

OMRON

Mobile Robot

HD

Safety Manual



I647-E-01

Copyright Notice

The information contained herein is the property of OMRON, and shall not be reproduced in whole or in part without prior written approval of OMRON. The information herein is subject to change without notice and should not be construed as a commitment by OMRON. The documentation is periodically reviewed and revised.

OMRON, assumes no responsibility for any errors or omissions in the documentation.

Copyright © 2020 by OMRON All rights reserved.

Any trademarks from other companies used in this publication are the property of those respective companies.

MPEG Layer-3 audio coding technology licensed from Fraunhofer IIS and Thomson.

Acapela© voice technology licensed from ACAPELA GROUP (<https://www.acapela-group.com>) Copyright2003, all rights reserved.

Created in the United States of America

Terms and Conditions Agreement

Warranties

- a. Exclusive Warranty. Omron's exclusive warranty is that the Products will be free from defects in materials and workmanship for a period of twelve months from the date of sale by Omron (or such other period expressed in writing by Omron). Omron disclaims all other warranties, express or implied.
- b. Limitations. OMRON MAKES NO WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, ABOUT NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OF THE PRODUCTS. BUYER ACKNOWLEDGES THAT IT ALONE HAS DETERMINED THAT THE PRODUCTS WILL SUITABLY MEET THE REQUIREMENTS OF THEIR INTENDED USE. Omron further disclaims all warranties and responsibility of any type for claims or expenses based on infringement by the Products or otherwise of any intellectual property right.
- c. Buyer Remedy. Omron's sole obligation hereunder shall be, at Omron's election, to (i) replace (in the form originally shipped with Buyer responsible for labor charges for removal or replacement thereof) the non-complying Product, (ii) repair the non-complying Product, or (iii) repay or credit Buyer an amount equal to the purchase price of the non-complying Product; provided that in no event shall Omron be responsible for warranty, repair, indemnity or any other claims or expenses regarding the Products unless Omron's analysis confirms that the Products were properly handled, stored, installed and maintained and not subject to contamination, abuse, misuse or inappropriate modification. Return of any Products by Buyer must be approved in writing by Omron before shipment. Omron Companies shall not be liable for the suitability or unsuitability or the results from the use of Products in combination with any electrical or electronic components, circuits, system assemblies or any other materials or substances or environments. Any advice, recommendations or information given orally or in writing, are not to be construed as an amendment or addition to the above warranty. See <http://www.omron.com/global/> or contact your Omron representative for published information.

Limitation on Liability; Etc.

OMRON COMPANIES SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, LOSS OF PROFITS OR PRODUCTION OR COMMERCIAL LOSS IN ANY WAY CONNECTED WITH THE PRODUCTS, WHETHER SUCH CLAIM IS BASED IN CONTRACT, WARRANTY, NEGLIGENCE OR STRICT LIABILITY.

Further, in no event shall liability of Omron Companies exceed the individual price of the Product on which liability is asserted.

Suitability of Use.

Omron Companies shall not be responsible for conformity with any standards, codes or regulations which apply to the combination of the Product in the Buyer's application or use of the Product. At Buyer's request, Omron will provide applicable third party certification documents identifying ratings and limitations of use which apply to the Product. This information by itself is not sufficient for a complete determination of the suitability of the Product in combination with the end product, machine, system, or other application or use. Buyer shall be solely responsible for determining appropriateness of the particular Product with respect to Buyer's application, product or system. Buyer shall take application responsibility in all cases. NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCT(S) IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

Programmable Products

Omron Companies shall not be responsible for the user's programming of a programmable Product, or any consequence thereof.

Performance Data

Data presented in Omron Company websites, catalogs and other materials is provided as a guide for the user in determining suitability and does not constitute a warranty. It may represent the result of Omron's test conditions, and the user must correlate it to actual application requirements. Actual performance is subject to the Omron's Warranty and Limitations of Liability.

Change in Specifications

Product specifications and accessories may be changed at any time based on improvements and other reasons. It is our practice to change part numbers when published ratings or features are changed, or when significant construction changes are made. However, some specifications of the Product may be changed without any notice. When in doubt, special part numbers may be assigned to fix or establish key specifications for your application. Please consult with your Omron's representative at any time to confirm actual specifications of purchased Product.

Errors and Omissions

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.

Even if it conforms to all instructions in this safety guide, it isn't possible to guarantee that a robot system will be free from an accident resulting in injury or death or considerable damage to property caused by the industrial robot. It is the customer's responsibility to implement appropriate security measures based on their own risk assessment.

Table of Contents

Chapter 1: Alerts and Special Information	7
1.1 Alert Levels	7
1.2 Alert Icons	7
Falling Hazards	8
1.3 Special Information	9
Chapter 2: Operational Safety	11
2.1 Definitions	11
2.2 General Hazards	11
2.3 Unprotected Areas	13
2.4 What to Do in an Emergency	16
Releasing the Brakes	17
Releasing an E-Stop	19
2.5 User's Responsibilities	20
Electrical Hazards	21
Magnetic Field Hazards	21
Burn Hazard	22
Qualification of Personnel	22
Payload Movement and Transfer	23
Configurable Warning Buzzer	23
Speakers	24
Mechanical Brakes	24
Fleet Management	25
Other Hazards	26
2.6 Risk Assessment	26
Exposure	26
Severity of Injury	26
Obstacle Avoidance	26
Safety System Behavior	27
2.7 Environment	27
General Environmental Conditions	27
Public Access	28
Operating Clearances	28
Obstacles	30
2.8 Intended and Non-intended Use	31
Intended Use	31
Non-Intended Use	31
HD-1500 Platform Modifications	33

2.9 Safety Considerations when Performing Maintenance	33
Electrical Hazards	34
Electrical Hazard Precautions	34
Burn Hazard	34
ESD Hazards	35
2.10 Safety Measures Prior and After Maintenance	35
Lock-Out, Tag-Out Procedure	35
2.11 Safety Inspection	39
Safety and Warning Devices	39
Warning Labels	40
2.12 Protective Stops Initiated by AMR Safety Lasers	41
2.13 Safety System Overspeed Faults	42
2.14 Laser Safety	42
2.15 Interlock Switches	44
2.16 Battery Safety	45
Battery Safety Precautions	46
Battery Maintenance	48
2.17 Charging Station	48
Safety Precautions	49
2.18 Payload Structure	53
Safety	54
Considerations	55
2.19 Additional Safety Information	63
Mobile Robot HD Safety Manual (Cat. No. I647)	64
2.20 Additional Safety Information	64
Mobile Robot HD Safety Manual (Cat. No. I647)	64
2.21 Disposal	64
Chapter 3: Safety Function Description	65
PL and PFH	65

Chapter 1: Alerts and Special Information

This chapter provides information on the alerts and special safety information you need to safely operate or work around an AMR.

1.1 Alert Levels

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



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



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



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

1.2 Alert Icons

The icon that starts each alert can be used to indicate the type of hazard. These will be used with the appropriate signal word - Danger, Warning, or Caution - to indicate the severity of the hazard. The text following the signal word will specify what the risk is, and how to avoid it.

Icon	Meaning	Icon	Meaning
	This is a generic alert icon. Any specifics on the risk will be in the text following the signal word.		This identifies a hazardous burn-related situation, or a Hot surface.
	This identifies a hazardous electrical situation.		This identifies a hazardous ESD situation.
	This warning icon warns against riding on the AMR.		This identifies a fire risk.

Icon	Meaning	Icon	Meaning
	This warning icon warns against hazardous magnetic field.		This identifies a tip hazard.
	This warning icon warns against a pinch hazard.		

Falling Hazards



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

Physical Barriers

Use physical barriers together with logical barriers (map restrictions) to prevent the AMR from approaching any fall hazard that is within its operating area. Such hazards include:

- The edge of a loading dock or ramp.
- Entrance to downward stairs.
- Any other vertical drop that exceeds the AMR's maximum step height.

Required characteristics of physical barriers are:

- **Strength**—The barrier must be attached to a solid wall or floor and should be strong enough to stop a fully-laden AMR traveling at maximum speed.
- **Continuity**—The barrier must extend around the hazard completely.
- **Visibility**—Mark all physical barriers to make sure that the AMR's safety lasers can detect them easily. Barriers must extend above and below the laser's sensing plane, particularly if the floor is not flat.

Logical Barriers

In addition to physical barriers, use MobilePlanner to create forbidden areas or lines on the workspace map to prevent AMRs from closely approaching a fall hazard. These restrictions must be continuous so that the AMR cannot plan a path around the logical barrier.

The map features mentioned in the preceding paragraph are not interlocked methods of preventing an AMR from entering a specific zone. These map features assume proper AMR localization, and therefore, if the AMR is not able to properly localize its current position it may enter the forbidden zones. You must always install physical barriers where there is a risk of property damage or safety hazard.

You can also use the configuration parameters *FrontPaddingAtSlowSpeed* and *FrontPaddingAtFastSpeed* to increase the AMR's safety clearances. This causes the AMR to decelerate as it approaches a hazard. See: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

1.3 Special Information

This manual uses the following typographic styles to identify specific types of information:

IMPORTANT: Information to ensure safe use of the product.

NOTE: Information for more effective use of the product.

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

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

Chapter 2: Operational Safety

2.1 Definitions

This document uses the following terms to describe the HD-1500:

AMR(Autonomous Mobile Robot): This term describes the HD-1500 with an attached **payload structure**, creating a complete **Mobile Robot**.

We use the term AMR when talking about controlling or monitoring the full mobile robot with attached payload structure.

Fleet Manager: The operational mode of the computing appliance (**EM2100 appliance**) that runs the FLOW Core software to control a fleet of AMRs.

Fleet Operations Workspace (FLOW): A computing system that consists of software and hardware packages, and is used to set up, integrate and manage a fleet of AMRs within a factory environment. FLOW consists of two main elements: **FLOW Core** and **FLOW iQ**.

FLOW Core: All of the software used by **Fleet Operations Workspace**. The software runs on the EM2100 appliance(s), the AMRs, and the user's PC.

FLOW iQ: A software package that captures, analyzes, and reports data to users in order to measure, evaluate and constantly improve their AMR fleet performance in the factory.

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

HD-1500:This is the model name of the AMRplatform. This document uses the model name HD-1500 when describing the setup, configuration, and connections.

Mobile Robot: An alternative industry term for AMR.

Payload Structure: Any passive or dynamic device attached to and possibly powered by the HD-1500. This could be as simple as a crate for carrying objects such as factory parts or as sophisticated as a robotic arm that picks up and manipulates factory parts.

Platform: The most basic part of the AMR. It includes:

- The chassis, drive assemblies, light discs, light strips, suspension, casters, battery and lasers.
- An on-board AMR controller with built-in Inertial Measurement Units (IMU), navigation software, data and power connectors for a **payload structure**.
- An Operator Panel.
- The HD-1500 skins (external covers), and the chassis where you attach a **payload structure**.

2.2 General Hazards

This section describes potentially hazardous situations and conditions.



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

- Do not ride on the AMR.
- Do not exceed the maximum weight limit.
- Do not drive the AMR on inclined floors or surfaces.
- Do not exceed the maximum recommended speed, acceleration, deceleration, or rotation limits.

Rotational speed becomes more significant when the payload's center of gravity is increasingly offset from the AMR's center of gravity.

- Do not drop the AMR, run it off a ledge, or otherwise operate it irresponsibly.



CAUTION: PERSONAL INJURY RISK

The user must not stand close to the AMR while it is rotating with no forward motion.

- Do not allow the AMR to drive through an opening that has an automatic gate or door unless the door and AMR are configured correctly with the Call/Door Box option.
- Do not throw an object in front of the AMR or suddenly step into the path of the AMR. The AMR braking system cannot be expected to function as designed and specified in such instances.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

Abrupt appearance of objects or persons in the path of the AMR could result in personal injury or property damage. You must make sure that the operating environment of the AMR is adequately controlled.

- Do not expose the AMR to rain or moisture.
- Do not use unauthorized parts to repair the AMR.
- Do not power on the AMR without its wireless antennas in place.
- Although the lasers used are Class 1 (eye-safe), OMRON recommends that you not look into the laser light.
- Reflective surfaces can interfere with the AMR's laser operation.
- Do not operate the AMR in areas where it may be exposed to intense interference light, such as direct sunlight.
- Do not operate the AMR in a flammable gas environment.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK
Do not operate the AMR in hazardous environments where there is explosive gas, and oil mist.

- Do not operate the AMR with the safety interlock switches disabled.



WARNING: ELECTRICAL SHOCK RISK, FIRE RISK, BURN RISK
The safety interlock switches shall not be defeated or bypassed as this could potentially result in short circuit.

- The HD-1500 shall only be powered by an HD-1500 battery. Do not use any other batteries.
- The HD-1500 battery shall only be charged by an HD-1500 charger. Do not use any other chargers.

2.3 Unprotected Areas

The HD-1500 charges its battery autonomously by driving itself to the docking target where it mates with the docking target's charging paddle, as displayed in the following figure.

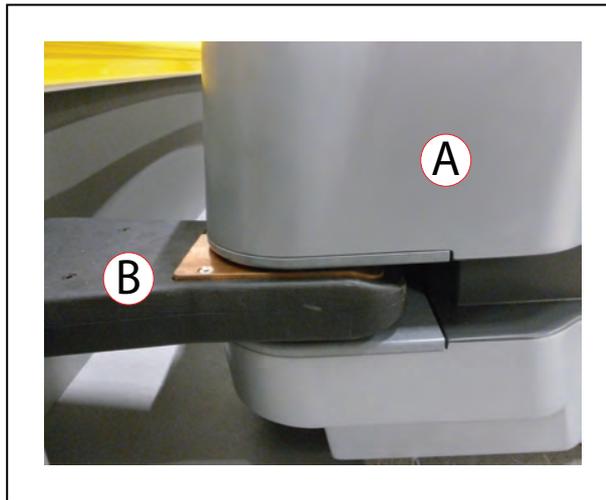


Figure 2-1. HD-1500 Mating with the Charging Paddle, (A) HD-1500, and (B) Charging Paddle

The HD-1500 travels at a low speed when docking:

- When traveling between 0 to 20 mm/s (or angular speed of less than 3 deg/s), there are no hardware-based safety laser protection zones. The HD-1500 beeps any time it moves at a linear speed below 20 mm/s, or an angular speed of less than 3 deg/sec for longer than 2 seconds. The AMR respects its software-based obstacle-avoidance clearances at all speeds, but it will not use a hardware-based safety laser protection zone at speeds below 20 mm/s or 3 deg/sec. This is done intentionally to allow operators to manually drive the AMR away from any obstacles that are too close to the AMR. It also allows the operators to back the AMR when needed.
- At speeds between 20 to 115 mm/s (or angular speed of less than 12 deg/s), the AMR's hardware-based laser protection zones exclude the area where the charging paddle enters the laser channel. The safety zones of the two safety scanning lasers are identical, and therefore, the unprotected areas are present at both front and rear ends of the AMR.

The operator must take necessary precautions to ensure that the operator's hands or other body parts do not get stuck in between the charging pad and the platform when docking.

- At speeds above 115 mm/s, the hardware-based laser protective zones are fully active and there are no unprotected areas.

The following table lists the hardware-based safety laser protection zones for the speeds mentioned in the preceding paragraph:

Table 2-1. Hardware-Based Safety Laser Protective Zones

Linear speed (mm/s)	Angular speed (deg/s)	Hardware-based safety laser protective Zones
$0 \geq$ and < 20	$0 \geq$ and < 3	No protective zones.
$20 \geq$ and < 115	$3 \geq$ and < 12	Two unprotected areas. Area where the charging paddle enters the laser channel (both at front and rear of the AMR).
≥ 115	≥ 12	No unprotected areas.



CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK
 Although the AMR respects its software-based obstacle-avoidance clearances at all speeds, the user must be aware of the location of the E-Stop buttons at all times, and keep out of the unprotected areas.



CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK
 It is the end user's responsibility to ensure that the area within the radius of 2 m from the center of the HD-1500 is kept clear, when the AMR is traveling at less than 115 mm/s.

