

## Mobile Robot LD

### Safety Guide



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## Revision History

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Revision code	Date	Revised Content
01	January, 2017	Original release
02	November, 2017	Changed upper battery storage temperature from 60°C to 45°C, added LD-90x (with LD-130CT) as being difficult to move with brake released, added Revision History. Revised definitions for Danger, Warning, and Caution to align with Omron's standards. Added Burn, Entanglement, and Explosion alerts, as well as Special Information.



# Chapter 1: Alerts and Special Information

## Alert Levels

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



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



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

## 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 entanglement situation.
	This identifies a hazardous electrical situation.		This identifies an explosion risk.
	This identifies a hazardous burn-related situation.		

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## Special Information

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

**IMPORTANT:** Information to ensure safe use of the product.

**NOTE:** Information for more effective use of the product.

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

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

# Chapter 2: Operational Safety

## 2.1 What to Do in an Emergency or Abnormal Situation

Press any E-Stop button (a red push-button on a yellow background) and then follow the internal procedures of your company or organization for an emergency or abnormal situation. If a fire occurs, use a type D extinguisher: foam, dry chemical, or CO<sub>2</sub>.

### Releasing the Brakes

In case of an emergency or abnormal situation, the LD Platform AIVs can be manually moved. However, only qualified personnel who have read and understood this manual and the AIV user's guide should manually move the AIV. 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 AIV.

**NOTE:** The LD-130CT and the LD-90x have a high gear ratio, and are very difficult to move, even with the brakes released.

### Releasing an E-Stop



**CAUTION:** INJURY OR PROPERTY DAMAGE RISK.

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

After the E-Stop button has been manually released, the AIV will wait until the motors are manually enabled.

Once the motors are enabled, the AIV will wait two seconds and then resume commanded motion, if there is adequate space to maneuver.

## 2.2 Definitions

**Platform:** The basic part of the robot, including the chassis, drive assemblies, suspension, wheels, battery, lasers, sonar, a core with gyroscope, navigation software, connectors for interfacing with and powering the payload structure, and platform covers.

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

**LD Platform OEM:** Either the LD-60 or LD-90 (or LD-90x) platform for 60 or 90 kg payloads.

**LD Platform Cart Transporter:** Either the LD-105CT or LD-130CT platform and cart. The platform has the HMI post (including extended arms) and the coupling plate attached, set up to transport a cart. This is also referred to as just a transporter.

**AIV (Autonomous Intelligent Vehicle):** A platform with a payload structure attached to it. This is your complete mobile robot, which will transport your products, parts, or data.

**Fleet:** Two or more AIVs operating in the same workspace.

**Enterprise Manager 1100:** A system that manages a fleet of AIVs. This includes the Enterprise Manager appliance and the software that runs on it.

### 2.3 User's Responsibilities

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

- Reading the installation and operation instructions, as well as this Safety Guide, before using the equipment.
- Ensuring that the environment is suitable for safe operation of the LD Platform.  
If a fleet of AIVs (two or more) is installed, the Enterprise Manager 1100 must be used, unless no two AIVs will ever operate in the same area.
- Ensuring that anyone working with or near an LD Platform has been adequately trained, and is following the AIV manual and this guide for safe AIV operation.
- Maintaining the AIVs so that their control and safety functions are working properly.

#### General Hazards

- Do not ride on the AIV.
- Do not exceed the maximum payload.  
Payload decreases as slope increases. Refer to the user's guide. The LD Platform Cart Transporter with a cart is not intended to operate on any slope.
- Do not exceed the maximum recommended speed, acceleration, deceleration, or rotation limits. See Center of Gravity in the AIV user's 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.
- Do not drop the AIV, run it off a ledge, or otherwise operate it in an irresponsible manner.
- Do not allow the AIV to drive through an opening that has an automatic gate/door unless the door and AIV 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 AIV wet, or expose the equipment to rain or moisture.
- Do not continue to run the AIV after hair, yarn, string, or any other items have become wound around the platform's axles, casters, or wheels.
- Do not use parts not authorized by Omron Adept Technologies, Inc.
- Do not turn on the AIV without the antennas in place.
- Although the lasers used are Class 1 (eye-safe), we recommend you not look into them.

## Falling Hazards



**WARNING: INJURY OR PROPERTY DAMAGE RISK.**  
The AIV 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

The edge of a loading dock, the entrance to downward stairs, or any other substantial drop that is within the AIV's expected operating area should be physically marked so that the AIV's navigation laser will see the barrier, and stop before reaching it. The AIV's navigation laser scans at 200 mm (7.9 inches), so the barrier must cover at least that height.

The barrier needs to be continuous at the site, so that the AIV can't drive around or through it to the dropoff.

### 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 AIV will not try to drive there.

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

## Electrical Hazards



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

- Do not use power extension cords with the charging dock unless properly rated.
- Never access the interior of the platform with the charger attached.
- Immediately disconnect the battery pack when removing the access cover.  
Avoid shorting the battery terminals.
- Do not use any charging dock not supplied by Omron Adept Technologies, Inc.
- If any liquid is spilled on the AIV, power off the AIV, clean up all possible liquid, and allow the AIV to air dry thoroughly before restoring power.

