IMR

IMR User's Manual

VAS CORPORATION

Table of Contents

1. Introduction

This manual covers the setup, operation, and user maintenance of an Industrial Mobile Robot Platform.

1.1. Definitions

Platform: The most basic part of the robot. It includes the chassis, drive assemblies, suspension, wheels, battery, lasers, an on-board Mobile Robot platform core with a built-in gyroscope, software needed to navigate, connectors for interfacing with and powering the payload structure, and the platform covers.

Payload Structure: You can attach anything into the platform. This could be as simple as a box for holding parts or documents that you want transported, or as complicated as a robotic arm that will be used to pick up parts to transport.

Mobile Robot Platform: Either the IMR-B, IMR-C or IMR-M platform with different payloads.

IMR (Industrial Mobile Robot): A Industrial Mobile Robot with a payload structure attached to it. This is your complete mobile robot, which will transport your products, parts, or data.

When referring to the initial setup, configuration, and connections, we will refer to the platform.

When talking about controlling or monitoring the full mobile robot, with a payload structure attached, we will refer to the IMR.

Fleet: Two or more IMRs operating in the same workspace.

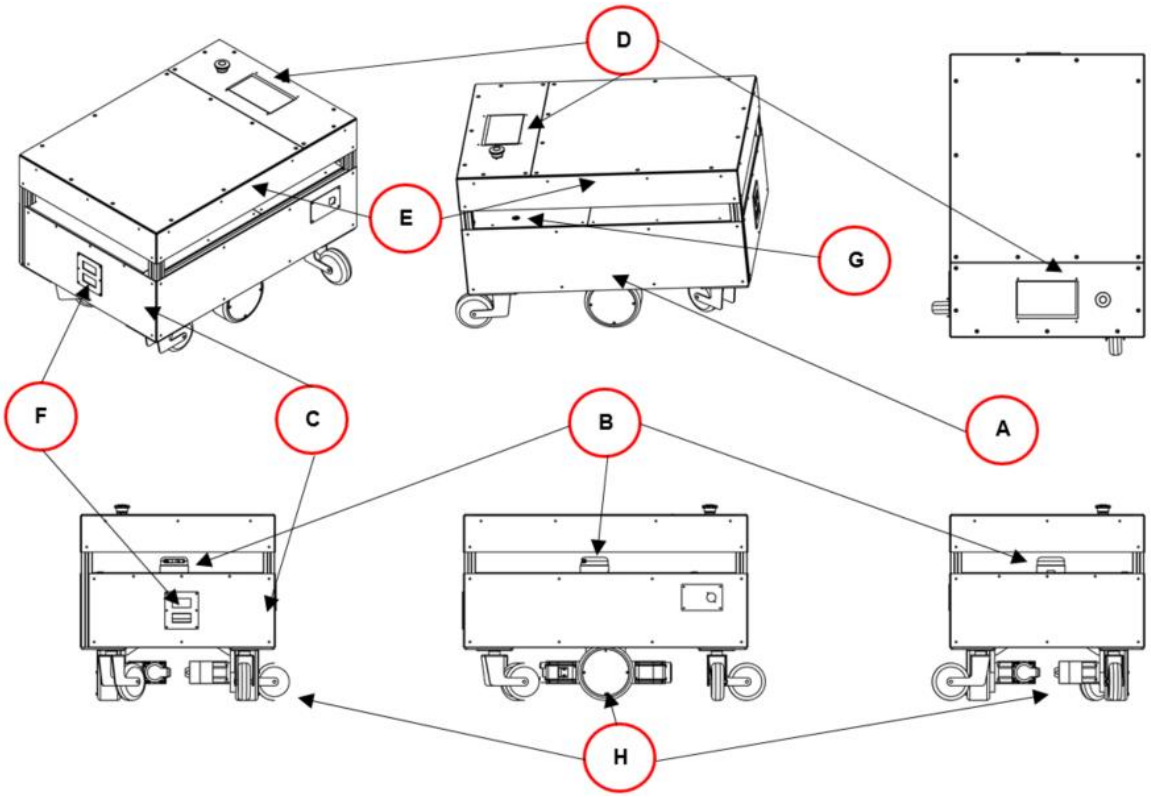
Fleet Management System: A system that manages a fleet of IMRs. This includes the Mobile Robot Supervisor Server (MRSS) appliance and the Mobile Robot Supervisor (MRS) software that runs on it.

The following table lists acronyms and abbreviations, and defines key terms found in this user manual:

Term	Definition
Goal	Map-defined virtual destination(s) for mobile robots.
IMR	Industrial Mobile Robot
IMR-B	Industrial Mobile Robot - Base
IMR-C	Industrial Mobile Robot - Conveyor
IMR-M	Industrial Mobile Robot - Manipulator
Joystick	A handheld, external input device for manually driving mobile robots.
Localization	The process by which mobile robots determine their location in their operating environment. Laser localization uses the robot's laser to scan its environment which it compares to its internal environment map.
MRCS	Mobile Robot Control System
MRS	Mobile Robot Supervisor
MRSS	Mobile Robot Supervisor Server
Obstacle	Objects and/or areas the mobile robots resist (attempt to avoid) crossing or entering,
Path	The manner in which the mobile robots drive from place to place in their environment.
Pose	A mobile robot's position (location and heading).
Platform	The base mobile robot (with or without payload) – includes chassis, drive train, suspension, wheels, battery, safety scanning laser, on-board core and software to navigate, interface connections for payload, and covers.
Route	A "to do" list or series of tasks, goals for the mobile robot to follow

1.2. Product Description

The Mobile Robot platform is a general-purpose, mobile robot platform, designed for working indoors and around people. It is self-guided and self-charging, with an automated docking station. The Mobile Robot platform is designed to carry loads up to 100 kg (220 lb).



IMR Platform Layout

Callout	Description	Callout	Description
A	IMR Platform Core Compartment	E	Status Indicator Lights
B	Safety Lidar	F	Battery Charging Interface
C	Battery Compartment	G	Start Button
D	Touch Screen and Emergency Button	H	Front Caster x2, Drive Wheel x2, Back Caster x2

The platform combines hardware and mobile-robotics software to provide an intelligent, mobile platform to transport your payload. The platform comes complete with the ability to know where it is within a workspace, and to navigate safely and autonomously to any accessible destination within that workspace, continuously and without human intervention.

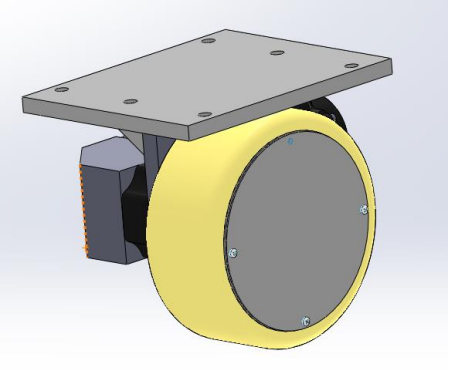
Its primary guidance uses a laser to navigate, comparing the laser readings to a digital map stored on the platform.

The platform provides a variety of interfaces and power connections to support your application-specific sensors and accessories, mounted on your payload structure.

Body and Drive

The IMR Platform are relatively middle size, mediumweight, and highly maneuverable. Their strong aluminum chassis and solid construction make them very durable.

Each platform uses a two-wheel, differential-drive, with spring-loaded passive casters front and back for balance. The drive-wheels have independent spring-suspension, with solid, foam-filled tires. The wheels are at the platform's mid-line, so the platform can turn in place.



IMR Drive Wheel

What's Included - Basic Components

- **One fully-assembled IMR Platform**

  The platform includes a navigation laser, a IMR Platform Core, includes an integrated computer, running Mobile Robot Mobile Robot Control System (MRCS). The core is housed inside the platform.

  Each drive wheel has an encoder and a Hall sensor to complement the safety scanning laser.

- **One battery**

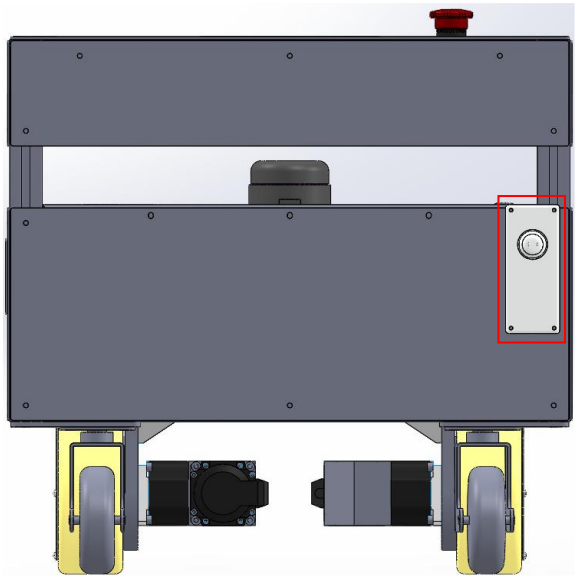
  Shipped separately from the platform to comply with dangerous goods shipping regulations.

- **Operator Panel**

  The operator panel includes a Touch Screen, an Emergency Stop Button and a Start Button. This will usually be mounted on the user-designed and -built payload structure.

- **Joystick**

  This is used for manually controlling the platform, mostly when making a scan to be used for generating a map.



You need at least one joystick for each fleet of IMRs. Once a map is generated, the map can be shared with multiple IMRs working in the same space.

1.3. Software Overview

A fair amount of software is involved in setting up and running an IMR Platform.

The platform comes with the following software:

- **Mobile Robot Software Suite**

  The Mobile Robot Software Suite includes all of the software used by the IMR Platform and the Fleet Management appliance.

- **MRCS**

  The Mobile Robot Mobile Robot Control System (MRCS) runs on the IMR Platform core. It operates ranging sensors like the safety scanning laser and camera, and performs high level, autonomous robotics functions like obstacle avoidance, path planning, localization, navigation, and so on. MRCS also controls the battery and status indicator lights.

  Before your IMR can perform autonomous mobile activities, you need to make a map of its operating space, and configure its operating parameters. MRCS has the tools to make this map and perform this configuration.

- **Mobile Robot Supervisor software**

  Mobile Robot Supervisor software allows you to monitor one or more IMR's activities and have them perform mobile tasks in the mapped space. Refer to the Mobile Robot Supervisor Software on page 49 for details.

- **How Can I Get Help?**

  For details on getting assistance with your VAS Corporation software or hardware, you can access VAS Corporation website at:

  http://www.vascorporation.com

2. Safety

2.1. What to do in an Emergency/Abnormal Situation

Releasing the brakes

In case of an emergency or abnormal situation, the IMR can be manually moved. However, only qualified personnel who have read and understood this manual and the Mobile Robot Safety Guide should manually move the platform. The brakes on the drive wheels are released when the Emergency Stop button is pressed. This requires battery power.

NOTE: The brakes are released immediately when pressing the Emergency Stop button, so the IMR platform might slip on slope, so attention must be paid during this situation.

General Hazards

IMPORTANT: The following situations could result in injury or damage to the equipment.

- Do not ride on the platform.
- Do not exceed the maximum weight limit.
- Payload decreases as slope increases.
- Do not exceed the maximum recommended speed, acceleration, deceleration, or rotation limits.

  Rotational speed becomes more significant when the payload's center of gravity is farther away (vertically and/or horizontally) from the platform's center of gravity.
- Do not drop the IMR, run it off a ledge, or otherwise operate it irresponsibly.
- Do not allow the IMR to drive through an opening that has an automatic gate/door unless the door and IMR are configured correctly with the Call/Door Box option. Refer to the Platform Peripherals User's Guide for details on the Call/Door Box.
- Do not get the IMR wet. Do not expose the IMR to rain or moisture.
- Do not continue to run the IMR after hair, yarn, string, or any other items have become wound around the platform's axles, casters, or wheels.
- Do not use unauthorized parts.
- Although the lasers used are Class 1 (eye-safe), we recommend you not look directly at the laser beams.

Releasing an E-stop

CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK

If the IMR's E-Stop is triggered, ensure that the cause of the E-Stop is resolved, and all surrounding areas are clear before releasing the E-Stop.

After the E-Stop button has been manually released, the motor driver is powered and the IMR will not be moving until the software is restarted.

There are two ways to restart the software:

- Use the command line to re-enable the nodes.
  roslaunch agv_test start_all.launch
- Shut down the system by the GUI or turn the Circuit Breaker off and restart all the system.

2.2. Dangers, Warnings, and Cautions

Alert Levels

There are three levels of alert notation used in our manuals. In descending order of importance, they are:

DANGER: Identifies an imminently hazardous situation which, if not avoided, is likely to result in serious injury, and might result in fatality or severe property damage.

WARNING: Identifies a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, and might result in serious injury, fatality, or significant property damage.

CAUTION: Identifies a potentially hazardous situation which, if not avoided, might result in minor injury, moderate injury, or property damage.

Falling Hazards

WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK The IMR can cause serious injury to personnel or damage to itself or other equipment if it drives off from a ledge, such as a loading dock, or downstairs.

