LD-Series

Integration Guide

I680-E-02

Introduction

This guide is OMRON’s original document describing the steps and considerations needed to properly integrate the Autonomous Mobile Robot (AMR) into a factory environment. Successful integration begins with comprehensive planning, as described in this document.
This guide does not describe all configuration steps that you must perform while using the software and hardware supplied with an AMR. Refer to *Related Manuals* on page 15 for more information.Review all necessary documents to ensure a thorough understanding of the functionality and performance of the AMR and associated systems before attempting use.

Intended Audience

This manual is intended for the following personnel, who must also have knowledge of factory automation (FA) systems and robotic control methods:

- Personnel in charge of introducing FA systems.
- Personnel in charge of designing FA systems.
- Personnel in charge of installing and maintaining FA systems.
- Personnel in charge of managing FA systems and facilities.

It is the end user’s responsibility to ensure that all personnel who will work with or around AMRs have attended an appropriate training 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 described in this document, you should allow only skilled persons or instructed persons to do certain procedures. Skilled persons have technical knowledge or sufficient experience to enable them to avoid either electrical or mechanical dangers. Instructed persons are adequately advised or supervised by skilled persons to enable them to avoid either electrical or mechanical dangers.
All personnel must observe industry-prescribed safety practices during the installation, operating, and testing of all electrically-powered equipment.
Before working with the AMR, every person must confirm that they:

- Have the necessary qualifications and training.
- Have access to *LD-60/90 Platform User's Manual (Cat. No. I611)* and other safety documentation.
- Have read and understand the related documentation.
- Have agreed to work in the manner specified by the documentation.

Contact your OMRON representative for recommendations on related training courses and materials.

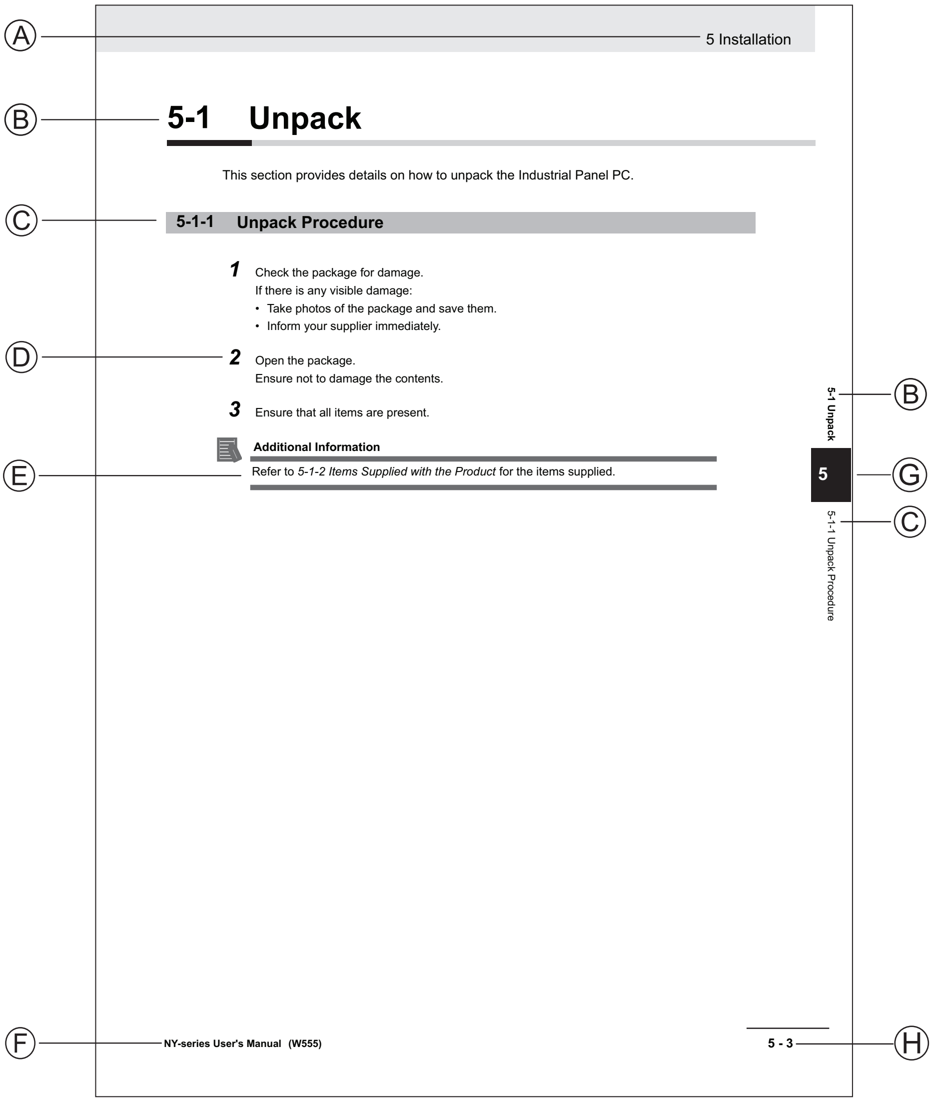
Units

All units are metric unless otherwise noted.

Manual Information

Page Structure

The following page structure is used in this manual.



Note: This illustration is provided as a sample. It will not literally appear in this manual.

Item	Explanation	Item	Explanation
A	Level 1 heading	E	Special Information
B	Level 2 heading	F	Manual name
C	Level 3 heading	G	Page tab with the number of the main section
D	Step in a procedure	H	Page number

Special Information

Special information in this manual is classified as follows:

Precautions for Safe Use

Precautions on what to do and what not to do to ensure safe usage of the product.

Precautions for Correct Use

Precautions on what to do and what not to do to ensure proper operation and performance.

Additional Information

Additional information to read as required.
This information is provided to increase understanding or make operation easier.

Version Information

Information on differences in specifications and functionality between different versions.

Sections in this Manual

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Section 3 Application Examples

Section 4 Getting Started

Section 5 Adjustments & Optimization

Section 6 Other Solutions & Examples

Appendix

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Terms and Conditions Agreement

Warranty and Limitations of Liability

Warranty

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Information presented by Omron Companies has been checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical or proofreading errors or omissions.

Safety Precautions

Definition of Precautionary Information

The following notation is used in this guide to provide precautions required to ensure safe usage of the product. The safety precautions that are provided are extremely important to safety.
Always read and heed the information provided in all safety precautions.
The following notation is used.

WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury. Additionally, there may be severe property damage.

Symbols

	The triangle symbol indicates precautions (including warnings). The specific operation is shown in the triangle and explained in text. This example indicates a general precaution.
	The filled circle symbol indicates operations that you must do. The specific operation is shown in the circle and explained in text. This example shows a general precaution for something that you must do.

Warning

WARNING

To maintain the security and reliability of the system, a robust cybersecurity defense program should be implemented, which may include some or all of the following:

Anti-virus protection

- Install the latest commercial-quality anti-virus software on the computer connected to the control system and keep the software and virus definitions up-to-date.
- Scan USB drives or other external storage devices before connecting them to control systems and equipment.

Security measures to prevent unauthorized network access

- Install physical controls so that only authorized personnel can access control systems and equipment.
- Reduce connections to control systems and equipment via networks to prevent access from untrusted devices.
- Install firewalls to block unused communications ports and limit communication between systems. Limit access between control systems and systems from the IT network.
- Control remote access and adopt multifactor authentication to devices with remote access to control systems and equipment.
- Set strong password policies and monitor for compliance frequently.

Data input and output protection

- Backup data and keep the data up-to-date periodically to prepare for data loss.
- Validate backups and retention policies to cope with unintentional modification of input/output data to control systems and equipment.
- Validate the scope of data protection regularly to accommodate changes.
- Check validity of backups by scheduling test restores to ensure successful recovery from incidents.
- Safety design, such as emergency shutdown and fail-soft operations in case of data tampering and incidents.

Additional recommendations

- When using an external network environment to connect to an unauthorized terminal such as a SCADA, HMI or to an unauthorized server may result in network security issues such as spoofing and tampering.
- You must take sufficient measures such as restricting access to the terminal, using a terminal equipped with a secure function, and locking the installation area by yourself.
- When constructing network infrastructure, communication failure may occur due to cable disconnection or the influence of unauthorized network equipment.
- Take adequate measures, such as restricting physical access to network devices, by means such as locking the installation area.
- When using devices equipped with an SD Memory Card, there is a security risk that a third party may acquire, alter, or replace the files and data in the removable media by removing or unmounting the media.
- Please take sufficient measures, such as restricting physical access to the Controller or taking appropriate management measures for removable media, by means of locking and controlling access to the installation area.
- Educate employees to help them identify phishing scams received via email on systems that will connect to the control network.

Precautions for Safe Use

- User-supplied bumpers connected to the User Bumpers connector are not safety-rated.
- Never connect devices directly to the battery. Always connect devices to the USER power and AUX power to ensure overcurrent protection. Refer to the AMR User's Manual for information regarding overcurrent protection.
- Although the AMR's software provides the option of using the map features to keep the AMR within its designated workspace, poor or improper localization may result in incorrect path planning. To ensure safety, you must always install physical barriers where there is a risk of property damage or personal hazard.
- The default parameters for Path Following mode were selected after extensive testing at OMRON for each specific AMR model. Changes to these parameters are advised only when the environment and payload demand changes in the AMR's default behavior.
- Regarding *SuperMaxTransDecel* and *EmergencyMaxTransDecel*: Emergency stops and protective stops occur at default deceleration rates, which are very high. In order to prevent toppling, always ensure the payload's center of gravity accounts for this.
- Regarding *CollisionRange*: It is strongly recommended to consult the local machine safeguarding authority before changing this parameter. The user is responsible for the safety impact of any changes made to this setting.
- Pinch points can be introduced when moving below the default speed for safety zone 0. This can occur while aligning with other equipment, or traveling in narrow spaces or tight clearance areas. The safety zone 0 default speeds for LD-series AMRs are as follows:
  - 225 mm/s (LD-90, LD-250)
  - 300 mm/s (LD-60)
- Contact your local OMRON representative to change the size of the safety laser scanners' safety zones.
- The AMR as a partly-completed machine is intended to be incorporated into other machinery and must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of EC Machinery Directive 2006/42/EC, where appropriate.
- Lasers cannot reliably detect glass, mirrors, and other highly-reflective objects. Use caution when operating the AMR in areas that have these types of objects. If the AMR 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 Areas in the map, so that the AMR can plan paths safely around these objects.
- Installation procedures require that you have put the AMR into a safe state for mechanical and electrical work. Always ensure the battery is disconnected.

Precautions for Correct Use

- Review the following AMR parameters for overhanging payloads: *Width, LengthFront, LengthRear*, and *Radius*. If modification of the parameters is necessary, ensure the updated values are used during path planning and obstacle avoidance.
- The AMR does not report its position while powered OFF. Manually docking an AMR while powered OFF may cause other AMRs in a fleet to attempt to use the occupied docking station.
- Docking stations can also be placed at goals, but this is not suitable for applications which actively draw current from the AMR's battery while it is recharging on the docking station.
- The battery should be turned off after balancing if it is not intended to be used for an extended period. Stored batteries must be balanced every six months to prevent significant deterioration.
- Battery voltage drops as the battery discharges. For a device that requires a consistent voltage input, use of a DC-to-DC converter is recommended.
- Follow all OMRON battery storage and maintenance recommendations. Refer to the AMR User's Manual for information.
- Do not attempt to operate the AMR before all setup steps have been completed. Refer to *Section 4 Getting Started* on page 4-1 for setup information.
- Minimize interference between the payload or payload structure and the AMR's sensors. Unavoidable interference can be configured as ignored in MobilePlanner and accounted for in safety zone design.
- Do not exceed the torque limits when mounting the payload structure using the self-clinching nuts.
- Do not exceed the torque limit when mounting the payload structure using the clip nuts.
- Ensure the following when relocating the AMR's operator panel:
  - Extension cable length does not exceed 2 m.
  - The cable is not routed near devices that can induce electrical interference.
  - The cable is routed in such a way that it avoids sharp bends, pinch points, and chafing to prevent damage to the sheath.
  - The cable is securely fastened to prevent entanglement.
- Substituting a higher gain antenna (with little to no loss in the added cable leading up to it) can cause the system to be non-compliant with local radiated emissions standards.

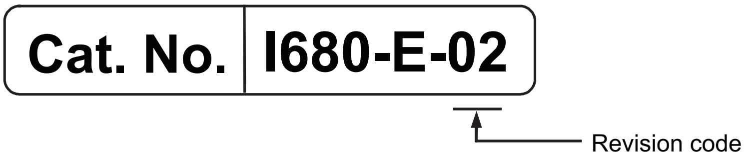
Related Manuals

Use the following related manuals for reference.

Manual Title	Description
Mobile Robot LD Safety Guide (Cat. No. I616)	Contains general safety information for LD-series AMRs.
Safety Laser Scanner OS32C Series User's Manual (Cat. No. Z296)	Describes the use of the OS32C Safety Laser Scanner.
LD-60/90 Platform User's Manual (Cat. No. I611)	Describes safety, components, operation, and maintenance of the LD-60/90 AMR.
LD-250 Platform User's Manual (Cat. No. I642)	Describes safety, components, operation, and maintenance of the LD-250 AMR.
Fleet Operations Workspace Core User's Manual (Cat. No. I635)	Describes fleet management, MobilePlanner software, SetNetGo, and configuration procedures for the AMR.
Advanced Robotics Command Language Enterprise Manager Integration Guide (Cat. No. I618)	Describes how to use the Advanced Robotics Command Language (ARCL) a text-based, command line operating language.
Fleet Operation Workspace Core Integration Toolkit User’s Manual (Cat. No. I637)	Contains information that is necessary to use the Integration Toolkit.
Fleet Operations Workspace iQ User's Manual (Cat. No. I665)	Contains information about data displayed by the FLOW application.
Enterprise Manager 2100 User's Guide (Cat. No. I631)	Describes the installation of an EM2100 appliance.
Advanced Robotics Command Language AMR Reference Guide (Cat. No. I617)	Contains information about the text-based command-and-response system.
LD Platform Peripherals User's Guide (Cat. No. I613)	Contains information about LD-series peripheral items.

Revision History

A manual revision code appears as a suffix to the catalog number on the front and back covers of the manual.



Revision code	Date	Revised content
02	May, 2023	Updates and revisions
01	September, 2022	Original production

1

AMR Overview

This section provides general information about the AMR.

1-1 AMR Components

This section provides a basic overview of the AMR and its hardware components. Refer to *A-1 Further Reading on AMR Components* on page A-2 for more information.

1-1-1 Product Description

LD-60/90/250 is a self-guided mobile robot platform designed to move material within dynamic indoor environments. The AMR features OMRON's software and controls, allowing it to intelligently navigate around people and unplanned obstacles, as well as self-charge in an automated docking station.
This class of AMR platform is referred to as LD-Series (Light Duty Series). Three LD models are available:

- LD-60 - Capable of carrying loads up to 60 kg.
- LD-90 - Capable of carrying loads up to 90 kg.
- LD-250 - Capable of carrying loads up to 250 kg.

These AMRs are designed for developers, integrators, and end-users. They can be customized for a variety of applications and payloads.
The base AMR platform includes chassis, drivetrain, suspension, wheels, battery, safety laser scanner, front low laser, rear-facing obstacle avoidance sensors, onboard controller with gyroscope and software for navigation, interface connections for payload, and covers.

Precautions for Safe Use

The AMR as a partly-completed machine is intended to be incorporated into other machinery and must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of EC Machinery Directive 2006/42/EC, where appropriate.

1-1-2 Basic Components

This section describes the AMR's basic components.

Body

The body of the AMR is comprised of the following components.

● Skins

Durable skins surround the AMR and allow easy removal for service. The LD-60/90 AMR's skins are plastic and secured by magnets, while the LD-250 AMR's skins are metal and secured with M6 screws (except its battery door skin).
The side skins each contain an LED light array and lighting controller. With the side panel removed, the drive unit is exposed. This allows access to the drive unit for service.
AMR options are available for handling products sensitive to Electrostatic Discharge (ESD). Refer to *Electrostatic Discharge (ESD) Skins* on page 1-6 for more information.

- **Front Bumper (LD-60/90 Only)**

  The AMR features a fixed front bumper, which serves as a backup to the obstacle-avoidance systems. The AMR comes to a complete stop when the bumper is hit with a force of at least 67 N.

- **Payload Bay**

  The payload bay is the space between and the AMR and payload structure, covered by a removable top plate. The payload bay houses the main control components of the AMR and provides access to the power and I/O connections. It also houses the AMR Core, the main processor and control unit of the AMR. The sonar controller is located in the front of the payload bay as well (LD-60/90 only).

Drive and Wheels

The AMR uses a two-wheel, differential drivetrain. The drive wheels are mounted directly to the drive assembly and have independent spring suspension. They are located at the AMR's midline, allowing it to turn in place. Each wheel also features encoders and Hall effect sensors. The tires are solid and foam-filled for the LD-60/90, and aluminum with polyurethane tread on the LD-250.
Casters in the front and rear allow the AMR to distribute its weight and balance effectively.

Interfaces

The AMR includes the following interfaces.

- **Maintenance & Pendant Ports**

  An access panel is located at the upper-right corner of the LD-60/90, and the upper-left rear corner of the LD-250. Upon release of the cover, two ports are exposed. The Ethernet port is for maintenance, and the 8-pin port is for connection of a manual drive pendant.
  The maintenance port, connected directly to the AMR Core, has the following characteristics:
  - Allows for configuration, maintenance, and programming
  - Has a static IP address of 1.2.3.4 with a subnet mask of 255.255.255.0
  - Requires a PC for access

  The pendant port is used for connecting the pendant when manually driving the AMR. This function is needed for initial map creation or if the AMR requires manual manipulation. Pendant control requires the AMR to have a charged, connected battery and to be powered ON.

- **Operator Panel**

  The operator panel is the central location for information and manual control of the AMR. The operator panel contains a color display (320 x 240 pixels), two buttons for powering the AMR ON and OFF, an E-STOP button, a manual brake release button, and a keyswitch.
  The operator panel can be relocated to a custom payload structure. Refer to *Relocating the Operator Panel* on page 2-27 for more information.

- **AMR Core**

  The primary controller for the AMR is known as the AMR Core. It includes an integrated computer loaded with the Fleet Operations Workspace (FLOW) Core software suite, which runs on the AMR version of the SetNetGo operating system.

The AMR Core is located in the center of the AMR. The top of the Core is accessible from the payload bay. It includes connections for the drive, laser, and safety systems. There are additional connections for user-supplied devices, such as input and output devices, and additional safety hardware.

Sensors

This section discusses the AMR's various sensors.

● Rear Sonar

The LD-60/90 features two pairs of rear-facing sonar sensors. Each sonar pair consists of one emitter and one receiver. The AMR's sonar pairs are designed for obstacle sensing while reversing. The maximum range of each pair is 5 m, though the typical accurate range is approximately 2 m.

● Rear Sensors

The LD-250 features three rear-facing sensors. Each sensor uses time-of-flight for obstacle sensing while reversing. Each sensor's maximum range is 1 m.

● Safety Laser Scanner

The AMR uses the safety laser scanner for navigation and map creation. It operates in a single plane at a height of 190 mm, parallel to the floor. The laser has a 240-degree focal range and looks ahead of the AMR at all times to navigate. This allows the AMR to respond to static and dynamic objects in its travel path. The laser's maximum safety protection range is 3 m, and its maximum navigation range is 50 m.

● Low Laser

The low laser is mounted to the front of the AMR. The low laser detects obstacles in front of the AMR, such as an empty pallet, which may be too low for the safety laser scanner to recognize. The scan height of the low laser is as follows:

AMR Type	Scan Height
LD-60/90	58 mm
LD-250	60 mm

Battery & Charging

This section discusses the AMR's battery and charging components.

● Battery

A 72 Ah lithium-ion battery powers the AMR. The rated battery runtime is approximately 15 hours for an unloaded LD-60/90 AMR and approximately 13 hours for an unloaded LD-250 AMR.
The battery can be recharged automatically while installed, or removed and recharged separately. Recharge time is approximately four hours. Upon reaching a full charge, the battery balances itself.

Precautions for Correct Use

The battery should be turned off after balancing if it is not intended to be used for an extended period. Stored batteries must be balanced every six months to prevent significant deterioration.

The battery lifespan is approximately 2000 recharge cycles.

The battery also provides power to any auxiliary devices connected to the AMR. Voltage is 22 to 30 VDC.

● Automated Docking Station

The docking station is the freestanding device the AMR uses to autonomously recharge its battery. The docking station detects the AMR's battery charge level and recharges it accordingly. When the AMR's battery is recharged to capacity (100%), the docking station stops supplying a charge. This allows the AMR to safely remain docked when not assigned to a job.

The AMR can also be manually docked for recharging while powered OFF. It will power ON while docked.

Precautions for Correct Use

The AMR does not report its position while powered OFF. Manually docking an AMR while powered OFF may cause other AMRs in a fleet to attempt to use the occupied docking station.

Additional Information

It is possible for the docking station to charge a spare battery, external to the AMR. However, only one battery can be recharged at a time. A docked AMR's battery will take precedence and interrupt recharging of a spare.

The docking station requires access to AC power (100 to 240 VAC, 50/60 Hz).

1-1-3 Optional Components

This section discusses optional components that are available for the AMR. Refer to the AMR's datasheet for part numbers and other information.

Pendant

The pendant is connected to the pendant port with a coiled cord and enables the AMR to be driven manually. This function is needed for initial map creation or if the AMR requires manual manipulation. Pendant control requires the AMR to have a charged, connected battery, and to be powered ON.

Spare Battery

Spare batteries are available and can be charged while not installed in an AMR.

Precautions for Correct Use

Follow all OMRON battery storage and maintenance recommendations. Refer to the AMR User's Manual for information.

Payload Structure Bumpers

Up to one front and one rear user-supplied bumper is supported, each with left, right and center sensors.

Precautions for Safe Use

User-supplied bumpers connected to the User Bumpers connector are not safety-rated.

Side Lasers

Side lasers can be added to an AMR to provide additional obstacle detection. Side lasers scan in a vertical plane near the path of the robot using a 270 degree field of view, allowing the AMR to detect obstacles at other heights that the AMR must avoid.
Refer to *6-2 Additional Sensors* on page 6-3 for more information about adding side lasers and other sensors.

