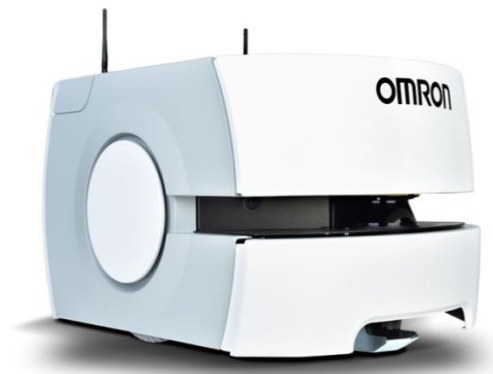


Mobile Robot LD, LD-CT

Assembly Instructions

According to Machinery Directive 2006/42/EC (ANNEX VI)



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Note:

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 safety measures based on their own risk assessment.

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1 Alert Notation

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



DANGER:

This indicates an imminently hazardous electrical situation which, if not avoided, will result in death or serious injury.



DANGER: This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



WARNING: This indicates a potentially hazardous electrical situation which, if not avoided, could result in serious injury or major damage to the equipment.



WARNING: This indicates a potentially hazardous situation which, if not avoided, could result in serious injury or major damage to the equipment.



CAUTION: This indicates a situation which, if not avoided, could result in minor injury or damage to the equipment.



Precautions for Safe Use: This indicates precautions on what to do and what not to do to ensure safe product use.

2 Abbreviations and terminology

Abbreviation / term	Description
EHSR	Essential health and safety requirements relating to the design and construction of machinery
LD	Low-duty
PL	Performance Level as per EN ISO 13849-1
PL _r	Required Performance Level as per EN ISO 13849-1
PL _a	Achieved Performance Level as per EN ISO 13849-1
Performance Level	Discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions
Required performance level PL _r	Performance level (PL) applied in order to achieve the required risk reduction for each safety function
Risk assessment	Overall process comprising risk analysis and risk evaluation
Safety Function	Function of the machine whose failure can result in an immediate increase of the risk(s)

3 Introduction

3.1 Assembly Instructions

The assembly instructions in this document deal with all safety-related aspects of the LD mobile robot and LD Cart Transporter robot, as a partly completed machinery, and of the interface between the partly completed machinery and the final machinery which have to be considered by the assembler when incorporating the partly completed machinery into the final machinery.



The LD mobile robot and the LD Cart Transporter are partly completed machines intended to be incorporated into other machinery and must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of EC Machinery Directive 2006/42/EC, where appropriate

The assembler, when incorporating the LD mobile robot or LD Cart Transporter into the final machinery, shall take the necessary measures to deal with the EHSRs from ANNEX I of the Machinery Directive, applicable to the LD mobile robot, that have not been applied and fulfilled or that have only been partly fulfilled by Omron.

The assembly instructions shall then form part of the technical file for the final machine.

These assembly instructions for the LD mobile robot, and the LD Cart Transporter robot as partly completed machinery, provide the necessary information to enable the manufacturer of the final machinery to draft the parts of the instructions as required from ESHR 1.7.4.

3.2 Definitions

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

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

AMR (Autonomous Mobile Robot): An OMRON mobile robot with a payload structure attached to it. This is your complete mobile robot, which will transport your products, parts, or data.

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

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

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

Enterprise Manager 2100: A system that manages a fleet of AMRs. This includes the Enterprise Manager appliance and the software that runs on it.

LD Platform Cart Transporter: A platform with the LD Platform OEM (including extended arms) and the coupling plate attached, set up to transport a cart. This is also referred to as just a transporter.

Cart: A cart, on four casters, that can be attached to an LD Platform Cart Transporter, for increasing the payload capacity of the LD Platform, as well as de-coupling its load from the robot platform. The cart has brakes on two casters, which can be released either by coupling with a transporter, or by using a manual brake-release lever on the cart

3.3 Product Description

The LD platform is a general-purpose, mobile robot platform, designed for working indoors and around people. It is self-guided and self-charging, with an automated docking station.

The LD platform is available in two versions, designed to carry loads up to 60 kg (132 lb) for the LD-60 and 90 kg (198 lb) for the LD-90 platform. Where appropriate, differences between the models are called out. Otherwise, this manual applies to both platforms.

The LD Platform Cart Transporter is designed for moving a detachable cart indoors, and around people. The LD Platform Cart Transporter is available in two models, designed to transport carts with a payload up to 105 kg (231 lb) for the LD-105CT and 130 kg (287 lb) for the LD-130CT platform. Where appropriate, differences between the models are called out. Otherwise, this manual applies to both LD Platform Cart Transporters.

Considerations for the LD Platform will generally also apply to the LD Cart Transporter unless otherwise specified. The LD Cart Transporter will have considerations that do not apply to the LD Platform, and it can be assumed that if the LD Cart Transporter is being addressed specifically, that the topic is not applicable to the base LD Platform.

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

Its primary guidance uses a safety scanning laser to navigate, comparing the laser readings to a digital map stored on the platform. Additional sensing for obstacle avoidance is provided by two rear-facing sonar pairs, a front-sensing bumper, and another scanning laser mounted below the safety-scanning laser for detecting obstacles approximately 60 mm above the ground. Additional sensing for navigation is provided by a gyroscope mounted on the internal LD core, and encoders and Hall sensors on each drive wheel.

In addition to the front safety scanning laser, each LD Platform Cart Transporter has two side lasers, oriented so that their scanning plane is perpendicular to the ground for detecting potential obstacles in its path that can't be detected by the safety scanning laser. It also has, a rear-facing obstacle-detection laser, to ensure that it is safe for the transporter to back up or turn in place.

For most applications, you will want to customize the platform with a payload structure, attached to the top of the platform, for some combination of picking up, transporting, and dropping off your parts, samples, or documents. Refer to Payload Structures (see section 7) on guidelines on designing a payload structure. The LD Cart Transporter is itself an application-specific payload structure; no modifications should be made to the LD Cart Transporter's platform if they would interfere with the safe operation of the onboard equipment for capturing the cart and locking it to the platform.

The LD platform provides a variety of interfaces and power connections to support your application-specific sensors and accessories, mounted on your payload structure. Refer to Connectivity (see section 8), for information on the available connectors on the LD platform. The LD Cart Transporter provides user-facing IO and power somewhat differently, with an additional circuit board. In the case that you need to add any connections mentioned in section 8 for the LD Cart Transporter you'll need to reference the LD Cart

Transporter User's Manual. The LD Cart Transporter comes with all the necessary connections made for engaging and disengaging with carts.

Body and Drive

The LD platform, which is the base platform of the LD Cart Transporter, is relatively small, lightweight, and highly maneuverable. It has a strong aluminum chassis and solid construction that makes it very durable. It has an IP rating of IP-40.

The platform is a two-wheeled, differential-drive vehicle, with spring-loaded passive casters at its front and rear, and independent drive-wheel spring-suspension for balance. Its solid, foam-filled wheels are at the mid-line of the platform, so that the platform can turn in place.

Safety Scanning Laser

The onboard navigation laser is a very precise scanning sensor. The laser provides 600 readings in a 240 degree field of view, with a typical maximum range of 40 m. The safe sensing range used for the platform's default safety protective fields has a maximum radius of 3 m. The laser operates in a single plane, positioned at 190 mm above the floor.

Glass, mirrors, and other highly-reflective objects cannot be reliably detected by the laser. Caution must be exercised when operating the AMR in areas that have these types of objects. If the AMR will need to drive in close proximity of these objects, we recommend that you use a combination of markings on the objects, such as tape or painted strips, and also use forbidden sectors in the map, so that the AMR knows to plan paths safely around these objects.

Low Front Laser

This laser is mounted beneath the safety laser and offers a 130 degree viewing angle through a cutout at the bottom of the front bumper. It detects obstacles that are low and in front of the LD Platform, such as an empty pallet, which might be too low for the safety scanning laser to see.

Sonar

The LD Platform's two rear-facing sonar pairs are for obstacle-sensing while backing up. The range is up to 5 m (16 ft), though the typical accurate range is only about 2 m (10 ft). Each pair consists of one emitter and one receiver. The sonar emitters and receivers are identical physically, but the transporter uses them differently.

Additional Lasers for LD Platform Cart Transporter

The LD Cart Transporter also has a rear-facing laser that is used during both turning in place and backing up when the transporter and cart are coupled.

A coupling laser mounted in the transporter coupling plate is used to locate a triangle on the underside of the cart's coupling plate. This is used by the transporter to accurately align with the cart, so it can couple with it.

What's Included - Basic Components

- One fully-assembled LD platform

The platform includes a safety scanning laser, front bumper, and two rear-facing sonar pairs. Each pair is one transmitter and one receiver.

- One battery

This is shipped separately from the platform, due to air shipping regulations.

- LD Platform core, which includes an integrated computer.

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

- Operator Panel

This includes a screen, an E-Stop button, ON and OFF buttons, a brake-release button, and a keyswitch, which can be locked to disable the OFF button to prevent accidental use or tampering. This must be mounted on the user-designed and-built payload structure. If the Operator Panel is not used a DB-15 connection jumper, provided with the platform, must be used to bypass the panel's E-stop. If the Operator Panel is not used, the system builder must provide the ON, OFF, Brake-Release, and E-STOP functionality using the User Interface connection on the LD Core.

The LD Cart Transporter does not come with an Operator Panel. It provides the ON, OFF, Brake-Release, E-STOP, and Key-switch functionality, along with a larger touchscreen display at the top of a post at the rear of the platform.

- Automated docking station

Allows the platform to charge itself, without user intervention. This includes a wall-mount bracket and a floor plate, for a choice of installation methods. See Installing the Docking Station section in LD User's Guide.

The LD Cart Transporter must use a longer wall-mounting bracket to space the dock further from the wall. This is because the rear-facing laser extends past the rear of the LD platform and would interfere with the wall if the standard wall-mounting bracket is used. The base LD Platform can also dock at these locations if your robot fleet contains both LD Cart Transporters and other LD AMRs.

A manual charging cord is included, so you can charge the battery or a spare battery outside of the platform.

- Joystick (option)

This is used for manually controlling the platform, mostly when making a scan to be used for generating a map. The LD platform's safety scanning laser's protective zones are still active when the user is manually controlling the platform with the joystick.

At least one joystick is needed for each fleet of AMRs.

What's Included – Additional Components for LD Platform Cart Transport

- Top plate and coupling plate

The platform top plate covers the payload bay of the platform, and supports the lower (platform) coupling plate, which engages the cart coupling plate, attached to the cart, and the coupling laser

- An HMI Post

This supports the two side lasers and the rear-facing laser, both for obstacle avoidance. It also supports the Operator Panel.

- Operator Interface

In addition to all the features of the standard Operator Panel mentioned above, the LD Cart Transporter's interface also supports two WiFi antennas, a light beacon indicating operating state, and LATCH and UNLATCH. The LATCH button will not cause the automatic latch mechanism to operate unless a proximity sensor on the LD Cart Transporter detects the metal chevron on the underside of the cart, and hall-effect sensors detect the magnets within the cart. This prevents operation when a person's hands could be near the moving latch, and it ensures that the cart is in a position where the latch operation will be successful.

- Cart

The cart is a frame mounted on four casters, designed so that it can couple with an LD Platform Cart Transporter. Once coupled, the cart moves with the transporter. When the transporter arrives at the intended goal, it uncouples from the cart and leaves, while the cart remains at the goal. Brakes automatically engage on the cart casters upon uncoupling, preventing it from rolling in case the floor isn't completely level. These brakes are not intended to stop the cart from rolling down a slope. The LD Cart Transporter is not capable of operating on slopes, and it must be prevented from doing so through physical and logical (software zones) barriers.

The cart has a manual brake-release lever, so it can be moved manually.

For Payload Structure Development

- Side-mount obstacle-detection lasers

Two lasers that scan the vertical plane on each side of the AMR. These are used to detect obstacles that are at heights the navigation laser can't see.

3.4 Related Manuals

There are additional manuals that cover related topics related to the LD and LC Cart Transporter platforms. The following manuals provide information on general safety, related products, advanced configurations and system specifications.

Table 1: Related Manuals

Manual Title	Description
Mobile Robot LD Safety Guide	Contains general safety information for all Omron Robotics and Safety Technology LD Platform-based robots.
LD Platform User's Guide	Describes the operation and maintenance of the LD Platform
EM2100 Installation Manual	Describes the Enterprise Manager 2100 system, for managing a fleet of AMRs.
Mobile Robot Software Suite User's Guide	Covers MobilePlanner software, the SetNetGo OS, and most of the configuration of an LD platform.

Omron LD Platform Peripherals Guide	Covers LD peripherals, such as the LD Touchscreen, Call/Door boxes, and Acuity Localization options.
LD Cart Transporter User's Guide	Describes the operation and maintenance of the LD Platform Cart Transporter

4 Safety

4.1 Intended Use



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.

The LD Platform-based mobile robots are designed for operating in industrial or professional environments. They must be deployed in a manner that takes into account potential risks to personnel and equipment.



WARNING: The assembly instructions together with the other robot related manuals must be strictly observed.

4.2 Non-intended Use

Non-intended use of the LD Platforms can:

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

They are not intended for use:

- In the presence of ionizing or non-ionizing radiation
- In life-support systems
- In hazardous (explosive) atmospheres
- In residential installations
- Where the equipment will be subject to extremes of heat or humidity
- In mobile, portable, marine, aircraft systems, or any other moving environment.
- Uncontrolled areas, for example, areas open to general public access

Application in such areas may require deployment of additional safety measures, and risk analysis.

