Application Guide

Mobile Robots

OL-450S

This guide takes a hands-on approach, using practical application examples to provide a deep understanding about the key features of the OL-450S, enabling users to quickly begin developing applications while minimizing learning time.

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Reference Materials

AMR (Autonomous Mobile Robot) OL-series User’s Manual (Cat. No. M109)

AMR (Autonomous Mobile Robot) OL-series Safety, Unpacking, and Assembly Guide (Cat. No. M110)

AMR (Autonomous Mobile Robot) OL-series Charging Station Safety, Unpacking, and Installation Guide (Cat. No. M111)

AMR (Autonomous Mobile Robot) OL-series Battery Safety, Unpacking, and Installation Guide (Cat. No. M112)

Fleet Operations Workspace Core Integration Toolkit MQTT API (Cat No. M107)

Sources

1. Uline, IH-9022pdf, https://img.uline.com/is/content/uline/IH-9022pdf 22
2. Orgattex UK, FIFO Monorail Stop 2, https://www.orgatexuk.co.uk/product/fifo-monorail-stop-2/ 26
3. Penn Elcom, 4in Swivel Automatic Caster with Rubber Blue Wheel - W0990-AUTO, https://www.penn-elcom.com/us/4in-swivel-automatic-caster-with-rubber-blue-wheel-w0990-auto. 27
4. Hokuyo, UST-05LX 2D LiDAR Sensor, https://hokuyo-usa.com/products/lidar-obstacle-detection/ust-05lx 29

Supporting Files

OL-450S ORT Application Video	Application video highlighting use of OL-450S in ORT's production warehouse
"OL450S.map" map file	MobilePlanner map file created using OL-450S with example Goals and Macros
FleetSnapShot.zrp	A debug Fleet Snapshot file including EM/AMR configuration, map, macros, and goals used in this Application Guide
Docking_Undocking	A debug Replay file (zrp) and video (mp4) demonstrating docking and undocking
ExternalTriangle_DropOff_PickUp	A debug Replay file (zrp) and video (mp4) demonstrating locating of an external cart target
FourCasterPickUp	A debug Replay file (zrp) and video (mp4) demonstrating picking up a cart with four fixed casters
LateralMotion	A debug Replay file (zrp) and video (mp4) demonstrating use of the Lateral Motion robot task
TwoCasterPickUp	A debug Replay file (zrp) and video (mp4) demonstrating picking up a cart with two fixed casters
OL450_Hokuyo_Bracket.stl	A CAD file (stl) used to mount an external scanner

Macros used in debug Replay files were modified from original OL450S.map to allow completion of LiftControl robot tasks in simulation.

Units

All units are metric unless otherwise noted.

Distances are provided in mm unless otherwise noted.

1. Introduction

The OL-450S is an Autonomous Mobile Robot (AMR) with integrated lifting capabilities which can be controlled through OMRON's *Fleet Operations Workspace* (FLOW) Core software ecosystem. The OL-450S is designed to transport payload carriers such as roll cages, pick carts, pallets, and trollies autonomously throughout a facility.

Before creating an application, thoroughly review the *AMR OL-series User's Manual (Cat. No. M109)* for information regarding initial setup, and to learn how to safely use and maintain the OL-450S. Unlike other OMRON AMRs that require a topper for application completion, the OL-450S is a fully integrated unit that does not need any customizations before being deployed in an application.

This guide is intended to give a more in depth understanding of the main OL-450S features with an overview of how to set up an application with specific examples. Basic knowledge of AMR programming is assumed, and the *MobilePlanner Help Library* can be referenced for further details on specific features and concepts.

2. Getting Started

The OL-450S is very similar to the existing fleet of Omron AMRs in terms of usability with a few notable differences.

2.1. Physical Controls

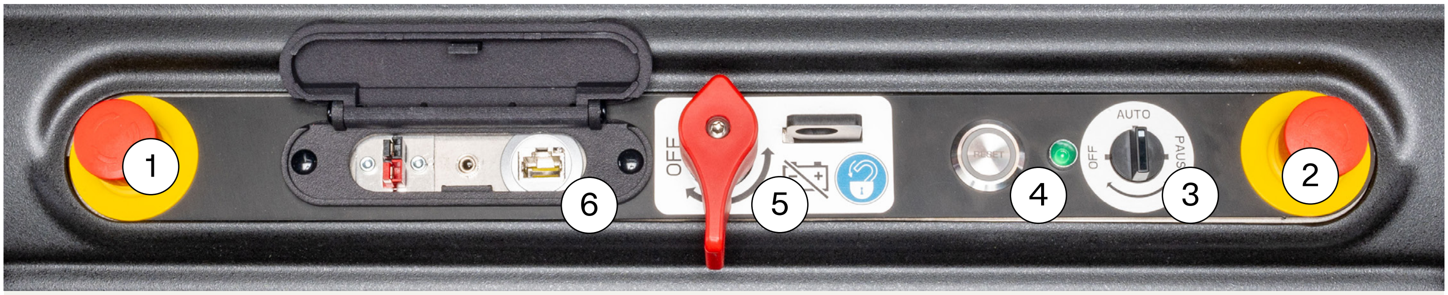

Figure 2-1 OL-450S Control Strip

Emergency Stop Buttons (1 & 2): Pressing either one of the emergency stop buttons will perform a Cat3 emergency stop of the AMR.

Mode Selector Switch (3): Unlike the *ON/OFF* buttons of other OMRON AMRs, the OL-450S includes a 3-position mode selector switch. When set to *AUTO*, the AMR will power up and normal operation will resume. When in the *PAUSE* state, the AMR will remain powered *ON*, but motion commands will be disabled. When set to *OFF* position, the AMR will be shut down.

RESET Button (4): The *RESET* button will return the AMR to an operational state after interruptions such as an emergency stop or Operation Stop are cleared. This is similar to pressing the *ON* button on the HMI for other OMRON AMR types to reenable the motors.

Physical Battery Disconnect Switch (5): Setting this switch to an *OFF* position will physically disconnect the battery. In this position, a physical lockout lock can be used for performing maintenance or to prevent unauthorized power up of the AMR. It is advisable to set the Mode Selector Switch to *OFF* to allow the AMR to properly shut down before using this switch to isolate the power.

Maintenance Port (6): Ethernet port to connect directly to the AMR and access tools such as SetNetGo.

2.2. Accessing SetNetGo

The SetNetGo utility can be accessed through the maintenance port at the default maintenance IP 10.39.46.1 to set the network IP address of the AMR or view any other AMR status or identifying information. Prior to accessing the SetNetGo, the client device (Laptop or PC) can be set to DHCP or a static IP between 10.39.46.100 and 10.39.46.149. Do not use addresses below 10.39.46.50 as these are reserved for internal OL-450S components. It is recommended to label the AMR with its IP address to make it easier when connecting to it directly.

2.3. Visual Indicators

The OL Series includes LED lighting with patterns similar to existing OMRON AMRs. The front and the rear light strips, and the elevated LED signal lamp provide visual indications of the AMR status.

2.4. Audible Indicators

An audible warning buzzer is included and can be configured via MobilePlanner to be activated for certain AMR actions. In the AMR configuration file under *Robot Interface > WarningSystems > Buzzer*, there are settings to disable all buzzer options, except for when an emergency or protective stop event occurs. Playing audio files or using the “say” robot task for audible feedback is not supported.

2.5. Manual Control

The Automatic Drive Control feature described in Section 4.3 can be used to give motion requests to drive the AMR. This feature is available only in MobilePlanner 9.2 or above and a minimum FLOW Core 5.0.0 software package is required. This feature may be needed on several occasions, including driving the AMR into its docking station if a map with a docking goal has not been created.

The OL-450S does not feature a brake release like other OMRON AMRs, hence precautions must be taken to avoid the battery from fully draining. In the event the AMR has no power, a service charger will be needed, or the AMR will need to be physically moved to the charging dock.

Physically moving the AMR can be accomplished with the optional Manual Mover or following procedures for lifting the AMR to place it onto a docking station. Do not attempt to push the AMR while power is *OFF* as this could cause damage. Refer to *AMR OL Series User's Manual (Cat. No. M109)* for further information regarding manually moving the AMR.

2.6. Safety

The AMR features 360-degrees of safety coverage using the two forward-facing safety-rated laser scanners and a rear safety bumper. As a small gap exists at the rear of the lifting plate that is outside the field of view of the front safety scanners, 360-degree safety laser coverage cannot be achieved using the two forward-facing safety scanners. The safety bumper at the rear of the lifting plate covers areas not monitored by the safety scanners. Since the bumper is a contact-based stop, the speed is limited to under 300 mm/s when driving in reverse.

2.7. Commissioning

Although the AMR is commissioned at the factory, commissioning must be performed as part of the initial setup or after changes to safety configuration to allow autonomous operation. Commissioning is used to verify the basic functionality of the safety scanners and emergency stop sources and should not be confused for IEC/ISO 61508 Functional Safety test. The commissioning procedure can be executed via the MobilePlanner menu bar under *Robot > Commissioning.*

Safety is the highest priority in AMR deployment. All implementations must adhere to ISO 3691-4:2020 for global safety requirements, with North American deployments requiring additional compliance to ANSI/RIA 15.08-2 integration protocols. Conformance with these standards is essential to ensure operational safety and regulatory alignment.

3. Multi Sensor Mapping

Mapping and configuration are handled similarly to existing OMRON AMRs by the MobilePlanner. The OL-450S can employ several of its available sensors for mapping. To configure a sensor to be used for mapping, go to *Robot Physical > Sensors > 2DLiDAR*, select the desired scanner to modify its *UseOptions* as shown in Figure 3-1. The OL-450S is the first AMR in OMRON's product line to include a 360-degree laser scanner at an elevated height of 2200 mm that can be used for mapping. The impact of each scanner on the final map must be considered prior to choosing the scanners for scanning. It is important to note that processing times will also take longer when multiple scanners are selected.

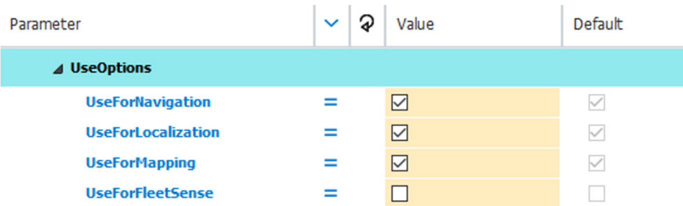

Figure 3-1 Sensor Use Options

3.1 Choosing the Right Scanner for Mapping

To illustrate the impact of using different scanners while mapping, a test environment shown in figure 3-2 was scanned to create a map file using the OL-450S.

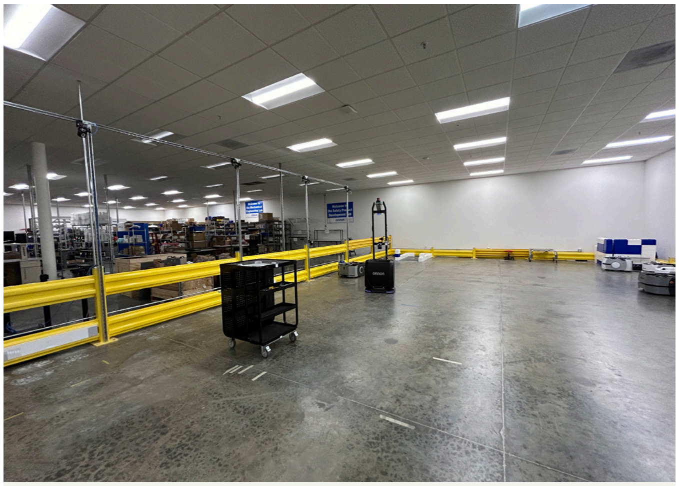

Figure 3-2 "OL-450S.map" Scan Area

The laser reading of all the scanners has been shown on the map with distinct colors:

Scanner_1 (Blue):	Left safety scanner
Scanner_2 (Magenta):	Right safety scanner
Scanner_3 (Red):	Rear scanner
Scanner_4 (Yellow):	High-mount 360-degree scanner

It can be observed in Figure 3-3, the left and right safety scanners can capture features close to the floor like the yellow fence, but the 360-degree scanner can capture features at a higher level and much further out like the walls surrounding the test area.

Figure 3-3 All Scanner Readings

Utilizing the left and right safety sensors for mapping may reduce localization scores because objects near the floor are subject to frequent changes in location and shape. The 360-degree scanner mounted at a higher plane can capture features that do not change as frequently even in a dynamic environment, improving the localization score.

It is recommended not to use the rear laser scanner for mapping for two reasons: (1) Due to its proximity to the floor, tilts in the AMR due to minor floor unevenness can make it see the floor, which results in false readings; and (2) it has the lowest resolution among all the onboard scanners.

Although all scanners can be used for mapping, only two can be used for localization. If more than two are selected, the first two enabled scanners in the *2DLiDAR* list with localization enabled will be used. If a scanner is not planned to be used for localization, then it is not recommended to be used for mapping either.

If the map is built with scanners at different elevations and those scanners are used for localization, disabling the "raytracing for localization on initialization" *(RayTraceAtInit)* parameter is recommended.

3.2 Scanning Considerations

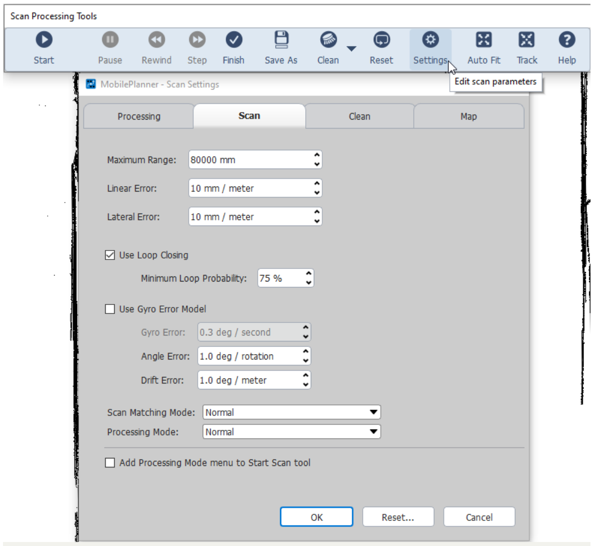

Figure 3-4 Scan Processing Maximum Range Setting

Before starting a scan, it is recommended to clear out old scan files to increase map file storage capacity. The 360-degree scanner produces substantially more data points than the lower safety scanners, so map file sizes are expected to be larger than than the ones generated by other OMRON AMRs. As this scanner has a range of 30 m, mapping large areas will require updating their scan settings to increase the maximum range when processing a scan as shown in Figure 3-4.

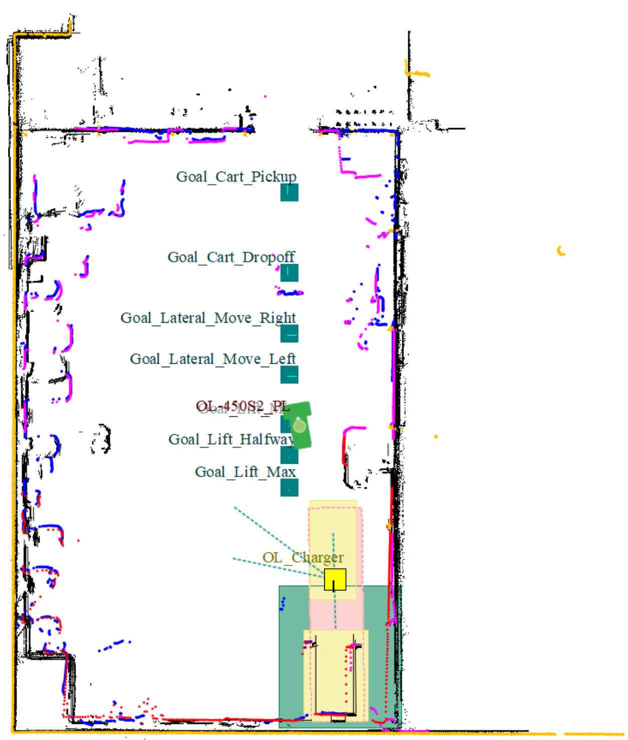

Figure 3-5 "OL-450S.map" Created Map File

As shown in Figure 3-5, once scanning is complete, points from all scanners used for mapping will be compressed onto a single-layer 2D map.

3.3. Mapping in Mixed Fleet Environment

When integrating an OL-450S into an existing fleet, it is important to account for differences in sensor placement, particularly when attempting to reuse a map generated by a different Omron AMR. The Front Safety Scanners in the OL-Series AMR are mounted lower to the floor and the 360-degree Scanner is mounted much higher when compared to other OMRON AMRs. Variations in sensor placement can lead to differences in the maps generated by the OL-450S and other OMRON AMRs. Figure 3-6 highlights this difference by comparing the map generated by an OL-450S with one created by a LD-90. A comparison of the different scanner heights can be seen in Figure 3-7 and Table 3-1. In cases where map features are consistent between the scanner heights, then using a common map in a mixed fleet will have little to no impact on the performance of the AMRs.

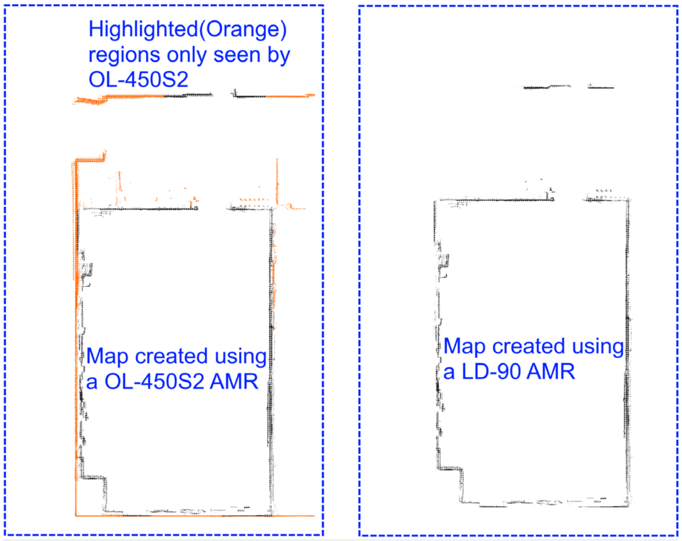

Figure 3-6 Maps Generated by an OL-450S2 and a LD-90

AMR Type	Main Scanning Plane (From Floor Surface)
OL-450S	2200 mm and range of 30 m 105 mm and range of 40 m
LD-60, LD-90, LD-250	190 mm and range of 40 m
HD-1500	181 mm and range of 40 m
MD-650, MD-900	175 mm and range of 40 m

Figure 3-7 OMRON AMR Safety Laser Scanning Planes

Table 3-1 shows the general guidelines on which AMR should be used to generate a common map file. It assumes mapping performed with OL-450S utilizes one of the front safety scanners and the higher 360-degree scanner.

Application Map Features	Mapping Recommendation
No change in features between 105-2200mm	Use map generated from any AMR
Changes in features above 200mm, And no change in features between 105-200mm	Use map generated with OL-450S
Changes in features between 105-200mm	Map with OL-450S and merge with map of another OMRON AMR type

Table 3-1 AMR Mapping Guideline

4. Navigation

The OL-450S only supports the Selectable Autonomy (SA) navigation framework. This framework allows for more deterministic and controlled navigation behaviors. By default, *Docking* and the *Send to Goal* commands will also utilize SA. When using an OL-450S with a mixed fleet of AMRs it is recommended that all AMRs use SA if they are in the same working environment. Natural Feature Navigation (NFN), also referred to as "Path Planning", is not currently supported for the OL-450S. The *Send to Point* command is not recommended as this drive mode utilizes NFN. Using NFN features might result in sub-optimal navigation maneuvers.

