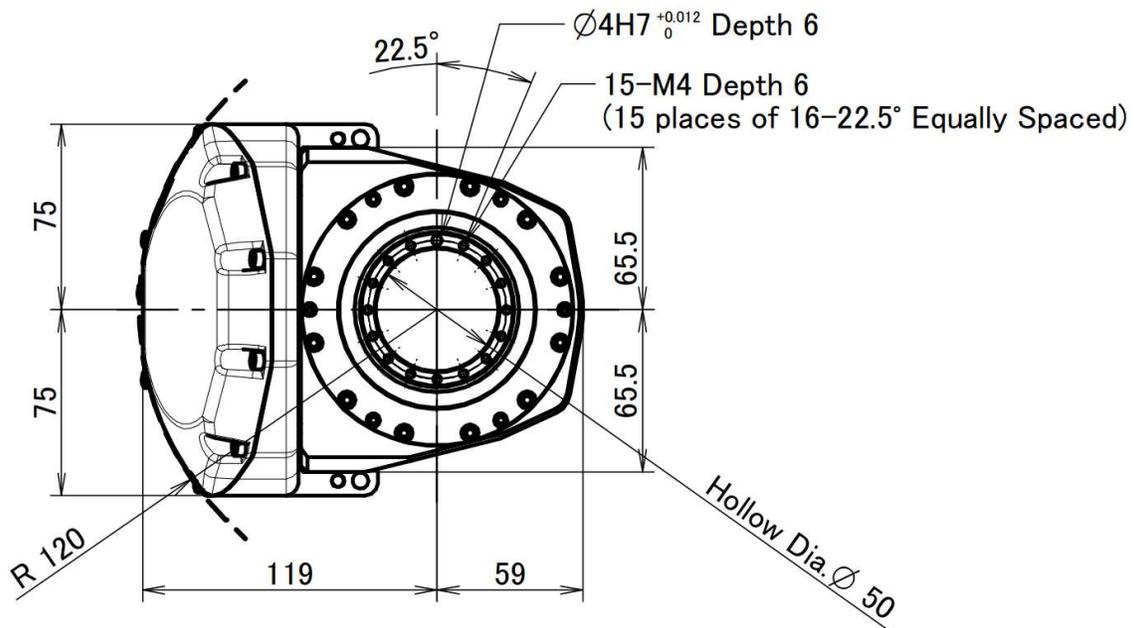


Figure 9 - FANUC M20iA wrist flange

Electrical Interface

The MetraSCAN 3D-R connects to the controller using one provided cable for both power and data. The default provided cable is a high-flex robotic grade cable, 16-meter-long, already terminated with the required connectors.

MetraSCAN 3D-R Calibration Artifact

Changes in the environment may affect the scanner calibration, mostly due to pressure or temperature variations, thus modifying the mechanical configuration. The scanner calibration must be optimized for the system to perform to specifications. The MetraSCAN 3D-R Calibration Artifact allows to perform this field calibration. The artifact can be integrated in the automated cell in multiple configurations:

- Permanent
 - The calibration artifact is mounted permanently in the cell. Precautions should be taken to protect the artifact from accidental damage or debris.
- Removable (manual)
 - A user will install the calibration artifact in a repeatable fixture before starting the calibration process.
- Mobile (automated)
 - A moveable fixture will move the calibration artifact to a repeatable position before starting the calibration process.

Consult with Creaform for simulation assistance and layout validation. In all cases, cell design must account for the following:

- The plate must be reachable by the robot with the MetraSCAN 3D-R. The TCP must be able to reach the center of the calibration plate (identified by the Z axis of Figure 10). The calibration poses will be above the calibration plate, avoid any obstructions.
- A sturdy, vibration-less mounting method for the artefact should be used.
- The C-Track requires line-of-sight to all 6 positioning targets (identified in Figure 13) during the calibration process.
- Make sure there are no reflective objects near the calibration plate.

The anchoring method should not interfere with the USB cable and power connector (identified in Figure 13) or apply any strain to the connector.

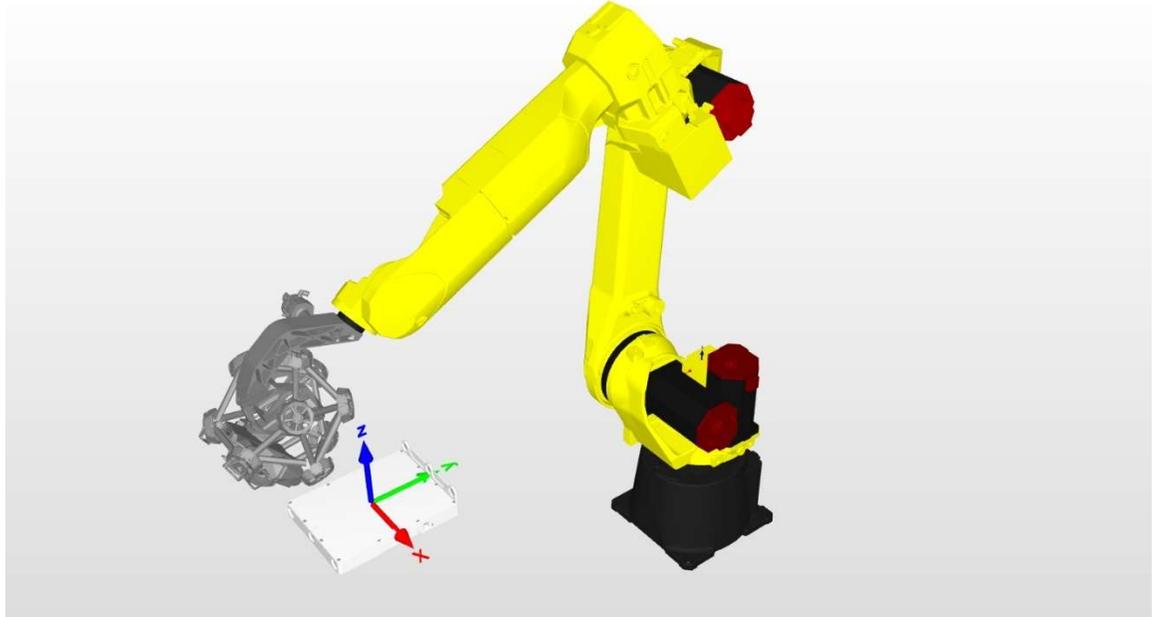


Figure 10 - Calibration pose example

The following information can be used for preliminary layout. Refer to the 3D Model for more details.

Parameter	Value
Width	242.0
Height	74.0
Length	301.0
Weight	3.410 <i>kg</i>

Position

The calibration artifact must be positioned in relation to the C-Track Coordinate system (see Figure 2). The center of the calibration plate – identified by the coordinate system in Figure 10) must be within the limits specified below:

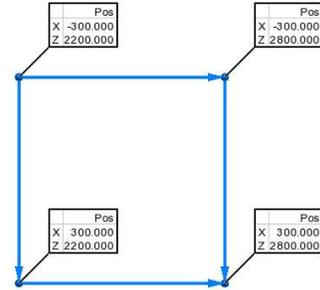
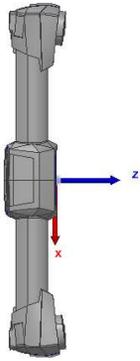


Figure 11 - Allowable zone in the C-Track XZ plan

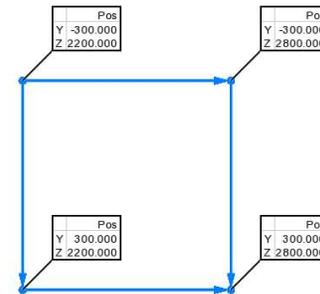
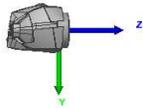


Figure 12 - Allowable zone in the C-Track YZ plane

The allowable zone is a cubic boundary defined by the following:

	Min	Max
X	-300	+300
Y	-300	+300
Z	2200	2800

In case the distance from the X axis is greater than 0 (calibration plate not centered to the C-Track), it is recommended to orient the plate toward the C-Track with angle $\theta = \tan^{-1} \frac{Z}{x}$

To ensure line-of-sight to the calibration plate targets, a tilt of the calibration plate forward by $\theta \approx 5^\circ$ is typically helpful.