Physical Barriers

The edge of a loading dock, the entrance to downward stairs, or any other substantial drop that is within the IMR's expected operating area should be physically marked so that the IMR's navigation laser will see the barrier and stop before reaching it. The IMR is designed to detect objects 200 mm tall, so the barrier must be at least that tall. However, because of variations in floor flatness, we recommend a barrier that is 250 mm tall.

The barrier needs to be continuous at the site, so that the IMR can't drive around or through it to the drop-off.

Logical Barriers

You should also use forbidden areas, sectors, or lines with several feet of safety zone (padding) before the actual drop-off, to ensure the IMR will not try to drive there. These need to be continuous at the site, so that the IMR can't plan a path to drive around or between them to the drop-off.

Special Information

There are several types of notations used to call out special information.

IMPORTANT: Information to ensure safe use of the product.

NOTE: Information for more effective use of the product.

Additional Information: Offers helpful tips, recommendations, and best practices.

Version Information: Information on differences in specifications for different versions of hardware or software

2.3. User's Responsibility

Safe use of the IMR is your responsibility. Safe use includes:

- Reading the installation and operation instructions, as well as the Mobile Robot LD Safety Guide, before using the equipment.
- Ensuring that the environment is suitable for safe operation of the IMR.
- Ensuring that anyone working with or near an IMR has been adequately trained and is following this guide and the Mobile Robot Safety Guide for safe IMR operation.
- Maintaining the IMRs so that their control and safety functions are working properly.

Electrical Hazards

WARNING: ELECTROCUTION RISK The docking station has AC power inside. Its covers are not interlocked.

- Do not use power extension cords with the docking station unless properly rated.
- Never access the interior of the platform with the charger attached.
- Immediately disconnect the battery after opening the battery compartment door. Avoid shorting the terminals of the battery.
- If any liquid is spilled on the IMR, power off the IMR, clean up all possible liquid, and allow the IMR to air dry thoroughly before restoring power.

Qualification of Personnel

It is the end-user's responsibility to ensure that all personnel who will work with or around IMRs have attended an appropriate training course and have a working knowledge of the system. The user must provide the necessary additional training for all personnel who will be working with the system.

As noted in this and the Mobile Robot Safety Guide, certain procedures should be performed only by skilled or instructed persons. For a description of the level of qualification, we use the standard terms:

- **Skilled persons** have technical knowledge or sufficient experience to enable them to avoid the dangers, electrical and/or mechanical
- **Instructed persons** are adequately advised or supervised by skilled persons to enable them to avoid the dangers, electrical and/or mechanical

All personnel must observe industry-prescribed safety practices during the installation, operation, and testing of all electrically powered equipment.

IMPORTANT: Before working with the IMR, every entrusted person must confirm that they:

- Have the necessary qualifications
- Have received the guides (both this user's guide, and the Mobile Robot Safety Guide)
- Have read the guides
- Understand the guides
- Will work in the manner specified by the guides

Payload Movement and Transfer

You should actively monitor and confirm the status of IMR payload movement, and transfer to or from facility equipment.

Payload transfer problems must trigger an IMR E-Stop that prevents the IMR from moving until an Operator resolves the problem and confirms the system is safe to use.

Your facility should provide an interlock between the IMR and facility equipment.

2.4. Environment

General Environment Conditions

You must always ensure that the platform ‘s operating environment remains safe for the platform. If there are unsafe areas for the platform, physically block those areas off so the platform’s scanning laser will detect the barriers, and the platform will not attempt to drive there. You can also block off these areas using forbidden zones in the Mobile Robot Supervisor software, but that should be in addition to physical barriers.

Public Access

The platform is designed for operating in indoor industrial or professional environments. It must be deployed in a manner that considers potential risks to personnel and equipment. The product is not intended for use in uncontrolled areas without risk analysis, for example, areas open to public access. Use in such areas may require deployment of additional safety measures.

Clearance

The platform is designed to operate in an environment that is generally level and has no doors or other restricted areas too narrow for the IMR. It is the user’s responsibility to ensure that adequate clearance is maintained on each side of the IMR, so that a person cannot get trapped between the IMR and a wall or other fixed object. You should consult the applicable standards for your area. An exception to side clearance can exist at pickup and drop-off locations where the IMR must get close to conveyors or other fixed objects.

The primary direction of travel of the platform is forward. When the platform is turning in place, with no forward movement, the detection of an obstacle in its path of rotation will not trigger an obstacle-detection condition.

CAUTION: PERSONAL INJURY RISK

Personnel who work with or around the IMR should not stand close to the IMR when it is turning in place (with no forward motion).

Obstacles

If the IMR will be entering high-traffic areas, the user must take appropriate precautions to alert people in those areas that an IMR will enter. If the traffic consists of other machines, the user must adjust the IMR ‘s and/or the other machine’s parameters to reduce the risk of a collision.

Safety Scanning Laser Emergency Stop

If an obstacle enters the IMR’s immediate path, the IMR will attempt to safety path plan and maneuver around the obstacle. If there isn’t adequate room, it will stop, and Error notification will display on the screen and wait for human intervention.

2.5. Intended and Non-intended Use

Intended Use

The Platform is designed to operate in indoor industrial or professional environments. In general, if a wheelchair can safely and easily navigate the environment (open, with gentle slopes), then it is safe for the robot.

Guidelines for save use

- Clean, dry floors — floors that are regularly swept, and routinely kept free of debris and liquids.

  IMPORTANT: Since the robot is not waterproof (IP20), floors must be kept relatively dry, as any dampness can cause the wheels to slip. This can cause problems for braking as well as navigation.
- Gentle slopes — wheelchair ramps are a good example of the amount of slope the robot can safely climb.
- Temperature — 5 to 60°C (41 to 140°F), with a recommended humidity range of 5% to 95%, non-condensing.

Non-Intended Use

You must deploy the robot in a manner that takes into account potential risks to personnel and equipment. The product is not intended for use in uncontrolled areas without risk analysis, for example, areas open to public access. Use in such areas may require deployment of additional safety measures. The platform is not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- In the presence of ionizing or non-ionizing radiation
- In life-support systems
- In residential installations
- Where the equipment will be subject to extremes of heat or humidity
- In mobile, portable, marine, or aircraft systems

NOTE: The gyroscope (if used) to assist in platform navigation requires a stationary environment for optimum accuracy. Therefore, we do not recommend them for use on a ship, train, aircraft, or other moving environment.

IMPORTANT: The instructions for operation, installation, and maintenance given in this guide and the IMR user's guide must be strictly observed.

Non-intended use of the platform can:

- Cause injury to personnel
- Damage itself or other equipment
- Reduce system reliability and performance

IMPORTANT: Since the robot is not waterproof (IP20), floors must be kept relatively dry, as any dampness can cause the wheels to slip. This can cause problems for braking as well as navigation.

If there is any doubt concerning the application, contact our support to determine if it is an intended use or not.

Platform Modification

If the user or integrator makes any changes to the platform, it is their responsibility to ensure that there are no sharp edges, corners, or protrusions.

Note that any change to the platform can lead to loss in safety or functionality. The user or integrator must ensure that all safety features are operational after modifications.

2.6. Battery safety

CAUTION: BATTERY DAMAGE RISK

After receiving the battery, immediately charge to a full charge to avoid discharging the battery below a usable state, which would require battery replacement.

Effective April 1, 2016, IATA regulations (UN 3480, PI 965) require that air-shipped lithium-ion batteries must be transported at a state of charge not exceeding 30%. To avoid total discharge, fully charge the battery immediately upon receipt.

NOTE: If the battery was not sent by air, it may be fully charged.

Safety Precautions

- Store batteries upright at:
  - One month: +5 to 45°C (41 to 113°F)
  - One year: 20 to 25°C (68 to 77°F)
- Never expose the battery to water. If the battery is leaking, submerge in mineral oil and contact your local support.
- In case of fire, use a type D extinguisher: foam, dry chemical, or CO_2.

Maintenance

Every six months:

- Inspect battery for damage or leaks
- Place battery on a charger and allow to fully balance (battery shows all solid LEDs when fully balanced).

3. Payload Structure

Everything that you attach to the IMR Platform is referred to as the payload structure. In some custom cases, we design and build the payload structure. In most cases, you will need to design a payload structure that suits your application.

The image above shows some of the available pre-designed payload structures, as well as an outline of a user custom-designed payload structure. The platform provides the mobility and navigation needed, as well as power and I/O connections between the platform and the custom payload structure, so the two can work effectively together. This chapter discusses considerations to be aware of when you design a payload structure for your platform.

3.1. Safety

Warning Label

A No Riding label ships, unattached, with each platform. You must place this in a prominent location on the payload, so operators will see it.

Other warning labels are applied at the factory.

Warning Lights

IMR have a readily-visible warning device, such as a flashing light, when it is either ready to move or is moving. The platform comes with the lighting system in the middle of the IMR's horizontal face.

3.2. Considerations

Performance

The main performance factors to consider in designing a payload structure are the size, weight, and center of gravity of the payload structure, and power requirements. Adding weight to the platform tends to have less effect on run-time than adding electrical power requirements. Operating your IMR on carpet will have a significantly shorter run-time than on hard surfaces.

Weight

On a hard surface, a certain amount of extra weight will not shorten the IMR's run-time very much. When adding a payload structure with substantial weight, the center of gravity of the entire AIV needs to be considered. This is particularly important if you intend to equip the platform with a robot arm, which would be lifting items off-center from the platform. A heavy payload structure, with most of its weight concentrated just above the platform, will be much more stable than the same weight payload structure in which the weight is either off-center or high above the top of the platform.

Power Consumption

Using devices on your payload structure that consume significant power will noticeably shorten the run-time of the IMR. You should try to minimize such power consumption whenever possible. Examples of power-consuming payload structures would be one with a robot arm attached, or a conveyor, as part of the payload structure. The standard Operator screen and light discs consume some power, but are not significant compared to the rest of the platform.

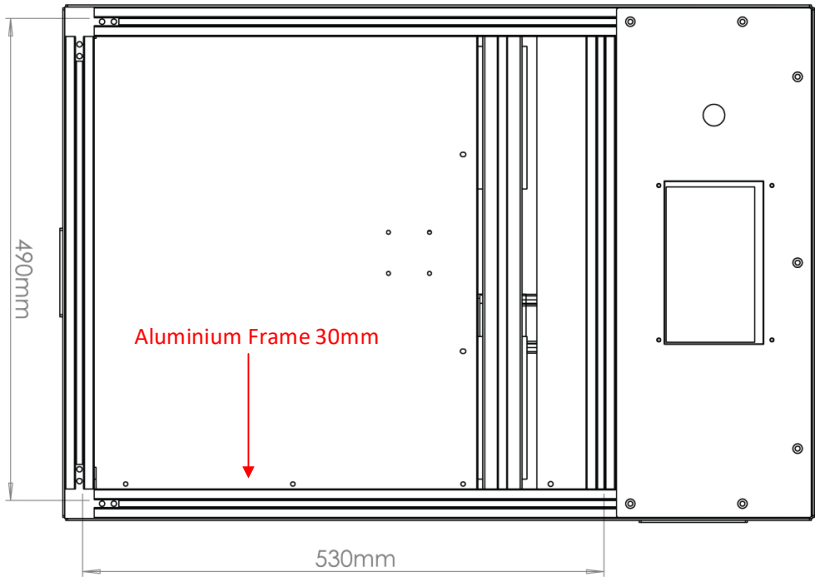
Payload Bay Access

The area between the platform and your payload structure is the payload bay. You will occasionally need to access the platform and the connectors in the payload bay. This is where you can access all of the platform power and I/O connectors. It's a good idea to provide access to this when designing your payload structure. Avoid damaging any wiring between your payload structure and the platform.

Dimensions and Design

Keep your payload structure no wider and no longer than the platform. Add whatever features your application needs above the platform itself.

Keep all payload structure higher than the top of the platform. If the payload blocks any of the platform's sensors, it won't be able to function correctly.



4. Operation

4.1. Operating Environment

Intended Use

The IMR Platform is designed to operate in indoor industrial environments. In general, if a wheelchair can safely and easily navigate the environment (open, with gentle slopes), then it is safe for the robot.

Guidelines for safe use:

- Clean, dry floors — floors that are regularly swept, and routinely kept free of debris and liquids.

  IMPORTANT: Since the robot is not water proof, floors must be kept relatively dry, as any dampness can cause the wheels to slip. This can cause problems for braking as well as navigation.
- Gentle slopes — wheelchair ramps are a good example of the amount of slope the robot can safely climb.
- Temperature — 5 to 60°C, with a recommended humidity range of 5% to 95%, non-condensing.

Clearance

The platform can operate in an environment that is generally level, with no doors or other restricted areas that are too narrow for the IMR.

You must ensure that adequate clearance is maintained on each side of the IMR, so that a person cannot get trapped between the IMR and a wall or other fixed object. You should consult the applicable standards for your area.

Obstacles

If the IMR will be entering high-traffic areas, take appropriate precautions to alert people in those areas that an IMR might enter. If the traffic consists of other machines, adjust the IMR and/or the other machine’s parameters to reduce the risk of a collision.

