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# Guidelines for the Integration of System Components

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## Executive Summary

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This report describes the composition of a Wiki page containing the guidelines for robot integration and to ensure the compatibility of software/hardware components with related documentation.

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## Abbreviations and Acronyms

| | |
|---|---|
| BEM | Box-Exchange Mechanism |
| CAN | Controller Area Network |
| GPS | Global Positioning System |
| IMU | Inertial Measurement Unit |
| LIDAR | LIght Detection And Ranging |
| NUC | Intel Next Unit of Computing |
| OS | Operating System |
| ROS | Robot Operating System |
| RTCM | Radio Technical Commission for Maritime Services (GNSS communication protocol) |
| RTK | Real Time Kinematic |
| USB | Universal Serial Bus |
| WiFi | Wireless network communication protocols |
| WP | Work Package |

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# 1. Introduction

"Guidelines for the Integration of System Components" is a deliverable for WP3 – describing the composition of a Wiki page containing the guidelines for robot integration and to ensure the compatibility of software/hardware components with related documentation. In this way, important information for the hardware and software required for the integration and operation of the robotic prototypes are documented and easily accessible by the partners. This method has the objective to allow for easy troubleshooting when and if those trouble occur.

# 2. Wiki setup, Structure and Access

The chosen method for the dissemination of critical information for the integration and operation was to set up a wiki page in the project's Github page. Setting up the wiki in this form has the advantage of:

a) Providing guidelines in a documented way for all components developed for the robotic prototypes, that can be used by all partners.
b) Ease of accessibility by all partners, allowing for both online and offline access.
c) Versioning control with options to revert to older versions but also check the differences between versions.
d) Ease of maintenance since the page is created in a simple Markdown format, which is easily formatted.

For the wiki setup, we opted to develop a dedicated repository called "documentation" under the project's CANOPIES Github workspace. In this way, required information will be gathered in one place instead of setting up several wikis for each individual repository corresponding to a different robotic component. Of course, this wiki does not replace the required documentation that is needed for each individual repository.

The wiki structure is the following:

1) Main page: main page with indices that allow the easy navigation of the user to specific sections and subsections.
2) Robot operation: includes the process for safely operating the mobile robot and dual arm.
   a) Mobile robot: includes safety concerns, instructions for mobile robot initialization and charging. In detail:
   b) Subsection for the Dual arm: includes safety concerns, instructions for dual arm initialization and charging.
3) Software setup: includes the guidelines for the installation and setup of the software for the mobile robot, BEM, dual arm.
   a) General robot setup: includes information on the general software setup of the robotic prototype robot.
   b) Mobile Robot: software guidelines required for the setup and operation of computers and sensors used on the mobile robot platform.
   c) Box Exchange Mechanism (BEM): describe software requirements for the box exchange mechanisms on both robotic prototypes.
   d) Dual arm: describes all required software setup, i.e., device drivers, operating system, ROS versions, interfaces, etc. for the Dual arm.
4) Hardware setup: includes the guidelines for the integration of components comprising the robotics prototypes.
   a) Mobile robot: includes the parts list, guidelines for the integration of mobile platform, including mechanical and electrical operations and physical sensor setup.

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b) **Dual arm**: includes the individual integration steps for the Dual arm.
c) **Box-Exchange-Mechanism (BEM):** described the individual integration steps of the box exchange mechanisms for both robotic prototypes.
d) **3D printed components**: place for sharing all 3D-printing components required for the robot's integration.

The wiki is expected to expand and change in the duration of this project, by adding and removing information as the project's activities unfold and new knowledge is acquired.

The wiki is accessible with proper credential throughout the Github repository of the CANOPIES project, reachable at https://github.com/canopies-h2020 .

For the sake of completeness, in Appendix we also include the current state of the wiki as of the date of submission of this deliverable, namely 29/10/2021.

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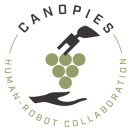
# 3. Appendix

## Home page



CANOPIES documentation for robot integration

### 1. Robot operation

**Initialization steps and safety concerns** for operating the robot.

1. Mobile robot
2. Dual arm

---

### 2. Software Setup

Documentation for the setup of the robot's software components including **drivers, ROS interfaces and general parameters**.

1. General robot setup
2. Mobile Robot
3. Box-Exchange-Mechanism(BEM)
4. Dual arm

---

### 3. Hardware Setup

Documentation for the setup of the robot's hardware components including **integration manuals, list of components, files of 3D printed components**.

1. Mobile robot
2. Box-Exchange-Mechanism(BEM)
3. Dual arm
4. 3D printed components

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## Home >> Robot operation

Includes the process for safely operating the mobile robot and dual arm.

- Mobile robot: includes safety concerns, instructions for **mobile robot** initialization and charging. In detail:
- Dual arm: includes safety concerns, instructions for **dual arm** initialization and charging.

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## Home >> Robot operation >> Mobile robot

This page includes the guidelines for the correct operation of the mobile base, including the operations of running, storing, and charging.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>

```
+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any operation will result in better understanding of the mobile base's capabilities and needs therefore it is HIGHLY ADVISED.
```

List of contents:


- Setting the mobile platform to operation
- Terminating operation and storage
- Charging


---

## Setting the mobile platform to operation

Getting the platform into operation describes the process of using it after a storing or charging session. The following procedures must be followed:

4. [**If the platform is charging**] **Remove the charging plug** and close the charging lead securing it with the flap.

```
- ! IMPORTANT ! : Do not proceed to Step 2 if the charging plug is not removed
```

5. **Inspect that the sensor power switch is off**.
    1. Open the Alitrak charging box.
    2. Verify that the switch in to the **O** position.
6. **Inspect and connect the main plug**.

```
- ! IMPORTANT ! : By connecting the main plug the user will power up the distribution blocks on top of the robotic platform. Therefore, DISCONNECTION OF ALL SENSORS IS NECESSARY BEFORE THIS STEP!
```

7. Check whether the pins have signs of discoloration or are bent in any way.

```
- ! If yes, contact DTI at tsko@teknologisk.dk or a local supervisor.
```

8. Remove any dust around the plug on the robot and the plug that is terminating to the robot.
9. Insert the plug. **NOTE:** the left side of the plug is the one with the least number of pins.
10. Secure the plug with the flap.

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11. **Initialize the platform startup sequence**.
    1. [**Check**] Step 3 is completed.
    2. Pull the emergency stop located on the back of the platform.
    3. Turn the key in the right direction all the way, also located on the back of the platform.
12. **Initialize and pair the controller.**
    1. [**Check**] Step 4 is completed.
    2. [**Check**] Battery on the back of the controller is connected.
    3. Turn the switch located on the back of the controller to the **I** position.
    4. [**Before pairing**] The user should look at the digital dials on the back of the platform.

```
- ! IMPORTANT ! : The user is expected to be aware of the battery load pe
rcentage!
```

    5. Press the green button on the controller. A "beep" coming from the platform should be audible.

```
+ In case that there is no audible beep. Then, repeat Steps 4 and 5.
```

    6. [**Check**] The **power level of the batteries is more than 70%.**

```
- ! IMPORTANT ! : IF THE POWER LEVEL IS NOT SUFFICIENT, DO NOT USE THE PL
ATFORM. USING THE PLATFORM CAN LEAD TO PERMANENT DAMAGE TO ITS BATTERIES!
```

    Next steps are a) Terminating operation and storing, b) Charging

13. **Powering up the on-board sensors**.

```
- ! IMPORTANT ! : Connecting the power to on-board sensors must be done w
ith extreme caution! DO NOT CONNECT ANY SENSOR POWER WIRE WHILE THE SENSO
R POWER CIRCUIT IS ON! Make sure that the sensors are connected to their
respective distribution blocks.
```

    1. Open the Alitrak charging box.
    2. Flip the sensor power switch to the **I** position.
    3. [**Check**] All sensors receive power and no other problems were detected.

## Terminating operation and storage

When the platform needs to be terminated and stored, the following steps must be followed:

14. **Power down the on-board sensors.**

    - ! IMPORTANT ! : Power down the on-board sensors must be done with extreme caution. Power down the individual components based on manufacturers specifications.

    1. Power down the NUC.

15. **Powering down the sensor power circuit.**

    - ! IMPORTANT ! : NOT PERFORMING THIS STEP WILL DRAIN THE PLATFORM'S BATTERIES AND CAN LEAD TO PERMANENT DAMAGE.

    1. Open the Alitrak charging box.
    2. Flip the sensor power circuit switch to the **O** position.
    3. Verify that the switch in to the **O** position.

16. **Initialize the platform shutdown sequence.**

    1. Push the emergency stop located on the back of the platform.

    - ! IMPORTANT ! : NOT PERFORMING THIS STEP WILL DRAIN THE PLATFORM'S BATTERIES AND CAN LEAD TO PERMANENT DAMAGE.

    2. Turn the key to the left in the upright position, also located on the back of the platform.
    3. [**Check**] The gauges on the back of the platform should be OFF.

17. **Initialize the controller shutdown sequence.**

    1. [**Check**] Step 3 is completed.
    2. Turn the switch located on the back of the controller to the **O** position.
    3. Remove the battery from the back of the controller.

    - ! IMPORTANT ! : Charge the controller battery if used for more than 3 hours.

18. **Inspect and disconnect the main plug.**

    - ! IMPORTANT ! : By disconnecting the main plug the user will power down the distribution blocks on top of the robotic platform. Therefore, SHUTDOWN AND DISCONNECTION OF ALL SENSORS IS NECESSARY BEFORE THIS STEP!

    1. [**Check and maintenance**] Clean the plug from any water or dust before removal!
    2. Unsecure the flap on top of the plug.
    3. Disconnect the plug.

- ! IMPORTANT ! : When disconnecting the plug do not apply extreme force that can damage the connector or the pins. Therefore, the best method for removal is a gentle motion removing the connector parallel to the ground.

4. Check whether the pins have signs of discoloration or are bent in any way.

! If yes, contact DTI at tsko@teknologisk.dk or a local supervisor.

---

## Charging

- DISCLAIMER: THE ALITRAK POWER SYSTEM IS CAPABLE OF DESTROYING ELECTRONICS, SENSORS AND HARMING HUMANS. THEREFORE, ALL OPERATIONS MUST BE PERFORMED WITH CAUTION AND FOLLOWING THE DESCRIBED SEQUENCES. THE PLATFORM SHOULD ONLY BE CHARGED UNDER SUPERVISION, ON A DRY, DUST FREE AND WELL VENTILATED ENVIRONEMENT. THE FUMES FROM THE BATTERIES WHILE CHARGING CAN BE HARMFUL TO YOUR HEALTH.

- CAUTION: BEFORE CHARGING THE USER SHOULD BE FAMILIAR WITH THE SECTION ABOUT CHARGING FOUND ON THE ALITRAK MANUAL. MOREOVER, THE USER SHOULD BE FAMILIAR WITH THE CHARGER MANUAL.

- Charging should only be performed when the platform is STATIONARY IN A COOL AND WELL-VENTILATED SPACE! The charging should be performed while the platform is UNDER SUPERVISION! For the longevity of the batteries do not charge if the power is not lower than 80%. THE SEQUENCE OF CHARGING IS CRUCIAL AND SHOULD NOT BE ALTERED!

The charging sequence is the following:

19. **Check the status of the platform**.

    1. Perform all the steps described in Terminating operation and storing.

    - ! IMPORTANT ! : DO NOT PROCEED IF YOU HAVE NOT FOLLOWED THE STEPS IN THE LINK BELOW

    TERMINATING OPERATION AND STORING

20. **Connecting the power plug on the platform side**.

    - ! IMPORTANT ! : THE PLUGS SHOULD ONLY BE HANDLED USING THEIR PLASTIC PARTS! DO NOT IN ANY WAY INTERACT OR UPSTRUCT ANY CONTACT BETWEEN THE PLUGS AND THE CONNECTORS.

    1. [**Check**] The power plug is clean from dust and any water!

    - ! IMPORTANT ! : CLEAN THE PLUG WITH A DRY RUG! DO NOT USE WATER!

    2. [**Check**] The battery charging housing on the platform is clean from dust and any water!

    - ! IMPORTANT ! : CLEAN THE PLUG WITH A DRY RUG! DO NOT USE WATER!

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3. Open the battery charging housing by removing the flap.
4. Open the battery charging housing door all the way.
5. Connect and secure the power connector from the charger to the platform.

- ! IMPORTANT ! : THE PLUG SHOULD BE CONNECTED CORRECTLY. DO NOT CHARGE IF THE PLUG IS NOT COMPLETELY CONNECTED. PROPER CONNECTION SHOULD INCLUDE SOME FORCE WITH A MOTION THAT THE PLUG REMAINS PARALLEL TO THE GROUND. FOR MORE INFORMATION HAVE A LOOK AT THE ALITRAK MANUAL.

21. **Connecting the power plug on the wall socket**.

- ! IMPORTANT ! : The socket used for initializing the charging process should not be in any way burdened with powering any other devices.

22. [**Check**] Step 2 is completed.
23. Connect the plug to the wall socket.
24. [**Check**] The charger is operational and charging.
    1. The charger fans should be audible.
    2. The charger will provide an initialization screen with a countdown.
    3. The charger display will provide an indication about the charging status.
25. **Completing the charging process**.
    1. The Alitrak charger will automatically stop the charging process. The platform is ready when the charger's screen indicates "AVAILABLE"

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## Home >> Robot operation >> Dual arm

This page includes the guidelines for the correct operation of the dual arm, including the operations of running, storing, and charging.

> For any questions or immediate needs please contact Maria Santamaria <maria.santamaria@pal-robotics.com>

```
-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
oves, eye protection and safety shoes.
```

```
+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any
alterations will result in a smoother integration therefore it is HIGHLY ADVISE
D.
```

## The Dual arm is currently under development. Guidelines about its operations will become available in the near future.

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## Home >> Software setup

This page includes the guidelines for the installation and setup of the software for the mobile robot, BEM, dual arm.

1. General robot setup
2. Mobile Robot
3. Box-Exchange-Mechanism(BEM)
4. Dual arm

## Home >> Software setup >> General robot setup

This page includes information on the general software setup of the robotic prototypes.

> For any questions or immediate needs please contact Kasper Camillus Jeppesen <kcj@teknologisk.dk>

## Operating System

The operating system for all x86 based computers on the robot is Ubuntu 20.04.
For Nvidia ARM based systems that rely on Jetpack there is the possibility of using 18.04.

## ROS version

The chosen ROS version is ROS Noetic for all x86 based computers on the the robot. This ROS version can be installed from binaries natively on Ubuntu 20.04.

In cases where there are no ROS Noetic binaries available for the OS distribution running on some specific hardware (E.g. Nvidia platforms) it is recommended to either run ROS related code through Docker or to make sure that the messages/services/actions exchanged have not changed from one ROS version to the next (e.g. Melodic to Noetic).

## ROS Workspace setup recommendations

As far as possible the local ROS workspaces will reflect the structure on the github organization. vcs `https://github.com/dirk-thomas/vcstool` and catkin_tools `https://github.com/catkin/catkin_tools` are recommended.

## Revision control of 3rd party packages

For 3rd party open source ROS packages (e.g. sensor drivers) it can be helpful to fork and version control it on our own private github - in this way we don't run into problems if the public repository undergoes updates that make it incompatible with our usage. Therefore, it is suggested to fork a working version of any 3rd party packages to our github repo.

One possible way is to do the following if you don't already have a local version of the repo in question:

Clone the public repo and push it to the private repo on the canopies-h2020 github.

```
git clone --bare https://github.com/exampleuser/public-repo.git
cd public-repo.git
git push --mirror https://github.com/yourname/private-repo.git
cd ..
rm -rf public-repo.git
```

In your local working directory (e.g. ROS workspace) clone our private repo and work as normally.

```
git clone https://github.com/yourname/private-repo.git
cd private-repo
make some changes
```

```
git commit
git push origin master
```

In case new changes from the public repo are needed we can pull and merge them to our private repo.

```
cd private-repo
git remote add public https://github.com/exampleuser/public-repo.git
git pull public master # Creates a merge commit
git push origin master
```

## Networking

All computers on the robot will be on the same gigabit network. Static IPs will be assigned to all devices that are always part of the robot (computers, sensors etc.) and a certain range will be reserved for DHCP for devices that are only sometimes part of the networking setup (e.g. developer laptops).

`Specific networking configuration to be decided in the near future.`

## Time synchronization

All computers on the robot will need to be time synchronized. The computer (NUC) dedicated to run the navigation and localization software is chosen as the master for time synchronization and uses the time from the GNSS receiver as the time it broadcasts. Every other computer on the network needs to connect to this time server as a client to receive the correct time.

`Setup files for time synchronization will be uploaded in the near future.`

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## Home >> Software setup >> Mobile robot

This page includes the software guidelines required for the setup and operation of computers and sensors used on the mobile robot platform.

The components are divided in the following categories:

1. Sensors
   - IMU - SBG
   - GPS - Septentrio
   - LIDAR - Ouster
2. CAN Bus

## Home >> Software setup >> Mobile robot >> Sensors - IMU - SBG

This page includes information on setting up and using the IMU - SBG Ellipse E.

> For any questions or immediate needs please contact Jonas Bæch <joba@teknologisk.dk>

List of contents:


- Environment
- Setup
- Configuration
- ROS driver


## Environment

The setup requires the following environment:

- OS: Linux Ubuntu 20.04
- ROS version: Noetic
- Sensor: SBG IMU Ellipse-E

## Setup

### Cloning the repository

Clone the repository from Github in the Mobile Robot Team and build workspace.

### UART configuration

Connect the sensors USB-output to the computer and find the connected port:

```
ls /dev*
```

Remember to match the port in the yaml file.

CANOPIES setup is using: 921600

Baudrate standard for SBG IMU is: 115200 - This needs to be used, if connecting the sensor for the first time.

### UDEV RULES

Best practice is to setup UDEV rules: https://wiki.debian.org/udev

If you have set up udev rules, then use i.e.:

portName: "/dev/sbg"

## Configuration

The SBG IMU parameters can be modified using both Linux and Windows.

### Linux

Use the yaml files created for the CANOPIES project.

The yaml files should be placed under *sbg_ros_driver/config/example/*.

Remember to update the launch file, if a new yaml filed is created:

If the SBG sensor is modified using SBGcenter and used with ROS afterwards, then set the following setting in the yaml file:

confWithRos: false

### Windows

The SBG IMU parameters can be changed from SBG's own configuration tool: SBGCenter. It can be found here: https://support.sbg-systems.com/sc/el/latest/getting-started/first-connection-to-ellipse

## ROS driver

The original ROS driver and further information can be found here:

- Wiki: http://wiki.ros.org/sbg_driver
- Github: https://github.com/SBG-Systems/sbg_ros_driver

### Usage

Launch node:

```
roslaunch sbg_driver sbg_ellipseE.launch
```

Read topic examples:

```
rostopic echo /imu/data
```

```
rostopic echo /sbg/nav_sat_fix
```

```
rostopic echo /sbg/ekf_nav
```

## Home >> Software setup >> Mobile robot >> Sensors - GPS - Septentrio

This page includes information regarding the GPS - Septentrio sensor setup and how to set it up.

> For any questions or immediate needs please contact Jonas Bæch <joba@teknologisk.dk>

List of contents:


- Environment
- Connecting to the GPS sensor
- Sending corrections over Wi-Fi
- Using the preconfigured base station/rover settings
- Data visualization and verification
- Sending corrections over cellular


### Environment

Setup using the following environment:

- OS: Linux Ubuntu 20.04
- ROS version: Noetic
- GPS Base station: Septentrio AsteRx-U
- GPS Receiver: Septentrio AsteRx-M3 PRO+
- GPS Antennas: Septentrio PolaNt-x MF

---

**ROS driver**: https://github.com/septentrio-gnss/septentrio_gnss_driver

**Wiki**: https://wiki.ros.org/septentrio_gnss_driver

> This setup was tested using commit: af4e99d8970d9ee6ef50f94e29cffb34d3cf4038
> Build and install instructions are included in the ROS driver.