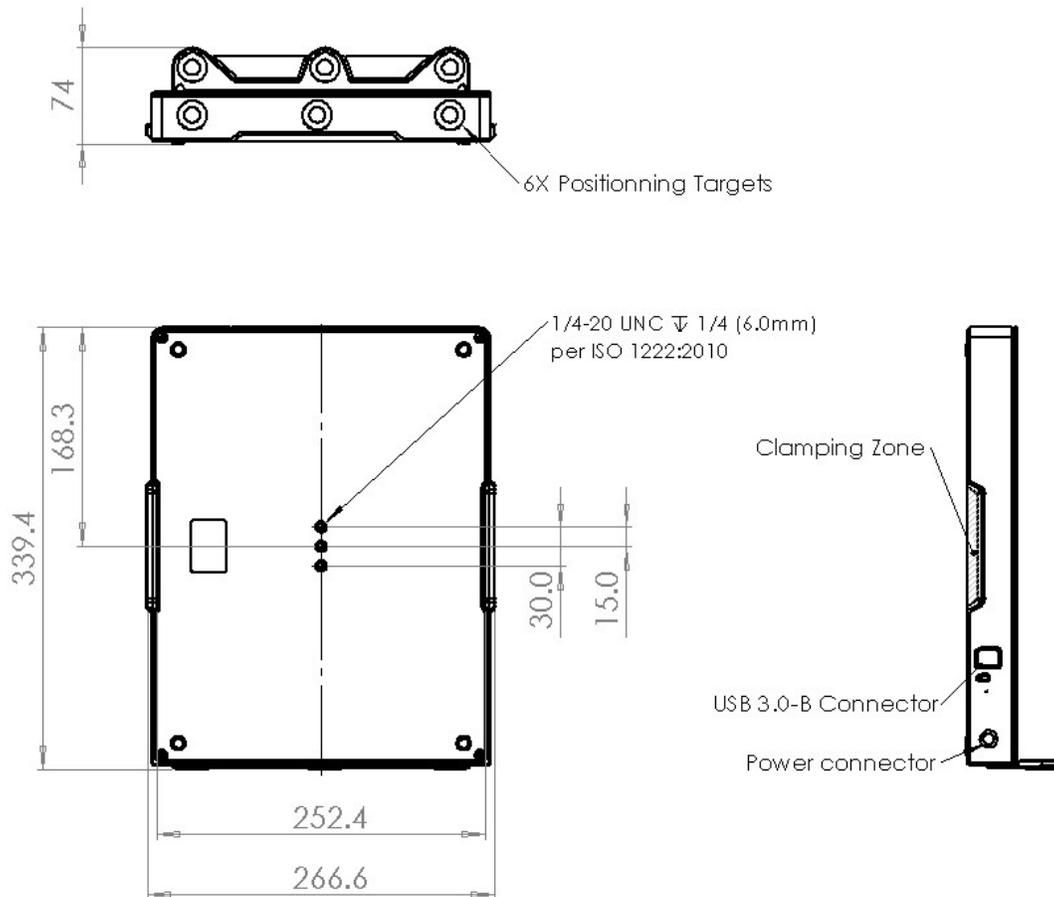


Figure 13 - MetraSCAN 3D-R Calibration Artifact Installation Drawing

Mechanical Interface

Mount the artifact on a sturdy, vibration-less surface that can withstand the weight of the system with an appropriate safety margin.

The artifact provides two mounting options:

1. Direct attachment

The artifact has a mounting attachment located on the bottom surface, at the center of the calibration plate. It features 3x 1/4–20 UNC X 1/4 inch (per ISO 1222:2010 – Photography – Tripod connections) threaded hole.

2. Set screw

The artifact has four rubber feet that allows the plate to rest on a flat surface. It is possible to clamp the artifact for additional security and stability. Use soft tip point or Nylon Set Screws in designated clamping zone on both sides of the artifact (Refer to Figure 13).

Electrical Interface

The MetraSCAN 3D-R Calibration Artifact connects to power using one provided cable. This USB 3.0 Standard-B cable can be connected at the back of the C-Track controller or in the host computer.

C-Track Controller

The C-Track controller is mandatory for use of the system. Cell design must account for the following:

- The controller is passively cooled. Make sure to leave a 10 cm gap around and on top of the controller to make sure there is adequate ventilation around it. It is not recommended to enclose the controller without validation with Creaform.
- Always use the device in a clean and dry environment. Avoid debris buildup on the controller that can affect heat dissipation.

Mechanical Interface

The following information can be used for preliminary layout.

Parameter	Value
Width	195.0
Height	95.0
Length (w/o cables)	300.0
Weight	4.2kg

The controller has rubberized feet and can be placed on any sturdy, vibration-less surface that can withstand the weight of the system with an appropriate safety margin. For a more robust mounting, Creaform provides an optional mounting bracket kit (sold separately), allowing for a secure anchoring with M3-0.5 or #6-32 UNC screws.

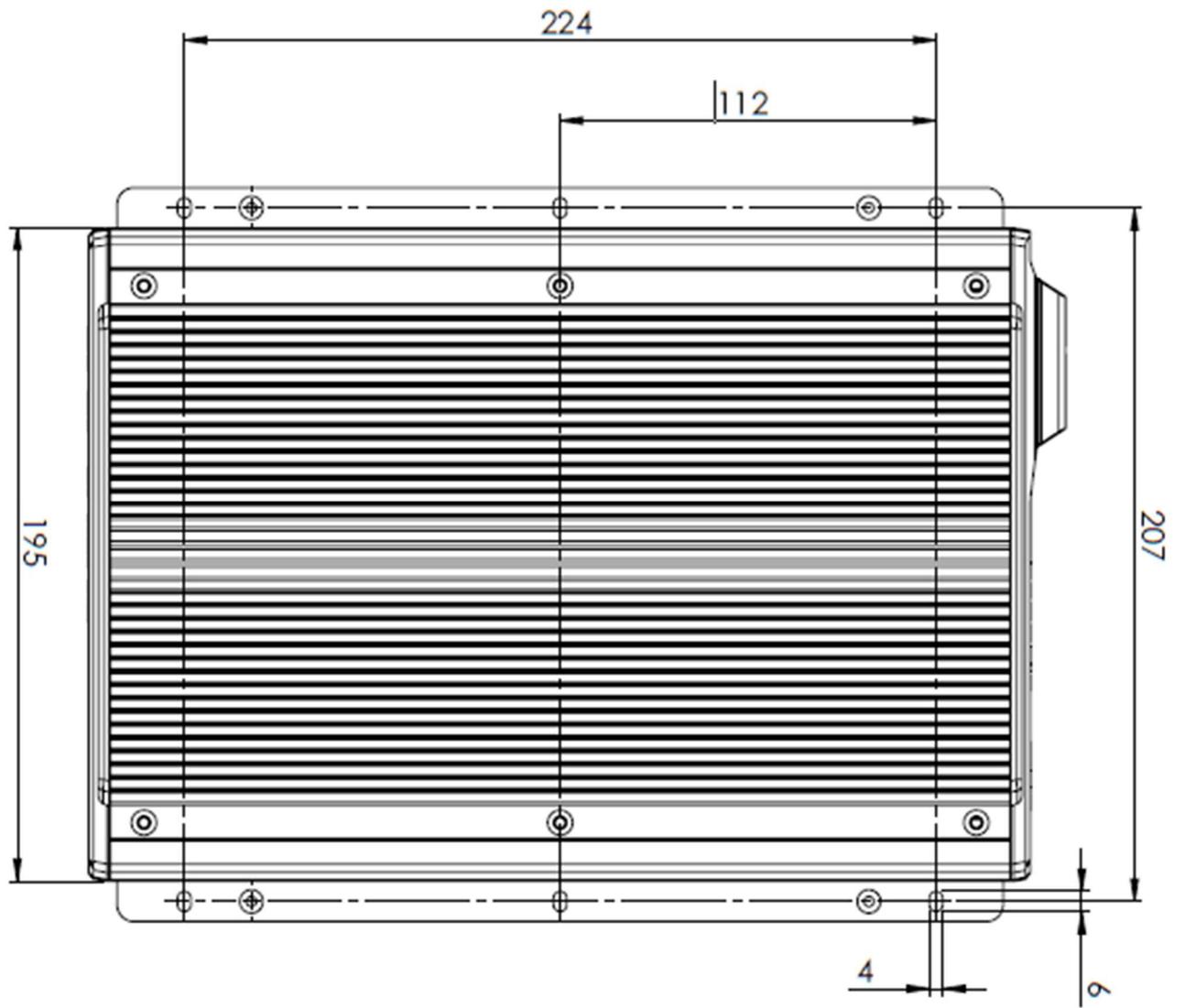


Figure 14 - C-Track Controller Installation Drawing (with optional brackets)

Electrical Interfaces



Figure 15 - Electrical Interfaces at the back of the C-Track controller

Power for the system comes from a power supply connected to the controller.

Parameter	Value
Input Voltage	100–240VAC
Input Frequency	50/60Hz
Maximum Current Draw	2.5A
Interface to power supply brick	IEC 60320 C13/C14

C-Link

The C-Link is an optional functionality which enables simultaneous measurement with up to 4 different C-Tracks using a single reference system.

