



OPERATION AND MAINTENANCE MANUAL

OTTO 1500 V2

OTTO 1500 V2

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CONTACT INFORMATION

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1 REVISION HISTORY

Table 1 Revision History

REVISION	DATE	CHANGES
A	November 2020	Initial release
B	December 2020	Revised EU-Declaration of Conformity
C	February 2021	Revised Declarations, safety admonitions updated, Attachment Interface clarifications, updated Safety Reset button functionality
D	August 2021	Revised safety information, edits made to Attachment Interface, preventative maintenance procedures

2 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!

Read and understand the Operation and Maintenance Manual (OMM) before using the robot, charger, or attachment.

For the physical location of elements on the product, refer to the Component Overview section of the OMM.

Failure to follow operating instructions could result in death or serious injury.

2.1 Safety Examples



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.**

2.2 General Hazards



WARNING!

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

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.

FIRE OR SHOCK HAZARD! Never use a power cord or cable that appears damaged.



CAUTION!

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

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 for 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.

2.2.1 Robot hazards



WARNING!

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

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 OMM.

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!

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

IMPACT HAZARD! Always maintain a safe distance from a robot in operation. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot OMM.

IMPACT HAZARD! While driving the robot manually, the safety fieldsets monitored by the LiDAR scanners are 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 OMM.

Do not expose the product for a prolonged period to temperatures outside the ranges specified in the product documentation.

IMPACT HAZARD! Never leave the manual bypass screws installed in the robot. This can prevent the braking system from functioning properly and can cause unpredictable driving patterns. For bypass screw locations, refer to the Component Overview section of the robot OMM.

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 OMM.

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.

Never lift the robot by the attachment or while the attachment is installed on the robot.

2.2.2 Charger hazards



WARNING!

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

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!

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

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.

Always remove the eye nuts from the lifting points before operating the charger to avoid damage to the charger or robots. For eye nut locations, refer to the Component Overview section of the charger OMM.

FIRE HAZARD! Chargers must only be operated 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.

2.2.3 Attachment hazards



WARNING!

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

Never operate the lift attachment without the bellow extended to cover the lift mechanism. Refer to the Maintenance section of the lift attachment OMM

Attachments must be designed to prevent users from being exposed to the hazards of the attachment.



CAUTION!

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

Never exceed the maximum total payload constraints of the product. For payload constraints, refer to the System Specifications for the product.










Never lift the robot by the attachment or while the attachment is installed on the robot.

CRUSH HAZARD! Objects can fall from the product. Where possible, secure loads to the product to avoid falling, tipping, shifting, or sliding.

2.3 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	LABEL TITLE	LABEL DESCRIPTION	LABEL	LABEL TITLE	LABEL 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. Keep clear of all docking OTTO AMRs.
	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 OTTO AMRs and another object. Keep hands and other objects clear of crush points at all times. Keep clear of all docking OTTO AMRs.
	Burn Hazard	Robot PC heat sinks and robot motors can become extremely hot during operation.		Impact Hazard	OTTO AMRs travelling through a facility can potentially impact objects and personnel. Keep clear of all docking OTTO AMRs.

	Manual Load Handling	Always use ergonomic technique when manually lifting loads.		OTTO AMR Movement	OTTO AMRs may suddenly begin moving autonomously or when being driven manually. Always be aware of OTTO Motors products and their potential for movement.
	Tripping Hazard	OTTO Motors products may pose a tripping hazard.		Automated Mobile Robot Traffic	Be aware that OTTO AMRs can be anywhere in the operating area of the facility at any time.
	Lock-Out/Tag-Out	When performing maintenance on an electrically powered OTTO Motors product, always follow the applicable Lock-Out Tag-Out procedure.		Personal Protective Equipment (PPE) Requirement	Proper PPE must be worn, including safety footwear (ie. steel toe) around OTTO Motors products. Insulated gloves and/or tools are recommended when performing any maintenance on OTTO Motors products.
	Do Not Ride	OTTO AMRs are not designed for carrying personnel and should not be ridden at any time.		Shock Hazard	Improper use/disconnection of a component with this label can result in a potential shock risk.
	Do Not Step	The labeled component must not be used as a step.			

2.4 Safety awareness

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 (AMR).

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

Additional items may need to be addressed based on the site-specific risk assessment.

- ☐ Proper PPE must be worn, including safety footwear (ie. steel toe).
- ☐ Crossing into the path of a moving OTTO AMR should be avoided, as well as placing or throwing obstacles into the path of a moving OTTO AMR.



WARNING!

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

IMPACT HAZARD! Always maintain a safe distance from a robot in operation. Be aware of the Emergency Stop button locations. For button location information, refer to the Component Overview section of the robot OMM.

- Be aware that an OTTO AMR 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, negative and overhanging obstacles, and the OTTO AMR LiDAR obstacle detection plane.
- The floor of the operating area should be kept free of dirt and debris.
- Personnel need to be aware of OTTO AMR docking and charging areas, where detection fields are reduced.

See the safety information in the operation and maintenance manual for the applicable OTTO AMR.

- Personnel should be aware of facility areas where OTTO AMRs travel through narrow aisles/corridors resulting in reduced clearance between OTTO AMRs and personnel and aisles/corridors shared between OTTO AMRs, other robots, and personnel.

See the safety information in the operation and maintenance manual for the applicable OTTO AMR.

- Personnel should be aware that OTTO AMR 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 OTTO AMRs, accessories, attachments, and payloads, while they are in autonomous operation. Using an Emergency Stop button is the only acceptable manner of interacting with an OTTO AMR or attachment while it is being operated autonomously.

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 OTTO AMRs do not drive or stop in those areas
- ☐ When required to move a product manually, personnel must ensure it is in an Emergency Stop state (in the case of an OTTO AMR) or shut down completely and should not push manually for prolonged periods.

See the Basic Usage section of the operations and maintenance manual for the applicable product.

- ☐ 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 an OTTO AMR.
- ☐ Alert personnel that while operating an OTTO AMR 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.

2.5 Facility conditions



WARNING!

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

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 OMM.

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.

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

2.5.1 General

- OTTO AMRs 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.

2.5.2 Driving surface

- To better assist OTTO AMRs 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 casters 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 Fleet Manager cannot be solely relied upon to prevent entry to areas with floors that don't meet OTTO AMR requirements.
- OTTO AMRs 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. Areas matching these descriptions 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.
- OTTO AMR 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 will begin to roll and may present a hazard.

2.5.3 Environment

For additional information on the operating environment conditions, refer to the System Specifications in the product OMM.

- OTTO AMR's 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 OTTO AMRs when shone directly into the robot's optical sensors.
- OTTO AMRs 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 AMR LiDAR safety systems.
- OTTO AMRs have no minimum ambient brightness requirements, as they are designed to operate in the dark.
- When the OTTO AMR detects a significant reduction in air quality, the AMR enters a safety stop.

2.6 Payload maximums



WARNING!

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

IMPACT HAZARD! Never bypass the drive wheels of the robot while on a sloped surface.

OTTO Motors products support a specific maximum payload and payload dimensions. OTTO AMR 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 OTTO AMR, payloads must not exceed the maximum payload documented on the attachment nameplate and dimensions specified in safety configuration documentation.

For robot, attachment, and accessory payload specifications, refer to the [Hardware Library](#).

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

2.6.1 OTTO 1500 AMR

For the default configuration for the OTTO 1500 AMR, payload dimensions must stay within the projected view of the OTTO 1500 AMR body and not project over the front, rear, or sides of the robot. The OTTO 1500 platform is rated to work with a specific maximum payload - this maximum payload changes when an attachment is connected to the robot because of the weight of the attachment itself. In this case, the OTTO 1500 AMR should only be loaded with the maximum payload documented on the attachment nameplate. Failure to load the OTTO 1500 AMR within the payload specifications will affect the safe operation of the robot.

2.7 Battery handling



WARNING!

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

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 OTTO AMRs and more specifically, the battery pack.

2.8 Charging the robots

For instructions on connecting the robot to a charger, refer to the Charging section of the robot operation manual.

For instructions on connecting the charger to a power supply, refer to the Installation section of the charger operation manual.

2.9 Overhang and underhang detection



WARNING!

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

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 OMM.

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

To assist OTTO AMRs without 3D perception capabilities in detecting obstacles, we encourage installation of perception-assist flaps (see below), especially in cases of potential mobile obstacles.

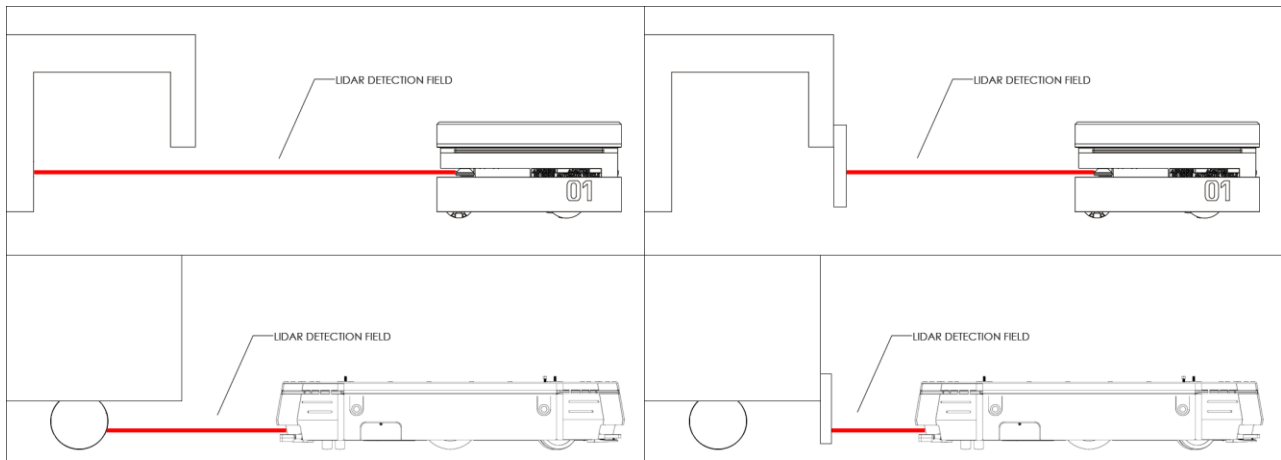


Figure 1 Perception-Assist Flap Installation

OTTO AMRs 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.

2.10 Standards compliance

OTTO Motors autonomy, safety systems and designed hardware comply with ANSI/RIA R15.08-1 standards. Compliance with ANSI/RIA R15.08-1 by third-party hardware platforms, attachments, and software safety configurations not modified by OTTO Motors, are the responsibility of those third parties and not of OTTO Motors.

2.11 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.

2.12 Safety Distance

Please refer to ISO 3691-4 Annex A and Safety Configuration document (022099 or the specific document for your facility provided by OTTO Motors or an authorized Partner) issued to you for your specific robot installation for references regarding the human exclusion zone during charging and other distances required for operation. The customer shall use clear floor markings to define this zone as a special hazard zone. ISO 3691-4 Annex A establishes minimum requirements for the preparation of the zones so that the AMR can safely operate. Employee training is recommended for a safe working environment with the system.

Where the robot is travelling through a corridor with a width narrower than 500 mm more than the width of the robot, it will enter a narrow hazard mode where the robot indicates a potential hazard with flashing lights, low speed and an audible tone. These areas should be considered restricted areas in accordance with local standards.

2.13 Safety System Functionality

This robot complies with ISO 3691-4 (2020) - *Industrial trucks - Safety requirements and verification - Part 4: Driverless industrial trucks and their systems*.

AMRs 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.

There are 2 LiDAR safety scanners on the robot - one at the front port corner and one at the rear starboard corner. 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.

[See Components Overview for the locations of the LiDAR safety scanners.](#)

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.

2.13.1 Perception Sensor Layout

See the applicable mechanical interfaces and sensor footprint documentation. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

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 (Safety Configuration 022099 by default). 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 and detects objects 200 mm tall at a 5 m distance from the robot. 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.

The 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.

2.13.2 Emergency Stop System

There are 2 types of Emergency Stops on the robot. When the Emergency Stop state is triggered, the system will immediately apply the brakes and cut all power to the drive motors. If an attachment is connected, a stop signal will be relayed to it. Likewise, an attachment can send an Emergency Stop state trigger to the robot.

Table 2 Emergency Stop Conditions

EMERGENCY STOP CONDITION	DESCRIPTION
Physical	An operator pressing one of the Emergency Stop buttons on the robot, the Manual Control Pendant, or an equipped attachment
Software	A software-triggered Emergency Stop caused by a system fault or self-diagnostic tool

See Components Overview for detail on button locations.

2.13.3 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. When the Safety Stop state is triggered, all motion is stopped, and a signal is provided to the attachment interface. This stop condition will attempt to reset itself every 2 seconds once the object has been cleared from the field.

Unlike the Emergency Stop system, Safety Stops do not remove energy from the system.

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 (022099 by default) and the MicroScan3 LIDAR Operating Instructions document for more details. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

2.13.4 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 requirement that is present in each zone.

Visit help.ottomotors.com for more information on Fleet Manager and the different Zone types.

2.13.5 Operation Modes

The robot 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 modes function.

2.13.5.1 Normal Mode

Normal 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.

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, measured as the difference between the two drive train speeds as read by the encoders on each drive train.

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

In normal mode, both drive trains must simultaneously move in the forward or reverse direction and are not allowed to move in opposite directions.

2.13.5.2 Hazard Mode

Hazard mode is used when robots must navigate down a narrow pathway 2.2 m or less in width, or between columns less than 2 m apart. 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, the robot 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.

2.13.5.3 Docking Mode

Docking mode is used when robots dock, when transferring payloads, or when charging. Personnel must be restricted from areas 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.

2.13.6 Attachment Interface

The robot is designed to support an equipped attachment. Any attachment must interface with the robot to transmit fault signals as well as receive enable signals. The Emergency Stop system is configured such that both the attachment and the robot can initiate an Emergency Stop state, halting operations on both systems immediately.

See Attachment Interface for more detail.

Attachments must be designed to prevent operators that are standing near the robot from being exposed to the hazards of the attachment.

2.13.7 Payload Stability

It is important for all users of the robot to understand the its stability and how lifting, turning, and stopping will affect the stability of the robot. The center of gravity will vary between payloads and even though payloads may be the same size, their weights may not be the same.

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

See OTTO 750 V2 AMR Stability and Center of Gravity for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

2.13.8 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.

3 INTENDED USE

OTTO Motors robots are Autonomous Mobile Robots (AMR) intended for use in industrial facilities. OTTO AMRs are intended to transport materials indoors in industrial buildings, utilizing visual mapping and location and intelligent navigation to plan their motion. They can perform autonomous navigation and route planning to achieve their planned Jobs and will operate without direct user intervention. Users are intended to have suitable training or familiarization as needed for their interactions with the vehicles and systems. This intended use extends to the OTTO infrastructure including - but not limited to - Chargers, Docks, Carts, Attachments, Custom Components, and software.

4 INTRODUCTION

This document provides important information pertaining to the safe operation and use of the OTTO Motors autonomous mobile robot (AMR), a heavy duty self-driving vehicle designed to move pallets, racks, and other large payloads through dynamic production environments.

Information in this document related to software functionality is up-to-date as of OTTO™ Software Version 2.22. Hardware functionality outlined in this document pertains both to the base platform and the functionality of any of its versions.