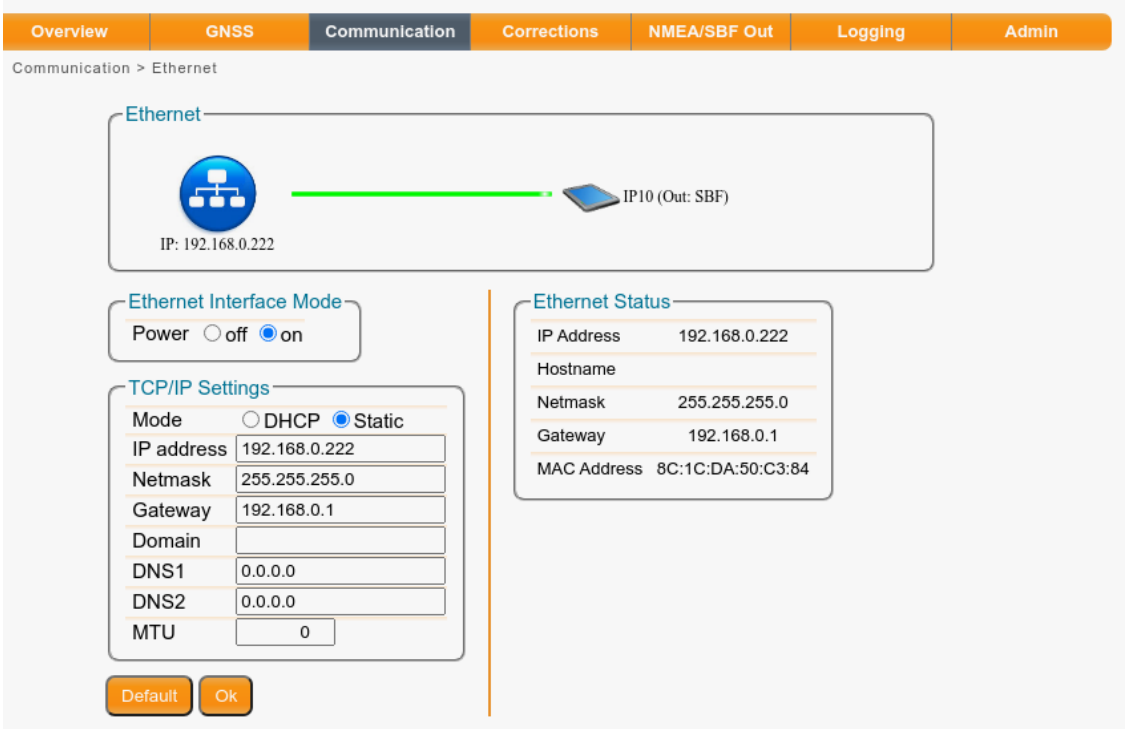
### Connecting to the GPS sensor

#### Step 1: Connect via USB

- Power up the device using USB –> micro-USB cable between computer and sensor.
- Go to web interface: 192.168.3.1

#### (Optional) Step 2: Setup Ethernet connection

- Modify IP settings on the device (as shown in the following picture):




- Set the ports to the following:




- Set the computer IP to be on the same subnet.

## Sending corrections over Wi-Fi

The process of sending corrections over Wi-fi is described by Septentrio in the following link.

Here we include the steps as described by Septentrio:

### Step 1: Configure base station

The first step is to configure the base station to send out correction data over ethernet.

- Open the web interface of the receiver.
- Make sure the receiver is in static mode.
- Go to Corrections and select Corrections Output.

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- Click on New RTCM3 Output. RTCM3 is the most compact and robust correction format and is recommended to use when possible.
- Tick the IP server box and hit next.
- Select New IP server connection and hit next.
- Select the ethernet port you wish to use, but make sure you avoid these numbers:
- Again, click next. This brings up an overview of output messages. The messages for RTK and DGNSS are selected by default. Click finish, and don't forget to hit the OK button to apply the changes.

### Step 2: Configure rover station

The next step is to configure the rover to receive corrections from the base station.

- Make sure your receiver has RTK capabilities
- Open the web interface of the rover.
- From the Communication menu, select IP ports.
- In the IP receive settings box, click on New IP Receive Connection.
- Fill in the correct port number. Select the TCP mode and also fill in the base station IP address. You can find this in the information bar at the top of the web interface of the base station. Hit OK. Don't forget to hit the OK button on the IP ports page as well to apply the changes.

### Step 3: Verify the configuration

To verify the configuration, check the overview page of both receivers. The Data stream box should show an active connection. In addition, check that the Corrections icon of the base station displays that corrections are being broadcast, and that the icon of the rover displays that corrections are being received.
If the rover receiver has RTK capabilities, you should see the position mode change to RTK fixed shortly after the first corrections are received

## Using the preconfigured base station/rover settings

### Step 1: Download the config files

You can find the config files in the Sententrio repository under Mobile Robot Team in the CANOPIES-h2020 Github.

### Step 2: Upload the configuration to another receiver.

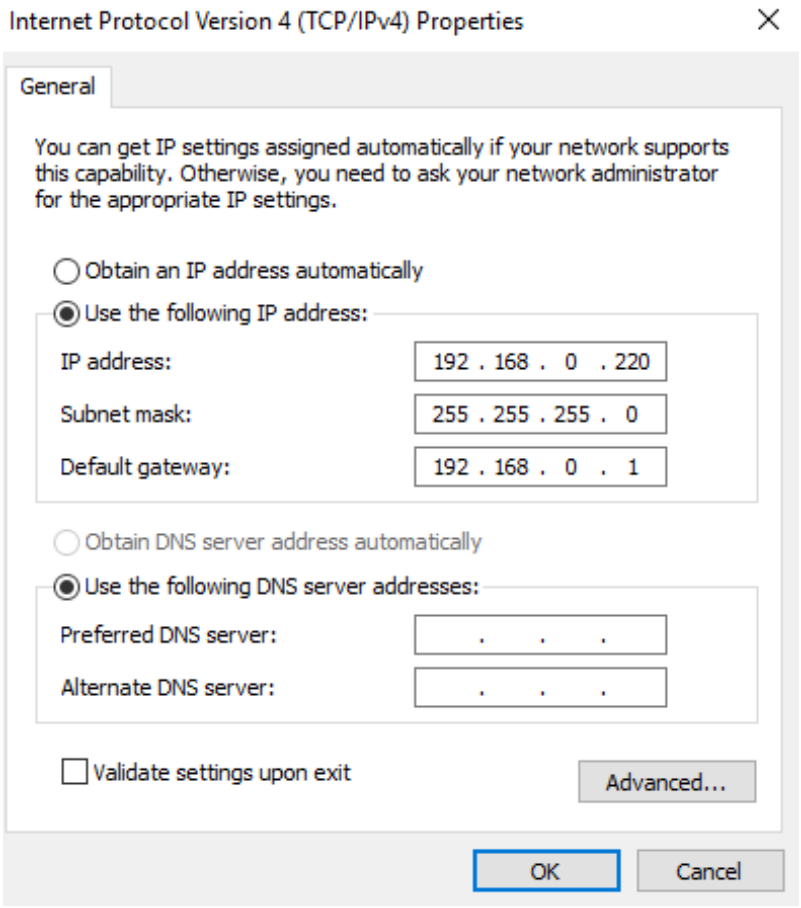
- Open the web interface of the receiver.
- Under the admin tab, go to configurations.
- Click on the blue arrow next to the configuration type of your interest, and select the file saved to your computer in the previous step.
- Hit the Proceed button to start the upload.
- Click OK when the upload is completed.

## Data visualization and verification

The following will describe how **RxTools** on **Windows** can be used to visualize and validate data.

### Step 1: Setting the subnet

Set your PC's IP to be on the same subnet as the device:




### Step 2: Setting up RXTools

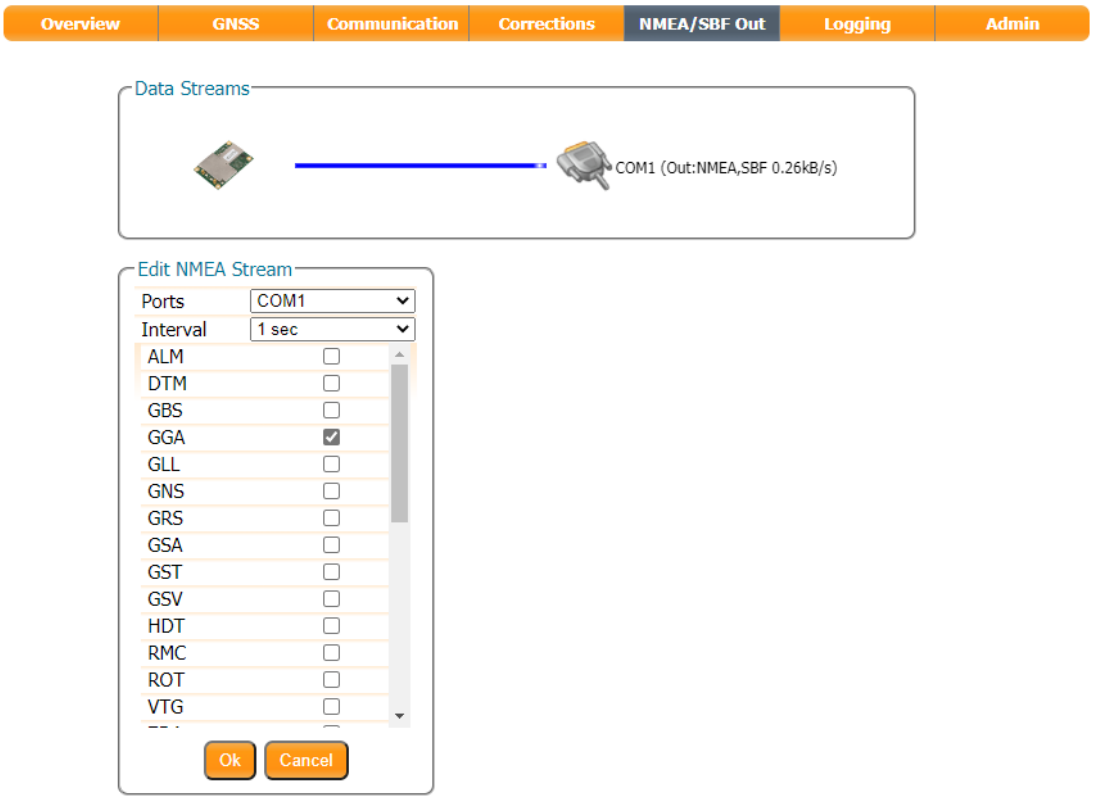
- Install RXtools from Septentrio and run RXlauncher
- Start RXControl
- File -> Change connection -> Add connection

You should be able to see data coming in and plot the position through the tool.

The GPS device must be set to output PVT data. See outputting data below.
You can also visualize GGA or validate GGA messages, ie. from USB through **RXtools Data Link**

### Step 3: Create new NMEA stream

- Go to NMEA/SBF out tab on the web interface
- Set the following settings




### Step 4: Outputting data

- Go to NMEA/SBF out tab on the web interface
- Add either NMEA or SBF stream
- Choose connection type, ie IP server to use ethernet connection
- Choose the port setup up earlier (28785)

To validate data, you can use NMEA to output GGA in human readable format
Otherwise you can use SBF to output PVT that can be visualized:

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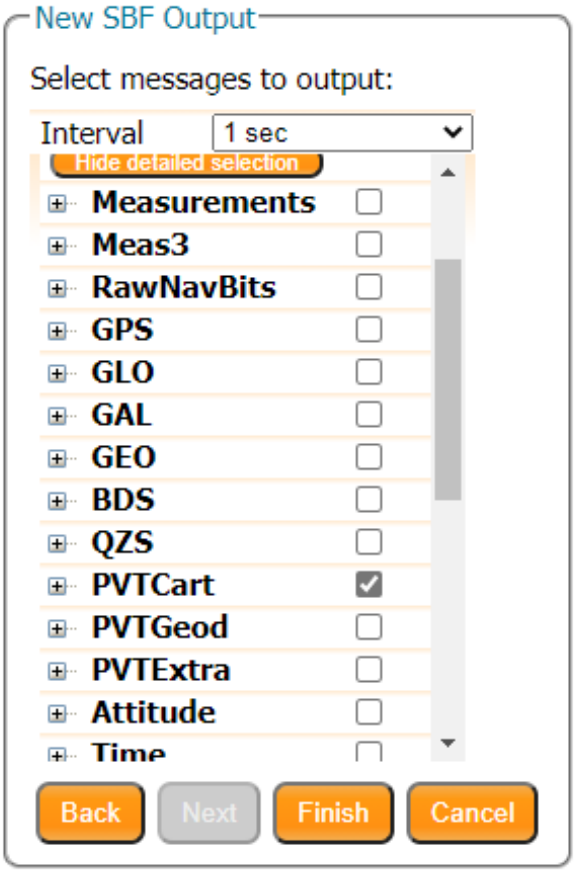


### Step 4: Using RxTools

- Open Rxtools
- Open Data link
- Specify the Serial connection
- Show data

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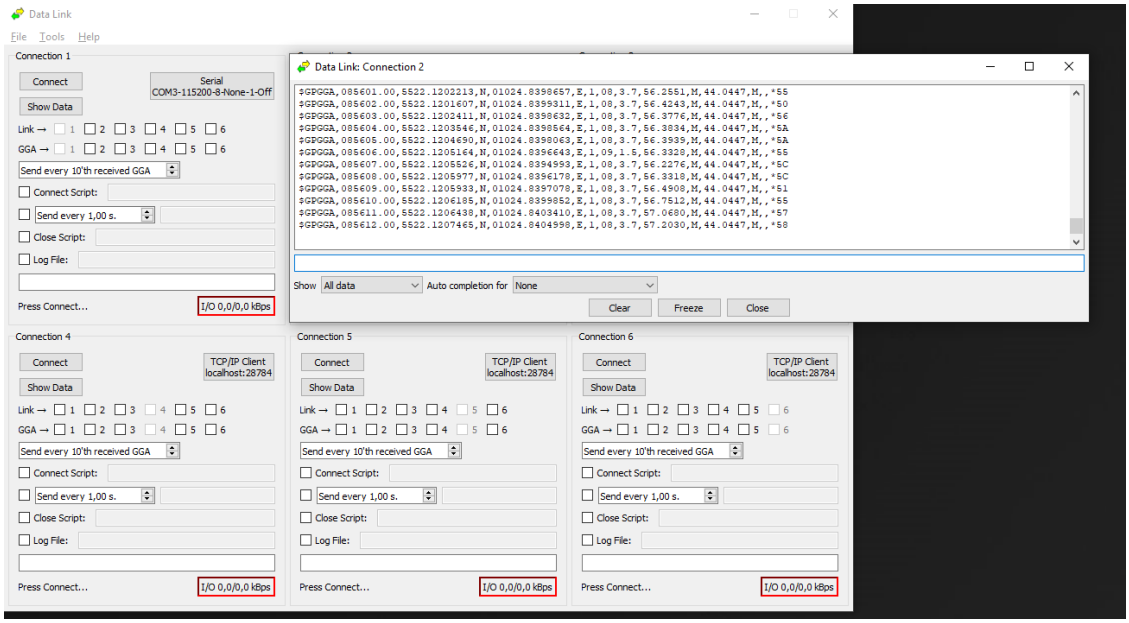


## Sending corrections over cellular

### Step 1: Setting up the AsterX-U as base station

- Connect antennas for **Cell AUX, Cell Main and Main ANT**

`-! Shutdown the device before the next step.`

- Insert SIM card.

### Step 2: Connect to device

- Connect via USB
- Go to the web interface: 192.168.3.1

### Step 3: Setup cellular communication

- From the web interface go to: Communication -> Cellular
- Enter PIN code if required.
- Find APN settings from your cell provider and insert into fields as shown below:

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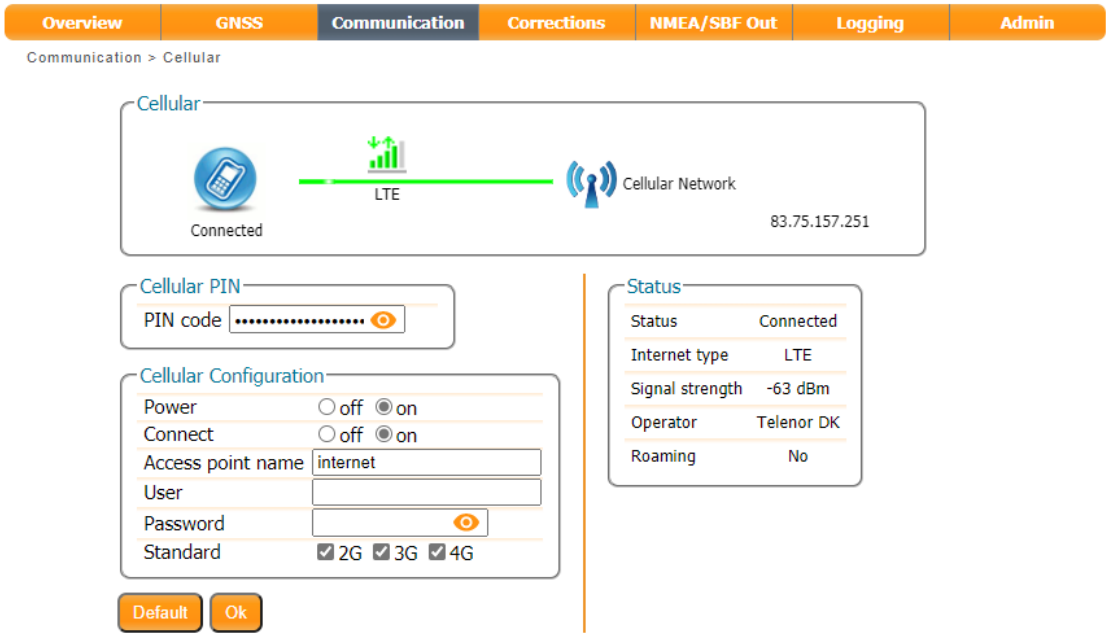

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## Home >> Software setup >> Mobile robot >> Sensors - LIDAR - Ouster

This page contains information on how to setup the Ouster LIDAR.

For any questions or immediate needs please contact Jonas Bæch <joba@teknologisk.dk>

List of contents:


- Environment
- Time synchronization
- Parameter settings


## Environment

Setup using the following environment:

- OS: Linux Ubuntu 20.04
- ROS version: Noetic
- Sensor: Ouster LIDAR OS1 gen2

## Time synchronization

```
- Before using the LIDARs make sure they are synchronized correctly. This can b
e done using the ROS driver and rostopic echo looking for differencies in their
timestamps.

- IF the LIDARs are not synchronized then use the following steps.
```

### Step 1: Update parameter timestamp_node

The parameter timestamp_mode needs to be updated using Netcat. It can be done with the following command:

## Parameter settings

```
nc lidar_ip port
```

**Example with lidar_ips:**

```
nc 192.168.88.12 7501
get_config_param active timestamp_mode
set_config_param TIME_FROM_PTP_1588
reinitialize
```

```
nc 192.168.88.13 7501
get_config_param active timestamp_mode
set_config_param TIME_FROM_PTP_1588
reinitialize
```

If the settings need to persist after sensor reset run after calling reinitialize:
`save_config_params`

After configuring the lidars to use PTP, configure ptp4l on the computer used to run the lidars:

```
sudo ptp4l -i <ethernet interface>  -m
```

**Example:**

```
sudo ptp4l -i enp88s0 -m
```

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## Home >> Software setup >> Mobile robot >> CAN Bus

This page includes instructions on how to setup the CAN Bus connection to the mobile base.