Cell design must account for the following:

- Calibration of every C-Track is mandatory.
- Calibration of the MetraSCAN can be performed in front of any C-Track.
- Each C-Track controller must be interconnected. The maximum distance between every controller is limited by the C-Link cable length of 10m. All controllers are daisy-chained from a master controller, chosen arbitrarily
- The C-Link mesh must be connected to a Gigabit Switch. This is built-in with the Productivity Station. When using other solutions, an external Ethernet switch is provided with the C-Link kit to be integrated.

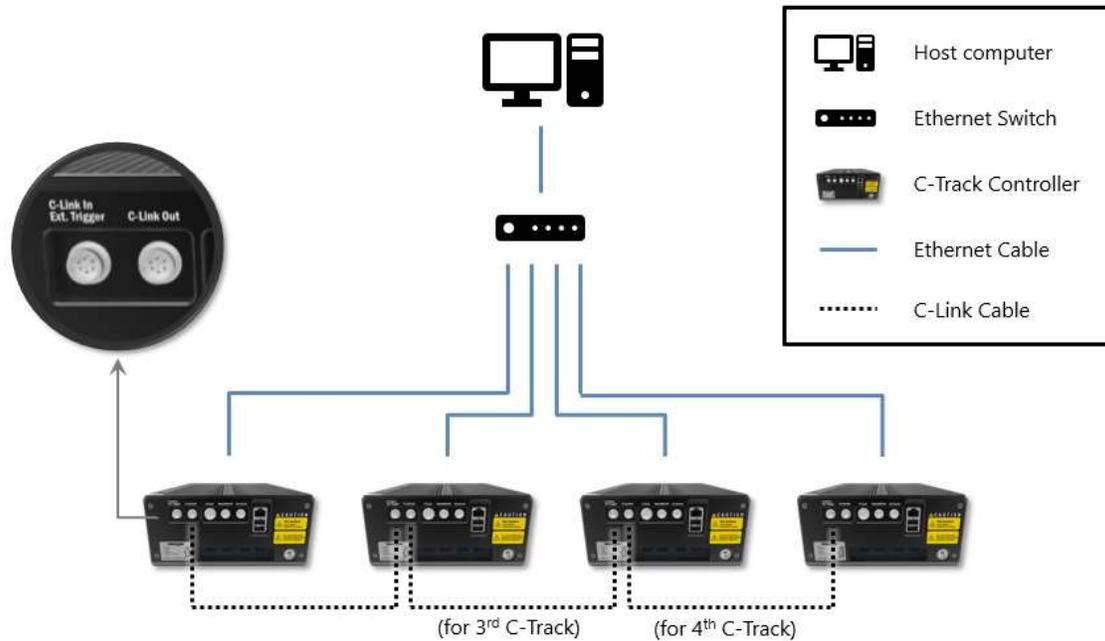


Figure 16 - Connection diagram for C-Link

Mechanical Interface

Do not cover the ventilation holes on the sides of the switch, and make sure there is adequate ventilation around it.

Parameter	Value
Width	98.0
Height	28.0
Length (w/o cables)	100.0
Weight	286g

You may mount the switch on a wall. Two mounting slots are provided on the bottom of the switch for this purpose.

Electrical Interface

The C-Link requires additional power to the Ethernet switch through a provided power supply (1.5m in cable length).

Parameter	Value
Input Voltage	100–240VAC
Input Frequency	50/60Hz
Maximum Current Draw	0.3A

In C-Link application, as shown on connection diagram, every controller must be connected through a C-Link cable. This cable dictates the maximum distance between every controller. The Ethernet cable length will dictate the distance to the Ethernet switch.

The kit is provided with:

- 2 X 10m Ethernet cables
- 2 X 20m Ethernet cables
- 3 X 10m C-Link cables

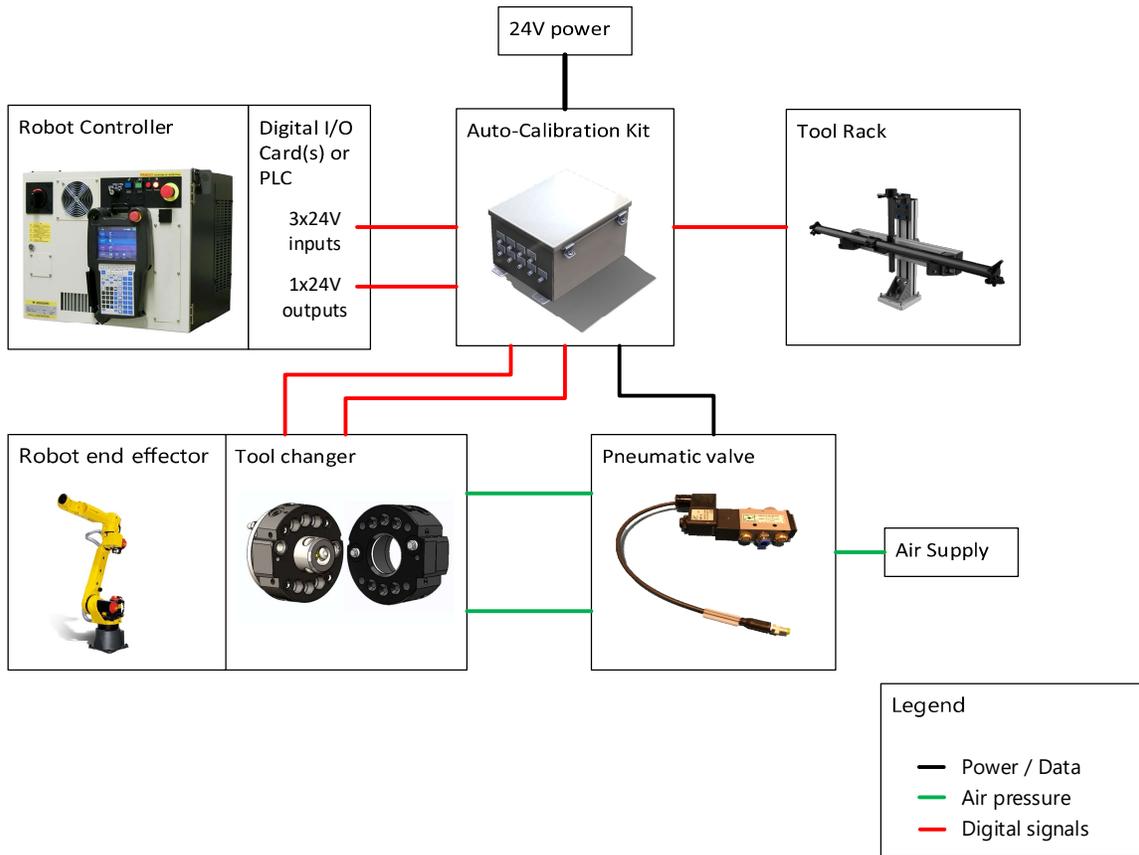
Positioning Model

- Targets must face the C-Track as much as possible. Optimize the incidence angle of the targets to the center of the C-Track body.
- Angles up to 30 degrees are tolerated
- For angles wider than 45 degrees, acquiring the targets cannot be automatic

Double-check the reflectivity of the targets dedicated to the setup and the ones on the calibration bar. Pay attention to dark marks or scratches. Use glass-protected targets whenever possible.

Auto-Calibration kit

The R-Series Auto-Calibration kit allows the C-Track calibration bar to be installed on the end effector bracket and put back in a tool rack at the end of use. It consists of a pneumatic tool changer, tool rack, bar holder, control box and hardware. To actuate the tool changer, a pneumatic valve is provided.



The Auto-Calibration Control Box is used for the protection and safety of equipment only. It allows to prevent unlock command to release the C-Track calibration bar when it is not in the tool rack.

