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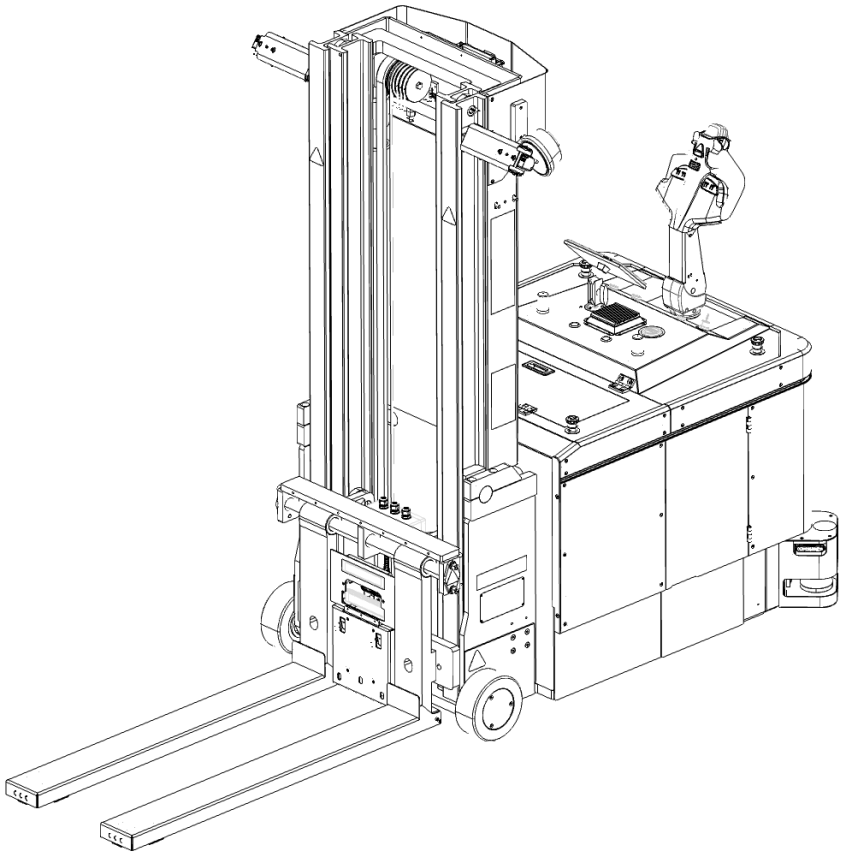

# OTTO Lifter MkIV - OMM-000108

Operation and maintenance manual

OMM-000108
Publication date Jan-23

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# 1. IMPORTANT SAFETY INFORMATION

The top priority of OTTO Motors is the safety of its users. OTTO Motors produces high power and fast-moving pieces of machinery that could cause serious injury, including death, if improperly used or maintained. Additional hazards may be identified and need to be addressed during the site-specific risk assessment.

Review the safety messages and all instructions before using the product. Save this document for reference.

**WARNING**
Failure to follow operating instructions may result in death or serious injury.

- Read and understand the operation and maintenance manual before using the robot, charger, or attachment.
- For the physical location of elements on the product, refer to the Component Overview section of the operation and maintenance manual.

## 1.1. Hazards

The following are examples of hazard notices:

**DANGER**
Failure to follow these instructions will result in SERIOUS INJURY, INCLUDING DEATH.

**WARNING**
Failure to follow these instructions may result in SERIOUS INJURY, INCLUDING DEATH.

**CAUTION**
Failure to follow these instructions may result in MINOR or MODERATE INJURY or DAMAGE to the system and/or property.

## General hazards

### WARNING

- BURN or SHOCK HAZARD! Never use this product if the enclosure or any of the connectors are broken, cracked, open, or show any other indication of damage.
- SHOCK HAZARD! Always perform the lock-out/tag-out procedure at the facility or on the product before inspecting, servicing, cleaning, removing components, or opening any enclosure.
- FIRE HAZARD! Observe all safety precautions when using flammable fluids.
- CRUSH HAZARD! Keep a safe distance from suspended loads.
- Always be aware of operation limitations such as floor grades, negative and overhanging obstacles, and the LiDAR obstacle detection plane.
- FIRE OR SHOCK HAZARD! Never use a power cord or cable that appears damaged.

### CAUTION

- Never operate the product after faulty parts are identified.
- Never expose OTTO Motors products to rain, condensation, or standing water. Store products in a clean and dry location.
- Use appropriately rated lift equipment and follow safe lifting procedures as defined by the facility when lifting the product.
- Wear appropriate safety equipment when operating or working around the product.
- TRIP HAZARD! Take care when walking around the product.
- Only qualified personnel should perform installations, maintenance, and inspections.
- Only use the attachments, accessories, tools, replacement parts, and cleaning products approved by OTTO Motors.
- Installation must be performed by an electrically qualified person to ensure compliance with local electrical codes.
- PINCH HAZARD! Keep objects and body parts away from pinch points.
- FIRE HAZARD! Observe all safety precautions when using flammable fluids.

## Robot hazards

### WARNING

- Always use level rigging when lifting or lowering the product.
- IMPACT HAZARD! Never bypass the drive wheels of the robot while on a sloped surface.
- Never use OTTO Motors products to transport people or live animals.
- CRUSH or IMPACT HAZARD! Robots must be prevented from traveling in areas that do not follow Facility Conditions specifications, such as ramps and stairwells.
- FIRE HAZARD! If the battery is damaged or a battery fire occurs, contact local emergency services and vacate the area. Do not use water to douse the fire.
- FIRE OR SHOCK HAZARD! Never use a power cord or cable that appears damaged.
- SHOCK HAZARD! Never attempt operation if the power supply is not within the specified voltage and current, as identified in the product documentation.
- FIRE HAZARD! Observe all safety precautions when using flammable fluids.
- CRUSH HAZARD! Pedestrians should be aware of hazard mode or docking mode audio-visual indications. When robots are in docking mode, the front of the robot is no longer safeguarded—personnel must be restricted from areas where robots will be docking. When robots are in hazard mode, the region safeguarded by LiDAR safety scanners is reduced in size. Under rare circumstances, robots can get mislocalized and enter docking hazard mode in an unintended location. For audio-visual indicator identification, refer to the Component Overview section of the robot operation and maintenance manual.
- CRUSH HAZARD! Payloads, attachments, or a combination thereof, should always remain within the stability envelope relevant to the specific robot model. For payload constraints, refer to the System Specifications for the product.
- CRUSH/PINCH HAZARD! Manual or automatic load transfer may introduce a crush or pinch hazard. Take care when performing a manual load transfer. A risk assessment should be conducted to mitigate hazard risk when designing load transfer systems.
- CRUSH or IMPACT HAZARD! All stairwells or similarly open holes must be marked and surrounded by obstacles exceeding 20 cm in height with spacing no greater than 30 cm. These obstacles must be able to withstand 2000 N of force without failing or be at least 70 mm wide from all directions and visible to the LiDAR.

**CAUTION**

- IMPACT HAZARD! Always maintain a safe distance from a robot in operation. A robot being operated in manual mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot operation and maintenance manual.
- IMPACT HAZARD! While driving the robot in manual mode, the safety field sets monitored by the LiDAR scanners can be disabled. To avoid impact, be aware of the robot's surroundings.
- Avoid making contact with the LiDAR safety sensors as they are fragile and easily damaged. For sensor locations, refer to the Component Overview section of the robot operation and maintenance manual.
- Do not expose the product for a prolonged period to temperatures outside the ranges specified in the product documentation.
- IMPACT HAZARD! Do not place anything on the robot that extends beyond its footprint. Refer to the robot Safety Configuration document for the footprint dimensions.
- CRUSH or IMPACT HAZARD! Keep low profile objects that the LiDAR cannot detect, such as forklift tines and pallets, outside of the robot's path. For sensor layouts, refer to the Component Overview section of the robot operation and maintenance manual.
- BURN HAZARD! Allow the product to cool before performing maintenance.
- Do not connect the robot to a manual charger and an automatic charger at the same time as this can result in damage to either charger.
- SHOCK HAZARD! Improper use or maintenance of robot batteries may result in a high energy discharge.
- Never exceed the maximum total payload constraints of the product. For payload constraints, refer to the System Specifications for the product.
- CRUSH HAZARD! Objects can fall from the product. Where possible, secure loads to the product to avoid falling, tipping, shifting, or sliding.

## Charger hazards

For instructions on connecting the robot to a charger, refer to the charging information in the Basic Usage section of the product operation and maintenance manual.

**WARNING**

- FIRE OR SHOCK HAZARD! Never use a power cord or cable that appears damaged.
- SHOCK HAZARD! Automatic chargers are powered by hazardous voltage levels. Do not touch the charge contacts when the product is in operation.
- Chargers must be installed with a disconnect that electrically isolates the charger and functions as an emergency switch.
- FIRE HAZARD! If the battery is damaged or a battery fire occurs, contact local emergency services and vacate the area. Do not use water to douse the fire.
- SHOCK HAZARD! Never attempt operation if the power supply is not within the specified voltage and current, as identified in the product documentation.

**CAUTION**

- CRUSH HAZARD! Always maintain a safe distance from a charger in operation.
- SHOCK HAZARD! Improper use or maintenance of robot batteries may result in a high energy discharge.
- Installation must be performed by an electrically qualified person to ensure compliance with local electrical codes.
- Do not connect the robot to a manual charger and an automatic charger at the same time as this can result in damage to either charger.
- BURN HAZARD! Allow the product to cool before performing maintenance.
- TRIP OR FIRE HAZARD! Position all cables where they cannot contact hot surfaces, be pulled, tripped over, or damaged.
- Never disconnect the system while it is under electrical load.
- GROUNDING ELECTRICAL HAZARD! The power supply for the charger must be grounded.
- FIRE HAZARD! Chargers and batteries must only be used in a well-ventilated area and must be easily accessible.
- FIRE HAZARD! Never smoke, use power tools, or perform any activity that can create sparks around a battery or charger.

## 1.2. Hazard labels

Review the following to learn more about the labels that may be used on OTTO Motors products. Hazards can also apply to attachments and accessories used in conjunction with an OTTO Motors product.

| Label | Title | Description | Label | Title | Description |
|---|---|---|---|---|---|
|  | **Grounding electrical hazard** | Improper grounding of OTTO Motors chargers can result in a potential shock risk. |  | **Pinching risk** | Keep hands and other objects clear of pinch points at all times.<br><br>Keep clear of all docking robots. |
|  | **Harmful battery substance** | Robot batteries contain harmful material. Always use proper handling procedures when handling robot batteries. |  | **Crushing risk** | Objects or personnel can be crushed between robots and another object.<br><br>Keep hands and other objects clear of crush points at all times.<br><br>Keep clear of all docking robots. |
|  | **Burn hazard** | Robot PC heat sinks and robot motors can become extremely hot during operation. |  | **Impact hazard** | OTTO Motors robots travelling through a facility can potentially impact objects and personnel.<br><br>Keep clear of all docking robots. |
|  | **Manual load handling** | Always use ergonomic technique when manually lifting loads. |  | **Robot movement** | Robots may suddenly begin moving autonomously or when being driven manually.<br><br>Always be aware of OTTO Motors products and their potential for movement. |
|  | **Tripping hazard** | OTTO Motors products may pose a tripping hazard. |  | **Shock hazard** | Improper use/ disconnection of a component with this label can result in a potential shock risk. |
|  | **Hydraulic pressure** | Components under hydraulic pressure and loss of pressure could result in injury. |  | Impact from above risk | Robots equipped with a lift can potentially impact objects and personnel from above. Keep clear of all docking robots. |
|  | **Automated mobile robot traffic** | Be aware that robots can be anywhere in the operating area of the facility at any time. | | | |

| Label | Title | Description | Label | Title | Description |
|---|---|---|---|---|---|
|  | **Personal Protective Equipment (PPE) requirement** | Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products.<br><br>Insulated gloves and/or tools are recommended when performing any maintenance on OTTO Motors products. |  | **Lock- out/tag-out** | When performing maintenance on an electrically powered OTTO Motors product, always follow the applicable lock-out/ tag-out procedure. |
|  | **Do not ride** | Robots are not designed for carrying personnel and should not be ridden at any time. |  | **Do not step** | The labeled component must not be used as a step. |

## 1.3. Safety awareness

> **WARNING**
>
> - IMPACT HAZARD! Always maintain a safe distance from a robot in operation. A robot being operated in manual mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot operation and maintenance manual.

Personnel present in a facility with OTTO Motors products need to be made aware or be accompanied by personnel who are familiar with the specific risks and hazards associated with automated mobile robots.

The following checklist identifies basic topics that should be addressed by site-specific worker and visitor safety orientation training.

- Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products.
- Crossing into the path of a moving robot should be avoided, as well as placing or throwing obstacles into the path of a moving robot.
- Be aware that a robot can be anywhere in the operating area of the facility at any time, and may pose a tripping hazard even when not in motion.
- Personnel need to be aware of operation limitations, such as floor grades, underhanging and overhanging obstacles, and the LiDAR obstacle detection plane.
- The floor of the operating area should be kept free of dirt and debris.
- Personnel need to be aware of robot docking and charging areas, where detection fields are reduced.
- Personnel should be aware of facility areas where robots travel through narrow aisles/corridors resulting in reduced clearance between robots and personnel and aisles/corridors shared between robots, other robots, and personnel.

- Personnel should be aware that OTTO Motors LiDAR safety scanners are laser products rated class 1/1M. Personnel must not look directly at the laser beam source.
- Personnel should keep all loose clothing and body parts away from robots, accessories, attachments, and payloads, while they are in autonomous operation.

In addition to the preceding basic items for all workers and visitors, the following should be considered for facility personnel, including drivers of other robots:

- High traffic areas, tight clearance areas, emergency exits, areas around electrical panels or in front of shelves and racking, and obstacles that are outside the field of view of safety sensors (i.e. overhanging obstacles) should have bollards placed around them so that robots do not drive or stop in those areas
- Operators of other industrial robots must not leave skids or other loads overhanging or unstable near the edges of racking as they may not be detected by a robot.
- Alert personnel that while operating a robot outside of the autonomy state, they are solely responsible for obstacle and collision avoidance.
- Maintenance not outlined in the operations and maintenance manual can only be performed by OTTO Motors-authorized personnel.

## Facility conditions

**WARNING**

- IMPACT HAZARD! Never bypass the drive wheels of the robot while on a sloped surface.
- CRUSH or IMPACT HAZARD! Keep low profile objects that the LiDAR cannot detect, such as forklift tines and pallets, outside of the robot's path. For sensor layouts, refer to the Component Overview section of the robot operation and maintenance manual.
- CRUSH or IMPACT HAZARD! Robots must be prevented from traveling in areas that do not follow Facility Conditions specifications, such as ramps and stairwells.
- CRUSH or IMPACT HAZARD! All stairwells or similarly open holes must be marked and surrounded by obstacles exceeding 20 cm in height with spacing no greater than 30 cm. These obstacles must be able to withstand 2000 N of force without failing or be at least 70 mm wide from all directions and visible to the LiDAR.