4.1. Navigating Narrow Aisles

It is expected that the OL-450S will be used in factories that include narrow passageways. For a safe operating zone of the AMR, a clearance of at least 500 mm in width and 2100 mm in height must be maintained on both sides of the AMR. There must be 500 mm clearance in front of the AMR in the direction of travel at all times. Zones with less than 500 mm of clearance between AMR and obstacles are considered hazard zones per ISO 3691-4 as illustrated in Figure 4-1. Hazard zones must be properly marked and be visually distinct. Personnel working near or in these zones must receive appropriate training on proper use of the AMR and AMR safety. The minimum aisle width that the AMR can operate without modification to its safety system is 1200 mm. When using the default settings to achieve its full linear speed of 1200 mm/s, aisles should be designed to be at least 2000 mm wide. The AMR will travel at a reduced speed for passageway that are lesser than 2000mm wide. If creating aisles where two OL-450S AMRs will be passing each other, then they should be designed to be at least 3800 mm wide, which provides 1900mm per AMR as shown in Figure 4-2. This allows both AMRs to maintain full speed. Lanes below this width may cause the AMR to slow down when traveling in close proximity to each other.

When operating in a narrow aisle that does not pose a safety risk, the slow down behavior can be modified under *Robot Operation > Move: Path Defaults > SlowDownMode*. Setting the mode to *Tight* or *Custom* configuration will allow the AMR to maintain a higher speed in areas that would normally cause it to slow down. This can be combined with the use of *MotionLimit* sectors to define on a map file any specific areas where the AMR speed should still be limited.

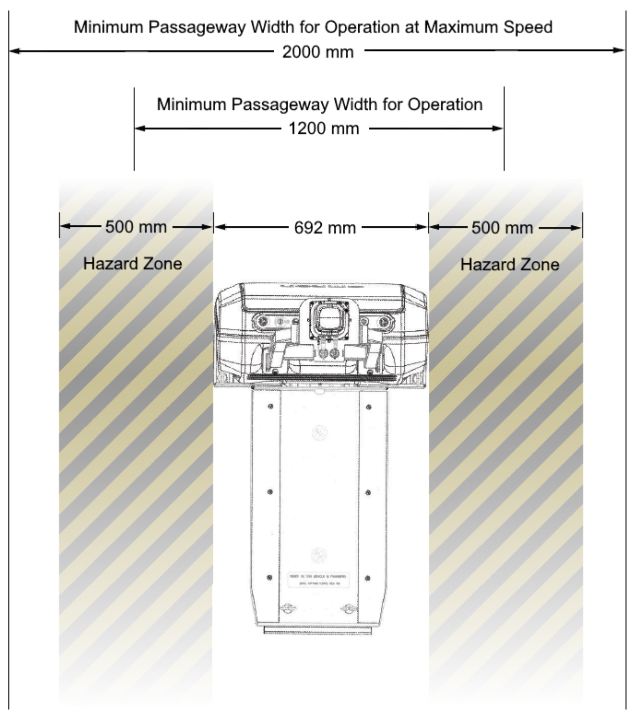

Figure 4-1 Passageway Behavior

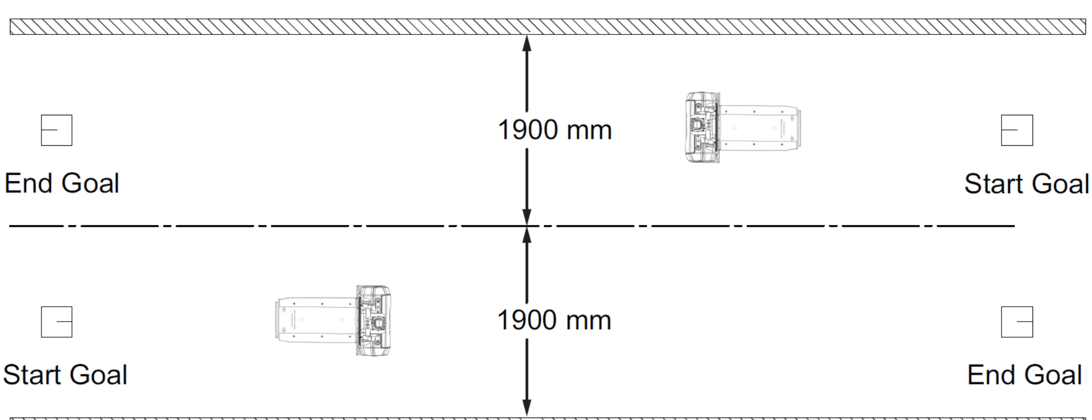

Figure 4-2 Minimum Lane Requirement to Maintain Maximum Speed

4.2. Handling Turns

The OL-450S S2 and S3 models have a swing radius of 685 mm and 712 mm respectively as shown in Figure 4-3; this is the distance from the AMR center of rotation to the furthest point on its perimeter when it rotates in place. For it to make a rotation in place, the AMR will require at least 100 mm of clearance to any point on its chassis. When the AMR is in motion, the minimum turn radius required is 750 mm. This is not reliant on the speed at which the AMR begins turning but is related to safety settings.

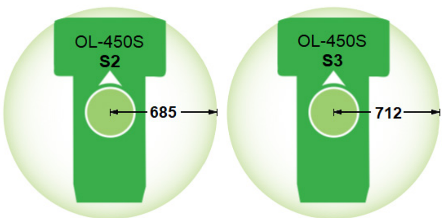

Figure 4-3 Swing Radius

In some cases, the OL-450S may need to make a sharp turn between a narrow aisle and a wider one, or vice versa. To facilitate smooth navigation in these situations, it is advised that narrow aisles be at least 1650mm wide and wider aisles at least 2150mm wide. These dimensions are conservative, based on the OL-450S's size and turning radius. Additionally, it is strongly recommended to implement preferred lines, particularly near corners, to help the OL-450S remain centered in the aisle. These preferred lines are shown in Figure 4-4. While the suggested aisle widths are conservative, the OL-450S can handle narrower aisles; however, thorough testing of the turn should be conducted before deployment in such cases.

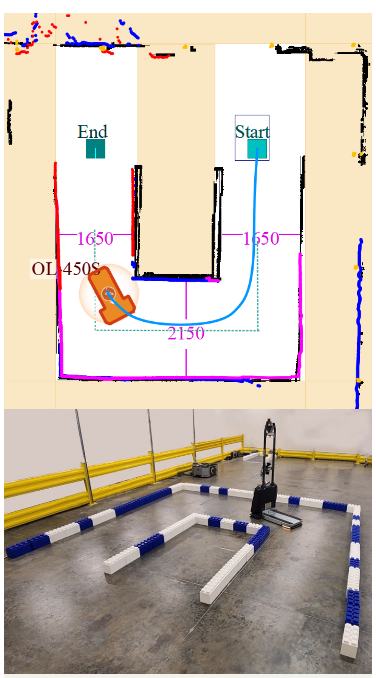

Figure 4-4 Handling Turns

4.3. Managing Undetectable Obstacles

It is important to remember that laser scanners can detect obstacles only if they are in the scan plane. Extra caution must be exercised with obstacles that have an overhang, as shown in Figure 4-5. Typical examples include tables or mounted shelves. These obstacles cannot be detected by the lower L & R safety scanners, and they may not be seen by the 360-degree scanner either if they are not in the scan plan. In this case, the overhanging obstacle can collide with the AMR's body during navigation. Special attention must be paid to these types of obstacles, especially during mapping and blocking the zones that have these kinds of obstacles with forbidden zones or using physical barriers that can be detected by the scanners.

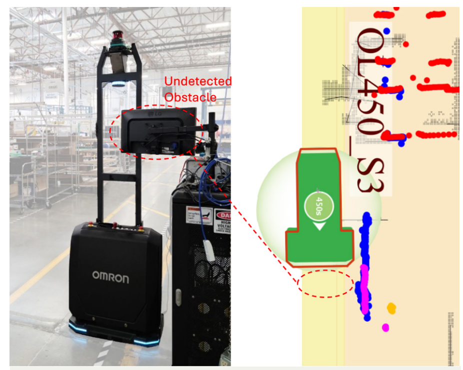

Figure 4-5 Overhanging Obstacle

4.4. Automatic Drive Control

As the OL-450S supports a new drive mode called *Automatic Drive Control* instead of a joystick to allow safe maneuvering of the AMR and includes new drive pad buttons to make lateral motions shown in Figure 4-6. Under this mode, the OL-450S can be controlled via MobilePlanner's on-screen drive pad or using the keyboard's arrow keys and the 'A' and 'D' keys for lateral motion. This mode of operation uses a single point of control, so other subsystems and users will be prevented from operating the AMR simultaneously. When an AMR is under operator control, the *Drive* button will show that it is *Locked* until control is released. The AMR's safety

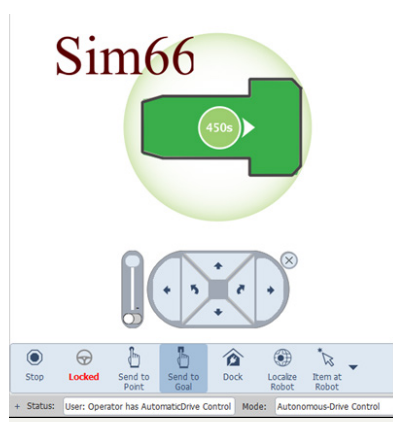

Figure 4-6 Automatic Drive Control

sensors are still active to prevent colliding with obstacles. If a map file has been created, the AMR will respect forbidden zones when using the drive pad. The keyboard's arrow keys can be used to move the AMR in and out of forbidden zones.

4.5. Lateral Motion

Using MobilePlanner, the OL-450S can be laterally moved sideways, left or right. Lateral motion can only be accomplished with the use of the Automatic Drive Control or the *LateralMove* robot task. Lateral motion is not currently available for autonomous path navigation. As lateral motions can only be executed with the use of a robot task, the AMR will need to come to a full stop at a goal to execute this motion. A common use case for this motion type is when navigating close to walls or narrow aisles and attempting a rotation is not possible without collision.

The lateral move task motion is like a move segment that runs in an open loop, relying only on the encoder and gyro data. Even though alignment error is relatively low in this open-loop mode (several millimeters for a 10-meter stretch), it can add up when using this mode to travel long distances. Hence, it is recommended to use this feature for very short distances only with enough clearance to account for any drifts during motion. The use of a *PrecisionDrive* task can be used to improve alignment before starting a lateral motion.

Macros can be created to include this robot task. This robot task or Macros can then be associated with specific goals to navigate the AMR in a lateral motion.

In the example "OL450S.map" file, two Macros and two Goals were created to demonstrate the usage of the *LateralMove* robot task as shown in Figure 4-7.

- **Goals**
  - Goal_Lateral_Move_Left
  - Goal_Lateral_Move_Right
- **Macros**
  - LateralMoveLeft
  - LateralMoveRight

These Macros show the parameters that should be set to move the AMR laterally in either the left or right direction by 1000mm at its maximum speed of 1.2 m/s.

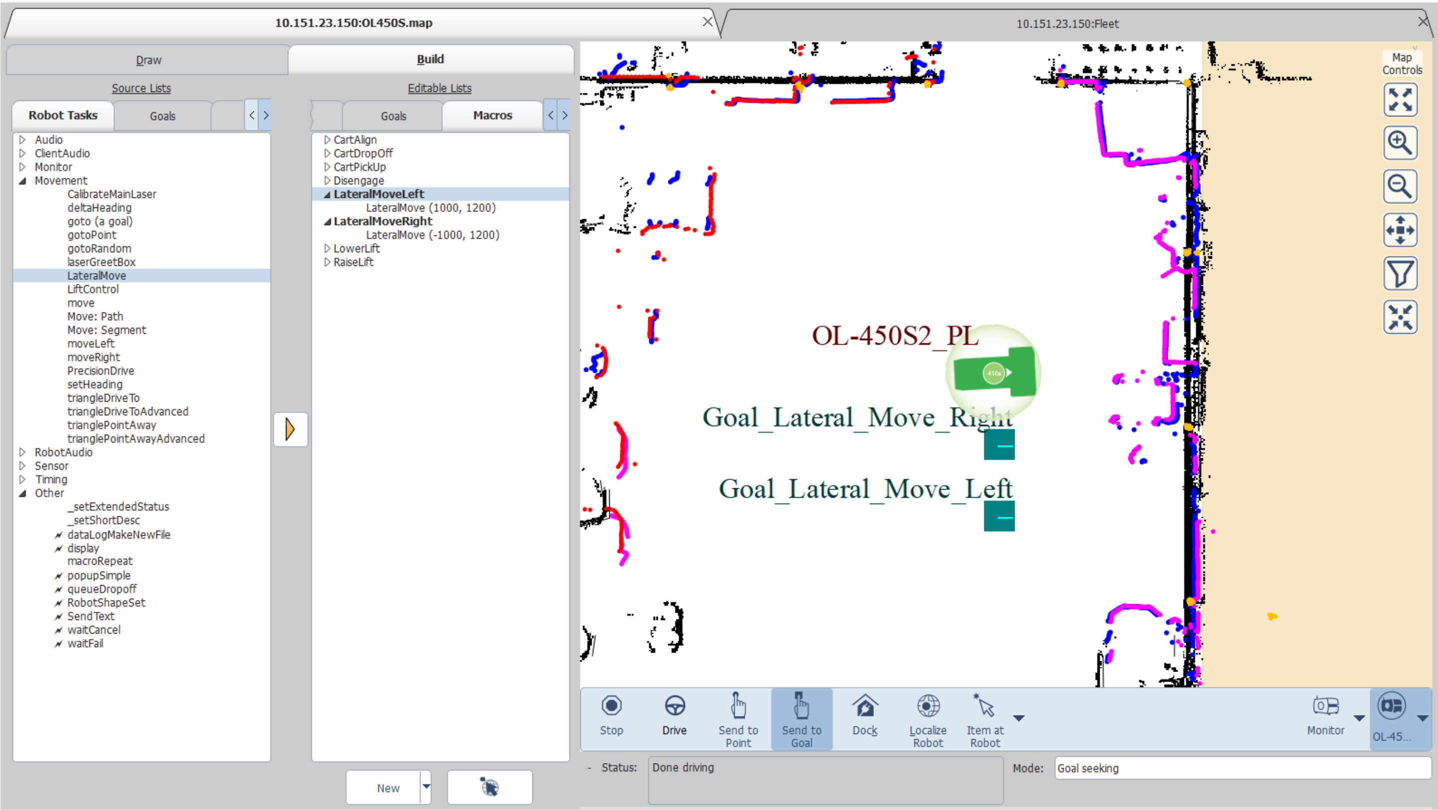

Figure 4-7 Lateral Motion Goals and Macros

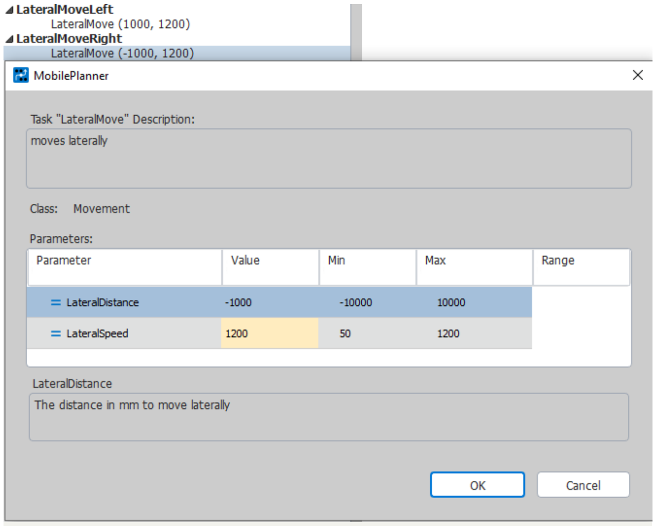

Figure 4-8 Lateral Motion Settings

Specifying positive values will move the OL-450S to the left, while negative values will move it to the right. Use the *LateralSpeed* parameter to control the maximum speed with which the OL-450S will travel laterally to execute the task as shown in Figure 4-8.

When using a mixed fleet of AMRs, it is recommended to create a custom task for goals that should only be completed by the OL-450S to prevent other AMR types from being assigned. If an AMR without the *LateralMove* capability is assigned, the goal will fail.

The approach distance for the *LateralMove* command is set to 1.5 meters and cannot be modified. This allows the AMR to come to a stop if it detects an approaching obstacle that is 1.5 meters away and within the commanded distance. An obstacle can be a physical object in the workspace, or a forbidden zone, as shown in Figure 4-9.

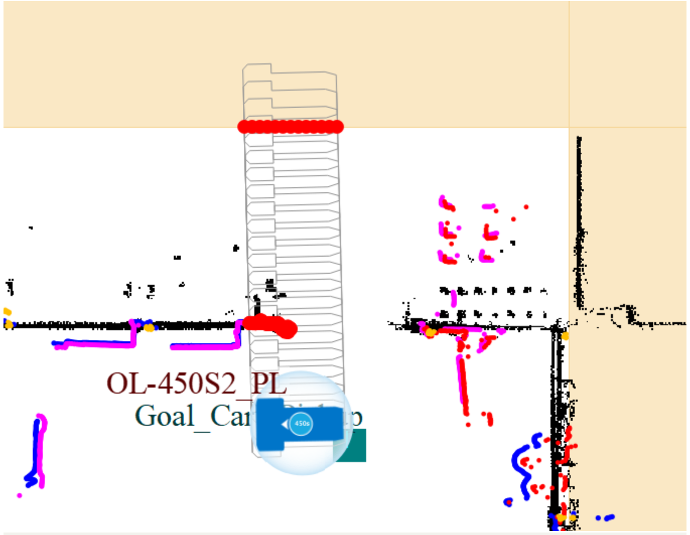

Figure 4-9 Lateral Motion Detecting Obstacle

5. Charging Station Configuration

The OL-450S features a mobile charging coil installed at the bottom for wireless charging. Once this charging coil is aligned with the charging station, it will automatically be detected and begin the charging process. A charging ramp has been provided, which can be assembled and attached to the floor before being used to charge the AMR. An appropriate location must be selected that allows sufficient space for the AMR to approach and engage with the charging station. While it is recommended to use the charging ramp, it is not required if the stationary charging coil is embedded in the ground instead. This guide will cover how to set up and configure the charging station target in MobilePlanner. Before configuring the charging station in MobilePlanner, the charging system should be set up, and a map file created. For hardware installation instructions and hazards of the charging station, refer to the *AMR OL-series User's Manual (Cat. No. M109).*

5.1. Configuration and Setup for Charging

This section covers how to set up charging using the charging ramp. If an alternate method such as embedding the charger coil in the floor is used, the docking configuration must be modified to align the center of the stationary charging plate with the center of the AMR charging coil. The AMR and stationary charger can be oriented at any 90-degree bias to initiate the charging process.

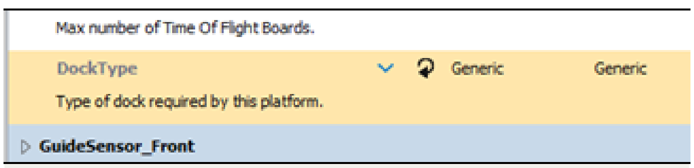

Figure 5-1 Setting DockType to Generic

5.2. Charger Goal

The OL-450S uses the standard docking goal used by the rest of OMRON's AMRs for charger docking. For the OL-450S to utilize the defined docking targets, it must be configured to use "Generic" DockType as shown in Figure 5-1 and a Dock Goal type of "Unspecified dock" as shown in Figure 5-4.