Additionally, please consider the following as non-intended use:

LD platform-based mobile robots are intended for use on generally level floors, in wheelchair-accessible areas.

The body of the robot must not come into contact with liquids. The drive wheels can tolerate damp floors, but the body of the robot must remain dry. Excessive liquid on the floor can lead to traction loss which will

reduce the robot's ability to stop, which could lead to hazards in the case where an obstacle enters the LD's safety scanning laser's protective field.

For no reason is the robot suitable for movement or transportation of people. Riding The LD platform is not permitted.

If there is any doubt concerning the application, ask OMRON Robotics and Safety Technologies to determine if it is an intended use or not.

4.3 User's Responsibilities

It is the end-user's responsibility to ensure that the mobile robots are used safely. This includes:

- Reading the installation and operation instructions, as well as the Mobile Robot LD Safety Guide, before using the equipment.
- Ensuring that the environment is suitable for safe operation of the AMR.
- If a fleet of AMRs (two or more) is installed, the Enterprise Manager must be used, unless no two robots will never operate in the same area.
- Ensuring that anyone working with or near an AMR has been adequately trained, and is following this guide and the Mobile Robot LD Safety Guide for safe robot operation.
- Ensuring that the AMRs are maintained, so that their control and safety functions are working properly.

General Hazards




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

- Do not ride on the platform.
- Do not exceed the maximum weight limit.
- Payload decreases as slope increases. (LD Cart Transporter is not for use on any slope)
- Do not exceed the maximum recommended speed, acceleration, deceleration, or rotation limits. See sections on Center of Gravity and Acceleration, Deceleration, and Rotation Limits in LD Platform User Guide.
- Rotational speed becomes more significant when the payload's center of gravity is farther away (vertically and/or horizontally) from the platform's center of gravity. Ensure that your application settings will not make the platform unstable in any circumstances, including emergency stopping.
- Do not drop the robot, run it off a ledge, or otherwise operate it in an irresponsible manner.
- Do not allow the AMR to drive through an opening that has an automatic gate/door unless the door and AMR are configured correctly with the Call/Door Box option. Refer to the LD Platform Peripherals Guide for details on the Call/Door Box.
- Do not get the AMR wet. Do not expose the AMR to rain or moisture.
- Do not continue to run the AMR after hair, yarn, string, or any other items have become wound around the platform's axles, casters, or wheels.
- Do not use unauthorized parts.

- Do not turn on the robot without the antennas in place
- Although the lasers used are Class 1 (eye-safe), we recommend you not look into them.

Falling Hazards

	<p>WARNING: The robot 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.</p>
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Physical Barriers

The edge of a loading dock, the entrance to downward stairs, or any other substantial drop that is within the robot's expected operating area should be physically marked so that the robot's navigation laser will see the barrier, and stop before reaching it. **The robot's navigation laser scans at 190 mm. The barrier must be taller than this height to account for any deviations in the floor that might angle the plane of the safety scanning laser up and over the barrier. Ensure that your barrier is tall enough for the scanning laser to see it by observing the laser returns as visualized in relation to the AMR's location on its internal map.**

Physical barriers must be used in any place where the AMR could feasibly access.


Logical Barriers

You should also use forbidden areas, sectors, or lines with several feet of safety zone (padding) before the actual dropoff, to ensure that the robot will not try to drive there.

These need to be continuous at the site, so that the robot can't plan a path to drive around or between them to the dropoff.

The robot may also encounter overhanging obstacles. These may be visible to its optional side lasers (standard with the LD Cart Transporter), but logical barriers should still be used to prevent the robot from planning a path through that space. If side-lasers are not used, or if they cannot detect the overhanging obstacle when the AMR is far enough away to prevent collision, then physical barriers must be used in addition to logical barriers to prevent this hazard. When in doubt, physical barriers should be used.

Electrical Hazards

	<p>WARNING: The docking station has AC power inside. Its covers are not interlocked.</p>
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- Do not use power extension cords with the docking station unless properly rated.
- Never access the interior of the platform with the charger attached.
- Immediately disconnect the battery after opening the battery compartment door.
- Avoid shorting the terminals of the battery.
- Only use a charger supplied by OMRON Robotics and Safety Technologies.
- 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.

Pinch Hazard and Entanglement Hazards

Robot Covers



CAUTION: Pinch hazard. The covers are held in place with strong magnets, which can pinch you if you are not careful. Follow the instructions in the Maintenance chapter for handling covers.

Latching System Latch for LD Platform Cart Transporter



CAUTION: Pinch hazard. The latch of the LD Platform Cart Transporter can pinch you if you are not careful. Keep your hands clear of the transporter when it is in action



CAUTION: Pinch hazard. During maintenance on the latch mechanism, the belt and pulley can pinch you if you are not careful. Keep your hands clear of the belt and pulley when they are in action



CAUTION: Entanglement Risk. The belt and pulley of the LD Platform Cart Transporter can entangle your hand during maintenance. Keep your hands clear of the belt and pulley when they are moving.

HMI Post-Cart Gap for LD Platform Cart Transporter



CAUTION: Pinch hazard. The coupling action of the LD Platform Cart Transporter and cart can pinch you if the cart payload is incorrectly designed, and you are not careful. Keep your hands clear of the space between the HMI post and cart when the platform and cart are coupling.

Magnetic Field Hazards

Robot Covers



WARNING: Magnetic fields can be hazardous to pacemaker wearers. Pacemaker wearers stay back 30 cm (12 in.) from the platform covers, which are held in place with strong magnets.

Docking Funnel



WARNING: Magnetic fields can be hazardous to pacemaker wearers. Pacemaker wearers stay back 30 cm (12 in.) from the underside of the platform, which is exposed during certain maintenance procedures for which the platform is tipped on its side.

Cart Magnet for LD Platform Cart Transporter



WARNING: Magnetic field can be hazardous to medical implants. Magnetic fields can be hazardous to medical implant wearers. Medical implant wearers stay back 30 cm (12 inches) from the bottom of the cart

Qualification of Personnel

It is the end-user's responsibility to ensure that all personnel who will work with or around mobile robots have attended an appropriate OMRON training course and have a working knowledge of the system. The user must provide the necessary additional training for all personnel who will be working with the system. This additional training should contain topics related to application-specific hardware that has been added to the LD Platform which will not have been covered by OMRON training,

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

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

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



WARNING: Before working with the robot, every entrusted person must confirm that they:

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

Payload Movement and Transfer

Monitoring and confirmation of the status of robot payload movement and transfer to or from facility equipment is the end-user's responsibility.

Payload transfer problems must trigger a robot E-Stop, preventing the robot from moving until an Operator has resolved the problem and confirmed that the system is safe to use. This handling of payload transfer problems is the end-user's responsibility.

Providing safe interface between the robot and facility equipment (e.g. conveyor belts) is the user's responsibility and should also be determined as the result of the Risk Assessment performed for the application.

Configurable Warning Buzzer

The LD platforms have a configurable warning buzzer. It is the user's responsibility to configure this buzzer as appropriate for the facility in which the robot will be operating. The buzzer will sound whenever the robot is moving backwards or is turning. Other situations are configurable.

The buzzer is configured with MobilePlanner, using the following parameters:

NOTE: These parameters are only available with the Mobile Robot Software Suite 5.0 and later.

- DriveWarningEnable

NOTE:

If this parameter is set to False, the remaining parameters will not be displayed.



WARNING: Disabling the DriveWarningEnable parameter violates the JIS D 6802 and EN 1525 standards. It is strongly recommended that you leave this set to True.

- DoNotWarnDrivingForwards

Default: False

- DoNotWarnTurningInPlace

Default: False

- DriveWarningLoudMilliseconds

Default: 500. If DriveWarningQuietMilliseconds is 0, this parameter is irrelevant.

- DriveWarningQuietMilliseconds

Default: 500. This is the length of time between warnings that the buzzer is silent. Setting this to 0 will cause a continuous warning.

Multi-Vehicle Avoidance

When multiple vehicles are operating in the same operating space, they must be connected to an Enterprise Manager 1100 (EM) via WiFi. The EM helps prevent collisions by sharing vehicles' dynamic X, Y, Theta, size, and path-planning information with each other. Vehicles then factor this data into their obstacle avoidance. This is not an interlocked method of preventing collisions. It is the end-user/integrator's responsibility to provide an interlocked method of preventing collisions.

NOTE:

When two AMRs approach each other directly, neither can properly determine the other's physical size. Their lasers scan several inches into the other's laser slot, returning an incorrect distance estimate. Because of this, any installation that has two or more AMRs working in the same operating space must be managed by the same Fleet Manager.

Traffic Control

A "switchable forbidden area" can be programmed on the map to prevent the AMR from entering an area based on the state of a discrete input. If this area is toggled on, for example, because another vehicle, such as a forklift is in that area, then the AMR will not be allowed to enter that area. This is a software-based tool that is used to mitigate risk. Users must provide physical barriers in cases where it is critical to prevent AMR access to specific areas. This function is not safety-rated and traffic control should be considered in the overall risk assessment.

4.4 Environment

General Environmental Conditions

It is the end-user's responsibility to ensure that the operating environment of the platform remains safe for the platform. If there are areas that are not safe for the platform to travel in, those areas should be physically blocked off so that the platform's scanning laser will detect the barriers, and the platform will not attempt to drive there. These areas can also be blocked off with forbidden zones in the MobilePlanner software, but that should be in addition to physical barriers.

Public Access

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

Clearance

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

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



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

Obstacles

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

Safety Scanning Laser Protective Stop

If an obstacle enters the transporter's immediate path, the safety scanning laser will trigger a protective stop by deasserting redundant OSSD signals to the LD Core. The AMR will execute a controlled stop for a maximum of 0.9 s before engaging its motor brakes. After the AMR has come to a complete stop, it will wait a minimum of two seconds before resuming commanded motion, with no human intervention necessary.

- If the obstacle is still in the transporter's path, it will first attempt to safely path plan and maneuver around the obstacle, if there is adequate room.
- If the transporter can't maneuver around the obstacle, it will search for another path to reach its goal. If it can't find another path, it will wait for human intervention.

Safety Scanning Laser Emergency Stop

A CPLD Channel 1 or 2 fault, is a system fault, reported by independent safety system to the firmware controlling the robot. A fault signal from the safety system, indicates that the robot is operating outside of the defined boundaries of safety standards EN1525/ANSI B56.5.

Both referenced standards state, that the speed of motion in directions not covered by the operator detection devices, reverse direction for the LD Platform, must be limited to <300 mm/s. For the LD-90 and the LD CT-105 this speed is 225 mm/s.

If an LD Platform is operated in a manner that exceeds this reverse speed limit, the safety system will generate and report a fault signal. In normal, autonomous operation, this condition triggers motion controllers to execute a controlled stop. However, if motion is disabled (E-Stop button is pressed) and the brake release is overridden, the safety system cannot stop the LD Platform since power to the motors has already been cut off. Once the fault condition is resolved, the safety system will stop reporting safety fault to the motion controllers, and the normal start-up process will initiate.

4.5 Battery Safety

- Store batteries upright (in an environment with relative humidity less than 70%) at:
 - One month: +5 to 45°C (41 to 113°F)
 - One year: 20 to 25°C (68 to 77°F)
- Do not expose batteries to water.
- If a battery is found to be leaking, do not expose it to water. If possible, submerge it in mineral oil and contact Omron Robotics and Safety Technology.
- In case of a fire, use a type D extinguisher: foam, dry chemical, or CO2.

4.6 Robot Modifications

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

Note that any change to the platform or cart can lead to loss in safety or functionality. It is the responsibility of the user or integrator to ensure that all safety features are operational after modifications.

4.7 Additional Safety Information

Accidental Cart Separation in LD Cart Transporter

In the unlikely event that the cart becomes unlatched from the platform while in motion, the cart's brakes are designed to stop the cart within six feet. The LD Cart Transporter will detect that the cart is no longer present through both inductive proximity sensing, and magnetic sensing, and it will come to a controlled stop.

Mobile Robot LD Safety Guide

OMRON provides other sources for more safety information:

The Mobile Robot LD Safety Guide provides detailed information on safety for LD Platform-based mobile robots. It also gives resources for information on relevant standards.

It ships with each mobile robot.

4.8 Risk Assessment

Omron as manufacturer are aware of our duties and responsibilities regarding the development, manufacturing and placing of safe mobile robots on the market and consistently implement them. However, Omron have no direct influence on the usage of our mobile robots. As a precaution, we point out the following:

The assembler incorporating the LD mobile robot into the final machinery, are obligated by law to ensure that a risk assessment is carried out in order to determine the health and safety requirements which apply to the whole machinery. The machinery must then be designed and constructed taking into account the results of the risk assessment.

Omron strongly recommends the assembler, to use EN ISO 12100 for this risk assessment.

The risk assessment and its outcome must be documented in the Assembler's Technical file for machinery, conform ANNEX VII of the Machinery Directive 2006/42/CE.

