

MiRHook

Technical Documentation



Version 1.8

Software release 1.8

Release date: 06.01.2017

MiR
MOBILE INDUSTRIAL ROBOTS

Table of contents

1	Introduction.....	3
2	The MiRHook hardware.....	3
3	Trolley specifications.....	4
4	Modifying the gripper for different thickness and/or length.....	5
5	Space requirements.....	6
5.1	Space required to pick up a trolley.....	6
5.2	Basic principle of driving with a trolley	6
5.3	Space required to turn a corner	6
5.4	Space required to park a trolley	7
5.5	Space required to park trolley in reverse	8
6	Accuracy	9
7	Safety.....	10
8	Creating QR markers.....	10
9	Setting up MiRHook in the web interface	12
9.1	Enable the Hook feature in the webinterface.....	12
9.2	Create an overall trolley type	13
9.3	Calibrate a specific trolley in the MiR system	14
9.4	Create a specific Trolley in the MiR system.....	16
9.5	Test and confirm that the setup was done correctly	17
10	Setting robot and trolley positions in the map	18
11	Example of a small application	19
12	Changelog.....	21
	Appendix A: Updating the MiRHook software	22

1 Introduction

The MiRHook is designed to fully automatically grip trolleys and transport them from one position to another. The MiR100 can be bought with the MiRHook integrated or the hook can be retrofitted on an existing MiR100.

2 The MiRHook hardware

The MiRHook is equipped with a camera, a gripper and an emergency stop for the complete system, i.e. the MiR100 robot and the hook (see Figure 1).



Figure 1 - The MiRHook hardware

The gripper can be exchanged for different trolley types.

⚠ Notice The robot can pick up trolleys only in normally illuminated environments since the 3D camera must be able to “see” the QR marker.

3 Trolley specifications

The MiRHook can accommodate trolleys with the following dimensions:

- Width: between 400 mm and 1500 mm.
- Height: maximum 2000 mm.
- Length: between 500 mm and 2400 mm.

In addition, the trolleys must have a gripping area at the front, bottom part of the trolley (typically a square tube) with the following dimensions:

- Position: 80-350 above floor, A
- Thickness: 15 to 25 mm, B
- Length: Min. 300 mm, C

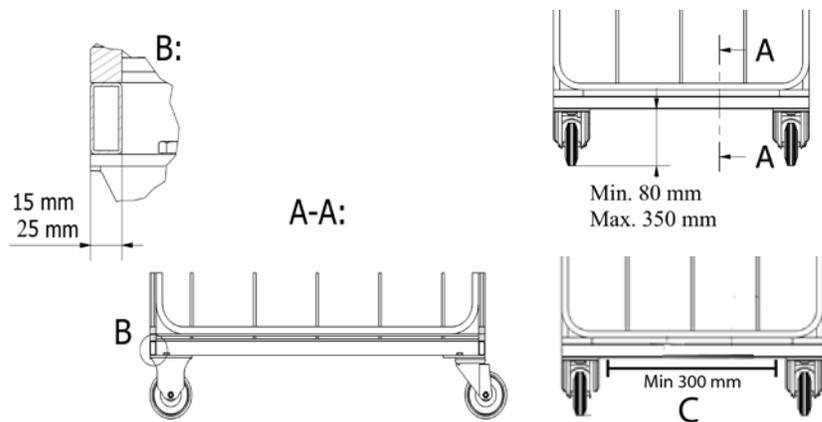


Figure 2 – Gripping area dimensions

For the robot to be able to locate and identify trolleys a QR-marker must be fixed on the front of the trolley, see chapter 8.

Wheel configuration of the trolley

The trolleys must be fitted with two rigid and two caster swivel wheels. The two rigid wheels can either sit on the front or the back of the trolley.

Whether the robot will work better with rigid wheels on the front or the back depends on the maneuvering conditions on the individual site and should be assessed before the gripping bar is fixed. In general, the following rules of thumb apply:

- **Two rigid wheels on the back and two swivels on the front:**
With this configuration the robot and trolley turns easily and drives with the most stability. Reverse parking is easier.
- **Two swivels on the back and two rigid wheels on the front:**
In areas with tight corner passages, the robot may turn the corners more easily with the rigid wheels on the front. If the rigid wheels are in the back, the trolley makes a larger turning curve requiring more space.