Robots, attachments, and accessories are designed to work on flat, clean surfaces. Facility conditions greatly affect their ability to operate safely and navigate properly.

- Robots should never be operated in spaces insufficient to their physical dimensions and safety configuration specifications.
- Areas in front of or behind chargers or other docking area, for example P&D stands, must be marked for personnel to avoid the space.

## Driving surface

- To better assist robots in achieving safe stopping distances, facility floors must be dry and clean with a coefficient of friction greater than 0.8. Debris on the floors may become caught in the wheels and lead to premature failure of wheels, casters, or drive components. Areas with floors that can't meet these requirements should be isolated by bollards or physical LiDAR-height barriers. Exclusion zones in

OTTO Fleet Manager cannot be solely relied upon to prevent entry to areas with floors that don't meet the robot requirements.

- Robots should never be driven onto curbs or across gaps in the floor that may result in damage to the robot drive systems, attachments, or accessories - for example, at the top of stairs, the top of dock doors, or mezzanines without a protective ledge.
- Robot drive wheels and cart brakes should never be manually bypassed on a ramp condition as this may lead to robots or carts navigating erratically and losing control. If stopped on a slope greater than that specified in system specifications, robots and carts may begin to roll and present a hazard.

## Environment

For additional information on the operating environment conditions, refer to the System Specifications in the product operation and maintenance manual.

- OTTO Motors robots use LiDAR with a wavelength of 905 nanometers, and are designed to operate indoors free of direct sunlight. Infrared light sources (including sunlight, light curtains, welding) may interfere with the operation of robots when shone directly into the robot's optical sensors.
- Robots rely on LiDAR to protect personnel from crushing or collision hazards. Although rare, very reflective or very light absorbent (eg. black) material can impede the LiDAR safety systems. Avoid the use of such materials in clothing or obstacles to assist their detection by OTTO Motors LiDAR safety systems.
- Robots have no minimum ambient brightness requirements, as they are designed to operate in the dark.
- When the robot detects a significant reduction in air quality, it enters a safety stop.

## Payload maximums and stability

OTTO Motors products support a specific maximum payload and payload dimensions. OTTO Motors robot maximum payloads and their dimensions change when an attachment or accessory is connected because of the weight of the attachment/accessory itself. In the case of an attachment/accessory-equipped robot, payloads must not exceed the maximum payload documented on the attachment nameplate and dimensions specified in safety configuration documentation.

For the robot to remain stable, the combined center of gravity must remain within the stability triangle of the robot. The following items can affect the combined center of gravity:

- Payload center of gravity
- Movement of the robot (acceleration, deceleration, turning, and sudden braking)
- Height of the load to be lifted

For robot, attachment, or accessory payload specifications, refer to the Stability and Center of Gravity, payload interface documentation, or nameplate for the applicable product.

Robots require a custom robot configuration and hardware configuration changes in order to accommodate payloads that project beyond the dimensions of the base robot platform, equipped accessory, or attachment. Contact OTTO Motors if a custom robot configuration is required.

## OTTO Lifter

For the default configuration for the OTTO Lifter robot, payload dimensions must stay within the projected view of the OTTO Lifter robot body and not project over the front or sides of the robot's forks. The OTTO Lifter platform is rated to work with a specific maximum payload—failure to load the OTTO Lifter robot within the payload specifications will affect its safe operation.

## Battery handling

> **WARNING**
>
> - FIRE HAZARD! If the battery is damaged or a battery fire occurs, contact local emergency services and vacate the area. Do not use water to douse the fire.
> - SHOCK HAZARD! Improper use or maintenance of robot batteries may result in a high energy discharge.

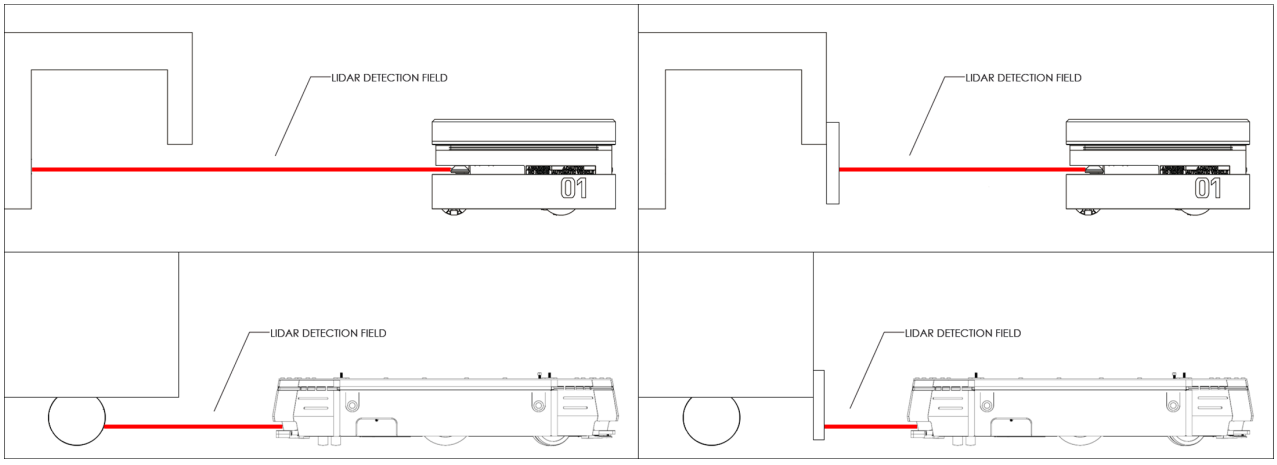
Like most applications using batteries, special precautions should be taken to handle this type of material. Battery packs should only be handled by trained personnel to ensure proper handling. Be aware of the operating environments for robots and more specifically, the battery pack.

## Overhang and underhang detection

> **WARNING**
>
> - CRUSH or IMPACT HAZARD! Keep low profile objects that the LiDAR cannot detect, such as forklift tines and pallets, outside of the robot's path. For sensor layouts, refer to the Component Overview section of the robot operation and maintenance manual.
> - IMPACT HAZARD! Do not place anything on the robot that extends beyond its footprint. Refer to the robot Safety Configuration document for the footprint dimensions.

OTTO Motors autonomous mobile robots (AMR) use LiDAR to detect potential obstacles and obstacles located above a robot's LiDAR detection plane may not be perceived by a robot. Existing equipment in the facility could be rendered invisible to a robot due to an "overhang", for example a robot with wheels offset from the body of the robot itself. In the example, the robot would detect the existing equipment's wheels but not its body panels, increasing the possibility of a collision.

To assist robots without 3D perception capabilities in detecting obstacles, perception-assist flaps should be installed (see following), especially in cases of potential mobile obstacles.



Robots capable of 3D perception, either integrated or through use of an equipped 3D Perception Attachment, are better able to detect overhanging obstacles without the presence of perception-assist flaps.

- Ideally, installed flaps should touch the floor; however, in instances where the flap can't be installed that close to the floor, the distance between the flap's bottom edge and the floor should not exceed 75 mm.
- Glass and mirror-like surfaces should be avoided as reflective materials can scatter LiDAR pulses. Rubber works especially well due to its flexibility, color, and durability.
- Flaps can be bolted directly to exterior body panels or secured using high-strength magnets.

## Safety system functionality

Autonomous mobile robots (AMR) move and travel differently depending on several factors including any detected obstacles, the robot's speed, the currently occupied zone, and the robot's current step, task, or job.

The robot is equipped with LiDAR safety scanners. These safety scanners have a Safety Detection Range that initiates response of the safety system. Safety scanner input is read directly by the perception system that relates the robot to its surroundings when localizing to a map, planning paths, and interacting with local infrastructure.

There is a protective field around the robot during normal operation. The size of this field is dynamic and grows larger as the speed of the robot increases, allowing the robot to stop safely between obstacles and itself at all speeds. Although the robot braking system may be performing correctly and as designed, it cannot be expected to function as designed and specified should an object suddenly appear in the path of the robot and within the designed safe stopping distance. Examples include but are not limited to objects falling from overhead or a pedestrian stepping into the path of robot at the last instant.

## Perception sensor layout

The LiDAR perception sensors present on the robot perform the following functions:

- Scan the surroundings of the robot to determine its location or observe features used during navigation.
- Provide safety functionality by applying 'stop zones' around the robot while it is in motion. LiDAR scanners are wired into the drive wheels directly and are able to size the required stop range based on the robot's ground speed and payload, dictating a safe stopping distance if autonomous control does not direct the robot to avoid an obstacle or stop before impacting an encountered obstacle.
- Detect obstacles and either stop the robot or re-plan a path around the obstacle, if possible.

The LiDAR scanners have restrictions based on robot speed, allowed turning distances, differential wheel speeds, and direction, depending on the LiDAR field set (LFS) they are commanded to apply.

The robot control system can request and confine itself to operate within one of these safety supervisor modes as dictated by the factory configuration of the LiDAR units. Under most circumstances, the system can automatically determine, control, and confine itself within LiDAR usage cases.

The robot's Open Detection Range is much larger than the fields used for the Safety Detection Range. The safety scanners are tilted up from the horizontal plane to avoid ground hits and to meet the testing requirements for ANSI/ITSDF B56.5, Safety Standard for Driverless, Automatic Guided Industrial robots and Automated Functions of Manned Industrial robots. This also allows for shorter objects to be detected closer to the robot.

Safety scanners use IR light to detect objects -highly reflective objects or highly matte objects can create issues with the light being able to detect the object. Standard industrial paints, finishes, and clothing should not present an issue.

## Emergency stop system

There are two types of emergency stops on a robot. When the emergency stop state is triggered, the system will immediately apply the brakes and cut all power to the drive motors.

| Emergency stop condition | Description |
|---|---|
| Physical | A user pressing one of the Emergency Stop buttons on the robot |
| Software | A software-triggered emergency stop caused by a system fault or self-diagnostic tool |

## Safety stop system

Safety stops are similar to emergency stops; however, they are triggered by an object being detected inside of the pre-defined LiDAR safety field. This stop condition will attempt to reset itself every 2 seconds once the object has been cleared from the field.

The LiDAR safety fields extend out from each LiDAR safety scanner. The active velocity of the robot will determine the size of the safety field to provide adequate stopping distance automatically. To remove the system from the safety stop state, all conditions that caused the state transition must be cleared.

See the applicable safety configuration for the robot and the MicroScan3 LIDAR Operating Instructions document for more details.

Credentialed OTTO Motors platform users can learn more on the OTTO Motors Support Center (login required). If access is required, contact OTTO Motors Support and they will be happy to answer any questions or provide access.

## Zone-specific behavior

Zones are areas in a map that change the behavior of a robot while it occupies the zone. Certain modes are only available in certain spaces due to a change of the safety requirements present in each zone.

## Robot modes

Robots can select from several modes in which the safety system can operate, determined by the robot occupying a particular zone type on a map, or by a condition on the map requiring a particular mode function.

## Autonomous mode

Autonomous mode is applied during typical operation in regular transit zones under standard traffic rules. The applied LiDAR safety field set is dynamically adjusted based on the speed of the robot as reported through its sensors.

**IMPORTANT**
Autonomous mode behavior also applies to the robot forks.

Depending on the speed that the robot is travelling, the safety scanners will select the matching safety field based upon the encoder input. Each field range has a maximum allowed turning rate.

Only one safety field set at a time will be selected based on robot speed.

## Manual mode

While controlling the OTTO Lifter autonomous mobile robot (AMR) using its tiller, there are no speed restrictions and the safety field sets monitored by the LiDAR are disabled. Height restrictions for the forks

are also disabled while in manual mode. There is a collision risk with objects while driving the OTTO Lifter in manual mode.

While controlling the autonomous mobile robot (AMR) using its pendant, there are no speed restrictions and the safety field sets monitored by the LiDAR are disabled. There is a collision risk with objects while driving the in manual mode.

> **CAUTION**
> IMPACT HAZARD! Always maintain a safe distance from a robot in operation. A robot being operated in manual mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot operation and maintenance manual.

## Hazard mode

Hazard mode is used when robots must navigate down a narrow pathway, the dimensions of which are determined by a robot's safety configuration. Robot speed in this mode is limited to 0.3 m/s for safety considerations.

Although hazard mode is designed to allow the robot to travel through narrow corridors, the robot can still turn freely. Turning is not affected by a safety field when in hazard mode and follows the 0.3 m/s speed constraint.

In hazard mode, robots will allow for the drive trains to move in opposite directions, allowing the robot to perform zero point turns or any directional motion that does not violate the 0.3 m/s speed constraint on either drive train.

Warnings and signage must be respected in these areas.

## Docking mode

Docking mode is used when robots dock when transferring payloads or charging. Robot speed in this mode is limited to 0.3 m/s for safety considerations.

The use of human exclusion zones is recommended where robots will be docking as both personnel and other objects will not be detected within the same safety field range as in other operation LiDAR modes.

Warnings and signage must be respected in these areas.

## Footprint safety

It should be noted that the overall profile including any attachment, payload, or combination thereof of the robot must remain within its safety configuration—this is measured by the projection of any part that has been extended outside the robot projected to the floor.

Depending on the attachment or payload to be mounted on the robot, the safety configuration may have to be adjusted to suit the attachment or payload to allow the robot to navigate autonomously with all of its safety features in place. Should the attachment configuration change or be removed, LiDAR safety field sets will need to be reset to match the current footprint for each robot. Safety configurations are based on the largest possible combination of attachment and payload at all times.

Extension of payload height will not be detected by the robot. Payload height needs to be qualified in the facility of installation and inspected in all spaces in which the robot will operate to reduce the risk of a collision.

## 1.4. Disclaimer

The information found within this documentation is subject to change without notice. This document may be periodically reviewed and revised in the future. OTTO Motors assumes no responsibility for any errors or omissions that may appear in this document. In no event shall OTTO Motors be liable for any costs or damages arising from the use of this document or the hardware and software described within. The reference documents listed in this manual shall be applicable at the latest revision in effect.

While OTTO Motors does its best to inform its users of potential risks, it is impossible to provide an exhaustive list of all possible hazards in your environment.

It is the responsibility of the user to be familiar with all applicable safety standards and ensure that the hardware, software, and/or services delivered by OTTO Motors (collectively referred to as the “Product”) are maintained and operated in a safe manner, in a suitable environment, and in accordance with the recommended maintenance requirements prescribed by OTTO Motors .

Without limiting the foregoing, it is the user’s responsibility to ensure that personnel operating the Product are adequately trained and comply with all laws, regulations, codes, and safe practices, including health and safety and workers' compensation laws, applicable to the user's activities and its ownership, possession, and use of the Product. Modification, removal or addition of components, or changes to the functionality or operation of the Product in any way, except as expressly authorized by OTTO Motors , may jeopardize the safety of the Product. If at any time you have any questions or concerns regarding the safe operation of your OTTO Motors product, contact OTTO Motors Support.