5.3. Defining the Target

Whether using the charging ramp or embedding the charging coil into the ground, a target must be constructed to allow the AMR to properly align with the charging coil. For best results, avoid using glossy or metallic materials for this target.

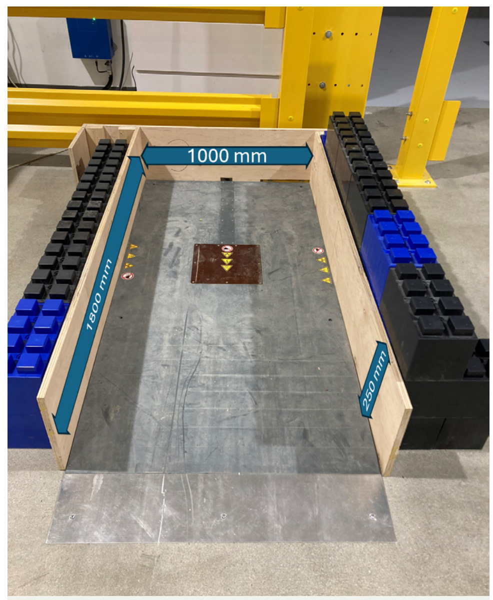

Figure 5-2 Default Charger Target Setup

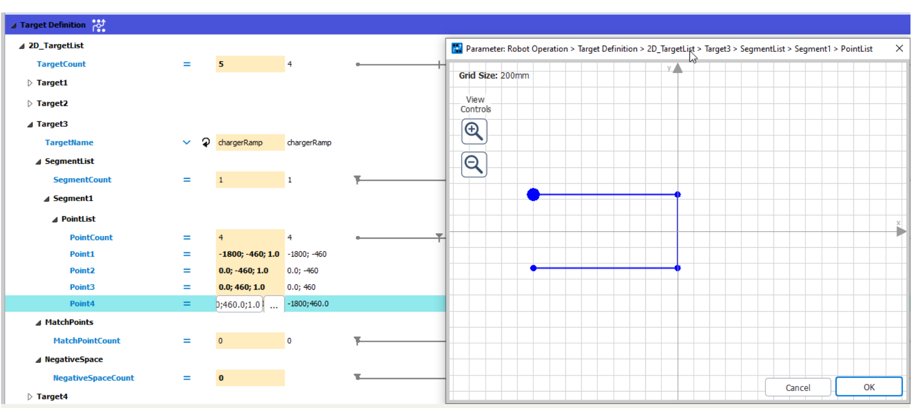

Figure 5-3 Charger Ramp Target Definition

5.3.1. Default Target

By default, a “chargerRamp” target is defined in the ARAM configuration, which surrounds three sides of the charging ramp with inside dimensions of 1800 x 920 mm as shown in Figure 5-2. The AMR is configured to drive forward onto the ramp and will drive in reverse when undocking. When undocking, it is important to ensure that the default decoupling distance set will clear the charging ramp and will not be obstructed by any obstacles. If necessary, it is also possible to change the default configuration under *Robot Operation > Docking* to have the AMR reverse into the charging ramp instead.

When using the default settings with the “chargerRamp” target shown in Figure 5-3, the docking goal should be centered along the charging ramp and located roughly 3000 mm from the far edge of the ramp as pictured in Figure 5-4.

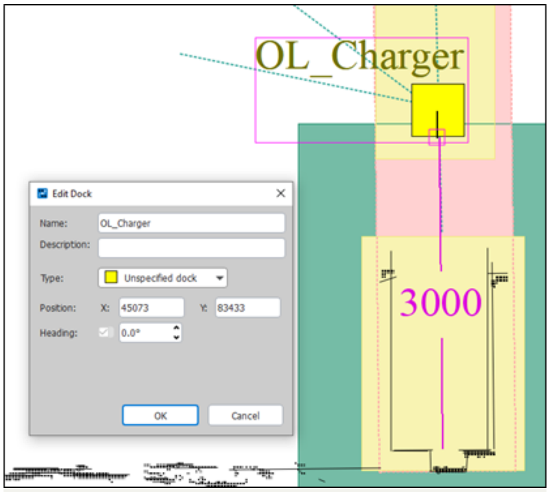

Figure 5-4 Setting Up Dock Goal

5.3.2. Custom Target

A custom target must be defined when the default charging target provided with the mobile planner cannot be used. This can be accomplished by modifying the existing “chargerRamp” target or creating a new target in the AMR configuration file under *Robot Operation > Target Definition > 2D_TargetList.* It may be necessary to increase the *TargetCount* option if a new target is being defined.

When configuring the docking goal for charging, it is important to ensure the charging coils on the AMR base and the charger are aligned as perfectly as possible, as the wireless charger only allows for a ±30 mm misalignment on both axes of the charger plane. To achieve the alignment for optimal charging, it is important to be aware of the exact location of the charging coils on the ramp and the AMR base. Figure 5-5 and Figure 5-6 can be used for this purpose.

5.3.2.1. Charger Coil Location on Ramp

The center of the coil is located 780 mm from the far edge of the ramp as shown in the Figure 5-5.

5.3.2.2. Charger Coil Location at the Base of the AMR

For the S2 model, the center of the charging coil on the AMR is 122 mm from the rotation point.

For the S3 model, the center of the charging coil on the AMR is 153 mm from the rotation point.

This is illustrated in Figure 5-6.

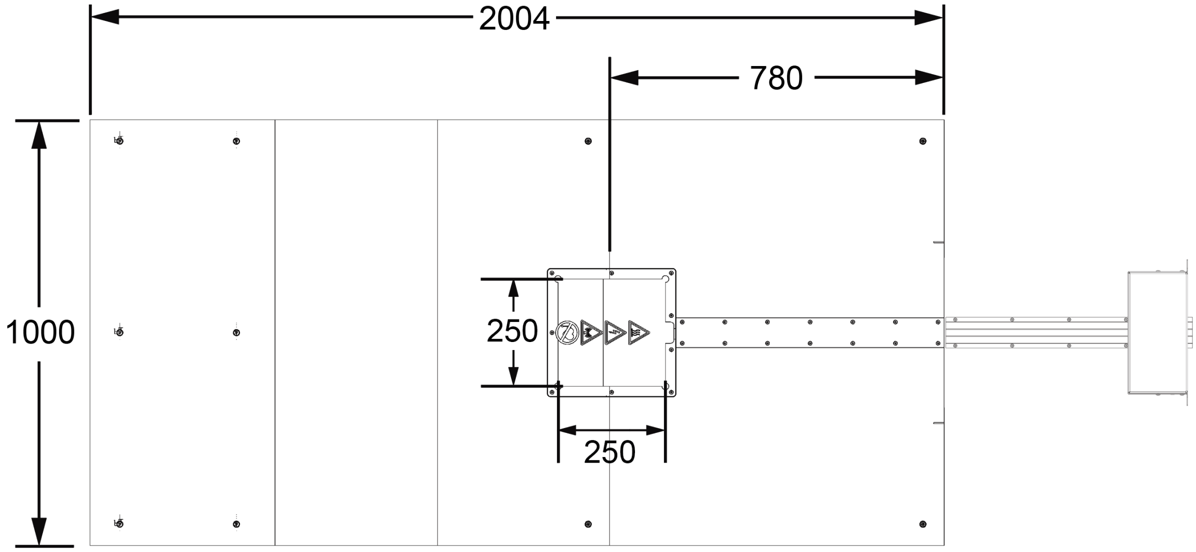

Figure 5-5 Charger Ramp Dimensions

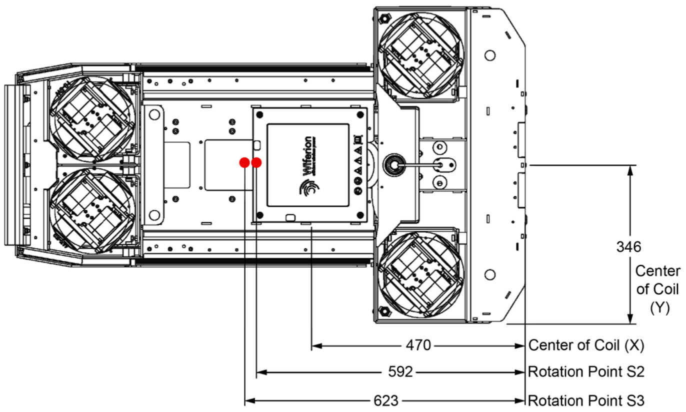

Figure 5-6 OL-450S Rotation Point and Center Of Charging Coil

5.3.2.3. Example Configurations

In this example, a custom target "customChargerRamp" was created using two white blocks as shown in Figure 5-7. Each block has a length and width of 305 mm x 150 mm, with a spacing of 300 mm between them.

In MobilePlanner, this custom target was defined using two line segments representing the face of each block as shown in Figure 5-8.

Figure 5-7 Custom Charger Target Setup

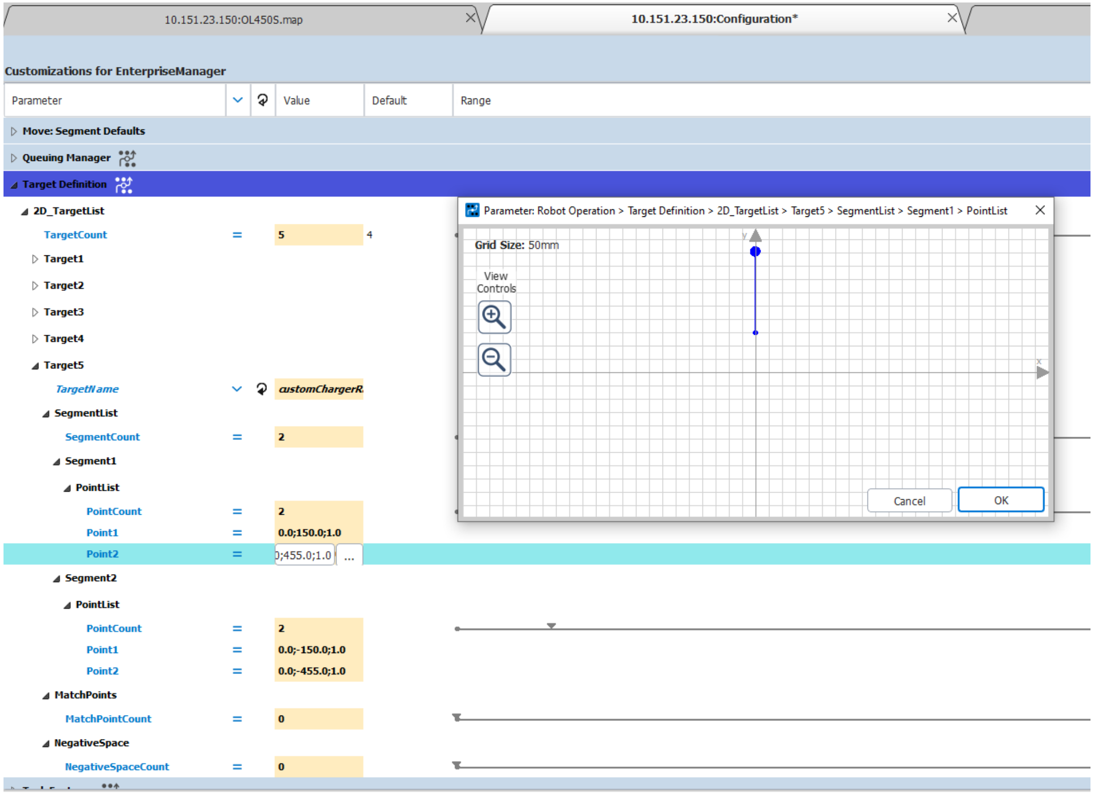

Figure 5-8 Custom Charger Target Definition

Once defined and saved into the AMR's configuration, this target can be selected for docking by updating the AMR's Target Shape under *Robot Operation > Docking > Target Shape* as shown in Figure 5-9. The docking parameters must be updated to allow proper alignment with the stationary charging coil. The Charger Goal defined in Section 5.2 may need to be adjusted to locate this custom target.

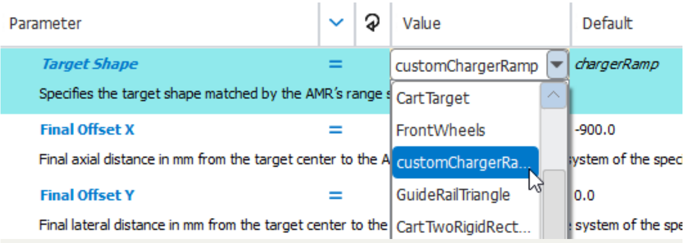

Figure 5-9 Selection of Custom Charger Target

5.3.2.4. Target Configuration

The Target Center is on the far edge of the charger ramp, as shown in Figure 5-10. The Docking Goal is centered 3000 mm from the Target Center. On the OL-450S, the rotational center is 122 mm from the wireless charger coil center. The Final Offset on the target is set at -900 mm on the X-axis with no Y-axis offset. This Final Offset is 122 mm away from the charger coil on the ramp, like the configuration on the AMR side. When the AMR arrives at the target, the rotational center of the AMR is aligned with the Final Offset. This configuration (Figure 5-12 Target Configuration) will ensure that the two charging coils are aligned as shown in Figure 5-11 Final Approach.

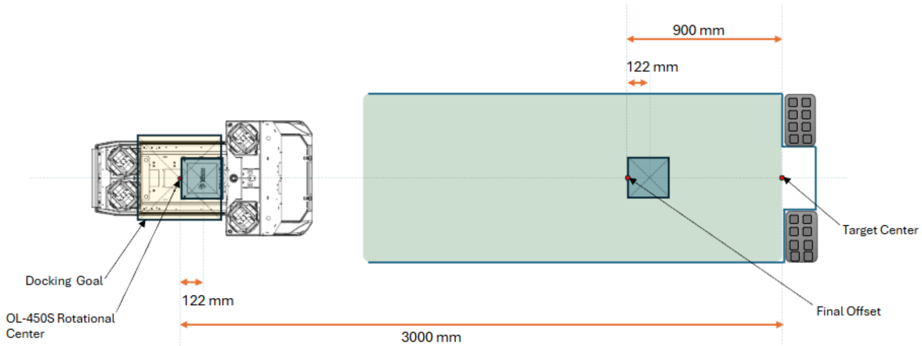

Figure 5-10 Custom Target Layout

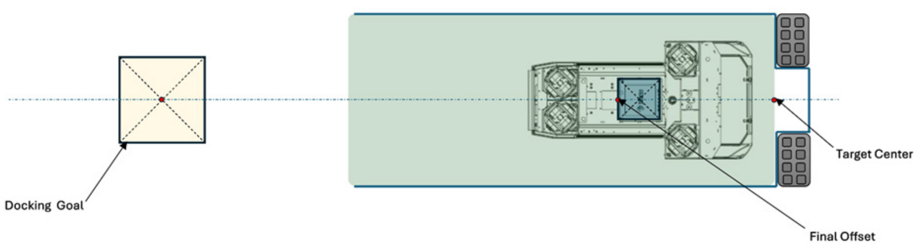

Figure 5 -11 Final Approach

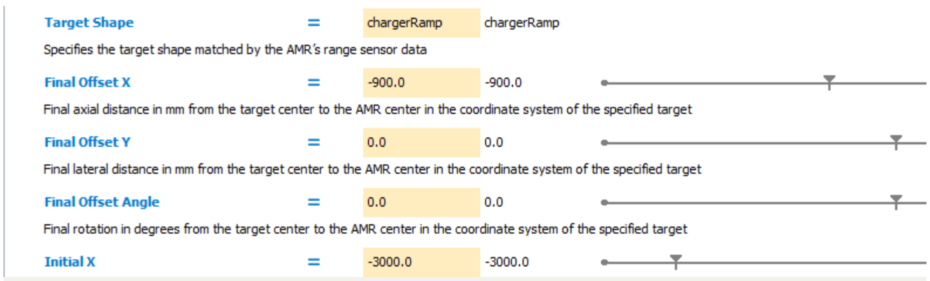

Figure 5-12 Target Configuration

5.4. General Considerations

A resisted sector is recommended to keep AMRs away from the ramp when not attempting to dock.

Docking management at the fleet level will prevent multiple AMRs from attempting to dock at the same dock. Use of *Multi-Robot* sector can be useful in rare cases where AMRs may interfere with each other while docking or undocking.

An *IgnoreSensorSector* can be used when reversing off the ramp. As the charging ramp has a slight incline, in some cases when the AMR is reversing off the ramp, its rear scanner may detect the floor as an incoming obstacle as shown in Figure 5-13. As the front scanners are at an elevated height, this is unlikely to be seen when the AMR is configured to drive in reverse when docking.

When sharing the Charging Station with multiple AMRs, features such as parking spaces or queuing lanes can be used to manage the traffic from the AMRs that are approaching and leaving the charging area.

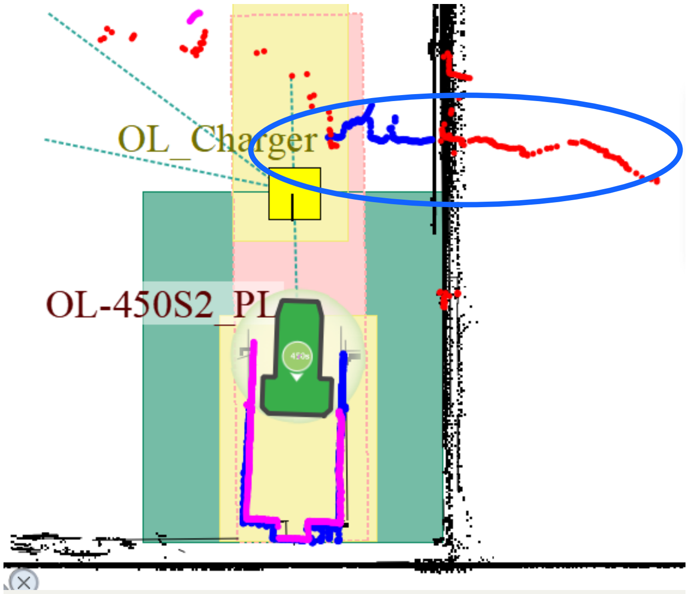

Figure 5-13 Rear Scanner Detecting Floor As Obstacle

6. Load Carrier Handling

With its low lifting plate height and high payload capacity, the OL-450S can handle a variety of load carriers. This section describes key considerations related to load carrier definition and setup.