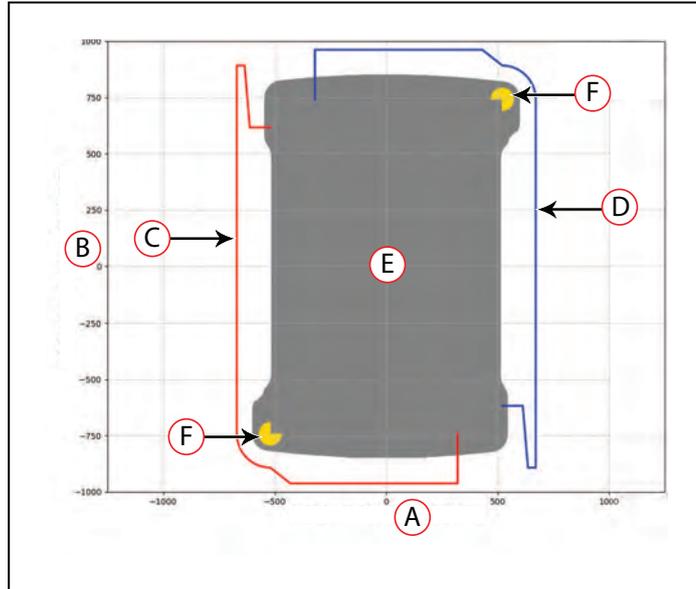


Figure 2-2. HD-1500 Protective Zones with Openings for the Charging Paddle - Movement at Less Than 115 mm/s (Dimensions are in mm)

ID	Description	ID	Description
A	AMR Y-axis	D	Front laser zone
B	AMR X-axis	E	HD-1500
C	Rear laser zone	F	Safety scanning laser

The following figure provides dimensions of the HD-1500 unprotected area. The same dimensions are true for the rear laser unprotected area.

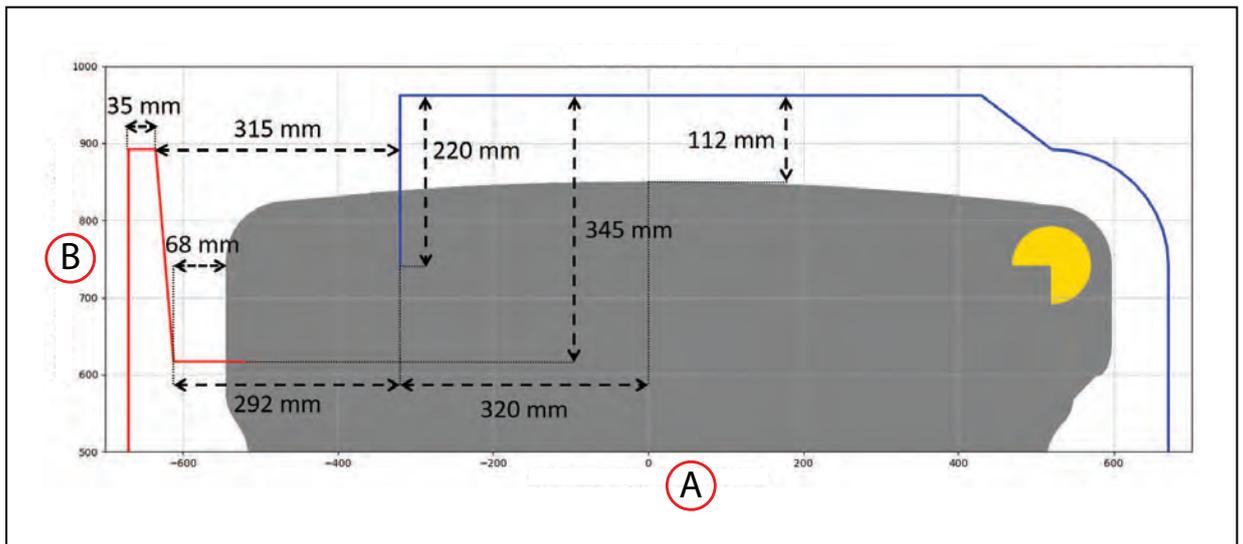


Figure 2-3. HD-1500's Unprotected Zone Dimensions - Movement at Less Than 115 mm/s, (A) AMR Y-Axis, and (B) AMR X-Axis

2.4 What to Do in an Emergency

In case of an emergency such as a fire or collision, you should stop the AMR quickly and safely. If the emergency situation is near the charging station, you must turn off the power using the main disconnect switch. You must also turn off the power supply box in case a docked AMR is E-Stopped.



CAUTION: Combustible Lithium Battery.

For AMR fire suppression use either foam, dry chemical extinguisher, ABC, AB, powdered graphite, copper powder, or a CO₂ extinguisher.

The HD-1500 has four E-Stop buttons, two on either side of the platform (a red push-lock button). The Operator Panel provides an additional E-Stop button (a red push-lock button on a yellow background). See the following figures.



Figure 2-4. E-Stop Button on the Platform



Figure 2-5. E-Stop Button on the Operator Panel

Use the User Safety Interface connection, located on the user access panel, to add E-Stop buttons to your payload structure, if required.

In the event of an emergency stop:

- The AMR uses motor power to come to a controlled stop then engages its motor brakes and removes power to its drive motors.
- Indicator lights on the AMR, and the pendant (if attached) show the E-Stop state.

A user-initiated E-Stop differs from a laser-initiated protective stop (they both are category 1 stop). The latter occurs when one or both of the AMR's safety scanning laser detects an object within its protected zone. In such cases, the AMR safely stops, and then resumes operation after a delay of at least two seconds, and after confirming that its protected zone is clear of obstacles.

An emergency stop initiated by pressing one of the E-Stop buttons, is a controlled stop function. In this case, the power to the AMR motors remains on in order to achieve a controlled stop. Once the controlled stop is achieved, the power to the motors is disconnected. If for any reason the controlled stop function fails or does not function as expected, the power will still be disconnected to the motors. Activating an emergency stop by pressing one of the E-Stop buttons requires manual deactivation of the E-Stop button, and manual reset of the AMR through the ON button for the AMR to restart its operation. The AMR will not automatically recover from an emergency stop initiated by pressing one of the E-Stop buttons on the AMR.

To use an E-Stop button:

1. Push firmly on the red button so that it latches.
2. Follow your site-specific emergency and safety procedures.

If you need to move the AMR manually after correcting the emergency condition, press and hold the brake release button and move the AMR. You can also use the pendant to drive the AMR manually, if it is safe to do so. In order to use the pendant, you must first release the E-Stop.

To enable the AMR's drive motors and put it back into service, follow the procedure described in: Releasing an E-Stop on page 19.

Releasing the Brakes

In case of an emergency or abnormal situation, the AMR can be manually moved. However, only qualified personnel who have read and understood this manual and the *HD-1500 Platform User's Manual (Cat. No. I645)* should manually move the platform. The brakes on the drive wheels can be released with the brake release button. This requires battery power, and an E-Stop must be pressed on the AMR.

NOTE: You should move the HD-1500 manually only when absolutely necessary during an emergency, for safety, or if it is lost or stuck. If you find that you must frequently move the HD-1500, use MobilePlanner to reconfigure its route to avoid problem areas.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

Using the brake release button while the HD-1500 is positioned on a slope of greater than 3% will cause the HD-1500 to roll down. You must not use the brake release button to move the HD-1500 manually, when positioned on a slope of greater than 3%, unless necessary precautions have been taken to prevent uncontrolled rolling of the HD-1500. The HD-1500 is not intended to be operated on ramps or sloped surfaces.



CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK

Pushing an HD-1500 requires significant effort and might cause personal injury or property damage. Take appropriate care and follow all safety instructions.



WARNING: PINCH RISK

Take necessary precautions when moving an AMR without its skins attached. The motor and motor assemblies will be exposed when the side skins are removed, exposing the potential pinch points. Refer to the following figure.

The rear and top of the AMR also pose pinch hazard when the rear skin and the top plate are removed.



Figure 2-6. Side Skin Removed - Exposing Motor and Motor Assemblies

Application-specific attachments can affect an AMR's stability. All operators should know the locations on the AMR (or its payload) where they can push safely without tipping the AMR over or damaging its components. This should be as low as possible and near the center of gravity.

OMRON recommends that you train personnel on the safe use of the brake release button, and procedures for safely pushing an HD-1500.



CAUTION: PERSONAL INJURY RISK

The pushing locations of the AMR are low. You must use safe pushing/pulling practices when manually moving the AMR.

Releasing an E-Stop

This section describes how to release an E-Stop and bring the AMR back into service.



CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK

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

To release an E-Stop:

1. Make sure that all surrounding areas are clear before you release the E-Stop button so that the AMR has room to maneuver.
2. Rotate the E-Stop button in the direction of the arrows on the button and allow it to pop up.
3. After you release the E-Stop button, you must enable the motors manually by pressing the green ON button on the operator panel.

After you enable the motors there is a delay of several seconds before the AMR can resume operation.

NOTE: If you manually move the AMR while it is powered off, it may not be able to determine its current location. Use the localization feature in MobilePlanner to localize the AMR.

Enabling motor power, either at the start-up or after an E-Stop release, must be done through a manual action at the system, and only after the operator has confirmed that it is safe to return the AMR to operation. Enabling the motor power must be an additional act after releasing an E-Stop, and it is done by pressing the Operator Panel's On button.

2.5 User's Responsibilities

You are responsible for continuous safe use of the AMR.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

Any modifications made to the AMR can lead to loss of safety or functionality of the AMR. It is the end-user's responsibility to perform complete risk assessment after making any modifications to the AMR, and to confirm that all safety features of the AMR are fully functional.



WARNING: PERSONAL INJURY RISK

It is the end-user's responsibility to perform a task-based risk assessment and to implement appropriate safety measures at the point of use of the AMR in accordance with local regulations.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

It is the end-user's responsibility to make sure that the AMR design and implementation complies with all local standards and legal requirements.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

It is the end-user's responsibility to make sure that the AMR is operated within its specifications, intended use, and intended environments.

Safe use of the AMR requires that you:

- Read the installation and operation instructions, in addition to the *HD-1500 Platform User's Manual (Cat. No. I645)*, before using the AMR.
- Review, and understand the safety protections (E-Stops, safety laser stopping distances, overhanging load, etc.) associated with your specific application and environment.
- Make sure that the environment is suitable for safe operation of the AMR.
- Make use of the Fleet Manager when two or more AMRs are used in the same environment, and are not confined to separate workspaces. See: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.
- Make sure that any person working with or near an AMR is trained, and has read the *HD-1500 Platform User's Manual (Cat. No. I645)* for safe AMR operation.
- Mechanically maintain and service AMRs for proper operation of all control and safety functions.

Electrical Hazards



WARNING: ELECTROCUTION RISK

The charging station has AC power inside. Its covers are not interlocked. You must disconnect the power prior to maintenance work.



WARNING: FIRE RISK, ELECTRICAL BURN RISK

The HD-1500 battery, and the charger outputs have high current. You must take appropriate precautions to avoid potential short circuit.

- Never access the interior of the platform with the charger attached.
- Avoid shorting the battery terminals or connectors.
- Do not use any charger or battery not supplied by OMRON. The charger shall only be used to charge an HD-1500 battery.
- The HD-1500 battery shall only be charged by an HD-1500 Charger.
- If any liquid is spilled on the AMR, power off the AMR, clean up all possible liquid, and allow the AMR to air dry thoroughly before restoring power. Contact your OMRON representative if you suspect that liquid has penetrated the skins or contaminated the AMR's interior.
- Avoid liquid near the charging station, and the AMR.
- Do not open the power supply box, electrician access box, or even the docking target until you have read the appropriate sections of this user's guide, and performed appropriate Lock-Out, Tag-Out (LOTO) procedure. See: Lock-Out, Tag-Out Procedure on page 35.

Magnetic Field Hazards

The rare-earth magnet embedded in the HD-1500 charging contacts create a strong magnetic field. Persons with medical implants must not approach the HD-1500. See the following figure for location of the charging contacts.



WARNING: MAGNETIC FIELD - MEDICAL IMPLANT RISK

Magnetic fields can be hazardous if you have a medical implant. Keep a minimum of 30 cm away from the HD-1500.

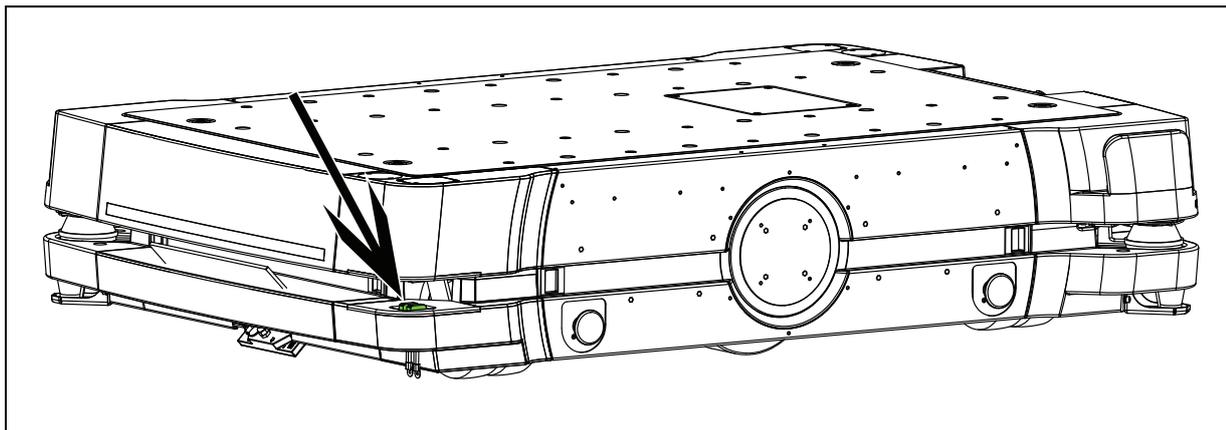


Figure 2-7. HD-1500 Charging Contacts Location

Burn Hazard



CAUTION: BURN RISK

The charging station and the charging contacts on both the docking target, and the AMR can get hot during the operation. The operator must allow for cool down prior to servicing.



CAUTION: BURN RISK

The AMR drive wheel motors can get extremely hot during the operation. The operator must allow the drive wheel motors to cool down prior to performing any maintenance work near or around them.

Qualification of Personnel

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 guide, and the *HD-1500 Platform User's Manual (Cat. No. I645)*, 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.

For example, replacing a battery is a task for a skilled person, while an instructed person can complete the task of charging a battery.

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

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

- Have the necessary qualifications and training.
- Have received the guides (both this user's guide, and the *HD-1500 Platform User's Manual (Cat. No. I645)*).
- Have read the guides.
- Understand the guides.
- Will work in the manner specified by the guides.

Payload Movement and Transfer

A typical AMR application uses a payload structure to transport objects within a facility. For example, the AMR might pick up and carry a crate of engine parts from one conveyor belt then deliver it to another conveyor belt.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

It is the end user's responsibility to ensure that the payload is properly secured to the HD-1500 platform, and that the payload does not experience any shifting during movement of the AMR. For example, when transporting containers of liquids, the operator must take necessary precautions to prevent sloshing of the fluid as it affects the stability of the AMR.

Intentional movement of the payload structure (such as conveyor or AMR arm) during the AMR movement is prohibited. It is the end-user's responsibility to design an appropriate interlock to prevent this.

During movement and transfer, you must actively monitor and confirm the transfer operation to make sure that it completes successfully. If any operation fails, a fail-safe interlock must trigger an AMR E-Stop condition. An E-Stop condition prevents the AMR from moving until you resolve the problem and confirm that it is safe to restart operations.

Your facility should provide such fail-safe interlocks between the AMR and any facility equipment with which it interfaces. After you attach your payload to the AMR, verify the correct operation of the fail-safe as part of your risk assessment.

Configurable Warning Buzzer

The HD-1500 has a configurable warning buzzer. You should configure this buzzer as appropriate for the facility in which the AMR will be operating. The warning buzzer is configured with MobilePlanner.

The buzzer must be audible above the ambient noise of the environment that the HD-1500 operates in. In environments with higher levels of noise, you may need to supply and install an additional warning buzzer to an appropriate location on the payload structure.

You can also configure the buzzer to activate in other specific situations, or to operate continuously whenever the AMR moves.