4.9 EHSRs fulfilled

The LD mobile robot as a partly completed machinery, fulfils the following essential requirements of the EC Machinery Directive 2006/42/EC:

Table 2: EHSRs fulfilled from ANNEX I, Machinery Directive 2006/42/EC

EHSR, Annex I	Title
1.1.1	General Remarks - Definitions
1.1.2	Principles of safety integration
1.1.3	Materials and products
1.1.5	Design of machinery to facilitate its handling
1.2	Control Systems
1.3.2	Risk of break-up during operation
1.3.4	Risks due to surfaces, edges or angles
1.5.1	Risks due to other hazards - Electricity supply
1.5.2	Risks due to other hazards - Static electricity
1.5.4	Risks due to other hazards - Errors of fitting
1.5.5	Risks due to other hazards - Extreme temperatures
1.5.10	Risks due to other hazards - Radiation
1.5.11	Risks due to other hazards - External radiation
1.5.12	Risks due to other hazards - Laser radiation
1.6.1	Machinery maintenance

5 LD series main safety functions

5.1 Performance levels

The LD series robots' main safety functions are implemented in hardware or electronic circuitry with certain diagnostic functions implemented in firmware. The European Standard EN 1525 (*Driverless Industrial Trucks and Their Systems*) provides normative requirements for this type of machinery.

Table 3 enlists the essential safety function requirements set forth in EN 1525.

The sequence of the EN 1525 clauses in this table are modified for ease of explanation of the functional blocks. This modification in sequence doesn't impact the performance level calculations in any way.

Table 3: essential safety function requirements and achieved PL

Normative Requirements for AMR Mobile Robots						Achieved Performance Levels PL _a	
EN 1525 Clause	Safety Requirement	LD Series Function	EN 1525 designated architecture (Cat EN 954-1)	Equivalent required PL: PL _r (EN ISO 13849-1)	Redundancy	PFH _d (1/h)	Actual achieved PL: PL _a (EN ISO 13849-1)
5.9.4	Protective Devices	Emergency Stop (E-Stop)	Category 3	PL _r = d	Dual Channel	3.33E-8	PL _a = e
5.9.5	Protective Devices	LiDAR Personnel Detection	Category 3	PL _r = d	Dual Channel	6.33E-7	PL _a = d
5.4	Speed Control	Forward & Reverse Speed Limits	Category 2 / 3	PL _r = d	Dual Channel	3.3E-8	PL _a = e
5.5	Battery Charging	Charging Dock Activation	Category 1	PL _r = b	N/A	1.1E-6	PL _a = c
5.9.5.8	Bypass of Protective Devices	Manual (Joystick) Bypass of Personnel Detection	Category 2	PL _r = b	Dual Channel	4.6E-8	PL _r = e
5.6	Load Handling	Cart Transporter Brakes	Category 1	PL _r = b	N/A	-	PL _a = b
5.7	Steering	N/A	N/A	N/A	N/A	-	N/A
5.8	Stability	OEM/Integration, N/A	N/A	N/A	N/A	-	N/A

5.2 Emergency Stop Circuit

Theory of operation

The emergency stop (E-STOP) is the most basic safety function of the LD Series robot and is a good starting point to overview the safety systems.

The vehicle has six basic E-STOP sources. Sources 1, 2, and 3 are visible from outside the vehicle. Sources 4 and 5 are either internal function or user connected inputs. The Safety scanning lasers issues a protective stop. This differs from an E-STOP only in that E-STOPS require that a human deliberately presses the ON button on the AMR before motor power is restored, whereas motor power will be restored automatically 2 s

after a safety stop initiated by the safety scanning laser. The Joystick signal that goes to the E-STOP chain is an ESTOP override function.

1. Red E-STOP mushroom button on the front panel
2. Front contact bumper
3. Safety scanning laser
4. User connected E-STOP button (via USER INTERFACE)
5. Core electronic internal speed limits
6. Joystick override

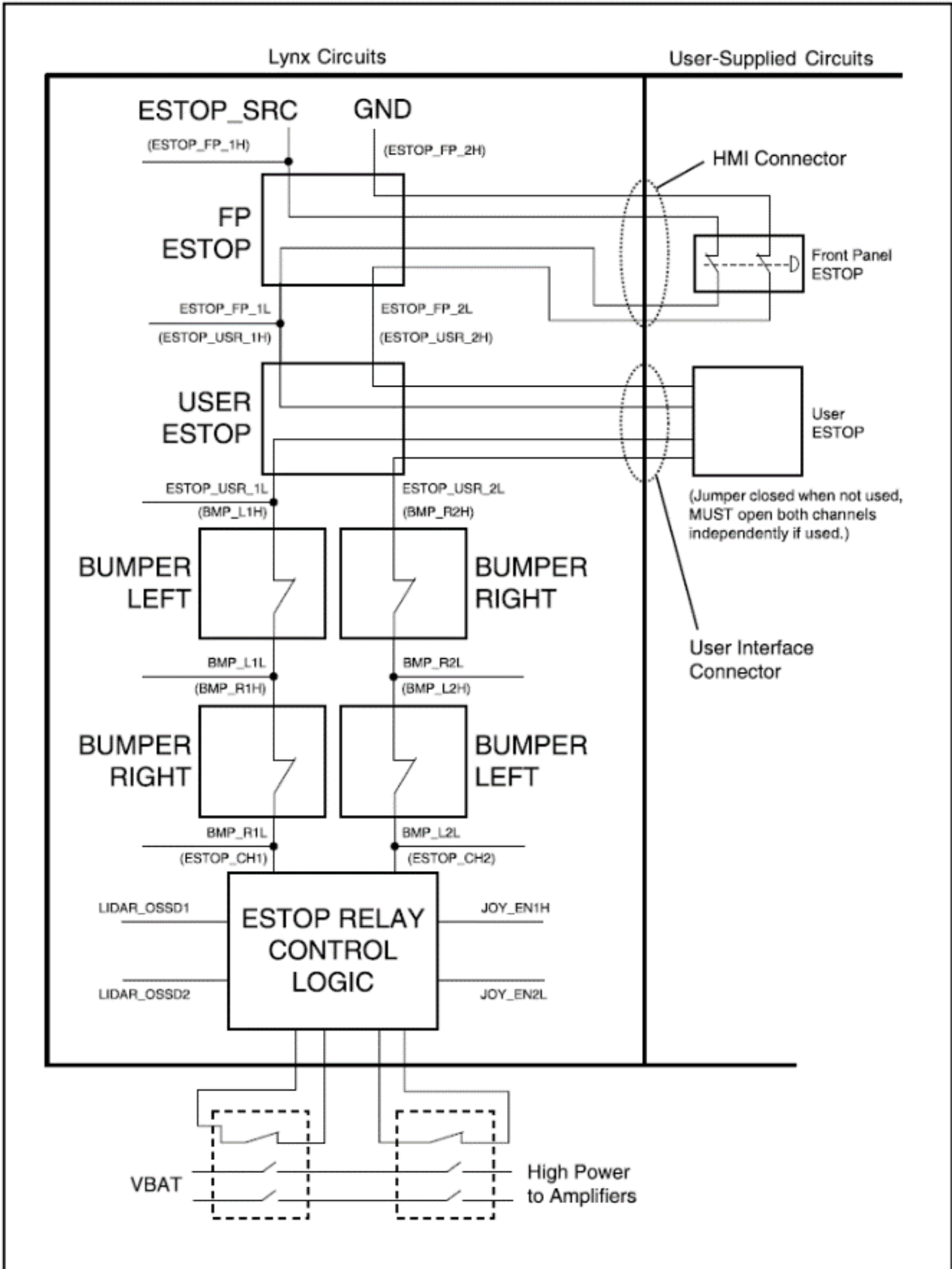


Figure 1: ESTOP Chain Diagram

6 Side Lasers

6.1 Introduction

Side lasers are optional for users building their own AMR from the LD Platform, and come pre-installed on the LD Cart Transporter models. This chapter covers installation on base LD models only.

Side Lasers scan in a vertical plane near the path of the robot, allowing the AMR to detect obstacles at other heights that the AMR must avoid. Side lasers can be added to an AMR to provide additional obstacle detection. They may be installed in varying locations based on need, but they must be oriented such that their scanning plane is perpendicular to the ground and aligned with the direction of robot travel. They should be mounted as the furthest point to the left and right of the AMR.

Side-mount lasers are not part of the AMR's hardware-based, safety-rated protection system. They provide information that is used by the robot software to mitigate risk and may improve AMR operation. It is the user's responsibility to ensure that the AMR's path is free of obstacles above the plane of the safety scanning laser that could interfere with any part of the completed AMR system

Positive Obstacles

Positive obstacles are those which would block the robot's path, such as tables and desks. Detecting positive obstacles is the primary and recommended use for side lasers. Side lasers have a resolution of 3 degrees.

Negative Obstacles

Negative obstacles are voids in the driving area of the robot, such as downward stairs, loading docks, or missing floor tiles.

Negative obstacle detection with side lasers should not be used as the primary method for avoiding negative obstacles. It is intended to be used as a secondary method of detection, with the primary method being traditional safety techniques to aid avoiding negative obstacles.

Primary methods include blocking off areas with missing floor tiles, staging safety equipment near areas missing floor tiles, and restricting traffic to dangerous areas.

Negative obstacle detection on the robot is implemented in software only and does not consist of CAT 3/PLd safety lasers. A test plan should be developed and executed prior to adding new functionality to equipment that currently exists in a production environment. Perform testing with each specific application and configuration to ensure the robot's safety. Test detection after changing parameters for each different expected obstacle. With customer payloads and laser positioning, dynamic testing must be done for each design at field application speed to ensure robot safety.

6.2 Installation

Components

The side lasers come as a kit with the following components:

- 2x lasers

- 2x laser guards
- Wiring harness
- Assembly kit, with mounting plate

The side laser kit is P/N 13456-100, and can be added to existing payload structures.

Mounting

Side lasers need to be mounted on your AMR payload structure, one on each side. They must be mounted far enough out so that their laser beams don't hit any part of the AMR.

Connections

The harness should be connected after the physical mounting procedure is completed.

The lasers connect to the Aux Sensor connector located on the upper front of the platform core using the supplied W-cable. This allows you to use one port for both side lasers and the low front laser.

6.3 Configuration

The parameters for the side lasers are set using the MobilePlanner software.

The first set of parameters are in:

Robot Physical > Laser_3 and Robot Physical > Laser_4.

Configuring the side lasers is generally performed by importing the factory-supplied configuration into the AMR's current configuration. Contact Omron for assistance.

For Laser_3 (right) and Laser_4 (left), the relevant parameters are:

- LaserAutoConnect: Should be checked to turn on the laser.

This parameter will not be shown unless Show Expert + Parameters is checked.

This tells the system that the laser exists, and should be connected at startup.

The other parameters will be hidden unless this parameter is checked.

- LaserX, LaserY, LaserZ: The location of the laser on the robot.

Measure to the sensing plane of each laser, which is about 20 mm from the top of the sensor housing.

- LaserX is mm, front-back, of the laser center from the robot's idealized center of rotation.
- LaserY is mm, left-right, of the laser center from the robot's idealized center of rotation.
- LaserZ is mm, from the floor to the center of the laser.

- LaserIgnore: By default, the sensor scans an area of 270 degrees.

This area should be modified so that the laser does not sense parts of the AMR. Zones entered here will be excluded from the search area.

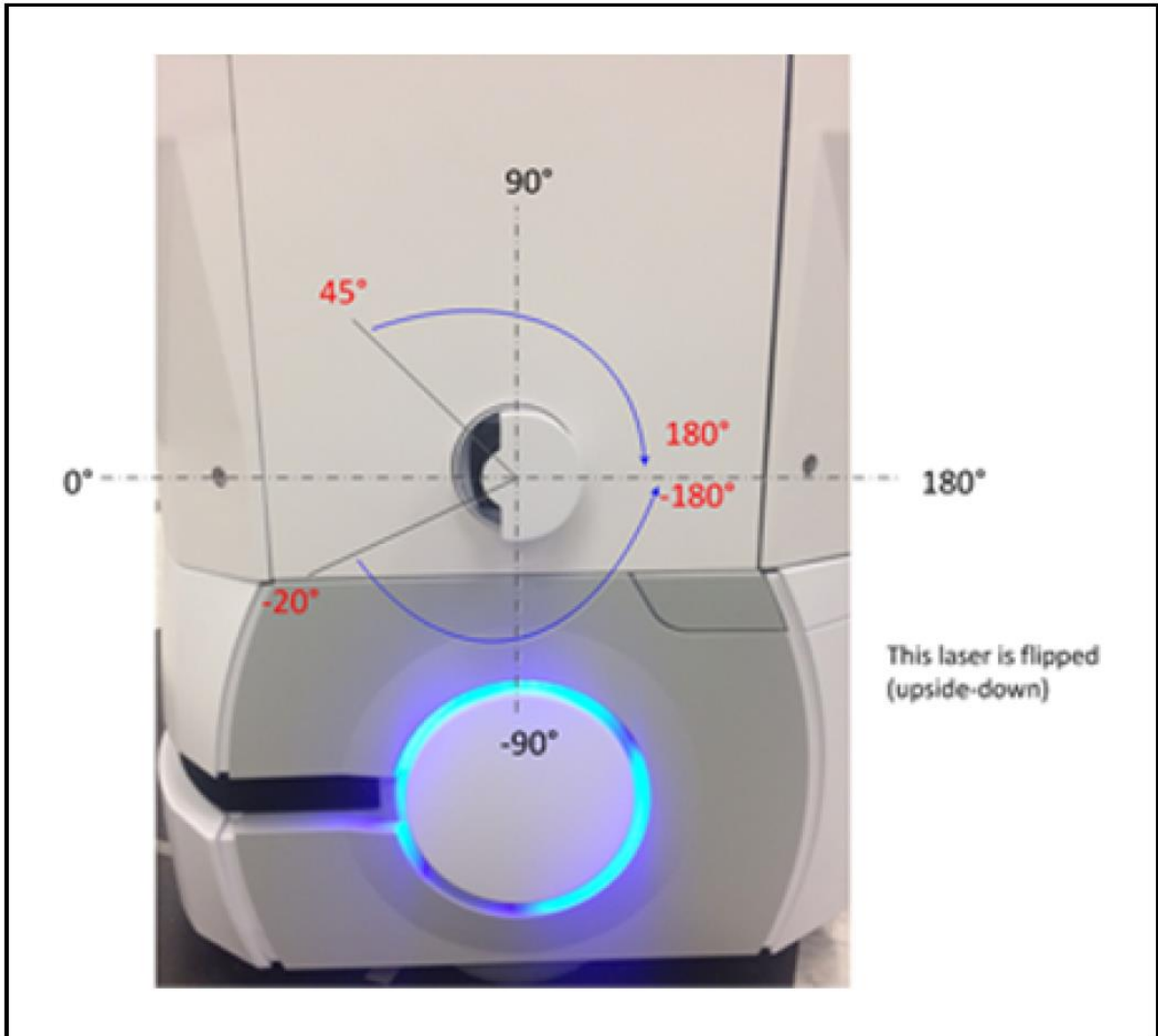


Figure 2: Left Side Laser (Laser 4)

The format for the angles is startangle1: stopangle1, startangle2: stopangle2, etc.