For any questions or immediate needs please contact Jonas Bæch <joba@teknologisk.dk>

List of contents:


- Connection and verification
- Alitrak CAN Bus messages


## Connection and verification

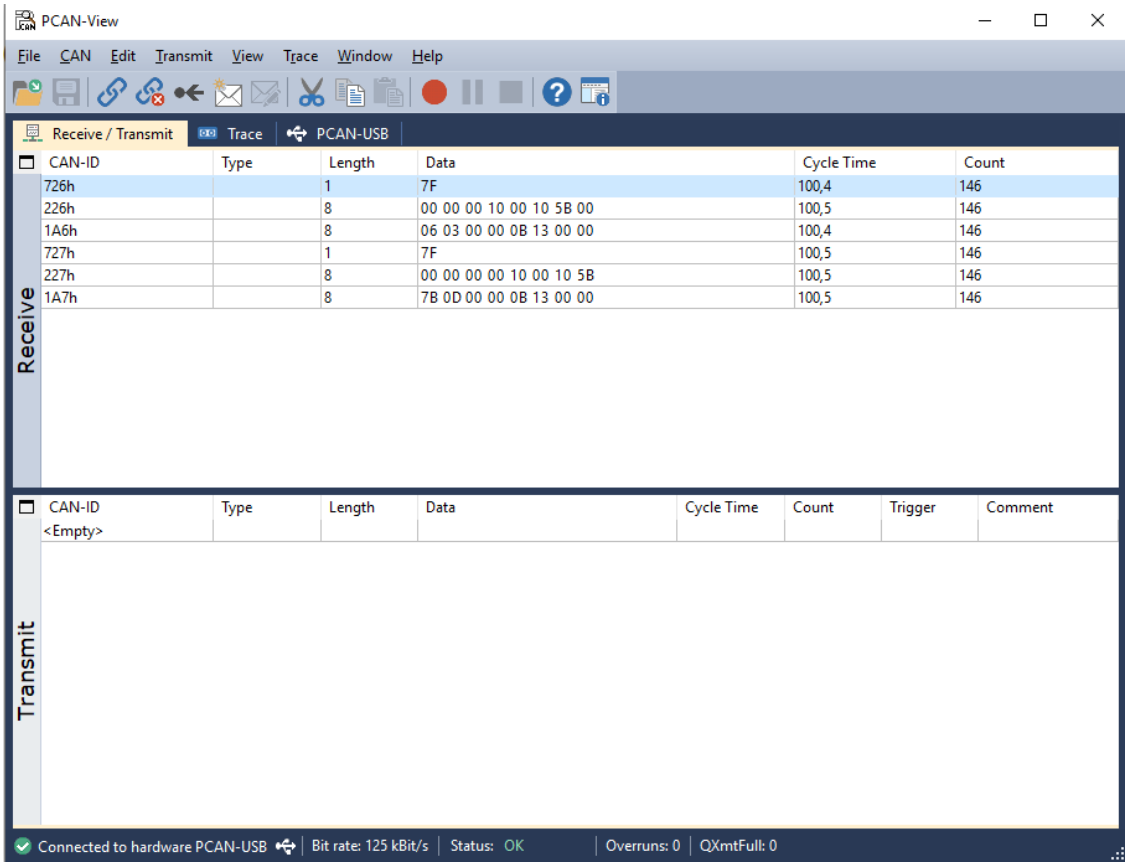
```
- !NOTE: That Alitrak platform must be turned ON and the controller has to be c
onnected before messages are published over the CAN Bus interface!
```

### Step 1: Connect the mobile base with the computer

- Connect the PCAN-USB from PEAK-System to the mobile base's external wiring loom.
- Connect the computer to the PCAN-USB.

### Step 2: Verify the connection

- Download the PCAN-USB tool from PCAN-USB: PEAK-System (peak-system.com)
- If the mobile base is turned **ON** you should be able to receive CAN Bus messages, as shown below:




## Alitrak CAN Bus messages

The dictionary for all available CAN messages can be found in the following images.

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| CURTIS | Specific CAN Messages | VCL Rev 1.05 |
|---|---|---|
| | Customer Name: ALITRAK | 27/11/2019 |
| | Project Name: TRACKED PLATFORM | |

Baud Rate = 125kbs NMT Management = No Controllers Node ID 38d and 39d

| Type | Identifier | Direction | Cycle time [ms] | Signal Byte No. | Signal name | Function description | BYTE | BIT | Raw Data | Display Data | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PDO1 MISO | 0x180 + Node ID | Curtis to PLC | 100 | | | | | | | | |
| | | | | 0 | Rotor_position_raw | Motor spinning position (each rotation is 4096 counts) | LO | | 0-4096 | 0-4096 | |
| | | | | 1 | | | HI | | | | |
| | | | | 2 | Motor_RPM | Motor RPM | LO | | 0-8000 | 0-8000 | rpm |
| | | | | 3 | | | HI | | | | |
| | | | | 4 | Keyswitch_Voltage | Voltage on battery B+ detection | LO | | 0-10500 | 0-105.0 | V |
| | | | | 5 | | | HI | | | | |
| | | | | 6 | Fault_Flash_Code | Reports Fault Code - Curtis manual is showing Faults | | | 0-99 | 0-99 | |
| PDO2 MISO | 0x280 + Node ID | Curtis to PLC | 100 | | | | | | | | |
| | | | | 0 | Current_RMS | RMS controller current | LO | | 0–10000 | 0–1000 | A |
| | | | | 1 | | | HI | | | | |
| | | | | 2 | Controller_Temperature | ControllerTemperature sensor readout | LO | | -1000–3000 | -100–300 | °C |
| | | | | 3 | | | HI | | | | |
| | | | | 4 | Motor_Temperature | Motor internal temperature sensor readout | LO | | -1000–3000 | -100–300 | °C |
| | | | | 5 | | | HI | | | | |
| | | | | 6 | Distance_Fine | Distance (cen be configured by Speed to RPM parameters) | LO | | -32768+32767 | -32768+32767 | |
| | | | | 7 | | | HI | | | | |
| PDO1 MOSI | 0x200 + Node ID | between Curtis controllers | 100 | | | | | | | | |
| | | | | 0 | *Reserved* | | | | | | |
| | | | | 1 | *Reserved* | | | | | | |
| | | | | 2 | *Reserved* | | | | | | |
| | | | | 3 | *Reserved* | | | | | | |
| | | | | 4 | *Reserved* | | | | | | |

Curtis Confidential Last Update:27/11/2020 Page 1

| CURTIS | Specific CAN Messages | VCL Rev 1.05 |
|---|---|---|
| | Customer Name: ALITRAK | 27/11/2019 |
| | Project Name: TRACKED PLATFORM | |

Baud Rate = 125kbs NMT Management = No Controllers Node ID 38d and 39d

| Type | Identifier | Direction | Cycle time [ms] | Signal Byte No. | Signal name | Function description | BYTE | BIT | Raw Data | Display Data | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 5 | *Reserved* | | | | | | |
| PDO2 MOSI | 0x300 + Node ID | PLC to Curtis controllers | 100 | | | | | | | | |
| | | | | 0 | VCL_Throttle | Throttle input to Controller - Negative means Reverse | LO | | -32768+32767 | -100 -100 | % |
| | | | | 1 | | | HI | | | | |
| | | | | 2 | PLC_Command_flags | Flags from PLC | LO | | | | |
| | | | | | *Interlock_Flag* | *enable flag - when ON with non zero VCL_Throttle will activate Main Cont* | | 0 | 0-1 | ON/OFF | |
| | | | | | *Brake_Release_Flag* | *when ON relase the brake for wheels spinning by non zero PWM2* | | 1 | 0-1 | ON/OFF | |
| | | | | | *Mode_Switch_flag* | *Speed change selector ON/OFF means M2/M1 speed selection* | | 2 | 0-1 | ON/OFF | |

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## Home >> Software setup >> Box Exchange Mechanism (BEM)

In this page, we describe software requirements for the box exchange mechanisms on both robotic prototypes.

For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>

## The Box Exchange Mechanism (BEM) is currently under development. Software requirements and setup will become available in the near future.

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## Home >> Software setup >> Dual arm

In this page, we describe all required software setup, i.e., device drivers, operating system, ROS versions, interfaces, etc. for the Dual arm.

For any questions or immediate needs please contact Maria Santamaria <maria.santamaria@pal-robotics.com>

## The Dual arm is currently under development. Software requirements and setup will become available in the near future.

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## Home >> Hardware setup

This page includes the guidelines for the integration of components comprising the robotics prototypes. The components are divided in the following categories:

1. Mobile robot
   - Integration parts list
   - Integration steps
2. Dual arm
3. Box-Exchange-Mechanism (BEM)
4. 3D printed components

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## Home >> Hardware setup >> Mobile robot - Integration parts list

In this page, we provide the list of parts that are required for the completion of each integration phase of the mobile robot.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>
>
> This excludes the parts required for the BEM and Dual arm installation. Please refer to their individual pages found here.

List of contents:


- Parts for mechanical alterations
- Parts for electrical alterations
- Parts for custom wire looms
- Parts for power cables


# Parts for mechanical alterations

> The part list quantities are in items not in number of parts, i.e., an item on the list can contain 10 parts. For the exact number for the individual parts can be found in their corresponding integration steps.

- 1x M8 flange nuts (RS components 725-9644)
- 1x Bosch Rexroth T-head bolt 30mm (RS components 197-1389)
- 1x Bosch Rexroth T-head bolt 50mm (RS components 197-1394)
- 1x Bosch Rexroth M6 slider (RS-components: 390-0408)
- 1x Bosch Rexroth Quick-install M6 slider (RS-components: 449-5115)
- 1x Bosch Rexroth M8 slider (RS-components: 449-5137)
- 1x Bosch Rexroth Quick-install M8 slider (RS-components: 390-0414)
- 1x M12 bolts (RS components 917-3217)
- 1x M12 spacers (RS components 797-6070)
- 10x Bosch Rexroth Angle bracket 20mm (RS components 459-7312)
- 2x Bosch Rexroth end caps (RS components 459-7283)

> The bolts and nuts can be easily sourced locally, therefore the quantities in this list are for actual parts.

- 4x M3x11mm hex headed bolt.

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- 4x M3 nut.
- 2x M6x25mm hex headed bolt.
- 4x M6x25mm hex headed bolt.

## Parts for electrical alterations

The part list quantities are in items not in number of parts, i.e., an item on the list can contain 10 parts. For the exact number for the individual parts can be found in their corresponding integration steps.

- 1x Terminal block end caps (RS-components: 687-9653)
- 2x Terminal block (RS-components: 687-9638)
- 1x Red connection bridge (RS-components: 652-9440)
- 1x Blue connection bridge (RS-components: 804-0403)
- 2x Meanwell DDR240C-24 DC-DC converter (RS-components: 179-2848)
- 1x 1000mm x 35mm x 7,5mm DIN rail (RS-components: 467-416)
- 1x PG 16 Cable Gland (RS-components: 390-123)
- 1x Cable sleeve 10m (RS-components: 668-1273)
- (Optionally, replacing the metal file) 1x Dremel sandpaper bit (RS-components: 420-6729)

The bolts and nuts can be easily sourced locally, therefore the quantities in this list are for actual parts.

- 2x M6x20mm hex headed bolt
- 2x M6 spacer
- 2x M6 nuts

## Parts for custom wire looms

Parts for these assemblies will become available in the near future.

## Parts for power cables

Parts for these assemblies will become available in the near future.

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## Home >> Hardware setup >> Mobile robot - Integration steps

This page includes the guidelines for the integration of mobile platform, including mechanical and electrical operations and physical sensor setup.

Contents of mobile robot integration:

- Integration steps - Mechanical: includes all mechanical alterations required to support the sensors and components on top of the mobile platform, i.e., side decks, GPS mounting.
- Integration steps - Electrical: includes all electrical alterations required to support the sensors and components, i.e., sensor power circuits, Alitrak plug alterations.
- Integration steps - Sensor specific: includes alterations specific to sensors, i.e., mounting and positioning of sensors.
- Integration steps - Components box: includes instructions for the installation of the components box and its included sensors interfaces.

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## Home >> Hardware setup >> Mobile robot - Integration steps >> Mechanical integration

In this page, we describe the individual integration steps for all mechanical alterations of the mobile robot.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>
>
> This excludes the mechanical alterations required for the BEM and Dual arm installation. Please refer to their individual pages found here.

```
-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
oves, eye protection and safety shoes.

+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any
alterations will result in a smoother integration therefore it is HIGHLY ADVISE
D.
```

List of contents:


- Side decks
- GPS+IMU beam


### Installation of side decks

#### Step 1: Collecting part and tools

For the assembly of the operation the side decks you will need:

*Parts*

- 2x Prefabricated 120x1215mm aluminum profiles.
- 1x Prefabricated 120x710mm aluminum profiles.
- 11x M12 bolts (RS components 917-3217)
- 11x M12 spacers (RS components 797-6070)
- 12x Bosch Rexroth end caps (RS components 459-7283)

*Tools*

- Wrench
- Pliers

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### Step 2: Aligning the decks (right and left)

- ! IMPORTANT ! : For the side deck installation there is no need to remove the top plate. Side deck can only be alligned as shown in the previous picture.

- Prepare four bolt assemblies, i.e., bolt plus spacer for each side deck.
- But two or the bolt assemblies through the first and last hole of the 120x1215 aluminum.
- Repeat for both sides.

+ PRO TIP: Use the tracks to hold the weight of the profiles while you perform the alignement and assembly.

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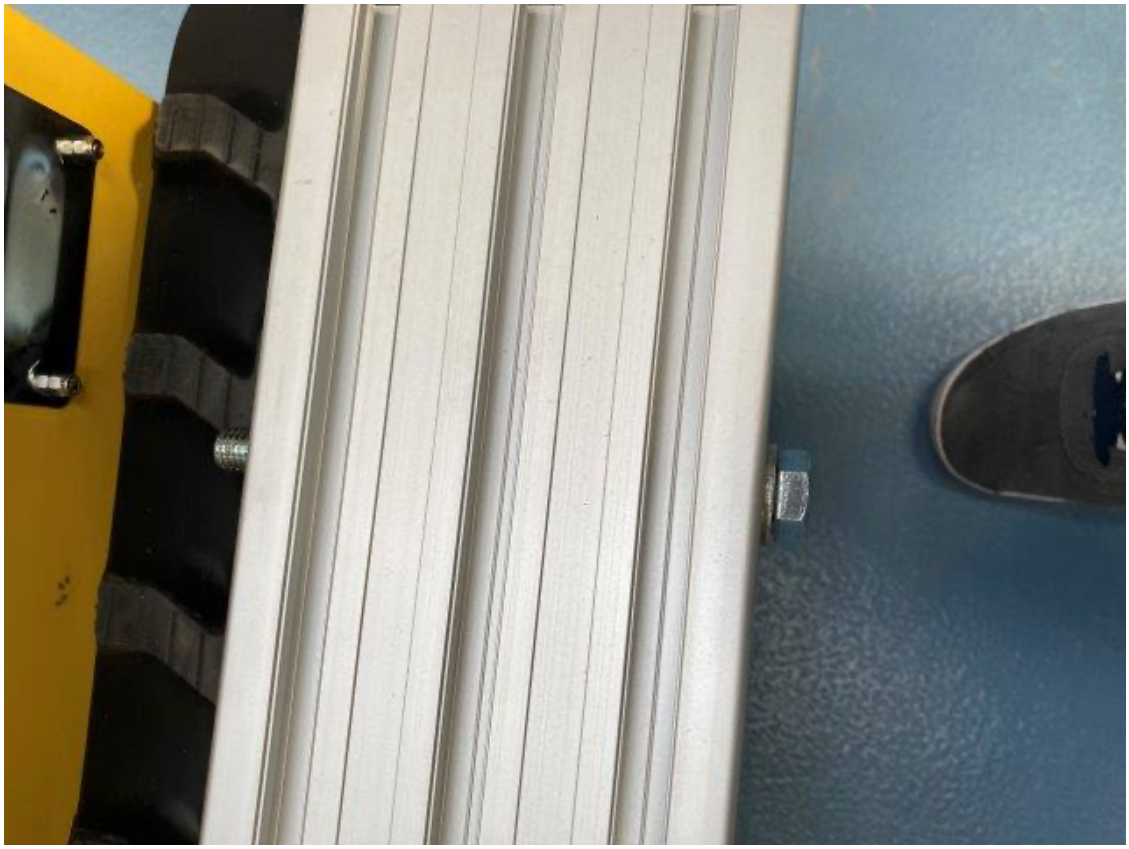

### Step 3: Attaching the decks (right and left)

- Screw the two bolts from Step 2.

- ! IMPORTANT ! : The is a small difficulty to screw the bolts since there is paint on the threads of the Alitrak. Moreover, DO NOT OVERTORQUE the bolts DO NOT USE POWER TOOLS TO TIGHTEN. When the screws seem to increase their resistance and can not visually go in any further do not attempt to overtighten.

- Screw the two remaining bolts to the central holes.
- Repeat for both sides.
- Adding end cups to the uncovered sides of the aluminum profile (except the side facing forward since it will interfere with Step 4).

-! IMPORTANT: If left uncovered the sides of aluminium profiles can injure a person. Therefore THEIR USE IS DEEMED NECESSARY.

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### Step 4: Aligning the decks (front)

- ! IMPORTANT ! : For the front deck installation there is no need to remove the top plate.

- Prepare three bolt assemblies, i.e., bolt and spacer for each side deck.
- Use the pliers to remove the top three dust cups.

+ PRO TIP : If the top plate is already removed then try to remove the cups from the back side pushing them out with a screwdriver. This method is much easier if there is access.

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- Put two of the bolt assemblies through the first and last holes of the 120x710 aluminum profile.

### Step 5: Attaching the decks (front)

- Screw the two bolts from Step 2.

- ! IMPORTANT ! : The is a small difficulty to screw the bolts since there is p aint on the threads of the Alitrak. Moreover, DO NOT OVERTORQUE the bolts DO NO T USE POWER TOOLS TO TIGHTEN. When the screws seem to increase their resistance and can not visually go in any further do not attempt to overtighten.

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- Screw the remaining bolt to the central hole.
- Adding end cups to the uncovered sides of the aluminum profile.

-! IMPORTANT: If left uncovered the sides of aluminium profiles can injure a person. Therefore THEIR USE IS DEEMED NECESSARY.

## GPS+IMU beam

### Overview of final assembly

This chapter covers the instructions for building the structural components of the GPS+IMU beam. Instructions about their individual installations can be found in Sensor integration.

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### Step 1: Collecting part and tools

For the assembly of the operation the side decks you will need:

*Parts*

- 1x Prefabricated 40x710mm aluminum profiles.
- 2x Prefabricated 40x180mm aluminum profiles.
- 4x Bosch Rexroth Angle bracket 20mm (RS components 459-7312)
- 8x M8 Flange nut (included in RS components 459-7312)
- 8x T-head bolt (included in RS components 459-7312)
- 2x Bosch Rexroth end caps (RS components 459-7283)

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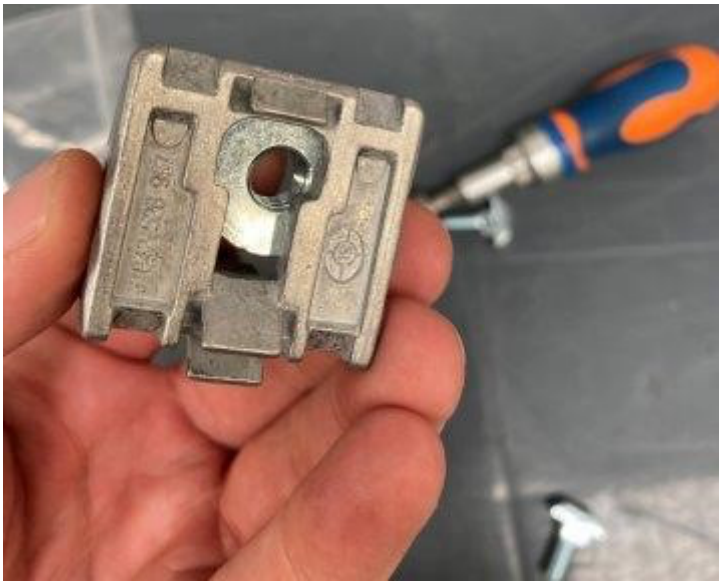
### *Tools*

- 13mm Socket wrench or wrench
- Measuring tape



### Step 2: Assembling the angle brackets

- Use a M8 flange nut to secure a T-bolt in each opening on the angle bracket.





- Repeat for ONLY ONE OF THE openings on the angle brackets.

+ PRO TIP: There is no need to tighten the bolts completely at this point.

- Repeat the assembly process for 4 angle brackets.

### Step 3: Assembling the supports for the main beam

- Use one prefabricated 40x180mm aluminum profile.
- Slide the angle brackets in the aluminum profile. The T-bolt found in the one side of the angle bracket needs to slide in the aluminum profile groove. The tabs on the angle bracket will help with the alignment.