- Any time the AMR moves at a linear speed below 20 mm/s, or a rotational speed of less than 3 deg/sec for longer than 2 seconds. This is done to alert the users of a very slowly moving AMR which is not configured with hardware-based safety zones by default.

NOTE: The software-based obstacle protection is used regardless of the AMR speed.

- For 2 seconds prior to starting motion any time it has stopped moving for at least 10 seconds. This includes the first motion after start-up.
- For 2 seconds when an emergency stop or a protective stop from hardware-based safety zones is triggered.

NOTE: These parameters are only available with the Fleet Operations Workspace 1.1 and later.



CAUTION: PERSONAL INJURY RISK

Changing buzzer parameter values might make the AMR unsafe and affect its compliance to safety standards. Refer to the applicable safety standards for your locale before you change any parameter values.

Speakers

The HD-1500 is equipped with two speakers, located at the front of the AMR.

When speakers are used as a means of notifying personnel of an approaching AMR, you must routinely verify that they are still functioning normally. Verify that the speakers are audible, and the sound level is at the same level as needed during the operation.

Mechanical Brakes

Perform annual inspection of the mechanical brakes for proper function. Follow these steps to verify that the mechanical brakes engage and disengage properly.

Before you begin, make sure it is safe to manually move the AMR to an open area with level floor.

1. Connect the pendant to the AMR, and drive forward approximately 2 m in order to align the casters in the direction of motion.
2. Next, release the three-position enabling device to ensure that the AMR is in protective stop mode.
3. Then, press and hold the brake release button, and push the AMR straight forward. One or two people should be able to push an unloaded or lightly loaded platform. For a heavily loaded platform, you may need more people.

You will hear a click sound when the brake release button is pressed. The AMR should roll smoothly at this point. Contact your OMRON representative if the AMR does not move.

4. Next, release the brake release button and then try to push the AMR forward with the

same amount of force used in the last step. The AMR should not move.

5. If the AMR moves, stop using the AMR, and contact your OMRON representative.

Fleet Management

When two or more AMRs operate in the same workspace they may not be able to accurately detect each other or to precisely determine each other's dimensions. This is due to the fact that the AMRs' scanning lasers are positioned inside of the platform perimeter. There are channels along the front, rear, and sides of the platform that allow a clear line of sight for the scanning laser. When two similar AMRs approach each other their scanning lasers will detect the inner surface of that channel and not the outer perimeter of the other AMR. Operating an HD-1500 with any of its skins detached will worsen this effect. Typically this will not present a problem, however, in close proximity each AMR will plan its motion more accurately with information from the Fleet Manager about the position of the other AMR.

To manage and administer multiple AMRs in the same workspace, you must use a EM2100 appliance configured as a Fleet Manager, running the Fleet Operations Workspace (FLOW) software.

The Fleet Manager controls AMRs over a wireless network (WiFi), improving the efficiency of AMR operations by sharing the information between all AMRs in the fleet. The shared information includes: improving the efficiency of AMR operations.

- Dynamic position and heading (velocity and direction of travel) of the AMR.
- AMR size (including payload structure).
- Path planning information (the individual AMR's intended route).



CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK
Improper path planning can result in personal injury or property damage.

IMPORTANT: Do not leave an AMR that is not localized, not connected to the Enterprise Manager, or not powered on in a location that can be accessed by other AMRs.

AMRs factor this data into their path planning.

IMPORTANT: Fleet Manager is not an interlocked method of collision prevention. It is your responsibility to implement interlocked methods of collision prevention where necessary.

For operational redundancy and fail-over you can add a second EM2100. See the *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for more information.

Other Hazards

NOTE: Hazards specific to maintenance are covered in Safety Considerations when Performing Maintenance on page 33, and Safety Measures Prior and After Maintenance on page 35.

2.6 Risk Assessment

Safety standards in many countries require appropriate safety equipment to be installed as part of the system. Safeguards must comply with all applicable local and national standards for the location where the AMR is installed.



WARNING: It is the end-user's responsibility to perform a task-based risk assessment, and to implement appropriate safety measures at the point of use of the AMR in accordance with the local regulations.

Exposure

Based on the risk assessment performed by OMRON, the hazards associated with exposure to the AMR are minimal. However, these significantly rely on the awareness and training of the personnel around the AMR. Along with common sense, the following should be observed and practiced in order to avoid the minimal risks associated with exposure to the AMR.

- Do not ride on the AMR. Riding on the AMR or staying in the vicinity of the AMR for long periods (when ON or while charging) will expose you to the magnetic fields generated by the AMR.
- The users must be aware of the HD-1500 unprotected zones (operating hazard zones), and keep a safe distance from the AMR to prevent personal injury.

Severity of Injury

The severity of injury depends on the type of payload and how the payload is integrated with the HD-1500. The severity of injury increases with the mass of the payload. Follow all industrial safety practices, such as use of steel-toe shoes around the AMR, and adding additional protection like side lasers, etc. depending on how the AMR is configured, to reduce any work-related injuries.

Obstacle Avoidance

The AMR will avoid obstacles unless modified or the safety systems are intentionally defeated. The AMR has a dual-channel, safety-rated laser to avoid obstacles. OMRON offers side lasers option that enables the AMR to avoid obstacles and persons.

IMPORTANT: When the pendant is connected to the AMR, the operator must maintain control of the pendant and AMR at all times.

The HD Platforms are fully-autonomous AMRs that, once configured, work around people in industrial settings with no intervention needed. Risks associated with integrating the AMR in the industry can be avoided, with a few basic steps.

- Only trained personnel, who understand what the AMR does, should be in the vicinity of the AMR.
- Audio and visual alarms are built into the AMR. Do not modify these unless necessary.
- Additional safety measures may be implemented as deemed necessary by the integrator after risk assessment is completed.

Safety System Behavior

The standard control system is fully-hardened to all EMI influences. In addition, software monitors and controls all dual redundancy safety-rated features for certainty.

2.7 Environment

General Environmental Conditions

Make sure that the HD-1500's operating environment remains safe for the HD-1500.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

An AMR can be unsafe if operated under environmental conditions other than those specified in this manual.

- **Environmental Hazards**—These are areas where it is unsafe for the HD-1500 to operate. Provide physical barriers that the HD-1500 can detect accurately with its scanning laser so that it does not attempt to drive near the hazard. Be aware that in addition to being easily detectable, a barrier must be strong enough to resist a fully-loaded HD-1500 traveling at its maximum speed.
- **Restricted Zones**—These are zones of inadequate clearance which cannot be protected by the AMR detection devices. Only authorized persons are permitted to enter. You can use map features such as forbidden areas to keep HD-1500s within their designated area of operation. See the *Fleet Operations Workspace Core User's Manual (Cat. No. I635)* for information about editing your workspace map.
- **Operating Hazard Zones**—These operating zones are areas of inadequate clearance (less than 500 mm) between the sides of the AMR (or front/rear of the AMR) and an obstacle such as a wall that would not leave sufficient room for a person to escape and avoid getting crushed between the AMR and the obstacle. It can also be an area which cannot be protected by the AMR detection devices. These areas shall be clearly indicated by suitable signs or preferably floor markings. In this operating hazard zone, the AMR speed shall be in accordance with ISO 3691-4, and shall emit additional audible or visual warnings.
- **Confined Zones**—These are zones of inadequate clearance, and where the AMR detection devices may be omitted, at any speed. The confined zones shall be marked, and be enclosed with fixed guards that are at least 2.1 m high.
- **Load Transfer Stations**—These are the designated locations for load transfer. When the load transfer stations are outside the restricted or confined zones, these stations shall be designed to prevent personal injury by the rigid parts of the AMR or its payload. These

load transfer stations shall be designated as operating hazard zones as defined in this section of the manual.

Although the HD-1500's software provides the option of using the map features to keep the HD-1500 within its designated workspace, you must always install physical barriers where there is a risk of property damage or personal hazard.

Public Access

The HD-1500 is designed to operate in indoor industrial environments, and in presence of trained personnel. You must deploy it only in applications where you anticipate and mitigate potential risks to personnel and equipment.

OMRON intends for the HD-1500 to be used in controlled areas for which a risk assessment has been conducted. OMRON does not intend the HD-1500 to be used in, for example, areas open to general public access.

Operating Clearances

This section provides information regarding the side clearances, rotation clearances, and the docking clearances when operating.

Side Clearances

The HD-1500 is designed to operate in environments that contain doors, passageways, or other constrained areas that are wide enough for it to traverse.

However, you must maintain adequate *side clearance* (free space) on both sides of the AMR so that it cannot trap a person against a wall or other fixed object. Consult the applicable Autonomous Vehicle and Robotics operating standards for your locale.

An AMR must often maneuver close to machinery, conveyors, or other fixed objects. In such cases, operating standards usually allow an exception to side clearance requirements.

For information about software parameters that you can use to control the HD-1500's front and side clearance zones, see: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

Rotation Clearances

The HD-1500 travels in forward and backward directions. To change its direction, the HD-1500 rotates on its center of rotation (turns in place). The HD-1500 has a full safety coverage of 360°, and therefore, obstacles will trigger a safety system event when the AMR rotates.

The HD-1500's Light Discs as well as its front and back light strips display a distinct turn signal pattern when it rotates.

Docking Clearances

You should set a 2.5 m distance between the docking target (the goal defined in the map) and the dock goal position of the AMR. This distance provides sufficient room for the AMR to align with the docking target when docking. See: Figure 2-8. and Figure 2-9.

When docked, the distance between the AMR and the docking target is less than 500 mm, and therefore, this area is considered to be a hazard zone.

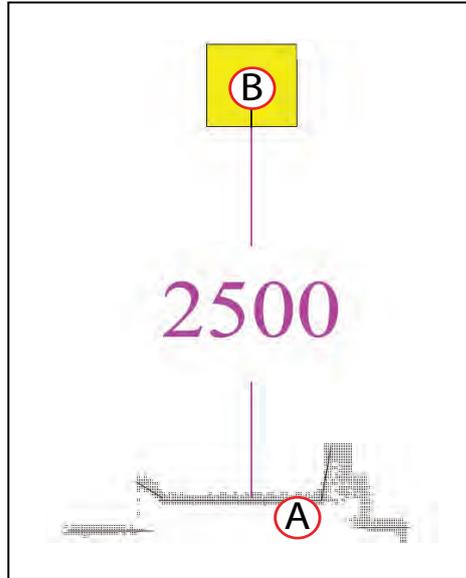


Figure 2-8. Goal Position - Measured From the Center of the Docking Target to the Center of the HD-1500, (A) Docking Target, and (B) HD-1500

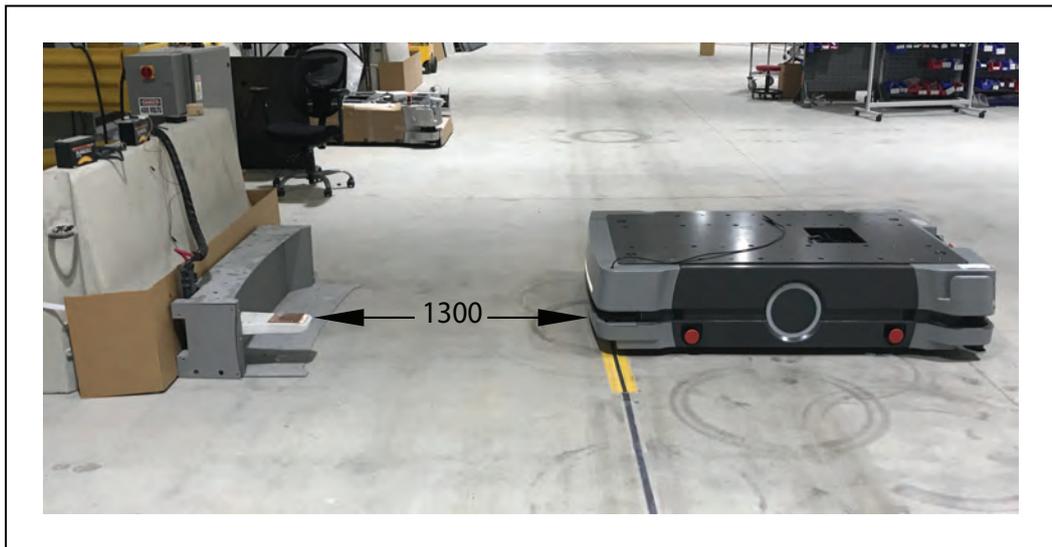


Figure 2-9. Goal Position - Measured from the Front Face of the HD-1500 to the Charging Paddle

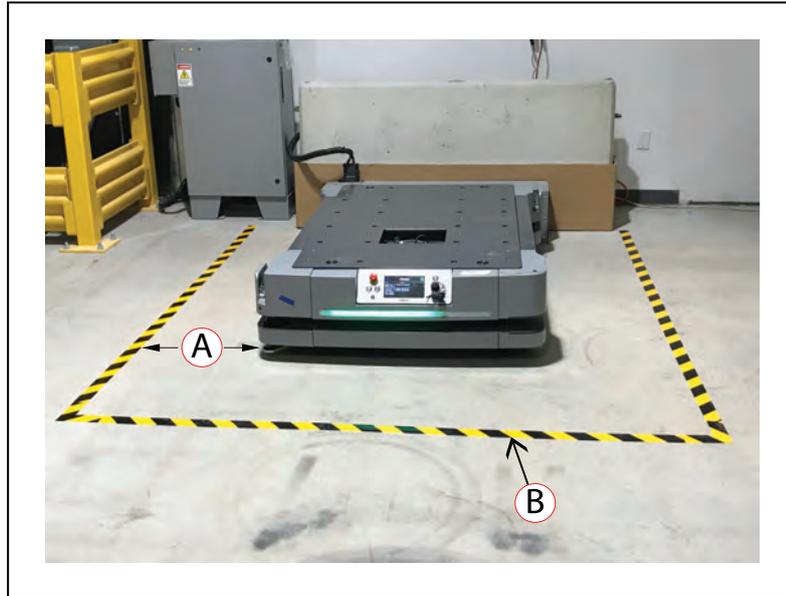


Figure 2-10. HD-1500 Docked with the Docking Target, (A) 500 mm, and (B) Floor Marking

Obstacles

Before an AMR enters a high-traffic area, you must take appropriate precautions to alert people working in those areas:

- The HD-1500 provides programmable warning features such as a warning buzzer, speech synthesis, and warning indicator lights.
- The user access panel provides user ports that enable you to add warning indicators to your payload structure.

If high-traffic areas include other moving vehicles such as fork-lift trucks or autonomous moving machines, consider adjusting the AMR's operating parameters to reduce the risk of a collision. You can do this by:

- Editing the workspace map to include features that restrict the AMR's operation in specific areas, such as preferred lines, resisted areas, and movement parameter sectors to reduce speed.
- Editing the AMR's configuration to affect its behavior in all locations, such as restricting its maximum speed.

Additional Information: For more information, see: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

IMPORTANT: The safety scanning laser password, required to make any safety-critical changes to the safety scanning laser configuration, can be changed by the user. The user can change the password to limit access by unauthorized users. For instructions on how to change the password, refer to *Safety Laser Scanner OS32C Series User's Manual (Cat. No. Z296-E1)*.

2.8 Intended and Non-intended Use

Intended Use

The intended use of the HD-1500 is to navigate autonomously in indoor industrial environments, and reach the specific locations it is deployed to. The HD-1500 is capable of transferring a payload of up to 1500 kg. You must ensure that the payload structure does not extend beyond the HD-1500's footprint. The center of gravity (CG) of the combined mass of the payload structure (including all onboard tooling and loads being transported) must be within the specified CG limits. The CG limits must be observed to ensure stability when loading and unloading the AMR. See: Center of Gravity (CG) on page 60.

OMRON does not provide the method of loading the payload onto or off the HD-1500. It is the end user's responsibility to perform a complete task-based risk assessment in accordance with EN ISO 12100, and ensure safe transfer of the payload. The HD-1500 shall be commissioned as instructed in this manual.

