OTTO MOTORS

OPERATION AND MAINTENANCE MANUAL

OTTO 1500 v1.2

OTTO 1500 v1.2

Document ID: OMM-000003

Revision: E

T01 RELEASE DATE FEB-20

Disclaimer

The information found within this document 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.

Safety

The top priority of OTTO Motors is the safety of its users. OTTO Motors produces high power and fast-moving pieces of machinery that potentially could cause serious injury, including death, if improperly used or maintained. In order to inform our users of some of these risks, throughout OTTO Motors documentation you will see safety messages corresponding to either a DANGER, WARNING, or CAUTION.

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

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

CAUTION Failure to follow instructions may result in INJURY or DAMAGE to the system and or property.

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.

CONTACT INFORMATION

OTTO Motors is committed to your success and satisfaction. We are located in Kitchener, Ontario. If you have any questions or concerns, visit our support knowledge base for more information, or get in touch with our support team.

CLEARPATH ROBOTICS INC.

2A-1425 Strasburg Road
Kitchener, ON N2R 1H2
24/7 Support: 1-844-733-6886
https://ottomotors.com/support
https://help.ottomotors.com

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 REVISION HISTORY

REVISION	DATE	CHANGES
D	April 2017	Update to maintenance frequency
E	February 2020	Significant revision to manual template, System Specifications, Components Overview, Basic Usage, Maintenance, Attachment Interface

Table 1 Revision History

2 INTRODUCTION

This document provides important information pertaining to the safe operation and use of the OTTO 1500 V1.2 self-driving vehicle (SDV).

Information in this document related to software functionality is up-to-date as of OTTO™ Software Version 2.16.

3 APPLICABLE DOCUMENTS

For additional information refer to the following documents. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

REFERENCE	NUMBER
OTTO 1500 V1.2 SDV Stability and Center of Gravity	ICD-000045
OTTO Charge 1500 Operations and Maintenance Manual	OMM-000001
OTTO 1500 Spare Parts List	SPL-000002
OTTO 1500 V1.2 SDV Payload Attachment Interface	ICD-000004
OTTO 1500 V1.2 SDV Operations and Maintenance Manual	OMM-000003

Table 2 Applicable Documents

4 PRODUCT SAFETY

DANGER Unsafe operation of the OTTO 1500 self-driving vehicle (SDV) will result in injury or death.

WARNING The OTTO 1500 V1.2 SDV is capable of operation without user input. Be aware that unless emergency stopped, the vehicle may move at any time. Ensure that anyone in the area in which an OTTO 1500 V1.2 SDV is operating understands the audible and visual notification system.

See **Components Overview** for more detail.

WARNING The OTTO 1500 V1.2 SDV should never be used to transport humans or animals. Do not ride on top of an OTTO 1500 V1.2 SDV.

WARNING The OTTO 1500 V1.2 SDV is a self-driving payload transport vehicle. Proper personal protective equipment (PPE) - including approved safety footwear with toe cap - should be worn when the vehicle is operating, similar to any other forklift or tugged vehicle.

4.1 Important Notes

- Read all instructions before using this product.
- Familiarize yourself with the System Specifications in the System Overview.
- All stairwells or similarly open holes must be marked and surrounded by obstacles exceeding 20 cm in height with spacing no greater than 1 m. 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.
- Your facility must be examined by an OTTO Motors consultant prior to autonomous navigation.

4.2 Risk Reduction

Despite the safety features OTTO Motors has put into place, the OTTO 1500 V1.2 SDV is heavy and capable of moving quickly. Never jump or throw obstacles in front of a moving vehicle. The best way to ensure protection of life and equipment around the OTTO 1500 V1.2 SDV is to keep a safe distance from it and pay attention to the light pipe and auditory warnings to anticipate the vehicle's intentions. If work is being done on the charge system, follow local Lock-Out Tag-Out procedures for safety.

See Basic Usage for more detail.

4.3 Hazards

The OTTO 1500 V1.2 SDV presents a number of risks to users even during the course of normal operation. All users should familiarize themselves with the potential hazards of the system so they can anticipate and avoid them.

The hazards currently identified are as follows:

DANGER

Impact

The LiDAR safety scanners can detect objects within a 100 mm (nominal) height from the ground.

When an OTTO 1500 V1.2 SDV is powered on, it should be assumed that it is always capable of accelerating, decelerating, or turning suddenly and quickly.

Always maintain a suitable safety distance. Ensure that all individuals working around the OTTO 1500 V1.2 SDV are familiar with Vehicle State Indicators. See **Components Overview** for more detail.

DANGER

Crushing/Impact

The OTTO 1500 V1.2 SDV assumes the environment is approved by OTTO Motors for autonomous driving. Stairwells, loading docks, and other unprotected vertical drops must not be accessible to the OTTO 1500 V1.2 SDV.

The OTTO 1500 V1.2 SDV has the potential to fall from unprotected vertical drops and steps and could present a crush hazard.

DANGER

Impact

The OTTO 1500 V1.2 SDV cannot detect objects positioned at its sides and may impact these objects when rotating or turning.

Always maintain a suitable safety distance. Ensure that all individuals working around the OTTO 1500 V1.2 SDV are familiar with Vehicle State Indicators. See **Components Overview** for more detail.

DANGER

Impact

OTTO 1500 V1.2 SDVs might be loaded with objects/payloads that extend over its default configured Navigation Specification (SC-000009).

Always maintain the correct footprint for the OTTO 1500 V1.2 SDV. Should a payload overextend the footprint configured in the loaded Navigation Specification approved by OTTO Motors, the OTTO 1500 V1.2 SDV will be unable to navigate safety and severe impacts may occur.

DANGER

Impact

The OTTO 1500 V1.2 SDV cannot detect objects positioned within its intended path above the viewing height of the LIDAR fields (100 mm nominal).

Always remove overhanging objects that may extend into the path of OTTO 1500 V1.2 SDV but not into the detection field of the LIDAR as OTTO 1500 V1.2 SDVs not equipped with a 3D Perception Attachment will be unable to navigate safety, possibly resulting in severe impacts.

WARNING

Electrical

OTTO 1500 V1.2 SDVs are powered by a high capacity 51V (nominal) battery system. Improper use or maintenance may result in a high energy discharge.

Never attempt to open an OTTO 1500 V1.2 SDV without following the Lock-Out/Tag-Out procedure. See **Basic Usage** for more detail. Maintenance should only be performed by designated and qualified individuals.

Fire

WARNING Catastrophic battery failure may occur at elevated temperatures. Although the system is equipped with a battery maintenance system, OTTO 1500 V1.2 SDVs should never be exposed to prolonged temperatures above what is outlined in the System Overview.

Pinch Point

WARNING Objects can be caught in the space between the vehicle frame and the floor. Keep hands and other objects clear.

Pinch Point

WARNING Objects can be caught in the space between the vehicle frame and Docks. Dock Zones are designed to be free of human operators and should be identified with physical warning symbols which must be respected. All individuals should avoid these designated areas at all times.

Impact / Crushing

WARNING Unstable Attachment loads may result in undesired motion. Always perform load testing of new attachments and loading procedures prior to implementation.

WARNING

Impact / Crushing

Objects may be knocked over/crushed, ropes, or cables being caught. The OTTO 1500 V1.2 SDV is only capable of viewing objects within a 100 mm (nominal) height from the ground.

Always be aware of objects which may be at risk within the operating environment.

4.4 Safety System Functionality

OTTO 1500 V1.2 SDVs move and travel differently depending on several factors including any detected obstacles, the vehicle's speed, the currently occupied Zone, and the vehicle's current Step, Task, or Job.

There are two LiDAR safety scanners on the OTTO 1500 V1.2 SDV - one on each end of the vehicle. 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 OTTO 1500 V1.2 SDV to its surroundings when localizing to a Map, planning paths, and interacting with local infrastructure.Keep reading for a general overview of the OTTO 1500 V1.2 SDV's safety system and the types of motion that the vehicle can express. See the **Components Overview** for an outline on how the OTTO 1500 V1.2 SDV indicates its different modes.

> **WARNING** Always maintain a safe distance from OTTO 1500 V1.2 SDVs. Never rely on proximity to the Emergency Stop buttons on the OTTO 1500 V1.2 SDV as a substitute for maintaining a safe distance.

4.4.1 Perception Sensor Layout

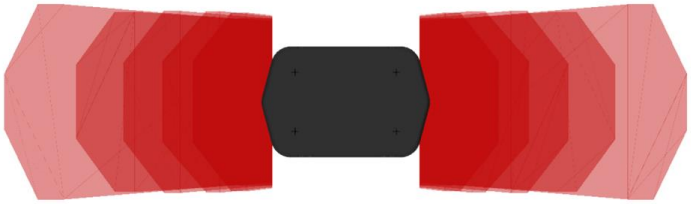


Figure 1 OTTO 1500 V1.2 SDV Sensor Layout

An OTTO 1500 V1.2 SDV will enter a Safety Stop state if an object enters the Safety Detection Range indicated by the red fields shown above.

The OTTO 1500 V1.2 SDV'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 vehicle. The safety scanners are tilted up from the horizontal plane (see below) to avoid ground hits and to meet the testing requirements for ANSI/ITSDF B56.5, Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles. This also allows for shorter objects to be detected closer to the OTTO 1500 V1.2 SDV.

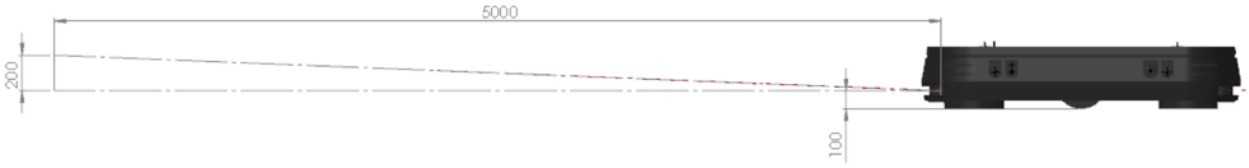


Figure 2 OTTO 1500 V1.2 SDV Open Detection Range (mm)

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.

> **CAUTION** Mirrors, reflective clothing, or light absorbing materials should be avoided in the detection range.

4.4.2 Zone-specific Behavior

Zones are areas in a Map that change the behavior of an OTTO 1500 V1.2 SDV while the vehicle 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.

4.4.3 Modes

The OTTO 1500 V1.2 SDV can select from several modes in which the safety system can operate, determined by the vehicle occupying a particular Zone type on a Map or by a condition on the Map requiring a particular modes function.

4.4.3.1 Normal Mode

<table>
<tr><th>CHARACTERISTIC</th><th>VALUE</th><th colspan="3">DESCRIPTION</th></tr>
<tr><td>Speed</td><td>0 - 2 m/s</td><td colspan="3">The safety scanners use encoder input (speed) to select the safety field required to stop the vehicle when traveling at that speed.</td></tr>
<tr><td>Turning</td><td>CAP table-enforced</td><td>Safety Field</td><td>Vehicle Speed (m/s)</td><td>Turning Cap (% speed difference between left and right motor)</td></tr>
<tr><td></td><td></td><td>0</td><td>0 - 0.3</td><td>30%</td></tr>
<tr><td></td><td></td><td>1</td><td>0.3 - 0.66</td><td>25%</td></tr>
<tr><td></td><td></td><td>2</td><td>0.66 - 1.02</td><td>15%</td></tr>
<tr><td></td><td></td><td>3</td><td>1.02 - 1.38</td><td>10%</td></tr>
<tr><td></td><td></td><td>4</td><td>1.38 - 1.74</td><td>5%</td></tr>
<tr><td></td><td></td><td>5</td><td>1.74 - 2.10</td><td>5%</td></tr>
<tr><td></td><td></td><td colspan="3">Depending on the speed that the OTTO 1500 V1.2 SDV 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 drivetrain speeds as read by the encoders on each drivetrain.
Only one safety field set at a time will be selected based on vehicle speed.</td></tr>
<tr><td>Direction</td><td>Forward or Reverse</td><td colspan="3">Both drivetrains must simultaneously move in the forward or reverse direction and are not allowed to move in opposite directions.</td></tr>
</table>

Table 3 Normal Mode Characteristics

4.4.3.1.1 Normal Low Speed Travel

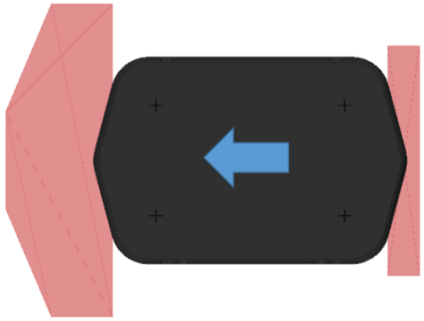


Figure 3 Low Speed Travel Field Set

In the above image, the OTTO 1500 V1.2 SDV is travelling in the direction of the arrow using safety field set 0 with a specific vehicle speed range (see above table for vehicle speed ranges for each safety field set). If the vehicle speed exceeds the speed range for safety field set 0, the safety scanner will change to safety field set 1, with a higher vehicle speed range. These safety field shifts will continue to occur until vehicle speed exceeds 2.1 m/s, at which point the safety scanner will place the OTTO 1500 V1.2 SDV in an Emergency Stop state as protection in the case that guidance software issues an invalid velocity command.

4.4.3.1.2 Normal High Speed Travel

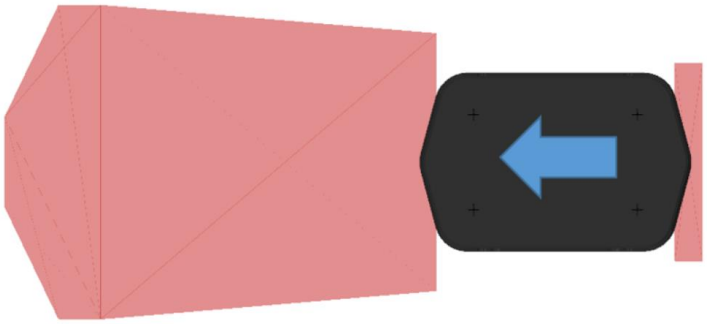


Figure 4 High Speed Travel Field Set

In the above image, the OTTO 1500 V1.2 SDV is moving at a speed between 1.74 m/s and 2 m/s, resulting in a much larger safety field set than for lower speeds as the vehicle will take longer to stop at this higher speed.