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- Place the angle bracket so that its bottom part is flush with the bottom part of the aluminum profile and tighten the M8 flange nut.

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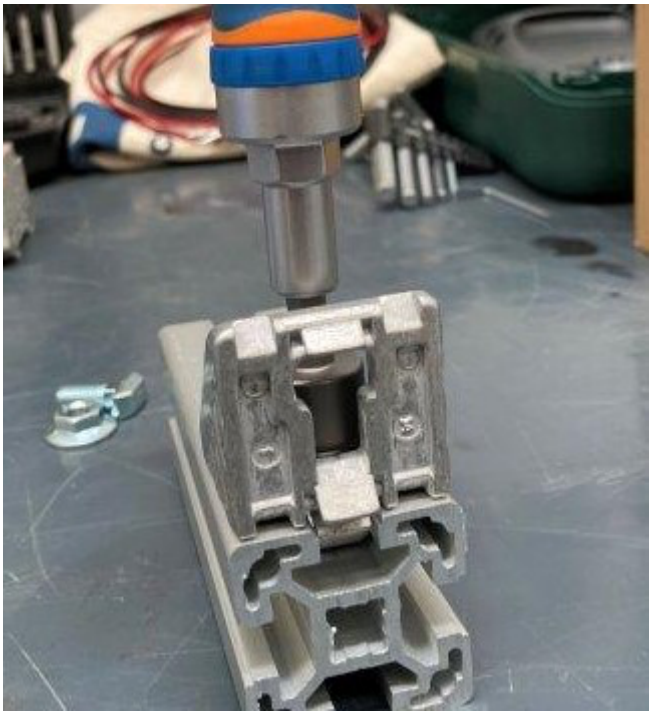

-! DO NOT overtighten the flange nut. The flange nut should fill secure.

+ PRO TIP: The T-head bolts can spin around in the aluminium profile groove. To combat that there is an engraved groove for a flat head screwdriver that will keep the T-head bolt in its place while you can tighten the flange nut with a wrench.

- Flip the assembly to 90 degrees on its side and repeat the previous step attaching an additional angle bracket. The final assembly for the first support should look like this.

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- Repeat the previous steps to create the second support mirroring the first one.

-! WARNING: The orientation of the second support is different from the first one. THE FULL ASSEMBLY SHOULD LOOK LIKE THE FOLLOWING PICTURE

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### Step 3: Assembling the main beam

- Alling the 40x710mm aluminum profile with the assembled beam supports (made in GPS+IMU beam: Step 2)
- From each side of the aluminum profile slide a T-head bolt towards the beam supports.



- Get the T-head bolt into the available groove of the beam support (as shown below). Add a M8 falge nut.

```
+ PRO TIP: Tighten the flange nut until it is .
```

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- The intersection between the edge of the support assembly should be **17cm** from the edge the aluminum profile for both sides. (In the image it can be seen that the intersection is at 54 cm)

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- Tighten both beam support assemblies. **Recheck** that the intersection on both sides in **17 cm**

-! DO NOT overtighten the flange nut. The flange nut should fill secure.

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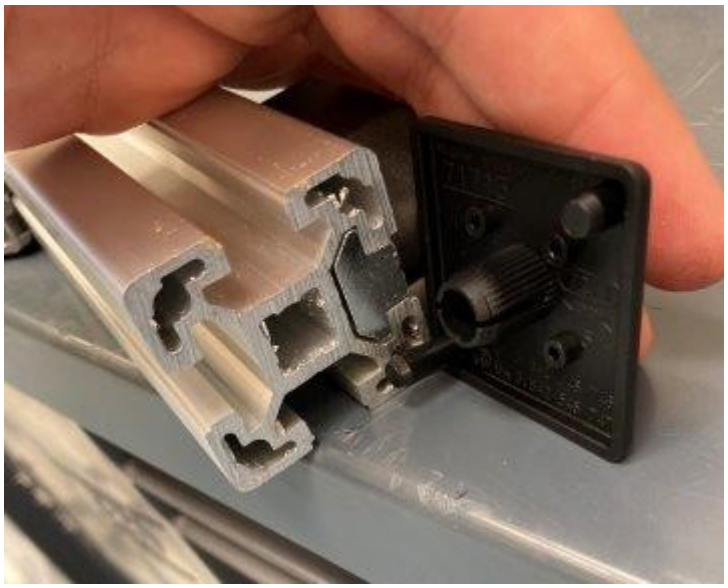
- Adding end cup to both sides of the aluminum profile.

-! IMPORTANT: If left uncovered the sides of aluminium profiles can injure a person. Therefore THEIR USE IS DEEMED NECESSARY.



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## Home >> Hardware setup >> Mobile robot - Integration steps >> Electrical integration

In this page, we describe the individual integration steps for all electrical alterations of the mobile robot.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>
>
> This excludes the electrical alterations required for the BEM and Dual arm installation. Please refer to their individual pages found here.



-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gloves, eye protection and safety shoes.

-! BEFORE STARTING THE PROCESS: PLEASE FOLLOW THE FOLLOWING STEPS. FAILING TO DO SO CAN RESULT IN THE DAMAGE OF THE ONBOARD ELECTRICAL COMPONENTS.

-! BEFORE STARTING THE PROCESS: DO NOT CHARGE THE BATTERIES AND DO NOT CONNECT THE ALITRAK CHARGER AT ANY POINT IN THE FOLLOWING PROCESSES.

-! BEFORE STARTING THE PROCESS: ALL STEPS MUST BE HANDLED WITH EXTREME CAUTION DUE TO DANGER OF ELECTROCUTION.



+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any alterations will result in a smoother integration therefore it is HIGHLY ADVISED.

*Preparatory steps*

- **Pull the Emergency button** in the back of the platform. This will disconnect the batteries from the motors.

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- **Remove the battery plug from the charging box**. This will brake the continuity on the batteries and the rest of the mobile platform's electrical components.



List of contents:

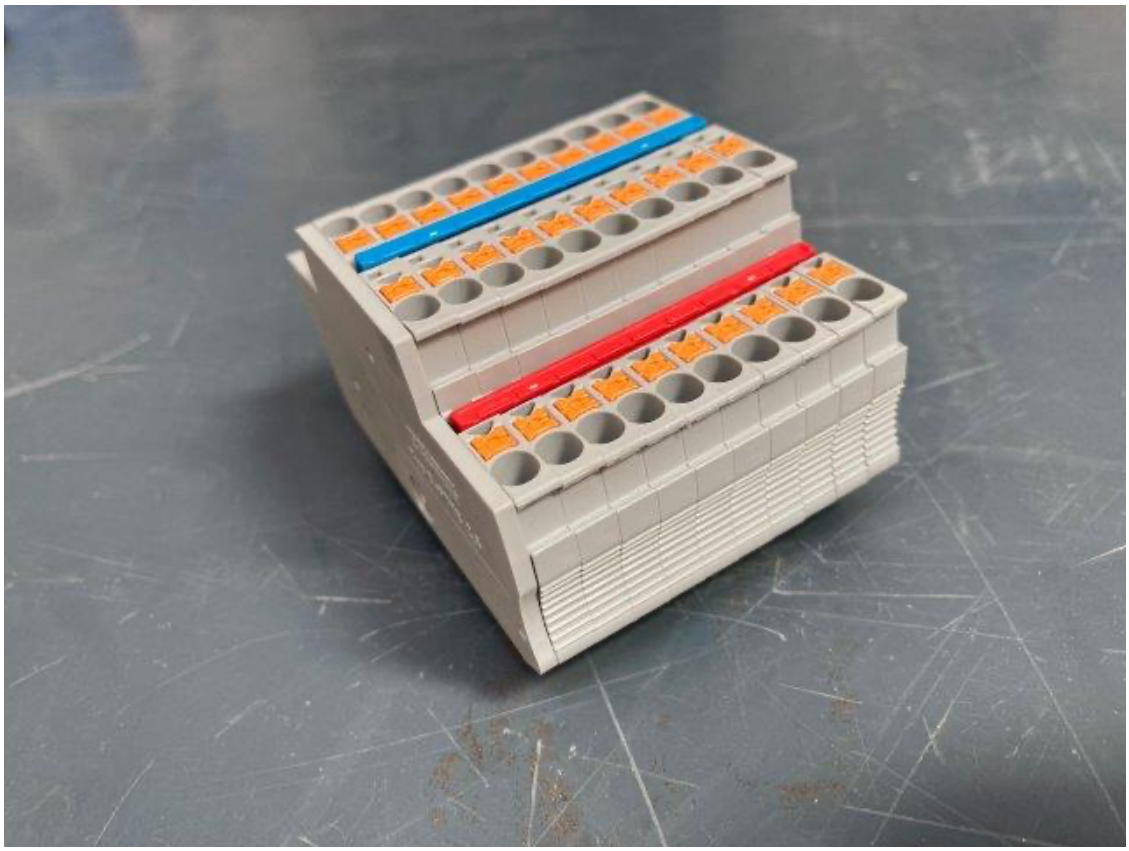

- Distribution block
- Mobile base plug alterations
- Mobile base socket alterations
- Sensor power circuit
- Power cables

- External wiring loom
- Internal wiring loom

# Distribution block

## Overview of final assembly

This chapter covers the instructions for assembling the power distribution blocks.



### Step 1: Collecting part and tools

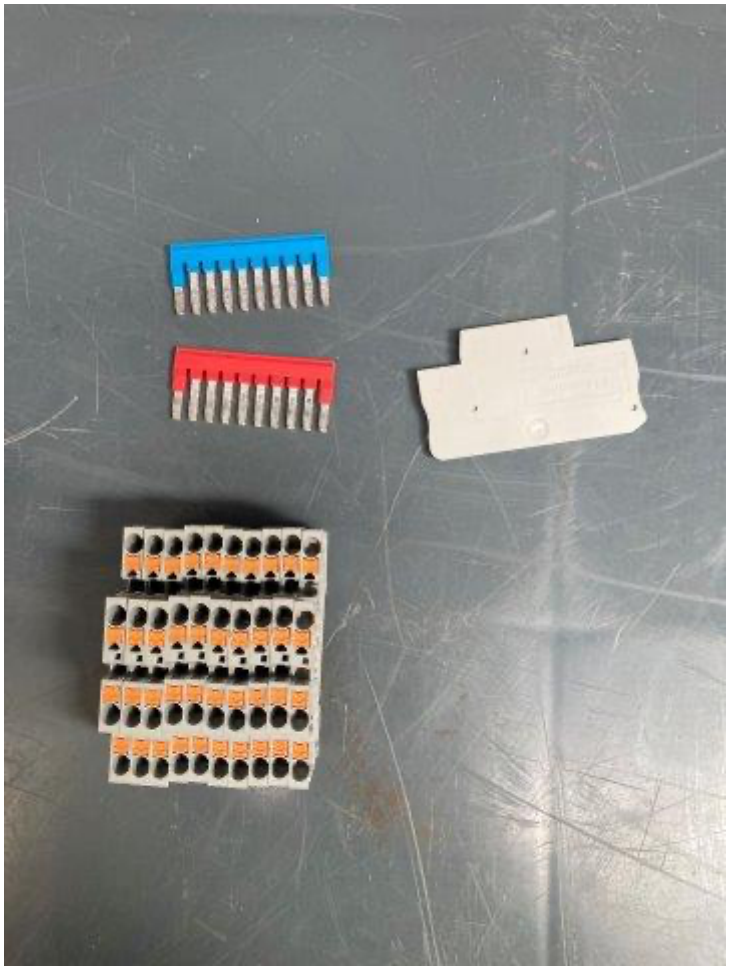
For the assembly of the operation the side decks you will need:

*Parts*

- 1x Terminal block end caps (RS-components: 687-9653)
- 10x Terminal block (RS-components: 687-9638)
- 1x Red connection bridge (RS-components: 652-9440)
- 1x Blue connection bridge (RS-components: 804-0403)
- 1x 100mm x 35mm x 7,5mm DIN rail (RS-components: 467-416)

*Tools*

- Multimeter



**Step 2: Assembling the distribution block**

- Align the terminal blocks one next to each other and then insert the blue connection bridge.

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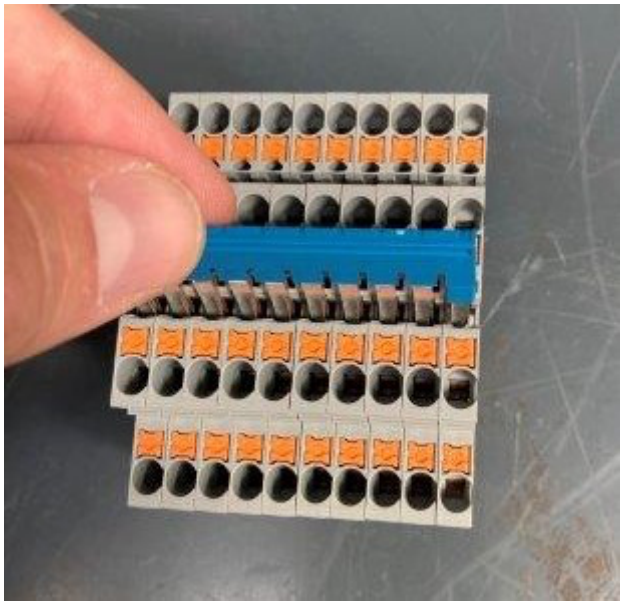

- Push the blue connection bridge until its top part is flush with the top part of the terminal blocks (as seen in the following picture).
- [**Check**] for continuity in the top row between two terminal blocks (preferably the ones furthest to each other) using the multimeter.
  - IF [**No continuity**] then there is a bad connection from the bridge. Push the connection bridge applying more pressure.

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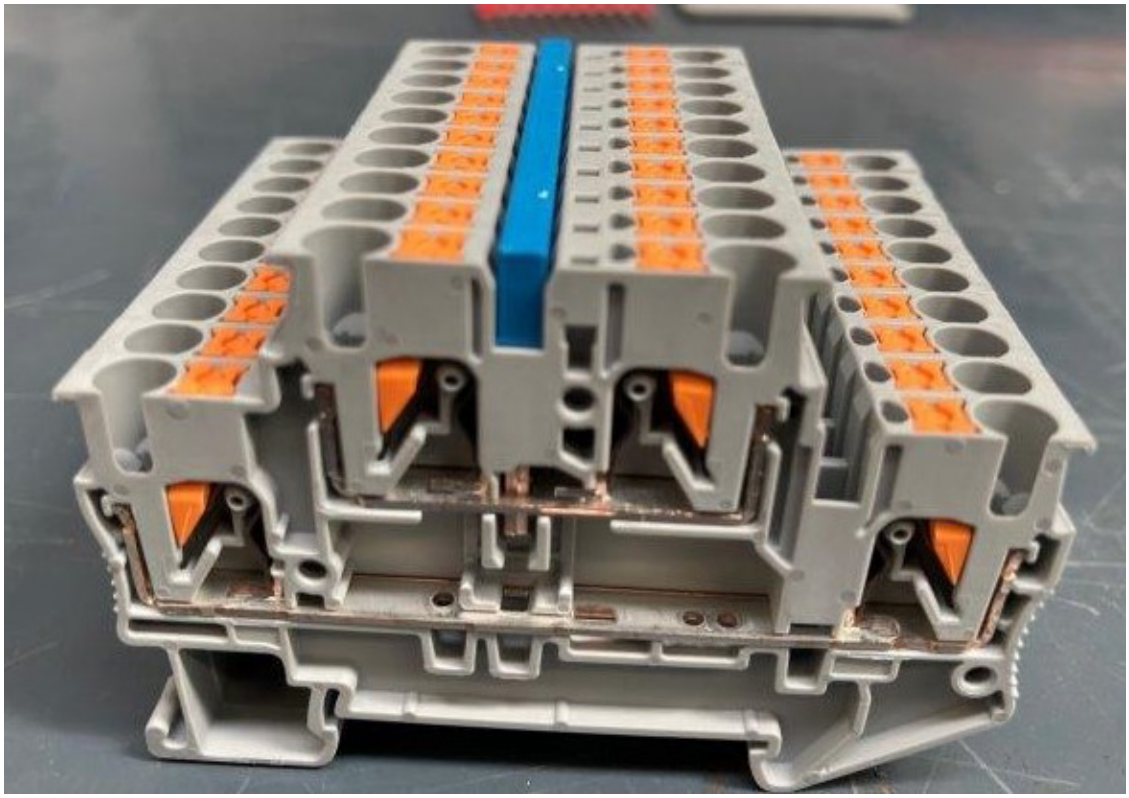
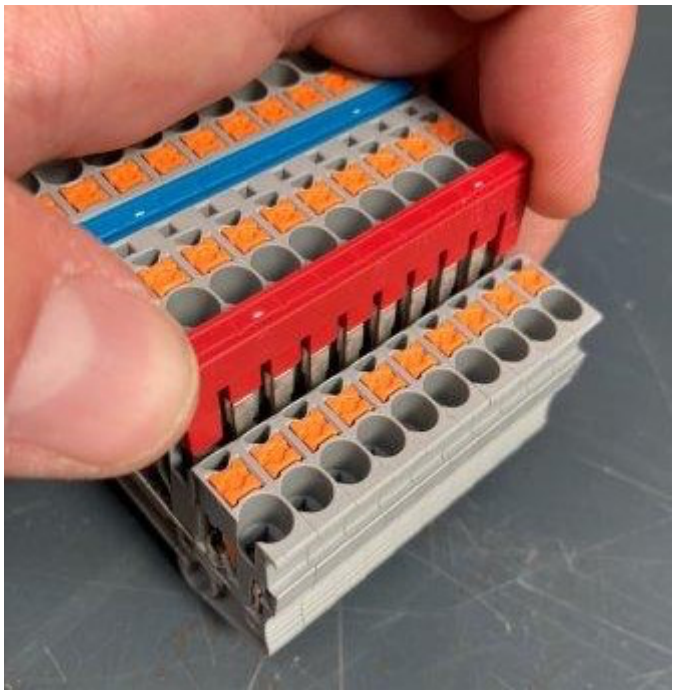


- Push the red connection bridge until its top part is flush with the top part of the terminal blocks (as seen in the following picture).



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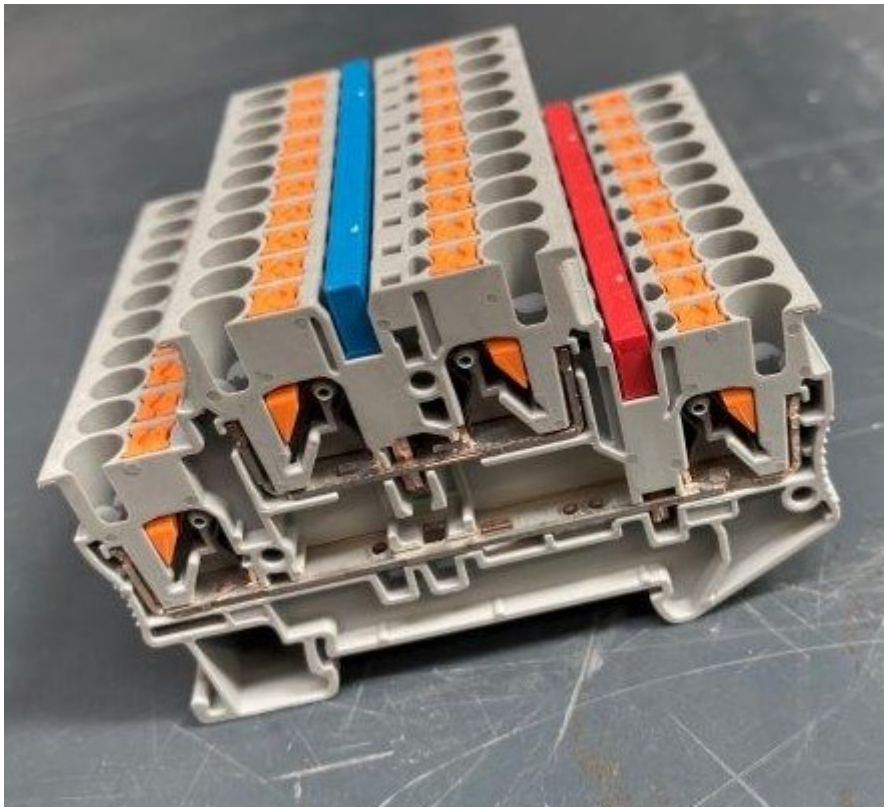
- [**Check**] for continuity in the bottom row between two terminal blocks (preferably the ones furthest to each other) using the multimeter.
  - IF [**No continuity**] then there is a bad connection from the bridge. Push the connection bridge applying more pressure.