The HD-1500 is designed to operate in indoor industrial environments. This includes structured or semi-structured workplaces such as warehouses, distribution and logistics facilities where general public access is restricted. The environment must be flat and level (maximum of 3% grade), free of clutter and debris, and with wide enough doorways to be navigable by an HD-1500. The HD-1500 can operate at its maximum speed through a 2200 mm opening, and will traverse at a slower speed through a 2100 mm opening.



DANGER: PERSONAL INJURY RISK

Improper operation of the AMR on inclined floors that do not comply with the applicable operating specifications can result in the AMR tipping over, and consequently a serious personal injury.

The following guidelines apply:

- **Floor**—Clean and dry floors that you sweep regularly and routinely keep free of debris, dust, and liquids.
- **Temperature**—5 to 40°C with a humidity range of 5% to 95%, non-condensing. Operating the HD-1500 at high or low ambient temperatures (particularly with a full payload and high speeds) can cause the battery to exceed its operating temperature limits.
- **Altitude**—Up to 2,000 m.

The HD-1500 has an ingress protection rating of IP20. Do not expose the HD-1500 to liquid.

Non-Intended Use

When deploying an AMR, anticipate potential risks to personnel and equipment. OMRON intends the HD-1500 for use in a carefully controlled and managed environment with restricted access granted only to authorized and trained personnel.

You must conduct a risk analysis before you deploy the HD-1500 in a new environment. Application of the HD-1500 in environments other than those described in the preceding paragraph generally requires additional safety measures.

OMRON does not intend the HD-1500 for deployment in environments that contain:

- Hazardous (explosive or corrosive) atmospheres.
- Ionizing radiation.
- Intense interference light, such as direct sunlight.
- Extreme heat or humidity.
- Inclined floors or ramps.
- Soft surfaces such as carpet.
- Floors that are damp or have any standing water.

IMPORTANT: The HD-1500 is not intended to operate in a damp/wet environment where it will be exposed to liquid or liquid ingress.

In addition, OMRON does not intend the HD-1500 for deployment in the following environments:

- Outdoor or uncontrolled areas without risk analysis.
- Environments with general public access.
- Life-support systems.
- Residential areas.
- Non-stationary areas, including moving floors or any type of land vehicle, watercraft, or aircraft. (HD-1500 navigation is assisted by sensing embedded in the AMR Controller that requires a stationary environment to be effective.).

IMPORTANT: You must always observe the instructions for operation, installation, and maintenance provided in this guide and in the *HD-1500 Platform User's Manual (Cat. No. I645)*.

Other non-intended use of the HD-1500 includes:

- Towing applications.
- Personnel riding vehicle.

IMPORTANT: The HD-1500 is not intended to be used with a battery that is not supplied by OMRON. Additionally, it is not intended to be charged by any charger other than the OMRON charging station.

Non-intended use of an HD-1500 can:

- Cause injury to personnel.
- Damage the HD-1500 or other equipment.
- Reduce reliability and performance.

If there is any doubt concerning the application, contact your OMRON representative for support.

HD-1500 Platform Modifications

OMRON recognizes that end-users or integrators make modifications to the HD-1500 to adapt it to a specific application. When doing so, make sure that:

- You use the User Safety Interface connection located on the user access panel, to include appropriate safety devices into the HD-1500's integrated safety systems.
- The modification causes no hazardous sharp edges, corners, or protrusions and does not extend further than the HD-1500 footprint. If the modification causes extension beyond the HD-1500 footprint, you must contact your OMRON representative for assistance with modifying the safety zones.
- The final design of the HD-1500 meets all relevant local and national safety standards, and requirements for the new intended use.
- There is no reduction in functionality.
- All safety features (such as lasers and brakes) are functional and operate within the specifications determined by local product safety standards for AMRs.
- You add additional safety features if determined to be necessary based on risk assessment results.
- You perform proper risk assessment in accordance with EN ISO 12100, and identify any risks associated with the modification made to the HD-1500 platform. It is the end-user's responsibility to ensure that these risks are properly mitigated/eliminated, so the AMR does not cause personal injury or property damage.

2.9 Safety Considerations when Performing Maintenance

This section describes important safety considerations when maintaining your AMR.

Prior to performing maintenance work on your AMR, you should make sure that the area you will be performing maintenance in, can not be interrupted by other AMRs and is adequately protected.

IMPORTANT: Only skilled or instructed persons, as defined in this manual, should perform the procedures and replacement of parts covered in this section.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

When working near the encoder cables, take care not to disconnect or damage them. Improper connection or disconnection of encoder cables may result in erratic motion of the AMR during operation. The AMR might rotate uncontrollably during loss of encoder signals.

Electrical Hazards



WARNING: ELECTROCUTION RISK

During maintenance and repair, you must turn off power to the charging station. Remove and lock up the power cord along with all other electrical inputs to prevent unauthorized third parties from turning on power. The access covers on the charging station are not interlocked.



WARNING: ELECTROCUTION RISK

There are no user-serviceable parts inside the charging station. Do not remove the covers of the charging station. There is high voltage inside, and the covers are not interlocked.



WARNING: FIRE RISK, ELECTRICAL BURN RISK

The HD-1500 battery, and the charger outputs have high current. You must take appropriate precautions to avoid potential short circuit.

Electrical Hazard Precautions

- There are no user-serviceable parts inside of the battery. Do not open the battery.
- Do not use any charger not supplied by OMRON.
- If the AMR comes into contact with any liquid:
 1. Power off the AMR.
 2. Clean off as much liquid as is possible.
 3. Allow the AMR to air dry thoroughly before restoring power.
 4. Contact your OMRON representative if you suspect that liquid has penetrated the skins or contaminated the AMR's interior.

Burn Hazard



CAUTION: BURN RISK

The charging station and the charging contacts on both the docking target, and the AMR can get hot during the operation. The operator must allow for cool down prior to servicing.



CAUTION: BURN RISK

The AMR drive wheel motors can get extremely hot during the operation. The operator must allow the drive wheel motors to cool down prior to performing any maintenance work near or around them.

ESD Hazards



CAUTION: PROPERTY DAMAGE RISK

The electrical charge accumulated on the HD-1500's skins does not have a path to ground, and therefore can not discharge. This can be hazardous to electrostatic sensitive devices. Users must keep the electrostatic sensitive devices at least 30 cm away from the AMR skins.

2.10 Safety Measures Prior and After Maintenance

Prior to performing maintenance work (safety inspection, cleaning, removing parts, installing parts, etc.), following safety measures must be taken:

- Ensure that the AMR has come to a complete stop, by pressing an E-Stop button.
- Power off the AMR by pressing the **OFF** button on the Operator Panel.

Once maintenance work has completed, and the AMR is ready for use, press the **ON** button on the Operator Panel.

Lock-Out, Tag-Out Procedure

You must complete the appropriate Lock-Out, Tag-Out (LOTO) procedure prior to any maintenance work on the charging station or the AMR.

The following sections describe the LOTO procedure for the AMR, and the charging station.

LOTO Procedure for the AMR

Follow this LOTO procedure for the AMR:

1. Prepare the AMR for shutdown. You must make sure that the AMR is in a safe location, and that there are no hazards near it. There must be sufficient clearance around the AMR to allow for safe maintenance work.
2. Press an E-Stop button.
3. Shutdown the AMR by pressing the **OFF** button on the Operator Panel.
4. Turn the AMR main disconnect switch to OFF position (horizontal position). The AMR main disconnect switch is located on the Operator Panel.

You must lock the main disconnect switch, and tag according to your facility requirement and regulations.

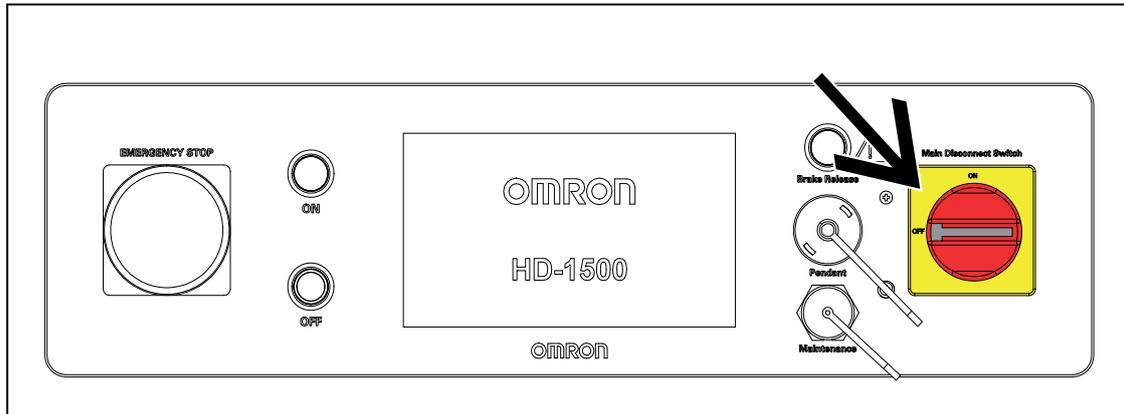


Figure 2-11. AMR Main Disconnect Switch Located on the Operator Panel

- Each motor controller is equipped with a capacitor that stores energy. You must check and make sure that the voltage left is less than 7 V. Probe the appropriate connector pins on the module displayed in Figure 2-12. using a digital multimeter. Prob the back of the pin 4 (positive), and pin 3 (negative) as shown in Figure 2-13.



WARNING: ELECTRICAL SHOCK RISK

Do not perform maintenance work on the AMR until the measured voltage is below 7 V.

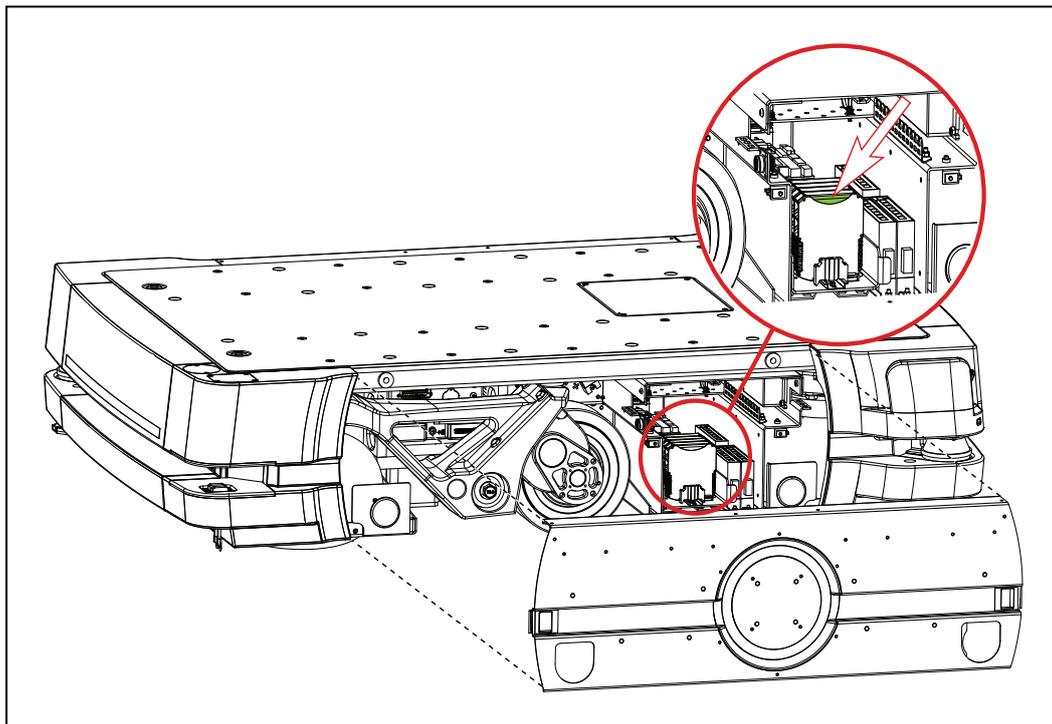


Figure 2-12. Location of the Module to be Probed

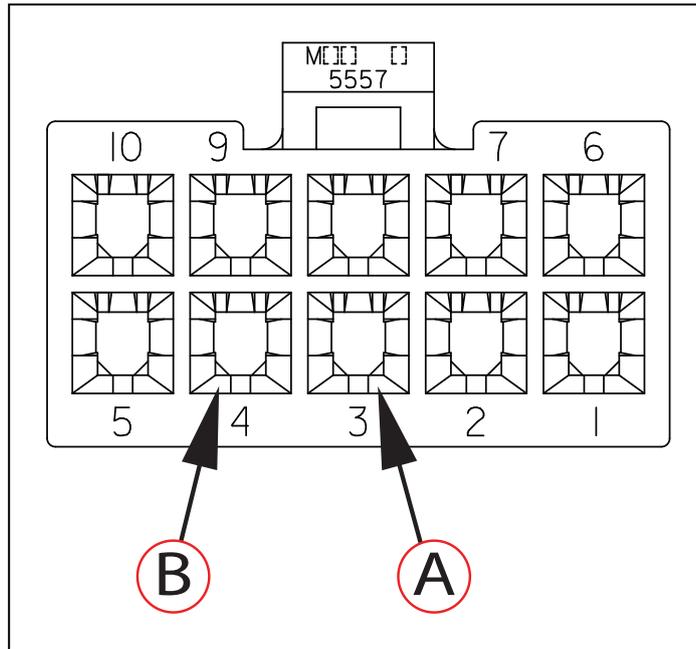


Figure 2-13. Module Connector Configuration - Viewed from the Rear, (A) Pin 3 (Negative), and (B) Pin 4 (Positive)

- Continuously check and verify that the AMR is de-energized by pressing the ON/OFF button on the Operator Panel.

LOTO Procedure for the Charging Station

Follow this LOTO procedure for the charging station:

- Turn the power off. You can do this by switching the main disconnect switch, located on the electrician access box, to **OFF** position.

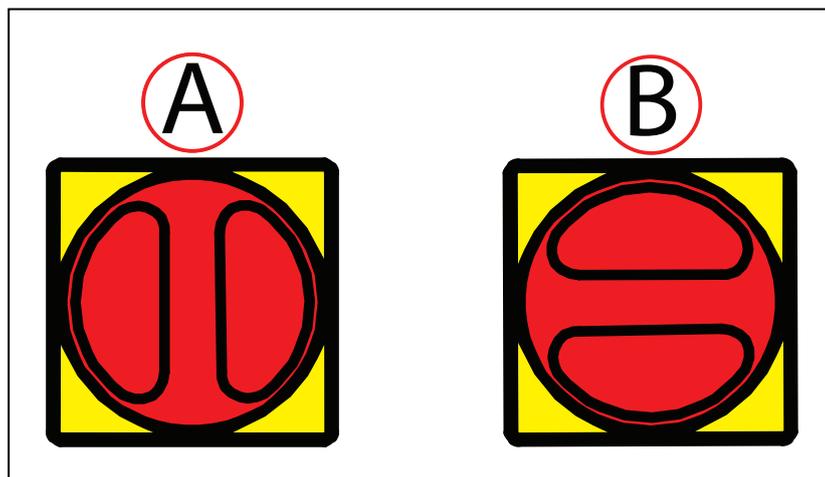


Figure 2-14. Main Disconnect Switch on the Electrician Access Box, (A) ON Position, and (B) OFF Position



Figure 2-15. Main Disconnect Switch Placed in OFF Position

2. Lock the main disconnect switch as displayed in the following figure. The type of lock used depends on your needs, and your facility LOTO requirements. You may also add your name to the lock, or have multiple names on the lock. This lets other users know who has locked the power supply box in case they must get in touch with that person.



Figure 2-16. Main Disconnect Switch Locked

3. Verify that the power is off. You can do this by checking the LED indicators, located on the power supply box. When there is no power going through the power supply box, the

blue LED is off.