4.4.3.2 Narrow Corridor Mode

CHARACTERISTIC	VALUE	DESCRIPTION
Speed	Variable between 0 - 0.3 m/s	Narrow Corridor Mode is utilized in aisles narrower than Normal Mode will allow. The speed of the OTTO 1500 V1.2 SDV is capped at 0.3 m/s to operate in a constrained space.
Turning	Open	Although Narrow Corridor Mode is designed to allow the OTTO 1500 V1.2 SDV to travel through narrow corridors, the vehicle can still turn freely. Turning is not affected by a safety field and follows the speed constraints outlined in the above row.
Direction	Bi-directional drive	In Narrow Corridor Mode, the OTTO 1500 V1.2 SDV will allow for the drivetrains to move in opposite directions, allowing the vehicle to perform zero point turns or any directional motion that does not violate the speed constraints outlined above on either drivetrain.

Table 4 Narrow Corridor Mode Characteristics

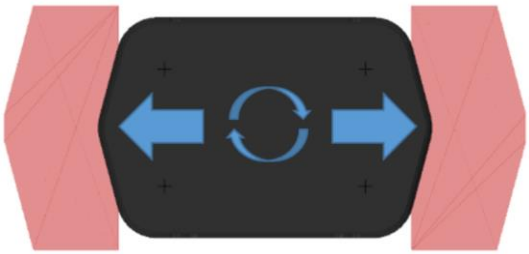


Figure 5 Narrow Corridor Safety Field Set

The above image shows the reduced safety field width, allowing an OTTO 1500 V1.2 SDV to operate in a narrow aisle.

If a person or obstacle is in the aisle, the OTTO 1500 V1.2 SDV will steer away from the object, creating clearance from the object and increased clearance through which a person to move.

4.4.3.3 Turning Mode

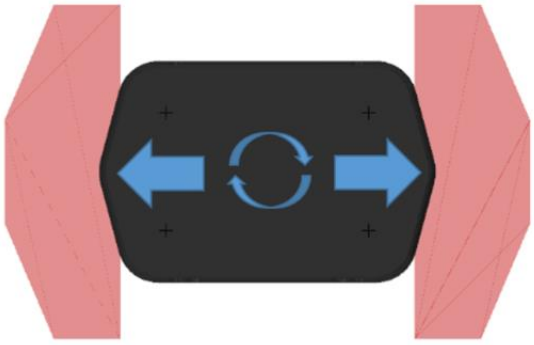


Figure 6 Turning Safety Field Set

OTTO 1500 V1.2 SDVs in Turning Mode can operate freely as long as the speed of any individual drive wheel does not exceed 0.3 m/s.

4.4.3.4 Docking Mode

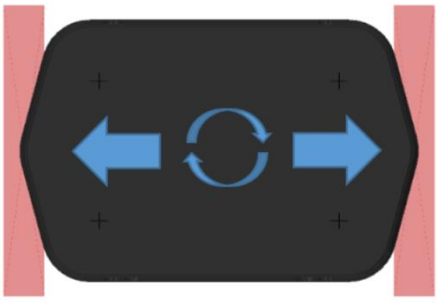


Figure 7 Docking Safety Field Set

OTTO 1500 V1.2 SDVs can operate freely as long as the speed of any individual drive wheel does not exceed 0.3 m/s. In this mode, the vehicle's safety field sizes are reduced to allow finer navigation around docks. Docking Mode safety fields in this mode do not allow for the stopping distance required to bring an OTTO 1500 V1.2 SDV to a complete stop at higher speeds.

WARNING

Never approach an OTTO 1500 V1.2 SDV while it is in Docking Mode. During this operation, the LiDAR safety field sizes are reduced. Objects are still detected in this mode and the vehicle will still use its autonomous function to prevent collisions.

In the case that an object or person enters the Safety Detection Range, the vehicle may not be able to stop to avoid a collision.

4.4.4 Attachment Interface

The OTTO 1500 V1.2 SDV is designed to be support an equipped attachment. Any attachment must interface with the OTTO 1500 V1.2 SDV to transmit fault signals as well as receive enable signals. The Emergency Stop system is configured such that both the attachment and the OTTO 1500 V1.2 SDV can initiate an Emergency Stop state, halting operations on both systems immediately.

See Attachment Interface and ICD-000004 - OTTO 1500 Attachment Interface for more detail. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

4.4.5 Brake Monitoring

The OTTO 1500 V1.2 SDV has been equipped with an electro-mechanical braking system that stops the vehicle from moving in the event of a Safety Stop, Emergency Stop, or power loss.

4.4.6 Battery Management System

To ensure the safety of the rechargeable batteries used in the OTTO 1500 V1.2 SDV, the vehicle is equipped with a Battery Management System (BMS) that provides cell voltage and temperature monitoring to report on battery status/health, in addition to diagnostic and data logging capabilities.

4.4.7 Footprint Safety

It should be noted that the overall profile including any attachment, payload, or combination thereof of the OTTO 1500 V1.2 SDV must remain within the Navigation Specification for each vehicle. This is measured by the projection of any part that has been extended outside the OTTO 1500 V1.2 SDV projected to the floor.

Depending on the attachment or payload to be mounted on an OTTO 1500 V1.2 SDV, the Navigation Specification may have to be adjusted to suit the attachment or payload to allow the vehicle 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 OTTO 1500 V1.2 SDV. Navigation Specifications are based on the largest possible combination of attachment and payload at all times.

CAUTION

The addition of components or payloads that would extend past that which is defined in the Navigation Specification will not be protected from collision during travel or identified by the OTTO 1500 V1.2 SDV in any way. The OTTO 1500 V1.2 SDV will not change speed or move otherwise to protect these extensions and will not prevent collision in any way.

Extension of payload height will not be detected by the OTTO 1500 V1.2 SDV. Payload height needs to be qualified in the facility of installation and inspected in all spaces in which the OTTO 1500 V1.2 SDV will operate to reduce the risk of a collision.

5 IN CASE OF A COLLISION

1. Stop the OTTO 1500 V1.2 self-driving vehicle (SDV) by pressing the **Emergency Stop** button on the side of the OTTO 1500 V1.2 SDV.
2. Is anyone hurt? Follow your internal procedures to address a workplace injury.
3. Document the incident.
    a. Note the time and place.
    b. Note which vehicle was involved.
    c. Interview any witnesses.
    d. Take photos or make a drawing.
4. Assess the state of the OTTO 1500 V1.2 SDV.
    a. Visually inspect the vehicle for damage and take photos of any damage found.
    b. If there is no visible damage, observe the vehicle after it returns to service.
    c. If any irregularities or differences in its behavior are observed, remove the affected OTTO 1500 V1.2 SDV from service and contact OTTO Motors support. If the damage is extensive, wait for communication from OTTO Motors before returning the vehicle to service.

Refer to Product Safety for more detail.

6 SYSTEM OVERVIEW

This section provides an overview of the important elements of the OTTO 1500 self-driving vehicle (SDV) system. The following figures give a tour of the key components of the OTTO 1500 V1.2 SDV for basic use.

6.1 System Specifications

COMPONENT	SPECIFICATION
Size and Weight	
Dimensions (L x W x H)	1810 x 1190 x 351 mm (71 x 47 x 13.85 in)
Mass	525 kg (1157 lbs)
Speed and Performance	
Maximum Total Payload	1500* kg (3306 lbs) * - 1900 kg option available
Maximum Speed	2.0 m/s (4.47 mph)
Turning Radius	0 mm (not programmable)
Suspension	Passive
Positional Accuracy	X, Y + / - 10 mm (0.4 in) Yaw + / - 1° Docking accuracy is subject to the deployment. Please speak to your OTTO Motors representative for more information.
Maximum Slope	5% / 3°
Drive Configuration	Differential Drive
Operating Environment	Indoor

Operating Temperature Range	0°C to 40°C (32°F to 104°F)
Non-Operating Temperature Range	0°C to 50°C (32°F to 122°F)
Battery and Power System	
Battery Chemistry	LiFePO4
Capacity	51 V Nominal 100 Ah
Charge Time	Designed for rapid-cycle opportunity charging
Drive Power	8760 W continuous
Interfacing and Communication	
Attachments and Accessories	Heavy Chassis Lift Attachment, Heavy Chassis Conveyor Attachment, OTTO Charge 1500, OTTO 1500 Manual Charger, Manual Drive Pendant, Payload Plate
Communication	Wifi (802.11 a/b/g/n/ac, 5 Ghz)
Attachment Control Systems Power	24 VDC, regulated, unswitched, 5A
Attachment Power Supplies	51.2 VDC nominal 50A, unregulated battery power, switched with safety circuit (51.2 VDC only)
Optional Attachment Interface	2x general purpose inputs and output, Ethernet POE, USB 2.0, CAN bus, attachment control line, attachment fault line, dual channel emergency stop breakout

7 COMPONENTS OVERVIEW

The components overview is intended to familiarize the user with some of the sensors and actuators in the OTTO 1500 self-driving vehicle system (SDV).

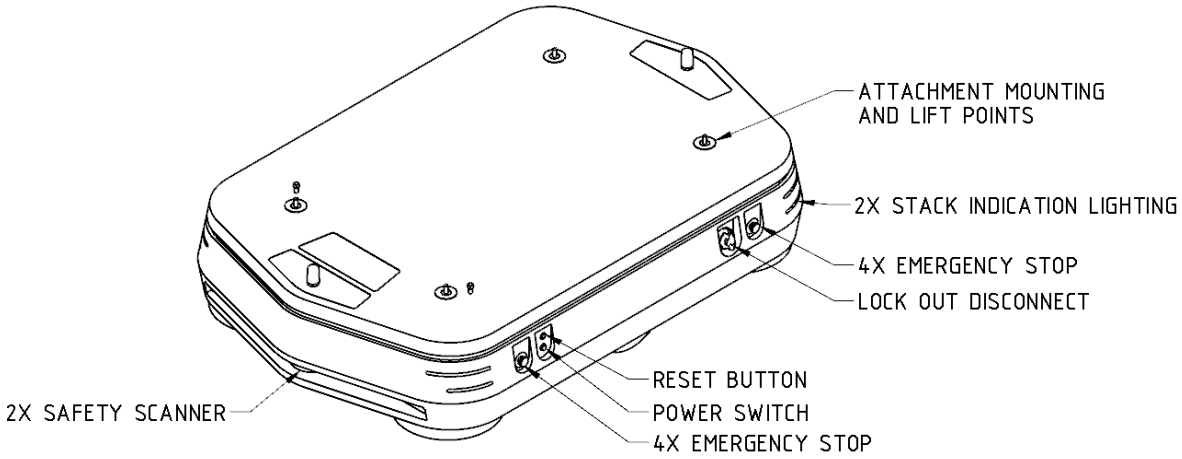


Figure 8 OTTO 1500 V1.2 SDV Port and Front

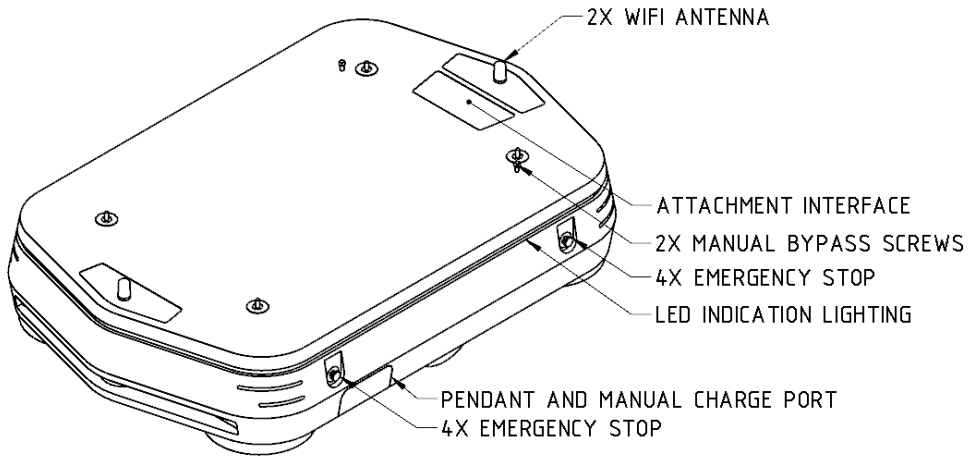


Figure 9 OTTO 1500 V1.2 SDV Starboard and Rear

7.1 Buttons and Ports

7.1.1 Emergency Stop Buttons

There are four Emergency Stop buttons - one located at each corner - on the OTTO 1500 V1.2 SDV that can be used to trigger an Emergency Stop state on the vehicle. Users should familiarize themselves with the Emergency Stops buttons and their locations on both the OTTO 1500 V1.2 SDV and any equipped attachment.

7.1.2 Safety Reset Button

The Safety Reset button is located above the Power Switch and is used by an operator to indicate that the OTTO 1500 V1.2 SDV is cleared for autonomous use. This button must be pressed following the OTTO 1500 V1.2 SDV's boot-up process to indicate the area is safe for autonomous navigation.

7.1.3 Power Switch

The Power Switch on the OTTO 1500 V1.2 SDV is a simple two-state switch that allows operators to turn the vehicle on and off. Once switched on, the OTTO 1500 V1.2 SDV can take up to 5 minutes to start up or shut down.

CAUTION Do not interact with the Power Switch during the start up or shut down sequence.

7.1.4 Attachment Interface

The Attachment Interface houses all the electrical connections for the attachment to interface with OTTO 1500. These connections are defined in ICD-000004.

