# **User Guide** (en)

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# Copyright and disclaimer



Contact the manufacturer:

Mobile Industrial Robots A/S
Emil Neckelmanns Vej 15F
DK-5220 Odense SØ

www.mobile-industrial-robots.com
Phone: +45 20 377 577
Email: support@mir-robots.com

CVR: 35251235

# Table of contents

# 1. About this document

This user guide explains how to set up and start operating your MiR250 robot and provides examples of simple missions you can expand to your purposes. This guide also contains information regarding the external and internal components of MiR250 along with instructions for proper maintenance of the robot. You will also find information regarding safety and specifications needed to commission a safe MiR250 robot application.

**NOTICE**

Save this manual. It contains important safety and operating instructions.

## 1.1 Where to find more information

At the MiR website, you can find the following resources under the **Manuals** tab on each product page:

- **Quick starts** describe how you start operating MiR robots quickly. It comes in print in the box with the robots. Quick starts are available in multiple languages.
- **User guides** provide all the information you need to operate and maintain MiR robots and how to set up and use top modules and accessories, such as charging stations, hooks, shelf lifts, and pallet lifts. User guides are available in multiple languages.
- **Commissioning guides** describe how to commission your robot safely and prepare it to operate in the workplace.
- **Operating guides** describe how to set up and use MiR accessories or supported functions that are mainly hardware-based, such as charging stations and shelf functions.
- **Getting started guides** describe how to set up MiR accessories that are mainly software-based, such as MiR Fleet.
- **Reference guides** contain descriptions of all the elements of the robot interface and MiR Fleet interface. Reference guides are available in multiple languages.
- **Best practice guides** specify how much space MiR robots need to execute common maneuvers.
- **REST API references** for MiR robots, MiR hooks, and MiR Fleet. HTTP requests can be used to control robots, hooks, and MiR Fleet.
- **MiR network and WiFi guide** specifies the performance requirements of your network and how you must configure it for MiR robots and MiR Fleet to operate successfully.

# 1.2 Version history

This table shows current and previous versions of this document.

| MiR250 | | | |
|---|---|---|---|
| Revision | Release date | Description | HW |
| 1.0 | 2020-06-26 | First edition | 1.0 |
| 1.1 | 2020-07-01 | General improvements throughout the document. | 1.0 |
| 1.2 | 2020-07-08 | Update section: Operating hazard zones<br>General improvements throughout the document. | 1.0 |
| 1.3 | 2020-11-30 | Added sections: Warranty, Markers, and Positions.<br>Updated section: Battery storage with Power save mode and Deep sleep mode.<br>General improvements throughout the document. | 1.0 |

# 2. Product presentation

MiR250 is an autonomous mobile robot that can transport loads up to 250 kg indoors within production facilities, warehouses, and other industrial locations where access to the public is restricted.


Users operate MiR250 via a web-based user interface, which is accessed through a browser on a PC, smartphone, or tablet. Each robot has its own network—see Connecting to the robot interface on page 52. The robot can be set up to run a fixed route, be called on demand, or perform more complex missions.

The robot interface of MiR250 can be accessed via Google Chrome, Google Chromium, Apple Safari, Mozilla Firefox, and Microsoft Edge browsers.

The robot uses a map of its work area to navigate and can move to any position on the map—see Navigation and control system on page 69. The map can be created or imported the first time the robot is used. While operating, the robot avoids obstacles that are not mapped, like people and furniture.

MiR250 is supplied with a fast swap removable lithium-ion battery.

MiR250 is available both in an ESD approved version, which is black, and a non-ESD approved version, which is gray.

Specifications for MiR250 are available on the MiR website.

# 2.1 Main features of MiR250

The main features of MiR250 are:

- **Driving in a populated workspace**
  The robot is designed to operate among people and maneuvers safely and efficiently in highly dynamic environments.
- **Overall route planning and local adjustments**
  The robot navigates autonomously to find the most efficient paths to its destinations. The robot adjusts the path when it encounters obstacles that are not on the map, like personnel and vehicles.
- **Efficient transportation of heavy loads**
  The robot is designed to automate transportation of loads up to 250 kg.
- **Sound and light signals**
  The robot continuously signals with light and sounds, indicating where it will drive and its current status, for example, waiting for a mission, driving to a destination, or destination reached.
- **User-friendly and flexible**
  The web-based user interface, accessed from a PC, tablet, or smartphone, gives easy access to operation and monitoring of the robot and can be programmed without any prior experience. Different user group levels and tailored dashboards can be set up to suit different users.
- **Alert for 'lost'**
  If the robot enters a situation where it is unable to find a path to its destination, it stops, turns on the yellow-purple running error light, and a custom defined Try/Catch action may be used to alert personnel or take other actions—see Creating the mission Try/Catch on page 158.
- **Automatic deceleration for objects**
  The built-in sensors ensure that the robot is slowed down when obstacles are detected in front of it.

- **Internal map**
  The robot can either use a floor plan from a CAD drawing, or a map can be created by manually driving the robot around the entire site in which the robot is going to operate. When the robot is mapping, the robot's sensors detect walls, doors, furniture, and other obstacles, and the robot then creates a map based on these input. After you've finished mapping, you can add positions and other features in the map editor—see Creating and configuring maps on page 108.

# 2.2 Top modules

The following top modules are available for MiR250:

- **MiR Shelf Carrier 250**
  A top module that allows MiR250 to tow shelves.

To learn more about the top modules, go to the MiR website.

# 2.3 External parts

This section presents the parts of MiR250 that are visible on the outside.


Figure 2.1. MiR250 external parts.

| **Table 2.1.**<br>Identification of the external parts in *Figure 2.1* | | | |
|---|---|---|---|
| **Pos.** | **Description** | **Pos.** | **Description** |
| 1 | Corner bumper: four pcs, one on each corner | 2 | Front cover: opens to front compartment—see Internal parts on page 21 |
| 3 | Swivel wheel with foot guard: four pcs, one in each corner | 4 | 3D depth camera: two pcs, both in the front—see Obstacle detection on page 74 |

| Pos. | Description | Pos. | Description |
| --- | --- | --- | --- |
| 5 | Nanoscan3 safety laser scanner: two pcs, in opposite corners—see Obstacle detection on page 74 | 6 | Status light: on all four sides of the robot—see Light indicators and speakers on page 101 |
| 7 | Side cover: opens to side compartment—see Internal parts on page 21 | 8 | Control panel—see Control panel on page 16 |
| 9 | Manual brake release switch—see Control panel on page 16 | 10 | Rear cover: opens to rear compartment—see Internal parts on page 21 |
| 11 | Signal light: eight pcs, two on each corner—see Light indicators and speakers on page 101 | 12 | Proximity sensor: eight pcs, two in each corner behind corner covers—see Obstacle detection on page 74 |
| 13 | Top plate | 14 | Left top compartment—see Internal parts on page 21 |
| 15 | Right top compartment—see Internal parts on page 21 | | |

## Identification label

MiR250 is delivered with an identification label mounted to the product. The identification label identifies the product, the product serial number, and the hardware version of the product.

The identification label of MiR250 is located behind the rear cover next to the battery.

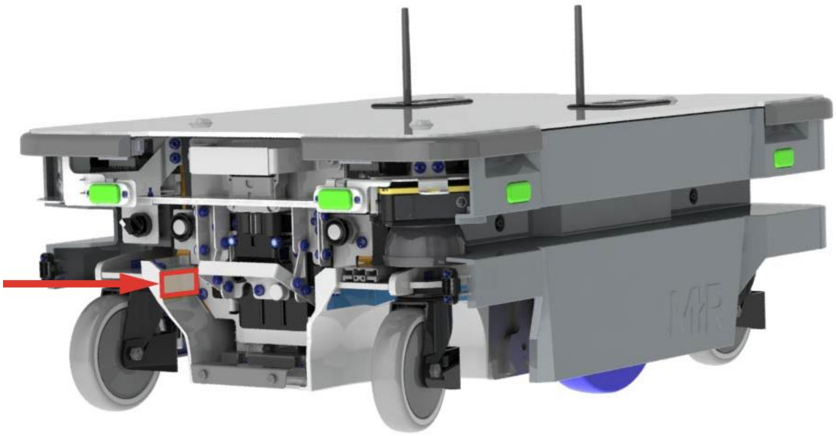


Figure 2.2. Placement of the identification label.

| | |
|---|---|
| Item number: | 800253 |
| Product serial number: | 202303000 |
| Hardware version: | V.1 |

Figure 2.3. Example of a MiR250 identification label.

# Nameplate

Every MiR application is delivered with a nameplate that must be mounted to the robot. The nameplate of MiR250 identifies the application model and serial number and includes the CE mark, the technical specifications, and the address of Mobile Industrial Robots. The nameplate identifies the complete MiR application, for example, a robot with a top module.

It is the responsibility of the commissioner to mount the nameplate on the application—see Mounting the nameplate on page 58.

| | | | | |
|---|---|---|---|---|
| Mass unloaded : | 83 kg | Nominal power : | 2x637 W | Contains FCC ID: TV7RB952-5AC2ND |
| Rated speed : | 2.0 m/s | Type : | Driverless truck | Contains FCC ID: RYK-261ACNBT |
| Max slope : | 5 % | Model : | MiR250 | |
| Rated capacity : | 250 kg | S/N : | 100000001 | This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. |
| | | Year of construction : | 2020 | |
| Max payload footprint : | 800x580 mm | | | |
| Lithium ion battery | | Made in Denmark | | |
| Nominal voltage : | 48 V | Mobile Industrial Robots A/S | | |
| Rated capacity : | 34 Ah | Emil Neckelmanns Vej 15F | | |
| Mass : | 14 kg | DK-5220 Odense SØ | | |
| Dimension : | 491x211x77 mm | | | |

Figure 2.4. Example of a MiR250 nameplate.

# Control panel

MiR250 has a control panel in the rear-left corner of the robot.

## The control panel buttons


Figure 2.5. The MiR250 control panel.

**Table 2.1.**
Identification of items on the control panel in *Figure 2.5*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Manual stop button | 2 | Resume button |
| 3 | Power button | 4 | Operating mode key |

### Manual stop

Pressing this button stops the robot. After pressing this button, you must press the Resume button to let the robot continue operating.

Color indication:

- Red: It is possible to engage the Manual stop.

### Resume

Pressing this button:

- Clears the Emergency stop state.
- Lets the robot continue operating after the Manual stop button was pressed or after the operating mode changes.
- Lets the robot start operating after powering up.

Color indication:

- Blinking blue: The robot is waiting for a user action (clear the Emergency stop state, acknowledge the change of operating mode).

### Power

Pressing this button for three seconds turns the robot on or shuts it off.

Color indication:

- Blue: The robot is off.
- Blinking green: The robot is starting up.
- Green: Normal operation.
- Blinking red: The battery level is too low to start without additional charging, or the robot is shutting down.

## The Operating mode key

The Operating mode key lets you switch between operating modes.

- **Left position: Autonomous mode**
  Puts the robot in Autonomous mode.

- **Middle position: Locked**
  Locks the robot. The robot blocks the wheels; you cannot start a mission or drive the robot manually.


- **Right position: Manual mode**
  Puts the robot in Manual mode.


For more information on operating modes, see Operating modes on the next page.

## Manual brake release switch

The Manual brake release switch is located below the control panel and releases the mechanical brakes on MiR250. You release the robot's mechanical brakes by turning the Manual brake release switch clockwise.

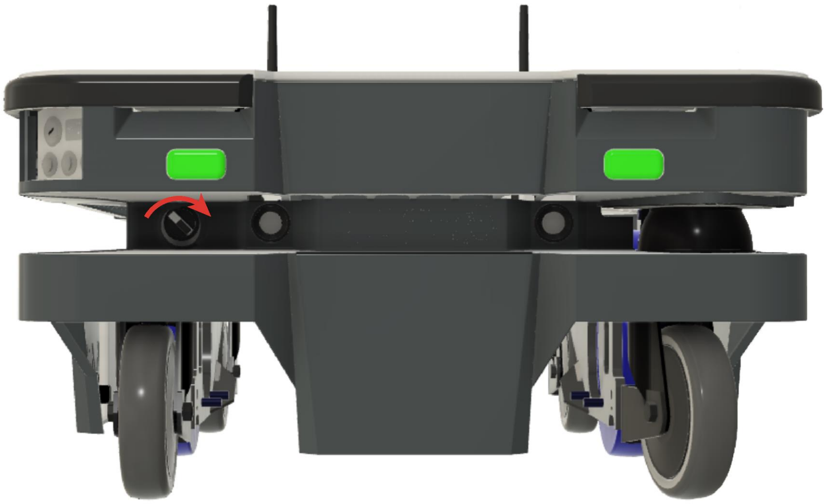


Figure 2.6. The manual brake release switch is located below the control panel.

The mechanical brakes require electrical power to be released, so if the robot is without power, the mechanical brakes cannot be released.

If MiR250 shuts down due to low battery percentage, there is still enough power to release the brakes for approximately a week after.

When driving in Autonomous mode, the robot engages and releases the mechanical brakes automatically.

The robot cannot operate while the mechanical brakes are released manually.

## Operating modes

MiR250 has two operating modes: Manual mode and Autonomous mode.

### Manual mode

In this mode, you can drive the robot manually using the joystick in the robot interface. Only one person can control the robot manually at a time. To ensure that nobody else takes control of the robot, the robot issues a token to the device on which you activate the Manual mode.

For information about activating this mode, see Driving the robot in Manual mode on page 53.

### Autonomous mode

In this mode, the robot executes the programmed missions. After switching the key to this mode, you can remove the key, and the robot will continue driving autonomously. In Autonomous mode, the joystick is disabled in the robot interface.

# 2.4 Internal parts

Most internal parts of MiR250 are accessed through covers that open to different compartments:

- Front compartment
- Rear compartment
- Side compartments
- Top compartments

To access the compartments correctly, see Accessing the internal parts on page 38.

**WARNING**

Removing covers from the robot exposes parts connected to the power supply, risking damage to the robot from a short circuit and electrical shock to personnel.

- Before removing any covers, turn off the robot, and disconnect the battery—see Disconnecting the battery on page 63.

## Front compartment

The front compartment holds several electronic components, such as the robot computer and the motor controller carrier board.

To open the front compartment, see Accessing the internal parts on page 38.

### Front compartment components

The front compartment components are listed in *2.4*.

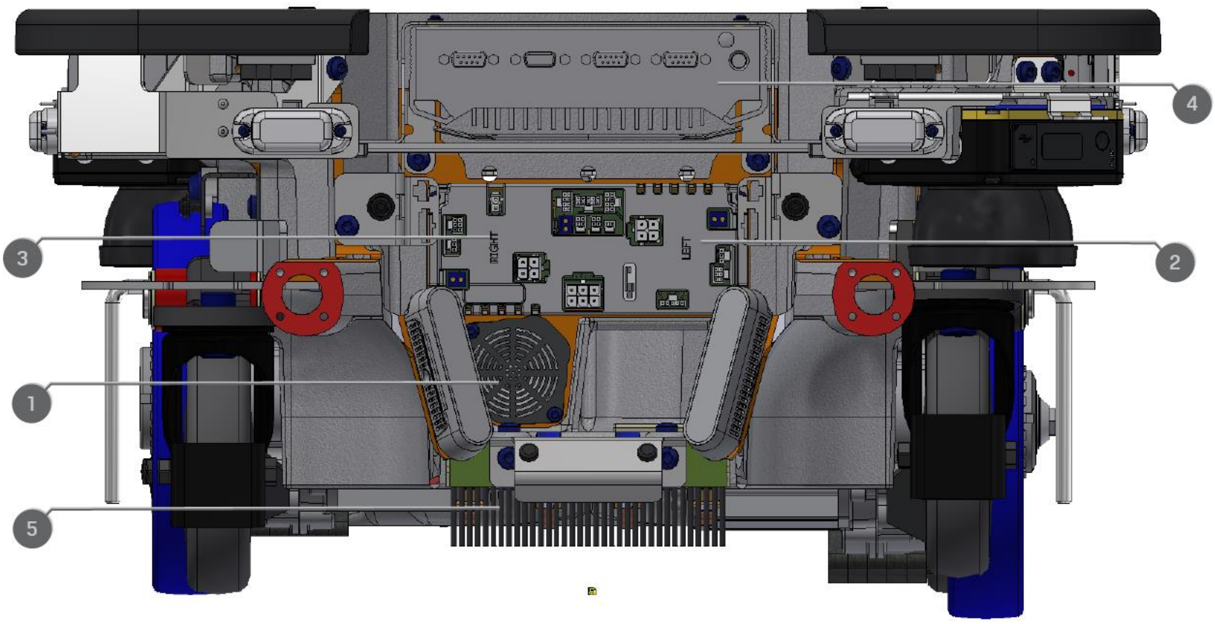



Figure 2.7. Internal parts of the front compartment.

**Table 2.1.**
Identification of internal parts in *Figure 2.7*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Loudspeaker | 2 | Carrier board with motor controller controlling the left-side drivetrain |
| 3 | Carrier board with motor controller controlling the right-side drivetrain | 4 | Robot computer |
| 5 | Charging pads under robot and broom for keeping dirt away from the charging pads | | |

## Rear compartment

The rear compartment holds the robot’s battery, Battery disconnect lever, power board, and safety PLC. The battery and Battery disconnect lever can be accessed without the use of tools. The other components in the rear compartment are only accessible via use of tools.

To open the rear compartment, see Accessing the internal parts on page 38.

**NOTICE**

The unique nameplate of your robot is to be mounted on the rear compartment cover—see Mounting the nameplate on page 58. Make sure you do not swap the cover with covers from other robots.

## Rear compartment components

The rear compartment components are listed in *Table 2.3*.

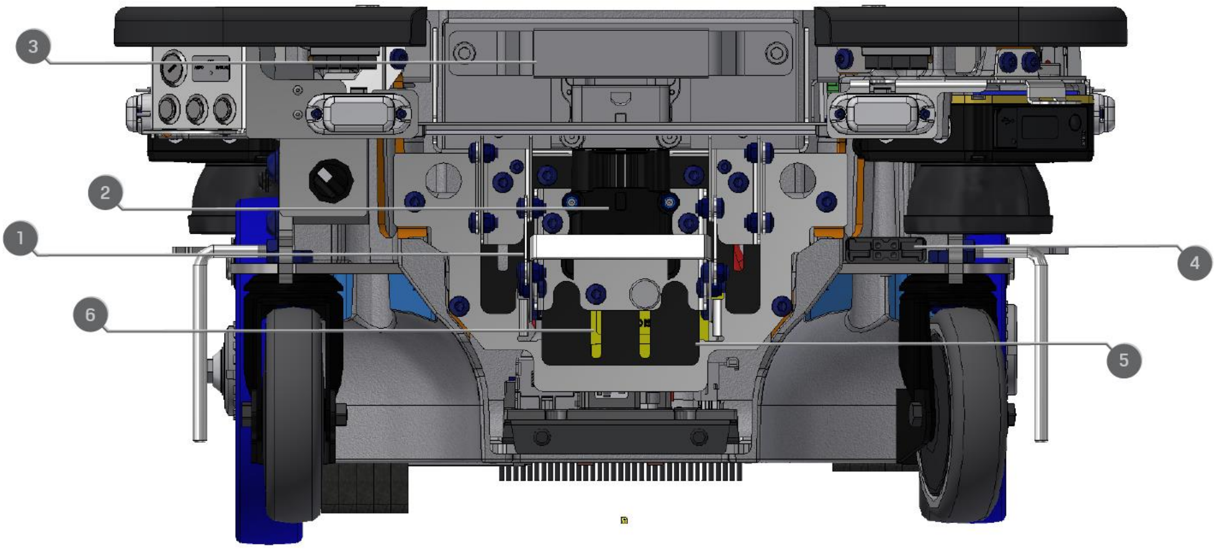



Table 2.2. Internal parts of the rear compartment.

**Table 2.3.**
Identification of internal parts in *Figure 2.7*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Battery disconnect lever | 2 | Battery connector |
| 3 | Battery | 4 | Cable charging interface |
| 5 | Power board for motor controller, robot computer, and safety PLC | 6 | Safety PLC |

# Side compartments

The side compartments contain the bogies and drive wheels.

To access a side compartment, see Accessing the internal parts on page 38.

## Side compartment components

The left side compartment components are listed in *Table 2.4*

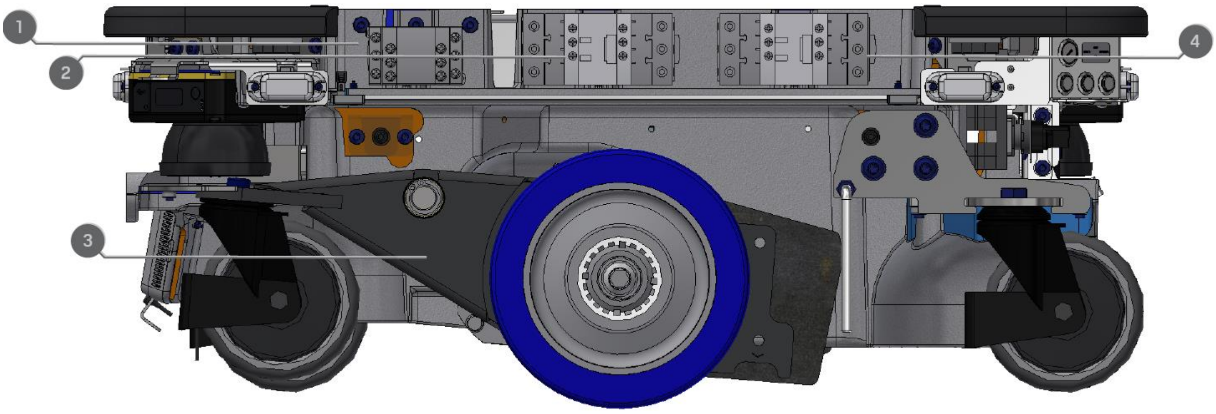



Figure 2.8. Internal parts of the left side compartment.

**Table 2.4.**
Identification of internal parts in *Figure 2.8*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Safe Stop 1 (SS1) contactor | 2 | Safe Torque Off (STO) contactor |
| 3 | Bogie and drivetrain consisting of motor, gearbox, encoder, brake, drive wheel, and assembly parts | 4 | Safe Torque Off (STO) contactor |

The right side compartment components are listed in *Table 2.5*

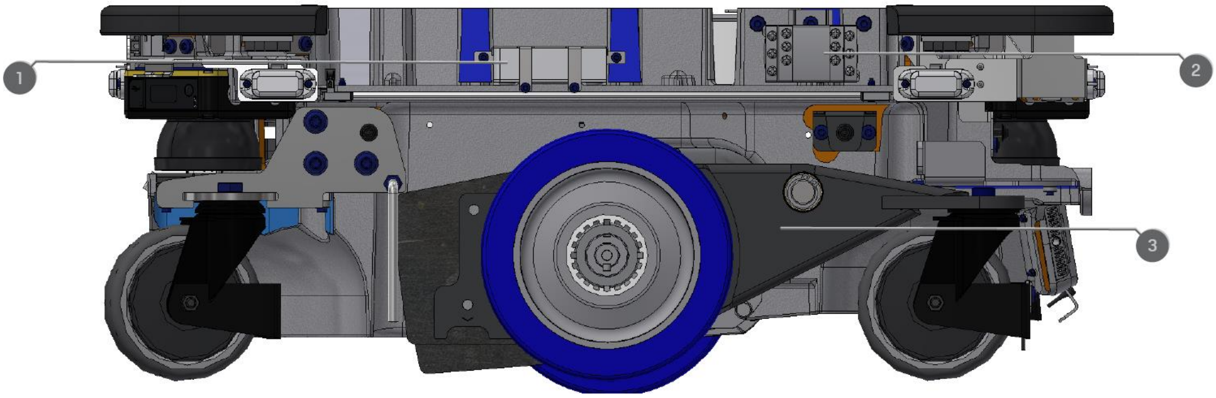



Figure 2.9. Internal parts of the right side compartment.

**Table 2.5.**
Identification of internal parts in *Figure 2.9*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Router | 2 | Safe Stop 1 (SS1) contactor |
| 3 | Bogie and drivetrain consisting of motor, gearbox, encoder, brake, drive wheel, and assembly parts | | |

## Top compartments

The two top compartments contain electrical interfaces that can be connected to top modules.

To open a top compartment, see Accessing the internal parts on page 38.

Figure 2.10. The top compartments on the robot.

## Top compartment components

The top compartments interfaces are listed in *Table 2.6*. For detailed information on electrical interfaces, see Interface specifications on page 199.

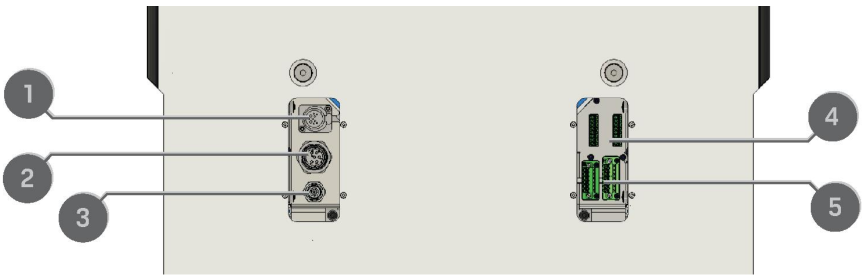



Figure 2.11. Interfaces in the top compartments.

**Table 2.6.**
Identification of interfaces in *Figure 2.11*

| Pos. | Description | Pos. | Description |
|---|---|---|---|
| 1 | Emergency stop | 2 | Auxiliary power connector |
| 3 | Ethernet | 4 | General purpose I/Os |
| 5 | Auxiliary safety functions I/Os | | |

# 3. Warranty

Mobile Industrial Robots offers a standard warranty on all products.

Contact your distributor to see the terms and extend of product coverage.

**NOTICE**

Mobile Industrial Robots disclaims any and all liability if MiR250 or its accessories are damaged, changed, or modified in any way. Mobile Industrial Robots cannot be held responsible for any damages caused to MiR250, accessories, or any other equipment due to programming errors or malfunctioning of MiR250.

# 4. Safety

Read the information in this section before powering up and operating MiR250.

Pay particular attention to the safety instructions and warnings.

**NOTICE**

Mobile Industrial Robots disclaims any and all liability if MiR250 or its accessories are damaged, changed, or modified in any way. Mobile Industrial Robots cannot be held responsible for any damages caused to MiR250, accessories, or any other equipment due to programming errors or malfunctioning of MiR250.

## 4.1 Safety message types

This document uses the following safety message types.

**WARNING**

Indicates a potentially hazardous situation that could result in death or serious injury. Carefully read the message that follows to prevent death or serious injury.

**CAUTION**

Indicates a potentially hazardous situation that could result in minor or moderate injury. Alerts against unsafe practices. Carefully read the message that follows to prevent minor or moderate injury.

**NOTICE**

Indicates important information, including situations that can result in damage to equipment or property.

# 4.2 General safety precautions

This section contains general safety precautions.

**WARNING**

If the robot is not running the correct software and is therefore not functioning properly, the robot may collide with personnel or equipment causing injury or damage.

- Ensure that the robot is always running the correct software.

**WARNING**

When the robot is in an operating hazard zone, there is a risk of injury to any personnel within the zone.

- Ensure that all personnel are instructed to stay clear of operating hazard zones when the robot is in or approaching the zone.

**WARNING**

The robot may drive over the feet of personnel, causing injury.

- All personnel must be informed of the side Protective fields of the robot and be instructed to wear safety shoes near an operating robot—see Personnel detection on page 89.

**WARNING**

The robot may drive into a ladder, scaffold, or similar equipment that has a person standing on it. Personnel risk fall injuries and equipment may be damaged.

- Don't place ladders, scaffolds, or similar equipment in the robot's work environment.

**WARNING**

The robot may drive down staircases or holes in the floor and cause serious injury to personnel and damage to the robot and to equipment.

- Mark descending staircases and holes as Forbidden zones on maps.
- Keep the maps up to date.
- Inform personnel that the robot cannot detect descending staircases and holes in the floor in time to stop.

**WARNING**

Contact with live electrical parts can cause electric shock.

- Do not touch any internal components of the robot while it is powered.

**WARNING**

Using a charging device different from the one supplied by the manufacturer can cause a fire and thereby burn injuries to nearby personnel and damage to the robot and equipment.

- Only use an original MiR charger.

**WARNING**

Attempting to charge batteries outside the robot can lead to electrical shock or burns.

- Never charge the batteries outside the robot.

**WARNING**

Lithium battery packs may get hot, explode, or ignite and cause serious injury if they are misused electrically or mechanically.

Observe the following precautions when handling and using lithium-ion batteries:

- Do not short-circuit, recharge, or connect with false polarity.
- Do not expose to temperatures beyond the specified temperature range or incinerate the battery.
- Do not crush, puncture, or disassemble the battery. The battery contains safety and protection devices, which, if damaged, may cause the battery to generate heat, explode, or ignite.
- Do not allow the battery to get wet.
- In the event the battery leaks and the fluid gets into one's eye, do not rub the eye. Rinse well with water, and immediately seek medical care. If left untreated, the battery fluid could cause damage to the eye.
- Use only an original MiR charger (cable charger or charging station) and always follow the instructions from the battery manufacturer.
- Do not touch damaged batteries with bare hands. Only personnel using suitable Personal Protection Equipment (PPE) and tools should handle damaged batteries.
- Isolate the battery and keep clear if the following conditions are observed:
  - The battery exhibits abnormally high temperatures.
  - The battery emits abnormal odors.
  - The battery changes colors.
  - The battery case is deformed or otherwise differs from the normal electrical or mechanical condition.
- Modifications or manipulations of the battery may lead to considerable safety risks and are therefore prohibited.
- Do not use the battery for anything other than MiR250.

**WARNING**

Load falling or robot overturning if the load on the robot is not positioned or fastened correctly can cause fall injuries to nearby personnel or damage to equipment.

- Ensure that the load is positioned according to the specifications and is fastened correctly—see Payload distribution on page 192.

**CAUTION**

Robot malfunctions can cause an electrical fire, causing damage and injury to equipment and personnel.

- Personnel operating near the robot must be informed on how to use an ABC fire extinguisher to put out an electrical fire should the robot malfunction and catch on fire.

**CAUTION**

Risk of trapping or injury to personnel if robots malfunction or if personnel enter operating hazard zones.

- Personnel operating near the robot must be informed on how to engage the robot's Emergency stop function in emergency situations.

## 4.3 Intended use

MiR250 is intended to be commissioned and used in indoor industrial environments where access for the public is restricted.

MiR250 is intended to be commissioned according to the guidelines in Commissioning on page 105. This is a prerequisite for safe usage of MiR250.

MiR250 is equipped with safety-related features that are purposely designed for collaborative operation where the robot operates without a safety enclosure or together with people.

MiR250 is intended to be used with top modules supported by Mobile Industrial Robots or custom modules that:

- Do not have any moving parts.
- Do not extend the footprint of the robot.
- Operate within the environmental conditions required for MiR250.
- Are within the requirements in Payload distribution on page 192.

If used with custom modules, all obligations of a manufacturer apply to the individual who performs the modifications in accordance with the machinery directive.

MiR250 is designed for and all risks are considered when used with one of the following types of top modules:

- MiR Shelf Carrier 250 to transport MiR supported shelves.

MiR250 can be used as a partly complete machine as defined in the EU machinery directive, with top modules that do not meet the above limitations. Those who design, manufacture, or commission a system that does not meet the limitations of use of MiR250 carry the obligations of a manufacturer and shall ensure a safe design according to EN ISO 12100. Guidelines outlined in this manual are not sufficient.

The following list gives examples of modules that are foreseeable misuse of MiR250:

- Top modules (including total payload) that increase the footprint of MiR250
- Conveyers (powered and non-powered)
- Industrial robot arms
- Devices that tow carts
- Customized load transfer stations

**NOTICE**

A safe machine does not guarantee a safe system. Follow the guidelines in Commissioning on page 105 to ensure a safe system.

# 4.4 Users

MiR250 is only intended to be used by personnel that have received training in their required tasks.

There are three types of intended users for MiR250: commissioners, operators, and direct users.

## Commissioners

Commissioners have thorough knowledge of all aspects of commissioning, safety, use, and maintenance of MiR250 and have the following main tasks:

- Commissioning of the product. This includes creating maps and restricting the user interface for other users and making brake tests with a full payload.
- Conducting the risk assessment.
- Determining the payload limit, weight distribution, safe fastening methods, safe loading and unloading of loads on MiR250, and ergonomic loading and unloading methods if relevant.
- Ensuring the safety of nearby personnel when the robot is accelerating, braking, and maneuvering.
- Marking operating hazard zones.

## Operators

Operators have thorough knowledge of MiR250 and of the safety precautions presented in this user guide. Operators have the following main tasks:

- Servicing and maintaining MiR250.
- Creating and changing missions and map features in the robot interface.

## Direct users

Direct users are familiar with the safety precautions in this user guide and have the following main tasks:

- Assigning missions to MiR250.
- Fastening loads to MiR250 securely.
- Loading and unloading from a paused robot.

All other persons in the vicinity of MiR250 are considered indirect users and must know how to act when they are close to the robot. For example, they must be aware that visibly marked operating hazard zones must be respected.

# 4.5 Foreseeable misuse

Any use of MiR250 deviating from the intended use is deemed as misuse. This includes, but is not limited to:

- Using the robot to transport people
- Using the robot on steep surface grades, such as ramps
- Making changes to the SICK configuration
- Driving the robot on cross slopes
- Exceeding the total payload
- Positioning or fastening loads incorrectly according to the specifications—see Payload distribution on page 192
- Using Emergency stop buttons for anything other than emergency stops
- Using the robot in medical and life critical applications
- Operating the robot outside the permissible operating parameters and environmental specifications
- Using the robot in potentially explosive environments
- Using the robot outdoors
- Using the robot in hygiene zones

# 4.6 Warning label

MiR250 is supplied with a warning label that specifies that it is strictly prohibited to ride on the robot.

The label must be placed on the robot or top module so that it is clearly visible.


Figure 4.1. The warning label must be placed on the robot or top module.

# 4.7 Residual risks

Mobile Industrial Robots has identified the following potential hazards that commissioners must inform personnel about and take all precautions to avoid when working with MiR250:

- You risk being run over, drawn in, trapped, or struck if you stand in the path of the robot or walk towards the robot or its intended path while it is in motion.
- You risk being run over, drawn in, trapped, or struck if you stand in the path of the robot or walk towards it while it is driving in reverse. The robot only drives in reverse when undocking from a marker, such as a charging station or load transfer station.
- You risk being crushed or trapped if you touch the robot while it is in motion.
- You risk being crushed or trapped if the robot places a load outside a designated drop-off area due to faulty localization.
- You risk losing control of the robot if it is accessed by unauthorized users. Consider increasing the IT security of your product—see IT security on page 67.

**NOTICE**

Other significant hazards may be present in a specific robot installation and must be identified during commissioning.

# 5. Accessing the internal parts

Most internal parts of MiR250 are accessed through covers that open to different compartments:

- Front compartment
- Rear compartment
- Side compartments
- Top compartments

The front and rear covers have to be removed before you can remove the side covers.

For more information on how to remove the covers on MiR250, see the video *How to remove and attach the covers on MiR250* on MiR Academy at the MiR website. Contact your distributor for access to MiR Academy.

**WARNING**

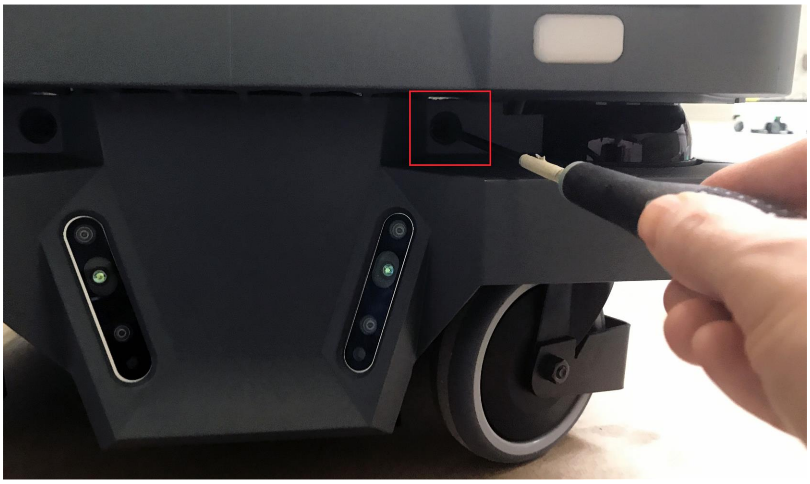
Removing covers from the robot exposes parts connected to the power supply, risking damage to the robot from a short circuit and electrical shock to personnel.

- Before removing any covers, turn off the robot, and disconnect the battery—see Disconnecting the battery on page 63.

# 5.1 Front compartment

To open the front compartment, follow these steps:

1. Unscrew the two screws holding the front cover with a T30 Torx screwdriver.



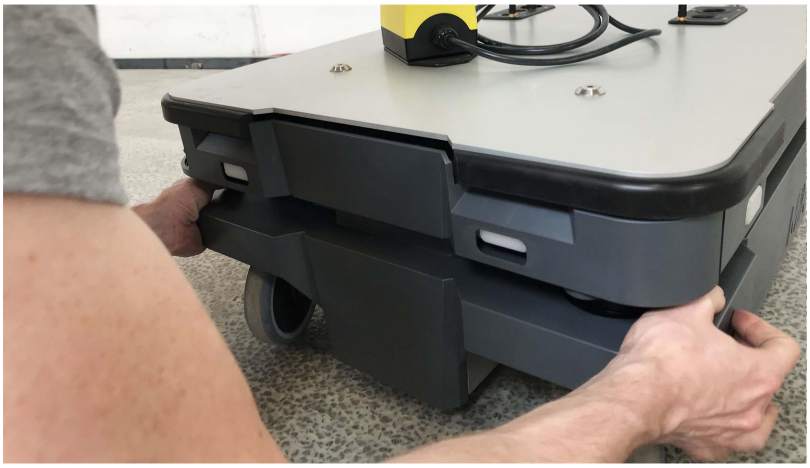
2. Pull the front cover off of the robot.

# 5.2 Rear compartment

To open the rear compartment, follow these steps:

1. Push the two white buttons at the same time.


2. Loosen the cover by first loosening the bottom corners one at the time, then the two top corners. Pull down and then out on each top corner.

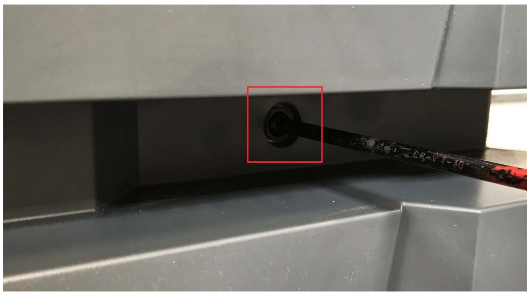


3. Pull off the cover.

## 5.3 Side compartments

To open a side compartment, follow these steps:

1. Turn the two screws counterclockwise with a T30 Torx screwdriver.



2. Pull the cover off.


# 5.4 Top compartments

To open a top compartment, unscrew the four screws with a T8 Torx screwdriver, and lift off the black plastic top cover.

**NOTICE**

With the antenna cables mounted, the plastic top covers can be lifted 50 mm. If you need to remove a cover completely, the antenna cable needs to be detached from the cover first. When reattaching the covers, make sure that the antenna cables are not damaged.

Figure 5.1. The top compartments of MiR250.

# 6. Getting started

This section describes how to get started with MiR250.

**NOTICE**

To be able to use MiR250, your robot must be running software version 2.9.0 or higher.

**NOTICE**

Read Safety on page 29 before powering up MiR250.

In some images in this section, the robot is shown with a MiR Shelf Carrier 250 top module.

## 6.1 In the box

This section describes the contents of the MiR250 box.

Figure 6.1. The box containing the robot and accessories.

The box contains:

- The MiR250 robot
- A MiR250 document folder containing a USB flash drive and the following printed documents:
  - *MiR250 Quick Start*
  - *The CE Declaration of Conformity for your robot*
  - *Getting the robot online*
  - *Passwords*
  - The unique nameplate for your robot
- The USB flash drive in the document folder has the following content:
  - *MiR250 User Guide*
  - *MiR250 Quick Start*
  - *MiR Network and WiFi Guide*
  - *MiR Robot Reference Guide*
  - *MiR Robot REST API Reference*
  - *Getting the robot online*
  - *CE Declaration of Conformity*

## 6.2 Unpacking MiR250

This section describes how to unpack the robot.

Keep the original packaging for future transportation of MiR250.

To unpack the robot, follow these steps:

1. Place the box with the robot so that there is at least three meters of free space at the front or the back of the box. This is necessary as the robot drives out of the box on a ramp.

2. Cut the protective straps surrounding the box.

3. Remove the lid from the box.

4. Take the folder with the printed documents and the USB flash drive out of the box.

5. Remove the walls of the box and the protective foam blocks.

6. Place the lid of the box so that you can use it as a ramp. Align the lid so that it is flush with the base of the box.

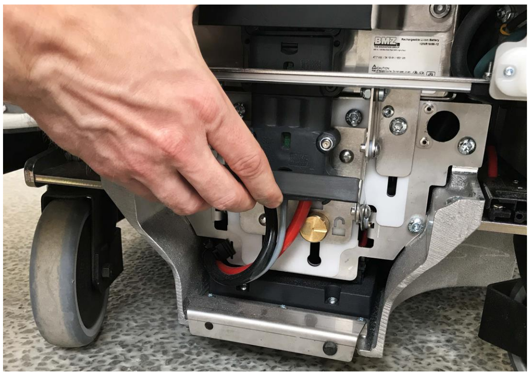
# 6.3 Connecting the battery

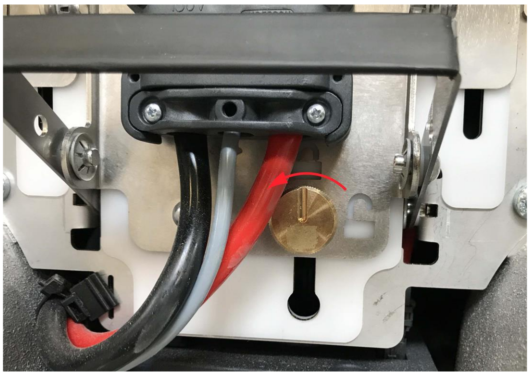
To connect the battery to the robot, you need to open the rear compartment—see Accessing the internal parts on page 38.

To connect the battery to the robot, follow these steps:

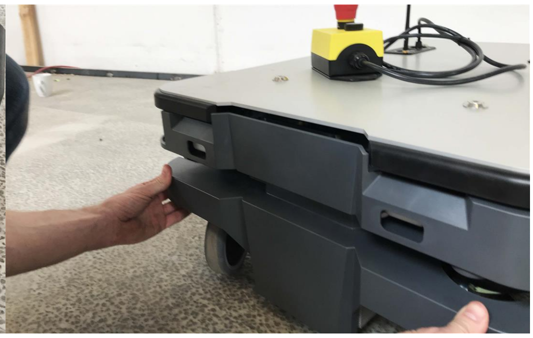
1. Turn the battery lever lock clockwise to unlock the battery lever.


2. Pull up the lever to connect the battery connector to the battery. Then turn the battery lever lock counterclockwise to secure the battery lever.





3. Reattach the rear cover by tilting it slightly so that the bottom point forward and insert it into the two attachment sockets. Press the two white buttons while attaching the cover to the robot.

4. Click the cover in place one corner at the time.

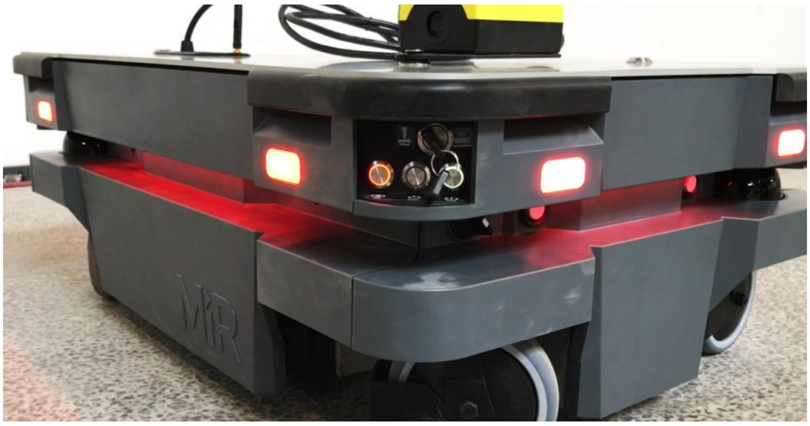
# 6.4 Powering up the robot

To power up the robot, follow these steps:

1. Press the Power button for three seconds to turn on the robot.

The status lights waver yellow, and the robot starts the software initialization process.

When the initialization process ends, the robot goes into Protective stop.



2. Press the Resume button to clear the Protective stop. The robot is now ready for operation.

# 6.5 Connecting to the robot interface

When the robot is turned on, it enables the connection to its WiFi access point. The name of the access point appears in the list of available connections on your PC, tablet, or phone.

**NOTICE**

The original username and password for the robot's web interface are in the document *Getting the robot online*.

The unique password for the WiFi access point is in the *Passwords* document.

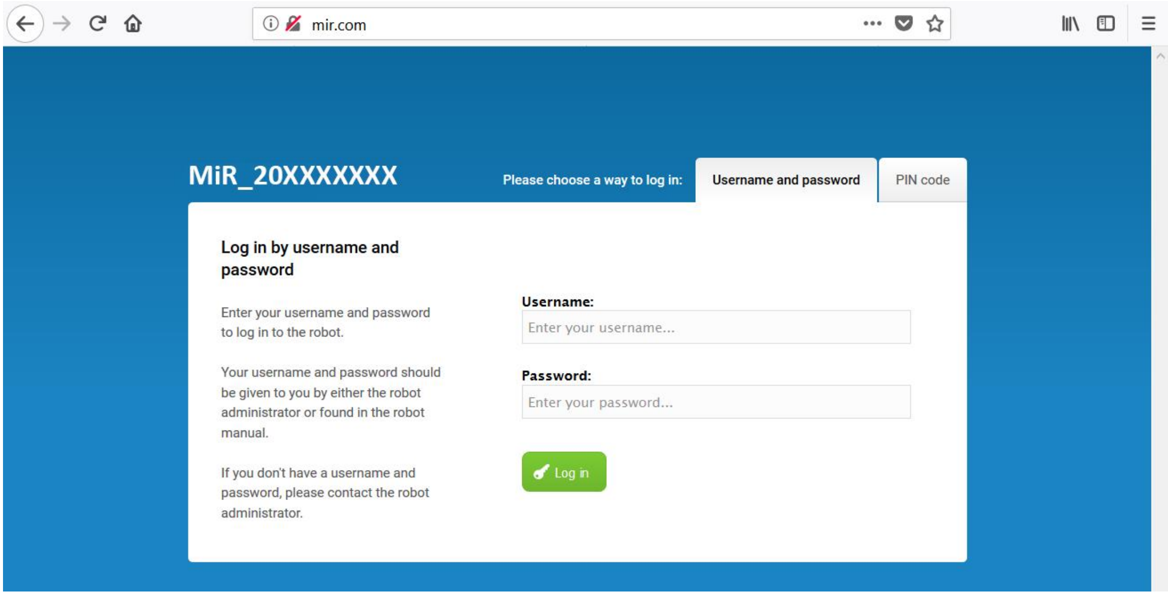
Both documents are in the box with the product.

To connect to the robot interface, follow these steps:

1. Using your PC, tablet, or phone, connect to the WiFi access point of the robot using the unique password for the WiFi access point. The access point name has the following format: **MiR_20XXXXXXX**.

   The access point name is derived from the robot application's model serial number.

2. In a browser, go to the address **mir.com** and sign in.




3. Switch to Manual mode, and drive the robot down the ramp—see Driving the robot in Manual mode below.

# 6.6 Driving the robot in Manual mode

**CAUTION**

When driving the robot in Manual mode, it is possible to mute the Protective fields and drive the robot into Forbidden zones and Unpreferred zones on the map. This means that the robot will only stop when it is very close to an obstacle and will not respond to zones on the map. This can result in injury to personnel or damage to equipment if the robot is not driven carefully.

- Drive carefully to avoid collisions with any personnel or objects when driving the robot in Manual mode.
- Avoid driving the robot manually without a clear visual of the robot.

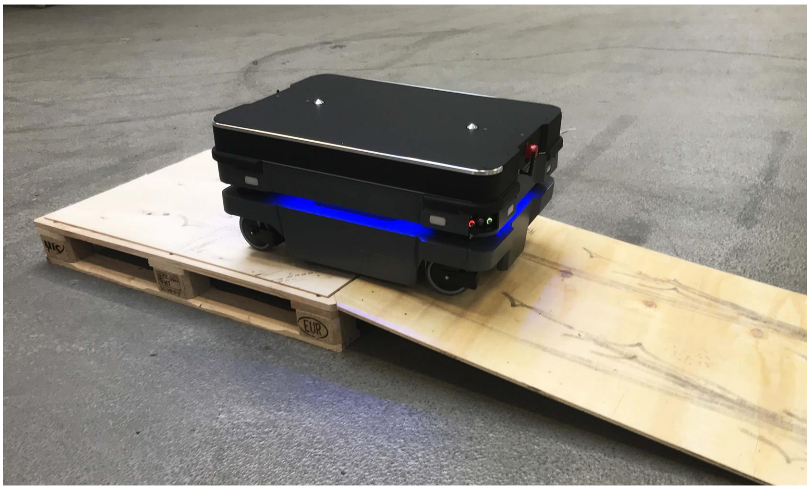
To drive the robot in Manual mode, follow these steps:

1. On the robot, turn the Operating mode key to Manual mode (turn it to the right).
2. In the robot interface, select **Manual control**. The Resume button on the robot starts blinking.