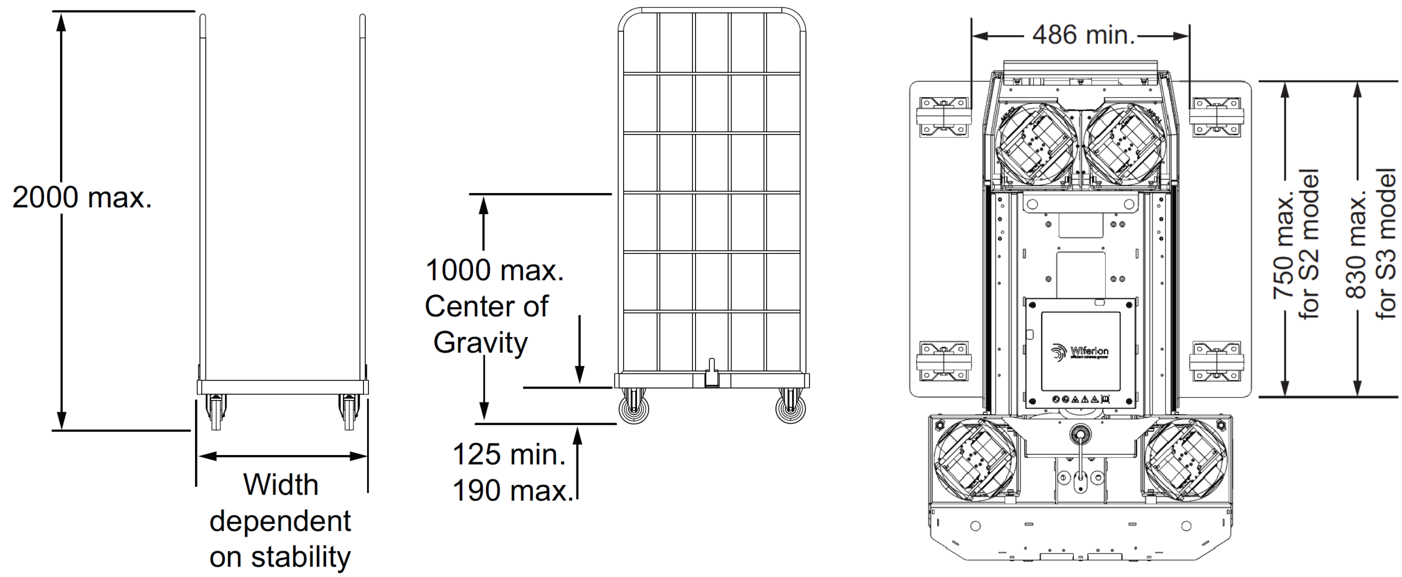

Figure 6-1 Load Carrier Specification Requirements

6.1. Load Carrier Definitions

For a full listing of load carrier requirements, users should refer to the *AMR OL-series User's Manual (Cat. No. M109).*

To perform a pickup and drop off, the load carrier must meet the specifications indicated in Figure 6-1.

- A minimum 125 mm clearance below the base will ensure the OL-450S can navigate below the load carrier at its minimum lifting plate height.
- A maximum 190 mm clearance below the base will ensure that casters or legs of the load carrier clear the plane of the safety scanner when the lifting plate is raised to its maximum height. Minimum clearance between the wheels on the side on which the lift engages must be at least 486 mm.
- Maximum length of a load carrier is 750 mm for S2 model, and 830 mm for S3 model, to avoid overhang at the rear of the lifting plate.
- Maximum overall height of 2000 mm
  - It is recommended to limit to 1800 mm to avoid blocking high laser when lift control is activated.
  - If the load carrier is within the frame of the AMR and in the scan plane of the 360-degree scanner, the AMR will still be able to navigate.
- Maximum width of the cart depends on stability
- A maximum payload of 450 kg. This includes the load carrier and any load carried by it.
- Maximum moment of inertia is 100 kg-m^2
- When loaded, the center of gravity (CG) of the load carrier should be no higher than 1000 mm. A reference to the CG pyramid from the user's manual has been provided for guidance shown in Figure 6-2. The CG of the combined mass of the load carrier, including the payload being transported, must be within the specified limits. The AMR OL-series User's Manual (Cat. No. M109) provides the full list of payload CG considerations.

It is important to note that dynamically alternating the AMR safety zones for varying load sizes is not supported. If custom safety scanner zones are required, it is recommended to use OMRON's zone generation tool when it is updated with support for the OL-450S. If managing varying load sizes, then the safety zones should be set to handle the largest size. The AMR's shape, speed and acceleration/deceleration parameters can be set when they arrive at goals to pick up and drop off load carriers if deemed necessary.

Before deploying an application in a production environment, load carriers must be tested with full load to ensure stability when performing an emergency stop in any direction.

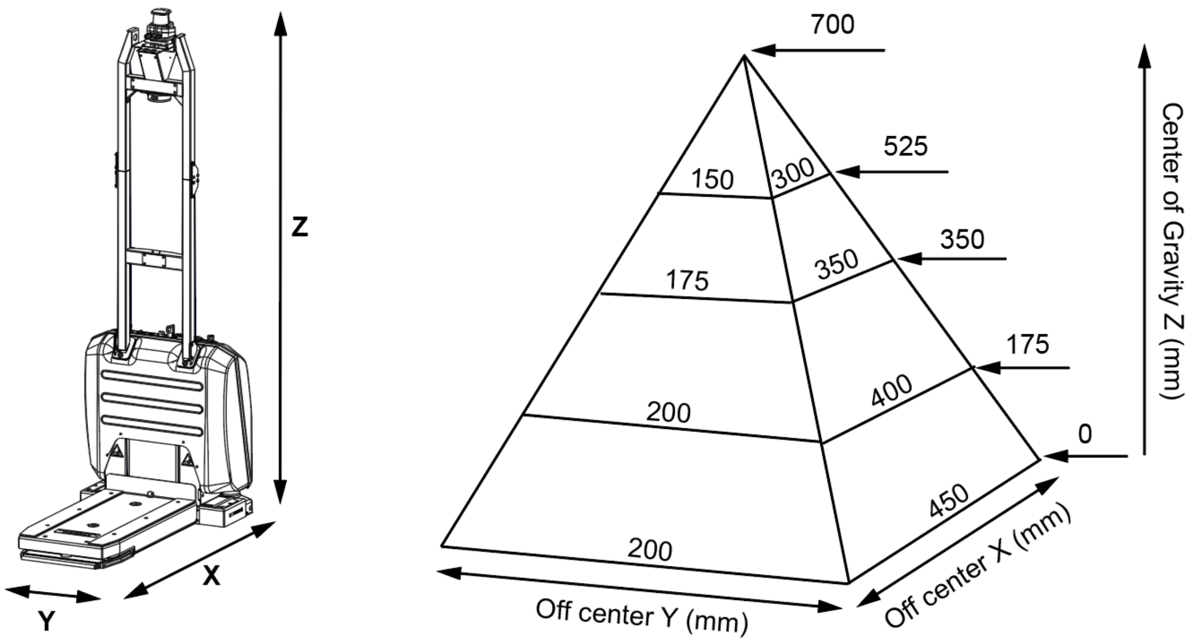

Figure 6-2 Center of Gravity Allowable Limits

6.2. Target Definition Considerations

The OL-450S uses one of its laser scanners to identify the load carrier and align with it prior to picking it up. The shape of the load carrier must be manually defined using the "Target Definition" configuration. This shape must represent the load carrier as "seen" by the laser plane of the AMR. At 40mm for the rear laser or 105 mm for the front laser, these will be the legs or the casters of the load carrier. Identifying the target correctly relies on how well the laser scan of the actual target matches the "Target Definition". This can be particularly challenging when using casters that are able to swivel. Hence, when using castors as a target, it is important to ensure that they are either locked in place or other mechanisms to ensure their alignment to the "Target Definition". An Uline Receiving Cart (Model H-9022)** is used as a target in this application as shown in Figure 6-3 Uline Receiving Cart (Model H-9022)**.

The diameter of each caster is 130 mm. The spacing between the two front rigid casters is 490 mm and the length from the center of the front to the rear casters is 560 mm.

In this application, the rear laser scanner was configured for target detection. Although the front laser has a better resolution, it had trouble locating all four casters due to its placement on the side of the AMR whereas the rear scanner has better visibility as it is in the center of the lifting plate. This is demonstrated in Figure 6-4 Scanner Readings Showing Front Scanner Versus Rear Scanner.

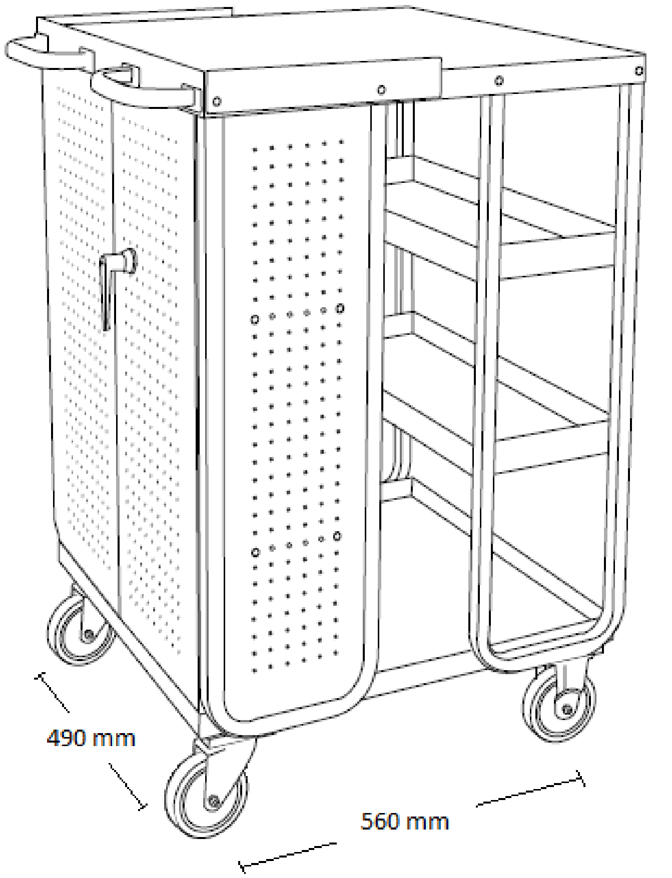

*Figure 6-3 Uline Receiving Cart (Model H-9022)***

**1. Uline, IH-9022pdf, https://img.uline.com/is/content/uline/IH-9022pdf

Figure 6-4 Scanner Readings Showing Front Scanner Versus Rear Scanner

With the rear laser scan plane at 40 mm, and the wheel diameter of 130 mm, the length of each wheel in the target will be 120 mm, as illustrated in Figure 6-5. This is calculated using the formula,

$$L = 2 * \sqrt{(H(D - H))}$$

L = Wheel length as seen by the laser
D = Diameter of the wheel
H = Height of the laser scan plane. 40mm for rear laser and 105mm for the front laser.

Better repeatability can be achieved with the rear laser, as it can detect all four casters when the AMR is centered. For a successful target identification, at least five detectable scanner points are required per caster.

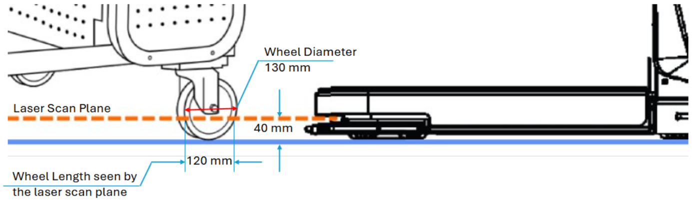

Figure 6-5 Wheel Length Scanned by the Rear Laser

6.3. Target Definition for a Load Carrier - Typical Scenarios

When determining how to train your target, most load carriers fall under three different scenarios.

1. Four fixed casters or four static legs
2. Two fixed casters
3. Four free spinning swivel casters

6.3.1. Four Fixed Caster Target or Four Static Legs

This option requires all four legs or casters of the load carrier to be in a fixed position. This greatly increases the probability of the AMR finding the target as the Target Definition of the load carrier matches the physical load carrier.

To create this target, four separate line segments of length 120 mm each representing the casters were defined in the AMR configuration via MobilePlanner under *Robot Operation > Target Definition > 2D_TargetList,* as shown in Figure 6-6. When defining the target, the use of *MatchPoints* is highly recommended. A minimum of 150 mm of mechanical tolerance should be accounted for in application design to account for errors when using robot tasks such as *PrecisionDrive*. Without any tolerance, the OL450S can collide with part of the load carrier. The set of parameters used to create this target can be found in Figure 6-7 and should only be used as a reference.

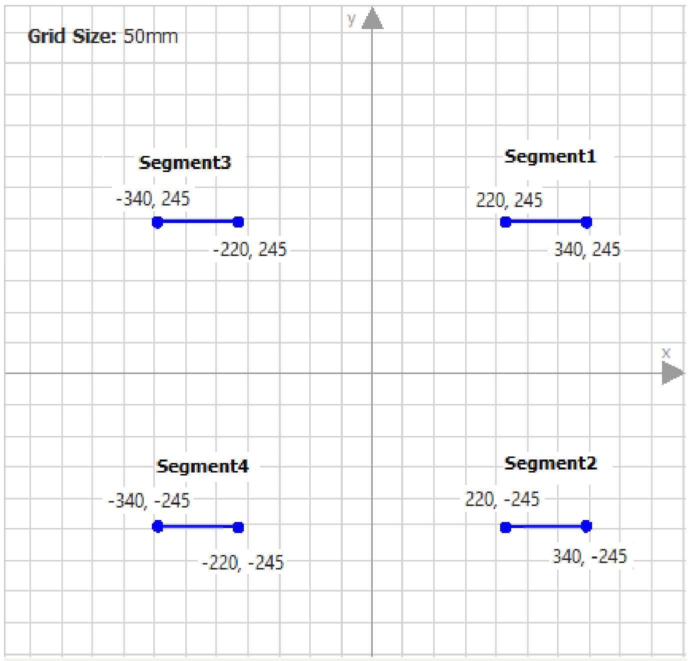

Figure 6-6 Four Line Segments to Represent Cart Target Definition

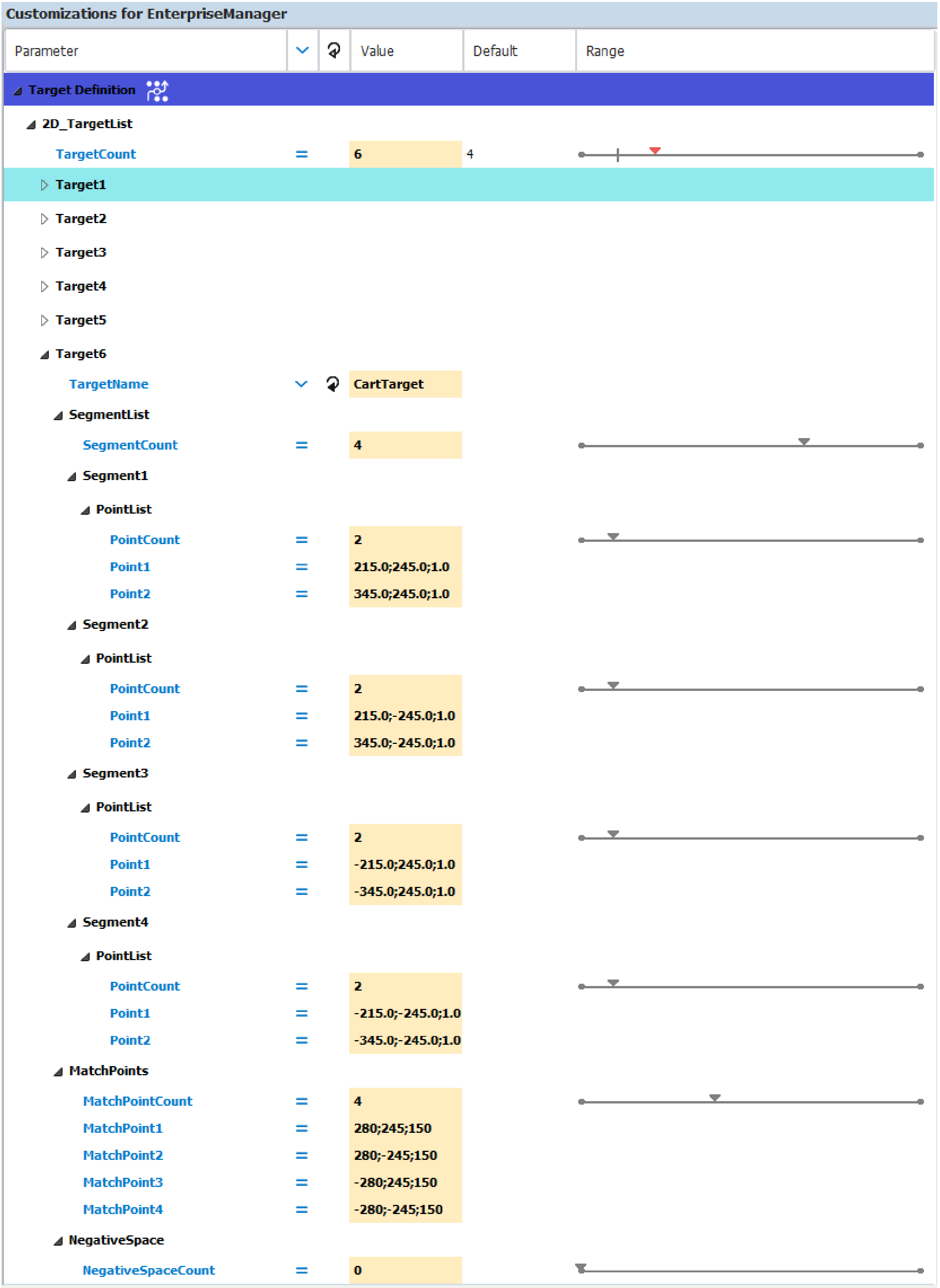

Figure 6-7 Four Fixed Caster Cart Target Definition

6.3.2. Two Fixed Caster Target

When it is not possible to fix all four casters of the load carrier, it is possible to detect the load carrier by using a Target Definition that represents just two wheels that are fixed as shown in Figure 6-8.

The same procedure for defining a target with four fixed casters can be used but with just two casters defined in the target as shown in Figure 6-9.