4 Modifying the gripper for different thickness and/or length

If the length or thickness of the trolley is slightly out of the specification, then it is possible to modify the gripper. The gripper length can be altered by unscrewing the upper gripper and changing the length between the arms – This requires some machine work. The thickness can be changed by adding spacers to the mounting of the lower-gripper (see image below).

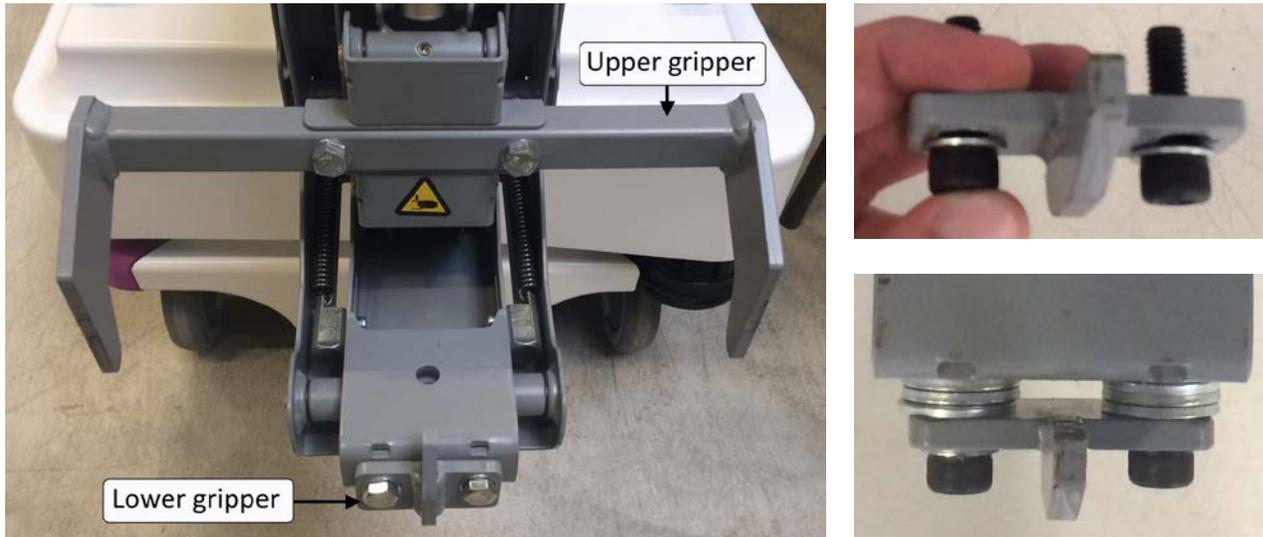


Figure 3 - The gripper may be mechanically modified to accommodate trolleys that are slightly out of specifications

5 Space requirements

5.1 Space required to pick up a trolley

As system operator, you are responsible of ensuring that the MiR100 has enough space to pick up the trolley. When preparing to pick up a trolley, the robot moves to a position in front of the given trolley position (1.7 m from the position). The robot camera orients itself towards the QR marker before backing towards the trolley. If misaligned more than 5 degrees, the robot will turn 90 degrees to the side to place itself on a line directly behind the trolley.

⚠ Make sure the space around the robot is clear as the alignment is done without collision check.