- Attach one terminal block end cap to the uncovered side of the terminal block.

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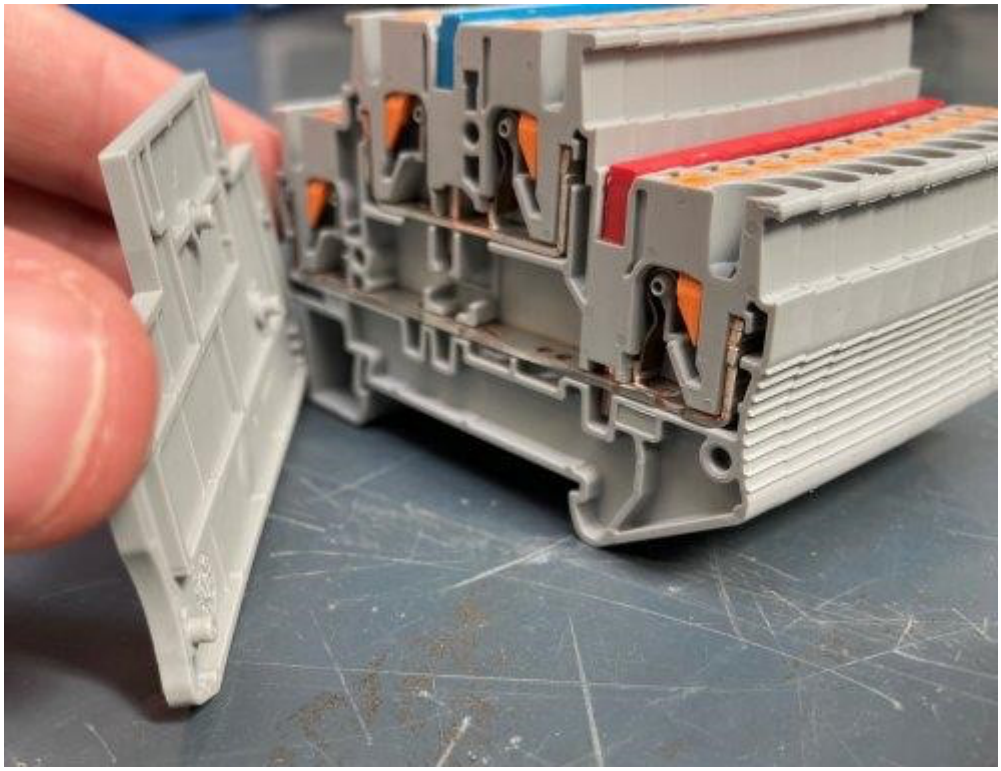

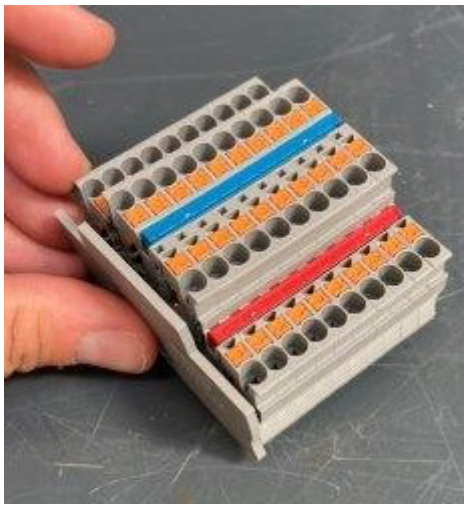

- (Optionally, but preferably) Use a piece of 10cm DIN rail to secure the distribution block. Doing so will give you more mounting options, i.e., securing the distribution block with bolts.

### Step 3: Connecting the distribution block with the sensor power circuit.



-! BEFORE STARTING THE PROCESS: Connecting the distribution block must be handled WITH EXTREME CAUTION DUE TO DANGER OF ELECTROCUTION.



This step assumes that alteration to the mobile base plug has already been completed.

- Connect the red wire from the mobile robot wiring loom to the bottom level of the distribution block.
- Connect the black wire from the mobile robot wiring loom to the top level of the distribution block.

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- [**Check**] Using a multimeter check for the voltage. It should show 24 volts.

## Mobile base plug alterations

### Step 1: Collecting part and tools

*Parts*

- 1x External wiring loom
- 1x PG 16 Cable Gland (RS-components: 390-123)
- 1x Cable sleeve 10m (RS-components: 668-1273)

*Tools*

- Phillips screwdriver
- Flathead screwdriver
- Multimeter

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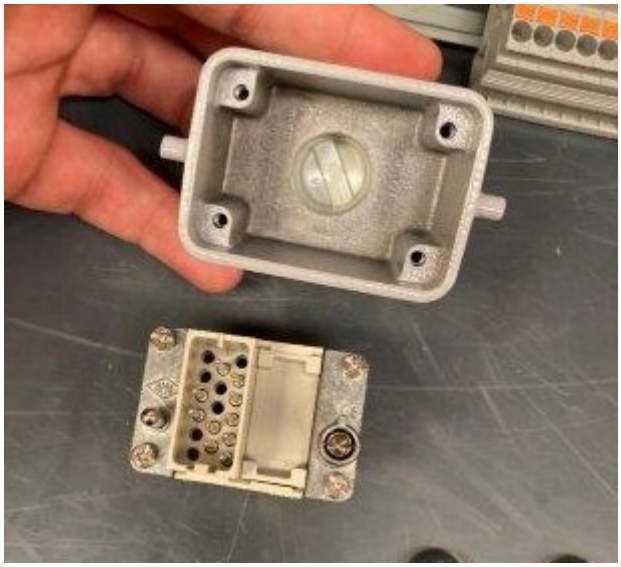
### Step 2: Disassembling the plug

- Using a Phillips screwdriver unscrew the four screws found in each cornet of the plug.

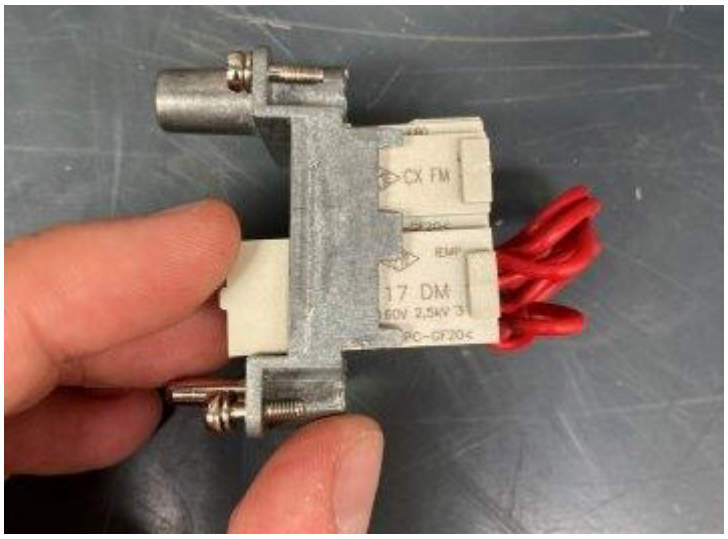




- Using a flathead screwdriver remove the the two locking tabs on the sides of the plug as shown in the following pictures.



- Slide each half of the plug out of the plug frame.



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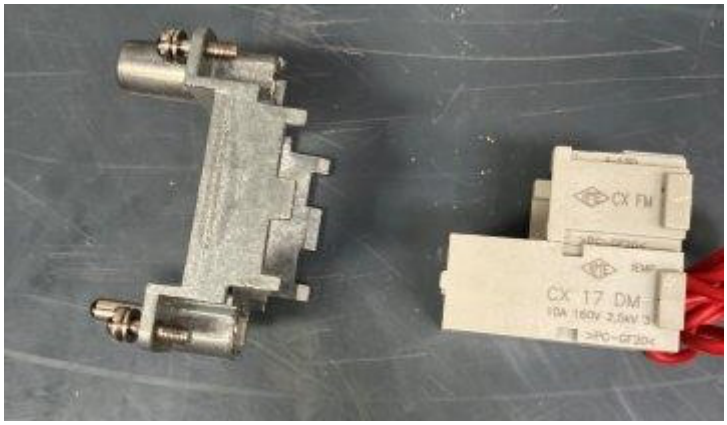
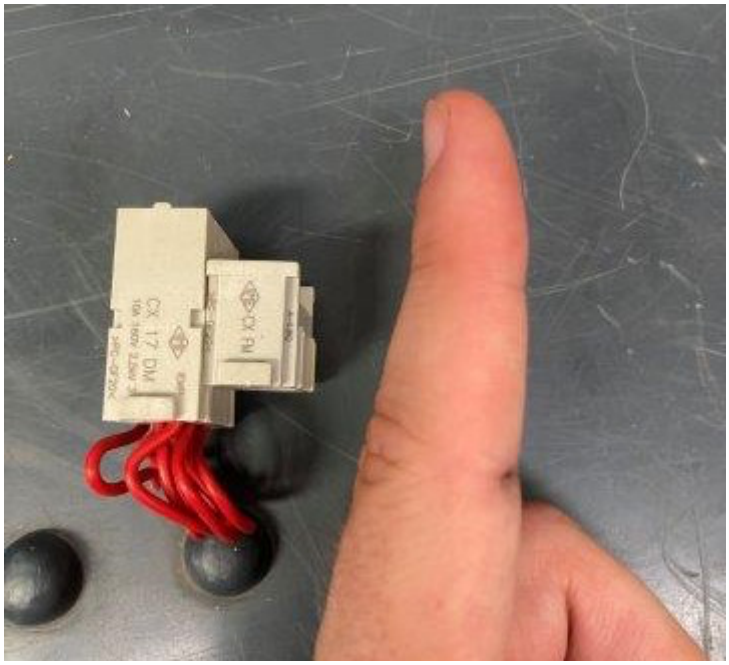



- Separate the two halves by sliding the dummy plug forward.



### Step 3: Reassembling the plug

- Slide the plug of the wiring loom towards in a way that the two halves become a common assembly.

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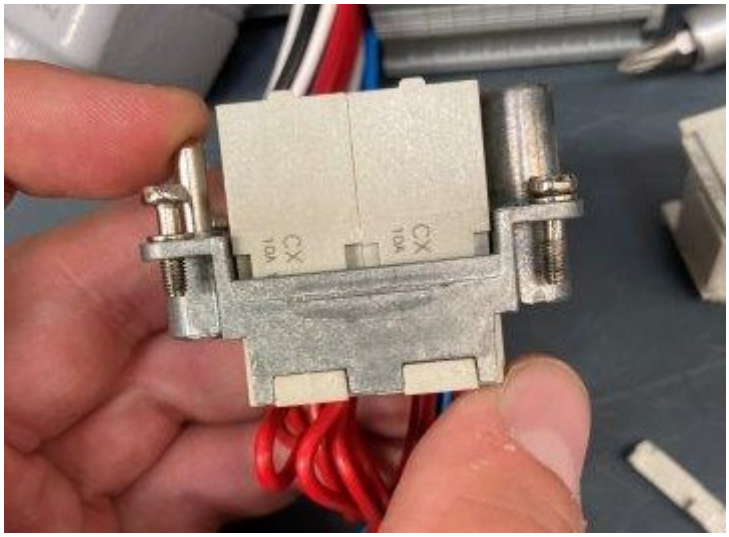
- Attach the new plug assembly in the plug frame. [**Check**] the orientation of the plug assembly before the next step. The plug assembly should become as seen in the following picture.

+ PRO TIP: The half corresponding to the wire loom is on the side of the hollow guiding pin, while the half that was already made by Alirak is on the side of t he solid guiding pin. You can also look at the next picture for a top-view refe rence.



- Reinstall the locking tabs from each side of the plug assembly.

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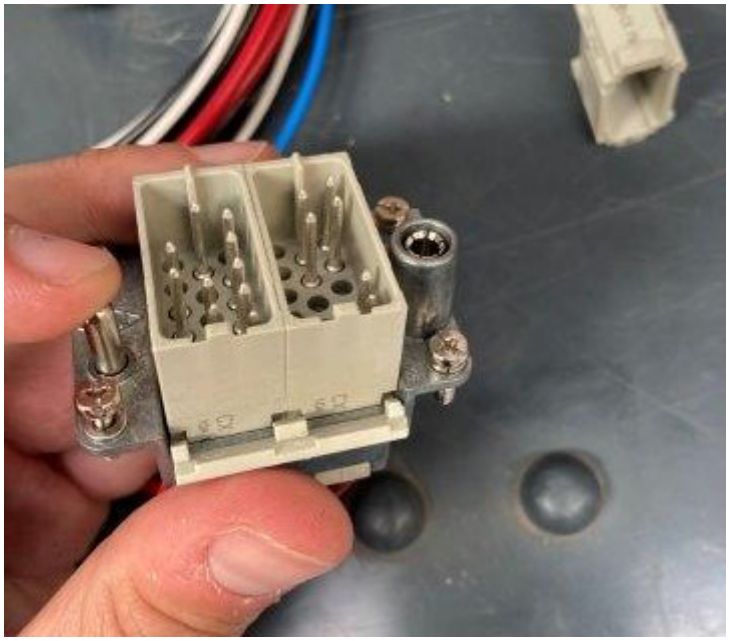

- Remove a flathead screwdriver to remove the cable cover from the back of the plug case.

+ PRO TIP: If you have trouble removing the plug with the screwdriver, consider using a coin instead.



- Pass the cables of the wiring loom through the opening on the back.

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- Set the plug assembly in the plug chassis and screw the four screws on each corner of the plug.

## Mobile base socket alterations

### Step 1: Collecting part and tools

*Parts*

- 1x Internal wiring loom - Loom with pins

*Tools*

- 1x H3 hex key
- 1x 13mm wrench or socket
- Multimeter
- Electrical tape

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### Step 2: Removing the mobile platform's top plate

In case of any questions or concerns regarding the top plate removal please consult the instructions from Alitrak on how to remove and store the plate.

- Use the 13mm wrench or socket to remove the bolts which secure the mobile platform top plate.

```
+ PRO TIP: During disassembly collect all the bolts in a zip lock bag.
```

### Step 3: Socket removal

- Remove the two top M3 bolts from the socket. (see the purple arrows in the following picture)



- Remove the two bottom M3 bolts from the socket. (see the purple arrows in the following picture)

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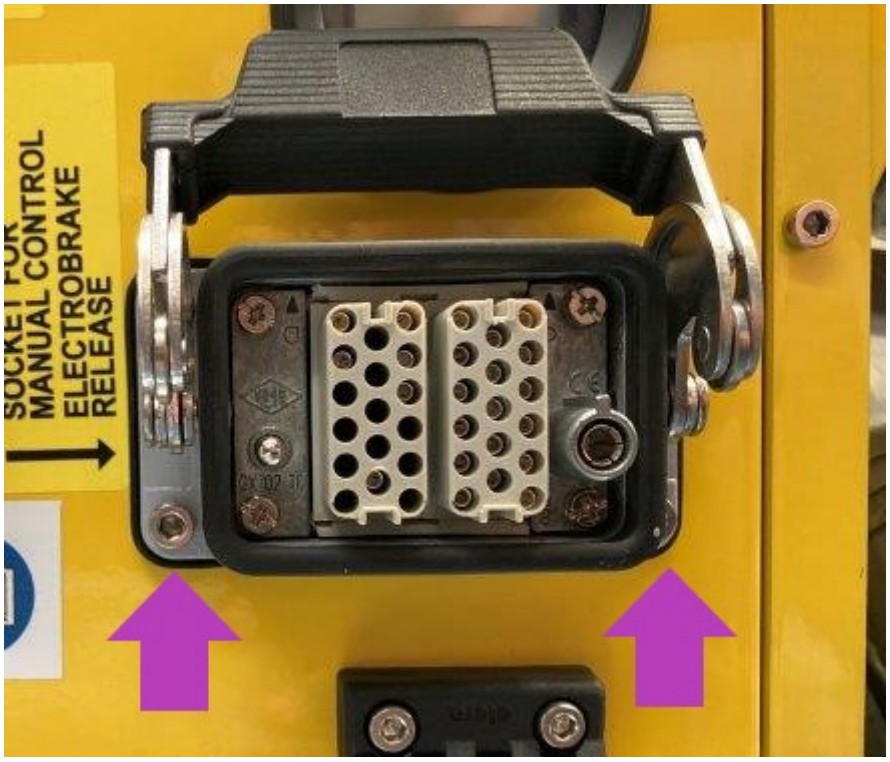


- Place the socket safely facing down.

  -! WHILE REMOVING THE SOCKET, DO NOT CONTINUE IF YOU FEEL ANY RESISTANCE. REMOVING THE SOCKET BY FORCE CAN DAMAGE THE PLUG AND THE CABLES.

  +PRO TIP: use the access provided by the removed top plate to carefully guide the cables outside the main chassis.

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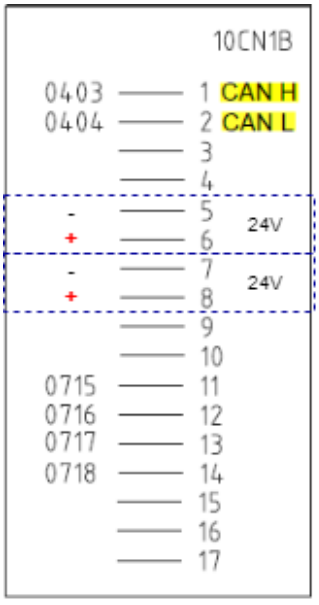
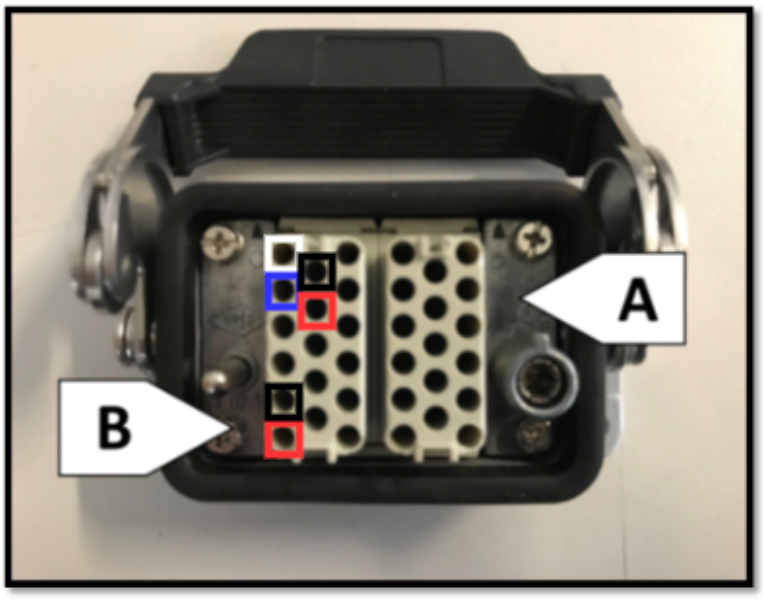
- Study the following diagram.

- !IMPORTANT!: Any deviations from this diagram will cause the sensor power cir cuit and mobile base plug not to function properly.