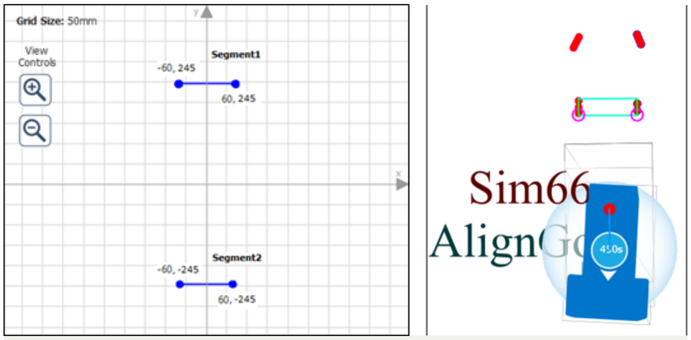

Figure 6-8 Two Fixed Caster Target Definition

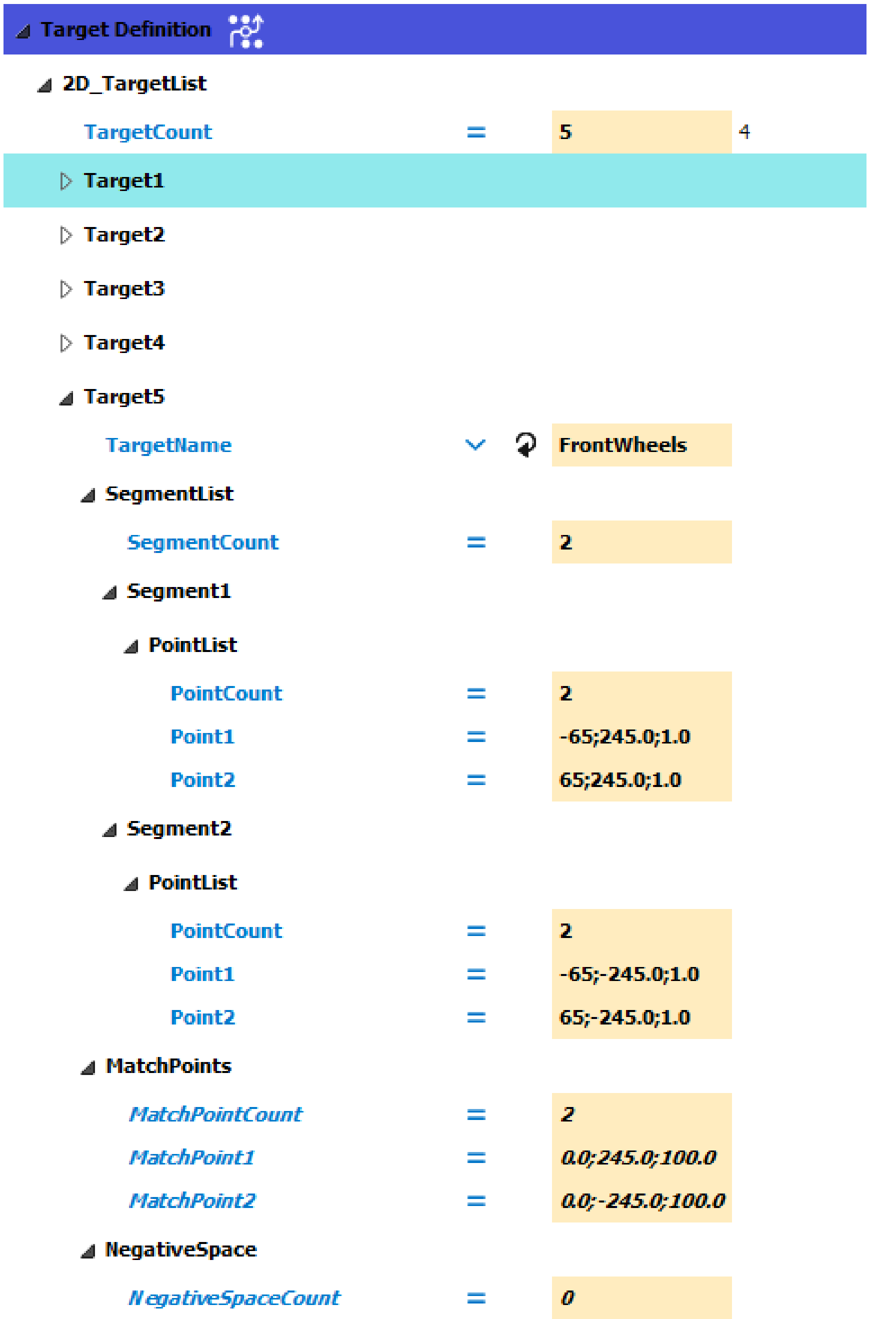

Figure 6-9 Two Fixed Caster Cart Target Definition

When using this method, there is a risk that the free spinning casters could be detected as the target if they match the Target Definition. This situation can be avoided by intentionally misaligning the free spinning casters or ensuring they are not detectable by the AMR. If that cannot be ensured, then this method is not recommended.

Figure 6-10 shows an instance where the AMR mistakenly uses the rear casters as the target instead of the ones in the front and as a result ends up colliding with the cart.

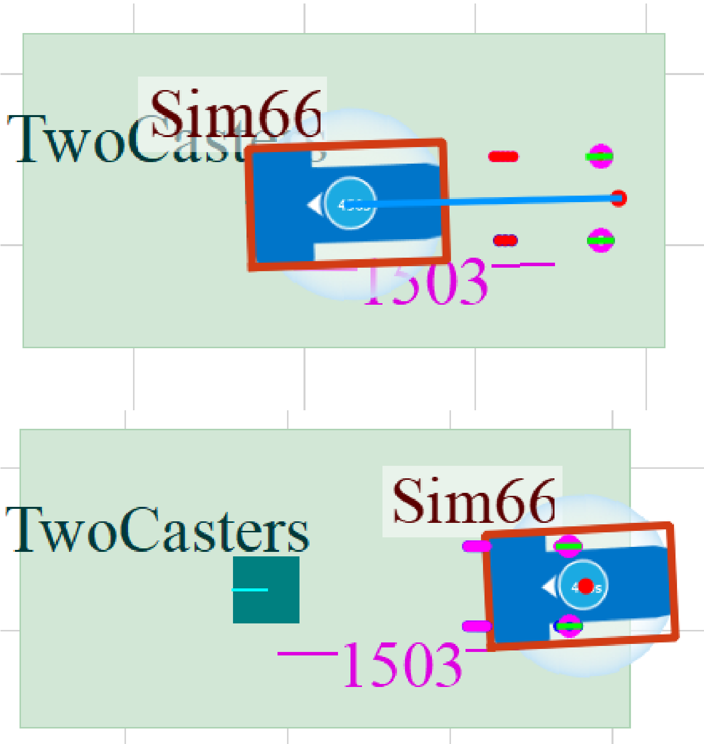

Figure 6-10 Failed Case when Detecting Two Casters

6.3.3. All Swivel Casters

The use of four swivel casters will be a challenging target to detect as the rotation of each caster is unpredictable and prone to alignment errors. The recommendation is to have a minimum of two rigid casters for load carriers. When this is not possible or if the legs of a load carrier cannot be reliably located, then the solution to this problem is to find a more easily identifiable target that can remain in the same position relative to the cart. There are many ways of achieving this, but the following methods are recommended.

1. **Align casters using guide rails:** Use guide rails in the pickup area to align the caster. This option provides the flexibility of having free moving casters that are easy to maneuver but also provides better target identification during pickup. Since the casters are aligned, they can be used as reliable targets for pickup. The Orgatexuk Fifo Monorail** is shown as an example in Figure 6-11. This method works only for pickup where the load carrier is manually driven into the rails by an operator prior to being picked up by the AMR. The OL-450S will not be able to drop off the load carrier as there is not a reliable way to align the free spinning wheels prior to dropping it in the rail.

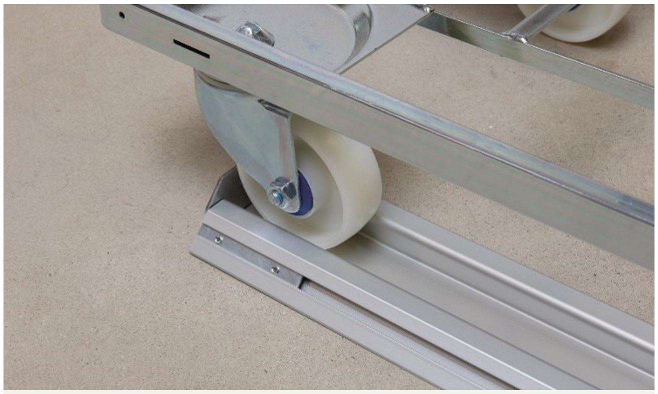

*Figure 6-11 Orgatexuk Fifo Monorail** to Align the Casters*

2. **Fixed target on the load carrier:** This method requires installing a fixture on the load carrier to be used as a target. This method works very well because there is no relative motion between the load carrier and the target, resulting in good repeatability for pickups. Two variations of this method are provided as examples:

   a. **Rigid Target:** In this variation, two solid rectangles are attached next to the wheels of the cart in the front to act as a target as shown in Figure 6-12.

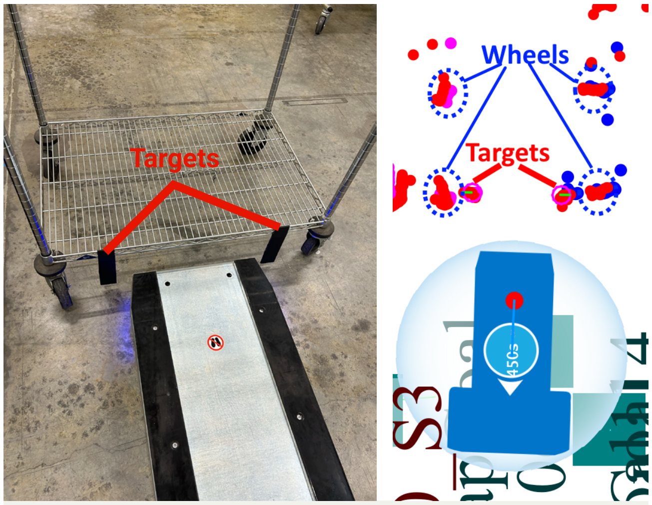

Figure 6-12 Cart with Rigid Targets

**2. Orgattex UK, FIFO Monorail Stop 2, https://www.orgatexuk.co.uk/product/fifo-monorail-stop-2/

b. **Flexible Target:** If the width of the cart is too narrow, a rigid target may interfere with the AMR lifting plate. An alternative is to use a flexible target that can hinge upwards when the AMR lifting plate drives into it.

In the example shown in Figure 6-13, an “E” shaped target about 350 mm wide with each vertical segment at 50 mm suspended to the rails of the platform of the cart. The shape was chosen as it is unique and less likely to be confused with something else. When the AMR drives into this target, it moves up and when the AMRs drive away during drop off, the target returns to its normal position.

For the AMR to “drive into” the target without considering it as an obstacle, a negative clearance value must be set in the move segment that drives the AMR under the cart prior to pick up.

Figure 6-13 Cart with Flexible Target

3. **Fixed target on a guide frame:** When it is not possible to modify the load carrier to add a fixed target directly on it, the target can be installed on a guide frame that will be used to align the load carrier with the target when dropped off. Unlike the guide rail method that cannot be used for AMR drop-offs, this method can be used for drop-offs.

   An Example Guide Frame is shown in Figure 6-14. In this example, the AMR will drive into the guide frame and the casters of the load carrier are expected to be outside the frame. Due to the caster’s unpredictable free spinning nature, there is a risk that they will come into contact with the guide frame when dropping off. To overcome this problem, it is recommended to use automatic self-aligning casters that return to a fixed position when lifted off the ground. The penn-elcom W0990-AUTO** is a good example of this type of caster.

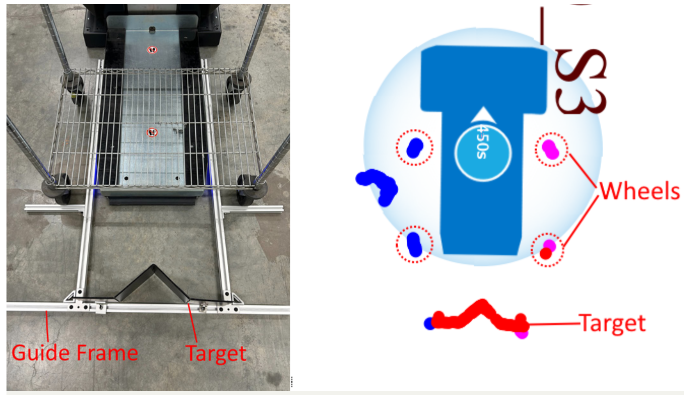

Figure 6-14 Target on a Guide Frame

6.4. Lift Control

The built-in lift system of the OL-450S can raise or lower the lifting plate using the MobilePlanner’s *LiftControl* robot task. Macros can be created to include this robot task as shown in Figure 6-15 and Figure 6-16. This robot task or Macros can be associated with specific goals to trigger the lifting system.

In the example “OL450S.map” file, three Macros and three Goals were created to demonstrate the usage of the *LiftControl* robot task.

- **Goals**
  - Goal_Lift_Min
  - Goal_Lift_Halfway
  - Goal_Lift_Max
- **Macros**
  - LiftControlToMinimum
  - LiftControlToHalfway
  - LiftControlToMaximum

These Macros show the parameters that should be set to lower the lifting system to its minimum height of 108 mm, a midpoint height of 208 mm, and its maximum height of 308 mm.

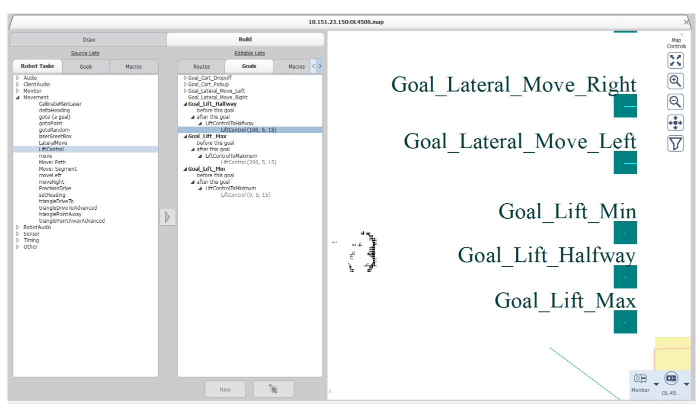

Figure 6-15 Lift Control Goals and Macros

**3. Penn Elcom, 4in Swivel Automatic Caster with Rubber Blue Wheel - W0990-AUTO, https://www.penn-elcom.com/us/4in-swivel-automatic-caster-with-rubber-blue-wheel-w0990-auto.

The OL-450S also includes two rubber strips on its lifting plate. This adds an extra centimeter to the height of the lifting plate, which should be considered. These rubber strips can be removed if they are not deemed suitable for your application. If removed, a suitable replacement is needed as these rubber strips support the stability of load carriers that are lifted.

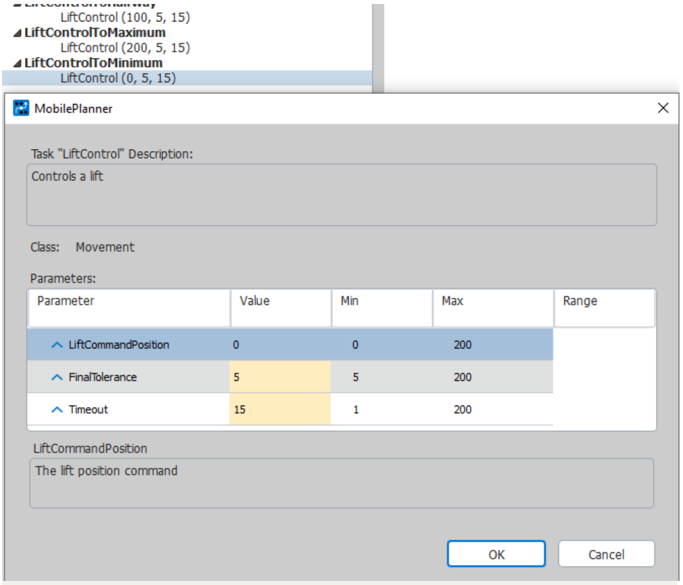

Figure 6-16 Lift Control Settings

When using a mixed fleet of AMRs, it is recommended to create a custom task for goals that should only be completed by the OL-450S to prevent other AMR types from being assigned. When an AMR without the *LiftControl* capability is assigned, the goal will fail.

When setting the *LiftCommandPostion*, the starting point of 0 mm is a relative position that corresponds with the height of the lifting plate, 108 mm (absolute position). It is recommended to set the *LiftCommandPosition* to the max value of 200 mm when lifting a load carrier.

While the AMR can operate with the lift system at any height within this range, applications must be designed so that any wheels or legs of a load carrier clear the plane of safety scanners when raised as shown in Figure 6-17. Failure to clear this plane may prevent and/or limit AMR motion. If this issue is encountered, adjusting the load carrier configuration must be considered, as it is not recommended to change safety settings to bypass this issue.

When commanded to do so, the lifting plate will move to the target position defined by LiftCommandPosition. Upon reaching this position, the system automatically checks whether the lifting plate's actual position falls within the predefined tolerance range defined by the parameter FinalTolerance. This allows for a small, acceptable deviation from the exact set position, ensuring precision while accommodating minor variations in positioning.

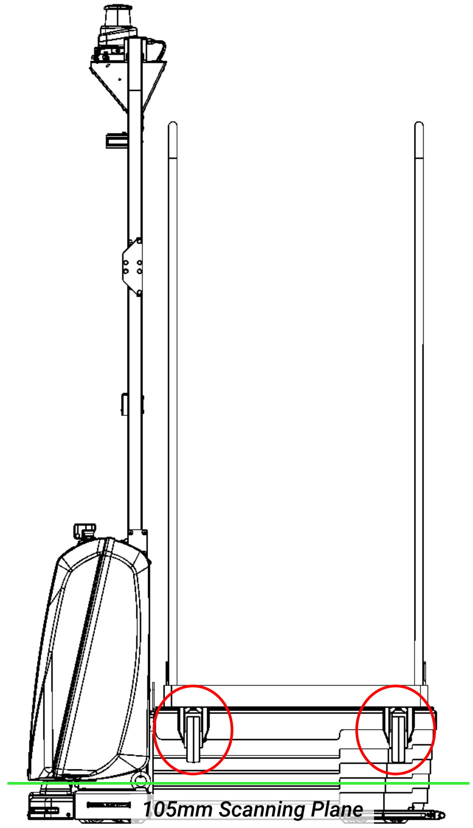

Figure 6-17 Casters Clearing Scanning Plane

The *Timeout* parameter is a failure detection mechanism in case an external condition prevents the lifting plate from reaching its commanded position. This value determines the maximum time in seconds by which the *LiftControl* task must succeed. If the lifting plate does not reach the commanded height by this time, the *LiftControl* task will fail. The lift control moves at a rate of 40 mm/s, so a timeout value that surpasses the time needed to reach the commanded lifting plate position should be set.

LiftControl		
LiftAtZeroPosition	False	boolean
LiftPosition	100.0	(mm)

Figure 6-18 Lifting Plate Feedback

DataStore values are available for the current lifting plate position and a Boolean indicating if the lifting plate is at the zero position, as shown in Figure 6-18. Refer to the Fleet Operations Workspace Core Integration Toolkit MQTT API (Cat. No. M107) for more information.

7. In-Transit Monitoring

After successfully picking up a load carrier, it is recommended to monitor its presence to ensure it is still in place during transit. This can be accomplished with the use of the *SensorCheckPolygonInstant* task combined with the *PayloadPresentTask*. These tasks can be used to verify the lifting plate is occupied or to check if it is empty when a payload is not expected while in transit. To utilize these features while in transit an additional external sensor will need to be installed to scan the OL-450S platform. For a list of all recommended sensors that work with this feature refer to the *Omni Lift User's Manual (Cat No. M109)*. The HOKYUO UST-05LX sensor was used in this guide as an example to demonstrate this feature. This feature is highly recommended as it enhances the safety of the AMR. When adding custom sensors (such as the HOKYUO UST-05LX), it is important to conduct a thorough assessment to ensure the OL-450S's existing certifications remain valid in the modified configuration.

7.1. Mounting the Sensor

The HOKYUO UST-05LX sensor was mounted on the horizontal bar of the mast of an OL-450S3 using a 3D printed mount as shown in Figure 7-1. The exact location and the orientation of the sensor must be configured in the Scanner configuration as shown in Figure 7-2.

7.2. Wiring the Sensor to the AMR

The HOKYUO UST-05LX uses a standard Ethernet to communicate with the OL-450S. The sensor's Ethernet cable can be directly plugged into the Service port of the OL-450S, as shown in Figure 7-1.

The service charger port that is capable of sourcing 16A at 24v can be used to power the sensor directly. It is highly recommended to use a 2A inline fuse for protection. The sensor itself draws less than 500mA of current.