3. On the robot, press the Resume button. The status lights turn blue, indicating that the robot is in Manual mode.
4. In the robot interface, select the joystick icon. The joystick control appears.


5. Drive the robot off the ramp using the joystick.

Place your foot in front of the ramp while the robot drives on it to keep the ramp from slipping.



# 6.7 Moving the robot by hand

You should generally avoid moving the robot by hand, but if, for example, the robot gets stuck near an obstacle and cannot be moved by manual control, it is possible to do so.

Before moving the robot by hand, make sure the mechanical brakes are released.

To release the brakes, the robot must be turned on—see Connecting the battery on page 48. When the robot shuts down due to low battery, there is still enough power to use the manual brake release for a week or more.

Release the brakes by turning the Manual brake release switch located below the control panel clockwise.

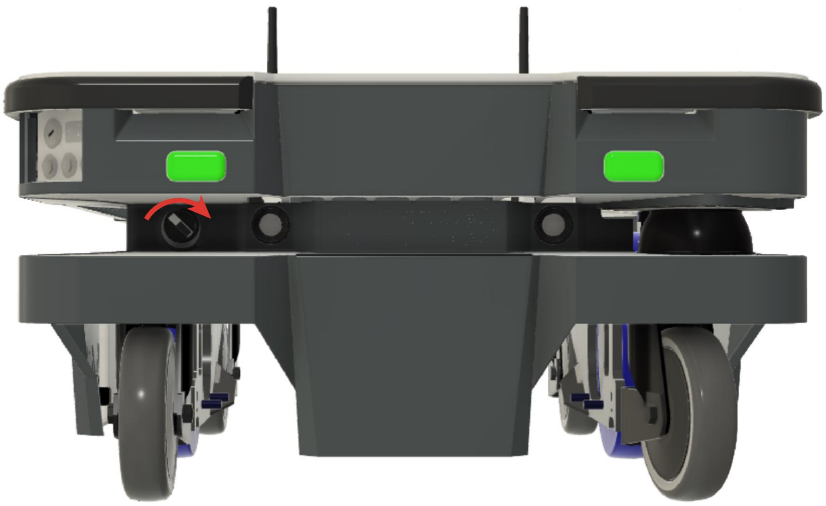


Figure 6.2. The Manual brake release switch is located below the control panel.

To move the robot by hand, either push or pull it.

Figure 6.3. When pushing the robot, only push on the top plate.

Figure 6.4. When pulling the robot, use either the front pull handle or the rear pull handle.

**NOTICE**

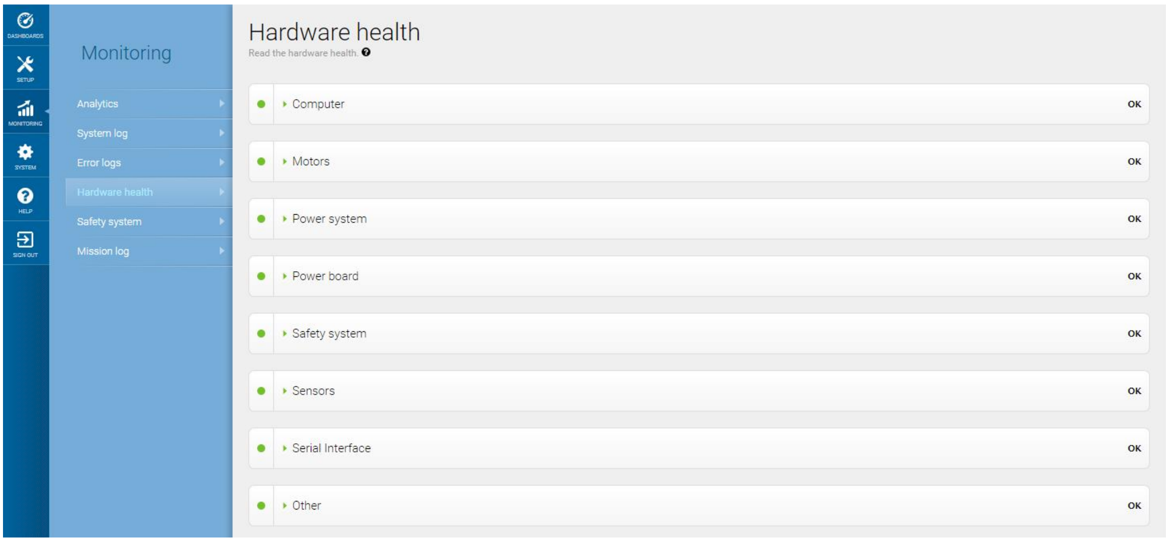
When handling the robot, do not push or pull the robot sideways, and do not use the covers for pushing or pulling. Only use the designated pull handles or the top plate.

# 6.8 Checking the hardware status

To check that all hardware components work as intended, follow these steps:

1. Sign in to the robot interface—see Connecting to the robot interface on page 52.
2. Go to **Monitoring > Hardware health**.

3. Check that all elements on the page have the **OK** status and that they have green dots on the left.




For more information, see Hardware health in *MiR Robot Reference Guide* on the MiR website.

# 6.9 Mounting the nameplate

Before using MiR250, you must mount its unique nameplate to it. The nameplate contains information specific to your MiR application—see Nameplate on page 16.

**NOTICE**

The nameplate must be mounted as described in the following steps. If mounted incorrectly, the CE mark is invalid.

To mount the nameplate correctly, follow these steps:

1. Locate the rear cover—see External parts on page 13.
2. Clean the area marked in the image below with a degreasing agent.

3. Mount the nameplate on the cleaned area.

# 6.10 Shutting down the robot

To shut down MiR250, follow these steps:

1. Ensure that the robot is not moving or executing an action.
2. Press the Power button for three seconds.

3. The robot starts the shutdown process. The status lights waver yellow, and the Power button blinks red.

4. When the robot finishes the shutdown process, the status and the signal lights go off, and the Power button turns blue.

When you shut down the robot for transportation, service, or repair, the battery must be disconnected—see Disconnecting the battery on page 63.

# 7. Battery and charging

The robot is powered by a fast swap lithium-ion battery that can be charged inside the robot with a MiR cable charger or a MiR Charge 48V charging station.

## 7.1 Charging the robot

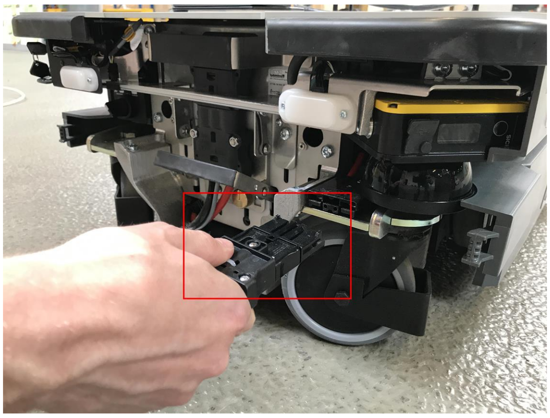
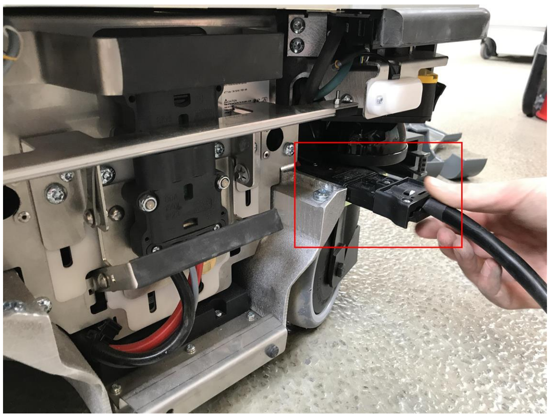
This section describes how to charge MiR250 using a MiR cable charger.

A MiR cable charger is not part of the MiR250 standard delivery. Contact your distributor for more information.

The robot is delivered 40-60% charged.

The rear compartment holds the robot's battery. To access the rear compartment, see Accessing the internal parts on page 38.

To charge MiR250 using the cable charger, connect the cable charger to the charging interface on the robot in the bottom-right corner.

Use only an original MiR cable charger.

If the robot has been inactive for more than a week or if its battery percentage has been below 5% for more than four hours, the battery goes into Power save mode, which disables the power to the robot—see Battery storage on the next page.

To disable Power save mode, disconnect the battery connector for 30 seconds and then reconnect it and wait 30 seconds before turning on the robot, or connect a MiR cable charger to the robot.

For information about the charging time, see specifications on the MiR website.

# 7.2 Disconnecting the battery

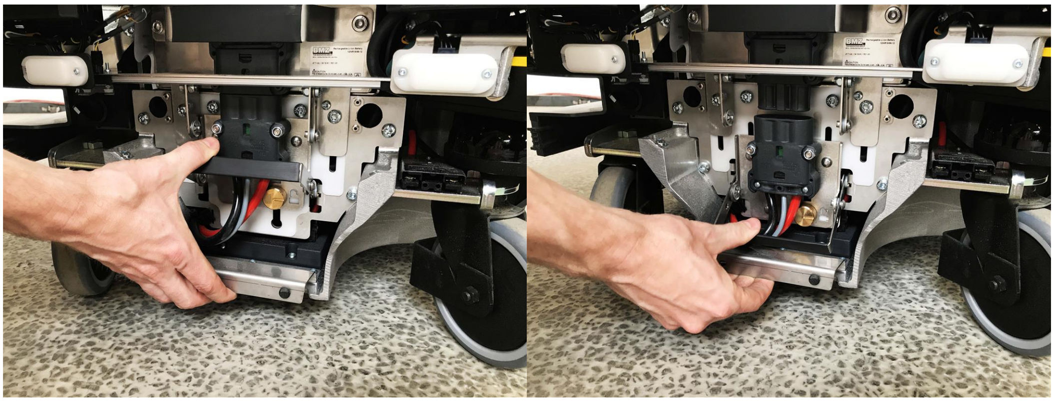
Whenever the robot is to be transported, undergo maintenance, or stored for long periods of time, you should always disconnect the battery.

The rear compartment holds the robot's battery. To access the rear compartment, see Accessing the internal parts on page 38.

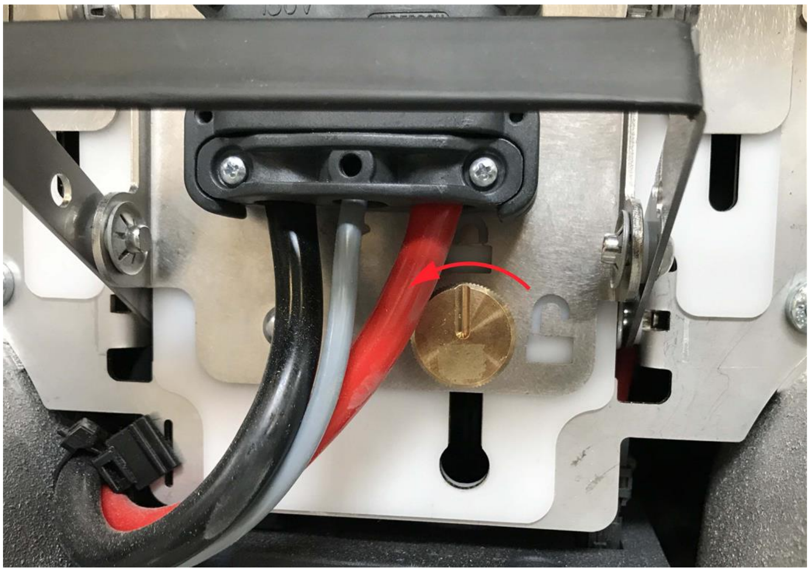
To disconnect the battery, follow these steps:

1. Turn the battery lock clockwise to release it.

2. Press down on the battery lever to disconnect the battery.



3. Turn the battery lock counterclockwise to lock it.



## 7.3 Battery storage

The battery should be stored in an area at room temperature with a non-condensing relative air humidity—see specifications on the MiR website. Temperatures and humidity below or above the specifications will shorten the service life of the battery.

The battery should not be exposed to nor submerged in any liquid as this may damage the battery.

Charge the battery before storage to preserve the service life of the battery.

> **NOTICE**
>
> If you store the battery for a longer period of time when it is almost depleted, you may not be able to get it running again. Contact your distributor if this occurs.

To preserve the battery, disconnect the battery from the robot before storing the robot.

## Power save mode

If the battery is not used for a period of time, it enters Power save mode. When the battery is in Power save mode, it will not power the robot until the battery is activated again.

To activate the battery after it has been in Power save mode, disconnect it from the robot for 30 seconds, reconnect it to the robot, wait 30 seconds, and then turn on the robot. If the robot cannot turn on, contact your distributor.

The amount of time it takes for the battery to enter Power save mode depends on the state of charge of the battery. The best state to store the battery at is when it is 80% charged. *Table 7.1* provides best practice values for storage time and the time it takes for the battery to enter Power save mode depending on the battery percentage.

**Table 7.1.**
Time taken for the battery to enter Power save mode and maximum storage time at various battery percentages

| Battery state of charge | Power save mode timeout | Maximum storage time |
|---|---|---|
| 100% | 1 week | 18 months |
| 75% | 1 week | 15 months |
| 50% | 1 week | 12 months |
| 25% | 1 week | 6 months |
| 5% | 4 hours | 2 months |
| 0% | 4 hours | 1 month |

The battery percentage displayed in the robot interface is based on when the robot will shut down due to low voltage. When the interface displays 0% battery percentage, the actual state of charge is around 5%

## Deep sleep

When the battery is completely depleted, the battery enters Deep sleep mode. It can be stored for six weeks in this state before the battery shuts down completely, and the battery cells may begin to take damage.

When you connect the battery to a charger, it should be brought out of Deep sleep mode, but if not, apply the same method as when it goes into Power save mode.

# 7.4 Battery disposal

Return unserviceable batteries to relevant facilities in accordance with local statutory regulations.

A crossed-out wheeled bin indicates that the product needs to be disposed separately and not as municipal waste—see *Figure 7.1*.

You are legally obliged to return used batteries and rechargeable batteries. Disposing used batteries in the household waste is prohibited. Batteries containing hazardous substances are marked with the crossed-out wheeled bin. The symbol indicates that it is forbidden to dispose the product via the domestic refuse. The chemical symbols for the respective hazardous substances are Cd= Cadmium, Hg = Mercury, Pb = Lead.

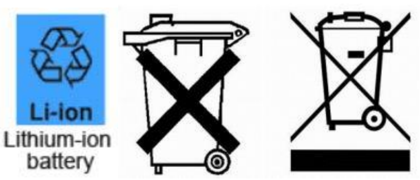



Figure 7.1. Battery disposal symbols.

# 8. IT security

IT security is a set of precautions you can take to prevent unauthorized personnel from accessing MiR250. This section describes the main IT-security related risks and how to minimize them when commissioning MiR250.

MiR250 communicates all data over the network that it is connected to. It is the responsibility of the commissioner to ensure that it is connected to a secure network. MiR recommends conducting an IT-security risk assessment before commissioning the robot.

Contact your distributor for a list of FAQs about IT security.

## 8.1 Managing users and passwords

Managing your users and passwords is the main way you can control access to MiR250.

There are three default users with predefined passwords for you to start using. These are described in the *MiR Robot Reference Guide* along with instructions to create new users, user groups, and passwords. MiR advises you to:

- Change the default password for all predefined users if you choose to continue to use them. Make sure to choose a strong password since MiR250 does not enforce any password rules nor expire the password.
- Create new user groups if more levels of access are necessary.
- Create dedicated user accounts under the relevant user group for each person accessing MiR250, and ensure that the users change the password on their first sign-in. It is not recommended to have several users share the same account.
- Only enable users with a minimum level of access to use a pin code to sign in. Users with a higher level of access are recommended to use a strong password to sign in instead.

## 8.2 Software security patches

To improve the security of MiR250, MiR supplies security patches to the operating system in new MiR software update files. When you install a security patch, it takes approximately 10-15 minutes longer to update a MiR product.

## Understanding MiR software versions

MiR uses the **Major.Minor.Patch.Hot fix** format to version software. For example, 2.8.1.1 means that the software is based on the second major release, the eighth minor release of the major version, the first patch release of the minor version, and, in this example, a single hot fix is included too.

- **Major releases** include the most significant changes that affect the entire robot software.
- **Minor releases** often include new features and smaller changes that only affect parts of the software.
- **Patch releases** focus on fixing small issues in the software and introducing quality improvements.
- **Hot fix releases** are only created when a patch release has introduced a critical issue that needs to be fixed immediately.

## Security patch policy

MiR applies the following policy when supplying security patches:

- New security patches are distributed per every minor release.
- All patch releases under a minor release include the previous security patches also. In other words, if you chose not to install the first software version in a minor release, such as version 2.9.0, the security patches will still be installed when you update to 2.9.1 or higher.

# 9. Navigation and control system

The navigation and control system is responsible for driving the robot to a goal position while avoiding obstacles. This section describes the processes and components involved in the robot's navigation and control system.

## 9.1 System overview

The purpose of the navigation and control system is to guide the robot from one position on a map to another position. The user provides the map and chooses the goal position the robot must move to. The diagram in *Figure 9.1* describes the processes in the navigation and control system.

The main processes involved in the navigation system are:

- Global planner
  The navigation process starts with the global planner determining the best path for the robot to get from its current position to the goal position. It plans the route to avoid walls and structures on the map.
- Local planner
  While the robot is following the path made by the global planner, the local planner continuously guides the robot around detected obstacles that are not included on the map.
- Obstacle detection
  The safety laser scanners, 3D cameras, and proximity sensors are used to detect obstacles in the work environment. These are used to prevent the robot from colliding with obstacles.
- Localization
  This process determines the robot's current position on the map based on input from the motor encoders, inertial measurement unit (IMU), and safety laser scanners.
- Motor controller and motors
  The motor controller determines how much power each motor must receive to drive the robot along the intended path safely. Once the robot reaches the goal position, the brakes are engaged to stop the robot.

Each part of the process is described in greater detail in the following sections.

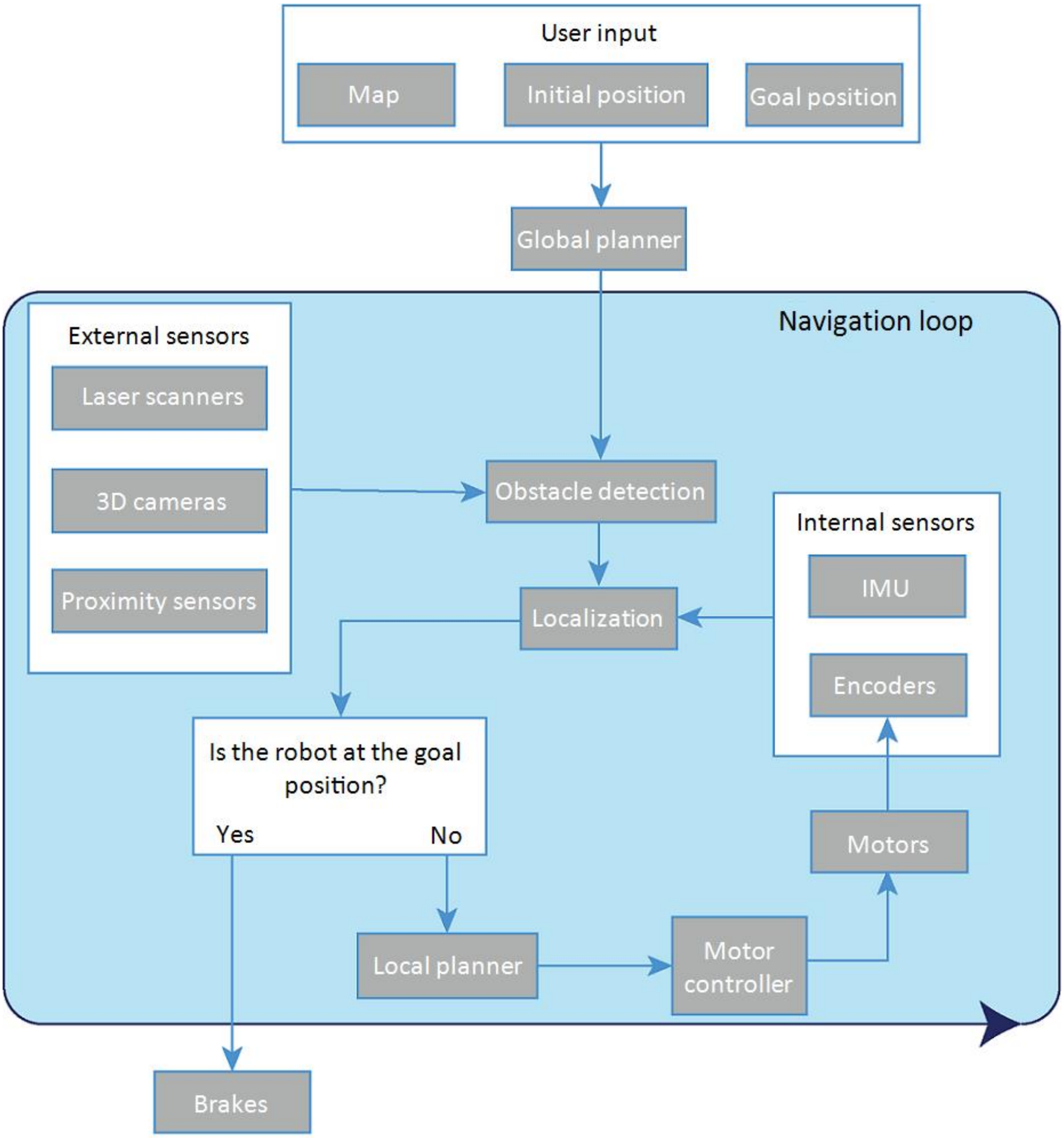



Figure 9.1. Flow chart of the navigation and control system. The user provides the necessary input for the robot to generate a path to the goal position. The robot executes the steps in the navigation loop until it reaches the goal position and stops by engaging the brakes.

# 9.2 User input

To enable the robot to navigate autonomously, you must provide the following:

- A map of the area, either from a .png file or created with the robot using the mapping function—see Creating and configuring maps on page 108.
- A goal destination on that map—see Markers on page 118.
- The current position of the robot on the map. This usually only needs to be provided when a new map is activated.

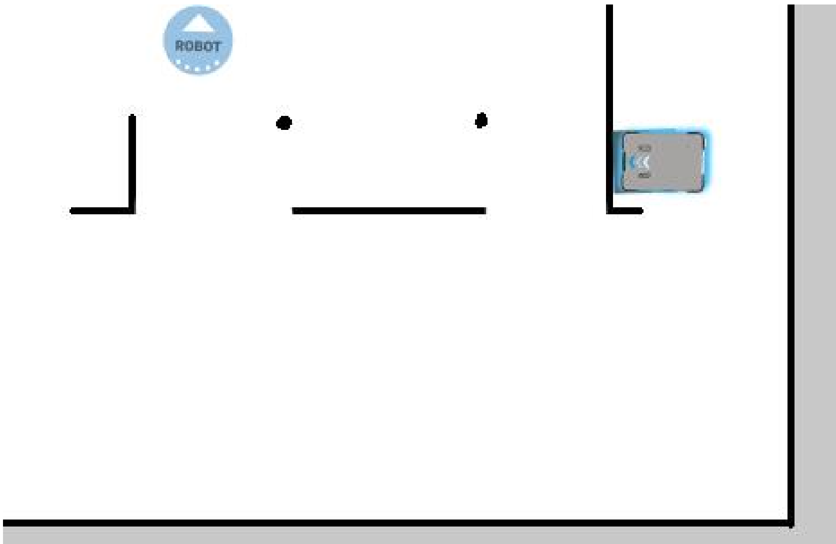



Figure 9.2. On the map, the current position of the robot is identified by the robot icon, and the goal destination in this example is the robot position. The robot computer now determines a path from the current position to the goal position.

Once the robot computer has a map with the robot's current position and a goal destination, it begins planning a route between the two positions on the map using the global planner.

# 9.3 Global planner

The global planner is an algorithm in the robot computer that generates a path to the goal position. This path is known as the global path.

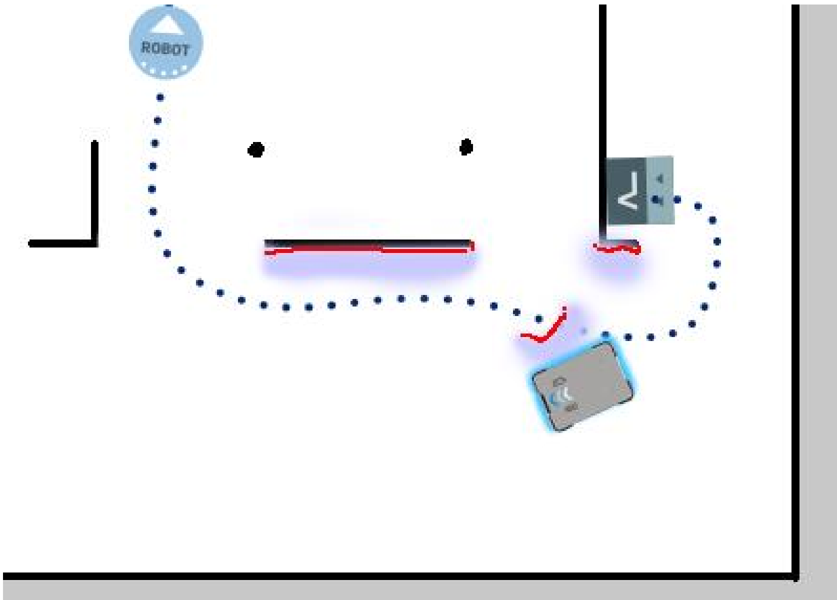



Figure 9.3. The global path is shown with the blue dotted line that leads from the start to the goal position.

The global path is created only at the start of a move action or if the robot has failed to reach the goal position and needs to create a new path. The generated path only avoids the obstacles the robot detected when the path was made and the obstacles marked on the map. The global path can be seen in the robot interface as a dotted line from the robot's start position to the goal position.


Figure 9.4. The dotted line from the start position of the robot to the goal position is the global path generated by the robot computer.

# 9.4 Local planner

The local planner is used continuously while the robot is driving to guide it around obstacles while still following the global path.

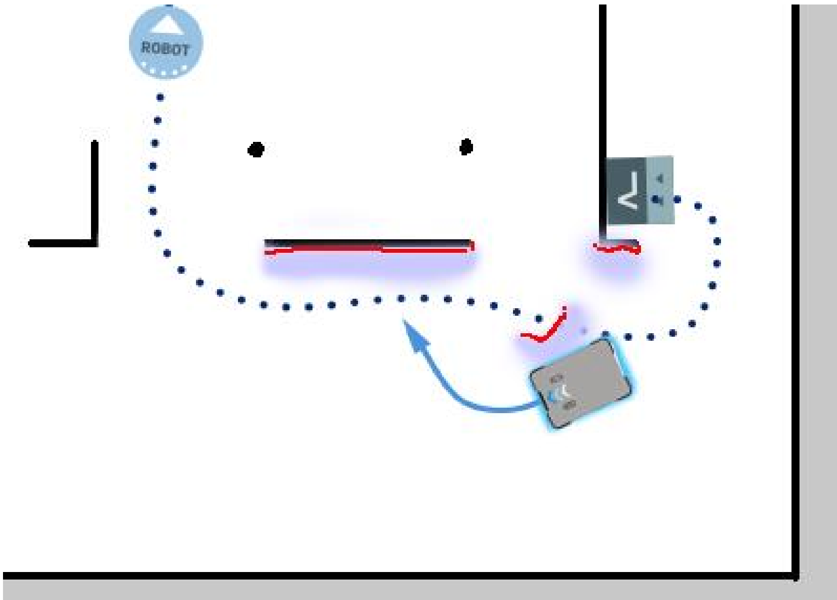



Figure 9.5. The global path is indicated with the dotted blue line and is visible on the map. The local path is indicated with the blue arrow, showing the robot driving around a dynamic obstacle.

Whereas the global planner creates a single path from start to finish, the local planner continues to create new paths that adapt to the current position of the robot and the obstacles around it. The local planner only processes the area that is immediately surrounding the robot, using input from the robot sensors to avoid obstacles.

The local path is not displayed in the robot interface. The arrows in the images here are visual aids used in this guide only.

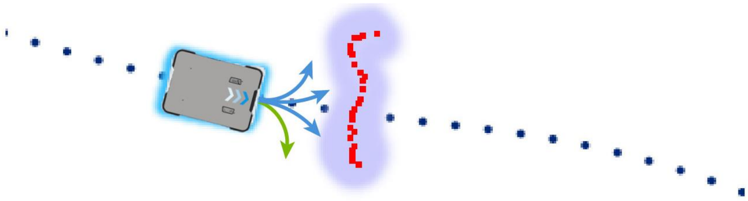


Figure 9.6. The local planner usually follows the global planner, but as soon as an obstacle gets in the way, the local planner determines which immediate path will get the robot around the obstacle. In this case, it will likely choose the path indicated with a green arrow.

Once the local path is determined, the robot computer derives the desired rotational velocity of each drive wheel to make the robot follow the local path and sends the desired velocities for each motor to the motor controllers—see Motor controller and motors on page 82.

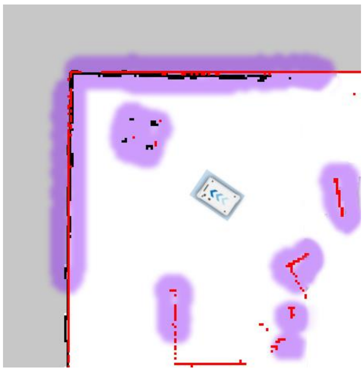
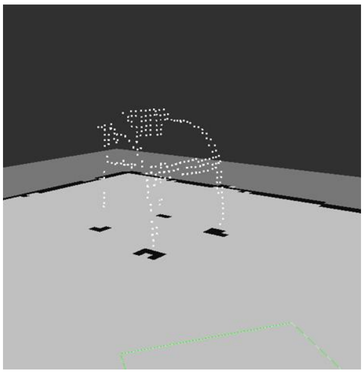
## 9.5 Obstacle detection

The robot detects obstacles continuously while driving. This enables the robot to use the local planner to drive around obstacles and to determine the robot's current position on the map.

Three sensor types are responsible for detecting obstacles:

- The safety laser scanners
- The 3D cameras
- The proximity sensors

**Table 9.1.**
Description of how the robot sees obstacles with its sensors

| What a human sees | What the laser scanners see | What the 3D cameras see |
| --- | --- | --- |
|  |  |  |
| A chair placed in the corner of a room is detectable by the robot. | In the robot interface, the red lines on a map are obstacles detected by the laser scanners, and the purple clouds are an aggregate of the 3D camera and laser scanner data. The scanners only detect the four legs of the chair. | The 3D cameras detect more details of the chair when the robot gets close enough to it. This view cannot be seen in the robot interface. |

## Safety laser scanners

Two safety laser scanners, diagonally placed on one front and one rear corner of the robot, scan their surroundings. Each safety laser scanner has a 270° field of view, overlapping and thus providing a full 360° visual protection around the robot.

When in motion, the safety laser scanners continuously scan the surroundings to detect objects.

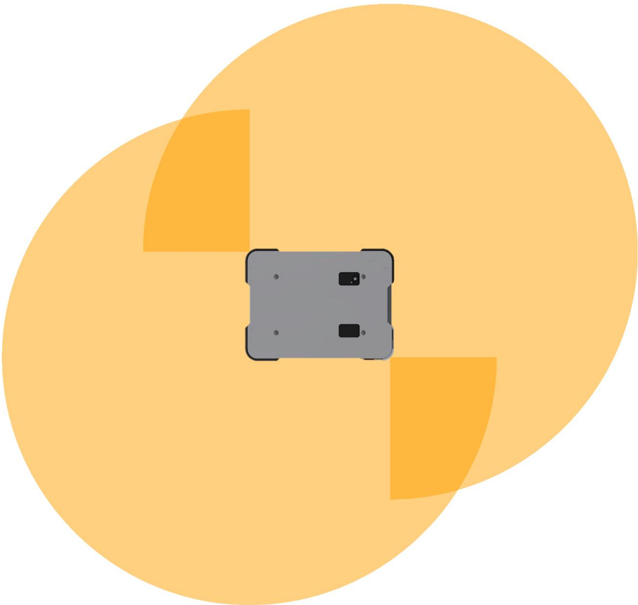


Figure 9.7. The two safety laser scanners together provide a full 360° view around the robot.

The laser scanners have the following limitations:

- They can only detect objects that intersect a plane at 200 mm height from the floor.
- They do not detect transparent obstacles well.
- The scanner data can be inaccurate when detecting reflective obstacles.
- The laser scanners may detect phantom obstacles if they are exposed to strong direct light.

If you are using the robot in an area with walls made of glass or reflective material, mark the walls as Forbidden zones on the map, not as walls—see Creating and configuring maps on page 108. Walls on the map that the robot cannot detect will confuse the robot's navigation system.

## 3D cameras

Two 3D cameras positioned on the front of the robot detect objects in front of the robot. The 3D cameras detect objects:

- Vertically up to 1800 mm at a distance of 1200 mm in front of the robot.
- Horizontally in an angle of 114° and 250 mm to the first view of ground.

The 3D cameras are only used for navigation. They are not part of the robot's safety system.

The camera readouts are used as 3D point cloud data. They are not recording recognizable objects or people.

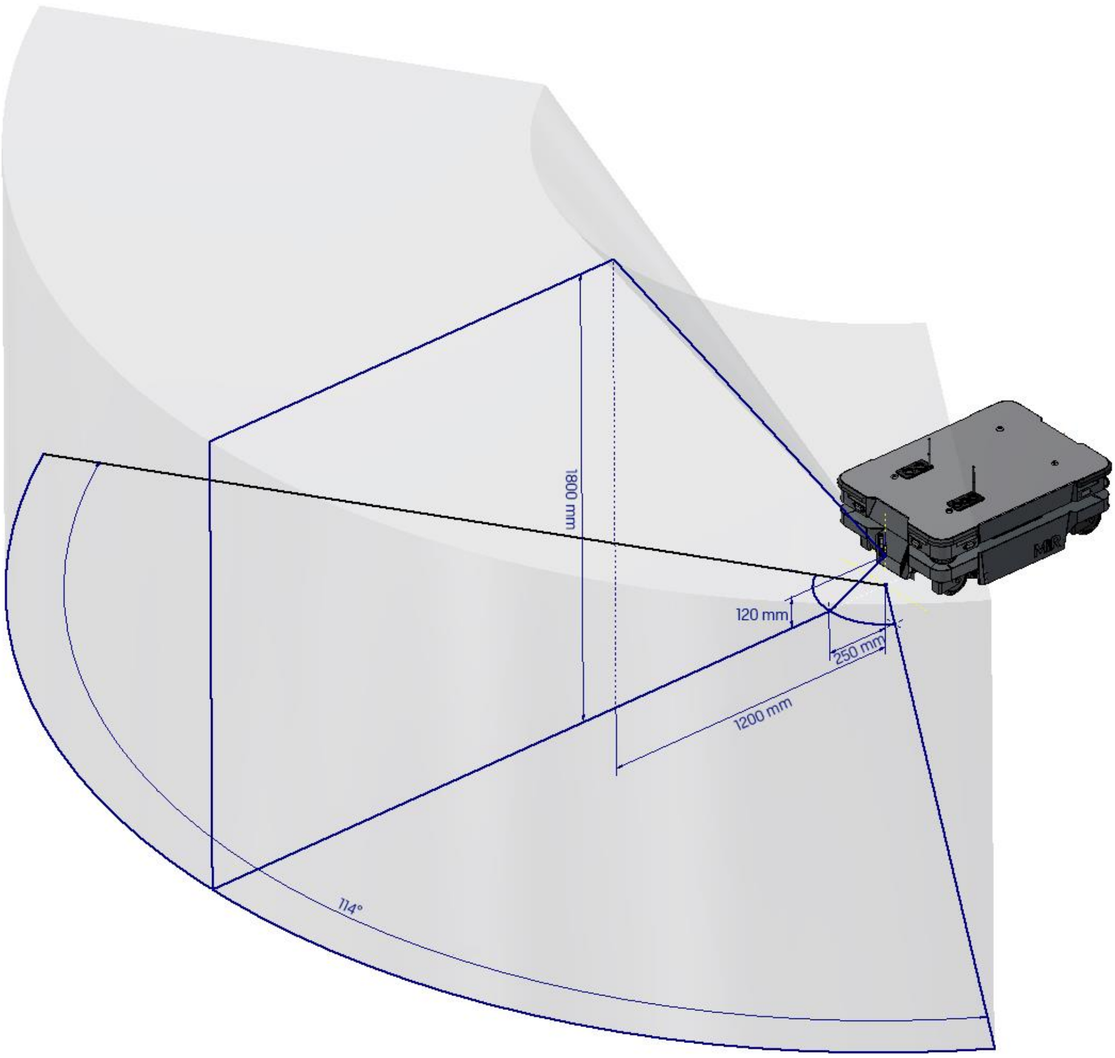



Figure 9.8. The two 3D cameras can see objects up to 1800 mm above floor height at a distance of 1200 mm in front of the robot and have a horizontal field of view of 114°.

The 3D cameras have the following limitations:

- They can only detect objects in front of the robot, unlike the full 360° view of the laser scanners.
- They do not detect transparent or reflective obstacles well.
- They do not detect holes or decending stairways.
- The cameras are not reliable at determining depth when viewing structures with repetitive patterns.
- The cameras may detect phantom obstacles if they are exposed to strong direct light.

## Proximity sensors

Proximity sensors placed in all four corners of the robot detect objects close to the floor that cannot be detected by the safety laser scanners.

Using infrared light, the proximity sensors point downwards and make sure that the robot does not run into low objects, such as pallets and forklift forks. They have a range between 5-20 cm around the robot.

Because of the proximity sensor's limited range, the data from them is only useful when the robot is standing still or moving at reduced speeds, for example, when the robot it pivoting or docking.

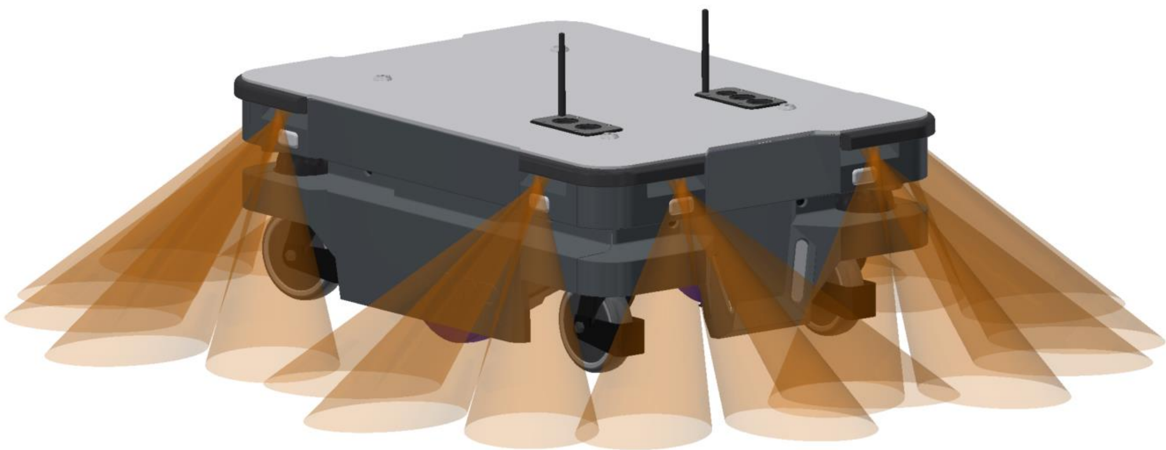


Figure 9.9. The proximity sensors in the corners of the robot detect objects below the safety laser scanners' plane of view.

The proximity sensors have the following limitations:

- They do not have a long range and are mainly used to detect obstacles missed by the laser scanners and cameras.
- When the robot is driving fast, obstacles detected by the proximity sensors are too close for the robot to stop for or avoid.

# 9.6 Localization

The goal of the localization process is for the robot to determine where it is currently located on its map. The robot has three inputs for determining where it is:

- The initial position of the robot. This is used as a reference point for the methods used to determine the robot position.
- The IMU and encoder data. This is used to determine how far and fast the robot has traveled from the initial position.
- The laser scanner data. This is used to determine the likely positions of the robot by comparing the data with nearby walls on the map.

This data is used by a particle filter to determine the most likely position of the robot on the map.

## IMU and motor encoders

Both the data from the IMU (Inertial Measurement Unit) and motor encoders is used to derive where and how fast the robot has traveled over time from its initial position. The combination of both sets of data makes the derived position more accurate.

If the drive wheels are worn down significantly—see Maintenance on page 184—or the robot is running with an incorrect gear ratio, the robot will miscalculate how far it has traveled based on the encoder data.

## Laser scanners and particle filtering

The robot computer compares the input from the laser scanners with the walls on the map to try and find the best match. This is done using a particle filter algorithm. The robot computer only compares input from the area where it expects the robot to be based on the encoder and IMU data. Therefore, it is important that the initial position of the robot is correct.

| Failed localization | Successful localization |
| --- | --- |

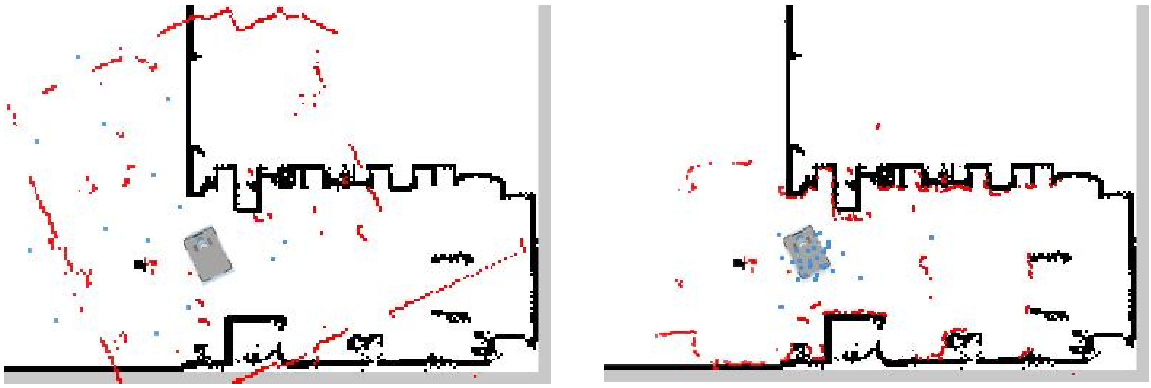
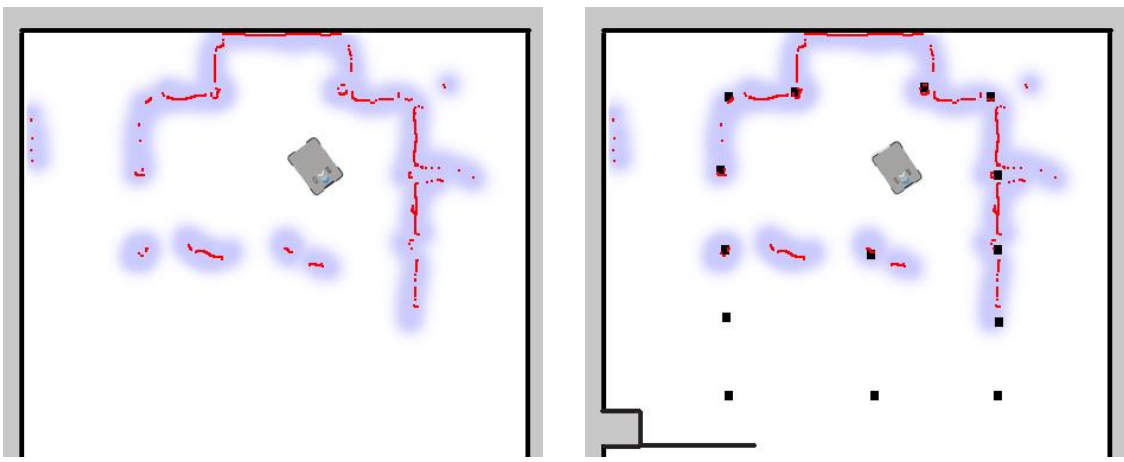


Figure 9.10. In a failed localization, the robot cannot determine a position where the red lines (laser scanner data) align with the black lines on the map. When the robot can localize itself, it determines a cluster of likely positions, indicated in the images above as blue dots.

To make sure the robot can localize itself well using particle filtering, consider the following when creating a map:

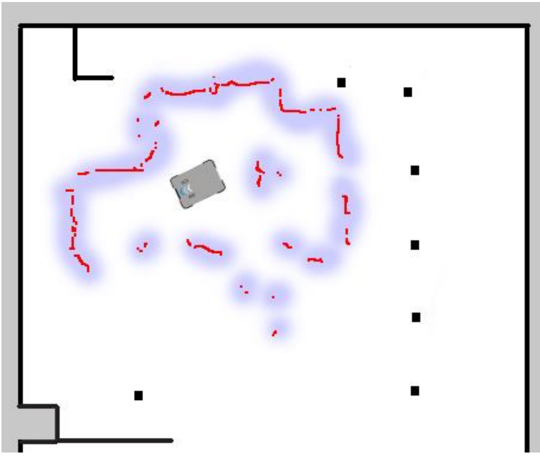
- There must be unique and distinguishable static landmarks on the map that are easily recognizable. A landmark is a permanent structure that the robot can use to orient itself, such as corners, doorways, columns, and shelves.

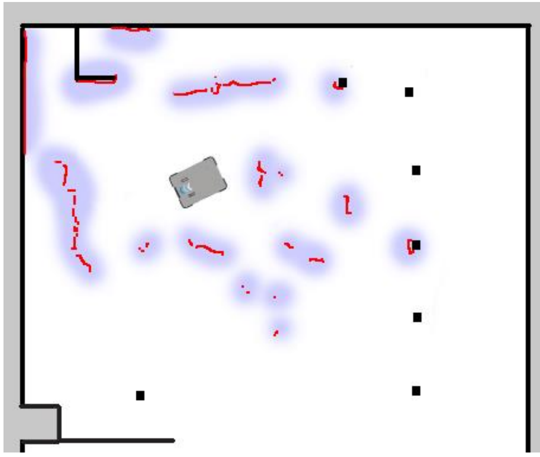
| No distinguishable landmarks | Many distinguishable landmarks |
| --- | --- |



- The robot must be able to detect the static landmarks that are marked on the map to be able to approximate its current position. Make sure there are not too many dynamic obstacles around the robot so that it cannot detect any static landmarks.

**Cannot detect any static landmarks** | **Can detect enough static landmarks**





- To improve the robot's localization, it can often help to divide long continuous walls on the map. Even if the walls are connected in the actual work environment, it can help the localization process if the walls on the map are divided into smaller sections.

**Undivided walls** | **Divided walls**

- The robot does not compare the laser scanner data with the entire map, but only around the area that it expects to be close to based on the IMU and encoder data and its initial position. This is why it is important that the initial position you place the robot at on the map is accurate.
- The robot can drive for a short distance without being correctly localized. As it drives, the estimated positions should converge to a small area, indicating the robot has determined an accurate estimate. If this does not occur within a set time limit, the robot reports a localization error.

# 9.7 Motor controller and motors

The robot keeps adjusting how much power is sent to each motor based on sensory input. This means the robot can correct its speed when going up slopes or when carrying a heavier payload, and it can change its driving direction to avoid moving obstacles.

# 9.8 Brakes

Once the approximated position of the robot determined from localization is the same as the goal position calculated by the global planner, the robot stops by using the dynamic brake function.

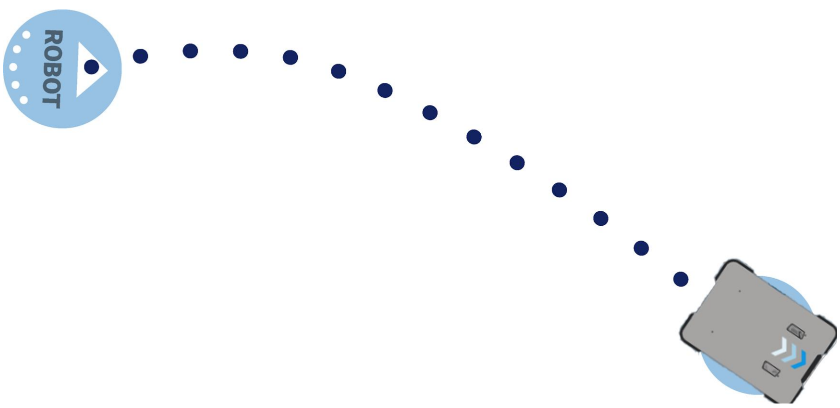



Figure 9.11. The robot has reached the goal position and stops by engaging the dynamic brake function.

The dynamic brake function stops the robot by short circuiting the power that was used to rotate the motor. When this happens, the power that was used to drive the robot forward is now reversed to stop the rotation of the drive wheels.

Once the robot has stopped, the mechanical brakes are enabled. These brakes are used to keep the robot in place once it has stopped. You can compare the mechanical brakes with the parking brake or hand brake in a car.

The mechanical brakes are only used to stop the robot when it is in motion in emergency situations triggered by the safety system.

The mechanical brakes are automatically released again when the robot receives a new order requiring it to move.

# 10. Safety system

The robot's safety system is designed to mitigate significant hazards which could lead to injury, for example, stopping the robot if a person is in its path.

MiR250 is equipped with a range of built-in safety-related functions as well as safety-related electrical interfaces designed for integration with a top module. Each safety function and interface is designed according to the standard ISO 13849-1. The safety-related functions and interfaces are selected to support compliance with EN 1525 and ISO 3691-4.

## 10.1 System overview

The safety system is controlled mainly by the safety PLC. The PLC regulates inputs and outputs from safety-related functions or interfaces involved with ensuring the safety of personnel working nearby the robot.

If a safety function is triggered, the robot uses its STO (Safe Torque Off) contactors to bring the robot to a category 0 stop (stopping by “immediate removal of power to the machine actuators" according to IEC 60204-1) followed by a controlled brake using an SS1 (Safe Stop 1) function. This is known as bringing the robot into Emergency stop or Protective stop, depending on the function—see Types of stop below.