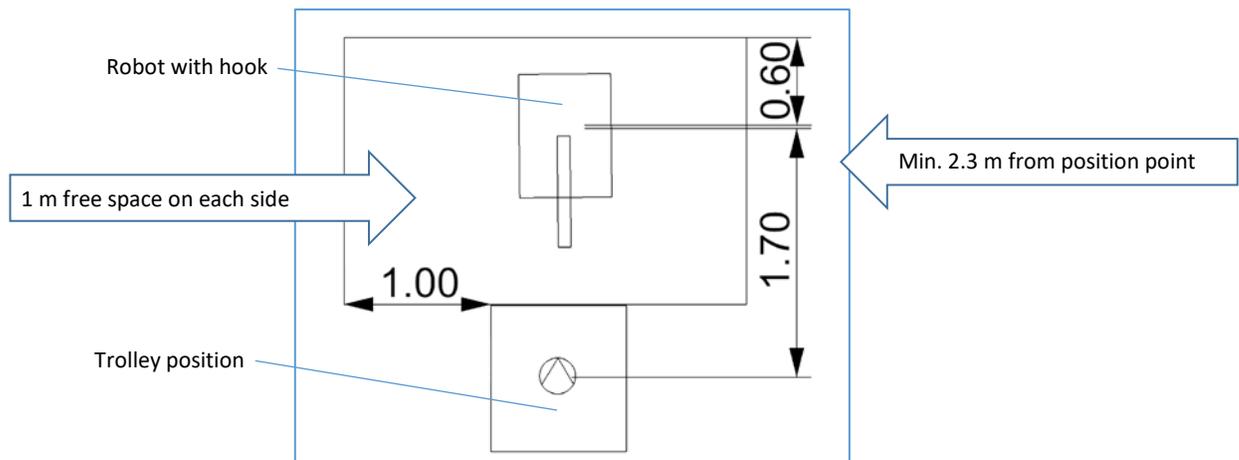


Figure 4 - Space required to pick up a trolley

5.2 Basic principle of driving with a trolley

Once a trolley is attached to the MiR100, the robot does not reverse when going from position A to position B, see chapter 6 Safety. As a result, its dynamic obstacle avoidance capabilities are somewhat restricted compared to when a trolley is not attached. The system operator needs to keep this in mind when choosing where to run the MiRHook.

5.3 Space required to turn a corner

The space required to turn a corner depends on the combined length of robot and trolley; a square measuring the total length of robot and trolley plus 500 mm is the optimum space turning a corner (see Figure 3).

Tips: 1. Less than 500 mm may work in areas with no or few dynamic obstacles.

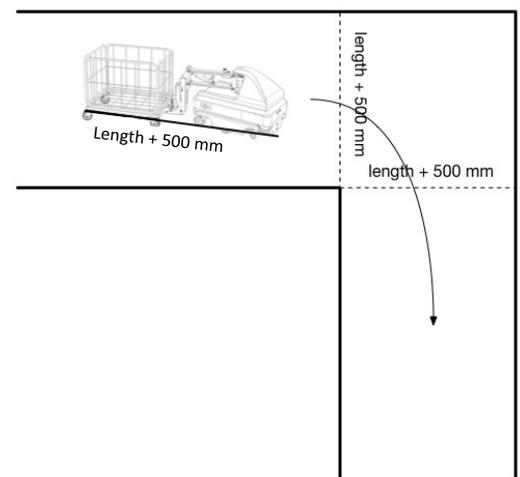


Figure 5 - Space required to turn a corner

2. Driving pattern and sensibility to dynamic obstacles depend on whether the front or rear wheels of the trolley are locked. If the corner space is limited, we recommend to test which works best in the individual case.

5.4 Space required to park a trolley

To park a trolley, the robot needs at least 50 cm of space to either side of the trolley.

In addition, it cannot park the trolleys safely closer than 25 cm to any obstacles behind the trolley, however, the robot can pick up a trolley parked closer than 25 cm to any obstacles behind it (see Figure 4).

Please note, that it should be possible for the robot to park and pick up trolleys at an angle of less than 5° between the trolley and the robot.



Figure 6 - Parking space for trolleys

5.5 Space required to park trolley in reverse

As system operator, you are responsible of ensuring that under normal operation the MiR100 has enough space to park the trolley. The space required is a square in front of the position equal to the full length (MiR100 + trolley) plus 50 cm.

- The robot moves to a position sideward to the placement position (1.5 m either coming from the right or left side).
- The robot checks if the placement space is free and then moves with the trolley so that the fixed wheels on the trolley are 0.2 m from the center line in the placement position.
- The robot now moves itself with the trolley to a position aligned with the position line and finally moves the trolley into place.
- When reversing with a trolley the robot will both warn with a loud beeping sound as well as blinking yellow color.

⚠ Caution When reversing, make sure that the space around the robot is clear. it is mandatory to mark the trolley areas as a hazard zones. Where only authorized personnel are allowed.