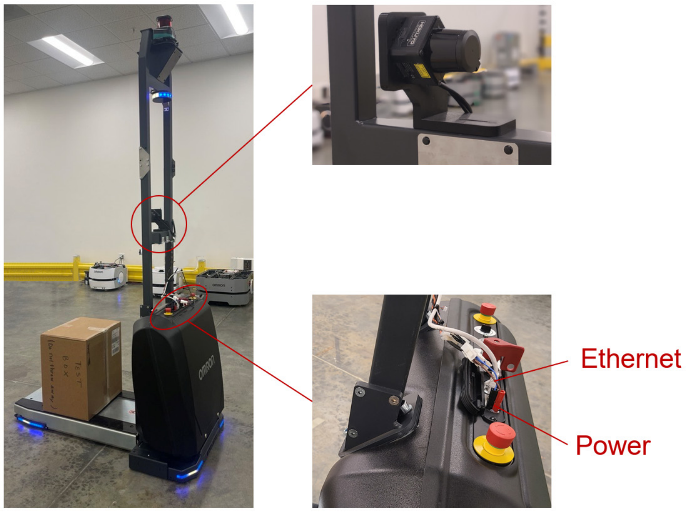

Figure 7-1 HOKYUO UST-05LX Sensor Placement and Connections

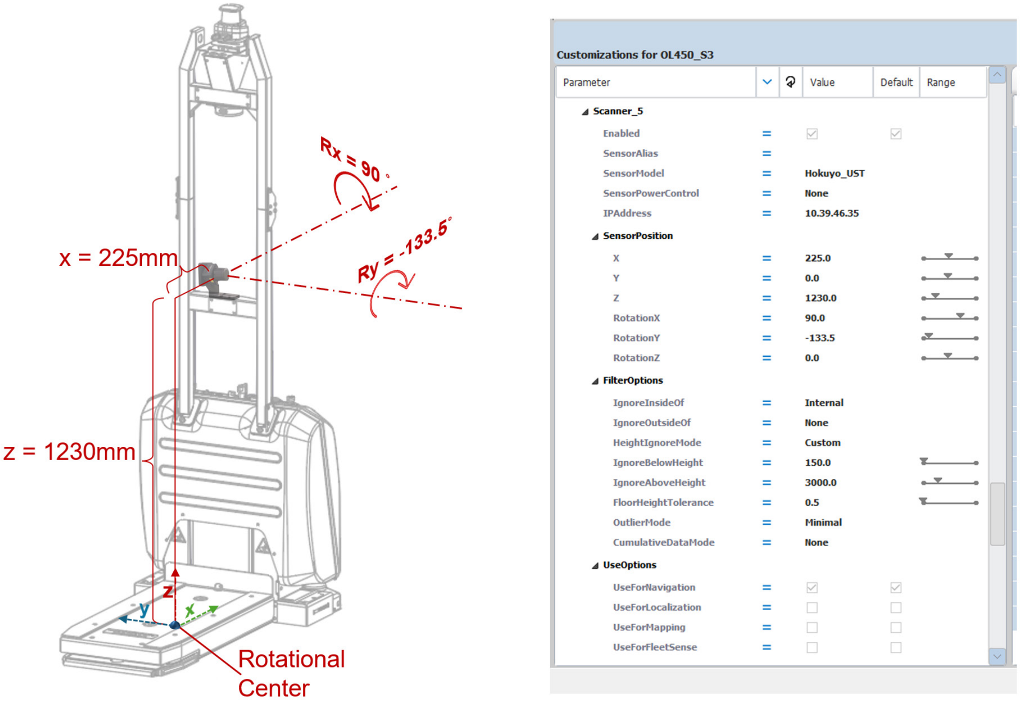

Figure 7-2 Configuring Scanner Settings

**Hokuyo, UST-05LX 2D LiDAR Sensor, https://hokuyo-usa.com/products/lidar-obstacle-detection/ust-05lx

7.3. Configuring the Scanner

To add a scanner in MobilePlanner, go to *Robot Physical > Sensors > 2DLidar* to enable and configure the new sensor in one of the available scanner slots. The settings used to configure the HOKYUO UST-05LX in this example application are shown in Figure 7-2. It is important to accurately specify the sensor's position, as this will be used to determine the presence of a payload. The XYZ offsets and rotations must be calculated with the AMR's center of rotation as the origin (at floor height), as shown in Figure 7-2.

The *FilterOptions* settings shown in Figure 7-2 will ensure the AMR features are not perceived as obstacles during navigation. This is done by setting the *IgnoreInsideOf* parameter to Internal. The *HeightIgnoreMode* should be set to Custom with height values set to ignore readings from the floor and above the max working height of the AMR.

7.4. Configuring In-Transit Monitoring

To monitor the presence or the absence of a payload during transit, a region must be monitored for scan points where the payload is expected or not expected to be present. This region is defined in the *SensorCheckPolygonInstant* task by setting Point_1 through Point_20, *PolygonMinimumHeight* and *PolygonMaximumHeight*. This concept is illustrated in Figure 7-3. The HOKYUO UST-05LX scan plane is represented by the red 2D plane. Since the HOKYUO UST-05LX has 270˚scan coverage, the scan plane must be limited to ensure that AMR features like the lifting plate are not mistaken for a payload. To achieve this, Point_1 through Point_4 are used to define a rectangle (blue rectangle) that wraps around the 2D scan plane where the payload is expected to be. The *PolygonMinimumHeight* parameter is set to a value greater than 320mm to ensure the lifting plate is excluded from the scan, and *PolygonMaximumHeight* parameter is set to a value lower than 2200mm to exclude the AMR features from the scan. The combination of the rectangle and the two height parameters creates a 3D shape represented by the green cuboid.

Since the scanner was configured to ignore the scan points that fall within the AMR's internal bounds, which is where the payload will be present, the *IncludeIgnoredReadings* parameter must be enabled. In this example, enabling *CheckAllSensors* will provide the same results as manually selecting to only use the HOKYUO UST-05LX. In applications that have multiple external scanners and there is a need to choose data from specific scanners, the *CheckAllSensors* can be disabled, which provides the ability to manually choose the desired sensors for this task. These settings are illustrated in Figure 7-4.

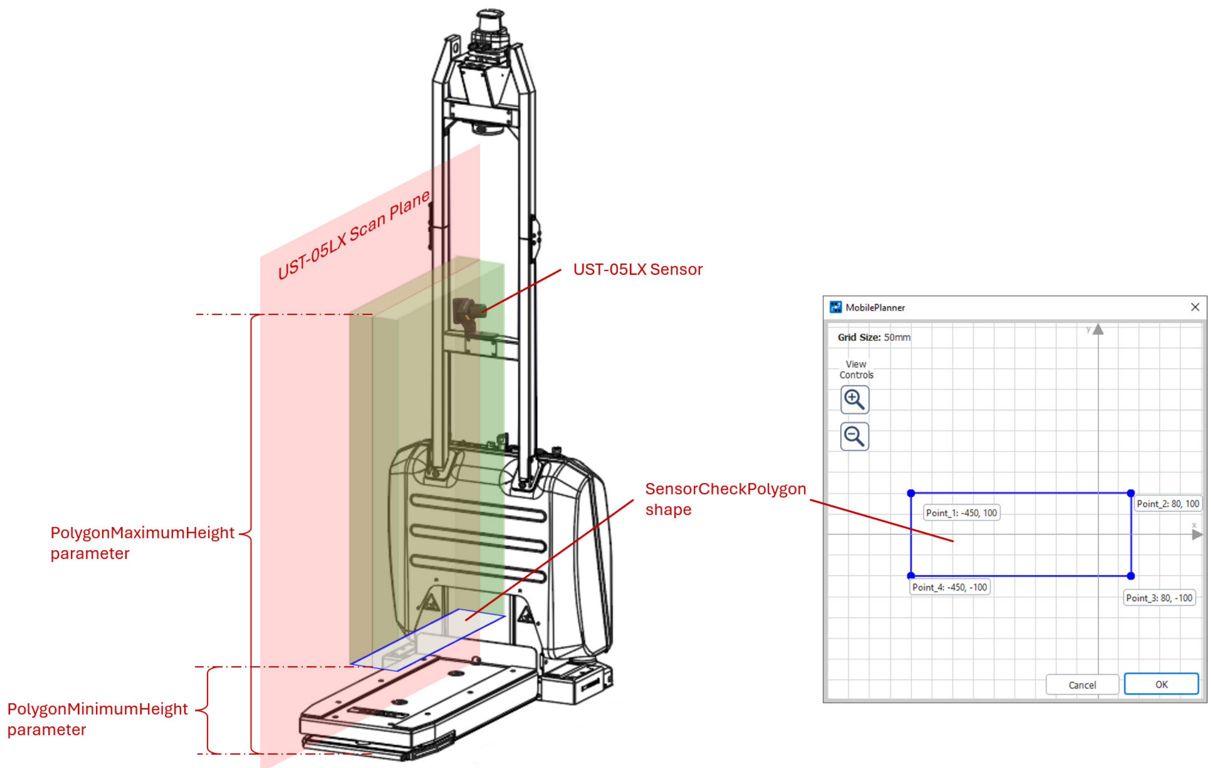

Figure 7-3 In-Transit Monitoring Scanner Region

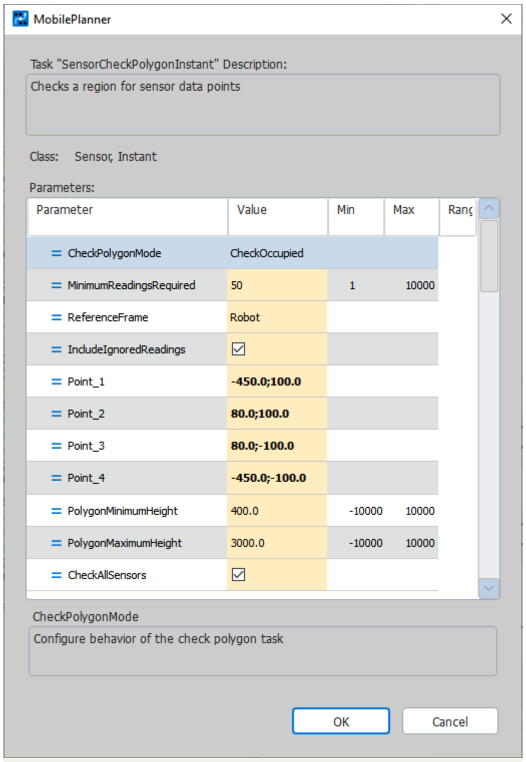

Figure 7-4 SensorCheckPolygonInstant Task Settings

When executed, the *SensorCheckPolygonInstant* task returns true or false depending on whether the *CheckPolygonMode* is set to *CheckOccupied* or CheckEmpty and depending on whether the payload is present or not. The *PayloadPresentTask* task controls the Monitor threads that check the *SensorCheckPolygonInstant* task every 250ms to check the payload status. When the *SensorCheckPolygonInstant* task fails and returns false, a fault is generated. To prevent false alarms, the Monitor threads have a minimum of 750 ms Timeout parameter. This acts as a debounce filter that waits for consecutive false readings from the SensorCheckPolygonInstant task for a time greater than this specified timeout before a fault is generated.

To enable a Monitor thread, it must be configured as Set and to disable it, it must be configured as Clear. To maintain its current state, it must be set to *KeepExisting*. Up to six Monitor threads can run simultaneously to check six different regions. A combination of *CheckOccupied* and *CheckEmpty SensorCheckPolygonInstant* tasks can be run for more complex loads. In the example, only Monitor1 was used.

The set of parameters used in this example for the *PayloadPresentTask* is shown in Figure 7-5.

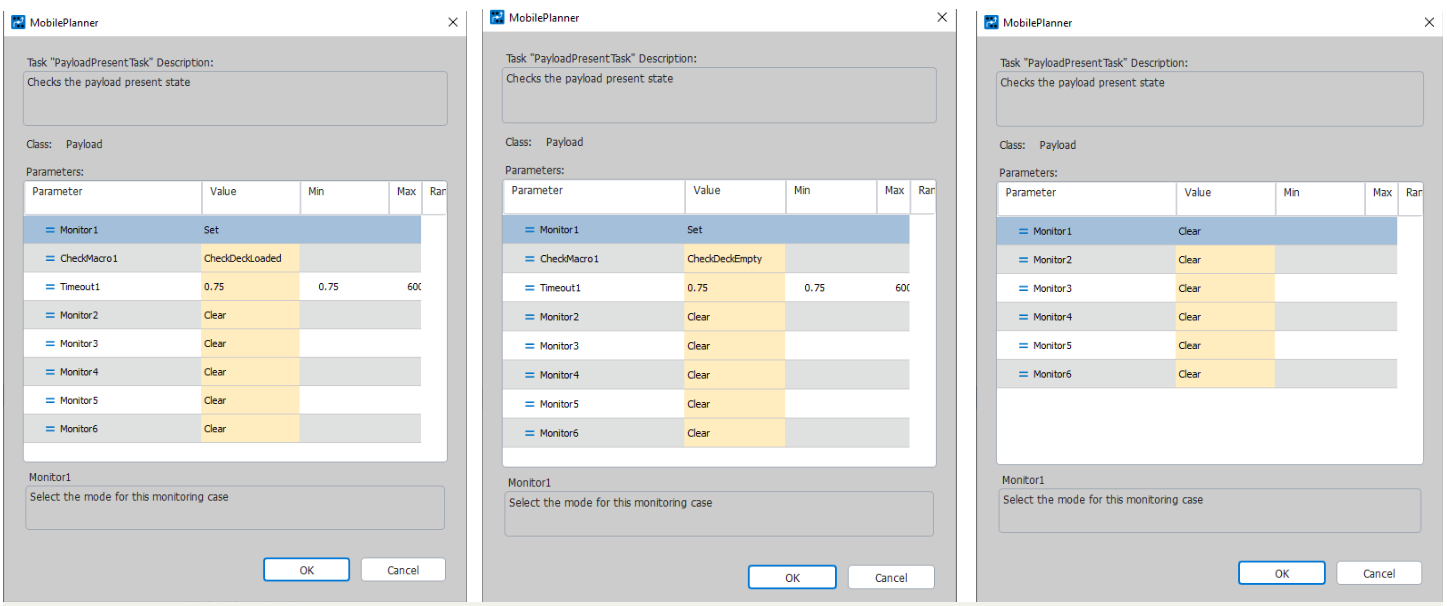

Figure 7-5 PayloadPresentTask Settings

All the Macros and the associated tasks and their relationships used in this example are shown in Figure 7-6.

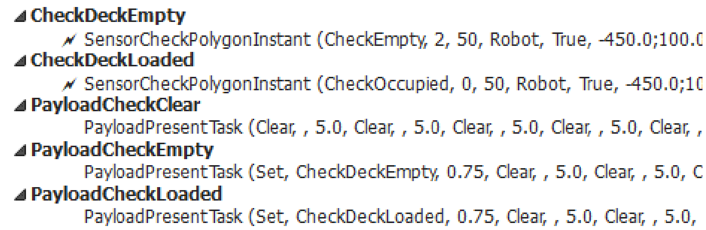

Figure 7-6 Macros and Tasks for In-Transit Monitoring

7.5. Recovering from an In-Transit Monitoring Fault

When using the PayloadPresentTask for monitoring while in transit, the AMR will halt if the monitoring Macro fails. The AMR will automatically resume operation five seconds after the fault condition is cleared without any additional user inputs. Due to this behavior, it is advised to press the emergency stop while manually recovering the payload. Failure to do so could result in the AMR resuming operation before the payload is securely positioned. Once the displaced load is properly positioned back on the AMR, the emergency stop can be released to allow the AMR to resume its normal operation.

The status of the monitoring threads can be viewed through the Diagnostic window as shown in Figure 7-7. Refer to section 9.1 Diagnostic Window, for further details on usage of this feature.

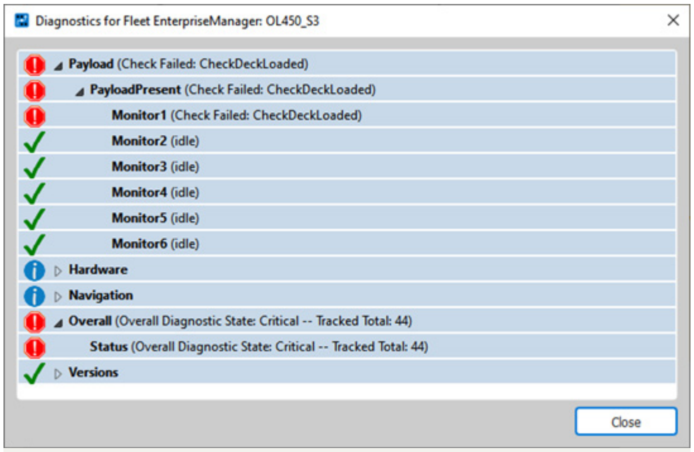

Figure 7-7 Diagnostic Window Payload Present State

8. Application Workflow

Once the target is trained, it can be used in an application. The typical application workflow consists of driving to and picking up a load carrier, followed by driving to and dropping off that load carrier at a destination. When using a mixed fleet of AMRs, it is recommended to create a custom task for goals that should only be completed by the OL-450S to prevent other AMR types from being assigned.

- Arrive at a pickup Pregoal
  - Align with cart using *PrecisionDrive*
  - Drive straight under cart with Move: *Segment*
  - Check load carrier positioning with *Sensor Check Polygon*
  - Raise lifting plate with *LiftControl*
  - Start in-transit monitoring with PayloadPresentTask
    - Verify presence with *SensorCheckPolygonInstant*
- Navigate to desired Dropoff
  - Stop in-transit monitoring with *PayloadPresentTask*
  - Lower lifting plate with *LiftControl*
  - Drive straight out from cart with Move: *Segment*

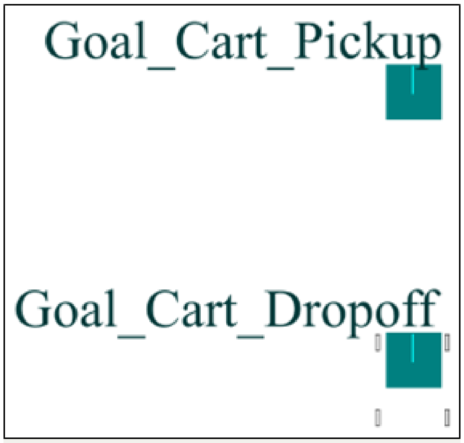

Figure 8-1 Pick Up Goal Relative to Load Carrier Location

8.1. Picking Up Load Carrier

To monitor the presence of the payload while in transit a Macro is also used. In the “OL450S.map” file, examples are shown to pick up a load carrier using different targets. This workflow will cover the case for four fixed casters. It uses a Goal and four Macros to demonstrate how to locate and pick up the load carrier. To monitor the presence of the payload while in transit a Macro is also used.

- Goals
  - Goal_Cart_Pickup
- Macros
  - CartFourCasterPickUp
    - LiftControlToMinimum
    - AlignFourFixedCasters
    - ReverseIntoCart
    - LiftControlToMaximum
  - PayloadCheckLoaded
    - CheckDeckLoaded

When defining the pickup goal, place it where the AMR should start searching for the load carrier, not where the load carrier actually is as shown in Figure 8-1. The goal should be placed at least 500 mm in front of the load carrier and pointed at it. This will allow the AMR enough distance to maneuver and align with the cart before reversing underneath it.

When defining the pickup goal, place it where the AMR should start searching for the load carrier, not where the load carrier actually is. The goal should be placed at least 500 mm in front of the load carrier and pointed away from it to use the rear laser for locating. This will allow the AMR enough distance to maneuver and align with the cart before reversing underneath it.

For applications where the load carriers are placed manually, at least 1000 mm should be used to correct placement errors. In total, it is recommended to reserve at least three meters of space for the cart and AMR pick up zone. Ensure that the lifting plate is set to a height low enough to clear the base of the load carrier before attempting to pick up.

8.1.1. Cart Pick Up Macro

The CartFourCasterPickUp Macro consists of a few Macros used to align with a load carrier and to change the lift control height. The *AlignFourFixedCasters*, and *ReverseIntoCart* Macros show the combination of robot tasks and parameters that were used to locate the example industrial receiving cart and drive underneath it. This consists of aligning to the cart using *PrecisionDrive*, a *SensorCheckPolygon* task to confirm cart alignment; a *Move:Segment* task to drive straight under the cart; and *SensorCheckPolygon* to confirm final cart positioning. A different align Macro should be created for each cart type in your application. In the “OL450S.map” file, the other Macros, such as *AlignTwoFixedFrontCasters* or *AlignExternalTriangle* Macros can be used for picking up a load carrier for either the two fixed caster case or when using an external target.

