EVA – Safety Manual

Version 4.0.0 - November 2020

IMPORTANT

Before attempting to set up or operate the robot:

1. Familiarise yourself with the safety instructions contained within this manual
2. Conduct a full risk assessment

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A. Overview

On its own, Eva is considered **partly completed machinery** and is supplied with a Declaration of Incorporation (DOI). The robot is essentially a component part of your application (i.e. the completed machine). Why? Like most industrial robots, Eva can be used in a wide range of applications. What might be considered safe for one machine, may not be safe for another. The way that you set up and use the robot and any other associated equipment will determine whether it meets all the Essential Health and Safety Requirements (EHSR) and any other mandatory requirements of the intended country or region.

Before you put the robot to work, ensure you have:

1. Read all safety instructions (this manual) and familiarised yourself with how the robot works (see **Technical Reference Manual**).
2. Conducted a risk assessment, covering the robot and any associated equipment (see **Section B – Risk Assessment** in this manual).
3. Installed all equipment in accordance with the manufacturer's instructions, applicable standards and safety and compliance requirements for your region.
4. Made instructions available for operating and maintaining the completed machine.
5. Made safety information available to the end user (e.g. manuals, warning/caution signs, training, etc.)
6. Completed functional checks on any safety equipment (e.g. emergency stops).
7. Completed a technical file and a relevant Declaration of Conformity for your installation.
8. Marked the machine with the relevant compliance makings and other mandatory information (e.g. CE mark, name of manufacturer, machine name and type, etc.).

It is *never* acceptable to use Eva when:

1. There is a risk of explosion.
2. The work being done is medical, life critical or life threatening.
3. The robot will be part of a system that elevates or transports people.
4. A full risk assessment has not been completed.
5. The performance ratings required are higher than those in the robot's documentation (see **Technical Reference Manual**).
6. The hazards require faster safety function reaction times than the robot is capable of (see **Section C – Protective Features** in this manual).

Whilst every effort has been made to highlight the hazards associated with the robot, there may be additional risks arising from the application, how the robot has been installed, and how it is used. It is essential that a full risk assessment is conducted to identify these risks before putting the robot to work. The information in this manual must not be construed as a warranty from Automata.

For more information on the EU Directives Eva conforms to and the standards that have been applied refer to the CE Declaration of Incorporation (DOI) supplied with the robot. A separate DOI has also been provided for UKCA. If you require a new copy of either DOI please contact Automata.

B. Risk Assessment

You must complete a risk assessment every time you change the robot's environment or the work it will do.

Performing a risk assessment is about identifying and documenting the risks associated with your application as well as the measures you have used to reduce those risks to acceptable levels. It's important to think about every part of the application and the environment, like obstacles, tools and other machinery in the area. As well as risks arising during operation, the risk assessment should also consider hazards associated with commissioning, decommissioning and maintenance activities.

ISO 10218-2 provides a comprehensive set of guidelines on how to achieve a safe integration for robotic applications. Annex A of this standard contains a good overview of the types of hazards you may encounter and can be used as the basis for risk assessment. For other machinery **ISO 12100** provides more general guidance. Alternatively, ask a safety professional for help.

Once the risk assessment is complete you must decide if the risks are **acceptable** before you let anyone work with the robot. If there are hazards, consider how easy it is for humans to access the dangerous area, and restrict this access or provide clear warnings. If there's any information or equipment that could reduce the danger, make sure it's easy to find.

Example Risks

Some hazards are very common with robots, for example:

1. Trapping fingers between robot joints, including a risk of pinching or crushing if the robot collides with itself
2. Cutting or piercing skin with sharp edges and points
3. Bruising from impact when the robot is moving
4. Sprains or bone fractures from being caught between a heavy payload and a hard surface
5. Power failure, poor grip or loose bolts causing equipment to fall or move in unexpected ways
6. Injuries or equipment damage because the emergency stop button is out of reach
7. Disorientation, inability to communicate effectively or recognise hazards due to poor lighting or noisy environment

Recommended Control Measures

The following control measures may be used to reduce the level of risk:

1. Conduct a risk assessment of the final machine and intended use case
2. Perform visual checks and/or proof tests upon commissioning the final machine
3. Perform visual checks and/or proof tests at predefined maintenance intervals
4. Ensure the brake release tool remains with the robot or in a secure, accessible location at all times
5. Ensure machine operators are outside the operating space of the robot whenever possible, except for maintenance or teaching operations when the robot is placed into teach mode
6. Staff involved in the commissioning or decommissioning of the installation should have been given appropriate training and information to allow them to conduct the work as safely as possible. This should cover handling and lifting techniques,

general tool use, and access to the risk assessment as a minimum. Appropriate Personal Protective Equipment (PPE) must also be provided

7. Machine operators should be appropriately trained or supervised by a trained individual following risk assessment. Appropriate PPE must also be provided
8. Care should be taken with loose items placed on the work surface to prevent knocking by operators or during robot movement
9. Where possible, the number of fixed items in the path of the robot's operating space should be kept to a minimum
10. The installation shall be positioned in such a way that an operator is not prevented from escaping the operating space of the robot (e.g. moving robot between operator and exit)
11. Machine controls/displays/indicators should be appropriately positioned for ease of access/visibility by operators
12. Ensure sufficient lighting around the integration. Particularly around the robot's movement envelope, emergency stop devices and other potential hazards
13. Trailing cables or other obstacles at ground level should be tied back, moved or covered to prevent trips or falls
14. Ensure the Emergency Stop Button is within easy reach of the operator at all times. Multiple emergency stop devices may be necessary to achieve this. Fixing the device(s) in place should also be considered to prevent them from moving out of reach.
15. Loose hair or clothing should be tied back or removed before approaching the robot
16. Spillable liquids should be kept away from the operating space at all times, unless related to the use case
17. Reduce sharp/angular edges on the end effector and other parts of the integration environment wherever possible
18. Appropriate fixings and mechanical assemblies should be specified to withstand the expected forces during use. Along with suitable tightening torques or thread locking techniques where appropriate
19. The exclusion zone should be sufficient in size to minimise the

risk of injury as a result of projectiles (e.g. end effector coming loose, objects under manipulation being thrown, etc.)

20. The surface on which the robot is placed and the positioning of the robot should be appropriately specified to ensure the stability of the equipment at all times under expected use conditions
21. Thought must be given to the ergonomics of any manual operations, such as backdriving the robot during teaching, to prevent overstretching in order to reach controls or reaching desired positions
22. Only the power supply provided shall be used to power the robot
23. The equipment should only be installed and used within the specifications stated in the user manual
24. Noise levels within the operating area should be kept to a safe minimum where possible, in order to reduce the likelihood of damage to hearing and to maintain an awareness of the environment. Ear protection should be considered where this is unavoidable
25. Limit access to machine controls where possible (e.g. use of passwords, physical locks, etc.)

Human Robot Collaboration

There has been a rising trend of small industrial robots classified as "**cobots**". But what does this mean? And can I use Eva for collaborative operations?

Generally speaking, cobots are industrial robots designed to work safely with humans. To achieve this, they will usually employ some of the collaborative techniques described within **ISO/TS 15066**. It's important to note that this is only a **technical specification**, not a fully fledged standard. Whilst it may indicate best practice, it is certainly not mandatory to follow all the requirements within.

However, there's more to creating a collaborative application than simply selecting a cobot. Whether or not the application is safe for human robot collaboration is as much about the **hazards created by the application and the environment** than it is about the robot and the safety features it has to offer. If you were to attach a hazardous payload to the end of the robot, would it still be considered a collaborative application? Probably not. For any robotic application, cobot or not, a risk assessment must be conducted to ensure the risks are identified and reduced to as low as reasonably practicable.

So, can we consider Eva as a cobot? . . . It depends on your application and the features you have deemed necessary for risk reduction.

Of the 4 collaborative techniques described within ISO/TS 15066, Eva employs the **hand guiding** technique (we call this **backdriving**). This can be considered as collaborative operation if the guidance provided in this and other manuals have been followed and a risk assessment covering this activity has been conducted.

NOTE: Eva does not provide safety-rated speed monitoring or a 3 position enabling device as recommended by ISO/TS 15066 for hand guiding operations. The severity and probability of injury has been deemed to be negligible for the majority of applications. A 3 position device may be fitted to the robot in addition to the emergency stop device if deemed necessary for the application.

NOTE: Eva does not provide Power and Force Limiting as described in ISO/TS 15066.