Readings inside these angles will be ignored.

An example would be

-20:-180,45:180

- LaserFlipped: For the laser on the left side of the robot, check the box.
This says the laser is upside-down, so the readings are interpreted correctly.
- LaserType: Set this value to tim3XX unless otherwise requested.
- LaserPortType: Set to serial when using the Aux Sensor connector.
- LaserPort: The ports available on the Aux Sensor connector are /dev/ttyUSB5 and /dev/ttyUSB6. Assure that the correct port is designated by the sensor's X,Y,Z position. The wiring harness is labelled so that /dev/ttyUSB6 is connected to the left laser.
- LaserPowerOutput: Set to Vertical_Laser_Power.

- LaserIsTilted: Designates that the lasers are side-mounted and will scan vertically. Check the box.

The parameter LaserIsTiltedNegativeSensor should be disabled if this is checked.

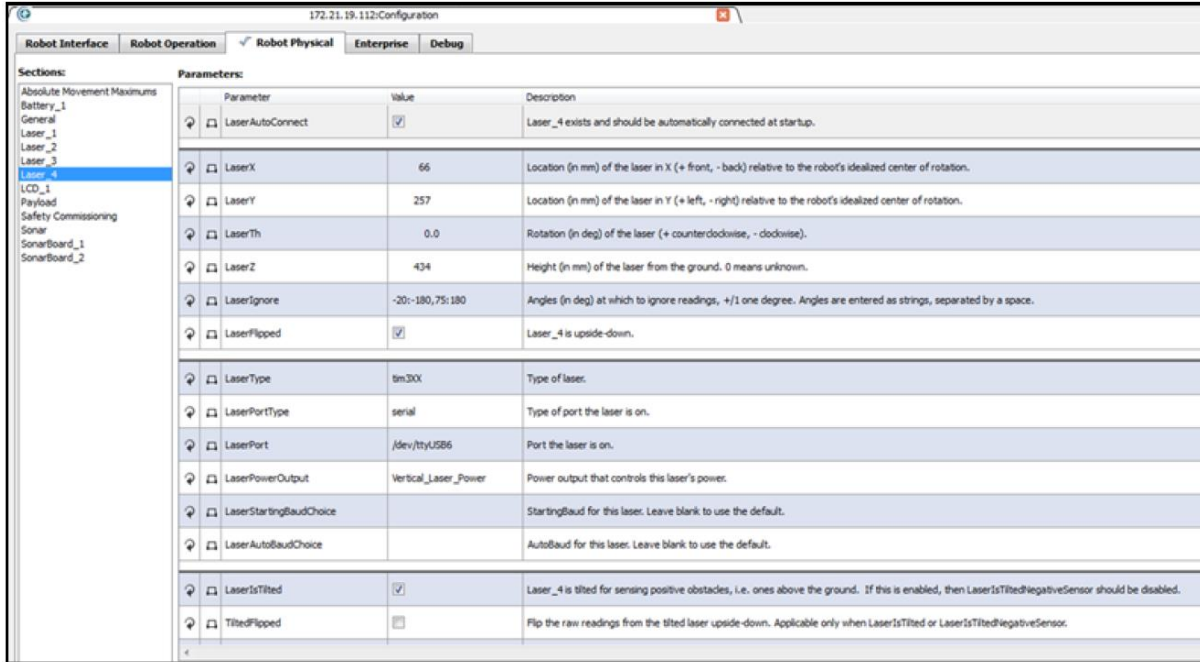


Figure 3: MobilePlanner Side Laser Parameters

In MobilePlanner, navigate to Robot Operation > Laser_3 and _4 Tilted. This portion of the configuration allows the laser to be configured for the application's specific environment.

In select cases, you will need to modify the Cumulative parameters. Sensor readings are often held on the map so that the robot remembers an obstacle even when it cannot be actively seen.

The length of time that the robot will remember these readings is MaxSecondstoKeepCumulative. In dynamic environments where the robot will be encountering many obstacles, but many open paths for the robot exist, this value should be about five seconds. If your environment has a restricted number of possible robot paths, this number should stay relatively large, such as thirty seconds, so that the robot does not rediscover the same obstacle multiple times. Contact your local Omron Support if you have difficulty tuning these parameters for your environment.

Robot Interface			
Robot Operation			
Robot Physical			
Enterprise			
Debug			
Sections:	Parameters:		
Bumpers Settings	Parameter	Value	Description
Driving problem response	● FloorAllowedHeight	100	Maximum height (in mm) to be considered the floor when detecting positive obstacles. The FloorAllowedAngle is added classified as a positive obstacle.
Files	● FloorAllowedAngle	2.0	Maximum angle (in deg) of the floor when detecting positive obstacles. This is added to the FloorAllowedHeight. Anyth obstacle.
Follow (laser) settings	● CeilingAllowedHeight	1800	Minimum height (in mm) to be considered the ceiling when detecting positive obstacles. The CeilingAllowedAngle is sub be classified as a positive obstacle.
Laser_1 Settings	● CeilingAllowedAngle	2.0	Maximum angle (in deg) of the ceiling when detecting positive obstacles. This is subtracted from the CeilingAllowed-he positive obstacle.
Laser_3 Tilted	● LogObstacles	False	Log data about the detected positive obstacles.
Laser_4 Tilted	● MinDistBetweenCurrent	25.0	Minimum distance (in mm) between the stored current readings.
Localization settings	● CumulativeBufferSize	500	Maximum number of readings to store in the cumulative buffer.
Map Features	● MaxSecondsToKeepCumulative	4	Duration (in sec) to store the cumulative readings. If 0 or negative, then the cumulative readings are not automatic
Path Planning Settings	● MaxDistToKeepCumulative	8000.0	Maximum distance (in mm) allowed between the current pose and the stored cumulative readings. If a reading exceed cumulative readings are not automatically discarded based on distance.
Patrol	● MinDistBetweenCumulative	100.0	Minimum distance (in mm) between the cumulative readings. If 0 or negative, then readings are not discarded due to t
Periodic Macros	● MaxInsertDistCumulative	5000.0	Maximum distance (in mm) allowed between the current robot position and the new cumulative reading. If a reading ex cumulative readings.
Queuing Manager	● UseCustomMaxRange	False	When enabled (true), the specified CustomMaxRange is used instead of the default maximum range for the sensor. (U only be enabled by expert users.)
Robot config			
Task Features			
Teleop Settings			
Triangle Drive To			

Figure 4: MobilePlanner Cumulative Parameters

After each side laser is configured, ensure that the laser designated to be on the left side is physically mounted on the left side of the robot. The easiest way to do this is to turn off one of the lasers using the LaserAutoConnect parameter and watch the laser readings in MobilePlanner.

In the image below you can see that the enabled side laser is showing readings on the left side of the robot.

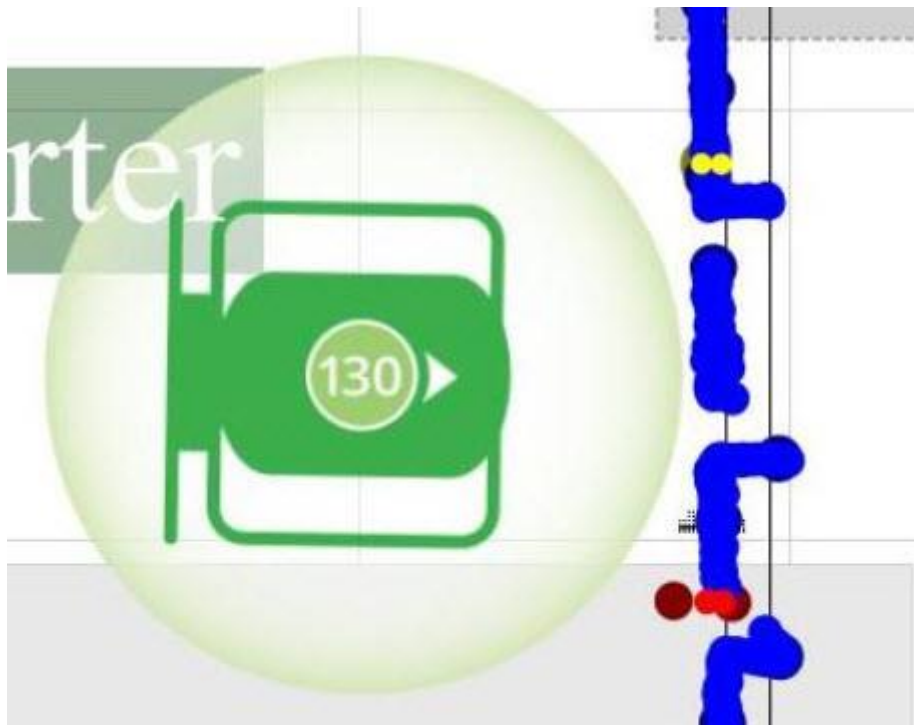


Figure 5: Checking the Left Side Laser

7 Payload Structures

Everything that you attach to the LD platform is referred to as the payload structure.

In the case of the LD Cart Transporter models, Omron designs and builds the payload structure. In most cases, you will need to design a payload structure that suits your application. This chapter discusses considerations to be aware of when you design a payload structure for your LD platform.

The LD platform provides the mobility and navigation you will need, as well as power and I/O connections between the platform and your payload structure, so the two can work effectively together.

7.1 Safety Warning

Warning Label

A No Riding label is shipped, unattached, with each platform. It is the user's responsibility to place this in a prominent location on the payload, so Operators will see it.



Warning Lights

An AMR is required for CE compliance to have a readily-visible warning device, such as a flashing light, when it is either ready to move or is moving. The platform comes with light discs on each side that do this. The core also provides an output, so you can add your own warning device. This may be necessary for taller payloads, which may make the side light discs not always visible.

The core has a Light Pole connector, which is in Rear Upper Core. This can be used to drive a warning device in a more prominent location for taller AMRs.

Warning Buzzer

The core provides an output for driving a warning buzzer. The default behavior of the buzzer is to sound when the AMR is moving in reverse, or when the safety systems are off, for example, when the platform is moving at a speed lower than 300 mm/s (225 mm/s for the LD-90 and LD CT-105 models). The warning buzzer's behavior is configurable by the user, so it can be used to sound, for example, whenever the AMR is moving.

A buzzer kit, with buzzer and harness, is available as an option.

7.2 Considerations

The main performance factors to consider in designing a payload structure are stability, size, weight, and center of gravity of the payload structure, and power requirements.

Weight

On a hard surface, a certain amount of extra weight will not shorten the AMR's run-time very much. When adding a payload structure with substantial weight, the center of gravity of the entire AMR needs to be considered. This is particularly important if you intend to equip the platform with a robot arm, which would be lifting items off-center from the platform.

A heavy payload structure, with most of its weight concentrated just above the platform, will be much more stable than the same weight payload structure in which the weight is either off-center or high above the top of the platform.

The weight of your payload structure added to the weight of the parts it is carrying must not exceed the rated capacity of your platform.

Payload Bay Access

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

If the payload structure is small and light enough, it can just be lifted off of the platform to access the connectors in the payload bay. Care should always be taken not to damage any wiring between your payload structure and the platform.

A larger, heavier payload structure may need some form of hinge, so that the payload structure can be tilted out of the way while you access the payload bay. Consideration should be given to harness length and position so that this can be accomplished without disconnecting or damaging any connectors or harnesses.

Dimensions

You must keep your payload structure no wider and no longer than the LD platform.

The most common payload structure is a vertical extension of the platform, adding whatever features are needed by your application above the platform itself.

Take care to keep all of the payload structure higher than the top of the LD platform. If any of the platform's sensors get blocked, it won't be able to function normally. This is critical in the case of the safety scanning laser.

If you purchased the optional vertical-mount lasers for your payload structure, you need to make sure that the payload structure will not interfere with the view of those lasers. Typically, the vertical lasers are mounted on the sides of the payload structure, so that they protrude enough to miss the payload structure itself with the laser beam. Some customers have found it prudent to build a protective guard over the vertical lasers, to protect the lasers from impact.