4.1 Included Items

The following items are included:

- Operation and Maintenance Manual
- OTTO Motors AMR

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

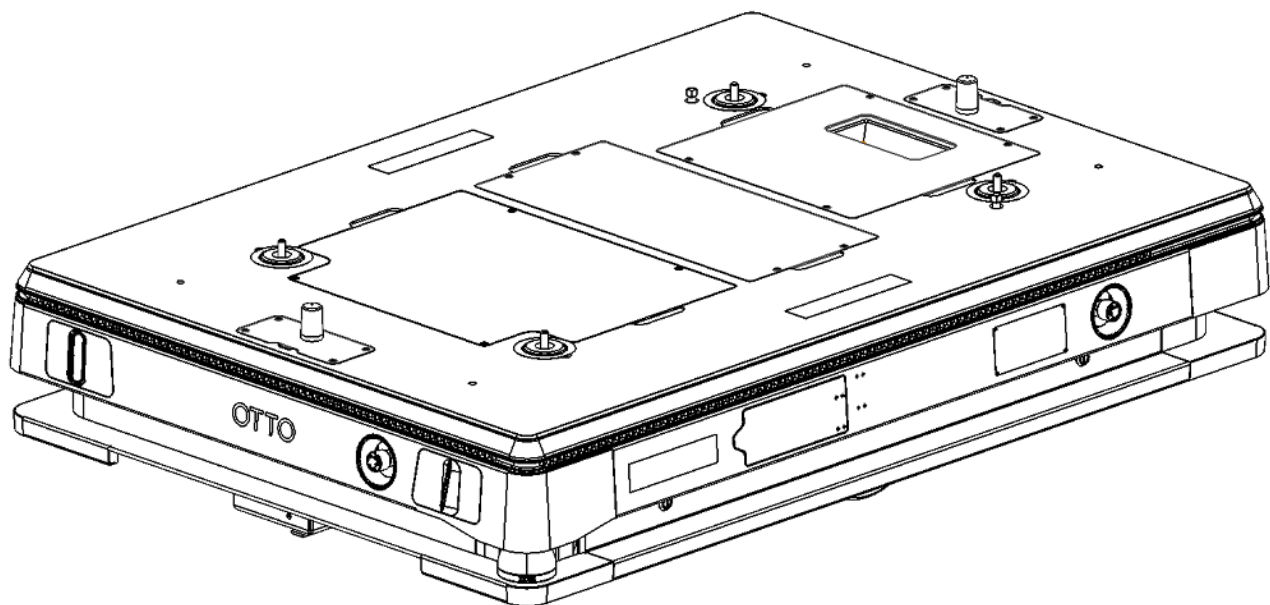


Figure 2 OTTO Motors AMR Isometric View



Figure 3 OTTO 1500 V2.0 AMR Nameplate



Figure 4 OTTO 1500 V2.1 AMR Nameplate

5 APPLICABLE DOCUMENTS

For additional information refer to the following documents. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

Table 3 Applicable Documents

REFERENCE	NUMBER
OTTO 1500 V2 AMR Operation and Maintenance Manual	OMM-000085
OTTO 1500 V2 AMR Stability and Center of Gravity	ICD-000090
OTTO 750/1500 V2 Manual Charger Operation and Maintenance Manual	OMM-000089
OTTO 750/1500 Fast Charger Operation and Maintenance Manual	OMM-000091
Default OTTO 1500 V2 Safety Configuration	022099
OTTO 1500 V2 AMR Sensor Footprint and Mechanical Interface	ICD-000088
SICK S3000 Operating Instructions	-

6 IN CASE OF A COLLISION

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

[See the Components Overview for Emergency Stop button locations.](#)

2. Is anyone hurt? Administer first aid immediately. Seek medical attention if necessary. Follow workplace injury and accident reporting procedures.
3. Document the incident.
 - a. Note the time and place.
 - b. Note which robot was involved.
 - c. Interview any witnesses.
 - d. Take photos or make a drawing.
 - e. If the robot is connected to Fleet Manager, create a Manual Snapshot to capture diagnostic information and robot sensor data to assist OTTO Motors in diagnosing the incident cause.
4. Assess the state of the robot.
 - a. Visually inspect the robot for damage and take photos of any damage found.
 - b. If there is no visible damage, observe the robot after it returns to service.
 - c. If any irregularities or differences in its behavior are observed, remove the affected robot from service and contact OTTO Motors support. If the damage is extensive, wait for communication from OTTO Motors before returning the robot to service.

[Refer to Safety Around OTTO for more detail.](#)

7 SYSTEM OVERVIEW

This section provides an overview of the important elements of the OTTO Motors autonomous mobile robot (AMR) system. The following figures give a tour of the key components of the robot for basic use.

7.1 System Specifications

COMPONENT	SPECIFICATION
Size and Weight	
Dimensions (L x W x H)	1837 x 1283 x 351 mm (72.32 x 50.51 x 13.85 in)
Mass	627 kg (1382 lbs)
Battery Mass	69 kg (152 lbs)
Battery Dimensions (L x W x H)	969 x 364 x 291 (38.15 x 14.33 x 11.46 in)
Speed and Performance	
Floor Gap/Obstacle Clearance	6 mm (0.24 in)
Maximum Total Payload	1500 kg (3306 lbs) with attachment 1900 kg (4189 lbs) total maximum payload
Maximum Speed	2.0 m/s (4.47 mph)
Maximum Turning Speed	1.5 rad/s (90°/s)
Maximum Docking Speed	0.3 m/s (0.7 mph)
Turning Radius	0 mm (not programmable)
Minimum Aisle Width (one way)	1915 mm (78 in)

Minimum Aisle Width (two way)	3570 mm (146 in)
Suspension	Passive, Rocker
Positional Accuracy	X, Y + / - 25 mm (0.98 in) Yaw + / - 3 ° <div>Positional accuracy is subject to the deployment. Please speak to your OTTO Motors representative for more information.</div>
Docking Accuracy	X, Y + / - 10 mm (0.4 in) Yaw + / - 1 ° <div>Docking accuracy is subject to the deployment. Please speak to your OTTO Motors representative for more information.</div>
Precision Upgrade Docking Accuracy	X, Y + / - 5 mm (0.2 in) Yaw + / - 1 ° <div>Docking accuracy is subject to the deployment. Please speak to your OTTO Motors representative for more information.</div>
Drive Configuration	Differential Drive
Battery and Power System	
Battery Charging Options	Autonomous opportunity charging (default) Manual charging
Battery Chemistry	LiFePO4
Capacity	52.8 V Nominal 70 Ah
Maximum Charge Rate	98 A
Charge Time	Designed for rapid-cycle opportunity charging
Drive Power	8760 W continuous

Battery Life	10,000 full charge cycles
Control System	
Sensors	2 x 3D perception cameras 2 x LiDAR safety scanners Embedded 6-axis IMU
Computer	Solid-state military spec computer with Intel i7-6700TE Quad Core, 16 GB RAM, nVidia GTX-1050 GPU
Interfacing and Communication	
Manual Control	Pendant-based manual control Guided autonomous control through OTTO App
Attachments and Accessories	1500 kg (3300 lbs) Lift Attachment, 1500 kg (3300 lbs) Conveyor Attachment, OTTO 750/1500 Fast Charger V2, OTTO 750/1500 Manual Charger V2, Manual Drive Pendant, 1900 kg (4190 lbs) Payload Plate
Communication	Wifi (802.11 a/b/g/n/ac/ax, 2.45GHz, 5 Ghz) 2 x long-range omnidirectional antennae
Attachment Control Systems Power	24 VDC, regulated, unswitched, 10A
Attachment Power Supplies	52.8 VDC nominal 50A, unregulated battery power, switched with safety circuit (44.8VDC (min) // 60VDC (max))
Optional Attachment Interface	1 x Ethernet, 1 x USB 3.1, 1 x HDMI, 5 x GPIO (2 safety rated), 1 x interface control line, dual-channel emergency stop breakout
Audio and Visual Indicators	Audio Tones 85 dB max. Visual Indicator 360° Light Pipe Indicator
Human-Robot Interaction	4 x Emergency Stop buttons (one per side) Safety Reset button Power button

Operating Environment

Maximum Floor Slope	1° / 1.6 %
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Operating Environment	Indoor
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IP Classification	IP20
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Operating Temperature Range	0°C to 40°C (32°F to 104°F)
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Non-Operating Temperature Range	0°C to 50°C (32°F to 122°F)
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Operating Relative Humidity	5 - 90 % non-condensing
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Non-Operating Relative Humidity	5 - 90 % non-condensing
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Maximum Operating Altitude	2000 m N.N. (6500 ft above sea level)
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Time-weighted Sound Pressure Emissions Level	> 70 dB(A)
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Ambient Light Immunity	< 3000 lx
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To avoid impacting the safety sensor wavelengths of 845 nm, wavelengths of +/- 10 nm should be avoided. Ambient light within these wavelengths will trigger robot Safety Stops.

Safety System

Intelligent Braking	Redundant monitoring with safety-system interlock
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Adaptive Fieldsets	Intelligent PL-d rated switching fieldsets (patent-pending)
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Standards Compliance	ISO EN 12100, ISO EN 13849-1, ISO 3691-1 (supercedes EN 1525), EN 60204-1, CE, FCC
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Some specifications above are dependent on software and robot configuration. Please speak to your OTTO Motors representative for more information.

Table 4 LiFePO4 Battery Technical Specifications

Cycle Life	10,000	70% DOD at 1C
Maximum Charge	100A	-
Maximum Discharge	200A	-
Operating Temperature	20°C to 45°C (68°F to 113°F)	Charging
	-20°C to 55°C (-4°F to 131°F)	Discharging
	-20°C to 45°C (-4°F to 113°F)	Storage

8 COMPONENTS OVERVIEW

The components overview is intended to familiarize the user with the separate components on the OTTO Motors autonomous mobile robot (AMR).

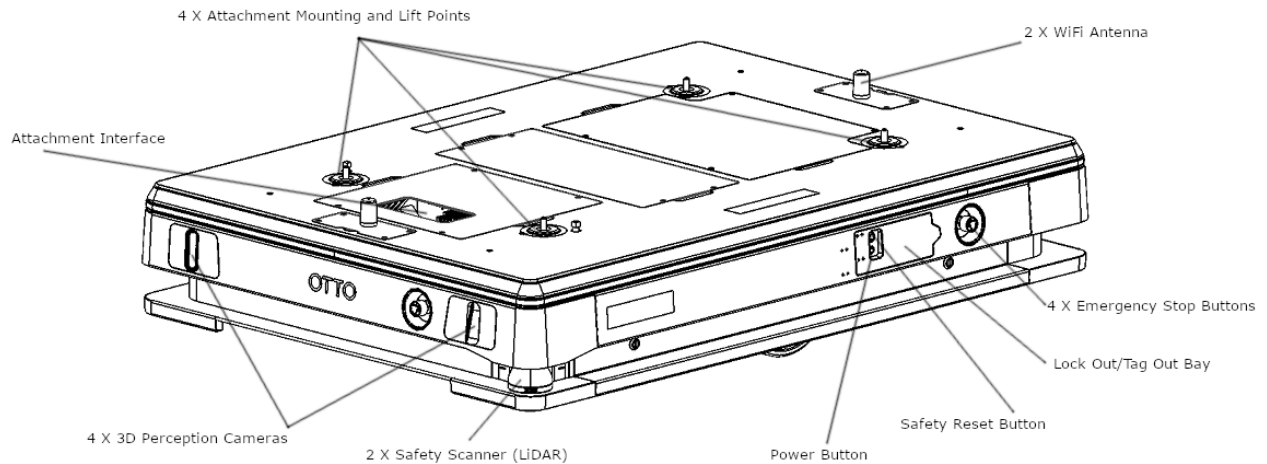


Figure 5 OTTO Motors AMR Port and Front

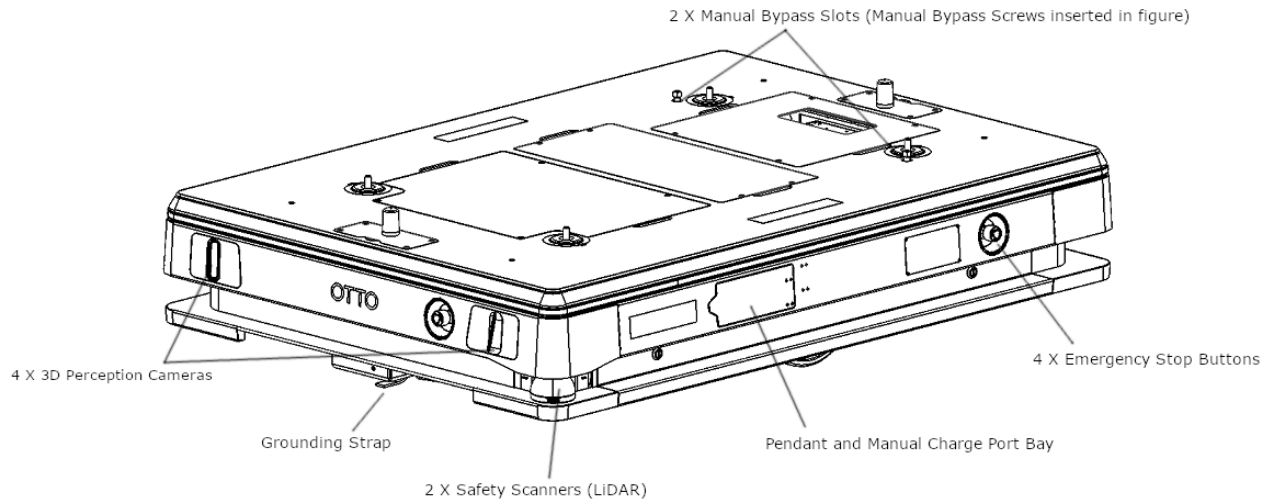


Figure 6 OTTO Motors AMR Starboard and Rear

8.1 Buttons and Ports

8.1.1 Emergency Stop Buttons

There are four Emergency Stop buttons - one located at each corner (see above) - on the robot that can be used to trigger an Emergency Stop state on the robot. Users should familiarize themselves with the Emergency Stop buttons and their locations on both the robot and any equipped attachment.

8.1.2 Attachment Interface

The Attachment Interface houses the electrical connections for an equipped attachment to interface with the robot.



WARNING!

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

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.

See Attachment Interface for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

8.1.3 Lock Out/Tag Out Bay

The Lock Out/Tag Out Bay is located behind the Safety Reset and Power Buttons and contains the Lock Out/Tag Out switch that allows personnel to remove energy from the system. To access the bay, push on the door.

See Basic Usage for more detail on the Lock Out/Tag Out procedure.

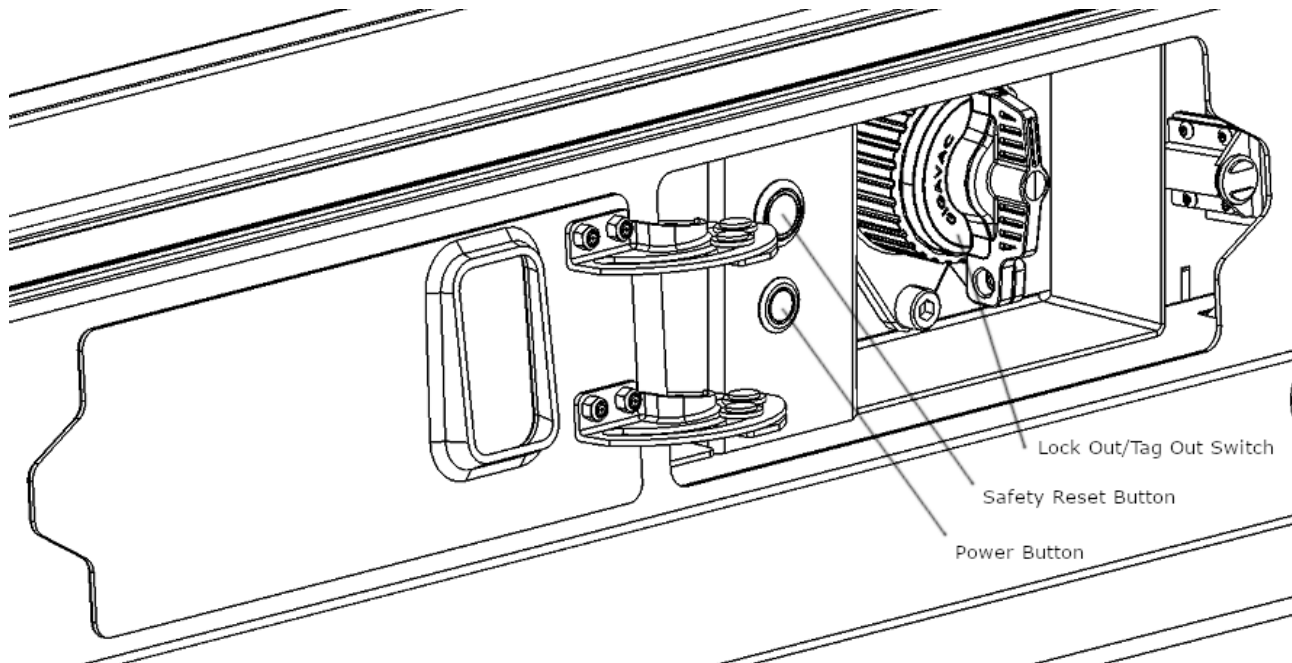


Figure 7 Lock Out/Tag Out Bay



WARNING!

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

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.

SHOCK HAZARD! Improper use or maintenance of robot batteries may result in a high energy discharge.

8.1.4 Safety Reset Button

The Safety Reset button is located above the Power Button and is used by an operator to indicate that the robot is cleared for autonomous use. This button must be pressed following the robot's boot-up process to indicate the area is safe for autonomous navigation.