It may be possible to operate the robot around people as a collaborative operation. This will depend on the outcome of your risk assessment. If however, you have determined that other collaborative techniques are necessary to render your collaborative operation safe, then you may need to consider other options:

- Can you integrate third party sensors (e.g. light curtains, interlocks, physical barriers, etc.) to reduce the risk?
- Can you reduce the speed of the robot or remove any hazards?
- Do you **need** the application to be collaborative or will separation suffice?

For further advice on human robot collaboration refer to ISO/TS 15066 or consult a safety professional with experience in this area.

C. Protective Features

Emergency Stop

Eva is supplied with a **Stop Category 0** emergency interface and emergency stop button. Immediately after the emergency stop has been triggered, electrical power to the robot actuators, base I/O and tool I/O is cut and the brakes in each joint are engaged, resulting in a sudden stop. This is likely to result in one or more of the robot joints dropping slightly due to the force of gravity. Be aware of the risk of collision or pinching. When using the I/O, take care that an interruption of power does not create any hazards, such as objects being dropped from grippers.

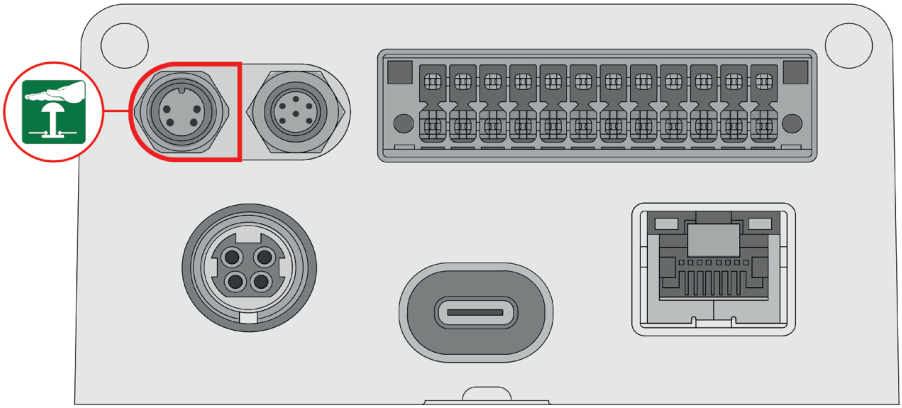
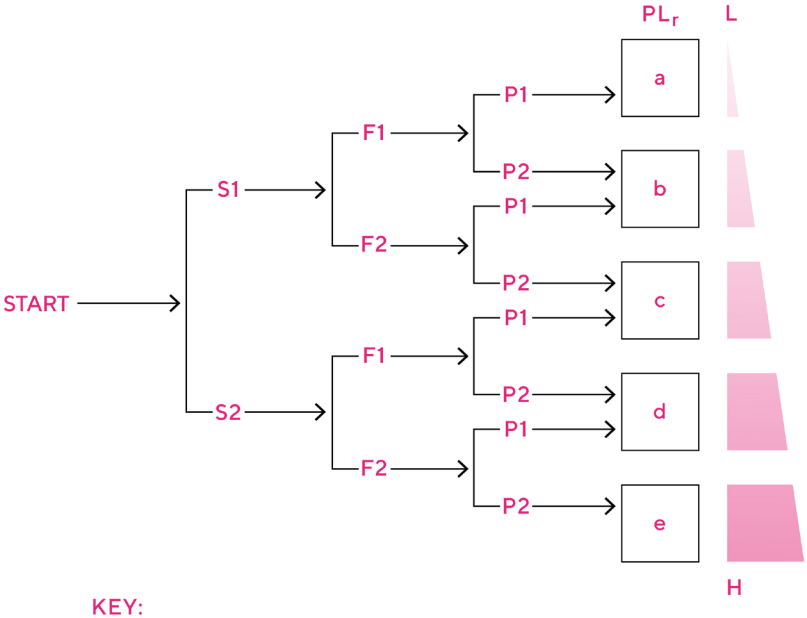


Diagram of emergency stop port location on base

The emergency stop is rated to **PLc, Structure Category 1** as per ISO 13849.

