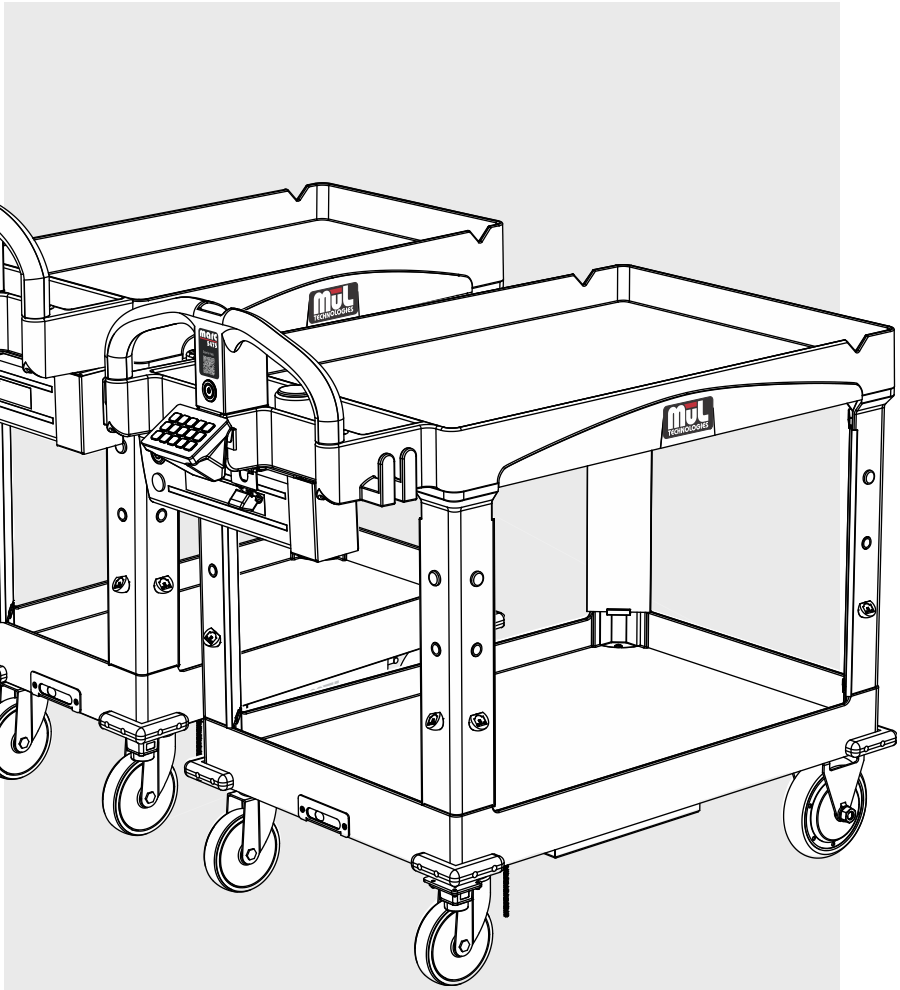
MiL TECHNOLOGIES®



MARC® 5470

MARC® 5475

User's Guide

Mobile Autonomous Robotic Cart
5 Series Model 5470 and Model 5475

Revision 260217B

Congratulations – and thank you!

MARC® is made by the highly experienced team at MūL Technologies® – manufacturers who want to bring autonomous mobile robots (AMR) that make practical sense to warehousing, manufacturing and logistics companies.

MūL Technologies' approach to AMR is different: We take commercial off-the-shelf (COTS) components and add minimum custom hardware to create intelligence/movement. MARC is the most cost-effective autonomous material handling solution on the market.

Finally, "the rest of us" have an affordable way to get all the benefits of AMR.

Thanks again – and know we are here for you!

Sincerely,
The MūL Technologies team

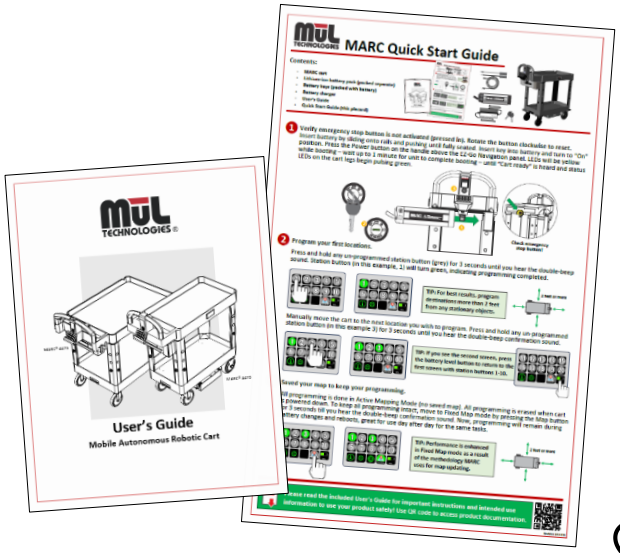
PLEASE READ THIS ENTIRE MANUAL BEFORE USING MARC. IT CONTAINS CRITICAL INFORMATION ON USING MARC SAFELY AND BEST PRACTICES FOR A SUCCESSFUL IMPLEMENTATION.

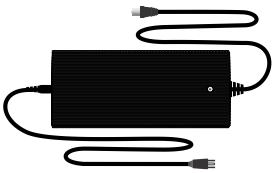
MūL Technologies Products are proudly designed and assembled in the United States.