Take care to avoid:

- glass doors and walls
- pits without railings or low bumpers
- floors with access panels removed
- loose cables, hoses, etc.
- large, highly-reflective objects

Environment and Floor

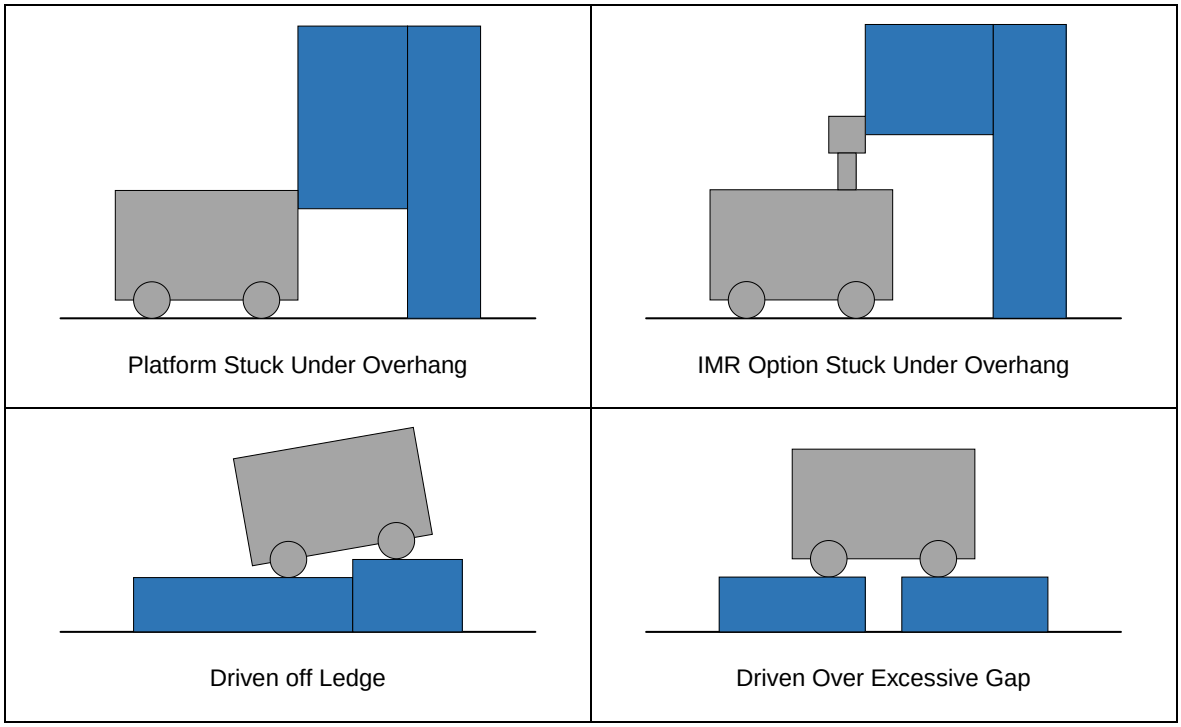
The floor should be flat and provide good traction.

Do not use the platform in hazardous environments (explosive gas, and oil mist).

Do not use the platform in the presence of ionizing or non-ionizing radiation.

Getting Stuck

It is possible, though not likely, for the IMR to get into a position from which it cannot move without Operator assistance. Some examples are shown in the figure below.



Platform Stuck Under Overhang

IMR Option Stuck Under Overhang

Driven off Ledge

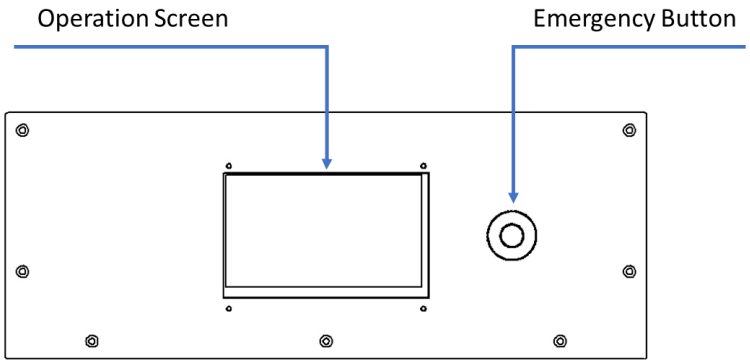
Driven Over Excessive Gap

4.2. Typical Operation

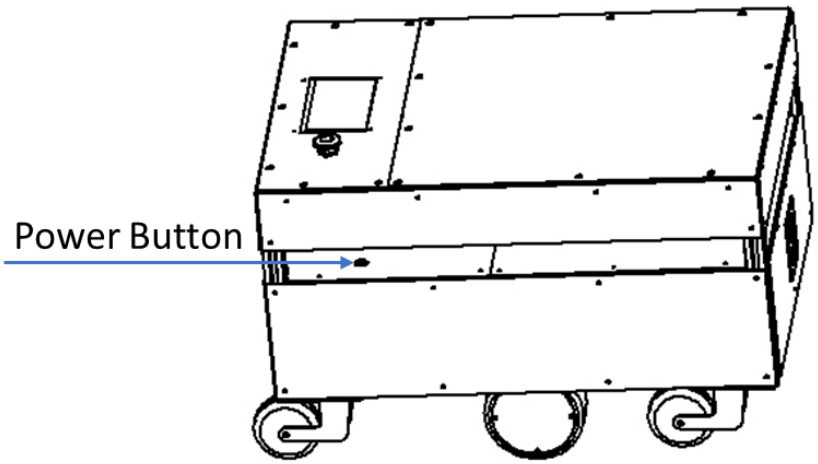
During normal start-up, the platform powers all its onboard systems and runs its onboard software and your integrated processes automatically to provide an application-ready IMR. If it has been given a map of its workspace and knows where it is within that environment (localized), IMR is ready to perform start-up and operate autonomously, without human intervention. Paths are not pre-programmed, but instead are generated dynamically onboard of the platform. Paths are updated many times per second to maintain a smooth trajectory and to account for any obstacles that are detected by the onboard sensors. Navigational parameters are stored onboard the platform, and can be viewed and modified using the Mobile Robot Supervisor software.

4.3. Operation Panel

The Operation Screen, Emergency Stop, are located on the Control Panel on top of the IMR.



The power button is located on the space in which the lidar is installed.

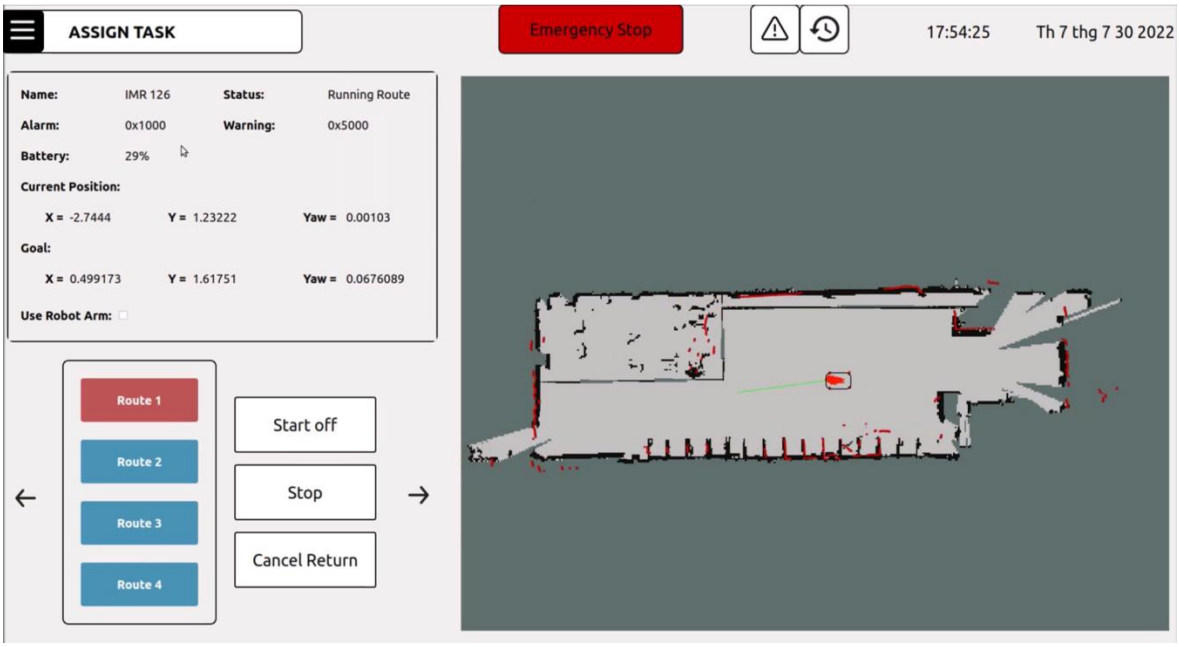


Screen

The screen is 7-inch IPS screen with hardware resolution of 1024x600, 5 points capacitive touch control, HDMI Screen.

Default/Sample Screen Contents

After the platform boots up you will see the main screen:



Emergency Stop

When pressed, the red, latching push-button prevents any IMR motion by disabling the motor driver.

To reset the Emergency Stop, twist the button slightly, so it pops up.

In normal use, the E-Stop button has three primary purposes:

- You need to interrupt or stop the platform for some reason, to keep it from performing its currently scheduled task.
- You are working near the platform and don't want it to move.
- You want to move the IMR manually.

ON button

The ON button turns on the whole system when pressed, and the software finished shutting down the IMR.

Other Controls and Indicators

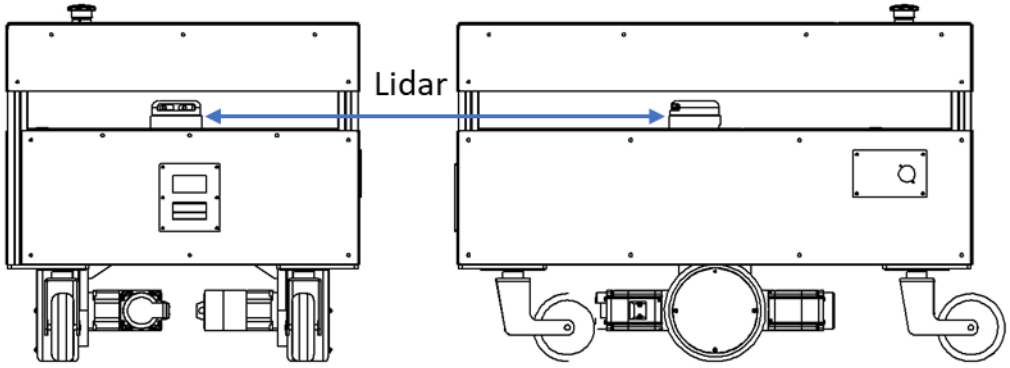
Mounted Color Light strip

Color	Description
Fading Blue	The light strip will light up and fade out slowly when the power ON button is pressed until the startup process finishes.
Green	The light strip turns green when correctly boot up and nothing is wrong with the hardware and ready to operate.
Red	The light strip turns red when in these cases: • The Emergency Button is pressed. • Running on low battery

4.4. Sensors

LIDAR

The IMR Platform has 1 LIDAR sensor for navigation and safety.



The LIDAR sensor is mounted as illustrated above.

The onboard LIDAR is a precise 360º, 25 meters scanning Radius & Mute brushless Motor lidar sensor for Obstacle Avoidance and navigation indoor/outdoor IMR. The LIDAR is positioned at 40cm above the floor. In most environments, the LIDAR provides highly accurate data.

The laser cannot reliably detect glass, mirrors, and other highly reflective objects. Use caution when operating the platform in areas that have these types of objects. If the platform will need to drive close to these objects, we recommend that you use a combination of markings on the objects (e.g., tape or painted strips), and also use forbidden sectors in the map, so that the platform knows to plan paths safely around these objects.

Magnetic Sensor

It is a 16-bit magnetic sensor that detects magnetic tape to follow to when moving to charging dock.

Encoder and Gyroscope

Each wheel has an encoder that tells the navigation system how far the wheel has turned, and in which direction. Each wheel also has a Hall sensor. The core has an internal gyroscope to track the platform's rotation. The platform uses a combination of rotation and distance traveled to back up the navigation laser during localization. These limit the area on the platform's map that the platform needs to search.

5. Mobile Robot Software Suite

5.1. Overview

The Mobile Robot Software Suite is a suite of mobile-robotics software applications for programming and operating one or a fleet of mobile robots. It uses a graphical user interface (GUI) for communicating with and configuring the mobile robots, and to display and edit mobile robot map files. The mobile robots use map files to determine where they are, plan navigable paths to goals, execute tasks at programmed goals, and to control other autonomous robot tasks.

Mobile Robot Control System (MRCS)

The Mobile Robot Control System (MRCS) runs on the robot's core, and does the following:

- Performs all the high-level, autonomous robotics functions, including obstacle avoidance, path planning, localization, and navigation, culminating in the robot’s motion.
- Manages wired and wireless communications with on-board software, for external monitoring, development, and systems coordination.
- Enables external monitoring and control with the Mobile Robot Supervisor software.