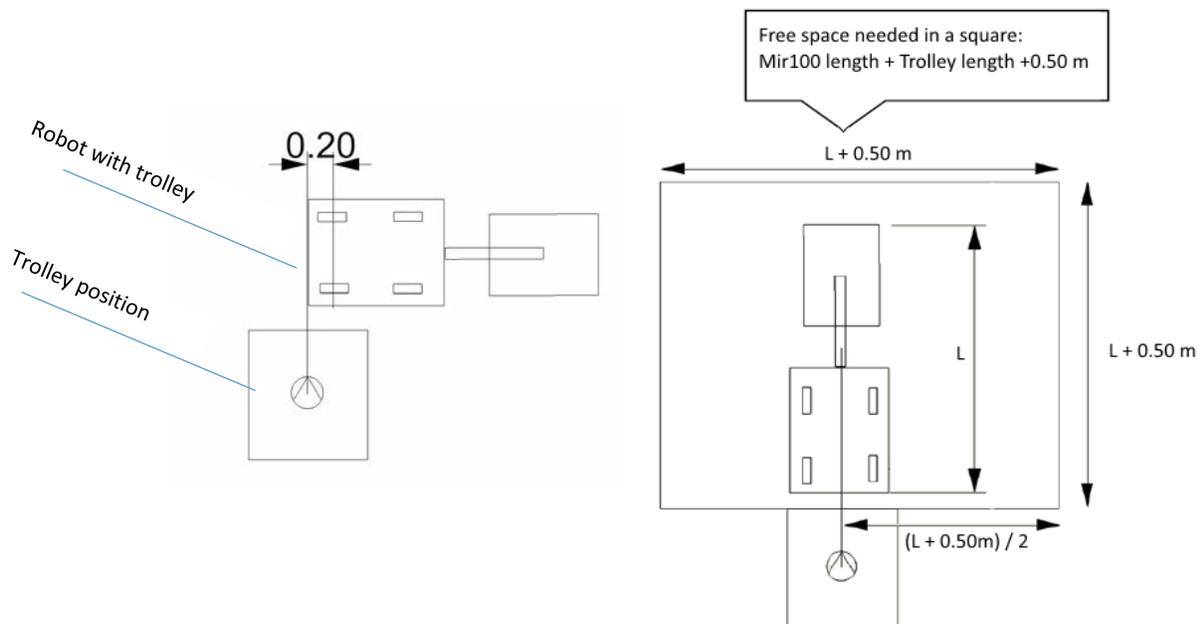


Figure 7 - Space required to park trolley in reverse.

6 Accuracy

The robot parks and picks up trolleys with an accuracy of 20 cm radius from the specified position and with an angle difference less than 10° relative to the specified position.

Similarly, a trolley is picked up at a given position if the trolley is placed with the above accuracy.

Each trolley is identified by its QR-marker. If several trolleys share the same QR-marker, the trolleys must be identical and the QR-marker must be placed with an accuracy of 1 cm on all trolleys.

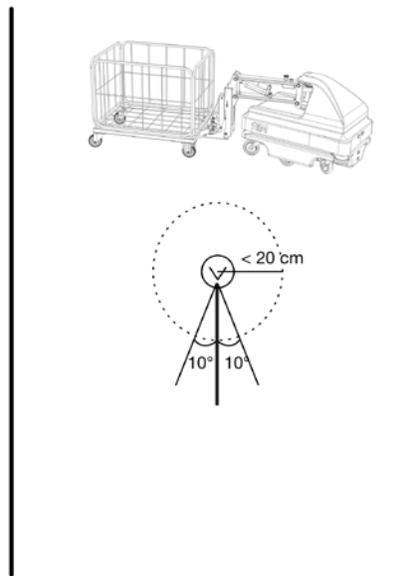


Figure 8 - Parking and picking up accuracy

7 Safety

Each individual application of the MiRHook requires its own safety evaluation.

The robot cannot detect objects between the robot and the trolley and it cannot detect objects behind the trolley (the robot does not reverse as part of the route; however, it can reverse when parking a trolley). For the same reason it is not possible to drive more than one trolley at a time, i.e., it is not allowed to chain trolleys together.

Two cameras are installed at the front of the robot: one on the lower robot skirt, detecting objects from 5-50 cm above the floor and one on the hook, detecting objects up to 200 cm above floor.

When driving with a trolley the maximum speed of the robot is 5.4 km/h.

The MiRHook can move trolleys with a total payload (incl. the weight of the trolley itself) of 300 kg when driving on a horizontal, flat and clean concrete surface.

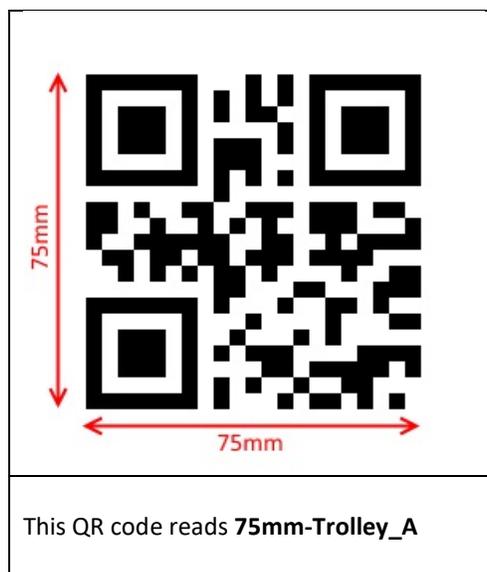
The MiR100 equipped with the MiRHook can drive on ramps with a maximum 5% inclination and a maximum payload (again incl. the trolley itself) of 200 kg.