See Attachment Interface and ICD-000004 - OTTO 1500 Attachment Interface for more detail. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

7.1.5 Pendant and Manual Charge Port Bay

The Pendant and Manual Charge Bay is a dual-purpose bay that allows operators to connect the OTTO 1500 Manual Charger or the Pendant used for manual control to an OTTO 1500 V1.2 SDV.

The bay is secured with a screw and also has a spring loaded hatch to keep the bay closed when it is not in use.

The Manual Charge Port includes a lock-out bracket for use during the Lock-Out/Tag-Out procedure outlined in **Basic Usage**.

7.1.6 Pendant Connection

The Pendant connection port is found behind the hinged plate on the side of the OTTO 1500 V1.2 SDV. To access the port, remove the screw and open the plate 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.

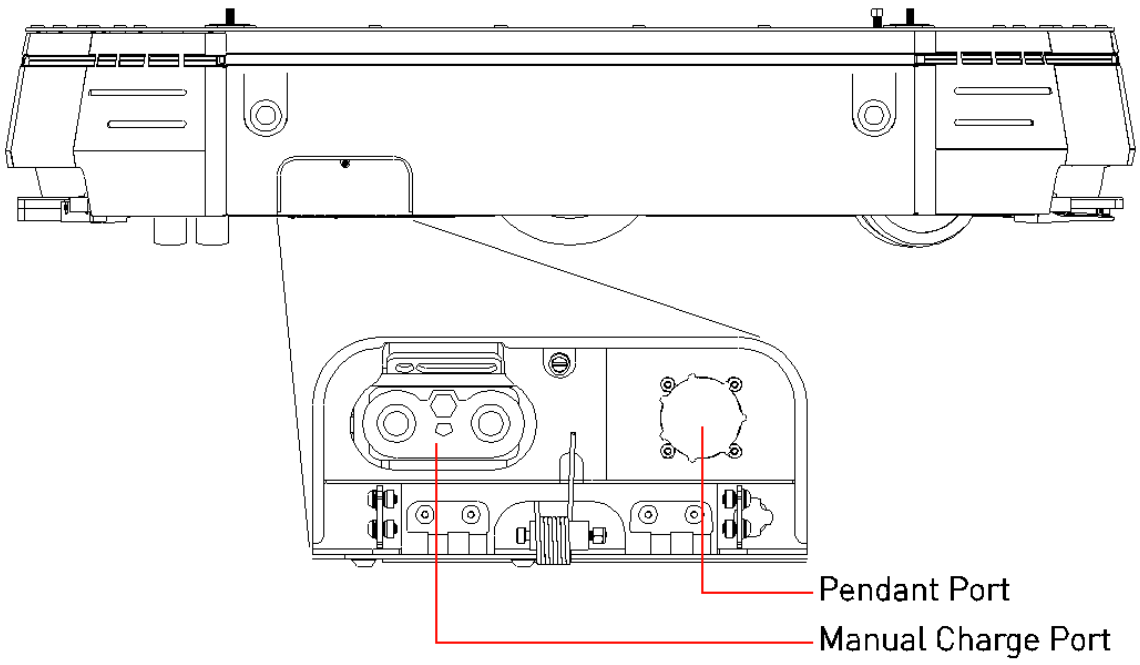


Figure 10 Pendant and Manual Charge Port Bay

7.2 Vehicle State Indicators

7.2.1 Light Pipe and Visual Indications

OTTO SDVs are equipped with light panels and pipes designed to signal what a vehicle is doing at any given time by changing the light color and flashing frequency - the light pattern - to indicate a vehicle's state or motion. Coupled with audible indications, vehicles will always make it obvious what behavior you can expect.

NAME	DESCRIPTION	VISUAL INDICATION
Starting Up	The OTTO SDV is on but has not completed the boot cycle.	 Full Solid Dull White
Normal Travel	The OTTO SDV is traveling normally.	 Front Solid Dull White Rear Solid Red
Reversing	The OTTO SDV is reversing.	 Rear Solid Dull White in direction of travel Front Solid Red with Dull White
Turning	The OTTO SDV is turning.	 Side Blinking Yellow in turn direction
Charging	The OTTO SDV is charging at a Charging Dock.	 Rear Corners Red Green Slowly Expanding indicating charge level Front Corners Orange
Charging v2.16 and later	The OTTO SDV is charging at a Charging Dock.	 Rear Corners Red Green Slowly Expanding indicating charge level in 20% increments Front Corners White

Parked	The OTTO SDV has entered a Parked state.	 Rear Corners Red Front Corners Dimmed
Docking	The OTTO SDV is docking.	 Front Solid Dull White Rear Solid Red Alternating Yellow Stripes
Narrow Corridor	The OTTO SDV is entering what it considers a narrow corridor.	 Front Dull White Rear Red Blinking Yellow Stripes
Manual Control v2.16 and later	The OTTO SDV is being manually controlled.	 Full Solid Blue Front Dull White
Manual Control v2.14 and earlier	The OTTO SDV is being manually controlled.	 Front Dull White Rear Red
Attachment Activated	The OTTO SDV has activated its attachment.	 Front Solid Dull White Rear Solid Red with Dull White Lights Strobe Effect
Working In Place	The OTTO SDV's movement is locked as it waits for further input from a user or attachment.	 Full Green
Blocked v2.16 and later	The OTTO SDV is blocked from proceeding on its planned path.	 Front Flash Yellow Rear Solid Red

Blocked **v2.14 and earlier**	The OTTO SDV is blocked from proceeding on its planned path.	 Front Solid Dull White Rear Solid Red
Safety Stopped	The OTTO SDV has been placed in a Safety Stop state.	 Front and Rear Flashing Red Front Narrow Solid Dull White
Emergency Stopped	The OTTO SDV has been placed in an Emergency Stop state.	 Full Flashing Red
Failed Target Find	The OTTO SDV has failed find its target (Dock, Cart, etc.).	 Front Solid Dull White Rear Solid Red
Lost	The OTTO SDV can't determine its location relative to its loaded Map.	 White Light Chasing
Lost Connection to WiFi/Fleet Manager	The OTTO SDV is disconnected from the WiFi signal/Fleet Manager.	 Front Flashing Yellow/Orange Rear Flashing Yellow/Orange Flashing color is dependent on OTTO SDV model and software version

Table 5 OTTO 1500 V1.2 SDV light pipe patterns and indicated state

7.3 Pendant

The Pendant allows for manual control of the OTTO 1500 V1.2 SDV.

See Basic Usage for detail on using the Pendant.

7.4 Manual Bypass Screws

The manual bypass screws allow the user to disengage the drive wheels from the floor and manually move the OTTO 1500 V1.2 SDV using the swivel castors. When the manual bypass screws are engaged, the vehicle will be free to move. See **Basic Usage** for detail on properly engaging the Manual Bypass Screws.

DANGER Payload weight and uneven floors can cause OTTO 1500 V1.2 SDV to move unexpectedly which poses a danger to users around the platform.

DANGER Do not leave the manual bypass screws in the OTTO 1500 V1.2 SDV. The screws can vibrate down and engage the rocker arms, causing unpredictable driving patterns and preventing the braking system from functioning properly.

DANGER With the bypass screws engaged, the OTTO 1500 V1.2 SDV will be free to move. Large payloads or uneven floors can create unpredictable or uncontrollable motion. Do not manually bypass the vehicle's drive wheels unless it is on flat ground. It is recommended that the payload be removed and the OTTO 1500 V1.2 SDV is moved with at least two people to maintain control.

7.5 WiFi Radio Antennas

There are two wireless antennas - one located at each end (front and rear) - of the OTTO 1500 V1.2 SDV.

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 OTTO 1500 V1.2 SDV, use one of the available extension kits to move the antenna to an appropriate location.

See ICD-000004 - OTTO 1500 Attachment Interface and RQS-000006 - IT Infrastructure Requirements for more detail. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

7.6 Perception Sensors

7.6.1 Safety LiDAR

DANGER

Obstacles outside of the LiDAR detection plane will not be identified by the OTTO 1500 V1.2 SDV's safety systems. While auxiliary sensors such as the 3D Perception Camera may detect the obstacles, it is a navigational aid only and should not be relied upon as a safety system.

OTTO 1500 V1.2 SDVs move and travel differently depending on several factors including any detected obstacles, the vehicle's speed, the currently occupied Zone, and the vehicle's current Step, Task, or Job.

There are two LiDAR safety scanners on the OTTO 1500 V1.2 SDV - one on each end of the vehicle. 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 OTTO 1500 V1.2 SDV to its surroundings when localizing to a Map, planning paths, and interacting with local infrastructure.

See Product Safety for more detail on safety system functionality.

7.6.2 Relative Encoders

Relative encoders are used to measure the rotational position and speed of the platform drive wheels and aid in tracking its odometry. These encoders are also used by the safety system to produce the safety field based on the velocity of the system.

7.6.3 Thermal Detectors

There are multiple thermal detectors in the OTTO 1500 V1.2 SDV positioned in the motors, brakes, battery, and electronics enclosure to ensure proper function and detect failure.

7.7 Swivel Castors and Drive Wheels

The OTTO 1500 V1.2 SDV is equipped with four swivel castors - one on each corner of the OTTO 1500 V1.2 SDV - used for load bearing purposes only. The swivel castors do not drive, steer, or brake the vehicle. There are two drive wheels on the vehicle, located at the center of each side.

The swivel castors 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 electro-mechanical brake.

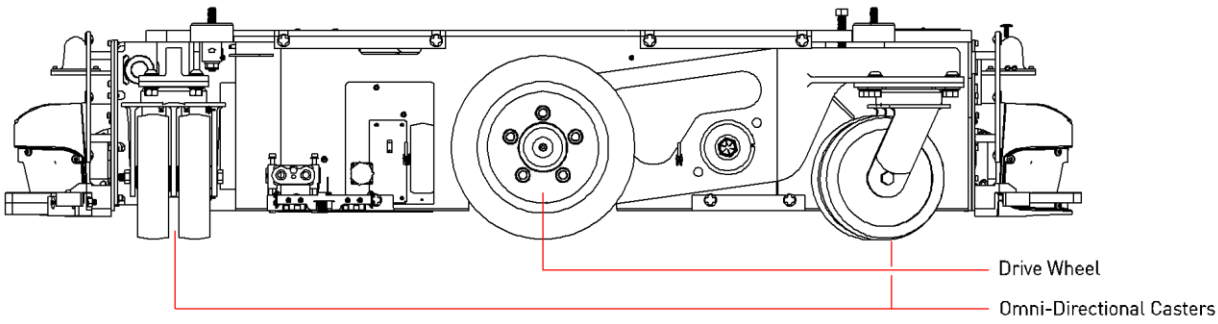


Figure 11 OTTO 1500 Drive System

7.8 Attachment Mounting and Lift Points

The four attachment mounting and lift point locations are used to hoist the OTTO 1500 V1.2 SDV for transport or physically mount attachments to the vehicle.

See Attachment Interface for more detail and exact specifications for the attachment mounting and lift point locations.

7.9 Lock-Out/Tag-Out

The OTTO 1500 V1.2 SDV is equipped with a Lock Out Disconnect switch equipped with a lock location, allowing operators to remove energy from the system by disconnecting the battery pack from the rest of the system.

See Basic Usage for instructions on Lock-Out/Tag-Out.

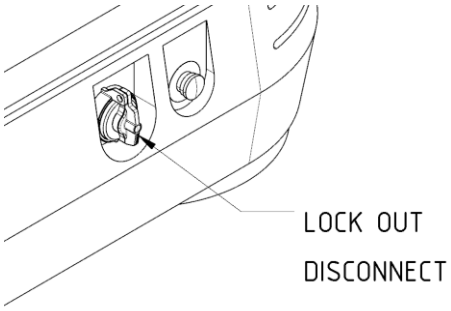


Figure 12 Manual Disconnect Switch

DANGER Not properly following the Lock-Out Tag-Out procedure can result in live voltage locations on the OTTO 1500 V1.2 SDV. Always be sure to Lock-Out/Tag-Out the vehicle before proceeding with inspections and maintenance.

DANGER The OTTO 1500 V1.2 SDV is a battery-operated system and will remain live at the battery cells and terminals. Any operations that require the removal of the cell covers shall be done by an OTTO Motors or equivalently trained technician.

7.10 Battery Pack

The OTTO 1500 V1.2 SDV uses a Lithium-iron Phosphate battery pack connected in series through a Battery Management System (BMS). An additional 12V lead-acid battery backup power supply is connected to the BMS to provide State-of-Charge and error code data when the system is powered off. The BMS will also report if there is a battery malfunction in the main pack. The backup power supply also provides a redundant power supply to control the safety contacts for the main battery cells.