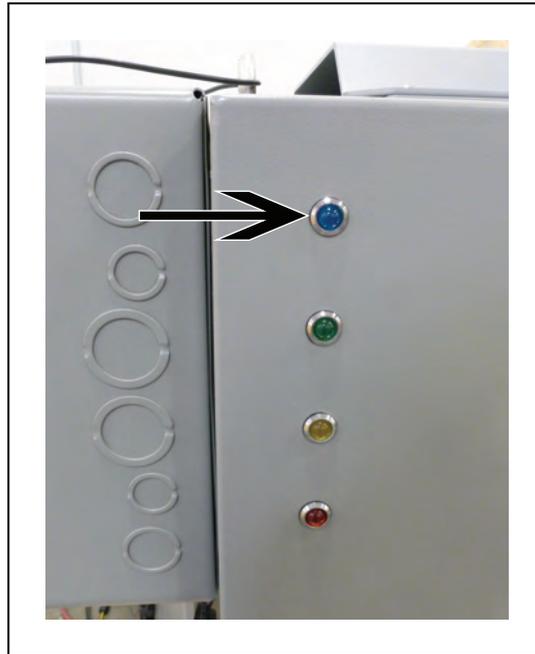


Figure 2-17. Blue LED Off

2.11 Safety Inspection

Safety and Warning Devices

Perform inspections of the following safety and warning devices for proper function.

The E-Stop buttons and the mechanical brakes must be inspected annually. The speakers must be inspected as needed. The rest of the warning devices listed in this section must be inspected weekly.

Flashing Light

Each AMR must have a readily visible flashing light, to serve as a warning whenever the AMR is ready to move or is moving. The exact nature of this light will vary depending on the design of the payload structure. For more information refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.

Light Discs

Check the light discs on each side of the AMR for proper function. Refer to *HD-1500 Platform User's Manual (Cat. No. I645)* for more information.

Front and Back Lights

Check the front and back lights of the AMR for proper function. For more information refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.

Buzzer

Check the warning buzzer for proper function. To comply with applicable standards, it is important that the buzzer be audible in all operating conditions and environments. The buzzer must exceed the ambient noise at the end use application. See also: Configurable Warning Buzzer on page 23.

Speakers

When the speakers are used as a means of notifying personnel of an approaching AMR, you must routinely verify that they are still functioning normally. Verify that the speakers are audible, and the sound level is at the same level as needed during the operation.

E-Stop Buttons

Inspect the E-Stop buttons for any sign of physical damage, and check for proper function.

Mechanical Brakes

Check the AMR mechanical brakes at least once a year, and make sure that the mechanical brakes properly engage and disengage. For instructions on how to perform the inspection, refer to the *HD-1500 Platform User's Manual (Cat. No. I645)*.

Warning Labels

The only warning labels that are shipped with the HD-1500, unattached to the platform, are the No Riding labels. All other labels are installed in the factory.

For information on where to attach the No Riding labels, refer to the *HD-1500 Platform User's Manual (Cat. No. I645)*.

Any additional safety labels for the payload structure or specific to the end-use application shall be evaluated by the user as part of the risk assessment.

2.12 Protective Stops Initiated by AMR Safety Lasers

Under certain conditions, the AMR safety systems might cause a protective stop.

For example, an AMR reacts to obstacles in its path by slowing and, if necessary, stopping safely. It then either plans a new path around the obstacle or (if the obstacle has moved) resumes its original path. The safety lasers initiate a protective stop any time they detect unavoidable obstacles in the AMR's path.

During the protective stop, the AMR decelerates to a stop at the maximum allowed rate. It then removes power to its motors and engages the brakes.

NOTE: A protective stop initiated by an intrusion into a safety laser's protection field differs from pressing an E-Stop button. After you press an E-Stop button, you must first resolve the problem and then manually resume AMR operation. See: What to Do in an Emergency on page 16.

Other circumstances might cause a protective stop, such as:

- User-supplied sensors connected to the Safety Controller.

After the AMR comes to a complete protective stop caused by laser protection zone intrusion, it waits a minimum of two seconds before it resumes operation. No user intervention is necessary and the AMR does the following:

1. Verifies that there is adequate space to maneuver.
2. Plans a local path deviation around the obstacle and resumes its operation.

This may cause the AMR to turn around, and move in a different direction. If no such path is available, the AMR fails the current job, and waits for the Fleet Manager to assign a new job.

2.13 Safety System Overspeed Faults

The HD-1500 has an independent safety system that uses a Machine Automation Controller (Safety Controller) to redundantly monitor its velocity. This device makes sure that the AMR always operates within the speed limits.

If the AMR operates outside the specified velocity limit, its Safety Controller reports a Channel 1 or Channel 2 system fault to its operating firmware and begins an emergency stop (E-Stop) sequence. The fault causes the AMR's motion controllers to execute a controlled stop (stop category 1).

If motion is already disabled (for example, an E-Stop button is engaged) and you override the brake release, the safety system cannot stop the AMR. This is because power to the drive motors is already disabled. After you resolve the error condition, the safety system stops reporting the safety fault to the motion controllers. At this point the safety system allows for the normal start-up process to begin but it does not automatically restart the AMR's operations.

Additional Information: Motion control configuration parameters in the ARAM software (such as *AbsoluteMaxTransVel* parameter) limit the maximum allowable velocities. Use MobilePlanner to modify the value of these parameters. See: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*.

When the HD-1500 protective stop is engaged, Polo commands a controlled stop at the highest deceleration allowed. During the deceleration process, the Safety Controller continuously monitors the deceleration. If the AMR is not able to stop quickly enough, the Safety Controller disables the drive motors and engages the mechanical motor brakes in order to stop the AMR. The motor brakes are powerful enough to stop a fully loaded HD-1500 traveling at its top speed. However, engaging the mechanical motor brakes to stop the AMR is not a typical function. In the unlikely event that this occurs, you receive an error message in MobilePlanner, and at the Operator Panel, which should not be ignored. This error can occur if:

- the HD-1500 software fails to command a controlled stop (for any reason).
- the floor is excessively slippery, and does not provide good traction.
- the AMR is traveling down a slope steeper than its specified capability.

There may be other reasons for why this error occurs. A single occurrence of this error may not cause a serious problem, however, repeated occurrence of this error should be investigated. If this error occurs multiple times a day, contact your OMRON representative for support.

The use of the mechanical motor breaks to stop the AMR too many times will reduce the effectiveness of the motor brakes. This increases the distance required for the AMR to come to a full stop.

If this error happens enough, MobilePlanner will present a stronger warning after each occurrence. If the problem is not resolved, the AMR may stop operating in order to prevent the use of the potentially degraded brakes. Generally the degradation of the motor brakes requires hundreds of occurrences.

2.14 Laser Safety

The safety scanning lasers, optional side lasers, and Low Lasers are all Class 1 lasers. The Class 1 laser, which is an invisible laser radiation, is safe under all conditions of normal use.

However, the maximum permissible exposure cannot be exceeded when viewing the laser with the naked eye. OMRON recommends that you avoid long-term viewing of the laser.

2.15 Interlock Switches

The HD-1500 is equipped with the interlock switches located on the battery door, and the AMR side skins. The interlock switches continuously monitor and ensure that the battery door, and the side skins are properly attached to the platform. This is to ensure that the battery compartment as well as the electronics bay enclosure are isolated, and protected from unauthorized/unsafe access. If the battery door, or any of the side skins opens or get removed, the interlock switches disable the AMR's motion and disable power to the main bus bars.



CAUTION: BURN RISK

Do not touch the AMR drive wheel motors when the side skins are removed, as the drive wheel motors can get extremely hot during the operation. You must allow sufficient time for the drive wheel motors to cool down prior to coming into contact with them.

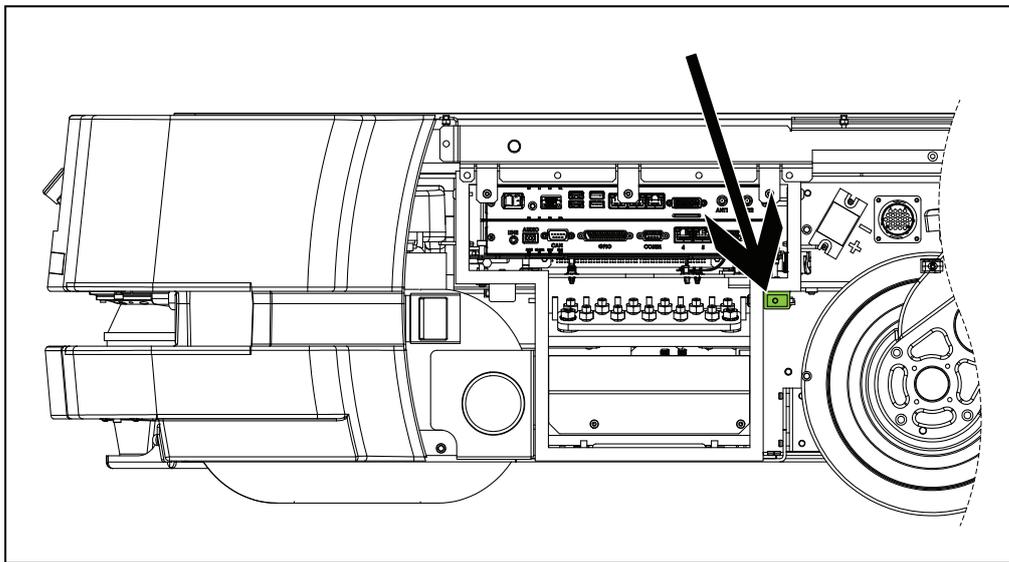


Figure 2-18. Location of the Interlock Switch on the Electronics Bay Access Door Frame

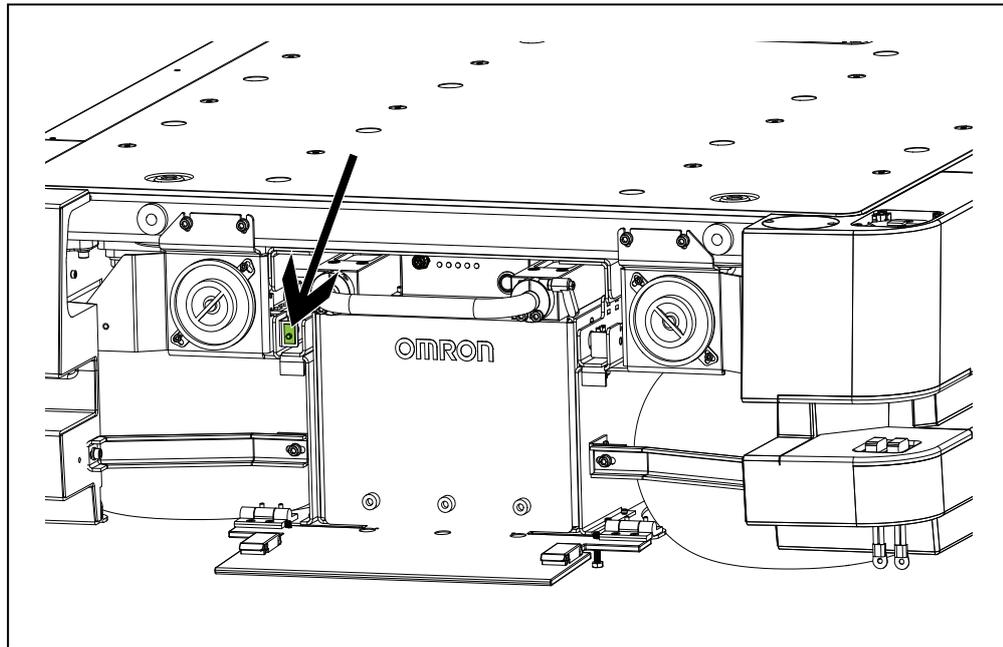


Figure 2-19. Location of the Interlock Switch on the Battery Door Frame

To restore power to the main bus bars, you must:

- Re-install the removed skin, or
- If the battery door was opened, close the battery door.

Once the above is done, the AMR will return to its normal operating mode.

IMPORTANT: If you remove the side skins or open the battery door while the HD-1500 is docked, and is charging its battery, the charging will stop. Once the removed skin is re-installed or the battery door properly closed, the charging will not re-engage automatically. The AMR must repeat the normal docking process for autonomous charging, and re-start charging.



WARNING: ELECTRICAL SHOCK RISK, FIRE RISK, BURN RISK

The interlock switches shall not be defeated or bypassed as this would energize the AMR, and expose the user to potential electrical hazards.

2.16 Battery Safety

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

NOTE: After receiving the battery, check its state of charge by pressing and holding in the push-button on the battery indicator. If the battery is in a low charge state, you must immediately charge to a full charge to avoid discharging the

battery below a usable state, which would require battery replacement. For information on the battery indicator, refer to the *HD-1500 Platform User's Manual* (Cat. No. I645).

Battery Safety Precautions

This section provides safety information and precautions when storing, transporting, and removing/installing the battery.

Storage

Store the batteries within the following temperature range:

- -20 to 35°C, 5-95% RH non-condensing

For transportation of up to 2 weeks, the manufacturer recommends:

- -20 to 60°C, 5-95% RH non-condensing

Storage Position

The batteries must be stored as displayed in the following figure. You must not lay the batteries on their sides, top, front or rear end.

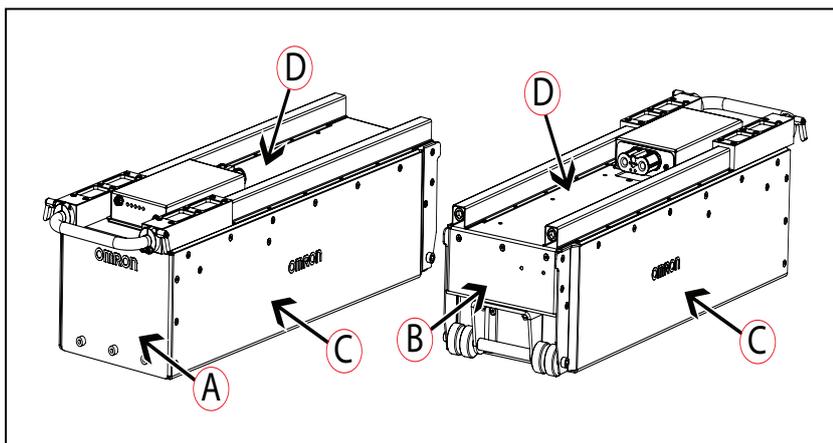


Figure 2-20. Position of the Battery for Storage

ID	Description	ID	Description
A	Front of the battery	C	Side of the battery
B	Rear of the battery	D	Top of the battery

Environmental Considerations

- Batteries stored at temperatures greater than 35°C or less than -20°C must stabilize for 4-8 hours until within the nominal operating temperature before use.
- Store the batteries on a flat surface, and in an area free of vibration.
- Do not stack anything on top of the batteries.
- Never expose the battery to water. If the battery is leaking, use a chemical neutralizer

(such as HF ACID EATER) to absorb the electrolyte. Then, clean up the electrolyte and the chemical neutralizer using a dry cloth, and put the cloth in a bag.

You should place the leaking battery in a bag or a drum containing the chemical neutralizer, and contact your OMRON representative.

IMPORTANT: You must wear proper PPE when working around a leaking battery.

IMPORTANT: Follow the appropriate disposal guidelines for your locale.

- Do not store in direct sunlight or near other heat sources.
- Do not store the batteries in a flammable environment.
- In case of fire use foam, dry chemical, ABC, AB, powdered graphite, copper powder or CO₂.

Battery Removal/Installation

Removal or installation of the battery must be performed by persons who have read and understood this manual as well as the *HD-1500 Platform User's Manual (Cat. No. I645)*. Refer to *HD-1500 Platform User's Manual (Cat. No. I645)* for instructions on how to replace the HD-1500 battery.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

If removal/replacement of the battery is not handled with care or in accordance with instructions provided in this manual, it can cause serious injury to personnel or damage to itself or other equipment.



WARNING: PERSONAL INJURY RISK

Use safe lifting practices when removing or installing the battery. See the battery lift points below:

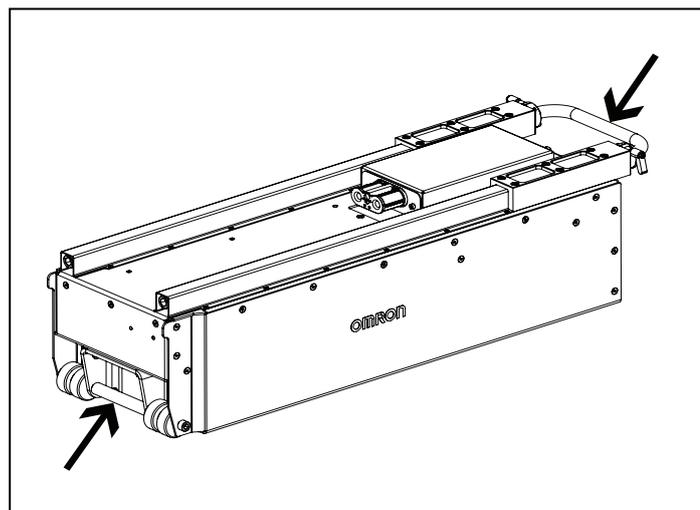


Figure 2-21. Battery Lift Points

IMPORTANT: The battery weights 68 kg. There must be at least 3 persons lifting the battery. For rolling the battery around, one person is sufficient.