8 Creating QR markers

A QR marker is needed for the MiRHook to identify the individual trolleys. The QR code contains the dimension of the marker and a unique name. The format is "SizeUnit-Name".

- Size: the length of one of the sides of the quadratic QR code.
- Unit: the measuring-unit of the size, for example mm (millimeters) or in (inches) etc.
- "-": Remember the hyphen (-) which separates size and unit from the name.
- Name: a unique name displayed in the system.

Example:



The recommended size of a QR marker is between 70 and 100 mm. But the system is open to all other sizes. The limit is whether the camera can see the QR marker or not.

QR markers can be created using any QR code generator. As long as the size is the same as stated in the QR-code, there is not requirements for how to create the codes. An easy and free method is to search the internet for QR code generators and use one of the many results.

9 Setting up MiRHook in the web interface

To use the MiRHook, the following setup and test procedures must be followed.

1. Enable the Hook feature in the webinterface, 9.1.
2. Perform a homing of the hook
3. Create an overall trolley type, 9.2
4. Calibrate the relation between robot and trolley, 9.3
5. Create a specific trolley in the MiR web interface, 9.4
6. Test and confirm that the setup was done correctly, 9.5

9.1 Enable the Hook feature in the webinterface

The Hook related menus are not automatically shown in the MiR100 webinterface. To enable those, the **Hook** feature must be activated.

1. In the webinterface, navigate to **Features** (Service" > Configuration > System settings > Features).
2. Under **External features**, tick the **Hook** option and click **Save**. You will now have access to the menu items that allow the set-up of trolleys.



Figure 9 - To be able to set up the robot for transportation of trolleys, make sure the **Hook** feature is activated.

9.2 Perform a homing of the hook

Before creating trolley types and trolleys a homing must be performed. A homing raises the hook to its topmost position and is used as a zero-point calibration of the hook.

1. In the webinterface, navigate to **Trolleys** (Service” > Configuration > Trolleys).
2. Under **Hook** actions, click **Start homing** and until the hook stops moving.

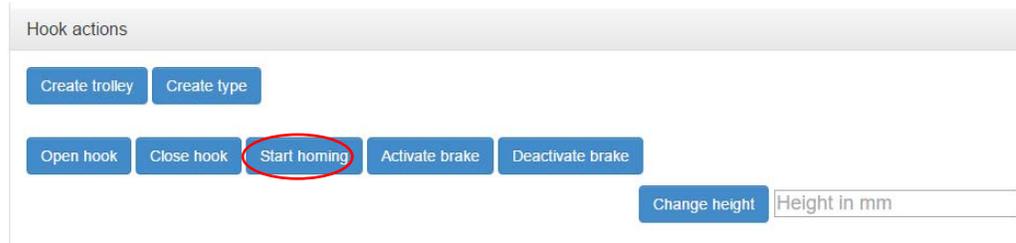


Figure 10 - A homing action functions as a zero-point calibration of the hook.

9.3 Create an overall trolley type

The trolley type(s) used for towing jobs must be defined. This is done to accommodate multiple trolleys of the same type. The procedure is as follows:

3. In the webinterface, navigate to **Trolleys** (Service” > Configuration > Trolleys).
4. Under **Hook** actions, click **Create Type**.
5. Enter the following information:
 - a. A custom name for this type of trolley.
 - b. The length (to the gripping area), width and height (from floor) of the trolley.

- c. The offset from the center of the locked wheels to the front of the trolley (gripping area).
Note: The locked wheels can be either at the front or the back of the trolley. Locked wheels at the back will give a higher offset value.