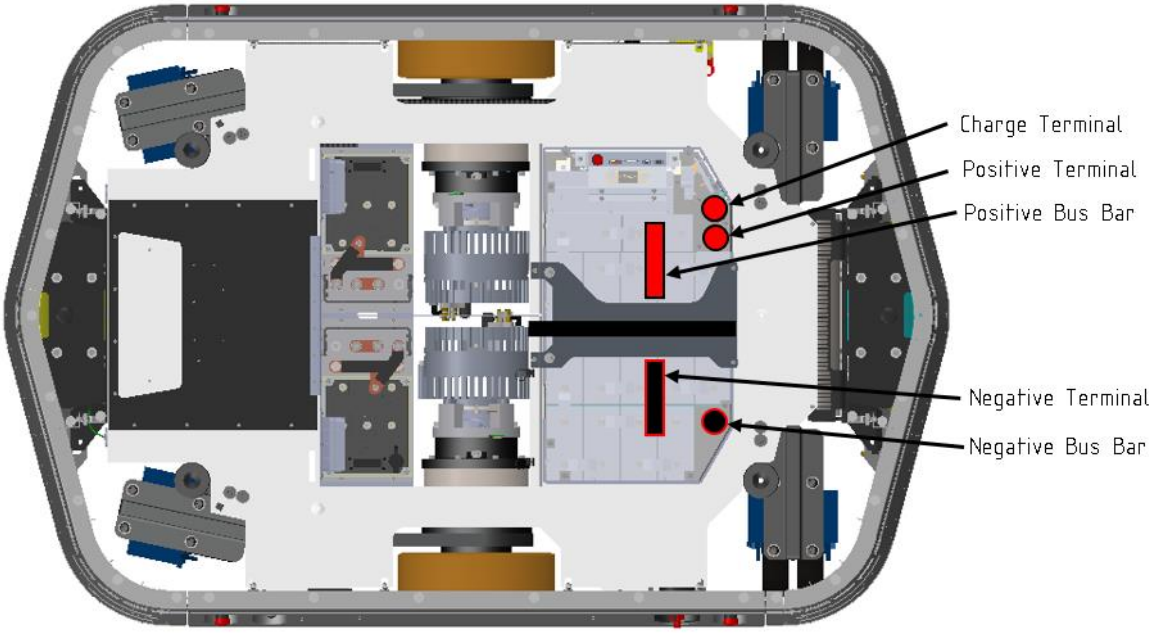


Figure 13 Live Voltage Locations

The power supplied to the motor controllers is routed through a main contactor relay. When an Emergency Stop state is triggered, the main contactor relays release, disconnecting the power supply from the motor controllers.

See the System Overview for OTTO 1500 V1.2 SDV battery system specifications.

CAUTION To avoid damaging the battery pack, do not operate the OTTO 1500 V1.2 SDV outside of the operating temperatures outlined in the **System Overview**.

7.11 Large Vehicle Controller

The Large Vehicle Controller (LVC) is the central nervous system of the OTTO 1500 V1.2 SDV and provides the central interface point between the computer, sensors, and actuators. The LVC system also provides low-level control and is an integral part of the safety control of the system. The motor controllers, electromechanical brakes, lights, and system power are all controlled by or connected to the LVC.

7.12 Onboard Computer

The OTTO 1500 V1.2 SDV has an onboard computer that performs all autonomous navigation and control of the vehicle. Environmental perception, navigation, and goal planning for the OTTO 1500 V1.2 SDV are the core autonomy functions that run on this computer.

7.13 Communication Network

The majority of the OTTO 1500 V1.2 SDV's components communicate directly through the LVC node. LiDAR safety scanners communicate directly with the onboard computer via USB.

2 CAN bus networks operate on the platform to provide communication between the safety critical components - one CAN bus provides communication between the LVC, computer, BMS, and interface, while the second CAN bus provides communication between the LVC, computer, 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.

8 BASIC USAGE

This section describes the operation of the OTTO 1500 V1.2 self-driving vehicle (SDV).

DANGER

Prior to using the OTTO 1500 V1.2 SDV, the surrounding area must be approved for autonomous navigation by an OTTO Motors representative. Never use the OTTO 1500 V1.2 SDV in an area without prior consultation by an OTTO Motors representative.

8.1 Lock-Out/Tag-Out

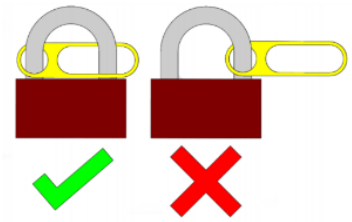
DANGER

Do not switch the Lock Out Disconnect without powering down the SDV with the rocker switch first. This will cause an improper shut down sequence and can cause damage to the OTTO 1500 V1.2 SDV.

In order to complete maintenance or inspection on the OTTO™ 1500 self-driving vehicle (SDV), ensure that the correct lock-out tag-out procedure has been followed to remove energy from the system.

1. Switch the **Power Switch** to the *OFF* position.
2. Wait until the indication lights have completely turned off.
3. Switch the **Lock Out Disconnect** to the *OFF* position.
4. Apply the first lock and tag to the **Lock Out Disconnect**.
5. Find and open the **Pendant and Manual Charge Port** on the side of the vehicle.
6. Apply the second lock and tag above the **Manual Charge Port**.

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



Each operator working on the platform must connect their own lock.

8.2 First Start-Up

Prior to operating the OTTO 1500 V1.2 SDV 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.

CAUTION Before performing these tests, ensure that the test area is safe to operate within and has been cleared of obstacles.

1. Visually inspect the exterior of the OTTO 1500 V1.2 SDV for any damage.
2. Inspect both the front and rear LiDAR scanners to ensure that the optical elements are not dirty or obstructed by foreign material.

CAUTION Do not wipe the lens of the safety scanner with anything not approved by OTTO Motors.

3. Press one of the four **Emergency Stop** buttons located at each corner of the OTTO 1500 V1.2 SDV to confirm the OTTO 1500 V1.2 SDV enters an Emergency Stop state.
4. Ensure that the OTTO 1500 V1.2 SDV is on flat ground prior to manual bypassing the drive motors.

DANGER The braking system on the OTTO 1500 V1.2 SDV will only function when the drive wheels are in contact with the floor. Once the manual bypass is engaged the OTTO 1500 V1.2 SDV will roll freely on its swivel castors. Ensure that the OTTO 1500 V1.2 SDV is on flat ground before manual bypassing the drive wheels.

5. Manually bypass the drive wheels of the OTTO 1500 V1.2 SDV. With the drive wheels raised off the ground, the safety system can now be validated without creating a hazard.
6. After performing the above instructions, the OTTO 1500 V1.2 SDV is ready to be powered on for the first time. Start up the OTTO 1500 V1.2 SDV. The drive wheels should not spin or attempt to create motion.
7. Disengage the drive wheel manual bypass.
8. Connect the Pendant to the pendant connection port.

9. Confirm that all Emergency Stop buttons on the OTTO 1500 V1.2 SDV, Pendant, and any equipped attachment are released.
10. On the Pendant, press and hold the yellow **Enable** button in the middle *ON* position.

> See Driving using the Pendant for more detail on using the Pendant.

11. Press the **Safety Reset** button on the OTTO 1500 V1.2 SDV. You will hear an audible click from the system and the light pipe will indicate that the OTTO 1500 V1.2 SDV is now in Manual Drive mode.
12. 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 OTTO 1500 V1.2 SDV responds accordingly.
13. After testing the drive system, disconnect the Pendant and allow the OTTO 1500 V1.2 SDV to begin driving autonomously.

> If the OTTO 1500 V1.2 SDV 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.

8.3 Starting Up

> See the Components Overview for details on button locations and vehicle state indicators.

> ⚠ **CAUTION** Note that when cycling power, the OTTO 1500 V1.2 SDV should be given at least 5 minutes between each state change (power on or power off).

1. Switch the **Power Switch** to the *ON* position.
2. The OTTO 1500 V1.2 SDV will begin its boot up sequence - this sequence should take between 30 and 60 seconds.
3. Once the boot up is complete, the OTTO 1500 V1.2 SDV will indicate an Emergency Stop state.
4. Confirm that all **Emergency Stop** buttons are released.
5. Press the **Safety Reset** button to clear the Emergency Stop state and return the OTTO 1500 V1.2 SDV to normal operation.

> If the OTTO 1500 V1.2 SDV 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 OTTO 1500 V1.2 SDV takes more than 6 minutes to boot or never indicates an Emergency Stop state during start up, contact OTTO Motors Support for assistance.

8.4 Shutting Down

CAUTION Note that when cycling power, the OTTO 1500 V1.2 SDV should be given at least 5 minutes between each state change (power on or power off).

1. Press an **Emergency Stop** button on the OTTO 1500 V1.2 SDV.
2. Switch the **Power Switch** to the *OFF* position.
3. Wait at least 5 minutes for the OTTO 1500 V1.2 SDV to shut down.

8.5 Charging

If the OTTO 1500 V1.2 SDV included an OTTO Charge 1500 V1.2, vehicles will be sent to charge autonomously without human intervention.

If the installation relies on a Manual Charger, perform the following steps:

1. Maneuver the OTTO 1500 V1.2 SDV into position next to the Manual Charger by driving it manually, autonomously, or moving it manually with the drive wheels manually bypassed.
2. Press an **Emergency Stop** button on the OTTO 1500 V1.2 SDV.

   Shut the OTTO 1500 V1.2 SDV down if you want to prevent the vehicle from indicating an Emergency Stop state.

3. Connect the Manual Charger to the manual charge port on the OTTO 1500 V1.2 SDV. The connector will click into position.

   CAUTION Do not attempt to connect the OTTO 1500 V1.2 Manual Charger to an OTTO 1500 V1.2 SDV while it is docked with an OTTO Charge 1500 V1.2 as this can result in damage to either charger.

Note that if the OTTO 1500 V1.2 SDV'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.

WARNING Always charge in a well-ventilated area with the charger's cooling fins of obstructions that may block airflow. Manual Charger may be hot after charging.

8.6 Moving an Unpowered OTTO 1500 V1.2

8.6.1 Drive Wheel Manual Bypass

In the event of having to manually bypass the drive wheels on the OTTO 1500 V1.2 SDV, the manual bypass screws should always be accessible, including when there is an attachment in place.

1. Ensure that the OTTO 1500 V1.2 SDV will not shift suddenly or roll when the drive wheels disengage with the floor. The OTTO 1500 V1.2 SDV will no longer be able to brake once the drive wheels lose contact with the floor.
2. Shut down the vehicle.
3. 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.
4. Once the drive wheels are bypassed, the OTTO 1500 V1.2 SDV can be easily moved on its swivel casters by pushing or pulling OTTO 1500 V1.2 SDV in the desired direction.

8.6.2 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.

8.7 Moving and Unpacking

There are two methods for moving an OTTO 1500 V1.2 SDV using a forklift, crane, or hoist. Method 1 - lifting the OTTO 1500 V1.2 SDV using the lift point locations - is the preferred method and is recommended at all times by OTTO Motors.

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 either lifting method.

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

DANGER Care should be taken to ensure that the OTTO 1500 V1.2 SDV does not shift or move during any hoisting or lowering activities.

DANGER If the vehicle has been moved or shipped with the drive wheels manually bypassed, it may be prone to shift its position because there is no active braking. The four load-bearing wheels are swivel castors and are not equipped with brakes.

CAUTION Lifting the OTTO 1500 V1.2 SDV in any manor other than that specified may result in permanent damage to the vehicle.

8.7.1 Method 1

The OTTO 1500 V1.2 SDV is equipped with four lift point locations as seen in the **Components Overview**. Lifting the OTTO 1500 V1.2 SDV using the lift point locations is the preferred and recommended method.

> **CAUTION** Avoid lifting or lowering the OTTO 1500 V1.2 SDV without level rigging. Contact with the front or rear LiDAR may result in critical damage to the sensors.

8.7.1.1 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)

OTTO 1500 V1.2 without Attachment

- 4 x Eye Nuts - McMaster 3019T34 (https://www.mcmaster.com/catalog/125/1593)

OTTO 1500 V1.2 with Attachment

- 4 x Eye Bolts - Grainger 35Z479 (https://www.grainger.com/product/FABORY-Eyebolt-35Z479)

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

8.7.1.2 Procedure

1. Shut down the OTTO 1500 V1.2 SDV.
2. Thread the Eye Nuts to the lift point locations on the OTTO 1500 V1.2 SDV 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 (Heavy Chassis Lift Attachment, Heavy Chassis 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 OTTO 1500 V1.2 SDV can now be lifted.

8.7.2 Method 2

The OTTO 1500 V1.2 SDV can also be lifted from the bottom using a forklift. Lifting the OTTO 1500 V1.2 SDV without using the lift point locations on the vehicle or attachment is not recommended by OTTO Motors and should only be attempted when Method 1 cannot be used.

CAUTION Avoid lifting or lower OTTO 1500 V1.2 SDV without level rigging. Contact with the front or rear LiDAR may result in critical damage to the sensors.

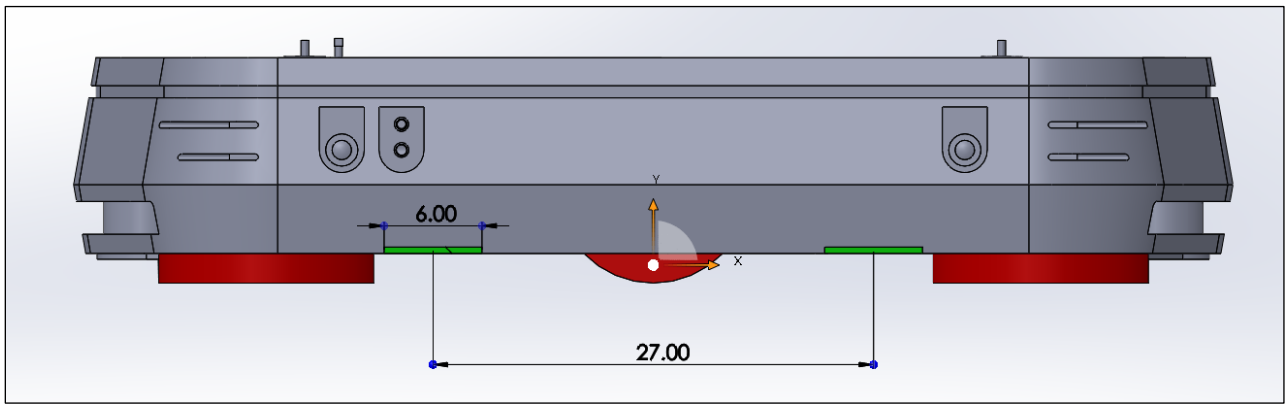


Figure 14 OTTO 1500 V1.2 SDV bottom-lift locations

8.7.2.1 Procedure

1. Shut down the OTTO 1500 V1.2 SDV.
2. Ensure that there are no straps, containers, or other obstacles that will catch or snag the vehicle as it is lifted and maneuvered.
3. Position the forklift on the side of the OTTO 1500 V1.2 SDV without the Pendant and Manual Charge Port Bay.