This performance level was deemed to be adequate for the majority of expected applications. To determine whether PLc is appropriate for your use case, we recommend conducting a simple risk assessment as illustrated in the diagram below (taken from ISO 13849-1, Annex A)



KEY:

- L Low contribution to risk reduction
- H High contribution to risk reduction
- PL_r Required performance level

RISK PARAMETERS:

- S **Severity of injury**
- S1 Slight (normally reversible injury)
- S2 Serious (normally irreversible injury or death)
- F **Frequency and/or exposure to hazard**
- F1 Seldom-to-less-often and/or exposure time is short
- F2 Frequent-to-continuous and/or exposure time is long
- P **Possibility of avoiding hazard or limiting harm**
- P1 Possible under specific conditions
- P2 Scarcely possible

Graph for determining required PLr for a safety function

If a performance level higher than PLc is deemed necessary for a particular application, we recommend placing the contacts of a safety relay or controller in-line with the robot's supply to cut the power in the event of an emergency. Care must be taken to ensure that there is no confusion between the emergency stop circuit native to the robot (rated to PLc) and the new emergency stop circuit that has been placed in line with the supply (rated >PLc).

Under worst case conditions (i.e. maximum speed and payload), Axis 1 could travel 12° over 0.25 seconds, Axis 2 could travel 44° over 0.59 seconds, and Axis 3 could travel 35.4° over 0.57 seconds, before a complete stop is achieved. It is recommended that tests to determine the actual stopping time and distance are performed on each use case, as these are likely to less than the worst case results detailed in this manual.

Ensure that any hazards or faults that caused the stop have been controlled or eliminated before disengaging the emergency stop button and restarting the robot. Disengaging the emergency stop will not restart motion until commanded to do so in Choreograph.

It's never acceptable to operate the robot without a connected emergency stop button.

It's recommended to use the button supplied with the robot. This must only be replaced with an appropriate emergency stop device, conforming to **IEC 60947-5-5**. Never connect an emergency stop device to any input other than the dedicated emergency stop input.

If the robot's on-board diagnostics detects a fault during operation it will immediately halt all movement, similar to an emergency stop. However, this is not safety rated. Neither is this classified as a category 0 stop, as power will remain present at the robot's actuators.

The emergency stop button is intended for halting robot movement in an **emergency only**. Over use of the emergency stop - particularly when the robot is moving - is likely to significantly reduce the life of the robot actuators leading to **premature failure**. Follow the shut down procedures in the **Technical Reference Manual** for further guidance.

Connector and pinout information for the emergency stop port can be found in the **Technical Reference Manual**.

Protective Stop

Eva is also supplied with a **Stop Category 0** protective interface and loopback connector. This operates in the same way as the emergency stop function, but is intended for everyday use, rather than only for emergency situations. The loopback connector must be connected whenever the port is not in use, in order to complete both channels of the protective stop safety circuits.

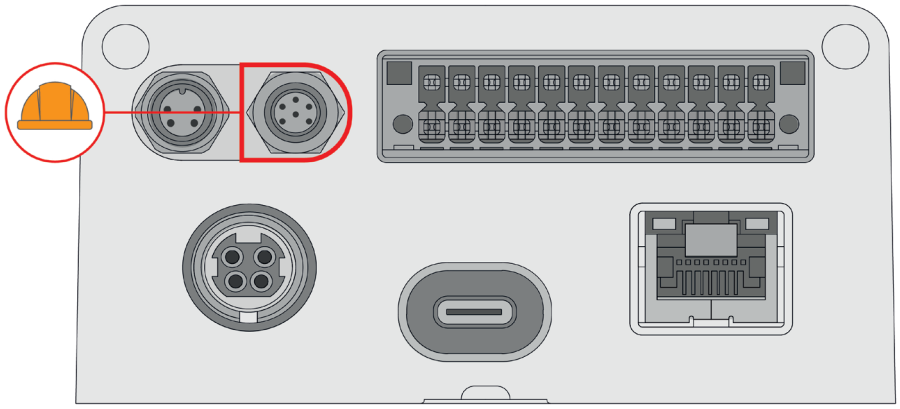


Diagram of protective stop port location on base

The protective stop is rated to **PLc, Structure Category 1** as per ISO 13849.

This performance level was deemed to be adequate for the majority of expected applications. To determine whether PLc is appropriate for your use case, refer to the diagram under the emergency stop description.

The protective stop port is intended to interface with volt-free contacts, such as a switch, interlock or a safety-relay. The port is not yet compatible with Output Signal Switching Devices (OSSD). However, this should be possible following a software update in the near future.

Connector and pinout information for the protective stop port can be found in the **Technical Reference Manual**.