Electrostatic Discharge (ESD) Skins

ESD skins are available to prevent damage to ESD-sensitive components. The skins are colored black and encase the AMR in an electro-conductive surface that provides a skin-to-chassis-to-wheel grounding path that drains off any charge the AMR might accumulate during operation.

Breakout Kit

The breakout kit enables connection to the AMR's digital I/O from another controller. The kit reduces the amount of time spent wiring when compared to wiring directly to the standard AMR Core digital I/O connectors. It includes the breakout cable, breakout board, and mounting hardware.

High Accuracy Positioning System (HAPS)

The High-Accuracy Positioning System (HAPS) is a sensor that detects magnetic tape applied to the floor. HAPS allows the AMR to achieve more accurate position control. For example, this can used when aligning with a fixed conveyor or traveling along a specific path through a light curtain.
The factory-supplied component is the HAPS sensor. One sensor allows accurate positioning driving forward along the magnetic tape. If the AMR is required to drive both forward and backward, two sensors are required.

Acuity Localization

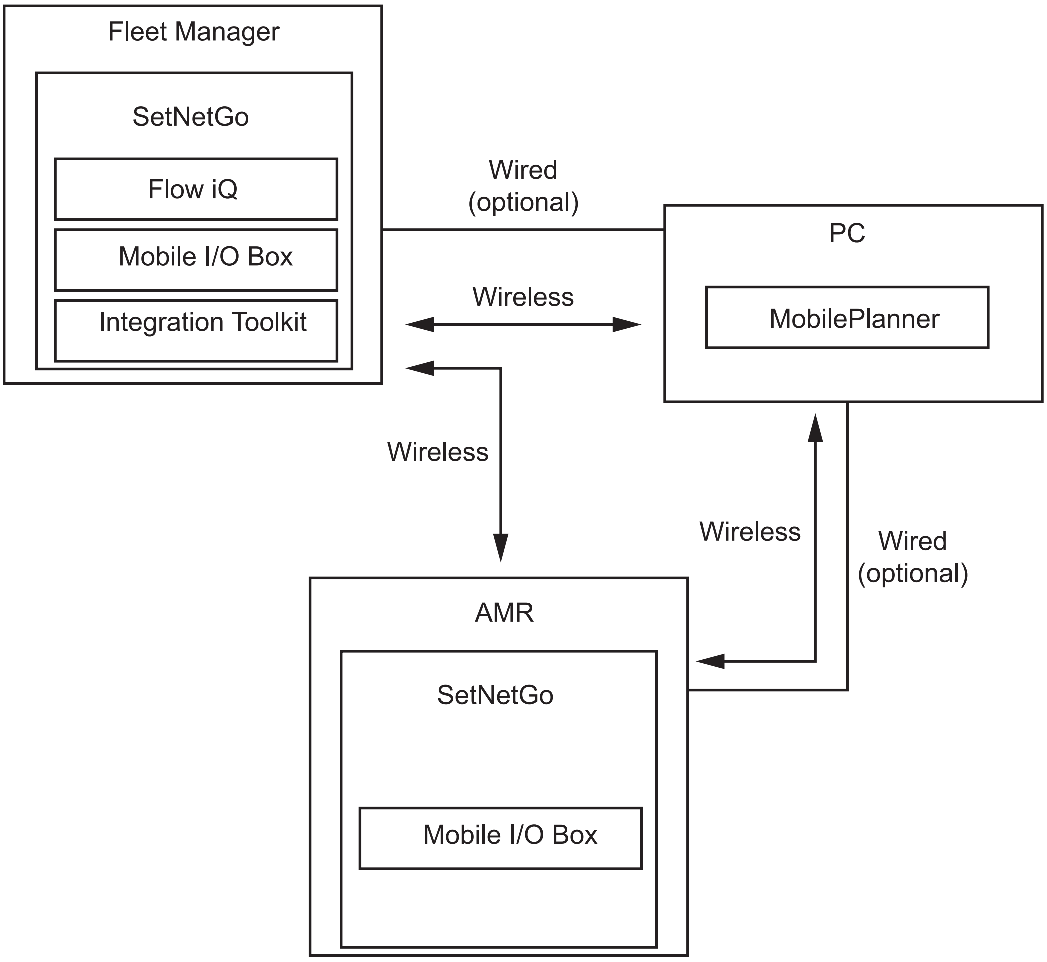
Acuity localization uses a camera to detect overhead lights for additional position reference. This option enables the AMR to localize itself in a highly dynamic environment where laser localization by itself may not be adequate. For example, Acuity localization may be used in warehouses where shipping pallets or rolling carts change locations often or block the laser's view of mapped features. Acuity is also useful where wide-open spaces do not provide enough near-by features for laser localization.

1-2 AMR Software

This section details the software that allows the AMR to perform its various functions. Refer to *A-2 Further Reading on AMR Software* on page A-4 for more information.

1-2-1 Software Architecture

Fleet Operations Workspace (FLOW) Core is a collection of software components designed for configuring, integrating, and managing one or more AMRs.
The figure below illustrates the relationship among FLOW Core's various components.



The sections that follow detail the major components.

1-2-2 FLOW Core on the AMR

The FLOW Core software suite running on the AMR Core performs functions such as:
- Managing the functions of mobility, including maintaining the drive speed and heading
- Acquiring sensor readings, such as from the encoders and gyroscope
- Assisting the safety system during E-Stop or protective stop operations
- Managing the bumper and pendant functions
- Computing and reporting odometry (X, Y, and heading) readings
- Computing and reporting a variety of other low-level operating conditions
- Operating ranging sensors like the safety laser scanner and sonar

- Performing high-level, autonomous robotics functions such as obstacle avoidance, path planning, localization, and navigation
- Sending motion commands to firmware
- Controlling the battery and light discs
- Managing digital I/O
- Managing wired and wireless Ethernet communications with off-board software for external monitoring, development, and systems coordination
- Managing integration with other systems
- Managing external monitoring, setup, and control with the MobilePlanner application (Refer to *1-2-3 MobilePlanner* on page 1-8 for more information)

1-2-3 MobilePlanner

This section describes the graphical user interface (GUI) component of FLOW Core that runs on a PC. MobilePlanner is a FLOW Core software component that provides the GUI for communicating with and configuring an AMR or fleet of AMRs. MobilePlanner also provides tools for displaying and editing map files. Before assigning tasks to an AMR, a digitized map of the workspace must be created.

After the map is created, it can be opened in MobilePlanner so features can be edited, added, or removed. Goals and docks must be added to the map for the AMR to successfully navigate the workspace.

- Goals are virtual destinations that the AMR drives to in its environment. For example, pickup/dropoff locations or areas that contain tools.
- Docks are locations the AMR uses for battery charging.

MobilePlanner can also be used for the following:

- Modifying AMR configurations
- Monitoring and manually controlling the AMR
- Initiating autonomous operations

Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for MobilePlanner installation information.

1-2-4 FLOW Core for Fleet Management

A Fleet Manager is required for interactions between AMRs. It is used to coordinate a fleet. Similar to the AMR, the Fleet Manager runs FLOW Core, hosted by the SetNetGo operating system. Refer to *1-2-5 SetNetGo* on page 1-8 for more information.

The Fleet Manager enables configuration of up to 100 AMRs through MobilePlanner. Fleet management activities include:

- Management of maps
- AMR configuration
- Job queue management
- AMR traffic coordination

1-2-5 SetNetGo

SetNetGo is the host operating system for FLOW Core. SetNetGo is used for the following:

- Network, configuration, and setup
- FLOW Core software upgrades

- Retrieving log files for troubleshooting
- Licensing and security
- Facility integration with Integration Toolkit (ITK)
- Fleet analytics with FLOW iQ

The SetNetGo interface is accessed with the following methods:

- Via MobilePlanner
- Via a web browser

The interface can be accessed by either method through a direct Ethernet cable connection to the AMR's Maintenance port or with a wireless connection (if remote connections are enabled).

The SetNetGo operating system also runs on the Fleet Manager.

Additional Information

SetNetGo is not included in the FLOW Core software package and must be updated separately.

1-3 AMR Functions & Behaviors

This section explores the basic methodology behind the AMR’s functions and behaviors. Refer to *A-3 Further Reading on AMR Functions and Behaviors* on page A-5 for more information.

Precautions for Correct Use

Do not attempt to operate the AMR before all setup steps have been completed. Refer to *Section 4 Getting Started* on page 4-1 for setup information.

1-3-1 Startup

During normal startup, the AMR powers ON the onboard systems. It then runs onboard software and integrated processes automatically. Provided the AMR has been supplied with a valid map of its work environment, it is ready to localize itself.

1-3-2 Localization

Localization is the process by which the AMR determines its location within its work environment.
The AMR's primary method of localization utilizes the safety laser scanner to scan and detect features in its environment.

Precautions for Safe Use

Although the AMR's software provides the option of using the map features to keep the AMR within its designated workspace, poor or improper localization may result in incorrect path planning. To ensure safety, you must always install physical barriers where there is a risk of property damage or personal hazard.

The AMR also uses a combination of wheel encoder counts and gyroscopic data to supplement laser localization.
A localization score is output based on the percentage of readings that match features on the AMR’s internal map. If the score is not sufficient, the AMR may drive a short distance before reporting it is lost.
While laser localization is sufficient for most applications, highly dynamic environments (>80% of the features change) may require the Acuity localization feature to improve localization scores.
When the AMR’s OFF button is pressed, its last known location is saved. This enables the AMR to automatically localize on the next startup.

Additional Information

If the AMR is moved from its last known location while it is powered OFF, it must be localized immediately upon startup. Without proper localization, the AMR may ignore map areas like forbidden areas that it should not enter.

1-3-3 Navigation, Obstacle Avoidance & Path Planning

Once the AMR has localized itself, it can safely navigate its environment. This section describes the systems and logic the AMR uses for navigation, path planning, and obstacle avoidance. Refer to *5-3 Navigation* on page 5-5 for more information.

Navigation Hardware

Navigation is aided by several hardware components: The safety laser scanner, low laser, rear-facing sensors, gyroscope, encoders, and Hall sensors. User-added sensors can aid navigation as well.
The AMR uses its safety laser scanner as its primary guidance to navigate, comparing the laser readings to its internal map.

Additional Information

- Areas with a ledge (e.g. edge of a loading dock, entrance to downward stairs) should be physically marked so the AMR's safety laser scanner can detect it. Barriers must be at least 250 mm tall to be accurately detected by the laser. It must also be continuous so the AMR cannot simply drive around or through it.
- Proper flooring is crucial. Rough or uneven floors can affect navigation and reduce the life of drivetrain components. Floors must also be kept relatively free of dust, dirt, grease, and water. Wet or dirty floors can cause the wheels to slip, thereby causing problems for braking, traction, and navigation.

Precautions for Safe Use

Although the AMR's software provides the option of using the map features to keep the AMR within its designated workspace, poor or improper localization may result in incorrect path planning. To ensure safety, you must always install physical barriers where there is a risk of property damage or personal hazard.

The low laser detects objects below the safety laser's sensing plane. Some objects that have a unique shape and taper outwards near the floor or are wider at the base may not be detected accurately by the low laser (rolling desk chair, hazard cones, column plinth, etc.).
The rear-facing sensors are relied upon for obstacle detection while the AMR is moving in reverse (e.g. while docking or if the front bumper has been activated).
The AMR Core has an internal gyroscope to track the AMR's rotational velocity.
Each drive wheel has an encoder and Hall sensor. The encoders report distance traveled and direction to the navigation system. The Hall sensors act as a backup to the encoders by tracking wheel rotation.
Optionally, the user may add side lasers for additional obstacle detection with custom payload structures.

Obstacle Detection

Dynamic Obstacle Tracking (DOT) allows for smoother motion around pedestrian traffic, forklifts, or any other moving vehicles. The tracking algorithm projects the path of moving objects in the same space as the AMR to avoid collisions and traffic jams. If a person is walking in the path perpendicular to the AMR, rather than trying to cross in front of the person's path, the AMR will slow down and move behind the person.

The AMR also keeps a short memory of previous laser points, called cumulative readings, to navigate more effectively. This enables the AMR to remember obstacles outside of its field of vision and prevent the AMR from planning an inefficient or blocked path.

Precautions for Safe Use

Lasers cannot reliably detect glass, mirrors, and other highly-reflective objects. Use caution when operating the AMR in areas that have these types of objects. If the AMR 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 Areas in the map, so that the AMR can plan paths safely around these objects.

Path Planning

The AMR's path to a goal is calculated dynamically on board; it is not pre-programmed. Paths are updated many times per second to maintain a smooth trajectory and to account for any obstacles detected by the AMR's sensors.

The AMR calculates a global path by assigning a value to each grid cell of its internal map between its current location and the goal. Grid cell "cost" is affected by physical objects, map objects, and AMR settings. The AMR takes the least "expensive" path from point A to point B.

As the AMR encounters an unmapped obstacle in its path, it makes a cost-based modification to its local path to avoid it, while still following the global path as closely as possible. If the AMR's path is completely blocked (e.g. a door is closed), it re-plans its global path with a suitable alternate route, if possible.

Navigation parameters are stored on board the AMR and are viewed and modified using MobilePlanner. Refer to *5-3-1 Path Planning & Path Following* on page 5-5 for more information.

1-3-4 Jobs, Tasks, Macros & Routes

Once the AMR is localized and able to safely navigate its environment, it can be assigned work. This section describes the different types of activities the AMR can perform and how they are organized.

Jobs

Jobs are requests for work the AMR receives and then executes. Jobs consist of two segment types:

- Pickup: Origin goal for a process
- Dropoff: Destination goal for a process

For example, an AMR could be requested to drive to a conveyor area to pick up parts, then drive to a bin on the other side of the plant to drop them off.

Jobs can be single segments (pickup or dropoff) or multiple segments (pickup, first dropoff, second dropoff).

Additional Information

Any suitable AMR (based on location, capabilities, charge, etc.) can be called to perform a pickup.

Jobs are requested through the following methods:

- MobilePlanner (refer to *1-2-3 MobilePlanner* on page 1-8 for more information.

- ARCL (refer to *2-8-3 Advanced Robotics Command Language (ARCL)* on page 2-12 for more information).
- Integration Toolkit: (refer to *2-8-4 Integration Toolkit (ITK)* on page 2-12 for more information.

Each job is assigned a JobID, and each job segment (pickup, dropoff) has an ID and priority. A higher priority is indicated with a higher number. Jobs are processed through the following methods:

- FIFO (First In, First Out): Jobs are processed by priority and in order of arrival in the system. The highest priority job is processed first, and then the oldest job is processed if priority is shared.
- Non-FIFO: Jobs are processed according to priority. If priority is shared, the most efficient (in terms of distance) job is assigned first.

Additional Information

Custom JobIDs and priorities can be adjusted. Dropoff job segments must always have a higher priority than pickup job segments.

Tasks

Tasks are instructions for the AMR to execute and are associated with goals on a map. Tasks can be configured to run before navigating to a goal, after arriving at a goal, or both.

Tasks are classified as instant or non-instant. Instant tasks can be executed while an AMR is navigating to a goal without interrupting motion. Executing a non-instant task will stop the existing motion, or interrupt the current task.

Tasks can, for example, instruct the AMR to:

- Read inputs
- Set outputs
- Command movement
- Command speech or play audio files
- Incorporate delays
- Follow magnetic tape

Macros

Macros are named and ordered task lists; they can also contain goals. They are useful for sets of tasks that are intended to be reused. Once a task is added to a macro and configured, the same task parameters are applied every time that macro is used.

Routes

Routes are ordered collections of goals. Tasks and macros can also be added to routes. This means the AMR can execute activities (read inputs, set outputs) at goals along its route.

Additional Information

Jobs are recommended over routes in industrial environments.

1-3-5 Positioning

Each goal must be carefully evaluated to determine required repeatability and accuracy for the application. Among a fleet of AMRs, repeatability and accuracy may vary due to physical differences in payload structures and other hardware.
The AMR's standard repeatability is measured two ways: To a position and to the standard target. An explanation of the standard target and guidelines for constructing it can be found in *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
An AMR may utilize the PrecisionDrive task in one of two modes: Standard or High Accuracy. The following positioning repeatability can be obtained using Standard mode of the PrecisionDrive task:

AMR Type	Location Type	Repeatability
LD-60/90	Position	Single AMR: ±65 mm Fleet of AMRs: ±85 mm
	Standard Target	Single AMR: ±25 mm position, ±2° rotation Fleet of AMRs: ±35 mm position, ±2° rotation
LD-250	Position	Single AMR: ±75 mm Fleet of AMRs: ±100 mm
	Standard Target	Single AMR: ±25 mm position, ±2° rotation Fleet of AMRs: ±35 mm position, ±2° rotation

Refer to *2-5 Positioning Requirements* on page 2-6 for the PrecisionDrive task's High Accuracy mode and options to improve standard repeatability and accuracy.

1-3-6 Docking & Charging

To dock autonomously, the AMR approaches the docking station, rotates, and then reverses onto the docking station. During autonomous docking and charging, all systems and accessories remain active. Connecting or disconnecting the AMR with network and onboard clients will not disturb the charging state.
A single AMR manages its own docking and charging. When the AMR is operating in a fleet, the Fleet Manager coordinates docking and charging. This prevents more than one AMR from attempting to access a docking station. Docking functions are coordinated with jobs. Refer to *1-3-7 Function within a Fleet* on page 1-14 for more information.

1-3-7 Function within a Fleet

The Fleet Manager serves as the central point of command when two or more AMRs are operating in the same area. It is responsible for the following:
- Holding maps and configurations
- Receiving all job requests
- Matching jobs to available AMRs
- Coordinating fleet traffic
- Gathering and reporting fleet-related information

When a map is created or modified, the Fleet Manager shares the map with all AMRs in the fleet. It also communicates each AMR’s current location and path information so multiple AMRs can navigate around each other smoothly.
Configuration changes are applied through the Fleet Manager when an AMR is available to accept updates (between a job dropoff and the next pickup, for example).

Refer to *4-3 Fleet Management* on page 4-5 and *5-4 Traffic Management* on page 5-14 for more information on fleet management and traffic.

2

Application Planning

This section outlines the necessary considerations for designing a safe and reliable AMR application.

2-1 Application Safety

It is the integrator's responsibility to design a safe, reliable AMR application.
Any of the following items have the potential to negatively impact the performance and safety of the AMR. Care must be taken to find a suitable solution.

Additional Information

The following items do not constitute an exhaustive list of all safety considerations. Refer to *Mobile Robot LD Safety Guide (Cat. No. I616)* for more information.

Consider the following elements in the AMR's environment:

- Wet, dirty, dusty, greasy, or uneven flooring
- Ledges or downward stairs
- Steep ramps
- Hoses, cables, or other items on the floor
- Objects that are wider at their base
- Tight spaces or hallways
- Areas off-limits to the AMR
- Goals or docking stations placed too close to other items
- Glass, mirrors, or other highly reflective objects
- Overhead fire sprinkler systems

For safety topics relating specifically to the AMR's payload, refer to *2-10-1 Safety Requirements & Other Guidelines* on page 2-15.

2-2 Risk Assessment

When introducing any piece of machinery to a work environment, it is important to identify any hazards or risks it brings. AMRs can pose a number of hazards, especially if not configured or operated properly, such as:

- Impact, collision
- Crushing, trapping
- Electrical shock, fire
- Sharp edges, protrusions

The health and safety of workers and others involved must be protected, and damage to other equipment and materials must be prevented. These goals are achieved by completing a comprehensive risk assessment: A thorough examination of hazards with a plan to reduce or eliminate risk.

OMRON has conducted a risk assessment for intended use of its AMRs, located within *Mobile Robot LD Safety Guide (Cat. No. I616)*. The integrator is responsible for conducting a risk assessment for the AMR as complete machinery. This means the payload, accessories, its operating environment and application must be taken into consideration.

Seek a qualified provider to deliver training on the risk assessment process to those who are responsible for the task but not familiar with it.

2-3 Mechanical Limits

It is important to design within mechanical limits to prevent damage to the AMR or other equipment. Consider the mechanical limitations below to ensure optimal AMR performance.

Item	LD-60	LD-90	LD-250
Payload Capacity*1*2	60 kg	90 kg	250 kg
Swing Radius	354 mm		525 mm
Translational Forward Speed	1800 mm/s	1350 mm/s	1200 mm/s
Rotational Forward Speed	180 degrees/s		120 degrees/s
Traversable Step*3	10 mm at 600 mm/s		
Traversable Gap	15 mm at 1200 mm/s		
Incline (Max. Payload)	3 %		
Floor Flatness (Minimum)	F_F25 (based on ACI 117 standard)		
Floor Coefficient of Friction*4	0.55 to 1.0		

*1. If the intended payload exceeds AMR capacity, consider mounting the structure on a cart for the AMR. This may affect accuracy at goals.

*2. Payload must comply with center of gravity recommendations. Refer to *2-10-4 Mechanical Design Considerations* on page 2-22 for more information.

*3. Faster or frequent driving over steps will shorten the lifespan of the drive components. Lower speeds may not traverse the step. Steps should have smooth, rounded profiles.

*4. The AMR’s traction on flooring will significantly impact applications that involve cart transportation.

2-4 Electrical Limits

It is important to design within electrical limits to prevent damage to the AMR or other equipment. Observe the limitations for the AMR components listed below.
Consider inrush current of all user-supplied devices. This may exceed the safe maximum for AMR components or negatively impact performance of other devices.
Battery voltage drops as the battery discharges. For devices that require a stable voltage, use of a DC-to-DC converter is recommended.

Precautions for Safe Use

Never connect devices directly to the battery. Always connect devices to USER power and AUX power to ensure overcurrent protection.

Additional Information

Refer to the AMR User's Manual for additional information on electrical characteristics.

Item	Specification	
Digital I/O	Inputs	0 to 30 VDC 0 to 7.5 mA 3.9 kΩ output impedance (minimum) PNP (sourcing) and NPN (sinking)
	Outputs	5 to 30 VDC 500 mA NPN (sinking)
Battery Output	USER Power	22 to 30 VDC • 2 connections with 4 A limit each • 2 connections with 10 A limit shared
	AUX Power	5, 12 and 20 VDC ±5% (regulated), 1 A max. each.