   See the Components Overview for more detail.

4. Position the forklift tines horizontally according to the image above.

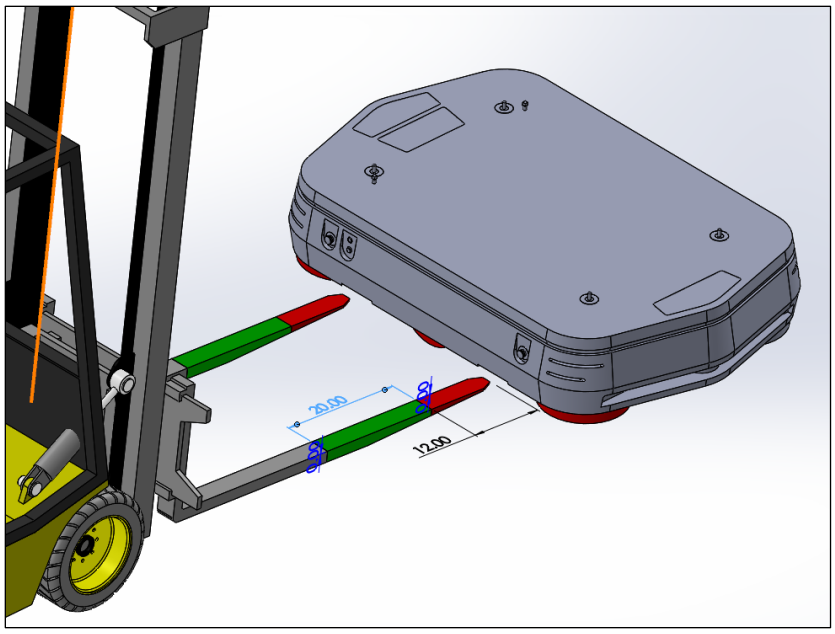


Figure 15 Forklift method tine positioning

5. The forklift tines should penetrate at least 12 in under the OTTO 1500 V1.2 SDV before making contact with the vehicle and the forklift tines should penetrate at least 32 in before attempting to lift the vehicle (see above).

> **CAUTION** Do not impact the side of the OTTO 1500 V1.2 SDV with the load backrest as it can damage the skins.

6. Use the tilt to ensure proper depth of engagement prior to contact with the vehicle. When lifting, the fork tines should be as flat as possible and parallel to the bottom of the OTTO 1500 V1.2 SDV.

> **CAUTION** The side skins on the vehicle are extended from the frame underneath and can be damaged by contact with the fork tines.

7. Once the minimum amount of engagement has been achieved the vehicle can be lifted.

> **CAUTION** The OTTO 1500 V1.2 SDV must remain flat and not be permitted to move on the fork tines.

8.8 Storage

Before storing the OTTO 1500 V1.2 SDV 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 vehicle when storing the OTTO 1500 V1.2 SDV for an extended period of time.

See Shutting Down for details.

8.9 OTTO App

OTTO App can be used to wirelessly control an OTTO 1500 V1.2 SDV if it's already connected to a wireless network.

If you're driving the OTTO SDV for the first time, you may need to connect it to your network. See 1.1 Connecting the OTTO 1500 V1.2 SDV to the Network for more detail.

8.9.1 Driving an OTTO SDV Manually

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

1. Launch the OTTO App for the OTTO SDV that you want to drive.
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** toggle to activate **Manual** mode. The **Drive Mode** toggle will turn green and a white joystick will appear.
4. Drive the OTTO SDV by selecting and holding the white joystick and moving it in the direction you want the OTTO SDV to travel.

CAUTION

The joystick affects the speed at which the OTTO SDV travels - the farther you push the joystick, the faster the OTTO SDV will travel.

To adjust the top speed at which an OTTO SDV will travel, tap the **Speed** toggle. OTTO SDVs will drive slower when the **Speed** toggle is disabled and its field sets will narrow for easier navigation around close objects.

8.9.2 Driving an OTTO SDV Autonomously

If the OTTO SDV 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 SDV cannot be driven autonomously via OTTO App.

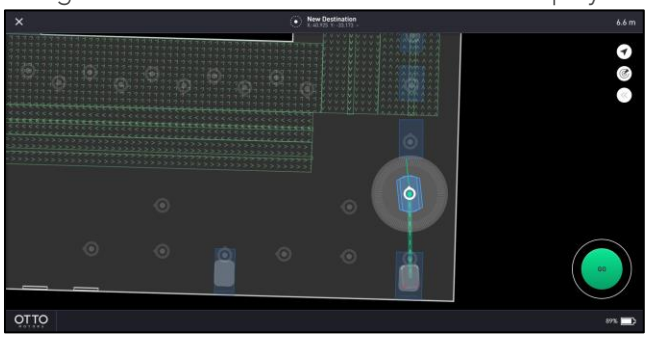
> **CAUTION** Drive with caution and make sure to never lose sight of the OTTO SDV.

1. Launch the OTTO App for the OTTO SDV that you want to drive.
2. Select either **Drive** or **Map** from the Main Menu ☰ to display the navigation controls in the bottom-right corner of the screen.

3. Make sure the **Drive Mode** 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.
4. Select **Move**. The joystick button will turn gray.

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

5. Select the location on the Map to which you want to send the OTTO SDV. The joystick button will turn green and the orientation circle will be displayed at the selected location on the Map.



6. Move the green line inside the orientation circle to define the direction in which you want the OTTO SDV to be facing when it stops at the selected location.

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

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

8.9.3 Driving using Markers

If at least one Marker is set up in the Map, OTTO can be sent directly to it.

1. Launch the OTTO App for the OTTO SDV that you want to drive.
2. Select **Main Menu** ☰ then select **Drive**.
3. Select **Markers**.
4. Select a Marker from the list.
5. Select **Go** to send the OTTO SDV on its way. A "Moving" notification is displayed.
6. Select **Stop** to stop the OTTO SDV at any time.

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

8.9.4 Driving using Waypoints or Routes

Use the OTTO App Workstation functionality to send an OTTO SDV to any previously configured Waypoint or Route.

1. Launch the OTTO App for the OTTO SDV that you want to drive.
2. Select **Main Menu** ☰ then select **Workstation**.
3. Select the desired Waypoint or Route.
4. Select **OK** to send the OTTO SDV on its way. A "Moving" notification is displayed.
5. Select **Stop** to stop the OTTO SDV at any time.

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

8.9.5 Localizing

If the OTTO SDV has been moved away from where it was last turned off or a new Map has been loaded, it will need to relocalize - this is usually automatic but occasional issues can occur if there are several parts of the Map that look similar.

To manually localize:

1. Launch the OTTO App for the OTTO SDV that you want to localize.
2. Select **Main Menu** ☰ then select **Map**.
3. Select **Advanced** then select **Localize**.
4. Select the position on the Map that corresponds to the real-world position of the OTTO SDV then drag in the direction corresponding to the 'front' of the OTTO SDV and release.
5. Verify that the OTTO SDV icon appears in the right location.

8.10 Driving using the Pendant

The OTTO 1500 V1.2 SDV can be driven manually using the Pendant. The Pendant includes directional buttons - Forward, Reverse, Left Turn, Right Turn - and an Enable, Emergency Stop, and Emergency Stop Reset button.

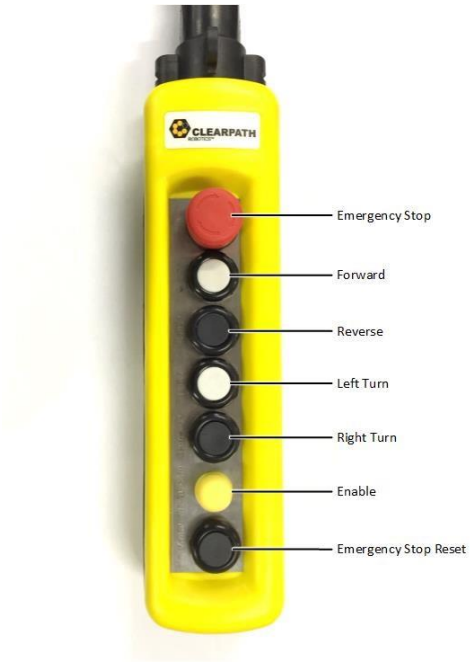


Figure 16 Pendant Controller

The Pendant directional buttons are dual-acting (two depressed states). The first level of depression allows the OTTO 1500 V1.2 SDV to move at slow speed and the second level allows movement at a faster speed.

The Enable button is a double-pole design allowing for 3 unique positions. The OTTO 1500 V1.2 SDV 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 operate in the *OFF* position.

WARNING When the Pendant is being used, the LiDAR field sets will be ignored and there will not be any autonomous obstacle avoidance. Pay close attention to where the OTTO 1500 V1.2 SDV is and avoid obstacles as you use the Pendant.

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 OTTO 1500 V1.2 SDV, Pendant, and any equipped attachment are released.

3. On the Pendant, press and hold the yellow **Enable** button in the middle *ON* position.
4. Press the **Safety Reset** button on the OTTO 1500 V1.2 SDV. You will hear an audible click from the system and the light pipe will indicate that the OTTO 1500 V1.2 SDV 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 OTTO 1500 V1.2 SDV.

8.11 Fleet Manager

The OTTO™ Fleet Manager software is the web application used to manage the behavior of a fleet of OTTO SDVs. Using Fleet Manager, you can customize how your OTTO SDVs move and work within your facility. You can also monitor the state and real-time movements of each vehicle in the fleet, as well as the status of all active and queued Jobs.

8.11.1 Connecting to the OTTO 1500 V1.2 SDV

OTTO™ self-driving vehicles (SDV) can be interfaced with on an individual basis using a computer and network cable.

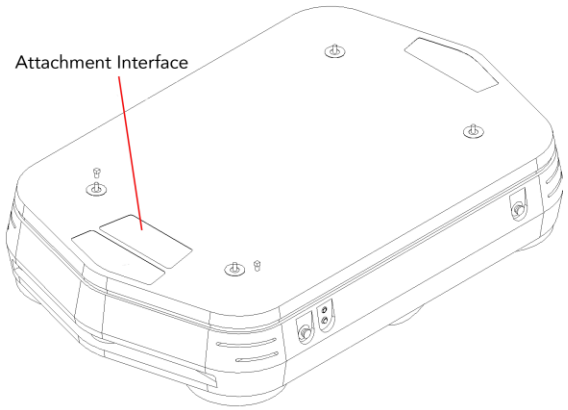
8.11.1.1 Connecting Network Cable

1. Using a network cable, connect the OTTO SDV to your computer.

   OTTO 1500 Self-Driving Vehicle

   The Ethernet port is located in the attachment interface bay on the top of the OTTO SDV.

   > Note that on OTTO 1500 V1.2 SDVs, the ethernet port is also used by ethernet-connected appliances attached to the SDV. If necessary, disconnect the appliance's network cable to connect your computer's network cable.



8.11.1.2 Setting Your Computer's Network Address

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

- **Network Address**: 10.255.255.20
- **Netmask**: 255.255.255.0

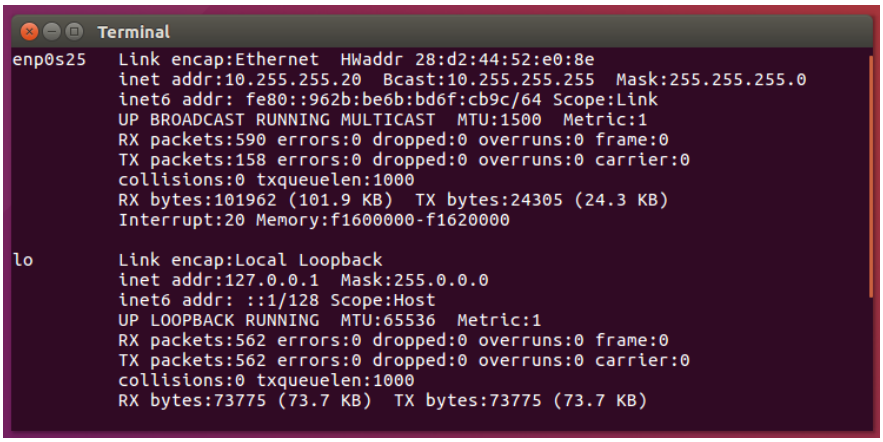
The steps below outline how to do this on Linux and Windows 7; for other operating systems, refer to the relevant documentation. Note that these steps will only need to be performed once per computer.

8.11.1.2.1 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**, enter 10.255.255.20 for the Address and 255.255.255.0 for the 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:

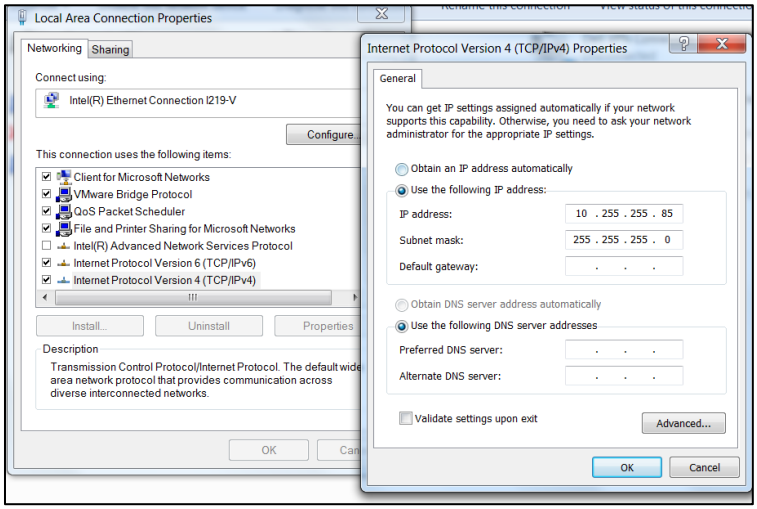
```
ifconfig
```

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



8.11.1.2.2 Windows 7

1. In the bottom-right corner of the screen, right-click the **Network icon** and click **Open Network and Sharing Center**.
2. Click **Change adapter settings**.
3. Right-click **Local Area Connection** and click **Properties**.
4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**.