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

Table 5 Safety Reset Button Light Indicator States

SAFETY RESET BUTTON LIGHT STATE	SAFETY SYSTEM STATUS
Solid Blue Light	Safety System Active
Slow Flash (500 ms on/off)	Emergency Stops clear, LiDAR safety scanners clear - press the button to indicate the area is safe for autonomous navigation
Fast Flash (100 ms on/off)	LiDAR safety scanners obstructed
No Light	Safety System Inactive - check that Emergency Stop buttons are cleared and OTTO App/Fleet Manager exceptions messages for further detail

8.1.5 Power Button

The Power Button on the robot allows users to turn it on and off. Once switched on, the robot can take up to two minutes to boot or shut down. Do not interact with the Power Button during the start up or shut down sequence.

8.1.6 Pendant and Manual Charge Port Bay

The Pendant and Manual Charge Bay is a triple-purpose bay that allows operators to connect the OTTO 750/1500 V2 Manual Charger or the pendant used for manual control of the robot, and includes storage for the manual bypass screws when they are not in use. To access the bay, push on the door.

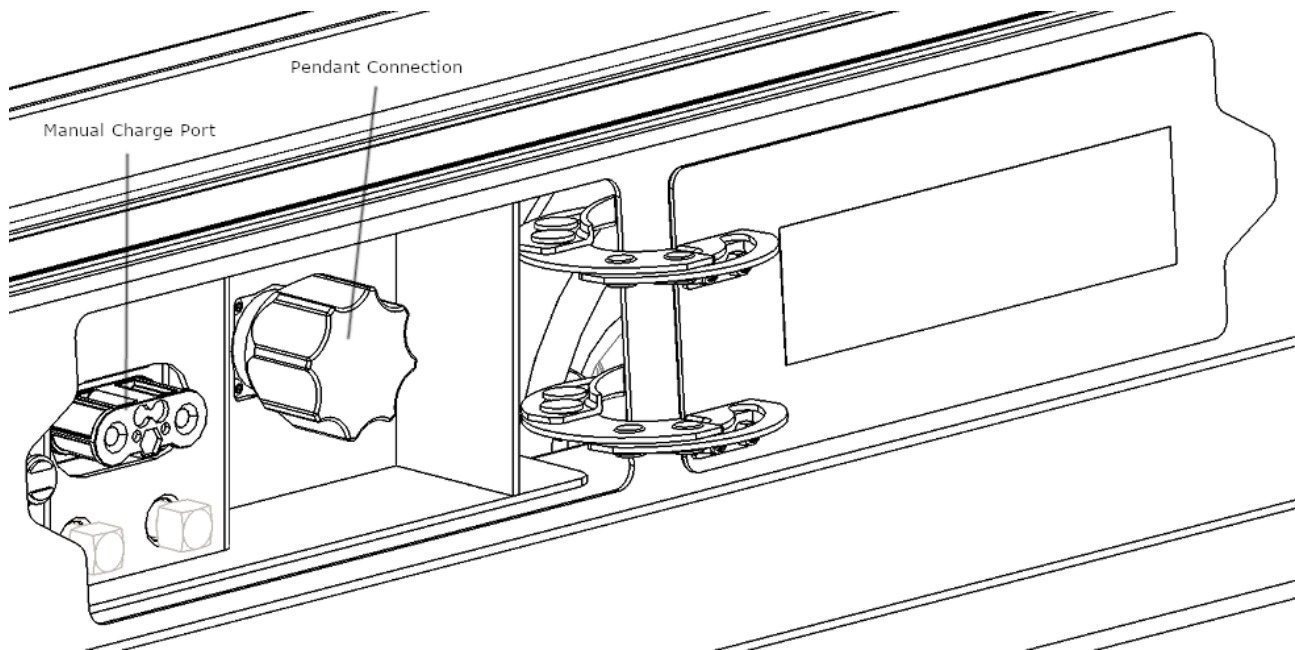


Figure 8 Pendant and Manual Charge Port Bay

See the operation and maintenance manual for the OTTO 750/1500 V2 Manual Charger for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

8.1.7 Pendant Connection

The pendant connection port is found inside the Pendant and Manual Charge Port. To access the port, push on the Pendant and Manual Charge Port Bay door. Remove the pendant port terminator plug to use the port. Return the pendant port terminator plug to the port prior to changing the system to autonomous mode, otherwise the system will remain in an Emergency Stop state.






8.2 Robot State Indicators








8.2.1 Light Pipe and Visual Indications








OTTO 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 what behavior you can expect.

OTTO AMRs 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 OTTO AMR. See the Basic Usage section of the operations and maintenance manual for the applicable OTTO AMR for instructions on changing robot volume settings.

Table 6 OTTO Motors AMR light pipe patterns and indicated state

NAME	DESCRIPTION	VISUAL INDICATION
Starting Up	The OTTO AMR is on but has not completed the boot cycle.	 Full Solid Dull White
Normal Travel	The OTTO AMR is traveling normally.	 Front Solid Dull White Rear Solid Red
Reversing	The OTTO AMR is reversing.	 Rear Solid Dull White in direction of travel Front Solid Red with Dull White
Turning	The OTTO AMR is turning.	 Side Blinking Yellow in turn direction
About to Move	The OTTO AMR is about to start traveling after an Emergency/Safety Stop or after not moving for at least 10 seconds.	 White Pulses Chasing from Center to Corners

Charging	The OTTO AMR is charging at a Charging Dock.	 <p>Rear Corners Red</p> <p>Green Slowly Expanding indicating charge level</p> <p>Front Corners Orange</p>
Parked	The OTTO AMR has entered a Parked state.	 <p>Rear Corners Red</p> <p>Front Corners Dimmed</p>
Docking	The OTTO AMR is docking.	 <p>Front Solid Dull White</p> <p>Rear Solid Red</p> <p>Alternating Yellow Stripes</p>
Narrow Corridor	The OTTO AMR is entering what it considers a narrow corridor.	 <p>Front Dull White</p> <p>Rear Red</p> <p>Blinking Yellow Stripes</p>
Manual Control	The OTTO AMR is being manually controlled.	 <p>Full Solid Blue</p> <p>Front Dull White</p>
Attachment Activated	<p>The OTTO AMR has activated its attachment.</p> <p>The OTTO 100 AMR has activated its integrated lift.</p>	 <p>Full Pulsing Yellow</p>
Working In Place	The OTTO AMR's movement is locked as it waits for further input from a user or attachment.	 <p>Full Green</p>

Blocked	The OTTO AMR is blocked from proceeding on its planned path.	 Front Flash Yellow Rear Solid Red
Safety Stopped	The OTTO AMR has been placed in a Safety Stop state.	 Front and Rear Flashing Red Front Narrow Solid Dull White
Emergency Stopped	The OTTO AMR has been placed in an Emergency Stop state.	 Full Flashing Red
Failed Target Find	The OTTO AMR has failed find its target (Dock, Cart, etc.).	 Front Solid Dull White Rear Solid Red
Lost	The OTTO AMR can't determine its location relative to its loaded Map.	 White Light Chasing
Lost Connection to WiFi/Fleet Manager	The OTTO AMR is disconnected from the WiFi signal/Fleet Manager.	 Front Flashing Yellow/Orange Rear Flashing Yellow/Orange Flashing color is dependent on OTTO AMR model and software version
Operating System Failure	The operating system for the OTTO AMR has failed to run.	 Full Solid Red

8.2.2 Speaker

Speakers are located at each corner without a LiDAR safety scanner. The speakers are intended to warn users of an approaching robot and works with the light pipe to indicate various robot states.

If the speaker is set to the highest volume, it can reach a sound pressure level of 71.4 dBA. In such conditions, proper hearing protection may be necessary. A final noise assessment at the workplace is required to determine the need of PPE.

8.3 Pendant

The Pendant allows for manual control of the robot.

See Basic Usage for detail on using the Pendant.

8.4 Manual Bypass Screws



WARNING!

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

IMPACT HAZARD! Never bypass the drive wheels of the robot while on a sloped surface.

IMPACT HAZARD! Never leave the manual bypass screws installed in the robot. This can prevent the braking system from functioning properly and can cause unpredictable driving patterns. For bypass screw locations, refer to the Component Overview section of the robot OMM.

The manual bypass screws allow the user to disengage the drive wheels from the floor and manually move the robot using the swivel casters. When the manual bypass screws are engaged, the robot will be free to move. See **Basic Usage** for detail on properly engaging the manual bypass screws.

The manual bypass screws can be stored inside the Pendant and Manual Charge Port when not in use.

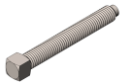


Figure 9 Manual Bypass Screw

8.5 WiFi Radio Antennas

There are two wireless antennas - one located at each end (front and rear) - of the robot.

The space above these antennas should remain clear of metallic obstructions for optimal signal strength and network connection as the antennas are omni-directional and require as much free space around them as possible to operate effectively. An inspection and test of the WiFi system in your facility is recommended for most applications.

If you are using an attachment or a payload that will interfere with the WiFi system on the robot, use one of the available extension kits to move the antenna to an appropriate location.

See Attachment Interface and RQS-000006 - IT Infrastructure Requirements for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

8.6 Perception Sensors

8.6.1 Safety LiDAR



WARNING!

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

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 OMM.

The robot uses two LiDAR (Light Detection and Ranging) safety scanners - one located at the front-left and another at the rear-right corner of the robot - 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.

[See Safety Around OTTO for more detail on safety system functionality.](#)

8.6.2 3D Perception Cameras

The robot is equipped with four 3D Perception Cameras that are used during autonomous navigation to avoid overhanging obstacles. Data from the 3D Perception Cameras is also used for diagnostic purposes.

8.6.3 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.

8.6.4 Thermal Detector

The thermal detector monitors the motors, brakes, and electronics enclosure to ensure proper function and detect failure.

8.7 Swivel Casters and Drive Wheels

The robot is equipped with four swivel casters - one on each corner - used for load bearing purposes only. The swivel casters do not drive, steer, or brake the robot. There are two drive wheels on the robot, located

at the center of each side.

The swivel casters and drive wheels are connected to the rocker arms. This passive suspension system allows for the drive wheels to remain in contact with the ground during operation. The drive wheels are connected with the drive motors through a planetary gearing system. The motor drive shaft is directly connected to the electromechanical brake.

8.8 Attachment Mounting and Lift Points

The four attachment mounting and lift points are used to hoist the robot for transport and unboxing and mount attachments mechanically to the robot chassis.

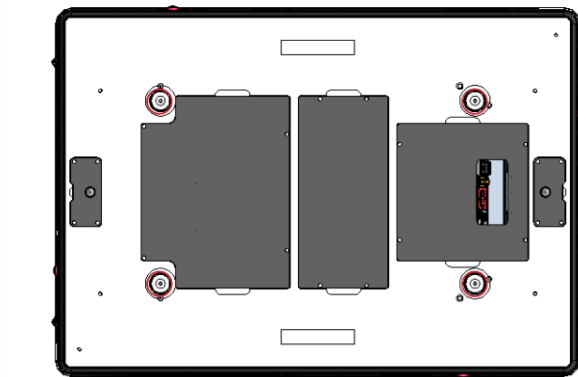


Figure 10 Attachment Mounting and Lift Points

[See Attachment Interface](#) for more detail and exact specifications for the lift points.

8.9 Battery Pack

The robot uses a Lithium-iron Phosphate battery pack connected in a 4s2p configuration. Each battery has its own battery management system (BMS) that reports various parameters of the battery to the system which aggregates the data to the PC through CAN communication protocol. Each individual battery status can be summoned through the PC using the battery diagnostic tool. Data such as charge voltage, SOC and temperature can be seen at any given time. The battery pack is modular and swappable. There is a single I/O point for CAN network and a single power output for battery power. The battery features a breaker and a redundant fuse for safety. Both can be accessed; however, safety precautions must be taken and only qualified personnel are allowed to complete any work on the battery.



WARNING!

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

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.

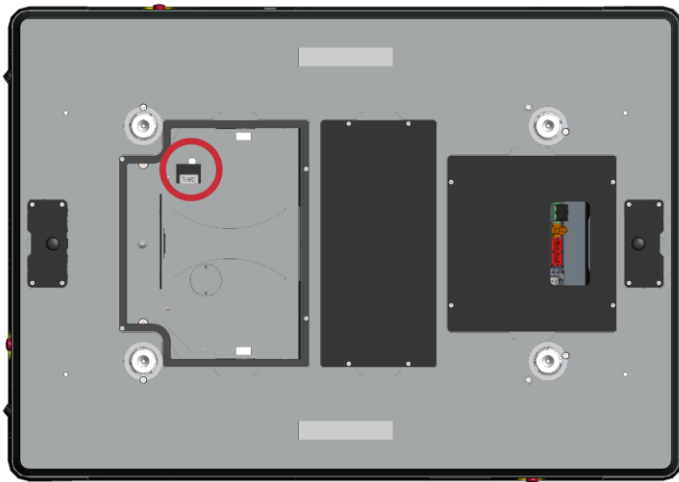


Figure 11 Live Voltage Locations

The battery pack contains two lifting points, one on each side. These were specifically designed to lift the battery pack.

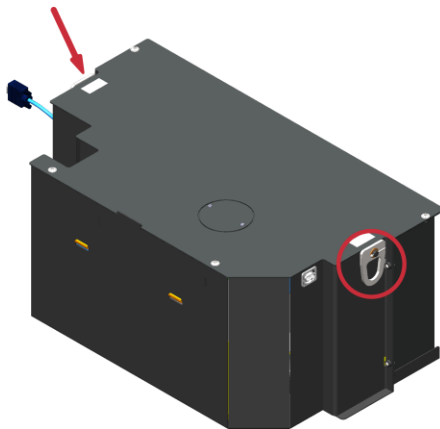


Figure 12 Battery Pack Lifting Points

See the System Overview for battery system specifications.

**CAUTION!**

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

Do not expose the product for a prolonged period to temperatures outside the ranges specified in the product documentation.

8.10 Electronics Bay

The Electronics Bay is the robot control unit of the robot that contains the PC and PLC logic controls and provides the central interface point between the sensors, LEDs, and actuators.

8.11 Onboard Computer

The onboard computer performs all autonomous navigation and control of the robot. Environmental perception, navigation, and goal planning for the robot are the core autonomy functions that run on this computer.

8.12 Communication Network

The majority of the robot's components communicate directly through the Electronics Bay. LiDAR safety scanners communicate directly with the onboard computer via Ethernet.

2 CAN bus networks operate on the platform to provide communication between the safety critical components - one CAN bus provides communication between the computer and the battery module, while the second CAN bus provides communication between the computer, PLCs, and left and right motor controllers.

An 802.11 WiFi bridge is also present to allow for wireless communication between the platform, external control systems, and any attachment accessories.

9 ATTACHMENT INTERFACE

The following describes the interface between the robot and its equipped attachment. The attachment interface sits between the AMR base platform and the attachment subsystem, providing personnel with ports for communication with the on-board PC, power sourced from the robot battery, and interfacing with the robot Emergency Stop circuit.

The base platform is designed to interface with several attachment types; therefore, the attachment Interface includes detection and handshaking of any equipped attachment to ensure that the base platform is aware of the attachment.

Because each attachment will have different requirements and construction, the attachment is responsible for basic control of any actuators and the translation of sensor data into a serial format. The base platform operates on a more abstract level, polling specific sensor data and issuing high-level commands to the attachment (e.g. move here).

For more information regarding communication between the attachment, the robot, Fleet Manager, or factory-side integration - including IAPI - see help.ottomotors.com or contact OTTO Motors for further details.

To reduce latency requirements on the attachment interface, attachments are also responsible for managing and responding to any rapidly changing sensor inputs (eg. current measurements, limit switches, encoders) required for safe operation. The robot is able to stop or power off the attachment in the event of faults in either the base platform or the attachment and in a general emergency stop situation.

For the purposes of this document, it is assumed that disruption of battery voltage power to the attachment will not result in uncontrolled and unsafe hazardous motion (ie. a lift style attachment cannot be back-driven by a nominal load when powered off).

9.1 Attachment Wireless Network Communication

If the attachment is to communicate over a wireless network in your application, this needs to be configured independent of the network used to communicate with the robot.

The location of the WiFi antennas on the robot must allow for the wireless signal to be available in all orientations of the robot relative to communication nodes. In the event that an attachment design will block one or both WiFi radio antennas on the robot and impede the robot's ability to communicate via wireless interface, the antennas will need to be moved to an alternate location on the attachment using an Antenna Extension Kit (Part #016899).

See the Components Overview or RQS-000006 - IT Infrastructure Requirements for more detail. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

9.2 Mechanical Interface Specifications

Attachments mount to the robot chassis via four attachment mounting points (see below).