2-5 Positioning Requirements

Each goal must be carefully evaluated to determine required repeatability and accuracy for the application. *1-3-5 Positioning* on page 1-14 provides standard positioning information using PrecisionDrive. While this may be sufficient for some applications, others call for the use of additional sensors or physical markers to boost positioning accuracy; for example, to ensure a safe and reliable transfer of goods from a conveyor to various AMRs. CAPS and HAPS options are available for increased positioning accuracy and improved repeatability as described below.

2-5-1 Cell Alignment Positioning System (CAPS)

An AMR may utilize the PrecisionDrive task in one of two modes: Standard or High Accuracy. If a CAPS license is detected, the AMR will operate in High Accuracy mode. In this mode, CAPS uses the AMR's existing sensors to detect a fixed-mount target in the workspace. It provides the following stop position repeatability:

AMR Type	Location Type	Repeatability
LD-60/90	Standard Target	Single AMR: ±8 mm position, ±0.5° rotation Fleet of AMRs: ±12 mm position, ±0.5° rotation
LD-250		Single AMR: ±8 mm position, ±0.5° rotation Fleet of AMRs: ±14 mm position, ±0.6° rotation

Additional Information

- Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for more information about CAPS licensing.
- "Fail if CAPS is not present" is a checkbox option available in MobilePlanner. If the application requires CAPS for improved positioning and the license is not active, the AMR will report an error.
- Use of CAPS can increase cycle time. If necessary, CAPS parameters can be modified to reduce cycle time at the cost of repeatability.

2-5-2 High Accuracy Positioning System (HAPS)

HAPS involves placing a magnetic line on the floor and installing additional sensors on the underside of the AMR so it can more accurately follow a path. HAPS provides the following stop position repeatability:

AMR Type	Location Type	Repeatability
LD-60/90	Marker	Single AMR: ±8 mm position, ±0.4° rotation
		Fleet of AMRs: ±10 mm position, ±0.5° rotation
LD-250		Single AMR: ±8 mm position, ±0.4° rotation
		Fleet of AMRs: ±10 mm position, ±0.6° rotation

Additional Information

- Refer to the AMR User's Manual for more information about HAPS components.
- Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for more information about MobilePlanner tasks for use with HAPS.
- Use of HAPS can increase cycle time. If necessary, HAPS parameters can be modified to reduce cycle time at the cost of repeatability.

2-6 Power Consumption

As stated in *Battery* on page 1-4, the LD-60/90's battery runtime under typical operation without payload is approximately 15 hours, and the LD-250's battery runtime under typical operation without payload is approximately 13 hours. However, runtime is directly impacted by current consumption (which affects overall power consumption).

Current consumption can also vary greatly by application. The following are just a few factors of many that can increase current consumption:

- Payload and payload structure weight
- Movement profiles
- Idle time and docking between jobs
- Flooring type

The table below provides information about velocity and payload impacts on current consumption.

Note the following conditions used to obtain the results:

- Both AMR types used a maximum acceleration of 600 mm/s^2.
- Maximum payloads were 60 kg and 90 kg, respectively.
- Both AMRs operated nonstop over a 15 m run on a smooth surface, using *GoToStraight* movement.
- No peripherals were connected.
- Multiple AMRs were used for each trial and the results have been averaged.

AMR Type	Velocity	Average Consumption, No Payload	Average Consumption, Max Payload
LD-60	1000 mm/s	2.39 A	3.18 A
	1400 mm/s	2.54 A	3.49 A
	1800 mm/s	2.66 A	3.62 A
LD-90	700 mm/s	2.77 A	3.38 A
	1000 mm/s	2.90 A	3.70 A
	1300 mm/s	2.92 A	3.87 A

Optional devices, such as side lasers, consume additional power. These must be factored into overall power consumption for the application, along with the payload structure and other user-supplied devices. Excessive power consumption will impact AMR runtime.

Also note that all onboard systems function continuously while charging.

Precautions for Safe Use

Never connect devices directly to the battery. Always connect devices to USER power and AUX power to ensure overcurrent protection. Refer to the AMR User's Manual for information regarding overcurrent protection.

Additional Information

Battery voltage drops as the battery discharges. For devices that require a specific voltage input, use of a DC-to-DC converter is recommended.

2-7 Recharging Strategy

There are a number of ways an AMR can recharge its battery, so a recharging strategy must be considered before commissioning an AMR. While it is possible to charge the AMR’s battery manually (either by pushing it into a docking station or charging external to the AMR), only autonomous charging will be covered in this section.

Normally an AMR monitors its charge state and docks itself when below a certain level. There are three different parameters that affect this behavior:

- *ParkLowStateOfCharge*: If the AMR’s State of Charge (SoC) falls below this value, it will choose to dock instead of park. It can still accept new jobs while in this state.
- *LowStateOfCharge*: If the AMR’s SoC falls below this value, it will refuse new jobs and dock itself. If it is currently executing a job, it will continue (unless its SoC falls below *AutoDockStateOfCharge*).
- *AutoDockStateOfCharge*: This is the critical charge value. If the AMR’s SoC falls below this value, it must dock regardless of status.

For example, an AMR has the following configuration:

- *ParkLowStateOfCharge* = 40
- *LowStateOfCharge* = 30
- *AutoDockStateOfCharge* = 20

This will produce the following behavior:

- With an SoC greater than 40%, the AMR will park and accept jobs as usual.
- Between 30% and 40%, it will still accept jobs but choose to dock instead of park.
- Between 20% and 30%, it will choose to dock rather than accept jobs.
- Below 20%, it will be forced to dock and cannot accept jobs.

When an AMR is idle (not assigned to a job), it is a perfect time for it to report to a docking station to recharge. Docking stations can be placed near goals (e.g. a conveyor offload area) and other frequently-visited areas, so an unassigned AMR can easily find a docking station. This function is referred to as "opportunity charging."

Precautions for Correct Use

Docking stations can also be placed at goals, but this is not suitable for applications which actively draw current from the AMR's battery while it is recharging on the docking station. Mobile manipulators are one such example.

The Fleet Manager can also manage recharging with fleet docking. Fleet docking ensures there are enough AMRs with sufficient charge to complete the required work. There are two options available for fleet docking:

- Explicit Number
- Percent of Fleet

Explicit Number specifies a fixed number of AMRs that will always be docked and recharging. The Fleet Manager will work to rotate the fleet in and out of the docking stations to ensure a constant flow of charged AMRs is always available.

The Percent of Fleet option specifies a percentage of the total fleet that will always be docked and recharging. The benefit to this strategy is that as the fleet grows, the number of docked AMRs will be adjusted automatically.

Both strategies are best suited for larger fleets. For smaller fleets, or when fleet docking is not used, it is recommended to have one docking station per three AMRs (for a full three-shift workday) to avoid recharging bottlenecks.

Additional Information

- Consider weekends, holidays, and other downtime in the chosen recharging strategy. Ensure the AMRs do not become fully discharged over these periods.
- It is important to allow batteries to fully charge to 100% periodically (balance). Runtime may diminish until the battery is fully charged and balanced.
- FLOW iQ can be used to monitor the battery imbalance state across a fleet.

Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for more information on docking and charging parameters.

2-8 Communication Considerations

This sections describes the different ways an AMR communicates with other devices, as well as related considerations.

2-8-1 Wireless Communication Overview

This section covers wireless communication. However, it should be noted that a single AMR can operate without wireless communication. If there are no other AMRs in the environment, it can simply rely on its internal map. If sending commands and receiving updates from the AMR is needed, then a wireless connection is required. Note that communication with two or more AMRs also requires a wireless connection (to a Fleet Manager).

Following initial setup (refer to *4-1 Prerequisites* on page 4-2), typical AMR communication takes place over wireless Ethernet. It is imperative to have high-quality wireless coverage in the AMR's work environment. This requires working with your IT department and conducting a comprehensive site survey. OMRON recommends the following for signal strength:

- -40 dBm or greater (ideal)
- -60 dBm (minimum)

In addition, OMRON recommends the following for bandwidth:

- Typical fleet bandwidth: 50 Kbps per AMR
- Unlikely to exceed 500 Kbps per AMR with additional MobilePlanner visualization features enabled

FLOW iQ may be used to analyze the wireless signal quality of a single AMR or fleet. License required. Refer to *Fleet Operations Workspace iQ User's Manual (Cat. No. I665)* for more information regarding this and other capabilities.

Additional Information

Additional consideration should be given for special applications; for example, streaming video over the AMR's wireless interface.

For additional information on supported wireless standards, encryption methods, and certificates, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

2-8-2 Wireless Support for Other Devices

User-added devices have the ability to communicate over the AMR's wireless signal. Devices connected to the following ports on the AMR Core can exchange information through port forwarding:

- User LAN
- RS-232

The AMR Core allows TCP and UDP port forwarding over the User LAN interface. This enables wireless access to onboard Ethernet devices, including OMRON Sysmac Machine Automation Controllers (MACs) and other Programmable Logic Controllers (PLCs). Through the controller, devices connected to the AMR's digital I/O can be written to and read.

Serial devices can also be reached using port forwarding over the RS-232 interface.

For information on choosing a mode for the User LAN interface, as well as configuring port forwarding, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

For additional information on communicating with external devices, refer to *2-9 Interfacing with External Equipment* on page 2-13 and *2-10-3 System Architecture Examples* on page 2-16.

Additional Information

The addition of a wireless router can be useful for isolating the AMR from other network traffic. This also allows other network devices to be located on board the AMR.

2-8-3 Advanced Robotics Command Language (ARCL)

Advanced Robotics Command Language (ARCL) is a text-based command-and-response system for interfacing with the AMR or Fleet Manager. ARCL allows you to operate and monitor the AMR, its accessories, and its payload devices over the network. It also allows you to submit jobs to the Fleet Manager and monitor the job status from start to finish. It is accessed from within MobilePlanner or via command prompt.
For additional information on setup, configuration, commands list, and examples, refer to *Advanced Robotics Command Language AMR Reference Guide (Cat. No. I617)*.

2-8-4 Integration Toolkit (ITK)

Integration Toolkit (ITK) is OMRON’s interface application that enables integration between the Fleet Manager and the end user’s client application, Manufacturing Execution System (MES), or Enterprise Resource Planning (ERP)/Warehouse Management System (WMS). This integration layer facilitates autonomous control for a fleet of AMRs using standard communication methods.
It facilitates full management and monitoring of all AMR job types such as pickup, dropoff, and multi-segment. ITK also allows tracking of AMR data directly and in real-time.
ITK offers the following communication channels:

- RESTful Web Services
- SQL with PostgreSQL Database
- RabbitMQ

Additional Information

- While it may be possible to achieve desired functionality with any one of the mentioned communication channels, using a combination of them is suggested for efficient integration with client applications.
- ITK can operate in parallel with existing ARCL communication. ITK does not replace ARCL for direct AMR control. Refer to *2-10-3 System Architecture Examples* on page 2-16 for more information.

For additional information on communication channels, setup, configuration, and examples, refer to *Fleet Operation Workspace Core Integration Toolkit User’s Manual (Cat. No. I637)*.

2-9 Interfacing with External Equipment

This section describes considerations for interfacing the AMR with other equipment in its environment.

2-9-1 Hardware Interfaces Overview

Most applications require an AMR to interface with other equipment at goals, such as payload transfer stations (side-load, vertical) or cart transportation. When operating in a fleet, it is important that every AMR is able to position itself accurately to perform the required tasks. It is equally important for every AMR to accomplish this with sufficient repeatability at the goal.

An AMR-mounted controller with I/O connections can accomplish these objectives by:

- Performing the handshake routine after alignment at the goal (refer to *2-9-3 Handshaking & Communication at the Goal* on page 2-13 for more information)
- Energizing actuators (conveyor rollers, for example) that may be on board the AMR
- Verifying the load has been successfully transferred

Common interface methods include transceiver pairs, communication over the factory LAN, and RFID.

Additional Information

Depending on the application requirements, communication with other equipment through a series of macros in MobilePlanner may be possible (without an additional controller).

2-9-2 Positioning

Before payload exchange takes place, the AMR must first position itself at the goal. Accuracy and repeatability are very important for a safe and reliable transfer of materials. Refer to *2-5 Positioning Requirements* on page 2-6 for a review of HAPS and CAPS.

Applications with close exchange tolerances (timing or physical dimensions) can also benefit from an additional check to verify the AMR's position before payload exchange. This can be accomplished with added photoelectric or magnetic sensors, as well as alignment pins, to ensure proper position and restrict movement during transfer.

Precautions for Safe Use

Pinch points can be introduced when moving below the default speed for safety zone 0. This can occur while aligning with other equipment, or traveling in narrow spaces or tight clearance areas. The safety zone 0 default speeds for LD-series AMRs are as follows:

- 225 mm/s (LD-90, LD-250)
- 300 mm/s (LD-60)

2-9-3 Handshaking & Communication at the Goal

A handshake process is important for applications that require communication between the AMR and other hardware at the goal. Once the AMR is positioned at the goal, the handshake process takes place. A typical handshaking procedure is described below.

1 Verify the presence of the payload.

A task toggles a digital output to trigger the AMR’s onboard PLC/MAC to check for the presence or absence of the payload.

2 The AMR's onboard PLC/MAC performs a handshake with the equipment at the goal. This could consist of:

- An alignment check – "Are the AMR and payload structure positioned correctly? Is the payload in the correct location?"
- A readiness check – "Is the pickup/dropoff station ready for the exchange?"

3 Payload is exchanged:

1) Actuators are started in the required direction.
2) Check performed – "Has the payload reached its end position?"
3) Actuators are stopped.

4 The AMR's onboard PLC/MAC gathers status of the actuators, payload, and equipment at the goal:

1) Check performed – "Are the actuators stopped?"
2) Check performed – "Has the payload reached its end position?"
3) Check performed – "Are both sides of the exchange stopped?"

5 The AMR checks for readiness from its onboard PLC/MAC.

6 The AMR departs for the next goal to complete the procedure.

This example procedure serves as an overview of the process that takes place at the goal and a sample of checks that can be performed. Steps in the procedure are driven by the needs of the application and may vary.

2-10 Payload Structure Considerations

A payload structure is typically required to secure an object during transport and facilitate payload transfer. Examples of payload structures include:

- Conveyor
- Lift
- Cart
- Collaborative robotic arm

This user-designed structure has a significant impact on the operational safety of the AMR, as well as safety of the payload itself. Therefore, it is crucial to consider all aspects of the AMR, its purpose, payload, and environment when designing the structure.

This section describes considerations for generic payload structure design. Additional considerations for common applications are covered in *Section 3 Application Examples* on page 3-1

2-10-1 Safety Requirements & Other Guidelines

There are several payload-related safety requirements:

- Adhere to all center of gravity limitations for payload and payload structure.
- The payload must be secure and fixed while the AMR is in motion.
- The weight of the payload plus structure must not exceed the AMR's maximum capacity.
- Damaged or worn casters and drive wheels can degrade AMR stability. Regularly inspect the casters and drive wheels for signs of damage, excessive wear, or uneven spots.
- Overhanging obstacles in the environment must be removed, marked, or designated by forbidden zones on the AMR's map.
- All E-STOP buttons must be located in areas that are easy to reach and within 600 mm of personnel. It is the end user's or system integrator's responsibility to ensure that any additional E-STOP buttons are placed in a location where the operator can easily access them in an emergency situation.
- E-STOP buttons must be connected to the safety circuit, and correct operation must be confirmed with the Commissioning procedure in MobilePlanner.
- When transporting liquids or chemicals, prevent spills. Protection must be added to all AMR surfaces that may come into contact with a spill.
- Extra care must be taken with non-solid payloads that may have a shifting center of gravity.
- An easily-visible, flashing light is required on all payload structure to signal when the AMR is in motion.

In addition, it is recommended to follow other payload-related guidelines:

- Motion parameters require safe limits and may need to be modified. Refer to *5-2 Motion* on page 5-3 for more information.
- Observe operating limitations for inclines.
- It is strongly recommended to install additional object detection devices (such as side lasers) to account for maximum payload dimensions.
- Collision may result from an overhanging payload and AMR rotation. Footprint and clearances may require modification.
- Payload transfer problems should trigger an emergency stop and provide an interlock to prevent harm. Refer to the AMR User's Manual for more information.

- It is possible for the AMR and payload structure to generate electrostatic buildup. Additional equipment may be necessary to prevent unsafe discharge.
- The payload structure should display all applicable safety labeling.

Additional Information

This does not constitute an exhaustive list of all safety considerations. Refer to *Mobile Robot LD Safety Guide (Cat. No. I616)* for more information.

2-10-2 Power Considerations

Several factors impact AMR runtime:

- Payload and payload structure weight
- Equipment on the payload structure that draws power from the AMR battery
- AMR accessories
- AMR motion settings, configured in MobilePlanner

Refer to the AMR User's Manual for power consumption of accessories. If power consumption becomes excessive due to powering additional devices, contact your local OMRON representative for support.

Precautions for Safe Use

Never connect devices directly to the battery. USER power and AUX power are the appropriate connection points because they are electrically protected.

Precautions for Correct Use

Battery voltage drops as the battery discharges. For a device that requires a consistent voltage input, use of a DC-to-DC converter is recommended.

2-10-3 System Architecture Examples

The following sections describe different system architectures for typical AMR control methods.

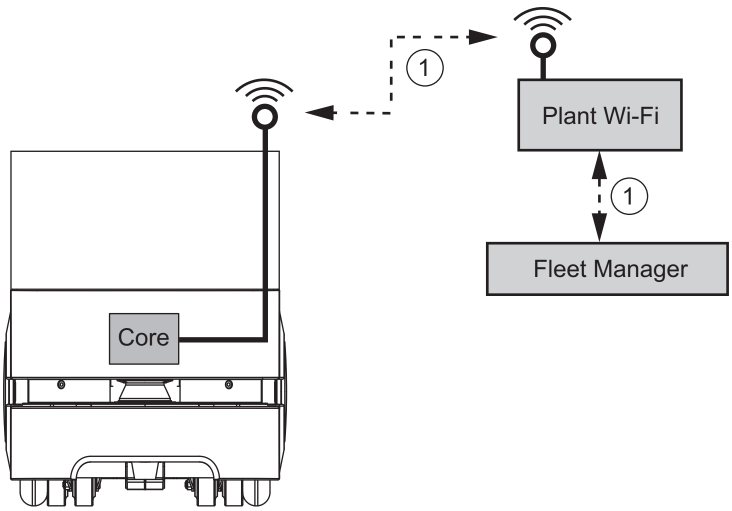
Additional Information

- Refer to *2-8 Communication Considerations* on page 2-11 for more information.
- Consider the following OMRON products when designing your system architecture:
  - NX102 MAC
  - NX1P2 MAC
  - NX-SL controller
- A PLC/MAC paired with an HMI is recommended to facilitate efficient fault reporting and recovery.
- Communication over ARCL requires some software expertise. Examples that exclude ARCL communication may be more suitable if the goal is to limit ARCL configuration and programming.
- OMRON offers an ARCL library for use with Sysmac Studio. The library contains a set of function blocks that allows communication between PLCs/MACs and AMRs, with or without a Fleet Manager. The function blocks facilitate many functions, for example:
  - Reporting AMR status
  - Task and macro execution requests
  - Pickup requests
  - Sending the AMR to a dock or goal
  - Querying input states
  - Enabling and disabling outputs

  Contact your local OMRON representative for more information.

Example 1

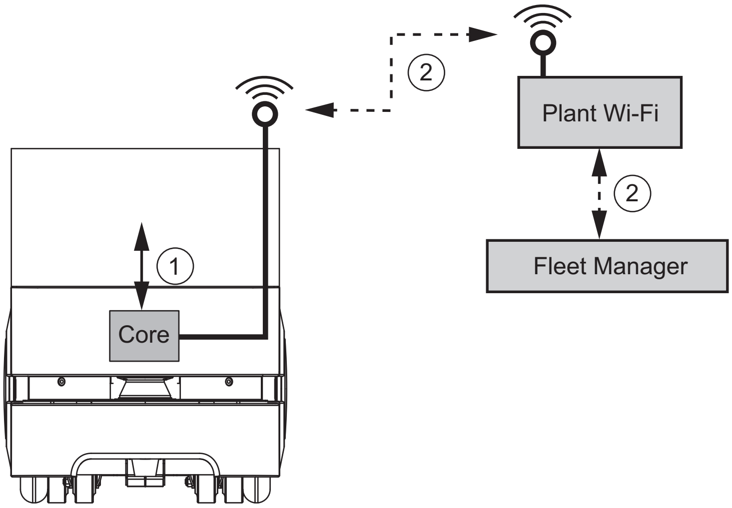
This example describes basic control of an AMR. In this example, the payload structure has no interaction with the AMR.



Item	Description
1	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Example 2

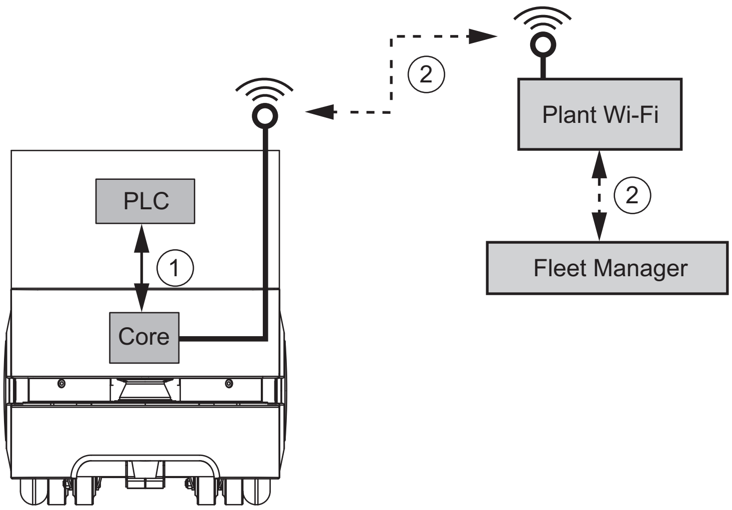
This example describes basic control of an AMR. In this example, the payload structure is controlled by the AMR Core.