Operating the AMR at high ambient temperatures (particularly when carrying a full payload at high speeds) can cause the battery to exceed its operating temperature limits. If this happens, do not try to access the battery. You must allow several hours for an overheated battery to cool sufficiently before trying to remove/replace it.

Battery Maintenance

Every six months:

- Inspect the battery for damage or leaks.
- Connect the battery to a charger and allow to fully balance (battery indicator shows all solid blue LEDs when the state of charge is $\geq 80\%$).

2.17 Charging Station

The HD-1500 charging station consists of two main parts; the power supply box, and the docking target which the AMR drives itself into. The charging station provides both manual and automated methods of recharging the AMR's battery.

The power supply box outputs a maximum of 6.84 kW of power, and can charge a fully depleted battery pack in 40 minutes.



WARNING: FIRE RISK, ELECTRICAL BURN RISK

The HD-1500 battery, and the charger outputs have high current. You must take appropriate precautions to avoid potential short circuit.



WARNING: ELECTRICAL SHOCK RISK

The charging station transfers high electric power, and contains hazardous voltage. The user must take necessary precautions when working near the charging station, and follow appropriate Lock-Out, Tag-Out (LOTO) instructions prior to any maintenance work done on the charging station.

Due to high power transfer, OMRON has taken several safety measures to keep the users safe:

- The electrician access box has a main disconnect switch, as displayed in Figure 1-1. When the user turns the main disconnect switch ON, the access door locks automatically, and prevents access to the interior of the electrician access box. This is to block access to the hazardous electrical circuits in the electrician access box.
- The main electrical compartment door can only be accessed with a key; this prevents unauthorized access to the main electrical compartment.
- When the HD-1500 engages with the charging paddle, the docking target performs a voltage check. It verifies that the HD-1500 is present before it begins charging the HD-

1500's battery. The docking target ensures that the voltage presented is between 40 to 57 volts. It also uses a detection sensor to verify the presence of the HD-1500.

The power supply box uses a 4 meter long power cord (25.4 mm diameter) to transfer power to the docking target.



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

You must route, and secure the power cord properly. It must be secured in such a way that prevents straining of the connection points. There must be a physical protection that prevents the tripping hazard and cable crushing.

If the power cord is laid on the ground, use a visible cover (e.g. yellow and black tripped cover) that goes over the power cord, and prevents crushing of the power cord.



WARNING: HOT SURFACE HAZARD

The docking target charging contacts heat up during the charging process. Take necessary precautions to avoid burn dangers.

Safety Precautions

Lock-out, Tag-out (LOTO)

Prior to any maintenance work on the charging station, you must perform Lock-Out, Tag-Out (LOTO) procedure. For information on how to perform LOTO, see: Lock-Out, Tag-Out Procedure on page 35.

Decommissioning

Follow these steps to discontinue the operation of a power supply box, and remove it from service:

1. Cut the facility power to the power supply box through the facility disconnect switch, and confirm that the blue LED is off.
2. Turn the power supply box main disconnect switch to OFF position as displayed in the following figure.

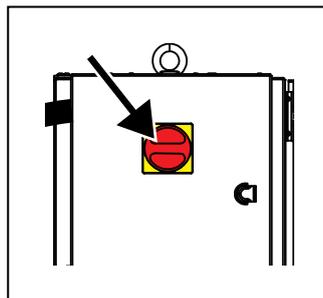


Figure 2-22. Main Disconnect Switch in OFF Position (Horizontal Position)

3. Then, remove the facility power cable from the electrician access box.

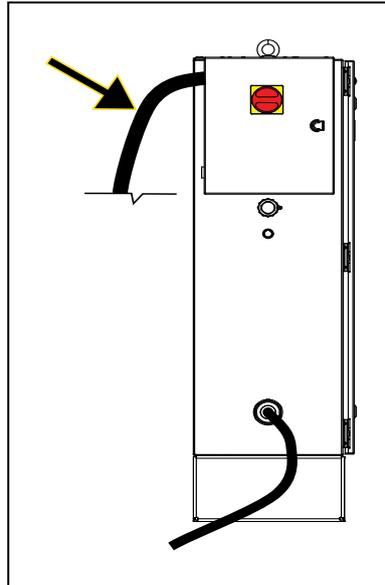


Figure 2-23. Facility Power Cable

Commissioning

Follow these steps to commission the power supply box:

1. Prepare the facility AC supply, and its disconnect switch.
2. Make sure that the facility power is in off state.
3. Wire the facility power to the electrician access box as instructed in the *HD-1500 Platform User's Manual (Cat. No. I645)*. You must make sure to adjust the jumpers as required for the voltage range.

To connect the facility power cable to electrician access box you must punch a hole through the electrician access box, and install a proper strain relief or conduit for the facility power cable used.

4. Once the wiring is complete, and the facility power cable is connected to the electrician access box, you can enable the facility power through the facility AC supply switch.
5. Confirm that the disconnect switches inside the electrician access box are in ON position.

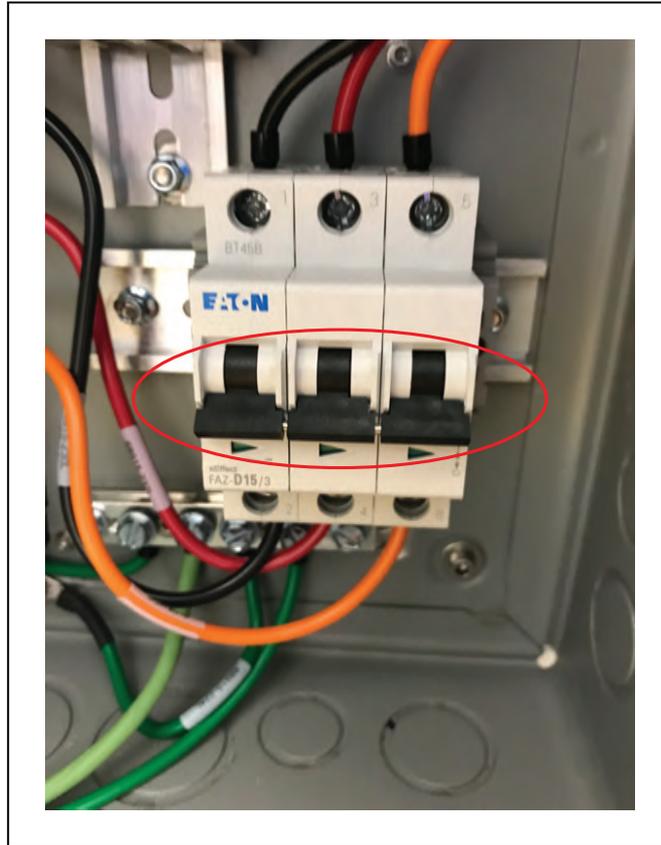


Figure 2-24. Disconnect Switches in the Electrician Access Box - ON Position

6. Turn the power supply box main disconnect switch (located on the electrician access box) to ON position (vertical position). This will allow the facility AC power to run through the power supply box.

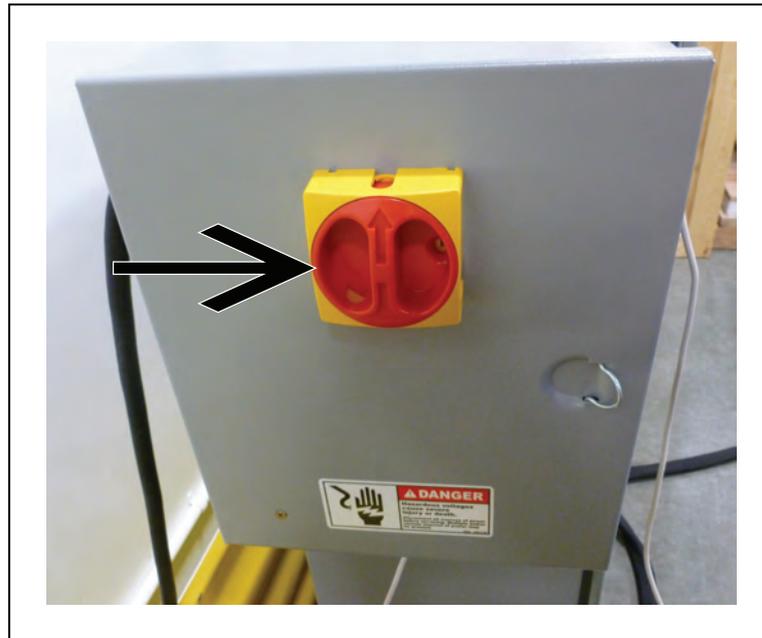


Figure 2-25. Main Disconnect Switch - ON Position

7. Next, confirm that the blue LED on the power supply box comes on.

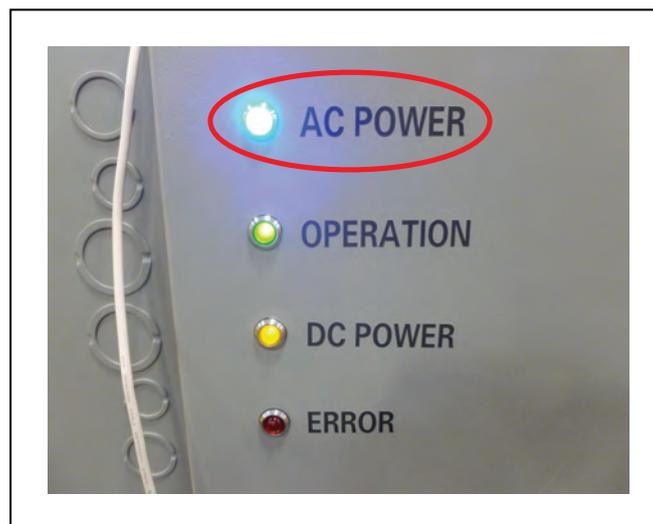


Figure 2-26. Power Supply Box Blue LED On

Installation

You must follow the instructions provided in this document for safe and correct installation of the charging station. Consider the following safety measures for power supply box installation:

- The power supply box and the docking target must be properly secured to the wall or floor prior to start-up. For instructions on how to install the power supply box and the docking target refer to the *HD-1500 Platform User's Manual (Cat. No. I645)*.

**WARNING: PERSONAL INJURY RISK**

Improper installation of the power supply box could result in tipping hazard. You must make sure that the power supply box is safely and properly installed.

- For instructions on how to safely move the power supply box refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.
- The power supply box must be installed according to the local regulations or codes, and by authorized personnel or licensed electricians.

**WARNING: ELECTRICAL SHOCK RISK**

Improper installation of the power supply box could result in electrical shock hazard. You must ensure of the safe and proper installation of the power supply box in accordance with the applicable rules and regulations, and by qualified personnel.

Storage

- Store both power supply box and the docking target at: -20 to 60°C
- Humidity: 5% to 95%, non-condensing

Environmental Considerations

- In case of fire, use a class C extinguisher: foam, dry chemical, or CO₂.
- IP rating for the power supply box is IP20.
- IP rating for the docking target is IP20.

NOTE: The IP rating for the copper charging pads is IP10. Do not expose them to liquid.

2.18 Payload Structure

A payload structure is any mechanical equipment that you attach to the HD-1500 for the purpose of performing a task. It might be as simple as shelves to receive bins of parts or as complex as a robot arm. In some cases, OMRON designs and constructs a custom payload structure for a specific application. In most cases the OMRON customer or an integrator designs and implements their own payload structure.

The HD-1500 provides the mobility and navigation for the payload structure together with the electrical power and data signal connections required to operate a payload structure. This chapter describes considerations and requirements when designing payload structures for the HD-1500.

Safety

Warning Labels

The only warning labels that are shipped with the HD-1500, unattached to the platform, are the No Riding labels. All other labels are installed in the factory.

For information on where to attach the No Riding labels, refer to the *HD-1500 Platform User's Manual (Cat. No. I645)*.

Any additional safety labels for the payload structure or specific to the end-use application shall be evaluated by the user as part of the risk assessment.

Warning Lights

Your HD-1500 must include warning lights appropriate for its application. In most cases, the light discs and the light strips in front and back of the AMR provide sufficient light indication. However, for large payload structures you may need to install an additional warning light (user-supplied) to ensure visibility of the AMR.



CAUTION: To comply with CE requirements, an AMR must have a readily-visible warning device, such as a flashing light (user-supplied) to indicate when it is either ready to move or is moving.

The HD-1500 provides the following:

- Colored light discs on each side that provide visual cues about the AMR's status and its pending movement. Refer to the *HD-1500 Platform User's Manual (Cat. No. I645)* for more information.
- Colored light strips in front and back of the AMR. Similar to light discs, these light strips provide visual cues about the AMR's movement status. Refer to the *HD-1500 Platform User's Manual (Cat. No. I645)* for more information.
- Provision for an auxiliary warning light on the AMR Controller. Refer to the *HD-1500 Platform User's Manual (Cat. No. I645)* for more information. You can use this connector to mount a warning light in a more prominent location, which might be more appropriate for AMRs that have taller payloads.

Warning Buzzer

The AMR Controller provides an output for controlling a warning buzzer as an auditory warning device. The warning buzzer is connected to the Safety Controller.

The buzzer must be audible above the ambient noise of the environment that the HD-1500 operates in. Depending on your environment's noise level, you may need to add an additional buzzer and install to a location on your payload structure where the buzzer noise level reaches higher than the ambient noise level.

You can optionally supply an LED signal tower which includes a built-in warning buzzer, or a dedicated warning buzzer. OMRON offers a variety of LED signal towers, and dedicated warning buzzers. Contact your OMRON representative for more information on the available options.

You require the following tools to install the additional warning buzzer:

- 3 mm allen wrench for M5 screws.

Before you begin, press an E-Stop button and turn the HD-1500 off.

Follow these steps to install your additional warning buzzer:

1. Remove the user access panel cover.
2. Locate the LIGHTS port on the user access panel.
3. Connect the buzzer cable to the LIGHTS port. For information on the type of connector required to connect to the LIGHTS port.
4. Then, connect the other end of the buzzer cable to the buzzer device itself, if it isn't connected already.
5. Configure the buzzer as appropriate for the environment in which the HD-1500 operates.
6. Mount the buzzer on your desired location, and verify that the buzzer works properly.

Considerations

Performance

Performance factors to consider when designing a payload structure are:

- Size, weight, and center of gravity of the payload structure.
- Power requirements for any electrical devices on the payload.
- Serviceability and maintenance requirements.

Weight Constraints

The total operating weight of the AMR should comply with its specifications for payload and any objects carried.



DANGER: PERSONAL INJURY OR PROPERTY DAMAGE RISK

The end-user of the AMR must perform a risk assessment to identify and mitigate any additional personal and property damage hazards caused by the payload.

When designing and implementing your payload, consider the following:

- If you operate the HD-1500 on the recommended hard, flat surface, additional payload mass has a minimal effect on battery duration and operating time between recharges.
- If the payload is tall and also has substantial weight, consider its effect on the AMR's center of gravity.
- If the payload overhangs or extends outward dynamically from the AMR (such as a robot arm), it has a greater effect on the center of gravity. This is particularly important if the payload is also conveying objects that add additional mass.
- If the payload structure shifts during AMR movement, consider its effect on the AMR's

center of gravity.

IMPORTANT: You must ensure that the payload structure is properly secured to the platform.

- If the AMR transports containers of liquids, consider the effect of the fluid sloshing on the AMR's stability.
- If the AMR's center of gravity is too far from the platform's center of gravity (due to uneven load distribution), the maximum stable speed of the AMR may be lower than the platform's default operating parameters. It is the end user's responsibility to ensure that the AMR is configured for safe operation.