Some interfaces are also used to signal safety-related states between the top module and robot, for example whether the robot is in motion or if the top module is in a state where the robot must stop or slow down. Each of these are connected through the safety-related electrical interfaces through two identical circuits to ensure redundancy.

### Types of stop

There are four different stopped states:

- Operational stop
- Protective stop
- Emergency stop
- Manual stop

The last three types of stop are monitored by the safety PLC.

## Operational stop

The robot is in Operational stop when it is stopped through the robot interface either through a mission action or by pausing the mission. The top module and all moving parts are still connected to a power supply.

## Protective stop

The robot enters Protective stop automatically to ensure the safety of nearby personnel. When the robot enters Protective stop, internal safety contactors are switched so the robot's top module and all moving parts of the robot do not receive power. You can hear the safety contactors emit audible clicks when they are switched.

When the robot is in Protective stop, the status lights of the robot turn red, and you are not able to move the robot or send it on missions until you bring the robot out of the Protective stop. The following cases describe the various Protective stops and how to bring the robot out of them:

- **A safety laser scanner detects an object in its active Protective field**
  Remove the object from the active Protective field—see Personnel detection on page 89. The robot will resume its operating state after two seconds.
- **The robot finishes the startup process**
  The Resume button will flash after startup. Press the flashing Resume button to bring the robot out of Protective stop.
- **Switching between Manual mode and Autonomous mode**
  After turning the Operating mode key to switch operating modes, the robot enters Protective stop, and the Resume button flashes. Press the Resume button to bring the robot out of Protective stop.
- **The safety system detects a fault, or the motor control system detects a discrepancy**
  To bring the robot out of Protective stop, resolve the fault causing the error. Use information regarding the error from the robot interface to determine the fault. Go to **Monitoring > Hardware health** to find specific information on what caused the issue. For further guidance, see the troubleshooting guides on the Distributor site.

## Emergency stop

The robot enters Emergency stop when an Emergency stop button has been pressed physically. When you press the Emergency stop button, internal safety contactors are switched so the robot's top application and all moving parts of the robot do not receive power. You can hear the safety contactors emit audible clicks when they are switched.

When the robot is in Emergency stop, the status lights of the robot turn red, and you are not able to move the robot or send it on missions until you bring the robot out of the Emergency stop. To do this, you must release the Emergency stop button and then press the Resume button. The Resume button begins flashing blue after you have released the Emergency stop button. If the robot is in Emergency stop, it will immediately resume an operating state after you press the flashing Resume button.

Figure 10.1. MiR250 has one Emergency stop button that must be connected through the electrical interface. You can also connect the interface to a series of additional Emergency stop buttons.

**CAUTION**

Emergency stop buttons are not designed for frequent use. If a button has been used too many times, it may fail to stop the robot in an emergency situation, and nearby personnel may be injured by electrical hazards or collision with moving parts.

- Only press Emergency stop buttons in emergencies.
- Regularly check that all Emergency stop buttons are fully functional—see Maintenance on page 184.
- Use the robot interface to stop the robot in non-emergency situations.

## Manual stop

The robot enters Manual stop when the red Stop button in the control panel is pressed. Manual stop brings the robot into the same state as a Protective stop where it can only be brought to an operational state by pressing the Resume button.

Figure 10.2. The Stop button is the left-most button on the control panel.

## Safety-related functions

The following functions are integrated within the robot itself and cannot be modified or used with other applications. The following list introduces the main safety-related functions integrated in MiR250:

- Personnel detection
  This function ensures that the robot stops before it collides with personnel or an object. If the laser scanners detect an object or person within a defined Protective field, the robot is brought to a stop. The function determines what the current speed of the robot is based on data from the motor encoders, and the function switches between predefined Protective fields accordingly. The faster the speed, the larger the Protective field is.
- Overspeed avoidance
  The safety system monitors if the motor encoder data indicates that the speed of each motor is above the limits for maximum rated speed. If the limit is exceeded, the robot enters Protective stop.
- Stability
  The safety system monitors if the motor encoder data indicates that the speed difference between the two motors are above predefined limits. If the limit is exceeded, the robot enters Protective stop.

## Safety-related electrical interfaces

The following interfaces are parts of the Auxiliary emergency stop and Auxiliary safety function interfaces that can be used to connect the safety PLC to a top module—see Internal parts on page 21. Each electrical interface is redundant, meaning they use two identical circuits. If one of the circuits fail, the robot enters Protective stop until both circuits are working correctly again and the robot is restarted, ensuring safe communication between the top module and robot—see Interface specifications on page 199.

The following list introduces the main safety-related electrical interfaces between MiR250 and its top module:

- Emergency stop circuit
  The Emergency stop circuit goes through the Auxiliary emergency stop interface and connects to the top module. It is intended that any number of Emergency stop buttons can be connected to the circuit. When the circuit is broken, the robot goes into Emergency stop.
- Safeguarded stop
  This function consists of a circuit that goes through the Auxiliary safety function interface that connects to the top module. This circuit can be used to bring the robot into Protective stop until otherwise signaled.
- Locomotion
  The locomotion function signals when the robot is driving. A top module can be connected to this interface if the top module should operate differently when the robot is driving, such as activating brakes or disconnecting the power to actuators.
- Shared emergency stop
  This function consists of a shared circuit between the robot and top module, enabling them to trigger each other into an Emergency stop.
- Reduced speed
  The reduced speed function can be connected to a top module, enabling it to make the robot reduce its speed to 0.3 m/s. This is for example used by MiR lifts to ensure that the robot does not drive fast when the lift is raised.

These functions are described in further detail in the following sections.

The diagram in *Figure 10.3* shows the inputs to these functions and interfaces and how they are all connected and monitored by the safety PLC. The safety PLC is able to switch the safety contactors to cut off power to the robot motors and the top module whenever a

Protective or Emergency stop is triggered. Also, the safety PLC sends information to the robot computer to be displayed in the robot interface (go to **Monitoring > Hardware health**) and to indicate the robot's status through the status lights and the speaker.

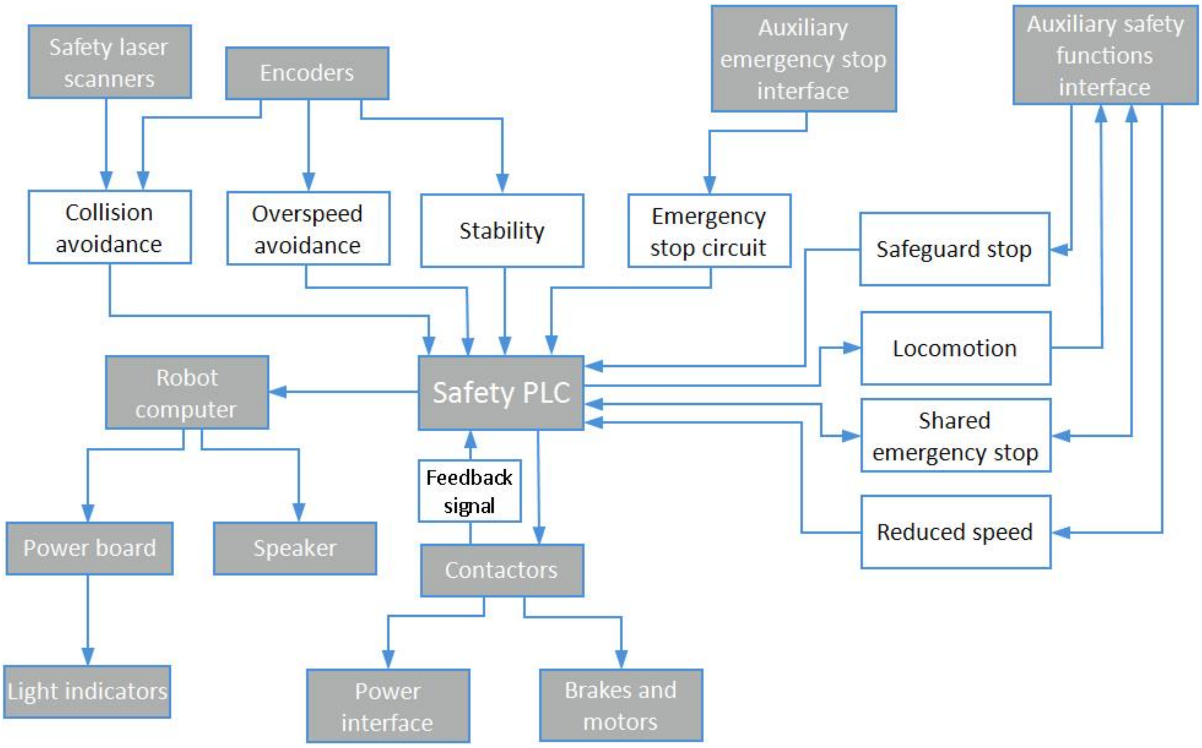



Figure 10.3. Overview of components involved in each safety function and interface. When a safety function is triggered, the safety PLC switches the STO and brake contactors so the brakes, motors, and power supply to the top module no longer receive power.

# 10.2 Personnel detection

The Personnel detection safety function prevents the robot from colliding with personnel or obstacles by stopping it before it collides with any detected obstacles. It does this using the safety laser scanners.

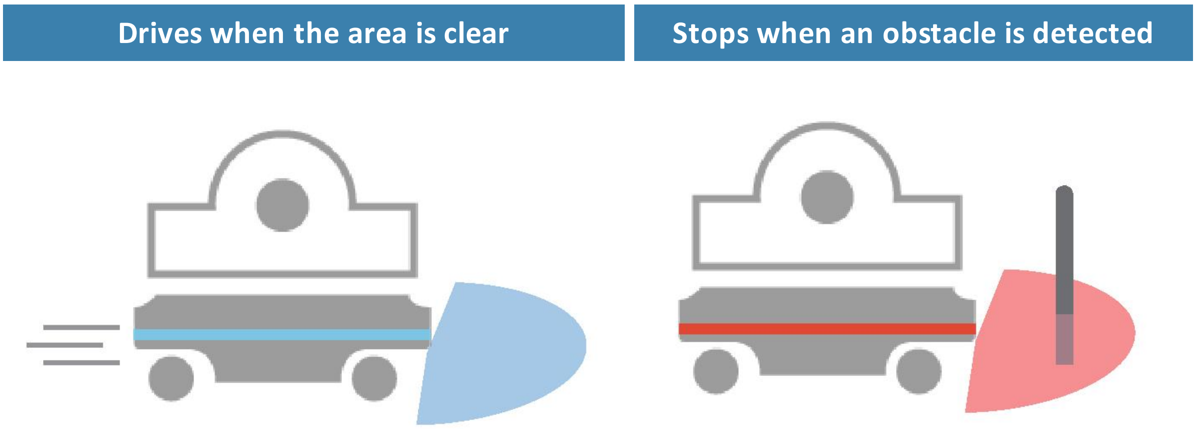



Figure 10.4. Personnel detection ensures that the robot drives when its path is clear and stops if an obstacle is detected within its Protective field.

The safety laser scanners are programmed with two sets of Protective fields. One field set is used when the robot is driving forward and the other when it is driving backward. The Protective field sets are part of the robot’s Personnel detection safety function. Each Protective field in the sets is an individually configured contour around the robot. The robot activates the correct field based on the speed. If a person or object is detected within the active Protective field, the robot enters Protective stop until the Protective field is cleared of obstacles for at least two seconds.

The tables in the following sections show the sizes of the Protective fields at given speeds. The faster the robot moves, the larger the scanners' field is. The speed of the robot is determined based on the encoder data.

The Protective fields on each side of MiR250 are 210 mm at all speeds.

**WARNING**

The Protective field sets are configured to comply with the safety standards of MiR250. Modifications may prevent the robot from stopping in time to avoid collision with personnel and equipment. Any modifications of the SICK configuration requires a new CE certification of the robot and compliance to all safety standards listed in the specification of the application and in other way declared.

- Do not modify the safety system without a competent third party to evaluate the safety of the design and performance of the robot after the modifications are applied.

## Field set when driving forward

The following table shows speeds and the field range when driving forward. The table describes the length of the Protective field in front of the robot in different cases. Each case is defined by a speed interval that the robot may operate at. The colors and cases in *Table 10.1* correspond to the field set shown in *Figure 10.5*.

**Table 10.1.**
Range of the robot's Protective fields within its forward speed interval cases.

| Case | Speed | Protective field range | Comments |
|---|---|---|---|
| 1 | 0.0 to 0.10 m/s | 0-80 mm | When pivoting |
| 2 | 0.10 to 0.30 m/s | 0-180 mm | |
| 3 | 0.30 to 0.50 m/s | 0-360 mm | |
| 4 | 0.50 to 0.90 m/s | 0-780 mm | |
| 5 | 0.90 to 1.30 m/s | 0-1350 mm | |
| 6 | 1.30 to 1.70 m/s | 0-2100 mm | |
| 7 | 1.70 to 2.10 m/s | 0-2850 mm | Forward at max. speed |

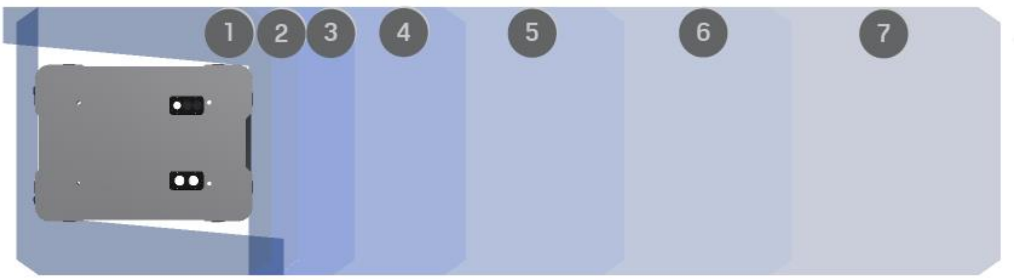



Figure 10.5. The illustration shows the field set contours when the robot drives forward. The range of the active field changes with the robot's speed.

## Field set when driving backward

The field set for driving backward is the same as the field set for driving forward. However, the robot is limited to a top speed of 1.0 m/s when driving backward and therefore only has five fields. The colors and cases in *Table 10.2* correspond to the field set shown in *Figure 10.6*.

**Table 10.2.**
Range of the robot's Protective fields within its backward speed interval cases.

| Case | Speed | Protective field range | Comments |
|---|---|---|---|
| 1 | 0.0 to -0.10 m/s | 0-80 mm | When pivoting |
| 2 | -0.10 to -0.30 m/s | 0-180 mm | |
| 3 | -0.30 to -0.50 m/s | 0-360 mm | |
| 4 | -0.50 to -0.90 m/s | 0-780 mm | |
| 5 | -0.90 to -1.00 m/s | 0-1350 mm | Backward at max. speed |

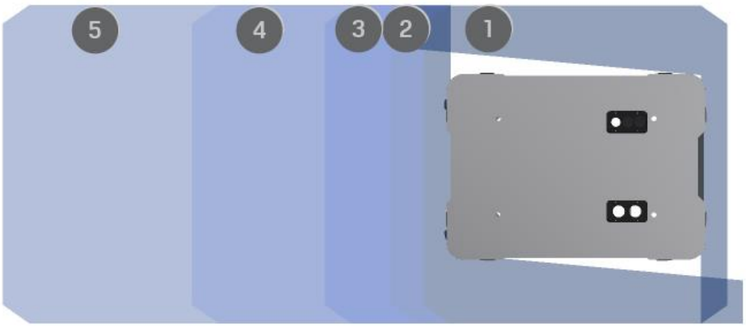



Figure 10.6. The illustration shows the field set contours when driving backward. The range of the active field changes with the robot's speed. The illustration also shows how the front scanner reduces its Protective field to a minimum when the robot moves backward.

**NOTICE**

Scanners measure distances to diffuse reflections, which means that a tolerance is added to the Protective field sets to secure a safe detection of persons crossing the Protective field sets. The tolerance distance is 65 mm.

## Muted Protective fields

When performing tasks that require the robot to move very close to surrounding objects, the robot mutes the Protective field sets.

**CAUTION**

When the robot has muted Protective fields, it may not stop in time to avoid collisions with obstacles or personnel in its path.

- Mark areas where the robot mutes its Protective fields as operating hazard zones, and inform personnel not to enter the zone while the robot is operating in it.

When muting the Protective fields, the robot does the following:

- Reduces the size of the field sets
- Turns off Collision detection
- Decreases the speed
- Flashes the yellow signal lights

You can also mute the Protective fields using the robot interface:

1. Put the robot into Manual mode—see Driving the robot in Manual mode on page 53.
2. In the robot interface, select **Muted Protective fields** in the joystick control.
3. In the dialog box, select **Yes** to acknowledge the muting of the Protective fields.

The status and the signal lights start flashing yellow, and the robot is ready to drive with muted Protective fields.

# 10.3 Overspeed avoidance

The overspeed avoidance function prevents the robot from driving if the motor encoders measure that the robot is driving faster than the predefined safety limit. This can occur if there is a hardware error in the robot, or if it drives down a steep slope.

If the robot is driving faster than the predefined safety limit, it is immediately brought into Protective stop. This ensures that the robot cannot drive if its speed cannot be controlled.

## 10.4 Stability

The stability function prevents the robot from driving if the motor encoders measure that the expected difference between how fast each wheel turns is outside the predefined safety limits. This indicates that the robot is not driving as intended, for example, if one of the wheels loses traction.

If the robot detects instability, it is immediately brought into Protective stop. This ensures that the robot cannot drive if it has lost control of the speed of each drive wheel.

## 10.5 Emergency stop circuit

The Emergency stop circuit goes through the Auxiliary emergency stop interface and uses external input to bring the robot into an Emergency stop. The interface uses two output pins to provide a 24 V signal and two input pins to bring the robot into Emergency stop.

It is intended that the circuit is set up so the 24 V signal delivered from the safety PLC outputs passes through all Emergency stop buttons of the top module and then continues to the two input pins. When the input pins both receive 24 V, the robot can operate. The connected Emergency stop buttons must break the circuit when you press them so both inputs receive a 0 V signal that will bring the robot into Emergency stop.

If the circuit or an Emergency stop button is installed incorrectly so the input signals are not the same, the robot enters Protective stop until the circuit is fixed.

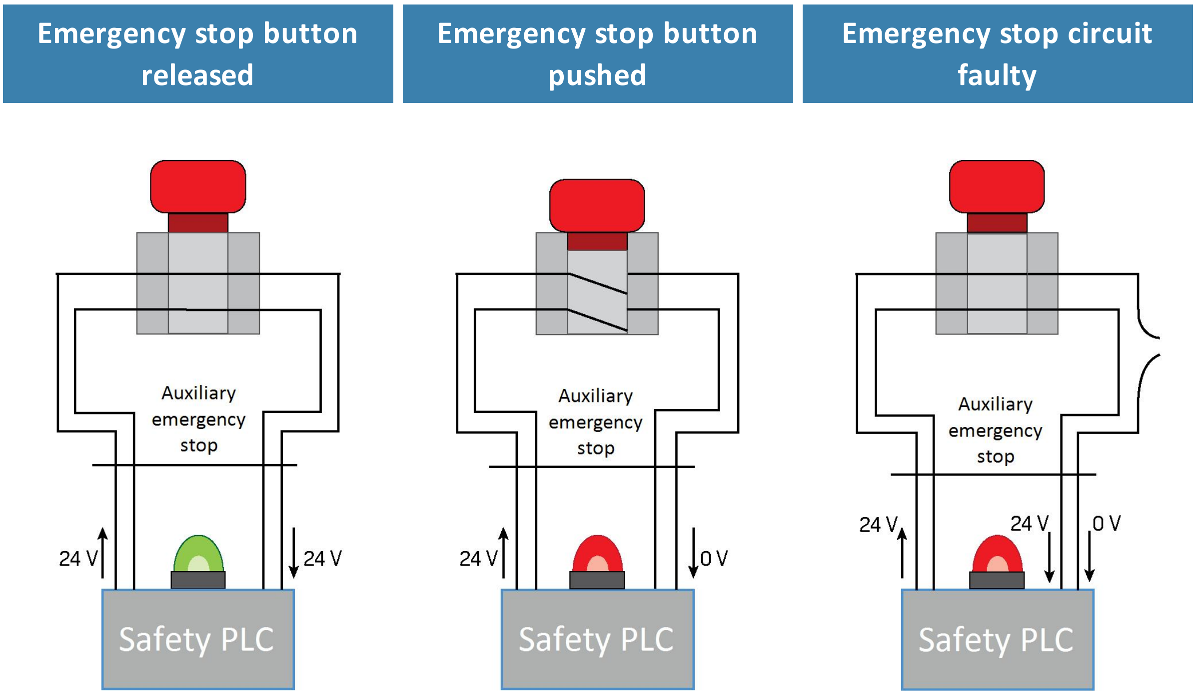



Figure 10.7. If the input pins deliver 24 V to the robot, it can operate. When you push a connected Emergency stop button, both pins deliver 0 V, and the robot enters Emergency stop. If the pins do not deliver the same input, the robot enters Protective stop until the circuits are fixed.

In the Auxiliary emergency stop interface, pins 2 and 3 deliver 24 V from the safety PLC, and pins 4 and 5 connect to the Emergency stop circuit inputs of the safety PLC. 24 V must be delivered to pins 4 and 5 for the robot to operate.

# 10.6 Safeguarded stop

The safeguarded stop interface provides an input to the robot that can bring the robot into Protective stop. This interface uses two input pins where both pins must receive 24 V for the robot to be able to operate. If either or both pins receive 0 V, the robot is brought into Protective stop. The robot can be brought out of Protective stop again if both pins receive 24 V again.

If the pins are unequally set for more than three seconds, the safety PLC registers this as an error in the system and needs to be reset before the robot can operate again. To do this, you must restart the robot.

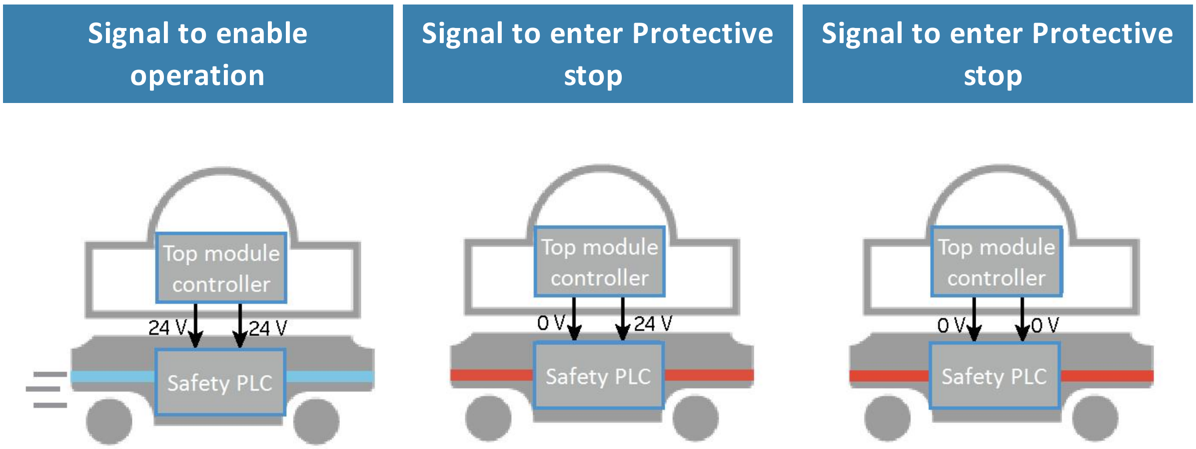



Figure 10.8. If both pins deliver 24 V to the robot, it can operate. If either or both of the pins deliver 0 V, the robot enters Protective stop.

Pins 2 in interfaces A and B of the Auxiliary safety functions are used for the Safeguarded stop function.

# 10.7 Locomotion

The Locomotion interface is used to signal to a top module that the robot is driving. This function uses two output pins, where both pins deliver 0 V when the robot is driving and 24 V when the robot is stopped. You can use this interface to make your top module behave differently depending on whether the robot is driving or not. The interface is intended to be used to ensure that the top module is programmed to go into a safe state when the robot is driving. For example by engaging the brakes in any actuators that may result in injury to personnel.

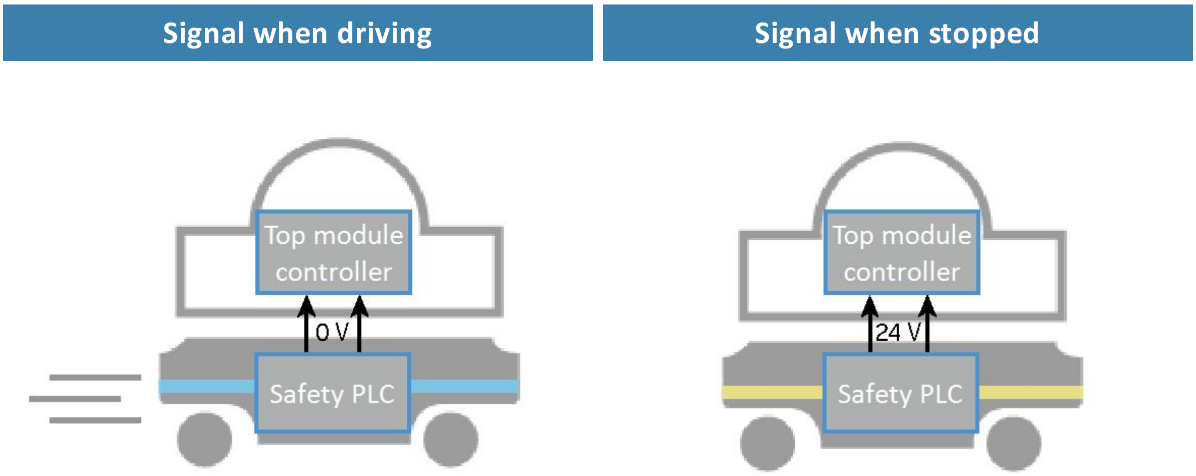



Figure 10.9. When the robot is driving, the safety PLC sends a 0 V signal to the top module through the Auxiliary safety function interface. When the robot is stopped, the signal becomes 24 V.

Pins 5 in interfaces A and B of the Auxiliary safety functions are used for the Locomotion function.

# 10.8 Shared emergency stop

The Shared emergency stop interface is used to control the Emergency stop state between the robot and a top module. The interface has two inputs for bringing the robot into Emergency stop and two outputs for signaling when the robot is in Emergency stop.

The outputs are used to signal to the top module that the robot is in Emergency stop. When the robot is in an operational state, the outputs deliver 24 V. As soon as the robot enters Emergency stop, they deliver 0 V.

The inputs are used to enable the top module to bring the robot into Emergency stop. When both inputs deliver 24 V, the robot can operate, but as soon as either or both of the inputs deliver 0 V, the robot enters Emergency stop.

These signals can be used if the top module has its own Emergency stop system and you want both the robot and the top module to enter Emergency stop when either system is triggered.

If the pins are unequally set for more than three seconds, the safety PLC registers this as an error in the system and needs to be reset before the robot can operate again. To do this, you must restart the robot.

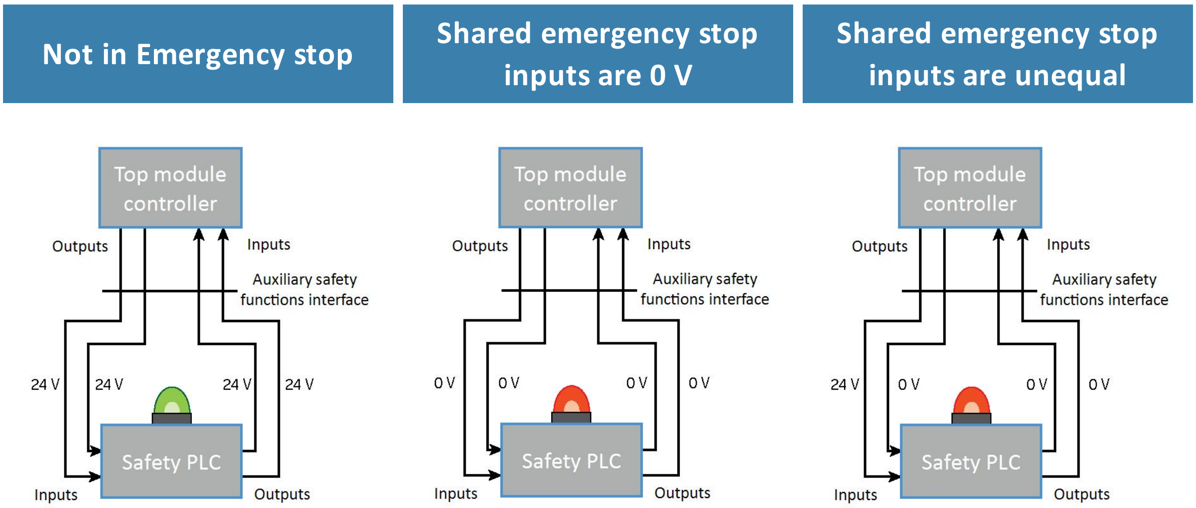



Figure 10.10. The three cases above respectively describe: 1. the robot is not in Emergency stop so the output is 24 V, 2. the robot is in Emergency stop because it receives 0 V input from the Shared emergency stop interface, and 3. the robot is in Emergency stop because the inputs are unequal.

In interfaces A and B of the Auxiliary safety functions, pins 3 are used for the input and pins 6 are used for the input of the Shared emergency stop function.

# 10.9 Reduced speed

The Reduced speed interface is used to signal to the robot that it must drive at a reduced speed of 0.3 m/s. This is the same speed used when the robot mutes its Protective fields. The interface uses two input pins where the robot drives at a reduced speed if either input is 0 V.

This can for example be used in cases where the top module can register whether the load it is carrying is not securely placed or the module is currently under operation.

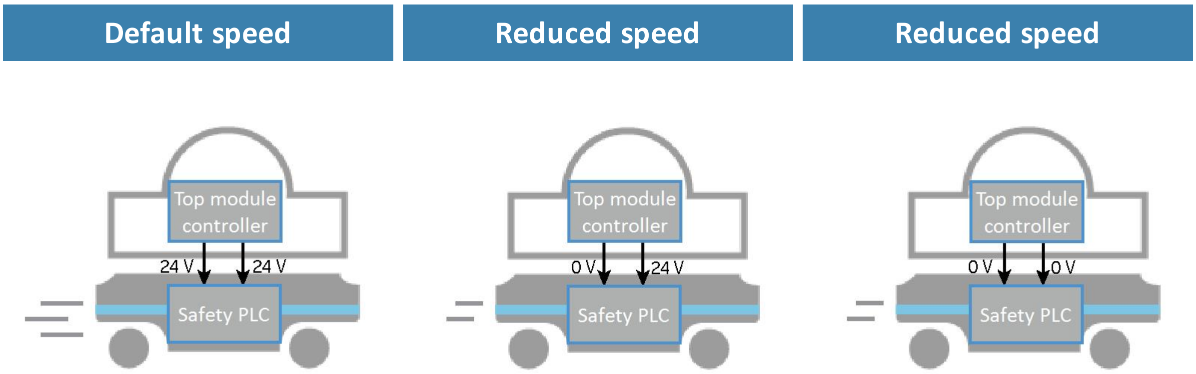



Figure 10.11. The robot drives at its default speed only when both inputs are 24 V. If either or both pins are 0 V, the robot drives at 0.3 m/s.

Pins 4 in interfaces A and B of the Auxiliary safety functions are used for the Reduced speed function.

# 10.10 Safety stop

There are two pairs of contactors used to stop MiR250: the STO (Safe Torque Off) contactors and the SS1 (Safe Stop 1) contactors. These are controlled by the safety PLC and are used when the robot goes into Protective or Emergency stop. The following processes occur to stop the robot safely:

1. The safety PLC first turns off the STO contactors so power is cut from the motors.

> To ensure that the STO contactors switch states as expected, there is a feedback circuit that connects to the safety PLC to verify that the contractors switch to the correct state. When the robot is starting up, the feedback circuit and STO contactors are checked before allowing the robot to be operated.

2. The safety PLC turns off the SS1 contactors to activate the dynamic brake function in the motors.
3. The safety PLC monitors data from the motor encoders to determine whether the robot has stopped within the expected amount of time.
4. Once the robot has stopped, the mechanical brakes are engaged to keep the robot in place, similar to the parking brake in a car.

The mechanical brakes are only intended to engage when the robot has stopped. Only when the dynamic brake function does not stop the robot within the expected amount of time are the mechanical brakes engaged to stop the robot while it is in motion. This is considered an emergency situation where the dynamic brakes have failed, and an error is reported in the robot interface. This can occur, for example, if the robot drives on surfaces that are not within specifications or the load on the robot does not fulfill the payload specifications—see Payload distribution on page 192.

# 10.11 Light indicators and speakers

The robot uses two types of light indicators to let people in the environment know what the robot is currently doing or planning to do.

- **Status lights**
  LED light bands on all four sides of the robot uses colors and light motion patterns to signal the current status of the robot.
- **Signal lights**
  The signal lights at the front and back of the robot show if the robot is about to turn a corner or go backward. Front lights are white and rear lights are red. Right and left turns are indicated by blinking.


Figure 10.12. Indicator lights on MiR250.

| Table 10.1. Identification of indicator lights in *Figure 10.12* | | | |
|---|---|---|---|
| **Pos.** | **Description** | **Pos.** | **Description** |
| 1 | Status lights | 2 | Signal lights |

## Status lights

The LED light bands running all the way around the robot indicate the robot's current operational state. Colors may also be used as part of missions, but as standard, status lights indicate the statuses described in *Table 10.2*.

| Table 10.2. Status light colors | |
|---|---|
| Red | Emergency stop |
| Green | Ready for job |
| Cyan | Drives to destination |
| Purple | Goal/Path blocked |
| White | Planning/Calculating |
| Yellow | Mission paused |
| Yellow wavering | Startup signal before PC is active |
| Yellow fade | Shutting down robot |
| Yellow blinking | Relative move, ignoring obstacles |
| Purple - yellow | General error, for example hardware, localization |
| Blue | Manual drive |
| Blue wavering | Mapping |
| Contracting white | Charging at charging station |

| | |
|---|---|
| White wavering | Prompt user / Waiting for user's response |
| Cyan wavering (robots connected to MiR Fleet only) | Waiting for MiR Fleet resource |

When the robot's battery reaches a critically low level of power (0-1%), the ends of the status lights flash red.

When the robot is charging in a charging station, the status lights on the side of the robot indicate the robot's battery percentage.

## Signal lights

Signal lights are used to indicate the robot's immediate motion plans by signaling forwards-backwards-braking and left-right turns.

The signal lights work similarly to lights used on cars; white at the front, red at the back, and indicating a left or right turn by blinking.

When the robot drives with muted Protective fields, for example, when docking to a marker, all signal lights blink yellow.

## Speakers

In **Setup > Sounds**, you can upload new sounds to the robot or edit the volume and length of the default sounds.

Sounds are used in missions and can be used as alerts: "Please step aside" or to attract peoples attention, for example, when the robot has arrived at a position.

When the robot drives with muted Protective fields it emits a warning sound. In **System > Settings > Safety system**, you can choose which sound the robot makes and the volume of the sound.

**CAUTION**

Changing the safety system can cause the robot to not comply with safety standards.

- Do not disable the sound in the safety system.

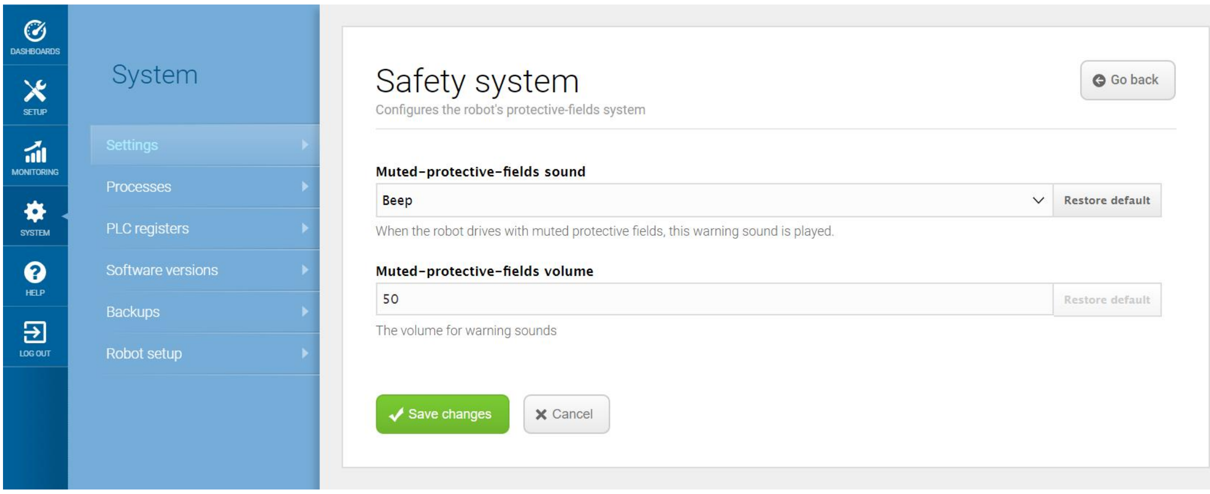



Figure 10.13. In the Safety system settings, you can modify the sounds the robot plays when the robot mutes its Protective fields.

**CAUTION**

It is the responsibility of the commissioner to ensure that the warning sounds are audible in the robot's work environment.

# 11. Commissioning

This section describes how to commission MiR250.

Commissioning should be done without any load on the robot, except when doing brake tests where the robot should have a load equaling the heaviest load it will be driving with.

Only persons assigned with the commissioning task should be present during commissioning.

It is the responsibility of the commissioner to:

- Analyze the work environment.
- Make a risk assessment of the full installation.
- Create and configure the site.
- Configure audio and light signals according to the environment.
- Change the robot's footprint or create new footprints depending on the top module or loads of the robot.
- Create operating hazard zones.
- Make a brake test.
- Create user groups and users.
- Create dashboards.
- Update robot software.
- Change the relevant system settings.

## 11.1 Analysis of the work environment

The work environment of the robot must fulfill a number of requirements for the robot to function properly and safely. This section describes the factors that must be considered when the robot is being commissioned to function in a work environment.

### Surfaces

The floor surface of the work environment must be dry. MiR250 functions on many different types of surfaces, but some materials can affect the performance and safety of the robot, such as very thick carpets or slippery floors.

It is the responsibility of the commissioner to test the performance and safety of the robot on the surfaces in the work environment—see Making a brake test on page 131.

## Light, reflections, and materials

Bright sunlight and reflective or transparent objects can affect the performance of the robot's laser scanners and cameras. This can result in the robot detecting nonexistent objects or failing to detect real objects.

Likewise, docking to markers made in very high gloss or transparent materials can reduce the effectiveness of the robot's scanners, hindering a successful docking.

It is the responsibility of the commissioner to test if sunlight, reflections from high gloss materials, and transparent objects affect the robot's performance or safety.

## Temperature and humidity

Temperatures outside of the approved temperature range can affect the performance and durability of the robot—see specifications on the MiR website. This is especially relevant for the robot's battery—see Battery storage on page 64.

## Inclines, doorways, gaps, and sills

The robot must operate within the approved specifications for driving on inclines, through doorways, and over gaps and sills—see specifications on the MiR website. Operating in areas that do not meet the specifications may result in the robot failing to complete the missions or losing control of its load.

## Space

The robot must have sufficient space to operate efficiently. Determine during commissioning if the robot has sufficient space to drive, dock, turn, and perform other tasks. Make sure to test each mission under the most likely operating conditions to determine if there is enough space for the robot to maneuver.

**CAUTION**

Driving in environments with no escape routes can lead to hazardous situations. There is a risk of damage to equipment or injury to personnel.

- At all times there must be at least 0.5 m wide and 2.1 m high pedestrian escape routes on each side of the robot, also in operating hazard zones.

### Dust

Dusty environments can affect the performance and durability of the robot. Dust can get into the robot computer and mechanical parts, affecting their performance and durability, and it can obstruct the view of the robot's sensor system. Make sure the environment MiR250 operates in is suitable for its IP rating—see specifications on the MiR website.

### Static landmarks and dynamic obstacles

The robot uses static landmarks to navigate by. If it cannot detect enough distinguishing landmarks, it cannot navigate the map efficiently—see Localization on page 79.

## 11.2 Risk assessment

To achieve a safe installation, it is necessary to make a risk assessment of MiR250 in the environment it will be used in. This is the responsibility of the commissioner.

The risk assessment must cover both MiR250 itself and also take into account potential load transfer stations, work cells, and the work environment.

> **NOTICE**
>
> Mobile Industrial Robots takes no responsibility for the creation and performance of the risk assessment, but we provide information and guidelines that may be used in this section.

It is recommended that the commissioner follows the guidelines in ISO 12100, EN ISO3691-4, EN 1525, ANSI B56.5, or other relevant standards to conduct the risk assessment.

In EN 1525 clause 4 there is a list of possible significant hazards and hazardous situations that the commissioner should consider.

A risk assessment of the application must be used to determine the adequate information for users. Special attention to at least the following Essential Health and Safety Requirements (EHSR) must be taken:

- 1.2.2 Control devices
- 1.3.7 Risk related to moving parts
- 1.7.1 Information and warning on the machinery
- 1.7.2 Warning of residual risks

- 1.7.3 Marking of the machinery
- 1.7.4 Instructions

The risk assessment will lead to new instructions that shall be written by the party who draw up the CE marking. The instructions must at least include:

- Intended use and foreseeable misuse.
- A list of residual risks.
- Training required for personnel.

# 11.3 Creating and configuring maps

The map is visible in the robot interface and is the basis for the robot's ability to navigate its surroundings safely and efficiently. The map illustrates the physical area in which the robot operates.

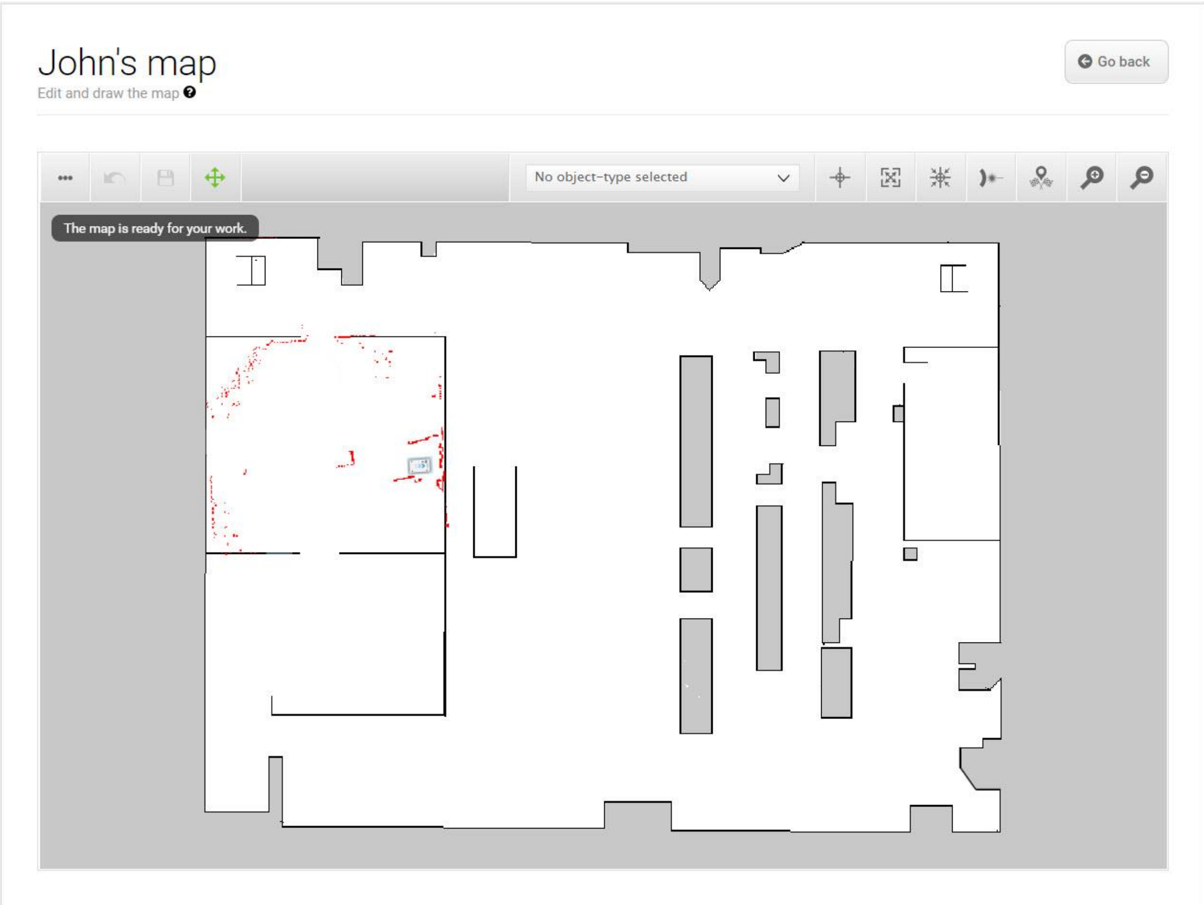



Figure 11.1. Example of a map without any added zones, positions, or markers.

The robot must have a map for every area that it operates in. It is important to create robust and reliable maps for the robot to perform effectively and safely.

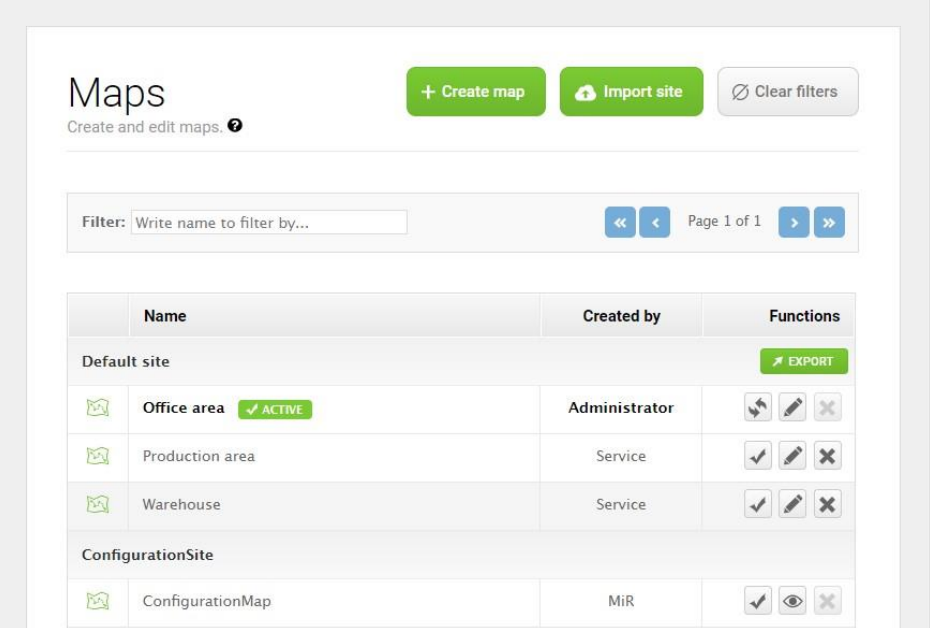



Figure 11.2. The **Default site** has three maps within it for the areas in the site: **Office area**, **Production area**, and **Warehouse**.

A site contains one or more maps that often connect to each other. The number of maps you need in a site depends on the work environment of the robot:

- If the operating area is very large, you may need to split the area into smaller maps.
  - You can tell that a map is too large if the robot takes a long time to plan its routes or often reports CPU errors.
  - In general, we recommend that maps should not exceed an area of 300 x 300 meters.
  - You can connect smaller maps using map transitions—see *MiR Robot Reference Guide*, or ask your distributor for the guide *How to set up transitions between maps*.
- If the robot must operate on different floors connected with ramps or elevators, you must have a map for each floor.
  - If you are using an elevator, ask your distributor for the guide *How to set up elevators in MiR Fleet*.
  - If you are using ramps, connect the maps using transitions—see *MiR Robot Reference Guide*, or ask your distributor for the guide *How to set up transitions between maps*.

Each site also includes other elements in the interface, such as missions. For the full list of what is included in a site, see *MiR Robot Reference Guide* on the MiR website or in the **Help** section of the robot interface.

## Creating a map

To create a new map, you drive the robot around its intended work environment while its sensors gather data to generate a map from. This process is known as mapping.

As the robot moves during mapping, the laser scanners detect physical obstacles, which are recorded on the map as walls. In the editing afterward, you can remove all obstacles that should not stay on the map, for example carts or boxes that were present at the time of recording but will not stay permanently.

Before you map a new location, be sure to do the following preparations:

- Clear the area of dynamic obstacles, such as pallets and carts. Dynamic obstacles can also be deleted from the map later.
- Ensure that all doors and gates that the robot should be able to go through are opened before mapping.

Avoid doing the following:

- Starting the mapping with the robot in a very open space.
- Getting the robot stuck close to walls or objects as you will have to push it away manually.

To create a new map, see *MiR Robot Reference Guide* on the MiR website. When mapping, you should apply the following best practices:

- Focus on mapping in a circular pattern around the perimeter of the working environment.
- When reaching long corridors with few obstacles, let the robot stay in position for approximately five seconds before moving down the corridor.
- Walk behind the robot as you map.
- End the mapping in the same place you started it.

For more information on creating a map, see the *Creating your first map*-course in MiR Academy on the MiR website. Contact your distributor for access to MiR Academy.

## Cleaning up a map

The robot navigates best when using a clean map with as little noise as possible. *Figure 11.3* is an example of what a map can look like after the mapping process but where it still needs further editing.