Item	Description
1	Payload structure is connected to AMR's digital I/O.
2	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Example 3

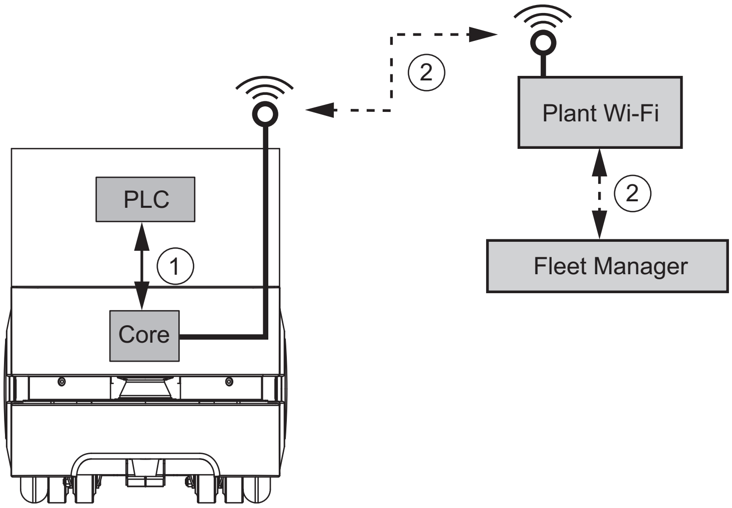
This example describes basic control of an AMR. The payload structure is controlled by a PLC that is connected via digital I/O to the AMR Core.



Item	Description
1	Onboard PLC communicates with AMR Core with digital I/O.
2	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Example 4

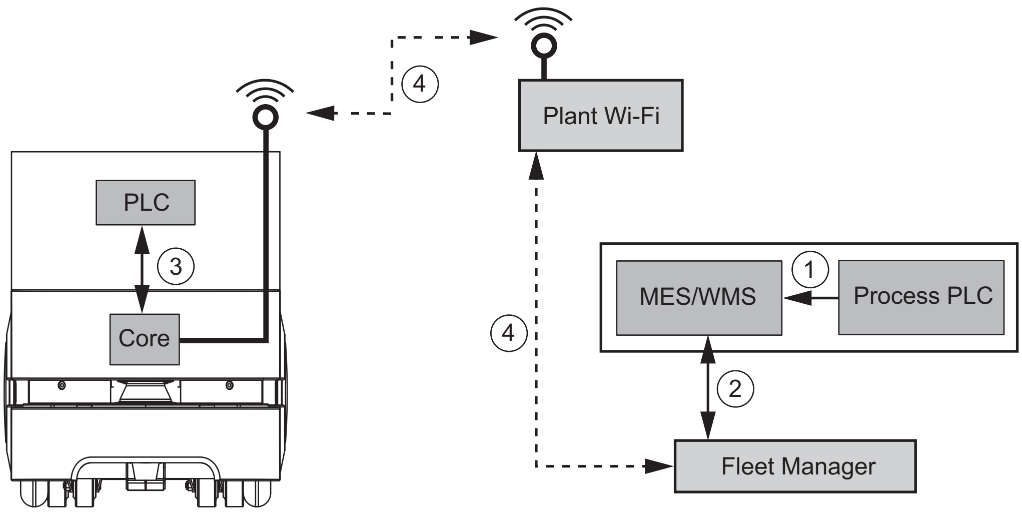
This example describes basic control of an AMR. The payload structure is controlled by a PLC that communicates with the AMR Core using ARCL.



Item	Description
1	Onboard PLC communicates with the AMR Core using ARCL.
2	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Example 5

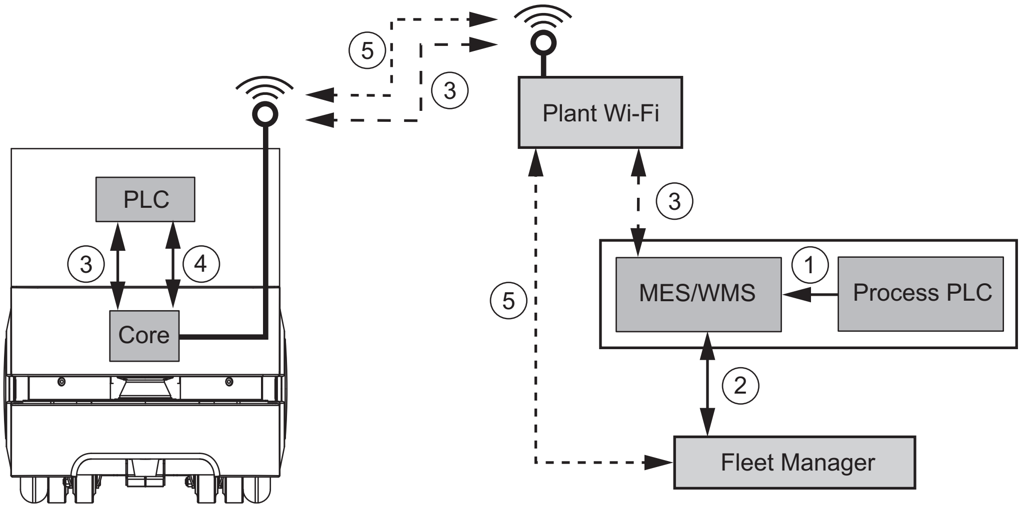
This example describes control of an AMR utilizing MES/WMS and a Process PLC. The MES/WMS interacts with the Fleet Manager using ITK.
The payload structure is controlled by a PLC that communicates with the AMR Core using ARCL.



Item	Description
1	Process PLC communicates with the MES/WMS at the plant machine level.
2	MES/WMS communicates with Fleet Manager over ITK for job management.
3	Onboard PLC communicates with the AMR Core using ARCL.
4	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Example 6

This example describes control of an AMR utilizing MES/WMS and a Process PLC. The MES/WMS interacts with the Fleet Manager using ITK. The MES/WMS interacts directly with the AMR PLC using port forwarding.
The payload structure is controlled by a PLC that communicates with the AMR Core using ARCL.



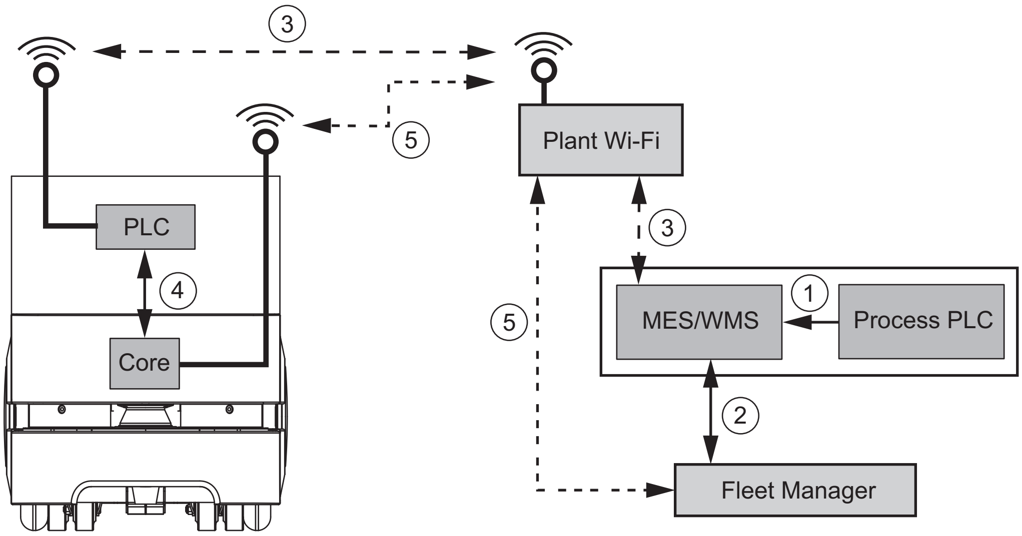
Item	Description
1	Process PLC communicates with the MES/WMS at the plant machine level.
2	MES/WMS communicates with Fleet Manager over ITK for job management.
3	MES/WMS communicates with AMR's PLC directly using Ethernet port forwarding for status, I/O, logic.
4	Onboard PLC communicates with the AMR Core using ARCL.
5	Status information from AMR Core is shared with Fleet Manager through wireless communication.

Additional Information

Port forwarding may increase bandwidth. Where bandwidth is a concern, separate the wireless communication for PLC and AMR Core.

Example 7

This example describes control of an AMR utilizing MES/WMS and a Process PLC. The MES/WMS interacts with the Fleet Manager using ITK. The MES/WMS interacts directly with the AMR PLC over the wireless network.
The payload structure is controlled by a PLC that communicates with the AMR Core using ARCL.



Item	Description
1	Process PLC communicates with the MES/WMS at the plant machine level.
2	MES/WMS communicates with Fleet Manager over ITK for job management.
3	MES/WMS communicates with AMR's PLC directly using wireless for status, I/O, logic.
4	Onboard PLC communicates with the AMR Core using ARCL.
5	Status information from AMR Core is shared with Fleet Manager through wireless communication.

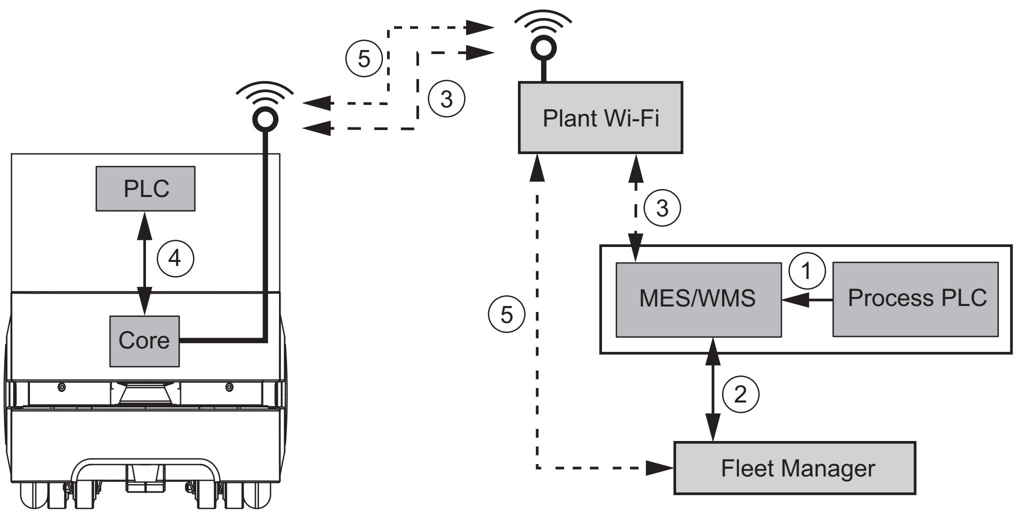
Example 8

This example describes control of an AMR utilizing MES/WMS and a Process PLC. The MES/WMS interacts with the Fleet Manager using ARCL. The MES/WMS interacts with the AMR Core using ARCL.

The payload structure is controlled by a PLC that communicates with the AMR Core using ARCL.

Additional Information

Port forwarding provides higher security. *Example 6* on page 2-20 is the recommended method for this type of control.



Item	Description
1	Process PLC communicates with the MES/WMS at the plant machine level.
2	MES/WMS communicates with Fleet Manager over ARCL for job management.
3	MES/WMS communicates with AMR’s PLC, via the Core using ARCL and macros.
4	Onboard PLC communicates with the AMR Core using ARCL.
5	Status information from AMR Core is shared with Fleet Manager through wireless communication.

2-10-4 Mechanical Design Considerations

Mechanical design of the payload structure affects not only the operation of the structure itself, but aspects of the AMR's functionality as well. Consider the following recommendations in the design phase:

- Build the structure using robust materials. Failure to do so can result in bending and sagging over the life of the structure, leading to increased downtime.
- Be extremely consistent in the build of the structure. This will provide for higher fleet repeatability at goals.

This section covers additional design considerations for the payload structure's mechanical components.

Maintenance & Service

Before beginning the mechanical design of the payload structure, it is important to consider serviceability. The AMR Core, as well as connections for power, safety, control, and network, require accessibility through the payload bay. Exterior skins also require removal periodically for service. The payload structure should not impede access for maintenance and service tasks. Depending on its design, the structure may require partial or complete disassembly or removal. This will significantly increase maintenance and service downtime.
Refer to the AMR User's Manual for maintenance tasks and instructions.

Additional Information

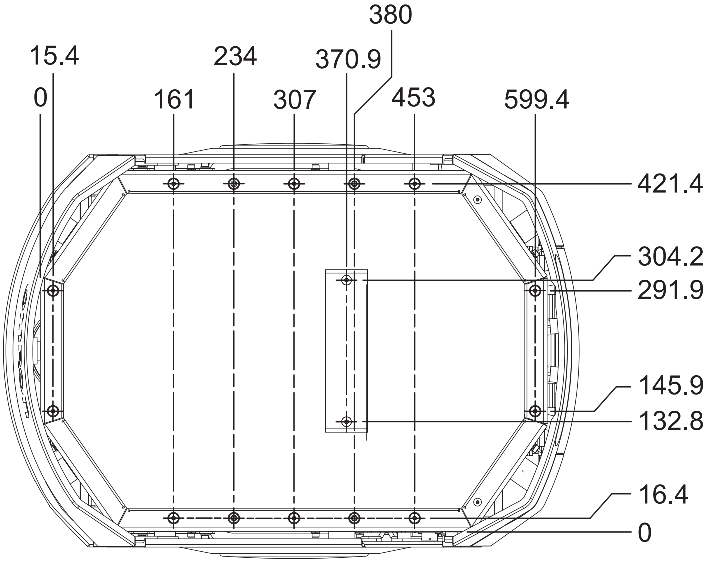
- Consider bend radius, flex cycles, and pinch points for all cables in this part of your design.
- Consider a single, modular industrial connector for running cables between the AMR and payload structure. This will facilitate maintenance and service tasks and reduce downtime.

Structure Mounting

This section describes the LD-series AMR's mounting points.

● LD-60/90 Upper Mounting Points

The following illustration shows the upper surface mounting points of the LD-60/90 AMR:



There are a total of 16 M6 threads (in the form of self-clinching nuts) on the upper mounting surface. The torque limit of the self-clinching nuts is 3 N-m.

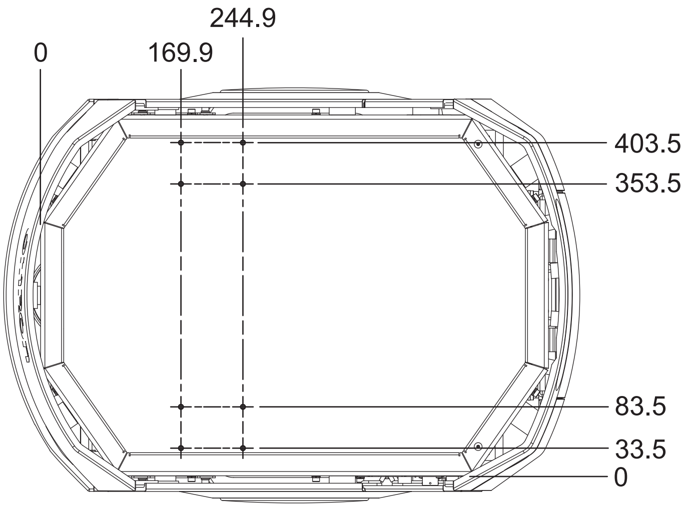
Precautions for Correct Use

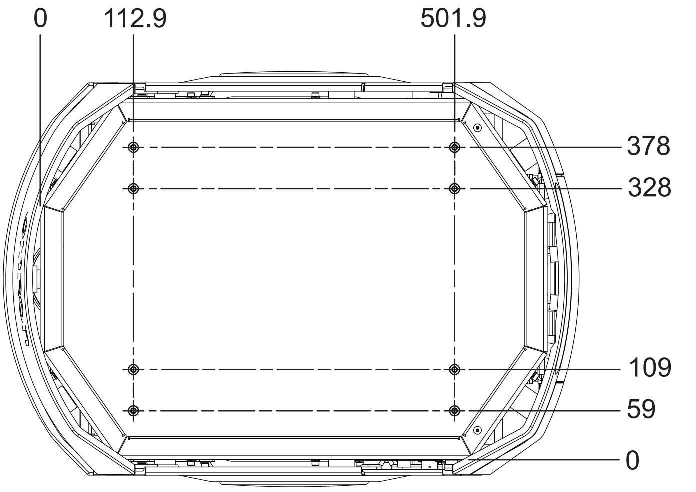
Do not exceed the torque limits when mounting the payload structure using the self-clinching nuts.

The upper mounting surface is located 40.7 mm above the lower mounting surface.

● LD-60/90 Lower Mounting Points

The following illustrations show the lower surface mounting points of the LD-60/90 AMR. The M5 threads are shown above, and M6 threads shown below:





There are a total of 8 M5 threads and 8 M6 threads (both in the form of self-clinching nuts) on the lower mounting surface. The torque limit for each of the self-clinching nuts is as follows:

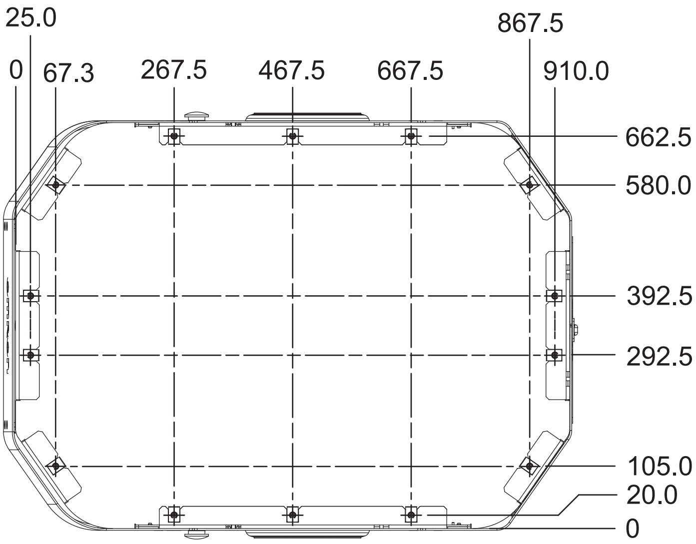
- M5: 14 N-m
- M6: 3 N-m

Precautions for Correct Use

Do not exceed the torque limits when mounting the payload structure using the self-clinching nuts.

● LD-250 Top Plate Mounting Points

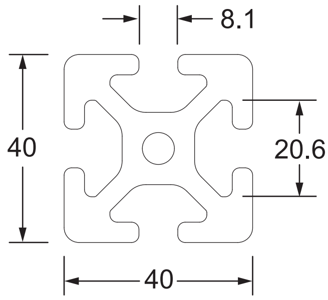
The illustrations below show the top plate mounting points of the LD-250 AMR. The following illustration shows the clip nut locations:

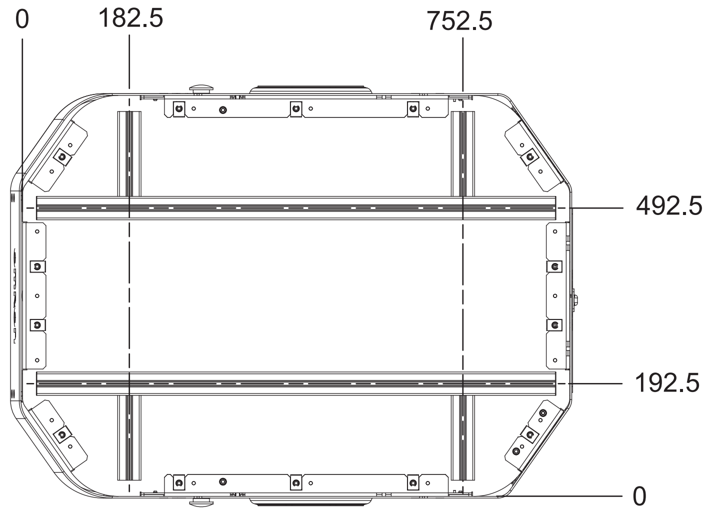


Precautions for Correct Use

Do not exceed the torque limit of 11.8 N-m when mounting the payload structure using the clip nuts.

The longitudinal (front to back) and transverse (side to side) T-slot extrusions are shown below:





Each extrusion's cross section is a 40 mm x 40 mm square T-slot profile with three open T-slots, one on each 40 mm face.

Clearances

The AMR, along with its payload and payload structure, should be able to navigate all areas of its work environment safely. This requires designing the payload structure in such a way to allow for proper clearance. Consider the following:

- Adequate horizontal clearance for passing other AMRs, equipment, or humans in tight corridors
- Vertical clearance for passing under objects or structures

Precautions for Correct Use

- Review the following AMR parameters for overhanging payloads: *Width, LengthFront, LengthRear*, and *Radius*. If modification of the parameters is necessary, ensure the updated values are used during path planning and obstacle avoidance.
- Minimize interference between the payload or payload structure and the AMR's sensors. Unavoidable interference can be configured as ignored in MobilePlanner and accounted for in safety zone design.

AMR clearances are adjusted through MobilePlanner. Refer to *5-3-3 Clearances* on page 5-10 for more information.

Additional Information

Clearances increase with speed.

Center of Gravity

The payload structure should be designed to match the AMR’s footprint as closely as possible, and as close to the AMR’s surface as possible. This provides for optimal stability over thresholds, gaps, steps, and flooring irregularities. The payload and payload structure should be centered on the AMR (between the drive wheels), but biased toward the rear of the AMR.

Additional Information

Illustrations of the AMR's center of gravity (excluding payload structure) are located in the AMR User's Manual. Illustrations showing safe center of gravity placements for payload structures of various weights can also be found in the manual.

Center of gravity calculations should be made for both the loaded and unloaded payload structure. Calculations should also be performed at different points of the structure's movement profile, to ensure there are no issues with traction or tipping. Consider an application with a collaborative robotic arm: The arm may carry payloads of various shapes and sizes, so the center of gravity over the range of motion will vary greatly. Consideration must also be given to the AMR's center of gravity while in motion (arm stationary, gripping payload).

Additional Information

OMRON is available to assist with payload structure modeling. Contact your local OMRON representative regarding designs outside of the recommended guidelines.

Inertia

Inertia must be carefully considered for optimal performance and stability. Payloads or structures with high inertia will degrade performance and can cause AMR instability during movement, as well as premature failure of the AMR drivetrain and related components. Transporting a payload with significant mass beyond the AMR footprint is not recommended. If payload and structure inertia values are questionable, contact your local OMRON representative for support.