Other Stop Functions

Eva does not have any internal protective stop features. The following stop conditions are **not safety-rated**, but do provide some level of protection for general use. A description of their functionality is given below:

- Releasing the backdriving button whilst performing hand guiding operations will not cut the power from the robot actuators or engage the brakes. A stationary position is maintained by the servo controller.
- Internal errors will command the robot actuators to stop and engage the brakes immediately. However, power will remain at the robot actuators.
- Pausing the robot using Choreograph or via the API will command the servo controller to maintain its current position. The actuator power will not be cut and the brakes will not be engaged.

Manual Brake Release

As long as no power is being supplied to the robot actuators, the brakes will be engaged automatically. However, in some emergency situations it may be necessary to move the robot joints without power. This can be achieved using the manual brake release tool.

NOTE: A manual brake release can only be performed on axes 2, 3 and 5.

To move the joints without power:

1. Disconnect all source of power from the robot. In some cases it may be appropriate to unscrew the base from its work surface and lay the robot down in a horizontal position.
2. Identify which joint needs to be moved, and push the brake release tool through the pin hole on the joint to disengage the appropriate brakes.
3. Keep the robot supported as you adjust the joint to a suitable position. Be mindful of the weight of the higher joints.

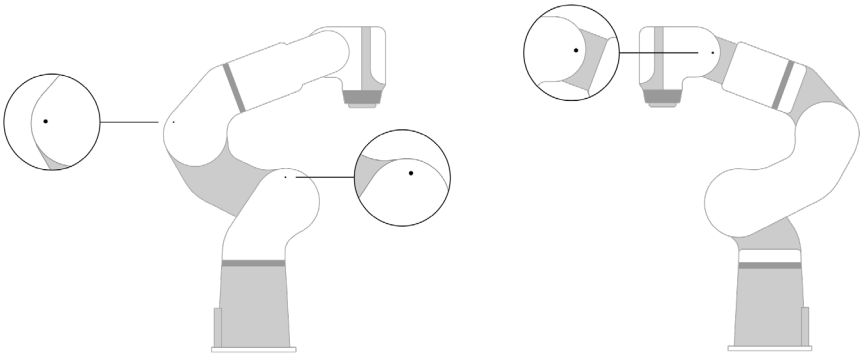


Diagram of brake release mechanism

Personnel should be trained on responding to abnormal situations, including being able to locate and identify the brake release tool and the brake release pin hole, as well as understanding the necessity of supporting the higher joints when brakes are released.

Operating Modes

Teach Mode

Teach mode is to be used for manual operations, such as setting and testing toolpaths. When in teach mode, the TCP speed is limited to **250 mm/s**. Toolpaths with a TCP speed higher than 250 mm/s will be capped when run in teach mode.

Backdriving is only possible when the robot is in teach mode, the lock is obtained and the backdriving button is held down. In order to maintain the lock, Choreograph must remain within the active tab of the browser.

Automatic Mode

Automatic mode is intended for normal operation once the toolpath has been set. The **TCP speed will not be limited** in this mode. The lock in Choreograph does not need to be maintained once the toolpath has started.

Loss of Communication

If communication between the robot and the computer controlling it is interrupted for more than **5-6 seconds**, the robot will enter a special mode. Choreograph must also remain within the active tab in the browser to prevent this mode from being triggered.

If the robot was running a toolpath or backdriving in **teach mode** before communication was lost, all power is cut from the robot actuators, halting movement and engaging the brakes. When communication is re-established, a reset must be performed in Choreograph before any operation can continue.

If the robot was running a toolpath in **automatic mode** before communication was lost, the toolpath will be allowed to continue. During the interruption, the loss of communication will be indicated in Choreograph. No action is required to continue operation once communication is re-established in automatic mode.

More information on robot operating modes can be found in the **Technical Reference Manual**.

Speed Limits

The robot's tool centre point (TCP) can reach a maximum speed of 1500 mm/second. For manual operations (humans nearby), it is recommended that the TCP speed does not exceed 250 mm/s.

NOTE: All toolpaths are limited to a maximum TCP speed of 250 mm/s when the robot is in "teach" mode

Any safeguards (guards, interlocks, etc) that are disabled during setup or maintenance must be restored to full functionality before executing hazardous work.

Singularity Avoidance

Certain positions present a challenging mathematical problem to the robot. These are called singularities.

Eva's control system is designed to avoid these positions rather than passing through them. This significantly reduces hazards from unexpected behaviour, but also forces the robot to work unusually hard in positions close to the singularities.