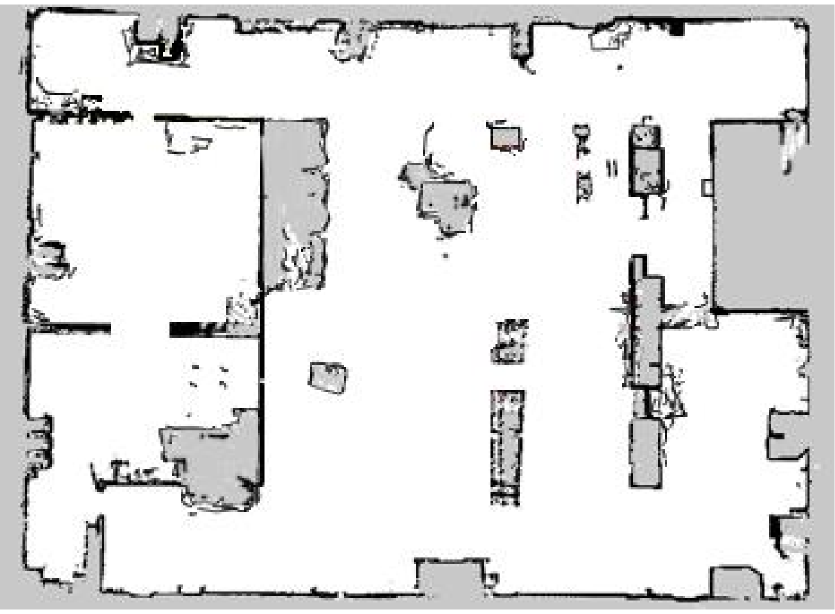
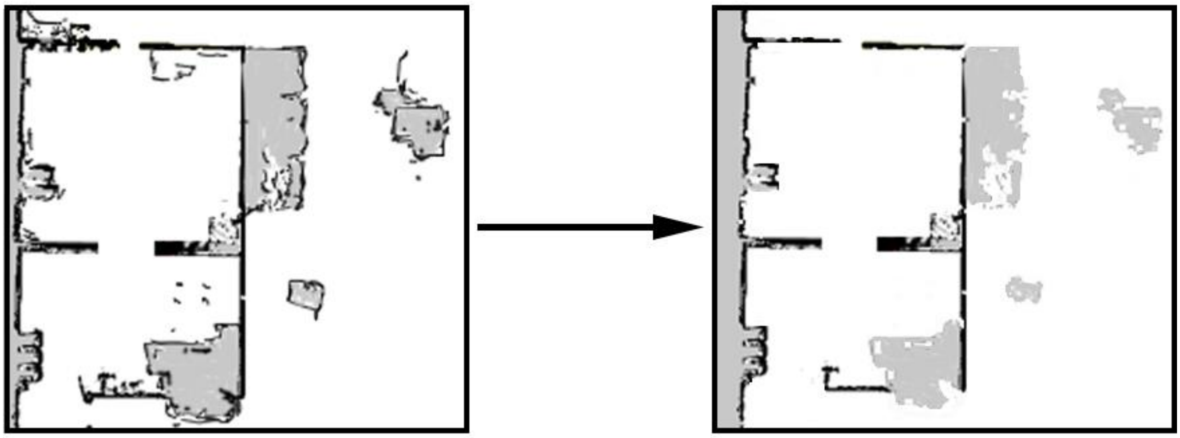


Figure 11.3. Example of a map that includes too much noise and dynamic obstacles.

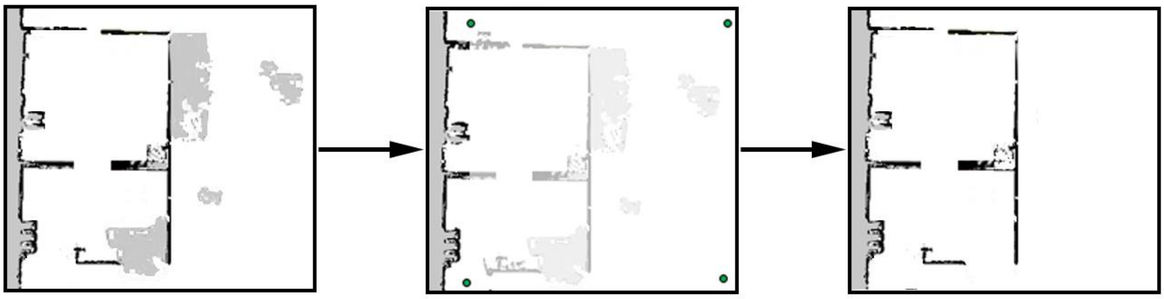
There are several tools in the robot interface that you can use to improve your map:

- Use **Erase uploaded or recorded data** when editing walls to remove walls that were created around dynamic obstacles and noise on the map.

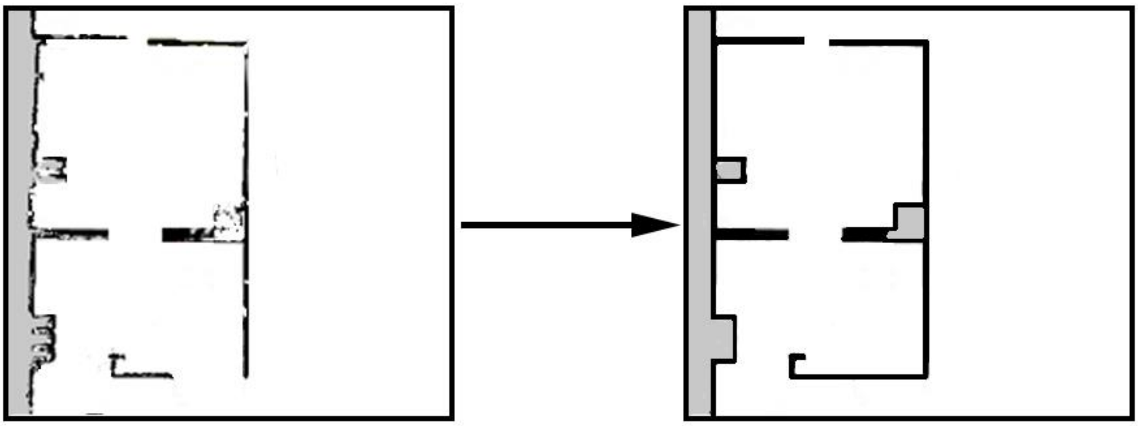
> Noise refers to recorded data that originates from interfering elements. This can be physical obstacles that make the robot record walls where there are none or more subtle interferences that can make recorded walls appear pixelated.



- Use **Draw a new shape** when editing floors to fill out the gray areas where there should be floor. When using this tool, you do not affect the walls on the map.



- Use **Draw a new line** when editing walls to create solid and even walls.



## Adding zones to the map

Adding zones to the map helps organize robot traffic. There are several different zones that can optimize the preferred paths and driving behavior of the robot.

For more information about what each zone does, see *MiR Robot Reference Guide* on the MiR website, or ask your distributor for the guide *How to use zones on a map*.

**NOTICE**

All zones are ignored when you drive the robot in Manual mode or when you use a Relative move action (except when using Relative move actions in Limit-robots zones).

### Examples of when and how to use zones

The following sections describe examples of cases where certain zones can be used to improve the robot's operations.

For more examples, contact your distributor for the guide *How to use zones on a map*.

#### Descending staircases

**Issue:** The robot sensors cannot detect descending staircases. Marking a staircase as a wall on the map will only confuse the robot as it will try to navigate from a wall that is not there.

**Solution:** Mark staircases and areas surrounding staircases or holes in the floor as Forbidden zones on the map.

#### Low hanging fixtures

**Issue:** If a low hanging fixture is outside of the robot sensors' range, the robot may try to travel beneath it. This can be dangerous if the robot is carrying a tall top module or load that can collide with the fixture.

**Solution:** Mark the area where the low hanging fixture is located as a Forbidden zone.

### Highly dynamic areas

A highly dynamic area is an area where objects are moved frequently. This could be a production area where pallets and boxes are often moved back and forth.

**Issue:** The robot will stop if a person steps out in front of it. In a transient work flow area, the robot will stop and reassess its paths many times a day, thereby wasting valuable time.

**Solution:** Mark highly dynamic areas on the map with Unpreferred zones (blue) or Forbidden zones (red) depending on the environment. Directional zones can also be used here to guide the robot in a specific direction.

If the robot has trouble with localization in a highly dynamic area, place some static objects with three meters of distance between them and mark them as walls on the map. Remove the 'walls' created from dynamic obstacles in the area. Static objects make it easier for the robot to localize and navigate the area.

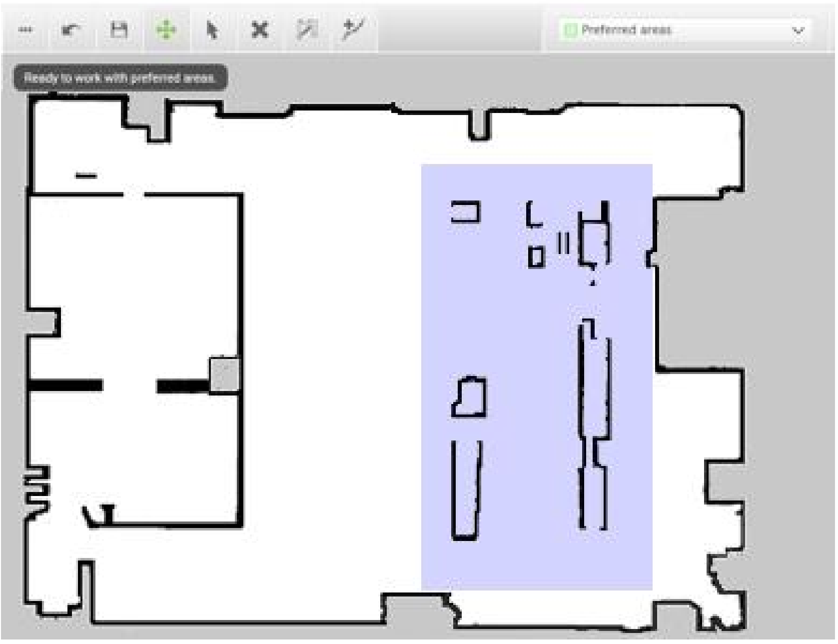



Figure 11.4. Unpreferred zones (marked with purple) can be used in highly dynamic areas to solve issues with replanning of paths.

### Doorways

Going through narrow doorways can cause problems for the robot's global planner since the robot must drive closer to wall edges than it usually would. It can also be hazardous for the people working near the robot, as they might not see the robot coming.

**Issue:** The robot does not plan its global path through narrow doorways, since this will bring the robot too close to a known obstacle.

**Solution:** Add a Critical zone (orange) in the narrow doorway to enable the global planner to make a path through the corridor. You only need to place the zone down the center of the doorway so the center of the robot is in the zone. Add Sound and light zones (yellow) in narrow doorways to warn people near the doorway that the robot is coming through.

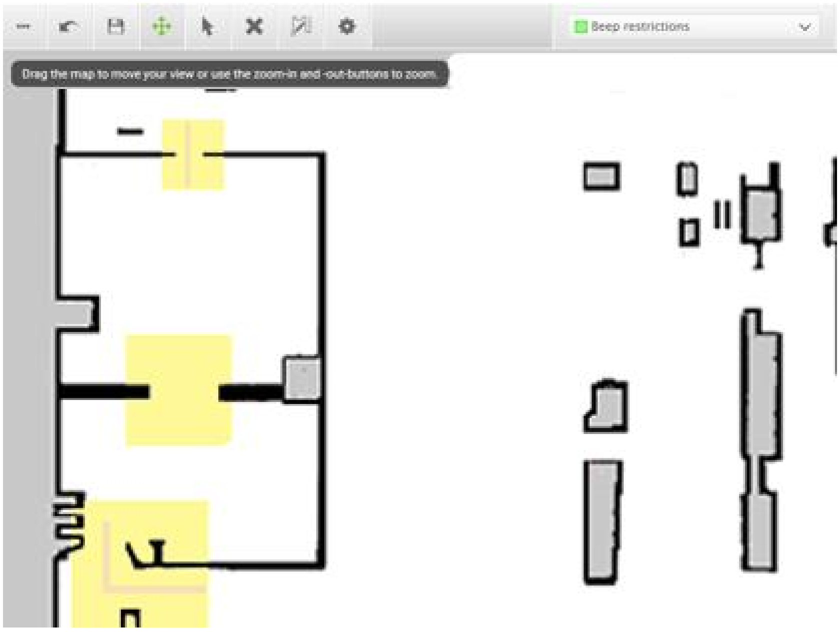



Figure 11.5. Narrow doorways can be marked with a Sound and light zone (marked with yellow) to warn people that a robot is coming through. A Critical zone (orange) can be placed in the narrow doorway to enable the global planner to make a path through the corridor.

### Shelves

Shelves are often placed in a certain height above the floor on four (or more) posts and will often appear as dots on a map for the robot. This may cause the robot to believe that there is enough space (if the posts are far enough apart) below the shelves to pass through. The robot will then plan a path underneath the shelves, but when it comes closer, the camera will see the obstacle. This could result in replanning paths several times a day.

**Issue:** The robot will only see shelves as dots on the map and believe that it can make a global plan underneath the shelves.

**Solution:** Add a Forbidden zone (red) around the shelves.

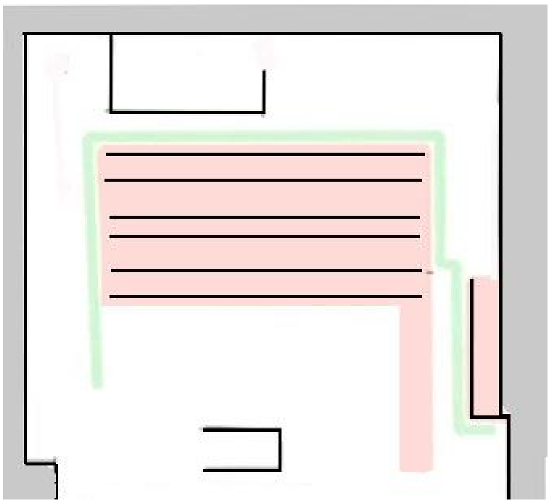


Figure 11.6. A Forbidden zone covering the shelf area.

### Glass

Highly transparent glass may not be detected by the safety laser scanners.

**Issue:** The robot will not stop before driving into a glass window, door, or other glass objects.

**Solution:** Make the glass visible to the safety laser scanners by gluing non-transparent window film on the glass in the scanner height, 150 to 250 mm, or mark the wall as a Forbidden zone. Edit the map afterwards in the robot interface and mark the glass as walls to help the robot localize.

## Directional lanes

**Issue:** In some areas, such as long corridors, robots driving towards each other may have a hard time passing each other efficiently.

**Solution:** If there is not enough space for the two robots to pass each other, you can create a two-way lane using Directional zones in combination with Forbidden or Unpreferred zones.

- Create a thin Forbidden zone (red) in the middle of the corridor parallel to the corridor walls. This is the lane separator.
- Create Directional zones (gray with arrows) on both sides of the Forbidden zone. Make the directions of the zones opposite.

With such a configuration, robots going in the opposite directions use different lanes and do not get in each others' way. Replacing the Forbidden zone with an Unpreferred zone gives robots more space for maneuvers, for example, if a robot needs to cross the lane separator to drive around an obstacle.


Figure 11.7. The robot drives down a two-way lane. The two Directional zone lanes are separated by a Forbidden zone.

If there isn't enough space for robots to pass each other, you can use a Limit-robots zone to specify that only one robot may drive down the corridor at a time.

To use Limit-robots zones, your robots must be connected to MiR Fleet.

# 11.4 Markers

Markers are defined as X-Y coordinates on a map that mark locations where you want the robot to travel to. Markers are points on the map that mark a physical entity, such as a charging station or a pallet rack, and enable the robot to position itself accurately relative to this entity.

You should always use markers when it is important that the robot is positioned accurately relative to an object in the work environment, such as load transfer stations and work stations.

Markers require the robot to do a docking sequence. When the robot is docking, it uses its safety laser scanners to detect the marker and drives itself to the correct position relative to the detected marker. The robot begins docking to a marker from the marker's entry position—see *Figure 11.8*. The entry position is automatically created approximately one meter in front of the marker and can be moved in the map editor.

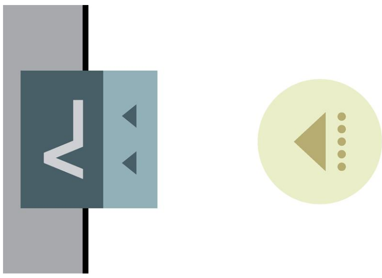


Figure 11.8. A VL-marker with its entry position.

There are four standard marker types that all MiR robots can use: V, VL, L, and Bar-markers.

A **V-marker** is a small, V-shaped marker that is designed for the robot to either dock to so its front or its rear is facing the marker. The V-marker is the simplest marker available for the robot. It consists of a V shape with an interior angle of 120° and sides of 150 mm.

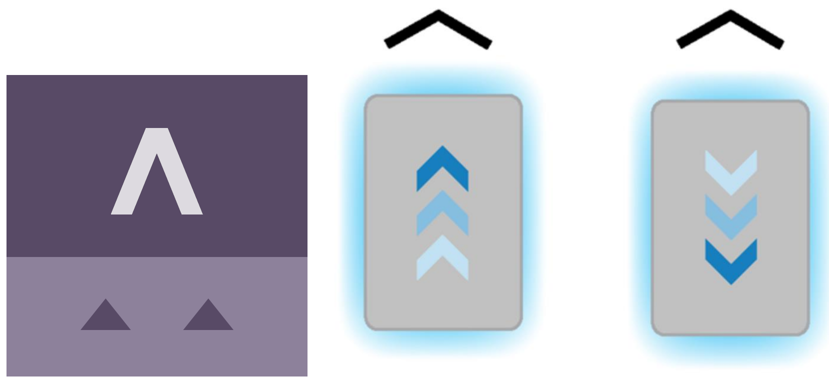


Figure 11.9. The icon used for V-markers in the interface and an illustration of how robots can dock to the marker.

A **VL-marker** is a larger marker that enables the robot to dock more accurately than V-markers. It consists of a V-marker with a 350 mm plate attached to the right of the V shape. Like V-markers, VL-markers are also designed for the robot to either dock to so its front or its rear is facing the marker.

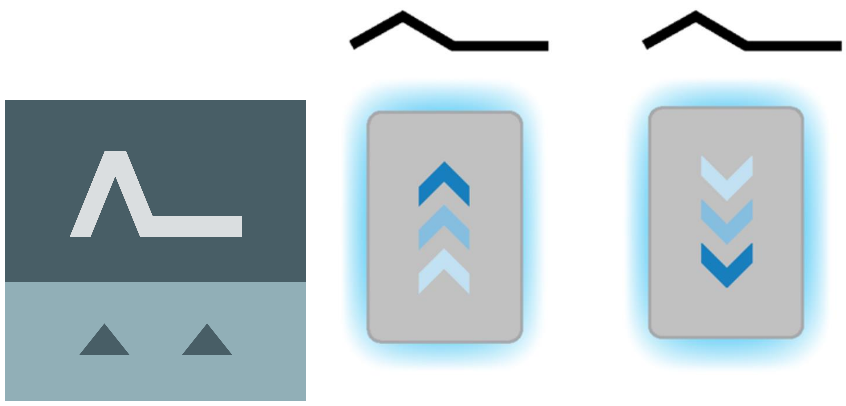


Figure 11.10. The icon used for VL-markers in the interface and an illustration of how robots can dock to the marker.

An **L-marker** makes it possible for the robot to dock in several different ways and orientations. Robots can both dock to the inside and outside of an L-marker, and the marker can be on any side of the robot. The marker is shaped liked an L with a defined angle of 90˚ and the dimensions 400 mm x 600 mm.

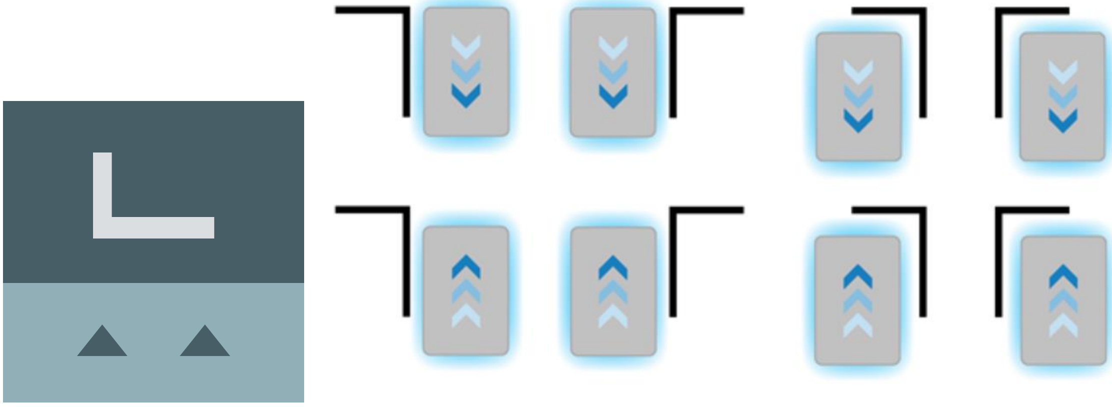


Figure 11.11. The icon used for L-markers in the interface and an illustration of how robots can dock to the marker.

A **Bar-marker** can be used for forward or reverse docking between two bars or plates, similar to pallet racks or shelves. Bar-markers must be between 400 mm and 750 mm long, and the distance between the bars must be between 750 mm and 1500 mm.

The distance between the bars must be larger than the footprint of your robot.

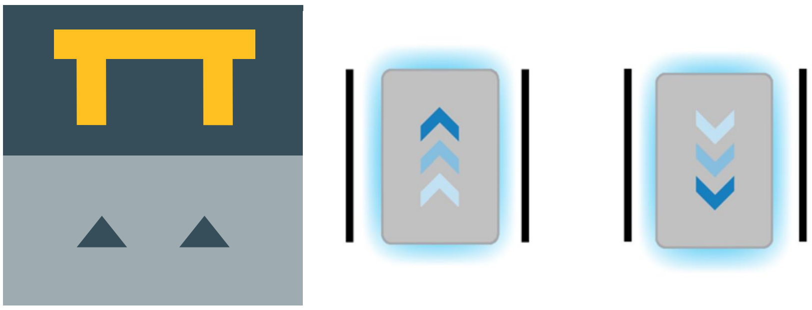


Figure 11.12. The icon used for Bar-markers in the interface and an illustration of how robots can dock to the marker.

A few centimeters between all the types of markers should make docking possible. Determine during commissioning if more space is required.

For further information on markers, contact your distributor for the guide *How to create and dock to V-markers, VL-markers, L-markers, and Bar-markers*.

To create a marker, see Creating markers on page 146.

## 11.5 Positions

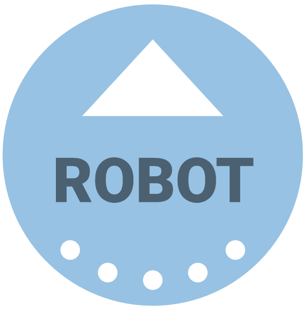
Positions are defined as X-Y coordinates on a map that mark locations where you want the robot to travel to. Positions mark a point on the map the robot travels to. To reach a position, the robot must be correctly localized on the map—see Localization on page 79.

Positions are used either as destination positions or as waypoints on a route that you want to use in missions. With positions, the robot does not compare its position to a physical entity, making them less accurate than markers.

Generally, positions are used to mark where robots should wait when they are idle, which points robots must pass through along a route, or as destinations you often want to send the robots to.

The final orientation of the robot is indicated by the arrow on the position icon.

There are different types of positions depending on whether the robot is part of a fleet or drives with top modules, but the standard position that is available in all MiR applications is the Robot position. This position has no special features, it simply marks a location where you want to be able to send the robot to.




To create a position, see Creating positions on page 151.

# 11.6 Creating missions

MiR robots function through missions that you create. A mission is made up of actions, such as: move actions, logic actions, docking actions, and sounds, which can be put together to form a mission with as many actions as needed. Missions themselves can also be embedded into other missions.

Most actions have adjustable parameters, for example, which position to go to. Most actions can also use variables, enabling the user to choose the value of a parameter each time the mission is used. This can be practical in cases where the robot performs the same series of actions in different areas of the site that require different parameter settings in the mission actions.

When you create a mission, you can save it in the default **Missions group**, or you can choose to save it in any of the available actions groups. The actions groups are found in the top bar of the mission editor window, and you can distinguish missions from actions by the small icons shown next to their names: missions have a target icon , and actions have a running-man icon .

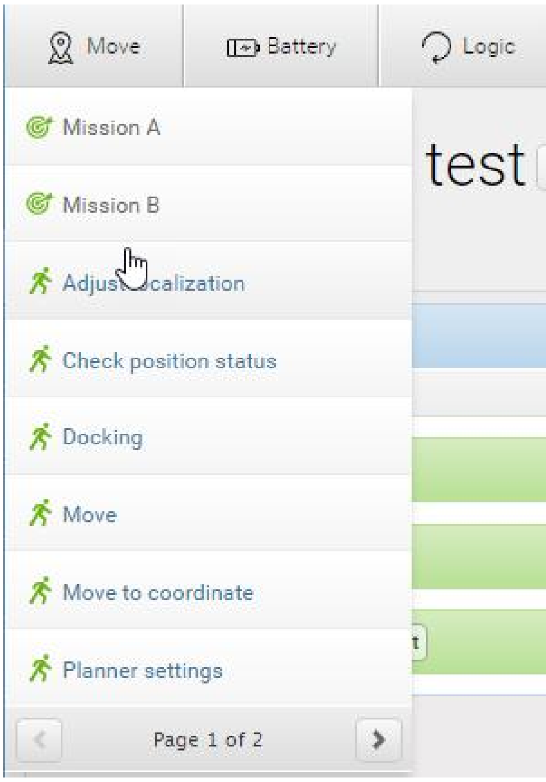



Figure 11.13. Different actions can be created and put together to make up a mission.

For more information on parameters and variables, contact your distributor to see the guide *How to use variables in missions*.

To create efficient missions, you should first familiarize yourself with the available actions in MiR Robot Interface—see the *MiR Robot Reference Guide*— and then consider:

- Which tasks do I want the robot to perform?
- Which actions are involved in this task and in which order are the actions executed?
- How much do each of these tasks differ? Are they similar enough that you can reuse the same mission but use variables for some of the parameters? If so, identify which of the parameters change in each mission—see *Figure 11.14*.

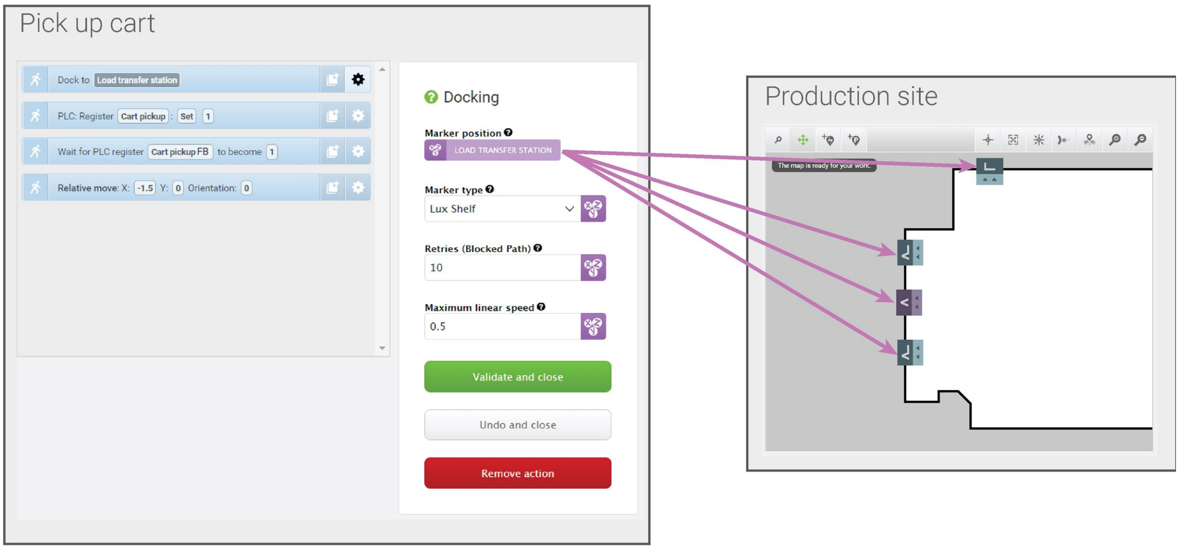



Figure 11.14. You can use variables to make a mission where you can set a parameter in one of the actions each time you use the mission (either when you add the mission to the mission queue or embed it in another mission). In this example, you can set the variable **Load transfer station** to any marker created on the map. This means that you can use the same mission for making the robot pick up a load from any of the markers on the map.

- Are there small parts of different missions that are the same each time where it would be worthwhile to make a mission for the repeated task and embed this mission into the larger missions? For an example, see *Figure 11.15*.

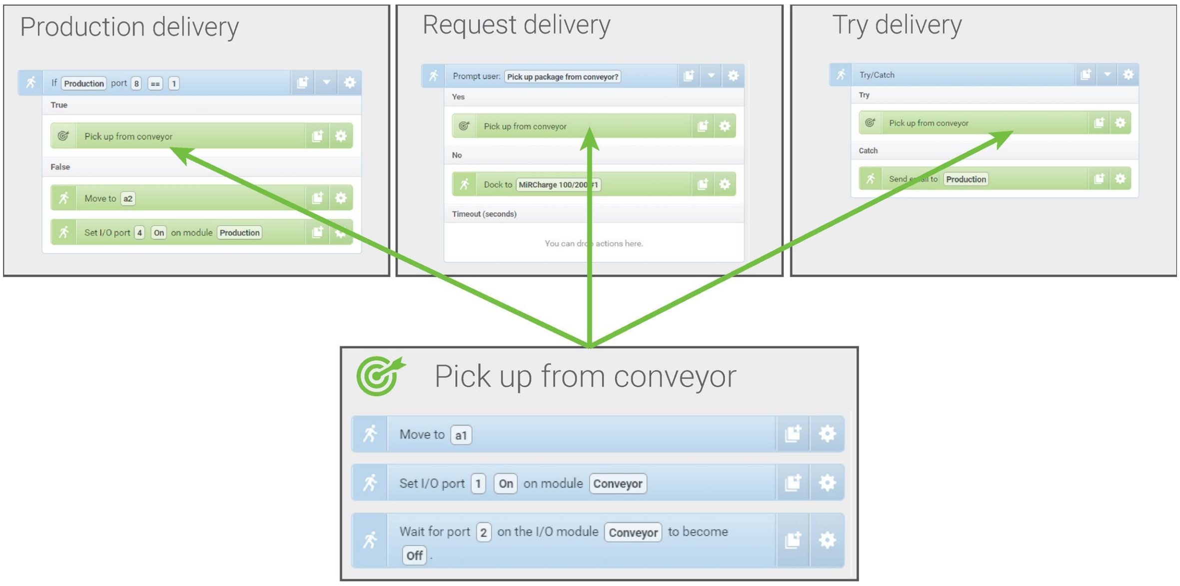



Figure 11.15. You can embed small missions into other missions. In this example, the mission *Pick up from conveyor* is used in three different missions. If you want to change how the robot picks up a package from the conveyor, you only need to change it once in the original mission instead of three times in each individual mission.

It is often a good idea to reuse the same missions if you know that any changes that may need to be applied to one of the tasks will also need to be applied to all other similar tasks.

When you make a mission, you should also consider all the possible outcomes from the mission and prepare it for the possibilities of error and what the robot should do if an error occurs—see an example of this in Creating the mission Try/Catch on page 158.

For more information on building robust missions, see the *Mission robustness* videos in MiR Academy on the MiR website. Contact your distributor for access to MiR Academy.

When you have figured out which tasks you want the robot to perform and how many different missions you need to create, you should consider how you want to organize the missions in different mission groups. You can consider the following:

- Do you want to add the missions into existing action groups?
- Do you want to create new mission groups to organize your missions in? If so, consider how you want to divide your missions. For example, you can divide them based on function, location, priority, or responsible users.

The section Usage on page 146 provides several examples of how to create simple missions with different types of mission actions and describes how you add a mission to the mission queue to test it. Whenever you create a mission, it is very important that you test it to ensure the robot performs as expected.

For more information on creating missions, see *MiR Robot Reference Guide* and the *Making your first missions*-course in MiR Academy on the MiR website. Contact your distributor for access to MiR Academy.

# 11.7 Creating a footprint

The footprint specifies how much space the robot occupies, including any loads or top modules. The footprint is defined by a number of points relative to the robot's center coordinate system and the total height of the robot application.

If your robot drives with loads or top modules that exceed the width or length of the robot, you must define new footprints for the robot to ensure that the robot plans its route correctly and avoids colliding with obstacles with its top module or load.

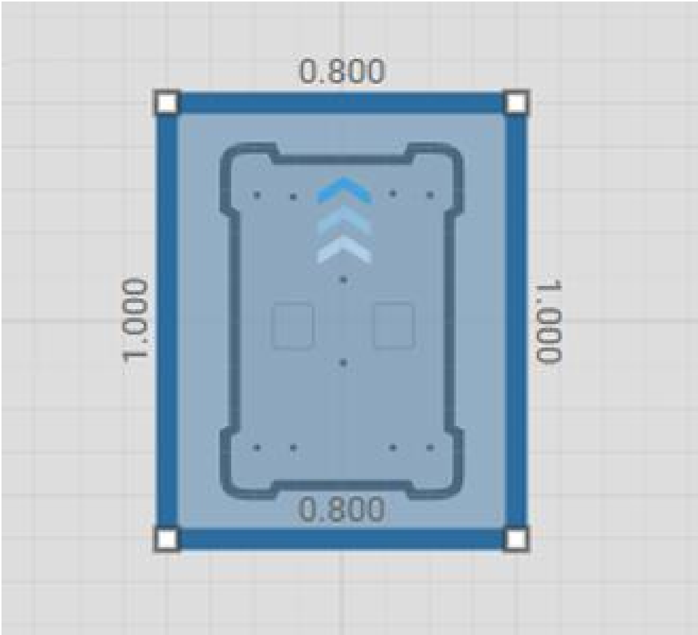
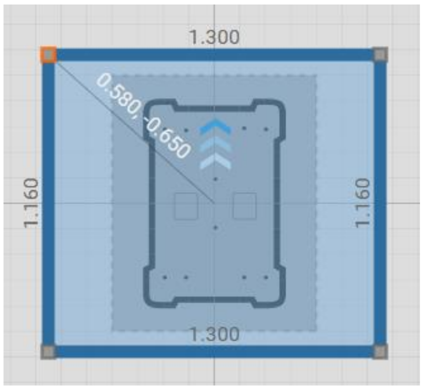
| Default footprint | Larger footprint |
| --- | --- |
|  |  |





Figure 11.16. Examples of the default robot footprint and an extended footprint. The values displayed along each line is the length of the edge in meters.

The number of footprints you need to define depends on:

- If there are low hanging fixtures that the robot can pass under only when it is not carrying certain loads or top modules, you must define new footprints for the various heights that the robot and its load can have to ensure that they don't collide with the low hanging fixtures.
- The top modules you use with your robot.
  - If a robot's top module exceeds the width or length of the robot, you must define a new footprint for that top module.
  - If a top module has moving parts that can extend over the edges of the robot's footprint while the robot is moving, you must define a footprint that includes the moving parts when they are at their most extended positions.
- The loads the robot transports.
  - For each load the robot transports that exceeds the length or width of the robot, you must define a footprint for that load.
  - If you prefer to only have one footprint for the robot when it is carrying oversized loads, create a footprint that is suitable for the load that has the largest footprint.

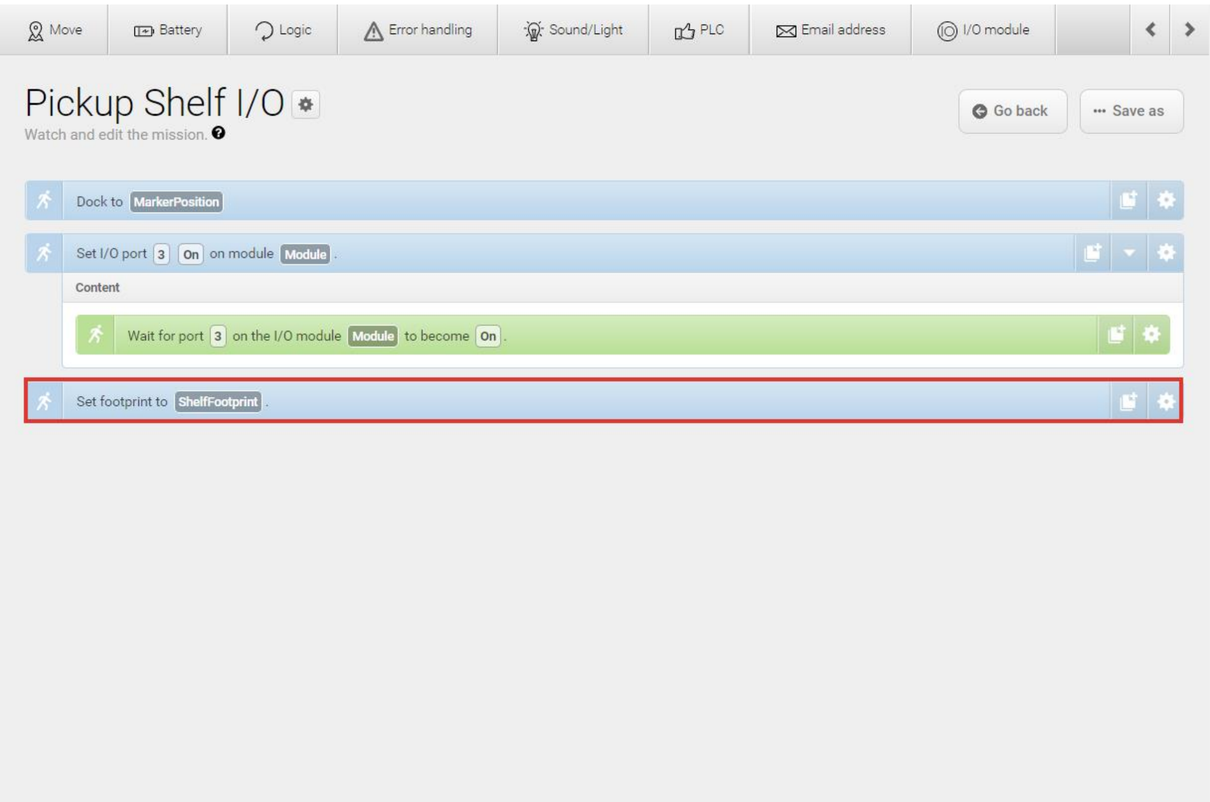
**CAUTION**

The footprint is only used by the robot's global and local planner to avoid obstacles. The Personnel detection safety function—see Personnel detection on page 89—still uses the same Protective field sets. If your robot is carrying a load or top module that extends the footprint in front of or behind the robot, it may collide with personnel or equipment.

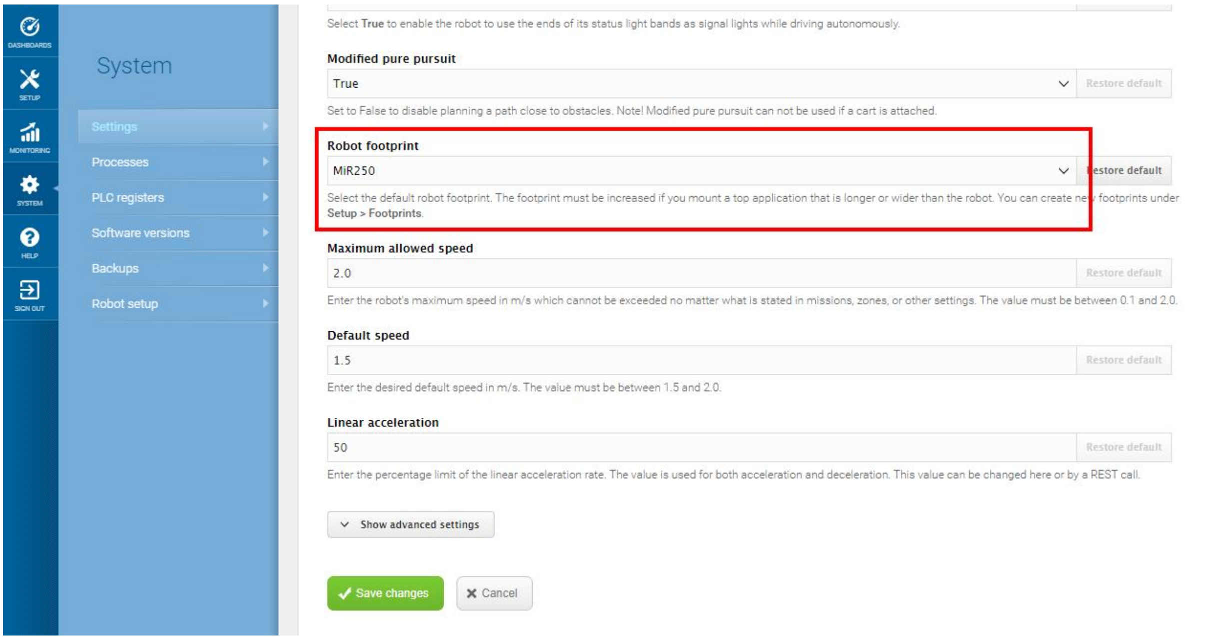
- Avoid extending the footprint in front of or behind the robot.
- Mark all areas where the robot drives with an unsafe load as operating hazard zones.
- Consider modifying the Protective field sets if necessary—see Personnel detection on page 89.

For a more thorough guide to creating footprints, contact your distributor for the guide *How to change the robot footprint*.
For more information about the footprint editor, see *MiR Robot Reference Guide* on the MiR website.

If you want to change the footprint in a mission, use the Set footprint action found under the Move action group. This is used to change the footprint when the robot picks up a load that extends the footprint or places a load and the footprint returns to the default.



If you want to edit the default footprint of the robot, for example if the mounted top module is larger than the robot, go to **System > Settings > Planner**, and select a new footprint under **Robot footprint**.




# 11.8 Using operating hazard zones

Operating hazard zones are areas that must be visibly marked to comply with safety standards in EN 1525 and ISO 3691-4. Personnel must be instructed to stay clear of operating hazard zones when a robot is approaching.

Areas where the robot drives with muted Protective fields and areas with inadequate clearance must be marked as operating hazard zones with signal tape or similar marking material.

To create a sufficiently large operating hazard zone, the marking must be at least one meter away from the potentially hazardous area in all directions.

Robots may need more space to operate than the required operating hazard zone. Consider expanding operating hazard zones to include the required free space for operation to ensure that the robot can operate smoothly. For the robot's space requirements, see the document *Best Practice: Space Requirements* found on the MiR website under **Manuals** for each product page.

It is not allowed to have work stations in operating hazard zones.

You can add zones to the map in the robot interface to mitigate the risks to personnel in operating hazard zones. We recommend considering whether adding the following zones can reduce the risks in an operating hazard zone:

- Speed zones can be used to reduce the speed of the robot to the minimum robot speed.
- Sound and light zones can be used to add acoustic and visual warnings when the robot drives into the zones.

For more information about zones, see the *MiR Robot Reference Guide*.

## Docking to a marker

If the robot needs to dock very close to a marker or another object, you can choose to make the robot mute its Protective fields temporarily—see Creating the mission Variable docking on page 164. This prevents the robot from entering Protective stop when it drives very close to an object. If the robot mutes its Protective fields, the area must be marked as an operating hazard zone.

The muting starts when the robot reaches the entry position approximately one meter from the marker. To indicate this to people nearby, MiR250 slows down and starts blinking yellow, using the eight signal lights on the corners of the robot.

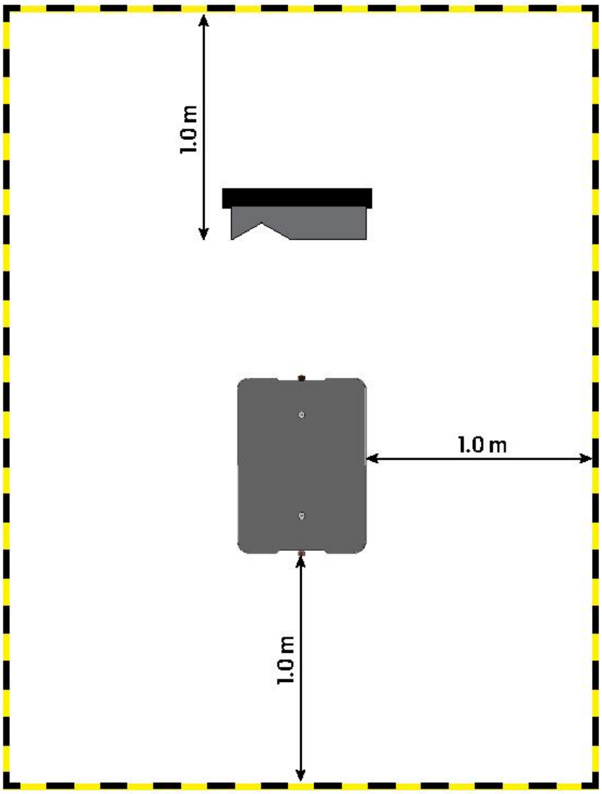



Figure 11.17. The striped black and yellow line identifies the required operating hazard zone around the marker. The robot is placed on the Entry position to the marker.

You must mark the floor area one meter around the docking marker and the robot when it is at the entry position. This is illustrated in *Figure 11.17* where the robot is docking to a VL-marker.

# 11.9 Making a brake test

It is the responsibility of the commissioner to perform an adequate test of the robot's braking capability.

The braking distance of MiR250 is particularly dependent upon four factors:

1. The speed of the robot
2. The payload of the robot
3. The surface the robot drives on
4. The decline of the surface the robot drives on

Because of this, it is not possible to predetermine the exact braking distance of MiR robots. The distance has to be determined in the environment and under the driving conditions the robot will be operating in.

The goal of the brake test is to ensure that the robot will brake in time to avoid a collision with a human or object when driving with maximum payload, with different field sets for different speeds, and at the steepest supported decline.

If the measured braking distance is too long, the Protective field sets of the robot should be made larger to ensure a safe installation. This can happen if the floor has low friction, for example, high gloss floors and similar. The Protective fields should always be at least somewhat larger than the braking distance at all speeds. To modify the field sets, contact your distributor for the guide *How to adjust the protective field sets on MiR250* .

# 11.10 Creating user groups and users

All users of the robot must have a user profile in the system. Users are administered in the Users section where you set up, edit, and delete system users.

The user profiles are created during commissioning. By default, the robot has three user groups: User, Administrator, and Distributor. Parts of the user interface can be locked by the commissioner. The locked parts are typically related to the safety of the robot system, and changing these settings can violate the CE marking of the robot.

It is important to analyze and consider who is:

- Working directly with MiR250 as direct users or operators?
- Responsible for MiR250 as commissioner?

Furthermore, the following questions should be answered:

- How many different users are there?
- What tasks does each user have with MiR250?
- What permissions should the different users have?
- What functions or widgets should be available for the different users?

For more details on users and dashboards, see *MiR Robot Reference Guide* on the MiR website.

## Create user groups

In **Setup > User groups**, you can create specific user groups with specific access to different parts of the robot interface.

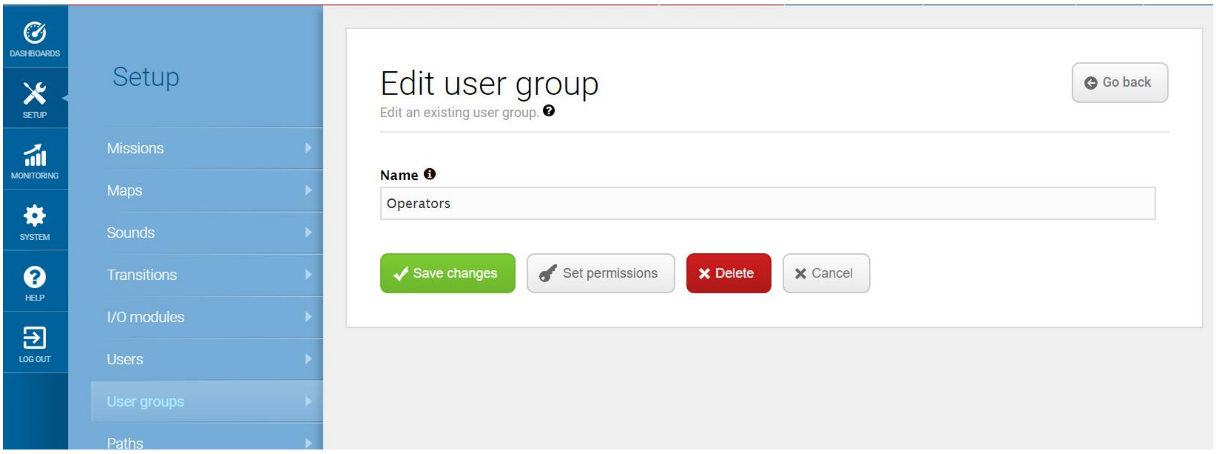



Figure 11.18. You can create specific user groups.

Under **Set permissions**, you can select the specific parts of the robot interface that the user group has access to.