Motion Limits

After analyzing the center of gravity, motion parameters must be adjusted in MobilePlanner. Motion parameters have a major impact on the AMR's safety and stability. One of the most important parameters is maximum deceleration. This comes into effect during an E-Stop or protective stop, where the AMR decelerates at the maximum allowed deceleration.
Safety zones protect the AMR from hitting obstacles. When an obstacle is detected inside a safety zone, a protective stop is triggered and the AMR decelerates at the maximum rated deceleration. As the AMR's speed increases, the safety system increases the length of the laser safety field in front of the AMR. If the payload extends beyond the dimensions of the AMR, safety zones must be increased.

Precautions for Safe Use

Contact your local OMRON representative to change the size of the safety laser scanner's safety zones.

The following adjustments should be considered for the application:

- Maximum linear speeds
- Maximum deceleration and total inertia (AMR + Payload Structure + Payload Inertias)
- Maximum deceleration parameter related to safety zones
- Maximum rotational speed
- Heading rotational speed related to swing radius, payload center of gravity

Refer to *5-2 Motion* on page 5-3 for more information about these parameters.

Overhanging Payloads

Additional considerations must be made for applications requiring overhanging payloads. For example, the AMR's footprint must be modified in MobilePlanner. The AMR must be aware of its own size, as well as the size of other AMRs in the area to properly navigate around them.
Additionally, the size of the AMR's default safety zones are dependent on the following factors:

- The AMR's specified payload and center of gravity limits
- The AMR's specified floor flatness, slope, cleanliness, and coefficient of friction
- The maximum deceleration parameter
- The AMR's default footprint

If any of the above items change, it must be verified that the AMR will stop at any speed to avoid collision. Refer to *Safety Laser Scanner OS32C Series User's Manual (Cat. No. Z296)* and contact your local OMRON representative for support.

Relocating the Operator Panel

The AMR's operator panel may be relocated to the payload structure; this will require a longer cable. A standard 15-pin D-Sub male-to-female extension cable may be used in this case.

Precautions for Correct Use

Ensure the following when relocating the AMR's operator panel:

- Extension cable length does not exceed 2 m.
- The cable is not routed near devices that can induce electrical interference.
- The cable is routed in such a way that it avoids sharp bends, pinch points, and chafing to prevent damage to the sheath.
- The cable is securely fastened to prevent entanglement.

Relocating Antennas

The AMR's wireless communication antennas may need to be relocated to prevent attenuation caused by the payload structure. Cable length and the addition of connectors can decrease wireless signal strength. Thus, the shortest possible cable is advised.
It is recommended to use the cables and antennas that are provided with the AMR. This ensures the maximum gain is not exceeded. If this is not possible, OMRON recommends sourcing a cable with the following characteristics:

- Double-shielded, low loss coaxial
- 50 Ω impedance

The connections call for RP-SMA connectors on each end, male and female.
For the chosen cable, maximum signal loss must be calculated. The following inputs are needed:

- Frequency (5 GHz or 2.4 GHz)
- Cable run length
- Cable product family and type

Once the signal loss is calculated, it should be deducted from the typical wireless signal strength (in dBm) the customer experiences. This will provide an idea if the loss for cable length and type is acceptable for the application.

Precautions for Correct Use

Substituting a higher gain antenna (with little to no loss in the added cable leading up to it) can cause the system to be non-compliant with local radiated emissions standards.

Mounting Acuity Cameras to Structure

If using Acuity, the camera should be mounted at the highest point of the payload to enhance vision and prevent occlusion.

2-11 LD-Series AMR Application Checklist

This section provides a printable checklist for application design.

The following conditions apply to the checklist:

- This checklist is to be completed by the System Integrator or System Designer.
- This checklist is intended for an individual AMR and not multiple AMRs.
- All design decisions are the responsibility of the individual completing the checklist.
- Retain this completed checklist for OMRON support requests. A completed checklist will expedite your support requests.

Additional Information

Read and understand subjects related to application planning in this document before beginning work on the checklist.

System Integrator / System Designer Information
Company Name:
Person Responsible:
Date:

End User & Project Information
Company Name:
Plant Location:
Project Name:
Delivery Date:
Other Details:

AMR Information
Model:
Serial Number:
Name:

Category	Item	Action	Details	Completed
Safety	Risk assessment	Execute	Documentation required	☐
	E-Stop safety circuit	Verify operation	Refer to AMR User's Manual for more information about the commissioning tool use	☐
	Bumper safety circuit	Verify operation		☐
	Safety zones	Verify	In the case of overhanging payloads, please complete the table for modified safety zones in the worksheet	☐
	E-STOP button circuit	Circuit check	All E-STOP buttons are connected to the safety circuit	☐
	E-STOP button operation	Test	Triggers an emergency stop	☐
	E-STOP button placement	Verify	Refer to *2-10 Payload Structure Considerations* on page 2-15	☐
	Payload Structure indicator(s)	Verify	Present on payload structure to reflect AMR readiness and movement.	☐
	Safety labeling	Verify	All applicable safety labels are present and visible.	☐
	Documentation	Collect and include	The following documents are included with this checklist: • A copy of the risk assessment • A diagram with any modifications made to the emergency stop circuit • A diagram with any modifications made to the bumper safety circuit • A safety zones report from the Laser Configuration Tool (if an overhanging payload is present)	☐

Category	Item	Action	Details	Completed
Environ-ment	Floor type	Verify	Floor surface is appropriate (refer to *2-3 Mechanical Limits* on page 2-4)	☐
	Floor cleanli-ness	Verify	Free of dust, dirt, grease, fluids, and debris	☐
	Traversable step	Verify	No more than 10 mm at 600 mm/s	☐
	Traversable gap	Verify	No more than 15 mm at 1200 mm/s	☐
	Floor incline	Verify	No more than 3% grade and appropriate for weight of payload plus structure. Cart applications may require less incline.	☐
	Floor hazards	Verify	Areas with a ledge (loading docks, stairs) have been physically blocked by a barrier at least 250 mm tall	☐
	Reflective ob-jects	Verify	Glass, mirrors, and any other reflective objects have been physically marked, or set as forbidden in MobilePlanner	☐
	Obstacles	Verify	Overhanging obstacles have been removed, physically marked, or marked as forbidden in MobilePlanner. Transient objects have been removed from the map	☐
	Repeatability	Calculate	Repeatability has been calculated for the application	☐
	Localization type	Verify	Circle any of the following localization or navigation options required for this application: • Standard localization • Acuity • HAPS • CAPS	☐
	Localization level	Verify	AMR is able to achieve a sufficient localization score during testing with map	☐
Electrical	Electrical limits	Verify	Connected devices do not exceed any electrical limits	Yes: ☐ Not Applicable: ☐
	ESD	Evaluate	ESD precautions have been taken and equipment installed (if transporting electrically-sensitive components)	Yes: ☐ Not Applicable: ☐
	Battery con-sumption	Calculate	Refer to *2-12-2 Battery & Power Consumption* on page 2-34	☐
	DC power con-ditioning	Verify	DC-to-DC converter added for devices that require specific voltage output from battery	Yes: ☐ Not Applicable: ☐
	Protection	Verify	All user-added devices are connected through USER Power or AUX Power and electrically protected	Yes: ☐ Not Applicable: ☐
Mechanical	Mechanical limits	Verify	Application does not exceed any mechanical limits	☐
	Evaluation	Execute	Refer to *2-12-6 Mechanical* on page 2-37	☐

Category	Item	Action	Details	Completed
Wireless	Evaluation	Execute	Refer to *2-12-4 Wireless Communication* on page 2-36	☐
	Signal strength	Verify	A wireless signal of -60 dBm or greater is available in all areas	☐
	Bandwidth	Verify	Adequate for the application	☐
	Documentation	Collect and include	All applicable sections of the Wireless Communication worksheet have been completed	☐
Controls	Evaluation	Execute	Refer to *2-12-5 Controls* on page 2-37	☐
	Documentation	Collect and include	The following documents are included with this checklist: • Diagram of the system architecture • Controller make and model (if applicable) • Controls networking method (if applicable) • Access point make & model • MES/WMS type details (if applicable) • Timing diagrams of machine handshake routine (if applicable)	☐
Software	Documentation	Collect and include	All software licenses are documented in the Software Worksheet section of this document	☐
	Username and Password	Change	Default username(s) and password(s) have been changed	☐
	DebugInfo file	Download	DebugInfo file has been downloaded for reference	☐

Category	Item	Action	Details	Completed
Payload	Weight	Verify	Payload structure and maximum payload weight (combined) are within the maximum capability specified for the AMR	☐
	Center of gravity	Verify	Payload center of gravity is verified to be within the safe center of gravity limits	☐
	Maintenance access	Verify	Mounted payload structure provides access for maintenance activities	☐
	Cabling	Verify	Bend radius, flex cycles, and pinch points have been respected	Yes: ☐ Not Applicable: ☐
	Component location	Verify	All components of the payload structure are located higher than the top of the AMR	☐
	Sensor unobstruction	Verify	Sensors function is not impeded or obstructed by payload or payload structure	☐
	Overhanging payload evaluation	Execute	Refer to *2-12-1 Safety Zones* on page 2-34	Yes: ☐ Not Applicable: ☐
	Side laser integration	Verify	Side laser(s) are installed if an overhang or protrusion might cause the AMR to encounter obstacles that are not visible to the safety laser scanners or the low lasers	Yes: ☐ Not Applicable: ☐
	Documentation	Collect and include	The following documents are included with this checklist: • A mechanical drawing showing front, side, top, and isometric views of the payload structure on the AMR • Software printout showing center of gravity for AMR, payload structure, and payload (combined) • Center of gravity printout for loaded payload structure • Center of gravity printout for unloaded payload structure • Center of gravity printouts along movement profile of the payload structure • Center of gravity printouts for loaded AMR in motion • Inertia calculations for payload • Values for AMR's footprint • Values for AMR clearances	☐
Other	Fleet simulation	Execute	Used to estimate the number of AMRs required, as well as lay out ideal traffic flow	Not Applicable: ☐

2-12 LD-Series AMR Worksheet

Use the following sections to complete the LD-Series AMR Worksheet.

2-12-1 Safety Zones

If safety zones have been modified, enter the new values in the table below.

Safety Zone Number	Activation Speed	Width	Length
0	• LD-60: 300 mm/s • LD-90: 225 mm/s • LD-250: 225 mm/s		
1	• LD-60: 600 mm/s • LD-90: 450 mm/s • LD-250: 450 mm/s		
2	• LD-60: 900 mm/s • LD-90: 675 mm/s • LD-250: 675 mm/s		
3	• LD-60: 1200 mm/s • LD-90: 900 mm/s • LD-250: 900 mm/s		
4	• LD-60: 1500 mm/s • LD-90: 1125 mm/s • LD-250: 1125 mm/s		
5*1	• LD-60: 1800 mm/s • LD-90: 1350 mm/s • LD-250: 1350 mm/s		
6*2	• LD-60: 1800 mm/s • LD-90: 1350 mm/s • LD-250: 1575 mm/s		
7*2	• LD-60: 1800 mm/s • LD-90: 1350 mm/s • LD-250: 1800 mm/s		

*1. LD-250's maximum speed is 1200 mm/s.

*2. AMR will not be able to achieve these speeds.

2-12-2 Battery & Power Consumption

Make a list of the AMR movements and stops (process steps) during its typical shift, including time spent and current drawn from the battery.

Include any charging steps as negative current. Report the value as the difference between charging and consumed currents.

Additional Information

Ah = Current flow in Amperes * Time spent in hours

Step	Description	Time Spent (Hours)	Current (Amps)	Power Drawn (Ah)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

- Total power consumption per cycle calculated: __________ Ah
- Number of process cycles AMR will complete during its shift: __________ cycles
- AMR battery capacity: __________ Ah
  - Refer to AMR User's Manual for this figure.
- Recommended State of Charge (SOC) window for the battery: __________
- Usable power capacity of battery (based on SOC window): __________ Ah
- Estimated battery change time (if battery requires replacement during shift): __________ minutes
- Required battery balancing frequency: __________ days/weeks
- Power consumption
  - Payload structure: __________ W
  - Optional accessories: __________ W
  - User-added devices: __________ W
  - Total: __________ W

2-12-3 Software & Licenses

Item	Software Package Name	Software/License Version
1	MobilePlanner	
2	FLOW Core	
3	FLOW iQ	
4	SetNetGo - AMR	
5	SetNetGo - Fleet Manager	
6	CAPS	
7	Fleet Simulator	
8		
9		
10		

- Login information
  - Username: ____________________
  - Password: ____________________

Additional Information

Attach as many logins to the worksheet as needed.

2-12-4 Wireless Communication

- Wi-Fi bandwidth requirements for all devices
  - AMR: __________ Kbps
  - Controller: __________ Kbps
  - HMI: __________ Kbps
  - Other devices:
    - ____________________: __________ Kbps
    - ____________________: __________ Kbps
    - ____________________: __________ Kbps
    - ____________________: __________ Kbps
    - ____________________: __________ Kbps
- Network information
  - Wireless network name: ____________________
  - Type of network (Production, Administrative, etc.): ____________________
  - Explanation (if this is not an exclusive network): ____________________________

____

- Devices using this network
  - Controllers: ____
  - PCs: ____
  - Material Tracking: ____
  - EMS/WMS: ____
  - IoT: ____
- Available Wi-Fi technology in the plant (Check all that apply)
  - 802.11a __________
  - 802.11b __________
  - 802.11g __________
  - 802.11n __________
  - 802.11ac __________
- AMR Wi-Fi configuration
  - Static IP address: ____________________________
  - Subnet mask: ____________________________
  - Gateway: ____________________________
  - DNS server(s): ____________________________
  - SSID for AMR network: ____________________________
  - Network mode:
    - Must be set to “Infrastructure.”
  - Radio mode: ____________________________
  - Channel set: ____________________________
  - Wireless watchdog IP address: ____________________________

- Wireless watchdog max count (0 disables): ___________________________
- Security encryption: ___________________________
- Authentication method: ___________________________

2-12-5 Controls

- Plant PLC information (if applicable)
  - Make & model: ____
  - Communication network used: ___________________________
- Wi-Fi access point information
  - Make & model: ____
- WMS/EMS information: ____
- Payload structure information (answer only if applicable)
  - Make & model of payload structure controller: ____
  - Connection method between payload structure and controller:
    ____
  - Programmer who wrote communication between controller and AMR Core:
    ____
  - Communication method between plant PLC and payload structure PLC:
    ____
  - Make & model of payload structure HMI: ____
  - Method of communication between HMI and payload structure controller:
    ____

2-12-6 Mechanical

- Maximum weight for combined center of gravity (Payload + Payload Structure): _________ kg
- Overhanging payload structure information (if applicable)
  - Maximum radial distance from the AMR’s center of rotation to farthest point? _________

For this calculation, refer to the relevant sections of *LD-250 Platform User's Manual (Cat. No. I642)* and *LD-60/90 Platform User's Manual (Cat. No. I611)*.

- Modified motion parameters (if applicable)
  - Maximum Translational Speed: _________
  - Maximum Rotational Speed: _________
  - Maximum Acceleration: _________
  - Maximum Deceleration: _________
  - Heading Rotation Speed: _________
  - Absolute Max Rotational Velocity: _________

3

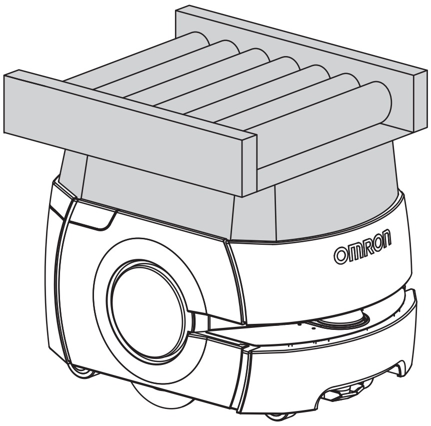
Application Examples

This section provides examples for common AMR applications.

3-1 Conveyor & Lift Application

This type of application allows the AMR to easily transfer and transport materials.The typical process is as follows:

- A lift operates underneath to position the conveyor structure vertically at the pickup goal.
- The conveyor structure aligns with the goal, performs a handshaking routine, and activates to transfer material to the AMR.
- Once transferred, the lift lowers. The AMR then navigates to the dropoff goal and transfers the material.



Additional Information

Consider HAPS or CAPS for improved positioning accuracy and repeatability at goals.

The following points for the application example are covered in the sections that follow:

- Associated components and power
- Associated I/O
- Safety considerations
- Affected parameters

3-1-1 Conveyor

This section contains all items related to the conveyor.

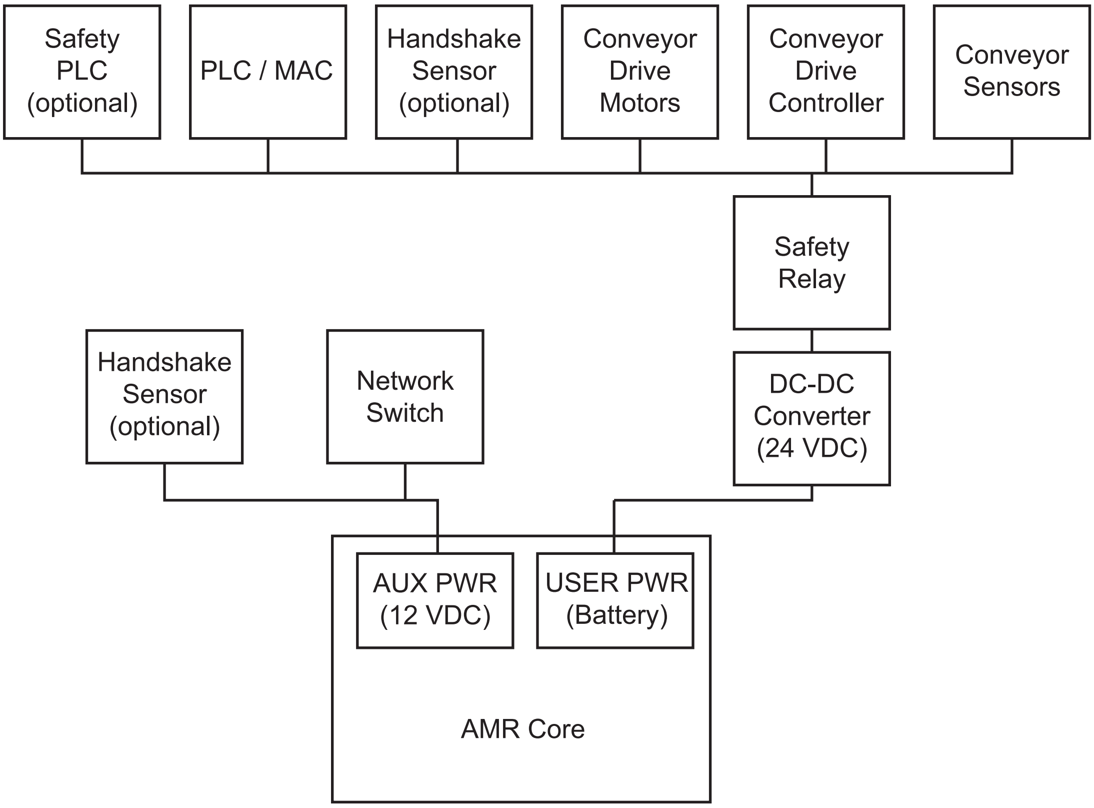
Components

The following main components are associated with typical conveyor applications:

- Drive roller to convey material
- Free rollers to transfer material
- Stopper to prevent material from sliding
- Sensor to detect material presence
- Proximity switches or similar for alignment at the goal

Power

A typical power distribution diagram for conveyor components is provided below.



I/O

Typical conveyor application I/O signals are provided below.

Type	Signal
Inputs	AMR ready status
	Ready for conveying in (goal) status
	Start of conveying in (goal) status
	Conveying in complete (goal) status
	Ready for conveying out (goal) status
	Start of conveying out (goal) status
	Conveying out complete (goal) status
	Command start of conveying in (AMR)
	Command start of conveying out (AMR)
	AMR movement status
	Error reset

Type	Signal
Outputs	Conveyor busy
	Run roller motor
	Light pole color
	Activate buzzer
	Ready for convey in
	Ready for convey out
	Start of convey in
	Start of convey out
	Conveyor speed output
	Error, communication
	Error, roller drive
	Error, stopper timeout
	Error, material position timeout
	Error, convey in/out timeout
	Error, material transfer timeout
	Error, goal not ready timeout

3-1-2 Lift

This section contains all items related to the lift.

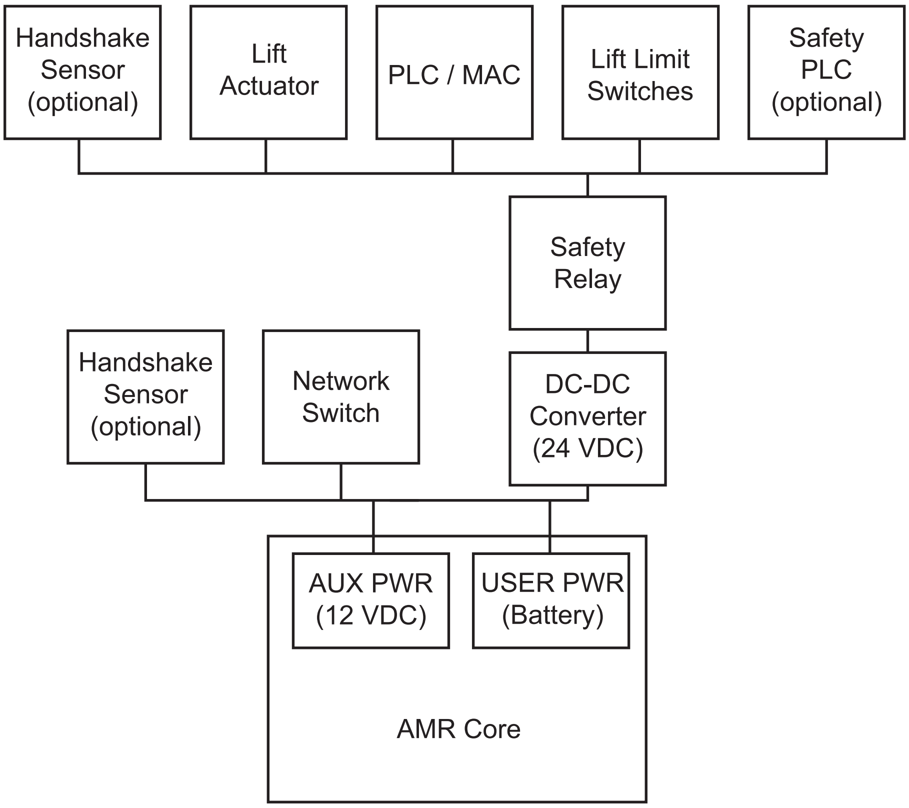
Components

The following main components are associated with a typical lift application:

- Actuator(s)
- DC-to-DC converter
- Controller (application-dependent)
- Lift surface
- Sensor to detect material presence
- Lift height sensor

Power

A typical power distribution diagram for lift components is provided below.



