User guide

MiR500

en

Revision:	1.1
Date:	2019/03

Copyright and disclaimer

Contact the manufacturer:

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

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

CVR: 35251235

Table of contents

1. About this document

This document contains the following information:

- How to start up and operate MiR500.
- Product presentation.
- Typical applications.
- Guidelines for proper maintenance of the robot.

1.1. Where to find more information

At www.mir-robots.com, the following extra resources are available. To access the pages in the Distributor site, sign in with your distributor account at http://www.mobile-industrial-robots.com/en/account/.

- Distributor site > Manuals
  http://www.mobile-industrial-robots.com/en/account/manuals/
  This page contains the following resources:
  - MiR500 Quick Start
    The short guide that lets you start operating the robot quickly. This document is in the box with the robot in the printed format. Available in multiple languages.
  - MiR500 Lift Operating guide
    The operating guide that describes how to set up and use MiR500 with MiR500 Lift.
  - MiR500 EU Pallet Lift Operating guide
    The operating guide that describes how to set up and use MiR500 with MiR500 EU Pallet Lift.
  - MiRCharge 500 Operating guide
    The operating guide that describes how to set up MiRCharge 500 and configure MiR500 for automatic battery charging at the charging station.
  - MiR Robot Interface 2.0 Reference Guide
    The reference that describes the elements of MiR500 interface. Available in multiple languages.
  - MiR500 REST API reference.
    The REST API reference for the robot.
- Distributor site > Download
  http://www.mobile-industrial-robots.com/en/account/download/
  This page contains the following resources:
  - CAD drawings.
    Click Show CAD-files to see the list of available CAD drawings.
  - Certificates.
    Click Show Certificates to see the list of certificates for the robot.
- Distributor site > How to
  http://www.mobile-industrial-robots.com/en/account/how-to/
  This page contains how-to articles that describe how to perform specific tasks with the robot.

- MiR500 product page
  http://www.mobile-industrial-robots.com/en/products/mir500/
  This page contains specifications, pictures, and brochures for MiR500.

1.2. Document history

This table shows latest and previous versions of this document and their interrelations with product software releases.

Revision	Release date	Description	SW	HW
1.0	2018-10-29	First edition.	2.4.0	1.0
1.1	2019-01-31	New section: Maintenance. Updated styles.	2.6.0	1.0

2. Safety

Read the information in this section before powering up and operating MiR500.

Pay particular attention to the safety instructions and warnings.

NOTICE
Mobile Industrial Robots disclaims any and all liability if MiR500 or its accessories are damaged, changed or modified in any way. Mobile Industrial Robots can not be held responsible for any damages caused to MiR500, accessories or any other equipment due to programming errors or malfunctioning of MiR500.

The section contains the following topics:

2.1. 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.

- Take proper precautions to avoid damage or injury.

CAUTION
Indicates a potentially hazardous situation that could result in minor or moderate injury. Alerts against unsafe practices.

- Take proper precautions to avoid damage or injury.

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

2.2. General safety precautions

This section contains general safety precautions.

WARNING
If the load on the robot is not positioned or fastened correctly, the load may fall or the robot may overturn.

- Ensure that the load is positioned according to the specifications and fastened correctly. See Payload specifications on page 63.

WARNING
Using a charger different from the one supplied by the manufacturer can cause a fire.

- Use only the original charger.

CAUTION
The robot can not see staircases going downwards and holes in the floor.

- Mark staircases or holes on maps with **Forbidden zones**.
- Keep the maps up to date.

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

Observe the following precautions when handling and using lithium batteries:

- Do not short-circuit, recharge or connect with false polarity.
- Do not expose to temperature 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 the original charger (cable charger or charging station) and always follow the instructions from the battery manufacturer.

2.3. Intended use

MiR500 is intended to be commissioned and used in indoor industrial environments where access for the public is restricted. For details about the environmental conditions in which the robot should operate, see Technical specifications on our website.

MiR500 is equipped with special safety-related features, which are purposely designed for collaborative operation, where the robot operates without fences and/or together with humans.

MiR500 can be used with the lift modules MiR500 Lift, MiR500 EU Pallet Lift and pallet racks MiR500 Lift Pallet Rack and MiR500 EU Pallet Rack, or it can be used with a customized top module or top manipulator. See details for add-ons on our website or in the operating guides.

2.4. Foreseeable misuse

Any use or application deviating from the intended use is deemed to be impermissible misuse. This includes, but is not limited to:

- **Use of the robot to transport people.**
  Risk of personal injury and/or damage to the robot.
- **Steep ramps on the route.**
  Risk of personal injury and/or damage to the robot. Steep surface grades (ramps etc.) may cause the robot to skid. See Technical specifications on the website.
- **Use outdoor.**
  Risk of personal injury and/or damage to the robot. MiR500 is designed and intended for indoor use only.

- **Overloading of the robot.**
  Risk of personal injury and/or damage to the robot. If the maximum payload on top of the robot is exceeded, it may cause overturning, falling load and damage to the robot. See Technical specifications on the website.
- **Failure to follow the guidelines for commissioning.**
  See Getting started on page 12 and Planning on page 24.
- **Failure to make a risk assessment of the full installation.**
  See Risk assessment below. This applies to the robot with any extra modules installed.
- **Failure to configure audible and light warning signal(s) according to the environment.**
  The risk reduction is not sufficient.
- **Operation outside the permissible operating rating parameters and environmental specifications.**
  Risk of instability, impact or tipping over.
- **Transportation of liquids or food.**
  Risk of instability.
- **Use in potentially explosive environments.**
- **Use in medical and life critical applications.**
- **Use for towing.**
- **Use on board ships.**
  Risk of personal injury and/or damage to the robot. Unstable surface caused by moving vessel may cause the robot to skid.

2.5. Risk assessment

One of the most important steps in achieving a safe installation is to make a risk assessment. The risk assessment is the responsibility of the individuals who are commissioning MiR500 in the environment it will be used in. Most often it will be an integrator who also designs and/or builds work cells or other required infrastructure related to MiR500.

The risk assessment must cover not only MiR500 itself, but also take into account potential top module/manipulator, load transfer, work cells and the environment it will be used in.

It is recommended that the integrator uses guidelines in ISO 12100, EN 1525, ANSI B56.5 or other relevant standards to conduct the risk assessment.

The risk assessment should consider two scenarios:

- Teaching (setup where maps are made and the missions are defined and verified) the robot while developing the robot installation.
- Normal operation of the robot installation.

In EN 1525, clause 4 there is a list of significant hazards, hazardous situations and events which can be used for inspiration.

2.6. Residual risks

Mobile Industrial Robots has identified the potential significant hazards listed below as hazards that must be considered by the integrator.

- Being run over, drawing-in, trapping or impact if a person steps into the route or walks towards MiR500 while in motion.
- Crushing, drawing-in or trapping at load transfer stations, work cells or charging stations.

NOTICE
Other significant hazards might be present in a specific robot installation.

2.7. Safety-related functions and interfaces

MiR500 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 and/or top manipulator. 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.

2.8. Limiting safety-related functions

MiR500 has several built-in safety-related functions that are used to ensure safe operation in the environment it is designed to be used in.

Advanced control software ensures that locomotion and the drive pattern are within safety related limits and thereby avoid triggering a safety function. Violations of limits will hence only occur in exceptional cases. Nevertheless, if a limit is violated, the safety system issues a category 0 stop (stopping by “immediate removal of power to the machine actuators according to IEC 60204-1”) followed by a controlled brake which brings MiR500 to a stop.

See Technical specifications on our website for more details.

Collision avoidance

The collision avoidance safety function ensures that the robot will come to a stop before it collides with a human or object.

The function measures the speed on the two driving wheels and switches between the predefined protective fields accordingly. The faster the speed, the larger the protective fields will be.

This ensures that the robot will be brought to a stop in case a human or object is detected within the active protective field.

Collision avoidance is automatically deactivated two seconds after the protective field is free.

Safe load position

The safe load position safety function ensures that the robot will not locomote, while MiR500 Lift orMiR500 EU Pallet Lift is not in the lowest position and hence there is a risk of compromising stability.

The safe load position safety system consists of interlock switches that detect if the lift modules are in the lowest position or not.

The input can be used for a customized top module/manipulator when a MiR500 Lift or MiR500 EU Pallet Lift is not installed.

The safe load position safety function must be manually deactivated by activation of the restart button.

Overspeed avoidance

The safety system monitors if the speed of each motor is above limits for maximum speed and hence an indication of speed control is lost for any reason.

The overspeed avoidance safety function must be manually deactivated by activation of the restart button.

Stability

The safety system monitors if the speed difference between the two motors are above predefined limits and hence an indication of speed control is lost for any reason.

The stability safety function must be manually deactivated by activation of the restart button.

Emergency stop

MiR500 has four emergency stop buttons and an option to connect additional emergency stop buttons through the electrical interface.

The emergency stop should only be activated in case of an emergency.

Emergency stop must be manually deactivated by activation of the restart button.

2.9. Safety-related electrical interfaces

The robot is equipped with several safety-related electrical inputs and outputs. All safety-related electrical inputs and outputs are dual channel. They are safe when low, e.g. the emergency stop is not active when the signal is high (+24V).

2.9.1. Safety-related electrical inputs

This section contains the safety-related electrical inputs of the robot.

External emergency stop button input

This input is for connection of an optional emergency stop button. If activated, the safety system issues a category 0 stop followed by a controlled brake which brings MiR500 to a stop.

Must be manually deactivated by activation of the restart button.

System emergency stop input

This input should be used in case a top manipulator has its own emergency stop circuit. The input must be used in combination with a system emergency stop output. With this, it is possible to ensure that activation of any emergency stop button will cause an emergency stop of both MiR500 and top manipulator. If activated, the safety system issues a category 0 stop followed by a controlled brake which brings the robot to a stop.

Must be manually deactivated by activation of the restart button.

Safeguard stop input

This input can be used to issue a category 0 stop followed by a controlled brake which brings MiR500 to a stop.

Will be automatically deactivated when signal is driven high again.

Load handling position (position control of load)

This input can be used to apply the safe load position (position control of load) safety function on a system with customized top modules or manipulators. A variety of sensors or interlock switches that detect load handling position or position of load can be connected and thereby enable the safe load position safety function.

2.9.2. Safety-related electrical outputs

This section contains the safety-related electrical outputs of the robot.

Locomotion

This safety related output is activated if the robot is in locomotion or intend to locomote within two seconds.

Note
The safety function is limited if locomotion is detected while the output is deactivated.

Shared emergency stop output

This output should be used in case a top manipulator has its own emergency stop circuit. The output should be used in combination with a system emergency stop input. With this, it is possible to ensure that activation of any emergency stop button will cause an emergency stop of both the robot and top manipulator.

Activated by an emergency stop button or emergency stop input.

2.10. Lithium battery

This section contains safety precautions related to lithium batteries in MiR robots.

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

Observe the following precautions when handling and using lithium batteries:

- Do not short-circuit, recharge or connect with false polarity.
- Do not expose to temperature 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 the original charger (cable charger or charging station) and always follow the instructions from the battery manufacturer.

3. Getting started

This section describes how to get started with MiR500.

The section contains the following topics:

3.1. In the box

This section describes the content of the MiR500 box.

The box contains:

1. The MiR500 robot
2. MiR500 document folder containing the printed documents and the USB flash drive.
3. Printed documents:
    - MiR500 Quick Start.
    - MiR username and passwords.
    - CE declaration of conformity.
4. USB flash drive with the following content:
    - MiR500 User Guide.
    - MiR Robot Interface 2.0 Reference guide.
    - MiR robot REST API reference.
    - MiRCharge 500 Operating Guide.
    - MiR500 Lift Operating Guide.
    - MiR username and passwords.
    - CE declaration of conformity.

3.2. Unpacking MiR500

This section describes how to unpack MiR500.

Note
Keep the original packaging for the future transportation of the robot.

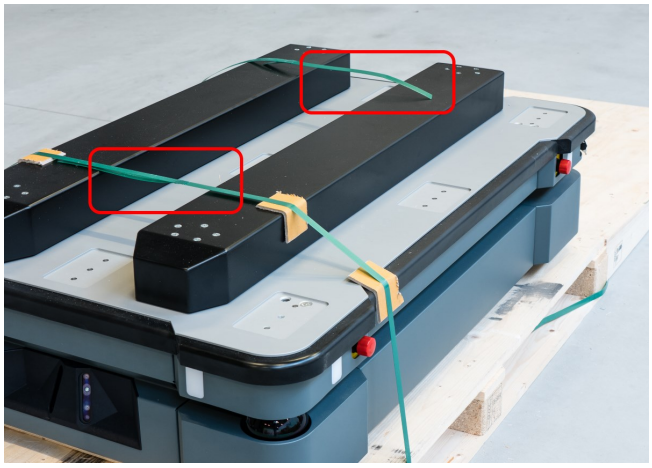
1. Place the box with the robot so that there is 3 m of free space at the front or the back of the box. This is necessary since the robot drives out of the box on the ramp.

2. Remove the screws that attach the walls of the box to the box lid and the base of the box.

3. Remove the lid from the box.

4. Take the folder with the printed documents and the USB drive out of the box.
5. Remove the walls of the box and the protective foam blocks.

6. Cut the protective straps.



7. 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.

8. Remove the wheel stop board from the pallet to let the robot drive on the ramp.

4. Commissioning

This section describes how to get started with MiR500.

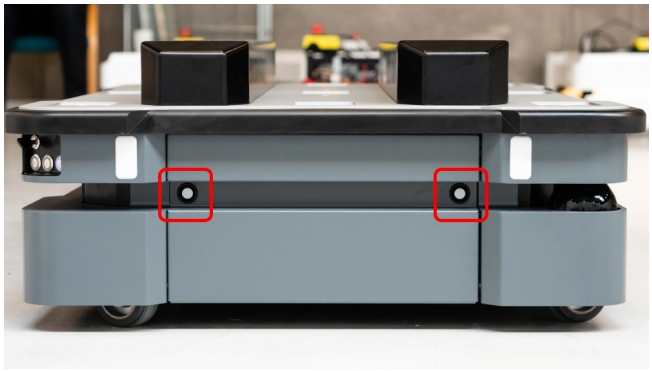
NOTICE
Read the Safety chapter before powering up the robot.

The section contains the following topics:

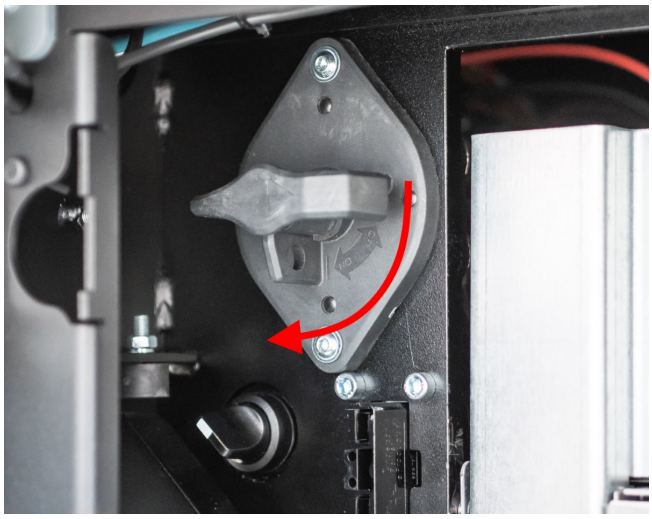
4.1. Powering up

Follow these steps to power up MiR500.