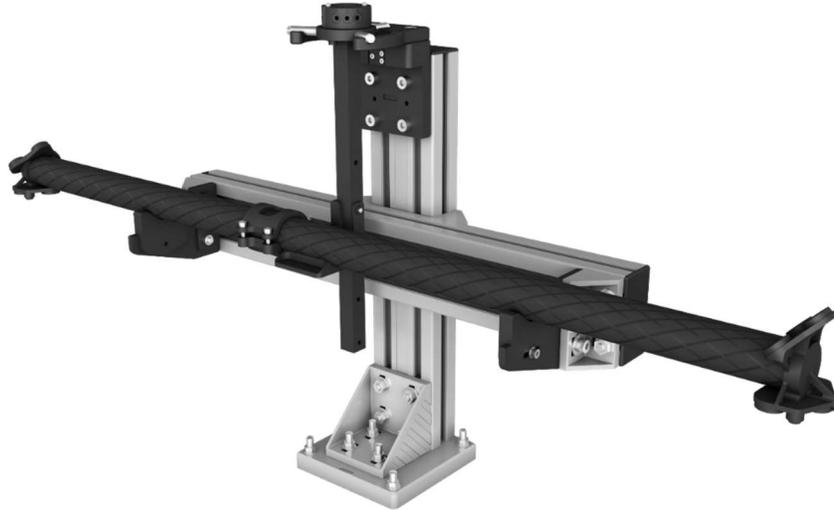


Figure 17 - Tool rack with calibration bar installed

Cell design must account for the following:

- The tool rack must be reachable by the robot with the calibration bar installed on the end-effector. This requires the area around the tool rack to be free of obstructions. Consult with Creafom for simulation assistance and layout validation.
- The tool rack must be installed on a sturdy, vibration-less surface that can withstand the weight of the system with an appropriate safety margin. To ensure adequate actuation of the tool changer, the tool rack position must be stable and repeatable. Doweling the tool rack in-assembly is possible but not provided.
- The tool changer requires air pressure at the end-effector of the robot. Proper operation of the locking mechanism requires a constant supply of clean, dry, nonlubricated air, with the following conditions:
 - Pressure range: 60-100 psi (4.1–6.9 Bar) (0.41–0.69 MPa).
 - Filter minimum: 40 microns.
 - Flow: Negligible
- The tool changer and pneumatic valve uses $\varnothing 4mm$ OD silicone hoses and push-to-connect connectors
- The control box must be powered by an external source provided by the integrator. This power is fed through to the pneumatic valve.

Characteristic	Value
Rated Voltage	24VDC (NEC Class 2)
Current Draw	1A

- The control box must interface with a digital I/O device with the following minimum requirements:

- 24VDC with PNP (Sourcing) polarity logic (NPN not supported)
 - 3 Digital In
 - 1 Digital Out
- The control box comes with terminated cables for all interconnects except for the loose wire end of the signal cables, which is to be connected to the I/O device.

Mechanical Interface

The following information can be used for preliminary layout. Refer to the 3D Model provided with the Integrator Package for more details.

Tool Rack

Parameter	Value
Width	616.0
Width (with bar)	1055.0
Height	505.0
Length	570.0
Weight	~5kg

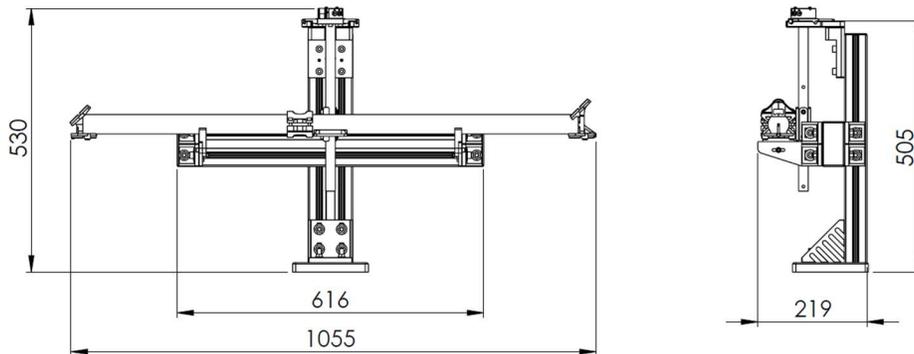


Figure 18 - R-Series Auto-Calibration kit - Bounding box dimensions

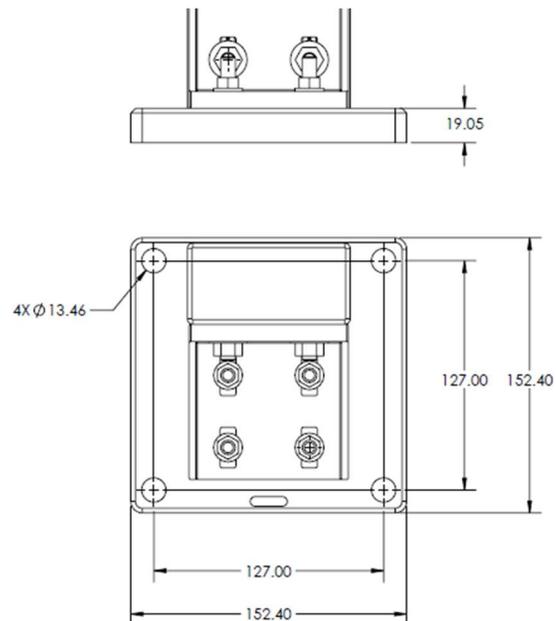


Figure 19 - Tool Rack Installation Drawing

Control box

Parameter	Value
Width	228.0
Height	159.0
Length (w/o cables)	292.0
Weight	~3kg

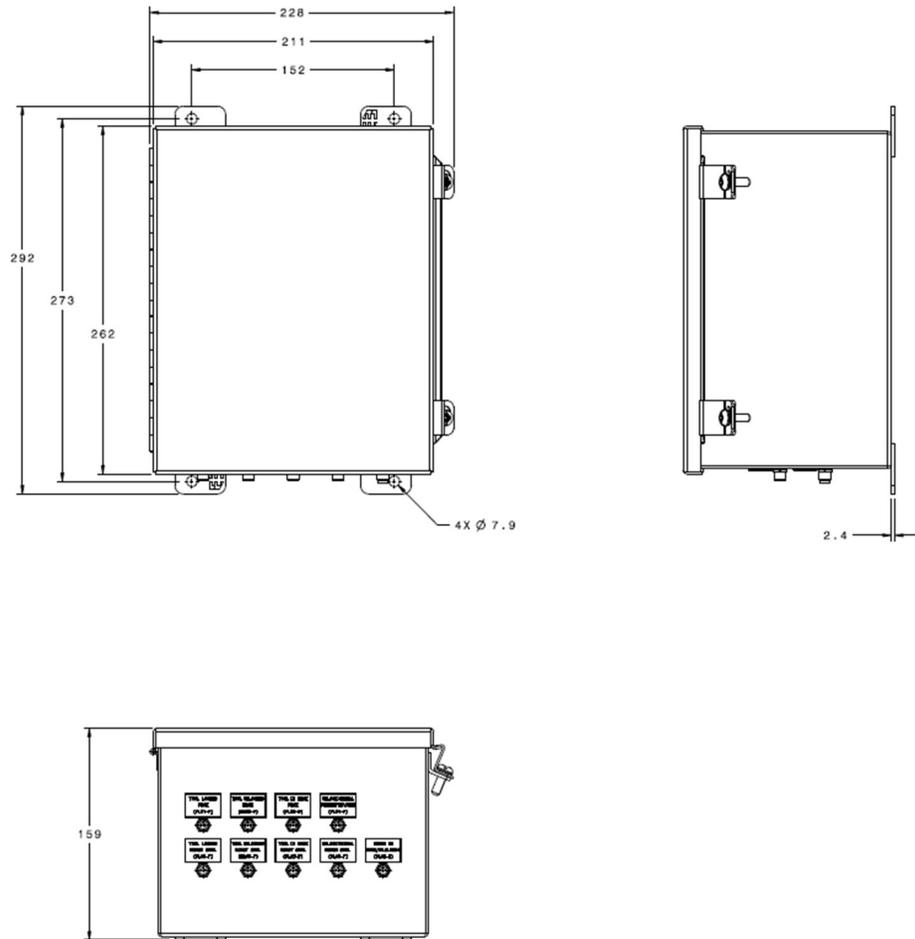


Figure 20 - R-Series Auto-Calibration Kit - Control Box Installation Drawing

Pneumatic Valve

A pneumatic valve is needed to actuate the tool changer. Creaform provides a 5-way/2-positions pneumatic valve compatible with eh electrical cabling provided with the Auto-Calibration Kit. Refer to the Schematics Diagram for details.

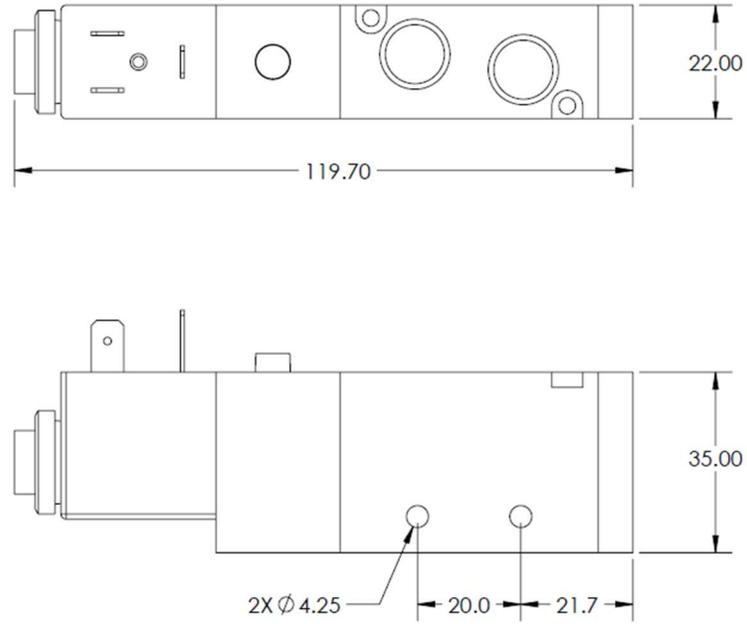


Figure 21 - Tool changer valve - Installation Drawing

R-Series IO Module

Overview

R-Series I/O Module is an input/output communication interface allowing communication between VElements and robot controllers.