I/O

Typical lift application I/O signals are provided below.

Type	Signal
Inputs	AMR ready status
	Ready for lift up status
	Start of lift up status
	Lift up complete status
	Ready for lift down status
	Start of lift down status
	Lift down complete status
	Delay timer(s)
	Lift speed
	AMR movement status
	Error reset

Type	Signal
Outputs	Lift busy
	Run lift controller
	Light pole color
	Activate buzzer
	Ready for lift up
	Ready for lift down
	Start of lift up
	Start of lift down
	Lift speed output
	Error, communication
	Error, lift controller
	Error, lift up/down timeout

3-1-3 Safety Considerations

Make the following safety considerations when designing conveyor & lift applications:

- Observe electrical and mechanical limits when designing the conveyor or lift payload structure.
- E-STOP pushbuttons should be present at the conveyor height, must be managed on the same circuit, and must halt motion on the AMR and payload structure.
- All center of gravity limits must be adhered to.
- The lift or conveyor must not operate while the AMR is in motion.
- Mechanical stops must be enabled while material is loading or present on the payload structure.
- Side lasers must be added to detect obstacles that may collide with the payload structure.
- The vertical footprint must be adjusted to prevent collisions.
- Apply safety labeling for conveyor hazards.

3-1-4 Affected Parameters

The following parameters should be considered and modified if necessary:

- AMR Footprint
- Radius
- Clearances
- Safety zones, if dimensions not kept within default footprint
- Motion parameters, accounting for center of gravity while fully loaded
- Inertia to prevent tipping during loading/unloading
- Traction parameters, if an issue

Forbidden zones can also be added for overhanging objects.

4

Getting Started

This section provides information about getting started with the AMR.

4-1 Prerequisites

A number of prerequisites must be met before beginning the setup process:

- Prepare a wireless network for AMR communication, as described in *2-8 Communication Considerations* on page 2-11 and *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
- Ensure the wireless network has adequate coverage.
- Complete the design and manufacturing process for the payload structure. This includes ensuring the payload and structure both comply with OMRON safety recommendations. Review section *2-10 Payload Structure Considerations* on page 2-15.
- Ensure the application is not designed to exceed any power or electrical limit, as described in *2-4 Electrical Limits* on page 2-5 and *2-6 Power Consumption* on page 2-8.
- Ensure the application is not designed to exceed any mechanical limit, as described in *2-3 Mechanical Limits* on page 2-4
- Remove the AMR from its shipping crate.
- Test the payload structure components, and mount the structure securely on the AMR. Perform all electrical and communication connections.
- Install all other required equipment (for Acuity, HAPS, etc.) based on the localization, accuracy, and repeatability needs of the application. A review of these concepts is found in *1-1-3 Optional Components* on page 1-5, *1-3-5 Positioning* on page 1-14, and *2-5 Positioning Requirements* on page 2-6.
- Install MobilePlanner on your PC. More information on this process is provided in *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
- Configure the AMR’s wireless communication settings. More information on this process is provided in *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
- Charge the AMR’s battery.
- Prepare the work environment for the AMR by cleaning the floor, removing extraneous objects, blocking dangerous areas like downward stairs, modifying reflective surfaces, etc.

4-2 Setup Process

The setup process must be completed before the AMR can operate safely on its own. After the items listed in *4-1 Prerequisites* on page 4-2 have been satisfied, the setup process can begin. The basic steps are described below.

Additional Information

The details in the following steps provide an overview only. Refer to the *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for more information.

1. Connect to the AMR
2. Create a map
3. Localize the AMR
4. Create tasks and macros

4-2-1 Connect to the AMR

Begin by connecting your PC to the AMR's maintenance port via Ethernet. This requires opening the AMR's access panel. A standard Ethernet cable is required. Once a physical connection is established, you can proceed with the following steps:

1. Manually configure the IP address and subnet mask for your PC.
2. Modify the network and security settings for the AMR using SetNetGo. It is accessed on your PC from within MobilePlanner or a web browser.
3. Within MobilePlanner, connect to the AMR using its established IP address, as well as the configured username and password.

4-2-2 Create a Map

After a wireless connection has been established, a map must be created by manually driving the AMR in the working environment. There are two methods for manually driving the AMR:

- Using the pendant while walking behind the AMR
- Wirelessly, through MobilePlanner using your keyboard

While being driven around its environment, the AMR uses its safety laser scanner to create a scan of static features. This scan is then used to create a map in MobilePlanner.

Use the following tips to improve map quality during creation:

- Perform the scan when the work environment is least busy.
- Drive slowly to prevent wheel traction issues. Traction loss introduces error into the scan.
- Allow the AMR to scan outer walls, as well as the interior of the workspace.
- Drive the AMR into tight corners, small corridors, and between static objects. Observe adequate clearance.

- Scan and press the goal button (if using the pendant) to mark the AMR's docking station. It will need to find this location to charge. Other important goals can be marked in this stage as well, if desired.
- The scan must terminate in the same location with the same heading as when the scan began.
- Looping the AMR through the same areas promotes accuracy. The map will benefit from sensor readings taken from different angles in the same work area. Be thorough.
- If using Acuity, scan bi-directionally (in one direction, and then the other). Scan in a clockwise direction for one scan, and counter-clockwise for another.

Regardless of the drive method, the scan must be started and stopped from within MobilePlanner.

Once the scan is complete, the scan file resides on the AMR. It must be selected and converted to a map file in MobilePlanner. This can take a considerable amount of time for larger maps.

Additional Information

When integrating the AMR into the final working environment, be sure to insert the customer's map into yours if you wish to retain configured items such as macros. Unneeded map features can be erased prior to insert.

4-2-3 Edit a Map

After the map is created, it must be edited in the following ways:

- Erasing dynamic objects
- Adding forbidden areas and sectors
- Adding goals (door goal, standby goal, etc.)
- Adding advanced lines and areas

Save the edited file to the AMR when finished.

4-2-4 Localize the AMR

In order for the AMR to begin work, it must be able to match its current, physical starting location with a location on its map. This is called localization. For more information on this behavior, refer to *1-3-2 Localization* on page 1-10.

Initial localization is performed in MobilePlanner.

4-2-5 Create Tasks & Macros

After the previous steps are completed, tasks and macros must be created.

There are many tasks available for use in MobilePlanner, including speech, enabling digital I/O, and performing accurate alignment. Tasks can also be collected into reusable macros. MobilePlanner's Route Builder is used to add tasks, goals, and macros to the map, associate tasks with routes and goals, and assemble a series of goals, tasks, and macros into routes.

4-3 Fleet Management

In order to coordinate two or more AMRs, a Fleet Manager is required. The Fleet Manager enables management of up to 100 AMRs through MobilePlanner. Fleet management activities include:

- Management of maps
- AMR configuration
- Job queue management
- AMR traffic coordination

The Fleet Manager configuration process is completed through the following steps:

1. Configuring the network settings for the Management Ethernet port
2. Configuring the network settings for the Fleet Ethernet port
3. Connecting the Management and Fleet ports to the LAN
4. Defining the login information
5. Configuring each AMR to connect to the Fleet Manager
6. Customizing each AMR, if desired

Additional Information

A FLOW Core license is required for setup and operation of the Fleet Manager.

Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for detailed instructions on the configuration process. Additional details are provided for applications that require a secondary, synced Fleet Manager for redundancy.

Once the Fleet Manager is configured and each AMR has been configured to connect to it, you can connect to the Fleet Manager via MobilePlanner to accomplish the following:

- Connect each AMR to the fleet.
- Create a subfleet of AMRs, if desired.

A subfleet is helpful for grouping AMRs by configuration. For example, AMRs can be grouped by function or location ("Conveyor AMRs" or "Production Area A"). Refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for detailed instructions on adding AMRs to a fleet, creating a subfleet, as well as monitoring and controlling the fleet.

Refer to *5-3-4 Fleets* on page 5-12 for information about parameters when working with fleets.

4-4 Support & Debugging

The DebugInfo file can assist with support and debugging during the integration process. It is a compressed data file gathered through SetNetGo that contains the following:

- A series of data logs, if enabled
- The complete AMR configuration
- The AMR's map, including all map object data, task data, and macros

The DebugInfo file can be thought of as a comprehensive AMR backup. It is provided as a zipped file. Instructions for how to download it are located in the AMR User's Manual. It is recommended to do so in the following cases:

- Before initial commissioning, to create an out-of-the-box default configuration
- During commissioning, once configuration is complete for the application
- To create a backup of a known-working configuration, so that an AMR that is not performing as required can be restored
- To gather logs and other information for troubleshooting, prior to contacting OMRON for support
- Before major AMR components are replaced, such as the Core
- When a replacement AMR needs identical settings to a decommissioned AMR

DebugInfo files are found in the following locations:

- Map file: **DebugInfo\home\admin\map_file_name.map**
- Default configuration file: **DebugInfo\usr\local\aramConfig\defaultAramConfig.txt**
- Useful log files: **DebugInfo\var\robot\logs**

These files include, but are not limited to:

- *log.txt*, the current AMR log file
- *logPrev.txt*, the log prior to the most recent shutdown
- Date-and-time-stamped collection of previous log files
- *shutdownLog.csv*

Contact your local OMRON representative for any questions regarding the contents of the DebugInfo file.

5

Adjustments & Optimization

This section provides tips on how to adjust settings and optimize functions of the AMR, or a fleet of AMRs.

5-1 Localization

Localization accuracy is dependent upon the accuracy of the map and the AMR's sensor measurements. It is possible for the AMR to encounter situations in which it has trouble localizing, which impacts its ability to navigate.

The most common problem with localization is map accuracy. Issues with map accuracy typically arise from the following:

- The scan used to create the map was not thorough.
- The environment may have changed in such a way that it no longer resembles the AMR's map.

An AMR that no longer recognizes its environment will report a poor localization confidence score (<20%). It will attempt to move and re-localize before reporting itself lost. If this becomes a common occurrence, localization must be improved.

Localization parameters can be modified to improve the confidence score. Many of these parameters affect CPU usage, laser scan detail, scan frequency, scan results comparison, and expected error. Before modifying any parameters, ensure it is necessary by reviewing the AMR's map and comparing with its environment. Typically, a re-scan of the environment is all that is needed. If modification of the localization parameters is necessary, save a copy of the current configuration file and contact your OMRON representative for support.

Additional Information

Poor wheel traction can also impact localization.

5-2 Motion

Values deemed appropriate for translational and rotational velocities, accelerations, and decelerations vary greatly by application. For example, 1800 mm/s could be an appropriate maximum velocity for an unloaded AMR in a wide, open space. If the environment contained a hallway and the AMR frequently crossed paths with workers or vehicles, the selected velocity should be substantially lower.
Accelerations and decelerations are also AMR-specific.
Linear velocities and accelerations should be proportional to rotational velocities and accelerations. In other words, if linear parameter values are decreased, rotational parameter values should also be decreased.
This section discusses different groups of motion settings.

Additional Information

Please note the following sections are not intended to serve as an exhaustive list of motion parameters. Situations like starting from a stop or reaching a goal have their own parameter sets. Motion parameters can also be changed by using sectors or tasks.

5-2-1 Absolute Movement Maximums

This group of parameters, contained in the *Robot Physical* section of the AMR's configuration in MobilePlanner, provides a set of AMR motion limits.
The following parameters are available:

- *AbsoluteMaxTransVel*: Absolute Maximum Translational Velocity in the positive direction
- *AbsoluteMaxTransNegVel*: Absolute Maximum Translational Velocity in the negative direction
- *AbsoluteMaxTransAccel*: Absolute Maximum Translational Acceleration
- *AbsoluteMaxTransDecel*: Absolute Maximum Translational Deceleration
- *AbsoluteMaxRotVel*: Absolute Maximum Rotational Velocity
- *AbsoluteMaxRotDecel*: Absolute Maximum Rotational Deceleration

No other movement setting or commanded movement can exceed the values of the maximum parameters.

5-2-2 Default Settings

This group of parameters, contained in the *Robot Operation* section of the AMR's configuration under *Robot config*, provides a set of default velocity, acceleration, and deceleration settings.
The following parameters are available:

- *TransVelMax*: Default Translational Velocity
- *TransAccel*: Default Translational Acceleration
- *TransDecel*: Default Translational Deceleration
- *RotVelMax*: Default Rotational Velocity
- *RotAccel*: Default Rotational Acceleration
- *RotDecel*: Default Rotational Deceleration

Tasks and sectors that have not been configured with motion settings will use the values of these parameters. If the task or sector has been configured with motion settings, these default parameters will not be used.

The values of these parameters cap all other similar values in other sections, except for parameters that contain *AbsoluteMax* in their names.

5-2-3 Path Planning Settings

This group of parameters, contained in the *Robot Operation* section of the AMR's configuration under *Path Planning Settings*, govern all path planning movement. The AMR will do most of its travel at these speeds.

The following parameters are available:

- *MaxSpeed*: Path Planning Maximum Translational Speed
- *MaxRotSpeed*: Path Planning Maximum Rotational Speed
- *HeadingRotSpeed*: Heading Maximum Rotational Speed
- *HeadingRotAccel*: Heading Maximum Rotational Acceleration
- *HeadingRotDecel*: Heading Maximum Rotational Deceleration

The default values for *MaxSpeed* and *MaxRotSpeed* are based on various tests conducted by OMRON for loaded and unloaded AMRs, and values higher than default are not recommended. Values lower than default may be useful when the AMR is carrying delicate payloads. Lowering *MaxSpeed* will increase cycle time.

HeadingRotSpeed, *HeadingRotAccel*, and *HeadingRotDecel* are related to how quickly the AMR tries to rotate to its goal heading after it reaches the goal. Values lower than default may be useful when the payload must be handled extra carefully. For an example calculation of *HeadingRotSpeed*, refer to *6-1 HeadingRotSpeed Calculation* on page 6-2.

Values in *Path Planning Settings* cannot exceed the values in *Absolute Movement Maximums*. In the event that the path planning speed settings are set to zero, the *TransVelMax* and *RotVelMax* settings will be used.

5-3 Navigation

This section describes how to optimize the AMR’s navigation. It covers the following topics:

- Path planning and path following
- Selectable Autonomy
- Clearances
- Fleets
- Dynamic Obstacle Tracking
- Virtual doors

5-3-1 Path Planning & Path Following

As discussed in *1-3-3 Navigation, Obstacle Avoidance & Path Planning* on page 1-11, the AMR uses a cost-based method for path planning. The following rules apply when the AMR searches for a path to a goal:

- Generally, a grid cell's cost increases as its distance to an obstacle decreases.
- Grid cells containing walls or other fixed objects have an infinite cost. The AMR will never enter infinite-cost cells as the cost is too high.
- Empty grid cells that are not near obstacles have the lowest possible cost.
- The AMR plans the lowest-cost path to its goal, taking traffic rules into account. If unmapped obstacles are encountered, it recalculates the lowest cost path around them.

The user can influence the shape and direction of the AMR’s planned path by modifying its map in the following ways:

- Adding preferred lines and direction sectors, thereby lowering the cost of the grid cells underneath
- Adding resisted lines and areas, which increases the cost of the grid cells underneath
- Adding forbidden lines and areas, which makes the cost of the grid cells infinite
- Adjusting the AMR’s padding and clearances
- Adjusting the amount of resistance for resisted sectors and lines
- Adjusting the resolution of the path planned by the AMR

Preferred lines, directions, and other traffic sectors are covered in more detail in *5-4 Traffic Management* on page 5-14.

Once the path is planned, and the AMR drives along the planned path, the user can modify the AMR’s parameters to accommodate the needs of different applications. These parameters control:

- Maximum translational and rotational speed while driving to goals (refer to *5-2 Motion* on page 5-3 for more information)
- Turning radius
- Translational and rotational speeds at goals

While driving, the AMR goes through three modes:

- Align mode: AMR turns in place to face the direction of the path toward the goal
- Path following mode: Allows the AMR to follow the path to the goal
- End move mode: Activated when the AMR is near the goal

This section discusses each mode and the parameters that influence them.

Additional Information

Reducing the size of grid cells significantly increases the amount of time the AMR uses to calculate its global path. This may cause considerable delay between its command executions and the start of navigation.

For more information, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

Align Mode

Two parameters influence the AMR's behavior during this alignment phase: *AlignAngle* and *AlignSpeed*. The impacts of adjusting them are listed below.

Parameter Name	Details
AlignAngle	Values lower than default are useful when the AMR's path needs to follow straight paths from its starting pose. Values higher than default may reduce goal-to-goal cycle time by reducing the time to align.
AlignSpeed	Modifying this value from default is generally not recommended. Values higher than default may be needed in environments where there is obvious slipping of the wheels when turning in place.

Path Following Mode

The majority of the time the AMR spends driving to a goal is spent in this mode. Several path planning parameters related to speed and clearances affect its behavior in this mode.

Precautions for Safe Use

The default parameters were selected after extensive testing at OMRON for each specific AMR model. Changes to these parameters are advised only when the environment and payload demand changes in the AMR's default behavior.

Additional Information

Clearance and motion parameters are a part of this mode as well. They are covered in their own respective sections: *5-3-3 Clearances* on page 5-10 and *5-2 Motion* on page 5-3.

Parameter Name	Details
PlanRes	This parameter decides the resolution of the planned path in the map. Values higher than default may be useful if the map is extremely large (e.g. maps with area greater than 1000 m x 1000 m). In this case raising the value will decrease the time to compute the path. Values lower than default may help the AMR navigate through very narrow openings, but it will increase the time to compute the path between distant goals in large maps. Lowering *PlanRes* must be done carefully and incrementally after testing on a simulator. Ensure the path planning times are acceptable before changing the default value.

Parameter Name	Details
PlanFreeSpace	The default value for this parameter is based on the shape of the base AMR model. Values lower than default will make the AMR drive closer to obstacles. This may also result in shorter paths with sharper corners, as well as less smooth motion. Values higher than default will result in larger excursions around obstacles and may increase goal-to-goal cycle times.
NumTimesToReplan	This parameter determines the wait time before a blocked AMR globally re-plans a new path to its goal. A value of 0 will not permit it to re-plan globally. This will result in the AMR reporting it failed to go to goal after not finding a local path around an encountered obstacle. Values higher than default will increase the time taken to re-plan globally. Values lower than default will decrease the time taken to re-plan globally.
SecsToFail	Values higher than default will permit the AMR to wait longer for unmapped obstacles or other AMRs to clear its path. This may be advisable if the AMR is operating within a fleet in a crowded environment, and there is a higher “cost” for the AMR to fail to reach its goal than to wait for obstacles to clear.
EndMoveSecsToFail	Values higher than default will permit the AMR to wait longer for unmapped obstacles that block its goal during its final end move. This may be advisable if the AMR is operating within a fleet in a crowded environment, and there is a higher “cost” for the AMR to fail to reach its goal than to wait for obstacles to clear.
LocalPathFailDistance	This parameter is related to the size of the AMR. Values higher than default will cause the AMR to stay further away from local obstacles when they block its path. Values lower than default may be advisable when the AMR is operating within a fleet in a narrow environment, and space is at a premium.
MarkOldPathFactor	Values lower than default will cause the AMR to strongly avoid flip-flopping around temporary obstacles if the default value does not produce the expected behavior. Values higher than default, or the maximum value of 1.0, will cause the AMR to always re-compute the optimal local path without being affected by the path in the previous cycle.
CentrifugalLimitMode	This mode is designed to prevent drive wheel slip on loaded AMRs operating on slippery/uneven floors. Disabling the mode for loaded AMRs may cause slipping in some environments. This may result in loss of localization and cause the AMR to stop driving. Setting a higher mode will typically result in the AMR taking longer to start driving from standstill, but may be useful for reducing slip with heavy loads.
ObsThreshold	Values higher than default may allow the AMR to drive through narrow spaces and closer to obstacles, but it is not recommended for safety reasons. Values lower than default will further increase the distance between the AMR’s path and obstacles.

Parameter Name	Details
CenterAwayCost	This parameter is related to path planning through one-way sectors. Values lower than default will cause the path to be planned away from the center line of the sector, especially when the AMR encounters obstacles while driving through the sector. Values higher than default will cause the AMR to try to get as close as possible to the center line of the sector.
OneWayToOldCostFactor	Values lower than default will allow the AMR to plan further away from the center of the one-way sector when it encounters obstacles inside the sector.
Resistance	Values higher than default will cause the AMR to have an increased avoidance of resistive lines and sectors. This will be noticeable when the AMR is forced into the resistive sector upon encountering obstacles. Values lower than default will allow the AMR to cross into the resistive sector more easily.
Preference	Values higher than default will give the AMR a stronger preference to follow the preferred lines. Values lower than default will allow it to deviate from the preferred line more easily if obstacles are near or on the line.
PreferredDirectionSideOffset	The default value of this parameter is related to the width of the AMR. Values higher than default may be needed if the payload width is larger than the base AMR width. This permits the AMR to stay further away from the sides of the sector.
PreferredDirectionWrongWayCost	Values lower than default will let the AMR bypass obstacles in its lane more easily. This is accomplished by allowing the AMR to cross over to the "opposing traffic" side of the sector. Values higher than default will make the sector more like a one-way sector.
PreferredDirectionAwayCost	Values lower than default will allow the AMR to avoid unmapped obstacles that may happen to be on the side offset line of the lane in the sector.
PreferredDirectionToOldCostFactor	Values lower than default will allow the AMR to move away from local obstacles based on *PlanFreeSpace*, rather than be closer to the preferred sector side offset. This is only relevant for local path planning and during obstacle avoidance.
PreferredDirectionToOldCostFactorMain	Values lower than default will allow the AMR to plan the main path based on *PlanFreeSpace*, rather than be closer to the preferred sector side offset. This is only relevant for global path planning during the initial path plan to the goal.
NoLocalPlanLookAhead	This parameter is only relevant for modes such as Follow mode, which is not relevant for normal path planning or following.