Ensure that any such guard does not block the laser beam.

The height of your payload structure will affect the center of gravity, covered in the next section.

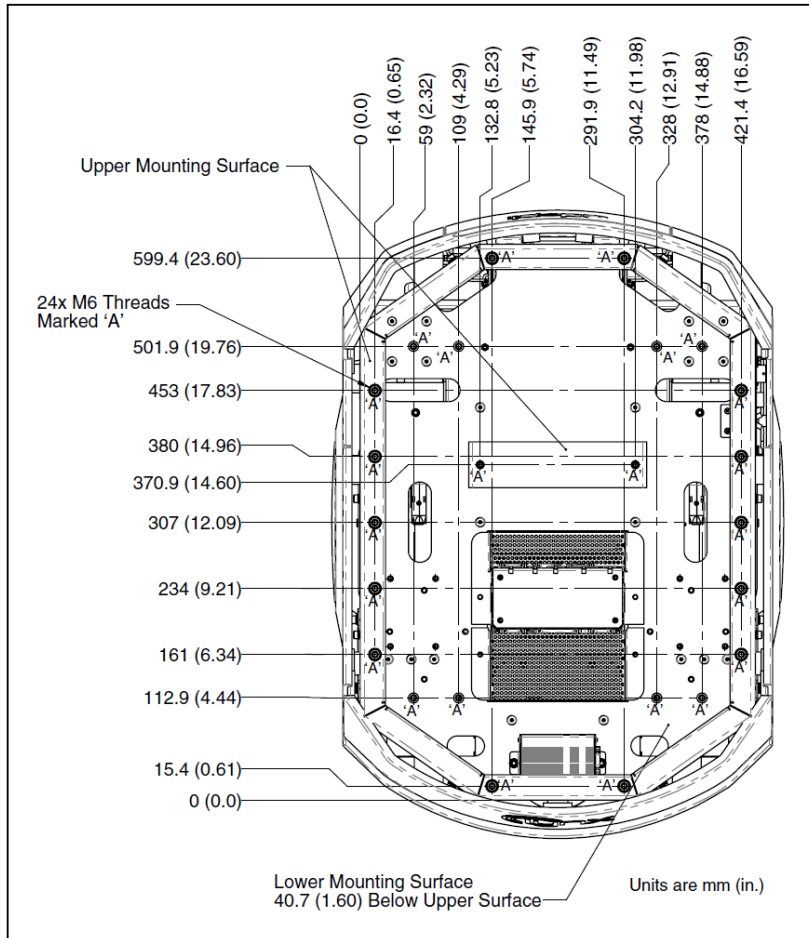


Figure 6: Platform Deck Dimensions, for Attaching Payload Structure with M6-threaded bolts

In the preceding figure, all of the M6 PEM nuts (A) have a torque limit of 3 N-m (26.6 in-lbf).



CAUTION: Do not exceed this torque when attaching your payload structure to these PEM nuts. See NOTE that follows.

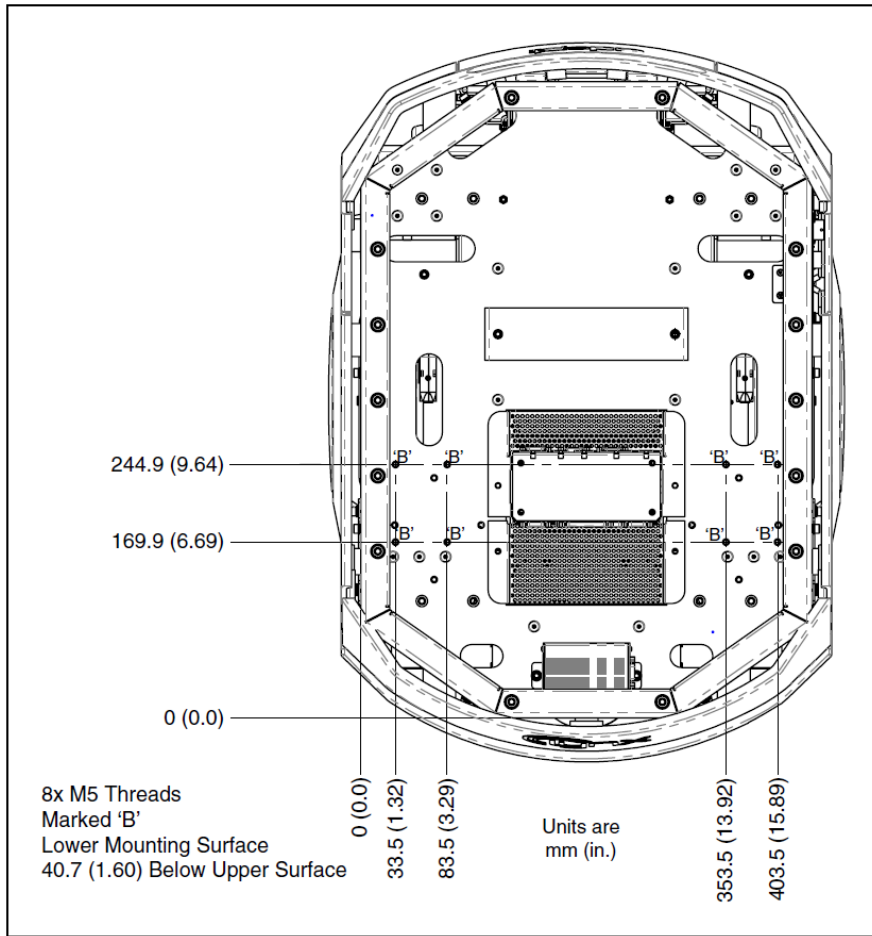


Figure 7: Platform Deck Dimensions, for Attaching Payload Structure with M5-threaded bolts

In the preceding figure, all of the M5 PEM nuts (A) have a torque limit of 14 N-m (124 in-lbf).

NOTE:

The M6 PEM nuts are inserted differently than the M5 PEM nuts, to increase the usable thread length. This also decreases the torque that can be applied to them, so the M5s have a much higher torque limit than the M6s in this application.

Center of Gravity

As much as possible, you should keep the payload structure center of gravity centered on the LD platform, and as low (close to the platform top) as possible. This will give you the best stability, particularly when crossing thresholds or irregularities in the floor.

The payload should be centered on the platform left-to-right, but biased toward the rear of the platform or cart according to the following figures.

The following figure shows the center of gravity of the platform, without payload structure.

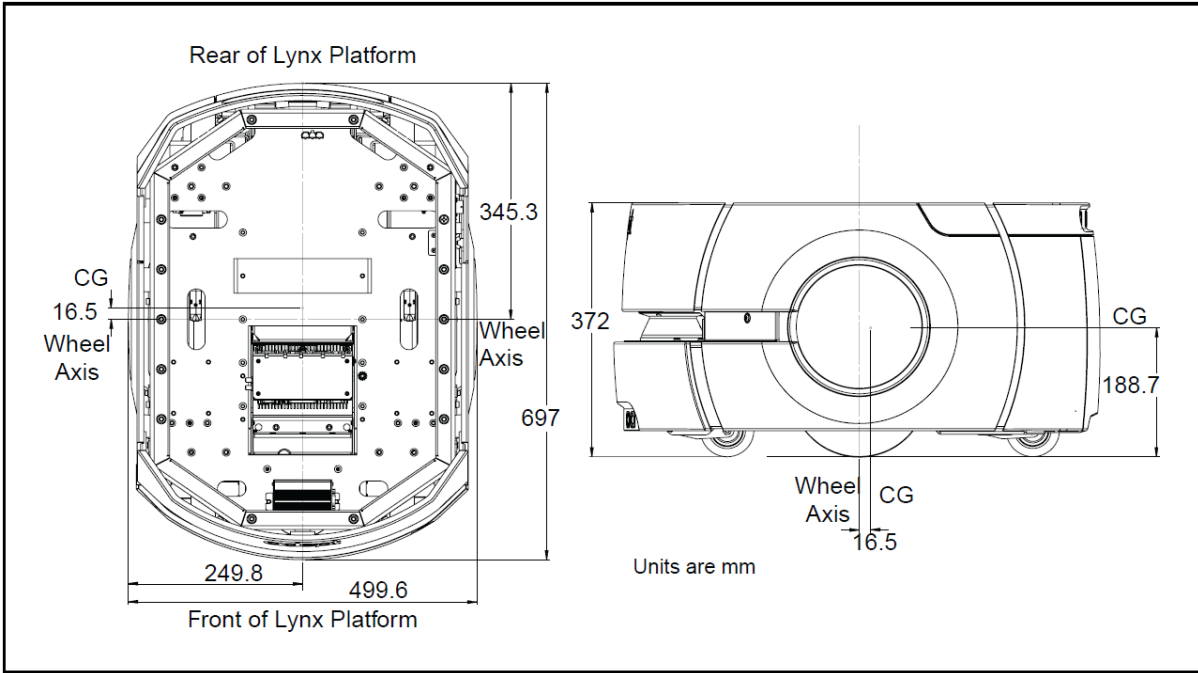


Figure 8: Center of Gravity of Platform

The three following figures show the calculations of safe placements for the center of gravity for payload structures with the weights listed. The center of gravity, in each instance, needs to be within the area shown. All units are mm.

NOTE:
 These figures show the limits of where the payload structure center of gravity can be placed. You should try to keep your CG as close to the center of these figures as possible.

IMPORTANT:
 Applications for which the CG cannot be maintained within these limits are not supported. OMRON recommends against such changes.

In the following three figures, light blue represents the payload structure, while dark blue represents the LD robot.

60 kg

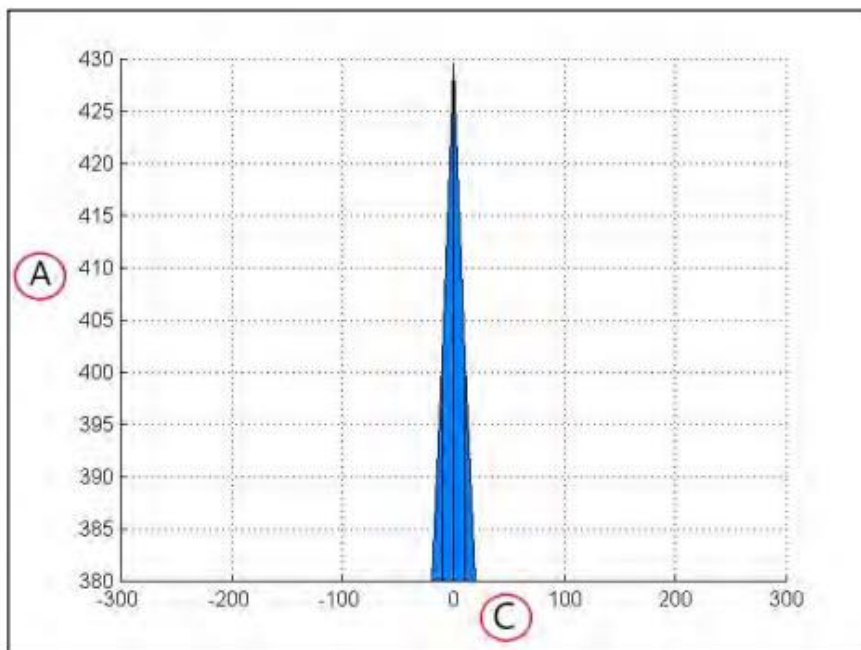
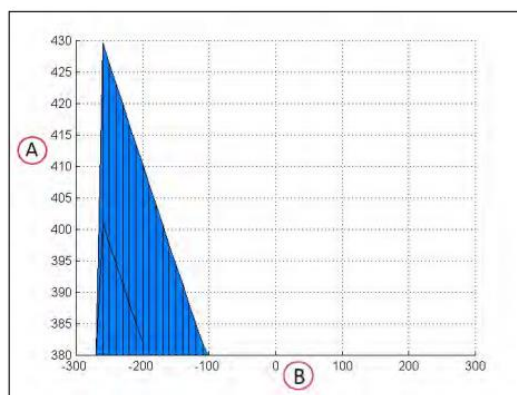
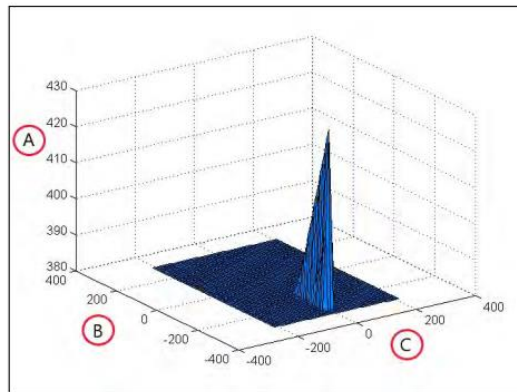


Figure 9: Center of Gravity Graphs, 60 kg (units in mm)

90 kg

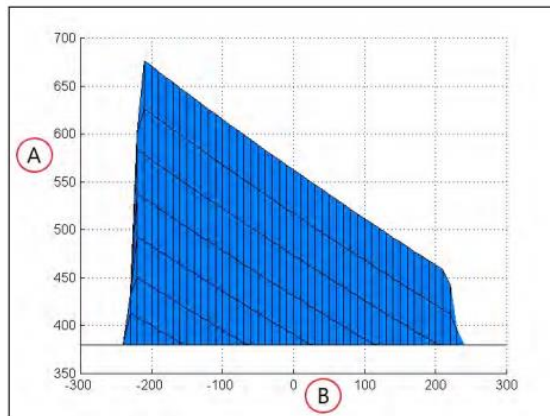
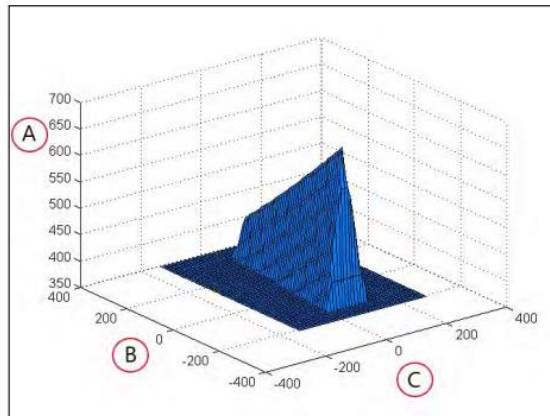


Figure 10: Center of Gravity Graphs, 60 kg (units in mm)

The following figures show the calculations of safe placements for the center of gravity for payloads with the weights listed for the LD Platform Cart Transporter. The center of gravity, in each instance, needs to be within the area shown. All units are mm.