5. In the **IP address** field, enter 10.255.255.20 and in the **Subnet mask** field, enter 255.255.255.0.
6. Click **OK** > **OK**.
7. Open a **Command** window and enter the following command:

```
ipconfig
```

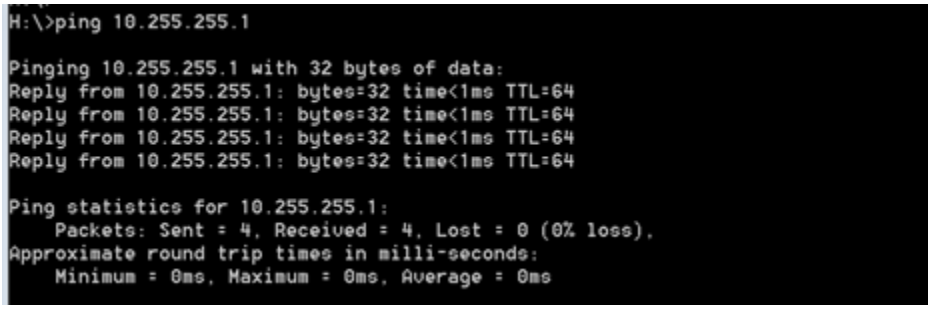
8. In the data that is returned, the `IPv4 Address` should match the address entered in **Step 5** above.

8.11.2 Pinging the OTTO SDV

1. Confirm that you can ping the OTTO SDV you plan to configure from the terminal window in Linux or the command prompt in Windows by entering the following command:

```
ping 10.255.255.1
```

You should receive a response similar to the following:



Some older OTTO 1500 V1.2 SDV models use a different IP address. If you're attempting to connect to an OTTO 1500 V1.2 SDV and didn't receive a ping response using the above IP address, change your computer's static IP address to 10.252.252.20 (see Setting Your Computer's Network Address) and attempt pinging 10.252.252.1.

If you're still unable to ping the OTTO 1500 V1.2 SDV, contact OTTO Motors Support.

- If you are configuring a single OTTO SDV that *will not* be added to a fleet using the OTTO Fleet Manager software, see **Connecting the OTTO 1500 V1.2 SDV to the Network**.
- If you are configuring an OTTO SDV that *will* be added to a fleet using the OTTO Fleet Manager software, the OTTO SDV must be on the same software version as the OTTO Fleet Manager.

CAUTION Once the correct software version is loaded onto the OTTO SDV, see **Connecting the OTTO 1500 V1.2 SDV to the Network**.

8.11.3 Connecting the OTTO 1500 V1.2 SDV to the Network

You'll need to connect your OTTO™ self-driving vehicle (SDV) to your network to truly take advantage of the SDV's autonomous capabilities.

1. Connect your computer to the OTTO SDV via ethernet cable.

   See Connecting to the OTTO 1500 V1.2 SDV for more information.

2. From a browser, navigate to `10.255.255.1:8090`.
3. OTTO Network Setup will be displayed. Expand **Hostname Settings**. Enter a **Hostname** for the OTTO SDV. 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 SDV.

4. Click **Apply**.
5. Expand **Network Settings**:
   a. Enter your network's **Access Point Name** (ssid) and **Passkey**, then click **Apply**.
   b. Select an **IP Type**.
      i. To assign a Static IP address, select *Static IP* from the **IP Type** drop-down. Configure the fields as required and click **Apply**.
      ii. To use a Dynamic IP address assigned by the network, select *Dynamic IP* from the **IP Type** drop-down and click **Apply**.
6. Restart the OTTO SDV using its restart button.

   The OTTO App can now be accessed over Wi-Fi for the configured OTTO SDV. 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 SDV in place of the hostname.

7. If you're configuring an OTTO SDV that will be added to a fleet using OTTO Fleet Manager, see **Adding the OTTO 1500 V1.2 SDV to Fleet Manager**; but, if you're configuring a single OTTO SDV that won't be added to a fleet, you're done!

8.11.4 Adding the OTTO 1500 V1.2 SDV to Fleet Manager

Your computer must be connected to the OTTO™ self-driving vehicle (SDV) and the SDV must be connected to your network.

> For more information, see Connecting the OTTO 1500 V1.2 SDV to the Network and Connecting the OTTO 1500 V1.2 SDV to the Network.

1. From a browser, navigate to `10.255.255.1:8090`. The IP Configuration screen is displayed.
2. On the setup screen, expand the **VPN Settings** section.
3. Enter the **VPN Port** and **VPN Password** for your facility.
4. Confirm the **Local VPN IP** and **Netmask** are as expected.

   > The Local VPN IP address should be unique from other vehicles in the fleet and cannot match the default Local VPN IP address of the Fleet Manager VPN IP (172.20.1.1).
   >
   > Example
   > Local VPN IP : 172.20.1.<XXX> (Where XXX coresponds to a unique value of your choice that is unique from other vehicles or Fleet Managers on your network.)
   > Netmask : 255.255.255.0

5. Enter the **Fleet Manager Hostname (or IP)**.

   > In a Multi-Host Deployment, this will be the Core IP address found under Host Information in Fleet Manager Settings.

6. Click **Exchange VPN Keys**.
7. Verify the OTTO self-driving vehicle is now connected to the OTTO Fleet Manager:
   a. In a new browser tab, open the OTTO Fleet Manager.
   b. Navigate to **Monitor** > **Vehicles** and in the list of vehicles in the fleet that is displayed, verify the new vehicle has been added. Note that it may take a few minutes for the vehicle to be displayed.
8. If the vehicle does not connect, restart the OTTO self-driving vehicle and the OTTO Fleet Manager.
9. If you are adding the vehicle to an existing OTTO Fleet Manager that has already been configured, restart all jobs in the job queue.

9 ATTACHMENT INTERFACE

The attachment interface sits between the OTTO 1500 V1.2 self-driving vehicle (SDV) base platform and the attachment subsystem. OTTO 1500 V1.2 SDVs can interface with several different attachments; therefore, the vehicle attachment interface includes attachment detection and handshaking to ensure that the vehicle is aware of the attachment.

Because each attachment has 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 (eg. move here).

For more information regarding communication between the attachment, the OTTO 1500 V1.2 SDV, 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 OTTO 1500 V1.2 SDV 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 48V 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).

See the Operations and Maintenance Manual for the OTTO 1500 Lift or Conveyor Attachment for more detail. These documents are available on the OTTO Motors Knowledge Base under help.ottomotors.com.

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 OTTO 1500 V1.2 SDV.

The location of the WiFi radio antennas on the OTTO 1500 V1.2 SDV must allow for the wireless signal to be available in all orientations of the vehicle relative to communication nodes. In the event that an attachment design will block one or both WiFi radio antennas on the OTTO 1500 V1.2 SDV and impede the vehicle'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 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 vehicle chassis via four attachment mounting points (see below).

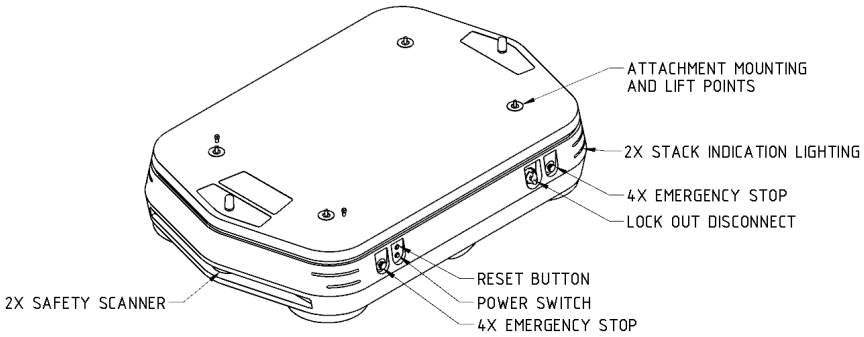


Figure 17 OTTO 1500 V1.2 SDV Port and Front

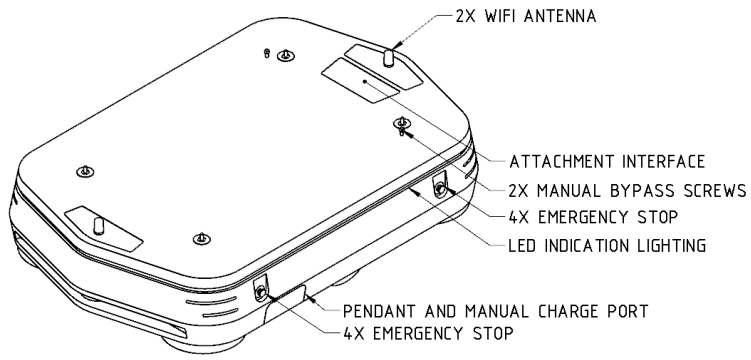


Figure 18 OTTO 1500 V1.2 SDV Starboard and Rear

In the baseline chassis configuration, the four mounting points are coupled to basic mounting blocks. Dimensions of the four mounting points are provided in ICD-000005 - OTTO 1500 Mechanical Interface.

See ICD-000005 - OTTO 1500 Mechanical Interface for more detail. These documents are available on the OTTO Motors Knowledge Base under 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 vehicle 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.

DANGER 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 OTTO 1500 V1.2 SDV chassis.

9.3 Electrical Interface Specifications

DANGER

Attachments must be designed to prevent users standing near an OTTO 1500 V1.2 SDV from being exposed to the hazards of the attachment. The Safety Detection Range of the OTTO 1500 V1.2 SDV does not cover all sides of the vehicle, meaning there are regions around the vehicle where a user can get close enough to reach into the attachment during normal operation.

The 48V battery voltage is switched by the attachment contactor on the OTTO 1500 V1.2 SDV 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 OTTO 1500 V1.2 SDV 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 OTTO 1500 V1.2 SDV chassis. In the event of such a fault, the vehicle will cease autonomous operation and indicate a user needs to examine the attachment.

9.3.1 Unswitched vs. Switched Power for Non-Safety Devices

In general, attachments should use the unswitched 24VDC power from the OTTO 1500 V1.2 SDV attachment interface for attachment logic power and inputs required to determine attachment states that could affect the safe operation of the vehicle.

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 vehicle 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 OTTO 1500 V1.2 SDV needs to know the state of the lift even if the lift is in an Emergency Stop state.

9.3.2 Electrical Interface Connections

See the Components Overview for the location of the attachment interface on the OTTO 1500 V1.2 SDV.

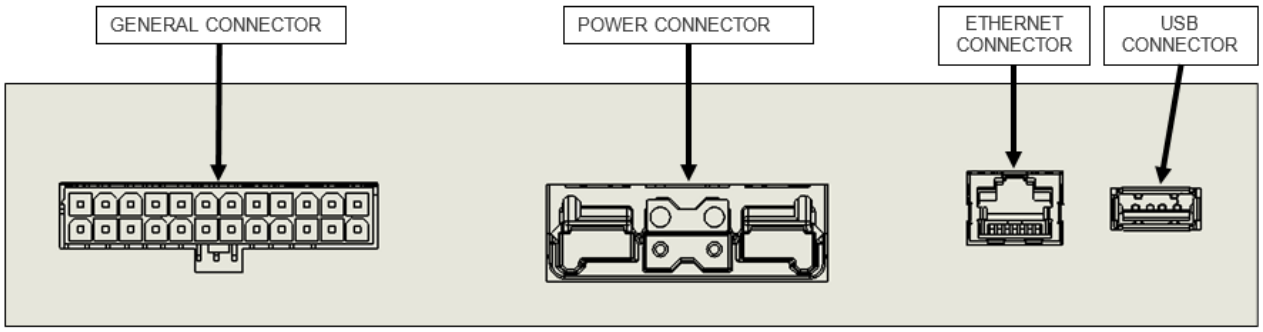


Figure 19 Attachment Interface Connectors

The part numbers for the SDV 1.2 and Attachment interface General Connections are identified in Table 4.1.3 1. Electrical Interface Connections

The connector details for the 48V Power Connector on the SDV 1.2 are summarized in Table 4.1.3-2 and Figure 4 3.

9.3.2.1 General Connector

PART NUMBER	MANUFACTURER	DESCRIPTION
	Vehicle Side	
39-30-1240	Molex	Mini-Fit® Jr. Header, Dual Row, Right Angle, with Snap-in Plastic Peg PCB
	Attachment Side	
39-01-2245	Molex	39-01-2245 Molex Mini-Fit JR, Receptacle Housing, Dual Row, 24CCT
39-00-0038	Molex	Mini-Fit Female Crimp Terminal, 18-24 AWG, 9.0A
314-023-1819-FR	Anixter	19 Conductor, 18 AWG, 105 Deg. C, 600V, FT4 Vertical Flame Test Rated Cable

Table 6 Attachment Interface General Connection Part Numbers

9.3.2.2 Power Connector (48V)

PART NUMBER	MANUFACTURER	DESCRIPTION
		Vehicle 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 Colour Code, Connection – 2 Pri. 4 Aux.
1339G2	Anderson Power Products	SBS Silver Plated Primary Contacts, Standard Type, #6AWG. (16 mm)
PM16P1620S30-50	Anderson Power Products	SBS75x Auxiliary Pins, Standard Length 7.7 mm, #20-16 AWG (0.75 - 1.0 mm)
PM16S1620S32-50	Anderson Power Products	Auxiliary Socket, #20-16 AWG (0.75-1.0mm)
DLO-10	Allied Wire	Diesel Locomotive, DLO 600/2000V 90C - #10 AWQG, 55AMP, 27/24 Strand, Black, OD 0.290” SPE Jacket
		Braiding
		Heat Shrink

9.3.2.3 Ethernet & USB

DESCRIPTION
Vehicle Side
Standard RJ45 Jack
Standard USB A Female
Attachment Side
Standard RJ45 Plug
Standard USB A Male

9.4 Safety Relay and Auxiliary Monitoring Contacts

The below figure illustrates the electrical connection available on the OTTO 1500 V1.2 SDV attachment interface and the connection of a typical safety relay with auxiliary monitoring contacts.