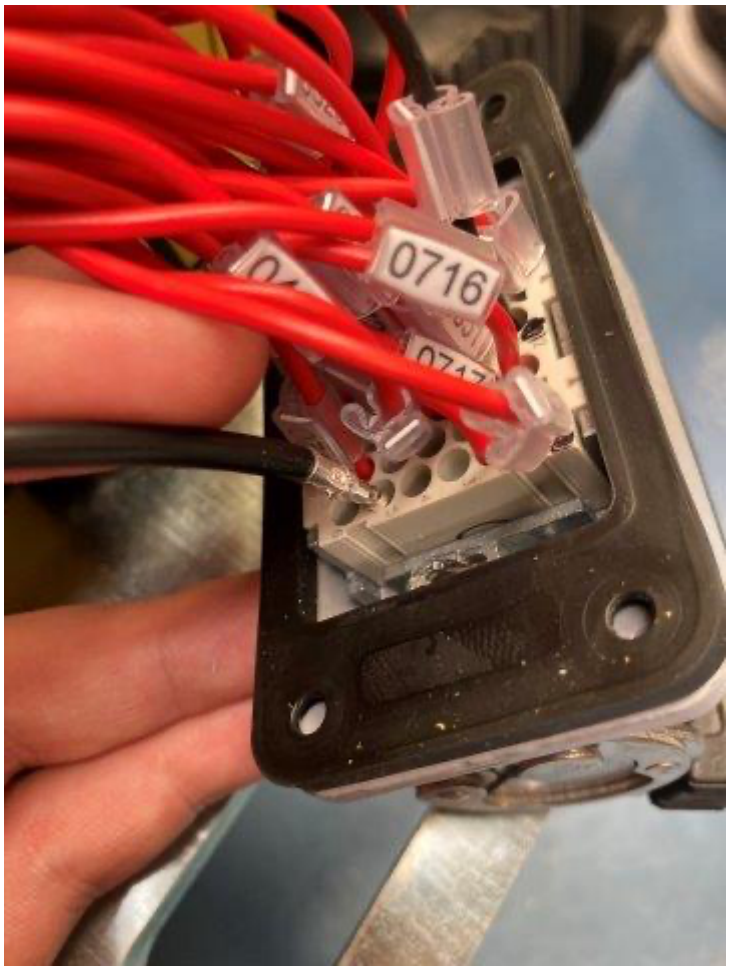



- Insert the pins from the back side of the plug. Push the pins until you feel them connect with the plug.

- !IMPORTANT!: When performing the installation, remember that you see the socket from the back and therefore you need to double check the pin positions before you install them. Once the pins are installed a special tool is required for their removal.

+PRO TIP: The plug in the back a very small etching of numbers corresponding to each pin hole.

+PRO TIP: if you can not feel the pins connected to the plug then try to apply moderate pressure in order to remove them. If you succeed, the pin was not properly seated.




- [**Check**] Using the multimeter, check for continuity between the installed pins and the end of the cables.
  - If the check **fails** then try to seat the pin again.

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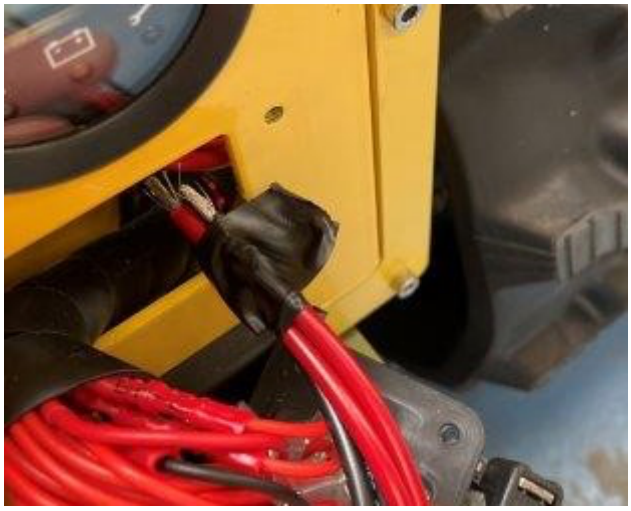
- Use some electrical tape to group the cables pairs from pins 5,6 and pins 7,8. This will make a) the connection with the sensor power circuit easier, and b) will help with the next step.



- Pass the cable pairs through the hole, as shown in the following image.

+PRO TIP: Use the access provided by the missing top plate by grabing the cables once they are through the hole.



- Gently put the socket assembly back into place guiding the cables back into the mobile platform.

+PRO TIP: Use the access provided by the missing top plate to verify that the cables are not pinched on stressed in any way.

- Reinstall the four M3 bolts securing the socket to the chassis.

  -! DO NOT overtighten the bolts. Stop as soon as the bolts fill secure.

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## Sensor power circuit



-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gloves, eye protection and safety shoes.

-! BEFORE STARTING THE PROCESS: PLEASE FOLLOW THE FOLLOWING STEPS. FAILING TO DO SO CAN RESULT IN THE DAMAGE OF THE ONBOARD ELECTRICAL COMPONENTS.

-! BEFORE STARTING THE PROCESS: DO NOT CHARGE THE BATTERIES AND DO NOT CONNECT THE ALITRAK CHARGER AT ANY POINT IN THE FOLLOWING PROCESSES.

-! BEFORE STARTING THE PROCESS: ALL STEPS MUST BE HANDLED WITH EXTREME CAUTION DUE TO DANGER OF ELECTROCUTION.



+ BEFORE STARTING THE PROCESS: It is strongly adviced that you have completed the alterations on the mobile base socket.

### Step 1: Collecting part and tools

*Parts*

- 1x Internal wiring loom - Ground cable, pair of jumper cables, and battery terminal connectors
- 2x 100mm x 35mm x 7,5mm DIN rail (RS-components: 467-416)
- 2x M6x20mm hex headed bolt (or slightly longer)
- 2x M6 spacer
- 2x M6 nuts
- 2x Meanwell DDR240C-24 DC-DC converter (RS-components: 179-2848)
- (Optionally, replacing the metal file) 1x Dremel sandpaper bit (RS-components: 420-6729)

*Tools*

- 1x Phillips screwdriver

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- 1x H5 hex key
- 1x 10mm wrench or socket
- 1x File for metal use
- 1x Cloth or rug able to cover the mobile base electronics
- (Optionally, replacing the metal file) 1x Power drill
- Multimeter

### Step 2: Removing the mobile platform's top plate

In case of any questions or concerns regarding the top plate removal please consult the instructions from Alitrak on how to remove and store the plate.

- Use the 13mm wrench or socket to remove the bolts which secure the mobile platform top plate.

```
+ PRO TIP: During disassembly collect all the bolts in a zip lock bag.
```

### Step 3: Installing the ground

- Step aside the plate holding the RC receiver of the mobile platform.

```
- WARNING: the receiver is connected and must remain connected to the mobile ba
se. DO NOT ATTEMPT TO REMOVE.
```

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- Use a cloth or rug to cover the area underneath the holes in the crossbeam above the mobile base's electronics.




- [**Before the next step**] the hole we want to alter is the one found **on the crossbeam and also closest to the chassis**. In the following picture it is shown the expected result.

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- Use a metal file (OR the sandpaper drill bit on a drill) to remove the paint.

+ PRO TIP: there is no difference in which tool you use to remove the paint. Using power tools is just a convenient way.

- IMPORTANT: a good ground requires a clean metal-to-metal contact. Therefore, make sure that the paint is removed from the surface.



- Remove the nut from the back of the ground wire assembly. The next figure shows the ground assembly (green wire).

- IMPORTANT: for a good connection, the series of the washers should not be altered.

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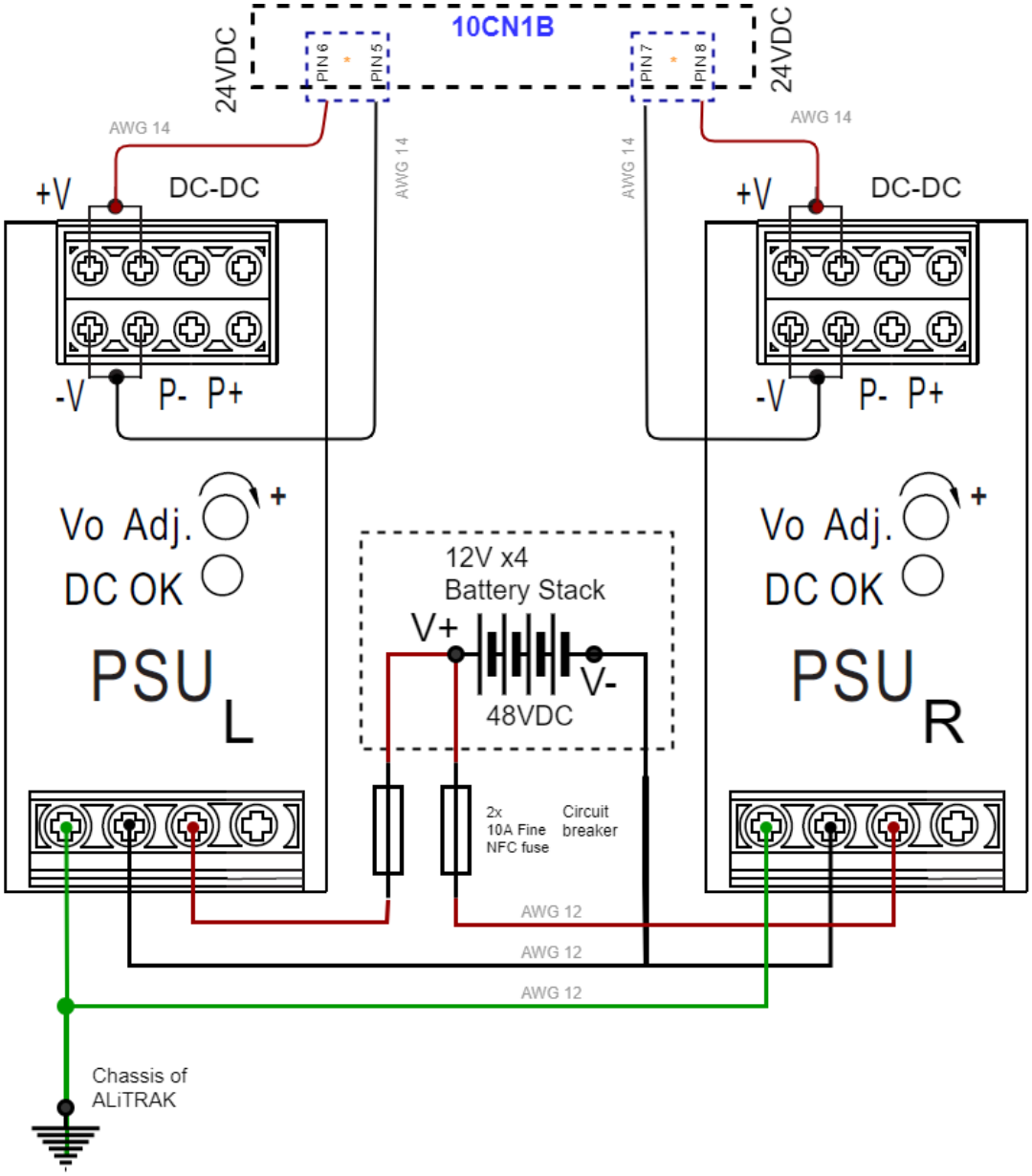
- Screw the ground wire assembly using the included bolt to the hole that we prepared in the previous steps.

### Step 4: Preparing the DC-DC convertors

Since we are installing two DC-DC convertors, the following steps must be duplicated for both.

- Study the following diagram.

- !IMPORTANT!: Any deviations from this diagram will cause the sensor power cir cuit and mobile base plug not to function properly.




| | | |
|---|---|---|
| Circuit | ALiTRAK external navigation power distribution | Rev 1.0 |
| Creation date | 23-06-2021 | Odense - Denmark |
| Open circuit | nil | -- |
| Closed circuit | Two DC-DC converter active (max 20A) | 48V-24V fused |
| References | [DDR-240-spec], [Wiring diagram], [Heavy duty contact, pin, crimp 14AWG] | |

- ! BEFORE YOU PROCEED: Check that all your cables are routed underneath the mo bile base's crossmember and will not affect the reinstallation of the top plate .

- Unscrew the **ground terminal** of the DC-DC convertor. Install one of the ground wires and fasten the screw on the terminal, so that the cable is secure.




- Unscrew the **-Vin** of the DC-DC convertor. Install the black wire of M6 battery terminals and fasten the screw on the terminal, so that the cable is secure.



- Unscrew the **+Vin** of the DC-DC convertor. Install the red wire of M6 battery terminals and fasten the screw on the terminal, so that the cable is secure.

- Unscrew the **+Vo** and **-Vo** terminals of the DC-DC convertor. Install the pair of jumper cables as shown in the picture. Tighten the screw only for the left terminals for both **+Vo**, **-Vo** and proceed to the next step.

```
+ PRO TIP: The -Vo terminals get in the way of the +Vo, limiting the access to
the screw. Therefore, first install the +Vo terminals.
```




- Unscrew the **+Vo** and **-Vo** terminals of the DC-DC convertor. Install the pair of jumper cables as shown in the picture. Do not tighten the screw terminals yet and proceed to the next step.
- While keeping the jumper cables in place, install the cables from the mobile base's socket to the corresponding DC-DC convertor. Keeping all the cables in terminal

```
- !IMPORTANT!: Any deviations from the diagram will cause the sensor power circ
uit and mobile base plug not to function properly.
```

```
+ PRO TIP: The -Vo terminals get in the way of the +Vo, limiting the access to
the screw. Therefore, first install the +Vo terminals.
```

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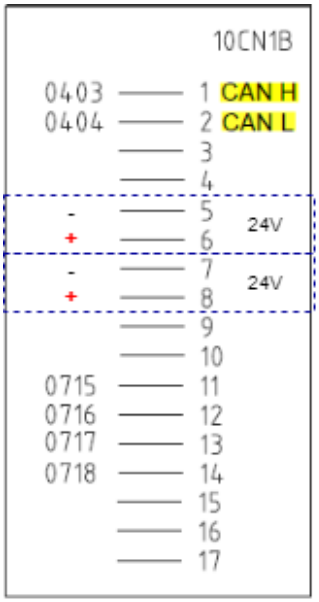
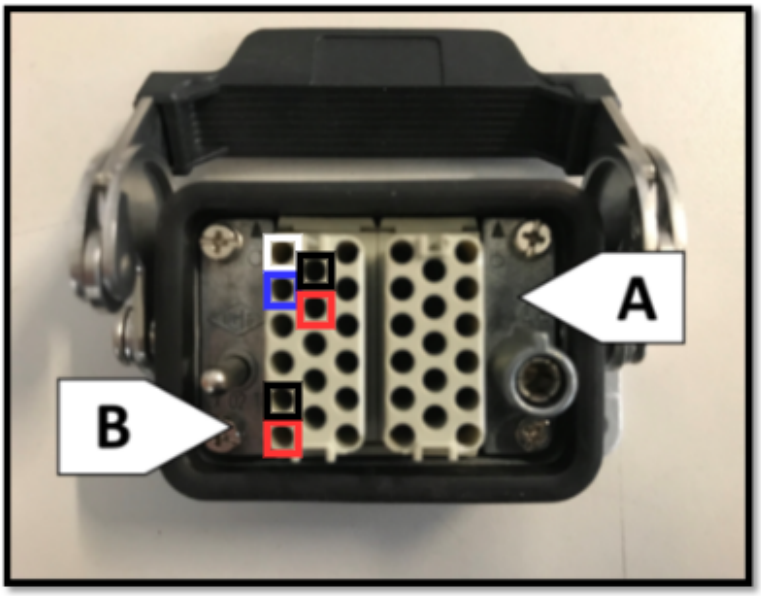
Do not get confused by the picture. The picture shows the installation of the power cables without the jumper cables which were installed in the previous step. However, for the correct operation you need to have the jumper cables as well as the cables from the socket secured in the same terminal positions (as shown in the diagram).




- [**Check**] for continuity between the DC-DC convertor terminals and the socket in the back of the mobile platform. On the side of the DC-DC convertor use the screws on each terminal. While in the side of the socket find the appropriate hole corresponding to each wire using the following diagram.




In case that the check [**FAILS**]:

- Check for continuity between the terminals on the DC-DC convertor. Recheck all your connections by pulling the wires with moderate force.
- Check for continuity between the socket positions and their corresponding wires. Recheck all your connections by pulling the wires with moderate force.

### Step 5: Secure the the DC DC convertors

- Apply some force and rotate the positive battery terminal by approximately 90 degrees. The DC-DC convertors should have enough space to rest on the batteries. (see next steps)

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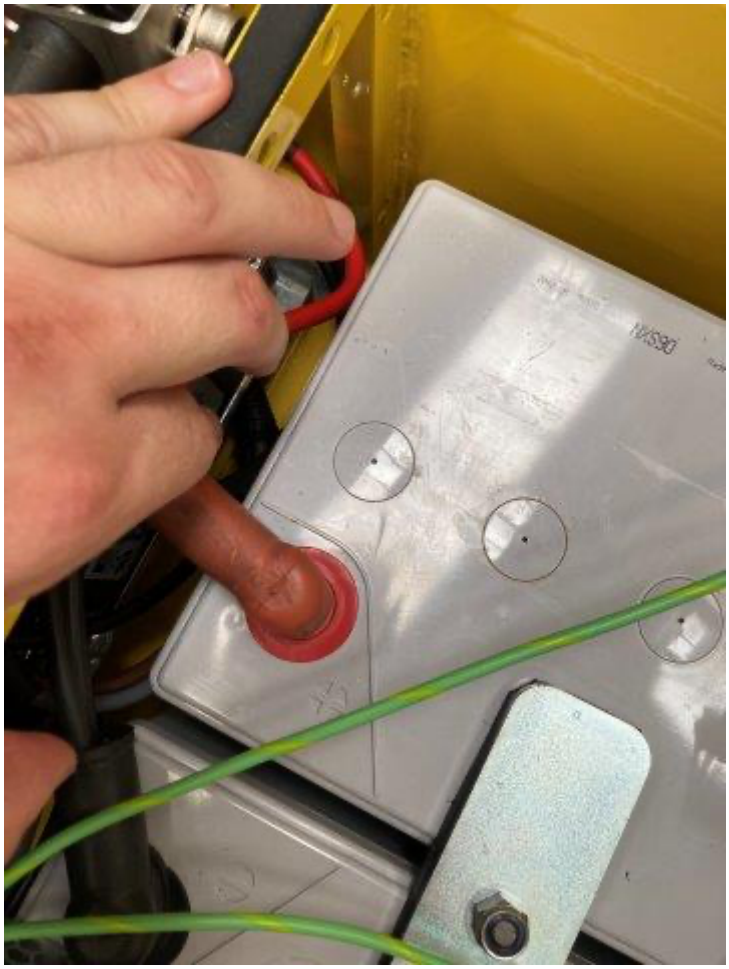

- Attach the 100mm x 35mm x 7,5mm DIN rail on the back of the DC-DC converter. Using the M6 bolt secure the DIN rail (and thus the DC-DC convertor) on the mobile base's chassis.

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### Step 6: Attaching the DC-DC connectors to the batteries



-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gloves, eye protection and safety shoes.

-! BEFORE STARTING THE PROCESS: PLEASE FOLLOW THE FOLLOWING STEPS. FAILING TO DO SO CAN RESULT IN THE DAMAGE OF THE ONBOARD ELECTRICAL COMPONENTS.

-! BEFORE STARTING THE PROCESS: DO NOT CHARGE THE BATTERIES AND DO NOT CONNECT THE ALITRAK CHARGER AT ANY POINT IN THE FOLLOWING PROCESSES.

-! BEFORE STARTING THE PROCESS: ALL STEPS MUST BE HANDLED WITH EXTREME CAUTION DUE TO DANGER OF ELECTROCUTION.