Mode of Operation

R-Series I/O Module uses an integer-based messaging system. Communication is handled in a Request-Reply fashion. The robot controller requests an action to be executed by the I/O Module and a reply will be generated to that request. Two communication channels are used, one for Actions and Events and one for Session Configurations. Every action, event and configuration are associated to a unique number.

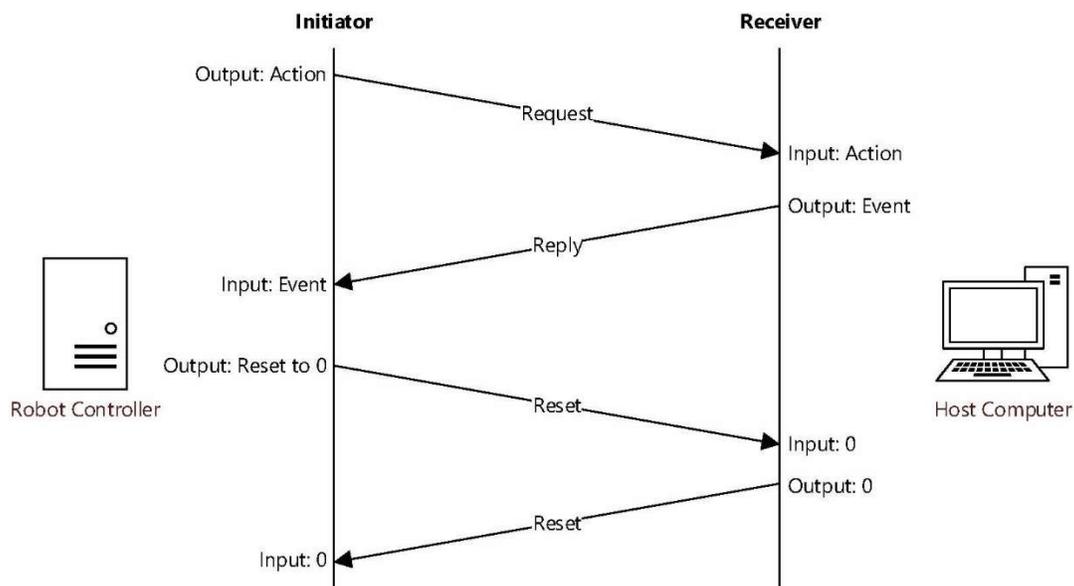
This is done through two communication channels:

- Actions and events
- Session configuration requests and replies

A total of four values are exchanged between the robot controller and R-Series I/O Module:

- An Action message sent from the controller
- An Event message sent to the controller
- A Configuration Change message sent from the controller
- A Configuration Acknowledged message sent to the controller

Communication on one channel is typically handled in the following fashion.



Communication interfaces

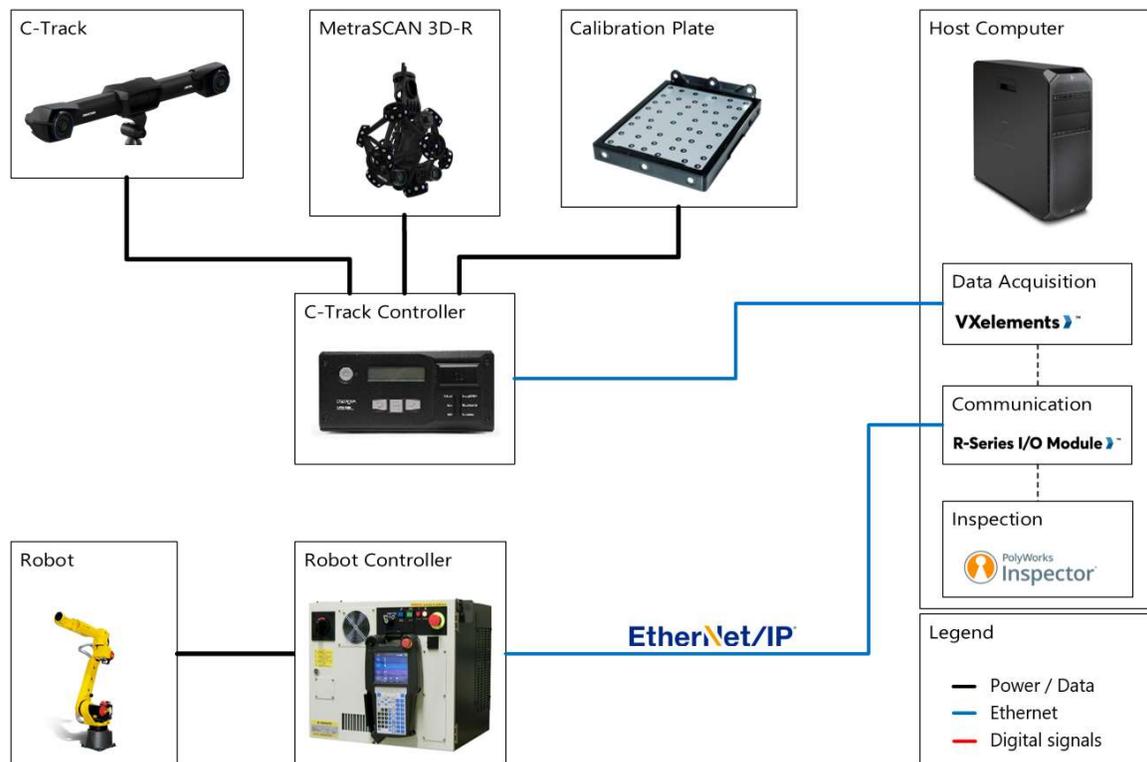
Communication from the host computer is handled using a dedicated network. The computer must have adequate number of Ethernet adapters (ex.: 1 for C-Track communication, 1 for I/O Module communication and optionally 1 for the local area network).

These values can be exchanged with a robot controller using one of the following methods:

- Over the EtherNet/IP™ protocol with supported controllers
- Over electrical digital signals between the R-Series I/O Module Hardware and an Input/Output card connected to a robot controller

EtherNet/IP™

Communication between the host computer and the robot controller is done through the EtherNet/IP™ protocol. Message length can be configured to be either 8 or 16 bits long, allowing to support 255 or 65535 different configurations respectively



This option is available with:

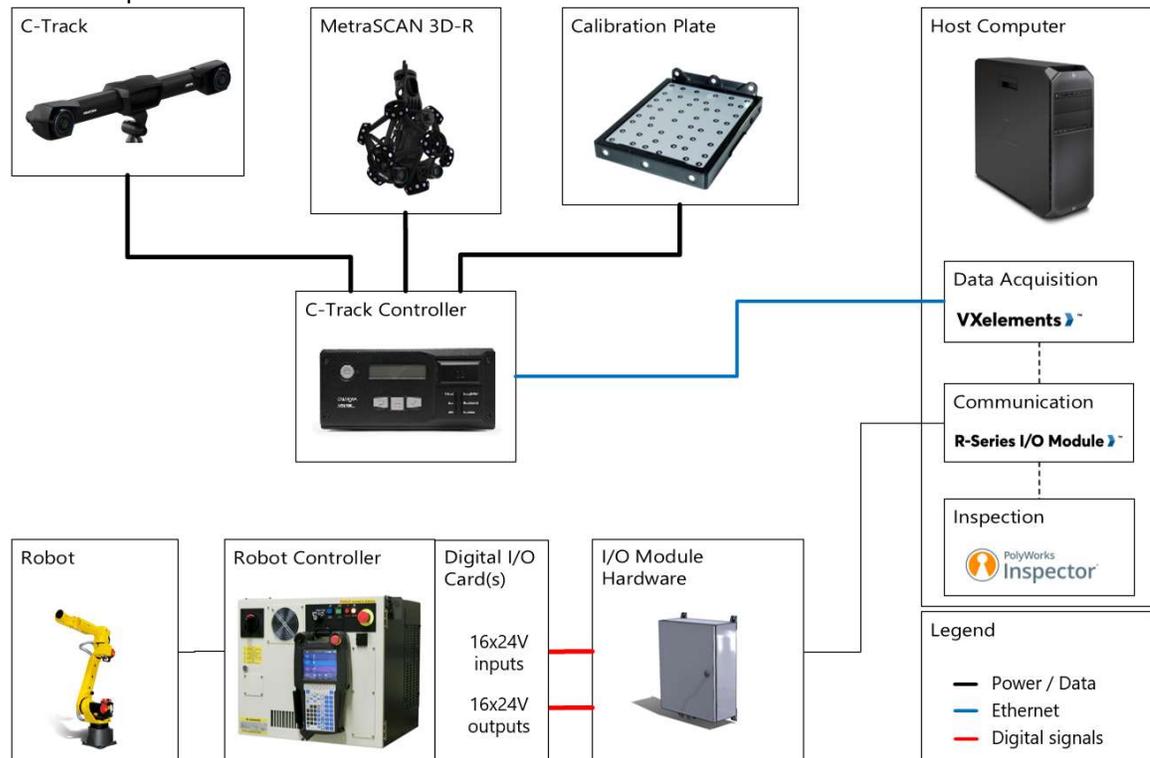
- Fanuc Robots controllers with Ethernet/IP available with the following requirements:

Fanuc controller model	Version
R-30i family (R-30iA, iB and derivatives)	Firmware V7.20+ with: R784 - Ethernet/IP Adapter or R860 - Advanced EIP (EtherNet/IP) Adapter
R-J2, R-J3, R-J3iB	Not supported

- Requires 32 Digital In (DI) and 32 Digital Out (DO) to be available in the configuration. This communication protocol can make use of Grouped Inputs/Outputs (GI, GO)

I/O Module Hardware

Hardware input/output communication box allowing communication between robot controllers or other components. I/O Module Hardware communication is to be used with digital input/outputs cards. It uses parallel communication on an 8 bits channel, allowing to support up to 255 configurations. Translation between bits value and decimal representation is done using binary to decimal unsigned conversion (without two-complement)



The R-Series IO Module can interface to a robot controller or programmable logic controller through digital signals. This option is provided with a physical enclosure

Electrical Interface

The IO Module hardware is powered by a built-in power-supply powered by an external source. Power cable is an IEC 60320 C13/C14 interface terminated with a country-specific AC power plug, 1-meter long.

Characteristic	Value
Rated Voltage	100-240VAC
Frequency	50-60HZ
Maximum Current Draw	< 1.50A

The IO Module hardware is connected to the host computer with a provided 8-meter Ethernet cable.

This option requires a digital I/O signal acquisition hardware. This can be provided through a built-in or add-on card in the robot controller, a remote I/O extension card, or a programmable logic controller (PLC) in direct communication with the robot controller. The configuration and connection of these components is under the integrator responsibility.

This option requires a digital I/O interface (controller side) with the following specification:

Characteristic	Value
Rated Voltage	24VDC
Polarity	PNP (Sourcing) or NPN (Sinking)
Digital In	16 recommended
Digital Out	16 recommended

Using fewer than 16 Digital inputs and outputs will limit the total number of actions possible, possibly impacting the capabilities of the system. A minimum feature set is possible with the following:

- Action and Event: 7 bits (for all available actions)
- Configurations: 1 bit (1 configuration)

This communication protocol can also make use of Grouped Inputs/Outputs (GI, GO) if available on the device, given that the total switching time is known for input to an application parameter.

The enclosure is provided with a 2-meters patch cable and a 16-meters extension. These cables are terminated with industrial connector except the loose wire end of the patch cable, which is to be connected to the I/O card.

Patch Cable (2 meters)



Extension Cable (16 meters)



Mechanical Interface

The physical enclosure must be installed on a sturdy, vibration-less surface that can withstand the weight of the system with an appropriate safety margin.

Cell layout must account for the following:

- The enclosure requires power and must be connected to the host computer with the provided 8-meter ethernet cable to the host computer.
- The enclosure must be connected to the IO card with the provided 2-meter cable.

The following information can be used for preliminary layout. Refer to the 3D Model provided with the Integrator Package for more details.

Parameter	Value
Width	406.0
Height	183.0
Length (w/o cables)	570.0
Weight	~12kg

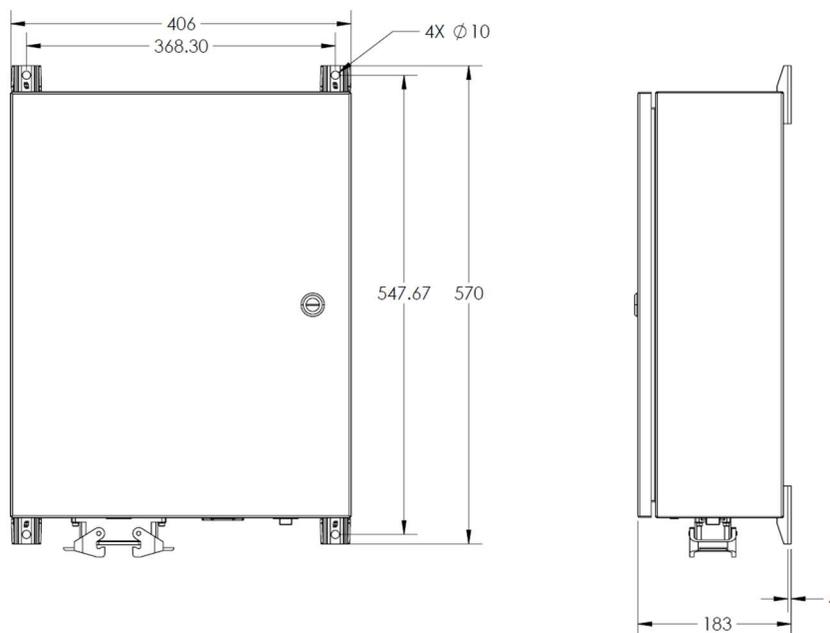


Figure 22 - R-Series IO Module Hardware Installation Drawing

Cabling and tubing

<p>Controller to C-Track tracker</p> <p>One cable w/ 3 connectors 2X USB 3.0 Type A to Type B 1X Power and Sync</p>  <p>4</p>	<p>Controller to MetraSCAN 3D-R scanner</p> <p>Two separate cables 1X USB 3.0 Type A to Type B 1X Power and Sync</p> 
<p>Controller to host computer</p> <p>1X RJ45 Ethernet 8m</p> 	<p>Controller to scanner calibration plate</p> <p>One cable w/ 2 connectors 1X USB 3.0 Type A to Type B 1X Power and Sync</p> 
<p>Controller to AC power</p> <p>1X IEC 60320 C13 cable to power supply brick – Terminated with a country-specific plug</p> 	

Cable Routing

Routing of the cables should account the provided length, the size of the repeater present along the length of some cables and the size of the connectors. No cycling force should be applied to the connectors or any strain-relieved area of the cable. Cables should be tied down

	Length	Minimum clearance hole
Included		
C-Track	16m	Ø40mm
MetraSCAN 3D-R USB 3.0	16m	Ø40mm
MetraSCAN 3D-R Power & Sync	16m	Ø10mm
MetraSCAN Calibration Plate	16m	Ø40mm
Ethernet	8m	Ø20mm
Optional		
R-Series IO Module hardware Digital signals (extension)	16m	N/A
R-Series IO Module hardware Digital signals (patch)	2m	N/A
C-Track Auto-Calibration Kit Digital signals	10m	Ø10mm

Ethernet

The supplied Ethernet cables are industrial-grade and already validated in automated applications. It is recommended to use the provided cables. If the provided cabling is not used, a minimum of CAT 6a grade should be used. Shielded twisted pair cables (FTP or STP) are recommended for industrial application where proximity to equipment may introduce electromagnetic interference. It is not recommended to use UTP (unshielded twisted pair) cabling. Industrial grade cables are recommended².

Robot Dress Pack

A robot dress pack is under the responsibility of the integrator. Cable management should be considered early and often during the design process.

The following considerations applies:

- Dress package should protect all cables and hoses from damage.
- Connection points on J1, J3, and J6 are favored for compatibility with robotic-grade MetraSCAN 3D-R cables and for easy maintenance
- Cables must be routed to allow pose flexibility and allow all necessary movements.
- Cables must be anchored at the end effector

² <http://www.hca.hitachi-cable.com/products/hca/products/premise/industrial/industrial-ethernet-table.php>

- Cable slack should be minimized using feedback or recirculation system.
- The motion of the robot should not stress the dress package

Cable to be routed through dress package to the end effector:

Cable	Conductor Size
Scanner	
MetraSCAN USB cable (robotic)	$\varnothing 13mm$
MetraSCAN Power & Sync cable (robotic)	$\varnothing 13mm$
With Auto-Calibration Kit	
Tool changer proximity switch - Lock	$\varnothing 4.3mm$
Tool changer air supply	$2X \varnothing 4mm$

Data Acquisition Computer

HP Z6 Industrial Computer

Creaform recommends the use of the provided HP Z6 G4 Workstation. This high-performance PC equipped with an Intel® Xeon™ processor and NVIDIA® QUADRO Graphics card is pre-validated by Creaform for compatibility with the MetraSCAN 3D-R.