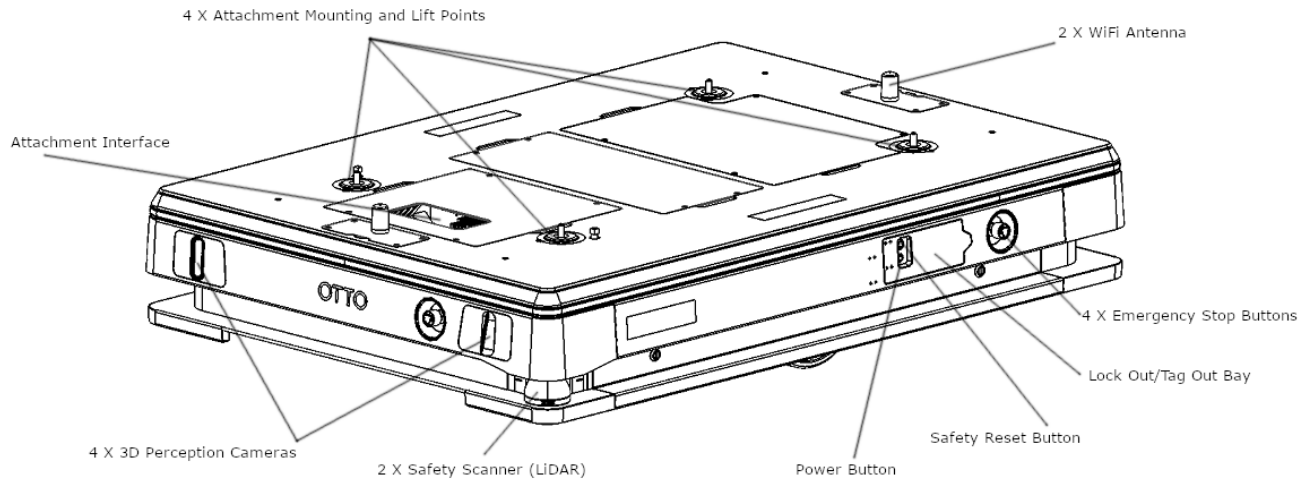


Figure 13 OTTO Motors AMR Port and Front

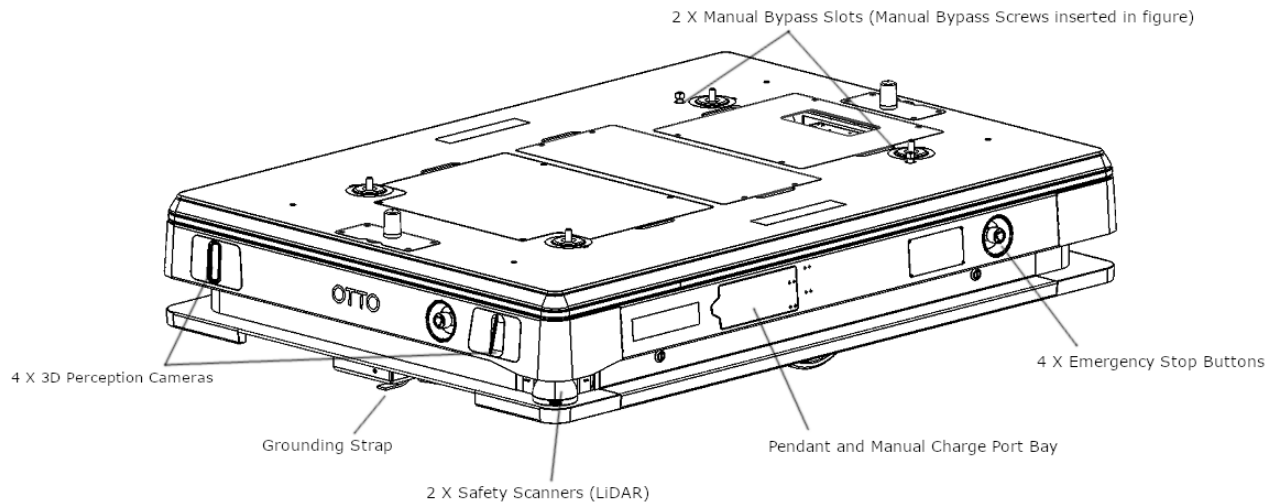


Figure 14 OTTO Motors AMR Starboard and Rear

In the baseline chassis configuration, the four mounting points are coupled to basic mounting blocks. When the chassis is equipped with the optional load sensing feature then the four mounting points are directly coupled to load sensing weight-transducers.

See the mechanical interface documentation for the robot for more detail. These documents are available on the OTTO Motors Support Center at help.ottomotors.com.

The current concept for each of the four mounting points is a mounting pad with four bolts and a center locating feature. Attachments are required to have sufficient structural rigidity to span between the mounting pads without making contact with the robot skins (eg. a rough specification of maximum allowable deflection would be 1 mm below the mounting surface). Load beams will deflect < 1.0 mm under maximum impact loading.

Attachments must be designed to minimize transverse forces on the attachment mounting points.

Maximum interface load ratings are dependent on the specifications outlined in the System Overview.

The attachment umbilical cable must be terminated with connectors that conform to the Electrical Interface Specifications and should have sufficient flex and clearance to allow the attachment to be mechanically mounted and plugged into the attachment interface connectors on the robot chassis.

9.3 Electrical Interface Specifications



WARNING!

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

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.

GROUNDING ELECTRICAL HAZARD! The power supply for the charger must be grounded.

Attachments must be designed to prevent users from being exposed to the hazards of the attachment.

The battery voltage is switched by the attachment contactor on the robot and is the primary means for eliminating hazards on an attachment. When an attachment is equipped with emergency stop input devices, these devices can trigger an Emergency Stop state on the robot via the Emergency Stop Input detailed in the preceding table.

If an attachment malfunctions in a potentially dangerous way, it must trigger an emergency stop condition to force the system into an Emergency Stop state to avoid a potentially dangerous condition. Attachments can also use the provided Attachment Fault Status line to indicate a malfunction to the robot chassis. In the event of such a fault, the robot will cease autonomous operation and indicate a user needs to examine the attachment.

9.3.1 Attachment Interface Signals

Table 7 Attachment Electrical Interfaces

INTERFACE	VOLTAGE	NOTES
Emergency Stop Input	24V	Dual-channel Emergency Stop from attachment to base platform. Must be closed to allow the safety relays in the robot to energize.
Contactor Monitoring Loop Monitoring	24V	Monitoring Loop for the safety loop. Must be closed to allow the safety relays in the robot to energize.
Emergency Stop Status	24V	24VDC single-channel interface from the robot safety relays. When on, the attachment is safe to energize.
Attachment Enable Output	24V Active High	24V output from robot to attachment indicating that the attachment is allowed to operate. Signal is Active High. If the enable line is disabled (low), the attachment must not move.
Attachment Fault Status	24V Active Low	Output from attachment to robot indicating that the attachment has encountered a problem (Active Low). If a fault is indicated on this input, the robot will cease autonomous operation and indicate that it needs an operator to examine the attachment. If not used, this signal must be tied high to PA_24V.
General Purpose Output x 2	Universal Output Drives to 24V or Drives to Ground	Additional 0 - 24VDC outputs available for communicating with the attachment.
General Purpose Input and SDV_ENABLE	24V	Additional 0 - 24VDC inputs available for communicating with the attachment. GPI_0 is used to signal to the robot that it is able to move after it has given control to the attachment.

Battery Power	44.8VDC (min.) 60VDC (max.)	<p>Unregulated, switched, up to 50A, 51.2V nominal. The Battery Power line is switched by the attachment contactor in the base platform and is switched immediately upon the Emergency Stop chain being broken.</p> <p>The Battery Power line is unswitched during a Safety Stop.</p> <p>Attachments that exceed 50A on start up can lead to contactor welding due to the peak inrush tolerance of the circuit. For more details on contactor specifications, see the robot product page in the Hardware Library.</p>
24V_PA	24VDC	Regulated, unswitched, up to 10A
USB 3.0	-	Unpowered (supply < 500mA)
HDMI	-	PC to external monitor connection for debugging and servicing
Ethernet	-	Attachment Ethernet Connection, bridged to Wi-Fi network

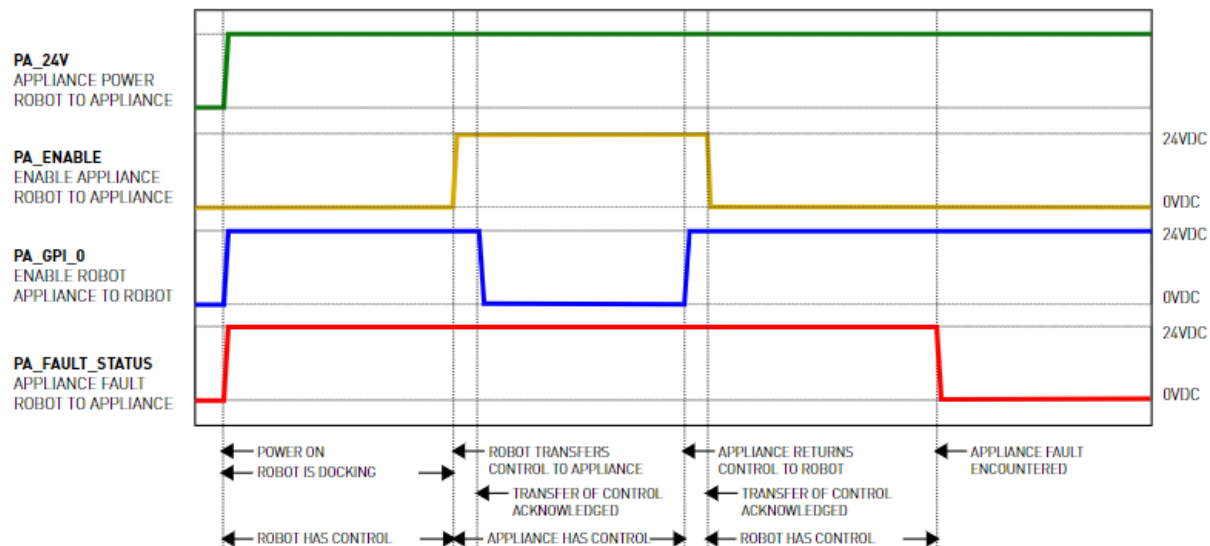


Figure 15 Attachment Interface Signals Timing Diagram

9.3.2 Unswitched vs. Switched Power for Non-Safety Devices

There are 2 different power supplies available in the attachment Interface: 24 VDC and battery voltage.

In general, attachments should use the unswitched 24VDC power from the robot attachment interface for attachment logic power and inputs required to determine attachment states that could affect the safe operation of the robot.

For example, power to pallet/part presence sensors and the associated logic control that passes this state information over the Ethernet/IP Attachment interface should remain powered, even during an Emergency Stop, so that the robot is able to perform tasks based on known states of the payload and attachment. Another example would be raised/lowered limit switches for lift-style attachments as the robot needs to know the state of the lift even if the lift is in an Emergency Stop state.

The attachment should use the switched battery voltage power feed for attachment power regarding actuators and locks that need to be unpowered in the event of a triggered Emergency Stop state. This power line is connected to the Emergency Stop loop of the robot; therefore, any Emergency Stops triggered on the robot will also trigger an Emergency Stop state on the attachment.

In the event of a triggered Emergency Stop state, the battery voltage power output (switched) will be disconnected from the power source. The 24 VDC power output (unswitched) will not be disconnected.

9.3.3 Electrical Interface Connections

See the [Components Overview](#) for the location of the attachment interface on the robot.

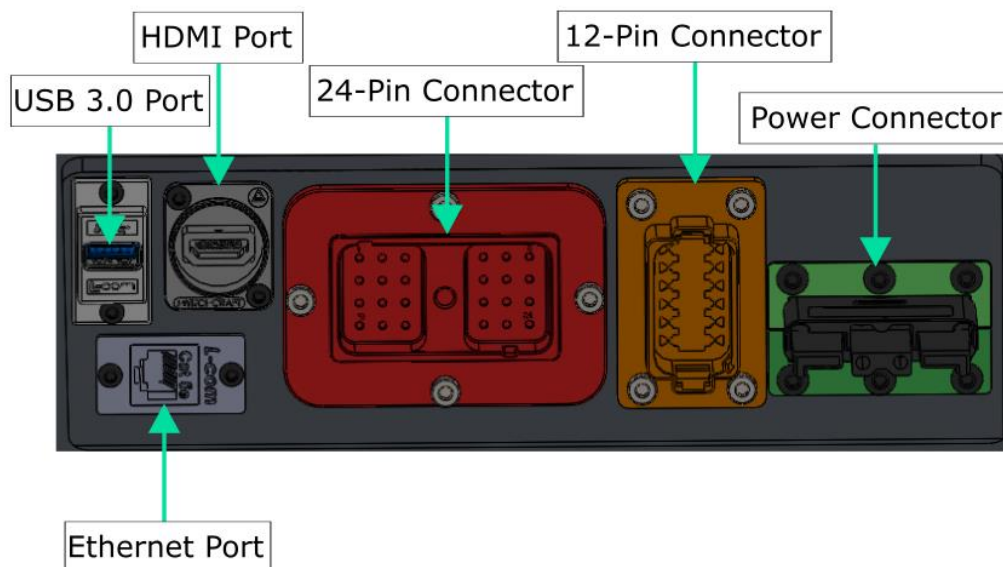


Figure 16 Attachment Interface Connectors

To assist in identifying the attachment interface connector types, the robot attachment interface includes the following decal.

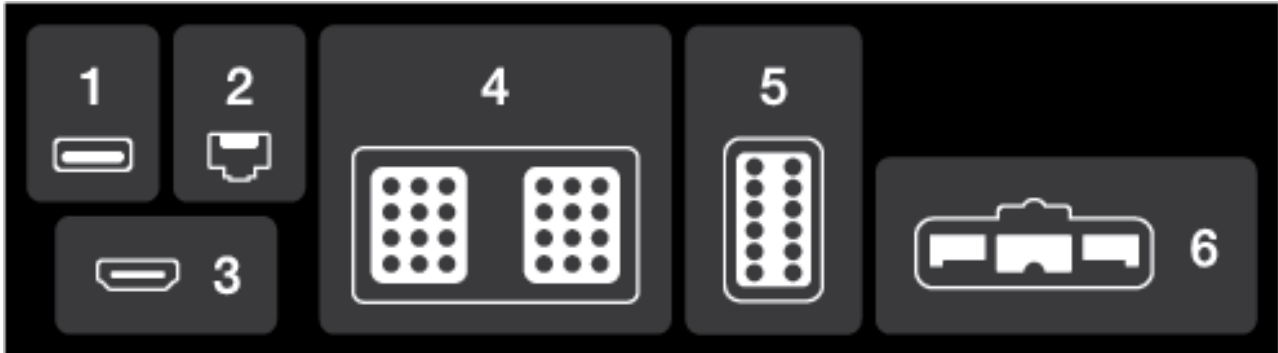


Figure 17 Attachment Interface Connector Decal

9.3.3.1 24-Pin Connector

Table 8 Attachment Interface 24-Pin Connector Part Numbers

PART NUMBER	MANUFACTURER	DESCRIPTION
Robot Side		
DRC12-24PAE	TE Connectivity	Connector, DRC Size 16, Receptacle, 24 Positions, 4 Rows, Rectangular, Sealed, A Key
Attachment Side		
DRC16-24SAE	TE Connectivity	Connector, DRC Size 16, Plug, 24 Positions, 4 Rows, Rectangular, Sealed, A Key
0462-201-16141	TE Connectivity	Terminal, Deutsch Size 16, Female, 20-16 AWG, Crimp, Nickel

9.3.3.2 12-Pin Connector

Table 9 Attachment Interface 12-Pin Connector Part Numbers

PART NUMBER	MANUFACTURER	DESCRIPTION
Robot Side		
DT04-12PA-L012	TE Connectivity	Connector, DT Series, Panel, Receptacle, 12 Positions, 2 Rows, Rectangular, Sealed A Key
Attachment Side		
DT06-12SA	TE Connectivity	Connector, DT Series, Plug, 12 Positions, 2 Rows, Rectangular, Sealed, A Key
0462-201-16141	TE Connectivity	Terminal, Deutsch Size 16, Female, 20-16 AWG, Crimp, Nickel

9.3.3.3 Power Connector (battery voltage)

Table 10 Attachment Interface Power Connector Part Numbers

PART NUMBER	MANUFACTURER	DESCRIPTION
Robot Side		
SBS75XPRBLK-BK	Anderson Power Products	Heavy Duty Power Connectors SBS75x R/A PCB CONN ASSEMBLED
Attachment Side		
SBS75XBLK	Anderson Power Products	SBS Connector Housing, Black-80VDC Color Code, Connection – 2 Pri. 4 Aux.
1339G2	Anderson Power Products	SBS Silver Plated Primary Contacts, Standard Type, #6AWG. (16mm)
PM16P1620S30-50	Anderson Power Products	SBS75x Auxiliary Pins, Standard Length 7.7mm, #20-16 AWG (0.75-1.0mm)

PM16S1620S32-50	Anderson Power Products	SBS75x Auxiliary Socket, #20-16 AWG (0.75-1.0mm)
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9.3.3.4 Ethernet, USB and HDMI

Table 11 Attachment Interface Ethernet, USB & HDMI Parts

DESCRIPTION
Robot Side
Standard RJ45 Jack
Standard USB A Female
Standard HDMI Female
Attachment Side
Standard RJ45 Plug
Standard USB A Male
Standard HDMI Male

9.4 Safety Relay and Auxiliary Monitoring Contacts

The below figure illustrates the electrical connection available on the robot attachment interface and connection of a typical safety relay with auxiliary monitoring contacts.