1. Open the rear maintenance hatch. To open the hatch, push two buttons on the hatch and pull the hatch.

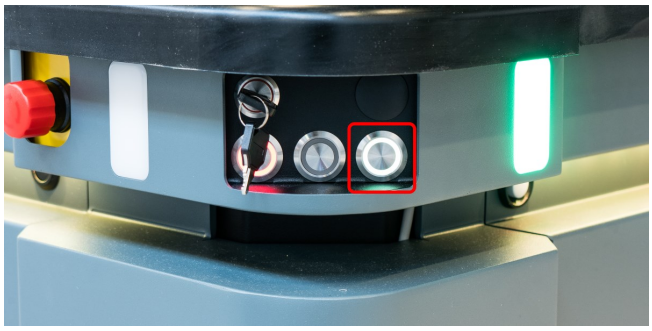


2. Turn the battery disconnect switch to position **ON**.



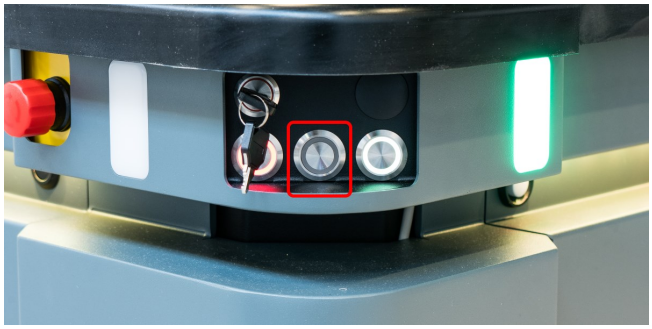
3. The **On/Off** button turns blue.
4. Close the maintenance hatch.
5. Ensure that all 4 emergency stop buttons are in the released state. Turn an emergency stop button clockwise to release it.

6. Press the **On/Off** button for five seconds.



7. The robot turns on the yellow indicator lights and starts the software initialization process. When the initialization process ends, the robot goes into the emergency stop mode.

8. Press the **Restart** button to clear the emergency stop. The robot is ready for operation, the status lights turn constant yellow.



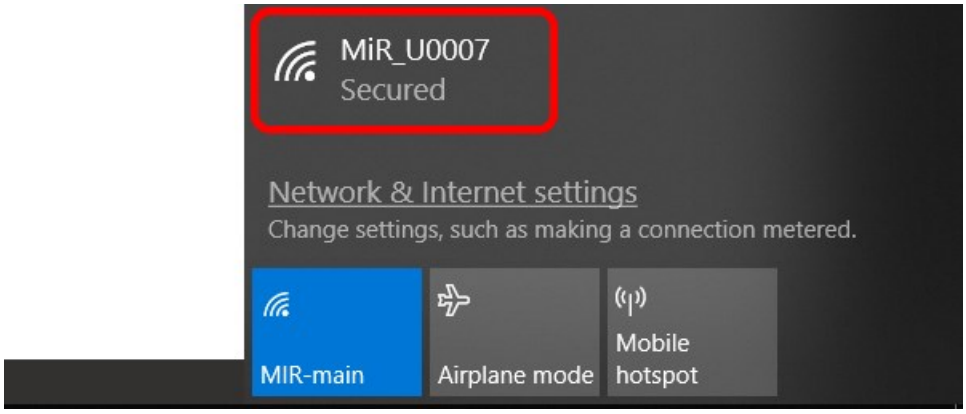
4.2. Connecting to the robot interface

When the robot is 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 laptop, tablet, or a phone.

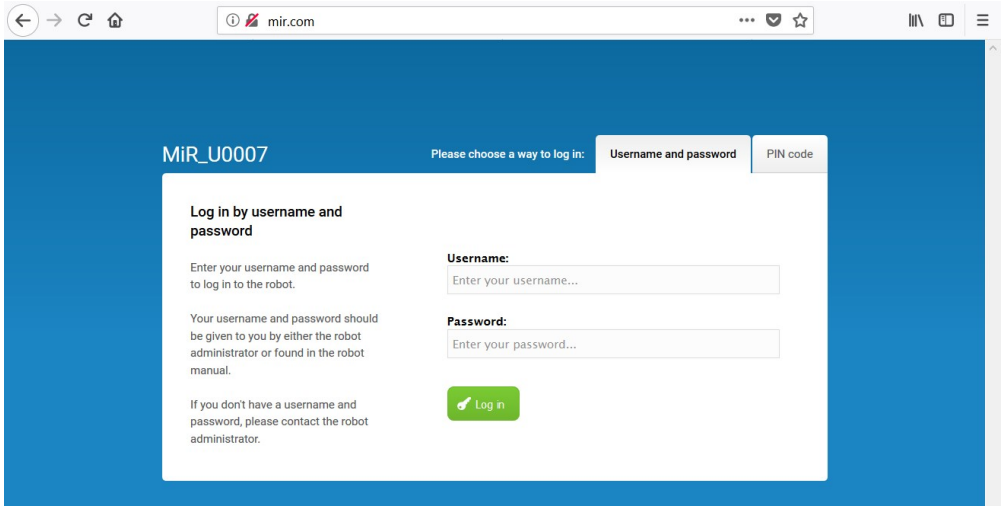
NOTICE
The username and password for the robot's WiFi access point and for accessing the web interface are in the MiR username and passwords document. The document is in the box with the robot.

Follow these steps to connect to the robot interface:

1. Using your laptop, tablet, or a phone, connect the WiFi access point of the robot. The access point name has the following format: MiR_UXXXX.



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



4.3. Driving the robot in manual mode

To drive the robot in Manual mode:

1. Put the Operating mode key into the Manual mode (turn to the right).
2. In the robot interface, select the joystick icon. The joystick control appears.
3. Select **Manual control**. The **Restart** button on the robot starts blinking.

4. Press the **Restart** button. The status lights turn blue indicating that the robot is in Manual mode.

5. Drive the robot using the joystick.

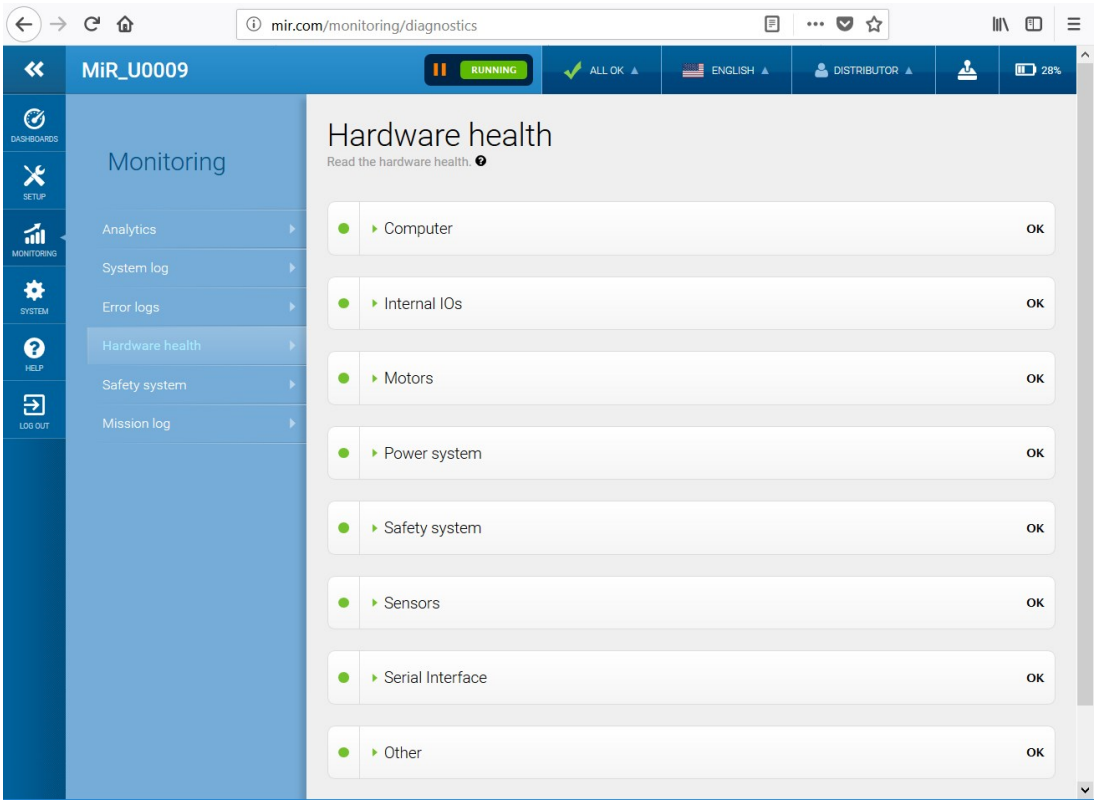
4.4. Checking the hardware status

To check that all hardware components work normally:

Sign in to the robot interface. See section Connecting to the robot interface.

Go to **Monitoring** > **Hardware health**.

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



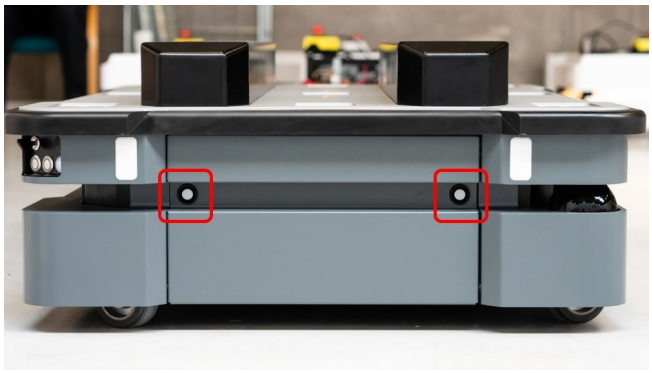
For more information, see Hardware health in MiR Robot Interface 2.0 Reference Guide.

4.5. Charging the robot

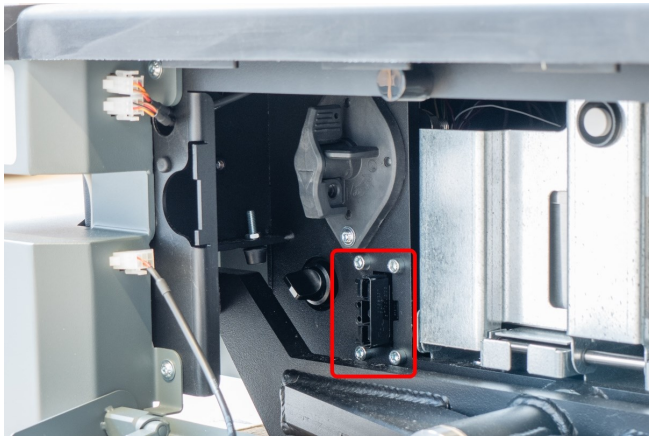
Note
A charger cable and an external charger is not part of the standard MiR500 delivery.

To charge MiR500 using the cable charger:

1. Open the maintenance hatch at the back of the robot. To open the hatch, push two buttons on the hatch and pull the hatch.



2. Connect the charger cable to the charging connector on the robot.

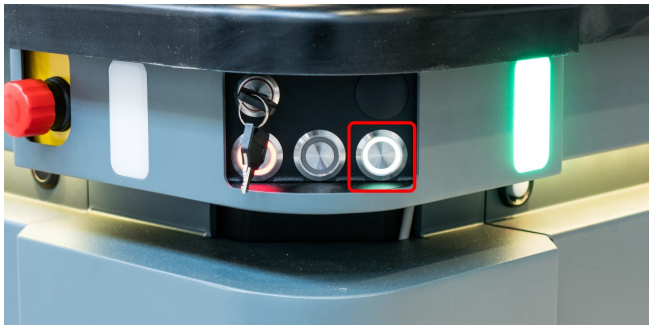


For information about the charging time, see the robot specifications at www.mir-robots.com.

4.6. Shutting down the robot

To shut down MiR500:

1. Ensure that the robot is not moving or executing an action.
2. Press the **On/Off** button for five seconds.



3. The robot starts the shutdown process. Status lights blink yellow, the **On/Off** button blinks red.
4. When the robot finishes the shutdown process, the status and the signal lights go off, the **On/Off** button turns blue.

   If shutting the robot down for transportation or service/repair, the battery disconnect switch must be turned off as well and the battery cable disconnected, see ...

4.7. Creating and configuring a map

The robot requires a map to operate.

For information about creating a map, refer to MiR Robot Interface 2.0 Reference Guide.

Section Creating an efficient map on page 29 describes how to make the map efficient and how to mitigate potential risks.

5. Planning

This chapter describes what needs to be considered before and during the installation of MiR500 in the company.

Before considering and installing the following, it is worth spending some time defining what tasks MiR500 must do in the work environment.

The correct setup and thorough training of the users will result in a successful and safe installation of MiR500.

For more details on the topics below, refer to the MiR Robot Interface 2.0 Reference Guide.

NOTICE
Read section Safety on page 5 before going through this chapter.

The section contains the following topics:

5.1. Analysis of the work environment

A thorough analysis of the environment where MiR500 is going to be implemented in is necessary for a successful and safe installation.

Note
Read the Technical specifications at www.mir-robots.com for more details on how much space MiR500 requires to operate safely and successfully.

5.1.1. What does the robot see?

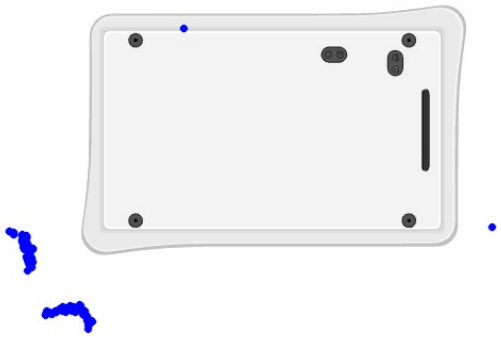
Before preparing the environment for MiR500, it is worth understanding how the robot works, what it can see and what it uses for navigation.

MiR500 is an autonomous and collaborative robot. The robot relies on localization techniques to orient itself in its environment. The robot uses path planning that consists of two parts: a global planner that does the general path planning between two positions and a local planner that causes the robot to follow the global path and also take into account the surroundings, so that the robot avoids dynamic obstacles based on sensor input.

MiR500 has two laser scanners that serve three main purposes:

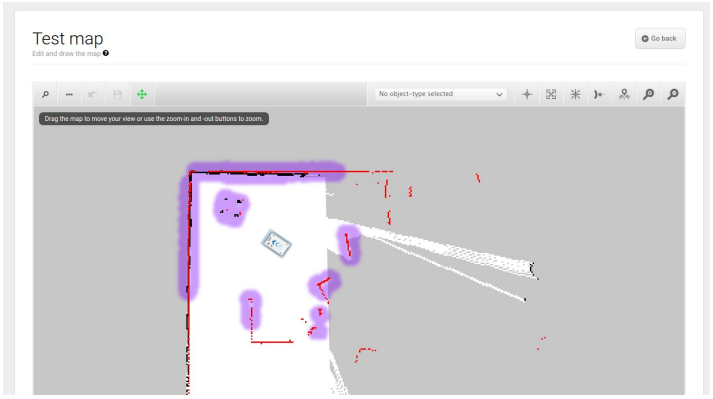
- Emergency stop: the laser scanners trigger the emergency stop as part of the SICK Safety system when an obstacle is within the emergency zone of the laser scanners.
- Mapping: the laser scanners record the environment to gather data that enable the creation of a map.
- Localization: the laser scanners use data to localize the robot in the map that has been generated and loaded into the robot.