# 2. Intended use

OTTO Motors robots are Autonomous Mobile Robots (AMR) intended for use in industrial facilities. OTTO Motors robots are intended to transport materials indoors in industrial buildings, utilizing SLAM mapping, and intelligent navigation and localization to plan their motion. They can perform autonomous navigation and route planning to achieve their planned jobs and will operate without direct user intervention. Operators are intended to have suitable training or familiarization as needed for their interactions with the robots and systems. This intended use extends to the infrastructure including—but not limited to—chargers, docks, carts, attachments, custom components, and software.

# 3. Introduction

This document provides important information pertaining to the safe operation and use of the OTTO Lifter autonomous mobile robot (AMR). The OTTO Lifter robot is a heavy duty AMR designed to move pallets through dynamic production environments.

**IMPORTANT**
Information in this document related to software functionality is up-to-date as of OTTO Motors software version 2.26. Hardware functionality outlined in this document pertains both to the base platform and the functionality of any of its versions.

Functionality described herein assumes access to a full deployment of OTTO Fleet Manager.

A robot being operated in manual or remote mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use.

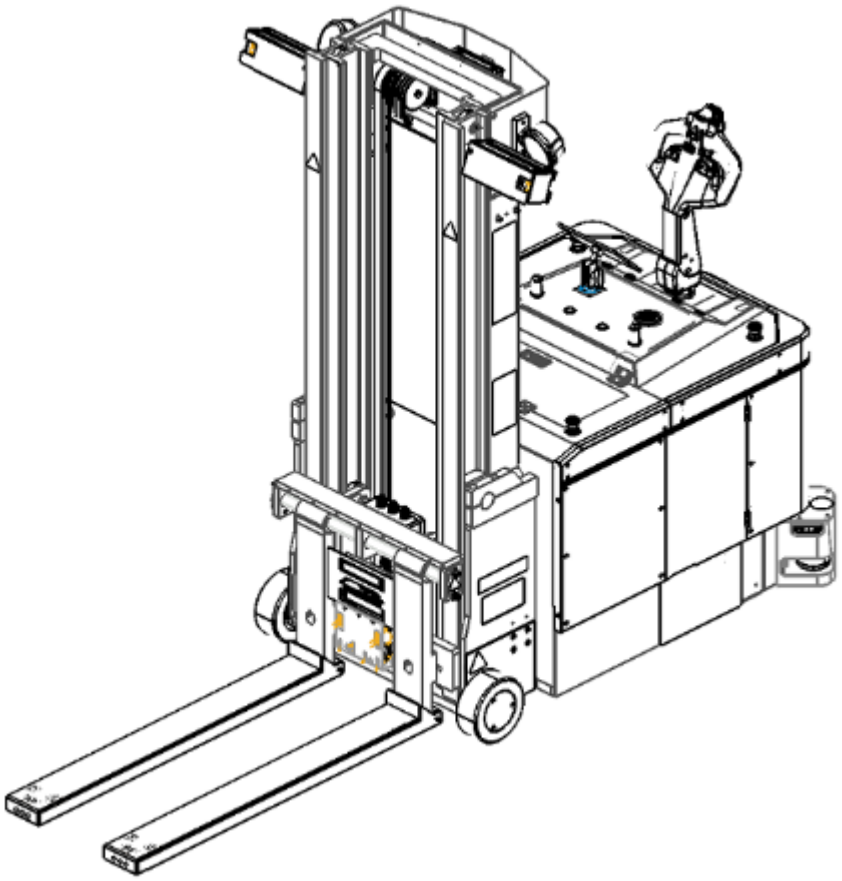
**CAUTION**
IMPACT HAZARD! Always maintain a safe distance from a robot in operation. A robot being operated in manual mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot operation and maintenance manual.

## 3.1. Included items

The following items are included:

- OTTO Motors robot
- Lock-out/tag-out cover bag (026239)
- OTTO Motors safety guide

**IMPORTANT**
No field modifications of the robot that influence the performance or safety of the robot are permitted. This includes, but is not exclusive to, modifications that affect the physical size, mass, or floor traction of the robot. No modifications may be carried out that affect the integrated sensors or internal electronics.



**OTTO™ Lifter Autonomous Mobile Robot**

Item: 021046 Forklift type: E (NFPA 505)

Serial Number:

See Manual for autonomous operations. Operate on level surfaces only. Operation and setup to be performed by qualified personnel. Read Operation and Maintenance Manual before use.

Contains Transmitter Module IC: 1000M-AX200NG
Contains Transmitter Module FCC ID: PD9AX200NG

| Manual Operation Payload Specs | Config 1 | Config 2 |
|---|---|---|
| Max. weight | Up to 1000 kg (2205 lbs) | 1000 kg (2205 lbs) |
| Max. payload width (centered on pallet) | 1016 mm (40 in) | |
| Max. payload depth (centered on pallet) | 1219 mm (48 in) | |
| Lift height C | 2700 mm (106.3 in) | |
| Load center distance A | 623 mm (24.5 in) | |
| Load center height B | 813 mm (32 in) | 623 mm (24.5 in) |
| Load center of gravity D | 0 mm | |
| Tine width (center to center) | 420 mm (16.5 in) | |
| Grade | 3% | |

Net mass: 2278 kg (5022 lb)

Date of Manufacture:

**Lead Acid Battery System**

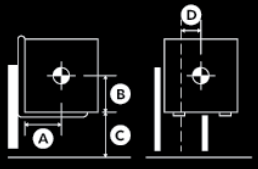
| | |
|---|---|
| Nominal capacity: | 375 Ah |
| Nominal voltage: | 24 V |
| Battery mass: | 298 kg (657 lbs) |
| Battery dimensions (L x W x H): | 850 x 219 x 627 mm (33.5 x 8.6 x 24.7 in) |

**Vehicle Limits**

Max. speed: 1.5 m/s

**Manufacturer**

Clearpath Robotics Inc. d.b.a. OTTO Motors
124 Bleams Rd,
Kitchener, ON,
Canada N2C 2K5




Designed and Manufactured by Clearpath Robotics Inc. in Canada | P/N: 026269_A

# 4. Applicable documents

For additional information, refer to the OTTO Motors Support Center at help.ottomotors.com.

| Reference | Number |
|---|---|
| OTTO Lifter MkIV operation and maintenance manual | OMM-000108 |
| OTTO Lifter MkIV stability and center of gravity | ICD-000101 |
| OTTO Lifter Manual Charger MkIV operation and maintenance manual | OMM-000110 |
| Default OTTO Lifter MkIV safety configuration | 025297 |
| OTTO Lifter MkIV sensor footprint and mechanical interface | ICD-000102 |
| Robot forklift pre-op checklist | OMM-000105 |
| SICK S3000 operating instructions | - |
| Base platform instruction handbook | - |

# 5. In case of a collision

### Cease operation

1. Stop the robot by pressing an **Emergency Stop** button on the robot or an equipped attachment.

> **IMPORTANT**
> For emergency stop button locations, refer to the Components Overview section of the robot operation and maintenance manual.

2. Is anyone hurt? Administer first aid immediately. Seek medical attention if necessary. Follow workplace injury and accident reporting procedures.

### Document the incident

1. Follow the facility's workplace health and safety procedures for incident reporting.
2. Interview any witnesses.
3. Note the time and place.
4. Note which robot was involved.
5. Take photos or make a drawing.
6. If the robot is connected to OTTO Fleet Manager, create a manual snapshot to capture diagnostic information and robot sensor data to assist OTTO Motors in diagnosing the incident cause.

### Inspect the robot

1. Shut down the robot.
2. Remove the robot from any high traffic areas.
3. Visually inspect the robot for damage and take photos of any damage found.

### Confirm safety system functionality

1. Lock-out/tag-out the robot and confirm lock-out/tag-out functionality by attempting to start up the robot. The robot should not start up while locked-out/tagged-out.
2. Remove the lock-out/tag-out, start up the robot, and confirm that the robot enters an emergency stop state.
3. Confirm functionality of all light/audible indications.
4. Confirm the emergency stop state can be cleared by pressing the **Safety Reset** button.
5. Confirm functionality of all **Emergency Stop** buttons.
6. Clear the emergency stop state, place an object within the Safety Detection Range of the robot to confirm the robot enters a safety stop state, then remove the object to confirm the safety stop state is cleared. Repeat this step for all LiDAR safety scanner locations on the robot.

#### Confirm OTTO App functionality

1. Access OTTO App for the applicable robot.
2. Confirm the robot can be driven in manual mode.
3. Confirm there are no exceptions presenting for the robot in OTTO App.

# 6. OTTO Lifter specifications

This section provides an overview of the important elements of the OTTO Lifter autonomous mobile robot (AMR).

**IMPORTANT**
Some of the following specifications are dependent on software, robot, and/or safety configurations.

Credentialed OTTO Motors platform users can learn more on the OTTO Motors Support Center (login required). If access is required, contact OTTO Motors Support and they will be happy to answer any questions or provide access.

## 6.1. Size and weight

| Component | Specification |
|---|---|
| Dimensions (L x W x H) | **OTTO Lifter MkIV:** 2811 x 1201 x 2095 mm (110.7 x 47.3 x 82.3 in) |
| Height (fully-raised forks) | 2900 mm (114.2 in) |
| Fork length | **OTTO Lifter MkIV:** 1214 mm (47.8 in) |
| Fork height | **OTTO Lifter MkIV:** 53.5 mm (2.1 in) |
| Fork width | 142.1 mm (5.6 in) |
| Fork spread, center to center | **OTTO Lifter MkIV:** 420 mm (16.53 in) |
| Fork spread, inside to inside | 308 mm (12.1 in) |
| Fork spread, outside to outside | 592 mm (23.3 in) |
| Mass | **OTTO Lifter MkIV:** 2278 kg (5022 lbs) |
| Mass without battery | **OTTO Lifter MkIV:** 1980 kg (4365 lbs) |

## 6.2. Speed and performance

| Component | Specification |
|---|---|
| Autonomous mode fork travel height | 300 - 500 mm (11.8 - 19.7 in) |
| Maximum autonomous mode raised pick-up/drop-off height | **OTTO Lifter MkIV:** Reference ICD-000113 - Raised pallet pick-up/drop-off interface control document<br><br>Credentialed OTTO Motors platform users can learn more on the OTTO Motors Support Center (login required). If access is required, contact OTTO Motors Support and they will be happy to answer any questions or provide access. |
| Maximum autonomous mode fork height with payload | **OTTO Lifter MkIV:** Reference ICD-000101 stability and center of gravity documentation<br><br>Credentialed OTTO Motors platform users can learn more on the OTTO Motors Support Center (login required). If access is required, contact OTTO Motors Support and they will be happy to answer any questions or provide access. |
| Floor obstacle clearance | 6 mm (0.24 in) |
| Maximum total payload | **OTTO Lifter MkIV:** 1000 kg (2205 lbs)<br><br>Credentialed OTTO Motors platform users can learn more on the OTTO Motors Support Center (login required). If access is required, contact OTTO Motors Support and they will be happy to answer any questions or provide access. |
| Maximum speed | 1.5 m/s (3.36 mph) |
| Maximum turning speed | 0.25 rad/s (14.3°/s) |
| Maximum docking speed | 0.3 m/s (0.67 mph) |
| Turning radius | **Autonomous mode**<br><br>See the safety configuration for the applicable robot.<br><br>**Manual mode**<br><br>**OTTO Lifter MkIV:** 2811 mm (110.7 in) |
| Autonomous mode fork travel height | 300 - 350 mm (11.8 - 13.8 in) |
| Manual mode ramp specification requirements | **Approach**<br><br>68.8°<br><br>**Breakover**<br><br>8°<br><br>**Departure**<br><br>9.2° |
| Positional accuracy | X, Y + / - 25 mm (0.98 in)<br><br>Yaw + / - 3 °<br><br>**IMPORTANT**<br>Positional accuracy is subject to the deployment. Please speak to an OTTO Motors representative for more information. |

| Component | Specification |
|---|---|
| Docking accuracy | X, Y + / - 50 mm (2 in)<br>**Raised drop-offs with dock target**<br>X, Y + / - 10 mm (0.4 in)<br>**IMPORTANT**<br>Docking accuracy is subject to the deployment. Please speak to an OTTO Motors representative for more information. |
| Pallet positioning tolerance (pick-up) | X, Y + / - 200 mm (7.87 in)<br>Yaw + / - 15.0 ° |
| Drive configuration | Three-phase AC drive |
| Service brake | Electromagnetic |

## 6.3. Battery and power system

| Component | Specification |
|---|---|
| Battery mass | 298 kg (657 lbs) |
| Battery charge options | Manual charging, battery replacement |
| Battery chemistry | 3PZS375, Wet Cell, Lead-Acid |
| Battery capacity | 24 V Nominal 375 Ah |
| Maximum charge rate | 55 A |
| Battery dimensions (L x W x H) | 830 x 219 x 627 mm (32.7 x 8.6 x 24.7 in) |
| Battery connector | E32550-1009 |
| Charge time (10% - 90%) | ~3 hrs (20 - 80 %) |
| Drive power | 2600 W |
| Battery life | 1500 full charge cycles |

## 6.4. Control system

| Component | Specification |
|---|---|
| Sensors | 5 x 3D perception cameras<br>3 x LiDAR safety scanners<br>Embedded 6-axis IMU |
| Computer | Solid-state military spec computer with Intel i7-6700TE Quad Core, 16 GB RAM, nVidia MXM-1050 GPU |

## 6.5. Interfacing and communication

| Component | Specification |
|---|---|
| Manual control | Tiller-based manual control |
| Attachments and accessories | 120 VAC OTTO Lifter AMR Manual Charger |

| Component | Specification |
|---|---|
| Communication | 2 x long-range omnidirectional antennae<br><br>WiFi (802.11 a/b/g/n/ac/ax, 5 Ghz)<br><br>Although robots can be configured to connect to a 2.4 GHz network, this is not recommended. 5 GHz is preferred because of its higher bandwidth, reduced channel overlap/noise, and its resistance against frequency pollution. The potential for business and user impact is greatly increased when deploying a system on an as-is 2.4 GHz network. |
| Audio and visual indicators | **Audio Tones** 83.7 dB max.<br><br>**Visual Indicator** 270° Light Pipe Indicator, gantry lights |
| Human-robot interaction | 10.4 in touch screen<br><br>Autonomous mode button<br><br>4 x Emergency Stop buttons<br><br>Safety Reset button<br><br>Robot mode key switch |

## 6.6. Operating environment

| Component | Specification |
|---|---|
| Supported pallets | All pallets must be 48 in (L) x 40 in (W), Grade A condition<br><br>• GMA pallets<br>• Block pallets<br>  • Bare wood block pallets<br>  • CHEP block pallets<br>  • PECO block pallets<br>• Stringer pallets<br>  • CHEP stringer pallets<br><br>**IMPORTANT**<br>Low quality, damaged, or obscured pallets will result in reduced performance as the OTTO Lifter uses the pallet face to track pallets. Broken pallet deck boards can adversely affect payload stability and the ability of the robot to dock. |
| Autonomous mode maximum floor slope | 1° / 1.7 % |
| Operating environment | Indoor |
| IP classification | IP20 |
| Operating temperature range | 0 °C to 40 °C (32 °F to 104 °F)<br><br>Please contact OTTO Motors if lower operating temperatures are needed. |
| Non-operating temperature range | -25 °C to 70 °C (-13 °F to 158 °F) |
| Operating relative humidity | 5 - 95 % non-condensing |
| Non-operating relative humidity | 0 - 95 % non-condensing |
| Maximum operating altitude | 2300 m N.N. (7545 ft above sea level) |

| Component | Specification |
|---|---|
| Sound pressure emissions level | 83.7 dB (audible indications)<br><br>102.4 dB (horn) |