## Pinch Hazard

### Platform Covers



**CAUTION: PINCH RISK.**  
The robot covers are held in place with strong magnets, which can pinch you if you are not careful. Follow the instructions in the AIV user's guide Maintenance chapter for handling covers.

## Magnetic Field Hazards

### Platform Covers

Magnetic fields can be hazardous to medical implant wearers. Medical implant wearers stay back 30 cm (12 inches) from the LD Platform covers, which are held in place with strong magnets.



**WARNING: MAGNETIC FIELD, PERSONAL INJURY RISK.**

Magnetic fields can be hazardous to medical implant wearers. Medical implant wearers stay back 30 cm (12 inches) from the platform covers, which are held in place with strong magnets.

### Docking Funnel



**WARNING: MAGNETIC FIELD, PERSONAL INJURY RISK.**

Magnetic fields can be hazardous to medical implant wearers. Medical implant wearers stay back 30 cm (12 inches) from the underside of the platform, which is exposed during certain maintenance procedures for which the platform is tipped on its side.

### Other Hazards

**NOTE:** Hazards specific to maintenance are covered in Safety Aspects While Performing Maintenance on page 21.

## Qualification of Personnel

It is the end-user's responsibility to ensure that all personnel who will work with or around LD Platforms 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.

As noted in this and the AIV 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.

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

- Have the necessary qualifications
- Have received the guides (both this guide, and the AIV user's 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 AIV payload movement and transfer to or from facility equipment is the end-user's responsibility.

Payload transfer problems must trigger an AIV E-Stop, preventing the AIV 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 an interlock between the AIV and facility equipment is the user's responsibility.

## 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 AIV will be operating. The buzzer will sound whenever the AIV is moving backwards or is turning. Other situations are configurable.

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

**Version Information:** 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.

**NOTE:** Disabling the DriveWarningEnable parameter violates the JIS D 6802 standard. 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-AIV Avoidance

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

**NOTE:** If two AIVs are approaching each other, neither will see the other because the incoming laser beams are interpreted as reflected beams. Because of this, any installation with more than one AIV working in the same operating space must be managed by the same Enterprise Manager.

## Traffic Control

Use a *switchable forbidden area* the map to prevent the AIV from entering an area based on the state of a discrete input. If this input is set from another vehicle, such as a forklift, while it is in that area, then the AIV will not be allowed to enter that area.

## Passing Lanes

Since the LD Platform technology does not use fixed tracks to guide the AIVs, the concepts of passing lanes and human safety areas are not relevant.

## 2.4 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 AIV is installed.

We have performed a Risk Assessment for Omron Adept Technologies, Inc. AIVs, based on the intended applications of the AIV. The conclusions are summarized in this section.

### PL and PFH

The Performance Level (PL) calculation for safety functions of the Omron Adept Technologies, Inc. AIVs are based on the ISO 12100 evaluation for the LD Platform and LD Platform Cart Transporter, with joystick, Enterprise Manager 1100, and MobilePlanner.

The PL achieved and the Probability of Dangerous Failure per Hour (PFH) are calculated using SISTEMA as per ISO 13849-1, based on requirements of EN 1525, for the following Safety Functions:

No.	LD Platform Function	PL Achieved	PFH [1/h]
1	Forward and Reverse	d	3.7E-7
2	Charging Dock Activation	b	1.1E-6
3	HMI Front Panel Emergency Stop (E-Stop)	d	3.4E-8
4	User Emergency Stop (E-Stop)*	d	3.6E-8

No.	LD Platform Function	PL Achieved	PFH [1/h]
5	Safety Laser Personnel Detection	d	3.6E-8
6	Manual (Joystick) Bypass of Personnel Detection	d	4.6E-8
The following safety function is applicable only to the Cart of the LD Platform Cart Transporter			
7	Cart Transporter Brakes	b	1.1E-6

\*The ESTOP pins on the User Interface connector are provided for use with a user-supplied external E-Stop. The user is responsible for calculating the overall PL and PFH, inclusive of user-supplied components, and performing a final risk assessment.

## Exposure

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

- Do not ride on the AIV. Riding on the AIV or staying in the vicinity of the AIV for long periods (when ON or while charging) will expose you to the magnetic fields generated by the AIV.
- When the AIV is turning in place, while not going forward, personnel must stay away from the AIV.

## Severity of Injury

The severity of injury depends on the type of payload and how the payload is integrated with the AIV. 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 AIV, and adding additional protection like side lasers, etc. depending on how the AIV is configured, to reduce any work-related injuries.

## Avoidance

The AIV will avoid obstacles unless modified or the safety systems are intentionally defeated. The AIV has dual-channel, safety-rated lasers to avoid obstacles.