The electrical connection inside the robot is not shown below.

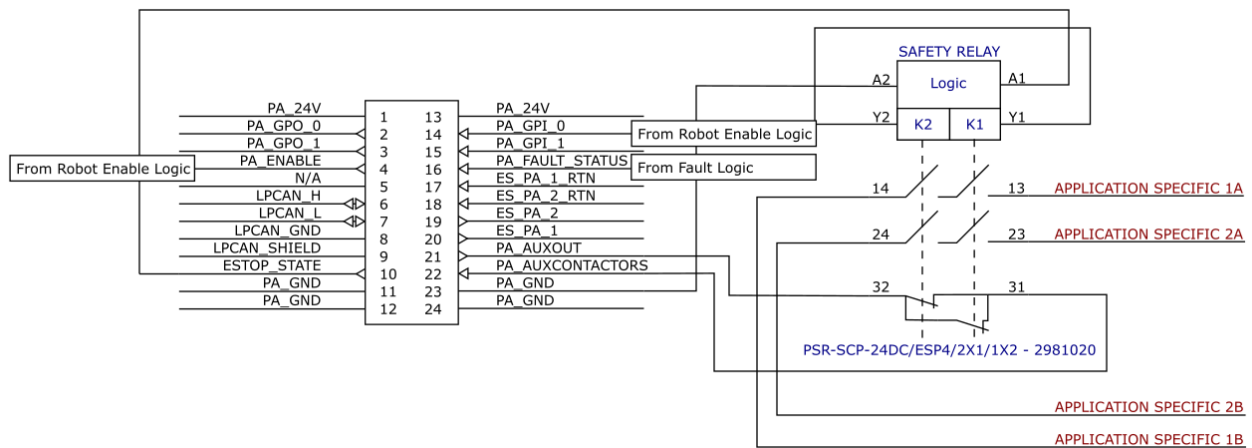


Figure 18 24-Pin Connector with Safety Relay and Auxiliary Monitoring Contacts

9.5 Connection Pinouts

9.5.1 Robot Side 24-Pin Connector

The pin-out numbering for the 24-pin connector is as shown below.

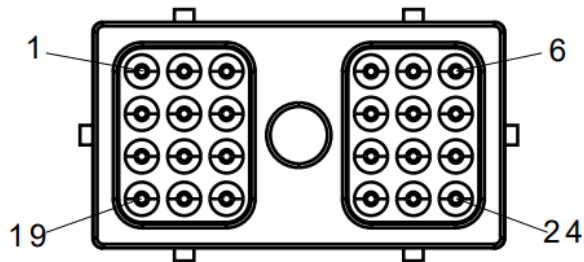


Figure 19 Robot Side 24-Pin Connector Pin-Outs

Table 12 Robot Side 24-Pin Connector Pin-Out Functions (wire entry side)

PIN	NAME	NOTES
1	PA_24V	24V, 10A total available across all connections Note that this is not fused power.
2	PA_GPO_0	General purpose out 0, PNP sourcing output, 500mA max.
3	PA_GPO_1	General purpose out 1, PNP sourcing output, 500mA max.
4	PA_ENABLE	Attachment enable
5	N/A	NOT USED
6	LPCAN_H	Reserved
7	LPCAN_L	Reserved
8	LPCAN_GND	Reserved
9	LPCAN_SHIELD	Reserved
10	ESTOP_STATE	24VDC single channel interface from AMR safety relays - when on, the attachment is safe to energize ESTOP_STATE will also go Low during Safety Stops.
11	PA_GND	Ground for the PA_24V signals, all except CAN signals, and Battery Voltage
12	PA_GND	Ground for the PA_24V signals, all except CAN signals, and Battery Voltage
13	PA_24V	24V, 10A total available across all connections Note that this is not fused power.

14	PA_GPI_0 (SDV_ENABLE)	General purpose in 0 (SDV_ENABLE) GPI_0 is used to signal to the AMR from the attachment that the robot is able to move after it has given control to the attachment
Attachment to use dry contact between PA_24V and input.		
15	PA_GPI_1	General purpose in 1
Attachment to use dry contact between PA_24V and input.		
16	PA_FAULT_STATUS	Attachment fault If not used, this signal must be tied high to PA_24V
Attachment to use dry contact between PA_24V and input.		
17	ES_PA_1_RTN	Return connection for the emergency stop loop channel 1
18	ES_PA_2_RTN	Return connection for the emergency stop loop channel 2
19	ES_PA_2	Output for the emergency stop loop channel 2
20	ES_PA_1	Output for the emergency stop loop channel 1
21	PA_AUXOUT	Output for the auxiliary contact monitoring
22	PA_AUXCONTACTORS	Return for the auxiliary contact monitoring
23	PA_GND	Ground for the PA_24V signals, all except CAN signals, and Battery Voltage.
24	PA_GND	Ground for the PA_24V signals, all except CAN signals, and Battery Voltage.

9.5.2 Robot Side 12-Pin Connector

The pin-out numbering for the 12-pin connector is as shown below.

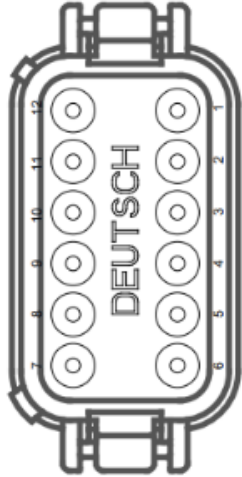


Figure 20 Robot Side 12-Pin Connector Pin-Out Functions

Table 13 12-Pin Connector Pin-Out Descriptions (wire entry side)

PIN	NAME	NOTES
1	SS_PA_1	Output for the safety stop loop channel 1
2	SS_PA_2	Output for the safety stop loop channel 2
3	SS_PA_1_RTN	Return connection for the safety stop loop channel 1
4	SS_PA_2_RTN	Return connection for the safety stop loop channel 2
5	PA_SAFE_IN_1	Safety Input 1 - OUT
6	PA_SAFE_IN_2	Safety Input 2 - OUT
7	PA_SAFE_IN_1_RTN	Safety Input 1 - RTN
8	PA_SAFE_IN_2_RTN	Safety Input 2 - RTN
9	PA_GPI_3	General purpose in 3

Attachment to use dry contact between PA_24V and input.		
10	PA_GPI_4	General purpose in 4
Attachment to use dry contact between PA_24V and input.		
11	PA_GPO_3	General purpose out 3, PNP sourcing output, 500mA max.
12	PA_GPO_4	General purpose out 4, PNP sourcing output, 500mA max.

9.5.3 Robot Side Power Connector (battery voltage)

If you are not planning to use the battery voltage power for your application, the battery voltage power contacts need to be populated in the connector for the connection to work properly.

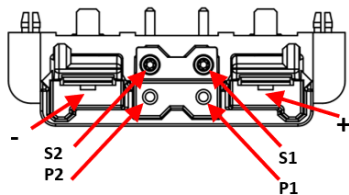


Figure 21 Robot Side SBS75 Pin-Out Details

Table 14 Robot Side Power Connector Pin-Outs

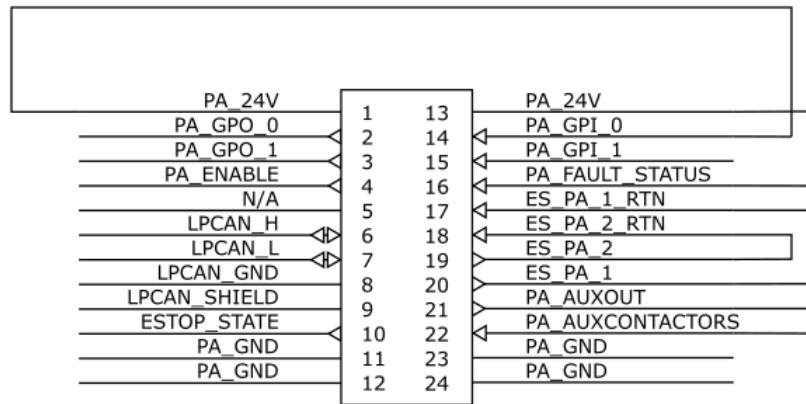
PIN	NAME	NOTES
+	BATTERY_VOLTAGE	Unregulated battery voltage 52.8V nominal, and is switched when an e-stop occurs
-	BATTERY_VOLTAGE_RETURN	Return for unregulated battery voltage
P1	N/A	NOT USED
P2	N/A	NOT USED
S1	N/A	NOT USED
S2	N/A	NOT USED

9.5.4 Minimum Required Connections

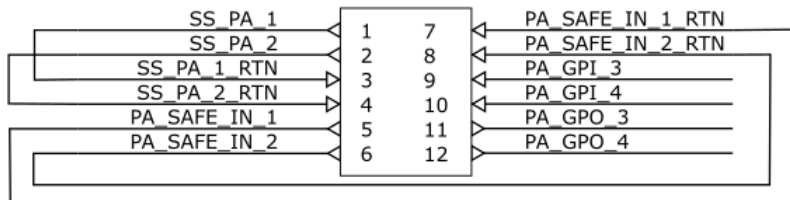
9.5.4.1 Passive Attachment

Passive attachments to not draw power from the base robot chassis.

- Emergency stop loop is closed.
 - ES_PA_1 connected to ES_PA_1_RTN
 - ES_PA_2 connected to ES_PA_2_RTN
 - PA_AUXOUT connected to PA_AUXCONTACTORS
- The PA_FAULT_STATUS connected to PA_24V
- PA_GPI_0 connected to PA_24V
- Safety stop loop is closed.
 - SS_PA_1 connected to SS_PA_1_RTN
 - SS_PA_2 connected to SS_PA_2_RTN
- Safety Input 1 connected to Safety Input 1 RTN
- Safety Input 2 connected to Safety Input 2 RTN



24-Pin Attachment Side Connector Shown



12-Pin Attachment Side Connector Shown

Figure 22 Attachment Side Minimum Connections for Passive Attachment

9.5.4.2 Active Attachment

Active attachments will draw power from the base robot chassis.

- Emergency stop loop is closed
 - ES_PA_1 connected to ES_PA_1_RTN
 - ES_PA_2 connected to ES_PA_2_RTN
 - PA_AUXOUT connected to PA_AUXCONTACTORS
- The PA_FAULT_STATUS connected to the Active Device on the attachment (PLC, etc.)
- PA_GPI_0 connected to the Active Device on the attachment (PLC, etc.)
- PA_ENABLE connected to the Active Device on the attachment (PLC, etc.)
- Safety stop loop is closed
 - SS_PA_1 connected to SS_PA_1_RTN
 - SS_PA_2 connected to SS_PA_2_RTN
- Safety Input 1 connected to Safety Input 1 RTN
- Safety Input 2 connected to Safety Input 2 RTN

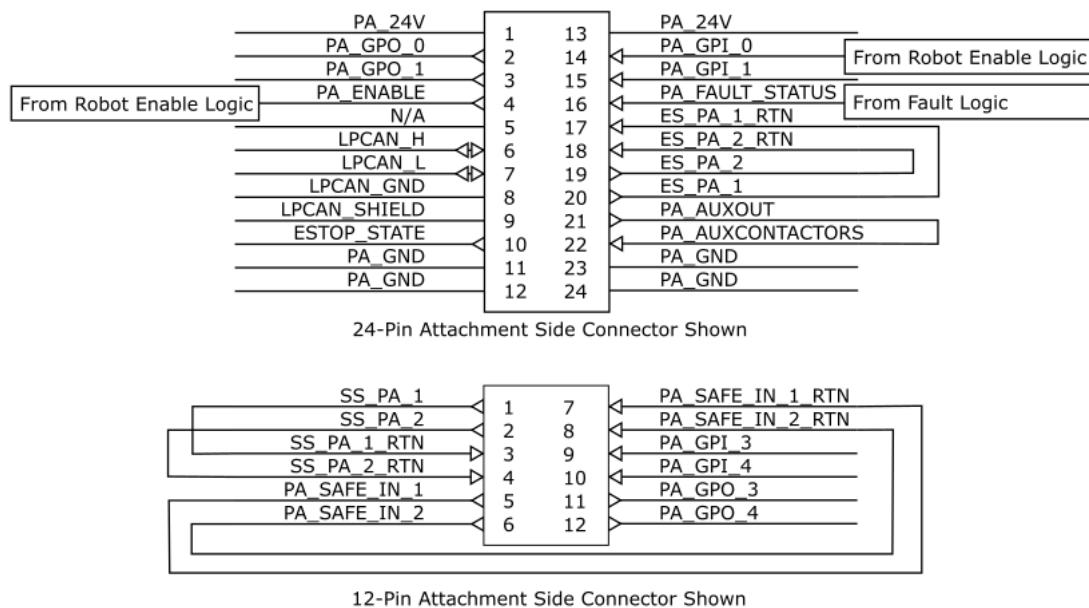


Figure 23 Attachment Side Minimum Connections for Active Attachment

9.5.5 General Purpose Outputs

The GPO's are 24V outputs with a maximum source current of 500mA.

9.5.6 General Purpose Inputs

The 24V Inputs, PNP type use the form shown below and must adhere to the following voltage requirements:

Table 15 General Purpose Input Voltage Requirements

PIN INPUT VOLTAGE	ROBOT LOGICAL INPUT STATUS
Input voltage > 11V	Logic High
Input voltage < 5V	Logic Low
11V > Input voltage > 5V	Indeterminate

9.6 Attachment Interface Examples

9.6.1 Conveyor-Style Attachment Interface Signal Example

Table 16 Conveyor-Style Attachment Example Interface Connections

INTERFACE	NOTES
Emergency Stop Input	None - attachment connector must have jumper across these terminals
Attachment Enable Input	Output to attachment indicating that the attachment is allowed to operate. If the enable line is disabled, the attachment must not move.
Attachment Fault Status	Input from attachment indicating that the attachment has encountered a problem. If a fault is indicated on this input, the robot will cease autonomous operation and indicate that it needs an operator to examine the attachment. If a fault is indicated on this input, the base robot will enter a Safety Stop state.
GPI_0	GPI_0 is used to signal to the robot that it is able to move after it has given control to the attachment.
Battery Voltage	Switched, up to 50A, 52.8V nominal

24 VDC	Unswitched, up to 10A
Ethernet	Attachment 100 Mbps Ethernet connection using Ethernet/IP

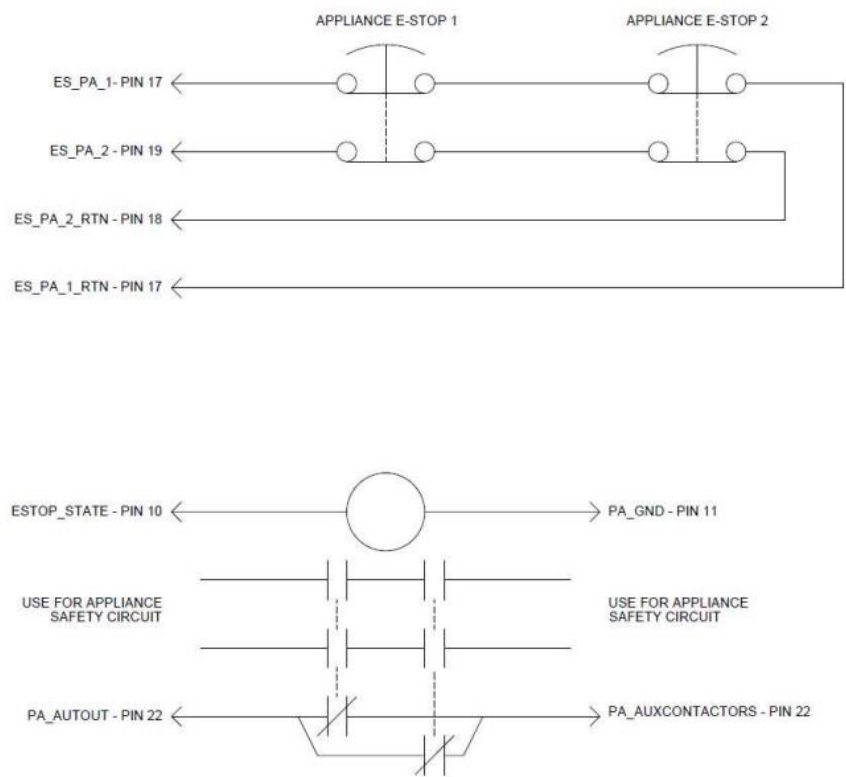


Figure 24 Conveyor-Style Attachment Safety Interface

9.6.2 Lift-Style Attachment Interface Signal Example

Table 17 Lift-Style Attachment Safety Interface

INTERFACE	NOTES
Emergency Stop Input	None - attachment connector must have jumper across these terminals
Attachment Enable Input	Output to attachment indicating that the attachment is allowed to operate If the enable line is disabled, the attachment must not move.