The following illustrations show how the robot sees the surrounding environment.

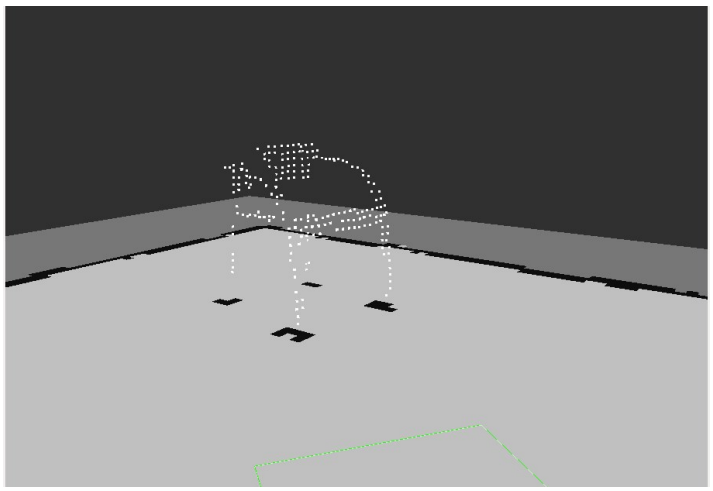


The laser scanners detect a dynamic object in the bottom left corner.

Human eyes see the chair and surrounding details.



Laser scanners of the robot will only detect parts of the chair. Here, the scanners detect the four legs of the chair in the upper left corner of the map.



The 3D camera will detect more details of the chair when it is close enough to it.

5.2. MiR500 user roles

Introducing MiR500 into the company will require some changes to the environment and the people working with the robot to achieve the optimal benefits. Spending some time defining and preparing the users will make the robot a much more effective collaborative robot and will form a positive and safe experience.

It is important to explain to the users what the robot can do, but also what it can not do. For example, the robot can transport heavy pallets, but it can not transport people. Based on the preparation of the environment, it is also worth explaining what is going to be difficult for the installation, both in the environment and for some of the users' work flow.

5.2.1. Types of users

It is important to analyze and consider who is:

- Working directly with MiR500.
- Working indirectly with MiR500.
- Responsible for MiR500.

Direct user

The direct user of MiR500 could be someone who commands the robot to carry out missions and works closely with the robot. Apart from training on how to use the robot (see Training of the users on the next page), the direct user will need to make adjustments to his/her work flow to include the robot in their work. The direct user also needs to know who is responsible for MiR500, so they can get help if the robot is not running missions as it should.

Indirect user

The indirect user of MiR500 could be someone working in the same environment as the robot, but not working directly with the robot. This user might need to change their work flow slightly for the company to make the most out of the robot. For example, if the user walks a certain path several times a day and this path crosses the robots path several times a day – it might be worth creating two paths. This way, the robot does not stop several times a day to let the indirect user pass, wasting valuable work time. It is important to note that MiR500 is a collaborative robot and will always stop, if someone walks out in front of it.

Responsible

The person responsible for MiR500 is someone who will know what to do if an issue with the robot occurs. The person responsible should know the most common errors and how to troubleshoot them. The responsible should also be instructed in maintenance and inspection of the robot. This user will need a more thorough basic training and should also know who to reach out to in case he/she can not solve the issue at hand.

Superuser

The superuser of MiR500 is usually someone from the development department, who understands how the robot is set up and works with it on a daily basis. The superuser also undergoes continuous training by Mobile Industrial Robots ApS. A superuser is therefore mainly relevant for bigger companies.

5.2.2. Interface and dashboards

Based on the considerations in Types of users on the previous page, there will most likely be different users with different tasks using MiR500.

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.

To make it as simple as possible for each user, it is worth investing some time in building up a unique dashboard for each user. Dashboards are an easy way for different user groups to control the robot giving direct access to their individual key functions.

Consider the following based on previous considerations on users of the robot:

- How many different users are there?
- What tasks do each user have with MiR500?
- What rights (edit and control) should the different users have?
- What functions or widgets should be available for the different users?

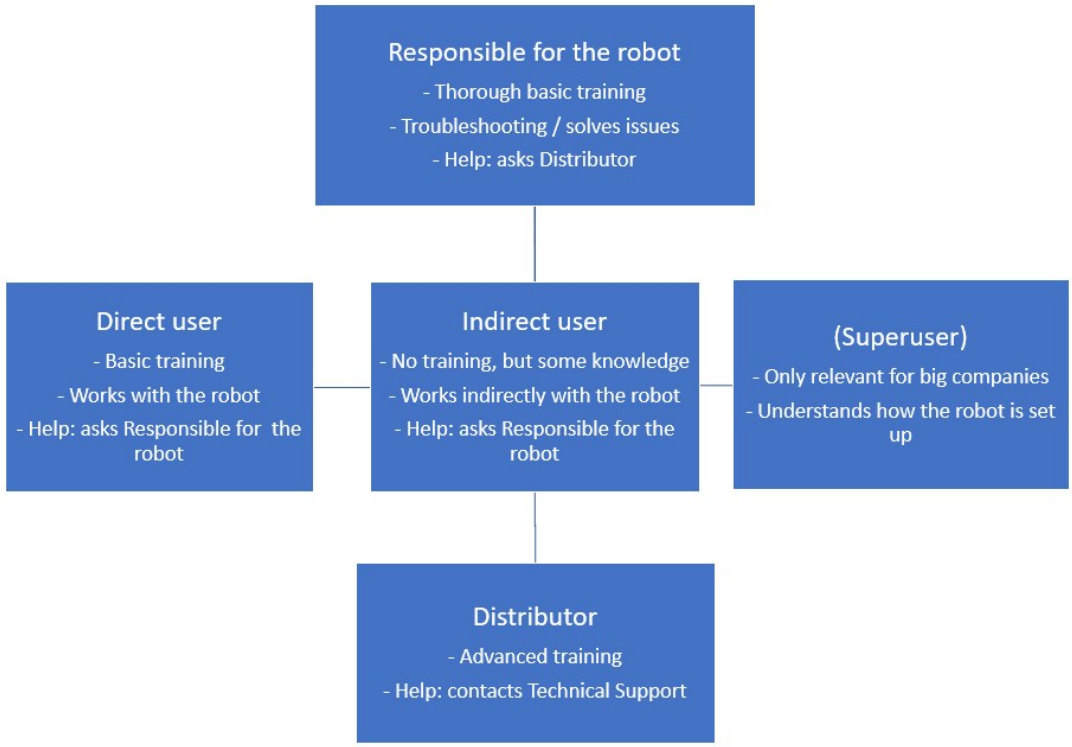
For more details on interface and dashboards, see MiR Robot Interface 2.0 Reference Guide.

5.2.3. Training of the users

It is very important to spend time on training the different users of MiR500. It is unlikely that all users will need to know all the features of the robot. Teaching should be done at different levels, to make it as simple as possible for the different users. This way, each user will quickly learn how to use the robot in the way they need to.

It is also important to establish a chain of communication for MiR500 in the company. This means that all users (direct, indirect and responsible) always know who to ask, if they have any problems or questions.

See Handover testing on page 34 for more information on training.



Chain of communication.

5.3. Creating an efficient map

After the preliminary analyses of the work environment and the work flows of the people working there, spending time on creating a good map is important for MiR500 to work safely and efficiently.

Creating a robust, reliable map for dynamic environments will pay off, as the map is the basis of the robot's ability to navigate its surroundings. A good map is also the basis for a safe and efficient robot.

Note
If you have not created a map before, see MiR Robot Interface 2.0 Reference Guide and How-to guides on our Distributor website.

5.3.1. Use zones on the map

Adding zones to the map can organize efficient robot traffic. There are several different zones that can optimize the preferred paths and driving behavior of the robot. For example, a **Forbidden zone** is a zone where the robot will never enter. A **Blink or Light zone** are zones where the robot either blinks or makes a sound to catch attention. In a **Preferred zone** the robot tries to run within a preferred area taking into account dynamic obstacles. In an **Unpreferred zone**, the robot tries to avoid the unpreferred zone but may go into it if there are no other possibilities. A **Directional zone** lets you organize the motion of robots by specifying the directions in which the robots can move in specific zones.

Adding zones to the map can also solve most of the issues with possible hazards in the work environment.

Downwards going staircases

MiR500 can not see downwards going staircases and holes in the floor.

Issue: The 3D camera can not detect downwards going 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.

Permanent low hanging fixtures

A permanent low hanging fixture could be a machine with a PC attached, for example a screen attached to an arm that can be moved in several directions. It could also be a boom barrier or boom gate, as seen near entries in supermarkets.

Issue: MiR500 will not see these dynamic low hanging fixtures. This could be dangerous with a top module attached to the robot.

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

Large highly dynamic areas

A large 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: MiR500 will always plan the shortest path from A to B. If this is through a large highly dynamic area, the robot will re-plan its path several times. The re-planning happens because the robot will encounter new dynamic obstacles in the environment often. This can lead to valuable time wasted on readjusting the path several times a day.

Solution: Mark large highly dynamic areas on the map with for example **Unpreferred zones** or create a path guide. In extreme cases, use **Forbidden zones**.

Transient work flow areas

A transient work flow area is an area where humans often move around. This could be part of a production area where people are assembling a product. It could also be an area where forklifts or other machines are operated.

Issue: MiR500 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 transient work flow areas on the map with for example **Unpreferred zones** or **Forbidden zones**, depending on the environment. **Directional zones** can also be used here to guide the robot in a specific direction.

Unpreferred zones (marked with purple) can be used in large highly dynamic areas and transient work flow areas to solve issues with re-planning of paths.

Doorways and ramps

Going through narrow doorways can cause problems for the robot because of the small space. Going up a ramp can cause similar problems, because of the upwards angle. Narrow doorways can also cause dangerous situations for the people working near the robot, as they might be on the other side of the door and can not see the robot coming.

Issue: The robot stops, because a narrow doorway is seen as an obstacle. Due to sensor input, the robot will not plan a path through a narrow corridor if it has an alternative path. The robot will always stop if a person steps out in front of it.

Solution: Add a **Critical zone** to the narrow doorway to force the global planner to make a path through the corridor. Add **blink and beep zones** in narrow doorways to attract attention. This will warn people near the doorway that the robot is coming through.

Narrow doorways can be marked with a Blink and/or beep zone (marked with yellow) to warn people that it is coming through.

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 shelf to pass through. MiR500 will then plan a path underneath the shelves, but when it comes closer, the camera will see the obstacle. This could result in re-planning paths several times a day, thereby wasting valuable work time for the robot.

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** (marked red in the image) around the shelves.

The shelves are marked as a Forbidden zone in the map.

Pallet rack

When MiR500 docks to a pallet rack, personnel detection means are temporarily muted. This could cause a dangerous situation, if a person steps in front of the robot and the pallet rack.

Issue: MiR500 mutes the personnel detection means temporarily when docking to a Pallet Rack. This could cause a dangerous situation.

Solution: Follow the mounting guidelines and mark the area around the Pallet Rack with tape or similar. Inform users of or near the robot of the safety issues regarding the Pallet Rack so they can take their precautions when working near the Pallet Rack.

5.4. Creating efficient missions

After creating a good map, it is worth spending time on creating and testing simple missions for MiR500 to work safely and efficiently.

Before building the missions, consider how the tasks could be solved in the simplest and safest way.

Note
If you have not created a mission before, see MiR Robot Interface 2.0 Reference Guide and How-to guides on our Distributor website.

Create simple missions

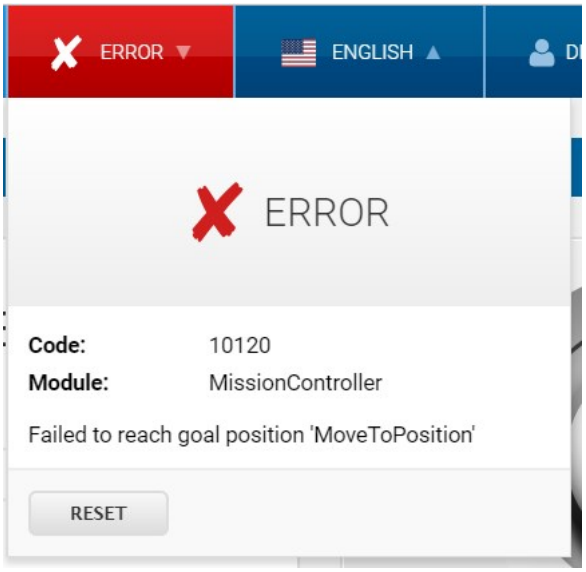
Creating simple missions will provide a good basis of solving safe and simple tasks. Simple missions include moving from point A to point B, go to waiting position, go to charge, pick up pallet etc.

Missions within missions

A good basis of different missions makes it possible to set up missions inside missions. This way, simple missions can be re-used in different, bigger and more complex missions.

5.5. Error handling

An error occurs when the robot is conflicted and cannot solve a situation on its own.



Errors include:

- Hardware faults.
- Failed localization.
- Failure to reach destination.
- Unexpected events in the system.

An error causes a full system stop. The robot is paused until a person acknowledges the error and clears it.

Proper setup of maps and missions effectively prevent most errors.

- Use Try/Catch actions.
- Define forbidden areas.
- Remove noise from maps.

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 Interface 2.0 Reference Guide.

5.6. Handover testing

It is very important to schedule time for handover testing. The new users of MiR500 might have new questions after they start using the robot or new issues or situations might have appeared.

Handover testing is important because it improves safety, increases users' happiness with the robot and increases return of investment.

- A good handover ensures that the users:
- Get comfortable with the product.
- Know the robot's limitations and possibilities.
- Can solve common issues.
- Recognize common errors.
- Know who to contact if they experience issues.

Inform users

Informing users about MiR500 and its functions at a level that matches their user type (direct, indirect etc.) will help ensure a safe and successful installation of the robot.

Useful information at different levels could be:

- Safety zones, planning of paths and deviations from planned paths, dynamic obstacles.
- Illustrate that MiR500 will stop before driving into obstacles.
- Daily/weekly/monthly cleaning, maintenance and inspection of robots.
- Changing missions, location of positions, zone areas.
- Color indications of the robot. Waiting for mission, pause, emergency stop, planning, carrying out mission, charging.

Simulate common tasks and issues

Try to simulate some common day-to-day tasks with MiR500 while the direct users, superuser and responsible persons use the robot as they would in their daily work.

Common tasks and issues could be:

- Triggering emergency stop and resetting the robot.
- Continue/Pause robot in interface.
- Turning on/off robot.
- Charging the robot, using cable and charging station.
- Manually locate robot on map, adjust localization.