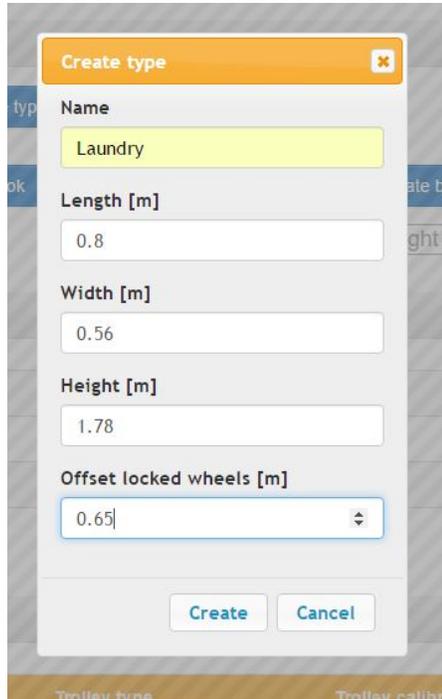


Figure 11 - Create a trolley type



6. Click “Create”.

9.4 Calibrate a specific trolley in the MiR system

The next step is to calibrate the relation between the MiRHook and the trolley. In the “Trolleys” menu under “Hook actions” you must now enter values into the “Change height” field to define Entry and Lock heights for the hook to use when docking to and gripping a trolley.



Figure 12 - Hook actions, change Hook height

When a value is entered in “Change height” and the button is pressed, the Hook will move up or down depending on the chosen value (see Figure 8). The value represents the height from the bottom of the Hook to the ground (mm).

1. First, insert a height which enables the Hook to go underneath the trolley. Remember this value as “Entry height”, for later use.
2. Place the trolley over the MiRHook.
3. Now enter a height which enables the Hook to grip the bottom frame (gripping area) without lifting or pushing the trolley. This step may require some trial and error until you have the correct height. When done, remember this value as “Lock height”.
4. Change the height back to “Entry height” and make sure the trolley is still positioned over the MiRHook.
5. Now attach the QR-marker to the trolley such that the camera on the MiRHook can see the QR-marker when the MiRHook is ready to grip the trolley (see Figure 9).

Note: The QR-marker must be placed completely vertically on the trolley grating. Otherwise the camera may have problems reading the code.

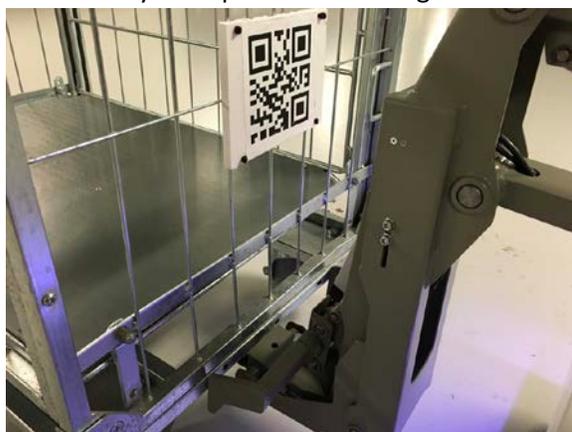


Figure 13 - Placement of the QR-marker

If the camera can see the QR-marker, the position values are displayed. Otherwise, the fields will just display N/A.

Live marker results	
Marker name	Trolley_B
X	-0.00 m
Y	-0.00 m
Z	0.16 m

Figure 14 - The MiRHook has identified the QR-marker

The calibration is now completed. Do not move the robot, hook or trolley and continue with the next step.

9.5 Create a specific Trolley in the MiR system

The next step is to set up a trolley in the MiR system.

1. Under Hook actions, click **Create trolley**.
2. Select the trolley type you created before.
3. From the drop-down menu, **Trolley calibration** choose **Create new using live marker**. Make sure that the hook is in **Entry height** position and that the camera can see the QR-marker. If done correctly, the **Trolley name** and **Entry height [mm]** will be shown, if not, the values will display **N/A** and the calibration must be redone.
4. Enter the **Lock height** in mm (the height that was set in step 3 in section 9.3).
5. Enter drive height (usually equal to the lock height).
6. Click **Create**. Now the trolley is linked to the MiR system.

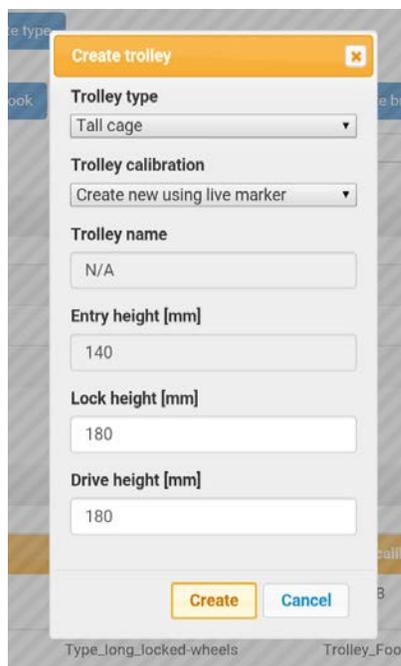


Figure 15 - Create trolley

9.6 Test and confirm that the setup was done correctly

To test the setup, move the trolley approximately one meter away from the robot and create a mission with one action **Pick up Trolley** and launch it. The action **Pick up Trolley** has two parameters, **Position** and **Trolley**; if both are left blank, MiRHook will try to lock to any known trolley.