End Move Mode

The transition from the driving mode to the end move mode allows the AMR to smoothly decelerate from its driving velocity to zero velocity. This makes the AMR coast to rest directly on top of the goal. If the goal is a *GoalWithHeading* type, the end move has an additional phase where the AMR rotates in place to align itself with the heading specified for the goal.
The parameters that decide when, where, and how an end move happens is controlled mainly by the goal parameters that follow.

Additional Information

HeadingRotSpeed, *HeadingRotAccel*, and *HeadingRotDecel* are a part of this mode as well. They are covered in *5-2 Motion* on page 5-3.

Parameter Name	Details
GoalTransDecel	Values lower than default will cause the end move to last longer. This may help in applications that call for the AMR to drive gently into its goal pose. This may also help if the AMR's wheels have less traction at goals due to environmental factors. Values higher than default will cause the end move to be completed faster. This may help with cycle time. Values much higher than default may result in sudden changes during the transition from driving to the end move.
GoalDistanceTol	Changing this value from default will not yield increased repeatability performance. Values lower than default: • May cause the AMR to not reach its goal because of localization errors. • May cause an AMR to fail its final positioning move if it happens to stop outside the configured tolerance. Values higher than default: • May be useful when the environment does not allow adequate localization. • May mask issues with localization or traction, as the AMR will be less strict in final positioning.
GoalSwitchTime	The default value is acceptable for most AMRs. Values higher than default may be needed in cases where the AMR is heavily loaded and needs to reach its goal gently. Values beyond 1 s may cause the AMR to transition into the end move too early and get stuck (if there are unexpected obstacles in the way).
GoalAngleTol	This parameter is considered when the goal has a heading. If the environment surrounding the goal allows for good localization, values below default may improve the goal angle repeatability. If the environment is subject to frequent changes, values higher than default may enable the AMR to reach the goal faster.
GoalSpeed	This parameter will limit the maximum speed when the AMR transitions into the End Move mode. Values much lower than default may cause the AMR to start the end move too soon and cause it to get stuck (if there are unmapped obstacles on the way to the goal).
GoalStopSwing	This flag should be set only in cases where the AMR is carrying payloads much larger than its default size. When set, it will prevent the AMR from turning in place near the goal to achieve the goal tolerance set by *GoalDistanceTol*. When compared to a smaller AMR, turning in place for a large AMR (or AMR carrying a large payload) may cause increased and possibly unsafe motion of its corners.
GoalOccupiedFailDistance	This value should be based on the size of the AMR or its payload. The value should be increased from default if the size of the payload is significantly larger than the default AMR size. Values lower than default are only recommended if there is a need for the AMR to wait closer to the occupied goal in crowded environments.

5-3-2 Selectable Autonomy

With Selectable Autonomy, users can tailor the traffic flow of their facility. They are able to choose when AMRs follow a consistent path, and when to allow full or partial autonomous driving. Selectable Autonomy provides Automated Guided Vehicle (AGV) predictability without sacrificing flexible obstacle handling (when space allows). This deterministic navigation strategy provides for even greater optimization and tuning. Cycle time is minimized, while transport reliability is maximized.
Contact your local OMRON representative for additional information on configuring Selectable Autonomy within MobilePlanner.

5-3-3 Clearances

Clearance settings limit how close the AMR can move to detected obstacles. The settings can be modified to alter the AMR's operation in the following ways:

- Adjusting the required clearance based on the AMR's speed
- Increasing the AMR's speed through doorways or other tight spaces
- Preventing the AMR from getting too close to obstacles
- Preventing rapid stop behavior with approaching obstacles
- Improving stopping behavior, in cases where the AMR does not slow down rapidly enough

For an overview of the AMR clearance concept and basic parameters, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
This section continues the discussion on parameters related to AMR clearance.

Parameter Name	Details
SuperMaxTransDecel	In the event an obstacle is expected to enter the AMR's Front Padding area, the AMR will decelerate using the value of this parameter. This allows the AMR to decelerate extremely quickly to avoid a collision.
EmergencyMaxTransDecel	In the event an object is expected in the Front Clearance area, the AMR will decelerate even more rapidly. In this case it will use the value of this parameter. In the event this parameter is set to zero, the value of *SuperMaxTransDecel* is used. The AMR can continue to decelerate using *EmergencyMaxTransDecel*, or it is possible for it to use the maximum deceleration rate allowed by the firmware.

Precautions for Safe Use

Regarding *SuperMaxTransDecel* and *EmergencyMaxTransDecel*: Emergency stops and protective stops occur at default deceleration rates, which are very high. In order to prevent toppling, always ensure the payload's center of gravity accounts for this.

Parameter Name	Details
CollisionRange	The AMR's safety laser has a maximum safety protection range of 3 m. This parameter allows for an adjustable safety protection range by modifying how far ahead the AMR can detect obstacles. If an object is detected, the AMR will use this parameter to prevent the object from entering its Front Padding area.

Precautions for Safe Use

Regarding *CollisionRange*: It is strongly recommended to consult the local machine safeguarding authority before changing this parameter. The user is responsible for the safety impact of any changes made to this setting.

Parameter Name	Details
FrontClearance	This parameter affects how the AMR behaves in narrow spaces or environments filled with unmapped obstacles. Values higher than default will slow down the AMR and increase goal-to-goal cycle time; however, it ensures safety. Values lower than default may cause the AMR to trigger a laser protective stop when avoiding unmapped obstacles in crowded environments.
RoundFrontClearance	Enabling this parameter can prevent AMRs with a non-rectangular shape from getting stuck on walls or other obstacles. This is especially useful if the corner of the clearance area is inside or close to an obstacle.
ChamferFrontClearance	This parameter can prevent AMRs with a non-rectangular shape from getting stuck in tight spaces. It models the front of the AMR as a rectangle with a 45 degree chamfer and cuts a portion of the AMR's left and right front corners. For example, a setting of 0.1 cuts the front corners at 10% of the clearance width. This is especially useful if the corner of the clearance area is inside or close to an obstacle.
SideClearanceAtSlowSpeed, *SideClearanceAtFastSpeed*	Values lower than default may allow the AMR to drive through narrow, crowded spaces. This may also cause the AMR to protective stop frequently if there are many unmapped obstacles, or when operating within a fleet.
FrontPaddingAtSlowSpeed, *FrontPaddingAtFastSpeed*	Values lower than default may allow the AMR to travel faster in fleets. Values higher than default may allow the AMR to slow down in crowded environments and avoid E-Stops. However, this may cause an increase in goal-to-goal cycle time.
RotVelThresholdForClearance	This parameter is for setting the rotational velocity threshold at which the side clearance of the safety zone starts increasing when driving. This must be set to zero for LD-series AMRs.
UseRadiusForPlan	Typically, an AMR will use half of its width to calculate its fit through narrow spaces. When this parameter is enabled, the AMR will use its radius instead. The AMR's radius is the greatest distance between its center of rotation and its outside edge. Enabling this parameter reduces the chances of getting stuck in narrow spaces, as it should be able to rotate 180 degrees and backtrack. This is also helpful in cases where the payload is larger than the base AMR. However, it may prevent the AMR from planning paths through narrow spaces (such as doorways).

Parameter Name	Details
UseRearFraction	The general shape of an unmodified AMR is ovoid. This shape allows the AMR to rotate 360 degrees about its midpoint without getting its corners caught on nearby obstacles like walls or doorjambs. This parameter sets the percentage of the rear half of the AMR to be used to size for path planning. For example, a setting of 0.5 uses half of the distance from the center of rotation (widest point) to the rear of the AMR. In situations where the AMR has been outfitted with a payload structure (e.g. a rectangular conveyor), the value of this parameter may need to be increased to keep the edges of the payload structure from colliding with obstacles. Values lower than default are not recommended and may result in collisions while turning.
CheckInsideRadius	Enabling this parameter will allow the AMR to check for obstacles inside its radius. Typically the AMR can move through a narrow opening without issue using its width, but enabling this parameter can further prevent situations where it may get stuck.
CheckInsideBounds	Enabling this parameter will enable the AMR to check for obstacles that fall inside its clearances. The AMR will check while it is adjusting its heading to start moving, or after it has reached a goal. Movement will be prevented if there is an obstacle inside the AMR's bounds in these instances. If the AMR stops in an undesired manner or gets stuck during these instances, disable this parameter.

Additional Information

Clearance settings can be displayed visually in MobilePlanner by clicking on **Map / Robot Data / Other Robot Data** and enabling the option for *Path Planning Clearances*.

5-3-4 Fleets

This section discusses settings for multiple AMRs operating within a fleet.

Parameter Name	Details
PathHalfWidthAdjustment	This parameter refers to padding added to the AMR's half-width, specifically when other AMRs check to avoid its path. To ensure each AMR has enough room to turn, the default value can be increased. Use the following formula: *PathHalfWidthAdjustment = Radius - HalfWidth* This assists the AMR in planning its path by taking into account other AMRs in the area.
PathMaxLength	The local path planning needs to take into account other AMRs within the local path planning area. Use the following formula to adjust this parameter: *PathMaxLength >= CollisionRange* For more information about *CollisionRange*, refer to *5-3-3 Clearances* on page 5-10.

Parameter Name	Details
PathCheckPadding	Multi-robot path planning projects a path of the other AMRs in the fleet by tracing a polygon through their paths and checking for collisions. Therefore, the traced polygon should be wider than the AMR's standard width. This parameter adds padding to the AMR's radius. Use the following formula to adjust this parameter: *PathCheckPadding > SideClearanceAtFastSpeed + PlanRes* *SideClearanceAtFastSpeed* and *PlanRes* are factors for safety. For more information about these parameters, refer to *5-3-3 Clearances* on page 5-10 and *Path Following Mode* on page 5-6 respectively.
StoppedSpeed	Moving AMRs in the area gain priority over stopped AMRs, so it is useful to know when an AMR is stopped. Only *StoppedSpeed* is used to determine whether the AMR is moving or stopped; *MovingSpeed* has been removed. The recommended value for *StoppedSpeed* is 50 mm/s.

5-3-5 Dynamic Obstacle Tracking

The AMR is equipped with Dynamic Obstacle Tracking (DOT), as discussed in *1-3-3 Navigation, Obstacle Avoidance & Path Planning* on page 1-11. DOT is configured within MobilePlanner as well. The default settings are suitable for tracking people-sized objects in a well-mapped, low-noise environment.

Noise, in this context, refers to false-positives detected by the DOT algorithm. For high-noise environments, the AMR's default settings can be modified. Modification of settings can affect AMR operation in a number of ways, such as:

- Noise reduction
  - Obstacle size and avoidance speed
  - Static obstacle filtering
  - Object grouping
- Ignore zones
  - Ignoring dynamic objects that are unlikely to cross into the AMR's work area
- Tuning
  - Detection distance for people
  - Detection distance for other AMRs

For more information, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

5-3-6 Virtual Doors

In order for the AMR to drive through areas it would normally avoid (e.g. a threshold with PVC strip curtains), a virtual door must be added to the map.

For more information, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

5-4 Traffic Management

An application may call for a single AMR or a fleet of AMRs to operate in high-traffic areas. This requires navigating around other AMRs, as well as other moving vehicles and equipment. Therefore it is important to be aware of the various traffic management features available.

Associated parameters for traffic management features, as well as instructions for their use, are referenced in *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

The map can be edited for improved traffic management. The following features can be added to the map for this purpose:

Feature	Description
Preferred line	Allows the AMR to drive as if it is on a virtual rail Reduces the path planning cost of the grid cells it crosses
Preferred direction	Causes the AMR to attempt to drive on the specified side
Forbidden lines and areas	Used to keep an AMR out of a specified area; infinite cost for path planning Can be switchable (e.g. forbidden area during certain times of day)
Resisted lines and sectors	AMR will enter these areas if a lower-cost route cannot be calculated Causes the AMR to attempt to avoid these areas Increased path planning cost
Need-to-enter sectors	Causes the AMR to only enter if the needed goal is inside Useful for preventing congestion in the area
Single AMR sectors	Allows only one AMR at a time in the area Useful for narrow hallways

Additional modifications to the operation of the AMR for traffic management purposes are listed below:

- Ignore or deactivate non-safety laser or sonar input (refer to *5-4-1 Ignoring & Deactivating Non-Safety-Rated Sensors* on page 5-14)
- Restricting the number of AMRs in an area at one time
- Placing task lists for the AMR to perform upon entrance and exit of a sector
- Adjusting the AMR’s audio output volume in high-traffic areas

5-4-1 Ignoring & Deactivating Non-Safety-Rated Sensors

This section provides information on ignoring and deactivating the AMR’s non-safety-rated sensors: Rear sonar, low laser, and side lasers.

Ignoring Sensors

Certain areas in the work environment call for ignoring the AMR’s non-safety-rated sensor readings. For example:

- Ignoring rear sonar readings to avoid false positives
- Ignoring front low laser readings on ramps

- Ignoring side laser readings under low ceilings

MobilePlanner allows the user to define these areas, known as Advanced Areas, in the AMR's map.

The following sensor-related sectors can be enabled in the AMR's configuration:

- *IgnoreSonar*
- *IgnoreLowLaser*
- *IgnoreTiltedLaser*

After enabling the desired sector and saving the configuration, refer to *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for instructions on adding Advanced Areas to the map.

Deactivating Sensors

Prior to replacement of an underperforming sensor, it is possible to deactivate it (if it is safe to do so). To deactivate any of the AMR's non-safety-rated sensors, first match the sensor with its reference in the AMR's configuration:

- Low laser: *Laser_2*
- Side lasers (optional): *Laser_3*, *Laser_4*
- Rear laser (optional): *Laser_5*
- Rear sonar: *SonarBoard_1*

Each laser can be deactivated by disabling its corresponding *LaserAutoConnect* option, and rear sonar can be deactivated by disabling its *SonarAutoConnect* option.

6

Other Solutions & Examples

This section provides solutions and examples for select topics that require more detail.

6-1 *HeadingRotSpeed* Calculation

If the payload overhangs the default AMR footprint, it alters the AMR's swing radius and exponentially affects its maximum safe rotational speed. If the AMR's size increases significantly, its maximum rotation speed should be adjusted to stay at or below 300 mm/s.

If the AMR's default swing radius is increased, reduce the value of the *HeadingRotSpeed* parameter to compensate for its increased size and increased rotational speed.

Consider the following example, where the AMR's radius is increased to 625 mm and *v* represents a threshold linear velocity of 300 mm/s:

$\omega = v / r$

$\omega = (300 \text{ mm/s}) / (625 \text{ mm}) = 0.48 \text{ rad/s}$

$\omega = 0.48 \text{ rad/s} * 180/\pi = 27.5°/\text{s}$

In MobilePlanner, the value of *HeadingRotSpeed* should be set to 27.5°/s.

6-2 Additional Sensors

This section outlines installation and configuration of additional sensors.

6-2-1 Rear Laser

An additional laser can be configured as either rear-facing or vertical. For the latter case, the laser must be mounted so that its sensing plane is perpendicular to the floor.

The rear-facing laser kit consists of the following items:

- Debug port DB9 adapter cable
- TiM to DB9 adapter cable with AUX power split
- TiM-510 laser

This section covers installation and configuration of the rear laser.

Installation

Prior to mounting the laser, the following points should be considered:

- The mounting location and angle must be appropriate for proper functionality.
- The cable routing should be such that it prevents cable abrasion, binding, or other strain.

Additional Information

When mounting the laser to a payload structure, custom brackets or optional brackets from the laser manufacturer may be required.

Precautions for Safe Use

The following procedure assumes that you have put the AMR into a safe state for mechanical and electrical work. Always ensure the battery is disconnected.

Install the laser as follows:

1 Remove all necessary components to access the AMR Core. Detailed instructions for this procedure can be found in the AMR User's Manual.

2 Connect the cable to the Core as follows:

1) Connect the DB9 plug to the Debug port.

2) Connect the Molex plug to the AUX power port.

3 Mount the laser so it faces the appropriate direction (this is typically the opposite direction of the main safety laser).

4 Route the cable to the laser, and use cable ties to keep it clear of moving parts. Allow enough slack for removing the payload structure.

5 Connect the cable's multipin connector to the laser.

Configuration

This section covers configuration of the rear laser.

● Initial Configuration

Configure the laser as follows:

1 Open MobilePlanner and connect to the AMR.

2 Click on the AMR's **Configuration** tab, and enable *Show Expert Parameters*.

3 Click to expand **Robot Physical**. Ensure the value of *MaxNumberOfLasers* is set to a minimum of five lasers.

4 Under *Laser_5*, configure the following parameters:

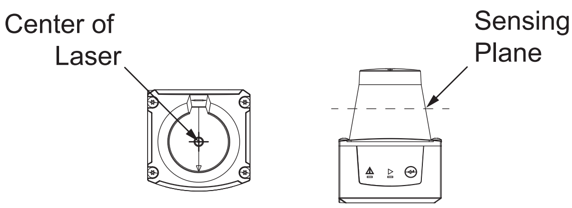
1) *LaserAutoConnect*: Enable the option.
2) *LaserType*: Select **tim3XX**.
3) *LaserPortType*: Select **serial**.
4) *LaserPort*: Type in */dev/ttyUSB11*.
5) *LaserPowerOutput*: Type in *Aux_20V*.

5 Save the configuration and wait for the AMR to reboot.

6 Open the workspace map and verify the laser readings.

● Position & Orientation

To further configure the laser in MobilePlanner, its position and orientation must be known. Refer to the following illustrations for assistance in determining these items:

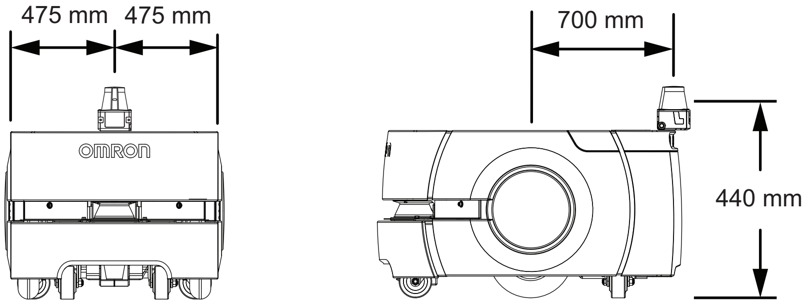


The illustration at left marks the center of the laser, the origin of the sensing field. The illustration at right shows the sensing plane: It is approximately 20 mm from the top of the sensor housing. These points are used to determine the laser's physical location relative to the AMR's center of rotation.

Determine the following measurements for the corresponding parameters:

- Front to back, from AMR's center of rotation to center of laser (*LaserX*)
- Left to right, from AMR's center of rotation to center of laser (*LaserY*)
- Height, from floor to sensing plane of laser (*LaserZ*)

The following example depicts sample measurements for *LaserX*, *LaserY*, and *LaserZ*:



● Ignored Segments

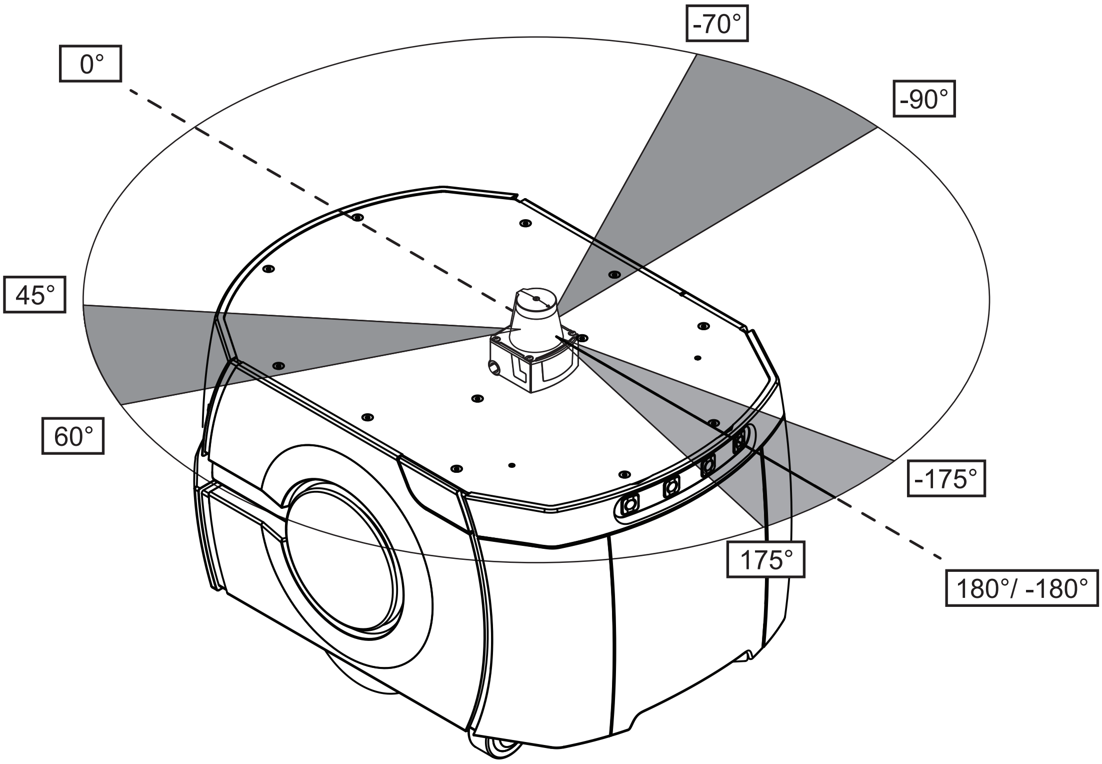
By default, the sensor scans an arc of 270 degrees. Segments of this arc may intersect with parts of the AMR, its payload, or laser protective covers. Therefore, these segments must be configured as ignored in the software. This will ensure the sensor does not detect parts of the AMR or AMR-mounted objects as obstacles, which could prevent motion.