> The electrical connection inside the vehicle is not shown below.

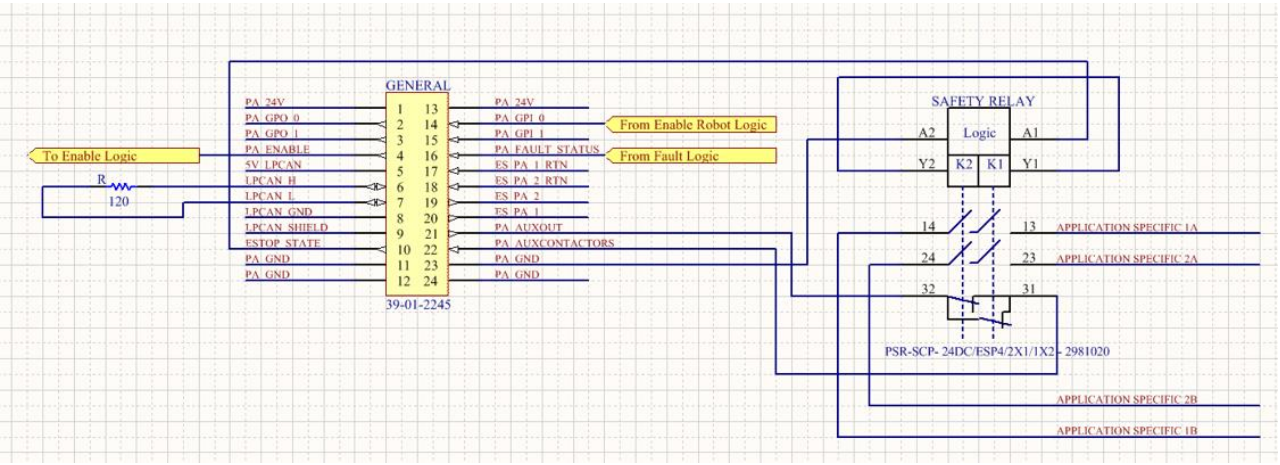


Figure 20 General Connector with Safety Relay and Auxiliary Monitoring Contacts

9.5 Connection Pinouts

9.5.1 Vehicle Side General Connector

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

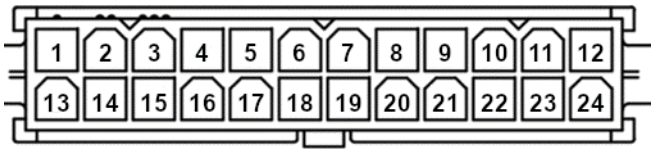


Figure 21 Vehicle Side General Connector Pin-Out Numbering

CAUTION Do not bond 24V and 48V ground together in addition to bonding to AC grounds.

PIN	NAME	NOTES
1	PA_24V	24V, 5A total available between Pin 1 and Pin 13 (see Vehicle Side General Connector Pin-Out) and S1 on the Power Connector (see Vehicle Side SBS75 Pin-Out Details)
2	PA_GPO_0	General purpose out 0
3	PA_GPO_1	General purpose out 1
4	PA_ENABLE	Attachment enable
5	5V_LPCAN	CAN 5V (NOT CURRENTLY USED)
6	LPCAN_H	CAN High, jumper to CAN Low through 120 Ohm resistor 120 Ohm resistor is BC Components MBB0207-50 0.5W, 1% (or equivalent)

7	LPCAN_L	CAN Low, jumper to CAN High through 120 Ohm resistor 120 Ohm resistor is BC Components MBB0207-50 0.5W, 1% (or equivalent)
8	LPCAN_GND	CAN Ground
9	LPCAN_SHIELD	CAN Shield
10	ESTOP_STATE	24VDC single channel interface from vehicle safety relays - when on, the attachment is safe to energize
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, 5A total available between Pin 1 and Pin 13 (see Vehicle Side General Connector Pin-Out) and S1 on the Power Connector (see Vehicle Side SBS75 Pin-Out Details)
14	PA_GPI_0 (SDV_ENABLE)	General purpose in 0 (SDV_ENABLE) GPI_0 is used to signal to the vehicle from the attachment that the vehicle 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	EA_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

Table 7 Vehicle Side General Connector Pin-Out Functions

9.5.2 Vehicle Side Power Connector

If you are not planning to use the 48V power for your application, the 48V contacts need to be populated in the connector for the connection to work properly.

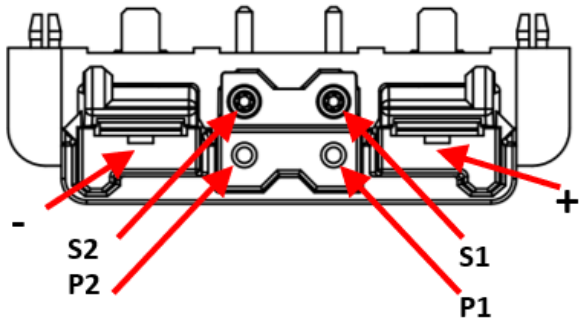


Figure 22 Vehicle Side SBS75 Pin-Out Details

CAUTION Do not bond 24V and 48V ground together in addition to bonding to AC grounds.

PIN	NAME	NOTES
+	BATTERY_VOLTAGE	Unregulated battery voltage 51.2V nominal
-	BATTERY_VOLTAGE_RETURN	Return for unregulated battery voltage
P1	NC	Not Connected Attachment
P2	PA_GND	Ground for the PA_24V signals, all except CAN signals and Battery Voltage
S1	PA_24V	24V, 5A total available between Pin 1 and Pin 13 (see Vehicle Side General Connector Pin-Out) and S1 on the Power Connector (see Vehicle Side SBS75 Pin-Out Details)
S2	PA_GND	Ground for the PA_24V signals, all except CAN signals and Battery Voltage

Table 8 Vehicle Side Power Pin-Out Functions

9.5.3 Minimum Required Connections

9.5.3.1 Passive Attachment

Passive attachments do not draw power from the base OTTO 1500 V1.2 SDV 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
- 120 Ohm Resistor connected between LPCAN_H and LPCAN_L
- The PA_FAULT_STATUS connected to PA_24V
- PA_GPI_0 connected to PA_24V

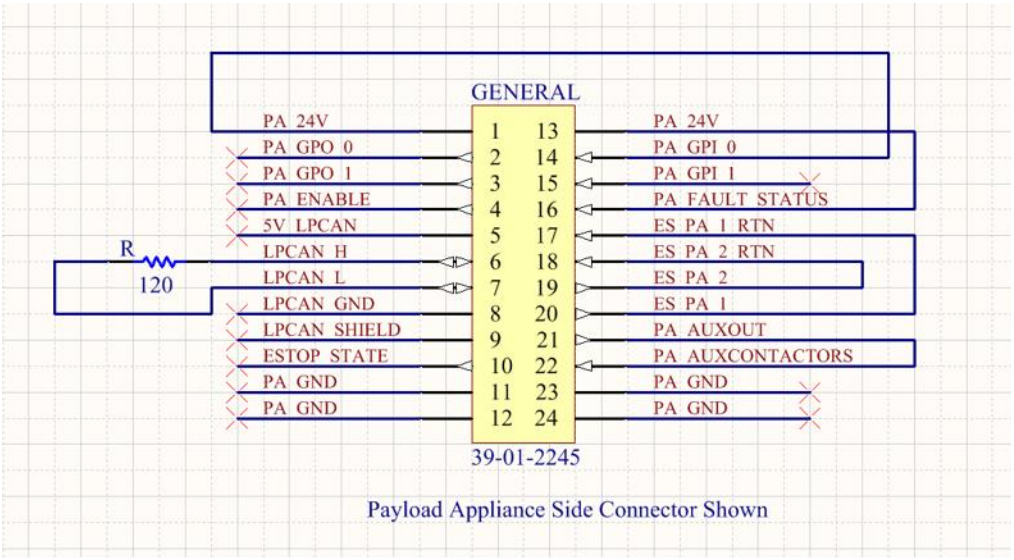


Figure 23 Attachment Side Minimum Connections for Passive Attachment

CAUTION Do not bond 24V and 48V ground together in addition to bonding to AC grounds.

9.5.3.2 Active Attachment

Active attachments will draw power from the base OTTO 1500 V1.2 SDV 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
- 120 Ohm Resistor connected between LPCAN_H and LPCAN_L
- 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.)

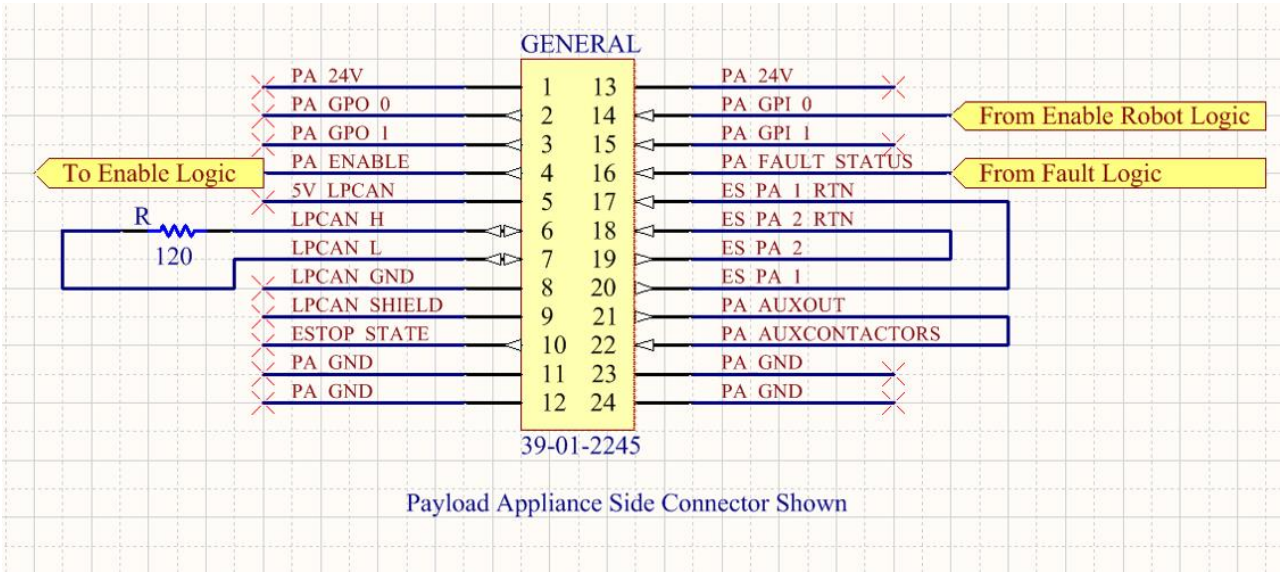


Figure 24 Attachment Side Minimum Connections for Active Attachment

9.5.4 General Purpose Outputs

The GPO's are 24V outputs with a maximum source/sink current of 200mA.

9.5.5 General Purpose Inputs

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

PIN INPUT VOLTAGE	VEHICLE LOGICAL INPUT STATUS
Input Voltage > 7V	Logic High
Input Voltage < 1.5 V	Logic Low
7V > Input Voltage > 1.5V	Indeterminate

Table 9 General Purpose Input Voltage Requirements

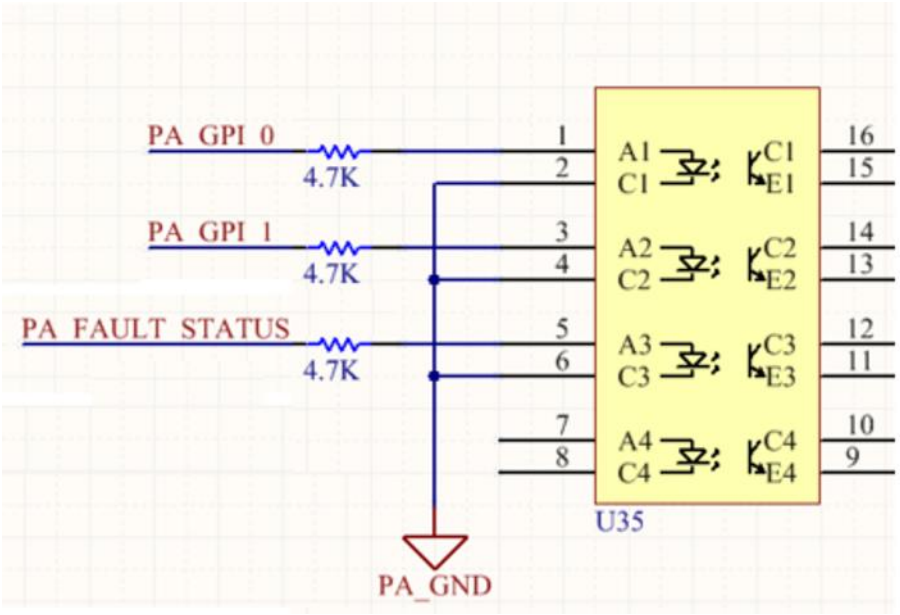


Figure 25 Digital Input Logic Hardware

9.6 Attachment Interface Examples

9.6.1 Conveyor-Style Attachment Interface Signal Example

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, vehicle 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 OTTO 1500 V1.2 SDV will enter a Safety Stop state.
GPI_0	GPI_0 is used to signal to the vehicle that it is able to move after it has given control to the attachment
Battery Voltage	Switched, up to 50A, 51.2V nominal
24VDC	Unswitched, up to 5A
Ethernet	Attachment 100 Mbps Ethernet connection using Ethernet/IP
CAN	120 Ohm Terminating Resistor connected between LPCAN_H and LPCAN_L