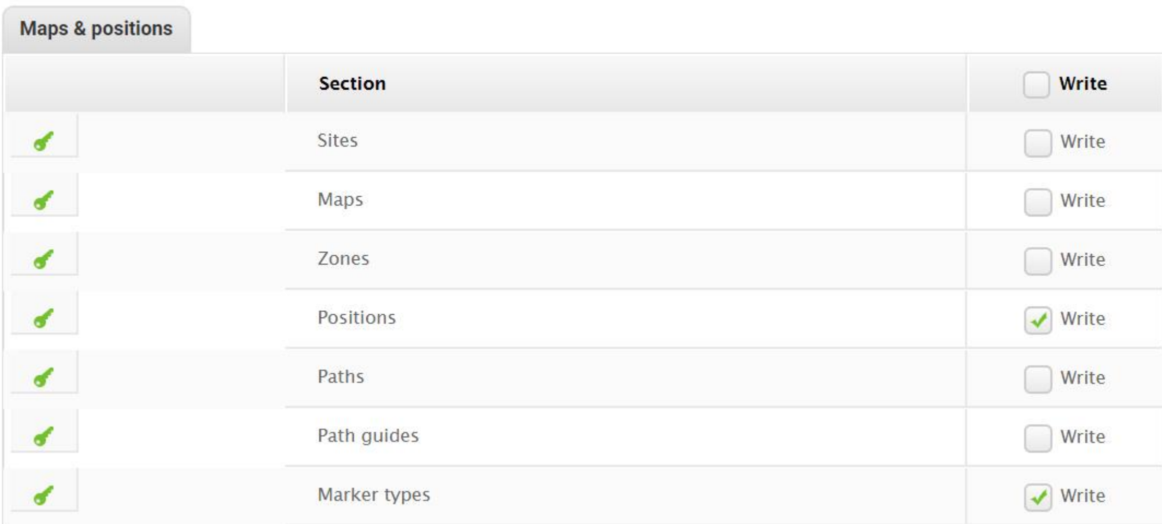



Figure 11.19. You can select the specific parts of the robot interface that the user group has access to.

## Create users

In **Setup > Users**, you can create new users and select:

- Which user group they belong in.
- If they are SingleDashboard users with no access to other parts of the interface than to control the robot from a dashboard.
- If they should be allowed quick access to the interface via a four digit PIN code. We only recommend PIN codes for users with no access to settings and safety system.

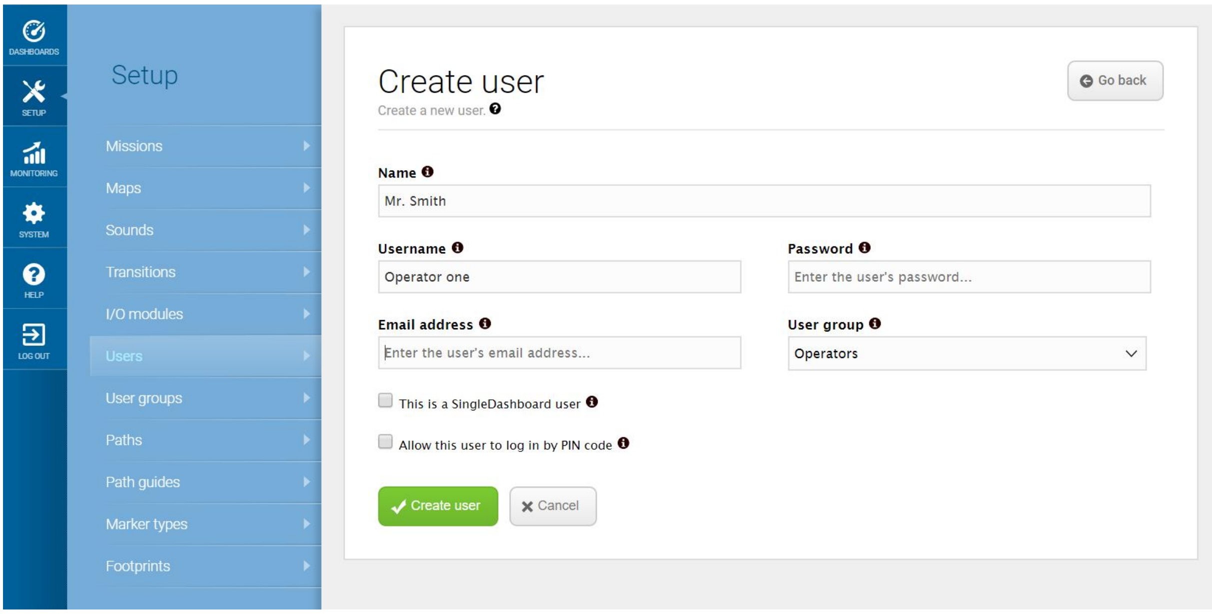



Figure 11.20. When you create a user, you must fill out the fields shown in this image.

**Table 11.1.**
Examples of which users MiR recommends should be able to edit which features

| Feature | User group |
|---|---|
| Controlling the robot manually | Operator |
| Creating maps and positions | Commissioner |
| Creating and editing missions | Operator |
| Adjusting warning sounds | Commissioner |

| Feature | User group |
| --- | --- |
| Creating new user groups | Commissioner |
| Assigning missions | Direct user |
| Changing system settings | Commissioner |

## 11.11 Creating dashboards

To make the user experience as easy and simple as possible, you can build a unique dashboard for each user. Dashboards are an easy way for different user groups to control the robot, giving direct access to the individual groups' key functions.

For more details on how to use and create dashboards, see *MiR Robot Reference Guide* on the MiR website.

A dashboard is made up of a number of widgets, each representing a feature in the system, for example a particular mission, the map the robot is operating on, or the current mission queue.

The system comes with a default dashboard—see *Figure 11.21*—, and users with access rights to create dashboards can create an unlimited number of additional customized dashboards.

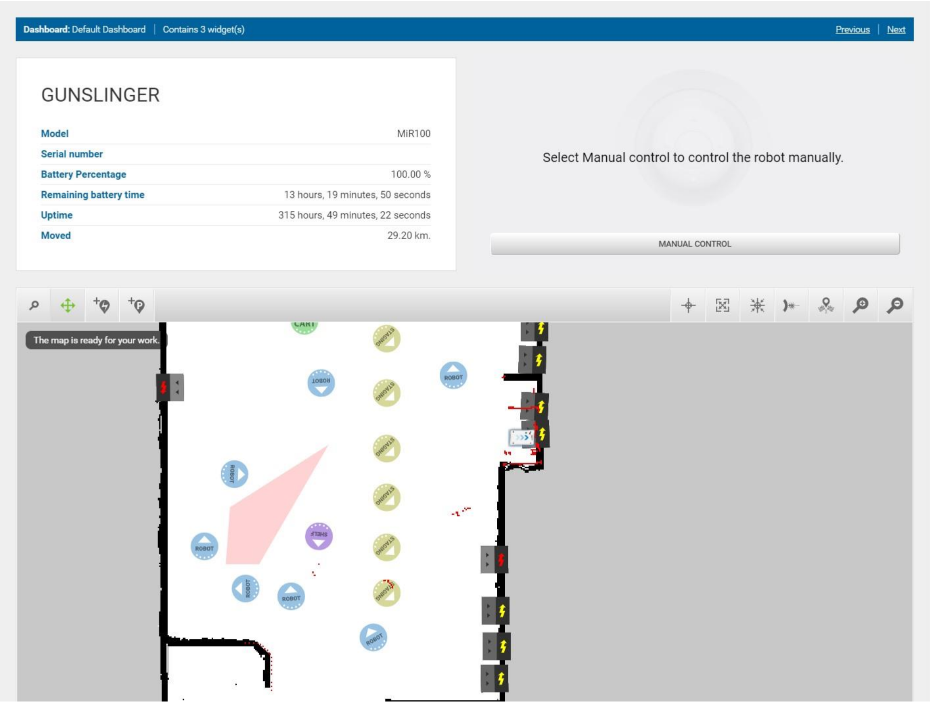



Figure 11.21. The default dashboard includes the robot information, a joystick for manual control, and the active map.

When creating new dashboards, you should consider the following:

- Who will be using the dashboards?
- Which functionalities will they need to use the most?
  - For example, if your robot uses many I/O modules, you may want to monitor them from the dashboard, or if there is a mission that the robot often has to execute on demand, you may want to add it to the dashboard.
- Will each user or user group need a different dashboard? If so, what should be included in each?
- Will some users need more than one dashboard?
  - Users that are responsible for both maintaining and operating the robot could have seperate dashboards for the maintenance routine and another dashboard for operating the robot.
- If you have any SingleDashboard users, which functionalities will they need and which would be useful to include?
  - Often it is not a good idea to include too many widgets in the dashboard as this can slow down the interfacing to the robot. Try to include only the necessary widgets.

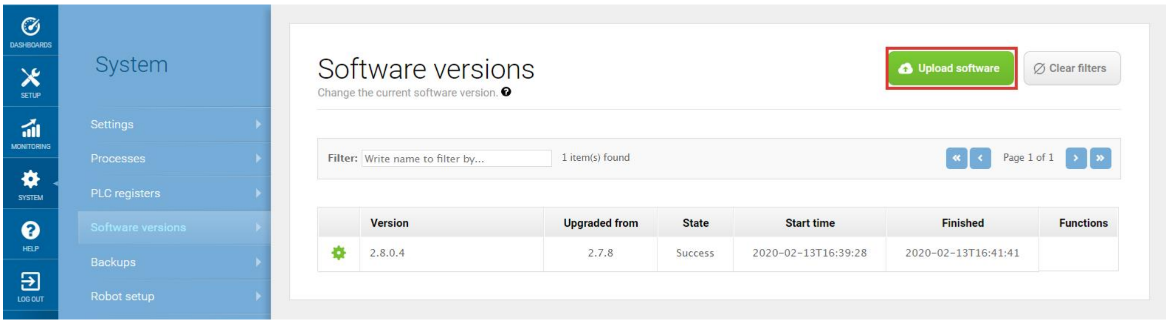
# 11.12 Updating MiR250 software

MiR continuously updates the software the robots use, either to fix issues, to improve existing features, or to introduce new features. Each software release is issued with a release note explaining the content of the update and its target audience.

Contact your distributor for the latest recommended update file.

Follow the steps below to update MiR250 software:

1. Connect your computer to the robot you want to update, and sign in to the robot interface.
2. Go to **System > Software versions** and select **Upload software**.




3. Locate and select the downloaded software package. It may take 10-20 minutes for the package to successfully upload depending on whether or not the software introduces new security patches.
4. Once the software is uploaded, turn the robot off and then on again.

# 11.13 Creating backups

It can be useful to create a backup if you at a later stage want to be able to revert to the exact state of the current software, including data such as settings, missions, and reports.

We recommend to create a backup in the following cases:

- Before you update the robot software.
- Before making any large changes to your site.

Backups take up some of your robot's memory space. It is a good idea to remove any old backups you are certain you will not need in the future.

For more information on how to create, roll back, and delete backups, see *MiR Robot Reference Guide* on the website.

# 11.14 System settings

This section describes some of the commonly used system settings of MiR250 that the commissioner must be aware of.

Only the basic system settings are explained in this section—see *MiR Robot Reference Guide* on the MiR website for more information.

In **System > Settings**, you can access the settings of the robot. Access to the settings must be restricted by the commissioner—see Creating user groups and users on page 132.

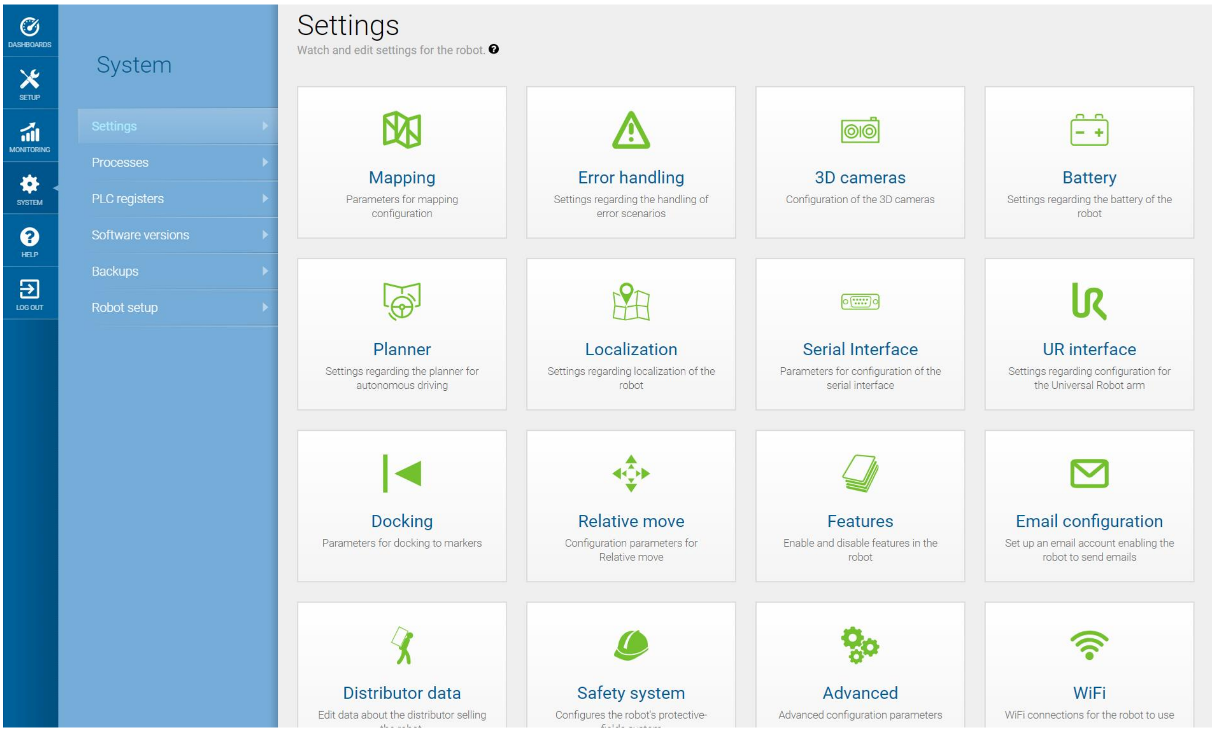



Figure 11.22. Under **System > Settings**, there are several menus where you can edit your robot's settings.

Remember to restart the robot if you have made any changes to the system settings.

## Planner

In the Planner section, you set the basic parameters for driving the robot.

This section refers to the local and global planner functions. For more information on the robot's path planners, see Global planner on page 71 and Local planner on page 73.

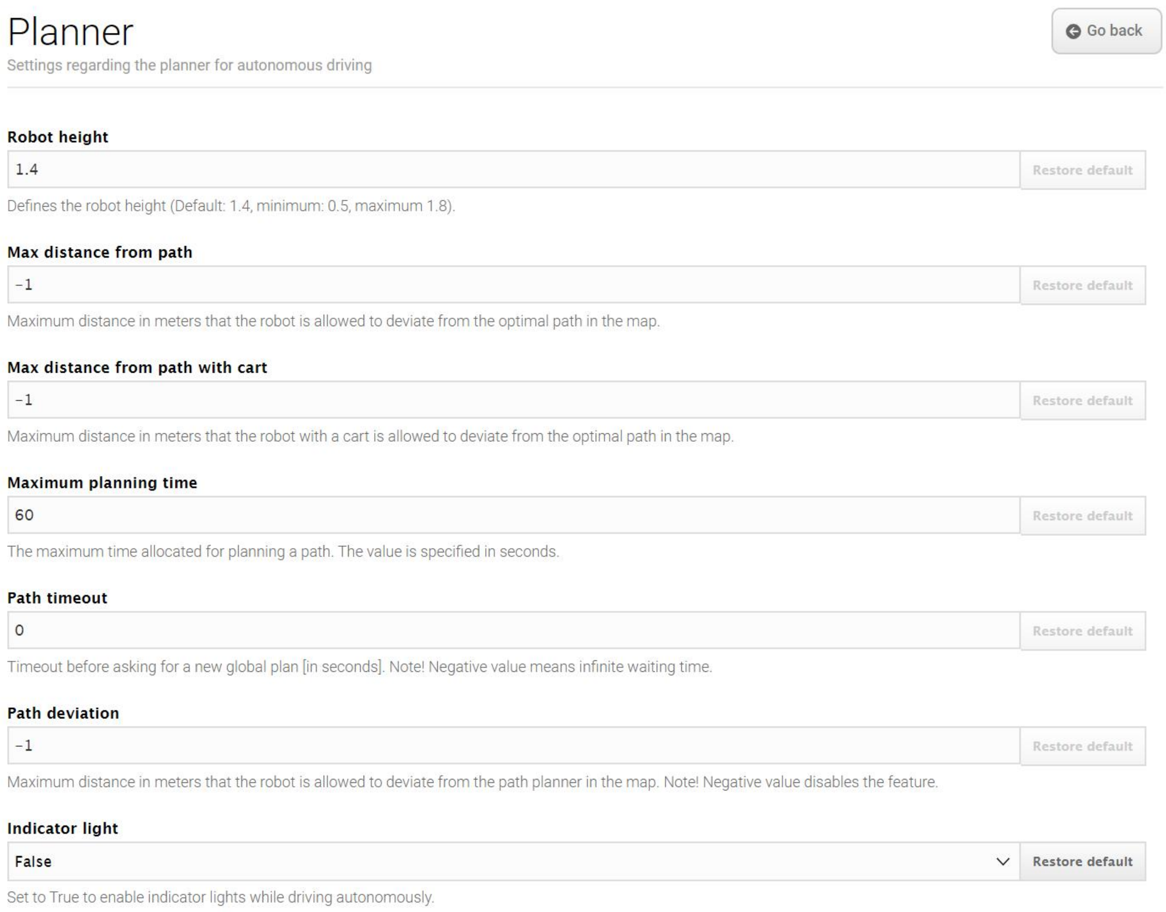



Figure 11.23. You set basic parameters for driving the robot in the Planner section.

**Robot height** defines the height of the robot including top modules. Use this setting if your robot operates permanently with a top module that makes the combined robot application higher than the robot itself. This prevents the robot from colliding with obstacles from above.

**Max distance from path** defines the maximum allowed distance in meters that the generated global path is allowed to deviate from the most direct path on the map. By default, this parameter is disabled, meaning the robot will always make a global path and follow it to the goal position no matter how far the path is. If you want to avoid the robot traveling paths of a specific length and report an error instead, enter the maximum length that the global path may exceed the most direct path.

**Maximum planning time** defines the maximum time allowed for planning a path. By default, this parameter is disabled, meaning the robot will always try to finish planning a global path no matter how long it takes. If you want the robot to report an error after a set time period instead, enter the maximum amount of time in seconds that the robot can spend planning a path before it reports an error.

**Path timeout** defines the maximum time the robot's path can be blocked before it generates a new global path. By default, this value is 0, meaning the robot will not wait if its current global path is blocked by an obstacle it cannot navigate around using the local planner. If you want the robot to wait and see if the obstacle moves before planning a new path, enter the maximum waiting time.

**Path deviation** defines the maximum distance in meters that the local path is allowed to deviate from the global path before it makes a new global path. By default, this parameter is disabled, meaning the robot can deviate from the global path using the local planner to go around an obstacle as far as possible in the map.

Optimizing the timeout and deviation of paths is useful in situations where you want to configure how strictly the robot should follow the path it has planned. Making the robot follow the exact path it has planned with little or no deviation is known as Line-following mode. This can be useful, for example, in narrow corridors where there isn't enough space for the robot to go around dynamic obstacles—see *Figure 11.24*.

For more information on Line-following, contact your distributor for the how-to guide *Enable Line-following mode*.

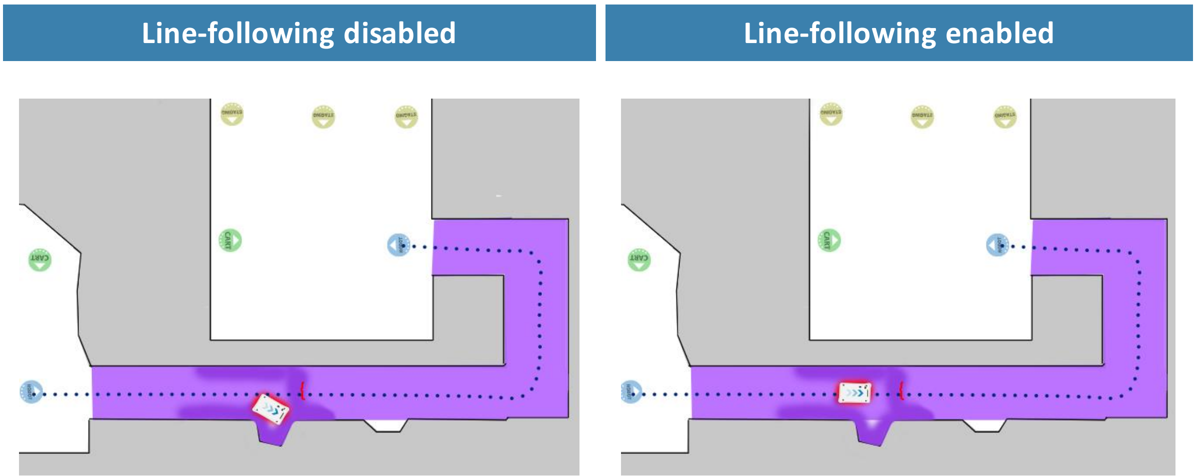



Figure 11.24. Example of where the robot might benefit from using a Line-following configuration. When there isn't enough space for the robot to go around an obstacle, it will often spend more time trying to maneuver around the obstacle and correct its trajectory afterward than it would have just waiting for the obstacle to move out of the way.

**Maximum allowed speed** defines the overall speed limit of the robot. The maximum allowed speed will never be exceeded no matter what is stated in a mission or Speed zone. This setting can be useful if, for example, the robot transports motion sensitive objects or if the work environment in other ways requires the robot to always stay below a certain speed threshold.

**Desired speed** sets the desired speed of the robot. This setting can be useful in the same way as maximum allowed speed, but with this setting, the robot will drive faster than the set desired speed in a Speed zone that requires it.

## Docking

In the Docking section, you can change the parameters regarding docking to and from markers.

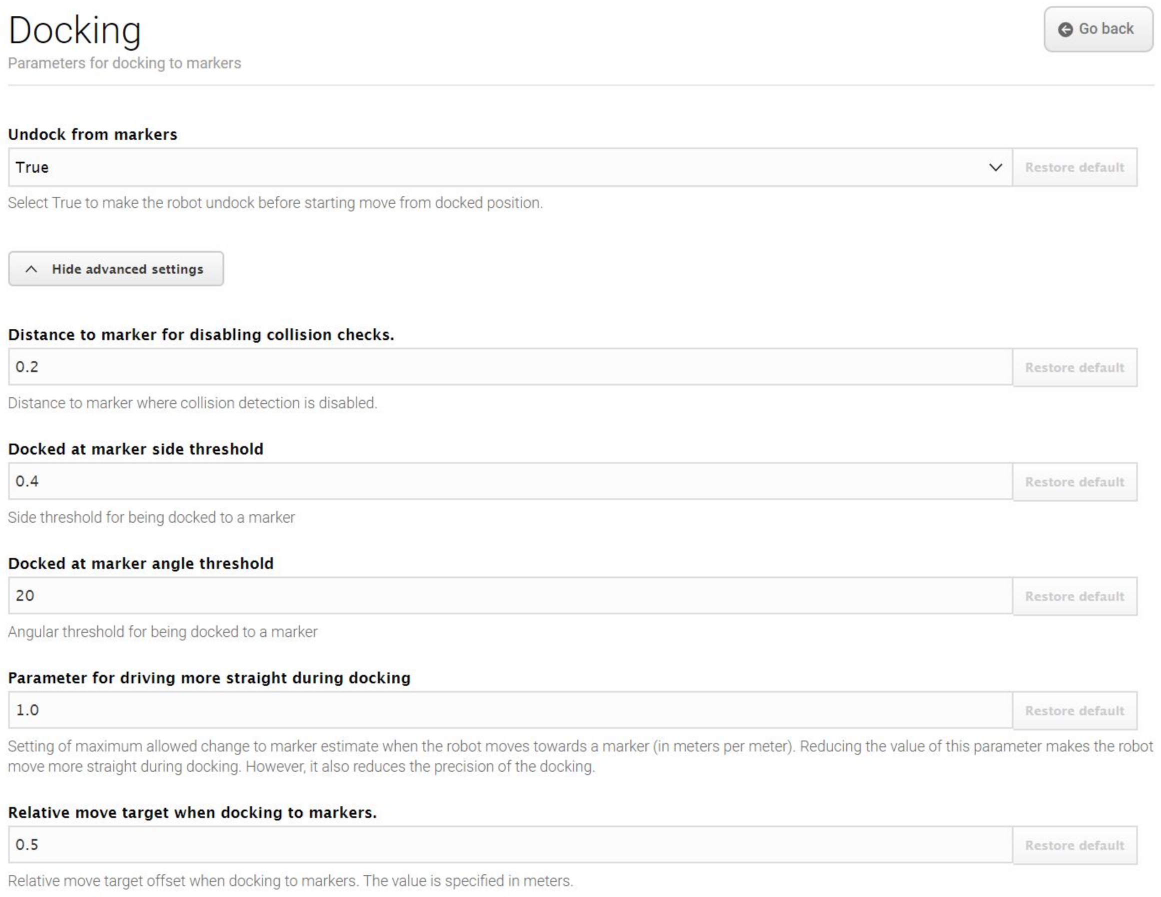



Figure 11.25. Change the parameters regarding docking to and from markers in the Docking section.

In **Undock from markers**, you can select if the robot should undock from a marker before it starts moving from a docked position. It is usually best to set this setting to **True** to prevent the robot from going into Protective stop when moving away from markers.

The robot cannot undock from L-markers automatically—see Markers on page 118. You must use a Relative move action—see Creating the mission Variable docking on page 164.

In the advanced settings, you can adjust the parameters for docking to markers. This can be useful in case of docking issues. To see the advanced docking settings, select **Show advanced settings**.

## Safety system

In the Safety system section, you can change which warning sound the robot should emit when it mutes its Protective fields and how loud the sound should play.

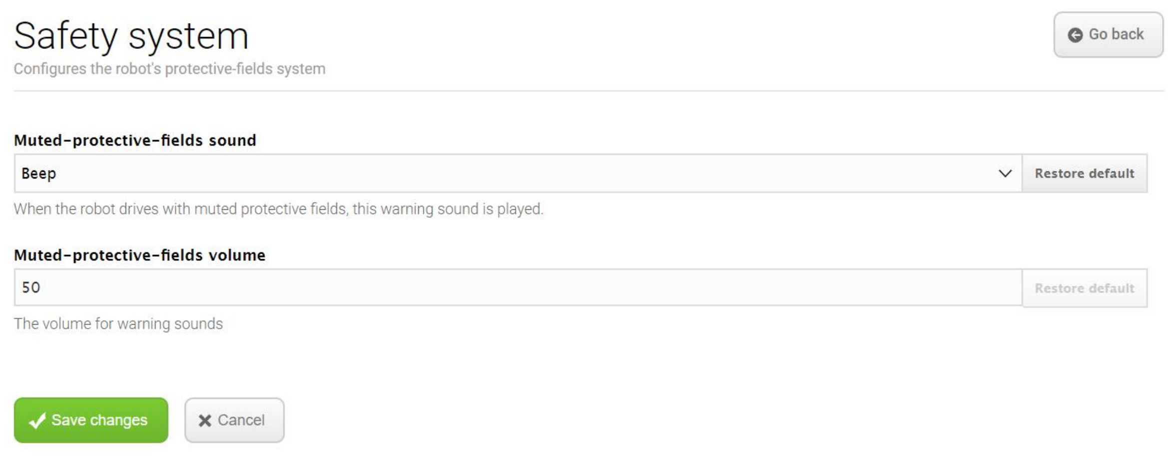



Figure 11.26. In the Safety system section, you can change the robot's warning sound.

Select **Muted protective fields sound** to change the warning sound that is played when the robot drives with muted Protective fields.

Select **Muted protective fields volume** to set the volume in decibel for the warning sound that is played when the robot drives with muted Protective fields.

**CAUTION**

Driving with muted Protective fields without audible warning sound risks damage to personnel and voids the CE marking of the application.

- Always have the robot play an audible warning sound when driving with muted Protective fields.

## Features

In the Features section, you can disable and enable robot features.

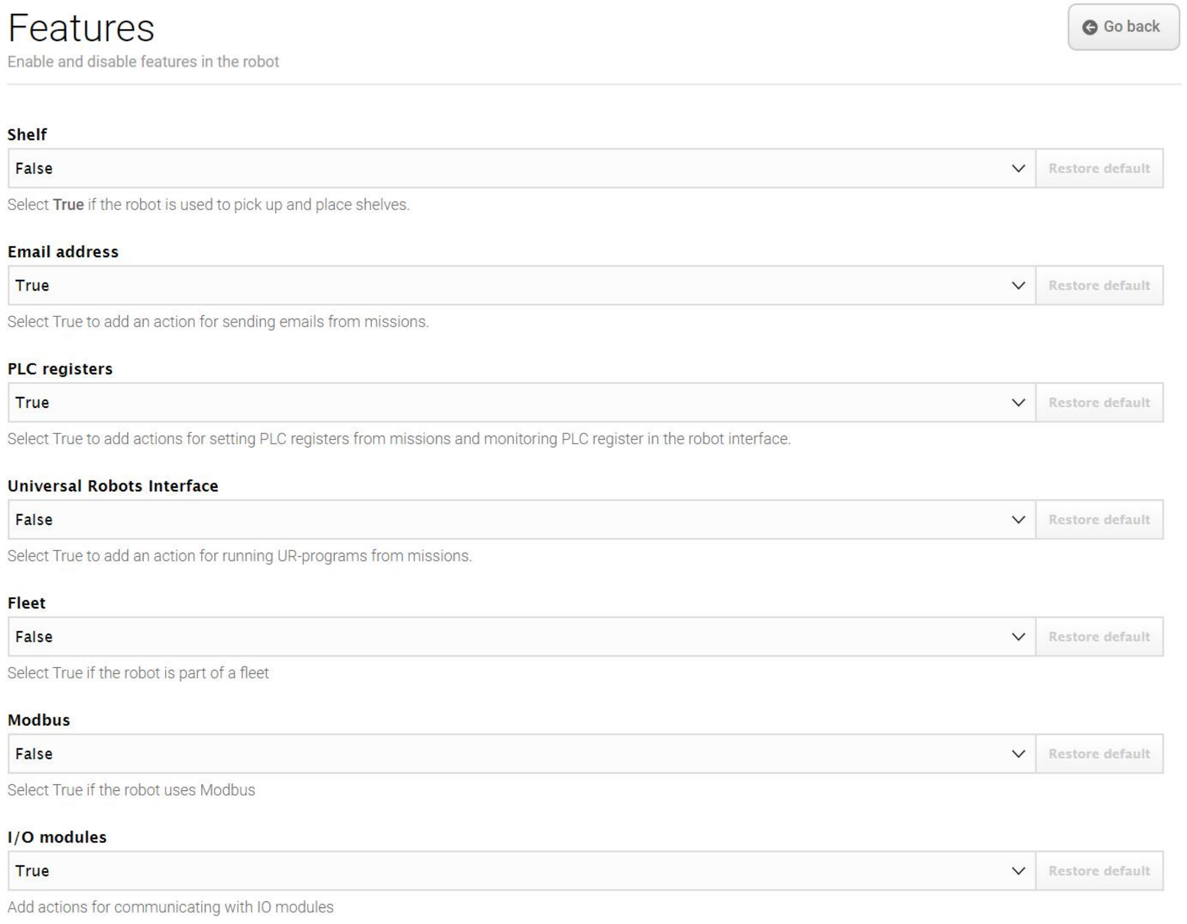



Figure 11.27. Disable and enable robot features in the Features section.

**Shelf** enables the shelf feature. Enable this feature if the robot is used to pick up and place shelves. This modifies how some of the pins in the electrical interfaces are used.

**Email address** enables an action for sending emails from missions. You can configure the email account that the robot sends the emails from under **System > Settings > Email Configuration**.

**PLC registers** enables actions for setting PLC registers from missions and monitoring PLC registers in the robot interface. When enabled, you can access the page **System > PLC registers** to set up the registers.

**Universal Robots Interface** enables an action for running Universal Robots programs from missions. Enable this feature if the robot drives with an application from Universal Robots.

**Fleet** makes the robot visible for MiR Fleet. Enable this feature if the robot is part of a fleet.

**Modbus** enables Modbus communications. When enabled, you can access the page **System > Triggers** to set up the Modbus triggers.

**Pallet lift** enables the lift feature. Enable this feature if the robot has a pallet lift or shelf lift top module mounted to it. This modifies how some of the pins in the electrical interfaces are used.

**I/O modules** adds actions for communicating with I/O modules. This can be used for setting PLC registers and trigger missions. Enable this feature if the robot uses I/O modules, for example, when any MiR top module is mounted to the robot.

**Mute protective fields** enables an action to mute the robot's Protective fields from missions.

# 12. Usage

The main way to use MiR250 is through missions that you create.

In the following sections you will find practical examples of how missions can be tailored to different tasks. The examples include:

- Setting markers and positions on the map.
- Creating a mission that uses a Prompt user action. The example mission is titled *Prompt user*.
- Creating a mission that uses a Try/Catch action. The example mission is titled *Try/Catch*.
- Creating a mission that uses variables. The example mission is titled *Variable docking*.
- Creating a mission that makes the robot drive through an 80 cm doorway. The example mission is titled *80 cm doorway*.

## 12.1 Creating markers

Before creating a marker, you must ensure that the robot is localized correctly on an active map. If in doubt, you can check if the red lines representing the laser scanner view match the black lines on the map, as shown in *Figure 12.1*.

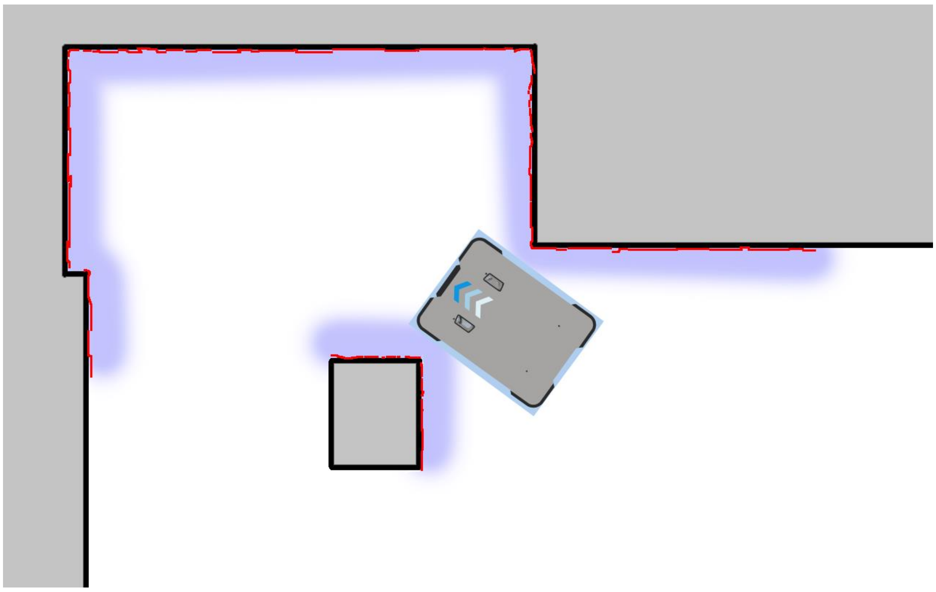
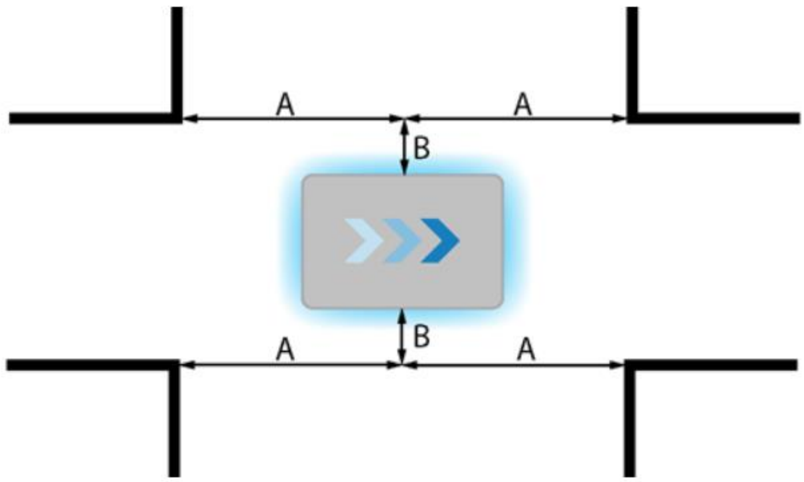
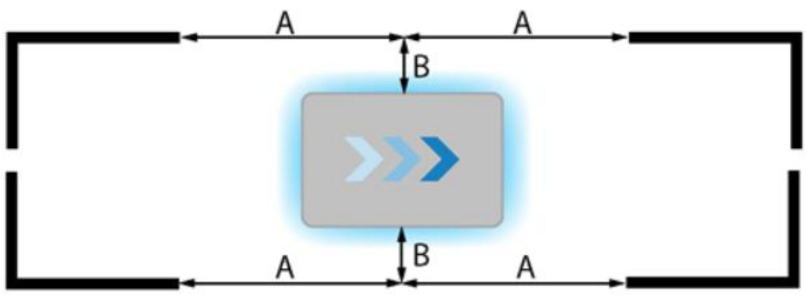


Figure 12.1. The red lines represent the obstacles the laser scanners detect. The robot is localized correctly when the red lines align with the black lines that represent walls.

Once the robot is localized, you can insert a marker on the map. In this example, we are using a VL-marker . To create a marker, follow these steps:

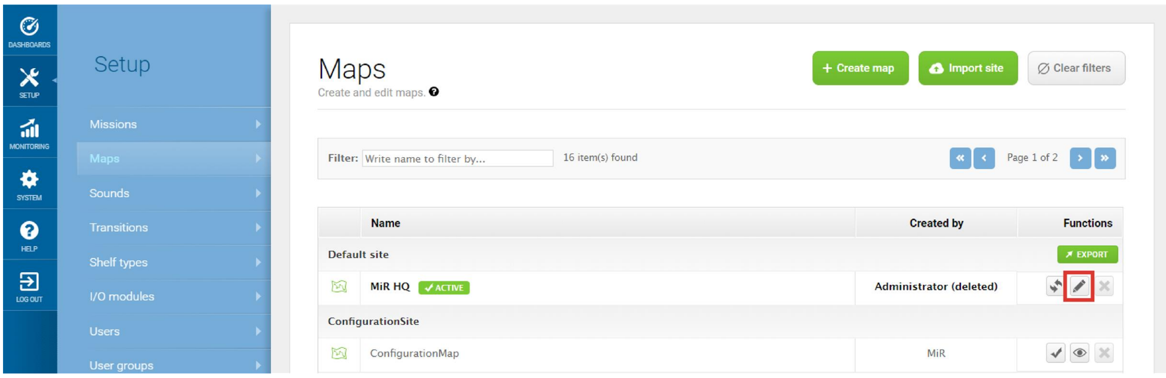
1. Place your physical marker where you want the robot to dock.
2. Manually drive the robot to the marker so the robot is facing the marker. The correct distance from the marker differs depending on the marker type:
   - For L-markers, the following values apply:
     - A: 700 mm ±50 mm
       B: 200 mm ±50 mm



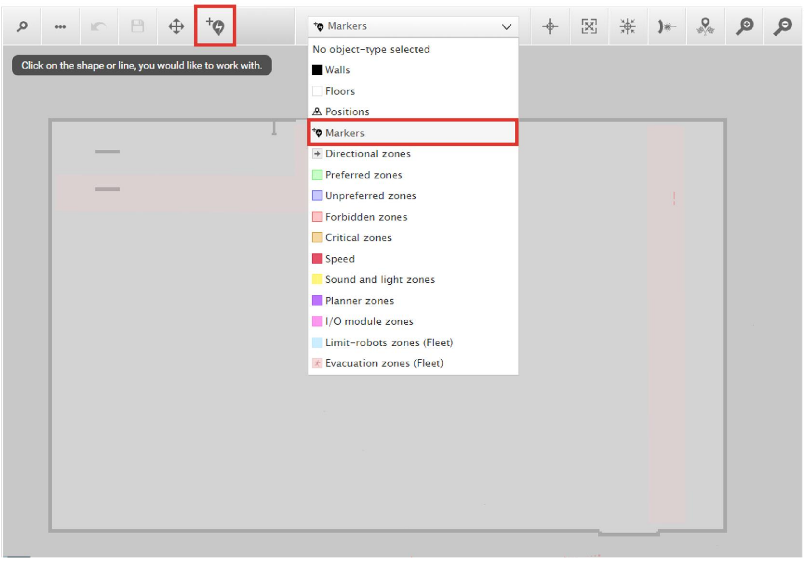




   - For all other markers, the robot must be positioned approximately one meter directly in front of the marker.

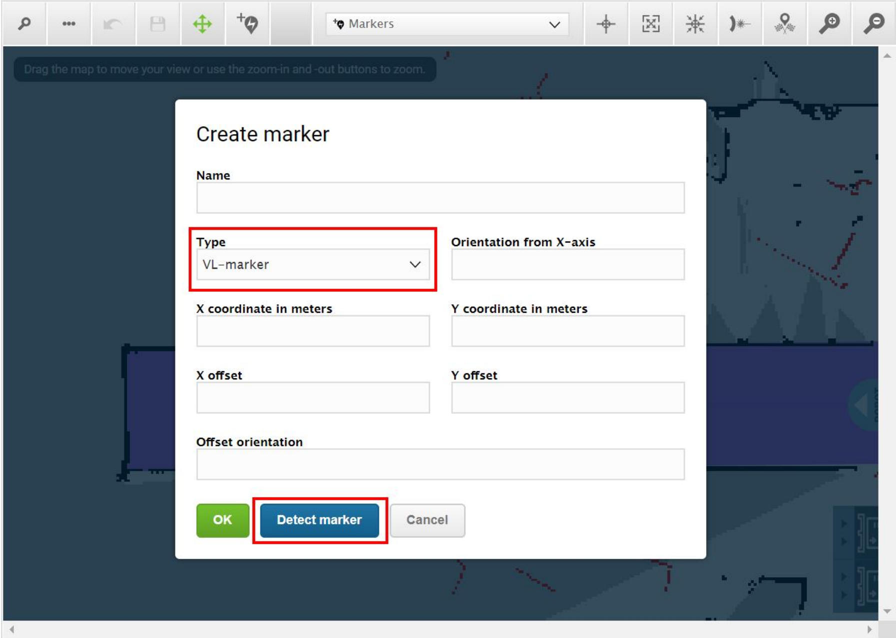
3. Go to **Setup > Maps**, and select **Edit** ✎ for the active map.




4. Within the editor, select **Markers** in the Object-type drop-down menu, and then select **Draw new marker** in the editor tools.



5. In the **Create marker** dialog box, name the marker. Under **Type**, select your marker type. In this case, a **VL-marker** is used. Then select **Detect marker**.

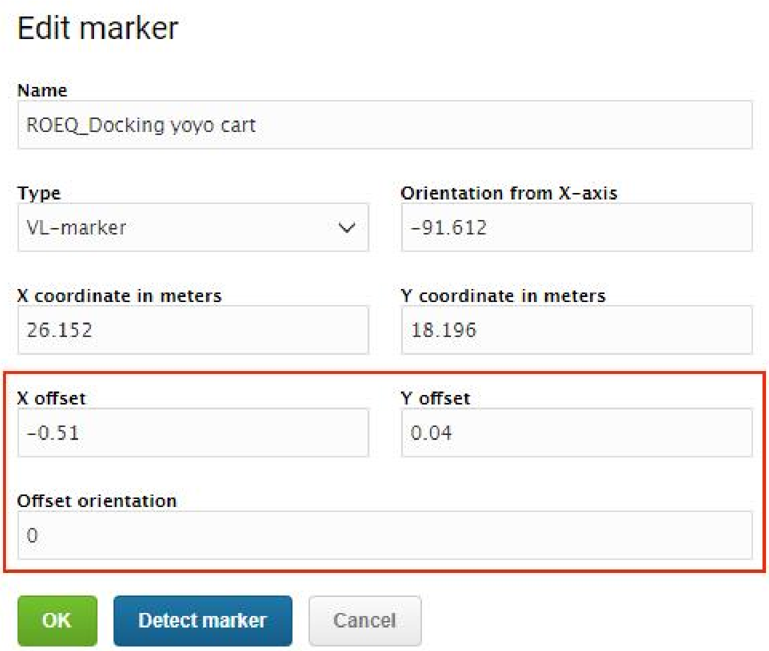



The X, Y, and orientation values will automatically be filled out with the current position of the robot.

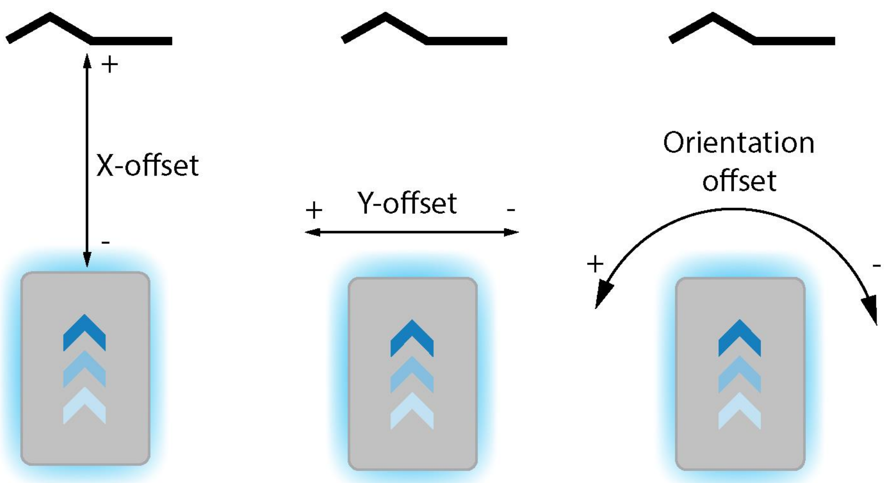
- If the robot cannot detect the marker, verify that the robot is correctly positioned and that the laser scanners can detect the marker in the active map by checking that red lines are displayed on the map where the marker is.
- If you are trying to make the robot detect an L-marker but it keeps detecting other objects with a 90° angle instead, shield the objects that the robot is not supposed to detect with a flat plate.
- If you want the robot to dock straight to the marker, set the orientation offset to 0°. If you want the robot to reverse into the marker, set the **Offset orientation** to 180°.

Detecting the marker with the rear scanner will automatically set the orientation offset to approximately 180° for a reverse docking.

- To change where the robot stops relative to the marker, you can adjust the offsets. These are valued in meters and are based on the centerpoint of the robot towards the marker.




- The X-offset moves the robot closer to or further from the marker in meters.
- The Y-offset moves the robot further to the left or right of the marker in meters.
- The orientation offset changes the final orientation of the robot in degrees.



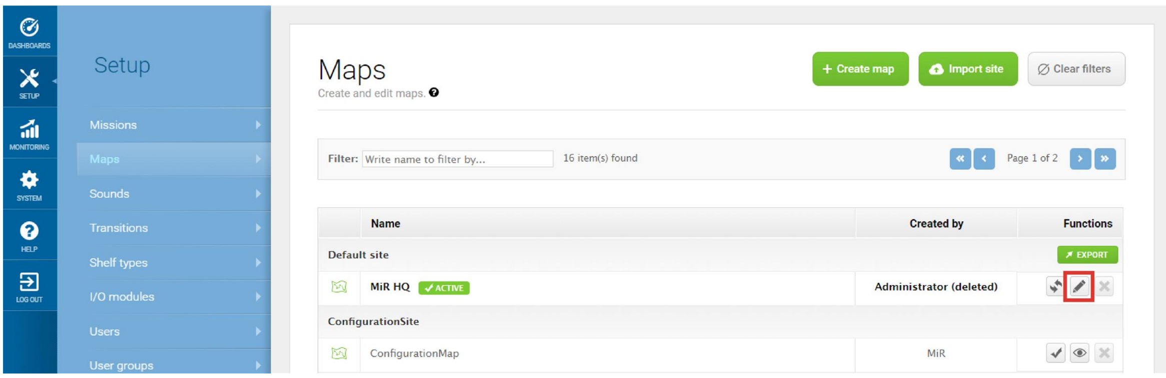
6. Select **OK** to create the marker. The marker is now visible on the map.

You can make the robot dock to the marker by selecting it on the map and selecting **Go to**. The marker can also be used in missions.

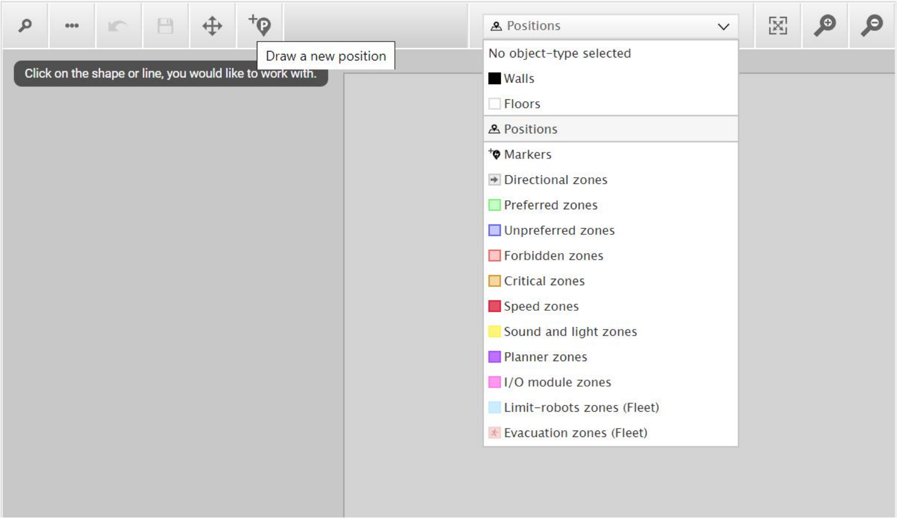

# 12.2 Creating positions

The following steps describe how to create a position on a map. In this example, we are creating a Robot position .