Mobile Robot Supervisor Server

The Server software running on the Server appliance provides:

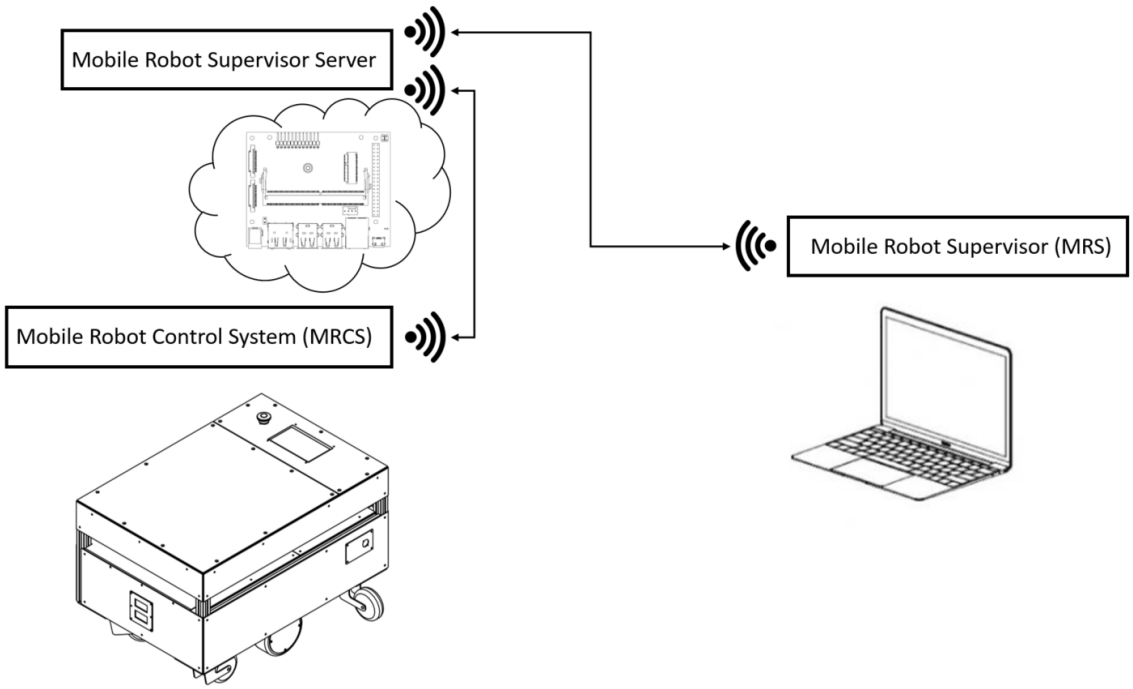
- Communicate between the MRCS and the Mobile Robot Supervisor software.
- Store Alarm data and Operation data of IMRs .

Mobile Robot Supervisor software

The Mobile Robot Supervisor software is the "control center" of the Mobile Robot Software Suite. Its user interface has the tools for all major IMR activities.

5.2. How the Mobile Robot Software Suite Components Work Together

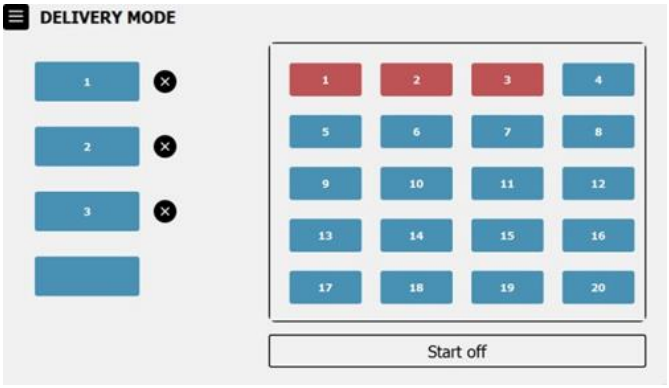
The figure below is a basic system architecture and illustrates the interrelationship between Mobile Robot Software Suite's various applications.



Components working together

5.3. Mobile Robot Control System (MRCS)

The Mobile Robot Control System (MRCS) is the "core" of the IMR. It will automatically run on your robot startup. Its user interface has the tools for all major IMR activities, such as monitoring status of IMRs, commanding individual IMRs to drive, modifying IMRs configurations, and more.

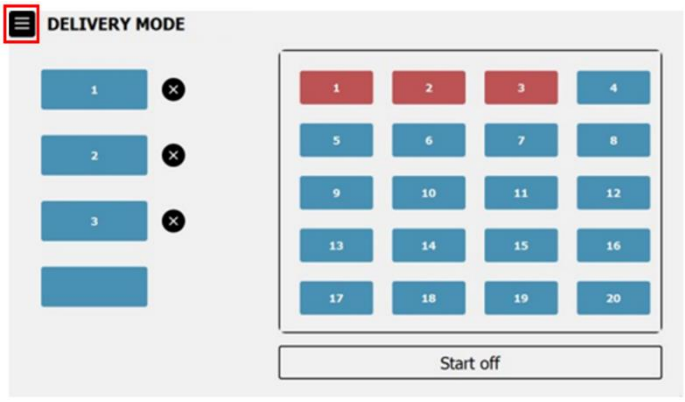


MRCS Delivery Interface

From the MRCS interface, you can:

- Create a delivery task, which can include up to four delivery positions. A schedule commands the robot to perform routes continuously.
- Set the system configuration parameters for the robot.
- Monitor the status of robot.
- View and interact with the task queuing manager.

To open the Mode selection menu, press on the menu button on the user interface:



The menu button on delivery interface

MRCS Main taskbar

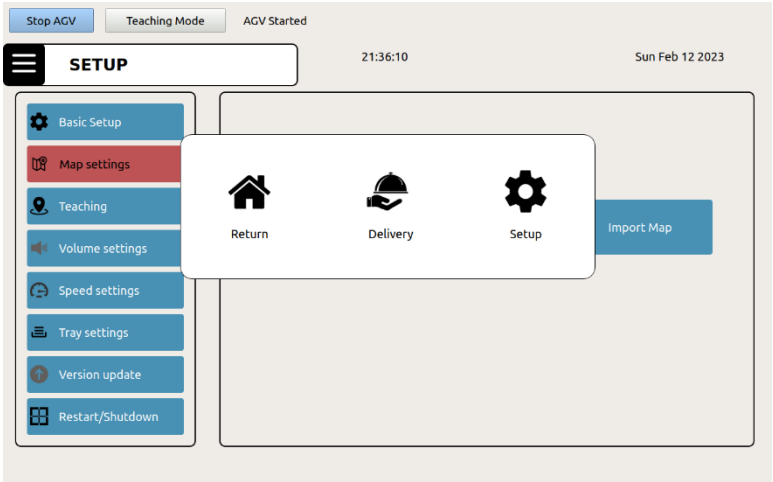
Before running the IMR robot, you need to start the core function from the MRCS Main Taskbar. The Taskbar is located on the top of program and consists these items:

- **Start/Stop AGV** button: This button used to turn on the core function of robot to allow it automatic moving. After pressing this button, please wait for the **AGV status** on the left changed to “AGV started” and then your IMR is good to go.
- **Navigating Mode/Teaching Mode** button: This button used to switch between other control modes of IMR. There are 2 control mode:
    - **Navigating:** In this mode, robot can run automatically after receiving orders from users. This is the default mode of IMR.
    - **Teaching:** In this mode, robot can only run using the attached joystick. This mode is used while walking the robot to scanning map. While robot is in this mode, it cannot run automatically even when receiving orders from users.
- **AGV Status:** Display the current core status of your mobile robot.

MRCS Menu

The MRCS Menu interface consists of the following button to run different modes of the robot:

- **Return** button: Command the robot to return to Home position immediately.
- **Delivery** button: Provide access to the Delivery Interface for running Delivery mode.
- **Setup** button: Provide access to the Setup Interface for configurating IMR’s parameters.

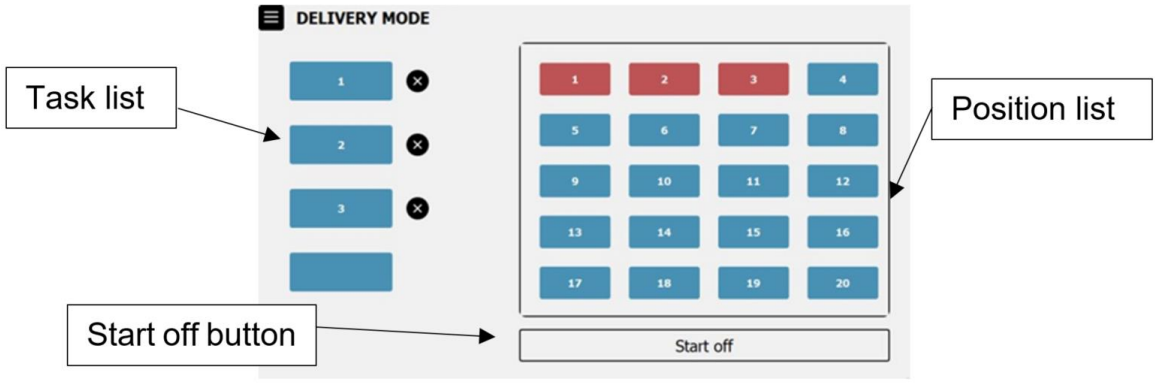


The MRCS Menu Interface

Delivery Mode

The Delivery interface consists of the following main sections:

- The Task list
- The Position list
- The Start off button

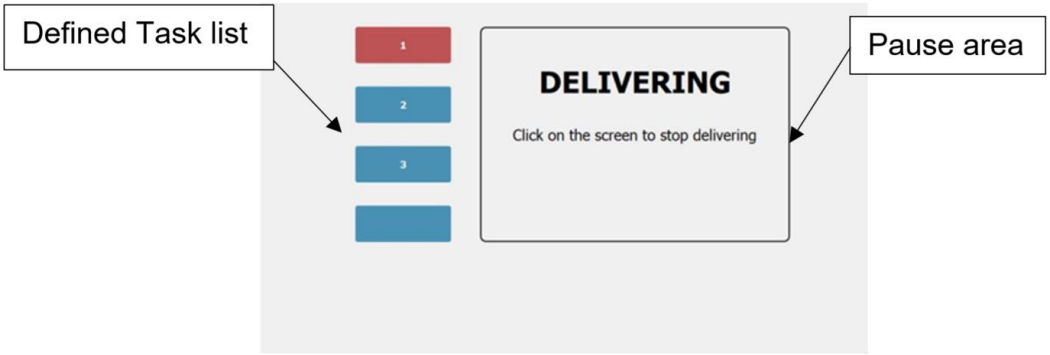


The Delivery interface

In Delivery mode, the robot can be used to run single position. Place the position from the Position list to the Task list by clicking on the Task cell, then click the Position buttton on Position list, the selected Position will be added to the corresponding Task cell.

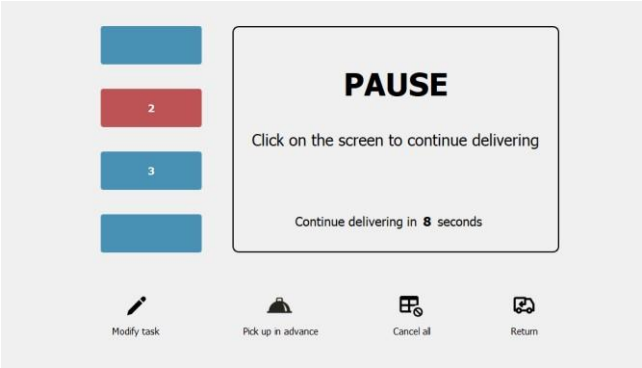
After finished planning robot task, press the Start off to start running all position in the Task list. A Running interface will appear. There are two main sections in the **Delivering interface**:

- Defined Task list: contains information of current position in Task list which robot heading to.
- Pause area



The Delivering interface

During the delivery process, you can touch on the Pause area on the interface, and the robot will stop for waiting immediately, if another touch command is not received after 10 seconds, the robot will continue to perform the remaining task list.



The Pause interface

After the robot is paused, the screen enters the **Pause interface**, you can perform operations such as modifying the task, bringing food in advance, canceling all tasks, and returning.

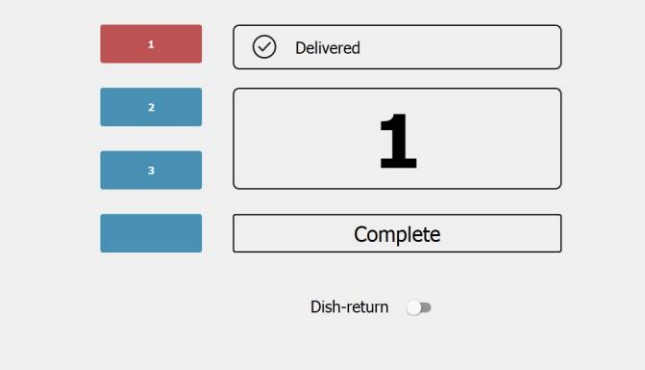
Click to modify the delivery position in Task list

Click to cancel the current delivery position in Task list

Click to cancel all delivery Task list.

Click to return to the Home position immediately.

When the robot arrives at the designated position according to the Task list, **the Delivered Interface** will appear and robot will not move until the Complete button is pressed. After pressing the Complete button, robot will start moving to next position in the Task list.