Attachment Fault Status	<p>Input from attachment indicating that the attachment has encountered a problem</p> <p>If a fault is indicated on this input, the AMR will cease autonomous operation and indicate that it needs an operator to examine the attachment.</p>
GPI_0	GPI_0 is used to signal to the AMR that it is able to move after it has given control to the attachment.
Battery Voltage	Switched, up to 50A, 52.8V nominal
24 VDC	Unswitched, up to 10A
Ethernet	Attachment 100Mbps Ethernet connection using Ethernet/IP

10 UNBOXING

Selection and implementation of the lifting method appropriate for the situation, and liability therefor, remains the sole responsibility of the user. Only certified forklift operators should attempt lifting the robot.



WARNING!

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

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.

CRUSH HAZARD! Keep a safe distance from suspended loads.



CAUTION!

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

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 OMM.

Use appropriately rated lift equipment for lifting the product.

10.1 Required Materials

- 4 x wear-resistant Web Sling, Flat Eye, 1 in wide, 1250 lbs. Choker Capacity, 6 in - McMaster 33625T121 (<https://www.mcmaster.com/catalog/125/1582>)
- 4 x Eye Nuts - McMaster 3019T34 (<https://www.mcmaster.com/catalog/125/1593>)

Pseudo-standard, confirm thread size and weight of installed attachment.

10.2 Procedure

1. Open the top of the crate.
2. Thread the Eye Nuts to the lift point locations on the robot or the Eye Bolts to the lift point locations on the installed attachment.

See Components Overview for more detail on the lift point locations.

If lifting the vehicle with an installed attachment, refer to the Operations and Maintenance Manual for the specific attachment (OTTO 750/1500 Lift Attachment, OTTO 750/1500 Conveyor Attachment, etc.) for more detail on lifting methods. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

3. Loop a Web Sling through each Eye Bolt/Eye Nut and secure to the lifting device.
4. Following the lift requirements for your facility, the robot can now be lifted from the crate.

11 BASIC USAGE

This section describes the operation of the robot.

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.

11.1 Lock-Out/Tag-Out



CAUTION!

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

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.

In order 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. Shut down the robot.
2. Wait until the light pipes have completely turned off.
3. Find and open the Lock Out/Tag Out Bay.
4. Switch the **Lock Out Disconnect** to the *OFF* position.



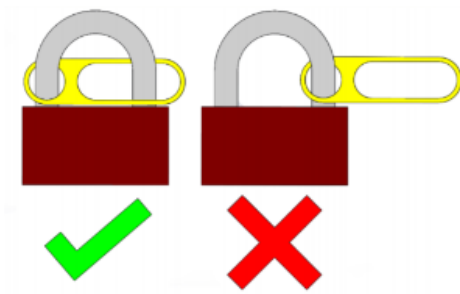
Figure 25 Lock-out/tag-out bay lock-out OFF position

5. Apply the lock and tag to the **Lock Out Disconnect**.
6. Find and open the Pendant and Manual Charge Port Bay.
7. Apply the lock and tag to the Manual Charge Port.



Figure 26 Pendant and manual charge port bay lock-out/tag-out

The lock on the lock-out bracket above the Manual Charge Port must be threaded through both holes on the bracket, as shown below:



All personnel working on the platform must connect their own lock.

11.2 First Start-Up



WARNING!

Failure to follow these instructions may result in **SERIOUS INJURY, INCLUDING DEATH.**
IMPACT HAZARD! Never bypass the drive wheels of the robot while on a sloped surface.



CAUTION!

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

Only use the attachments, accessories, tools, replacement parts, and cleaning products approved by OTTO Motors.

Prior to operating the robot for the first time, it is important to perform a hardware operational check to determine if there is any hardware damage or defects caused during shipping.

See the [Components Overview](#) for detail on the LiDAR scanners, the pendant connection port, and the pendant and manual charge port bay, and button locations.

1. Before performing these tests, ensure that the test area is safe to operate within and has been cleared of obstacles.
2. Visually inspect the exterior of the robot for any damage.
3. Inspect both LiDAR scanners to ensure that the optical elements are not dirty or obstructed by foreign material.
4. Press one of the four Emergency Stop buttons located at each corner of the robot to confirm it enters an Emergency Stop state.
5. Ensure that the robot is on flat ground prior to manual bypassing the drive motors.
6. **Manually bypass the drive wheels of the robot.** With the drive wheels raised off the ground, the safety system can now be validated without creating a hazard.
7. After performing the above instructions, the robot is ready to be powered on for the first time. **Start up the robot.** The drive wheels should not spin or attempt to create motion.
8. **Disengage the drive wheel manual bypass.**
9. Connect the Pendant to the pendant connection port.
10. Confirm that all Emergency Stop buttons on the robot, pendant, and any equipped attachment are released.
11. On the Pendant, press and hold the black **Enable** button in the middle *ON* position.

See [Driving using the Pendant](#) for more detail on using the Pendant.

12. Press the **Safety Reset** button on the robot. You will hear an audible click from the system and the light pipe will indicate that the robot is now in Manual Drive mode.
13. On the Pendant, while holding the **Enable** button in the middle *ON* position, press the **Forward**, **Reverse**, **Left Turn**, and **Right Turn** buttons, and confirm that the robot responds accordingly.
14. After testing the drive system, disconnect the Pendant and allow the robot to begin driving autonomously.

If the robot fails to perform as expecting during the above procedure, there may be a mechanical or electrical issue with the system. Contact OTTO Motors Support for assistance.

11.3 Starting Up

See the [Components Overview](#) for details on button locations and robot state indicators.

Note that when cycling power, the robot should be given at least 5 minutes between each state change (power on or power off).

1. Confirm that the robot is not locked out/tagged out.
2. Press the **Power Button**.
3. The robot will begin its boot up sequence - this sequence should take between 30 and 60 seconds.
4. Once the boot up is complete, the robot will indicate an Emergency Stop state.
5. Confirm that all **Emergency Stop** buttons are released.
6. Press the **Safety Reset** button to clear the Emergency Stop state and return the robot to normal operation.

If the robot takes between 60 seconds and 6 minutes to boot, it is possible that there is a networking error preventing the boot up sequence. If the robotR takes more than 6 minutes to boot or never indicates an Emergency Stop state during start up, contact OTTO Motors Support for assistance.

11.4 Shutting Down

Note that when cycling power, the robot should be given at least 5 minutes between each state change (power on or power off).

1. Press an **Emergency Stop** button on the robot.
2. Confirm that the Lock Out/Tag Out disconnects in both the Lock Out/Tag Out Bay and Pendant and Manual Charge Port Bays are set to *Off*.
3. Press the **Power Button**.
4. Wait at least 5 minutes for the robot to shut down.

11.5 Charging



CAUTION!

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

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.

11.5.1 Important Notes

There are 3 switches on the outside of the robot:

- The Power Button
- The Lock Out/Tag Out switches

[See the Components Overview for details on button and switch locations.](#)

While the Lock Out/Tag Out disconnects in both the Lock Out/Tag Out Bay and Pendant and Manual Charge Port Bays are set to **OFF**:

- Do NOT plug in the Manual Charger for any duration
- Do NOT turn the Power Button **ON**

Do NOT turn the Lock Out/Tag Out disconnects **OFF** if:

- The robot is **ON**
- The robot is charging (with a Manual Charger or an OTTO 750/1500 Charger/Fast Charger V2)

If the robot included an OTTO 750/1500 Charger/Fast Charger V2, vehicles will be sent to charge autonomously without human intervention. The robot will shut itself down at 20 - 25% battery state-of-charge.

If the installation relies on a OTTO 750/1500 Manual Charger V2, perform the following steps:

1. Maneuver the robot into position to be out of any high traffic area. The charger can be taken to the vehicle, if an outlet is close, or the vehicle moved to it by driving it manually, autonomously, or moving it manually with the **drive wheels manually bypassed**.
2. Press an **Emergency Stop** button on the robot.

Shut the robot down if you want to prevent the vehicle from indicating an Emergency Stop state. Using a Manual Charger on a robot that is currently on will keep the robot in the powered on state. Attempting to power off the robot by pressing the Power Button will not have the desired effect and the robot will remain powered on while connected to the Manual Charger.

3. Confirm that the Lock Out/Tag Out disconnects in both the Lock Out/Tag Out Bay and Pendant and Manual Charge Port Bays are set to *On*. The robot main disconnect must be in the *ON* position prior to connecting the Manual Charger. Using the Manual Charger with the main disconnects in the *Off* position can result in the robot being put into an unrecoverable state.
4. Connect the Manual Charger to the manual charge port on the robot. The connector will click into position.

Note that if the robot's battery pack is exhausted below 10% State of Charge (SoC), the vehicle will not turn on when the Manual Charger is connected until the SoC rises above 25%. Charging from 10% to 25% takes approximately 30 minutes.

5. When using the Manual Charger on a robot that is shut down, the vehicle will power on when the battery % reaches a minimum threshold, meaning the Power Button will still be in the 'OFF' position, despite the robot being 'On'.
6. Disconnect the Manual Charger from the robot - the robot will not shut down automatically.
7. Press the **Power Button**. Wait for 30 seconds.
8. Press the **Power Button**. Wait for another 30 seconds.

11.6 Moving



WARNING!

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

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.



CAUTION!

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

Use appropriately rated lift equipment for lifting the product.

11.6.1 Transport

The robot is equipped with four hoist locations as seen in the **Components Overview**. Only these points should be used to lift or orient the platform.

11.6.2 Drive Wheel Manual Bypass

In the event of having to manually bypass the drive wheels on the robot, the manual bypass screws should always be accessible, including when there is an attachment in place.

1. Ensure that the robot will not shift suddenly or roll when the drive wheels disengage with the floor. The robot will no longer be able to brake once the drive wheels lose contact with the floor.
2. Using a 15 mm 12-point socket, turn the manual bypass screws clockwise until the drive wheels lift up and away from the floor at least 10 mm.
3. Once the drive wheels are bypassed, the robot can be easily moved on its swivel casters by pushing or pulling the robot in the desired direction.

11.6.3 Disengaging Drive Wheel Manual Bypass

1. Using a 15 mm 12-point socket, turn the manual bypass screws counter-clockwise until the drive wheels regain contact with the floor.
2. Remove the manual bypass screws and store them in the Manual Charge Port Bay.

11.7 Storage

Before storing the robot for an extended period of time (greater than 2 days), ensure that the environmental requirements are met according to the **System Overview** and the battery is at 100% SoC. If possible, discharge the battery once a month and recharge it to maintain the life of the battery pack.

You must completely power off the robot when storing it for an extended period of time.

[See Shutting Down for details.](#)

11.8 Connecting to the robot

OTTO autonomous mobile robots (AMR) can be interfaced with on an individual basis using a computer and network cable.

11.8.1 Step 1 - Connect Network Cable

The Ethernet port is located in the attachment interface on top of the robot.

1. Using an Ethernet cable, connect your computer to the robot.

11.8.2 Step 2 - Set Computer Network Address

In order to connect a computer to an OTTO self-driving vehicle, the computer must have the following configurations:

- **Network Address:** 10.255.255.200
- **Netmask:** 255.255.0.0

The steps below outline how to do this on Linux and Windows 7 - for other operating systems, refer to the relevant documentation.

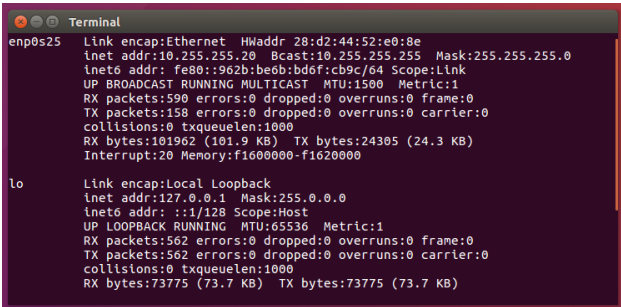
Note that these steps will only need to be performed once per computer.

11.8.2.1 Linux

1. From the system tray, click the **Network Manager** icon and select **Edit Connections**. The **Network Connections** screen is displayed.
2. Click **Add**. The **Choose a Connection Type** dialog box is displayed.
3. Select *Ethernet* from the drop-down menu and click **Create**.
4. Click the **IPv4 Settings** tab and do the following:
 - a. Enter a distinctive name for the network in the **Connection name** field.
 - b. From the **Method** drop-down list, select *Manual*.
 - c. Click **Add** and in the new line added under **Addresses**, use the above network address and netmask.
 - d. Click **Save**.
5. Select the newly created network connection by clicking the **Network Manager** icon.
6. Open a **Terminal** window and confirm the IP is set correctly by entering the following command:

```
ifconfig
```

7. In the data that is returned, the **inet addr** should match the address entered in **Step 4c** above.



```

enp0s25  Link encap:Ethernet  HWaddr 28:d2:44:52:e0:8e
         inet addr:10.255.255.20  Bcast:10.255.255.255  Mask:255.255.255.0
         inet6 addr: fe80::962b:be0b:b0f:cb9c/64 Scope:Link
         UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
         RX packets:590 errors:0 dropped:0 overruns:0 frame:0
         TX packets:158 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1000
         RX bytes:101962 (101.9 KB)  TX bytes:24305 (24.3 KB)
         Interrupt:20 Memory:f1600000-f1620000

lo       Link encap:Local Loopback
         inet addr:127.0.0.1  Mask:255.0.0.0
         inet6 addr: ::1/128 Scope:Host
         UP LOOPBACK RUNNING  MTU:65536  Metric:1
         RX packets:562 errors:0 dropped:0 overruns:0 frame:0
         TX packets:562 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1000
         RX bytes:73775 (73.7 KB)  TX bytes:73775 (73.7 KB)

```

Figure 27 Linux ifconfig

11.8.2.2 Windows 10

1. In the bottom-right corner of the screen, right-click the **Network** icon and click **Open Network & Internet Settings**.
2. Click **Change adapter options**.
3. Right-click **Ethernet** and click **Properties**.
4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.