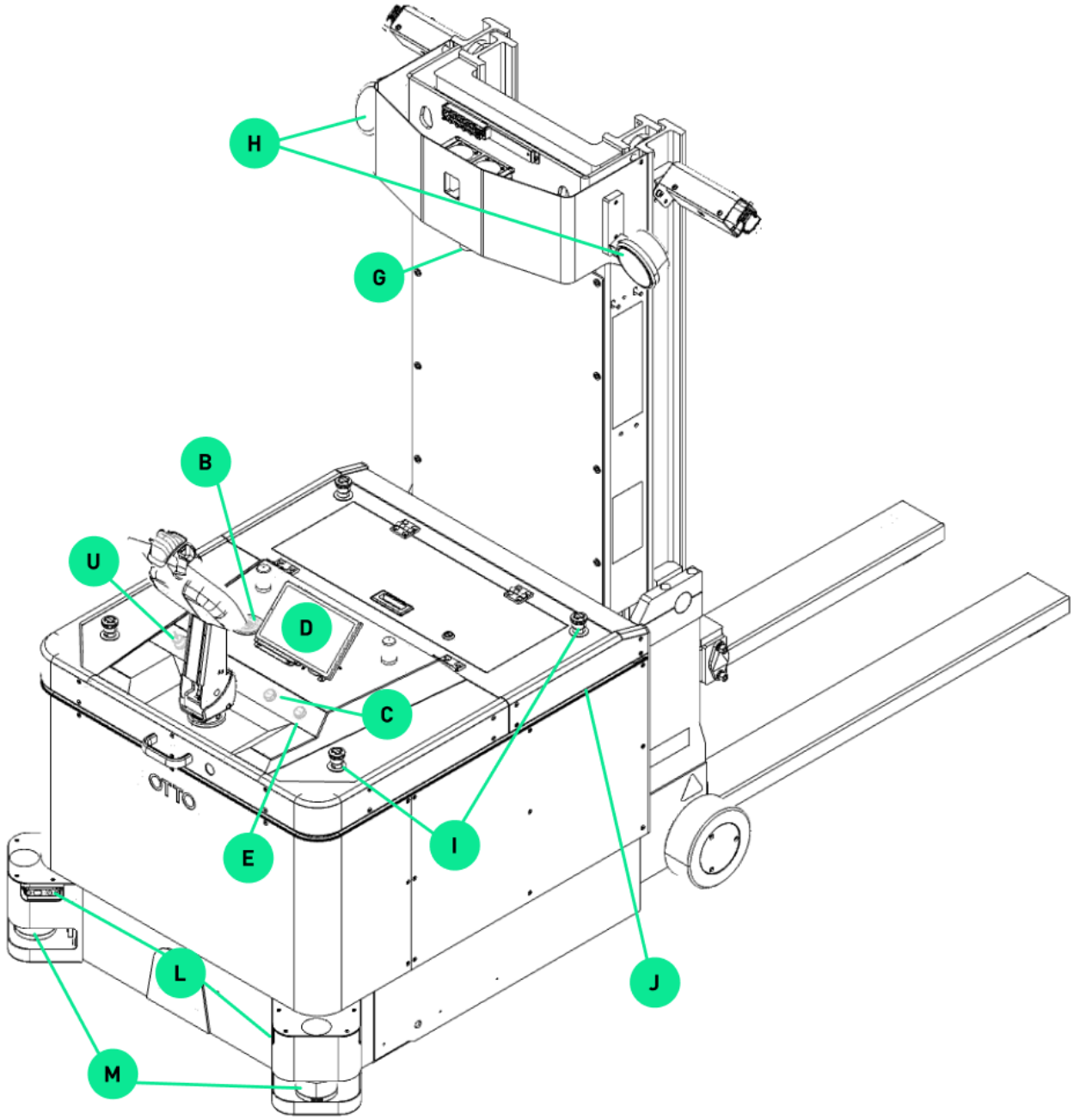
## 6.7. Safety system

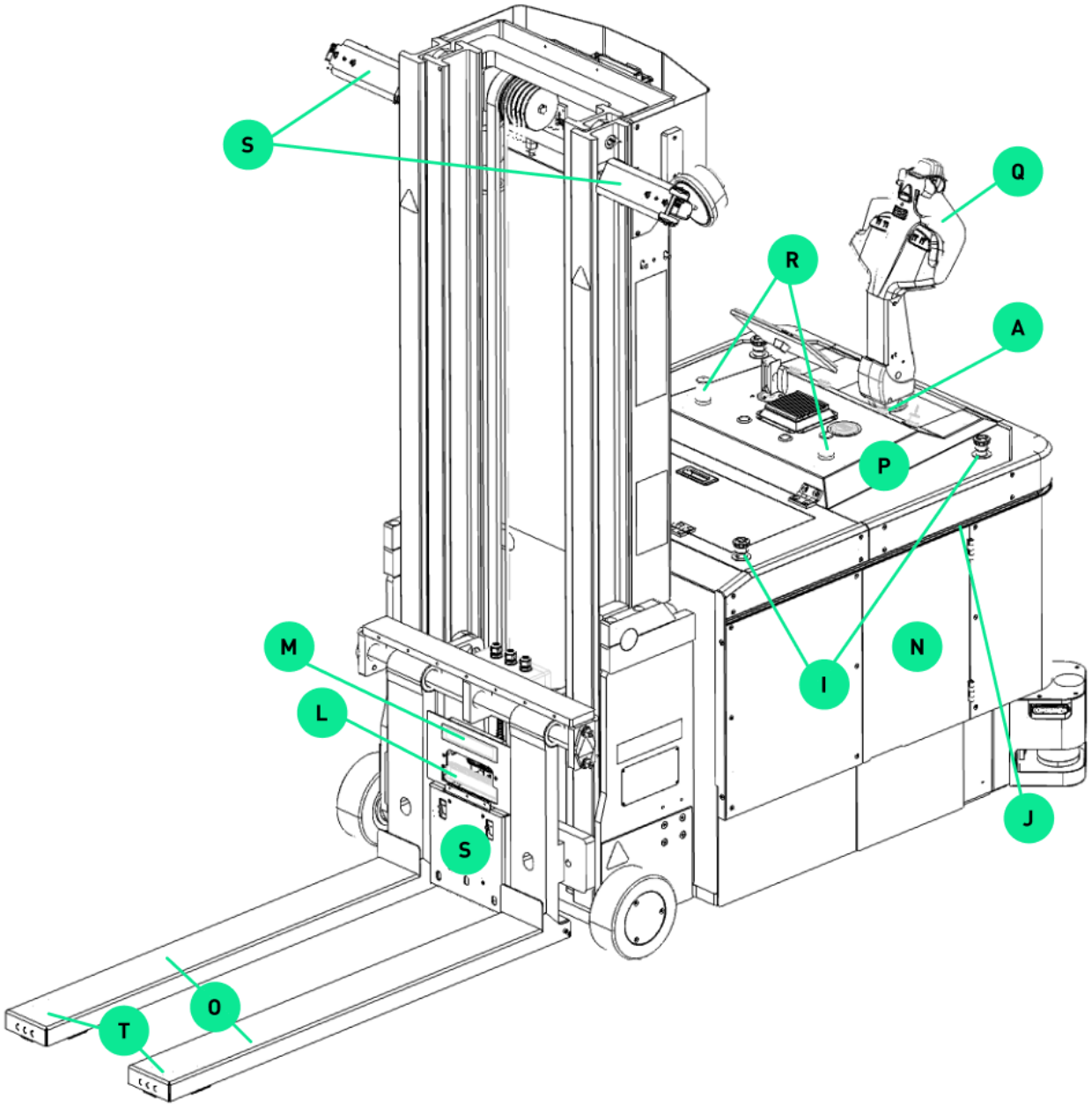
| Component | Specification |
|---|---|
| Intelligent braking | Redundant monitoring with safety-system interlock |
| Adaptive field sets | Intelligent PL-d rated switching fieldsets (patent-pending) |
| Standards compliance | FCC (RF, for example: WiFi, 5G) ; CSA equivalent: ICES, ISO 12100, ISO 13849 |

# 7. Components overview

The components overview is intended to familiarize users with the separate product components.

## 7.1. Components



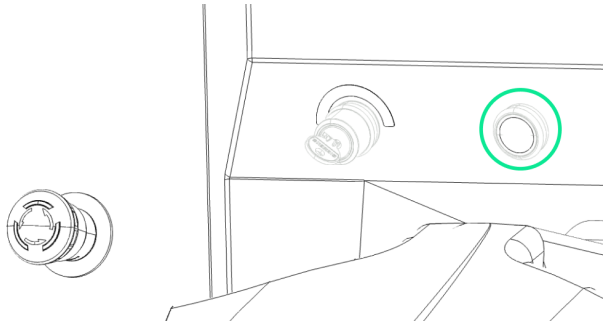



| | |
|---|---|
| A | Power button |
| B | Robot battery state indicator |
| C | Safety Reset button |
| D | Digital interface |
| E | Auto button |
| G | Dome light |
| H | Direction lights |
| I | Emergency Stop buttons |
| J | Light pipe |
| L | 3D perception cameras |
| M | Safety LiDAR |

| | |
|---|---|
| N | Left side door |
| O | Forks |
| P | Top door |
| Q | Tiller |
| R | WiFi antenna |
| S | Dock assist sensors |
| T | Fork impact sensors |
| U | Key switch |
| V | Rear door |
| W | Top rear door |

## 7.2. Power button

The OTTO Lifter autonomous mobile robot (AMR) is started up and shut down using the Power button.

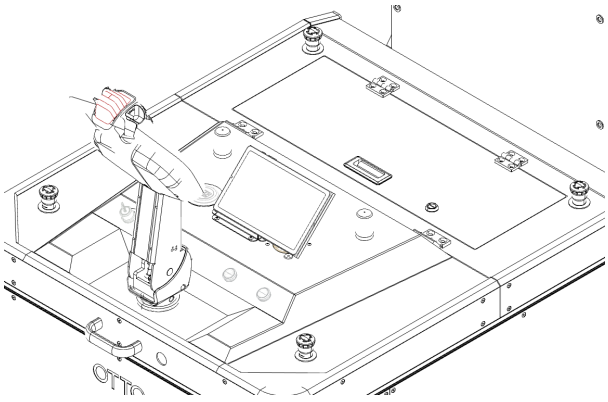


## 7.3. Emergency Stop buttons

The OTTO Lifter autonomous mobile robot (AMR) has 4 Emergency Stop buttons located at each corner of the robot that can stop any unsafe and hazardous motion or movement.

Pressing any of the **Emergency Stop** buttons will remove power from any motions controls to prevent further movement.

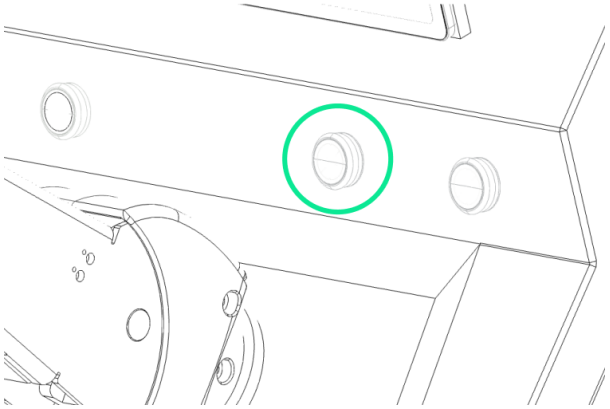
Pressing the **Safety Reset** button when all Emergency Stop buttons are no longer pressed will reset the system and return power to the motion controls.



## 7.4. Safety Reset button

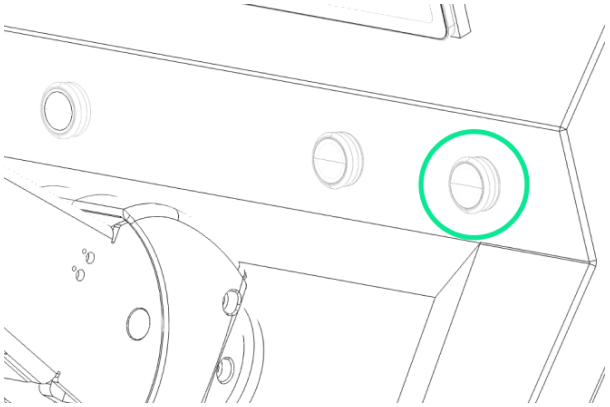
The Safety Reset button can be pressed to indicate that the OTTO Lifter autonomous mobile robot (AMR) is again cleared for autonomous operation after an emergency stop state has been cleared. The Safety

Reset button will be illuminated if the robot entered an emergency stop state and the conditions have been cleared to indicate that the safety system is now ready for reset.



## 7.5. Auto button

The Auto button is used to control the operation mode of the OTTO Lifter. This button, when pressed, toggles the robot between autonomous and manual mode.



| Auto button light state | Safety system status |
|---|---|
| Solid yellow light | Safety system active - robot is in autonomous mode |
| Flashing yellow light | Safety system inactive - robot is in tiller mode |
| No light | Robot is off |

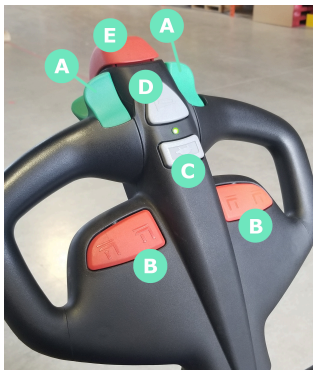
## 7.6. Digital interface

The digital interface on the OTTO Lifter displays Workstation Dispatch for viewing the robot's current job and letting users skip and retry individual tasks within a job.

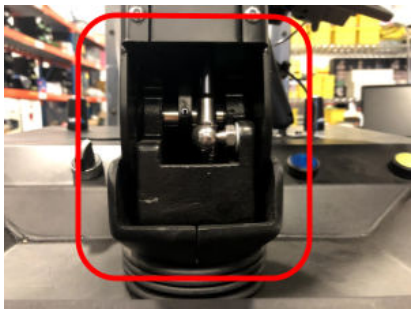
Note that the digital interface can be rotated for easier viewing.

## 7.7. Tiller

The tiller is used by an operator to control the OTTO Lifter autonomous mobile robot (AMR) when it is in manual mode. Operation of the robot acts much like a traditional electric pallet stacker, allowing operators to control forward and reverse travel, raise and lower the forks, and steer the robot.




| | |
|---|---|
| A | Movement controls |
| B | Fork controls |
| C | Fine control mode button |
| D | Horn button |
| E | Safety belly switch |



**CAUTION**
PINCH HAZARD! Keep objects and body parts away from pinch points.

## 7.8. Robot battery state indicator

The robot battery state indicator displays the current charge state of the robot battery.