It is recommended to use the rear facing scanner to track the target up to the final linear motion. While it is also possible to use the front safety scanner, this requires more tolerance considerations. As the front safety lasers can provide more laser points per rotation, this should only be considered when attempting to detect small features that the rear scanner fails to detect. However, precision is expected to be lost when the AMR performs a 180-degree rotation before picking up load carrier.

8.1.1.1. Precision Drive to Align

The recommended robot task that should be used to first align with a load carrier is *PrecisionDrive as shown in Figure 8-2*. This task will utilize one of the targets defined in section 6.3, "Target Definition for a Load Carrier - Typical Scenarios" to locate your load carrier and drive it to a location relative to this target. For applications that require increased accuracy, then the Cell Alignment Position System (CAPS) is recommended. Contact your local OMRON representative for instructions on ordering and obtaining the license key files for this feature.

The parameters needed for *PrecisionDrive* are application specific. The set of parameters used in this example can be found in Figure 8-3 or in the "OL-450S.map" file and should only be used as a reference. Only a single laser can be used for this task. This means the *Parameter Mode* need to be updated to *Advanced* to see the option to change the *PrimaryLaser* to Laser_3 when using the rear scanner.

Figure 8-2 PrecisionDrive "CartTarget" Located

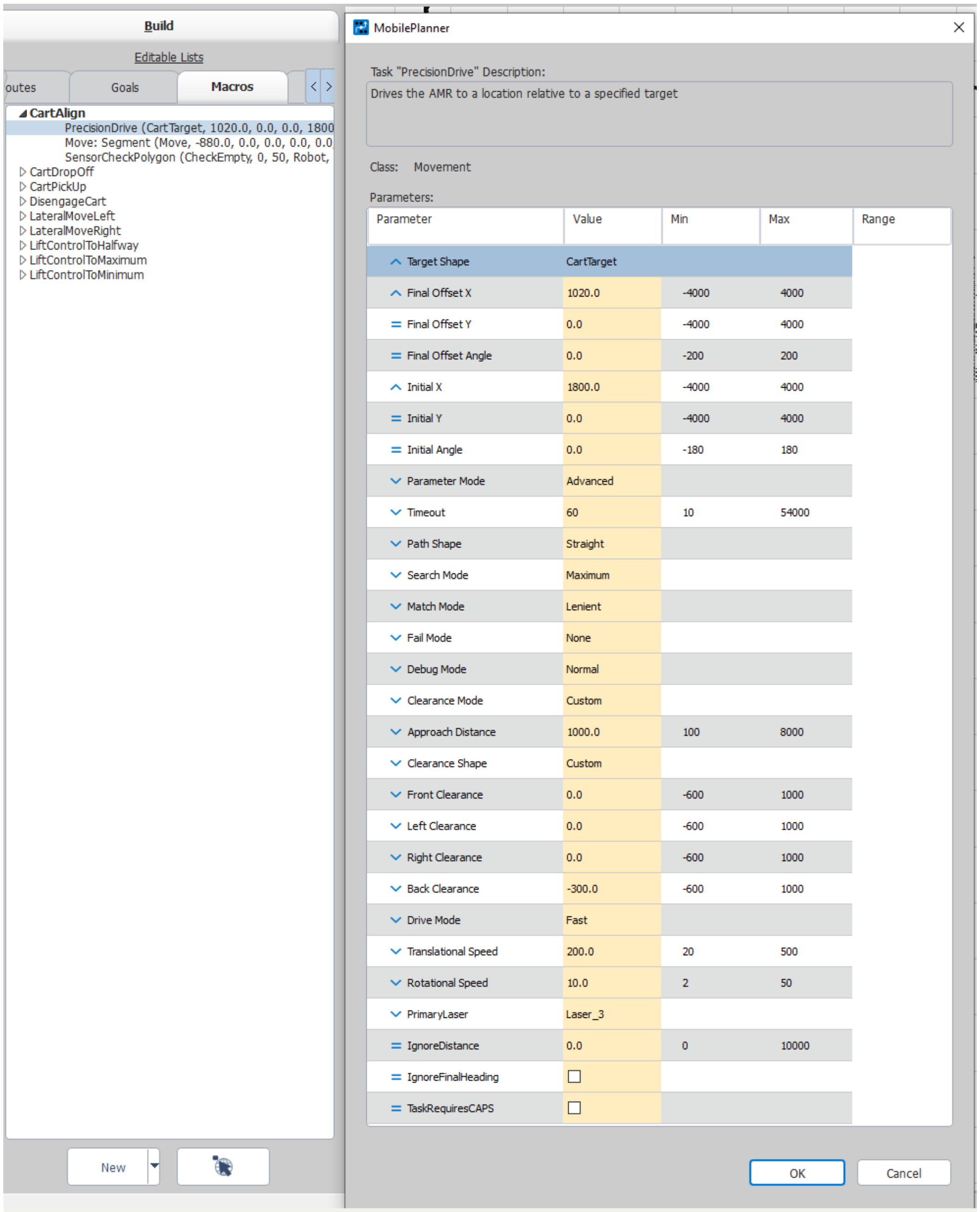

Figure 8-3 PrecisionDrive Task Settings

Optionally, the *SensorCheckPolygon* task can be used after this *PrecisionDrive* task to verify proper alignment with a load carrier. It is recommended to make any rotational adjustments before attempting to drive underneath the targeted load carrier. Refer to section 8.1.1.3 Sensor Check Polygon, for further details on usage of this feature.

To verify the presence of the load carrier after alignment, four separate *SensorCheckPolygon* tasks were performed. The mode for each is set to *CheckOccupied* for the four polygons shown in Figure 8-4. In this application, each caster of the load carrier is expected to produce a minimum of 5 laser data points as the success criteria. If any of the wheels are not located, then the task will fail.

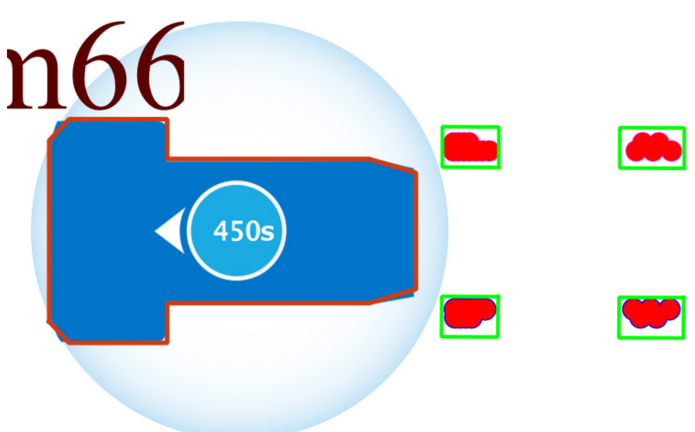

Figure 8-4 SensorCheckPolygon to Verify Presence of Readings

An extra *SensorCheckPolygon* task is also performed to check that it is safe to navigate under the load carrier. Figure 8-5 shows a polygon with its mode set to *CheckEmpty* to verify that there were no laser readings in the area beneath the cart.

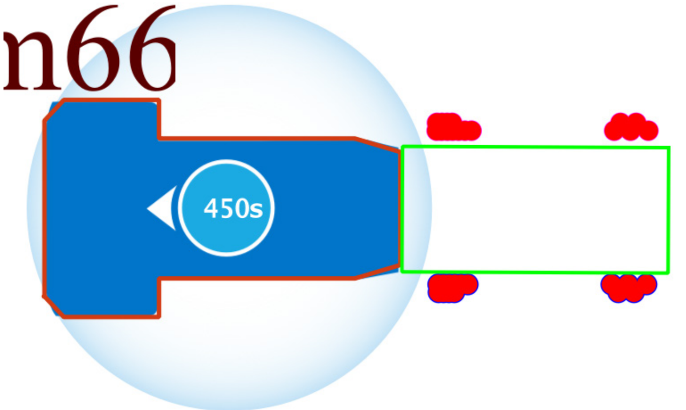

Figure 8-5 SensorCheckPolygon to Check Empty

8.1.1.2. Move: Segment

After the AMR is aligned with the load carrier, it can now perform a straight-line motion to reverse and position itself underneath the cart. This can be accomplished with a *Move: Segment* task to perform a straight-line motion. This will require that the AMR is accurately aligned before being called.

The exact parameters needed for *Move: Segment* are application specific. Based on how the target was trained, the AMR center and the available working area of the lifting plate must be noted as shown in Figure 8-6 as these values will be needed when defining the distance that AMR will need to traverse.

The set of parameters used in this example can be found in Figure 8-7 and should only be used as a reference. The *Clearance Shape* parameter under the *Move:Segment* task may need to be modified if the casters or legs of the load carrier are within the AMR shape when reversing.

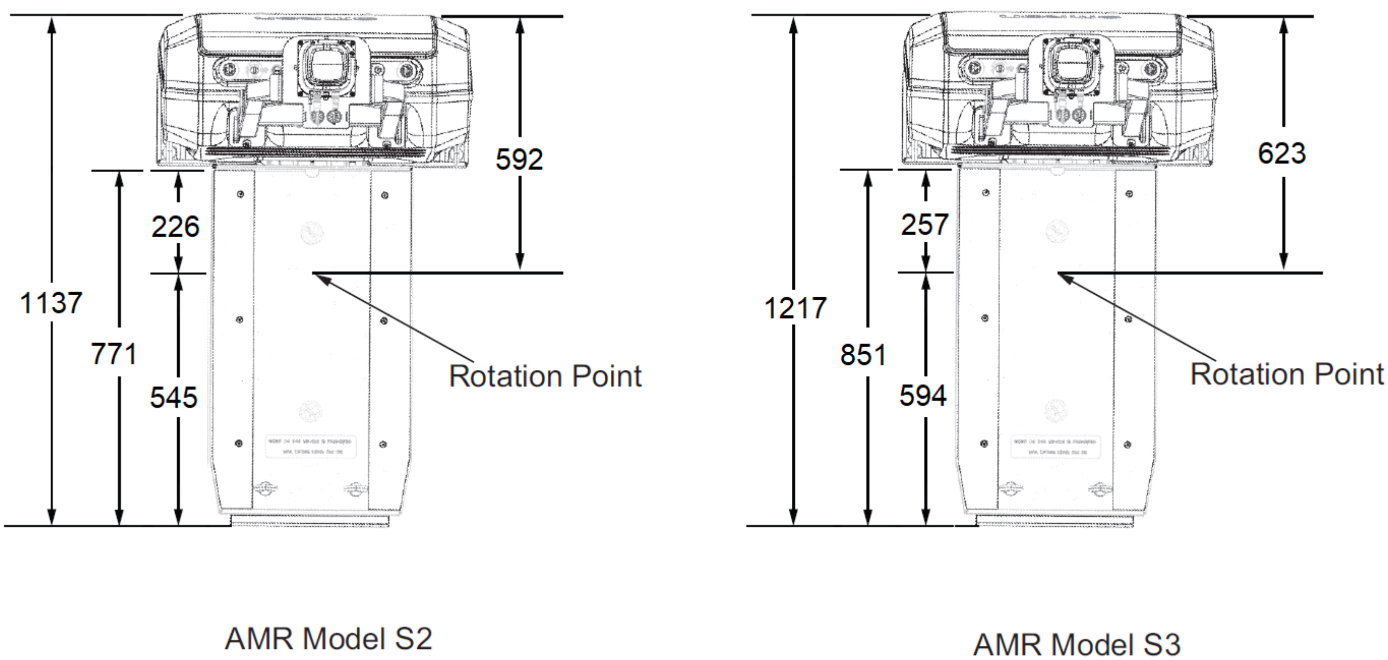

Figure 8-6 AMR Center And Lifting Plate Length

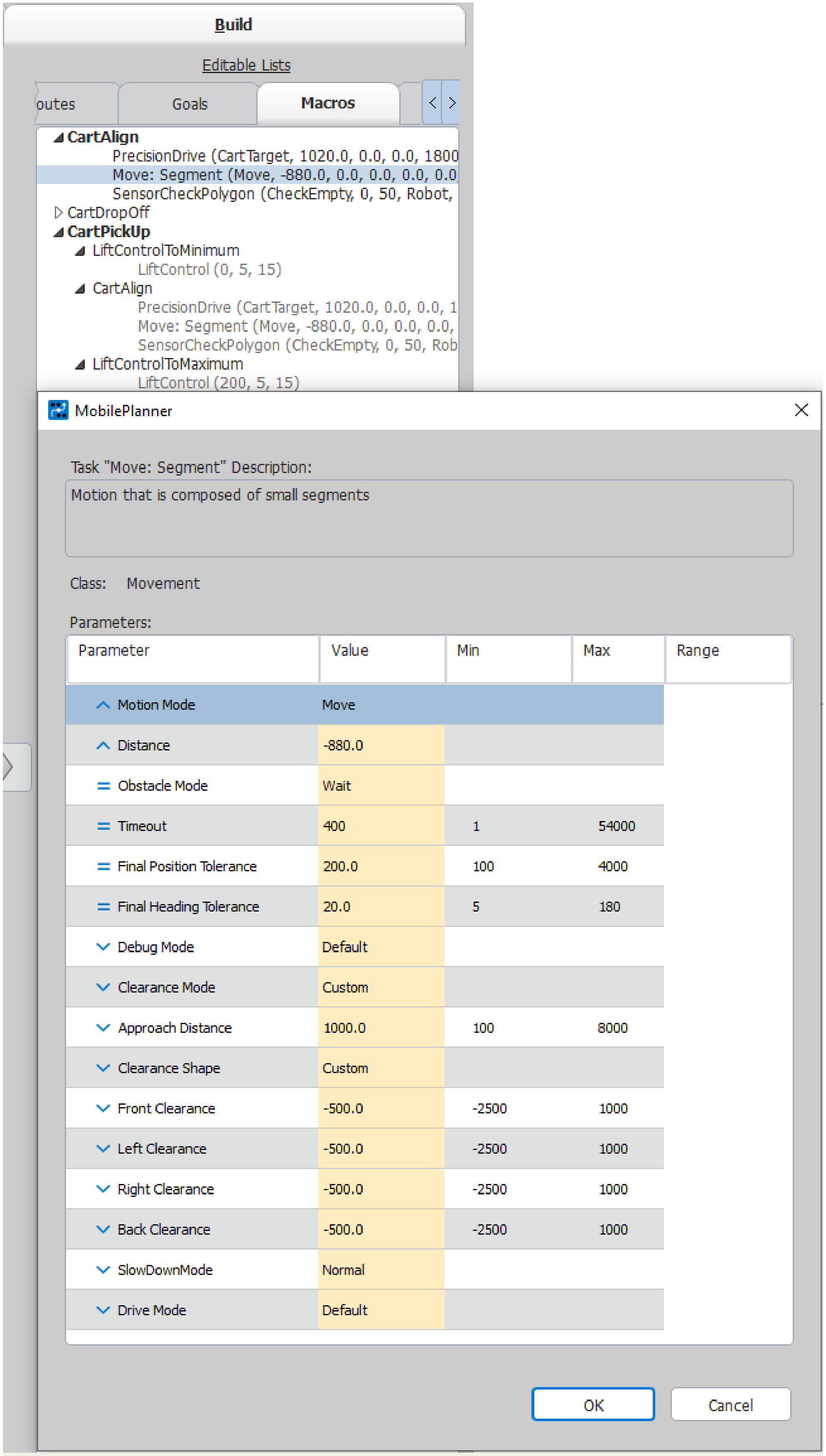

Figure 8-7 Move: Segment Pick Up Task Settings

8.1.1.3. Sensor Check Polygon

Once the AMR has completed its straight-line motion and is positioned under the load carrier, the *SensorCheckPolygon* task can be used to ensure the casters of the load carrier are in the correct position prior to lifting the cart. This task allows defining a region to check sensor data points. It has two modes to check if a region is either empty or occupied. While using *SensorCheckPolygon* in your application is optional, this feature must be enabled to comply with ISO-3691-4:2023 requirements for cart handling. It is also recommended to use, as failure to verify load carrier position could result in instability.

The diagram in Figure 8-8 shows a failed region by setting up the *SensorCheckPolygon* task to verify that zero sensor readings were recorded in a rectangular region directly behind the AMR bumper. This confirmed the load carrier had become misaligned as the AMR was reversing. If failures are found during normal operation, the cause of the error must be assessed, and the application should be updated to improve its robustness.

When the AMR is close to the cart, laser readings are often within the typical bounds of the AMR and as a result, automatically ignored. To use these ignored readings, the *IncludeIgnoredReadings* parameter needs to be checked.

The parameters needed for *SensorCheckPolygon* are application specific. The set of parameters used in this example can be found in Figure 8-9 and should only be used as a reference.