To prolong the robot's life, it's advisable to avoid difficult tasks in positions where axes 1, 4 and 6 are working in parallel, or when axis 1 is co-linear (both parallel and aligned) with axis 4 or axis 6.

See the diagram below for examples.

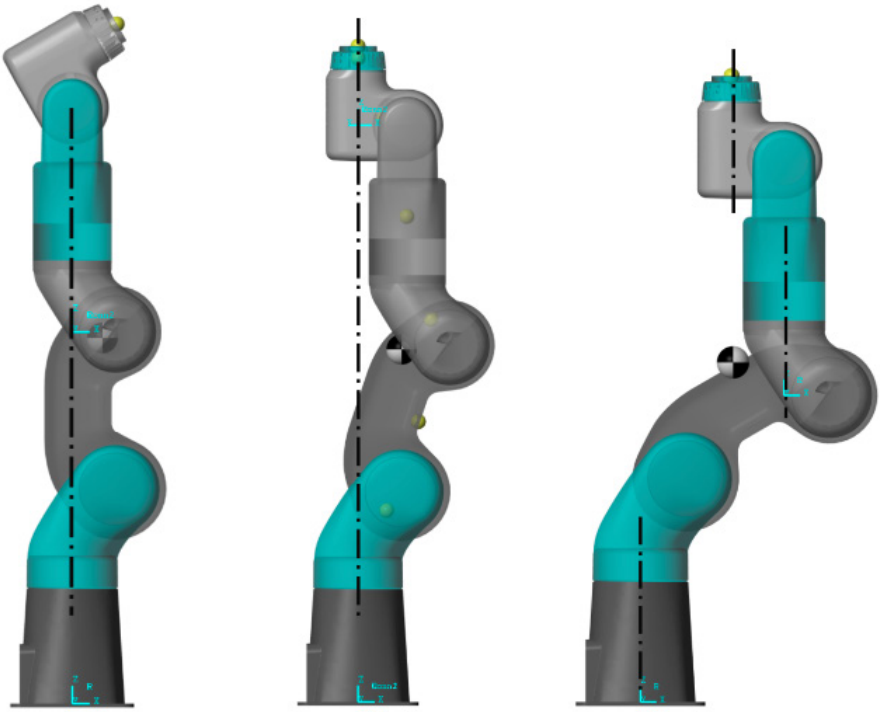


Diagram of robot singularity poses

Joint Limits

The joint limits are set as follows:

Axis 1: Resisted by a software limits at -179.0°, +179.0°.
Axis 2: Mechanically prevented from exceeding -155.0°, +70.0°.
Axis 3: Mechanically prevented from exceeding -160.0°, +45.0°.
Axis 4: Resisted by a software limits at -179.0°, +179.0°.
Axis 5: Mechanically prevented from exceeding -155.0°, +10.0°.
Axis 6: Resisted by a software limits at -179.0°, +179.0°.