Note that the robot will initiate shutdown at 30% charge level by default when operating autonomously.

## 7.9. Light pipe and visual indications

OTTO Motors autonomous mobile robots (AMR) are equipped with light panels and pipes designed to signal what a robot is doing at any given time by changing the light color and flashing frequency—the light pattern—to indicate a robot's state or motion. Coupled with audible indications, robots will always make it obvious the behavior that can be expected.

OTTO Motors robots rely on audiovisual indications to warn nearby personnel of their presence, intent, and mode of motion. Ensure that the robot audio volume is at least loud enough that nearby personnel can detect the presence of the robot.

| Name | Description | Visual indication |
|---|---|---|
| **Starting up** | The robot is on but has not completed the boot cycle. |  <br>Full solid red to full dull white |
| **Normal travel** | The robot is traveling normally. |  <br>Front solid dull white<br>Rear solid red |
| **Reversing** | The robot is reversing. |  <br>Rear solid dull white in direction of travel<br>Front solid red with dull white |
| **Turning** | The robot is turning. |  <br>Side blinking yellow in turn direction |
| **About to move** | The robot is about to start traveling after an emergency/ safety stop or after not moving for at least 10 seconds. |  <br>White pulses chasing from center to corners |
| **Charging** | The robot is charging. |  <br>Rear corners red<br>Green slowly expanding indicating charge level in 20% increments<br>Front corners white |
| **Parked** | The robot has entered a parked state. |  <br>Rear corners red<br>Front corners dimmed |

| Name | Description | Visual indication |
|---|---|---|
| **Docking** | The robot is docking. |  <br>Front solid dull white<br>Rear solid red<br>Alternating yellow stripes<br>**WARNING**<br>CRUSH HAZARD! Pedestrians should be aware of hazard mode or docking mode audio-visual indications. When robots are in docking mode, the front of the robot is no longer safeguarded—personnel must be restricted from areas where robots will be docking. When robots are in hazard mode, the region safeguarded by LiDAR safety scanners is reduced in size. Under rare circumstances, robots can get mislocalized and enter docking hazard mode in an unintended location. For audio-visual indicator identification, refer to the Component Overview section of the robot operation and maintenance manual. |
| **Hazard** | The robot is entering what it considers a narrow pathway. Safety fields are reduced in size. |  <br>Front solid dull white<br>Rear solid red<br>Blinking yellow stripes<br>**WARNING**<br>CRUSH HAZARD! Pedestrians should be aware of hazard mode or docking mode audio-visual indications. When robots are in docking mode, the front of the robot is no longer safeguarded—personnel must be restricted from areas where robots will be docking. When robots are in hazard mode, the region safeguarded by LiDAR safety scanners is reduced in size. Under rare circumstances, robots can get mislocalized and enter docking hazard mode in an unintended location. For audio-visual indicator identification, refer to the Component Overview section of the robot operation and maintenance manual. |
| **Remote control** | The robot is being manually controlled using OTTO App. |  <br>Full solid blue<br>Front dull white |
| **Manual control** | The robot is being controlled manually using its tiller/ pendant. |  <br>Full solid blue, rear pulsing light blue |

| Name | Description | Visual indication |
|---|---|---|
| **Attachment activated** | The robot has activated its attachment or its integrated lift. |  Full pulsing yellow |
| **Working in place** | The robot's movement is locked as it waits for further input from a user or attachment. |  Full solid green |
| **Waiting for input** | The robot's movement is locked as it waits for further input from a user. |  Full pulsing between white and green |
| **Blocked** | The robot is blocked from proceeding on its planned path. |  Front flashing yellow<br>Rear solid red |
| **Safety stop** | The robot has entered a safety stop state. |  Corners flashing red |
| **Emergency stop** | The robot has entered an emergency stop state. |  Full flashing red |
| **Failed target find** | The robot has failed find its target—for example, a dock or cart. |  Front solid dull white<br>Rear solid red |
| **Lost** | The robot can't determine its location relative to its current map. |  White light chasing |
| **Lost connection to WiFi/OTTO Fleet Manager** | The robot is disconnected from the WiFi signal/OTTO Fleet Manager. |  Front flashing yellow/orange<br>Rear flashing yellow/orange<br>Flashing color is dependent on the robot model and software version |
| **Operating system failure** | The operating system for the robot has failed to run. |  Full solid red |

## 7.10. Safety Reset button states

The light on the Safety Reset button indicates the different states of the robot safety system:

| Safety Reset button light state | Safety system status |
|---|---|
| Solid blue light | Safety system active |

| Safety Reset button light state | Safety system status |
|---|---|
| Slow flash (500 ms on/off) | Emergency Stop buttons clear, LiDAR safety scanners clear<br><br>Press the **Safety Reset** button to indicate the area and robot are safe for autonomous operation. |
| No light | Safety system inactive<br><br>Check that **Emergency Stop** buttons are cleared and see software exceptions for more detail. |

## 7.11. Speakers

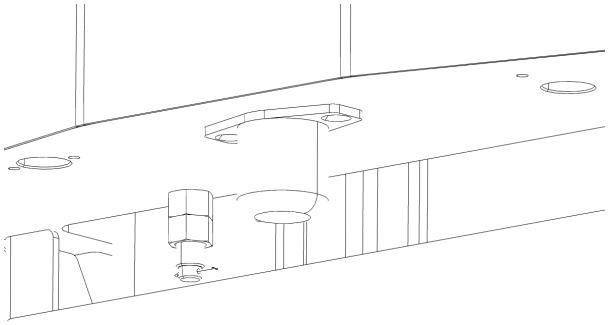
One speaker for the horn is located near the tiller handle to enable warning of personnel of an approaching robot or set up to announce robot presence at stop lines. Another speaker is mounted to the lift mast to broadcast audible indications and work with the light pipe to indicate various robot states.

**IMPORTANT**

If the speaker is set to the highest volume, audible indications can reach a sound pressure level of 83.7 dB. In such conditions, proper hearing protection may be necessary. A final noise assessment at the workplace is required to determine the need for PPE.

## 7.12. Dome light

The dome light located at the top of the gantry assembly indicates the state of the robot.

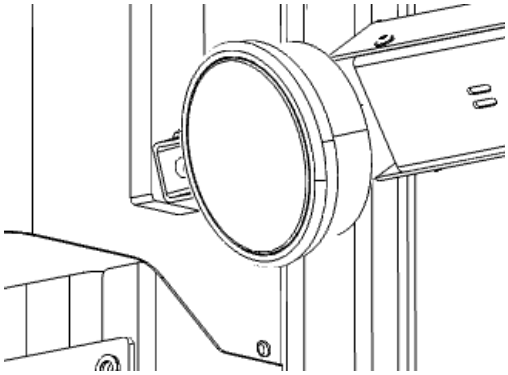


| Robot status | Description | Dome light state |
|---|---|---|
| **Starting up** | The robot is on but has not completed the boot cycle. | OTTO Lifter MkIV: Off |
| **Normal travel** | The robot is traveling normally. | OTTO Lifter MkIV: Full solid green |
| **Parked** | The robot has entered a parked state. | OTTO Lifter MkIV: Off |
| **Docking** | The robot is docking. | OTTO Lifter MkIV: Blinking yellow |
| **Hazard** | The robot is entering what it considers a narrow pathway. Safety fields are reduced in size. | OTTO Lifter MkIV: Blinking yellow |
| **Manual control** | The robot is being controlled manually using its tiller/pendant. | OTTO Lifter MkIV: Blinking yellow<br><br>OTTO Lifter V1: Full solid blue |
| **Attachment activated** | The robot has activated its attachment or its integrated lift. | OTTO Lifter MkIV: Full solid green<br><br>OTTO Lifter V1: Blinking yellow |
| **Working in place** | The robot's movement is locked as it waits for further input from a user or attachment. | OTTO Lifter MkIV: Full solid green |
| **Waiting for input** | The robot's movement is locked as it waits for further input from a user. | OTTO Lifter MkIV: Blinking yellow to green |

| Robot status | Description | Dome light state |
|---|---|---|
| **Blocked** | The robot is blocked from proceeding on its planned path. | OTTO Lifter MkIV: Blinking yellow<br>: Blinking yellow |
| **Safety stop** | The robot has entered a safety stop state. | OTTO Lifter MkIV: Blinking red |
| **Emergency stop** | The robot has entered an emergency stop state. | OTTO Lifter MkIV: Blinking red |
| **Failed target find** | The robot has failed find its target—for example, a dock or cart. | OTTO Lifter MkIV: Off |
| **Lost** | The robot can't determine its location relative to its current map. | OTTO Lifter MkIV: Blinking red |
| **Lost connection to WiFi/OTTO Fleet Manager** | The robot is disconnected from the WiFi signal/OTTO Fleet Manager. | OTTO Lifter MkIV: Blinking red |

## 7.13. Direction lights

The direction lights indicate the direction that the robot is traveling.

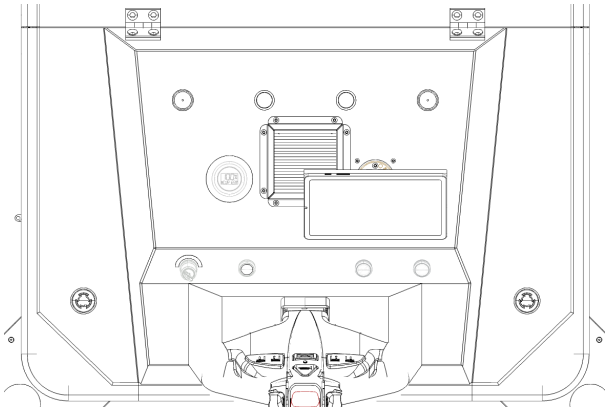


## 7.14. Lift points

The lift points are used to hoist the robot for transport.

## 7.15. Top door

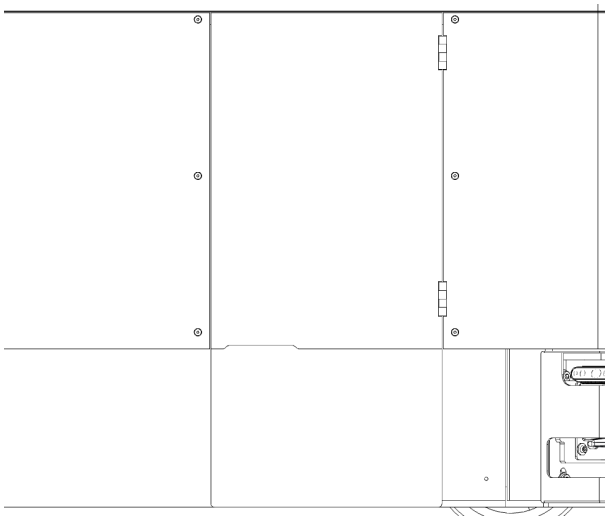
The top door enables access to the inner components of the robot and the battery release handle. Note that a safety lock is present that needs to be disengaged to close the top door.



> **CAUTION**
> PINCH HAZARD! Keep objects and body parts away from pinch points.

## 7.16. Left side door

The left side door enables access to the OTTO Lifter autonomous mobile robot (AMR) battery compartment.



## 7.17. Safety LiDAR

> **WARNING**
>
> - CRUSH or IMPACT HAZARD! Keep low profile objects that the LiDAR cannot detect, such as forklift tines and pallets, outside of the robot's path. For sensor layouts, refer to the Component Overview section of the robot operation and maintenance manual.
> - IMPACT OR CRUSH RISK! The fork-side LiDAR safety scanner is blocked when the forks are at a height of 30 cm and lower.

The robot uses 3 LiDAR (Light Detection and Ranging) safety scanners (see Components Overview [28] for specific locations) to detect obstacles, prevent collisions, and localize in the environment. The LiDAR is connected directly to the drive system to help avoid collisions, preventing the robot from moving if there is an obstacle in the LiDAR field.

## 7.18. 3D perception cameras

The OTTO Lifter autonomous mobile robot (AMR) is equipped with 5 3D perception cameras (located at each LiDAR scanner location) that are used during autonomous navigation to avoid overhanging obstacles. Data from the 3D perception cameras is also used for diagnostic purposes.

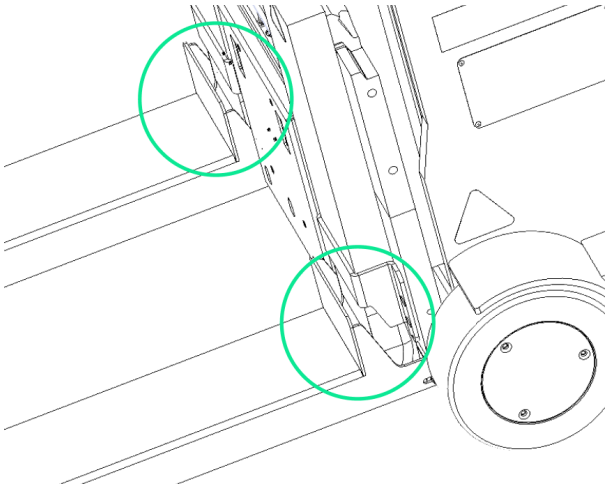
The fork-side 3D perception cameras are used primarily for pallet tracking when picking up payloads.

## 7.19. Fork impact sensors

Each fork is equipped with a suite of sensors that detect force placed on the forks from the front, inside, and outside edges. The fork impact sensors also provide the robot with the ability to pierce pallet wrap while maintaining the ability to detect collisions with hard objects.

Note that the area between the fork impact sensors and the forks must remain clear of debris or the function of the fork impact sensors will be adversely affected.

> **CAUTION**
> PINCH HAZARD! Keep objects and body parts away from pinch points.



## 7.20. Dock assist sensors

The fork side of the robot includes a dock assist laser sensor on each side of the gantry assembly and a cluster of sensors between the forks to assist with payload alignment. The dock assist sensors can detect if a payload is properly engaged, secured, shifts, or is lost while the robot is in motion.

## 7.21. Incremental encoders

Incremental encoders are used to measure the rotational position and speed of the platform drive wheels and aid in tracking its odometry. The encoders are also used to determine if a mechanical failure has occurred in the drive train.

# 8. Basic usage

This section describes the operation of the product.

Prior to using the robot, the surrounding area must be approved for autonomous navigation by an OTTO Motors representative. Never use the robot in an area without prior consultation by an OTTO Motors representative.

## 8.1. Locking-out/tagging-out the OTTO Lifter

> **WARNING**
> SHOCK HAZARD! Always perform the lock-out/tag-out procedure at the facility or on the product before inspecting, servicing, cleaning, removing components, or opening any enclosure.

To complete maintenance or inspection on the robot, ensure that the correct lock-out/tag-out procedure has been followed to remove energy from the system.

1. Park the robot manually or autonomously in a safe location where it won't interfere with facility traffic.
2. Fully lower the forks to their lowest position.
3. Shut down the robot and wait until all lights are off, indicating that all of the electrical systems are without power.
4. Open the left side door.
5. Disconnect the battery from the robot.