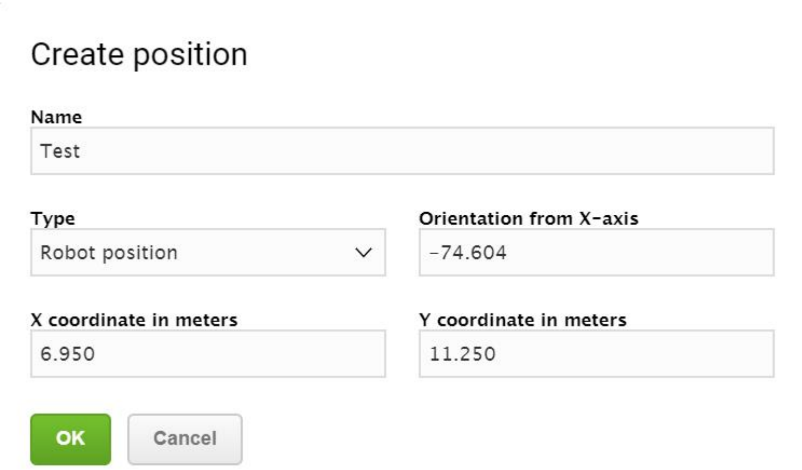
1. In the robot interface, enter the map editor of the map where you want to create a position. This is done by going to **Setup > Maps** and selecting **Edit** next to the map you would like to work on.



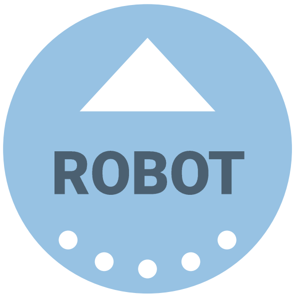
2. In the Object-type drop-down menu, select **Positions**, and then select **Draw a new position**.




3. Select where on the map you want the position to be, and choose in which direction you want it to face.
4. Name the position. Under **Type**, select which type of position you want to make. In this example we are making a Robot position.



5. Select **OK** to create the position. The position is now visible on the map.




You can send the robot to the position by selecting it on the map and selecting **Go to**. The position can also be used in missions.


# 12.3 Creating the mission *Prompt user*

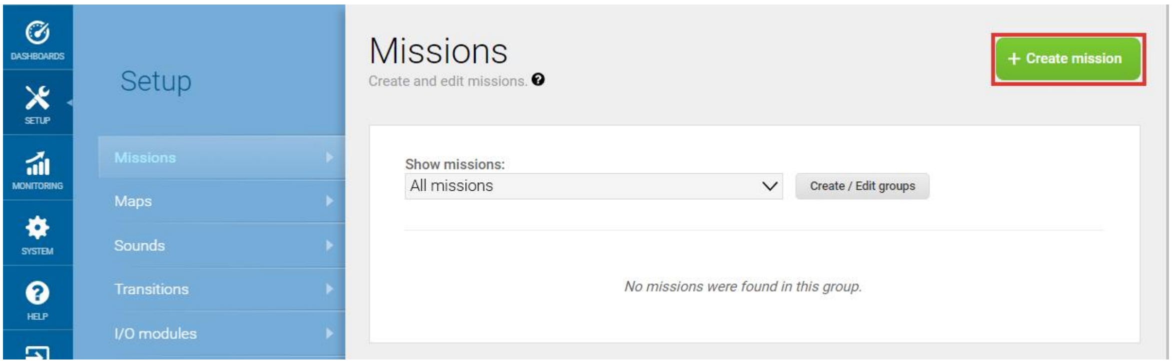
Prompt user actions are used for prompting the user with a question on how the robot should proceed. *Prompt user* is an example mission that uses a Prompt user action that lets you choose whether to send the robot to one position or another.

Before you create the mission *Prompt user*, it is assumed that you have completed the following:

- Created two robot positions named *p1* and *p2* as described in Creating positions on page 151.
- Defined a user group named *Users*.

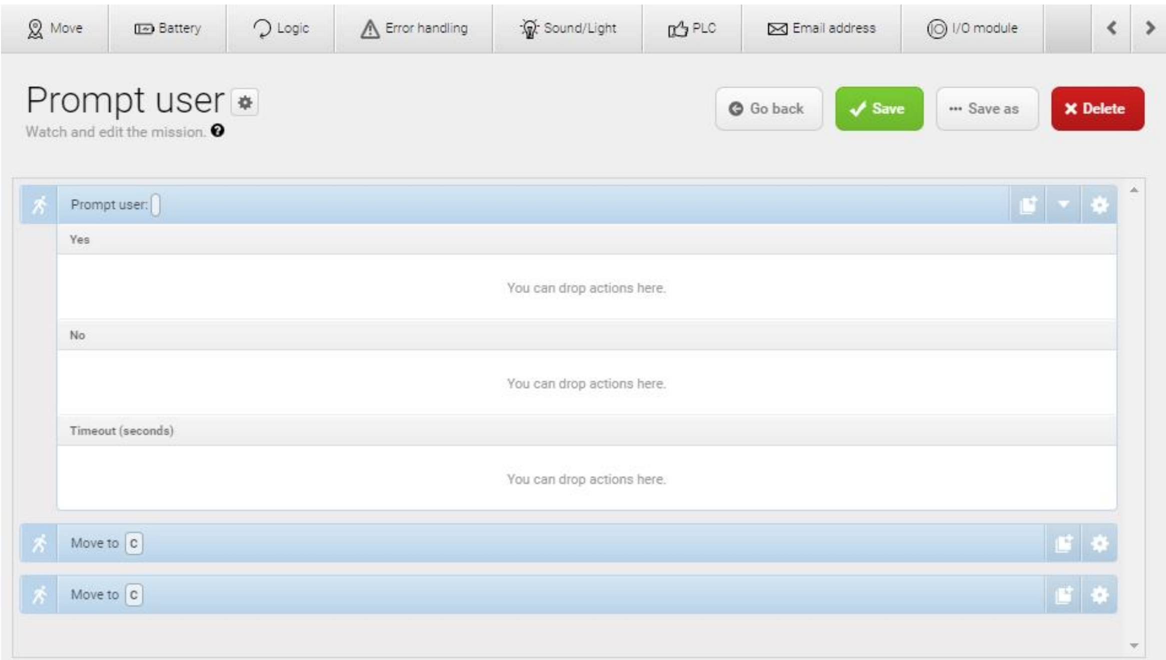
To create the mission, follow the steps below:

1. Go to **Setup > Missions**. Select **Create Mission**.



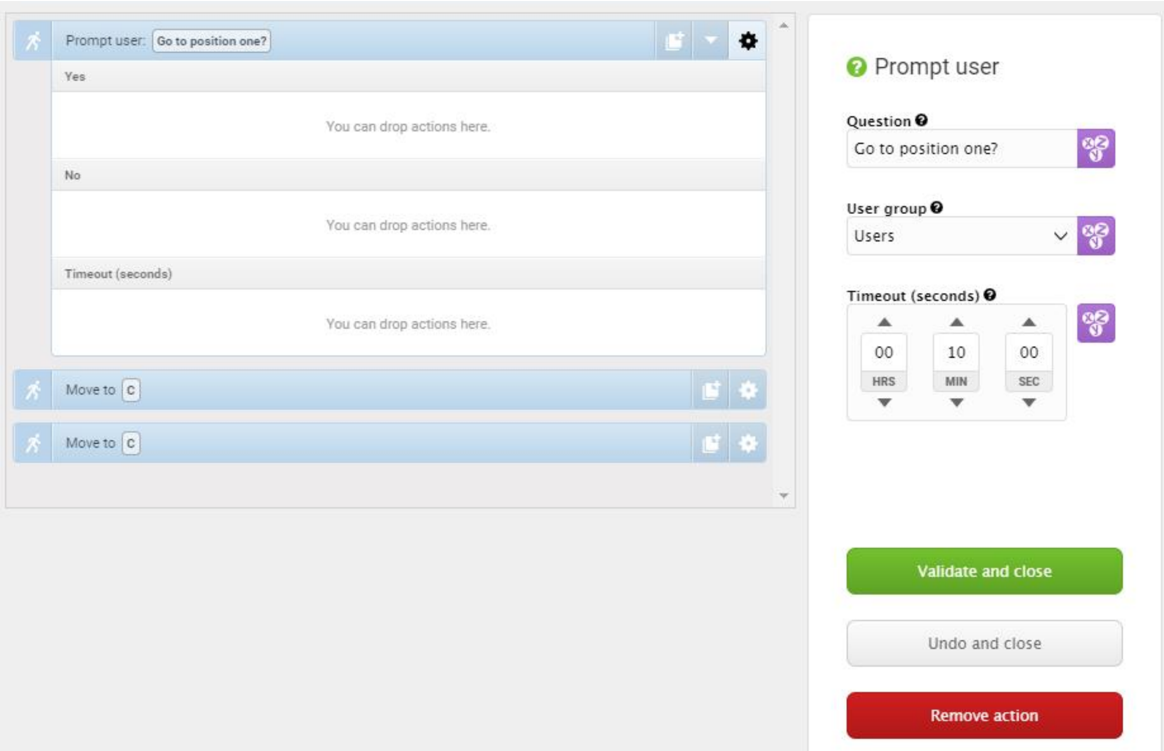

2. Name the mission *Prompt user*. Select the group and site you want it to belong to. Select **Create mission**.

3. Select the following actions:
   - In the Logic menu, select **Prompt user**.
   - In the Move menu, select **Move**.
   - In the Move menu, select **Move**.

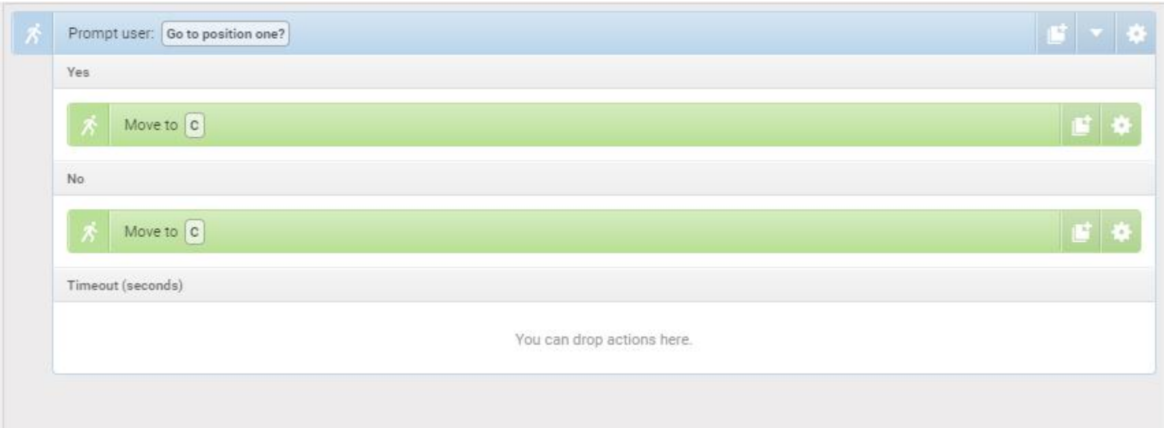



The following steps describe which parameters each action should be set to. To modify the parameters, select the gearwheel ⚙ at the right end of the action line to open the action dialog box. When you have set the parameters, select **Validate and close**.

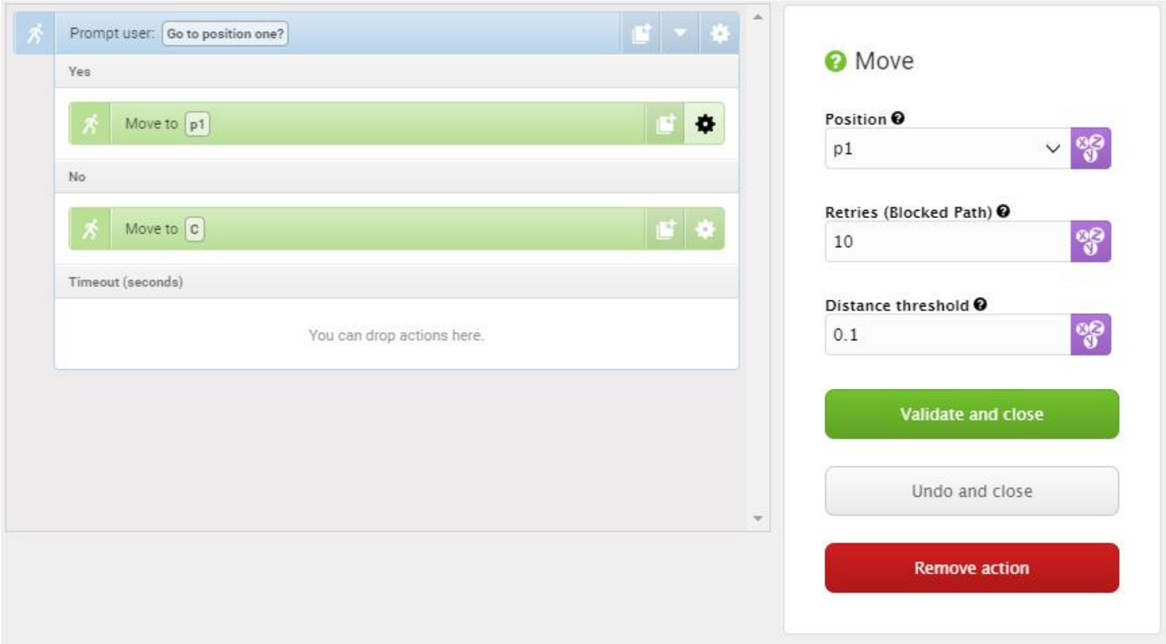
4. In the Prompt user action, set the parameters as follows:
   - **Question**: Enter the question **Go to position one?**.
   - **User group**: Select **Users**.
   - **Timeout**: Set the timeout to 10 minutes.



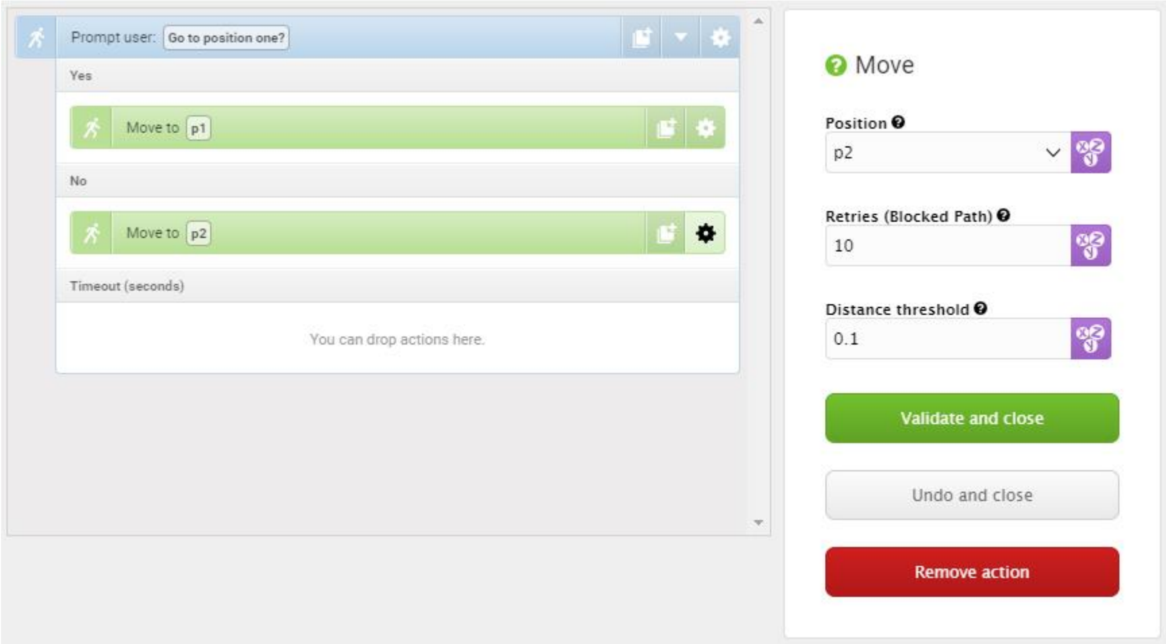

5. In the Prompt user action, drag a Move to action under the **Yes** box and a Move to action under the **No** box.



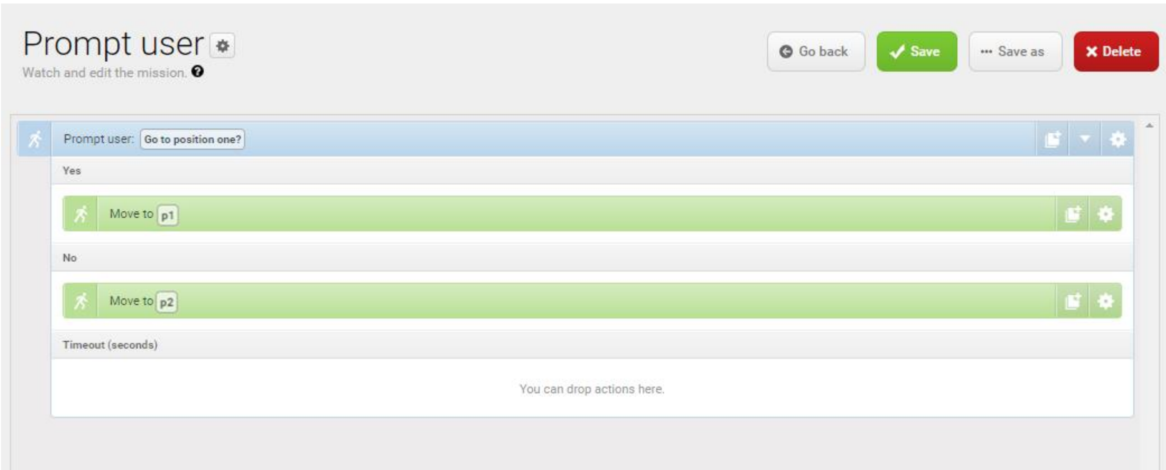
6. In the first Move to action, under **Position**, select **p1**.



7. In the second Move to action, under **Position**, select **p2**.




The mission should look like this:




8. Select ✓ **Save** to save the mission.

# 12.4 Creating the mission *Try/Catch*

Try/Catch actions are used to handle mission errors. When you use a Try/Catch action, you can define what the robot should do if, at any point, it fails to execute its main mission. This prevents the robot from going into an error state and stopping in the middle of a mission by providing an alternative course of action if the main mission fails.

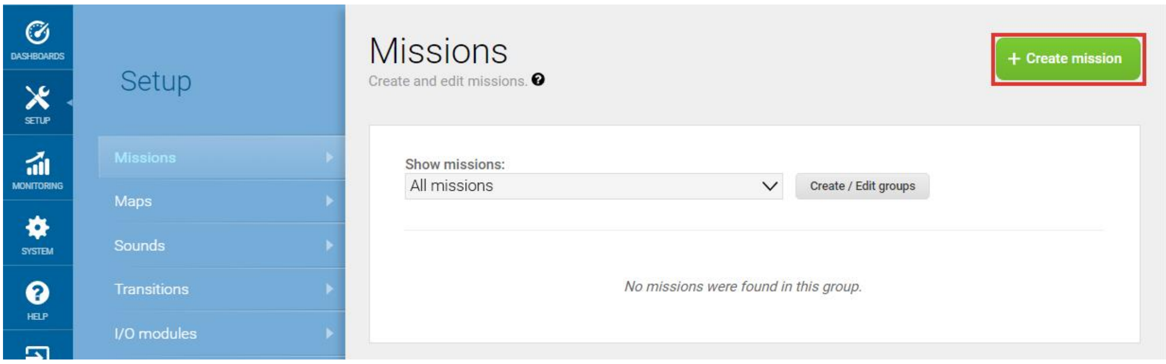
*Try/Catch* is a mission example where the robot runs the mission *Prompt user* created in Creating the mission Prompt user on page 153, and if the robot for some reason fails to complete the mission, the robot plays a sound.

To create the mission *Try/Catch*, it is assumed you have completed the following:

- Created the mission *Prompt user* as described in Creating the mission Prompt user on page 153.

To create the *Try/Catch* mission, follow the steps below:

1. Go to **Setup > Missions**. Select **Create Mission**.

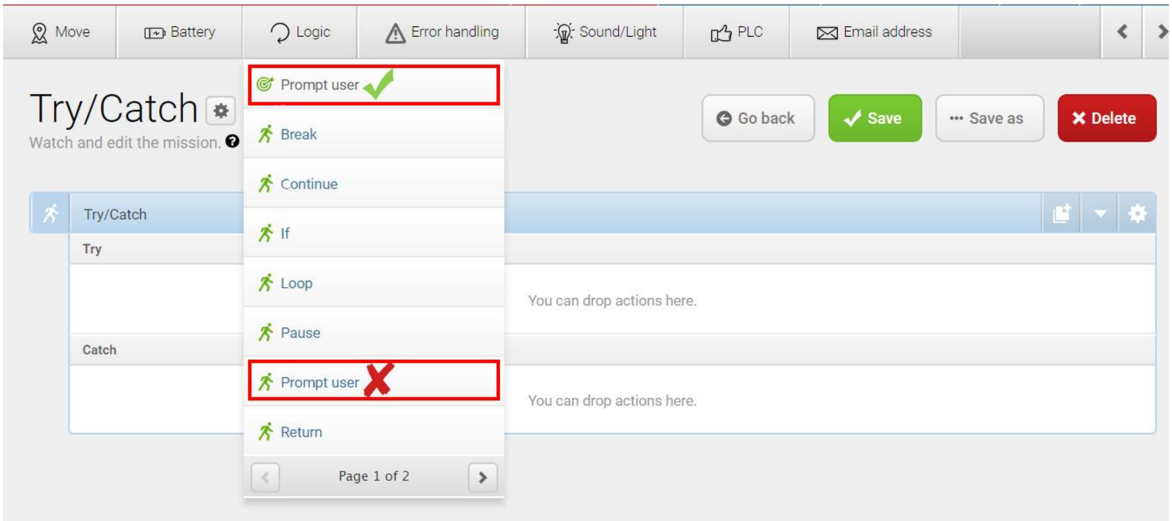



2. Name the mission *Try/Catch*. Select the group and site you want it to belong to. Select **Create mission**.

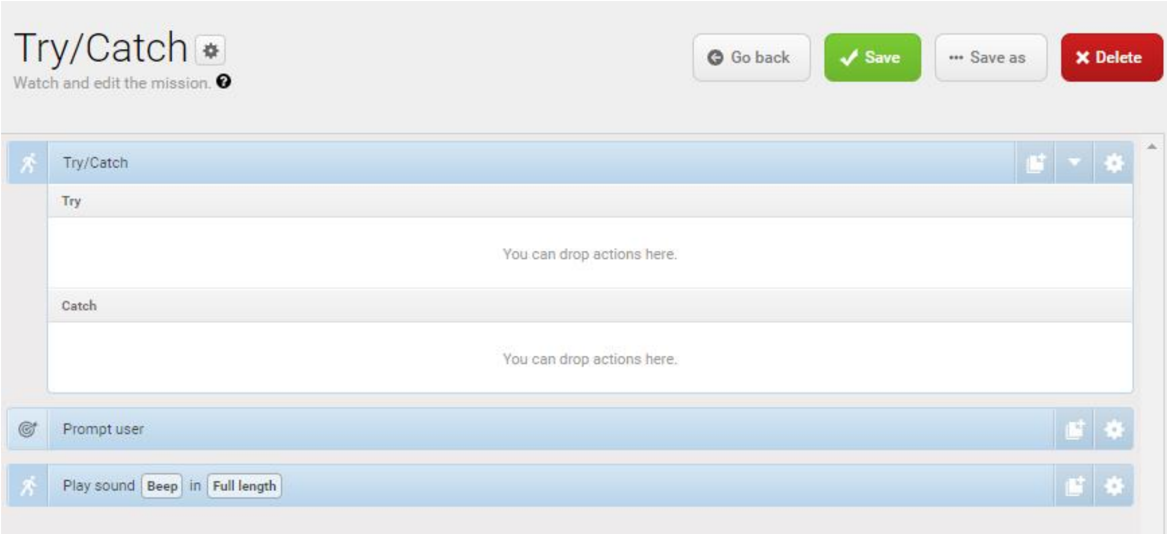
3. Select the following actions:
   - In the Error handling menu, select **Try/Catch**.
   - Select the Prompt user mission you have made.

The mission menu you have saved the mission under will figure as a menu in the mission editor. The menus contain both missions and actions.

Missions have this icon and actions have this icon . In this example, the mission is saved under the Logic menu that also includes the Prompt user action . Be sure to select the Prompt user mission .

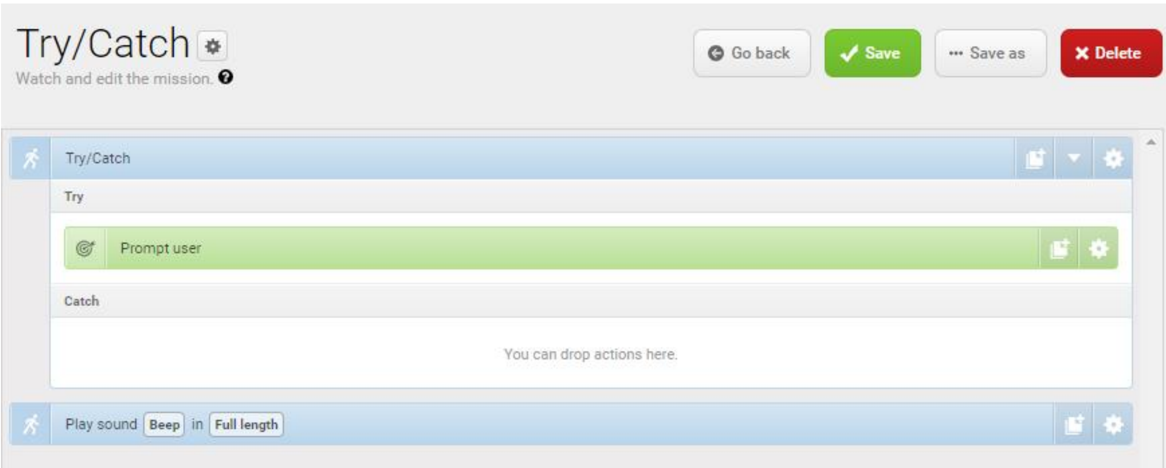



- In the Sound/Light menu, select **Play sound**.

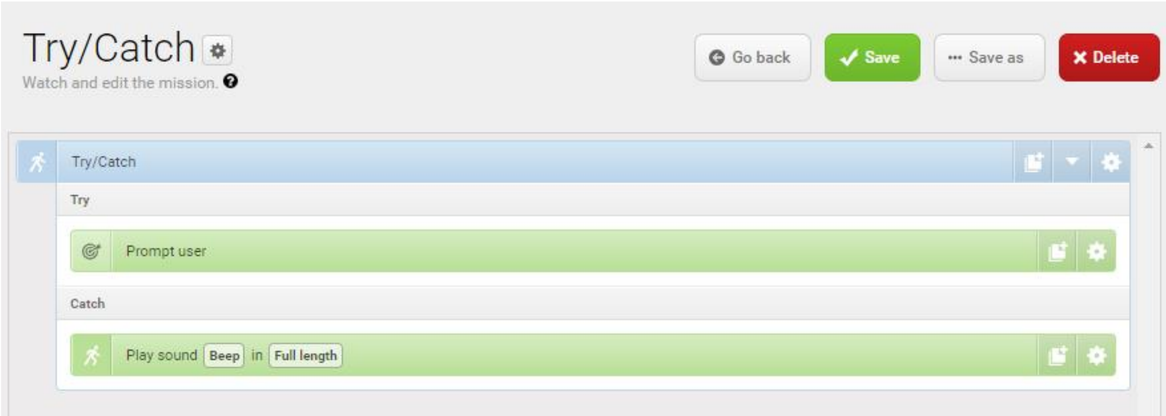



The following steps describe which parameters each action should be set to. To modify the parameters, select the gearwheel ⚙ at the right end of the action line to open the action dialog box. When you have set the parameters, select **Validate and close**.

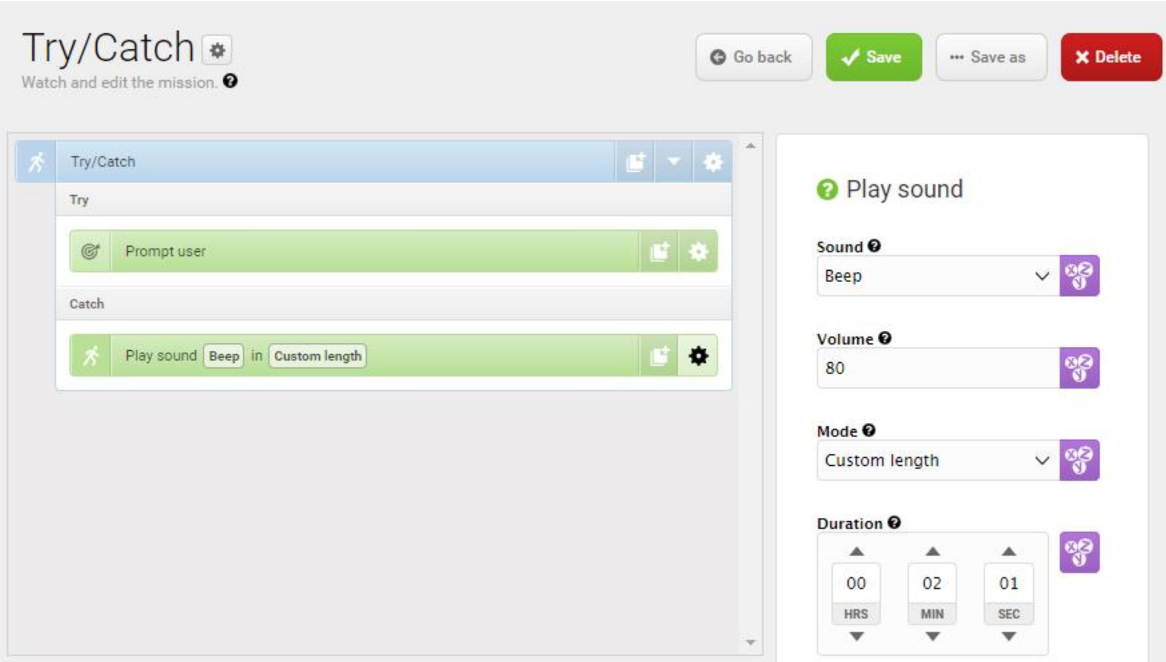
4. Drag the Prompt user mission into the **Try** box under **Try/Catch**.



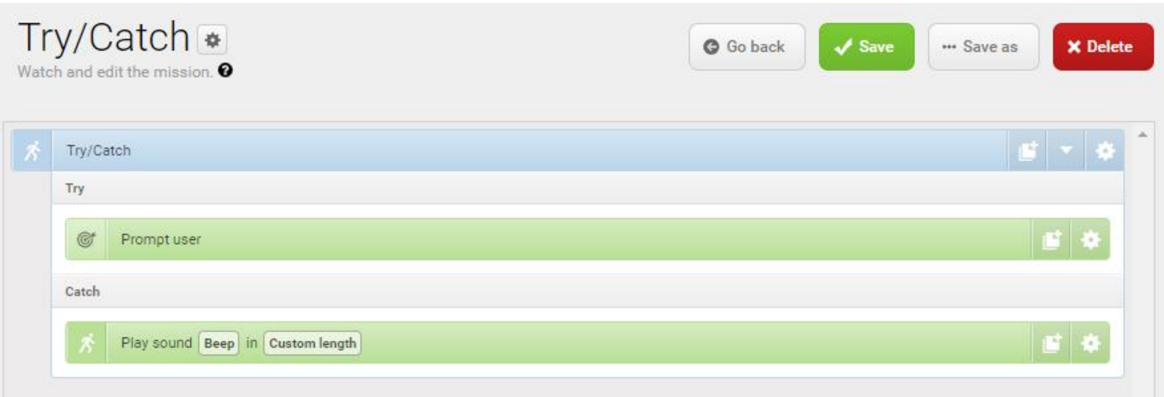
5. Drag the Play sound action under the **Catch** box under **Try/Catch**.



6. In the Play sound action, set the parameters as follows:
   - **Sound**: Select **Beep**.
   - **Volume**: Enter the value **80**. This is approximately 64 dB.
   - **Mode**: Select **Custom length** so you can enter the duration of time the sound is played.
   - **Duration**: Set the duration to two minutes.




The mission should look like this:




7. Select ✓ **Save** to save the mission.

# 12.5 Creating the mission *Variable docking*

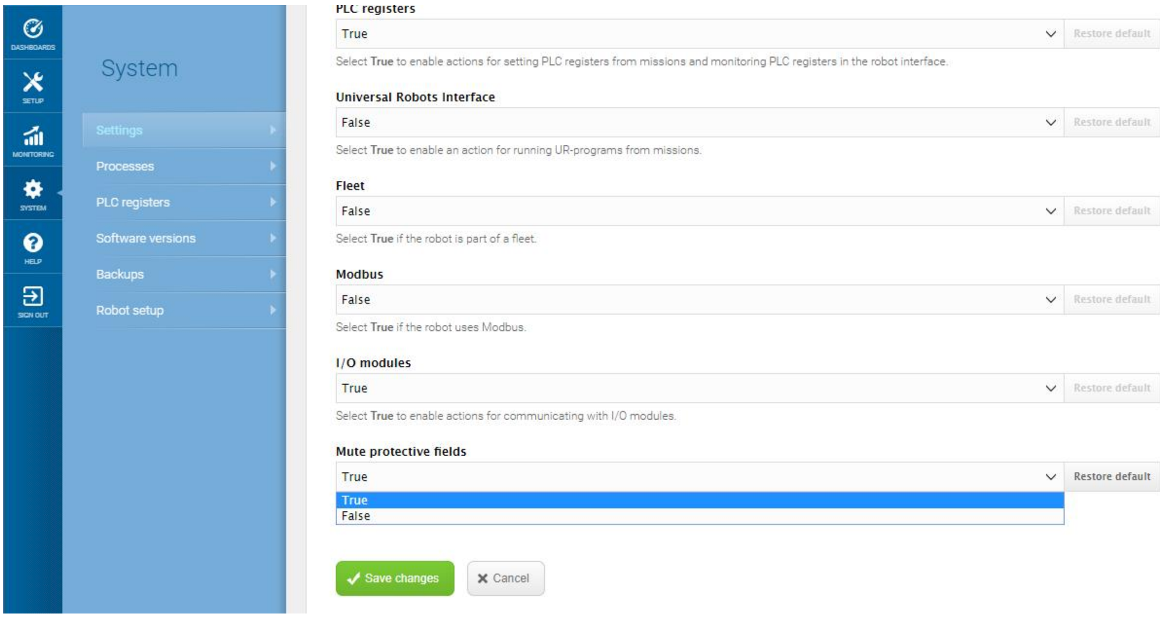
All mission actions that require the user to specify the value of a parameter when they choose to use the mission have the option of defining a variable. If you use a variable in a mission when you add the mission to the mission queue or embed it inside another mission, you must select a value for the parameter where the variable is used. This allows you to reuse the same mission for different but still similar tasks.

*Variable docking* is a mission example that enables you to select which marker the robot should dock to, whether to mute the Protective fields when the robot is docking, and how long the robot should wait before undocking each time you use the mission.

When the robot docks to a marker, it often has to drive very close to an obstacle, for example, the marker itself. To prevent the robot from triggering a Protective stop when it drives too close to the obstacle, you can make it mute its Protective fields.

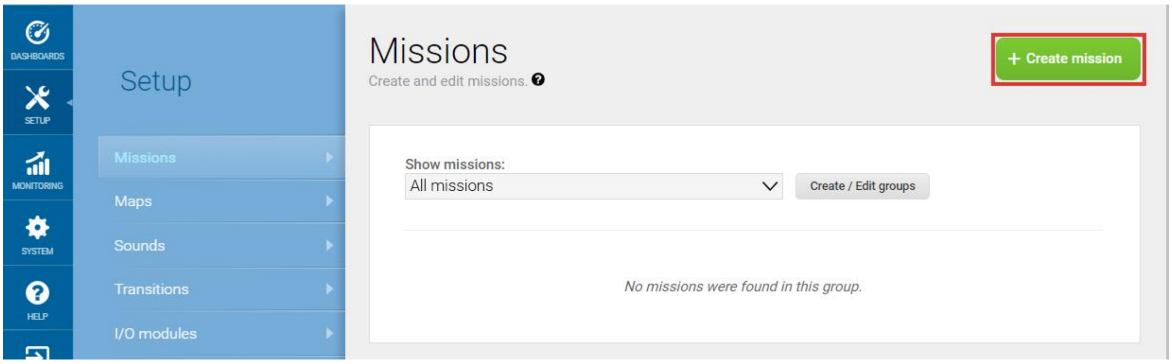
To create the mission *Variable docking*, it is assumed you have completed the following:

- Enabled the muting of the Protective fields. Go to **System > Settings > Features**, and set **Mute protective fields** to **True**.



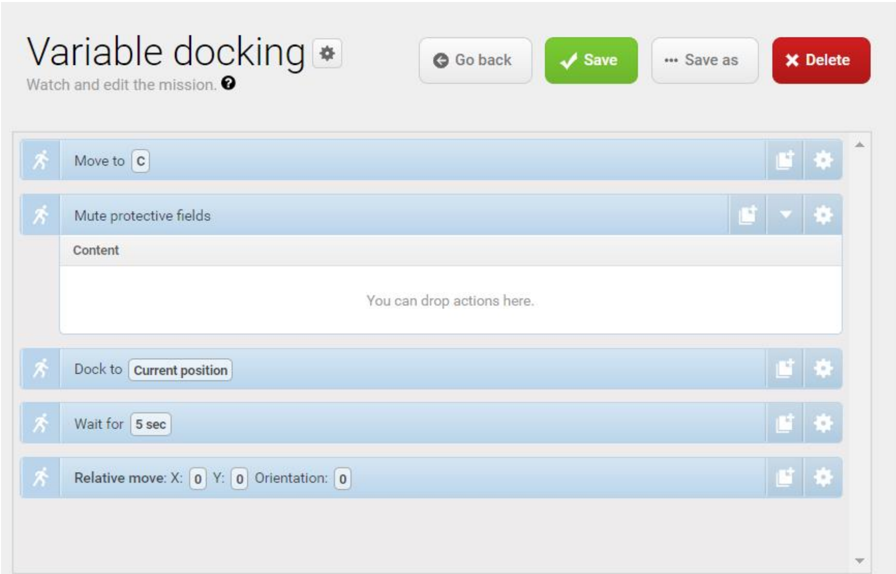
To create the mission, follow these steps:

1. Go to **Setup > Missions**. Select **Create Mission**.



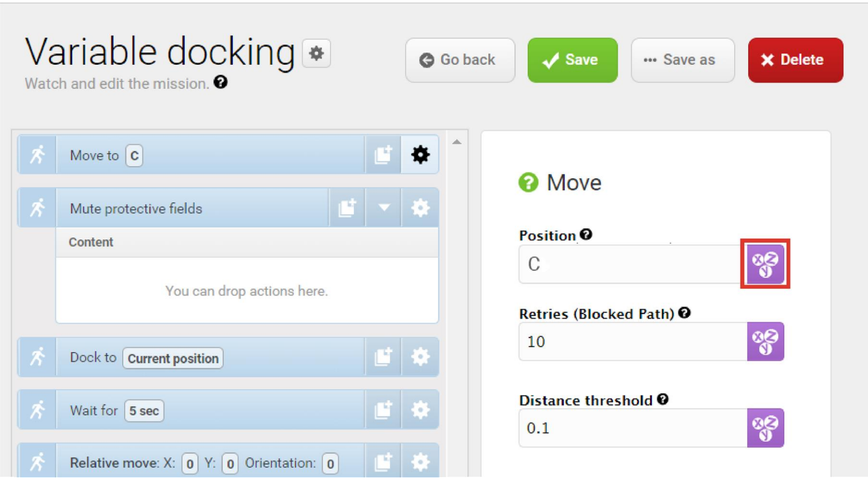

2. Name the mission *Variable docking*. Select the group and site you want it to belong to. Select **Create mission**.

3. Select the following actions:
   - In the Move menu, select **Move**.
   - In the Safety system menu, select **Mute protective fields**.
   - In the Move menu, select **Docking**.
   - In the Logic menu, select **Wait**.
   - In the Move menu, select **Relative move**.

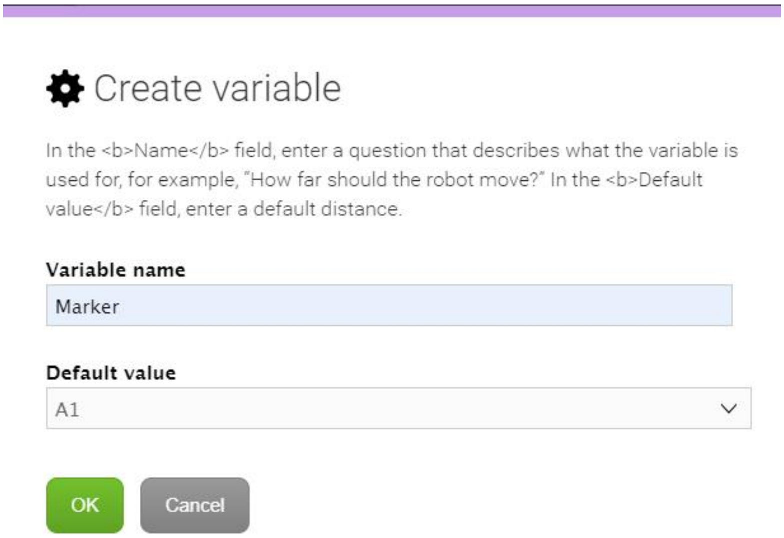



The following steps describe which parameters each action should be set to. To modify the parameters, select the gearwheel ⚙ at the right end of the action line to open the action dialog box. When you have set the parameters, select **Validate and close**.

4. In the Move action, make the parameter **Position** a variable that can be set each time you use the mission. The following steps describe how to create a variable:
   - Under **Position**, select **Variables** .

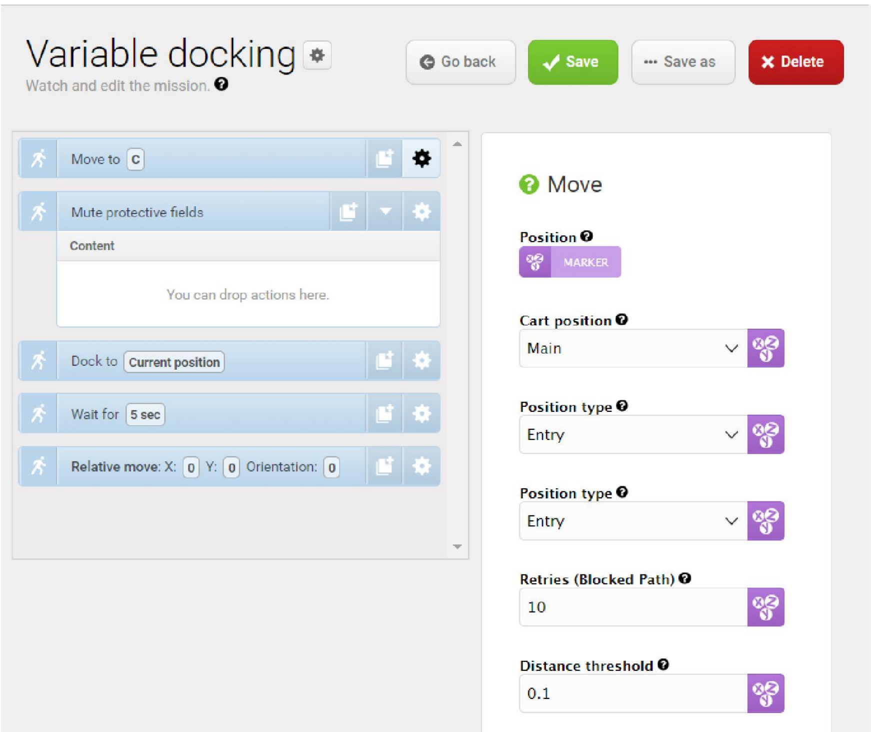



   - Select **Create variable** in the upper-right corner.
   - Name the variable *Marker*. Select **OK**.



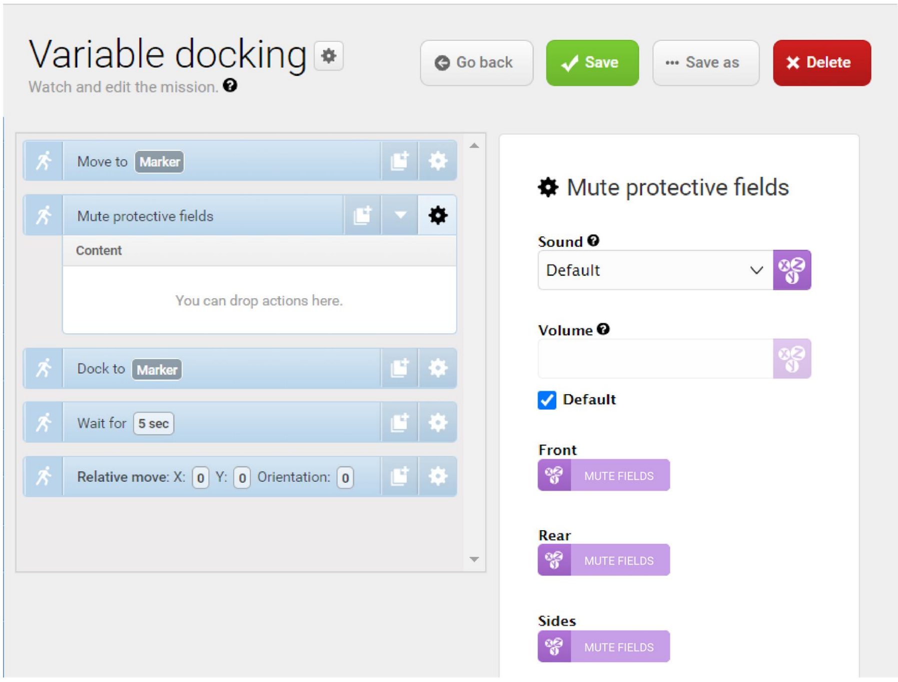

   - Under **Position type**, select **Entry**. This will make the robot move to the entry position of the marker.

If the parameter **Position type** does not show up at first, select **Validate and close**, and then open the action dialog box again.



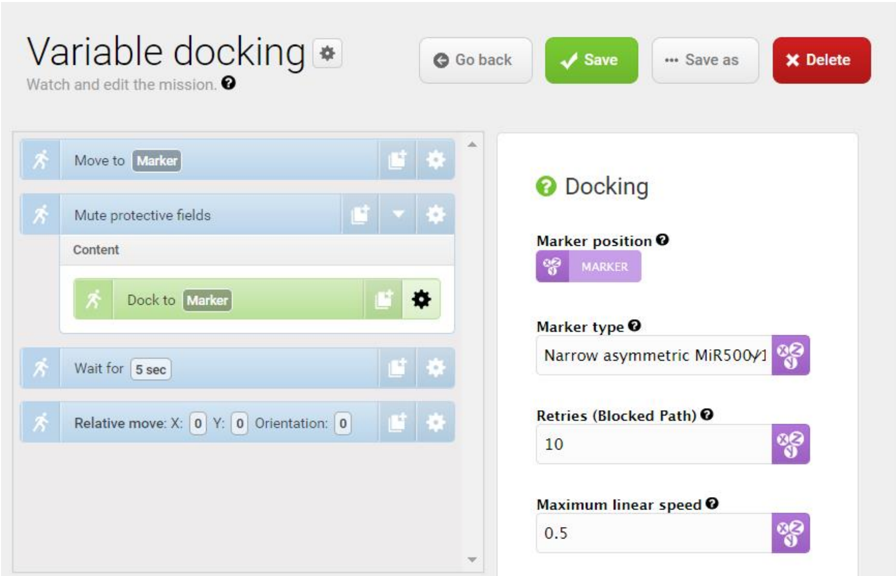
5. In the Mute protective fields action, set the parameters as follows:
   - **Sound:** Select **Default**
   - **Front:** Create a variable titled **Mute fields**.
   - **Rear:** Create a variable titled **Mute fields**.
   - **Sides:** Create a variable titled **Mute fields**.

MiR250 cannot mute specific Protective fields; you can either mute all or none of the fields. Otherwise, the robot reports an error. If you use a variable with the same name in all parameters, you ensure that you apply the same parameter setting to all.

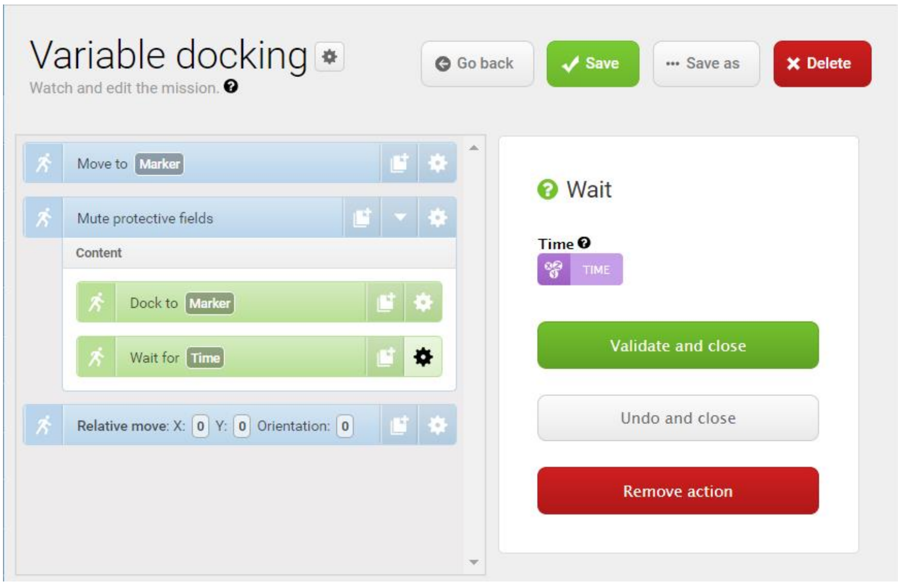


6. Drag the Docking action into the Mute protective fields action, and under **Marker position**, create another variable titled *Marker*.