NOTE: The total weight of your payload structure plus any objects carried by the payload must not exceed the maximum payload capacity of your HD-1500.

Power Consumption

Any electrical devices on your payload structure that consume significant power will noticeably shorten the AMR's run time. Examples of power-consuming payload structures are robot arms attached, or a motorized conveyor.

Minimize power consumption whenever possible. The battery is rated at 3696 W*hr (3.7 kWh).

Power Limits

OMRON recommends that you use external current limiting devices to prevent transient current overload. The limits are:

- For Battery_Out max inrush peak current is 50A.

Momentary current spikes over these thresholds will activate current limiting protection causing power loss at the connector. Simultaneous inrush loads might trip the over current protection at the battery. The maximum permitted duration of an overcurrent level is as follows:

Current Protection Level (A)	Overcurrent Level (A)	Overload Duration (ms)
50	100	100
(user power)	205	1

Payload Attachment Location

The HD-1500 chassis is where you attach and secure your payload structure to the platform. The user panel allows you to make the necessary electrical connections from your payload structure to the AMR Controller.

Considerations when designing your payload structure are:

- Provide access to the payload attachment location for serviceability. You must ensure that the mechanical connection points, as well as the electrical connections are conveniently accessible.
- Always take care to not damage any cabling between your payload structure and the

HD-1500. Provide adequate slack in all cables, or include connectors. Also, provide adequate strain relief where more flexibility is required.

- Label all cables for accurate reconnection.

Payload Dimensions and Design

To maintain safe operation of the AMR when adding a payload, the following considerations might apply.

Avoid Projections and Overhangs

Your payload structure should not overhang or project beyond the outer dimensions of the platform. Doing so might place parts of the structure outside the safety envelope provided by the safety lasers.



WARNING: If you do design an overhanging payload, you must:

- Contact your OMRON representative to change the size of the safety scanning lasers' safety zones.
- Repeat the safety commissioning. For instructions on how to perform safety commissioning, refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.
- Modify the *Robot Physical: General* parameters to change the AMR's width, LengthFront, LengthRear, and potentially its Radius. Refer to: *Fleet Operations Workspace Core User's Manual (Cat. No. I635)*. When making these modifications, ensure that the AMR's accurate dimensions are used during path planning and obstacle avoidance.

Side lasers are useful if the overhang might cause the AMR to encounter obstacles that are not visible to the safety scanning lasers, or the low lasers.

Do Not Block AMR Lasers



WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK

The entire payload, and anything it carries, must be kept higher than the top of the platform. If the payload blocks any of the HD-1500's sensors, it cannot function correctly. This is important in the case of the side lasers.

The optional side lasers are mounted sideways to create vertical scanning planes and detect objects high enough that they are not detectable by the safety scanning lasers. Mount the side lasers in such a way, that they protrude enough to miss the payload structure itself with their laser beams. Refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.

IMPORTANT: It is the end user's responsibility to ensure that the payload structure does not obstruct the side lasers' beam.

If it is not possible to prevent some interference between the payload structure and the side lasers' sensing plane, you might be able to use the *LaserIgnore* parameter to constrain sensing to zones that do not include the payload structure. However, this might compromise the

detection ability of the sensors, and you should avoid using *LaserIgnore* parameter if at all possible.

When installed in factory, the side lasers are mounted at the outer edge of the laser corners, above the safety scanning lasers, and are protected by aluminum cover fins. If you relocate the side lasers, consider using protective guards to protect them from damage. Make sure that guards do not block the lasers beam or extend outward too far.

Do Not Block Wireless Antennas

You must ensure that the payload structure does not obstruct the wireless antennas. If it is not possible to prevent some interference between the payload structure and the wireless antennas, you may relocate the wireless antennas to a payload position where the signal does not get attenuated. For information on how to relocate the wireless antennas.

IMPORTANT: It is the end user's responsibility to ensure that the payload structure does not attenuate the wireless antennas' signal.

Do Not Block E-Stop Buttons

You must ensure that the payload structure does not block or limit easy access to the E-Stop buttons. The E-Stop buttons shall be placed within 600 mm of reach. The operator should be able to easily reach an E-Stop button from any approach angle without the need to reach across the moving AMR or any moving payload parts.

The payload structure shall not be positioned in such a way that would put the operator in danger while trying to reach an E-Stop button.

Do Not Block Light Discs, Front and Back Light Strips

You must ensure that the payload structure does not block the light discs, front and back light strips as they provide visual indication of the AMR movement.

Mounting Locations in the Platform

The HD-1500 chassis provides the mounting structure necessary for the end user to attach their payload structure to the platform. The platform top cover is secured onto the chassis, and therefore, the user can attach the payload structure directly on to the top cover.

Payload Mount Points

The top cover has longitudinal and transverse mounting points. Figure 2-27. or the location of the mounting points and the center lines.

IMPORTANT: Do not exceed 10 kN per mounting point.

For the location of the center of gravity, refer to the *HD-1500 Platform User's Manual (Cat. No. I645)*.

The chassis steel bars bear the main structural load of any payload. You can easily adjust and move your payload in relationship to the HD-1500's center of gravity. See: Center of Gravity (CG) on page 60.

Use mounting screws appropriate for the mass of your payload. To maintain access to the mounting locations or the user access panel, ensure that the mechanical connection points as well as the electrical connections are conveniently accessible.

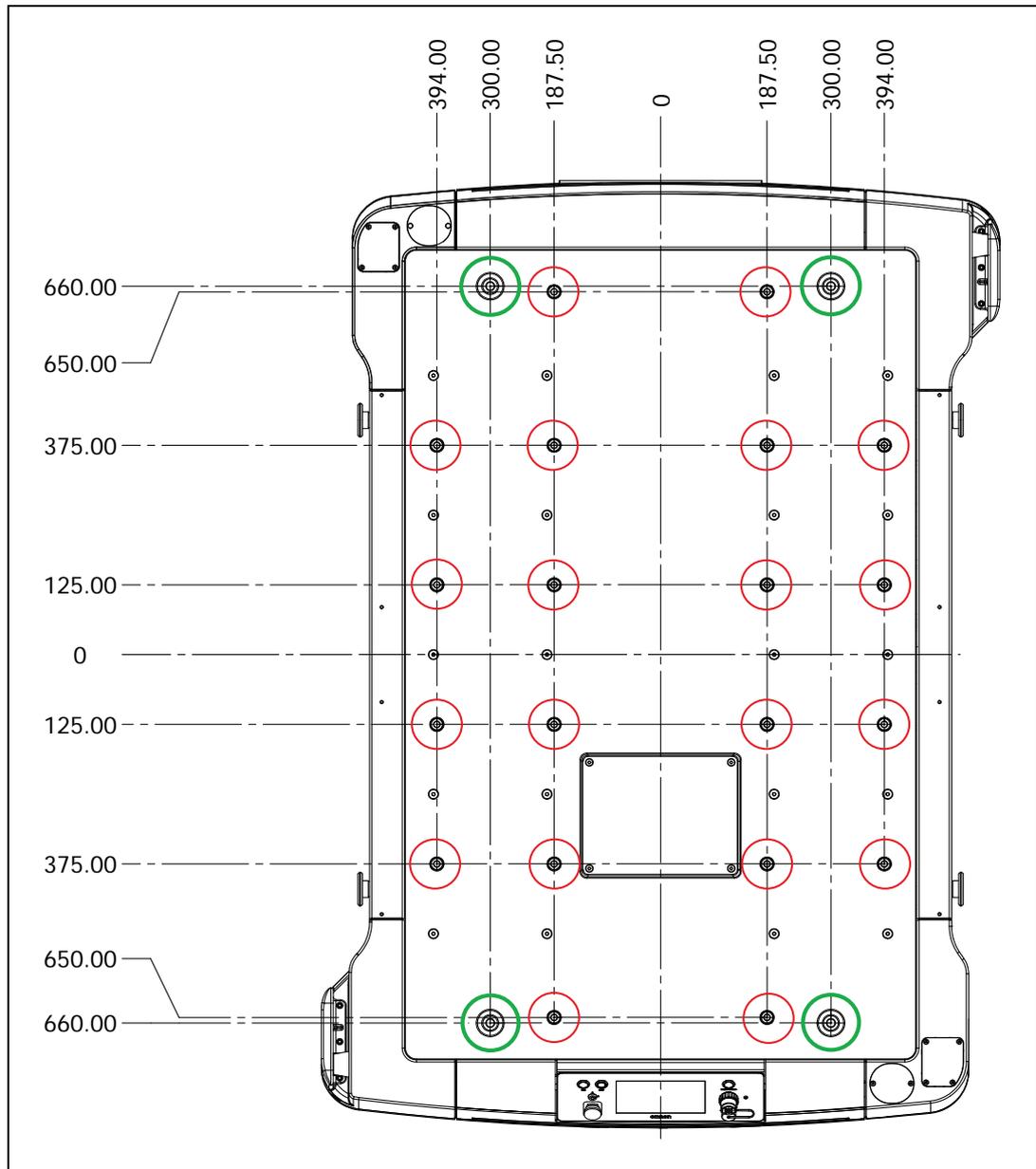


Figure 2-27. Chassis Payload Mount Locations - (20) M12 X 1.75 Threaded Holes, and (4) M16 X 2.0 Threaded Holes (units are in mm)

AMR Coordinate System

OMRON AMRs use the X, Y, Z and Theta (θ) coordinate system displayed in Figure 2-28. This information is relevant for some of the procedures used in this manual, such as identifying which are the left or right sides of the AMR. For example, the AMR Controller is located near

the rear of the AMR, and the +X direction is the direction of AMR forward travel. Refer to the following figure.

The origin of the AMR coordinate system is the ideal point on the floor exactly half way between the center of the two drive wheels. The origin of the coordinate system is the AMR's center of rotation.

Coordinates are required for procedures such as installing and configuring options such as lasers, and for understanding the center of gravity envelope. The AMR's coordinates also relate to the map coordinates.

The rotation value Theta (θ) specifies the AMR's angle of rotation, which determines its heading, or direction of travel.

The origin of the vertical coordinate (Z) is set at ground level ($Z=0$). The value of Z is required when you calculate the mount position of options (such as side lasers). You then specify the position of the option in MobilePlanner.

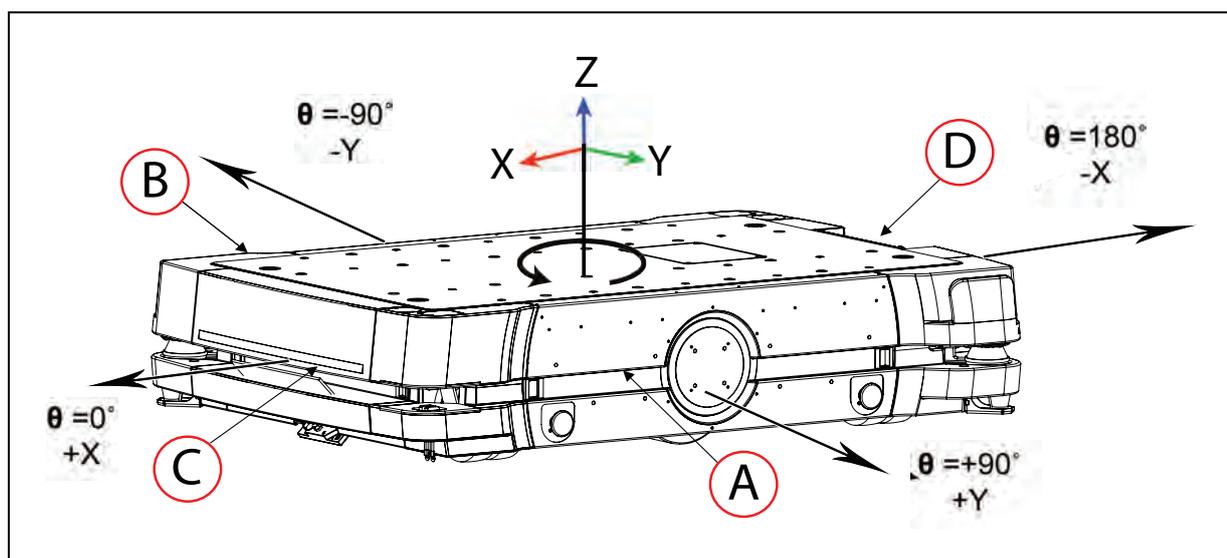


Figure 2-28. AMR Coordinate System

Callout	AMR Reference	Theta θ (Rotation)	X, Y Coordinate
A	Left side	+90 degrees	Positive Y
B	Right side	-90 degrees	Negative Y
C	Front	0 degrees	Positive X
D	Rear	180 degrees	Negative X

Additional Information: For location of the AMR's center of rotation, refer to *HD-1500 Platform User's Manual (Cat. No. I645)*.

Center of Gravity (CG)

Keep your payload structure's center of gravity (CG) centered over the HD-1500's own center of gravity and as low (close to the HD-1500's top) as possible. This provides optimum stability,

particularly when the HD-1500 crosses raised thresholds or irregularities in the floor.

Refer to *HD-1500 Platform User's Manual (Cat. No. I645)* for information that will help you design and locate the payload, in particular:

- **Center of Rotation**—The mid-point of a line between the center of the drive wheel hubs, about which the HD-1500 will rotate.
- **Center of Gravity**—The unloaded HD-1500's center of gravity.
- **X and Y Axis Mid-lines**—Lines that cross in the HD-1500 center of rotation.
- **AMR Coordinate System**—The X,Y,Z, and Theta reference system relating the AMR to its environment, and to the relative position of other devices such as the optional side lasers. See: AMR Coordinate System on page 59.

Tilt Detection and Reporting

The tilt detection feature monitors the angle of the HD-1500 (with respect to flat ground) during its operation. If the AMR tilts 60 degrees or more in any direction, an E-Stop occurs and the power is discontinued to any user-supplied equipment. This will not prevent an improperly loaded AMR from tipping over.

Safe Payload Placement

The following figures show the calculated safe CG placements for HD-1500's maximum allowed payload weight (1500 kg). The payload structure's CG must be within the area shown.

Assumptions in these calculations are:

- The payload is securely attached to the AMR.
- The payload does not overhang the AMR.
- The AMR does not exceed its specified default limits for:
 - Acceleration, deceleration, and velocity.
 - Angular velocity.
 - Coefficient of friction (0.6 min).
- The casters and drive wheels are in good condition.

You must inspect the casters and drive wheels for signs of damage, excessive wear/tear, or uneven spots as they could degrade the AMR stability.

In the following graphs:

- X is the direction of the AMR's motion (rear to front).
- Y is perpendicular to the AMR's direction of motion (side to side).
- Z is the vertical dimension (height).

All units are in millimeters (mm). See also: AMR Coordinate System on page 59.