The Delivered interface

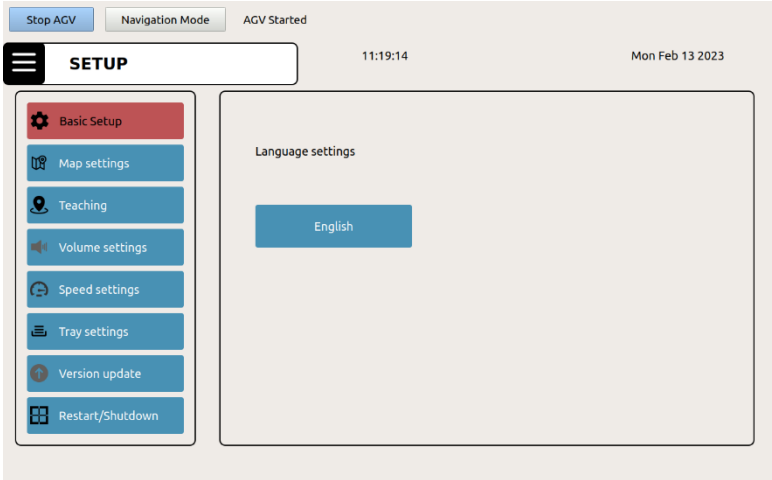
After finished running all positions in the Task list, the robot will automatically return to the Home position.

Setup Mode

The Setup interface consists of the following main sections:

• The Config list: there are eight tabs under the Config list: Basic Setup, Map settings, Teaching, Volume settings, Speed settings, Tray settings, Version update and Restart/Shutdown.

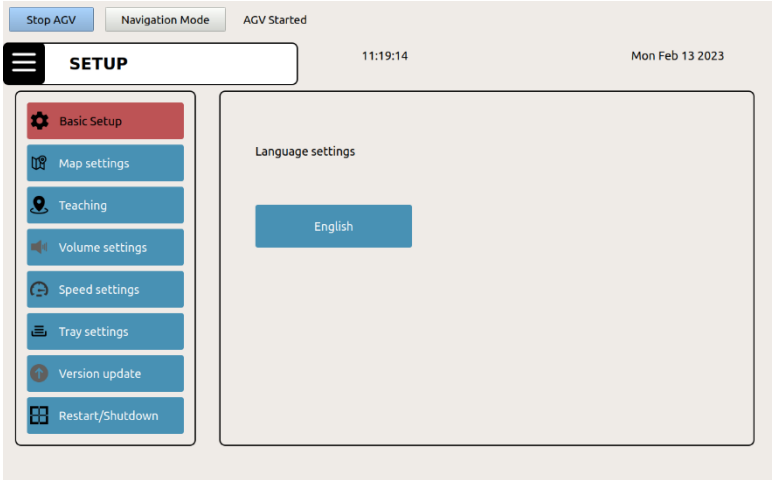
• The Config parameters: contains necessary tools to configurate parameters of your IMRs.



The Setup interface

Basic Setup

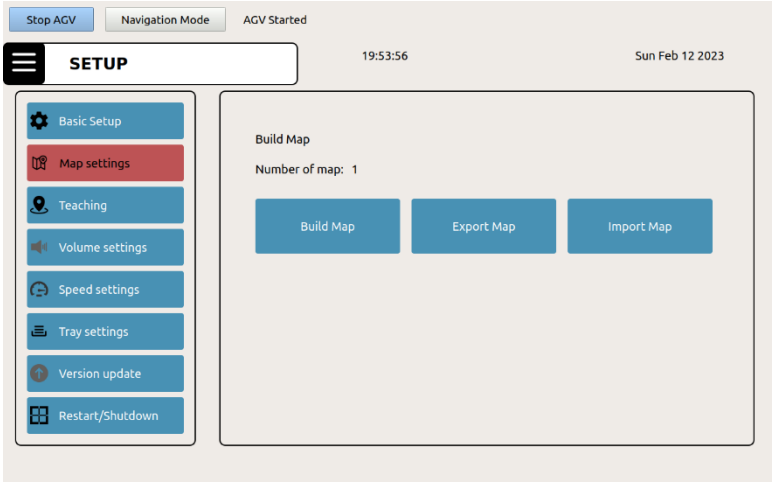
When **Basic Setup** tab is selected, you can modify Languages used on IMR. This version currently supports English only.



Basic setup

Map settings

When **Map settings** tab is selected, you can modify the map used on IMR by scanning new map, export or import current map data.

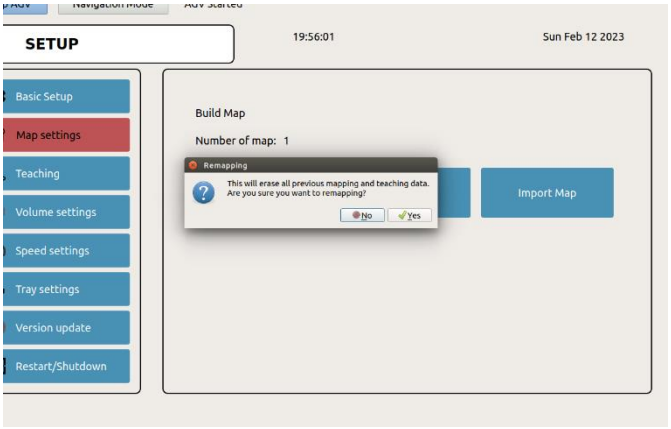


Map setting window

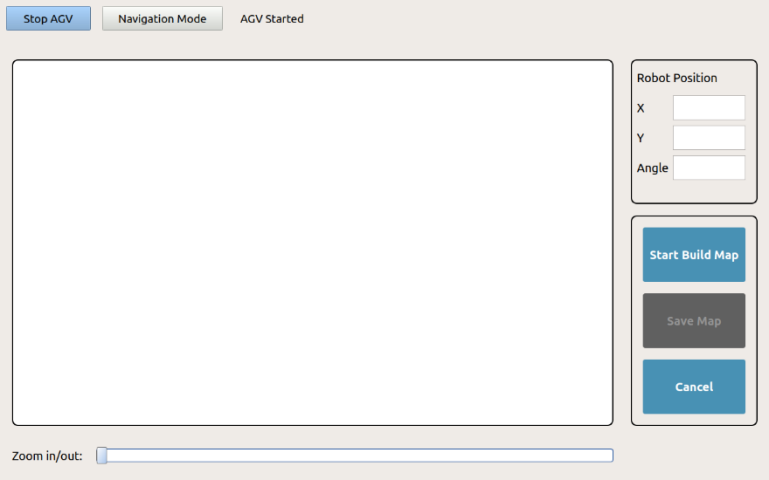
Press **Build Map** to start building a new Map.

Press **Export Map** to export the Map to another device

Press **Import Map** to import the New Map to AGV

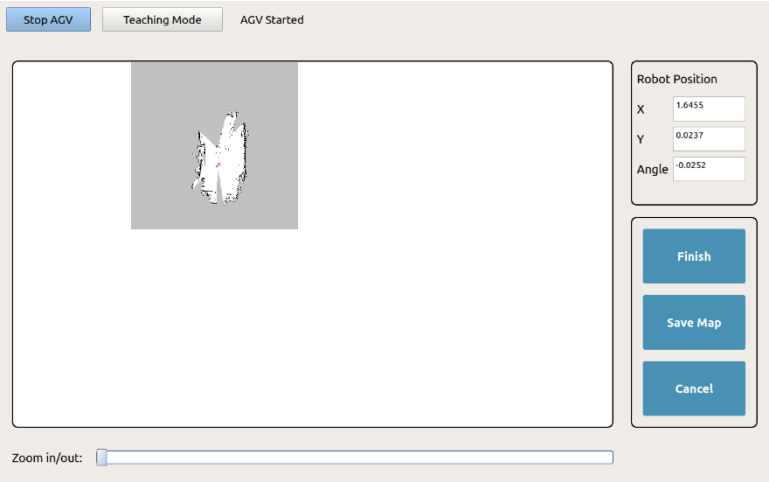


Press **Yes** to open Build Map program, press **No** to exit build map.



Build Map window

Press **Start Build Map** to start Build Map Program. Press **Cancel** to Stop and cancel Build Map Program.

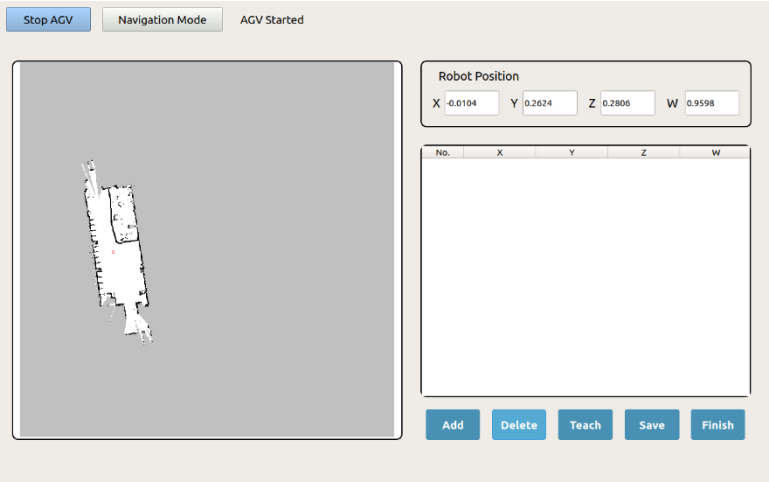


New maps will be continuously updated to the screen during the build map process. The robot location on the map is displayed in the **Robot Position** group.

Press **Save Map** to save new map into the AGV. Press **Finish** to stop build map program.

Teaching

On **SETUP** menu, press **Teaching** button to open Teaching window.

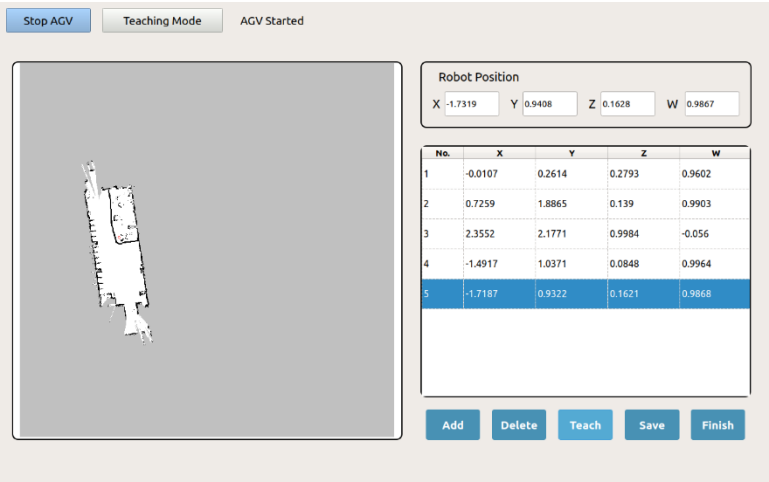


Teaching window

Robot position is displayed on **Robot Position** group. The **teaching table** shows the teaching points.

Press **Add** to add point to the teaching table.

To teach points, control the robot to move to a new position, press to table row and press **Teach** button. If User want to delete teach point, press to table row want to delete and press **Delete** button.



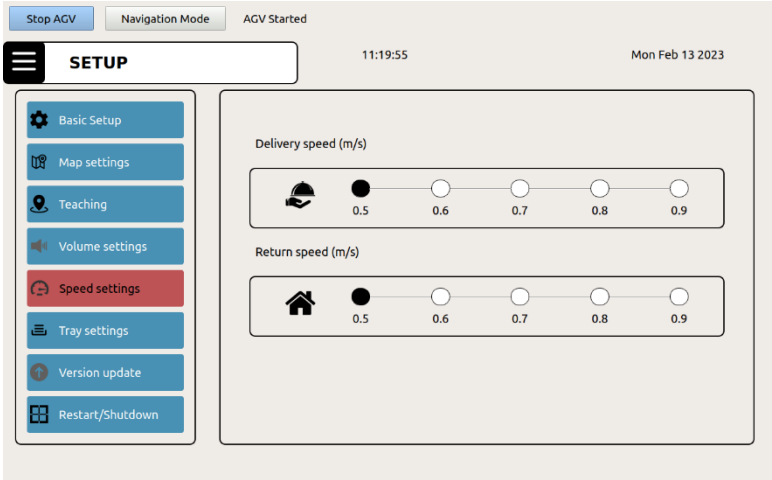
Press **Save** to save teaching table to AGV. Press **Finish** to stop teaching program.

Speed settings

When **Speed settings** tab is selected, you can modify maximum running speeds of IMR.

Delivery speed (m/s): The maximum running speed of robot on Delivery Mode. The speeds are ranged from 0.5 to 0.9 meter per second.

Return speed (m/s): The maximum speed of robot when returning to **Home** position. The speeds are ranged from 0.5 to 0.9 meter per second.