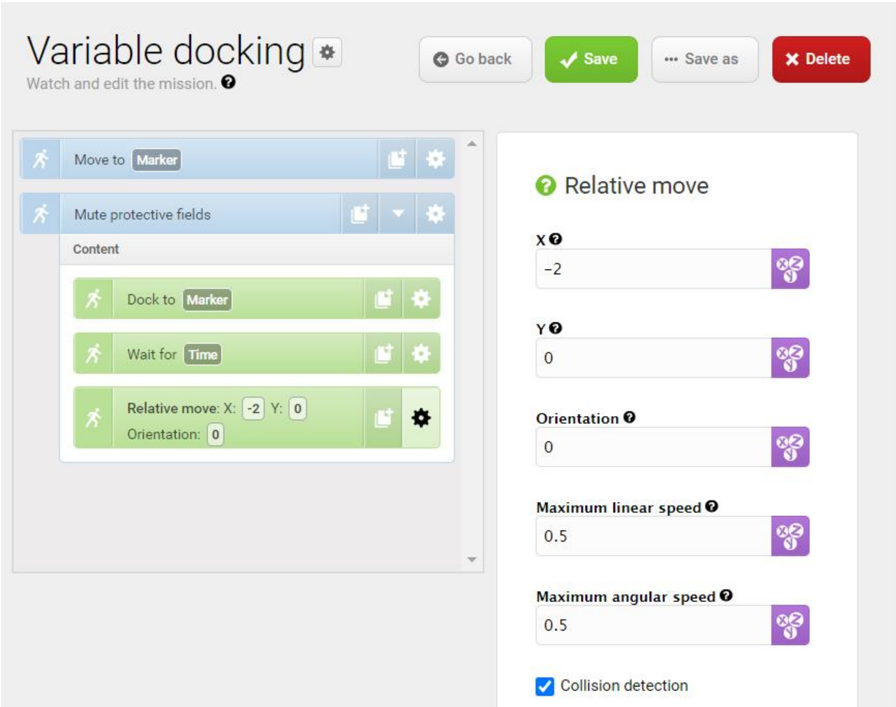
If two variables share the same name, the value you select for that variable will be applied both places. In this case, by using the variable *Markers* in two places, you ensure that the robot docks to the same marker that it moved to in the first action.



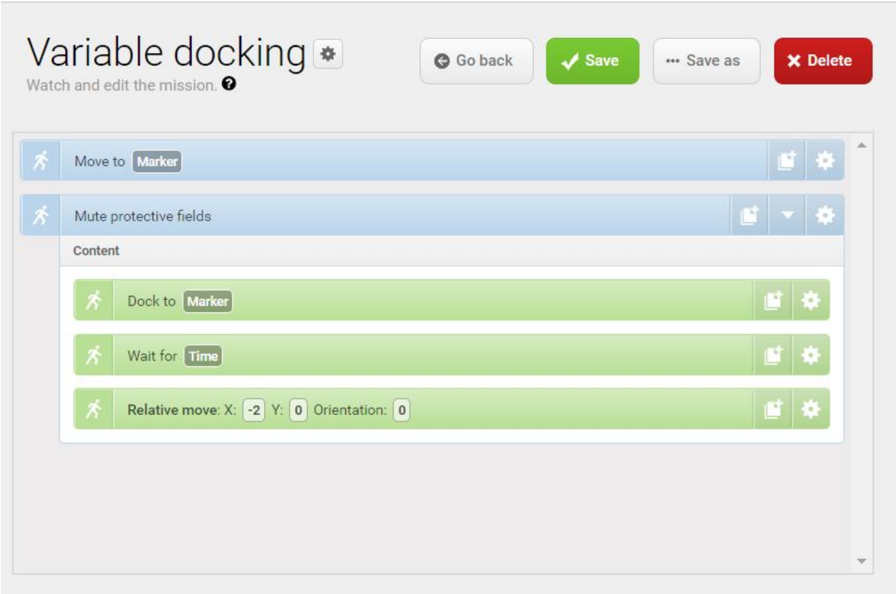
7. Drag the Wait action into the Mute protective fields action, and under **Time**, create another variable titled *Time*.




8. Drag the Relative move action into the Mute protective fields action, and under **X**, enter **-2**. This will make the robot move two meters back to undock from the marker.



9. Select ✓ **Save** to save the mission.




# 12.6 Creating the mission *80 cm doorway*

This section describes how to create a mission that makes the robot drive through a doorway that is 80 cm wide in one direction. To do this, the robot does the following actions:

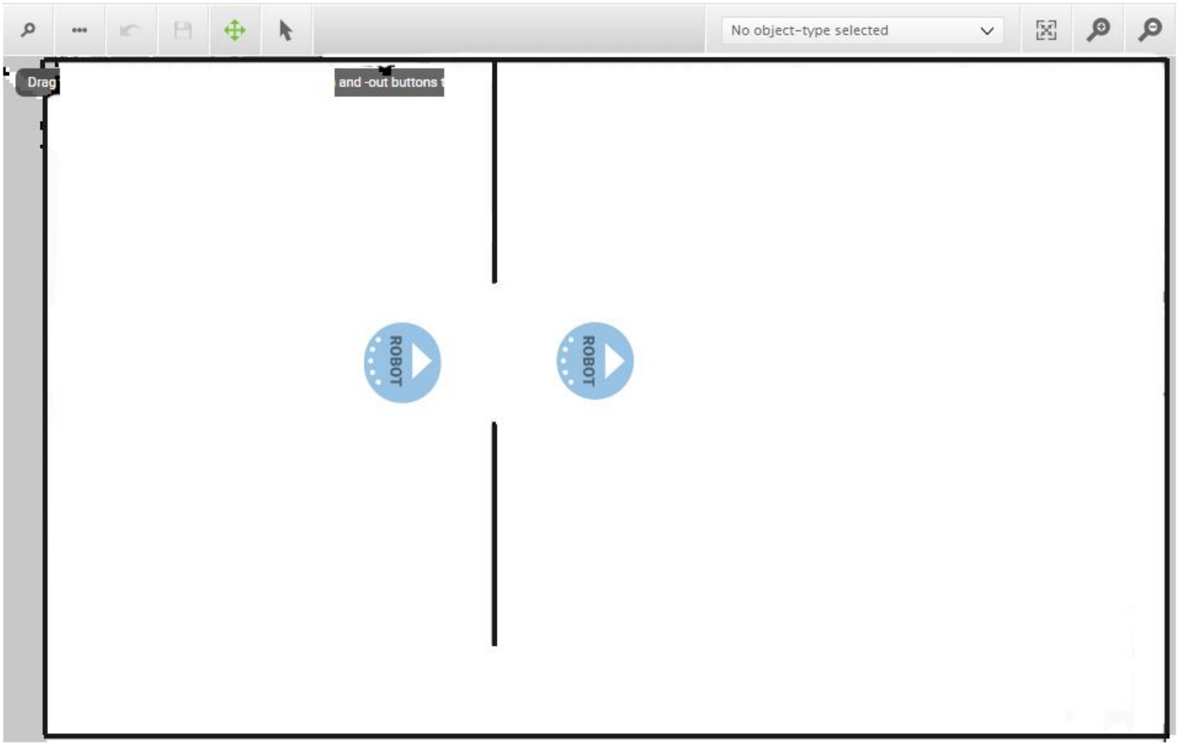
1. Moves to a position in front of the 80 cm wide doorway (the narrowest possible for MiR250).
2. Adjusts its localization.
3. Sets a defined narrow footprint.
4. Mutes its Protective fields so it can traverse the doorway.
5. Goes through the doorway to a position on the other side.
6. Changes its footprint back to default.

To create the mission, it is assumed that you have completed the following:

- Created a map. To drive through narrow doorways, it is very important that the map is accurate and thoroughly cleaned, and that the robot is localized accurately—see Creating and configuring maps on page 108.

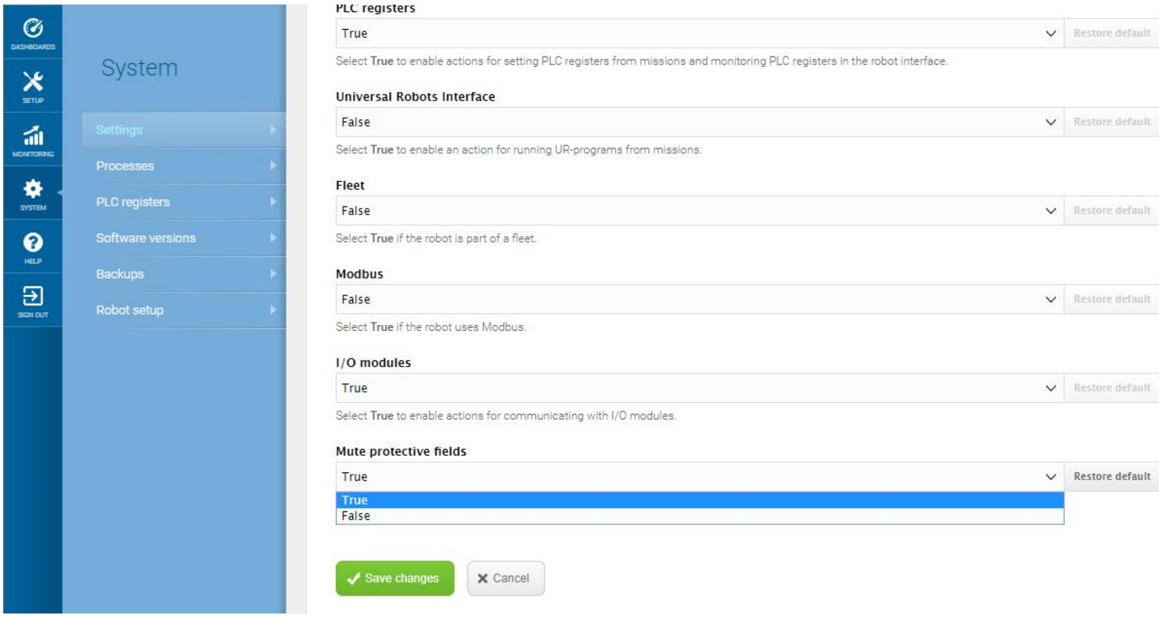
For better localization, draw the walls where the doorway is, and make the doorway approximately one meter wide in the map by deleting some of the walls on each side of the doorway. You may need to delete more of the wall if the robot will not go through the doorway.

- Placed a robot position on each side of the doorway where the first position is named **pos 1** and the second **pos 2**. The positions must be placed in front of and directly in the middle of the doorway, and they must point in the same direction (the driving direction of the robot).

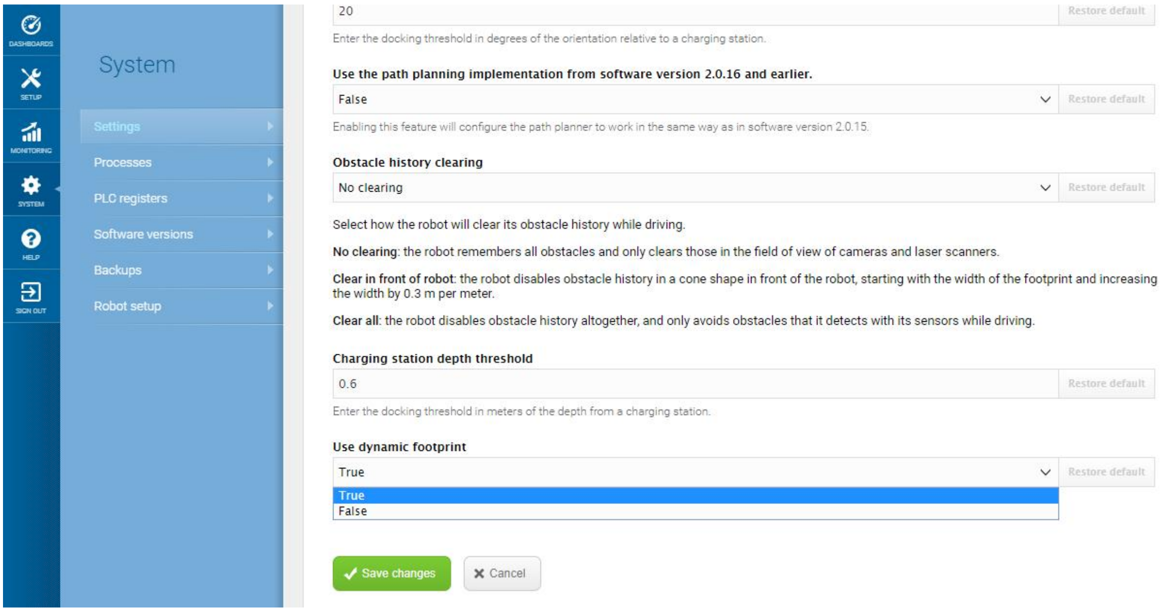



- Made the area around the doorway an operating hazard zone as the robot will be driving through the doorway with muted Protective fields—see Using operating hazard zones on page 129.

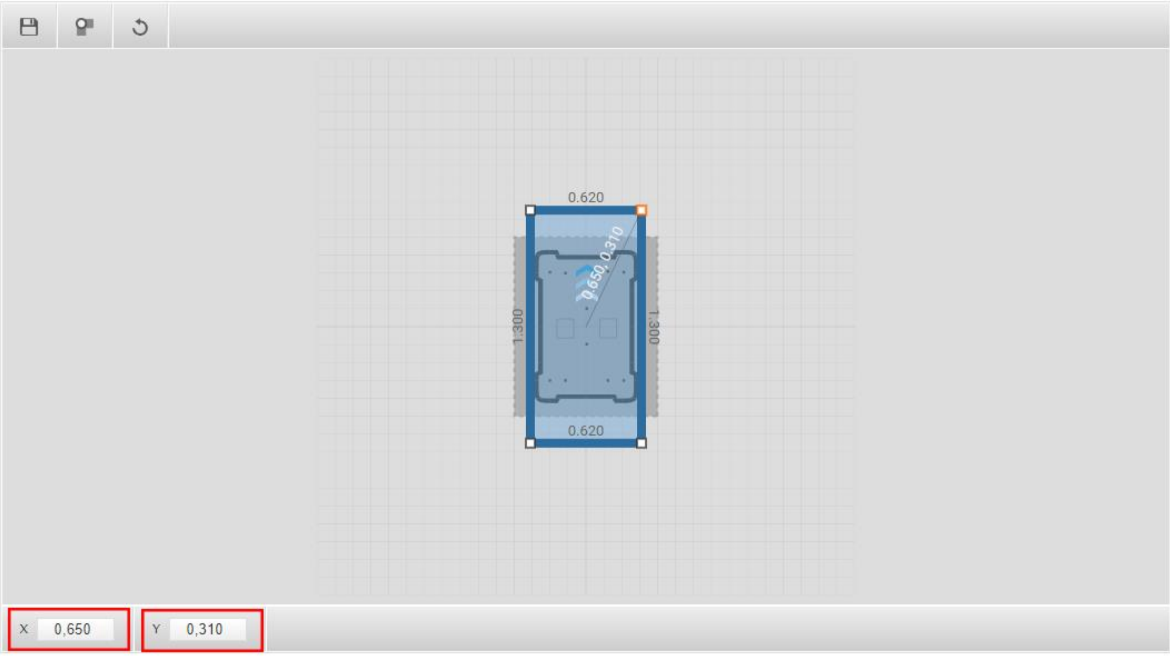
- Enabled the muting of Protective fields. Go to **System > Settings > Features**, and set **Mute protective fields** to **True**.




- Enabled the use of dynamic footprints. Go to **System > Settings > Planner > Show advanced settings**, and set **Use dynamic footprint** to **True**.



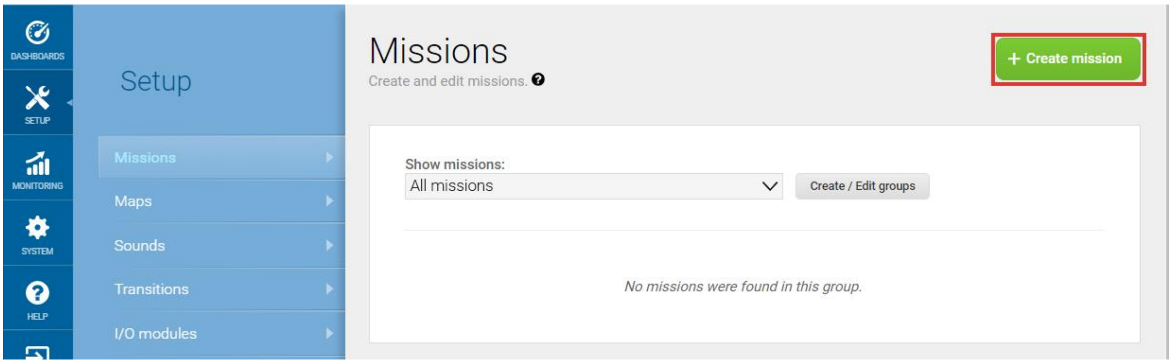
- Created a footprint named **Narrow doorway** that is 620 mm wide and 1300 mm long—see Creating a footprint on page 125. The robot must be centered in the middle of the footprint.



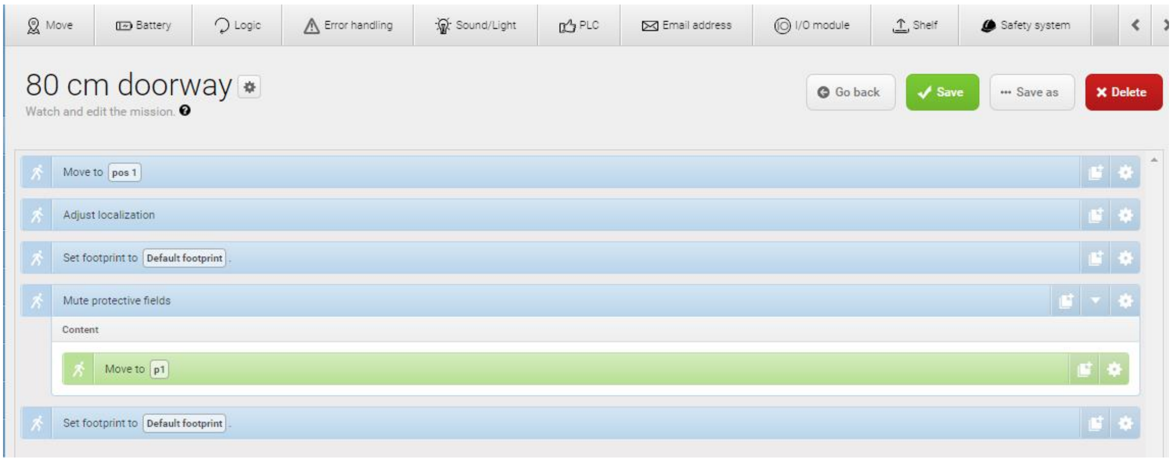

This mission only drives the robot through the doorway in one direction. If you want the robot to go both ways, you need to make a new set of positions facing the opposite direction and a new mission using these positions.

To create the mission, follow the steps below:

1. Go to **Setup > Missions**. Select **Create Mission**.

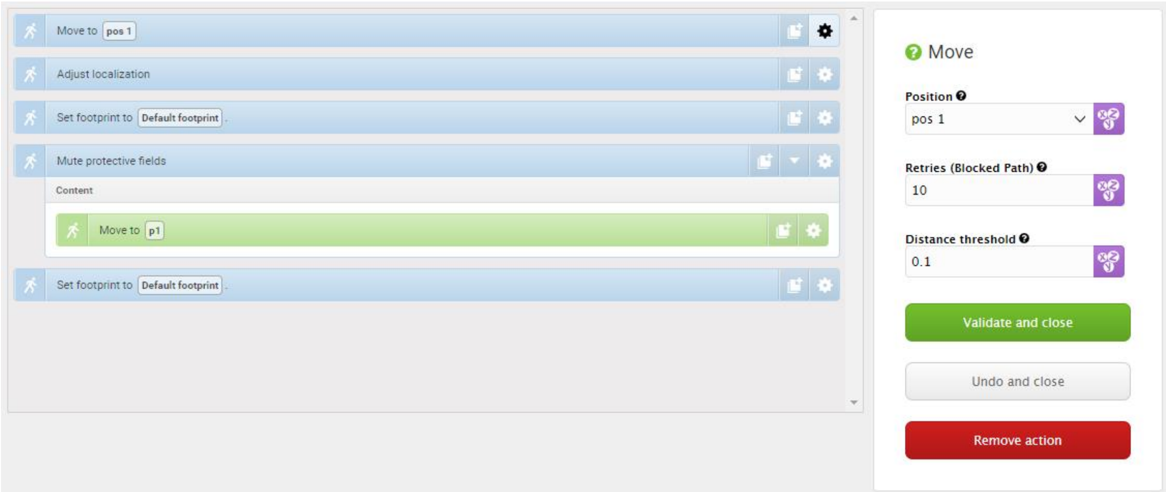


2. Name the mission *80 cm doorway*. Select the group and site you want it to belong to. Select **Create mission**.
3. Select the following actions:
   - In the **Move** menu, select **Move to**.
   - In the **Move** menu, select **Adjust localization**.
   - In the **Move** menu, select **Set footprint**.
   - In the **Safety system** menu, select **Mute protective fields**.
   - In the **Move** menu, select **Move to** and drag it into the **Mute protective fields** action.
   - In the **Move** menu, select **Set footprint**.

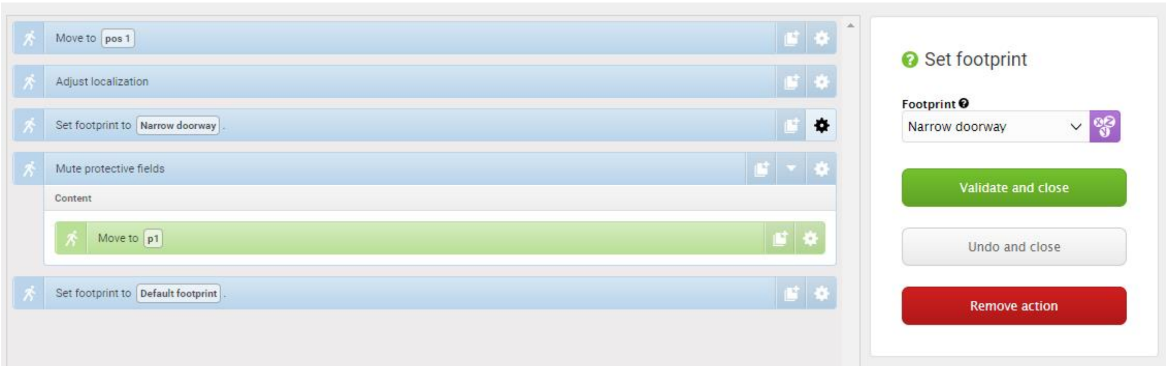



The following steps describe which parameters each action should be set to. To modify the parameters, select the gearwheel ⚙ at the right end of the action line to open the action dialog box. When you have set the parameters, select **Validate and close**.

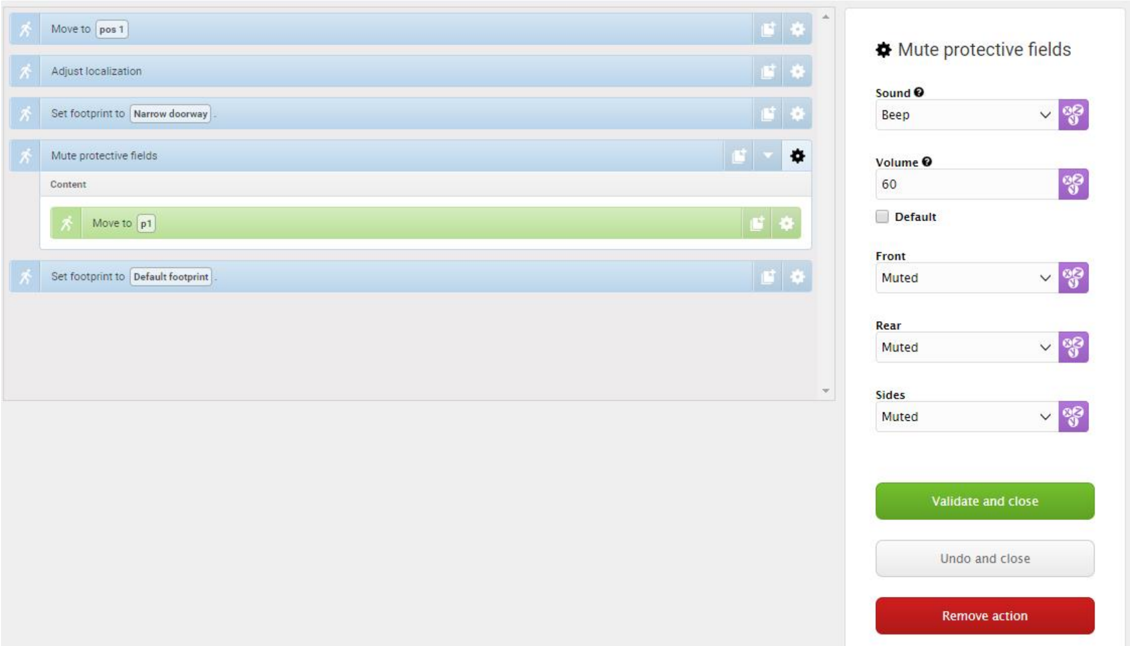
4. In the **Move** action, under **Position**, select **pos 1**.



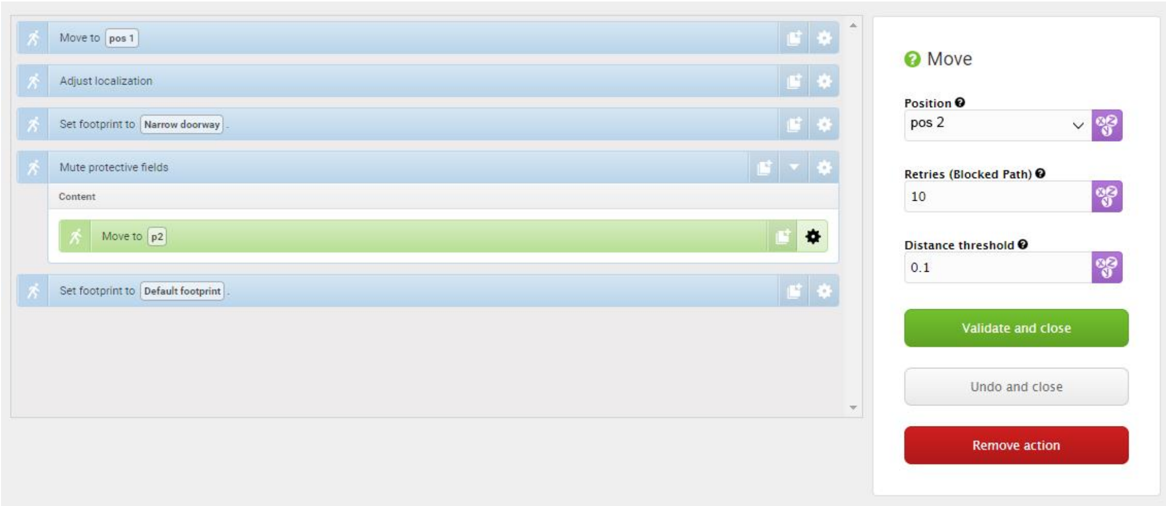

5. In the **Set footprint** action, select **Narrow doorway**.



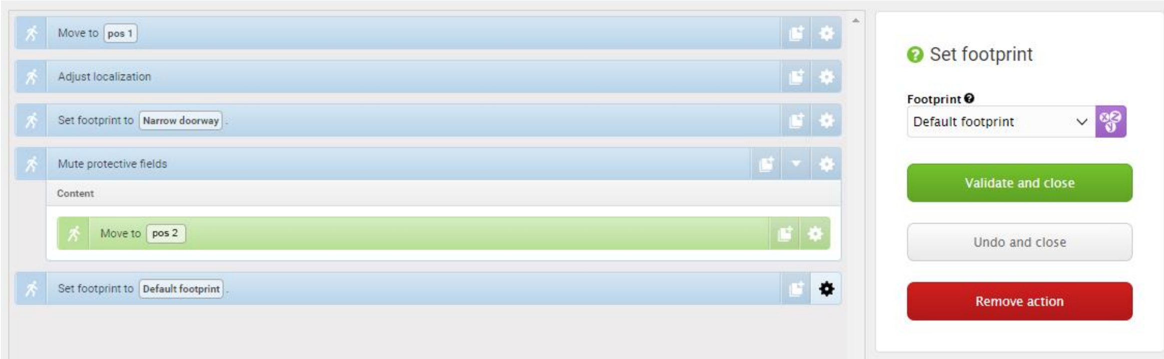
6. In the **Mute protective fields** action, set the parameters as follows:
   - **Sound**: Select **Beep**.
   - **Volume**: Enter the value 60. This is 48 dB approximately.
   - **Front**: Select **Muted**.
   - **Rear**: Select **Muted**.
   - **Sides**: Select **Muted**.




7. In the **Move** action, under **Position**, select **pos 2**.



8. In the **Set footprint** action, select the robot's default footprint.




9. Select **Save** ✓ to save the mission.

# 12.7 Testing a mission

After you create a mission, always run the mission to test that the robot executes it correctly.

> **NOTICE**
>
> Always test missions without load to minimize potential hazards.

To run a mission, follow these steps:

1. Go to **Setup > Missions**.
2. Select **Queue mission** next to the mission you want to run. The mission is now added to the mission queue.
3. Select **Continue** ▶ to start the mission.
4. Watch the robot execute the mission, and verify that it performs as expected.

We recommend running the mission 5-10 times to ensure that it runs smoothly. If something interrupts the mission, use a Try/Catch action in that step of the mission and decide what the robot has to do if a mission action fails.

# 13. Applications

You can install top modules on top of MiR250 for specific applications. For more information about top modules, see the MiR website.

Top modules from MiR are delivered with Operating guides with instructions on how to mount them on and operate them with the robot.

For detailed instructions on how to mount top modules and accessories, contact your distributor.

## 13.1 Mounting a top module

MiR250 has four M8 holes for mounting top modules as shown in *Figure 13.1*. The tightening torque is 18 Nm.

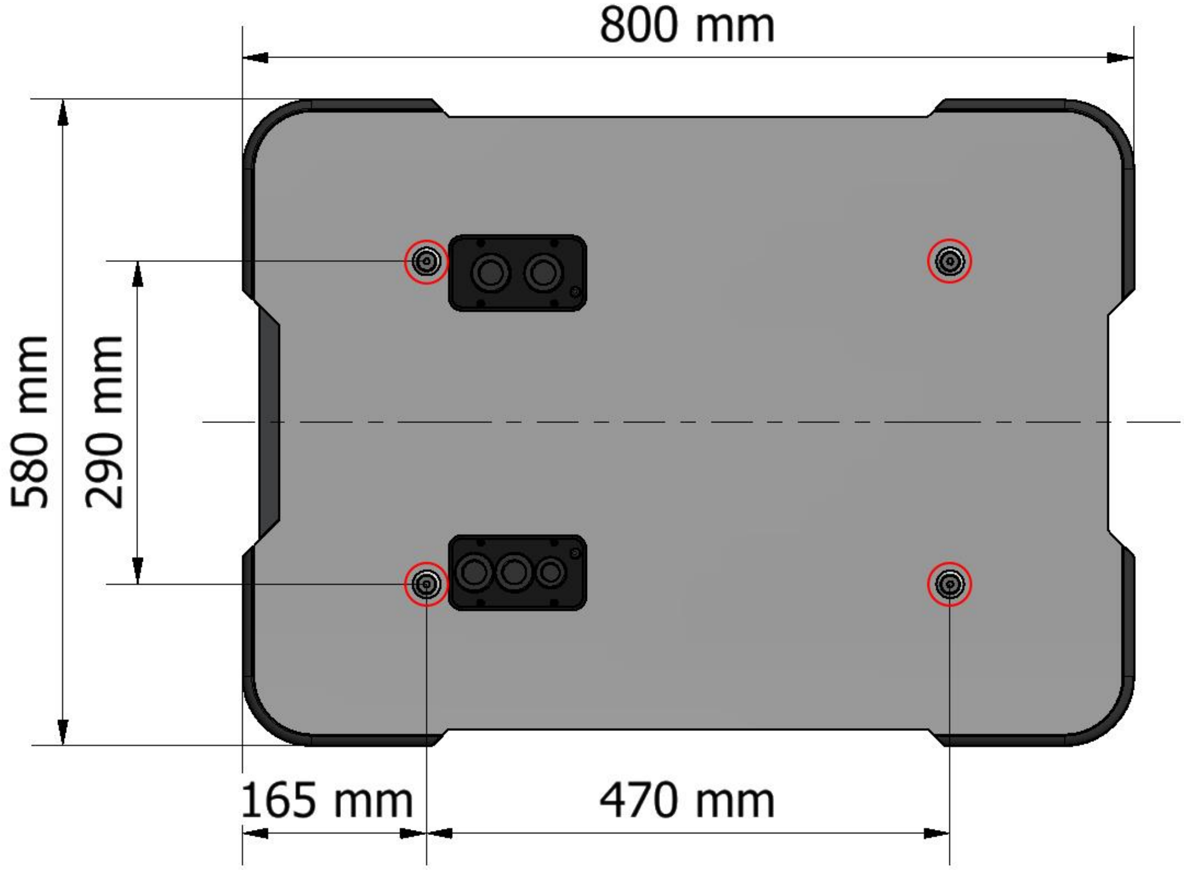



Figure 13.1. Mounting holes on the top of MiR250.

Certain top modules may require the installation of an extra Emergency stop button. Perform a risk assessment according to standard ISO 12100—see Risk assessment on page 107.

The mounting holes are in the chassis, so the top cover does not need to be on the robot when you mount a top application.

**CAUTION**

Certain top modules may lead to new hazards and increased risks that cannot be eliminated or reduced by the risk reduction measures applied by Mobile Industrial Robots.

- Perform a risk assessment according to standard ISO 12100 when mounting a top module—see Risk assessment on page 107.

**CAUTION**

MiR250 may tip over if weight and payload specifications are not met, risking damage to equipment or injury to nearby personnel.

- Stay within the specifications for weight and the total payload's center of gravity—see Payload distribution on page 192.

## Interface dimensions

MiR250 has five electrical interfaces to communicate with a top module—see Interface specifications on page 199. *Figure 13.2* illustrates the dimensions of the top interface covers and grommets.

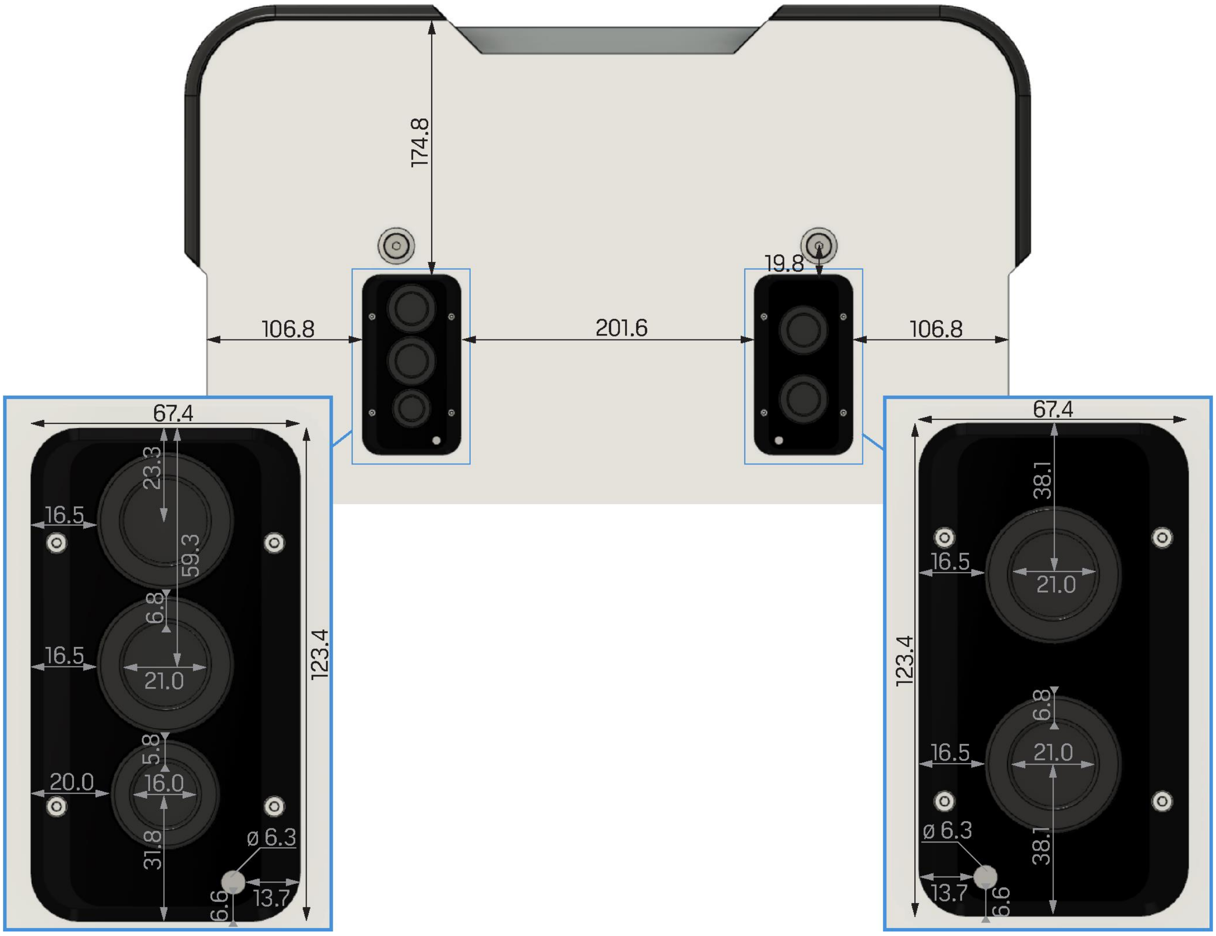



Figure 13.2. Dimensions for the top electrical interface covers. All dimensions are provided in mm.

# 14. Maintenance

The following maintenance schedules give an overview of regular cleaning and parts replacement procedures.

It is the responsibility of the operator to perform all maintenance tasks on the robot.

The stated intervals are meant as guidelines and depend on the operating environment and frequency of usage of the robot.

It is recommended to make a maintenance plan to make sure that all maintenance tasks are done and that the responsible(s) are aware of their tasks.

**NOTICE**

Only use approved spare parts. Contact your distributor for the list of spare parts and the appropriate how-to guides.

Mobile Industrial Robots disclaims any and all liability if unapproved spare parts are used. Mobile Industrial Robots cannot be held responsible for any damages caused to the robot, accessories, or any other equipment due to use of unapproved spare parts.

## 14.1 Regular weekly checks and maintenance tasks

Once a week, carry out the maintenance tasks in *Table 14.1*.

**Table 14.1.**
Regular weekly checks and maintenance tasks

| Parts | Maintenance tasks |
|---|---|
| Robot top cover | Clean the robot on the outside with a damp cloth.<br>Do not use compressed air to clean the robot. |
| Laser scanners | Clean the optics covers of the scanners for optimum performance. Avoid aggressive or abrasive cleaning agents.<br>In the robot interface under **Monitoring > Hardware health > Emergency stop**, see if **Front scanner cover** and **Back scanner cover** is **Clean**.<br>**NOTICE**<br>Static charges cause dust particles to be attracted to the optics cover. You can diminish this effect by using the anti-static plastic cleaner (SICK part no. 5600006) and the SICK lens cloth (part no. 4003353). See the manufacturer's own documentation. |
| Swivel wheels (the four corner wheels) | Remove dirt with a damp cloth, and make sure nothing is entangled in the wheels. |
| Drive wheels (the two middle wheels) | Remove dirt with a damp cloth, and make sure nothing is entangled in the wheels. |
| Status lights | Check if the LED light band is intact. Ensure the light shows all the way around the robot. Clean with a soft cloth to ensure even lighting around the robot. |
| Signal lights | Check if the signal lights on the four corners blink and show light correctly. |

# 14.2 Regular checks and replacements

Before starting replacement tasks that involve removal of the top or side covers:

- Shut down the robot—see Shutting down the robot on page 60.
- Disconnect the battery—see Disconnecting the battery on page 63.

*Table 14.2* contains the parts that you should check and how often you should do that.

**Table 14.2.**
Regular checks and replacements

| Part | Maintenance | Interval |
|---|---|---|
| Robot top cover | Check mounting. Ensure it sits evenly on top of the robot with connections accessible. | Check monthly, and replace as needed. |
| Safety PLC | In the robot interface under **Monitoring > Hardware health > Communication**, see if the robot is running with the correct SICK configuration or if the warning **The SICK Safety PLC is running a non-standard configuration** is shown. | Check monthly and after commissioning or if you make any changes to the robot setup. |
| Robot hardware | In the robot interface under **Monitoring > Hardware health**, check if there are any warnings (marked with yellow). | Check monthly and after commissioning or if you make any changes to the robot setup. |
| Front, rear, and side compartment covers | Check mounting. Ensure the covers are even and are not in contact with the wheels. | Check monthly, and replace as needed.<br>ℹ If you replace the cover with the robot's nameplate, make sure to mount a new copy of the nameplate to the replacement cover. |

| Part | Maintenance | Interval |
| --- | --- | --- |
| Loudspeaker and signal lights | Check that all visual and auditory warnings function. | Check monthly, and replace as needed. |
| Swivel wheels (the four corner wheels) | Check bearings and tighten, and check the wheels for wear and tear. | Check weekly, and replace as needed. |
| Drive wheels (the two middle-wheels) | Check wheel surfaces for wear. | Check every six months, and replace as needed.<br>**NOTICE**<br>The robot must be calibrated after replacement of the wheels. |
| Safety laser scanners | Check for visual defects, for example cracks and scratches. | Replace as needed. |
| Control panel | Check that all buttons on the control panel function. | Every three to four months. |
| Emergency stop | Check that the Emergency stop buttons work, push down the red button, and check that the Emergency reset button lights up. | Every three to four months / according to *EN/ISO 13850 Safety of machinery - Emergency stop function.* |
| Charging pads/broom | Check if the charging pads are dirty or dusty and if the broom is intact. Clean the broom. | Check monthly, and replace as needed. |
| CAN connectors for charging station terminals | Disconnect the battery on the robot. Using your hands, ensure that each connector moves up and down freely. | Check monthly. |
| 3D cameras | Check for visual defects, for example cracks and scratches. | Check monthly, and replace as needed. |

| Part | Maintenance | Interval |
|---|---|---|
| Proximity sensors | Check for dust or dirt, and clean with a swab. | Check weekly. |
| Manual brake release switch | Check if the Manual brake release switch functions by releasing the brakes and pushing the robot gently forward. Remember to enable the brakes again when done. | Check monthly, and replace as needed. |
| Safety marking on the floor | Check if the safety markings around operating hazard zones are intact and visible. | Check every six months, and replace as needed. |
| Safety stickers and nameplate | Check if the safety stickers, identification label, and nameplate on the robot are still intact and visible. | Check every six months, and replace as needed. |

**CAUTION**

If the robot has been impacted, it may be structurally damaged, causing a risk of malfunction and injury to personnel.

- If you suspect the robot has suffered any damage, you need to conduct a thorough inspection to ensure that the robot's strength and structure is not compromised.

# 14.3 Battery maintenance

The battery is generally maintenance-free but should be cleaned if it gets very dirty. Before cleaning, the battery must be removed from any power source. Only use a dry and soft cloth to clean the housing of the battery, and do not use abrasives or solvents.

For storage of the battery, see Battery storage on page 64.

For disposal of the battery, see Battery disposal on page 66.

# 15. Packing for transportation

This section describes how to pack the robot for transportation.

The robot is shown with a MiR Shelf Carrier 250.

## 15.1 Original packaging

Use the original packaging materials when transporting the robot.

Figure 15.1. The packing materials.

The packaging materials are:

- The bottom of the box (the pallet)
- The lid of the box (the ramp)
- The walls of the box
- Protective foam blocks: Side blocks and the top layer
- Protective corner braces. The braces prevent the robot from being damaged by the transport straps

## 15.2 Packing the robot for transportation

Before packing the robot for transportation:

- Shut down the robot—see Shutting down the robot on page 60.
- Disconnect the battery—see Disconnecting the battery on page 63.

To pack the robot, repeat the steps in Unpacking MiR250 on page 45 in the reverse order.

**NOTICE**

Pack and transport the robot in an upright position. Packing and transporting the robot in any other position voids the warranty.

## 15.3 Battery

The lithium-ion battery is subject to transport regulations. Make sure that you follow the safety precautions in this section and the instructions in Packing for transportation on the previous page. Different regulations apply depending on the mode of transportation: land, sea, or air.

Contact your distributor for more information.

**CAUTION**

Lithium-ion batteries are subject to special transportation regulations according to United Nations Regulation of Dangerous Goods, UN 3171. Special transport documentation is required to comply with these regulations. This may influence both transport time and costs.

# 16. Disposal of robot

MiR250 robots must be disposed of in accordance with the applicable national laws, regulations, and standards.

Fee for disposal and handling of electronic waste of Mobile Industrial Robots A/S robots sold on the Danish market is prepaid to DPA-system by Mobile Industrial Robots A/S. Importers in countries covered by the European WEEE Directive 2012/19/EU must make their own registration to the national WEEE register of their country. The fee is typically less than 1€ per robot. A list of national registers can be found here: https://www.ewrn.org/national-registers.

For battery disposal, see Battery disposal on page 66.

# 17. Payload distribution

The following drawings illustrate where the center of mass (CoM) of payloads must be located for safe operation with different payloads.

**WARNING**

Load falling or robot overturning if the load on MiR250 is not positioned or fastened correctly can cause damage to equipment and injury to personnel.

- Ensure that the load is positioned according to the specifications and is fastened correctly.

**CAUTION**

Bumps and holes can cause loads to fall off of the robot, causing damage to equipment and injury to personnel.

- The floor the robot drives on must be even without bumps and holes for the payload specifications to be valid. If bumps and holes are present, the commissioner must take additional measures to ensure a safe operation.

**CAUTION**

A slippery surface can cause instability when driving with payloads, causing damage to equipment and injury to personnel.

- The friction coefficient between the floor and the drive wheels on the robot must be in the range of 0.60 to 0.80 for the payload specifications to be valid. If the friction coefficient is not in this range, the commissioner must take additional measures to ensure a safe operation.

The specifications apply to total payloads of up to 250 kg.

# 17.1 Side view

## At 1.2 m/s with no incline

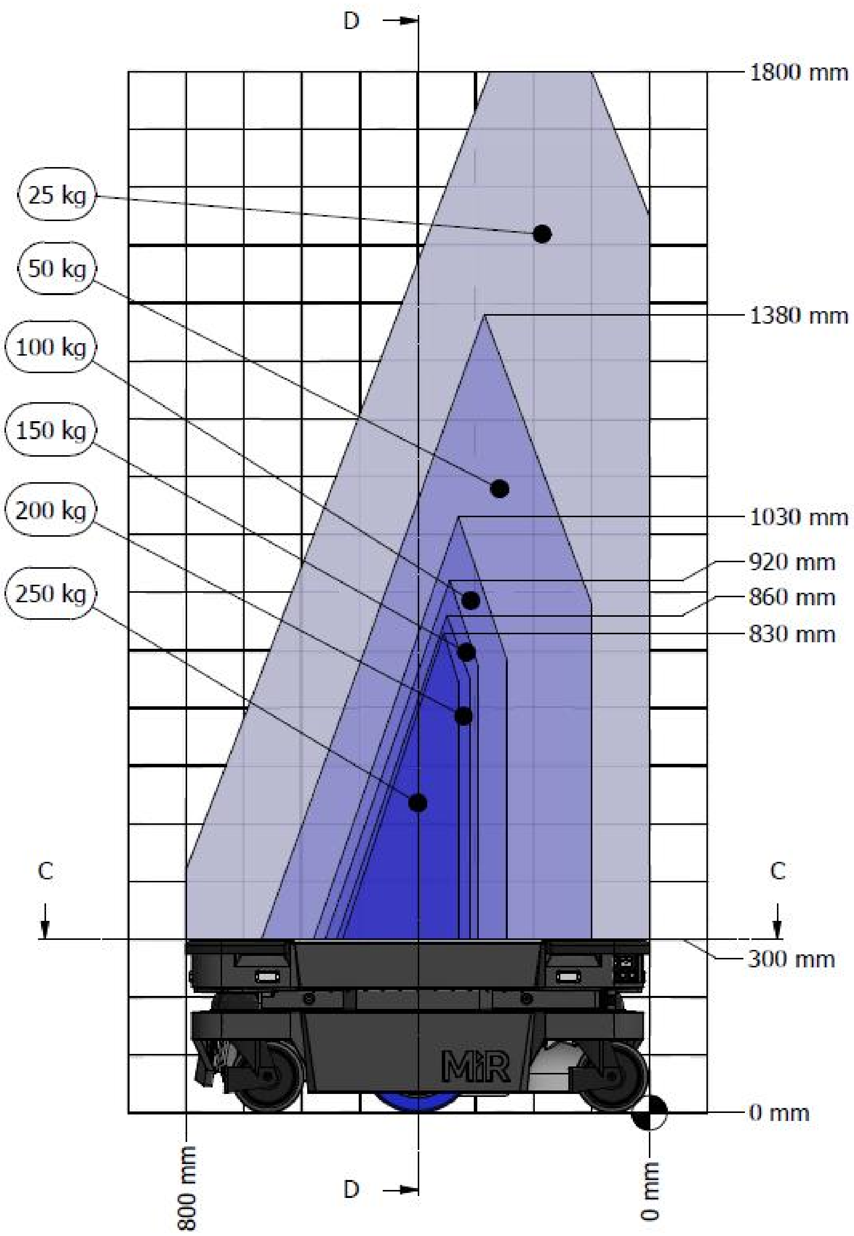



Figure 17.1. The center of mass (CoM) of payloads seen from the side.