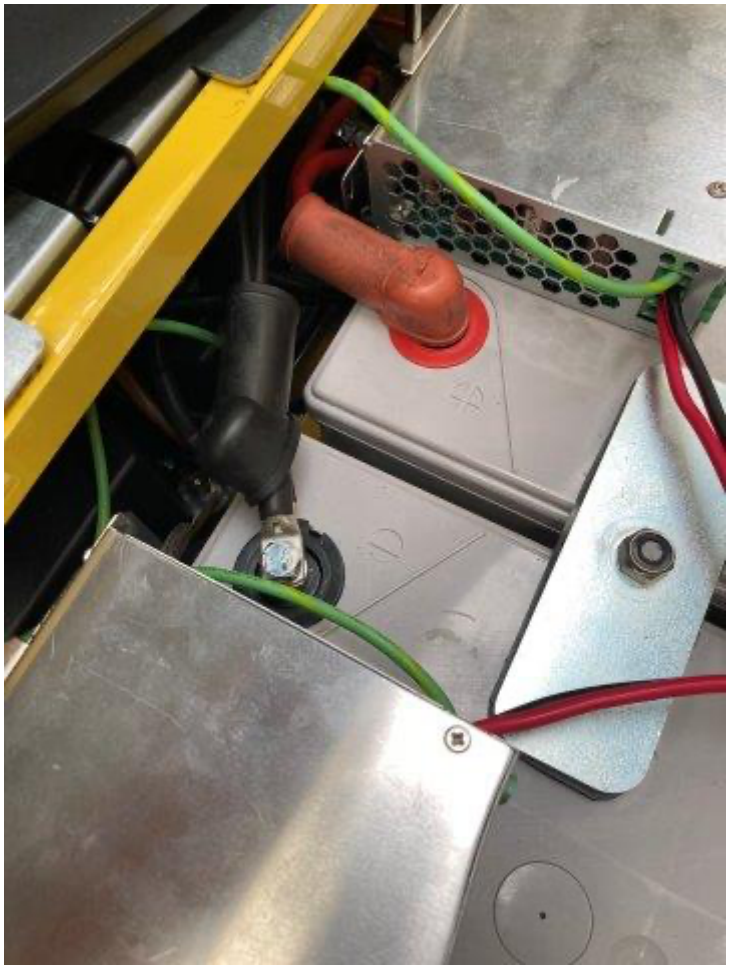


- Use a 10mm socket wrench or wrench to remove the negative terminal (black wires) from the mobile base battery. Remove the terminal in between the DC-DC convertors.

- !IMPORTANT!: The socket wrench or wrench must have a rubber handle.

- !IMPORTANT!: IT IS STRONGLY ADVISED NOT TO DISCONNECT BOTH BATTERY TERMINALS AT THE SAME TIME OR AT ANY OTHER STAGE OF THIS PROCESS.

- !IMPORTANT!: By removing the plastic covers from the battery terminals, you expose the batteries to potential short circuits. Therefore, HANDLE THIS AND THE FOLLOWING PROCESSES WITH EXTREME CARE.



- Remove the bolt from the terminal. [**Beware**] the terminal has several spacers that might fall during disassembly.

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- Remove the spacers from the battery terminal assembly. Attach the **black** M6 ring terminals from each of the DC-DC convertors on the bolt.



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- Reinstall the terminal back to batteries. [**WARNING**] during the installation sparks might appear (especially in the beginning while reconnecting the terminal). Therefore, it is very important to [**KEEP ALL SAFETY MEASURES LISTED ABOVE**]
- Use a 10mm socket wrench or wrench to remove the positive terminal (red wires) from the mobile base battery. Remove the terminal in between the DC-DC convertors.

- !IMPORTANT!: The socket wrench or wrench must have a rubber handle.

- !IMPORTANT!: By removing the plastic covers from the battery terminals, you expose the batteries to potential short circuits. Therefore, HANDLE THIS AND THE FOLLOWING PROCESSES WITH EXTREME CARE.

- Remove the bolt from the terminal. [**Beware**] the terminal has several spacers that might fall during disassembly.
- Remove the spacers from the battery terminal assembly. Attach the **red** M6 ring terminals from each of the DC-DC convertors on the bolt.

- Reinstall the terminal back to batteries. [**WARNING**] during the installation sparks might appear (especially in the beginning while reconnecting the terminal). Therefore, it is very important to [**KEEP ALL SAFETY MEASURES LISTED ABOVE**]

## Power cables

Due to the various sensor and component power cable types, specifications are not yet available.

Specifications and schematics about the development of power cables will become available in the near future.

For any questions or immediate needs please contact tsko@teknologisk.dk

## External wiring loom

The external wiring loom is provided preassembled by DTI. However, the specifications and schematics of external wiring loom will become available in the near future.

For any questions or immediate needs please contact tsko@teknologisk.dk

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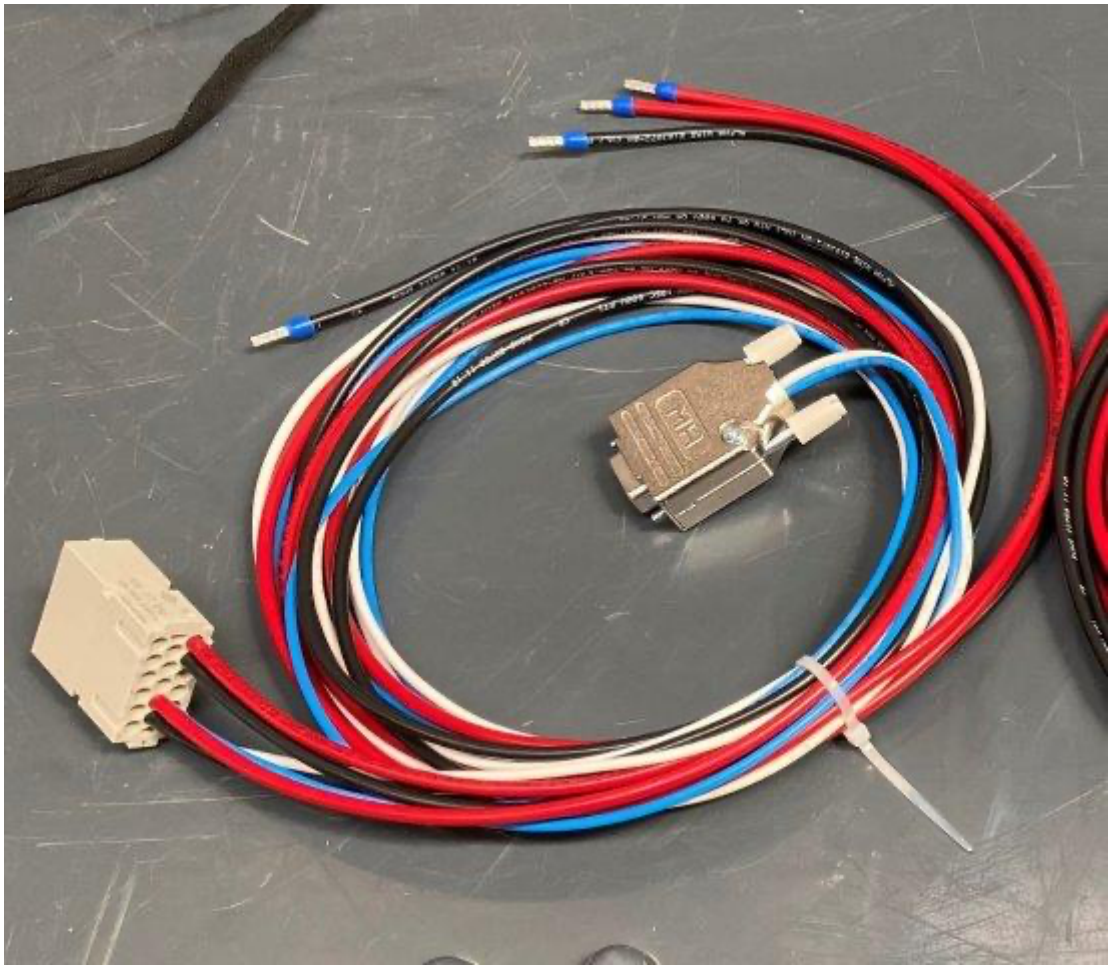

## Internal wiring loom

The internal wiring loom is provided preassembled by DTI. However, the specifications and schematics of external wiring loom will become available in the near future.

For any questions or immediate needs please contact tsko@teknologisk.dk

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## Home >> Hardware setup >> Mobile robot - Integration steps >> Sensor integration

In this page, we describe the individual integration steps for all sensor on the mobile robot.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>
>
> This excludes the sensor integration required for the BEM and Dual arm installation. Please refer to their individual pages found here.

```
-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
oves, eye protection and safety shoes.

+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any
alterations will result in a smoother integration therefore it is HIGHLY ADVISE
D.
```

List of contents:


- Ouster LIDAR installation
- IMU assembly and installation
- GNSS antenna assembly and installation


# Ouster LIDAR installation

### Overview of final assembly

This chapter covers the instructions for the installation of the Ouster LIDARs on the mobile platform.

```
-! THIS STEP'S PREREQUISITE is Hardware setup >> Mobile robot - Integration ste
ps >> Mechanical integration # Installation of side decks

-! BEFORE STARTING THIS PROCESS: Please keep all measures of safety including g
loves, eye protection and safety shoes.
```

Instructions about this installation's prerequisite can be found in Mechanical integration.

Installed components are highlighted (blue color) in the following image.

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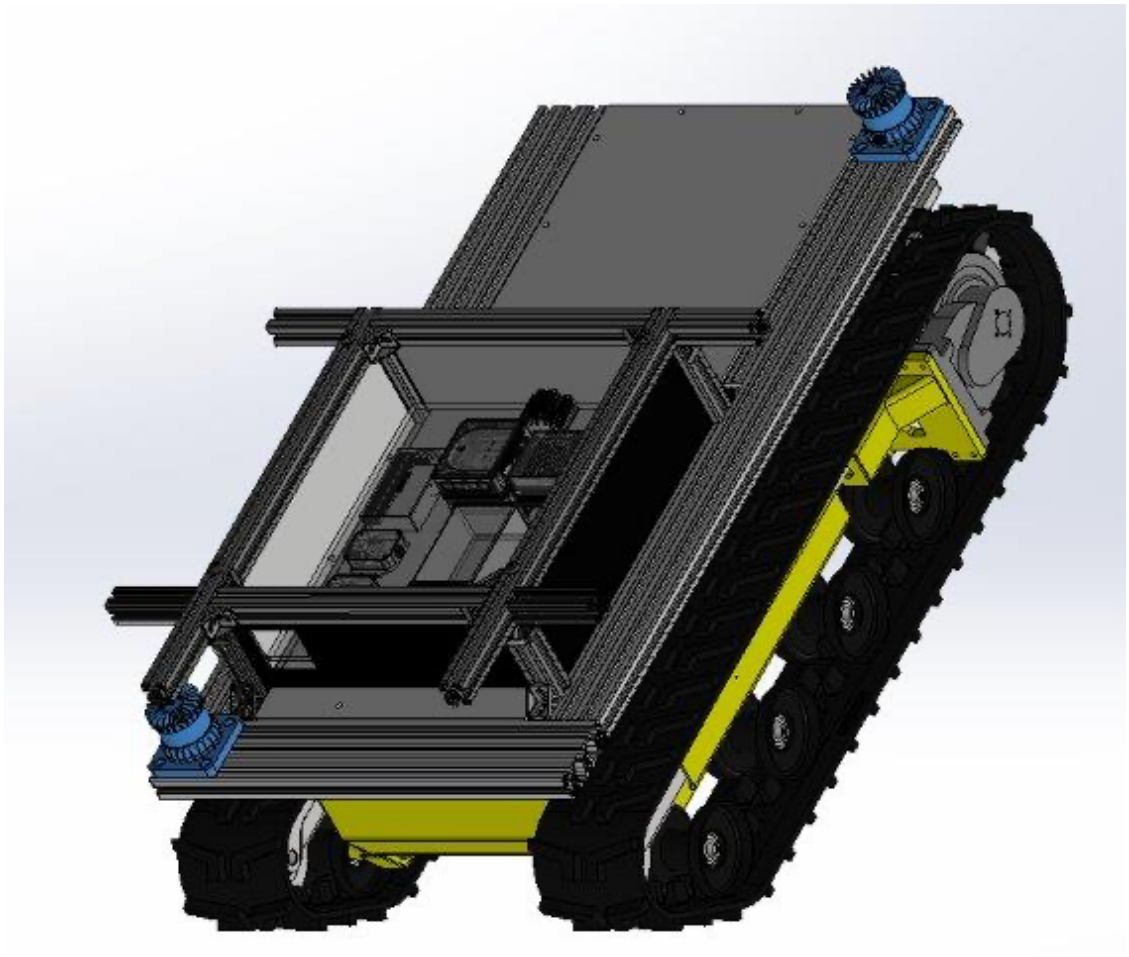

### Step 1: Collecting part and tools

For the installation of the two Ouster sensors you will need:

*Parts*

- 2x Ouster LIDARs
- 8x M8 flange nuts (RS components 725-9644)
- 8x Bosch Rexroth T-head bolt 30mm (RS components 197-1389)

*Tools*

- 13mm wrench
- Measuring tape

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### Step 2: Installing the right front LIDAR (2 options for execution)

-! BEFORE STARTING THIS PROCESS: Remember that the correct position for placing the sensor is done based on the referenced part of the Alitrak platform, i.e., the back side is the one including the power charger box, Alitrak gauges, etc.

*Option 1*

- Insert a T-head bolt through each hole of the LIDAR.

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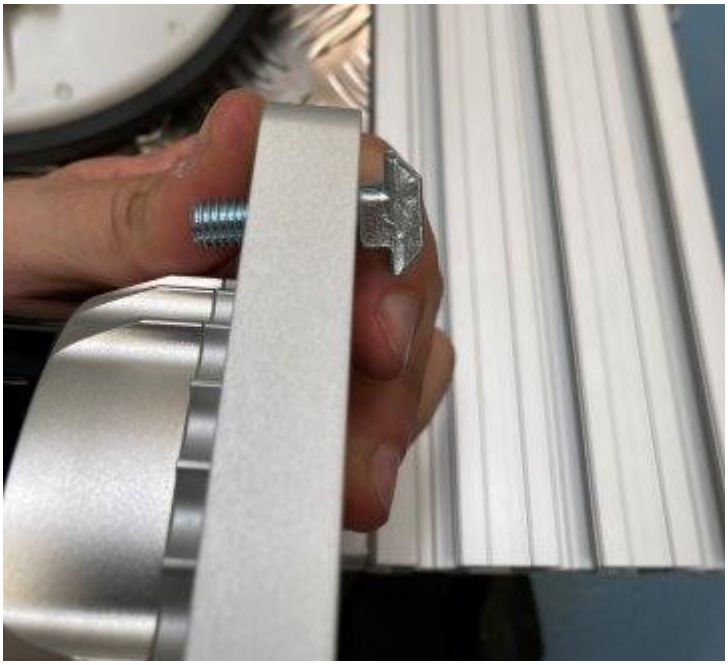

+ PRO TIP: Screw the M8 flange nuts loosly. That will help with the align ement of the T-head bolts and the grooves on the side decks.

- Slide the LIDARS onto the front side decks, adding the LIDAR to the front right corner of the mobile platform.

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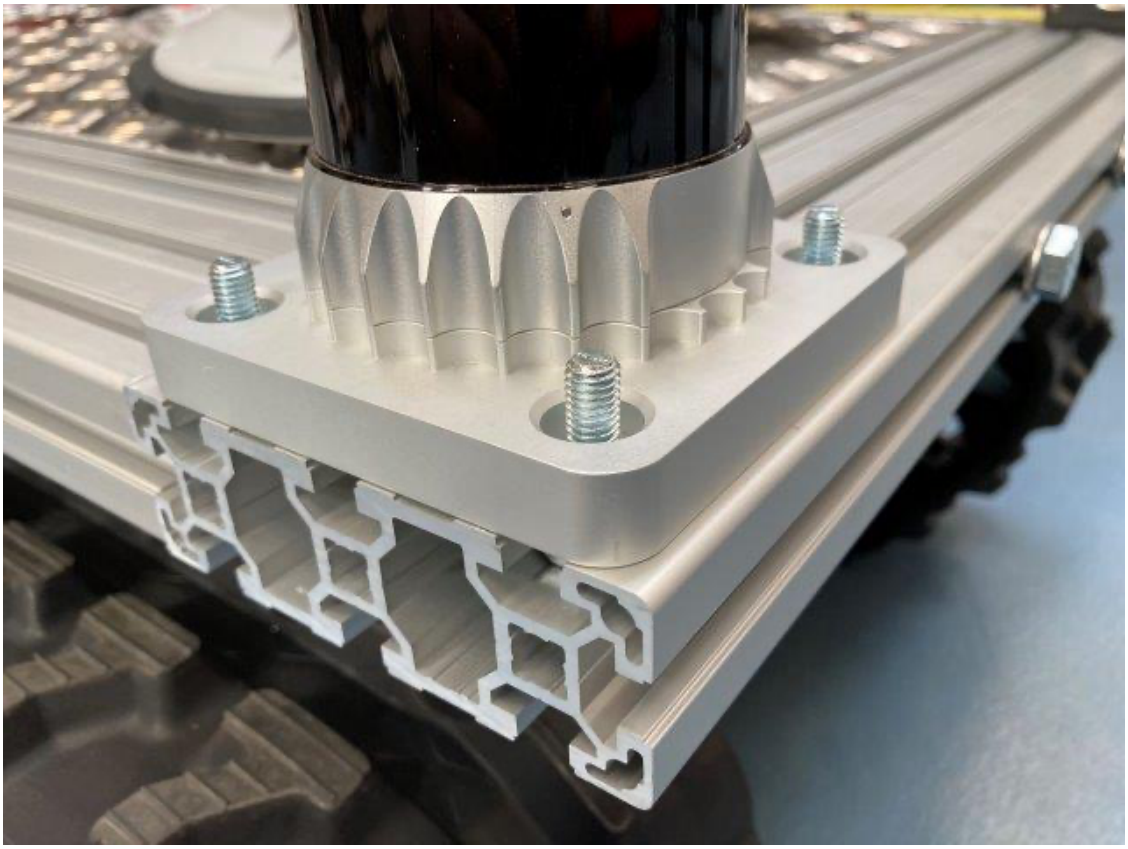
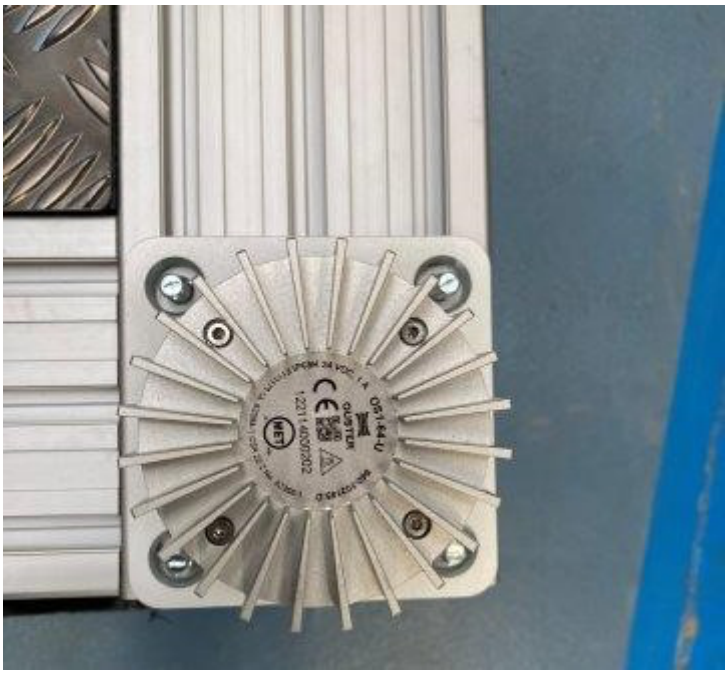


- Align the LIDAR, being flush with the end of the front side deck.



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- Using the your hands pre-tighten the flange nuts until flush. Then using a wrench, tighten the four flange nuts.

  + PRO-TIP: Tighten the nuts in a criss-cross pattern so that eaqual amount of torque is applied to all nuts.
  + PRO-TIP: In the case that a T-head bolt spins inside the groove then you can use a flathead screwdriver to realign it using the engraved cutout in the top of the T-head bolt.

  -! DO NOT overtighten the flange nut. The flange nut should fill secure.



*Option 2*

- Slide the T-head bolt on the grooves of the front side deck (right side).