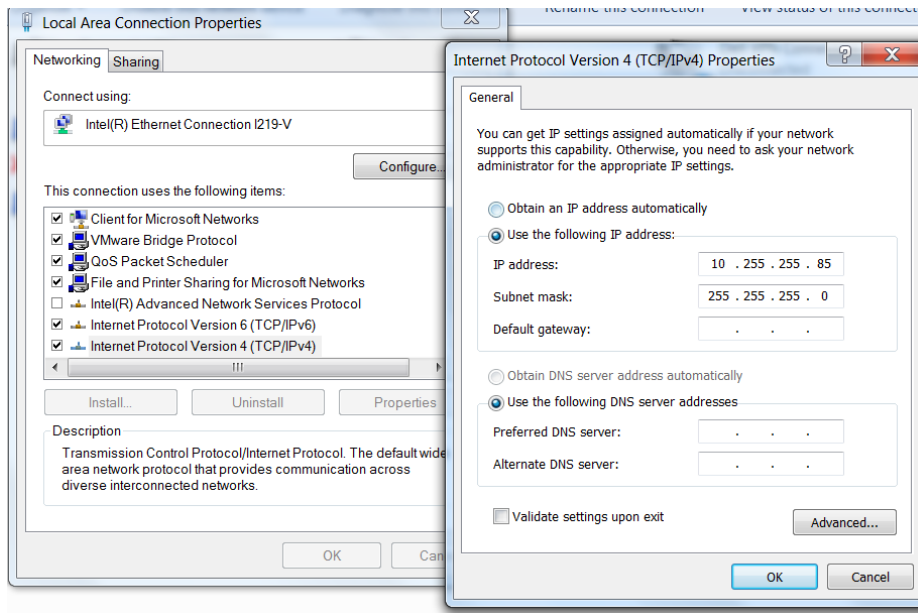


Figure 28 Windows 10 TCP/IPv4 Properties

5. In the **IP address** field, use the above network address and netmask.
6. Click **OK** > **OK**.
7. Open a **Command** window and enter the following command:

```
ipconfig
```

8. In the data that is returned, the **IPv4 Address** should match the address entered in **Step 5** above.

```
H:\>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection* 12:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix  . :

Ethernet adapter Local Area Connection 2:

    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix  . :

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix  . :
    Link-local IPv6 Address . . . . . : fe80::755a:a9ad:1a83:a062%14
    IPv4 Address. . . . . : 10.255.255.85
    Subnet Mask . . . . . : 255.255.255.0
    Default Gateway . . . . . :
```

Figure 29 Windows 10 ipconfig

11.8.3 Step 3 - Ping the OTTO AMR

- Confirm that you can ping the OTTO AMR to configure from the terminal window in Linux or the command prompt in Windows by entering the following command:

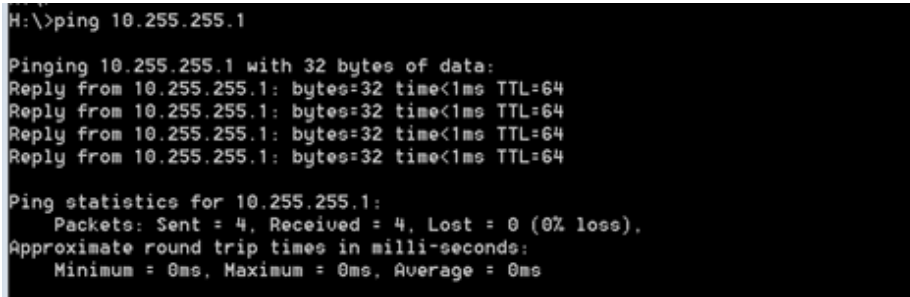
```
ping <vehicle IP address>
```

The IP address entry depends on the robot model.