6. Lock-out the robot side of the battery connection by covering the battery connection with the lock-out/tag-out cover bag provided.


7. Lock the bag closed with the provided lock and use the tag provided according to facility standards.
8. Attempt to start up the robot and operate the robot in tiller mode with the lock-out/tag-outs applied. Confirm that no power is available.
9. Ensure that all locks remain in place until all users are done working with the OTTO Lifter before re-energizing the system.

## 8.2. Starting up the OTTO Lifter

1. Perform the following checks before starting up the robot.

### Robot off checks

| | OK | Requires maintenance |
|---|---|---|
| General condition—note any scratches or damage to robot skins or light pipe | | |
| Inspect the guarding and replace if it is damaged | | |
| Leaks—hydraulic fluid, battery water | | |
| Forks—forks are not bent, fork tips are not at different heights, retaining pin and heel secure, fork hook is not worn, fork marking are legible, remove any debris, visually check condition | | |
| Wheels—free of debris, check condition | | |
| Fork impact sensors/fork covers—free of debris, check condition | | |
| Hydraulic hoses, mast chains/rollers, cables, and stops—check visually for corrision, deformation or damage. Replace if necessary. | | |
| Electrical—inspect wiring/connections/terminals/contactors for damage—confirm screw terminals are secure | | |
| Tiller handle—secure, free of debris, returns to neutral position after use | | |
| LiDAR safety scanners—clean with an OTTO Motors-approved product | | |
| 3D perception cameras—clean with an OTTO Motors-supported product | | |
| Dock assist sensors—clean with an OTTO Motors-supported product | | |
| Buttons—secure—check visually | | |
| Safety warnings—attached | | |
| Battery—check water/electrolyte level, corrosion check, no rotten egg smell present, and charge | | |
| Hydraulic fluid level—check level | | |
| Nameplate—attached and information matches model, serial number, and attachments | | |

2. Open the left side door and plug charged battery into the robot connector.
3. Insert the robot key into the robot key switch and turn the key to the **Auto** or **Manual** position.

4. Wait until the light pipe pattern has changed to the emergency stop state pattern.
5. When ready, check that the **Emergency Stop** buttons are released, then press the **Safety Reset** button to enable the system. The light pipe should now switch to the neutral state pattern.
6. The robot may be set to neutral mode. Confirm the position of the robot on the map is accurate and select **Yes**.

## 8.3. Shutting down the OTTO Lifter

1. Press an **Emergency Stop** button.
2. Press the **Power** button. Press and hold the **Power** button to force system shutdown and skip the shutdown sequence.
3. Wait until all lights on the robot are off, indicating that all of the electrical systems are without power (at least 30 seconds).

## 8.4. Replacing the OTTO Lifter battery

The battery on the OTTO Lifter can be replaced quickly to avoid manual charging and potential downtime for the robot.

Operators should be familiar with the robot components [28] before attempting a battery replacement.

**WARNING**

SHOCK HAZARD! Always perform the lock-out/tag-out procedure at the facility or on the product before inspecting, servicing, cleaning, removing components, or opening any enclosure.

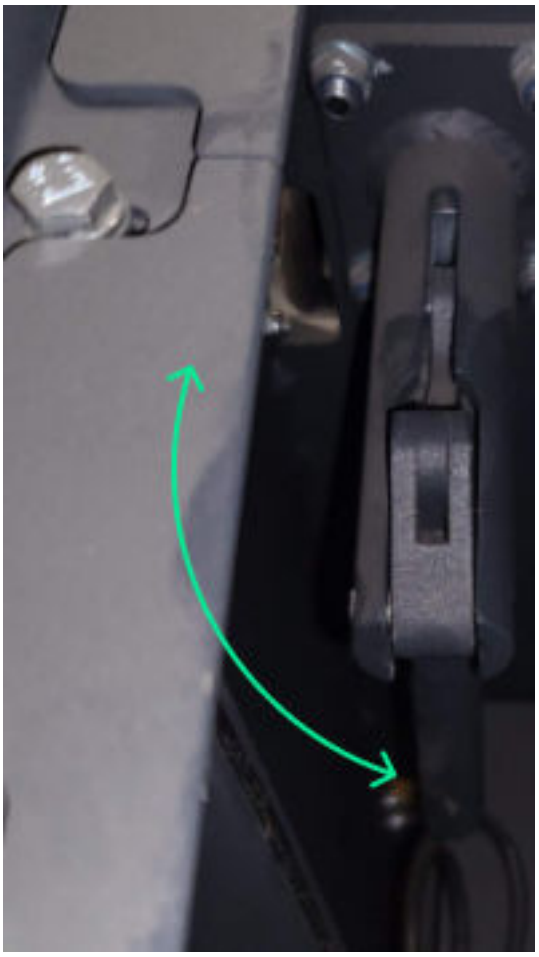
**CAUTION**

- Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products.
- BURN HAZARD! Flooded lead acid batteries contain sulfuric acid which is highly corrosive and considered a Class 8 Dangerous Good for transport. Care must be taken to avoid skin contact with any battery fluids.
- FIRE HAZARD! Chargers and batteries must only be used in a well-ventilated area and must be easily accessible.

1. Before replacing the battery, review facility procedures relating to eye washing, battery acid spills, and other related procedures.
2. Position a battery transfer cart nearby using a pump truck.

3. Lock-out/tag-out the robot [40].
4. Open the top rear door.
5. Open the left side door.
6. Position the battery transfer cart in front of the open battery compartment. Use the pump truck to lower the battery transfer cart to the floor.

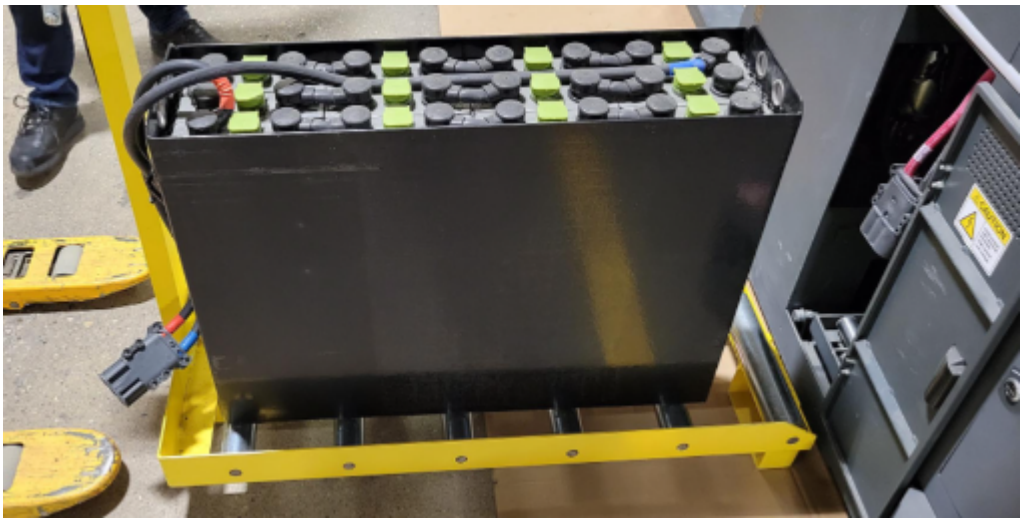
7. Release the battery retention pin using the lever located under the top rear door of the robot.



8. Pull the robot side of the battery connection up and out of the way of the battery compartment.

9. Using the handle on the battery, pull the battery out of the battery compartment and onto the battery transfer cart.

> **CAUTION**
> PINCH HAZARD! Keep objects and body parts away from pinch points.



> **WARNING**
> CRUSH HAZARD! OTTO Lifter batteries are extremely heavy and can tip easily. Take care when handling the battery and make sure that batteries are secure during the battery replacement procedure.

10. Before connecting a replacement battery to the robot, make sure that all battery cell fill caps on the battery are closed.

11. Return the robot to operation.

## 8.5. Manually charging the OTTO Lifter

The OTTO Lifter autonomous mobile robot (AMR) relies on a manual charger to charge the battery.

Always attempt to charge the OTTO Lifter before the robot automatically shuts down at 25% charge level. A low battery exception will be displayed at 30% charge level. It is recommended that the battery be charged up to full capacity as intermittent charging can affect the battery life and capacity.

1. Move the robot out of any high traffic area. The charger can be taken to the robot, if an outlet is close, or the robot moved to it by driving it autonomously or in manual mode.
2. Shut down the robot.
3. Open the left side door.
4. Disconnect the battery power cable from the robot by pulling down on the connector (see the following).

5. Check the charger output cables and connector to ensure there is no visible damage.
6. Ensure the OTTO Lifter Manual Charger indicator light is solid red.
7. Plug the OTTO Lifter Manual Charger into a 120 V outlet.

> **CAUTION**
> Do not use an extension cord with the OTTO Lifter Manual Charger as this can result in damage to the charger.

8. Connect the disconnected battery power cable from the OTTO Lifter into the charger cable on the OTTO Lifter Manual Charger.
9. Once the robot is fully charged and the indicator light on the manual charger is solid green, shut down the battery charger.
10. Unplug the charger connector from the battery. Perform a check for robot functionality.

## 8.6. Storing the OTTO Lifter

The OTTO Lifter MkIV autonomous mobile robot (AMR) and its lead-acid battery pack should be stored within the non-operating temperature range of:

-25 °C to 70 °C (-13 °F to 158 °F)

If storing for an extended period of time, it is recommended that the battery be charged to full before storing. The battery water level should then be checked and the battery charged back up to full every 6 months of storage.

## 8.7. Connecting to a robot using an Ethernet cable

OTTO Motors robots can be interfaced with using a computer with an Ethernet port and an Ethernet cable.

The Ethernet port on the OTTO Lifter autonomous mobile robot (AMR) is located under the right side door of the robot.

1. Connect one end of an Ethernet cable to the robot.
2. Connect the other end of the Ethernet cable to the Ethernet port on a computer.
3. Configure the network address and netmask on the computer using the following values (this procedure will differ depending on the computer operating system):

**Network address**: 10.255.255.200
**Netmask**: 255.255.0.0

4. Confirm the robot can be pinged from the computer by opening a terminal/command window and entering the following command:

```
ping <robot IP address>
```

The IP address entry depends on the robot model:

| Robot model | IP address |
|---|---|
| OTTO Lifter | IP address 10.255.255.1 |

## 8.8. Connecting a robot to a network

Robots must be connected to a network to truly take advantage of the robot's autonomous capabilities.

OTTO Motors robots come with 2.4 GHz wireless frequency disabled but OTTO Motors robots can support both 2.4 GHz and 5 GHz wireless frequencies. 5 GHz is strongly recommended as the 2.4 GHz frequency may result in performance issues. If 2.4 GHz is required for the robot to connect, contact OTTO Motors Support for assistance in changing the robot's settings.

1. Connect a computer to the robot using an Ethernet cable [47].
2. Using a supported browser, navigate to http://10.255.255.1:8090. OTTO Network Setup will be displayed.
3. Select **Use Robot Settings** to view the current settings of the robot being configured.
   Select **Use Browser Settings** to save the current settings for easier and faster configuration of multiple robots.
   The robot **Hostname**, WiFi Settings **Passkey**, and **VPN Password** are not saved when using the Use Browser Settings option.
4. Enter a **Hostname** for the robot.
   Hostnames must begin with a letter as hostnames beginning with a number aren't supported.

> **TIP**
> If the configuration screen becomes slow to respond after changing the hostname, restart the robot.

5. Select **Apply**.
6. Enter the network's **Access Point Name** (ssid) and **Passkey**, then select **Apply**.
7. Select an **IP Type**.
   To assign a Static IP address, select **Static IP** from the **IP Type** menu. Configure the fields as required, and select **Apply**.
   To use a Dynamic IP address assigned by the network, select **Dynamic IP** from the **IP Type** menu, and select **Apply**.
8. Select **Save and Restart Network**.
9. Restart the robot.

## 8.9. Adding a robot to a fleet

To add a robot to the fleet, a computer must be connected to the OTTO Motors autonomous mobile robot (AMR) and the robot must be connected to the network. It is also assumed that OTTO Fleet Manager has been fully deployed.

1. Connect a computer to the robot using an Ethernet cable [47].
2. Using a supported browser, navigate to http://10.255.255.1:8090. OTTO Network Setup will be displayed.
3. Under **VPN Settings**, enter the **OTTO Fleet Manager Hostname (or IP)**.
   In a multi-host deployment, this will be the Core VM IP address.
4. Enter the **VPN Port** and VPN Password for the facility. The default port number is 655 and the password is "clearpath".
5. Select **Exchange VPN Keys**.
6. Verify the robot is now connected to OTTO Fleet Manager:
   a. In a new browser tab, open OTTO Fleet Manager.
   b. Navigate to **Monitor** > **Robots** and in the list of fleet robots that is displayed, verify the new robot has been added. Note that it may take a few minutes for the robot to be displayed.
   c. If the robot does not connect to OTTO Fleet Manager or is not added to the fleet, restart the robot and OTTO Fleet Manager.
   d. If adding the robot to an existing OTTO Fleet Manager that has already been configured, restart all jobs in the job queue.

## 8.10. Autonomous operation

In autonomous mode, the OTTO Lifter autonomous mobile robot (AMR) senses the environment, tracks pallets, and plans paths based on the obstacles it detects.

> **IMPORTANT**
> Low quality, damaged, or obscured pallets will result in reduced performance as the OTTO Lifter uses the pallet face to track pallets. Broken pallet deck boards can adversely affect payload stability and the ability of the robot to dock.

When autonomous mode is enabled:

- Forks are raised to travel height
- Robot will remain in a paused state if an unstable payload is detected
- The robot will enter a safety stop state if an operator interacts with the tiller, requiring autonomous mode to be re-enabled. See Enabling autonomous mode [49] for more detail.

### Enabling autonomous mode

1. Confirm the following:
   - The robot is clear of obstacles on all sides by at least 1 m
   - Forks are lowered to the floor
   - There are no obstacles located above or below the forks

> **WARNING**
> - CRUSH or IMPACT HAZARD! Robots must be prevented from traveling in areas that do not follow Facility Conditions specifications, such as ramps and stairwells.
> - CRUSH HAZARD! Payloads, attachments, or a combination thereof, should always remain within the stability envelope relevant to the specific robot model. For payload constraints, refer to the System Specifications for the product.

> **CAUTION**
> - CRUSH or IMPACT HAZARD! Keep low profile objects that the LiDAR cannot detect, such as forklift tines and pallets, outside of the robot's path. For sensor layouts, refer to the Component Overview section of the robot operation and maintenance manual.