105 kg

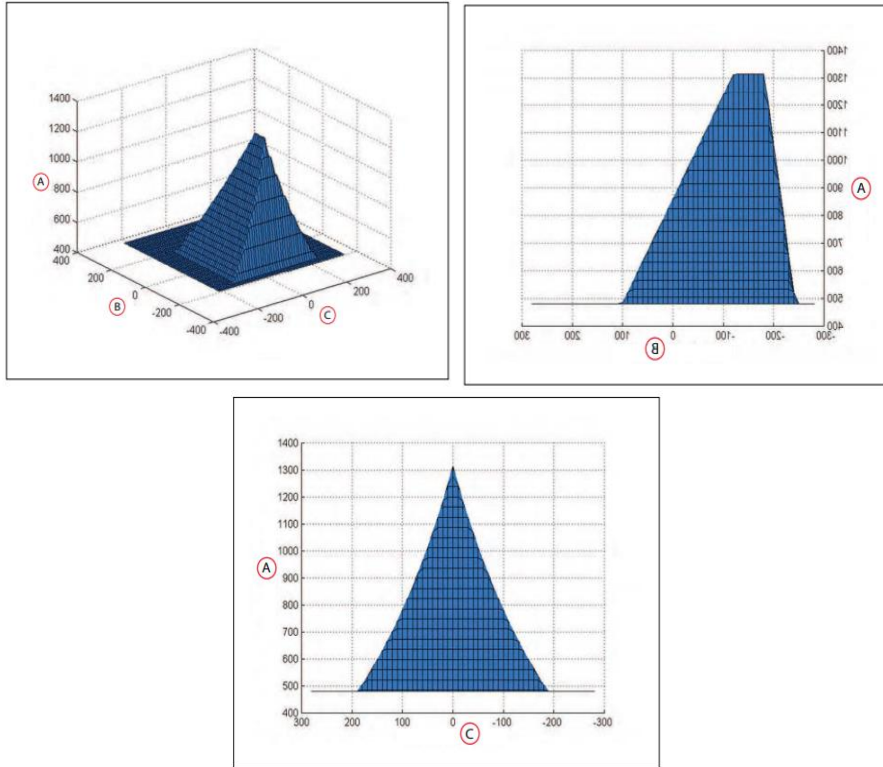


Figure 13: Center of Gravity Graphs, 105 kg

130 kg

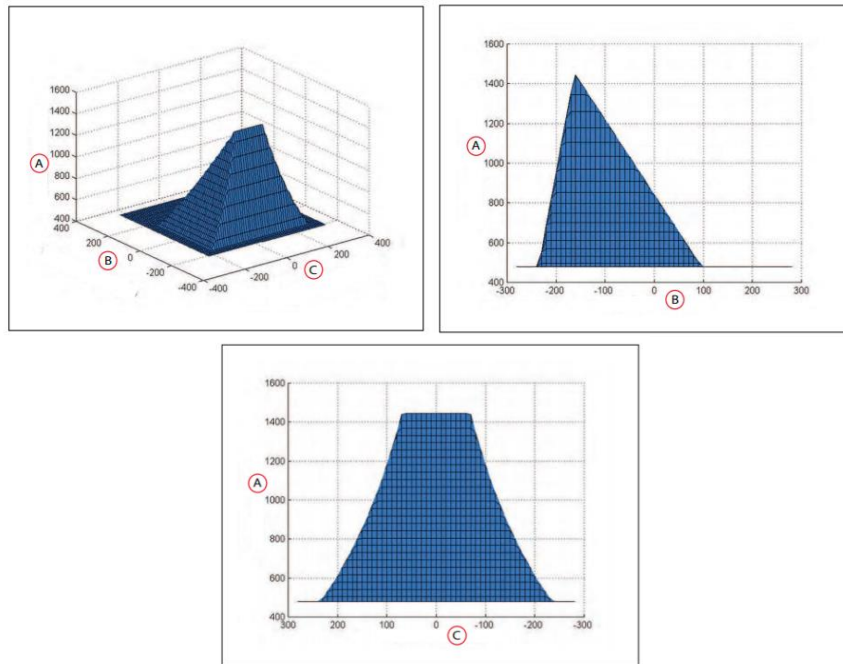


Figure 14: Center of Gravity Graphs, 130 kg

7.3 Payload-Related Tradeoffs

If you have to extend your center of gravity beyond the guidelines given here, you will need to adjust various parameters in the MobilePlanner software to compensate for that.

Contact your robot provider to get a new set of plots based on parameters that differ from those used to produce the plots shown here.

In general, lowering the maximum accel, decel, and rotation speeds will be required. Refer to Acceleration, Deceleration, and Rotation Limits in the User's Manual.

7.4 Connections Between Platform and Payload Structure

The LD platform provides a variety of I/O and power connections, which you can use to make your AMR more effective.

Operator Panel

The Operator screen, E-Stop, Brake-release, ON, and OFF can be "moved" using a single connector (the HMI Panel connector). This allows you to put many of the more common operator controls somewhere on your payload structure with just one cable.



Figure 11: Standard Operator Panel

Option Connections

The platform provides connectors for a user-supplied payload bumper and additional sonar units that can be placed on the payload structure.

8 Connectivity

Most of the connections that are available to the user are in the payload bay, which is the space between the platform and any payload structure placed on top of it. These include I/O and power connections. Some are required; others are available if needed. The two exceptions are the Joystick port, and the Maintenance Ethernet port, which are located under a small access panel on the left side of the LD platform, in the upper-right corner. Both of these ports have a second, connected port inside the payload bay. See Figure 14. The LD Cart Transporter models have additional electronics in the payload bay that control the automated latching system, and the user interface at the top of the post at the rear of the platform. Connections that differ from the base LD Platform are addressed below.

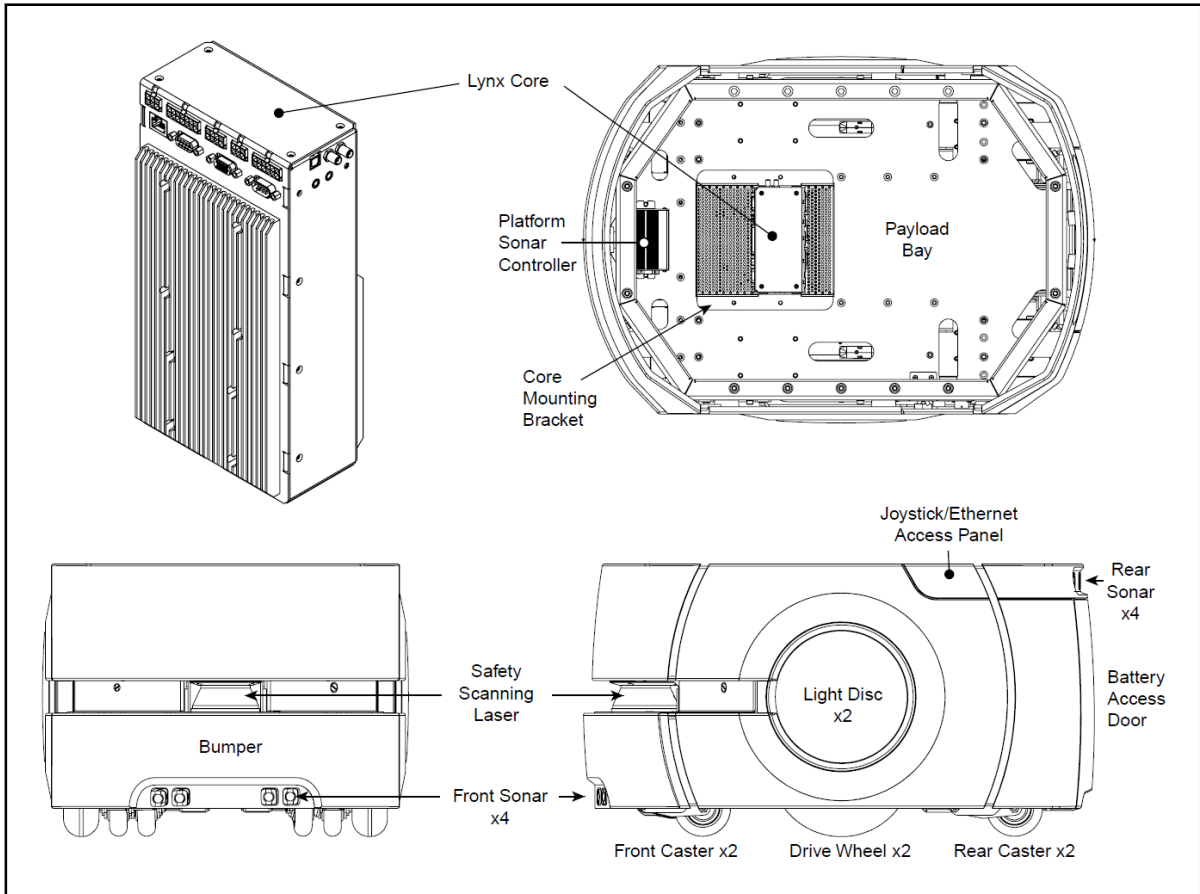


Figure 12: Location of Parts on the Platform

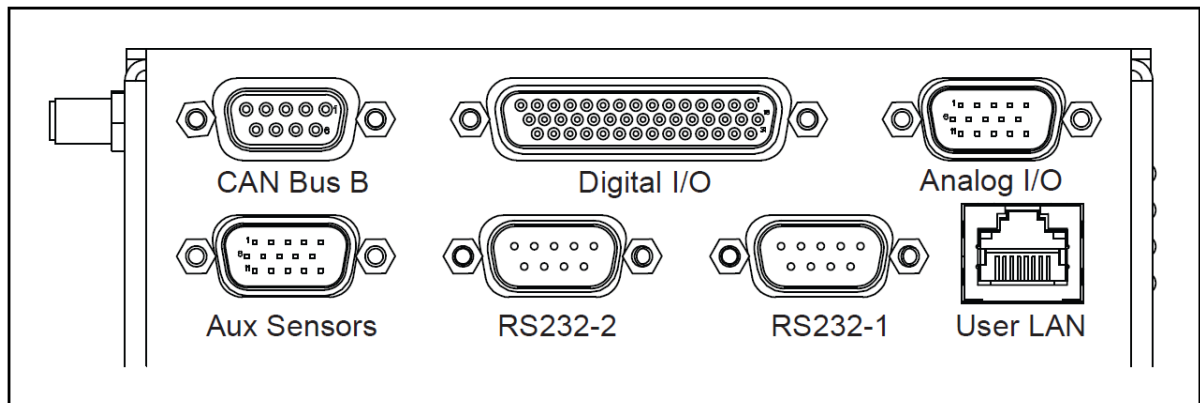


Figure 13: Front Upper Core

Aux Sensors

Connector type: HDB15M

Use: Low Front Laser, optional vertical lasers

Pin No.	Designation		Notes
	Hardware	Software	
1	RS232_VERT1_TXD		/dev/ttyUSB5 (side lasers)
2	RS232_VERT2_TXD		/dev/ttyUSB6 (side lasers)
3	RS232_FOOT_TXD		/dev/ttyUSB7 (side lasers)
4	5V_SW1	USB_1_and_2_Power	5 V @ 1 A (shared with USB port 1)
5, 10	SW_20V_VERT	Vertical_Laser_Power	20 V @ 300 mA
6, 7, 8	GND		
9	5V_SW2	USB_1_and_2_Power	5 V @ 1 A (shared with USB port 2)
11	RS232_VERT1_RXD		/dev/ttyUSB5 (side lasers)
12	RS232_VERT2_RXD		/dev/ttyUSB6 (side lasers)
13	RS232_FOOT_RXD		/dev/ttyUSB7 (side lasers)
14	5V_SW3	USB_3_Power	5 V @ 1 A (shared with USB port 3)
15	SW_20V_FOOT	Foot_Laser_Power	20 V @ 150 mA

LD Platform Core Rear, Upper

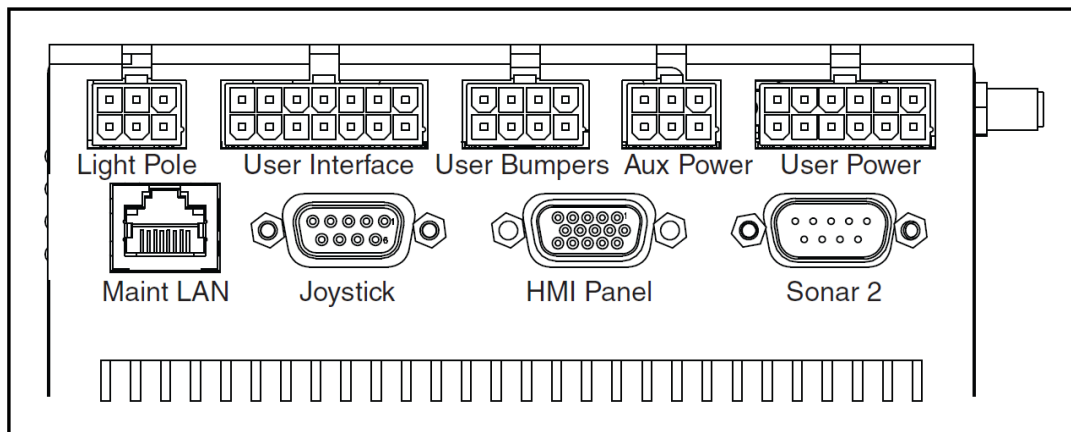


Figure 14: Rear Upper Core

NOTE:

The connectors in the top row of the rear upper core mate with Molex Mini-Fit Jr™ 5557 series receptacles.