Table 10 Conveyor-Style Attachment Example Interface Connections

9.6.1.1 Safety Interface

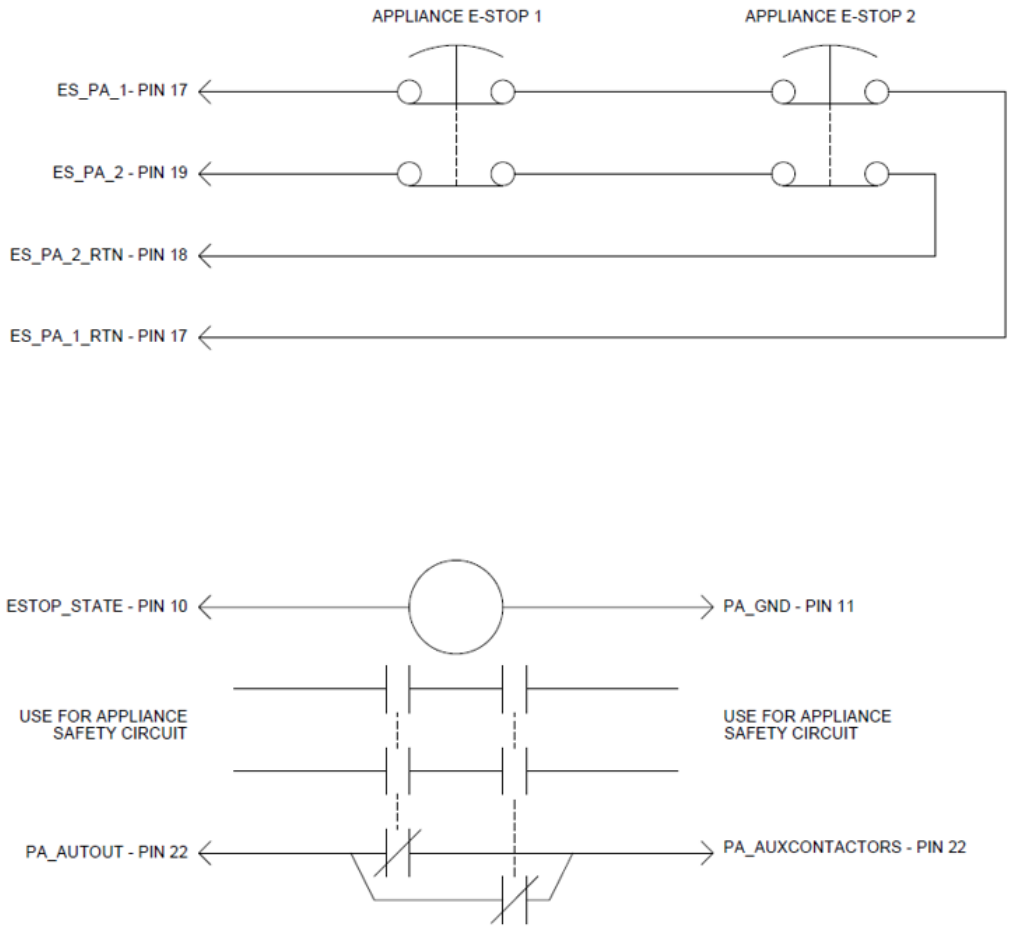


Figure 26 Conveyor-Style Attachment Safety Interface

9.6.2 Lift-Style Attachment Interface Signal Example

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, vehicle will cease autonomous operation and indicate that it needs an operator to examine the attachment.
GPI_0	GPI_0 is used to signal to the vehicle that it is able to move after it has given control to the attachment
Battery Voltage	Switched, up to 50A, 51.2V nominal
24VDC	Unswitched, up to 5A
Ethernet	Attachment 100 Mbps Ethernet connection using Ethernet/IP
CAN	120 Ohm Terminating Resistor connected between LPCAN_H and LPCAN_L

Table 11 Lift-Style Attachment Example Interface Connections

10 MAINTENANCE

COMPONENT	DAILY	WEEKLY	MONTHLY	BI-MONTHLY	12 MONTHS	24 MONTHS
Visual circle check and inspection	✓					
Inspect and clean the LiDAR screens and cavity, if necessary	✓					
Visual inspection underneath robot to ensure ESD drag chain intact and contacting the ground		✓				
Exterior cleaning			✓			
Interior cleaning				✓		
Inspect electrical enclosure fan filters and clean or replace, if necessary				✓		
Copper contact cleaning				✓		
Inspect drive wheels and casters for damage to treads					✓	
Inspect drive wheels and castors for minimum remaining tread thickness					✓	
Replace oil in left and right drive-trains					✓	
Inspect copper contacts and replace, if required						✓
Remove rocker arms, inspect and lubricate bearings and replace, if required						✓

Table 12 Maintenance and Inspection Schedule Summary for OTTO 1500 V1.2 SDV

DANGER While conducting any maintenance, the OTTO 1500 self-driving vehicle must be locked-out and tagged. There are still live battery terminals accessible inside the vehicle even when locked- and tagged-out.

WARNING Safety boots or shoes with steel toes should be worn at all times while working with the OTTO 1500 self-driving vehicle.

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

10.1 Daily Preventative Maintenance

Perform the following tasks once every operational day.

10.1.1 Circle Check

Perform a brief circle check of your OTTO self-driving vehicles every day:

- Ensure no damage has occurred since the vehicle(s) last ran
- Ensure the light pipe is functioning correctly by pressing and the E-Stop button and checking for a full red ring
- Ensure the speaker is functioning correctly by pressing an E-Stop button and listening for the horn
- Ensure all four E-Stop buttons are functioning correctly by pressing and resetting them one-at-a-time
- Ensure the vehicle's LiDAR are functioning correctly. To test, place a lightweight object, such as a cardboard box, approximately 5 cm in front of the stationary vehicle 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 vehicle to test the safety function.

10.1.2 Daily LiDAR Cleaning

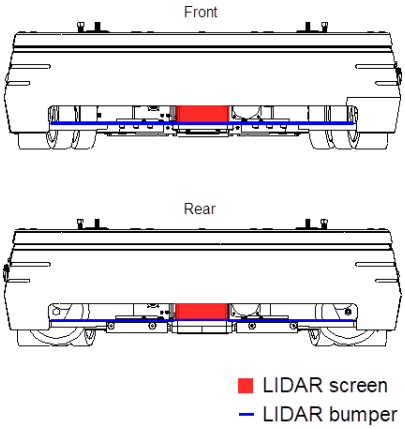
10.1.2.1 Materials/Tools Required

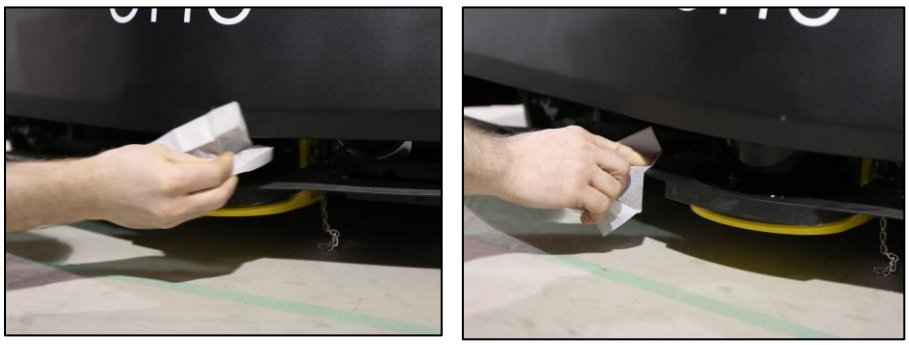
- Flashlight
- Antifog/Antistatic Lens Cleaning Wipes (OTTO Motors Part Number 015591)

> **CAUTION** Do not use abrasive items or solvents on the LiDAR assembly, as this will damage the LiDAR lens over time.

10.1.2.2 Procedure

1. Inspect LiDAR and LiDAR cavity with flashlight for any dust and/or debris.
2. Using the lens cleaning wipes, clear the LiDAR cavity of any dust/debris. Clean the LiDAR and the cavity with different wipes.





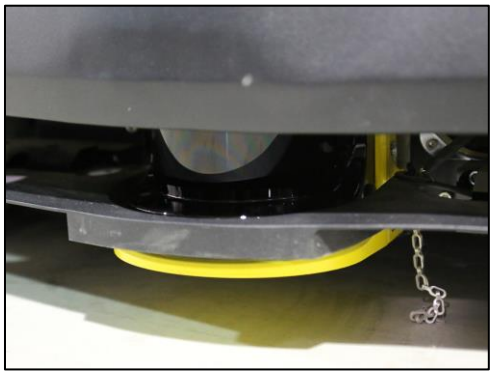
10.2 Weekly Preventative Maintenance

Perform the following tasks once every week:

10.3 Check Drag Chain

Perform a visual inspection underneath your OTTO self-driving vehicles once a week:

- The OTTO will either have an ESD drag chain OR a Rubber Strip. Ensure the chain/strip is intact and contacting the ground.



10.4 Monthly Preventative Maintenance

Perform the following tasks once every month:

10.4.1 Exterior Cleaning

10.4.1.1 Materials/Tools Required

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

10.4.1.2 Procedure

1. Ensure the OTTO 1500 self-driving vehicle is turned off.
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 Ethernet port and manual charging port on the back of vehicle.

- 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 vehicle to service.

10.5 Bi-Monthly Preventative Maintenance

Perform the following tasks once every two months:

10.5.1 Interior Cleaning

This maintenance procedure requires opening the OTTO 1500 self-driving vehicle. As per the Terms and Conditions agreement, do not open a vehicle that is under warranty without express permission from OTTO Motors, else the warranty will be voided.

10.5.1.1 Materials/Tools Required

- 4mm Allen Key
- Damp Cloth
- ESD-Safe Electronics Vacuum
- 3 mm Allen Key
- Torque Screw Driver

10.5.1.2 Procedure

1. Ensure the OTTO 1500 self-driving vehicle is turned off.
2. Ensure the breaker switches have been locked out and tagged as per the Lock-Out Tag-Out Procedure.
3. Remove the payload plate.
4. Remove the front, rear, and side panels.
5. Inspect the air filters with the flashlight. If dirty, they can be cleaned with a vacuum.

CAUTION

DO NOT use a non-ESD-safe vacuum cleaner inside the OTTO 1500 self-driving vehicle, as electronics will be irreparably damaged.

DO NOT use compressed air to clean inside the vehicle, as dust may be blown into sensitive parts and cause damage.

6. Gently hold the electronics vacuum above the electronics and components in question and vacuum away any accumulated dust and debris. Avoid touching the components with the vacuum cleaner. An electronics vacuum is ESD safe and will not damage the sensitive electronics inside the vehicle.
7. With the damp cloth, wipe down all flat surfaces near the drive wheels.
8. Inspect all areas and ensure there is no damage or excess build-up of debris.
9. Return the vehicle to service by replacing the front, rear, and side panels, reinstalling the payload plate, removing the lock-out/tag-out locks and tags, and then turning the vehicle on.

10.5.2 Copper Contact Cleaning

10.5.2.1 Materials/Tools Required

- Scotch Brite Pad

10.5.2.2 Procedure

1. Ensure the OTTO 1500 self-driving vehicle and the OTTO Charge 1500 battery charger are turned off.
2. Using the Scotch Brite Pad, clean the surface of the copper contactors on the OTTO 1500 self-driving vehicle.

Before

After

3. Using the Scotch Brite Pad, clean the surface of the contactors on the OTTO Charge 1500 battery charger.

10.6 Annual Preventative Maintenance

10.6.1 Wheel Inspection and Lubrication

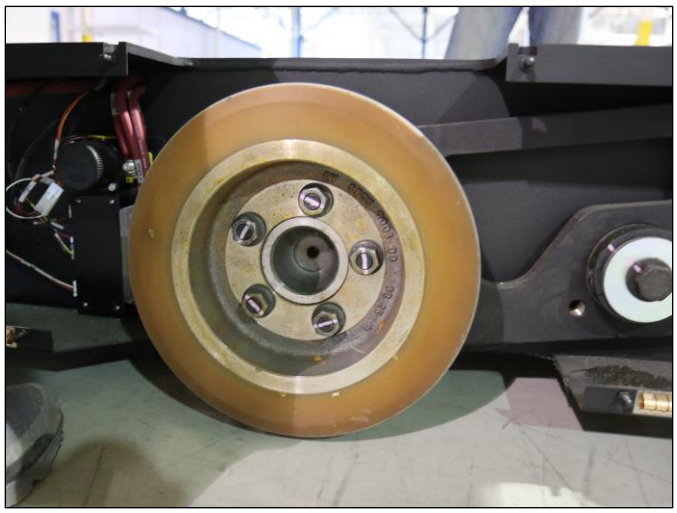
This maintenance procedure requires opening the OTTO 1500 self-driving vehicle. As per the Terms and Conditions agreement, do not open a vehicle that is under warranty without express permission from OTTO Motors, else the warranty will be voided.

10.6.1.1 Materials/Tools Required

- 4mm Allen Key
- Grease Gun
- Super Lube® Multi-Purpose Synthetic Grease with Syncolon® (PTFE) (Clearpath Part # 005826)

10.6.1.2 Procedure

1. Ensure the OTTO 1500 self-driving vehicle is turned off.
2. Ensure the breaker switches have been locked out and tagged as per the Lock-Out Tag-Out Procedure.
3. Remove the top panel.
4. Turn the lifting bolts clockwise until the OTTO 1500 self-driving vehicle can roll freely.
5. Inspect the castors by pushing the Self Driving Vehicle to rotate them. Ensure they can rotate easily without noise. Ensure no debris is on or in the castors.
6. Inspect the drive wheels. Ensure they have no debris or damage.
7. Apply grease to the castors. Apply grease only to where the castor swivels.
8. Rotate the castor 90 degrees and apply grease again.



9. Rotate the castors fully in both clockwise and counter-clockwise directions.
10. Replace the top plate.
11. Return the vehicle to service.