Note: When you move the trolley away from the robot, the X, Y and Z values must still show under “Live marker results”. If they read N/A, it means that the trolley has been moved too far away.

With this mission, the robot will attempt to fetch any trolley visible to the MiRHook camera. If the hook does not find the trolley, the calibration must be redone going through the above steps again.

Figure 16 - Testing the setup with Pick up trolley action

After a successful “Pick up trolley” mission, now create and run a “Place trolley” mission. The action **Place trolley** has three parameters **Position**, **Reverse into place** and **Release Trolley**. Select position from drop-down list, decide if the MiRHook should release the trolley after the trolley is parked and change No to Yes if you want the trolley to be backed into place.

Note: If possible, always use missions when locking / unlocking trolleys.

Figure 17 - Testing the setup with Place trolley action

10 Setting robot and trolley positions in the map

To create “pick up trolley” and “place trolley” missions, trolley positions must be defined in the map. To do this, navigate to either the **Command View** or **Positions** menu and select **Create new position**. Under **Position type**, select **Trolley position**.

Note: If you want to set the position where the robot with trolley is placed right now, the position will be placed below the center of the trolley. If no trolley is attached when you click **Use robot position**, the position will be placed below the center of the robot.

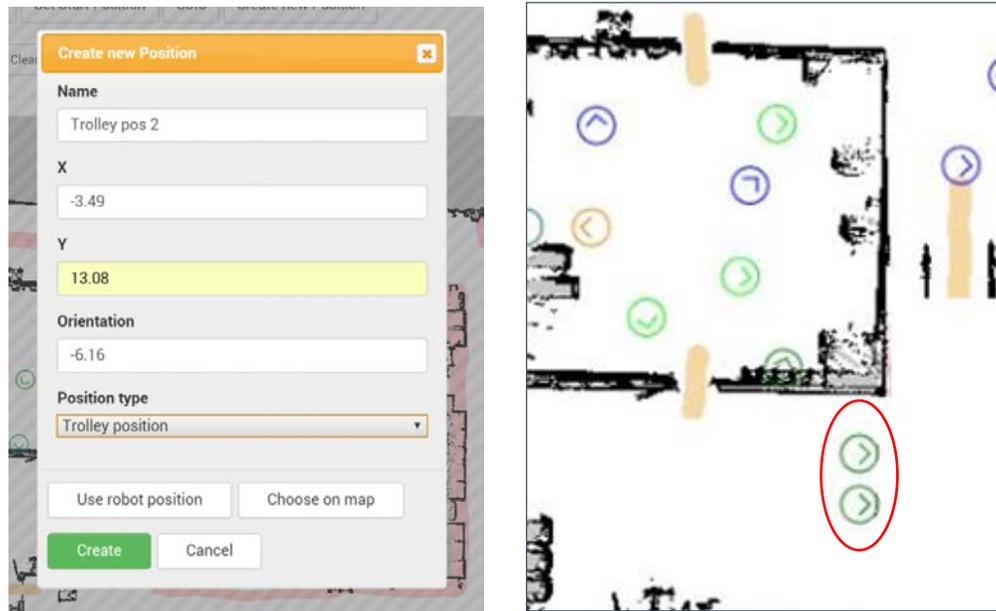


Figure 18 - Setting up trolley positions in the map. Trolley positions are shown in a dark green color.

11 Example of a small application

The task at hand is to pick up a trolley at position A, drive with the trolley attached to position B and return it to position A. This can be done in the following way:

First define two positions, A and B. Position A is used for picking up and placing trolleys and must be defined as a Trolley position (dark green in the map). Position B is a normal Robot position (blue in the map) which the robot with hook can move to but not to pick up or unload a trolley.