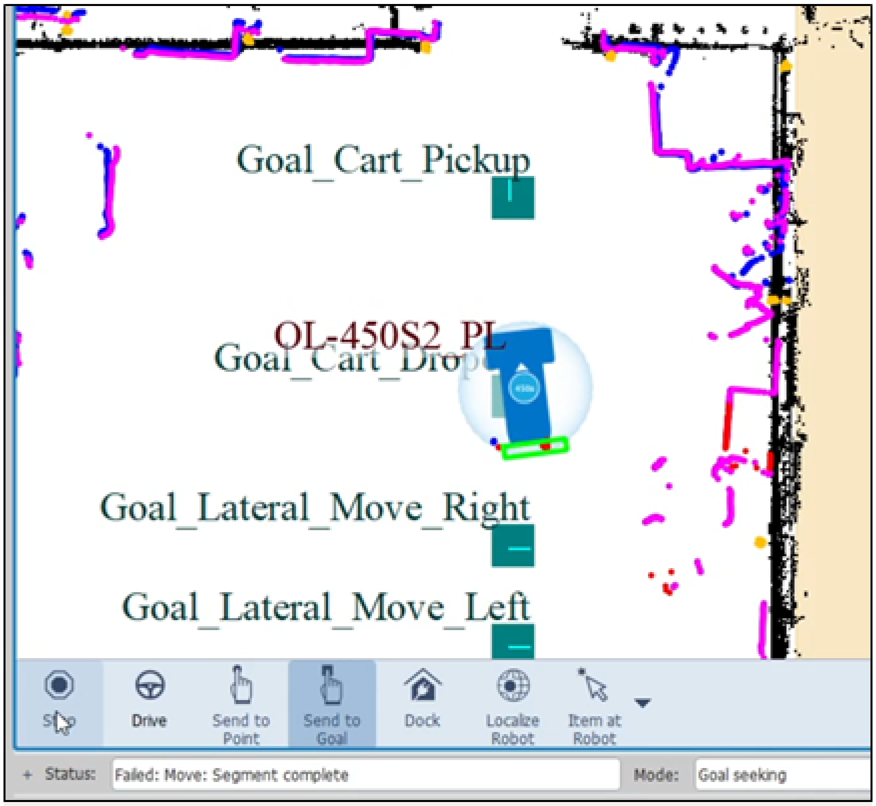

Figure 8-8 Usage of SensorCheckPolygon Task

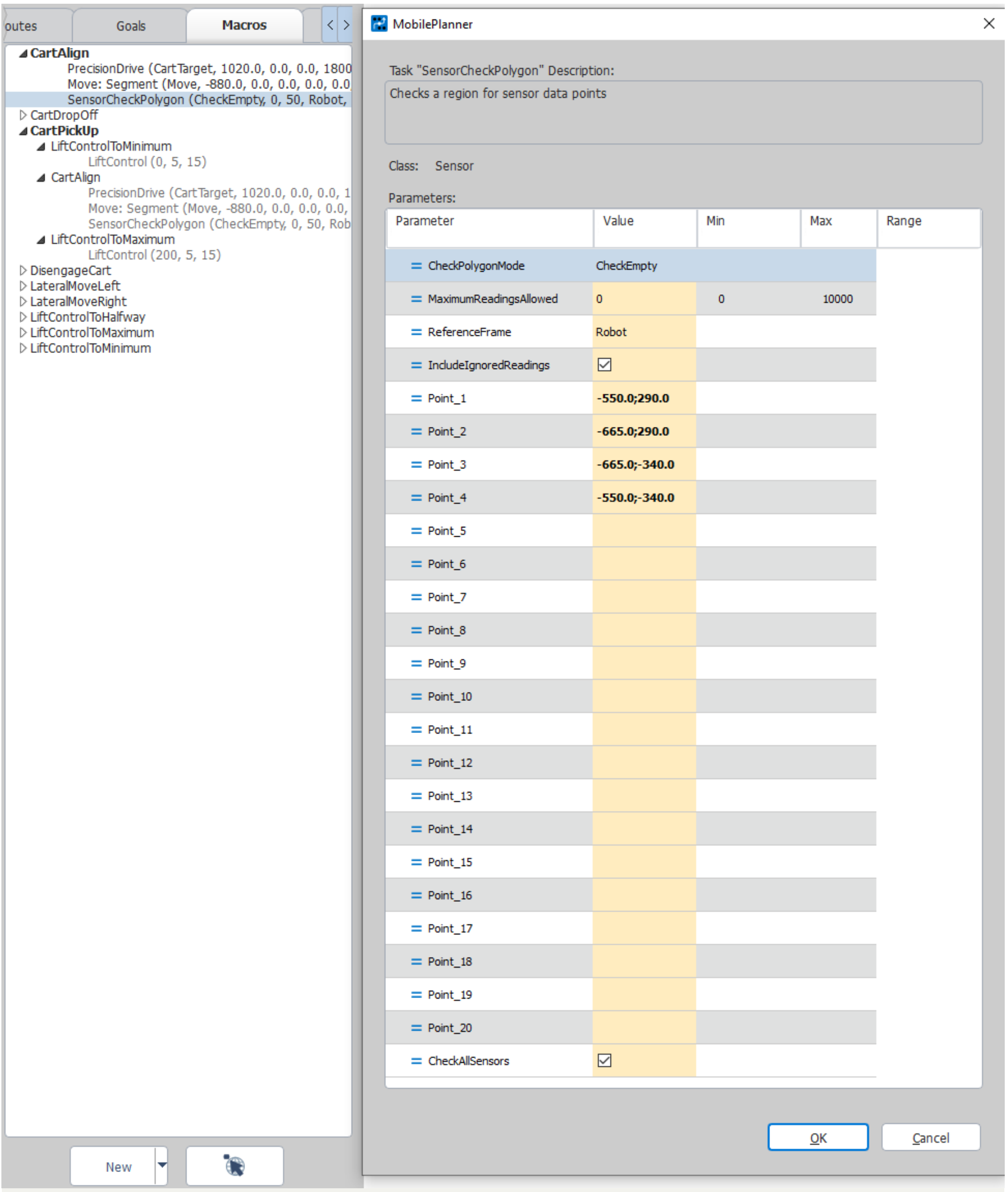

Figure 8-9 SensorCheckPolygon Task Settings

8.1.1.4. Lift Control

After successfully navigating under the load carrier, the *LiftControl* task can be used to raise the lifting plate and navigate to a drop off location. It is recommended to raise the lifting plate to its maximum height. Refer to section 6.4. Lift Control, for information on usage of this robot task.

8.1.1.5. Payload Present Task (Start In-Transit Monitoring)

The PayloadCheckLoaded Macro includes a PayloadPresentTask to start monitoring for the presence of a payload. This Macro is run before navigating to the drop off goal. The task will set CheckDeckLoaded as the Macro to use for monitoring. It is configured to use a SensorCheckPolygonInstant with its mode set to CheckOccupied. Refer to section 7 In-Transit Monitoring for more information on usage of this robot task.

8.2. Dropping Off Load Carrier

In the example “OL450S.map” file, a Goal and 4 Macros were created to demonstrate a standard load carrier drop off operation.

- Goals
  - Goal_Cart_Dropoff

- Macros
  - PayloadCheckClear
  - CartDropOff
  - LiftControlToMinimum
  - DriveForward1000

When defining the drop off goal, the rear heading of the goal should be placed at least 200 mm away from obstacles to prevent colliding with AMR bumper when reversing under load carrier. To have a successful application pick up, it is important that the drop off position is repeatable. When possible, it is recommended to use PrecisionDrive at the drop off goal to increase repeatability. Use of this task would be expected when using physical guides or an external target to determine the drop off location.

8.2.1. Payload Present Task (Turn Off In-Transit Monitoring)

The PayloadCheckClear Macro includes a *PayloadPresentTask* which is used to stop monitoring for the presence of a payload. When using the in-transit monitoring feature, failure to run this Macro once arrive at the drop off location may prevent the AMR from disengaging from the load carrier. Refer to section 7 In-Transit Monitoring for more information on usage of this robot task.

After completing the drop off operation, a *PayloadPresentTask* can be started to prevent the AMR from operating with unauthorized payloads. This can be accomplished by setting the mode for *SensorPolygonCheckInstant* to *CheckEmpty*.

8.2.2. Cart Drop Off Macro

The *CartDropOff* Macro shows a set of robot tasks and parameters that were used to drop off the example industrial receiving cart and disengage from it. This consists of using a *LiftControl* task to lower the lifting plate and a *Move: Segment* to drive straight out from under the cart. A cart drop off macro should be created for each variety of cart lengths in your application.

8.2.1.1. Lift Control

After arriving at the drop off location, the *LiftControl* task can be used to lower the lifting plate. It is recommended to return the lifting plate to its minimum height, also referred to as the home position. Refer to section 6.4 Lift Control, for information on usage of this robot task.

8.2.1.2. Move: Segment

After the lift control is lowered, the AMR can now perform a straight-line motion to drive forward and out from under the cart.

The parameters needed for *Move: Segment* are application specific. The set of parameters used in this example can be found in Figure 8-10 and should only be used as a reference. In general, the *Distance* value should exceed the length from the front of the load carrier that was dropped off to the rear of the lifting plate. In some cases, where there is minimal clearance between the load carrier and the OL-450S, the Clearance settings need to be updated. Setting the *Clearance Mode* to *Custom* and setting a *Tight* value for the *Clearance Shape* should be sufficient in most cases. Alternatively a custom clearance shape can be defined using negative values for Left/Right sides.

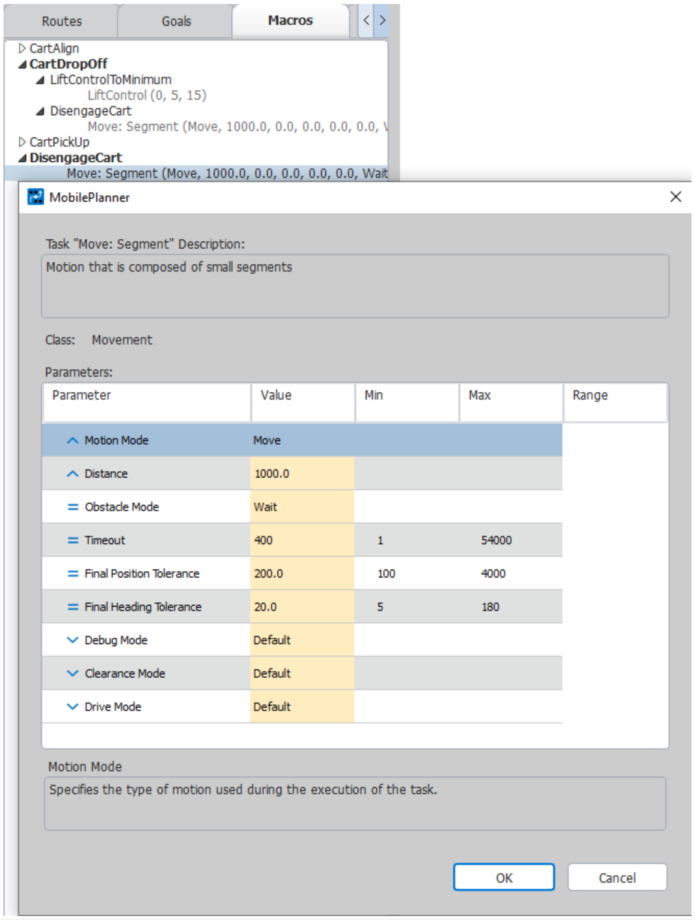

Figure 8-10 Move: Segment Drop Off Task Settings

9. Simulation Support

Both the OL-450S2 and OL-450S3 models are supported in simulation, as shown in Figure 9-1. This will require using a minimum version of SNG8.4.4 and FLOW Core 5.0. The base Simulator will require restarting before new fleets can be created with OL-450S AMRs.

When attempting to simulate robot tasks, use of the *LiftControl* task to change the current lifting plate height is not currently supported in simulation. Nor will it be possible to simulate lifting of dynamic obstacles, such as the cart's casters being picked up and dropped off. A workaround is to mimic the cart casters by manually drawing Map Data Lines into the map file at the expected pick-up location. This will allow the AMR to execute robot tasks such as *PrecisionDrive*, Move: Segment, and SensorCheckPolygon when simulating a pickup operation as shown in Figure 9-2. This can be useful to estimate your application cycle time before building a real application. In the example shown below, the rear scanner is used to detect a simulated cart. It is important to ensure the rear scanner is enabled to successfully locate with Laser_3.

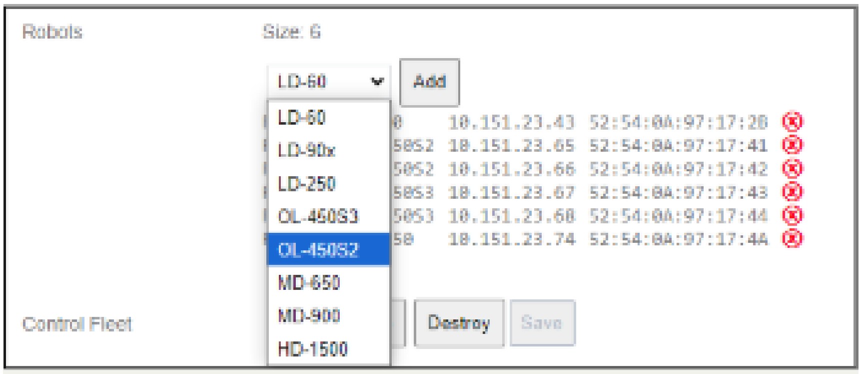

Figure 9-1 Simulation Support Of OL-450S

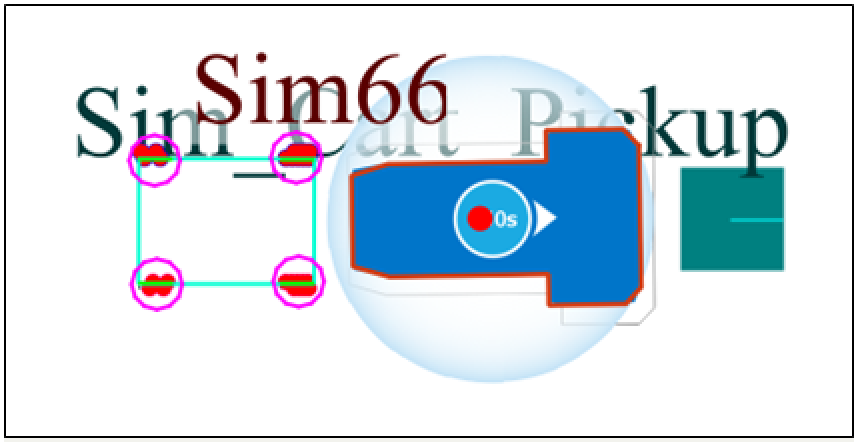

Figure 9-2 Simulation Cart Pick Up

10. Troubleshooting

To collect troubleshooting information, the SetNetGo tool can be used to download a Debug Info File under the *Status > Debug* Info tabs. This is a collection of configuration, log, and system status files that can be used for debugging and troubleshooting. With the latest version of FLOW Core 5.0 comes additional tools to support debugging and troubleshooting OMRON AMRs via MobilePlanner. This includes a new Diagnostic Window, Fleet Snapshot, and Replay.

10.1. Diagnostic Window

When connected to an AMR, the current state of various AMR components can be monitored via the Diagnostic Window in MobilePlanner, as shown in Figure 10-1. This feature can be accessed through the menu bar under *Robot > Debug > Diagnostic*. This will be helpful when it is suspected the AMR is experiencing a hardware error to indicate which components may be affected.

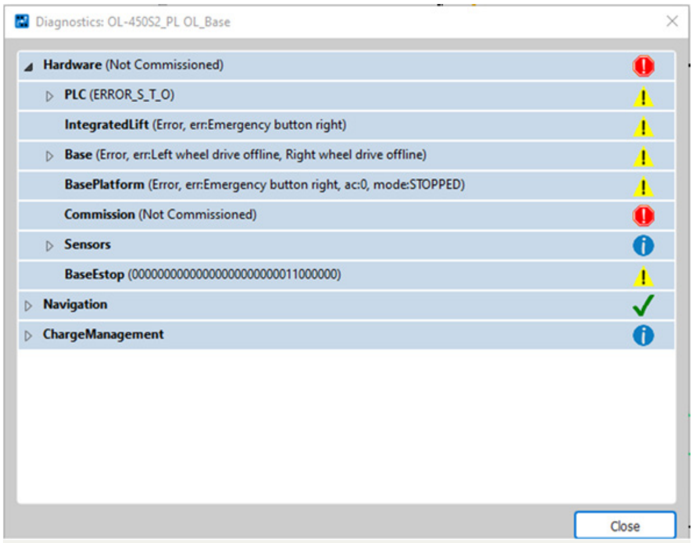

Figure 10-1 Diagnostic Window

10.2. Replay

Starting with FLOW Core 5.0, the MobilePlanner has a new feature to create recordings that can capture data related to Robot Pose, Robot Status, Battery State of Charge, Scanner Readings, and Diagnostic Updates.

This feature can be started through the menu bar under *Robot > Debug > Start Recording* and ended by selecting Robot > *Debug > Stop Recording*. The fleet hierarchy will have an indicator when there is an active recording, as shown in Figure 10-2. The recordings can be saved as a (*.zrp) file, which can later be viewed offline using MobilePlanner.

To replay a recording, double click on the file in its saved location or go to *File > Open* in MobilePlanner's menu bar to locate the saved recording. The *Replay* will open read-only versions of the Fleet, Map, and Configuration tabs and a time control window as shown in Figure 10-3. The configuration can be viewed as if connected to the live fleet, and all AMRs present in the Fleet will show up in the list. The configuration will contain any AMR or Family-specific parameter differences.

A red icon will appear in the fleet explorer window and the opened tabs to indicate a *Replay* is playing. The time control window will allow you to control the playback of the Replay and allows jumping to desired time stamps.

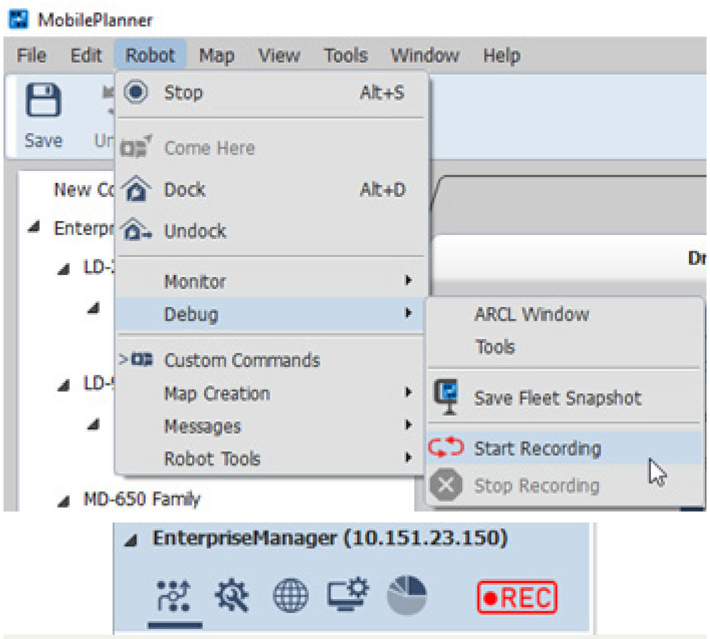

Figure 10-2 Replay Feature Recording

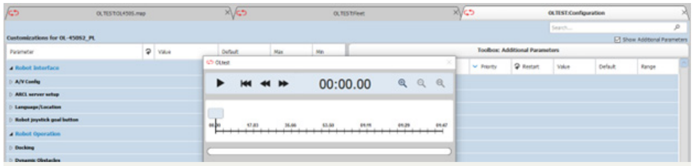

Figure 10-3 Replay Time Control

10.3. Fleet Snapshot

A simplified version of the *Replay* feature is to *Save Fleet Snapshot.* This feature is useful for capturing an instantaneous image of an AMR or Fleet at a given point in time. It is a one-click operation to support sharing of configuration information. This feature can be accessed through the menu bar under *Robot > Debug > Save Fleet Snapshot* as shown in Figure 10-4. The snapshots can be saved as a (*.zrp) file, which can later be viewed offline using MobilePlanner.

To view the Snapshot, double click on the file in its saved location or go to *File > Open* in MobilePlanner's menu bar to locate the saved file. The *Snapshot* will open read-only versions of the Fleet, Map, and Configuration tabs containing information from the time of capture. The configuration can be viewed as if connected to the live fleet, and all AMRs present in the Fleet will show up in the list. The configuration will contain any AMR or Family-specific parameter differences.

A red icon will appear in the fleet explorer window and the opened tabs to indicate a *Snapshot* is open.

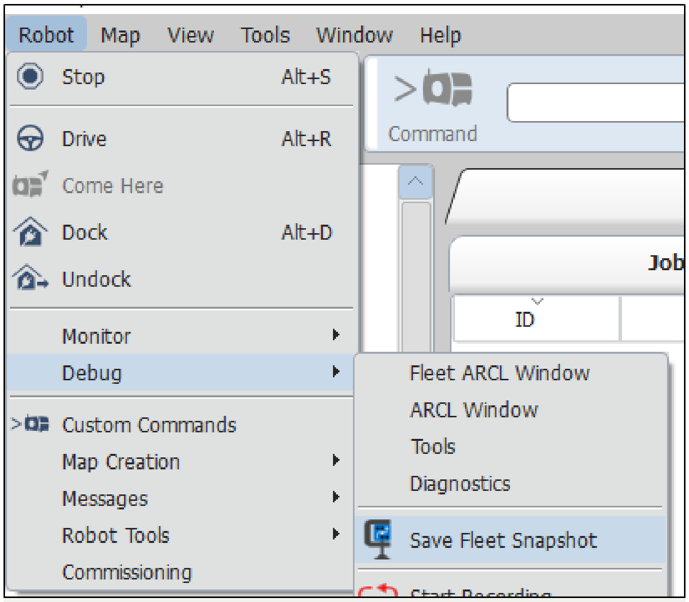

Figure 10-4 Save Fleet Snapshot Menu Option

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4225 Hacienda Drive
Pleasanton, CA 94588

robotics.omron.com
(925) 245 - 3400

M127-E-01 (0325) 0325