- Manually make robot drive to position and coordinates on map by clicking on the map.
- Run missions, clear missions from queue, see status of missions.
- Maintenance of robot.
- Manual driving.
- Get familiar with dashboard and interface.
- Blocked paths.
- Robot getting stuck in emergency stop when getting pushed into objects or objects being placed close to robot.
- How to recognize that the robot has a problem with charging.
- Narrow paths where the robot might find it difficult to pass. This illustrates the importance of having wide and clear paths for optimal driving of robot.

Future possibilities

After the initial installation of MiR500, it is a good idea to inform users of other possibilities they might find useful after having used the robot for some time. This could include:

- Sound and blink zones.
- Preferred zones.
- Directional zones.
- Incorporation with other plant management systems, such as ERP.
- MiRFleet.
- Rest calls.

Stay in contact

It is important to stay in contact with the users after the installation of MiR500. Make sure to follow up with the following in mind:

- If the customer does not call for support, it might be because the robot is running perfectly, but it might also be because they have problems and gave up on the robot.
- Urge them to contact you with problems, especially in the beginning.
- Contact customers yourself in the beginning to make sure they are happy and the product is working satisfactorily.

Note
A good handover also includes making a risk assessment. Read more in Risk assessment on page 8.

6. Product presentation

MiR500 is an autonomous mobile robot that can transport loads up to 500 kg and pallets indoors within production facilities, warehouses, and other industrial locations.

Users operate MiR500 via a web-based user interface, which is accessed via a browser on a PC, smartphone or tablet. Each robot has its own network. See Connecting to the robot interface on page 18. The robot can be set up to run a fixed route, be called on demand or perform more complex operations (missions).

The robot performs localization and navigation via a map which can be created or imported the first time the robot is used. The internal map contains defined locations (office, product delivery, production hall etc.) that are used for logistical planning. While operating, the safety laser scanners ensure that the robot avoids dynamic obstacles (people, furniture) that are not mapped.

With a MiRCharge 500, the robot handles moving to a charging station automatically. All it takes is the definition of a charging mission and a charging position on the map.

The section contains the following topics:

6.1. Main features of MiR500

The main features of the MiR500 are:

- **Driving in a populated workspace**
  The robot is designed to operate among people and maneuvers safely and efficiently in even highly dynamic environments.
- **Overall route planning and local adjustments**
  The robot autonomously navigates to find the most efficient path to its destinations. The robot adjusts the path when it encounters obstacles which are not on the map (like people and objects).
- **Efficient transportation of heavy loads**
  The robot is designed to automate transportation of loads up to 500 kg across industries, allowing employees to focus on higher value activities.
- **Sound and light signals**
  The robot continuously signals with light and sounds indicating its current mode, for example waiting for job, driving to destination, destination reached or alert mode.
- **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 the 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 customer defined 'catch' action may be used to alert people or take other actions.
- **Automatic deceleration for objects**
  The built-in sensors ensure that the robot is slowed down when obstacles are detected in front of it.
- **Optimal surface operations**
  The robot is made to run on a level, dry floor with a maximum incline of 1% at 0,5 m/s. 3D cameras detect and avoid objects from 30-3500 mm above floor level.
- **Internal map**
  The robot can either use a floor plan from a CAD system or a map can be created by manual navigation around the entire site in which the robot is going to operate. When mapping, the robot's sensors detect walls, doors, furniture and then creates a map based on this input. After creation of the map, positions and other features can be added in the map editor.

Add-ons

The following add-ons are available for the MiR500:

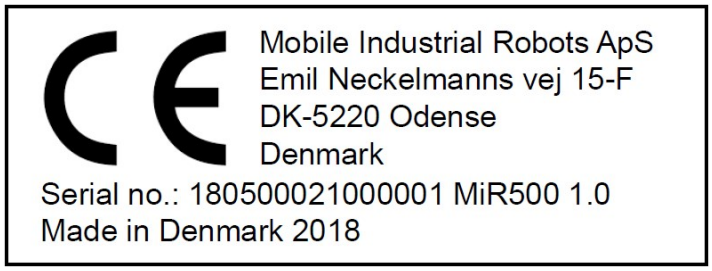
- **MiR500 Lift**
  A lift platform may be mounted on MiR500 enabling it to automate the internal transport of US standard 40*48 pallets.
- **MiR500 EU Pallet Lift**
  A pallet lift for EU pallets may be mounted on MiR500 enabling it to automate the internal transport of EU pallets.

- **MiR500 Lift Pallet Rack**
  Use a MiR500 EU Pallet Rack with MiR500 to enable it to place and pick up US standard 40*48 pallets autonomously.
- **MiR500 EU Pallet Rack**
  A pallet rack may be used with MiR500 enabling it to place and pick up EU pallets autonomously from MiR500 EU Pallet Rack.

Note
To read more about the add-ons, go to www.mir-robots.com.

6.2. Identification label

The identification label of MiR500 is placed above the MiR controller behind the rear maintenance hatch.



CE	Mobile Industrial Robots ApS declares that MiR500 meets the requirements of the applicable EC directives.
Serial number	The 15-digit serial number is a unique identifier of the robot. The last four digits form part of the original name of the robot, e.g. MiR U0008.
MiR500 1.0	Product name and hardware version.

Example of MiR500 CE marking and identification label.

6.3. MiR500 control panel

MiR500 has a control panel in the rear-left corner of the robot.

6.3.1. The Operating mode key

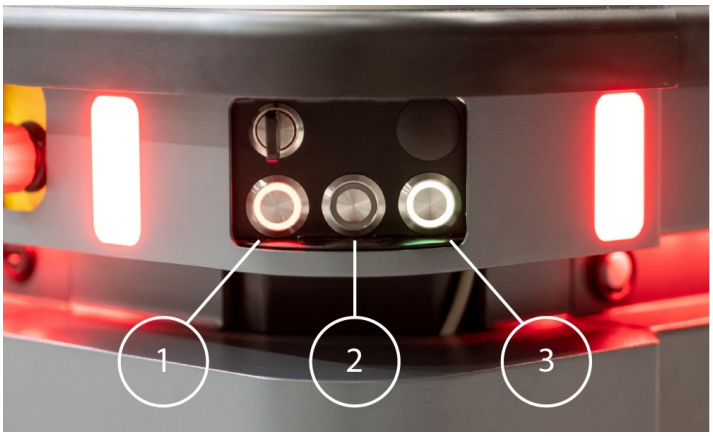
The Operating mode key lets you switch between operating modes.

- Left position: **Autonomous mode**.
  Puts the robot in the **Autonomous mode**.
- Middle position: **Stop**.
  Stops 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 the **Manual mode**.

For more information on operating modes, see MiR500 operating modes on the next page.

6.3.2. The control panel buttons

The buttons on the control panel have the following functions.



1. Stop	3. On/Off
2. Restart	

Stop

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

Color indication:

- Red: The robot is on.

Restart

Pressing this button:

- Clears the emergency stop state.
- Lets the robot continue operating after the **Stop** button was pressed.
- Lets the robot continue operating after powering up or after the operating mode change.

Color indication:

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

On/Off

Pressing this button for five seconds turns the robot on or shuts it down.

Color indication:

- Blue: The robot is off.
- Blinking green: The robot is starting up.
- Green: Normal operation.
- Red: The robot detected an error.
- Yellow: The battery level is low.

6.4. MiR500 operating modes

MiR500 has the following operating modes:

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 section Driving the robot in manual mode on page 19.

Autonomous mode

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

6.4.1. Muting of the personnel detection means

When performing tasks that require to move very close to surrounding objects, the robot mutes the personnel detection means. Docking to a pallet rack is the example of such task.

When muting the personnel detection means, the robot does the following:

- Reduces the size of the safety zones.
- Turns the collision detection off.
- Decreases the speed.
- Flashes the yellow indicator lights.

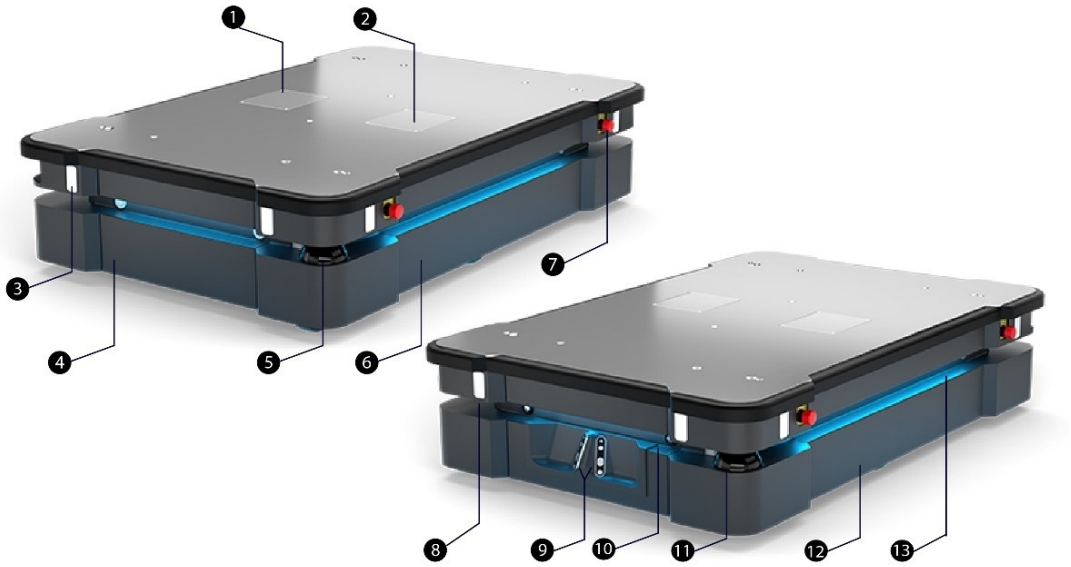
You can also mute the personnel detection means using the robot interface:

- Put the robot into the Manual mode. See section Driving the robot in manual mode on page 19
- In the robot interface, in the Joystick control, select **Mute personnel detection means**.
- In the prompt dialog, select **Yes** to acknowledge the muting of personnel detection means.

The status and the signal lights start flashing yellow, the robot is ready to drive with muted personnel detection means.

6.5. MiR500 external parts

This section presents the parts of MiR500 that are visible on the outside.

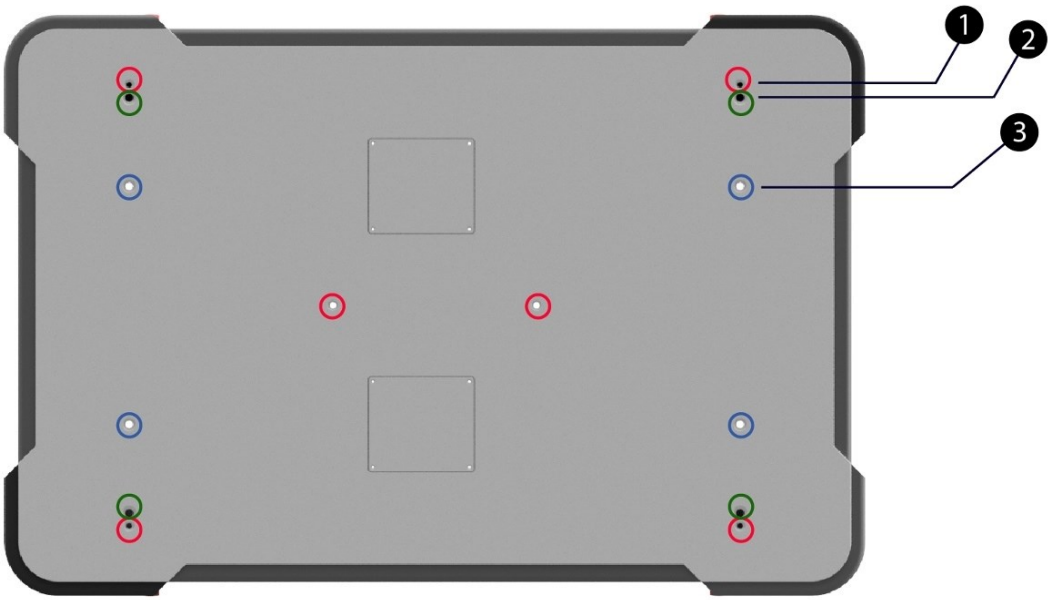


1.	Left cover plate: access to power interface, GPIO interface and Ethernet interface	8.	Proximity sensors: eight pcs., two in each corner behind corner cover (see Sensor system on page 48)
2.	Right cover plate: access to safety interfaces Aux. safety functions and Aux. Emergency stop	9.	3D depth cameras: two pcs., detect objects in front of the robot (see Sensor system on page 48)
3.	Signal light: eight pcs., two on each corner (see Sensor system on page 48)	10.	Front maintenance hatch: opens to front compartment (see MiR500 internal parts on page 43)
4.	Rear maintenance hatch: opens to rear compartment (see MiR500 internal parts on page 43)	11.	Front safety laser scanner (see Sensor system on page 48)
5.	Rear safety laser scanner	12.	Left-hand side maintenance hatch
6.	Right-hand side maintenance hatch	13.	Status light: on all four sides of the robot (see Sensor system on page 48)
7.	Emergency stop button: four pcs., two on each side		

MiR500 external parts

MiR500 top cover

View of MiR500 from the top:



1.	Not accessible; used for fixation of the top cover.	3.	M10 mooring holes for fixation of top module, e.g. MiR500 EU Pallet Lift or MiR500 Lift. Fore more information on mounting top modules, see Mounting a top module on page 61.
2.	M12 lifting holes; one in each corner used for fixation of transportation eye bolts. **Note** M12 lifting holes can also be used to mount top modules. If a top module is mounted using these holes, it is necessary to drill M12 lifting holes in the top application in order to lift the robot.		

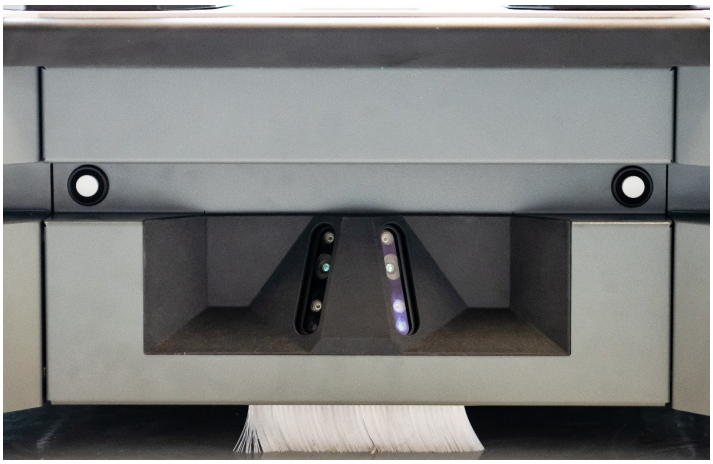
6.6. MiR500 internal parts

Most internal parts of MiR500 are reached through maintenance hatches that open to different compartments:

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

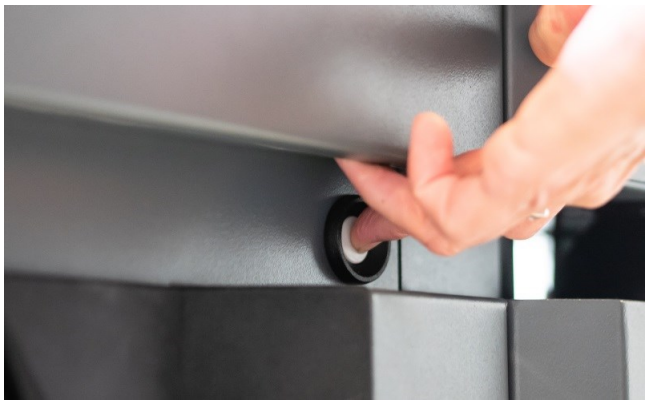
6.6.1. Front compartment

The front compartment holds the electronic components that may need regular service or replacement, such as PC, main control board and safety PLC.