Speed settings

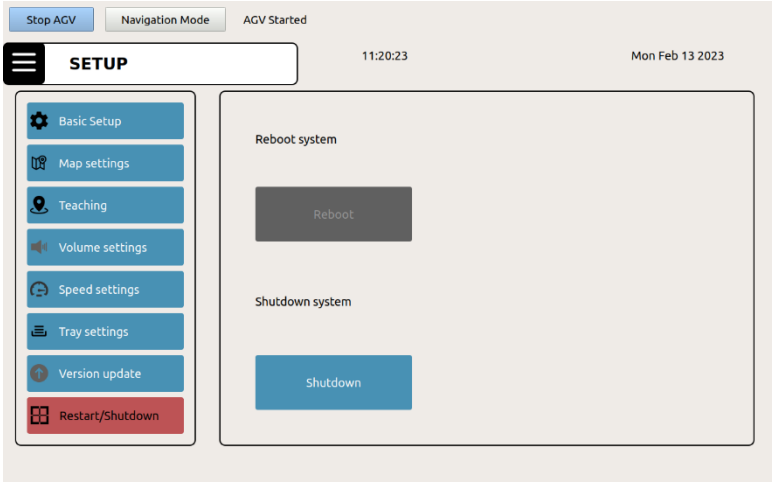
Trays Setting

Tray settings enable the maximum number position robot can move to in Delivery mode. The current version of AGV support maximum 4 point for Delivery mode.

Press to any **Select tray quantity** button to select maximum number of positions.

Restart/ Shutdown

On **Restart/Shutdown** tab, you can restart or shutdown the robot.

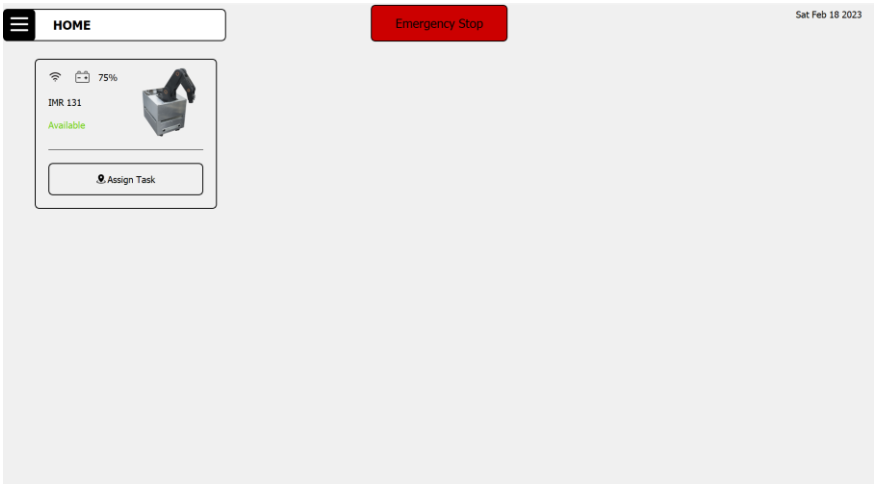


Press **Shutdown** button to shut down the IMR robot**.**

Press **Reboot** button to reboot the IMR robot.

5.4. Mobile Robot Supervisor software

Mobile Robot Supervisor software has features you can use to scan the robot environment, configure the robot, create and edit maps, and more. The interface is designed to be user-friendly and efficient, which reduces the learning curve and the time needed for deployment.



Mobile Robot Supervisor main menu

From the Mobile Robot Supervisor interface, you can:

- Connect to and view status of the mobile robot.
- Create floorplans (maps) of the environment by importing and analyzing a robot's scan data.
- Edit maps by adding obstacles, docks, forbidden areas, and more. You can also erase stray or unwanted artifacts, combine pieces of maps, and make other changes.
- Download and upload files, including maps and scan data, to and from a robot.
- With the Mobile Robot Supervisor Server (MRSS), monitor the alarm history and operation history of IMRs.

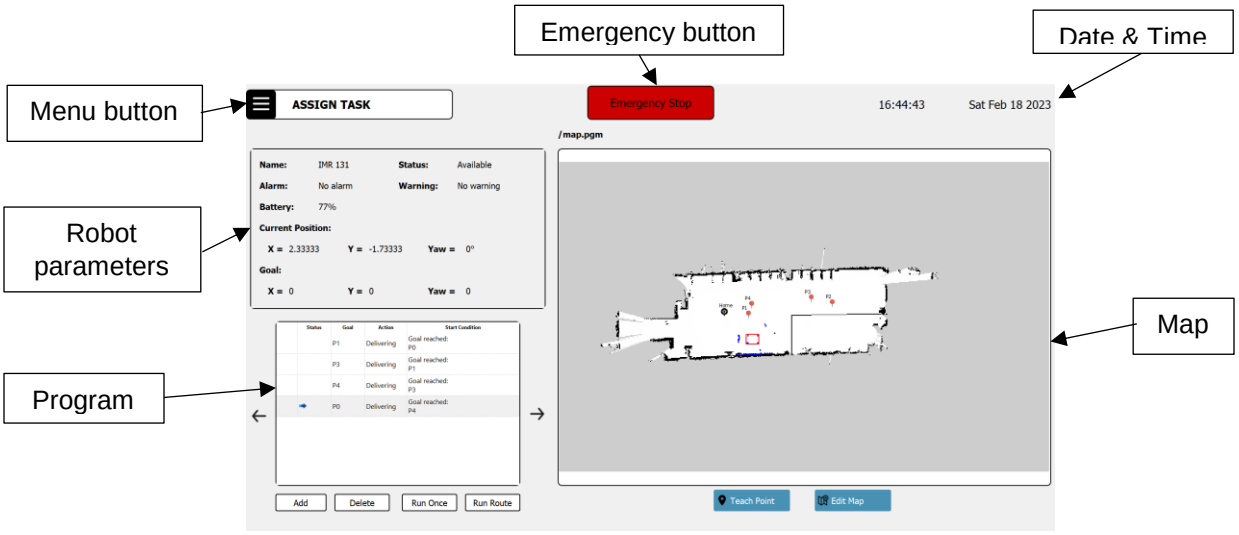
The Mobile Robot Supervisor Interface

The Mobile Robot Supervisor interface consists of the following main sections:

- Menu button
- Emergency button
- Parameters
- Program
- Map
- Datetime
- Alarm history button
- Operation history button

NOTE: By default, all the IMR information in Parameter are hidden, and will be displayed when the Mobile Robot Supervisor is connected to a robot.

The following figure is an example of the Mobile Robot Supervisor interface showing a map of a single mobile robot, containing Home and saved Teach Points.



The Mobile Robot Supervisor Interface (Example)

The following table describes the parameters displayed.

Parameters		Description
Name		The model and ID of current mobile robot Example: IMR 126 with - IMR – Industrial Mobile Robot - ID number - 126
Status		The state of current mobile robot. There are total four states: - Home - Running Once - Running Route - Returning
Alarm		The Alarm status of current mobile robot. The Alarm and Warning codes are displayed in the next table
Warning		The Warning status of current mobile robot. The Alarm and Warning codes are displayed in the next table
Battery		The battery percentage of current mobile robot
Current Position	X	The X coordinate of mobile robot in map
	Y	The Y coordinate of mobile robot in map
	Yaw	The Yaw angle of mobile robot in map
Goal	X	The X coordinate of robot’s goal in map
	Y	The Y coordinate of robot’s goal in map
	Yaw	The Yaw angle of robot’s goal in map

The following table describes the error code information.

Code	Name	Description	Possible Cause	Correction
0x1000	No error	Robot operate normally	-	-
0x1001	Battery critical	Battery percentage below 10%	Sensor read battery voltage below 24V	Recharge the robot
0x1002	Robot stuck	Robot could not find any valid trajectory to goal	The goal sent to robot is out of map	Recheck the goal coordinate
			Obstacle detected on the goal coordinate	Move the obstacle out of goal coordinate
0x1003	Emergency stop	Emergency button is pressed	Emergency button on robot is pressed	Release emergency button and restart system

The following table describes the warning code information.

Code	Name	Description	Possible Cause	Correction
0x5000	No warning	Robot operate normally	-	-
0x5001	Battery low	Battery percentage below 25%	Sensor read battery voltage below 25V	Recharge the robot
0x5002	Obstacle detected	Obstacle detected on robot moving path	Obstacle detected on robot moving path	Move the obstacle out of robot moving path

Map Interface

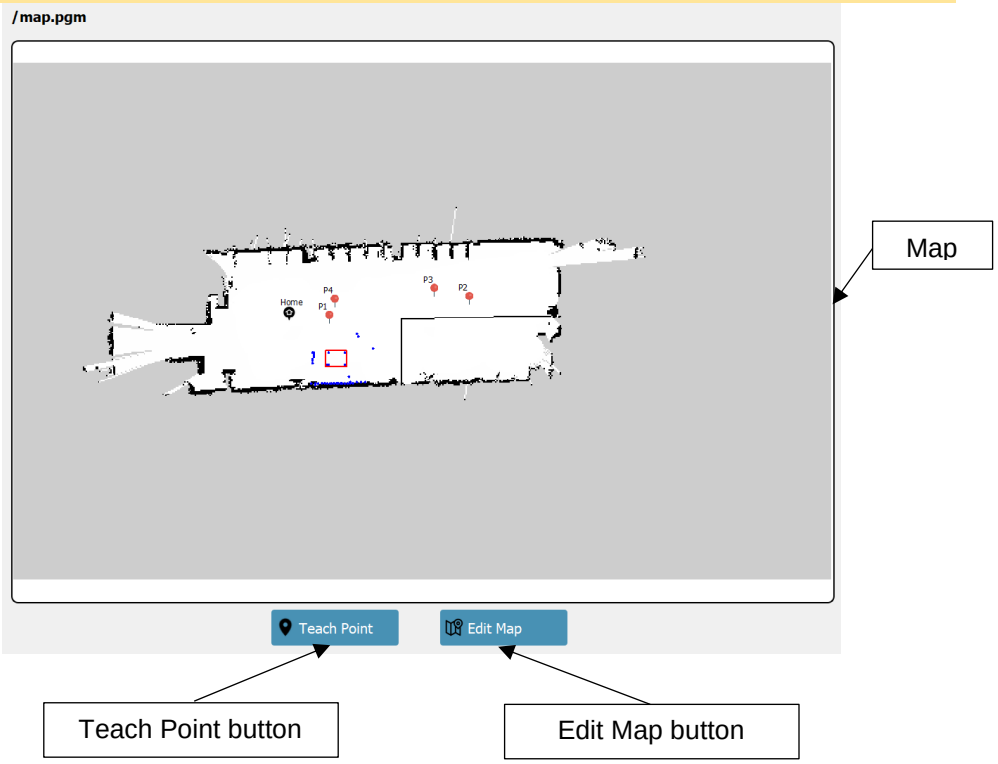
The Map Interface displays the map file that you are editing. When you first start Mobile Robot Supervisor, no map is displayed until you connect to a robot. You can also open a map saved locally on your computer or network.

The Map interface consists of the following main sections:

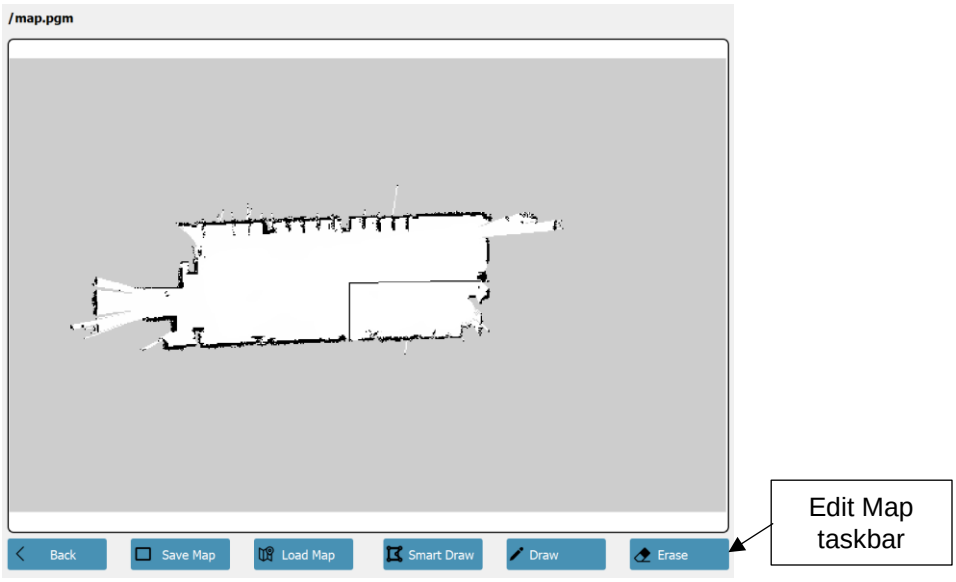
- Map
- Teach Point button
- Edit Map button

Below is an example of the Map interface with a map file opened.

NOTE: You can Zoom In / Zoom Out the opened map with your middle mouse.