The case dimensions are 6.65 x 18.3 x 17.5 in; 16.9 x 46.5 x 44.5 cm



The case can be rack-mounted horizontally using brackets (sold separately). It takes up 4U of rack space. It can be mounted in rack-ready servers cabinet compliant with the EIA 310-D Standard.

An optional computer cabinet is available for purchase. The cabinet is an open-design with lockable caster-wheel and is provided without a monitor, keyboard, mouse, and power distribution.

Networking Interfaces

The HP Z6 computer has 3 network interfaces. All adapters have 1000 Mbps capabilities.

Here is a summary of the available Ethernet ports with data rate capabilities :

#	Connection	Device name	Rate capabilities
1	C-Track	Intel Ethernet I210-T1 GbE NIC	10/100/1000 Mbps
2	R-Series IO Module / Robot	Intel Ethernet I219-LM	10/100/1000 Mbps
3	Local Network	Intel Ethernet X722 for 1GbE*	1000 Mbps

**For Intel X722, all adapters and components must have Gigabit 1000BASE capabilities.*

Here is the summary of the usage and the default configuration :

#	Usage	Subnet	Default config as shipped
1	C-Track Controller connection	Fixed	IP : 200.200.200.1 Subnet : 255.255.255.0
2	R-Series I/O Module Hardware or FANUC EtherNet/IP	Configurable	I/O Module HW : 10.XX.XX.XX FANUC EtherNet/IP : 192.168.1.1
3	Plant Network	Configurable Default: DHCP	DHCP

Internal Creaform network: The adapter #1 is reserved for internal use by Creaform for communication between the main computer and C-Track controller(s). No additional components can be added to this network switch. IP addresses of components must not be changed.

For EtherNet/IP configuration: communication with industrial components can connect through adapter #2 to an industrial network switch (integrator-provided). R-Series I/O Module software must be able to communicate through EtherNet/IP directly to the robot controller on this network.

For R-Series I/O Module Hardware configuration: R-Series I/O Module Hardware is connected directly to adapter #2. Communication with industrial components must connect through adapter #2 to an industrial network switch.

For connection to a domain controller: The computer can be added to a Windows domain through adapter #3

Non-Creaform Computer Requirements

For the use of VXelements, here are the recommended minimum requirements in case a Creaform-supplied hardware is not used.

Processor	Intel® Xeon® W Processor <i>Advanced Vector Extensions 2 (AVX2) support mandatory³</i>
Operating System	Windows 10 <i>Only 64 bits operating systems are supported</i>
Graphics Card	NVIDIA Quadro RTX5000, OpenGL 4.5 and higher, CUDA 10 support required (NVIDIA card only)
Memory	64 GB (recommended)
Hard Drive	Solid-state drive (SSD) with at least 1000 GB of free space
Display	1920 X 1080 <i>Higher resolutions not supported</i>
Connecting Ports	3x LAN 1GbE USB3.0

³ Refer to Intel ARK for detail on supported Instruction Set Extensions <https://ark.intel.com/>

Computer Cabinet



Software

The industrial computer is delivered with a tested version of Windows 10. Any Windows update must be validated with Creafom Support to ensure compatibility.

Network settings

The C-Track controller communicates with VXelements on the host computer through an Ethernet connection.

Refer to the User Manual for the TCP/IP settings that must be configured for each network interface card. See <https://support.microsoft.com/en-ca/help/15089/windows-change-tcp-ip-settings> for support.

The provided software will update the license information and get the latest help files through an internet connection to Creafom's website.

For this process to work properly, the computer needs to be able to go through the firewall on TCP ports 80, 443, 1947 and the dynamic port range 49152-65535.

If an external firewall is present, add the following domain to the white list:

- <https://creafom3d.com> (port 443)

EtherNet/IP makes use of TCP port number 44818 for explicit messaging and UDP port number 2222 for implicit messaging

VXscan-R Integration

Creaform offline programming solution must be used in a CUBE-R-like environment. To respect such criteria, a cell must have certain components, and respect a few constraints. These constraints do not apply if you wish to use R-Series I/O Module.

It is the responsibility of the integrator to ensure the robotic cell respects all norms and laws that apply to it. A full safety assessment must be done prior to commissioning.

Creaform suggest the use of the Dual Check Safety function in FANUC robots.

Components

A cell must contain the following components, to which you will need the following information to create the cell layout in VXscan-R.

Creation of the Custom Layout is done in the Edit Layout tool, available through a VXNFR licence. Refer to the VXscan-R Training Script for information on how to use the tool.

1. Robot
 - a. Robot models supported:
 - i. FANUC M-20iA with R-30iB Plus controller version 9.30 or later
 - ii. FANUC M-10iA with R-30iB Plus controller version 9.30 or later
 - b. Home position
 - i. A robot joint position from where all calibrations and scanning programs are going to start and finish.
 - c. Pick and Place robot programs
 - i. Robot programs for the following steps of the different calibration programs.
 1. Pick tool program: Attaching the calibration bar to the tool changer
 2. Place tool program: Removing the calibration bar from the tool changer

1. A robot joint position where the scanner is not visible to the C-Track, used for Automated Photogrammetry and target detection.
6. MetraSCAN-R calibration equipment
 - a. Components and position used for the scanner calibration trajectories.
 - b. Required information:
 - i. Pose of the calibration plate's reference frame in relation to the robot frame
 - ii. Model for collision of the deployed calibration equipment
 - iii. Position of model in relation to the robot frame
 - iv. Rotary table angle position during calibration

Design Constraints

Certain design choices must be respected to allow a custom cell to be compatible with VXscan-R.

1. Automated calibrations are required.
 - a. Automated calibrations can be done with a Manual tool changer or a Pneumatic tool changer.
 - b. VXscan-R does not support manual calibrations
2. All components must be fixed in space
 - a. All poses input in the components must remain true overtime
 - ie. Robot or C-Track cannot be installed on a linear axis
 - ie. Center of rotation of the rotary table must remain the same
3. Must use a MetraSCAN-R Black|Elite or a MetraSCAN-R Black|Elite HD scanner
 - a. This in turns requires a computer that supports these Creaform scanners. Such as the Creaform provided HP Z6 Workstation.
 - b. The calibration bar must be setup with the following TCP on the bar holder:
 - X. 370 mm
 - Y. -50 mm
 - Z. 50 mm

Robot & Robot Controller Constraints

The robot and robot controller are also subjected to limitations towards how they can be used and integrated to VXscan-R. These limitations are separated into two different groups:

Robot Purchase Limitations

These options/configurations must be purchased from FANUC:

1. M-20iA Robot
 - a. Standard wrist flange
 - b. Standard J1 370 degrees range
 - c. Hollow-wrist configuration
 - i. With Material Handling Conduit from J3 to J6 option
 - d. KAREL option
 - i. Part No. RTL-R632
 - e. User Socket Messaging option
 - i. Part No. RTL-R648
 - f. Motion Package option
 - i. Part No. RTL-R809
 - ii. Minimal components of the option are:
 1. Constant Path option
 2. ADV-CP Speed Control option
 3. ADV-CP Path Control option
2. M-10iA Robot
 - a. Standard Arm length configuration
 - b. Hollow-wrist configuration
 - i. With Material Handling Conduit from J3 to J6
 - c. KAREL option
 - i. Part No. RTL-R632
 - d. User Socket Messaging option
 - i. Part No. RTL-R648
 - e. Motion Package option
 - i. Part No. RTL-R809
 - ii. Minimal components of the option are:
 1. Constant Path option
 2. ADV-CP Speed Control option
 3. ADV-CP Path Control option
3. Rotary table (Optional)
 - a. A rotary table is not mandatory, but can be setup

No additional cable sleeve or tools can be installed on the robot. The collision envelope used by VXscan-R cannot be edited, hence even if you design a DCS to avoid additional collisions, VXscan-R could create trajectories that will trigger errors when the robot enters DCS zones.

Robot Controller Setup Limitations

These parameters apply to both the M10iA and M20iA.