To open the front compartment:

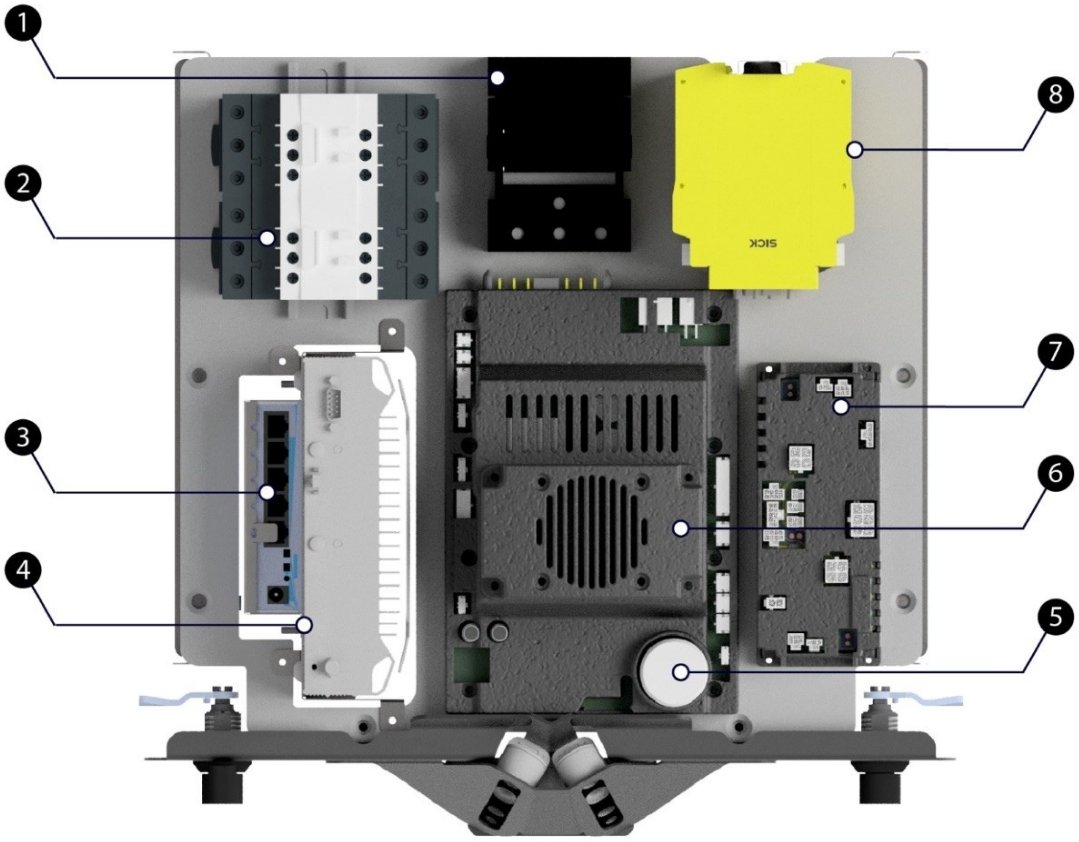
1. Push the two white buttons and pull the hatch.



2. Turn the two levers 180°. The right lever goes from top to bottom and the left lever goes from bottom to top. Then pull out the compartment drawer while holding underneath it and lifting slightly.

Front compartment components

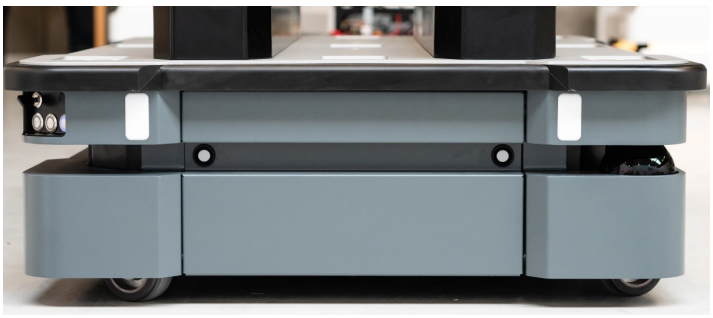
The front compartment contains the following components:



1.	Cable chain	6.	Loudspeaker
2.	Safe Torque Off contactors	7.	Power board: controlling power distribution for motor controller, PC and safety PLC
3.	Access point/Router	8.	Motor controller
4.	Robot computer	9.	Safety PLC
5.	Buzzer		

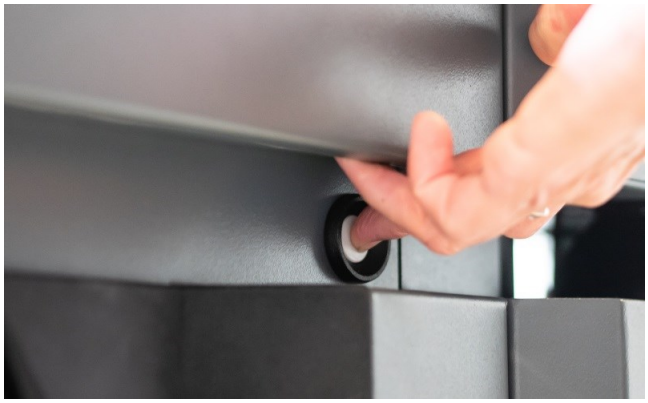
6.6.2. Rear compartment

The rear compartment holds the robot's battery.



To open the rear compartment:

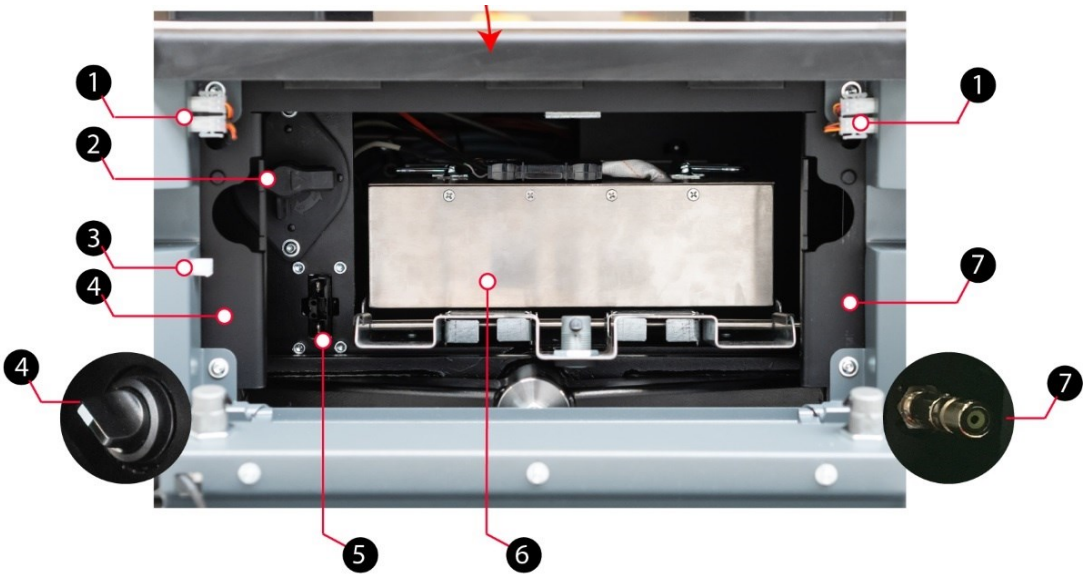
1. Push the two white buttons.



2. Pull the hatch.

Rear compartment components

The rear compartment contains the following main components:

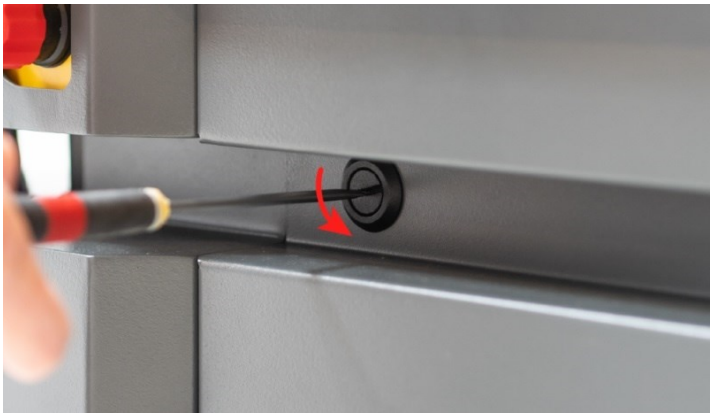


1.	Connectors for proximity sensors	5.	Charging connection interface, for external charger
2.	Battery disconnect switch, shown in Off position	6.	Battery with connector, main power to the robot
3.	Connector for status light band	7.	Connection interface for MiR Controller
4.	Brake release button, shown in On position. When turned off, the brakes are released, and the robot can be pushed manually		

6.6.3. Side compartments

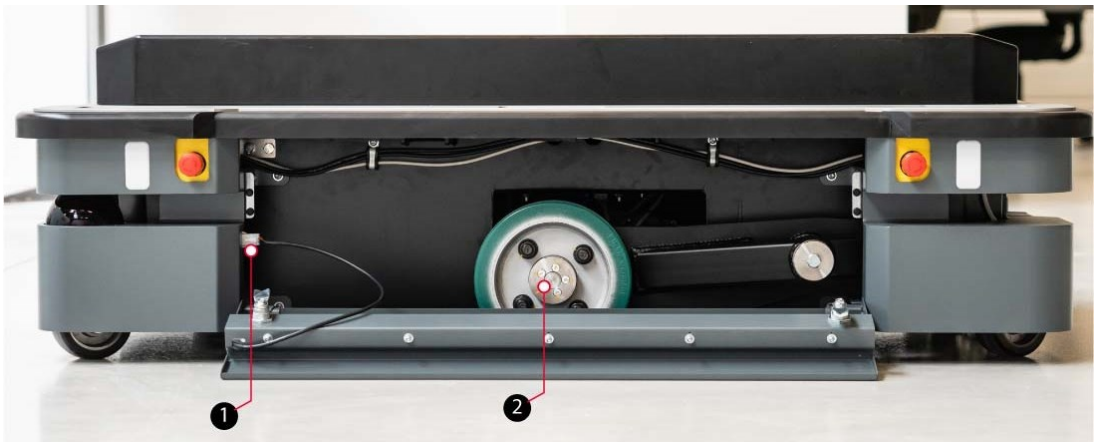
The side compartments contain the right- and left-hand side bogies and drive wheels.

To open a side hatch: turn the two screws 90° counterclockwise with a flat-head screwdriver, and pull the hatch.



Side compartment components

The left- and right-hand side compartments contain the following components (the same on both sides):

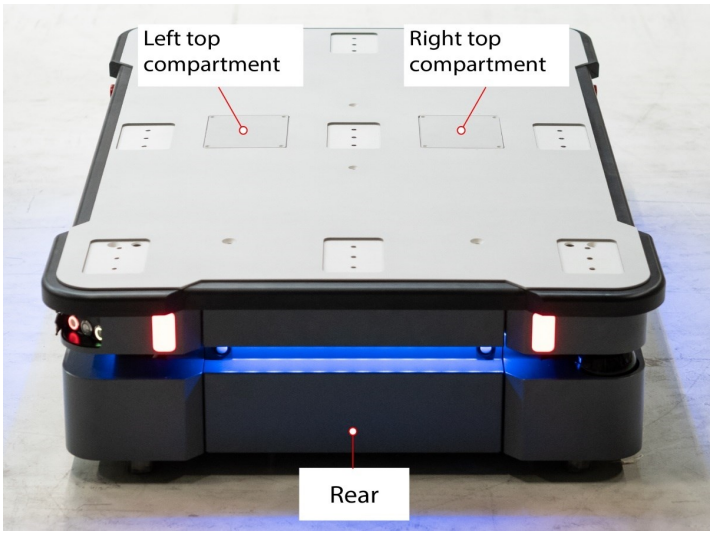


1.	Connector for status light band	2.	Drive wheel

6.6.4. Top compartments

The two top compartments hold interfaces to external units, for example MiR500 EU Pallet Lift or MiR500 Lift.

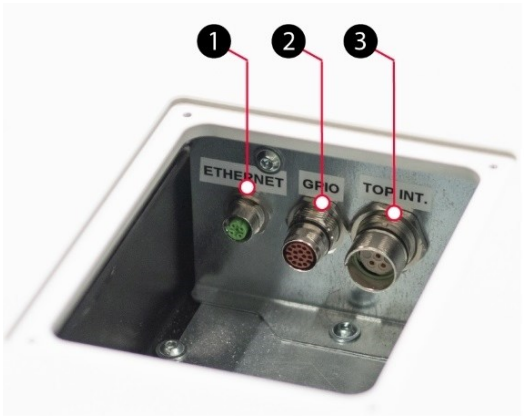
To open a top compartment, remove four screws and lift off the top cover.

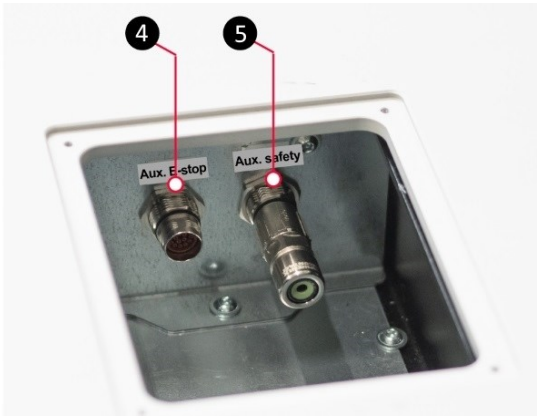


The two top compartments contain interfaces for top applications and added safety functions.

Top compartment components

The top compartments contain the following electrical interfaces for top applications. For detailed information, see Interface specifications on page 65.





1.	Ethernet	4.	Auxiliary emergency stop
2.	GPIO: General purpose I/O	5.	Auxiliary safety functions
3.	Power		

6.7. Sensor system

Collaboration between the robot's internal and external sensors ensures that the robot can navigate in the environment and most importantly secures that it can operate safely among people and objects like furniture, machines, pallets etc.

This section describes the functionality of the different parts of the sensor system.

The robot is equipped with the following sensors:

- Safety laser scanners
- 3D cameras
- Proximity sensors
- Internal sensors

6.7.1. Safety laser scanners

The safety laser scanners on MIR500 are of the type AOPDDR (active opto-electronic protective device responsive to diffuse reflection). AOPDDR is a protective device that uses opto-electronic transmission and reception elements to detect the reflection of the optical radiation generated by the protective device. The reflection is generated by an object in a defined two-dimensional area. This is a type of ESPE (electro-sensitive protective device). In this guide, the term **safety laser scanner** is used.