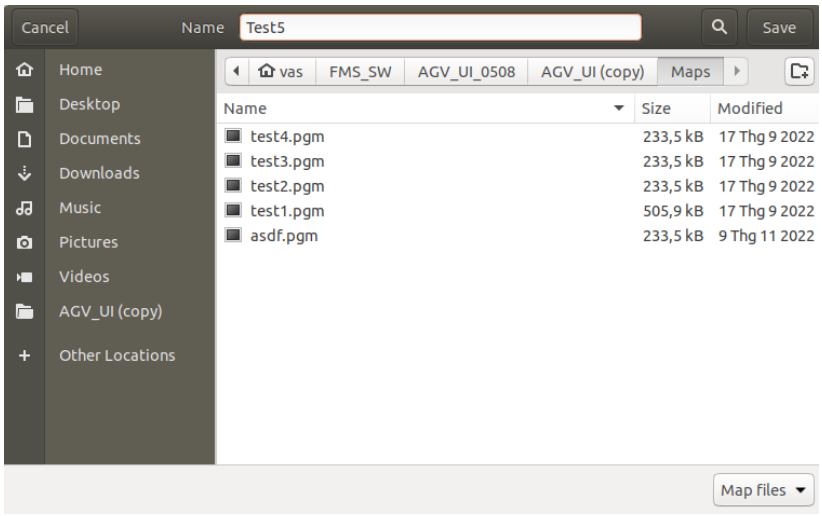
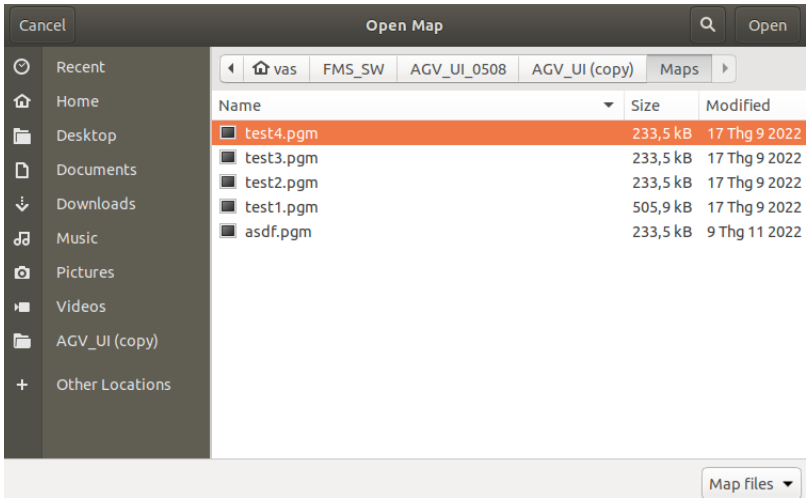
If you press on the **Edit Map** button, an Edit Map taskbar will appear to change or modify current map.

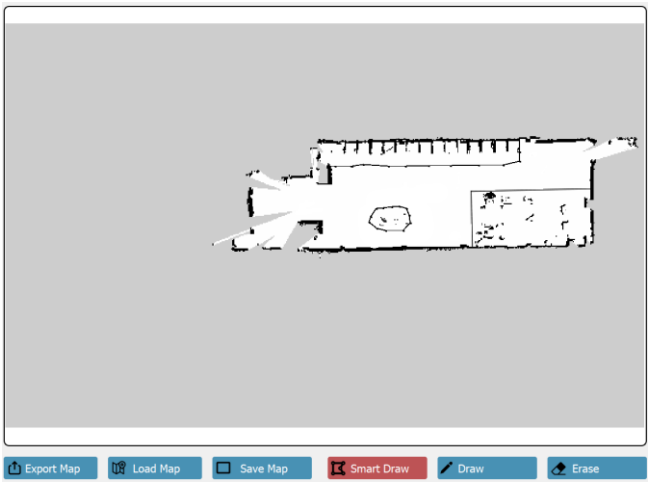
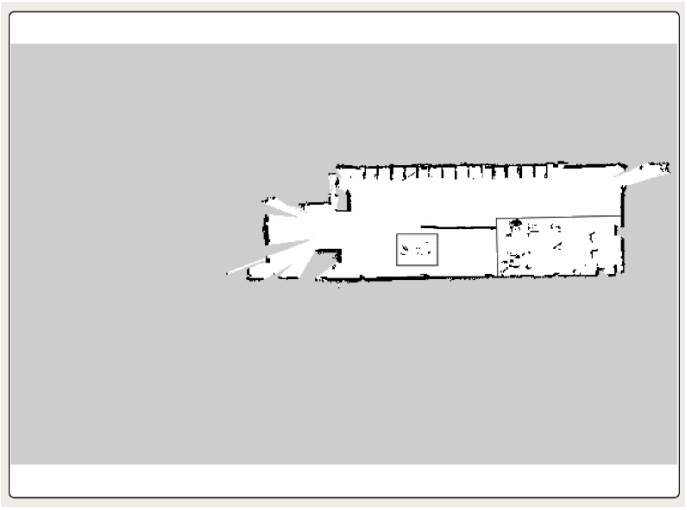


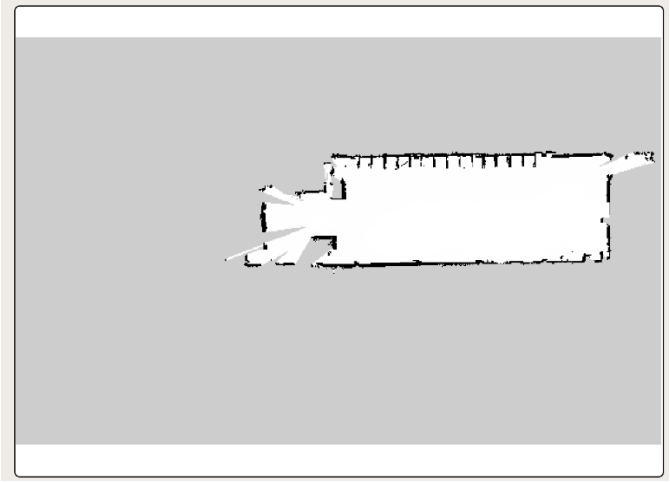
The Map Interface

You can use the Edit Map taskbar to add and edit map items.

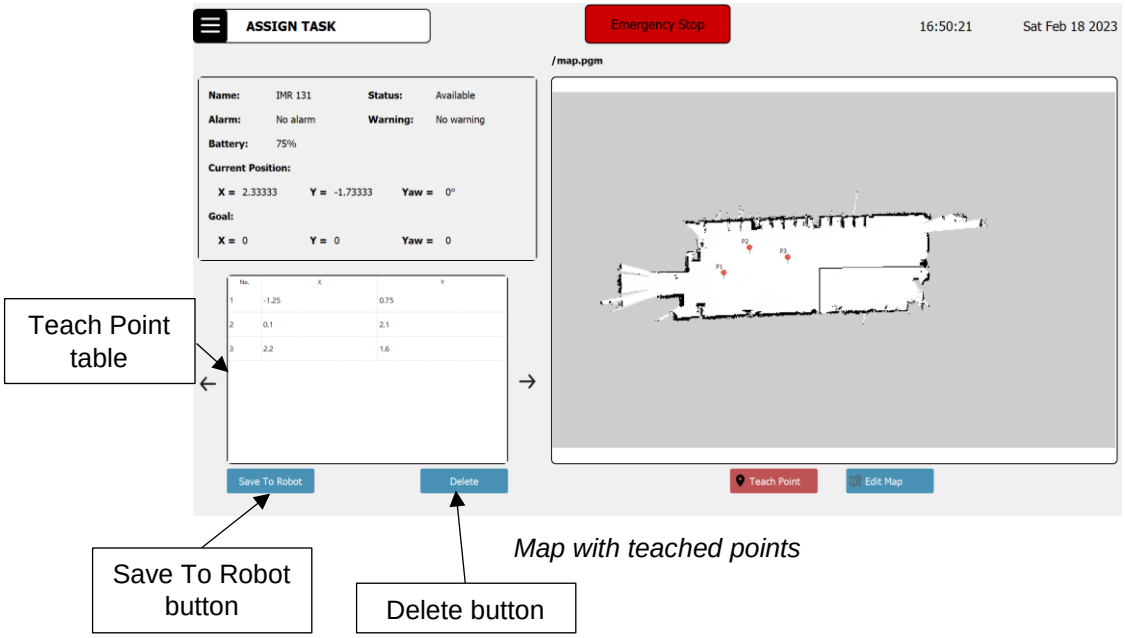
The following table lists the Edit Map buttons and their functions.

Name	Description
Save Map	Save map file (.pgm) to computer. First, click on the **Save Map** button, a dialog will appear. Then you can select map files from your computer  *Save Map dialog*
Load Map	Load map file (.pgm) from computer. First, click on the **Load Map** button, a dialog will appear. Then you can select map files from your computer.  *Open Map dialog*

Smart Draw	Draw an undifined-shape obstable the current map. This could use to cover a restricted area which robot could not enter. First, click on the **Smart Draw** button, then click on different points aroud the area which contains obstables. A boundary will appear to cover the obstacle area following your click-point. After finished drawing obstacles, you can click on **Save Map** to save new map files to your computer.  *Map after drawing obstacles*
Draw obstacle	Draw a round-shape obstacle the current map. This could use to cover a restricted area which robot could not enter. First, click on the **Draw obstacle** button, then start drawing obstacles directly on map. After finished drawing, you can click on **Save Map** to save new map files to your computer  *Map after drawing obstacles*

Erase Obstacle	Erase unwanted features on current map. First, click on the **Erase** button, then start erasing features directly on map. After finished erasing, you can click on **Save Map** to save new map files to your computer  *Map after erasing features*

If you press on the **Teach Point** button, an Teach Point table will appear to display your teached points directly from map. In this Teach Point map, you can select the point for robot moving to directly on map. All you need to do is click on your desired position on map and teach point data will be displayed on table.



Map with teached points

You can delete your unwanted teach point from table by selecting the row contain teach point and press **Delete** button.

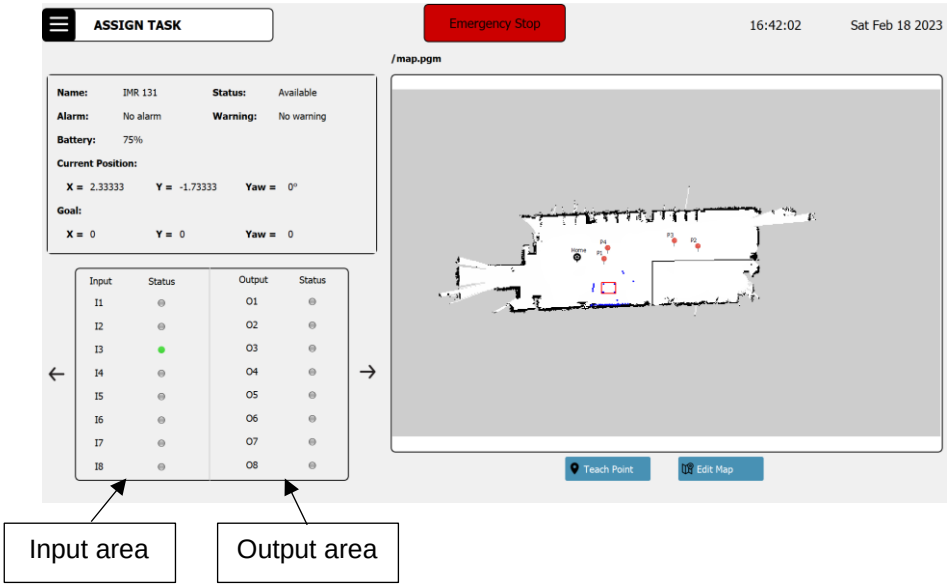
After finished teach point from map, you can press **Save To Robot** button to send points data to IMR.

IO Interface

The IO Interface displays the Input / Output status on your mobile robot.

The IO interface consists of the following main sections:

- Input area
- Output area



The **Input area** contains eight inputs and LED to indicate status of current input.

The **Output area** contains eight outputs and clickable LED button to change status of current output.

Program Interface

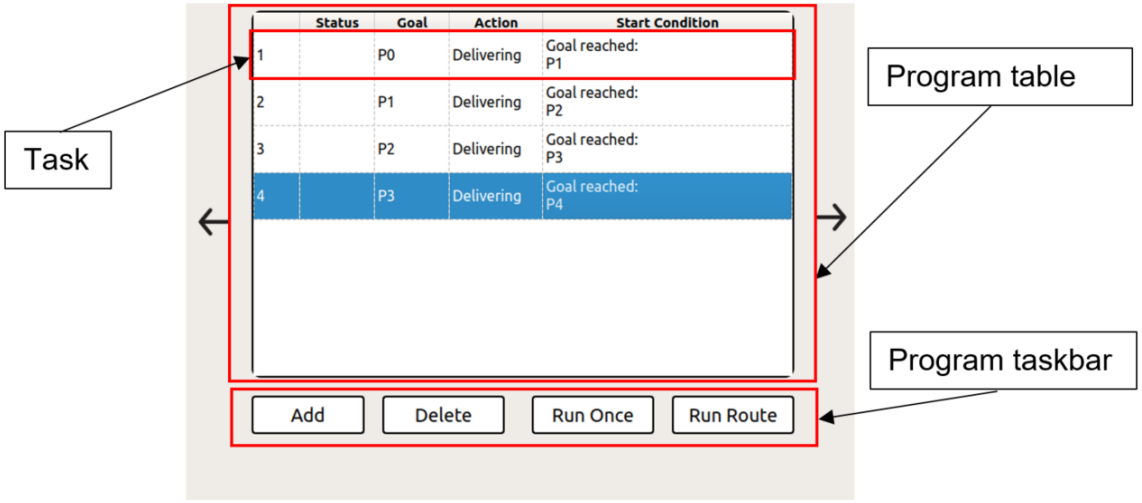
A IMR is unique in its ability to navigate freely and safely in a workspace, autonomously driving from one goal to another to perform various tasks (the lowest-level work the robot performs).Mobile Robot Supervisor gives you the flexibility to manually program a complex series of tasks for the robot to perform at a goal before moving on to the next goal and performing additional tasks.