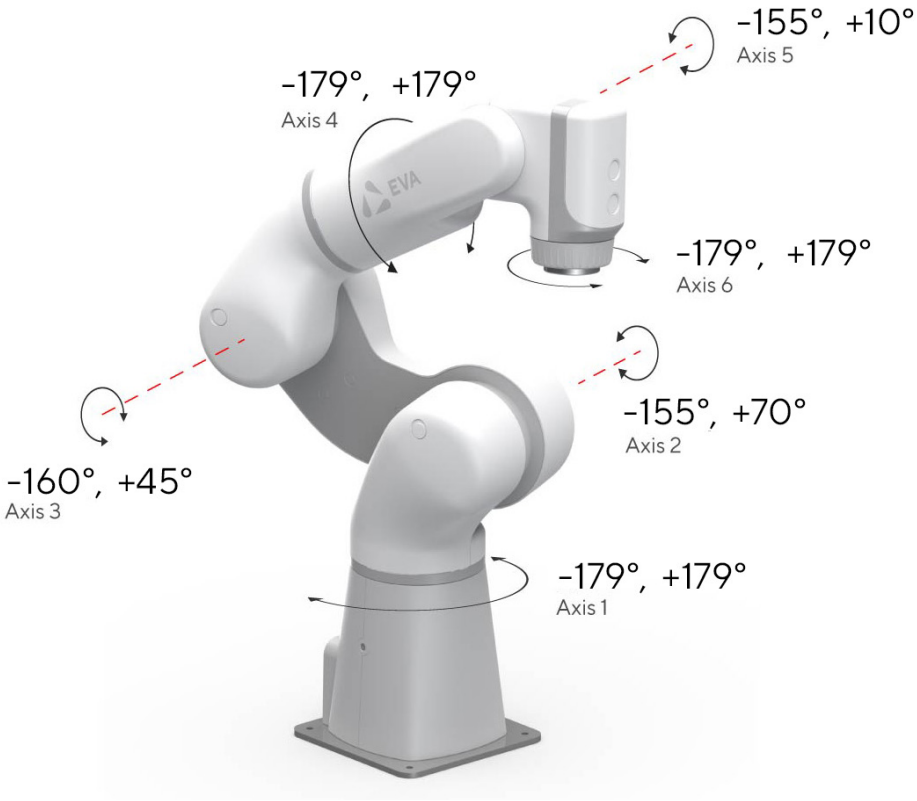


Diagram of robot axes

NOTE: Axes 1, 4 and 6 have no mechanical limits (software only). The software limits are not safety-rated and cannot be adjusted in Choreograph. The mechanical limits on axes 2, 3 and 5 are non-adjustable.

For applications where safety-rated joint limits are required - e.g. to prevent collision - third-party sensors or physical barriers are recommended.

D. Electrical Safety

Eva's electrical equipment has been designed and developed in accordance with **IEC 60204-1**. The following instructions should be followed in order to maintain electrical safety:

1. The robot is supplied with a Class II power supply. As such, a protective earth connection is not required.
2. Eva is rated to IP20. Ensure that all equipment in your system not rated for water exposure (including the robot) remains dry. If water gets inside any unit, remove all power and contact your supplier.
3. The robot has been designed according to international Electromagnetic Compatibility (EMC) standards, to industrial limits. Interference that falls outside of these limits can cause disturbance, unexpected behaviour or even damage to the robot with excessive exposure.
4. Using cables longer than 3 metres is not recommended. Perform extended tests before attempting to use longer cables to connect the robot to any other equipment.
5. Completely remove power from the system before attempting to remove or transport the robot to a new location, or when changing the tool.
6. Always plug the robot into the power supply provided. Never use anything less than a Class II supply to power the robot. Contact Automata or your supplier if you need to replace the power supply.
7. Read the **electronic interfaces** section of the **Technical Reference Manual** before connecting equipment to the I/O port on the robot base or head.

E. Maintenance

Do not make unauthorised modifications to the robot.

Non-qualified personnel are strictly prohibited from attempting to carry out repairs on Eva. In the event of malfunction, disconnect the robot from power and contact your supplier.

F. Disposal

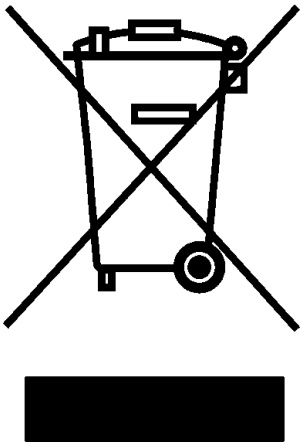
EU Waste Electrical and Electronic Equipment (WEEE) Directive

In August 2005, the European Union implemented the EU WEEE Directive 2002/96/EC and later the WEEE Recast Directive 2012/19/EU, requiring producers of electronic and electrical equipment to manage and finance the collection, reuse, recycling and to appropriately treat WEEE that the producer places on the EU market after August 13, 2005.

The goal of this directive is to minimize the volume of electrical and electronic waste disposal and to encourage re-use and recycling at the end of life. When sent to landfill, WEEE decays over time, resulting in hazardous materials leaking into the environment and water supplies. WEEE Disposal also poses a number of health risks that need to be adequately managed. For example, exposure to substances released during processing (such as mercury released from fluorescent tubes, lead and phosphorous pentachloride as a result of breaking cathode ray tubes).

Automata has met its obligations to the WEEE Directive by signing up to the UK's Distributor Take Back Scheme. A tool to locate suitable recycling services in your area is available from www.recyclenow.com/local-recycling.

If you have purchased Automata products in the EU and are intending to discard these products at the end of their useful life, please do not dispose of them with your other household or municipal waste. Automata has labelled its branded electronic products with the WEEE Symbol to alert our customers that products bearing this label should not be disposed of in a landfill or with municipal or household waste in the EU. Instead, please be aware that Automata is making a return and collection system available to you, free of transportation and recycling costs, for discarding these products.



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