2. Turn the robot key switch to the **Auto** position.
3. Press the **Auto** button.

### Auto button light states

| Auto button light state | Safety system status |
|---|---|
| Solid yellow light | Safety system active—robot is in autonomous mode |
| Flashing yellow light | Safety system inactive—robot is in manual mode |
| No light | Robot is off |

4. If the robot does not enter autonomous mode, troubleshoot the potential causes.

## Dispatching jobs

1. Launch Workstation Dispatch.
   The main menu is displayed to the left of the screen.
2. To display the workstation interface, under the **Change Workstation**, select a workstation.
   A series of buttons corresponding to the available workstation jobs is displayed above the list of current and next-in-queue jobs.
3. To queue the corresponding job, select **Workstation Job**.
4. To switch to a different workstation, select **Main Menu** ☰ and select a new workstation from the **Change Workstation** list.

## Troubleshooting autonomous mode

> **IMPORTANT**
> Note that the OTTO Lifter autonomous mobile robot (AMR) will enter a blocked state whenever attempting to dock with an unsupported pallet type.

**Robot in blocked state when attempting to find a pallet**

1. Enable manual mode on the robot.
2. Using the tiller, manually pick up the pallet. Ensure that the fork impact and dock assist sensors are not triggered.
3. Confirm the robot is clear of obstacles on all sides by at least 1 m, if so, remove them.
4. Confirm there are no obstacles located above or below the forks and check for pieces of pallet or stretch wrap, if so, remove them.
5. Skip the load task in OTTO Fleet Manager. Enable autonomous mode on the robot.

**Robot in blocked state but still attempting to move**

1. Confirm the robot is clear of obstacles on all sides by at least 1 m, if so, remove them.
2. Confirm there are no obstacles located above or below the forks, if so, remove them.
3. If all the above steps fail to remove the robot from a blocked state, use manual mode to move the robot to a space clear of obstacles, lower the forks to the ground, then restart the job in OTTO Fleet Manager.

**Robot in blocked state/task in failed state in OTTO Fleet Manager**

1. Confirm the robot is clear of obstacles on all sides by at least 1 m, if so, remove them.
2. Confirm there are no obstacles located above or below the forks, if so, remove them.
3. Retry the task in Fleet Manager.
4. If all the above steps fail to remove the robot from a blocked state, use manual mode to move the robot to a space clear of obstacles, lower the forks to the ground, then restart the job in OTTO Fleet Manager.

**Robot enters a safety stop state**

1. Confirm the robot is clear of obstacles on all sides by at least 1 m, if so, remove them.
2. Confirm there are no obstacles located above or below the forks and check for pieces of pallet or stretch wrap, if so, remove them.
3. Confirm there is no material triggering the safety stop by obstructing a payload presence sensor, if so, remove it.
4. Press the **Safety Reset** button.
5. If the above steps do not remove the robot from the safety stop state, check the safety stop exception to confirm the source of the stoppage. If an exception indicates that the source of the stoppage is the robot secondary sensors, enable manual mode on the robot, lower the payload to the floor, and retry the task in OTTO Fleet Manager.

## 8.11. Manual mode operation

Operators using the OTTO Lifter autonomous mobile robot (AMR) in manual mode must receive appropriate training for manual operation of the robot. All autonomous safety features of the robot are disabled when it is in manual mode.

### Enabling manual mode

Manual mode allows control of the OTTO Lifter autonomous mobile robot (AMR) using its tiller, allowing the user to drive the robot forward, backwards, or rotationally, as well as raise and lower the forks. This is useful when recovering from a fault, completing maintenance tasks, or controlling the robot outside of normal operating conditions.

> **CAUTION**
> IMPACT HAZARD! Always maintain a safe distance from a robot in operation. A robot being operated in manual mode should only be operated by personnel who have been trained and authorized according to the standards of the facility in which the robot is in use. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot operation and maintenance manual.

When manual mode is used, the OTTO Lifter AMR is not able to move autonomously. Note that manual mode cannot be enabled if the robot is in a safety stop or emergency stop.

1. Turn the robot key switch to the **Manual** position.
2. Press the **Auto** button.

### Auto button light states

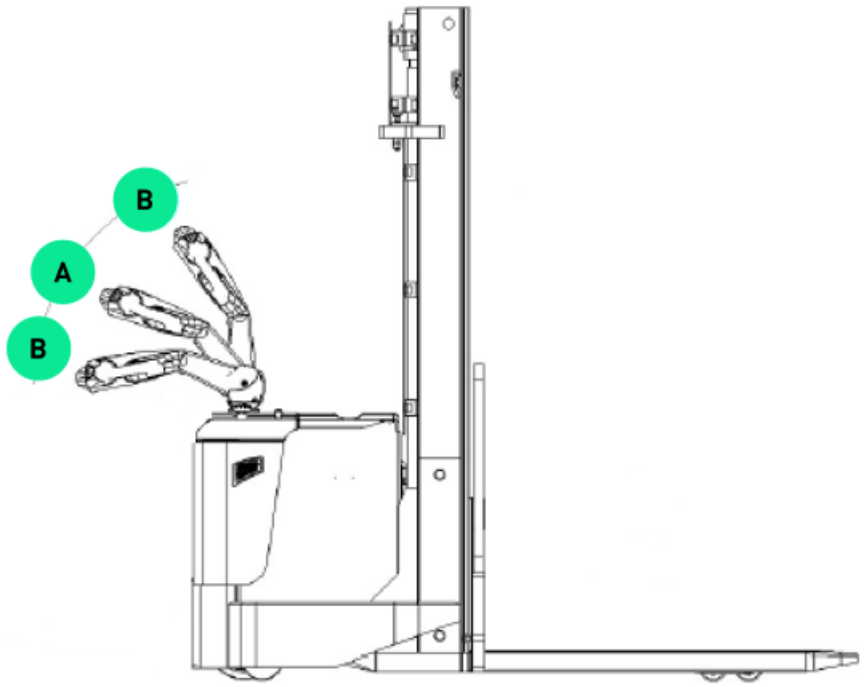
| Auto button light state | Safety system status |
|---|---|
| Solid yellow light | Safety system active—robot is in autonomous mode |
| Flashing yellow light | Safety system inactive—robot is in manual mode |
| No light | Robot is off |

3. Perform any manual work required using the tiller with the robot in manual mode.

## Raising and lowering forks

1. Move the tiller to the middle position.

### Tiller positions



The tiller must be moved to the middle position (A) to operate the robot in manual mode using its tiller.

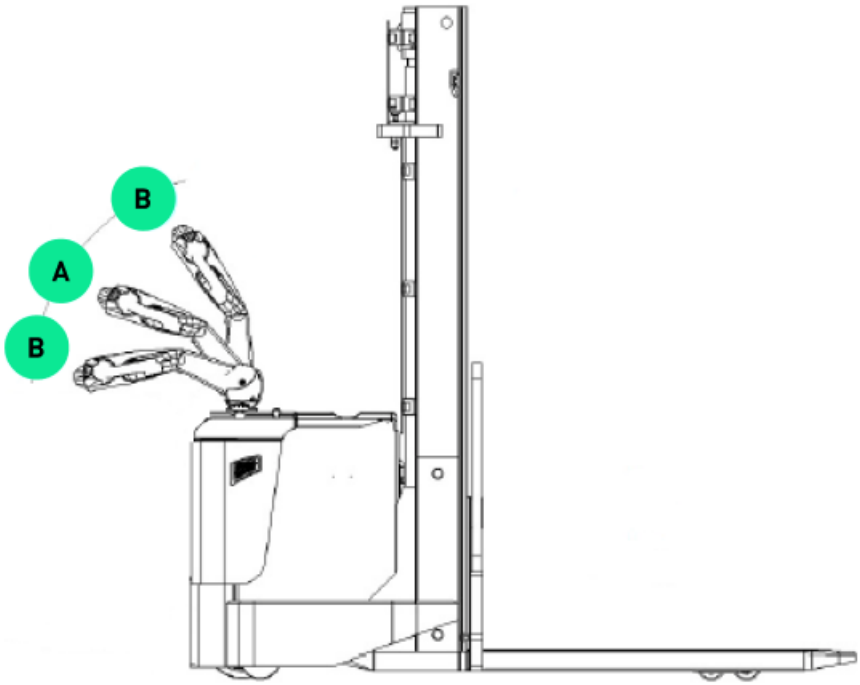
The robot can't operate in autonomous mode when the tiller is in the middle position (A). Autonomous mode requires the tiller to be in a neutral position (B).

2. Use the red buttons on either side of the center of the tiller:
   - To RAISE the forks, press the button with the arrows pointing up on the lift controls (closest to the center of the tiller).
   - To LOWER the forks, press the button with the arrows pointing down on the lift controls (farthest from the center of the tiller).

## Moving forward and backward

- Move the tiller to the middle position.

### Tiller positions




The tiller must be moved to the middle position (A) to operate the robot in manual mode using its tiller.

The robot can't operate in autonomous mode when the tiller is in the middle position (A). Autonomous mode requires the tiller to be in a neutral position (B).

- To move the robot toward the forks, push movement controls up until the desired speed is reached.
- To move the robot toward the tiller side, push movement controls down until the desired speed is reached.

When the accelerator is released, it will return to the neutral position, and the robot will decelerate until it comes to a complete stop. When stopped, the parking brake will be engaged.

### Using the horn

To activate an audible horn to warn others that the robot is being operated in manual mode, press the **Horn** button.

> **IMPORTANT**
> The horn can reach a sound pressure level of 102.4 dB. In such conditions, proper hearing protection may be necessary. A final noise assessment at the workplace is required to determine the need for PPE.

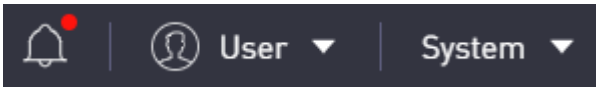
## 8.12. Exceptions

The Exceptions menu displays relevant robot alerts, OTTO App, and OTTO Fleet Manager. Nuisance messages—or messages unhelpful to diagnosing exceptions and troubleshooting—are automatically excluded.

### Accessing exceptions in OTTO Fleet Manager

The **Exceptions** menu can be accessed through the top menu bar in OTTO Fleet Manager, through **Active Alerts** in an individual robot pane, or by clicking any active exceptions through the **Monitor Robots** pane.

1. Launch OTTO Fleet Manager.
2. In the top menu bar, click .




The entire exceptions list will be displayed until additional filters are applied.

OR

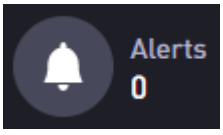
1. To view exceptions for a specific robot, select **Monitor** > **Fleet**.
2. If there are any active exceptions for a particular robot, select the number.


OR

1. To view exceptions through Workstation Dispatch, select **Configure** > **Workstations**.
2. Select for the applicable workstation.
3. Select **Alerts** in the bottom menu bar.

### Accessing exceptions in OTTO App

1. Launch OTTO App for the applicable robot.
2. Select **Alerts** in the bottom menu bar.

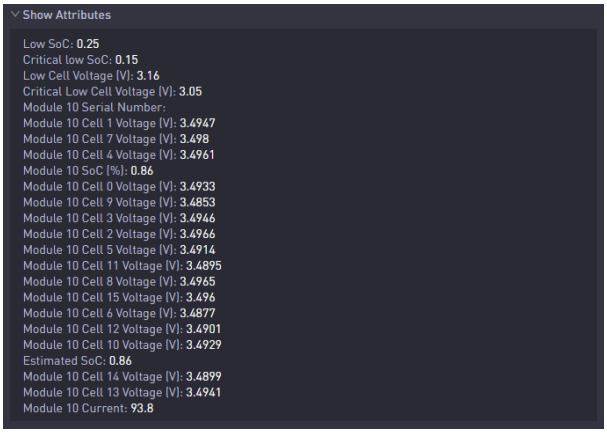


### Navigating exceptions

Once the exceptions window is accessed, a list of unfiltered exceptions will be displayed, sourced from the robot fleet, OTTO App and OTTO Fleet Manager.

1. Select an individual exception to obtain more detail.


2. If desired, select **Show Attributes** to display additional detail. Typically the detail shown through clicking Show Attributes will only be useful to advanced users or OTTO Motors Support staff.




### Filtering exceptions

Exceptions can be filtered by their severity (error or warning), state (active or resolved), or source using the filter field.

1. Select .
   a. To filter by **Warning**- or **Error**-level exceptions, select **Severity**.
   b. To filter by **Active** or **Resolved**exceptions, select **State**.
   Filtering by resolved exceptions is an excellent way to search for errors that are transient in nature.
2. To remove all filters from the exceptions list, select **Clear All Filters**.

# 9. Preventative maintenance

**WARNING**

- SHOCK HAZARD! Always perform the lock-out/tag-out procedure at the facility or on the product before inspecting, servicing, cleaning, removing components, or opening any enclosure.

> **CAUTION**
>
> - PINCH HAZARD! Keep objects and body parts away from pinch points.
> - Only qualified personnel should perform installations, maintenance, and inspections.

Take special care while maintaining and inspecting electrical equipment and devices. All personnel working on or around the system are to be aware of, and adhere to, all CAUTION, DANGER, and WARNING labels. These labels are posted for the purpose of reducing the risk of injury to all personnel. Never take the attitude that the signs and notices of this type are applicable only to inexperienced personnel.

## 9.1. Maintenance schedule

Failure to follow the maintenance checks and intervals outlined below could lead to unsafe conditions.

| Component | Daily | Monthly | 3 months | 6 months | Annually |
|---|---|---|---|---|---|
| Robot off check | ✓ | | | | |
| Robot on check | ✓ | | | | |
| **Hydraulic** | | | | | |
| Inspect the hydraulic fluid level, refill if necessary | | | | | ✓ |
| Check and adjust the function of the pressure valve (1500 kg +0 / +10%) | | | | | ✓ |
| **Mechanical** | | | | | |
| Lubricate steering bearing, wheel bearings, chain, grease nipples, and main frame post | | | ✓ | | |
| Confirm fork impact sensor functionality | | | ✓ | | |
| Detailed fork inspection | | | ✓ | | |
| **Electrical** | | | | | |
| Check the frame leakage (insulation test) | | | ✓ | | |
| Check the electrical system of the drive motor | | | ✓ | | |
| Confirm string pots are tight, free of debris, and in their proper location | | ✓ | | | |
| Inspect and clean rear door and computer fan filters to assist thermal detector functionality—replace fans, if necessary | | ✓ | | | |
| **Battery** | | | | | |
| Clean and grease the terminals and check for corrosion/damage | | | ✓ | | |
| **Brakes** | | | | | |
| Inspect the brakes | | | | ✓ | |

## 9.2. Circle check

Perform a brief circle check of the robot every day.

- Ensure no damage has occurred since the robot(s) last ran
- Ensure the light pipe is functioning correctly by pressing and the **Emergency Stop** button and checking for a full red ring
- Ensure the speaker is functioning correctly by pressing an **Emergency Stop** button and listening for the horn
- Ensure all **Emergency Stop** buttons are functioning correctly by pressing and resetting them one-at-a-time
- Ensure the robot's LiDAR safety scanners are functioning correctly. To test, place a lightweight object, such as a cardboard box, approximately 5 cm in front of the stationary robot and confirm that a safety stop is triggered. The safety stop will be observable with the sounding of the horn and the corner lights flashing red. Do not step in front of the robot to test the safety function.