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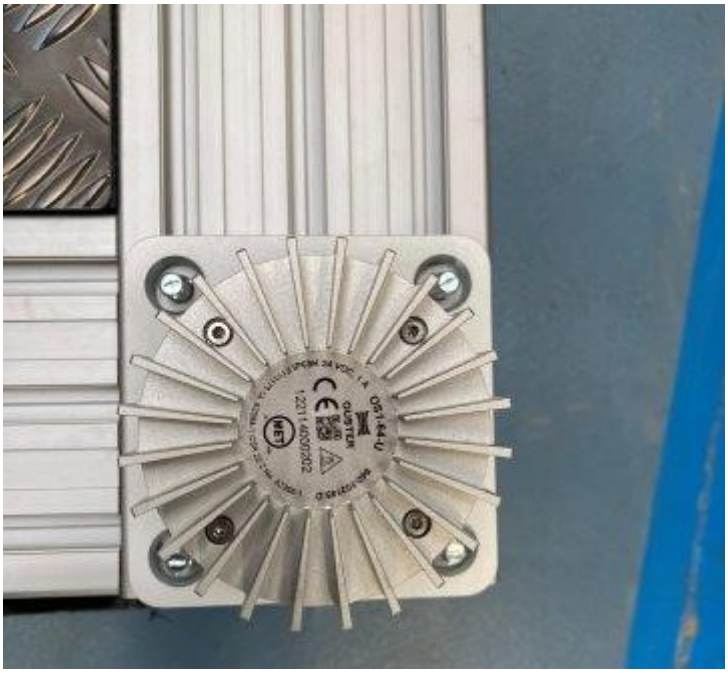
- Lower the LIDAR aligning the holes with the installed bolts.
- Align the LIDAR, being flush with the end of the front side deck.



- Using the your hands pre-tighten the flange nuts until flush. Then using a wrench, tighten the four flange nuts.

```
+ PRO-TIP: Tighten the nuts in a criss-cross pattern so that eaqual amoun
t of torque is applied to all nuts.
```

+ PRO-TIP: In the case that a T-head bolt spins inside the groove then you can use a flathead screwdriver to realign it using the engraved cutout in the top of the T-head bolt.

-! DO NOT overtighten the flange nut. The flange nut should fill secure.



### Step 3: Installing the left back LIDAR

Similar to Step 2 this can also be performed with two options a) attaching the T-head bolts on the LIDAR and then slide it to the grooves of the side deck; and b) sliding the T-head bolts on the side deck and then lowering the LIDAR into place. Here we describe the second one.

-! BEFORE STARTING THIS PROCESS: Remember that the correct position for placing the sensor is done based on the referenced part of the Alitrak platform, i.e., the back side is the one including the power charger box, Alitrak gauges, etc.

- Slide the T-head bolt on the grooves of the front side deck (right side).

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- Lower the LIDAR aligning the holes with the installed bolts.
- Align the LIDAR, being flush with the end of the back side of the left side deck.



- Using the your hands pre-tighten the flange nuts until flush. Then using a wrench, tighten the four flange nuts.

```
+ PRO-TIP: Tighten the nuts in a criss-cross pattern so that eaqual amoun
t of torque is applied to all nuts.
+ PRO-TIP: In the case that a T-head bolt spins inside the groove then yo
u can use a flathead screwdriver to realign it using the engraved cutout
in the top of the T-head bolt.

-! DO NOT overtighten the flange nut. The flange nut should fill secure.
```

### Step 4: Connect both LIDARs to their corresponding interface boxes.

More information about the connection of LIDARS and interface boxes can be found in the Sensor box

## IMU assembly and installation

### Overview of final assembly

This chapter covers the instructions for installing the IMU on the GPS+IMU beam structure. Instructions for the assembly of the GPS+IMU beam structure can be found here Mechanical integration.

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### Step 1: Collecting part and tools

*Parts*

- 4x M3 hex headed bolt.
- 4x M3 nut.
- 2x M6x25mm hex headed bolt.
- 2x Bosch Rexroth M6 slider. (RS-components: 390-0408)
- 1x IMU mounting solution. (see 3D printed components)

*Tools*

- H2 Hex key.
- H5 Hex key.




### Step 2: Attaching the IMU with the mounting solution

- Unscrew the four M3 bolts in each side of the IMU mounting solution.

  -! Please be aware that the included M3 nuts can slide out of the grooves on the IMU mounting solution. Handle with caution.

- Align the holes of the IMU with the holes on the IMU mounting solution.
- Screw the M3 bolts securing the IMU on the IMU mounting solution.

  -! DO NOT overtighten the bolts. Stop as soon as the bolts fill secure.




### Step 3: Installation on the aluminum profile.

- Remove the end caps of the GPS+IMU beam assembly.
- Slide 2x Bosch Rexroth M6 sliders on the top side of the aluminum profile (part of the GPS+IMU beam structure).

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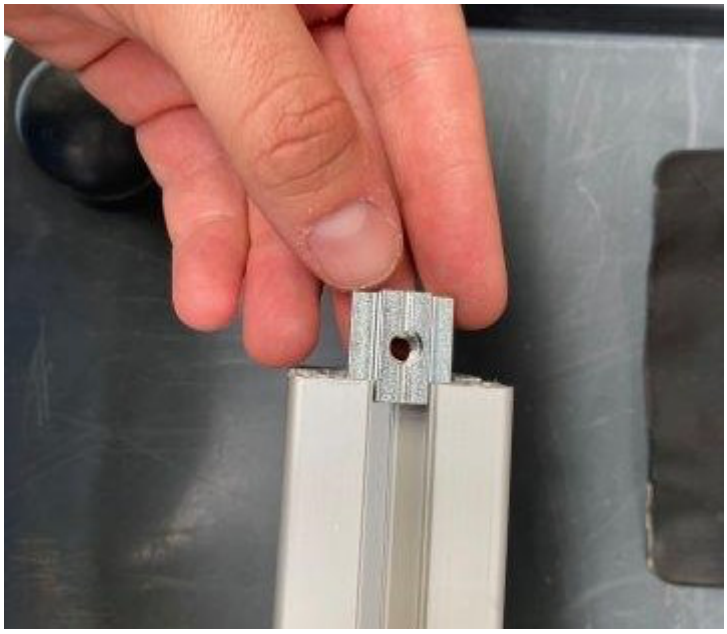

- Install the 2x M6x25mm hex headed bolts on holes of the IMU mounting solution.

  + PRO TIP: Do not tighten all the way.

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G.A No 101016906



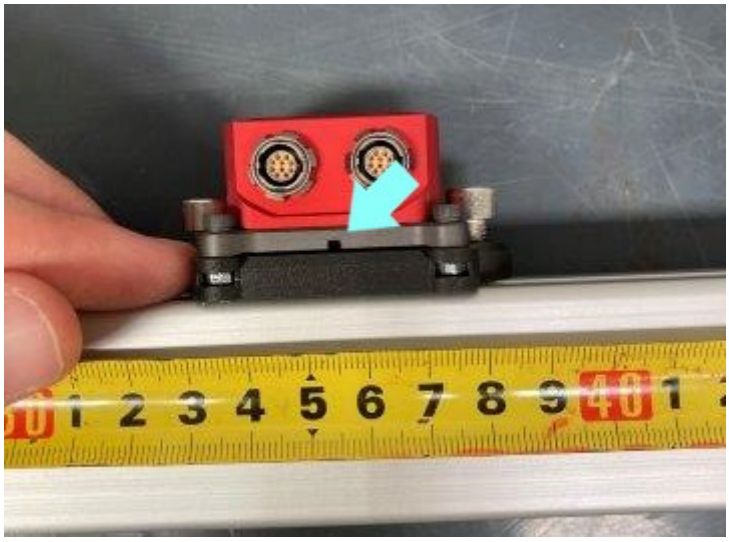
- Align and screw the bolts with the holes on the sliders until attached on the sliders. [**Important for next step**]At this point the sliders should be able to slide freely.

  -! DO NOT overtighten the bolts. Stop as soon as the bolts fill secure.



- Using a measuring tape, reference the center of the IMU. The IMU notch (here denoted with an turquoise arrow) should align with the 35,5 cm mark of the measuring tape.

  -! IF THE INSTALLATION IS NOT PERFORMED CORRECLTY, IT WILL AFFECT THE PER FORMANCE OF THE MOBILE BASE.



- Tighten the screws keeping the alignment from the previous step.

  -! DO NOT overtighten the bolts. Stop as soon as the bolts fill secure.

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# GNSS antenna assembly and installation

## Overview of final assembly

This chapter covers the instructions for installing the GPS mounts on the GPS+IMU beam structure. Instructions for the assembly of the GPS+IMU beam structure can be found here Mechanical integration.



## Step 1: Collecting part and tools

For the assembly of the operation the side decks you will need:

*Parts*

- 2x 2 inch Hex Bolt with UNC thread - 5/8.
- 2x GPS mounting solutions. (see 3D printed components)
- 4x M6x25mm hex headed bolt.
- 4x Bosch Rexroth M6 slider. (RS-components: 390-0408)

*Tools*

- H5 Hex key.

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### Step 2: Assembling the mounting solution

- Install the bolt to the GPS mounting solution. The installation must be done in such a way that the bolt head is nested in the hex groove.





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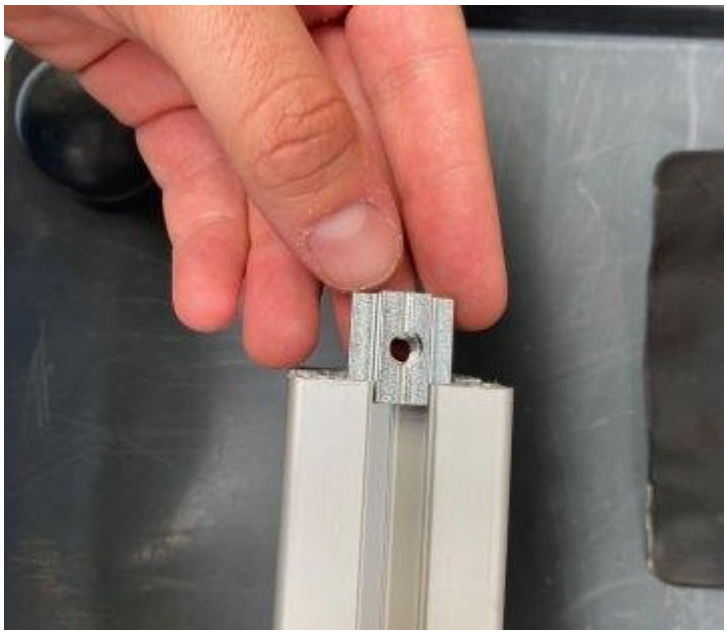
### Step 3: Installation on the aluminum profile.

- Remove the end caps of the GPS+IMU beam assembly.
- Slide 4x Bosch Rexroth M6 sliders on the top side of the aluminum profile (part of the GPS+IMU beam structure).



- Align the holes of the GPS mount assembly with the holes on the sliders, as well as, aligning the whole assembly to be flush with the end of the GPS+IMU beam.

  -! IF THE INSTALLATION IS NOT PERFORMED CORRECLTY, IT WILL AFFECT THE PERFORMANCE OF THE MOBILE BASE.



- Tighten the screws keeping the alignment from the previous step.

  + PRO TIP: Start screwing the bolts with your hands and then use the tool to tighten securly.

  -! DO NOT overtighten the bolts. Stop as soon as the bolts fill secure.



- Re-install the end caps.

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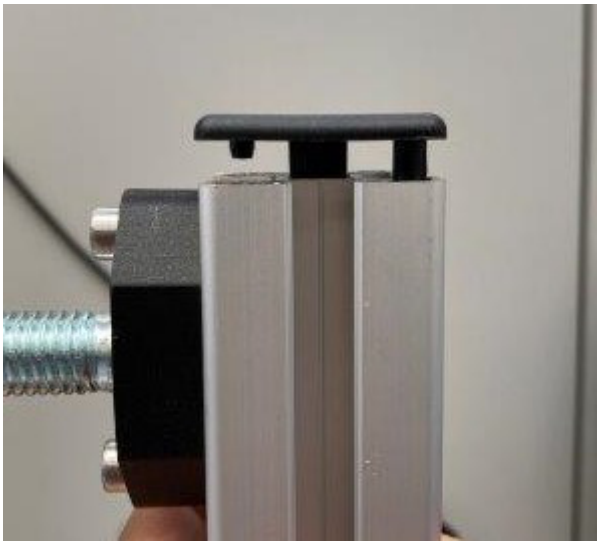

- The antennas can now be simply threaded on the GPS mounts. [**Do not forget**] to attach the antenna cables.

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## Home >> Hardware setup >> Mobile robot - Integration steps >> Components box integration

In this page, we individually describe the integration steps of the box housing all compute modules and sensor modules on the mobile robot.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>
>
> This excludes the sensor integration/installation. Please refer to their individual pages found here.

```
-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
oves, eye protection and safety shoes.

+ PRO TIP BEFORE STARTING THE PROCESS: Reading the manual before attempting any
alterations will result in a smoother integration therefore it is HIGHLY ADVISE
D.
```

## The components box is currently under development. Specifications and instructions will become available in the near future.

> For any questions or immediate needs please contact tsko@teknologisk.dk

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## Home >> Hardware setup >> Box Exchange Mechanism (BEM)

In this page, we describe the individual integration steps of the box exchange mechanisms for both robotic prototypes.

For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>

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D.
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## The Box Exchange Mechanism (BEM) is currently under development. Specifications and instructions will become available in the near future.

This project is funded by the European Union G.A No 101016906

## Home >> Hardware setup >> Dual arm

In this page, we describe the individual integration steps for the Dual arm.

> For any questions or immediate needs please contact Maria Santamaria <maria.santamaria@pal-robotics.com>

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-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
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D.
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## The Dual arm is currently under development. Specifications and instructions will become available in the near future.

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## Home >> Hardware setup >> 3D printed components

In this page, we share all 3D-printing components required for the robot's integration.

> For any questions or immediate needs please contact Tsampikos Kounalakis <tsko@teknologisk.dk>

```
-! BEFORE STARTING THE PROCESS: Please keep all measures of safety including gl
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List of contents:


- IMU mounting solution
- GNSS antenna mounting solution
- Intel Realsense mounting solution
- Components box backplate


## IMU mounting solution

The IMU mounting solution creates more mounting options for the SBG-Systems Ellipse-E. A preview of the part can be seen in the following picture.

The integration guide for the complete assembly can be found in Integration steps - Sensor specific

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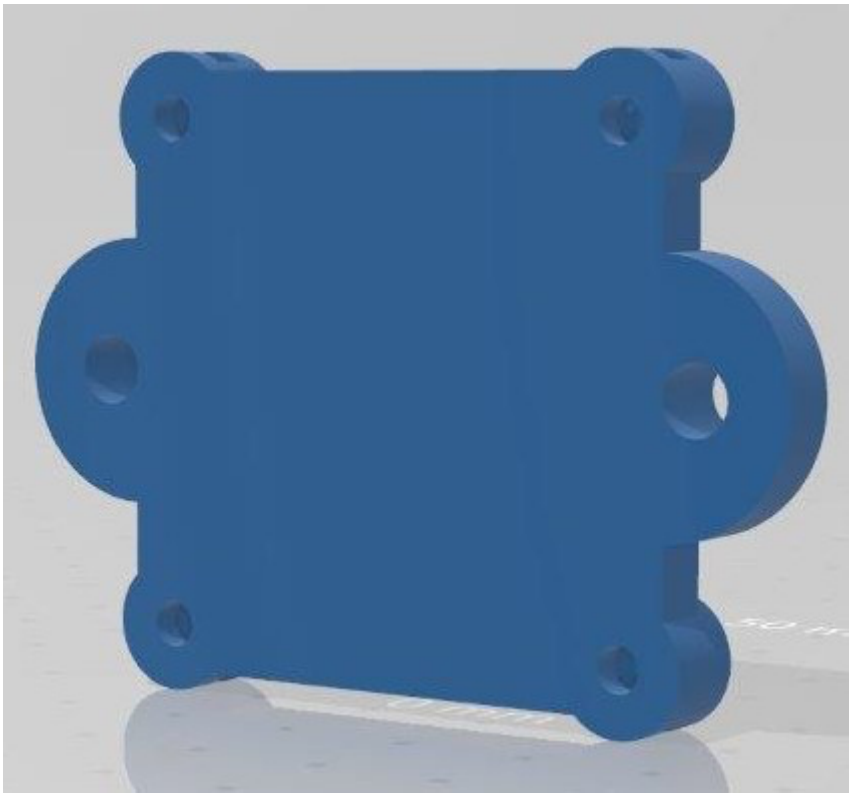

## GNSS antenna mounting solution

The GNSS antenna mounting solution creates more mounting options for the Septentrio GNSS antennas. A preview of the part can be seen in the following picture.

The integration guide for the complete assembly can be found in Integration steps - Sensor specific

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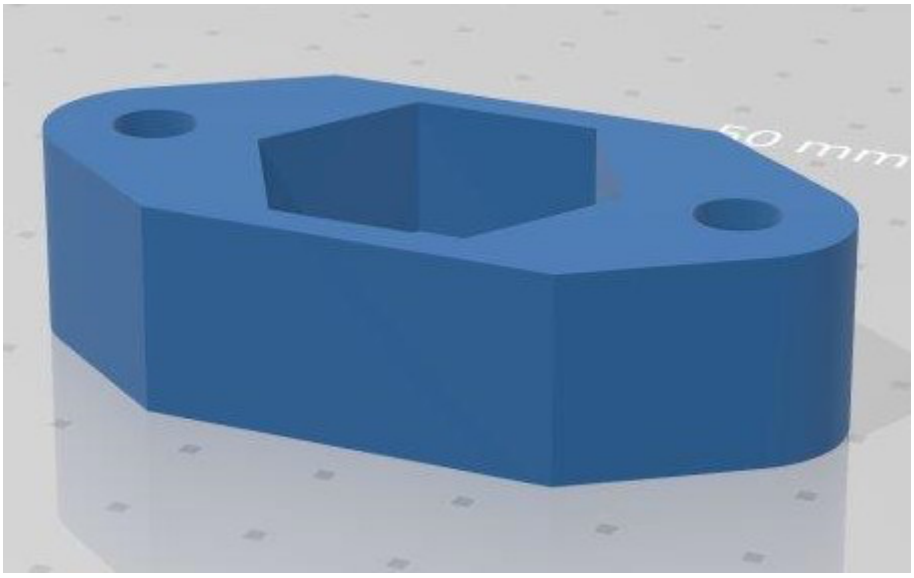
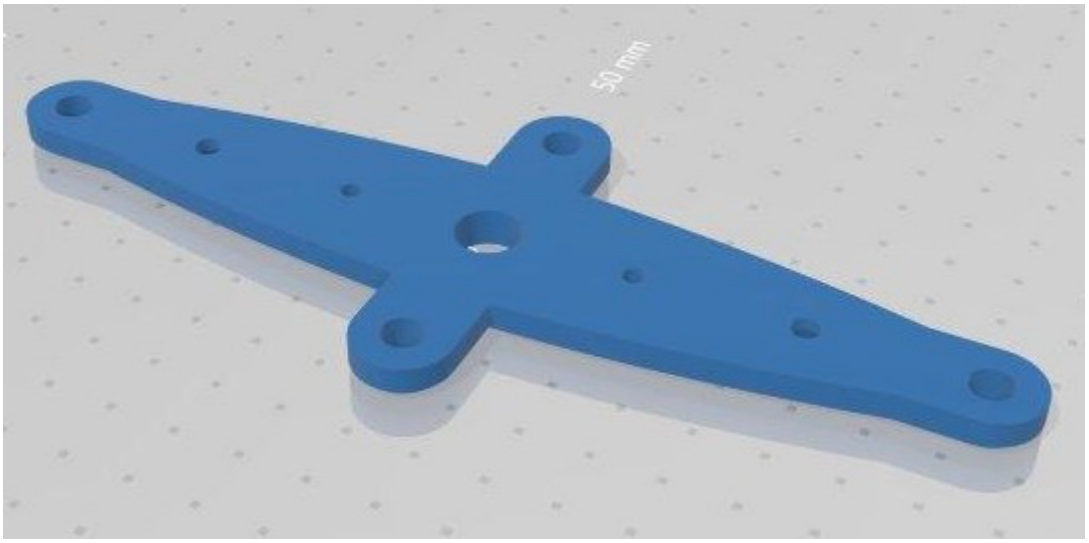



## Intel Realsense mounting solution

The Intel Realsense mounting solution creates more mounting options for both the Intel Realsense D435i and D455 in both horizontal and vertical orientation. A preview of the part can be seen in the following picture.




## Components box backplate

The Components box backplate is a modification of the backplate of the components box that will allow the use of active ventilation and attaching cable caps for dust protection.

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