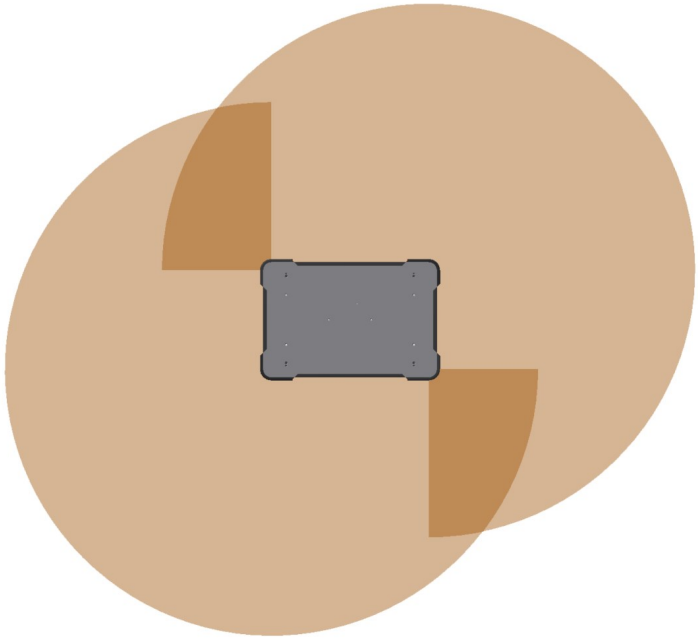
Scanner functions

Two safety laser scanners, diagonally placed on front and rear corners 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.

The safety laser scanners serve three purposes:

- They are used for mapping, see also Planning on page 24 and MiR Robot Interface 2.0 Reference Guide.
- They are used to localize the robot in the environment and plan routes between points.
- They continuously scan the surroundings when the robot operates thereby avoiding collision with objects and people.

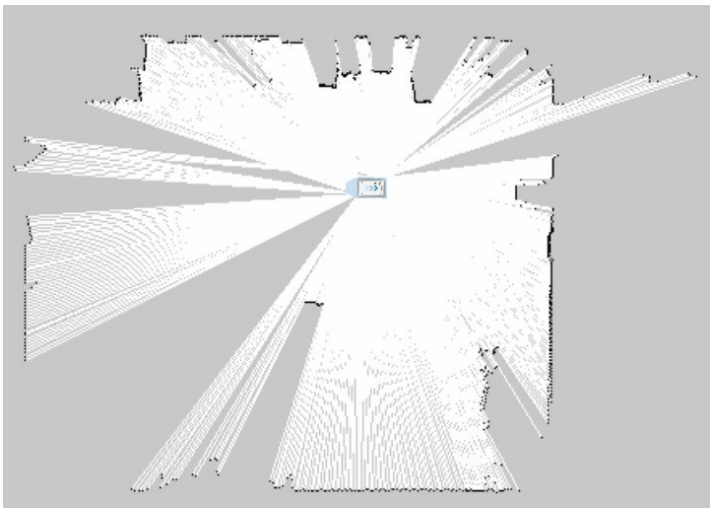
The safety laser scanners detect objects in a plane approximately 180 mm above ground. Objects above or below are not detected by the safety laser scanners.



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

When in motion, the safety laser scanners continuously scan the surroundings using a distance of up to 40 m while taking into account and weighting the viewed objects in a so-called "particle filter".

When mapping, the safety laser scanner's view is reduced to 20 m to support that maps will get the highest possible quality.

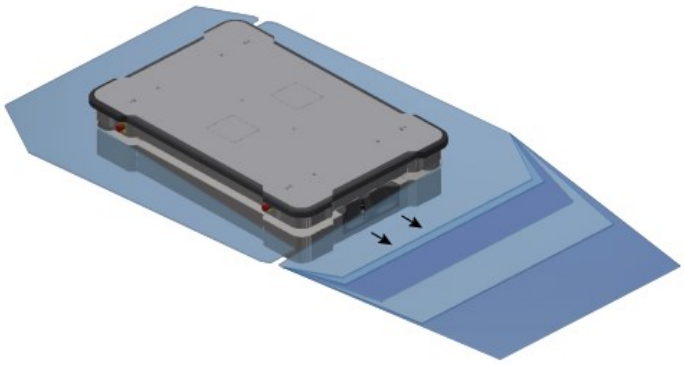


The safety laser scanners see up to 20 m when mapping an area.

Signals from safety laser scanners are combined with input from 3D cameras and proximity sensors and used to evaluate if an object or person is in the path of travel. In that case, the robot gradually slows down while trying to avoid the obstacle. If unable to make its way around the obstacle, the robot stops and waits for clearance.

Protective fields

The protective fields are part of the robot's personnel detection means. The protective fields consist of individually configured contours. The active protective field is automatically selected based on the speed of MiR500. A person or object within an active protective field will bring the robot to a protective stop and the robot will remain stopped until the protective field is free.



Protective fields of the front and rear safety laser scanners.

Protective field settings

The following table shows how the protective fields are configured.

Protective fields in the driving direction:

Safety fields	Speed range	Field size
Protective field 1 (innermost)	<0.1 m/s	35 cm
Protective field 2	0.1-0.3 m/s	40 cm
Protective field 3	0.3-0.6 m/s	60 cm
Protective field 4	0.6-0.9 m/s	85 cm
Protective field 5	>0.9 m/s	135 cm

Protective fields opposite the driving direction:

Safety fields	Speed range	Field size
Protective field	all speeds	35 cm

Note
When the robot moves backwards, the protective fields switch, so that the largest protective fields are in the driving direction.

CAUTION
The speed/zone rate is configured to comply with the safety standards of MiR500.
If they are changed, Mobile Industrial Robots takes no responsibility for any safety related incidents, and the warranty becomes void.

Muted personnel detection means

When docking to pallet rack or a charging station, the protective fields are muted to avoid unintended activation. Muted protective fields is part of the drive mode Muted personnel detection means where the robot also slows down the speed. For more information, see Muting of the personnel detection means on page 40.

6.7.2. 3D cameras

Two 3D depth cameras positioned on the front of the robot detect objects in front of the robot while the robot's local planner continuously adjusts its planned routes around such objects.

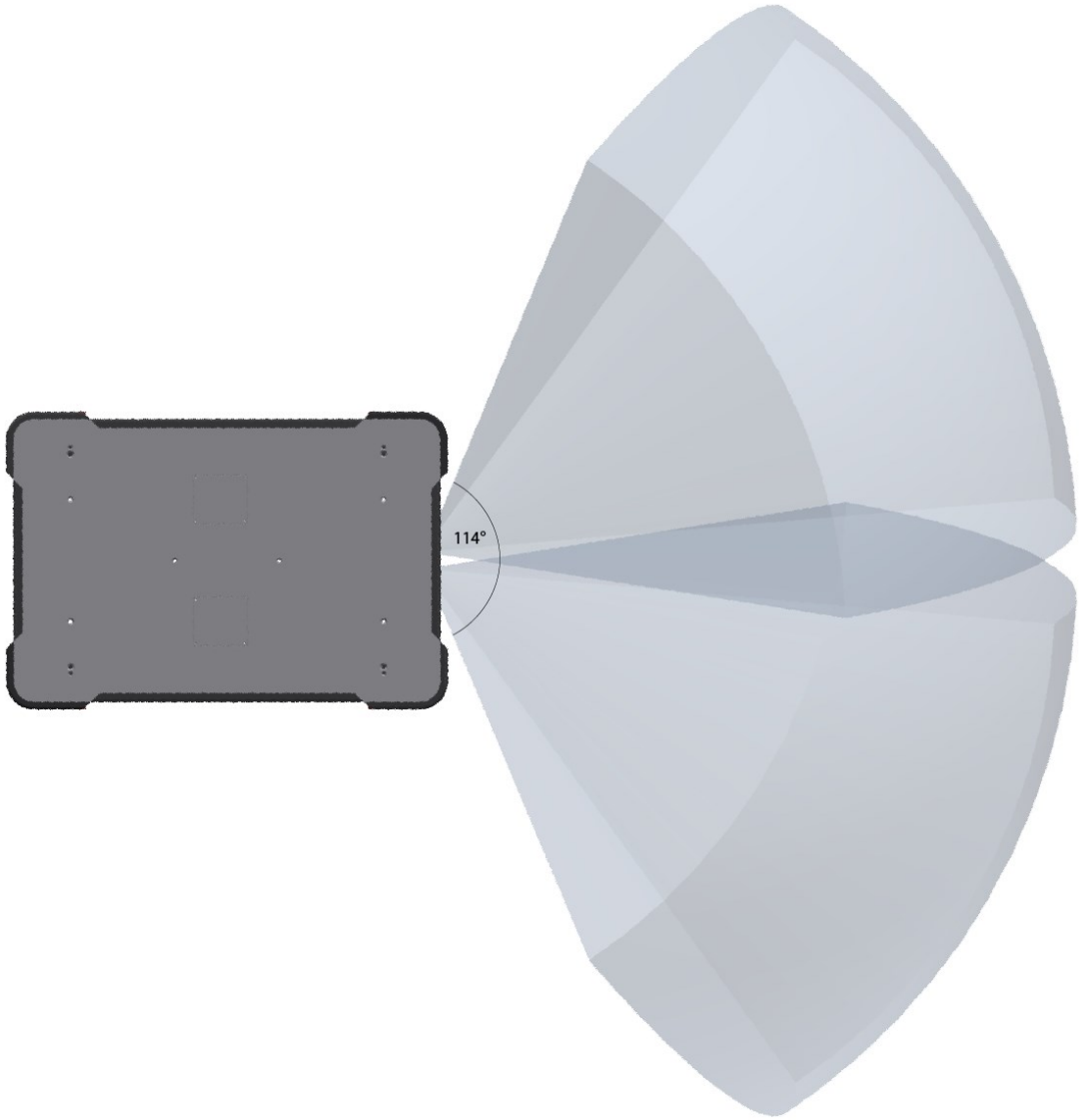
The 3D cameras detect objects:

- Vertically up to 1700 mm at a distance of 950 mm in front of the robot.
- Horizontally in an angle of 114° and 250 mm to the first view of ground.

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

The following illustrations show the fields of view of the cameras.

The two 3D cameras can see objects up to 1700 mm above floor height.



The two 3D cameras have a horizontal field of view of 114°.

6.7.3. 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.

The proximity sensors in the corners of the robot detect objects close to the floor.

6.7.4. Internal sensors

The internal sensor system of the robot consists of the following components:

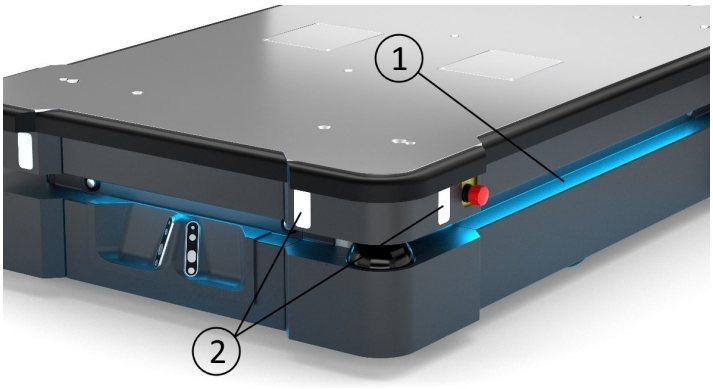
- **Gyroscope (IMU)**
  Measures the orientation and angular velocity of the robot.
- **Motor encoder**
  Provides closed loop feedback signals by tracking the speed and/or position of the motor shaft.
- **Accelerometer**
  Measures non-gravitational acceleration.
- **Wheel encoders**
  Detect wheel movements.

6.8. Light indicators

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**
  An LED light band 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 people in the environment if the robot is about to turn a corner or go backwards.

The following illustration shows the light indicators.



1.	Status lights	2.	Signal lights

Status lights

The LED light band running all the way around the robot indicates the robot's current operational state. Colors may also be used as part of missions, but as standard, the robot is delivered with the following setup.

Red	Emergency stop
Green	Waiting for job
Cyan	Drives to destination
Purple	Goal / Path blocked
White	Planning / Calculating
Dark Orange	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, e.g. hardware localization
Blue	Manual drive joystick
Blue (blinking)	Mapping
Rainbow	Charging: Charging station or cable
White (blinking)	Prompt user / Waiting for user's response

Signal lights

Signal lights are used to indicate the robot's immediate motion plans, for example 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 are used to indicate for example a left or right turn by blinking.

When the robot drives with muted personnel detection means, for example when docking to a Pallet Rack, all signal lights blink yellow. For more information, see Muting of the personnel detection means on page 40.

7. Maintenance

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

Note
The stated intervals are indicative and depend on the operating environment and frequency of usage of the robot.

The section contains the following topics:

7.1. Regular weekly checks and maintenance tasks

Once a week carry out the following maintenance tasks:

Parts	Maintenance tasks
Robot top plate and sides	Clean the robot on the outside with a damp cloth. **Note** Do not use compressed air.
Laser scanners	Clean the optics covers of the scanners for optimum performance. Avoid aggressive or abrasive cleaning agents. **NOTICE** 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.
Caster 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.
LED light band	Check if the LED light band is intact. Does the light show all the way around the robot.
Signal lights	Check if the signal lights on the four corners blink and show correctly all the way around the robot.

7.2. Regular checks and replacements

Before starting replacement tasks that involve removal of the top plate:

- Press the **On/Off** button to turn off the robot.
- Push the battery switch button to remove power from the battery.
- Turn off relays and unplug the battery.

The following table contains the parts that you should check and the intervals when you should do that:

Part	Maintenance	Interval
Robot top plate	Check mounting. Does it sit evenly on top of the robot with connections accessible.	Check monthly and replace as needed.
Caster wheels (the four corner wheels)	Check bearings and tighten.	Check weekly and replace as needed.