## Robot off checks

| | OK | Requires maintenance |
|---|---|---|
| General condition—note any scratches or damage to robot skins or light pipe | | |
| Inspect the guarding and replace if it is damaged | | |
| Leaks—hydraulic fluid, battery water | | |
| Forks—forks are not bent, fork tips are not at different heights, retaining pin and heel secure, fork hook is not worn, fork marking are legible, remove any debris, visually check condition | | |
| Wheels—free of debris, check condition | | |
| Fork impact sensors/fork covers—free of debris, check condition | | |
| Hydraulic hoses, mast chains/rollers, cables, and stops—check visually for corrision, deformation or damage. Replace if necessary. | | |
| Electrical—inspect wiring/connections/terminals/contactors for damage—confirm screw terminals are secure | | |
| Tiller handle—secure, free of debris, returns to neutral position after use | | |
| LiDAR safety scanners—clean with an OTTO Motors-approved product | | |
| 3D perception cameras—clean with an OTTO Motors-supported product | | |
| Dock assist sensors—clean with an OTTO Motors-supported product | | |
| Buttons—secure—check visually | | |
| Safety warnings—attached | | |
| Battery—check water/electrolyte level, corrosion check, no rotten egg smell present, and charge | | |
| Hydraulic fluid level—check level | | |
| Nameplate—attached and information matches model, serial number, and attachments | | |

## Robot on checks

**CAUTION**

Confirm that the robot has sufficient space to test full range of motion when performing the operational inspection as the forks will be raised to their maximum height and the robot will be moving.

**IMPORTANT**
Unusual noises must be investigated immediately.

| | OK | Requires maintenance |
|---|---|---|
| Check battery level indicator for function and confirm charge level | | |
| Tiller drive control—forward/back, regenerative braking (plugging)—functioning smoothly (with and without fine control mode), release tiller to confirm robot stops as intended | | |
| Lift and lowering control—functioning smoothly (with and without fine control mode) | | |
| Emergency Stop buttons—functioning | | |
| Safety belly switch—functioning, robot reverses when safety belly switch is engaged | | |
| Horn and lights—functioning | | |
| Digital interface—functioning | | |
| WiFi connectivity—functioning | | |
| Robot state indicators—light pipe, dome light, speaker, direction lights - functioning | | |

## Checking the battery water level

**WARNING**

- SHOCK HAZARD! Always perform the lock-out/tag-out procedure at the facility or on the product before inspecting, servicing, cleaning, removing components, or opening any enclosure.
- Always use level rigging when lifting or lowering the product.
- BURN HAZARD! Do not overfill the battery.

**CAUTION**
Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products.

1. Open the left side door.
2. Using a battery cart, remove the battery from the OTTO Lifter.
3. Remove each cap (A) on the battery one at a time.


The water level under each cap should reach the midpoint of the water fill basket (B).

4. If required, add distilled water until the water level reaches the required level.

## 9.3. Monthly preventative maintenance

Perform the following tasks at least once each month.

### Inspecting and replacing OTTO Lifter guarding

> **CAUTION**
>
> - Never operate the product after faulty parts are identified.

1. Inspect the guarding for damage.
2. If the guarding needs to be removed:
   a. Shut down the robot.
   b. Remove the fixing screws and remove the guarding carefully. The screws will remain with the guarding.

> **IMPORTANT**
> Contact OTTO Motors Support for assistance.

3. To reattach the guarding, replace it and reattach the fixing screws.

### Inspecting string pots

1. Inspect the string pots to ensure the cables do not have any debris on the wires or where they enter/leave the unit. If there is some debris, carefully remove it from the cable. Having a clean cable will ensure your lift system is running accurately.
2. Fully lower the forks to their lowest position.
3. Shut down the robot.
4. Inspect the string pots for debris on the wires or where they enter/leave the unit. Remove any debris carefully. Replace and calibrate the string pots if the string pots or cable are damaged.

> **IMPORTANT**
> Contact OTTO Motors Support for assistance.

## 9.4. 3-month preventative maintenance

Perform the following tasks at least once every 3 months.

### Lubricating the OTTO Lifter periodically

1. Shut down the robot.
2. Lubricate the following components using grease specification DIN 51825, standard grease:
   - Steering bearing
   - Wheel bearings
   - Main frame post

## 9.5. 6-month preventative maintenance

Perform the following tasks at least once every 6 months.

### Brake inspection

1. Visually inspect the brake pad by lifting up the dust protection ring (021966), observing for a build up of foreign material.
2. Check the brake performance and, if necessary, replace the brake disc, or adjust the air gap.

## 9.6. Annual preventative maintenance

Perform the following tasks at least once annually.

### Inspecting and refilling hydraulic fluid

The hydraulic fluid should meet the following requirements:

| Operating temperature range | -5° C - 25° C | > 25° C |
|---|---|---|
| Type | HVLP 32, DIN 51524 | HVLP 46, DIN 51524 |
| Viscosity | 28.8 - 35.2 | 41.4 - 47 |

Waste material like oil must be properly disposed of and recycled according to regulations and, if necessary, brought to a recycling center.

1. Fully lower the forks to their lowest position.
2. Follow the lock-out/tag-out procedure.
3. Inspect the hydraulic fluid level. The oil level height shall be in the not lifted position, minimum 8.4 L to 8.6 L. If necessary, add oil at the filling point.

# 10. Disposal

Always observe valid environmental protection regulations.

If disassembling the product for disposal, pass on any commercially-viable disassembled components for recycling. Separate materials as far as possible by type.

Do not incinerate or dispose of the batteries. Return end-of-life or defective batteries to the nearest recycling center per appropriate local regulations.

Waste material like oil must be properly disposed of and recycled according to regulations and, if necessary, brought to a recycling center.

# 11. Troubleshooting

This section lists possible issues that may be encountered when using the product.

If there is a malfunction and the robot cannot be operated out of the working zone, refer to Basic Usage [39] for instructions on safely moving it.

| Observation | Issue | Resolution |
|---|---|---|
| Payload can't be lifted | Load weight too high | Lift only the maximum capacity, located on the nameplate. |
| | Battery discharged | 1. Disengage the forks with the payload.<br>2. Charge the battery.<br>3. If charging the battery fails to solve the issue, lock-out/tag-out the robot [40] and check the battery water level. |
| | Hydraulic oil level too low | 1. Disengage the forks with the payload.<br>2. Lock-out/tag-out the robot [40].<br>3. Check the lift hydraulic oil. Refill if required. |
| | Oil leakage | 1. Disengage the forks with the payload.<br>2. Lock-out/tag-out the robot [40].<br>3. Repair the hoses and/or the sealing of the cylinder. |
| | Payload is misaligned on the robot forks | Refer to the robot dashboard to determine how to align the payload. |
| Lift stops at a specific height | Lift is not reaching expected height | 1. The robot has a specific lift height when traveling autonomously—see autonomous mode fork height in System Overview [23].<br>2. Check workflows for specific lift height parameters. |
| Robot does not move autonomously | Emergency Stop button(s) are pressed | 1. Release the **Emergency Stop** button(s) when safe to do so.<br>2. Press the **Safety Reset** button.<br>3. Enable autonomous mode [49]. |

| Observation | Issue | Resolution |
|---|---|---|
| | Tiller is stuck in the middle position | 1. Move the tiller to a neutral position—see tiller positions [52]<br>2. Confirm that the robot is in autonomous mode.<br>3. Troubleshoot autonomous mode operation [39].<br>4. If the tiller cannot move to a neutral position, repair or replace the tiller. |
| | Robot is not in autonomous mode | Enable autonomous mode [49]. |
| | Robot is in neutral mode in OTTO Fleet Manager | In OTTO Fleet Manager, select the **Manual** button to toggle autonomous mode. |
| Robot will not start up | Battery is charging | Charge the battery completely and then remove the main power plug from the electrical socket. |
| | Battery not connected | Connect the battery correctly. |
| | Fuse is faulty | Check and possibly replace fuses. |
| | Battery is discharged | Charge the battery [46]. |
| Robot travels very slowly | Battery is discharged | Check the battery status at the robot battery state indicator. |
| | Electromagnetic brake is engaged | Check the electromagnetic brake and contact OTTO Motors Support. |
| | Robot is in docking or hazard mode or it has entered a Speed Limit zone. | Verify map layout is correct and robot hasn't entered docking or hazard mode, a Narrow Corridor zone, or a Speed Limit zone. Slower robot speeds are expected under these conditions. |
| | Debris stuck in wheels | 1. Lock-out/tag-out the robot [40].<br>2. Check the wheels for debris and, if necessary, remove it. |
| | Robot detects nearby debris | Remove any debris from the ground in the immediate area. |
| OTTO Lifter is reporting 'blocked' via its user interface | The robot is unable to plan its path if it appears that something is blocking its goal position or too close to its start position | Remove any physical objects that may be obstructing the robot's path. |
| Planned path visible in interface but the robot is not moving | Robot LiDAR scanners likely dirty | 1. Confirm there is no retroreflective material present nearby.<br>2. Confirm the robot is in autonomous mode.<br>3. If the robot was in autonomous mode and the robot was still not moving, lock-out/tag-out the robot.<br>4. Inspect the LiDAR and LiDAR cavity with a flashlight for any dust or debris.<br>5. Remove any dust or debris using OTTO Motors-supported cleaning products.<br>6. Start up the robot [41].<br>7. If all of the above checks fail, contact OTTO Motors Support. |
| Red blinking lights and audible notification | Robot in emergency stop state | 1. Confirm that all **Emergency Stop** buttons are released.<br>2. Press the **Safety Reset** button to try and clear any emergency stops.<br>3. If all the above checks fail, fully shut down [42], then start up the robot [41]. |
| Safety stop light pattern will not clear | Robot may be stuck in a safety stop state | 1. Confirm there are no nearby obstacles.<br>2. Confirm there is no retroreflective material present nearby.<br>3. Lock-out/tag-out the robot [40].<br>4. Inspect the LiDAR and LiDAR cavity with a flashlight for any dust or debris.<br>5. Remove any dust or debris using OTTO Motors-supported cleaning products. |
| Robot is making a loud or unusual mechanical noise | The drive wheel or wheels have debris on them. | 1. Lock-out/tag-out the robot [40].<br>2. Check the drive wheel and the two front wheels to ensure no debris or objects are jammed in the wheel cavities or in the wheels. |

| Observation | Issue | Resolution |
|---|---|---|
| | Lift making loud or unusual noises | 1. Lock-out/tag-out the robot [40].<br>2. Confirm that there is no debris in the chains and that there are no deformations along the travel of the mast.<br>3. Confirm there is a sufficient level of hydraulic lift fluid. |
| | Controls or electrical cabinet | Turn off the robot immediately and contact OTTO Motors to determine a safe course of action. |
| Steering issues | Steering is not behaving correctly | 1. Press an **Emergency Stop** button.<br>2. Return the tiller to the middle position.<br>3. Release all **Emergency Stop** buttons.<br>4. Press the **Safety Reset** button to try and clear any emergency stops.<br>5. Enable autonomous mode [49].<br>6. Wait for homing to complete. |
| | The tiller will not move back to the neutral position. | Repair or replace the tiller. |
| Digital interface loading screen is repeating | OTTO Fleet Manager inoperative | Confirm OTTO Fleet Manager status to ensure it's operating properly. |
| | Poor WiFi connection | Confirm status of WiFi network. |
| | Robot dashboard URL incorrect | Confirm the correct robot dashboard is being accessed. |
| Digital interface displaying blank gray screen | Digital interface browser error | Swipe up from the bottom of the display and tap **<** repeatedly until the loading screen appears. |

# 12. Declarations

This OTTO Motors product adheres to the standards summarized in this section and the following declarations apply:

## 12.1. SUPPLIER'S DECLARATION OF CONFORMITY

**47 CFR § 2.1077 Compliance Information**

**OTTO Lifter MkIV**

**Responsible Party:**

Clearpath US

One Marina Park Drive, 10th Floor Boston, MA 02210

**On behalf of:**

Clearpath Robotics Inc.

Suite 2A, 1425 Strasburg Road Kitchener, Ontario Canada N2R 1H2

**Point of Contact:**

Chief Financial Officer 1-844-733-6886

legal@clearpath.ai (legal@clearpath.ai)

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

This device may not cause harmful interference, and

This device must accept any interference received, including interference that may cause undesired operation.

**Contains Transmitter Module FCC ID: PD9AX200NG**

## 12.2. CAN ICES-003(A) / NMB-003(A)

Issue 7

October 2020

**Contains Transmitter Module IC: 1000M-AX200NG**

# 13. Robot forklift pre-op checklist - OMM-000105

## 13.1. Robot forklift safety and operational checks

**IMPORTANT**
Ensure that the below checklist is completed prior to each shift.

### Robot information

| |
|---|
| **Date/Time** |
| **Inspector name** |
| **Robot name** |

### Robot off checks

| | OK | Requires maintenance |
|---|---|---|
| General condition—note any scratches or damage to robot skins or light pipe | | |
| Inspect the guarding and replace if it is damaged | | |
| Leaks—hydraulic fluid, battery water | | |

| | OK | Requires maintenance |
|---|---|---|
| Forks—forks are not bent, fork tips are not at different heights, retaining pin and heel secure, fork hook is not worn, fork marking are legible, remove any debris, visually check condition | | |
| Wheels—free of debris, check condition | | |
| Fork impact sensors/fork covers—free of debris, check condition | | |
| Hydraulic hoses, mast chains/rollers, cables, and stops—check visually for corrision, deformation or damage. Replace if necessary. | | |
| Electrical—inspect wiring/connections/terminals/contactors for damage—confirm screw terminals are secure | | |
| Tiller handle—secure, free of debris, returns to neutral position after use | | |
| LiDAR safety scanners—clean with an OTTO Motors-approved product | | |
| 3D perception cameras—clean with an OTTO Motors-supported product | | |
| Dock assist sensors—clean with an OTTO Motors-supported product | | |
| Buttons—secure—check visually | | |
| Safety warnings—attached | | |
| Battery—check water/electrolyte level, corrosion check, no rotten egg smell present, and charge | | |
| Hydraulic fluid level—check level | | |
| Nameplate—attached and information matches model, serial number, and attachments | | |

## Robot on checks

**CAUTION**
Confirm that the robot has sufficient space to test full range of motion when performing the operational inspection as the forks will be raised to their maximum height and the robot will be moving.

**IMPORTANT**
Unusual noises must be investigated immediately.

| | OK | Requires maintenance |
|---|---|---|
| Check battery level indicator for function and confirm charge level | | |
| Tiller drive control—forward/back, regenerative braking (plugging)—functioning smoothly (with and without fine control mode), release tiller to confirm robot stops as intended | | |
| Lift and lowering control—functioning smoothly (with and without fine control mode) | | |
| Emergency Stop buttons—functioning | | |
| Safety belly switch—functioning, robot reverses when safety belly switch is engaged | | |
| Horn and lights—functioning | | |
| Digital interface—functioning | | |
| WiFi connectivity—functioning | | |
| Robot state indicators—light pipe, dome light, speaker, direction lights - functioning | | |