Connection	Type	Description
Light Pole	Mini-Fit 2 x 3	Connects to a user-supplied light tower with 3 lights and 1 buzzer, using a default configuration
NOTE: The following four functions are pins on the User Interface connector.		
Brake-release	Mini-Fit 2 x 7	Pins for user-supplied brake release
ON		Pins for user-supplied ON button; same function as Operator Panel ON
OFF		Pins for user-supplied OFF button; same function as Operator Panel OFF
ESTOP		Pins for user-supplied E-Stop (must be used or jumpered)

Connection	Type	Description
User Bumpers	Mini-Fit 2 x 4	Payload structure bumpers, user-supplied, connected between ESTOP_SRC and USER_BMP# (for each of the 6 inputs). Contacts 1 - 3 are for a front bumper, 4 - 6 for rear. Contacts should be 12 V @ 10 mA.
Aux Power	Mini-Fit 2 x 3	5, 12, and 20 VDC Outputs
User Power	Mini-Fit 2 x 6	Battery and switched battery power
Maint LAN	RJ45, Shielded	Directly connected to the externally-mounted Maintenance Ethernet, Auto-MDIX.
Joystick	DB9F	Directly connected to the externally-mounted Joystick port
HMI Panel	HDB15F	Operator screen, E-Stop, Brake_Rel, ON, OFF
Sonar 2	DB9M	Not used

User Interface

Connector type: Mini-Fit® 7 x 2

Use: Brake release, ON, OFF, E-Stop

Pin No.	Designation	Notes
1, 2, 3	FBAT_ALWAYS	Fused VBAT @ 500 mA
4	ESTOP_USR_1L	Short 4 & 11 to close ESTOP_USR_1
5	ESTOP_USR_2L	Short 5 & 12 to close ESTOP_USR_2
6	ESTOP_OUT_1L	Pins 6 & 13 short when ESTOP_CH1 is closed
7	ESTOP_OUT_2L	Pins 7 & 14 short when ESTOP_CH2 is closed
8	OFF_BUTTON	Short to FBAT_ALWAYS to signal OFF (min 1 s pulse)
9	START_BUTTON	Short to FBAT_ALWAYS to signal ON (min 1 s pulse)
10	MOTOR_BRAKE	Short to FBAT_ALWAYS for manual brake release
11	ESTOP_USR_1H	Short 4 & 11 to close ESTOP_USR_1
12	ESTOP_USR_2H	Short 5 & 12 to close ESTOP_USR_2
13	ESTOP_OUT_1H	Pins 6 & 13 short when ESTOP_CH1 is closed
14	ESTOP_OUT_2H	Pins 7 & 14 short when ESTOP_CH2 is closed

NOTE:

An E-Stop jumper or a user-supplied E-Stop button needs to be attached to the E-STOP port on the User Interface connector for the platform to function. The jumper is provided as part number 12730-000L. An E-Stop button would be user-supplied.



CAUTION: If you are using a user-supplied E-Stop, you must run the Safety Commissioning to verify the E-Stop's functionality before putting the robot into service.

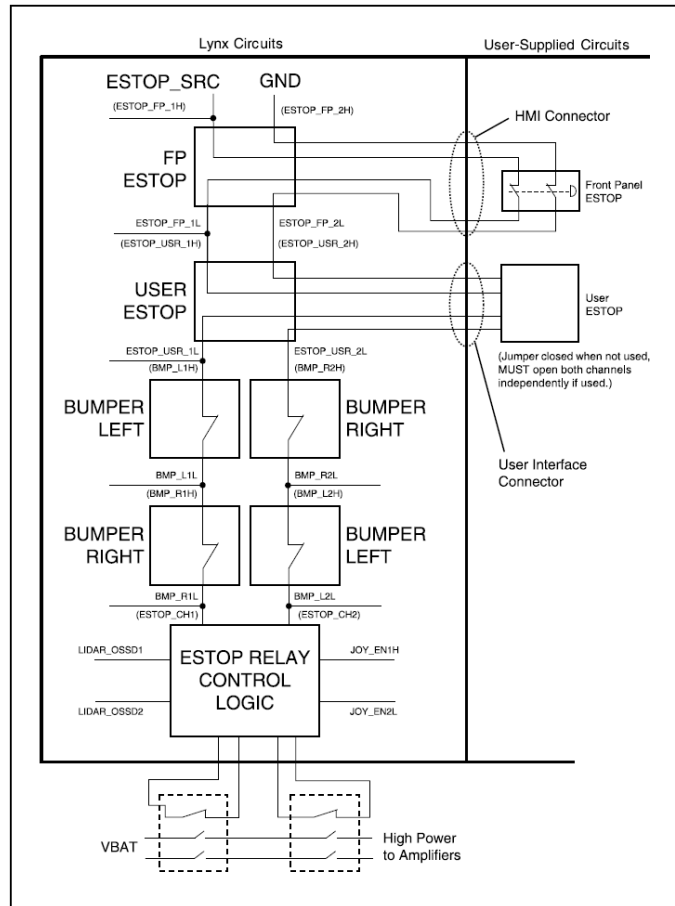


Figure 15: ESTOP Chain Diagram

User Bumper

NOTE:

Pins 1 through 3 are for a front-mounted bumper, 4 through 6 are for a rear-mounted bumper.

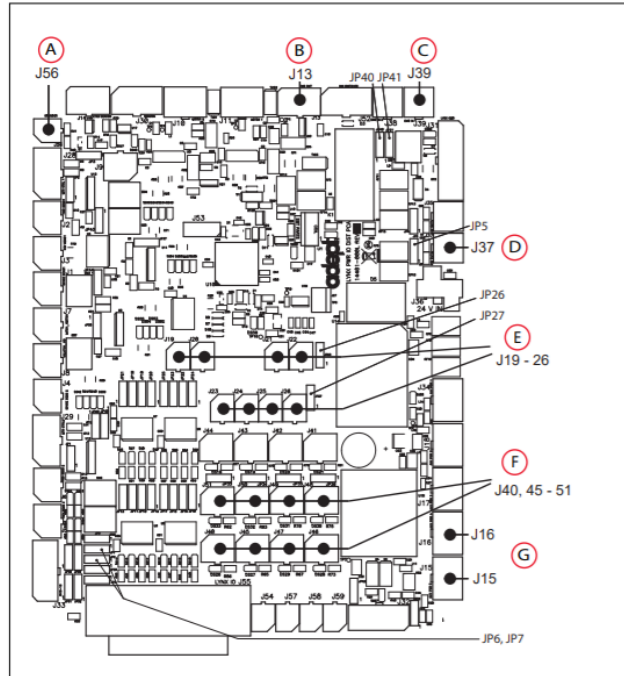
Connector type: Mini-Fit® 4 x 2

Use: Optional bumper for payload structure

Pin No.	Designation	Notes
1	USER_BUMPER_1	Short to ESTOP_SRC to signal bumper hit Front left bumper sensor.
2	USER_BUMPER_2	Short to ESTOP_SRC to signal bumper hit Front center bumper sensor.
3	USER_BUMPER_3	Short to ESTOP_SRC to signal bumper hit Front right bumper sensor.
4	USER_BUMPER_4	Short to ESTOP_SRC to signal bumper hit Rear right bumper sensor.
5	USER_BUMPER_5	Short to ESTOP_SRC to signal bumper hit Rear center bumper sensor.
6	USER_BUMPER_6	Short to ESTOP_SRC to signal bumper hit Rear left bumper sensor.
7, 8	ESTOP_SRC	12 V ESTOP Source Output @ 10 mA

Cart Specific PCA

The transporter uses pins 9-16, both Input and Output. The cart PCA is powered by the User Power from main LD Platform core. User Interface goes through the PCA to the Operator panel. User Interface goes through the PCA to the Operator panel.



Callout	Description	Callout	Description
A	User Beeper Out	E	User I/O Out 1-8
B	User EMO Out	F	User I/O In 1-8
C	User EMO Switch Connector	G	User Power Out
D	User Power		

9 Technical Specifications

9.1 Dimension Drawings

For standard platform:

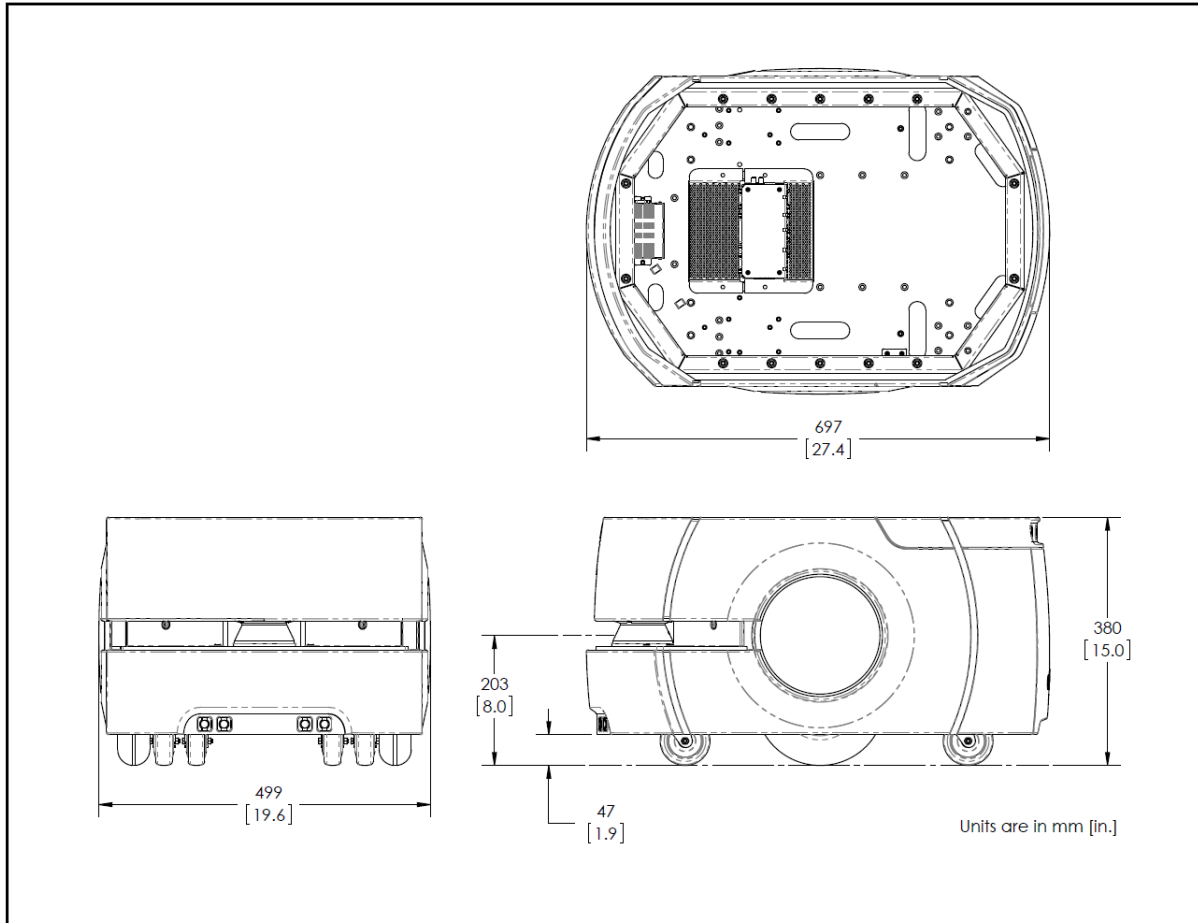
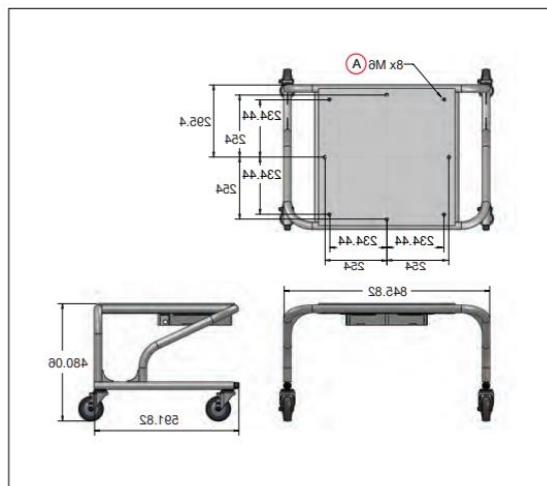
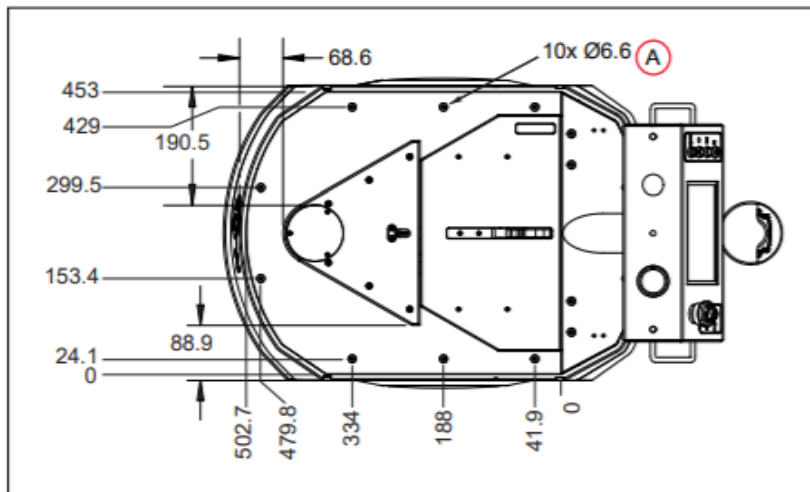
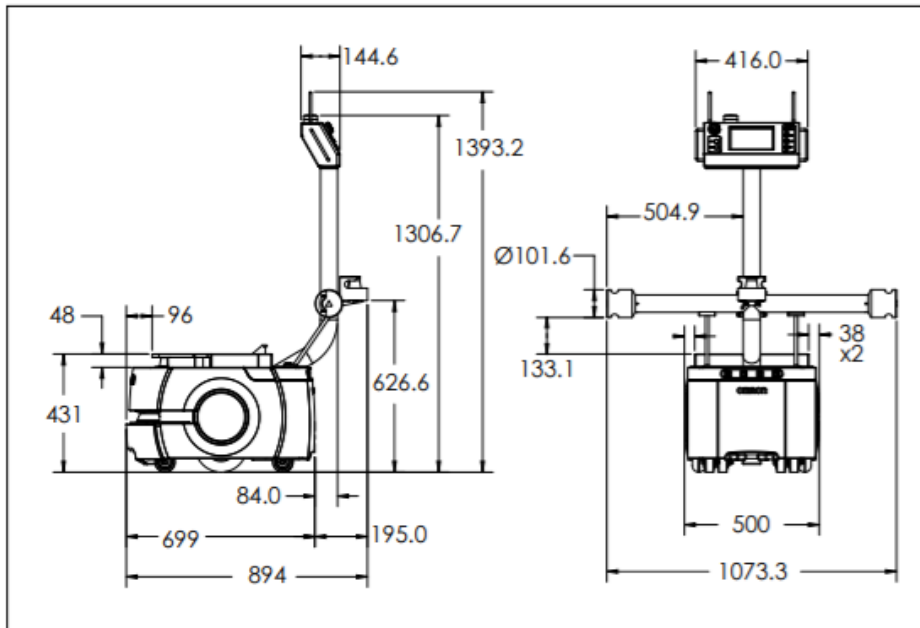