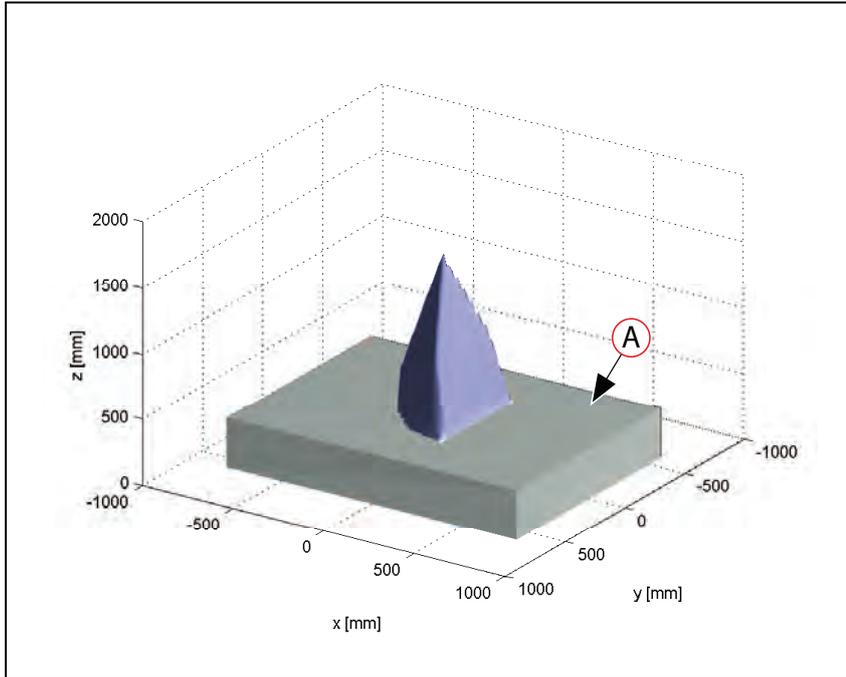


Figure 2-29. 3D View of Recommended Payload CG, (A) HD-1500

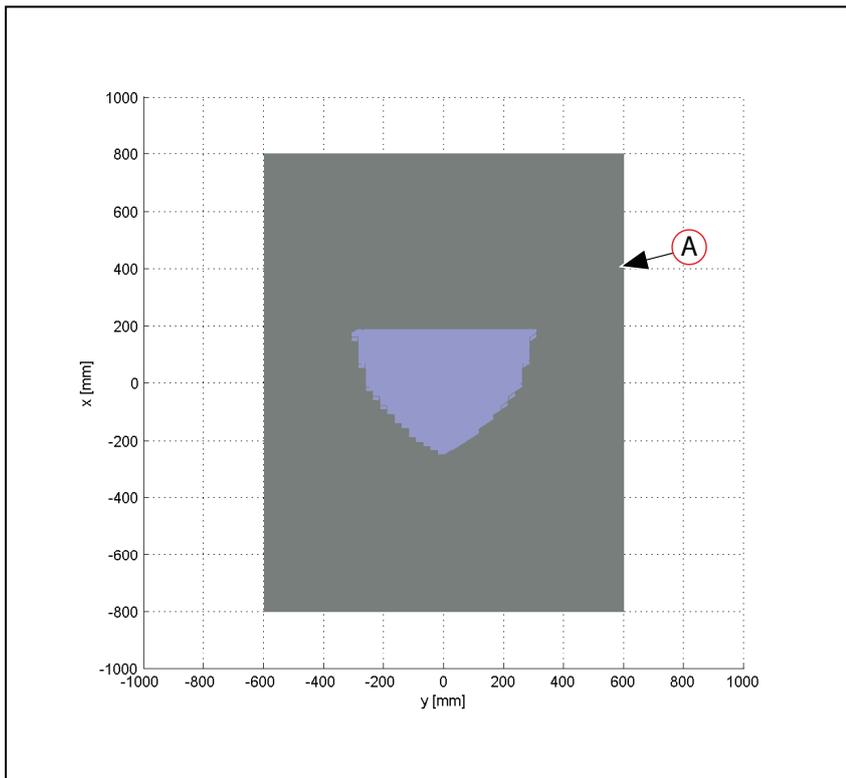


Figure 2-30. Top View of Recommended Payload CG, (A) HD-1500

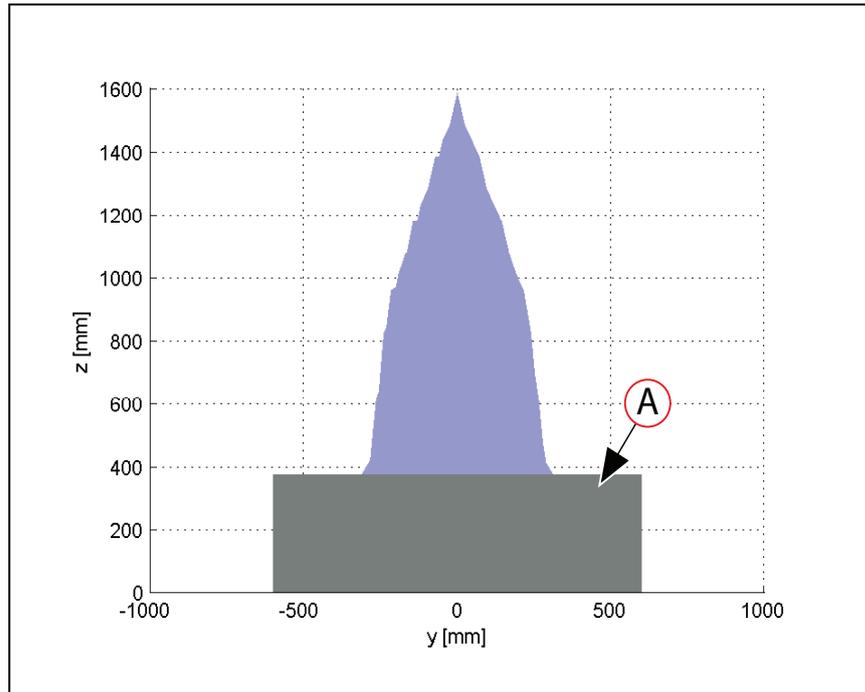


Figure 2-31. Front View of Recommended Payload CG, (A) HD-1500

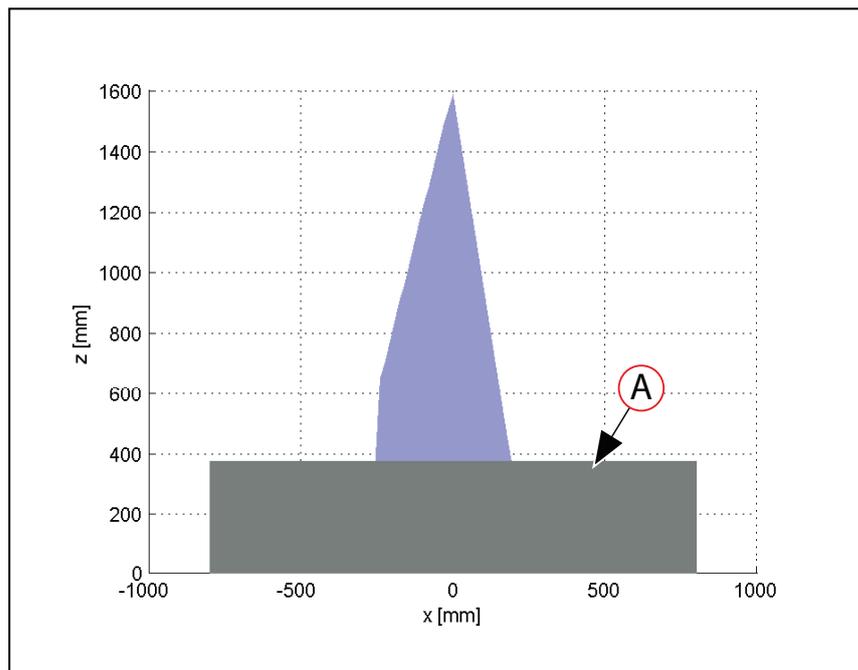


Figure 2-32. Side View of Recommended Payload CG, (A) HD-1500

2.19 Additional Safety Information

Contact your OMRON representative for other sources of safety information.

Mobile Robot HD Safety Manual (Cat. No. I647)

The *Mobile Robot HD Safety Manual (Cat. No. I647)* is included with your HD-1500 and provides detailed information about safe operation of your HD-1500. It also provides resources for information about relevant standards.

2.20 Additional Safety Information

Contact your OMRON representative for other sources of safety information.

Mobile Robot HD Safety Manual (Cat. No. I647)

The *Mobile Robot HD Safety Manual (Cat. No. I647)* is included with your HD-1500 and provides detailed information about safe operation of your HD-1500. It also provides resources for information about relevant standards.

2.21 Disposal



Dispose of in accordance with applicable regulations.

Customers can contribute to resource conservation and protecting the environment by the proper disposal of WEEE (Waste Electronics and Electrical Equipment). All electrical and electronic products should be disposed of separately from the municipal waste system via designation collection facilities. For information about disposal of your old equipment, contact your OMRON representative.

Do not incinerate or dispose of the HD-1500 battery. Return the end-of-life or defective batteries to a designated facility per the appropriate local regulations.

Chapter 3: Safety Function Description

This chapter provides information on the safety function of the HD-1500.

PL and PFH

The Performance Level (PL) calculation for safety functions of the OMRON AMRs are based on the ISO 13849 standard. PL evaluation has been performed for the HD-1500, including the supplied pendant.

The PL achieved and the Probability of Dangerous Failure per Hour (PFH) are calculated using SISTEMA as per ISO 13849-1 for the following Safety Functions:

Table 3-1. Compliance, ISO 13849-1 Functional Safety Information

Function #	Safety Function	Safety Stop Type	Reset Type	PL	Cat	PFHd
SF0	E-Stop Button on Pendant	Emergency Stop	Manual Reset	d	3	5.67E-07
SF1	Enabling Device on Pendant	Protective Stop	Automatic Reset	d	3	5.67E-07
SF2	E-Stop Button on Operator Panel	Emergency Stop	Manual Reset	d	3	5.67E-07
SF3	E-Stop Connection on User Panel	Emergency Stop	Manual Reset	TBD by the user	3	5.79E-08
SF4	E-Stop Buttons on Side of AMR	Emergency Stop	Manual Reset	d	3	5.67E-07
SF5	Safety Laser Scanner Detection	Protective Stop	Automatic Reset	d	3	6.50E-07
SF6	Safe Motion Detection	Protective Stop	Manual Reset	d	3	5.67E-07
SF7	Protective Stop Connection on User Panel	Protective Stop	Automatic Reset	TBD by the user	3	5.79E-08
SF8	Brake Release Monitoring	Protective Stop	Manual Reset	b	B	7.13E-06
SF9	Warnings	N/A	N/A	b	B	5.71E-06
SF10	Automatic Battery Charging	N/A	N/A	b	1	7.13E-06

Table 3-2. Safety Function (SF) Descriptions

Function #	Safety Function	Description	What is controlled
SF0	E-Stop Button on Pendant	Pressing the E-Stop button on the pendant results in an emergency stop (controlled stop)* ¹ . In this case, the power to the AMR motors remains on in order to achieve a controlled stop. Once the controlled stop is achieved, the power to the motors is disconnected. SF0 has functional safety rating of Pld Category 3* ² .	AMR
SF1	Enabling Device on Pendant	The pendant is used in manual mode to drive the AMR under the operator control. The three-position enabling device must be held in the center enable position to allow the AMR to move. Releasing the enabling device or compressing it beyond the center position will cause a Category 1 Stop* ¹ on the AMR. This is a protective stop, and the AMR resumes its operation automatically after a two-second delay, and when the pendant enabling device is held in the center enable position. SF1 has functional safety rating of Pld Category 3* ² .	AMR
SF2	E-Stop Button on Operator Panel	Pressing the E-Stop button on the Operator Panel results in an emergency stop (controlled stop)* ¹ . In this case, the power to the AMR motors remains on in order to achieve a controlled stop. Once the controlled stop is achieved, the power to the motors is disconnected. SF2 has functional safety rating of Pld Category 3* ² .	AMR
SF3	E-Stop Connection on User Panel* ³	The user-supplied E-Stop button can be attached to the SCPU connection located on the user access panel. Pressing the user-supplied E-Stop button results in an emergency stop (controlled stop). In this case, the power to the AMR motors remains on in order to achieve a controlled stop. Once the controlled stop is achieved, the power to the motors is disconnected. The final SF3 functional safety rating is to be calculated using the given PFHd value (logic and output) combined with the user supplied E-Stop (input) PFHd values. If no user E-Stop is connected to the user access panel SCPU connector, then an E-Stop jumper	AMR

Function #	Safety Function	Description	What is controlled
		must be attached to the connector. Refer to <i>HD-1500 Platform User's Manual (Cat. No. I645)</i> for specific information.	
SF4	Emergency Stop (Four E-Stop buttons on the sides of the HD-1500)	There are four E-Stop buttons on the sides of the AMR (two E-Stop buttons on each side of the AMR). Pressing any E-Stop button on the sides of the AMR initiates the emergency stop (controlled stop) ^{*1} function. In this case, the power to the AMR motors remains on in order to achieve a controlled stop. Once the controlled stop is achieved, the power to the motors is disconnected. SF4 has functional safety rating of Pld Category 3 ^{*2} .	AMR
SF5	Safety Laser Scanner Detection	Each safety scanning laser has 70 safety zones (1-70). When safety zones of the two safety scanning lasers overlap, they create a total of 41 safety zone pairs. If an obstacle (such as a person) intrudes into the safety zones, the safety scanning laser will trigger a protective stop (category 1 stop). Since this is also a controlled stop, the power to the AMR motors remains on in order to achieve a controlled stop. In such cases, the AMR safely stops, and then resumes operation after a delay of two seconds, and after confirming that its protected zone is clear of obstacles. SF5 has functional safety rating of Pld Category 3 ^{*2} .	AMR
SF6	Safe Motion Detection	The SF6 monitors for overspeed and speed inconsistency. The AMR linear speed is limited to 1800 mm/s (both forward and backward). If the calculated speed exceeds this speed limits, the HD-1500 protective stop is triggered. In such cases, the AMR safely stops, and requires manual re-set. SF6 has functional safety rating of Pld Category 3 ^{*2} .	AMR
SF7	Protective Stop Connection on User Panel ^{*3}	A user-supplied protective device can be attached to the SCPU connection located on the user access panel. The user-supplied protective device initiates a protective stop, and resets automatically once the protective device signal is cleared, and after a two-second delay. If no user-supplied protective device is connected to the user access panel SCPU con-	AMR

Function #	Safety Function	Description	What is controlled
		<p>connector, then an E-Stop jumper must be attached to the connector. Refer to <i>HD-1500 Platform User's Manual (Cat. No. 1645)</i> for specific information.</p> <p>The final SF7 functional safety rating is to be calculated using the given PFHd value (logic and output) combined with the user supplied protective device (input) PFHd values.</p>	
SF8	Brake Release Monitoring	<p>SF8 monitors the brake, and ensures it is in use when necessary, and not in use when not necessary. The brake release monitoring initiates a category 1 stop, and requires manual reset in order to resume AMR operation.</p> <p>SF8 has functional safety rating of Plb Category B.</p>	AMR
SF9	Warnings	SF9 is for the visual warning system, and has functional safety rating of Plb Category B.	AMR
SF10	Automatic Battery Charging	<p>SF10 is used to ensure that the AMR is properly connected to docking target before the charging contacts are activated.</p> <p>SF10 has functional safety rating of Plb Category 1.</p>	AMR

*1 Stop Categories according to IEC 60204-1 (NFPA79).

*2 The PL achieved and the Probability of Dangerous Failure per Hour (PFHd) are calculated using SISTEMA as per ISO 13849-1, for the Safety Functions listed in Table 3-1.

*3 The SCPU connector on the user access panel is provided for use with a user-supplied external E-Stop along with a user-supplied protective device. The user is responsible for calculating the overall PL and PFHd, inclusive of user-supplied components, and performing a final risk assessment.

OMRON Corporation Industrial Automation Company
Kyoto, JAPAN

Contact: www.ia.omron.com

Regional Headquarters

OMRON EUROPE B.V.
Wegalaan 67-69, 2132 JD Hoofddorp
The Netherlands
Tel: (31)2356-81-300/Fax: (31)2356-81-388

OMRON ASIA PACIFIC PTE. LTD.
No. 438A Alexandra Road # 05-05/08 (Lobby 2),
Alexandra Technopark,
Singapore 119967
Tel: (65) 6835-3011/Fax: (65) 6835-2711

OMRON ELECTRONICS LLC
2895 Greenspoint Parkway, Suite 200 Hoffman Estates,
IL 60169 U.S.A.
Tel: (1) 847-843-7900/Fax: (1) 847-843-7787

OMRON ROBOTICS AND SAFETY TECHNOLOGIES, INC.
4225 Hacienda Drive, Pleasanton, CA 94588 U.S.A
Tel: (1) 925-245-3400/Fax: (1) 925-960-0590

OMRON (CHINA) CO., LTD.
Room 2211, Bank of China Tower, 200 Yin Cheng Zhong Road,
PuDong New Area, Shanghai, 200120, China
Tel: (86) 21-5037-2222/Fax: (86) 21-5037-2200

Authorized Distributor:

© OMRON Corporation 2020 All Rights Reserved.
In the interest of product improvement, specifications are
subject to change without notice.

Cat. No. I647-E-01

1120

31500-100 A