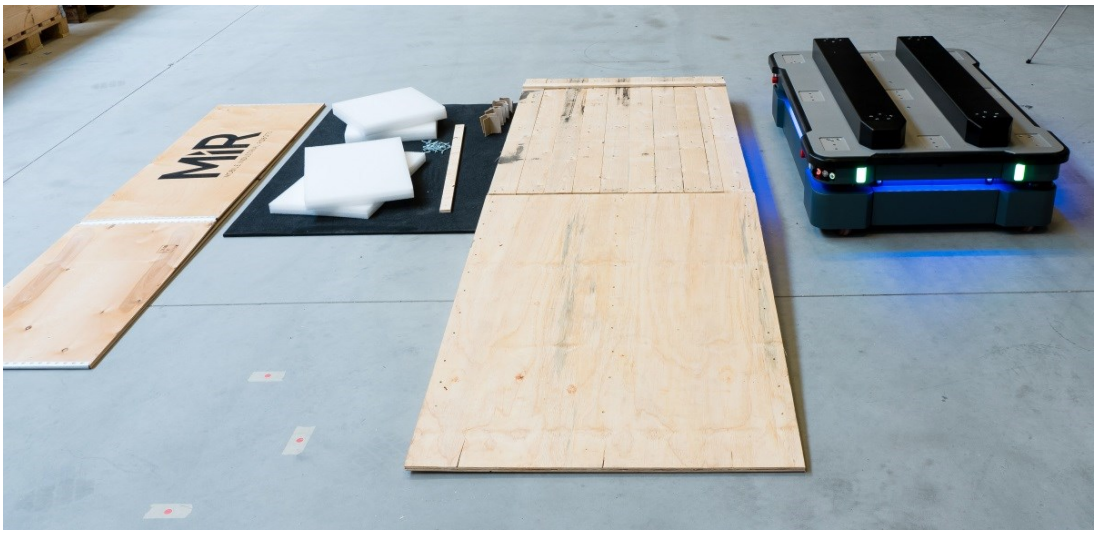
Part	Maintenance	Interval
Drive wheels (the two middle-wheels)	Check wheel surfaces for wear.	Check every six months and replace as needed. **NOTICE** The robot must be calibrated after replacement of the wheels.
Scanners	Check for visual defects, e.g. cracks and scratches.	Replace as needed. **NOTICE** The robot must be calibrated after replacement of the scanners.
Emergency stop	To 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.
ESD tail	To check the ESD tail, open the left-hand side maintenance hatch and make sure that the tail has contact with the ground.	Check every six months and replace as needed.
Broom (front of robot)	Open the front maintenance hatch and remove the three screws to get to the broom. If the charger pads are dirty or dusty, check the broom.	Check every six months if the broom is intact. Replace as needed.
3D cameras	Check for visual defects, e.g. cracks and scratches.	Check monthly and replace as needed.
Proximity sensors	Check for dust or dirt.	Check weekly and clean with a swab.
Manual brake release	Check if the brakes can be deactivated. Activate the brakes and push the robot gently forward. Remember to deactivate the brake after testing.	Check monthly and replace as needed.

7.3. Packing for transportation

This section describes how to pack the robot for transportation.

7.3.1. Original packaging

Use the original packaging materials when transporting the robot.



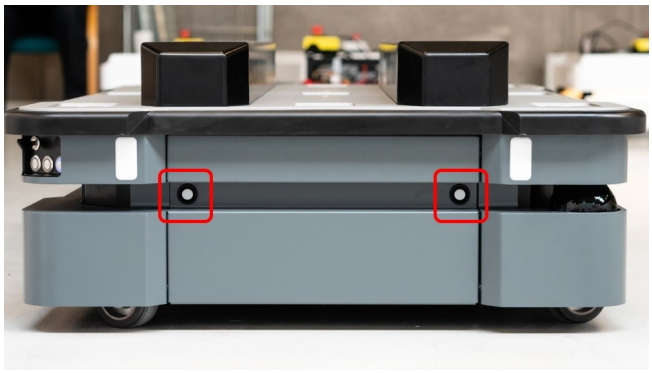
The packaging materials are:

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

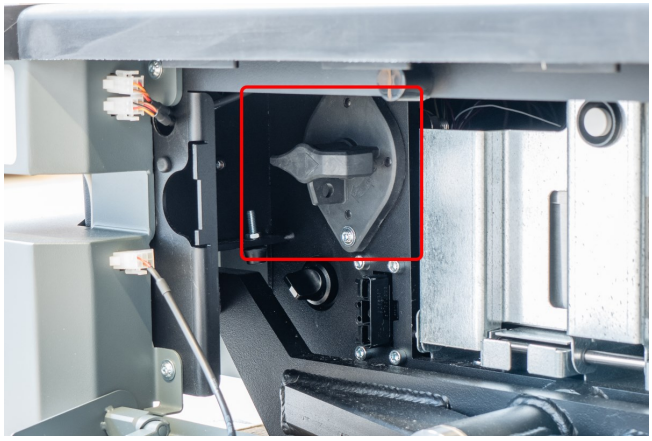
7.3.2. Packing the robot for transportation

To pack the robot for transportation:

1. Shut down the robot. See section Shutting down the robot on page 22.
2. Open the rear maintenance hatch.



3. Turn the battery disconnect switch to position **OFF**.



Repeat the steps in section Getting started on page 12 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.

7.3.3. Battery

The lithium battery is subject to transport regulations. Make sure that you follow the safety precautions in this section and the instructions in section 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 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.

8. Applications

You can install top modules on top of MiR500 for specific applications. For more information about top modules, go to the following page:

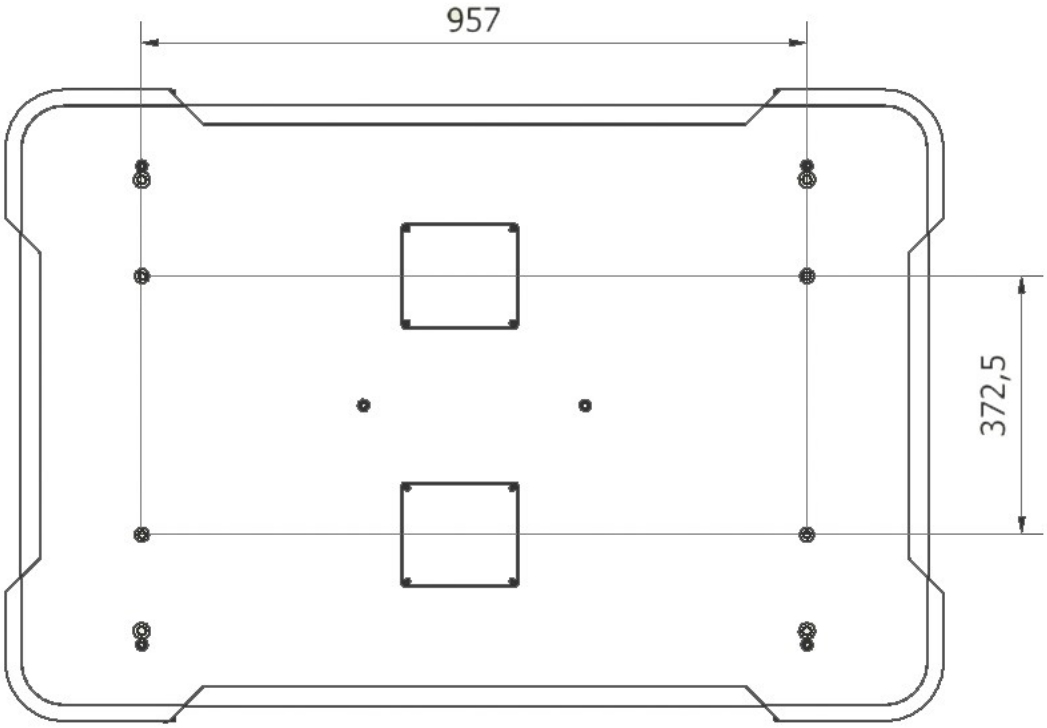
http://www.mobile-industrial-robots.com/en/mir-tradeforum/

For instructions on how to mount top modules and accessories, refer to the application manuals at www.mir-robots.com or contact your distributor.

8.1. Mounting a top module

MiR500 has four M10 holes for mounting top modules. Tightening torque: 47 Nm.

See MiR500 external parts on page 41 for more information on the mounting holes.



Mounting holes on the top of MiR500.

CAUTION
Certain top modules may require the installation of an extra emergency stop button. Perform risk assessment according to standard ISO 12100.

CAUTION
Certain top modules may lead to new hazards and/or increased risks which cannot be eliminated or reduced by the risk reduction measures applied by Mobile Industrial Robots. Perform risk assessment according to standard ISO 12100.

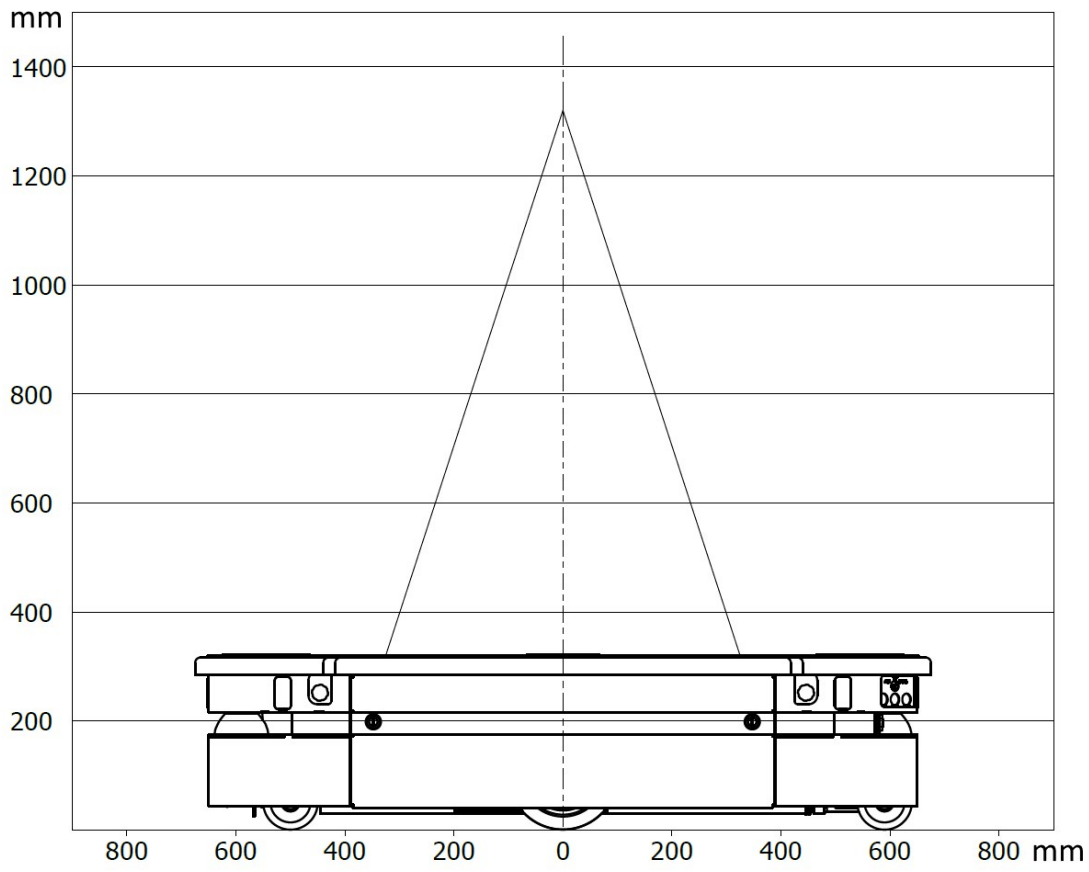
CAUTION
Stay within the specifications for weight and the payload's center of gravity, see Payload specifications on page 63.

9. Payload specifications

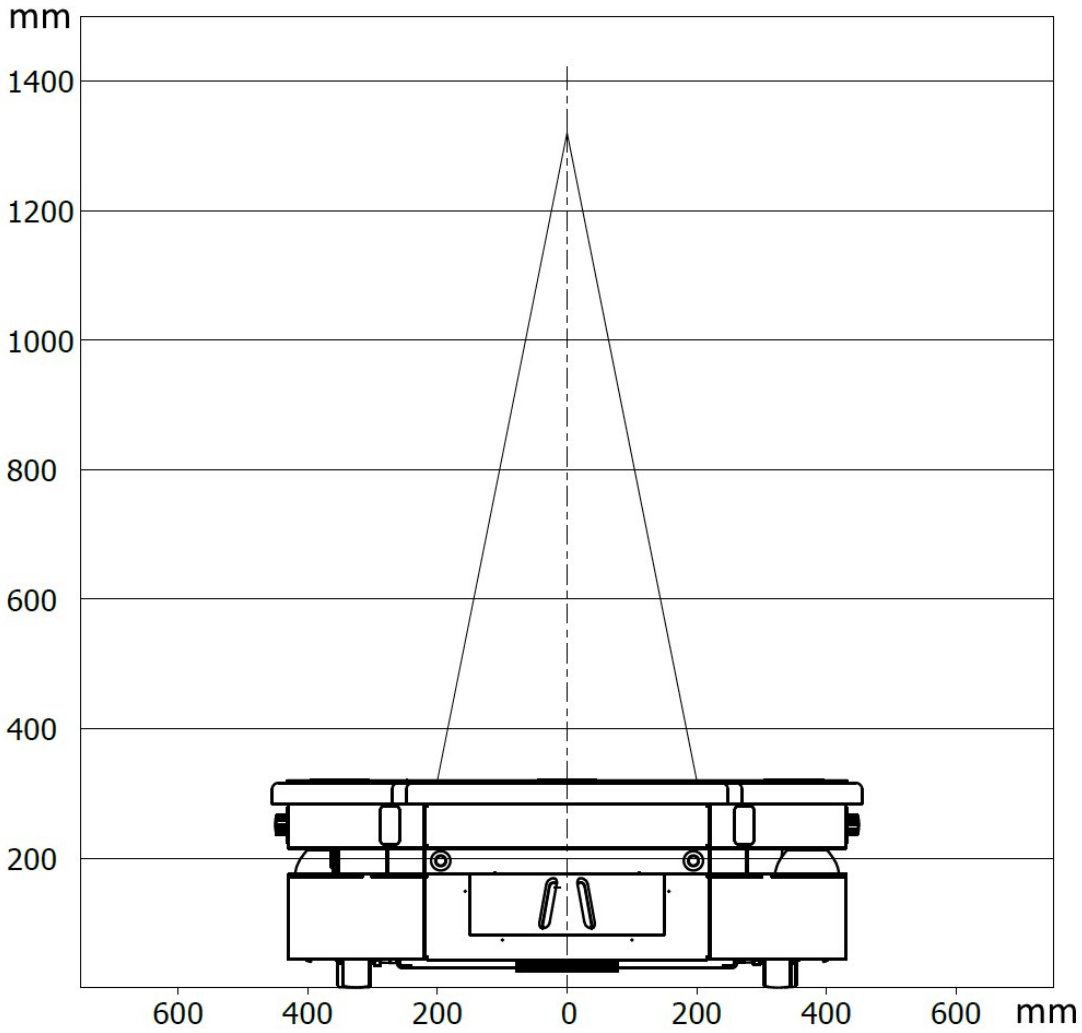
The following drawings illustrate the center of mass (CoM) specifications for safe operation at different payloads.

The specifications apply to payloads of up to 500 kg.

Side view



Front view



10. Interface specifications

This section describes the specifications of the top application interface.

NOTICE
Read Safety on page 5 before using the electrical interface.