Table 18 Robot IP Addresses

ROBOT MODEL	IP ADDRESS
OTTO 750/1500 V1.2 SDV	10.255.255.1
OTTO 750/1500 V2 SDV	10.253.253.1

You should receive a response similar to the following:



```
H:\>ping 10.255.255.1

Pinging 10.255.255.1 with 32 bytes of data:
Reply from 10.255.255.1: bytes=32 time<1ms TTL=64
Reply from 10.255.255.1: bytes=32 time<1ms TTL=64
Reply from 10.255.255.1: bytes=32 time<1ms TTL=64
Reply from 10.255.255.1: bytes=32 time<1ms TTL=64

Ping statistics for 10.255.255.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Figure 30 OTTO AMR Ping Result

- If configuring a single OTTO AMR that *will not* be added to a fleet using the OTTO Fleet Manager software, **connect the robot to the network.**

11.9 Connecting the robot to the network

OTTO Motors autonomous mobile robots (AMR) must be connected to the network to truly take advantage of the robot's autonomous capabilities.

OTTO robots come with 2.4 GHz wireless frequency disabled, but OTTO 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, please contact your OTTO Motors representative to assist in changing the robot's configuration.

1. Connect a computer to the OTTO AMR via ethernet cable.

See [Connecting to the robot for more information](#).

2. From a browser, navigate to <http://10.255.255.1:8090>. OTTO Network Setup will be displayed.
3. Click **Use Robot Settings** to view the current settings of the OTTO AMR being configured.

Click **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 OTTO AMR. Hostnames must begin with a letter as hostnames beginning with a number aren't supported.

If the Configuration screen becomes slow to respond after changing the hostname, restart the OTTO AMR.

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

The OTTO App can now be accessed over Wi-Fi for the configured OTTO AMR. From a Google Chrome browser, go to `<hostname>:5000`. If your network isn't set up to resolve hostnames, use the IP address of the OTTO AMR in place of the hostname.

11.10 OTTO App

OTTO App can be used to wirelessly control a robot if it's already connected to a wireless network.

OTTO™ App software enables control and Workflow creation for a single robot.

The main functions of OTTO App include:

1. Driving the associated OTTO autonomous mobile robot (AMR).
2. Recording and updating a facility Map.
3. Map configuration using Endpoints and establishment of Traffic rules.
4. Creation of basic Workflows to get your OTTO AMR to work right away.

If you're managing a fleet of OTTO AMRs using Fleet Manager, you will need to use OTTO App to record the facility Map, which can then be exported and uploaded to Fleet Manager for use by the fleet and advanced editing.

11.10.1 Launching OTTO App

Every OTTO autonomous mobile robot has its own unique URL from which you can access its OTTO App software - this URL can be accessed from any computer or supported tablet that is connected to the same network as the OTTO AMR. Each OTTO AMR has its own version of the OTTO App.

The URL consists of two parts: the OTTO AMR's hostname or IP address followed by " :5000".

The robot name or IP address used in the URL must match those set for the robot from the IP Configuration screen. See [Connecting a robot to the network](#) for more detail.

For example, the OTTO App for an OTTO autonomous mobile robot with the following name and IP address can be accessed from either of the following URLs:


EXAMPLE OTTO AMR SETTINGS	EXAMPLE URL
Hostname: otto-50	http://otto-50:5000/
IP Address: 10.27.210.141	http://10.27.210.141:5000

To launch the OTTO App for an OTTO AMR:

1. Using a Chrome™ browser, navigate to the OTTO AMR's hostname or IP address into the address bar followed by port ":5000".
2. Wait for the application to load.

11.10.2 OTTO AMR Settings

OTTO App allows you to configure the settings of a single OTTO autonomous mobile robot (AMR).

1. To change the settings for a specific OTTO AMR, launch the OTTO App for that robot.
2. Select **Main Menu**  and select **Robot**. The **OTTO AMR Settings** screen is displayed.
3. Change the settings as desired:

Volume

Adjust the volume on the OTTO AMR's audio notifications using the slider or by entering a number in the text field.

Tap **Test** to test the new volume level on the robot.

Set Lock Password

Create a password to lock OTTO App for this OTTO AMR.

The default password for every OTTO AMR is "4321".

Map Quality

Lower the map quality if you're experiencing performance issues whilst mapping. We encourage users to switch the quality back to high after mapping to get the best experience.

Reset Remapping Data

Select the **Reset Remapping** Data button to delete all remapping data from a robot.

Show Lift Controls

Use the toggle to display lift controls for robots with an integrated lift (ie. OTTO 100).

Manual Snapshot

The **Create New Manual Snapshot** button is used to create manual snapshot files used for diagnostics by OTTO Motors Support staff.

4. Select **Save** to save any changes you've made.

**CAUTION!**






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

IMPACT HAZARD! While driving the robot manually, the safety fieldsets monitored by the LiDAR scanners are disabled. To avoid impact, be aware of the robot's surroundings.

11.11 Driving an OTTO AMR Manually

1. Launch OTTO App for the OTTO AMR to be driven.

See [Launching OTTO App](#) for more detail on accessing OTTO App.

2. Confirm manual driving settings are as desired in the **Robot menu**.
3. Select either **Drive**  or **Facility**  from the **Main Menu**  to display the navigation controls in the bottom-right corner of the screen.
4. The OTTO AMR mode may be set to neutral. Confirm the position of the OTTO AMR on the map is accurate and select **Yes**.
5. Select the **Drive Mode** icon .
6. Select the **Settings** icon .
7. Select the **Manual** toggle to activate Manual mode. A white joystick will appear.

If Drive Assist is enabled and a robot has no current goal, the Drive Mode toggle will display Assisted mode instead of Manual mode.

If Drive Assist is enabled and the robot has an existing goal, the Drive Mode toggle will place the robot into Manual mode, allowing one to perform goal recovery with the joystick. As soon as the existing goal is cancelled or completed, the vehicle will then enter Assisted mode.

Select the **Lift** toggle and disable **Drive Assist** to enable control of the OTTO AMR integrated lift.

Note that this control is only available for robots with an integrated lift.


8. Drive the OTTO AMR by selecting and holding the white joystick and moving it in the desired direction the OTTO AMR should travel. The arrow keys on a keyboard can also be used.

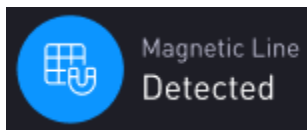
Driving with the joystick affects the speed at which the OTTO AMR travels - the farther the joystick is pushed, the faster the OTTO AMR will travel.

To adjust the top speed at which an OTTO AMR will travel, use the Speed slider. OTTO AMRs will drive slower the lower the slider is set and robot field sets will narrow for easier navigation around close objects.

Click Main Menu  then click OTTO to customize the joystick sensitivity using the Joystick Sensitivity slider.

11.12 Magnetic Line Following

If a Magnetic Line is detected by a robot, the below icon will appear in the bottom menu bar. To command an OTTO AMR to follow a detected Magnetic Line until the line terminates, select the **Follow Magnetic Line** icon  displayed above the joystick.



Note that robots will ignore Zones related to path planning (ie. Assumed Cost, Preferred Direction, etc.) when following a Magnetic Line.

Magnetic Line Zone properties will also override any properties associated with a Narrow Corridor Zone.

11.13 Enabling Drive Assist

Drive Assist leaves safety rules enabled through a robot's Safety Configuration - the same as an OTTO AMR operating in the Autonomy state - to avoid nuisance Safety Stops, preventing accidental collisions with obstacles, and vehicle entry into Exclusion Zones.






Note that OTTO AMRs being driven manually with Drive Assist enabled will not respect Preferred Direction Zone rules and will traverse the zone both forwards and backwards.

See the [Hardware Library](#) for Safety Configuration information applicable to your vehicle model.

To enable Drive Assist:

1. Launch the OTTO App for the OTTO AMR to be driven.

See [Launching OTTO App](#) for more detail on accessing OTTO App.

2. Select either Drive  or Map  from the Main Menu  to display the navigation controls in the bottom-right corner of the screen.
3. Select the Drive Mode icon .
4. Select the Settings icon .
5. Select the Drive Assist toggle.

OTTO AMRs will not be affected by Preferred Direction or Assumed Cost (with a cost less than 1.0) zones when operating under Drive Assist control. These zones influence the path that the robot would prefer to take and said path is being commanded manually by the user in this mode.

11.14 Driving an OTTO AMR Autonomously


If the OTTO AMR has been added to Fleet Manager, the Map in OTTO App must match the Map in Fleet Manager. If the maps don't match, an OTTO AMR cannot be driven autonomously via OTTO App.

OTTO AMRs also require at least a 30% Localization Score with its environment to be operated autonomously.

Drive with caution and make sure to never lose sight of the OTTO AMR.

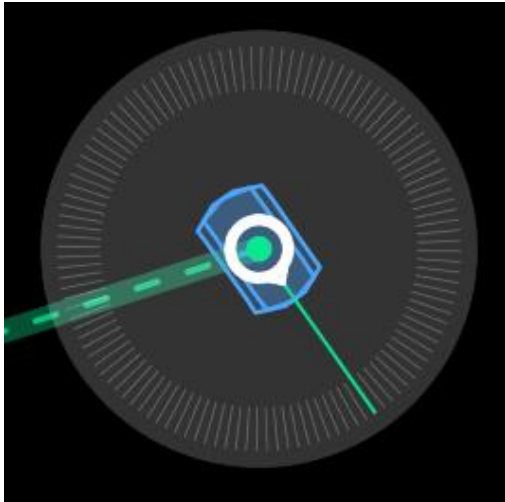
1. Launch the OTTO App for the OTTO AMR to be driven.

See [Launching OTTO App](#) for more detail on accessing OTTO App.

2. Select either **Drive** or **Facility** from the **Main Menu**  to display the navigation controls in the bottom-right corner of the screen.
3. The OTTO AMR mode may be set to neutral. Confirm the position of the OTTO AMR in the map is accurate and select **Yes**.
4. Make sure the **Manual** toggle is disabled and Manual Mode is off. When disabled, the Drive Mode toggle is gray and the joystick will be a blue Move button.
5. Select **Move**. The joystick button will turn gray.

Select the X in the top-left of the screen to cancel the move command.

6. Select the location on the Map to which you want to send the OTTO AMR. The joystick button will turn green and the orientation circle will be displayed at the selected location on the map.
7. Move the green line inside the orientation circle to define the direction in which you want the OTTO AMR to be facing when it stops at the selected location.





8. Select **Go** to send the OTTO AMR on its way. A "Moving" notification is displayed.
9. Select **Stop** to stop the OTTO AMR at any time.

You can select the Drive Mode toggle at any point to enter Manual drive mode.

11.15 Driving with Markers

If at least one marker is set up in the map, an OTTO autonomous mobile robot (AMR) can be sent directly to it.

1. Launch OTTO App for the OTTO AMR to be driven.
2. Select **Main Menu**  then select **Drive**.
3. Select **Endpoints** .
4. Select the **Show Markers** ☒ checkbox.
5. Select a marker from the list.
6. Select **Go** to send the OTTO AMR on its way. A "Moving" notification is displayed.
7. Select **Stop** to stop the OTTO AMR at any time.

Select the Drive Mode toggle at any point to enter Manual drive mode.

11.16 Driving using the Pendant



CAUTION!

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

IMPACT HAZARD! While driving the robot manually, the safety fieldsets monitored by the LiDAR scanners are disabled. To avoid impact, be aware of the robot's surroundings.

The robot can be driven manually using the pendant. The pendant includes directional buttons (forward, reverse, left turn, right turn) and black enable, red emergency stop, and safety reset buttons.



Figure 31 Pendant Controller

The pendant directional buttons are dual-acting (two depressed states). The first level of depression allows the robot to move at slow speed and the second level allows movement at a faster speed.

The black enable button is a double-pole design allowing for 3 unique positions. The robot is only able to be manually driven using the pendant when the enable button is pressed to the middle **ON** position. If the enable button is not pressed or is fully depressed, it will be in the **OFF** position.

While controlling the robot using the pendant, there is a 30 cm/s speed restriction, and the safety fieldsets monitored by the LiDARs are disabled.

There is a collision risk with objects while driving the robot using the pendant. It is the user's responsibility to ensure they operate the robot safely within its safe operating conditions and keep bystanders and objects out of the path of the robot.

1. Connect the pendant to the pendant connection port.

See the Components Overview for detail on the pendant connection port.

2. Confirm that all Emergency Stop buttons on the robot, pendant, and any equipped attachment are released.
3. On the Pendant, press and hold the black **Enable** button in the middle **ON** position.
4. Press the **Safety Reset** button on the robot. You will hear an audible click from the system and the light pipe will indicate that the robot is now in Manual Drive mode.
5. On the pendant, while holding the **Enable** button in the middle **ON** position, press the **Forward**, **Reverse**, **Left Turn**, and **Right Turn** buttons to manually drive the robot.

12 MAINTENANCE

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

Table 19 Maintenance Schedule

COMPONENT	DAILY	WEEKLY	MONTHLY	6 MONTHS
Visual inspection and cleaning of LiDAR lenses.	✓			
Inspect 3D perception cameras for dust, damage, etc.		✓		
Battery calibration		✓		
Visual inspection underneath robot to ensure grounding strap intact and contacting the ground.			✓	
Exterior cleaning			✓	
Copper contact cleaning			✓	
Battery cell balancing			✓	
Electrical Enclosure Fan Filter Inspection				✓

12.1 Lock-Out/Tag-Out



CAUTION!

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

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.

In order 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. Shut down the robot.
2. Wait until the light pipes have completely turned off.
3. Find and open the Lock Out/Tag Out Bay.
4. Switch the **Lock Out Disconnect** to the *OFF* position.



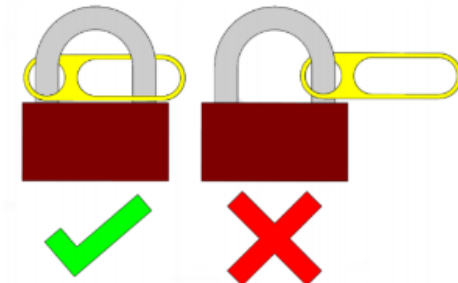
Figure 32 Lock-out/tag-out bay lock-out OFF position

5. Apply the lock and tag to the **Lock Out Disconnect**.
6. Find and open the Pendant and Manual Charge Port Bay.
7. Apply the lock and tag to the Manual Charge Port.



Figure 33 Pendant and manual charge port bay lock-out/tag-out

The lock on the lock-out bracket above the Manual Charge Port must be threaded through both holes on the bracket, as shown below:



All personnel working on the platform must connect their own lock.

**WARNING!**

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

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!**

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

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

To order any of the parts referenced in the following maintenance procedures, please contact OTTO Motors Support.

12.2 Maintenance Safety

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. Contact your supervisor to post additional safety labels if you feel it necessary.

When an equipment problem occurs, the first priority is to assure that power has been disconnected from the affected area, as well as from the control panel, where troubleshooting and repairs will be performed. Once you verify that power is locked out, make sure you inform other personnel in the area of the situation so they do not unexpectedly restore power.

When performing any kind of maintenance or repair involving electrical components, follow the guidelines listed below:

- NEVER attempt to open the main electrical enclosure or adjust any cabling to or from the enclosures while the system is on.
- NEVER perform maintenance unless you are a designated and qualified individual
- NEVER reset a circuit breaker or replace an open fuse before determining and correcting the cause of the circuit interruption.

- NEVER bypass or use a jumper to replace any limit switch, fuse, circuit breaker, or other circuit protection or safety device.
- NEVER replace an open fuse with another that is not rated at the proper current and voltage. Always double-check correct fuse specifications rather than replace the open fuse with one of the same current and voltage rating.
- NEVER rest tools on motors, transformers, terminal strips, or other control panel or electrical components. Any tools used should be kept in a tool box or pouch.
- NEVER restore power or restart equipment before verifying that all tools, spare parts, etc. have been removed from the work area and safely stored.
- NEVER restore power or restart equipment before ALL personnel are aware of the condition and are safely clear of the equipment.
- ALWAYS replace any safety devices and guards removed during maintenance or repair before restoring power or restarting equipment.
- ALWAYS use extreme caution and follow recommended safety procedures when performing any electrical inspection or maintenance.

12.3 Daily Preventative Maintenance

Perform the following tasks once every operational day.

12.3.1 Circle Check

Perform a brief circle check of your 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 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.

12.3.2 Daily LiDAR Cleaning

12.3.2.1 Materials/Tools Required

- Flashlight
- Antifog/Antistatic Lens Cleaning Wipes (OTTO Motors Part Number 015591)

CAUTION!

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

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.

12.3.2.2 Procedure

1. Inspect LiDAR with flashlight for any dust and/or debris.
2. Using the lens cleaning wipes, clean the LiDAR.

12.4 Weekly Preventative Maintenance

Perform the following tasks once every week:

12.4.1 3D Perception Camera Inspection

12.4.1.1 Materials/Tools Required

- Flashlight
- Antifog/Antistatic Lens Cleaning Wipes (OTTO Motors Part Number 015591)

CAUTION!

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

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.

12.4.1.2 Procedure

1. Inspect 3D perception cameras with flashlight for any dust and/or debris.
2. Using the lens cleaning wipes, clean the 3D perception cameras.

12.4.2 Battery Calibration

The function and health of the robot battery is monitored by a Battery Management Unit (BMU) which is internal to the battery pack itself.

Over the operating life of the robot, the State of Charge (SoC) of the battery may drift from what is being calculated by the BMU. This occurs when the battery is charged and discharged multiple times within a particular range and never hits 0 or 100% SOC. When this occurs, the robot battery may suddenly drop in SoC while operating or the robot may unexpectedly shut down. To resolve this issue, it is required to perform a calibration of the battery and BMU.

The frequency of the SoC calibration, although suggested once a week, can be determined by the end user, as the frequency of charge cycles will vary between sites. For software 2.20 and later the calibration of SoC is done automatically—users may notice that the OTTO AMR stays in the charger a little longer than normal.

12.4.2.1 Required Materials

- Robot experiencing a battery SOC misalignment
- OTTO 750/1500 Fast Charger V2
- Laptop or tablet connected to the same network as the robot
- A pylon at least 300 mm (11.8 in) in height

12.4.2.2 Procedure

Battery calibration is performed by charging the battery with the OTTO 750/1500 Fast Charger V2 at 2.5 C (100 amps (A)) in the constant current (CC) mode of the charge cycle until it hits the threshold.

12.4.2.3 Setup

1. OTTO 750/1500 Fast Charger V2 setup
 - a. Place a pylon in front of the charger to ensure no robots drive into the dock while it is being used.
 - b. On the OTTO 750/1500 Fast Charger V2 electronic unit (Ecotec battery charger) display, press the **OK** button to enter the charger's menu and double-check the charging parameters:
 - i. Navigate to **Service** and press **OK**.
 - ii. Navigate to **Charging param** and press **OK**.
2. Robot setup
 - a. If battery calibration is required due to a sudden SOC drop and the robot is dead, use a manual charger to charge the robot to 10-14% SoC before sending to the OTTO 750/1500 Fast Charger V2.
 - b. If the robot is connected to Fleet Manager, navigate to **Monitor > Fleet > robots** in Fleet Manager, click the robot, and set the robot to **Unavailable**.

12.4.2.4 Calibration

1. CC Charge Mode
 - a. Navigate to the OTTO App interface for the robot.
 - b. Remove the pylon blocking the OTTO 750/1500 Fast Charger V2.
 - c. Using OTTO App, send the robot to charge at the OTTO 750/1500 Fast Charger V2.
 - d. Wait for at least 30 minutes and the current on the charger will drop below 500 mA. This is visible on the display of the wall unit for the OTTO 750/1500 Fast Charger V2.

Once the battery hits this threshold, the robot can be moved out of the charger.

12.4.2.5 Post-Maintenance

1. Restore robot availability
 - a. If the robot is connected to Fleet Manager, navigate to **Monitor > Fleet > Robots** in Fleet Manager, click the robot, and set the robot to **Available**.
2. If the profile on the OTTO 750/1500 Fast Charger V2 was changed, return the charger to the profile needed for the installed fleet before making the charger available to the fleet.

12.4.2.6 Confirmation

1. To verify that the calibration has been performed correctly, return the robot to service so it can be assigned to regular jobs.
2. The robot can be left unattended but the SoC should be checked every 30 minutes before the next charge cycle to make sure it is discharging as expected.
3. If the battery voltage does not suddenly jump and the robot does not shut down unexpectedly during this time, the calibration was successful.

If the robot continues to experience issues with battery performance after completing this calibration procedure, contact OTTO Motors Support for further direction.

12.5 Monthly Preventative Maintenance

Perform the following tasks once every month:

12.5.1 Exterior Cleaning

12.5.1.1 Materials/Tools Required

- Lint Free Cloth
- Cloth or Scratch-Free Sponge, dampened with water

12.5.1.2 Procedure

1. Ensure the robot is shut down.
2. Using a lint-free cloth, gently remove any dust or debris.
3. If required, gently rub affected areas with the damp cloth. The cloth or sponge used should be damp only and should not be dripping any liquid.

- Be cautious to avoid the power and Emergency Stop buttons, as well as the Attachment Interface.
 - Do not rub aggressively on any stickers or number decals.
4. Inspect the Attachment Interface area. Clean with a lint free cloth if necessary.
 5. Return the robot to service.

12.5.2 Check Grounding Strap

Perform a visual inspection underneath your OTTO autonomous mobile robots once a week:

- Ensure the grounding strap is intact and contacting the ground.

12.5.3 Copper Contact Cleaning

12.5.3.1 Materials/Tools Required

- Scotch Brite Pad

12.5.3.2 Procedure

1. Ensure the robot is shut down.
2. Using the Scotch Brite Pad, clean the surface of the copper contactors on the robot.

Before



After



12.5.4 Battery Cell Balancing

The function and health of the robot battery is monitored by a Battery Management Unit (BMU) which is internal to the battery pack itself.

Over the operating life of the robot, the voltage of individual cells will begin to diverge from each other. This can lead to incorrect SoC or reduced capacity. Typically battery cells should be within a range of 50 mV - if not, the robot battery may suddenly drop in SoC while operating or the robot may unexpectedly shut down. To resolve this issue, it is required to perform the cell balancing of the battery and BMU.

This process will perform a battery calibration as well. If only SoC drift is the issue, follow the Battery Calibration procedure.

12.5.4.1 Required Materials

To perform this maintenance, you will require the following:

- OTTO 750/1500 V2 AMR
- OTTO 750/1500 Fast Charger V2
- OTTO 750/1500 Manual Charger V2
- Laptop or tablet connected to the same network as the robot
- A pylon at least 300 mm (11.8 in) in height

12.5.4.2 Procedure

The cell balancing is performed by charging the battery with the OTTO 750/1500 Fast Charger V2 at 2.5 C (100 amps (A)) in the constant current (CC) mode of the charge cycle.

Once the CC mode of charging is complete, switch to using the manual charger to charge the robot in constant voltage (CV) mode and keep the battery floating at its maximum voltage.

12.5.4.2.1 Cell Balancing

1. Stage 1 (CC Charge Mode)
 - a. Navigate to the OTTO App interface for the robot.
 - b. Remove the pylon blocking the robot.
 - c. Using OTTO App, send the robot to charge at the OTTO 750/1500 Fast Charger V2.
 - d. Wait for at least 30 minutes and the current on the charger will drop below 500 mA. This is visible on the display of the charger electronic unit for the OTTO 750/1500 Fast Charger V2.

Once the battery hits this threshold, the robot can be moved out of the charger.

- e. Send the robot to a waypoint outside of the charger close to a manual charger. These locations should be as close together as possible. Delay in performing Stage 2 of the balancing may affect the process.

2. Stage 2 (CV Charge Mode)

- a. Press the **Emergency Stop** button on the robot to prevent it from driving away while connected to the charger.
- b. Plug the manual charger into the robot immediately to avoid voltage drop (longer delays might affect the process).
- c. Leave the robot turned on and connected to the manual charger for 1 hour or longer to ensure all cell voltages are greater than 3.4V.
- d. Unplug the manual charger and shut down the robot.
- e. Turn off the breakers so the batteries are at complete rest for 8 hours or longer - this allows the cells to balance quicker (the time could be longer depending on the degree of cell balancing needed).

12.5.4.3 Confirmation

1. After the robot has sat turned off for 8 hours or longer, the cell balancing procedure is complete.
2. To verify that it has been performed correctly, run the robot from 100% SOC to 10%:
 1. Configure two waypoints and have the robot drive a route repeatedly between them.
 1. The robot can be left unattended but the SoC should be checked every 30 minutes to make sure it is discharging as expected.
 2. If the battery voltage does not suddenly jump or the cells voltages are in acceptable range and the robot does not shut down unexpectedly during this time, the cell balancing was successful.

If the robot continues to experience issues with battery performance after completing this calibration procedure, contact OTTO Motors Support for further direction.

12.5.4.4 Post-Maintenance

1. Restore robot availability
 - a. If the robot is connected to Fleet Manager, navigate to **Monitor > Fleet > Robots** in Fleet Manager, click the robot, and set the robot to **Available**.
2. If the profile on the OTTO 750/1500 Fast Charger V2 was changed, return the charger to the profile needed for the installed fleet before making the charger available to the fleet.

13 DISPOSAL

Always observe environmental protection regulations valid to your region.

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

13.1 Battery Disposal

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

14 TROUBLESHOOTING

Examine the following table for possible methods to recover from an unexpected state of the robot. If possible, consult Fleet Manager and view Exceptions for the specific vehicle from Monitor Vehicles pane to begin your assessment.

See [Components Overview](#) for detail on button locations and vehicle state indicators.

STATE	ACTION
Robot will not turn on	<p>First, check that the circuit breaker is enabled.</p> <p>Next, press the Power Button momentarily.</p> <p>If neither of the above work, connect the OTTO 750/1500 V2 Manual Charger to recover the battery.</p>
Robot stuck in charger	<p>The charge cycle will not complete if a LiDAR Safety Stop is triggered in the Dock. Check that the areas directly in front of the OTTO AMR is clear of obstacles.</p> <p>If the above was not the issue, look between the vehicle and the charge contacts to confirm that the charge contacts on the OTTO AMR physically connect with the charge contacts in the charger.</p> <p>Check that the OTTO AMR is not physically jammed in the charger, either on the charge contacts or on the rollers on the sides.</p> <p>Are the wheels moving? If the drive wheels attempt to turn, but the OTTO AMR cannot leave the charger, then it is physically jammed.</p> <p>Check that the Map is using the correct Steps to exit the charger. Using an invalid Marker Move Step (possibly sourced from an out-of-date Map) when exiting the charger may cause the vehicle to remain in the charger.</p>

Robot is stuck in Emergency Stop State	<p>The Power Button includes a blue light that will indicate when the robot can be reset. If the blue light is on, press the Safety Reset Button.</p> <p>If the above is unsuccessful, check that all Emergency Stop Buttons are pulled out.</p> <p>Confirm that the Attachment Interface dummy plugs (12-pin and 24-pin) and the Pendant Connection dummy plugs are plugged in.</p> <p>Check for any errors in OTTO App and, if possible, Fleet Manager.</p> <p>If the above fails, shut down the robot and start it again.</p> <div data-bbox="505 642 1435 720" style="border: 1px solid #00A68F; padding: 5px; margin-top: 10px;"> <p>See Basic Usage for more detail.</p> </div>
Robot is stuck displaying Safety Stop light pattern	<p>Check for nearby obstacles or debris in the LiDAR cavity. Clean the LiDAR with a microfiber cloth. Check area for retroreflective material (a surface that reflects light back to its source with a minimum of scattering).</p>
Robot is making a loud or unusual mechanical noise	<p>If the sound is coming from the bottom of the vehicle, check the castors and drive wheels to ensure no debris or object is jammed in the wheel cavities or the wheels.</p> <p>If the sound is coming from the top of the vehicle, check to make sure the lift/attachment has not caught on anything externally or internally.</p> <p>Contact OTTO Motors Support if the issue cannot be resolved.</p>
Robot will not move to instructed location	<p>Check surrounding area for obstacles blocking the vehicle path. Note this may include yourself.</p> <p>Check that a valid LiDAR field set and Safety Configuration are loaded onto the OTTO AMR.</p> <p>Talk to OTTO Motors Support for instructions on diagnosing a blown traction motor fuse.</p> <p>The Safety Configuration will include information about the space required by the OTTO AMR for autonomous navigation.</p>

15 DECLARATIONS

15.1 EU-Declaration of Conformity

This declaration of conformity is suitable to the European Standard EN ISO/IEC 17050-1: 2010 – Conformity assessment - Supplier's declaration of conformity - Part 1: General requirements.

We Pilz Ireland, Business & Technology Park, Model Farm Road, Cork, Ireland declare as authorized representative under the sole responsibility of the manufacturer that the machine:

Machine name: Autonomous Mobile Robot (AMR)

Model: OTTO™ 1500 V2

Serial number(s): B10-XXXX200XX

manufactured by:

Clearpath Robotic Inc. dba OTTO Motors
124 Bleams Road
Kitchener, ON – N2C 2K5
Canada

to which this declaration relates, is in conformity with the following European Directives

2006/42/EG/ 2006/42/EC Machinery Directive

2014/53/EU Radio Equipment Directive

Conformity is declared in reference to the following standard(s) or other normative document(s):

EN ISO 12100:2010 Safety of machinery – General principles for design – Risk assessment and risk reduction (EN ISO 12100: 2010)

EN 60204-1:2018 Safety of machinery – Electrical equipment of machines – Part 1: General requirements

EN ISO 13849-1:2015 Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design

ISO 3691- 4:2020 Industrial trucks — Safety requirements and verification – Part 4: Driverless industrial trucks and their systems

Person authorized to compile the Technical File:

Cork, Ireland, 25 January 2021.



Pilz – Signature

John McAuliffe, Managing Director

Pilz Ireland

Business & Technology Park – Model Farm Road,
Cork

Kitchener, Ontario, Canada, 25 January 2021.



Clearpath Robotics –Signature

Ryan Gariepy, Chief Technology Officer

Clearpath Robotics

124 Bleams Road – Kitchener, ON Canada

15.2 Supplier's Declaration of Conformity



47 CFR § 2.1077 Compliance Information

OTTO 1500 V2

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

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Contains Transmitter Module FCC ID: PD9AX200NG

15.3 CAN ICES-003(A) / NMB-003(A)



Issue 6

January 2016

Contains Transmitter Module IC: 1000M-AX200NG

These are important Safety Instructions and should be saved for reference. Original instructions provided in English.

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