1. Must not interfere with the different reserved registers used by VXscan-R

PARAMETERS	DETAILS
DATA REGISTERS (R)	
R[34-39]	Registers used to manage the UFRAME of the calibration plate
R[44-49]	Registers used to manage the UTOOL of the calibrated TCP
R[43]	Register used to store the actual override value
POSITION REGISTERS (PR)	
PR[1]	Used to define UTOOLS and UFRAMES
STRING REGISTERS (SR)	
SR[10-11]	String registers used by VXscan-R
FLAGS (F)	
F[60]	Flag used by VXscan-R
F[100]	Asset Protection State Flag – Scalebar on robot
F[101]	Asset Protection State Flag – Calibration plate installed
F[102]	Asset Protection State Flag – Can calibrate C-Track
F[103]	Asset Protection State Flag – Can calibrate scanner
F[104]	Asset Protection State Flag – Can move robot
F[105-110]	Reserved/Not currently used
USER ALARMS (UALRM)*	
UALRM[1]	Will display “Tool rack signal mismatch” in VXscan-R
UALRM[2]	Will display “Unlock request signal mismatch” in VXscan-R
UALRM[3]	Will display “Unlocked signal mismatch” in VXscan-R
UALRM[4]	Will display “Locked signal mismatch” in VXscan-R
UALRM[5]	Will display “Tool rack signal mismatch” in VXscan-R
UALRM[6]	Will display “Arm stowed signal mismatch” in VXscan-R
UALRM[7]	Will display “Arm deployed signal mismatch” in VXscan-R
UALRM[8]	Will display “Air pressure signal mismatch” in VXscan-R
UALRM[9]	Will display “Communication port signal mismatch” in VXscan-R
UALRM[10]	Will display “Robot joints mismatch” in VXscan-R
FRAMES RESERVED	

UTOOL 1, 3 & 4	Reserved for Scanner calibration
UFRAME 2 & 4	Reserved for C-Track calibration

2. Axis limits must allow the following range of motion, at minimum:
 - a. J1: -170 @ 170
 - b. J2: -100 @ 160
 - c. J3: -185 @ 273.12
 - d. J4: -200 @ 200
 - e. J5: -120 @ 120
 - f. J6: -270 @ 270
 - g. J7: -370 @ 370
3. Rotary table (Optional)
 - a. Must be included within the same group as the first 6 axis of the robot on the controller.
 - b. Must be setup for clockwise rotations
4. Communication must be setup properly:
 - a. Setup Server
 - i. S4 and S5 tags
 1. Protocol: SM
 2. Current state: Started
 3. Startup state: Start
 - ii. One extra tag (does not matter which, default is S1)
 1. Protocol: FTP
 2. Current state: Started
 3. Startup state: Start
 - b. HTTP Setup
 - i. KAREL must be UNLOCKED
 - ii. KCL must be UNLOCKED
5. Payloads must be setup according to the solution selected

PAYLOADS	
PAYLOAD 1	Scanner only
PAYLOAD 2	Scanner + calibration bar

- a. Refer to the User Manual "Robot Tool Load and Setup" section for more details on the values to input
6. Asset Protection State flags must be programmed properly and must be accessible at all time to the software

- a. This only applies when buying the Creaform Asset Protection option.
 - b. See the "State Flags" section for more details
7. CubeRConfig.XML Files
- a. The Signature file is important to the functioning and commissioning of a cell running in VXscan-R
 - i. The appropriate original file will need to be copied to the FR: disk of the controller.
 1. Auto or Manual, depends on the tool changer of the scanner.
 - ii. Make sure to remove any prefix or suffix from the file title, to ensure it is exactly: "CubeRConfig.XML"
 - b. Refer to the VXscan-R Training Script for more information on the commissioning tool *Calibrate CUBE-R*.

Robot Programs

Most of the robot programs and robot controller parameters that VXscan-R needs are pushed automatically by the software upon connection to the robot. There are 4 robot programs that are not generated by VXscan-R and needs to be programmed by the integrator prior to commissioning of the cell.

- Pick tool program
 - The robot program that will attach the C-Track calibration bar to the tool changer of the scanner.
 - Must start and finish at the Home position.
- Place tool program
 - The robot program that will remove the C-Track calibration bar to the tool changer of the scanner.
 - Must start and finish at the Home position.
- Install plate program
 - The robot program that will position the scanner calibration plate in front of the C-Track for scanner calibration.
 - Must start and finish at the Home position.
- Remove plate program
 - The robot program that will remove the scanner calibration plate from the C-Track field of view after the scanner calibration.
 - Must start and finish at the Home position.

State Flags

The State Flags are used by VXscan-R's Asset Protection to understand if certain actions can be performed at any given time, or to modify the behavior of VXscan-R to certain situations. They must respect a certain logic and must be available at all time.

This does not apply to a cell without the Asset Protection option.

The standard CUBE-R flags are used as examples, but it is the integrator's responsibility to design a cell with proper safety logics.

The five flags used by the software are the following:

- Flag 100: Scalebar on the robot
- Flag 101: Calibration plate installed
- Flag 102: C-Track calibration can be started
- Flag 103: MetraSCAN-R calibration can be started
- Flag 104: Robot can move

Flag 100 – Scalebar on the robot

This flag is normally OFF except when the C-Track's scalebar is attached to the tool changer of the scanner. When this flag is ON it will be impossible to start a scan program. If requested to, the software will ask the user if the bar should be dropped in the tool rack first and proceed to do so with the "Place tool program" if accepted.

For a standard CUBE-R, the logic is as follow:

$$\text{BarOnRobot} = \text{ToolLocked AND !ToolUnlocked AND !ToolInRack}$$

Flag 101 – Calibration plate installed

This flag is normally OFF except when the calibration plate is deployed for scanner calibration. When this flag is ON it will be impossible to start a scan program. If requested to, the software will ask the user if the plate should be stored and proceed to do so with the "Remove plate program" if accepted.

For a standard CUBE-R, the logic is as follow:

$$\text{PlateInstalled} = \text{ArmDeployed AND !ArmStowed}$$

Flag 102 – C-Track calibration can be started

This flag must be ON to start the C-Track calibration process (Tool pickup included). It is only checked by the software for the C-Track calibration process, and nowhere else.

For a standard CUBE-R, the logic is as follow:

$$CanCalibCtrack = AirPressureOk$$

Flag 103 – MetraSCAN-R calibration can be started

This flag must be ON to start the scanner calibration process (Plate deployment included). It is only checked by the software for the MetraSCAN-R calibration process, and nowhere else.

For a standard CUBE-R, there are no prerequisite conditions to this flag:

$$CanCalibScanner = TRUE$$

Flag 104 – Robot can move

This flag must be ON to enable any robot movement. This applies to all possible robot requests (starting calibrations, starting a scan program, requesting a "Go Home").

For a standard CUBE-R, the flag is always ON unless one of the following incongruities happen:

1. Proximity switches on the Tool Rack and Tool Changer's Locked position have identical values (ON-ON or OFF-OFF)
2. Proximity switches for the "Deployed" and "Stored" position on the swing arm of the plate have identical values (ON-ON or OFF-OFF)
3. The Tool Changer returns Locked and Unlocked at the same time

$$CanMove =$$

$$!(ArmStowed == ArmDeployed) AND !(ToolInRack == ToolLocked) AND !(ToolLocked AND ToolUnlocked)$$

Computer Setup

The computer that will operate the CUBE-R with VXscan-R needs to, at least, provide the minimum requirement as described in the MetraSCAN-R Black User Manual. It strongly recommended to purchase the Creaform supported Z6 Industrial Computer, for maximal compatibility and easier troubleshooting from our Support team.

The minimal and recommended system specifications are:

Component	Minimal	Recommended (Z6)
Processor	Intel Core™ i7 (6+ cores) – 2.6GHz or more	Intel Xeon™ W-3245 Processor 3.2 GHz

Operating System	Windows 10 (64-bit)	Windows 10 Pro for Workstation 64
Graphics Card	NVIDIA Quadro RTX 5000, OpenGL 4.5 and higher	NVIDIA Quadro RTX 5000 (16GB)
Memory	64 GB	96 GB
Hard Drive	Solid-state drive (SSD) with at least 200GB of free space	<ul style="list-style-type: none"> • HP Z Turbo Drive M.2 1 TB TLC 2nd SSD • HP Z Turbo Drive M.2 256 GB TLC SSD
Connecting Ports	USB 3.0 & Ethernet	<ul style="list-style-type: none"> • Ethernet I210-T1 GbE NIC (C-Track) • Intel Ethernet I219-LM (Robot) • Intel Ethernet X722 for 1GbE (local network) 4x USB 3.0
Display Output	1920 x 1080	4x DisplayPort (mDP 1.4) + 1x USB-C

VXscan-R also requires the custom layout of the cell to be setup on the computer that will run the CUBE-R.

- Refer yourself to the VXscan-R Training Script for more information on the creation and usage of a *.CUBER custom layout file with the *Edit Layout* tool.