You can add tasks and goals to program, then use the program within a route or several routes.

For example, you could create a program in which the robot heads to Point 1, speaks a phrase and waits for a human action, after which it then heads to Point 2, where it waits for a specified time, then heads to Point 3.

The Program interface consists of the following main sections:

- Task
- Program table
- Program taskbar



The Program Interface

Task

Task is a single activity that the mobile robot can perform, such as going to a goal or checking sensors. The robot executes multiple tasks inside program to accomplish useful work, such as enabling DIO and telling the robot to move. These tasks are already available on the robot but need to be defined and programed by user.

Program table

The **Program table** contains information about robot's tasks programed by user. Those information are described in the following table.

Column	Description
Status	Indicates which task in program table robot is executing.
Goal	Indicates the goal which robot is heading to.
Action	Indicates robot's type of action. There are two action types of robot: - **Delivering**: When robot moving from current position to a new position. - **Returning**: When robot moving from current position to Home position.
Start Condition	Indicates the required condition of robot to execute this task. There are five action types of robot: - **Goal reached**: When robot reached a designated goal. - **Action finished**: When robot completed an action. - **Input signal ON**: When the state of an input signal is ON. - **Input signal OFF**: When the state of an input signal is OFF. - **Start time**: When the system datetime coincide with a specific datetime.

Program taskbar

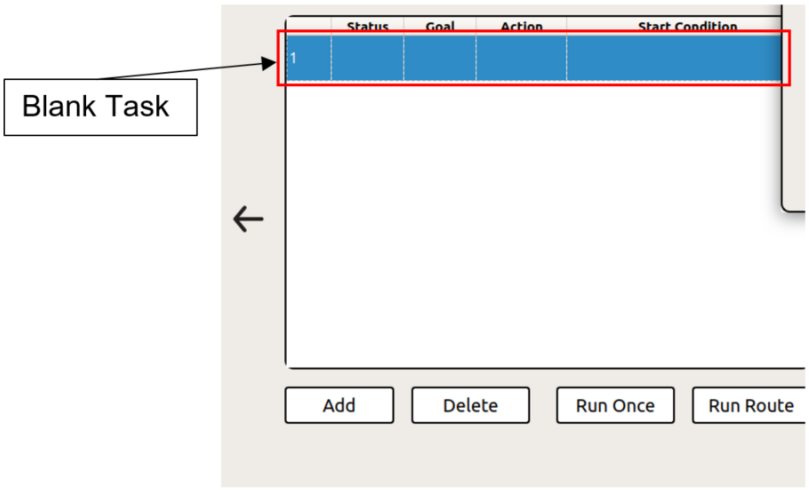
The **Program taskbar** contains necessary tools for robot programming. Those tools are described in the following table.

Column	Description
Add	Add a blank task in program table.
Delete	Delete a selected task in program table.
Run Once	Run the Program once.
Run Route	Run the Program repeatability.

How to setup a running program for mobile robot from Program table?

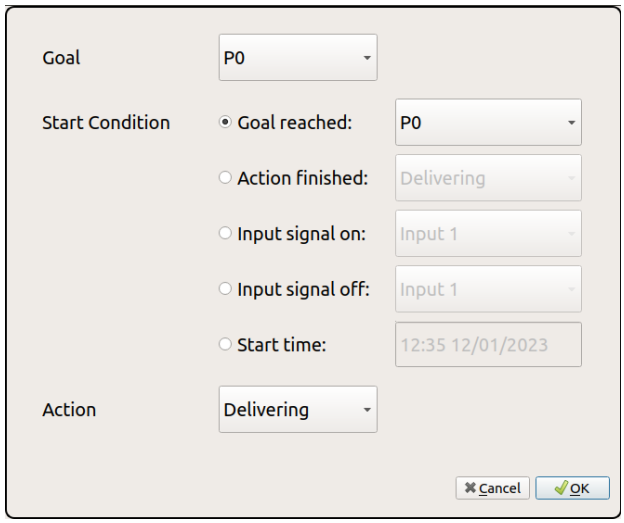
To create a task:

1. Click on the **Add** button to create a blank task in Program table.



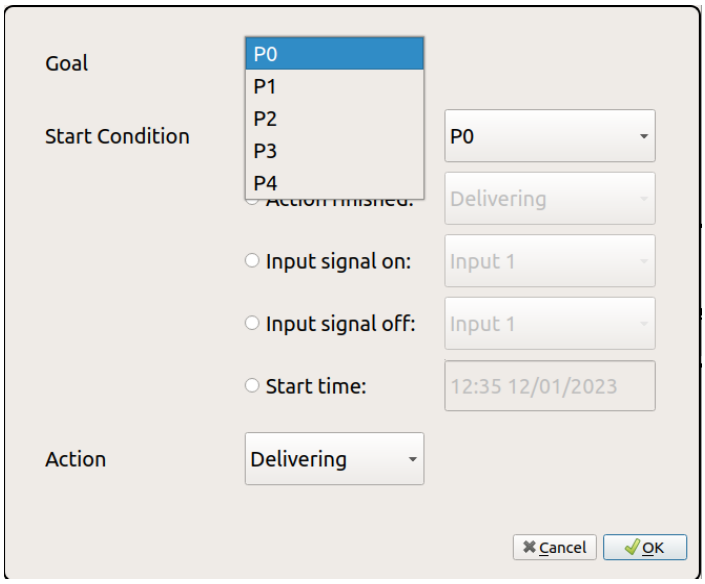
Creating a blank task

2. Double-click on the blank task and the Task dialog will appear.

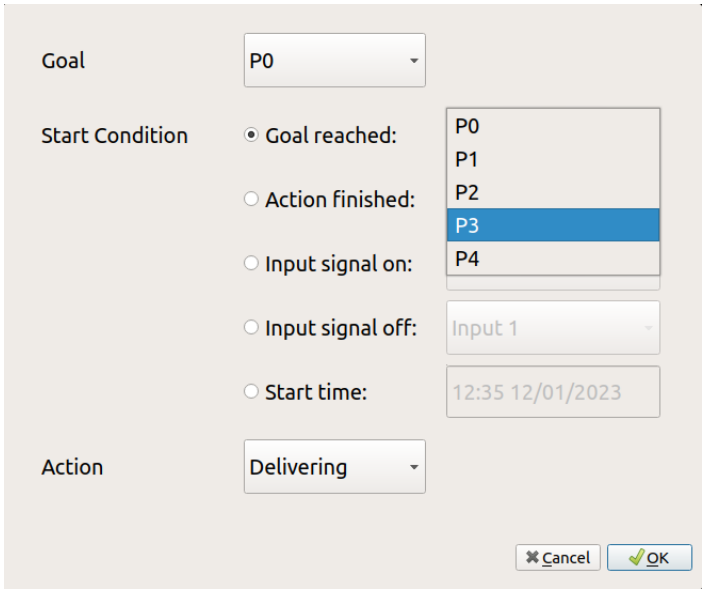


The Task Programming dialog

This Task dialog contains selectable data to program your task. You can select your prefered Goal for robot in this task, the Start condition of robot and type of robot's action in this dialog.

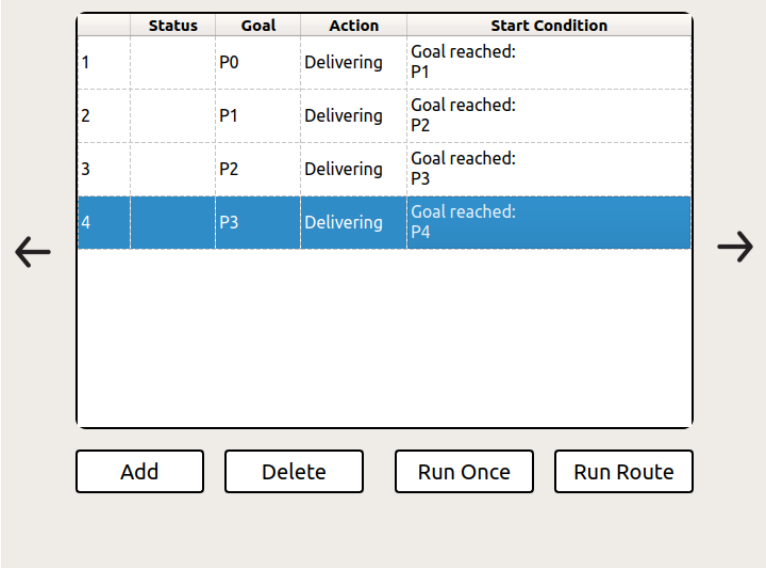


Programming Goal for blank task



Programming Start condition for blank task

3. After finished programming, click **OK** to save your task data to Program table or click **Cancel** to close the dialog without making any changes.

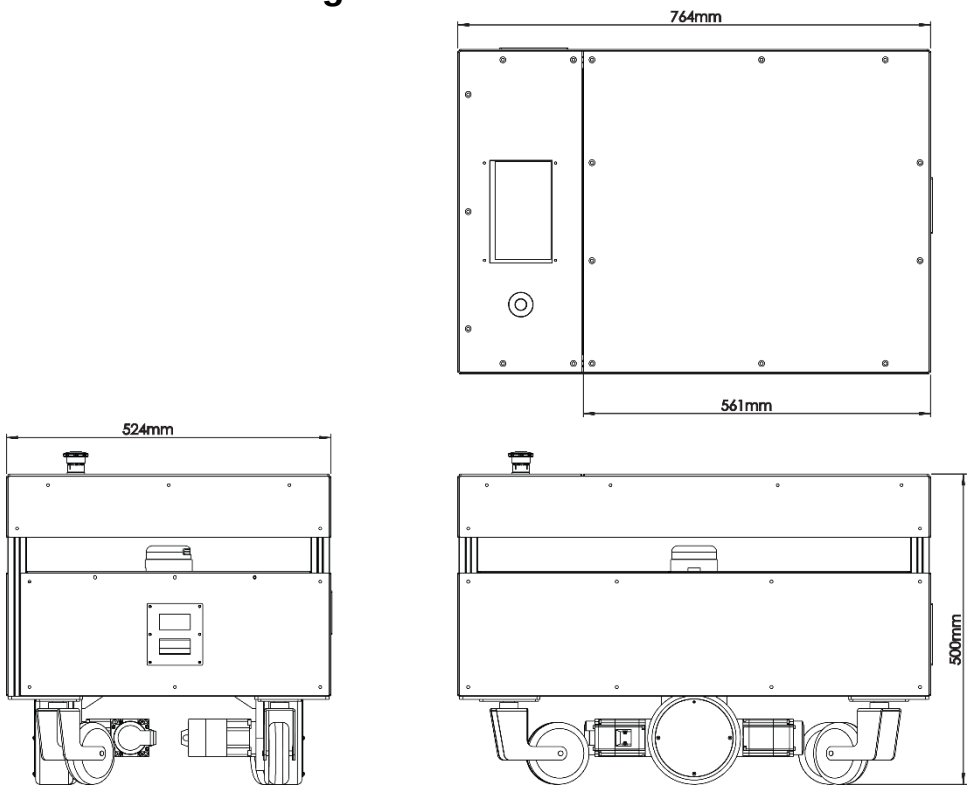


Programming table with multiple tasks

4. Click on **Run Once** button to run the Program table once or click on Run Route to run the Program table repeatedly.

6. Technical Specifications

6.1. Dimension Drawings



6.2. Platform Specifications

Physical

Description	Specification
Length	764 mm
Width	524 mm
Height (body)	500 mm
Body clearance	50 mm
Drive Train	
Drive wheels	2 yellow rubber
Wheel dimensions	150 x 50 mm
Passive casters	2 front, 2 rear, spring-loaded
Caster diameter	120 x 32 mm
Brakes	2 (one each axle)

6.3. Performance

Description	Specification
Performance	
Max payload – level	100kg
Turn radius	0 mm
Translation speed, max	1000 mm/s
Rotational speed, max	40º/s

Sensor

Description	Specification
Sensors	
Safety Scanning Laser	1 at the center of the platform 344 mm (7.9 inches) above floor 360°, 25 m range
Position encoders	2 encodes (one each wheel) 2 Hall sensors (one each wheel)
Analog gyroscope (Core)	2000º/s max rotation

Revision History

Revision	Date	Descriptions	Author
REVE.001	30.12.2022	Initial version	P.P.D N.H.N.L