**IMPORTANT:** The AIV's obstacle avoidance system, using the safety navigation laser, is not used when the joystick is connected. When the joystick is connected to the AIV, the Operator must maintain control of the joystick and AIV at all times.

In addition, there are side lasers (standard on the LD Platform Cart Transporter and optional for the LD Platform OEM), bumpers on the LD Platform OEM, and SONAR that are used to prevent the AIV from driving into an object or person.

Follow all industrial safety practices, such as steel toe shoes, and adding additional protection like side lasers, etc. depending on how the AIV is configured.

The LD Platform OEM and LD Platform Cart Transporter are fully-autonomous AIVs that, once configured, work around people in industrial settings with no intervention needed. Risks associated with integrating the AIV in the industry can be avoided, with a few basic steps.

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

The AIV will come to a complete stop when the bumpers are hit with a force of at least 67 N.

### 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.

## 2.5 Environment

It is the end-user's responsibility to ensure that the operating environment of the AIV remains safe for the AIV. If there are areas that are not safe for the AIV to travel in, those areas should be physically blocked off so that the AIV's scanning laser will detect the barriers, and the AIV 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 AIV. It is the user's responsibility to ensure that adequate clearance is maintained on each side of the AIV, so that a person cannot get trapped between the AIV 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 dropoff locations where the AIV must get close to conveyors or other fixed facility objects.

The primary direction of travel of the LD Platform is forward. When the AIV 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: IMPACT INJURY RISK.**

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

## Obstacles

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

## 2.6 Intended Use

The LD Platform is not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- Uncontrolled areas, for example, areas open to general public access.

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

The LD Platform is 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.

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

**NOTE:** The gyroscope used to assist in navigation in LD Platforms requires a stationary environment for optimum accuracy. Therefore, we do not recommend the LD Platform for use on a ship, train, aircraft, or other moving environment.

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

## Non-intended Use

Non-intended use of LD Platform AIVs can:

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

LD Platforms are intended for use on generally level floors, in wheelchair-accessible areas. Some LD Platforms, and any LD Platform Cart Transporter, will not fit through a standard-width ADA door or opening.

The body of the AIV must not come into contact with liquids. The drive wheels can tolerate damp floors, but the body of the AIV must remain dry.

If there is any doubt concerning the application, ask your local Omron Support to determine if it is an intended use or not.

### **AIV Modifications**



**WARNING: INJURY OR PROPERTY DAMAGE RISK.**

Any change to the AIV can lead to loss in safety or functionality. It is the user's responsibility to perform a risk assessment for the whole (modified) AIV after any such changes and to confirm that all safety features of the AIV are operational.

### ***Payload Structure***

Attaching a payload that is larger than the footprint of the top of the platform or is outside the recommended CG may impact safety and functionality. It is the user's responsibility to perform a risk assessment and declare compliance for the whole (modified) AIV.

### ***Reprogramming or Reconfiguration***

Reprogramming or reconfiguration of the AIV safety components or parameters may impact safety and functionality. It is the user's responsibility to perform a risk assessment and declare compliance for the whole (modified) AIV.

### ***Sharp Edges, Protrusions***

Adding a payload can introduce sharp edges, corners, or protrusions to the AIV. It is the user's responsibility to perform a risk assessment and declare compliance for the whole (modified) AIV.

### ***Manufacturer's Declaration***

The manufacturer's declaration applies to the AIV as it was placed on the market. It is the responsibility of the end user to verify compliance of the system in the final application inclusive of any modifications or additions.

## 2.7 Safety Aspects While Performing Maintenance

### Electrical Safety



**WARNING: ELECTROCUTION RISK.**

During maintenance of the charging dock, disconnect the AC power cord to the charging dock. Keep it locked up until you are done with maintenance.



**WARNING: SHOCK RISK.**

During maintenance and repair, disconnect the battery of the AIV as soon as possible. Avoid shorting the terminals of the battery.

### Other Risks



**CAUTION: BURN RISK.**

Parts of the drive train can get hot during operation. Allow the platform to cool down before servicing.



**CAUTION: ENTANGLEMENT RISK.**

Keep all body parts and clothing away from moving parts. E-Stop and power-down the robot before maintenance.

### Battery Safety Information



**WARNING: EXPLOSION RISK.**

The mobile robots use lithium ion batteries. If a battery is ruptured and exposed to water, it may ignite or explode.

If the battery is found to be leaking, do not expose to water. If possible, submerge in mineral oil and contact your local Omron Support.

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.

### Safety Precautions

- Batteries must be stored upright at 5 to 45°C (41 to 113°F) - for up to one month.  
Store at 20 to 25°C (68 to 77°F) for up to one year.
- Do not expose to water.
- If the battery is found to be leaking, do not expose to water. If possible, submerge in

mineral oil and contact your local Omron Support.

- In case of fire, use a type D extinguisher: foam, dry chemical, or CO<sub>2</sub>.

### **Maintenance**

Every six months:

- Inspect battery for damage or leaks.
- Place battery on a charger and allow to fully charge.



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