MiR500 has five electrical interfaces divided into two groups:

- General purpose interfaces:
  - Power
  - GPIO
  - Ethernet
- Safety interfaces:
  - Auxiliary Emergency Stop
  - Auxiliary Safety Functions

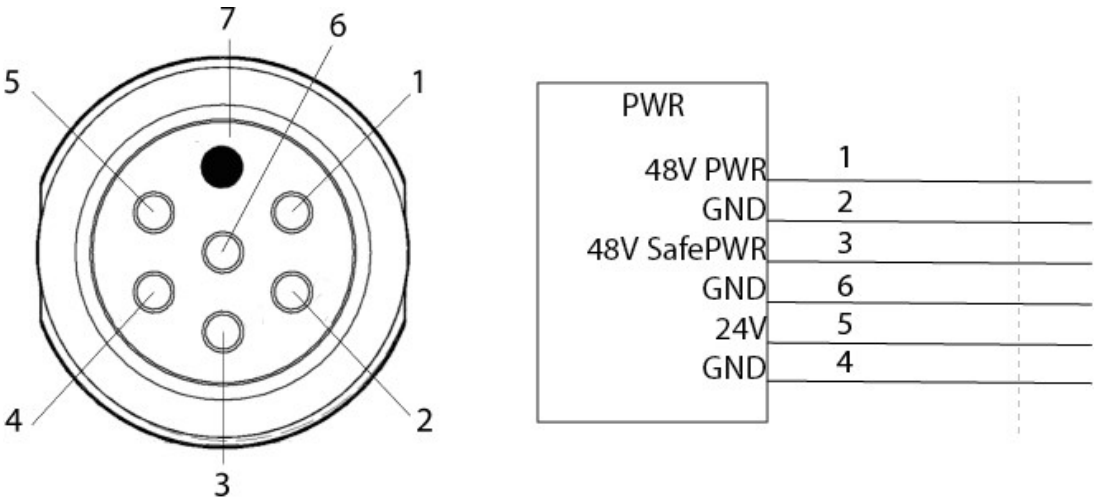
To see the locations of the interfaces on the robot, see section Top compartments on page 47.

10.1. General purpose interfaces

This section describes the general purpose interfaces located in the left-hand side compartment on the top side of MiR500.

Power

An auxiliary power connection for top applications is provided in the top left-hand side compartment. See Connector list on page 71 for more information.



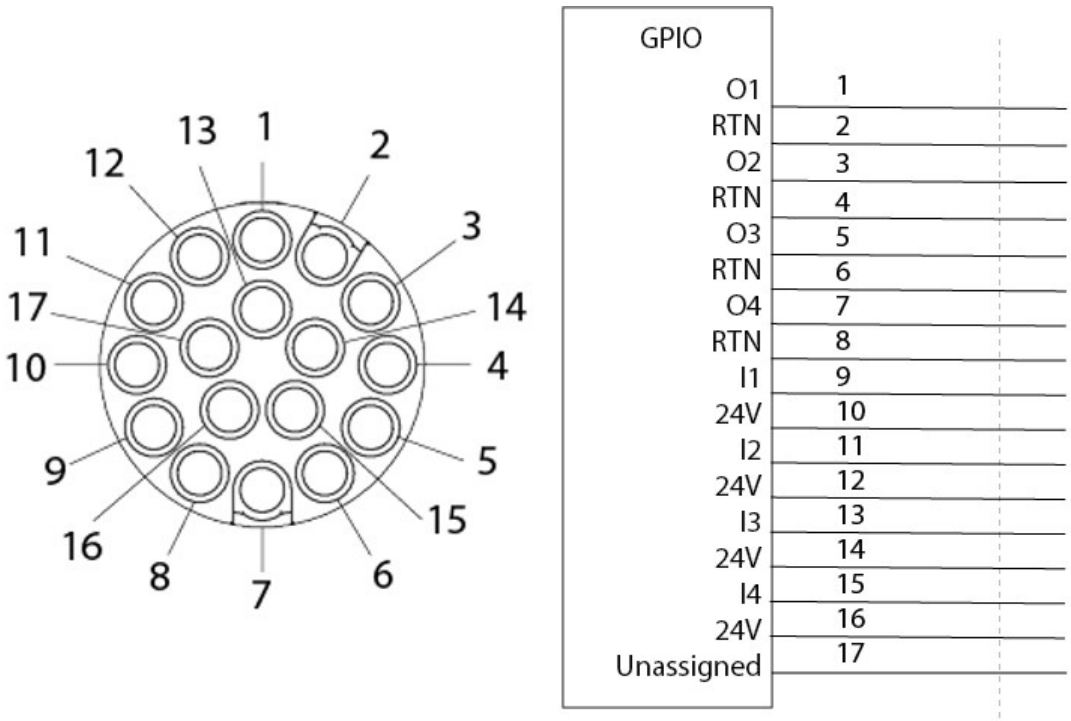
Pin numbers: female connector viewed from the front (left) and wiring diagram (right).

The following table contains the description of the pins of the Power interface.

Pin number	Signal name	Max. current	Description
1	48V power	20A	Always on when robot is on. Intended for high power loads like motors or actuators.
2	GND		Ground.
3	48V safe power	20A	Turns off in case of a “protective stop” (emergency stop). Intended for high power loads like motors or actuators.
4	GND		Ground.
5	24V	2A	Always on when robot is on. Intended for low power use like powering an external PLC.
6	GND		Ground.
7	Unassigned		Unassigned.

GPIO

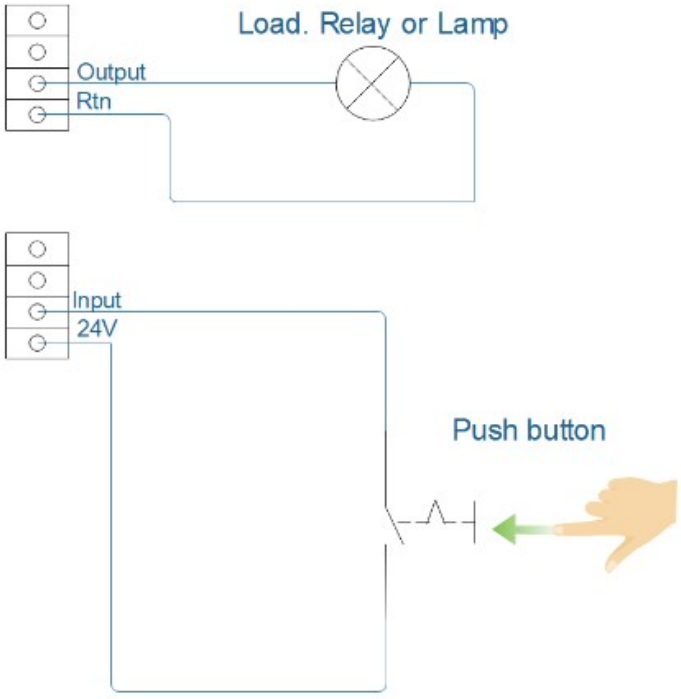
A GPIO connection is in the top left-hand side compartment.



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

A variety of top applications requires a general purpose and "simple-to-use" digital I/O (GPIO).

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



The GPIO has the following features:

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

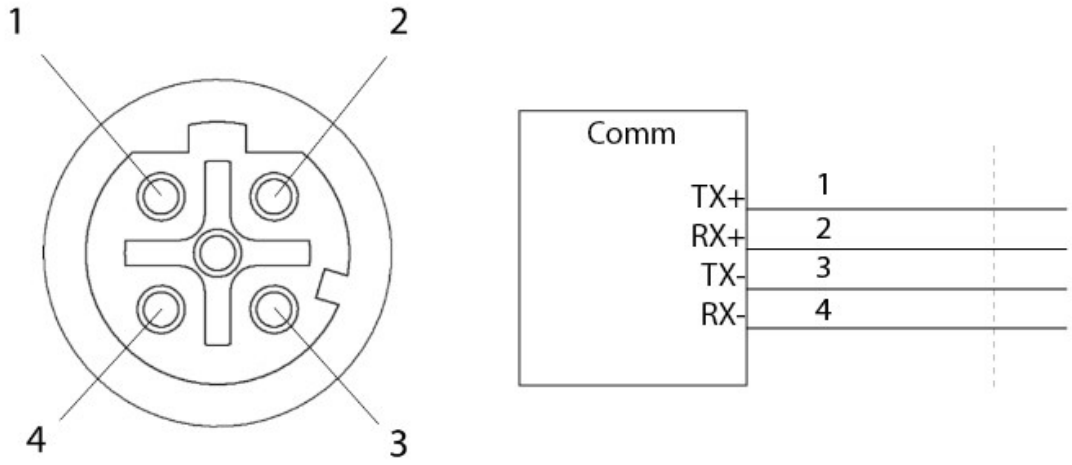
The following table contains the description of the pins of the GPIO interface.

Pin number	Signal name	Max. current	Description
1	O1	1A @ 24V	Output 1.
2	RTN		Protected return.
3	O2	1A @ 24V	Output 2.
4	RTN		Protected return.
5	O3	1A @ 24V	Output 3.
6	RTN		Protected return.
7	O4	1A @ 24V	Output 4.
8	RTN		Protected return.
9	I1		PNP Input 1.
10	24V	1A @ 24V	Protected output.
11	I2		PNP Input 2.
12	24V	1A @ 24V	Protected output.

Pin number	Signal name	Max. current	Description
13	I3		PNP Input 3.
14	24V	1A @ 24V	Protected output.
15	I4		PNP Input 4.
16	24V	1A @ 24V	Protected output.
17	Unassigned		Unassigned.

Ethernet

An Ethernet connection is in the top left-hand side compartment.



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 71.

Various protocols can be supported, e.g. Modbus.

The following table contains the description of the pins of the Ethernet interface.

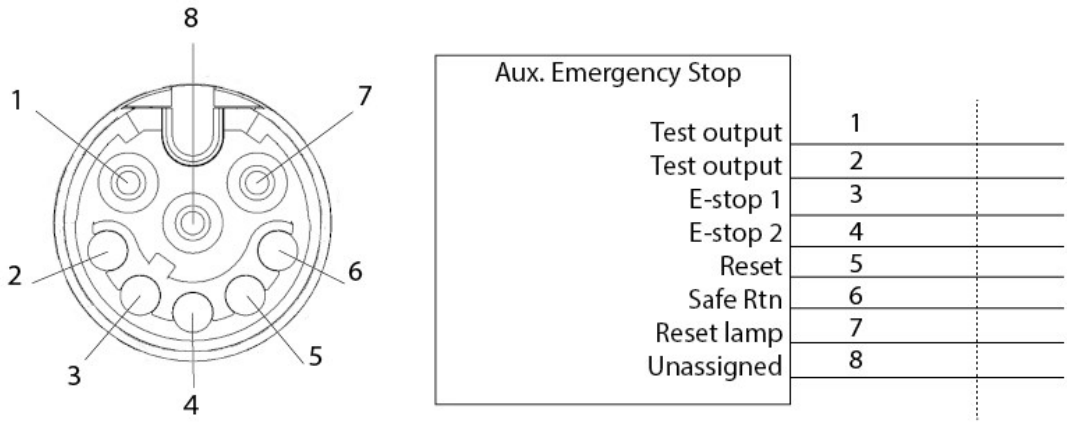
Pin number	Signal name
1	TX+
2	RX+
3	TX-
4	RX-

10.2. Safety interfaces

This section describes the safety interfaces located in the right-hand side compartment on the top side of MiR500.

Auxiliary emergency stop

An **Auxiliary emergency stop** connection is provided in the top right-hand side compartment.



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

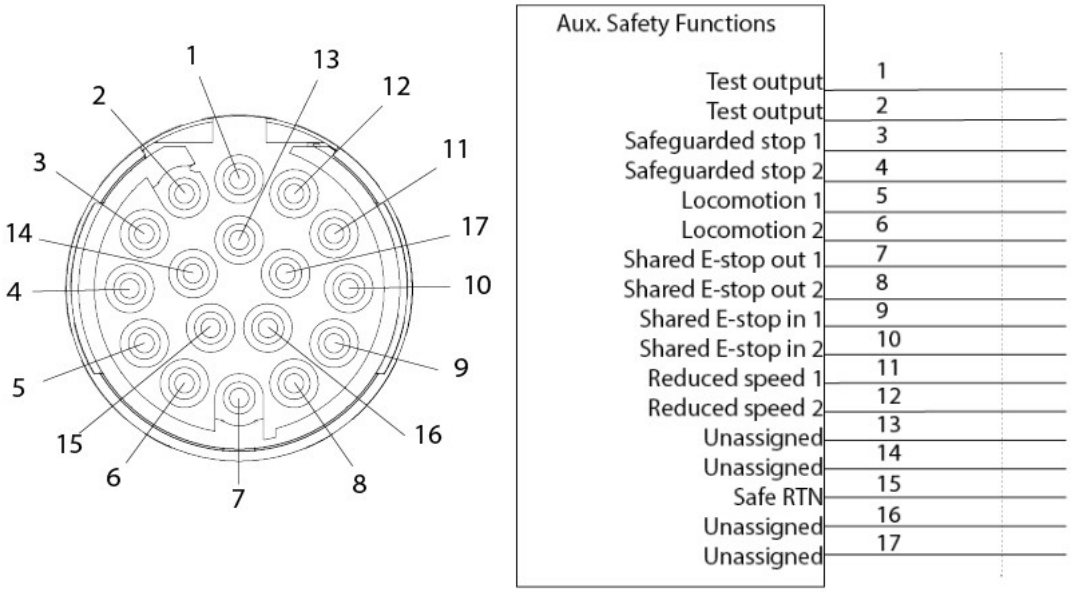
Auxiliary emergency stop is designed to support emergency stop and other safety functions.

The following table contains the description of the pins of the **Auxiliary emergency stop** interface.

Pin number	Signal name	Description
1	Test output	
2	Test output	
3	E-stop 1	Emergency stop 1.
4	E-stop 2	Emergency stop 2.
5	Reset	
6	Safe RTN	Safe return.
7	Reset lamp	
8	Unassigned	Unassigned.

Auxiliary safety functions

An **Auxiliary safety functions** connection is provided in the top right-hand side compartment.



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

The **Auxiliary safety functions** interface is designed to support emergency stop and other safety functions.

The following table contains the description of the pins of the **Auxiliary safety functions** interface.

Pin number	Signal name	Description
1	Test output	24V out.
2	Test output	24V out.
3	Safeguarded stop 1	A low signal will result in the robot stopping and is not able to move until it is high again, no reset is needed.
4	Safeguarded stop 2	A low signal will result in the robot stopping and is not able to move until it is high again, no reset is needed.
5	Locomotion 1	Output - high when the robot is standing still.
6	Locomotion 2	Output - high when the robot is standing still.
7	Shared E-stop out 1	Shared emergency stop out 1. Output - low when the robot is in e-stop.
8	Shared E-stop out 2	Shared emergency stop out 2. Output - low when the robot is in e-stop.
9	Shared E-stop in 1	Shared emergency stop in 1. Input - Low = robot goes to e-stop.
10	Shared E-stop in 2	Shared emergency stop in 2. Input - Low = robot goes to e-stop.
11	Reduced speed 1	Input - circuit broken will result in that the robot can not drive fast.
12	Reduced speed 2	Input - circuit broken will result in that the robot can not drive fast.

Pin number	Signal name	Description
13	Unassigned	Unassigned.
14	Unassigned	Unassigned.
15	Safe RTN	Safe return - Ground.
16	Unassigned	Unassigned.
17	Unassigned	Unassigned.

10.3. Connector list

We recommend the following connectors for the five different interfaces.

Connector name	Connector type
Power	M23 6p
GPIO	M17 17p
Ethernet	M12 4p
Auxiliary Emergency Stop	M17 8p
Auxiliary Safety Functions	M17 17p