The figure illustrates the configuration of a trolley mission. On the left, a configuration panel is divided into three sections:

- Section 1:** 'Pickup Trolley' with a 'DELETE' button. The 'Position' is set to 'Position A' and the 'Trolley' is 'Trolley_Food_01'.
- Section 2:** 'Move To Known Position' with a 'DELETE' button. The 'Position' is 'Position B'. It includes 'Retries (Blocked Path)' set to 10 and a 'Distance to goal threshold' of 0.25.
- Section 3:** 'Place Trolley' with a 'DELETE' button. The 'Position' is 'Position A', 'Reverse into place' is 'No', and 'Release Trolley' is 'Yes'.

On the right, two maps show the mission path. The top map shows the robot starting at 'Position B robot position' (blue circle) and moving to 'Position A trolley position' (dark green circle). The bottom map shows the robot returning from 'Position A trolley position' to 'Position B robot position'. The path is marked with a green line and arrows, and a blue square indicates the robot's position during the move.

Figure 19 - Trolley mission

1. **Pickup Trolley:** Position is a predefined trolley position type named Trolley A and the specific trolley is named Trolley_Food_01.
2. **Move To Known Position:** From first position, a movement to a predefined position “Move to known position” action is inserted. This is a normal robot position which the robot with trolley will move to and use as a via position on the route. Normal robot positions cannot be used as pick up and park trolley positions.
3. **Place Trolley:** The robot will park the trolley in this position. It will not be parked in reverse, and the robot will release the hook from trolley and move forward a bit as a final action.

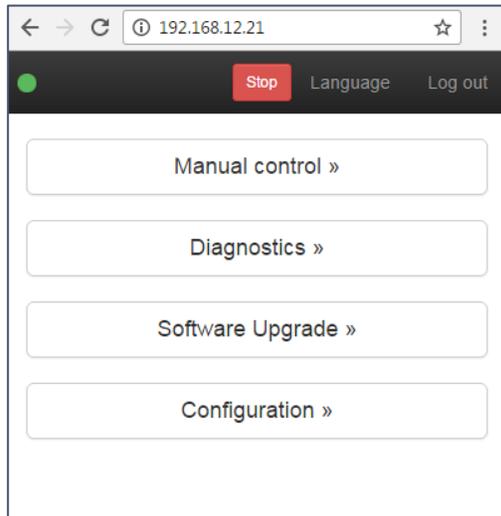
12 Changelog

Version	Date	Changes
1.0	01.02.2016	Document created
1.1	04.02.2016	General small corrections. Reworked section 7 "Usage".
1.2	10.04.2016	Major update throughout document.
1.3	02.04.2016	Added space requirements for pick-up and reverse parking
1.4	20.09.2016	Updated for SW release 1.7. Configuration of hook missions made simpler.
1.5	11-10-2016	Updated illustration for 4.1 & 4.3
1.6	24-10-2016	Appendix added: Updating the MiRHook software. Chap 1.: Notice added about requirements for light in the operation environment.
1.7	10.11.2015	Description of driving space requirements changed (chap. 4.3)
1.8	06-01-2017	Updated for SW release 1.8 Trolley specifications changed New section "Modifying the gripper for different thickness and/or length" added.

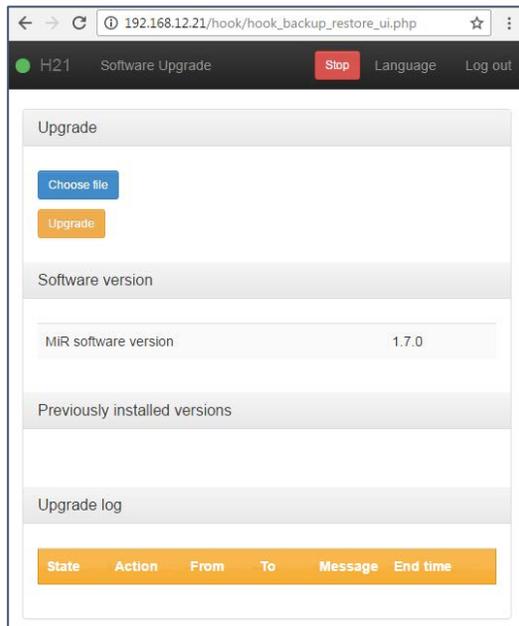
Appendix A: Updating the MiRHook software

Follow this procedure to upgrade the MiRHook software:

1. Connect your computer to the robot’s WiFi.
2. In a web browser, for example Google Chrome, enter the IP address 192.168.12.21. (Note the IP!) This will take you to the MiRHook web interface.
3. In the web interface, go to “Software update”.



4. Click Choose file and select the file containing the new software version. The file is the same as you use to update the robot itself.



5. Click upgrade and wait for the data to load.