## At 2.0 m/s with no incline

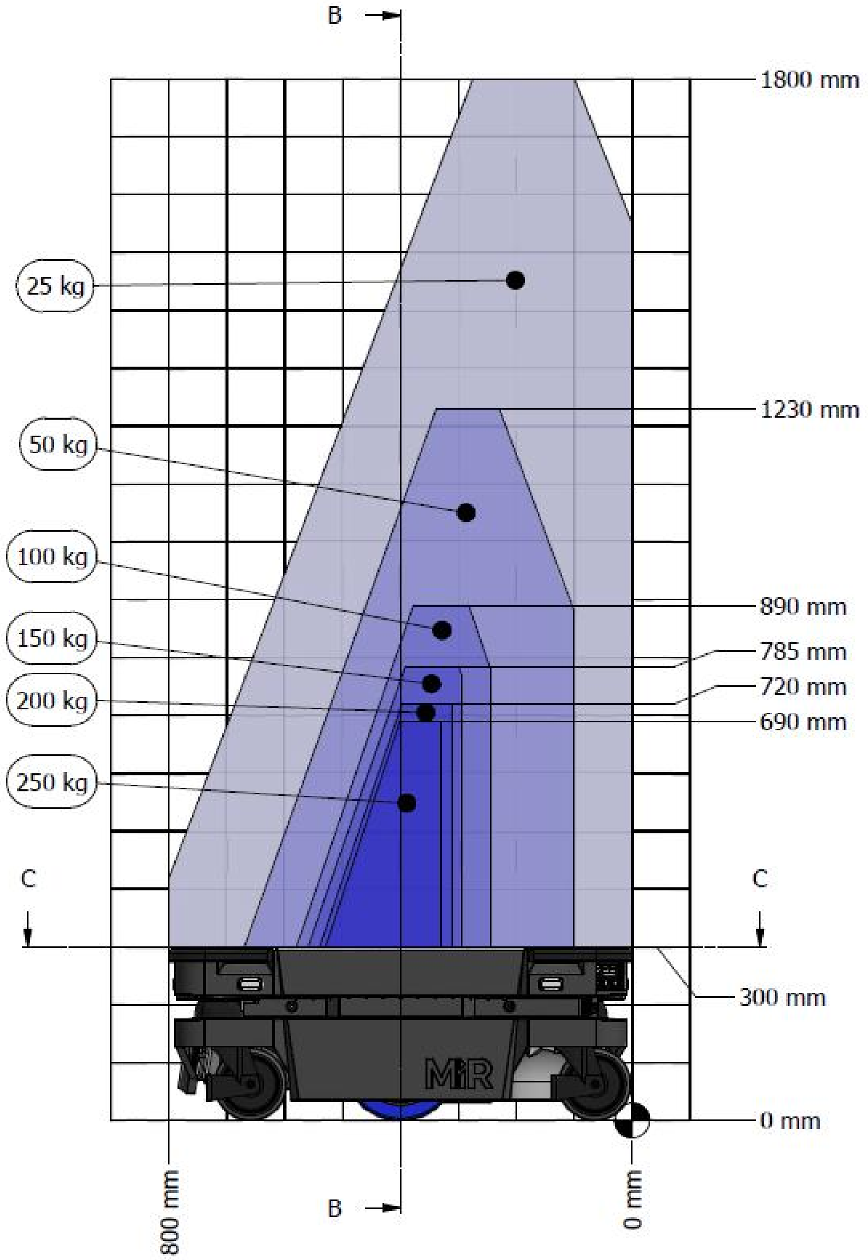



Figure 17.2. The center of mass (CoM) of payloads seen from the side.

# 17.2 Front view

## At 1.2 m/s with no incline

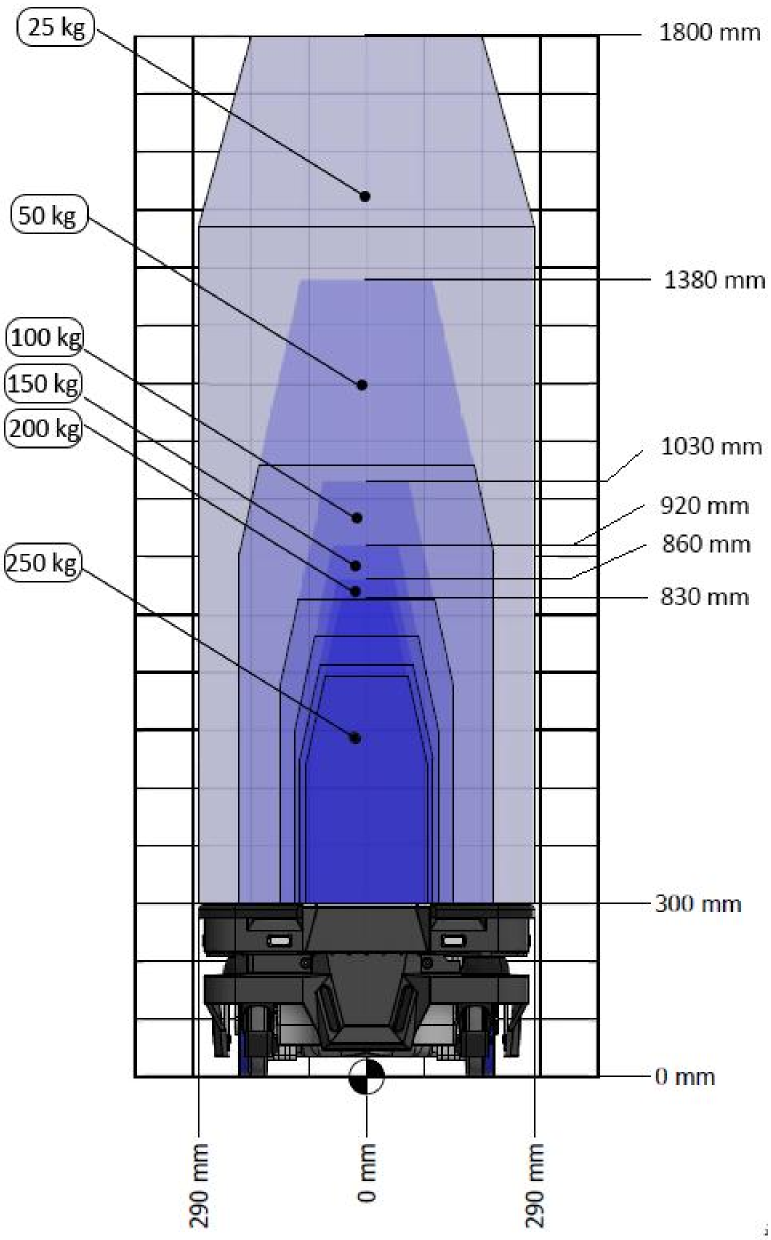



Figure 17.3. The center of mass (CoM) of payloads seen from the front.

## At 2.0 m/s with no incline

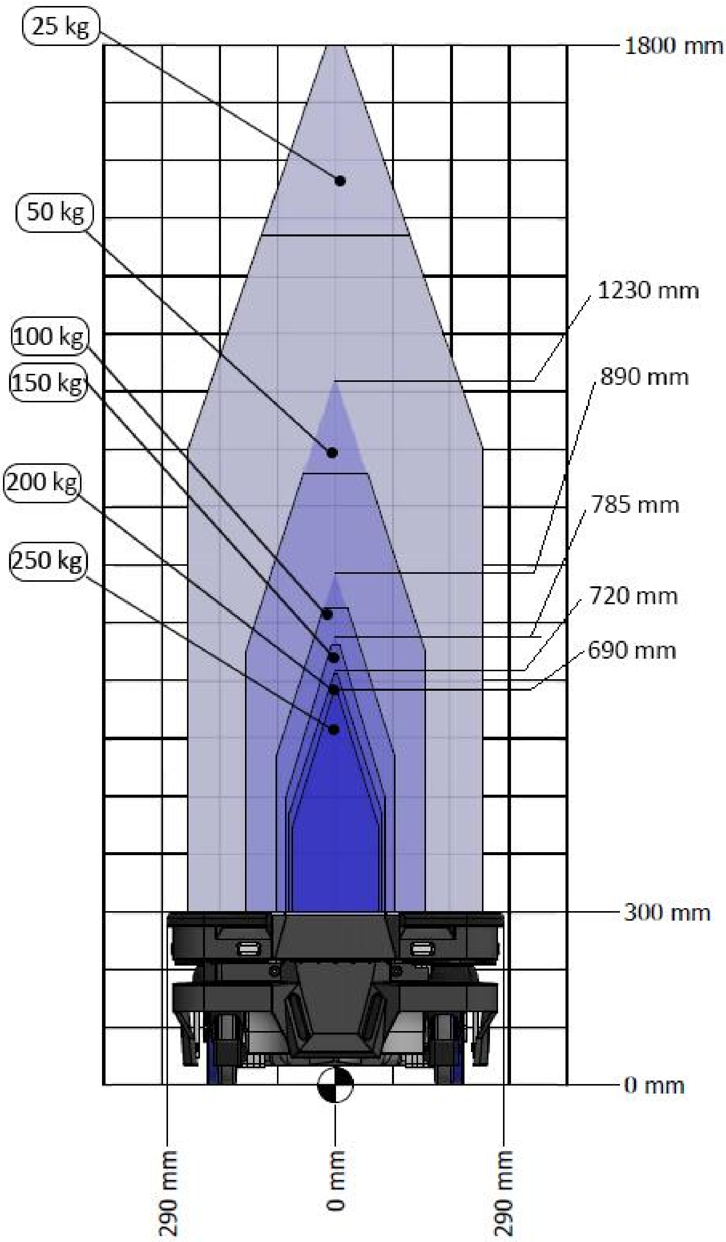



Figure 17.4. The center of mass (CoM) of payloads seen from the front.

# 17.3 Top view

## At 1.2 m/s with no incline

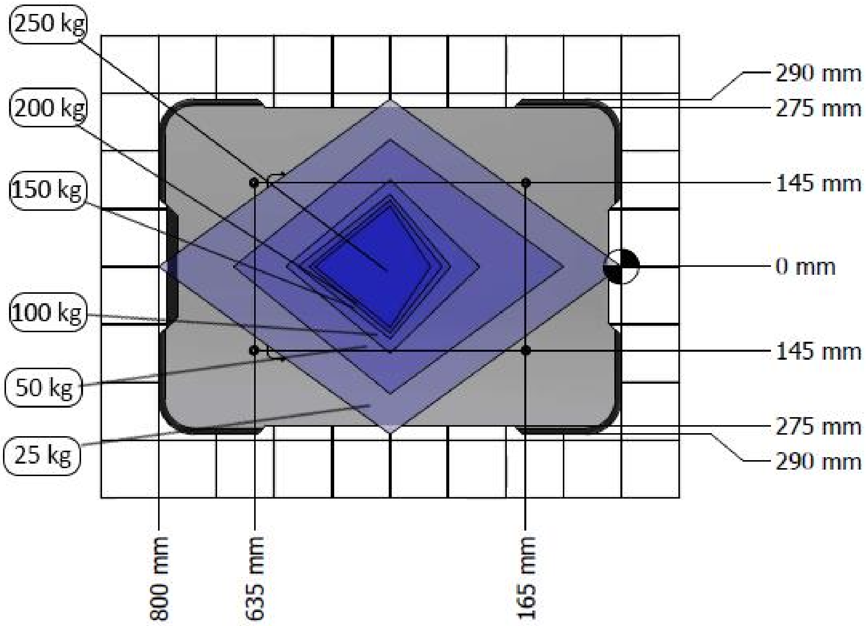



Figure 17.5. The center of mass (CoM) of payloads seen from the top.

## At 2.0 m/s with no incline

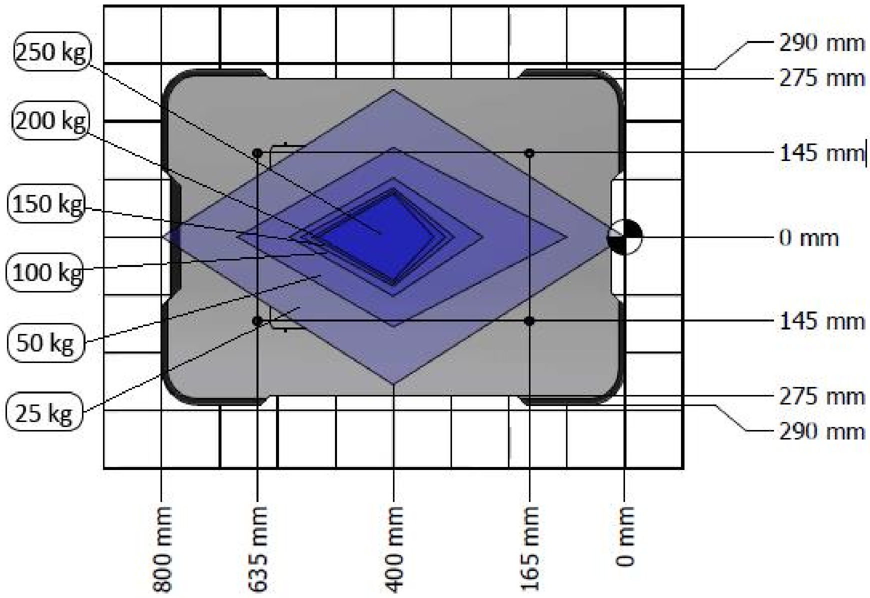



Figure 17.6. The center of mass (CoM) of payloads seen from the top.

# 18. Interface specifications

This section describes the specifications of the top application interfaces.

**NOTICE**

Read Safety on page 29 before using the electrical interface.

MiR250 has seven electrical interfaces divided into two groups:

- Robot's left side:
  - Power
  - Emergency stop
  - Ethernet
- Robot's right side:
  - GPIO A
  - GPIO B
  - Auxiliary Safety Functions A
  - Auxiliary Safety Functions B

To see the locations of the electrical interfaces on the robot, see Internal parts on page 21.

## 18.1 Left side interfaces

This section describes the general purpose interfaces located in the left side compartment on top of MiR250.

## Emergency stop

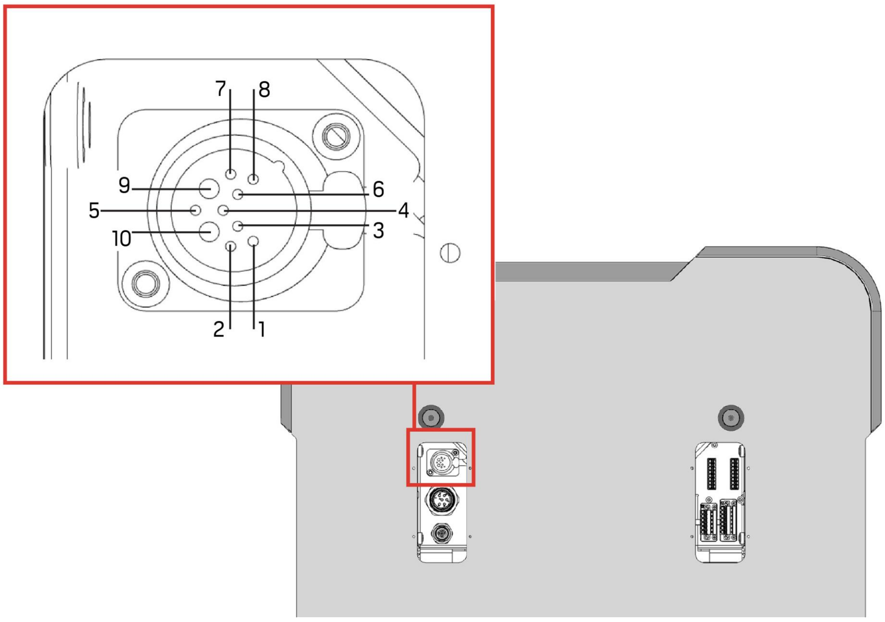



Figure 18.1. The pins of the Emergency stop interface.

**Table 18.1.**
Description of pins in the Emergency stop interface in The pins of the Emergency stop interface. above. For more information on how to use the Emergency stop interface, see Emergency stop circuit on page 95

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 1 | SAFE_ RETURN | Ground | Return for lamp signal. |
| 2 | Test output 1 | Output | Safety output 1. Should be connected through Emergency stop buttons to input 1 and 3. |
| 3 | Test output 2 | Output | Safety output 2. Should be connected through Emergency stop buttons to input 2. |
| 4 | E-stop 1 | Input | Safety input 1 |

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 5 | E-stop 2 | Input | Safety input 2. |
| 6 | Restart | Input | Safety input 3. |
| 7 | RST_ LAMP_24_ V | Output | 24 V output for powering the lamp on the Emergency stop box. |
| 8 | NC | | Not connected to the robot. |
| 9 | NC | | Not connected to the robot. |
| 10 | NC | | Not connected to the robot. |

## Power

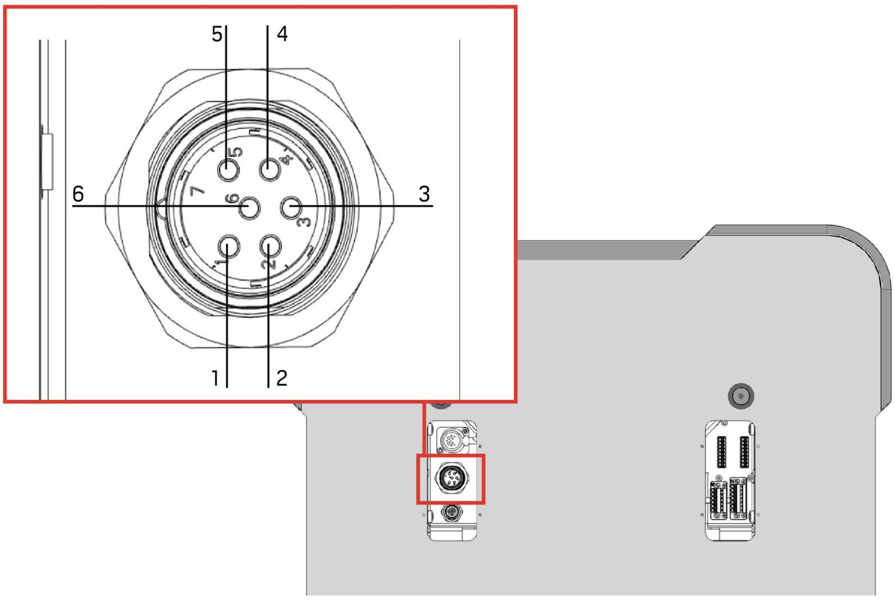



Figure 18.2. Pin numbers: female connector viewed from the front (left) and wiring diagram (right).

The maximum current across pins 1 and 3 combined is 10A. You cannot receive 10A from both of the pins at the same time.

**CAUTION**

Connecting power and ground signals to the chassis while stacking the 24 V and 48 V power supplies can lead to severe damage to the robot and electrical shock.

- Never connect power and ground signals to the chassis, and never stack the 24 V and 48 V power supplies.

**CAUTION**

Connecting 48 V power supplies to 24 V pins or vice versa can lead to severe damage to the robot and electrical shock.

- Never connect 48 V power supplies to 24 V pins or vice versa.

**CAUTION**

The robots are not designed to absorb inverse current from top modules. This can damage the electrical components inside the robot, and the top module will likely not work as intended.

- Never connect a top module that can deliver an inverse current to the robot interfaces.

**Table 18.2.**
Description of the pins in the power interface in Pin numbers: female connector viewed from the front (left) and wiring diagram (right). on the previous page

| Pin no. | Signal name | Max. current | Description |
|---|---|---|---|
| 1 | 48V power | 10 A | Always active when robot is on.<br><br>Intended for high power loads like motors and actuators.<br><br>Voltage range before the power board shuts off: 41 V to 53.8 V |

| Pin no. | Signal name | Max. current | Description |
|---|---|---|---|
| 2 | GND | | Power ground. |
| 3 | 48V safe power | 10 A | Inactive in case of a Protective or Emergency stop.<br>This output is controlled by the internal safety PLC through the STO contactor to ensure that power is always disconnected from this pin in case of a Protective or Emergency stop.<br>Intended for high power loads like motors or actuators.<br><br>Voltage range before the power board shuts off: 41 V to 53.8 V. |
| 4 | GND | | Power ground. |
| 5 | Isolated 24V | | Fully isolated from the robot. |
| 6 | Isolated GND | | Fully isolated from the robot. |
| 7 | Unassigned | | Unassigned. |

## Ethernet

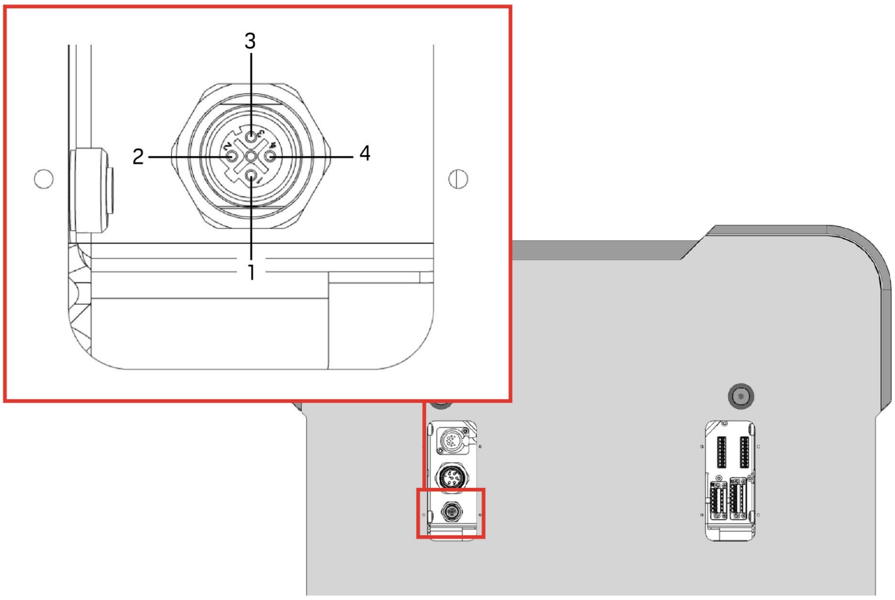



Figure 18.3. Ethernet connection. Pin numbers (left) and wiring diagram (right).

The communication interface is 10/100 Mbit Ethernet using a M12 connector—see Connector list on page 211.

Various protocols can be supported, for example Modbus. For more information on how to use Modbus, contact your distributor for the how-to guide *How to use Modbus with MiR robots*.

**Table 18.3.**
Description of the pins in Ethernet connection. Pin numbers (left) and wiring diagram (right). above

| Pin number | Signal name |
|---|---|
| 1 | TX+ |
| 2 | RX+ |
| 3 | TX- |
| 4 | RX- |

# 18.2 Right side interfaces

This section describes the general purpose interfaces located in the right side compartment on top of MiR250.

## GPIO A and B

The GPIO interfaces have the following pins:

- Four inputs, for use with 24 V, but robust against 48 V.
- Four outputs, for use with 24 V.

The GPIO supports low current/power devices like relays, contactors, lamps, and separate PLC units.

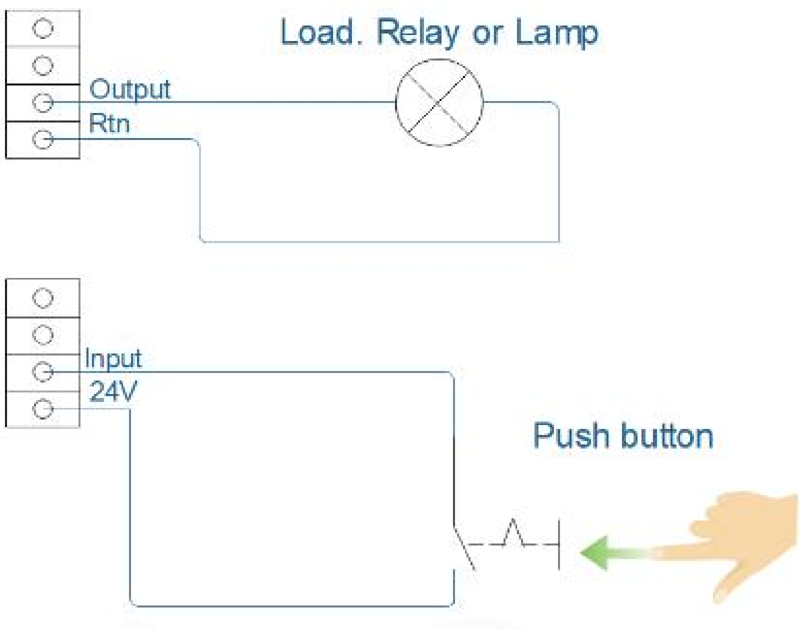
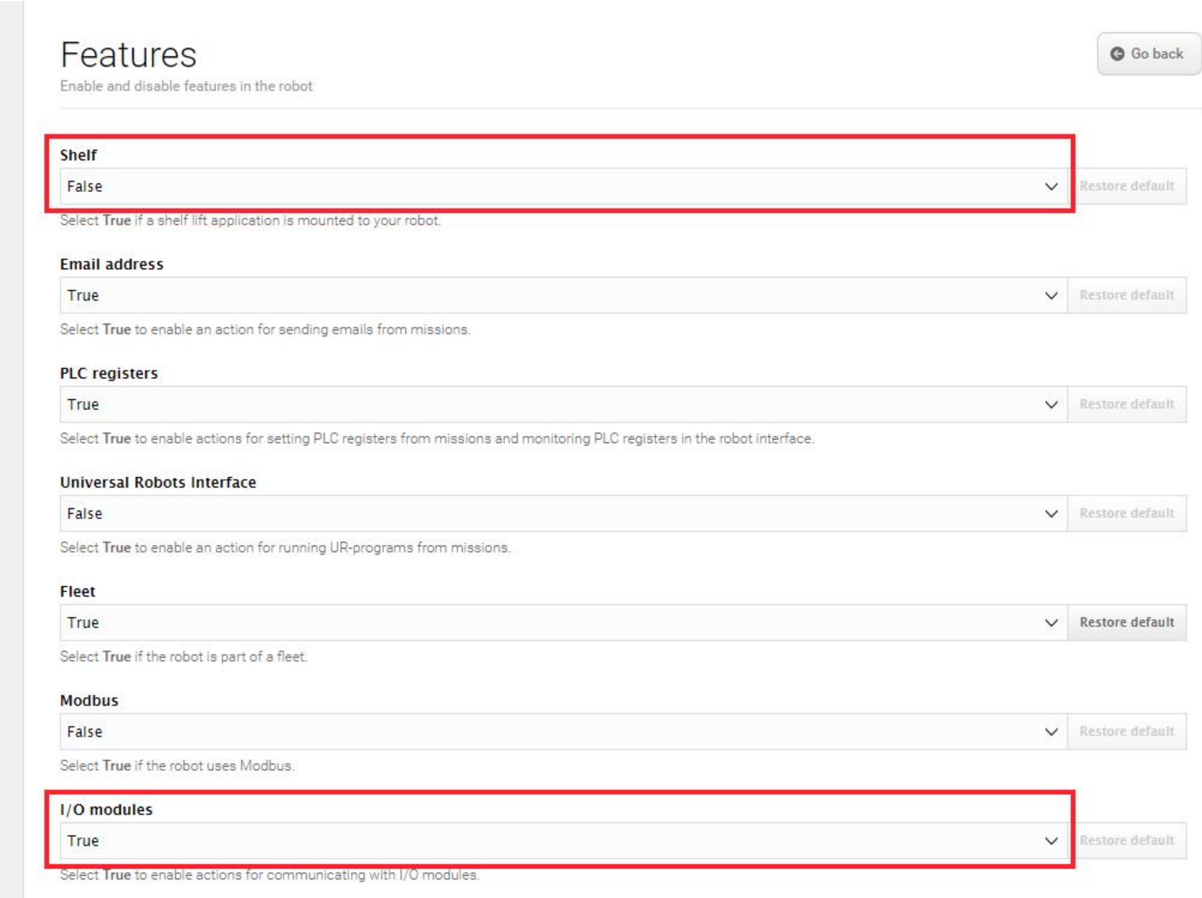



Figure 18.4. Outputs and RTNs are intended for sending signals to the top application, and inputs and 24V pins are intended to receive signals from the top application.

To use the GPIO for a top application of your own design, ensure that the **Shelf** feature is disabled by setting it to **False** under **System > Settings > Features** and that **I/O modules** is enabled by setting it to **True**.




This enables the GPIO interface to work as input and output to top modules that can be used in missions.

Outputs (OUT1, OUT2, OUT3, OUT4) can be toggled on and off by the robot in a **Set I/O module** mission action or manually in **Setup > I/O modules**.

A top module can be connected to the output pins and monitor when they are active at 24 V. RTN is used as ground.

Inputs (IN1, IN2, IN3, IN4) can be used by the top module to send inputs to the robot. When 24 V (or more than 20 V) is connected to the input pin, the robot registers the input as active.

The number in the signal names of the electrical GPIO pins are shifted by one in the internal I/Os displayed in the robot interface. Meaning that output **0** in the robot interface controls signal OUT1—see *Table 18.4*.

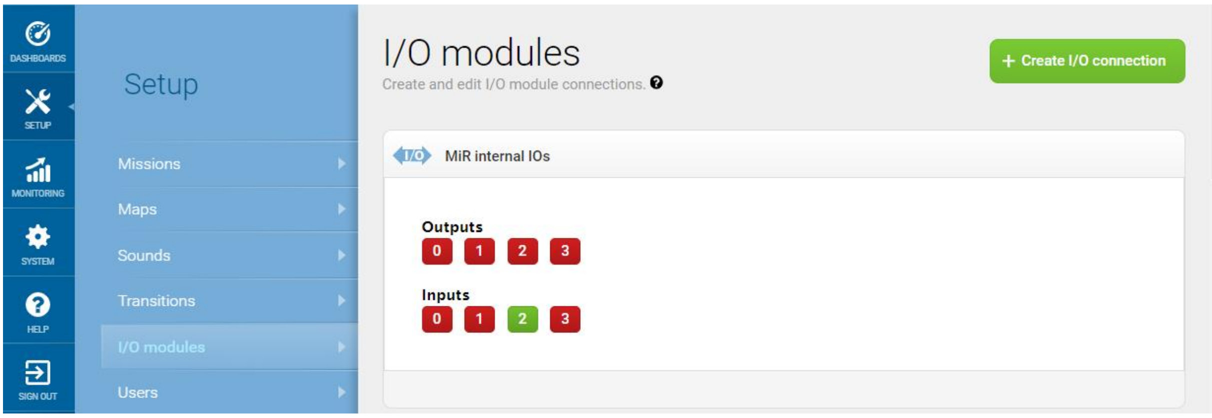



Figure 18.5. Example of I2 registered as active by the robot.

Output pins must be connected to RTN pins, and input pins must be connected to 24 V pins.

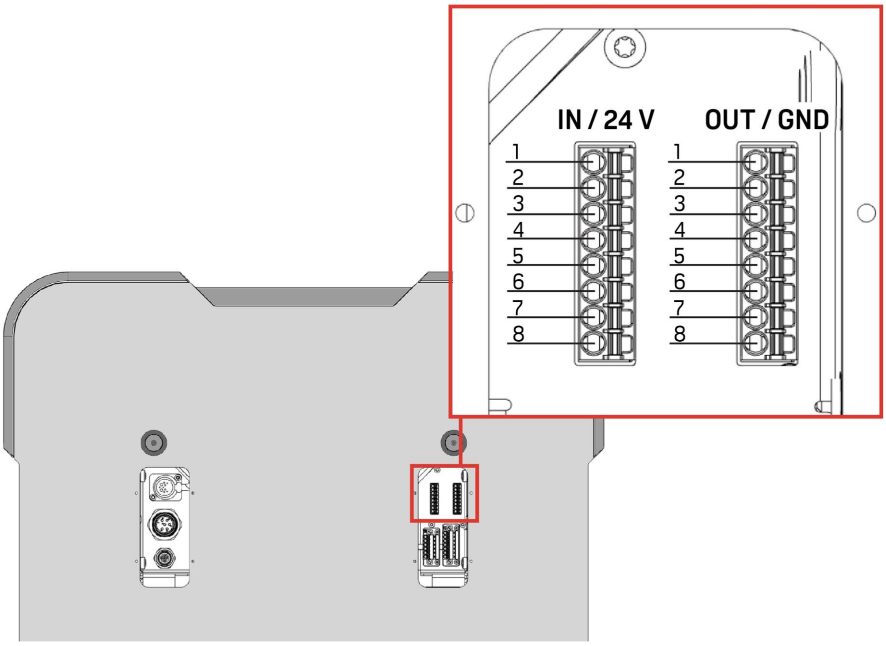



Figure 18.6. Pin numbers for the GPIO interfaces.

**Table 18.4.**
Description of the pins in the input interface in Pin numbers: female connector viewed from the front (left) and wiring diagram (right). on page 201

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 1 | OUT1 | Output | Output 1. Maximum 1 A at 24 V |
| 2 | GND | Ground | Protected return. |
| 3 | OUT2 | Output | Output 2. Maximum 1 A at 24 V. |
| 4 | GND | Ground | Protected return. |
| 5 | OUT3 | Output | Output 3. Maximum 1 A at 24 V. |
| 6 | GND | Ground | Protected return. |
| 7 | OUT4 | Output | Output 4. Maximum 1 A at 24 V. |
| 8 | GND | Ground | Protected return. |

**Table 18.5.**
Description of the pins in the in the input interface in Pin numbers: female connector viewed from the front (left) and wiring diagram (right). on page 201

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 1 | IN1 | Input | Input 1. |
| 2 | 24V | Output | 24 V output. 2 A maximum total over all 24 V output. |
| 3 | IN2 | Input | Input 2. |
| 4 | 24V | Output | 24 V output. 2 A maximum total over all 24 V output. |
| 5 | IN3 | Input | Input 3. |
| 6 | 24V | Output | 24 V output. 2 A maximum total over all 24 V |

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| | | | output. |
| 7 | IN4 | Input | Input 4. |
| 8 | 24V | Output | 24 V output. 2 A maximum total over all 24 V output. |

To use the GPIO functionality, it is necessary to connect the fitting FMC 1.5/ 8-ST-3.5 (1952322) connector made by Phoenix Contact.

## Auxiliary Safety Functions A and B

The Auxiliary safety functions interfaces are designed to support Emergency and Protective stops and other safety functions—see Safety system on page 84.

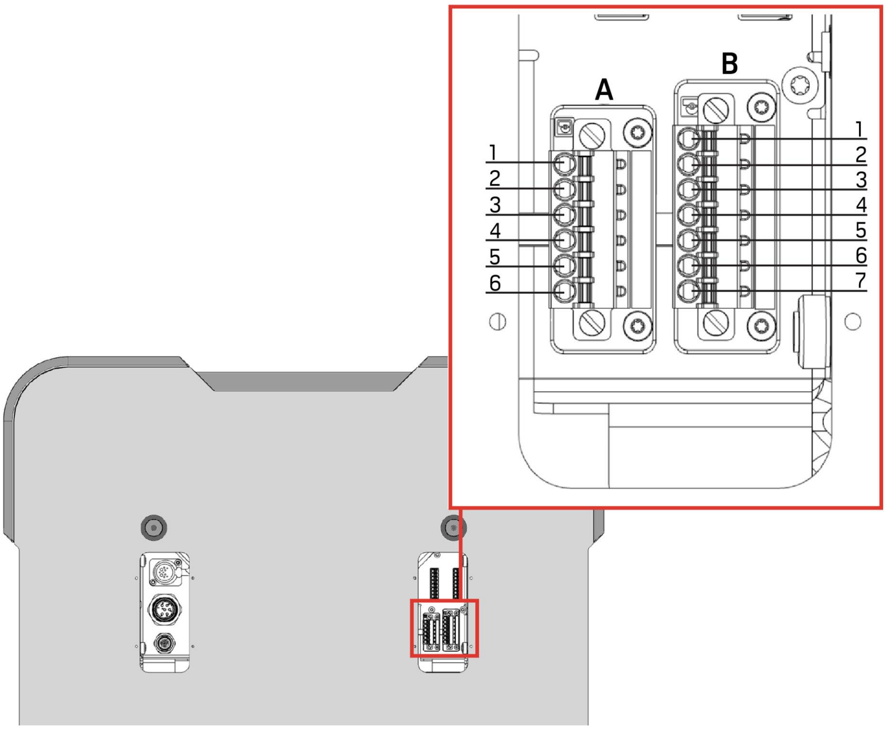



Figure 18.7. The pins of the Auxiliary safety functions interfaces.

## Safety A:

**Table 18.6.**
Description of the pins in the Auxiliary safety function interface A in The pins of the Auxiliary safety functions interfaces. on the previous page

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 1 | Test output 1 | Output | 24 V test signal. Sends test pulses (not on constantly). |
| 2 | Safeguarded stop 1 | Input | When inactive, the robot enters Protective stop. If this pin and the other Safeguarded stop pin are unequally set for a period greater than three seconds, the robot must be restarted. |
| 3 | Shared emergency stop in 1 | Input | When inactive, the robot goes into Emergency stop. |
| 4 | Reduced speed 1 | Input | When inactive, the robot drives with reduced speed. |
| 5 | Locomotion 1 | Output | Is active when the robot is standing still. |
| 6 | Shared emergency stop out 1 | Output | Is inactive when the robot is in Emergency stop. |

## Safety B:

**Table 18.7.**
Description of the pins in the Auxiliary safety function interface B in The pins of the Auxiliary safety functions interfaces. on the previous page

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| 1 | Test output | Output | 24 V out test signal. Sends test pulses (not on |

| Pin no. | Signal name | Type | Description |
|---|---|---|---|
| | 2 | | constantly). |
| 2 | Safeguarded stop 2 | Input | When inactive, the robot enters Protective stop. If this pin and the other Safeguarded stop pin are unequally set for a period greater than three seconds, the robot must be restarted. |
| 3 | Shared emergency stop in 2 | Input | When inactive, the robot goes into Emergency stop. |
| 4 | Reduced speed 2 | Input | When inactive, the robot drives with reduced speed. |
| 5 | Locomotion 2 | Output | Is active when the robot is standing still. |
| 6 | Shared E-Stop out 2 | Output | Is active when the robot is standing still. |
| 7 | SAFE_ RETURN | | Safe return for output signals. |

## 18.3 Connector list

**Table 18.8.**
Description of the connectors used for the different interfaces

| Connector | Description | Manufacturer | Part number |
|---|---|---|---|
| Power | Cable connector, M23, 6 way, male | Phoenix Contact | 1619775 |
| GPIO | Single wire connector, female, pitch 3.5mm 8 way. | Phoenix Contact | 1952322 |
| Ethernet | Cable assembly, 1m, M12, 4 way to RJ45 | Lumberg | 0985 806 103/1M |

| Connector | Description | Manufacturer | Part number |
|---|---|---|---|
| Auxiliary emergency stop | Cable connector, 8 + 2 way, XLR, male | Neutrix | NC10MXX-14-B |
| Auxiliary safety functions - long connector | Single wire connector, female, Pitch 3,81mm, 7 way | Phoenix Contact | 1851287 |
| Auxiliary safety functions - short connector | Single wire connector, female, pitch 3,81mm, 6 way | Phoenix Contact | 1851274 |
| Antenna | Cable connector, RP-SMA, male, gold | AMPHENOL RF | RSMA1111A1-3GT50G-1A-50 |

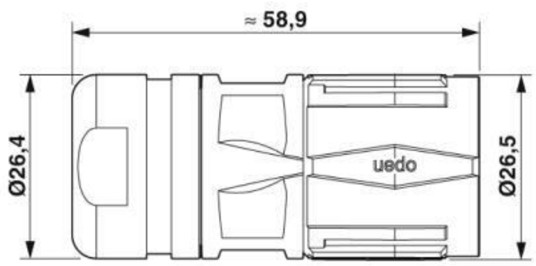
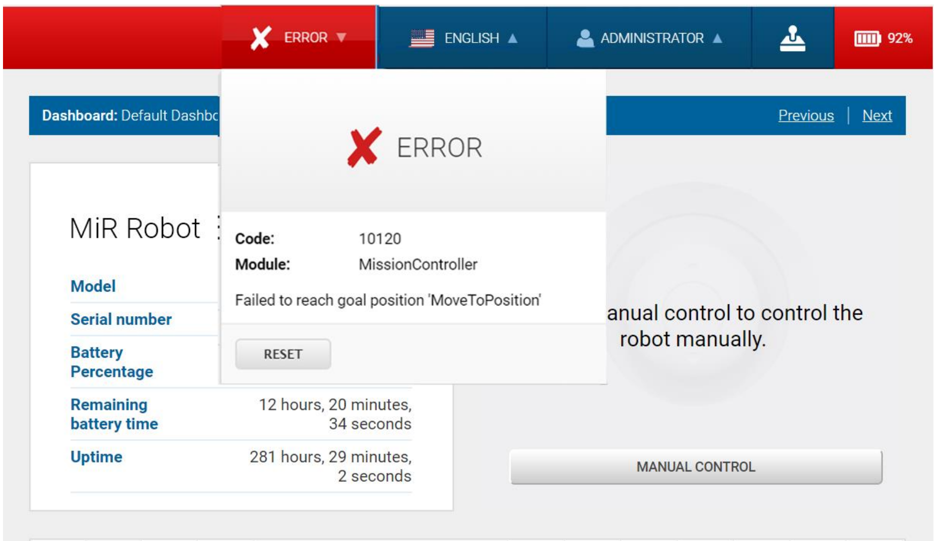



Figure 18.8. Connector dimensions for the Power connector.

# 19. Error handling

The robot enters an error state when it can't solve a problem on its own.




Errors include:

- Hardware faults
- Failed localization
- Failure to reach destination
- Unexpected events in the system

An error triggers a Protective stop. The robot is paused until a user acknowledges the error and clears it.

## 19.1 Software errors

Software errors such as localization and failure to reach the goal destination can be prevented with the proper setup of maps and missions:

- Always test your missions under full observation and normal work environment conditions before leaving the robot to execute the missions autonomously—see Testing a mission on page 179.
- Use Try/Catch actions to make the robot react in a specific way if it fails to execute certain actions—see Creating the mission Try/Catch on page 158.

- Use Prompt user actions in missions that require intervention from users—see Creating the mission Prompt user on page 153.
- Define forbidden areas with Forbidden or Unpreferred zones on the map—see Creating and configuring maps on page 108.
- Remove noise from maps—see Creating and configuring maps on page 108.
- Create Directional or Preferred zones to guide the robot around areas that are difficult for the robot to travel through—see Creating and configuring maps on page 108.

To clear an error, select the red warning indicator in the interface, and select **Reset**.

For more details on setting up missions and error handling, see *MiR Robot Reference Guide* on the MiR website.

## 19.2 Hardware errors

If the error is a fault in the hardware, either you will not be able to clear it, or the error will return until the fault is fixed. If this occurs, you can try to fix the issue with these actions:

- Turn your robot off and then on again. This resets the robot components and may resolve the issue.
- Check that the Emergency stop button is released.
- Check your robot for any physical damage such as cracks, dents, or severe scratches or contamination such as dust, dirt, and grease. Pay special attention to the 3D cameras, safety laser scanners, and drive wheels.

- Sign in to the robot interface and go to **Monitoring > Hardware health**. The interface displays which component is failing and often for what reason. This can help identify the source of the error. If an internal component is failing, turn off the robot, disconnect the battery, and have the commissioner or operator visually check the internal component for obvious faults.

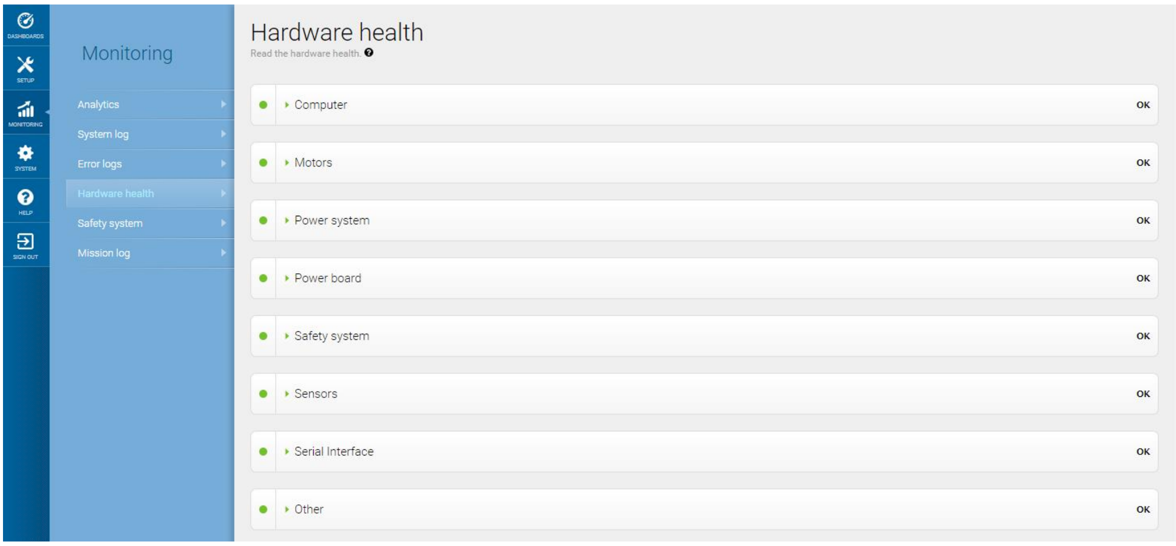



Figure 19.1. The interface in Hardware health displays which component is failing and often for what reason.

- For further troubleshooting, contact your distributor for specific MiR troubleshooting guides or assistance from MiR Technical Support.

For a full list of MiR error codes, contact your distributor for the document *Error codes and solutions*.

# Glossary

## A

### Autonomous mode

Mode in which the robot drives autonomously based on the missions you assign to it.

## C

### Commissioner

Commissioners have thorough knowledge of all aspects of commissioning, safety, use, and maintenance of MiR250 and have the following main tasks: commissioning the product, including creating maps and restricting the user interface for other users; making the risk assessment; determining the payload limit, weight distribution, and safe methods of fastening of loads to MiR250; and ensuring the safety of nearby personnel when a MiR robot is accelerating, braking, and maneuvering.

## D

### Direct user

Direct users are familiar with the safety precautions in the user guide and have the following main tasks: assigning missions to MiR250 and fastening loads to MiR250 properly.

### Dynamic obstacle

Dynamic obstacles are obstacles that are moved around, such as pallets, crates, and carts. These should not be included when creating a map.

## E

### Emergency stop

Emergency stop is a state the robot enters when an Emergency stop button has physically been pressed. When the robot is in Emergency stop, the status light of the robot turns red, and you are not able to move the robot or send it on missions until you bring the robot out of Emergency stop. To do this, you must release the Emergency stop button and then press the Resume button.

## G

### Global path

The global path is the route the robot calculates that leads it to its goal position.

## I

### Identification label

The identification label is the label that is mounted to the product in production. The label is used to identify the components in your MiR application. It identifies the product model, the hardware version, and the product serial number.

## L

### Local path

The local path is the route the robot creates within its immediate vicinity that guides it around obstacles while still following the global path.

### Localization

The method used by the robot to determine its position on the map relative to where it is in the work environment.

## M

### Manual mode

The mode in which you can drive the robot manually using the joystick in the robot interface.

### Marker

A marker of a physical entity that the robot can dock to. This enables the robot to position itself accurately relative to the marker.

### MiR application

A MiR application is either a single MiR product or a combination of MiR products that is able to execute certain tasks. A MiR application is often a MiR base robot combined with a MiR top module. If a custom top module is used, the CE mark on the nameplate of the base robot does not extend to the top module.

## MiR robot interface

The MiR robot interface is the web-based interface that enables you to communicate with your MiR robot. It is accessed by connecting to the robot's WiFi and then going to the site mir.com or by entering the robot's IP address in a browser.

## Muted Protective fields

When the Protective fields are muted, the robot moves at a reduced speed, and the Protective field sets are minimized so the robot does not enter Protective stop until it is very close to an obstacle.

# N

## Nameplate

The nameplate is the label delivered with your MiR application that must be mounted before you commission the robot. The nameplate identifies the MiR application model, application number, mechanical and electrical specifications, and includes the CE mark of your application.

## Noise

With MiR robots, noise in maps refers to recorded data that originates from interfering elements. This can be physical obstacles that make the robot record walls where there are none or more subtle interferences that can make recorded walls appear pixelated.

# O

## Operating hazard zone

Operating hazard zones are areas where the robot drives with muted Personnel detection and areas with inadequate clearance for personnel to work close by the robot.

## Operator

Operators have thorough knowledge of MiR250 and of the safety precautions presented in the User guide of MiR250. Operators have the following main tasks: servicing, maintaining, and creating and changing missions and map positions in the robot interface.

## P

### Payload

The payload is the weight the robot carries. Total payload capacity is the maximum weight the robot can carry, including the weight of any top modules, shelves, carts, or other devices.

### Position

A position is a set of X-Y coordinates on the map that you can send the robot to.

### Protective field sets

The Protective fields sets are a part of the Personnel detection safety function. They are contours surrounding the robot that change size depending on the speed of the robot. When a safety laser scanner detects a person or object within the active field, the robot enters Protective stop until the field is clear.

### Protective stop

Protective stop is a state the robot enters automatically to ensure the safety of nearby personnel. When the robot enters Protective stop, the status light of the robot turns red, and you are not able to move the robot or send it on missions until it is brought out of Protective stop. The robot goes into Protective stop in a number of situations: if a safety laser scanner detects an object in its active protective field, when the robot finishes the startup process, when the robot has switched between Manual mode and Autonomous mode, if the safety system detects a fault, or if the motor control system detects a discrepancy.

## S

### Static landmark

Static landmarks are obstacles that cannot be moved, such as walls, columns, and fixed structures. These must be included on the map and are used by the robot to localize itself.