Figure 16: ILD Platform Top, Side, and Front Dimensions

For Cart Transporter platform:



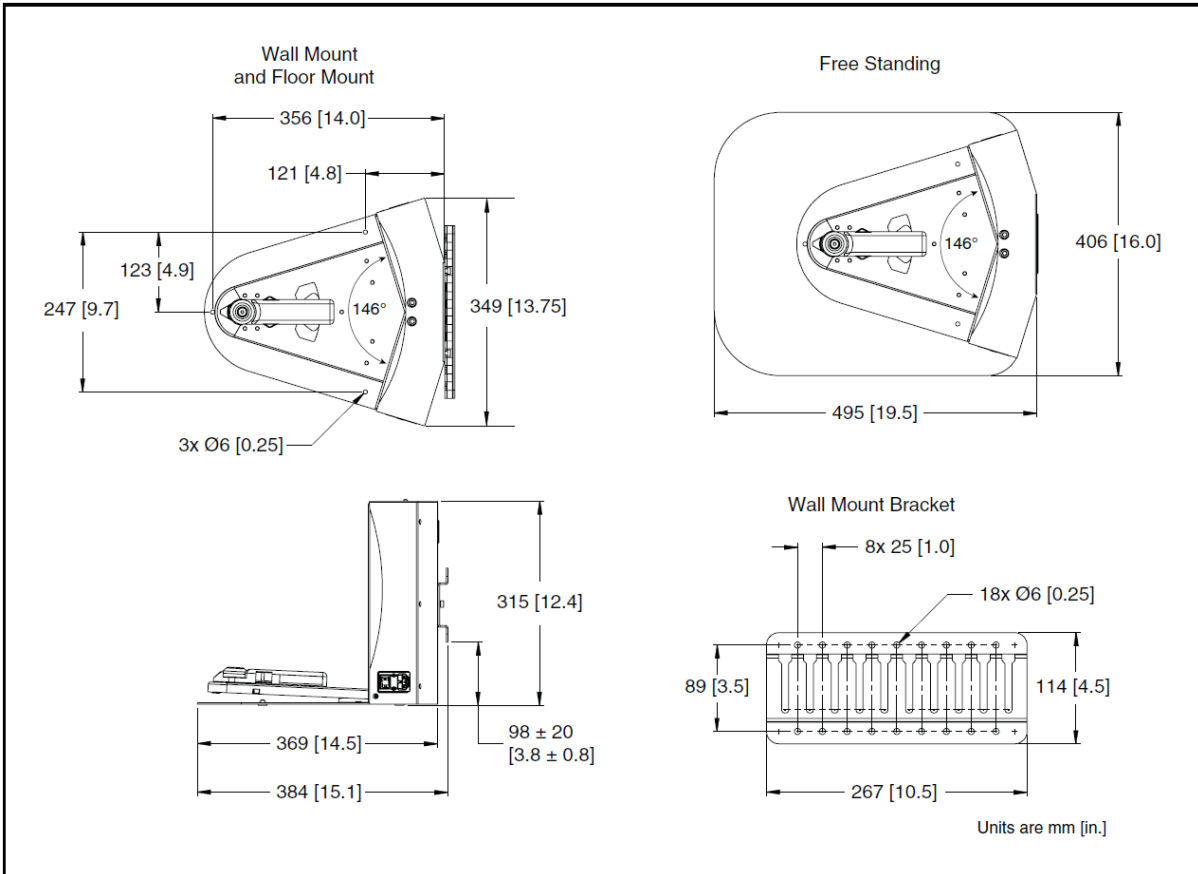


Figure 17: Docking Station Dimensions

9.2 Platform Specifications

Physical

Description	Specification for Standard Platform	Specifications for Cart Transporter Platform
Physical		
Length	686 mm	894 mm
Width	483 mm	1073 mm
Height (body)	371 mm	383 mm
Body clearance	38 mm	50 mm
Weight (with battery)	60 kg (132 lb)	81 kg (179 lb)
Rating		
IP rating	IP40	IP20
Cleanroom rating	Fed Class 100, ISO Class 5	Fed Class 100, ISO Class 5
NOTE: Fed Class 10 (ISO Class 4) is attainable in many cases. Contact Omron Robotics and Safety Technology.		
Joystick IP rating	IP56	IP56
Drive Train		
Drive wheels	2 grey non-marking foam-filled rubber	2 grey non-marking foam-filled rubber
Wheel diameter	200 x 50 mm (7.9 x 2.0 in.) nominal	200 x 50 mm (7.9 x 2.0 in.) nominal

Description	Specification for Standard Platform	Specifications for Cart Transporter Platform
Passive casters	2 front, 2 rear, spring-loaded	2 front, 2 rear, spring-loaded
Caster diameter	Caster diameter 75 mm (3 in.) nominal	Caster diameter 75 mm (3 in.) nominal
Brakes	2 (one each axle)	2 (one each axle)
Steering	Differential	Differential

Performance

Description	Specification
Performance	
Max payload – level	LD-60: 60 kg (132 lb) LD-90: 90 kg (198 lb) LD-105CT: 105 kg (231 lb) LD-130CT: 130 kg (287 lb)
Swing radius	LD: 343 mm LD-CT: 698.5 mm
Turn radius	0 mm
Translational speed, max	LD-60: 1800 mm/sec (67 in./sec) LD-90: 1300 mm/sec (51.2 in./sec) LD-105CT: 1350 mm/s (53.1 inches/s) LD-130CT: 900 mm/s (35.4 inches/s)
Rotational speed, max	LD-60: 300 degrees/sec LD-90: 225 degrees/sec
Traversable step, max LD-60	15 mm (0.6 in.)
Traversable step, max LD-90	10 mm (0.4 in.)
Traversable step, max LD-CT	5 mm (0.2 in.)
NOTE: A speed of 250 -300 mm/sec and 250 mm/sec, for the LD-60 and LD-90, is required for these steps. Faster or frequent driving over such steps or gaps will shorten the lifespan of the drivetrain components. Lower speeds may not traverse the step. Steps should have smooth, rounded profiles.	
Traversable gap, max	LD-60 and LD-90: 15 mm (0.6 in.) LD-105CT and LD-130CT: 5 mm (0.2 in.)
Climb grade	1:12
Traversable terrain	Generally wheelchair accessible
Minimum floor flatness	FF25 (based on the ACI 117 standard)
NOTE: ACI 117 is the American Concrete Institute's standard for concrete floors. FF is flatness, FL is the level. Higher FF numbers represent flatter floors. FF 25 is a fairly lenient specification.	
Battery	
Run-time	LD: 13 hours, approx., no payload LD-CT: 15 hours, approx., no payload
Duty cycle	80%
Weight	20 kg (44 lb)
Voltage	22 - 30 VDC
Capacity	LD: 60 Ah LD-CT: 72 Ah
Energy	LD: 1.5 kWh nominal LD-CT: 1.84 kWh nominal

Description	Specification
Recharge time	LD: 3.5 hours, approx. LD-CT: 4 hours, approx..
Life span	7 years, approx., 16 hrs/day, 5 days/wk 4 years, approx., 19/7 (full-time)

Sensors

Description	Specification
Sensors	
Safety Scanning Laser	1 at front of platform, 203 mm (8 in.) above floor 250°, 15 m range, Class 1, eye-safe, PLd as per EN ISO 13849-1
Sonar pairs (Each sonar is one emitter and one receiver, working together)	2 at rear of platform, 2 m range 2 at front of platform, in bumper, 2 m range (only in LD)
Position encoders	2 x 512 quadrature (one each wheel) 2 x Hall sensors
Analog gyroscope (LD core)	320 degree/s max rotation
Bumper	1 at front of platform, 2 pairs of sensors
Side Lasers (LD-CT)	2 on horizontal tubes of HMI post 270°, 4 m range, Class 1, eye-safe
Coupling Laser (LD-CT)	1 on platform deck, passing through the top plate into the coupling plate 270°, 4 m range, Class 1, eye-safe
Vertical Lasers (option)	2 on sides of payload structure, user-mounted
Upward-facing camera (Acuity option)	1 on payload structure, user-mounted
Payload Structure bumpers (option)	6 inputs, user-designed and mounted sensors (3 front, 3 rear)

Battery outputs

Nominal	Qty	Actual	Maximum Current	Description
5 VDC	1	5 VDC ±5%	1 A	Switched Aux power
12 VDC	1	12 VDC ±5%	1A	Switched Aux power
20 VDC	1	20 VDC ±5%	1A	Switched Aux power
22-30 VDC	2	Battery	4 A	Switched
22-30 VDC	1*	Battery	10 A	Switched
22-30 VDC	1*	Battery	10 A	Safe, Switched
* 10 A Switched and 10 A Safe, Switched share the 10 A of current.				

Cart

Description	Specification for Standard Platform
Physical	
Length	592 mm
Width	846 mm
Height (body)	480 mm
Weight	23 kg (50 lb)
Rating	
Caster ESD	ESD rated
Suspension	
Passive Casters	2 front, 2 rear, spring-loaded rating
Caster Diameter	100 mm (4 in.) nominal
Caster Brakes	2 rear casters

9.3 Docking Station Specifications

Description	Specification
Current	8 A Thermal fuse in AC power switch (10 A Time-lag fuse at switch for legacy dock)
Contacts	2
Voltage	100 to 240 VAC, 50 to 60 Hz
Power consumption	800 W
Short circuit current rating (SCCR)	1500 A
Humidity	5 to 95% non-condensing
Temperature	5° to 40° C (41° to 104° F)
Dimensions – WxDxH with Floor plate	349 x 369 x 315 mm [13.75 x 14.5 x 12.4 in.] 495 x 495.5 x 317 mm [16 x 19.5 x 12.5 in.]
Weight	8.2 kg (18 lbs)
Mounting	Wall bracket, directly to floor, or on floor with floor plate
Indicators	Power on - blue Charging - yellow
Connector	For out-of-platform battery charging

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