When identifying these values:

- Degrees of arc relate to the AMR's coordinate system, and not the laser's angular range.
- 0° specifies the AMR's forward direction of travel.
- Specify values in the ranges 0° to +180° and 0° to -180°, in a clockwise direction (with respect to the top surface of the rear laser).
- The value for an ignored segment cannot span +180° to -180°. Thus:
  - To ignore a 10° segment between +175° and -175°, two ranges must be specified: -175° to -180°, 180° to 175° (for example).
  - Specifying the range -175° to 175° causes the software to ignore a 350° segment, clockwise from 175° to -175°.
- Also consider the parameter *LaserTh*, which specifies the sensing field orientation, and whether the laser is tilted when calculating the ignored segment.

The format for inputting the segments in MobilePlanner is *<startangle1>:<stopangle1>,<startangle2>:<stopangle2>*, etc. Readings inside these angles will be ignored. Input as many ignore segment angle pairs as necessary.

Consider the following example, showing an LD-60/90 AMR with rear laser:



Shaded areas represent segments to be ignored.

The procedure for identifying and inputting the ignored segments into MobilePlanner is as follows:

1. Begin at the 0° mark. Follow a counter-clockwise path along the positive range of the arc (between 0° and 180°) to identify the start and stop angles of segments to be ignored.
2. Continue to work counter-clockwise along the negative range of the arc (between -180° and 0°). Identify the start and stop angles, as in step 1.
3. Within MobilePlanner, input the angle pairs into the *LaserIgnore* parameter using the following format: *<startangle1>:<stopangle1>,<startangle2>:<stopangle2>*. Input as many pairs as needed, separated by commas.

The ignored segments for this example are configured in MobilePlanner as follows:

LaserIgnore: *45:60,175:180,-180:-175,-90:-70*

● Setting Values

To set the coordinate values and ignored segments for the laser:

1 Open MobilePlanner and connect to the AMR.

2 Click on the AMR's **Configuration** tab, and enable *Show Expert Parameters*.

3 Click to expand **Robot Physical**. Select *Laser_5*.

4 Enter the laser's mounting location coordinates for the following parameters:

- *LaserX*
- *LaserY*
- *LaserZ*

5 Use the *LaserIgnore* parameter to specify any ignored segments of the sensing field.

6 Enable the *LaserFlipped* parameter if the laser is inverted, or is on the left side of the AMR.

7 Set the value of *LaserTh* to correspond to the direction of the laser's scan field in relation to the AMR's direction of travel (e.g. 180 for laser pointing away from the direction of travel).

8 Verify the laser is detecting obstacles in the correct locations. The laser location configuration must be accurate to the laser's physical mounting location on the AMR.

9 Verify the installation to ensure the AMR can:
- Stop before it collides with obstacles detected by the laser
- Dock and charge

6-2-2 Side Lasers

Additional lasers can be mounted to the sides of the payload structure to provide additional obstacle detection. The lasers scan in a vertical plane near the path of the AMR, allowing it to detect obstacles at heights other than what the safety laser is able to detect.
The side laser kit consists of the following items:
- Two TiM-510 lasers
- Two laser guards
- 2 m J8 cable, with support for up to three lasers
- Two assembly kits, with mounting plates

This section covers installation and configuration of the side lasers.

Installation

Prior to mounting the laser, the following points should be considered:
- The mounting location and angle must be appropriate for proper functionality.
- The lasers must be mounted in an orientation so that their sensing planes are vertical and parallel to the floor. The front of the lasers must not be aimed towards the ceiling or floor; this may result in false object detection.
- The cable routing should be such that it prevents cable abrasion, binding, or other strain.
- The laser guard has adequate clearance.

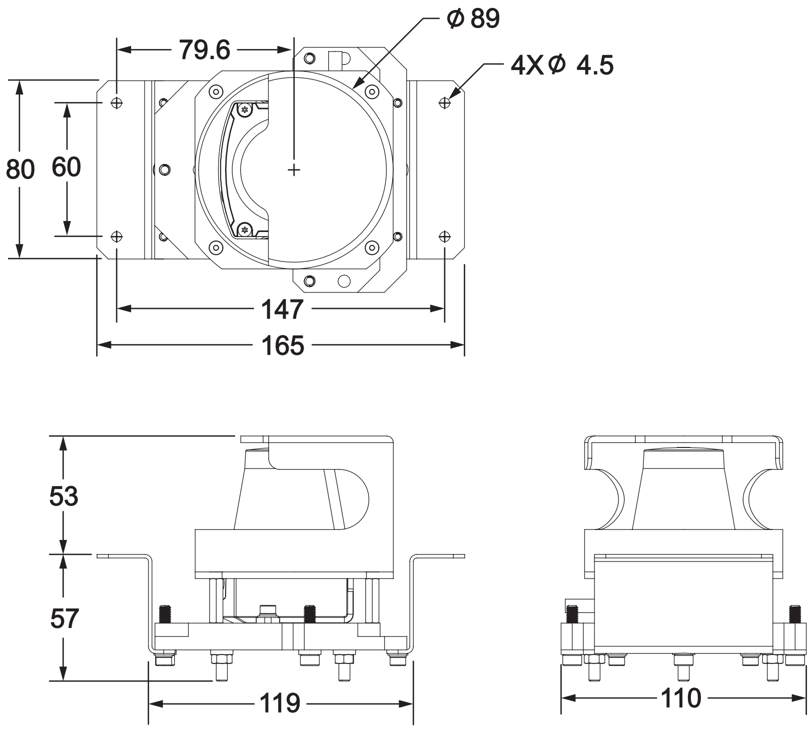
Additional Information

When mounting the lasers to a payload structure, custom brackets or optional brackets from the laser manufacturer may be required.

Precautions for Safe Use

The following procedure assumes that you have put the AMR into a safe state for mechanical and electrical work. Always ensure the battery is disconnected.

The dimensions (in mm) for the side laser assembly are provided below:



Listed below are the tools required for mounting the side laser assembly:

- 3.3 mm drill bit
- 3 mm hex key

Install the lasers as follows:

1. At the mounting location, create holes spaced at the proper distance for the mounting plates on each side.
2. Create holes for the laser guards to be installed. Ensure the position of the holes is such that the laser guards can be installed over the lasers without obstructing the sensing area.
3. Install the lasers using the provided M4 hex screws, applying a torque of 1 N-m.
4. Install the laser guards over the lasers using the provided M4 screws, applying a torque of 1 N-m.
5. Remove all necessary components to access the AMR Core. Detailed instructions for this procedure can be found in the AMR User's Manual.
6. Connect the provided cable to the Aux Sensor port on the AMR Core, if it was not previously installed.
7. Route the other ends of the cable to each side laser, as well as the low laser, and use cable ties to keep the cable clear of moving parts. Allow enough slack for removing the payload structure.

Configuration

This section covers configuration of the side lasers.

● Initial Configuration

Configure the lasers as follows:

1 Open MobilePlanner and connect to the AMR.

2 Click on the AMR's **Configuration** tab, and enable *Show Expert Parameters*.

3 Click to expand **Robot Physical**. Ensure the value of *MaxNumberOfLasers* is set to a minimum of four lasers.

4 Under *Laser_3* (right) and *Laser_4* (left), configure the following parameters:

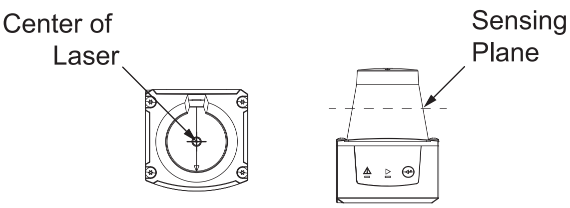
1) *LaserAutoConnect*: Enable the option.
2) *LaserType*: Select **tim3XX**.
3) *LaserPortType*: Select **serial**.
4) *LaserPort*: Type in */dev/ttyUSB5* for *Laser_3* and */dev/ttyUSB6* for *Laser_4*.
5) *LaserPowerOutput*: Type in *Vertical_Laser_Power*.
6) *LaserFlipped*: Enable the option for the left laser only.
7) *LaserIsTilted*: Enable the option if the lasers are being used for vertical object detection.
8) *LaserTiltedNegativeSensor*: Disable the option if *LaserIsTilted* is enabled.

5 Save the configuration and wait for the AMR to reboot.

6 Open the workspace map and verify the laser readings.

● Position & Orientation

To further configure the laser in MobilePlanner, its position and orientation must be known. Refer to the following illustrations for assistance in determining these items:

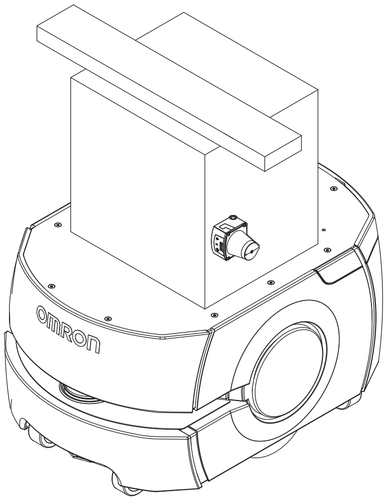


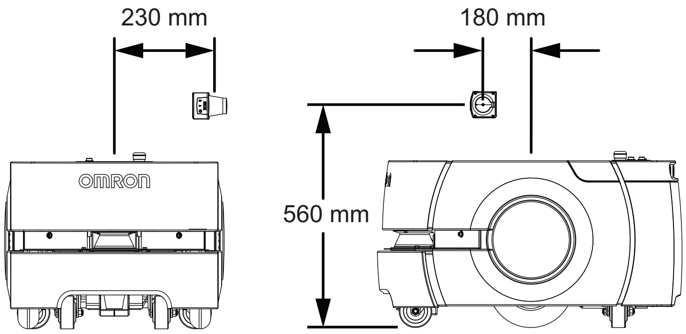
The illustration at left marks the center of the laser, the origin of the sensing field. The illustration at right shows the sensing plane: It is approximately 20 mm from the top of the sensor housing. These points are used to determine the laser's physical location relative to the AMR's center of rotation.

Determine the following measurements for the corresponding parameters:

- Front to back, from AMR’s center of rotation to center of laser (*LaserX*)
- Left to right, from AMR’s center of rotation to center of laser (*LaserY*)
- Height, from floor to sensing plane of laser (*LaserZ*)

The following example depicts a side laser mounted to a payload structure, as well as sample measurements for *LaserX*, *LaserY*, and *LaserZ*:





● Ignored Segments

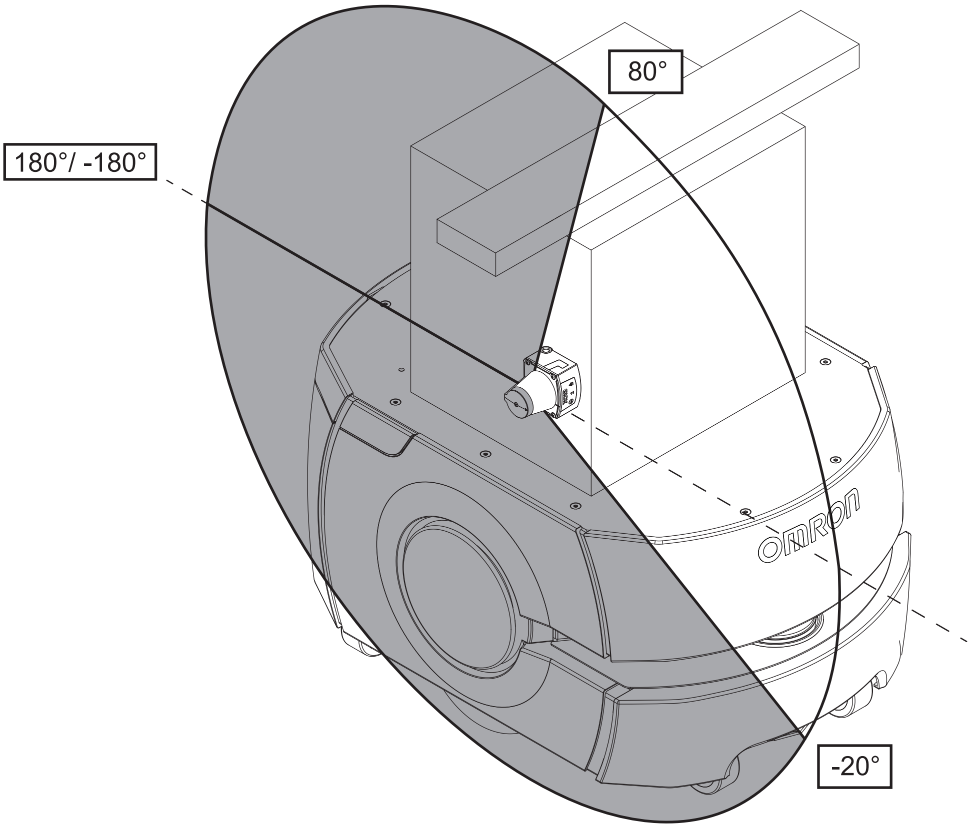
By default, the sensor scans an arc of 270 degrees. Segments of this arc may intersect with parts of the AMR, its payload, or laser protective covers. Therefore, these segments must be configured as ignored in the software. This will ensure the sensor does not detect parts of the AMR or AMR-mounted objects as obstacles, which could prevent motion.

When identifying these values:

- Degrees of arc relate to the AMR's coordinate system, and not the laser's angular range.
- 0° specifies the AMR's forward direction of travel.
- Specify values in the ranges 0° to +180° and 0° to -180°, in a clockwise direction (with respect to the top surface of the side laser).
- The value for an ignored segment cannot span +180° to -180°. Thus:
  - To ignore a 10° segment between +175° and -175°, two ranges must be specified: -175° to -180°, 180° to 175° (for example).
  - Specifying the range -175° to 175° causes the software to ignore a 350° segment, clockwise from 175° to -175°.
- Also consider the parameter *LaserTh*, which specifies the sensing field orientation, and whether the laser is tilted or flipped when calculating the ignored segment.

The format for inputting the segments in MobilePlanner is *<startangle1>:<stopangle1>,<startangle2>:<stopangle2>*, etc. Readings inside these angles will be ignored. Input as many ignore segment angle pairs as necessary.

Consider the following example, showing an LD-60/90 AMR with a right side laser (tilted):



Shaded areas represent segments to be ignored.

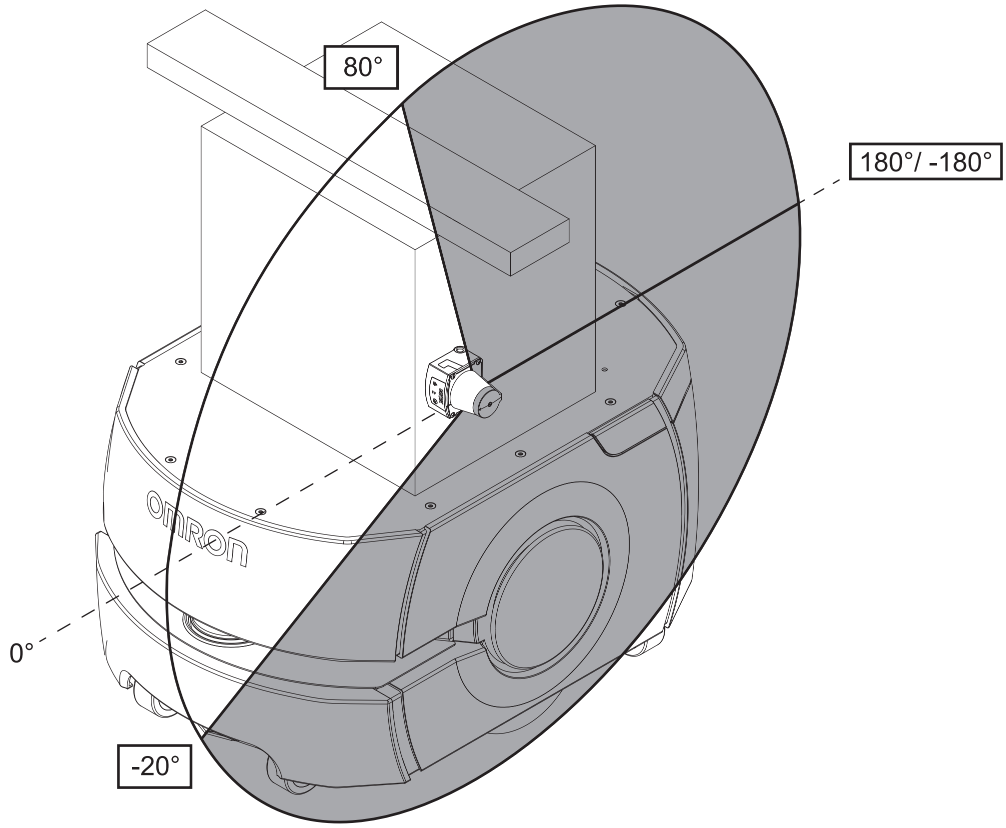
The procedure for identifying and inputting the ignored segments into MobilePlanner is as follows:

1. Begin at the 0° mark. Follow a counter-clockwise path along the positive range of the arc (between 0° and 180°) to identify the start and stop angles of segments to be ignored.
2. Continue to work counter-clockwise along the negative range of the arc (between -180° and 0°). Identify the start and stop angles, as in step 1.
3. Within MobilePlanner, input the angle pairs into the *LaserIgnore* parameter using the following format: *<startangle1>:<stopangle1>,<startangle2>:<stopangle2>*. Input as many pairs as needed, separated by commas.

The ignored segments for this example are configured in MobilePlanner as follows:

LaserIgnore: *80:180,-180:-20*

The next example shows an LD-60/90 AMR with a left side laser (tilted and flipped):



Shaded areas represent segments to be ignored.

The procedure for identifying and inputting the ignored segments into MobilePlanner is as follows:

1. Begin at the 0° mark. Follow a clockwise path along the positive range of the arc (between 0° and 180°) to identify the start and stop angles of segments to be ignored.
2. Continue to work clockwise along the negative range of the arc (between -180° and 0°). Identify the start and stop angles, as in step 1.
3. Within MobilePlanner, input the angle pairs into the *LaserIgnore* parameter using the following format: *<startangle1>:<stopangle1>,<startangle2>:<stopangle2>*. Input as many pairs as needed, separated by commas.

The ignored segments for this example are configured in MobilePlanner as follows:

LaserIgnore: *80:180,-180:-20*

● Setting Values

To set the coordinate values and ignored segments for the lasers:

1 Open MobilePlanner and connect to the AMR.

2 Click on the AMR's **Configuration** tab, and enable *Show Expert Parameters*.

3 Click to expand **Robot Physical**. Under *Laser_3* and *Laser_4*, enter the lasers' mounting location coordinates for the following parameters:

- *LaserX*
- *LaserY*
- *LaserZ*

4 Use the *LaserIgnore* parameter to specify any ignored segments of the sensing field.

5 Verify the laser configured as left is physically mounted on the left side of the AMR. This can be achieved by disabling one laser using *LaserAutoConnect* and watching the readings on the left side of the AMR.

6 Verify the installation to ensure the AMR can:

- Stop before it collides with obstacles detected by the laser
- Dock and charge

A

Appendix

A-1 Further Reading on AMR Components

Refer to the following resources for further reading on AMR components.

Additional Information

Contact your local OMRON representative for recommendations on related training courses and other materials.

Resource	Topic
AMR User's Manual	Safety information
	Technical specifications, drawings, and parts list
	Basic components overview
	AMR Core and status indicators
	Battery storage and maintenance
	Spare battery charging
	Light discs, beacon, and status indicators
	Lasers, sonar, encoders, gyroscope and bumpers
	Pendant overview and usage
	Optional components overview
	Operator panel components
	Connections, interfaces, and associated wiring diagrams
	Acuity localization • Overview, components, installation scenarios, and limitations • Payload structure design • Installation, software configuration, and creating a map
	High Accuracy Positioning System (HAPS) • Overview and specifications • Payload structure design • Installation, software configuration, creating a map, operation

Resource	Topic
LD Platform Peripherals User's Guide (Cat. No. I613)	Acuity localization • Overview, components, installation scenarios, and limitations • Payload structure design • Installation, software configuration, creating a map, operation • Camera specifications
	Side lasers • Positive and negative obstacles • Installation, components, mounting, connections, and configuration
	Rear-facing laser • Location and orientation • Installation, configuration, and laser zones
	High Accuracy Positioning System (HAPS) • Overview, components, specifications • Sensor installation, tape and marker application • Software configuration, and associated AMR tasks

A-2 Further Reading on AMR Software

Refer to the following resources for further reading on AMR software.

Additional Information

Contact your local OMRON representative for recommendations on related training courses and other materials.

Resource	Topic
Fleet Operations Workspace Core User's Manual (Cat. No. I635)	FLOW Core overview, requirements, installation
	Fleet Manager configuration
	SetNetGo features, usage, and licensing
	Configuring ARAM
	MobilePlanner overview, functions, and use

A-3 Further Reading on AMR Functions and Behaviors

Refer to the following resources for further reading on AMR functions and behaviors.

Additional Information

Contact your local OMRON representative for recommendations on related training courses and other materials.

Resource	Topic
AMR User's Manual	Operating environment and intended use
	Mapping overview
	Power & charging • Battery indicators • Autonomous and manual charging • Battery balancing
	High Accuracy Positioning System (HAPS) • Overview and specifications • Components and software requirements • Installation, software configuration, and associated AMR tasks
	Acuity Localization • Overview, components, installation scenarios, and limitations • Payload structure design • Installation, software configuration, and creating a map
Fleet Operations Workspace Core User's Manual (Cat. No. I635)	FLOW Core overview, requirements, installation
	Fleet Manager configuration and operation
	Driving the AMR via pendant or MobilePlanner
	MobilePlanner features and usage • Scanning and working with map files • Configuring the AMR • Jobs, tasks, macros, routes, Route Builder, and queuing • Cell Alignment Positioning System (CAPS) • Traffic management, path planning, collision avoidance, and controlling speed • AMR localization overview, utilizing lasers, Acuity, limitations and parameters

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