Table of Contents

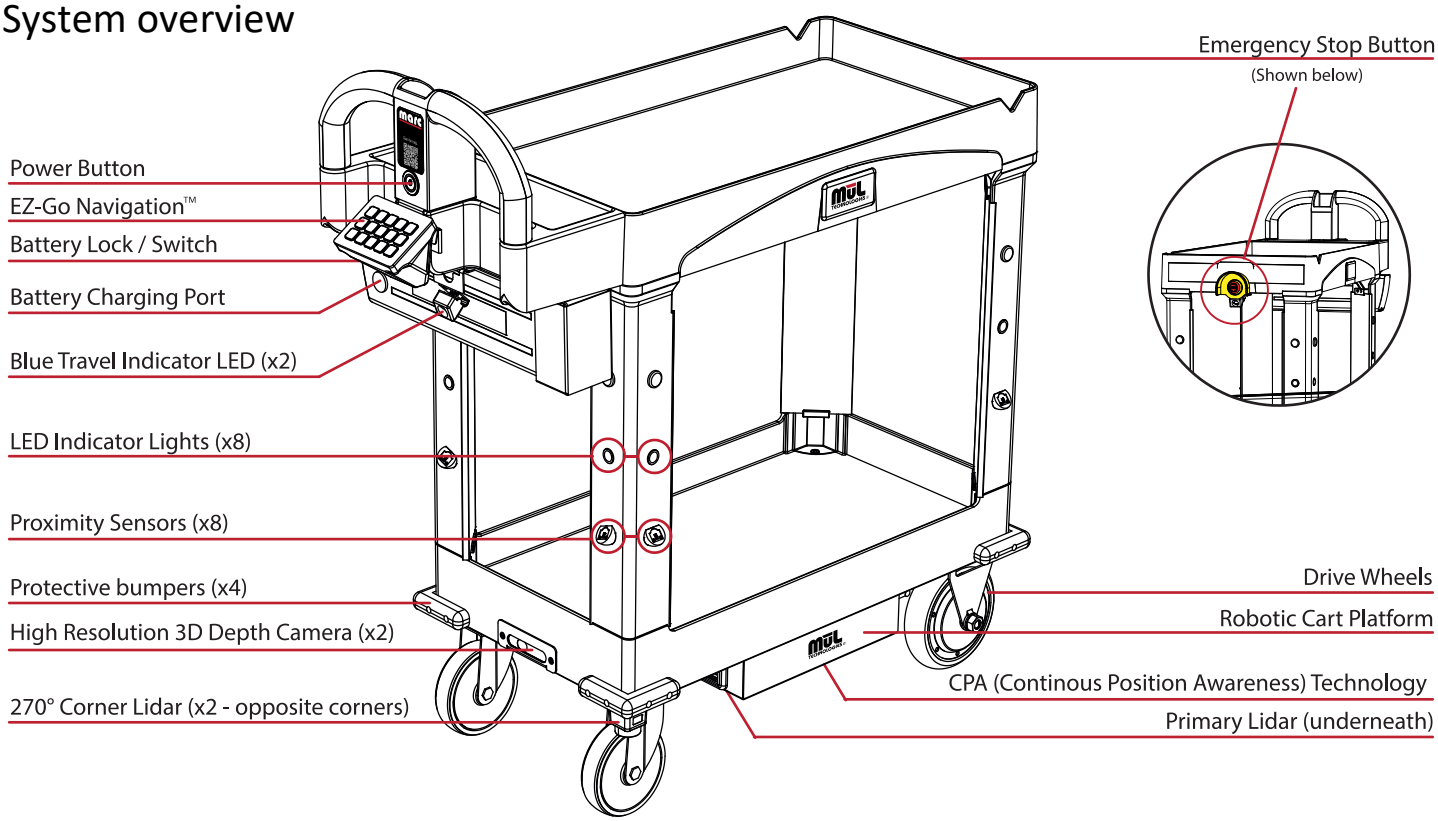
Packing list

- MARC cart
- Battery (packaged separately) with keys
- Battery charger
- USB-C to LAN adapter kit
- User's Guide (this document) and Quick Start Guide





System overview

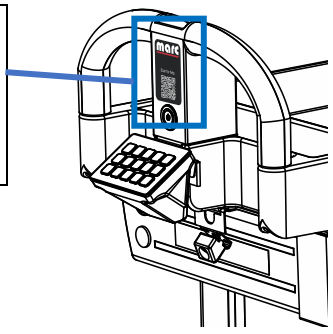


Where to find additional resources

Additional resources for MūL Technologies MARC systems can be found in a variety of places.

Item	Location / description	QR code (if applicable)
Product documentation (including User's Guide)	www.multechnologies.com/documentation	
Contact the MūL Technologies support team	Visit our web site: multechnologies.com Reach out to the team: support@multechnologies.com or by phone at 262-242-8830 Mailing address: MūL Technologies 10202 North Enterprise Drive Mequon, WI 53092	
MARC system FAQs	www.multechnologies.com/faq	
MARC online assistance	www.multechnologies.com/support	

INFO	For convenience, there is a QR code on the handle label of the cart to quickly scan while not near a computer, for example using a mobile phone on the manufacturing floor. This QR code leads directly to the online support area of the MūL Technologies web site.



Understanding the safety information in this document

MARC has been developed to be simple and safe to use. Please make sure anyone who is in the area where MARC carts are in operation has read and understands all the safety information before working with or around the autonomous carts.

Symbol	Meaning
	Indicates a potentially hazardous situation that could result in death or severe personal injury if proper precautions are not taken.
	Indicates a situation that could result in personal injury or damage to the equipment if proper precautions are not taken.
	Indicates generally useful information, tips and best practices to assist the user with the setup, operation and maintenance of the equipment, including MARC systems and battery packs.
	Indicates danger of electrical shock. Please use extreme caution when working with lithium-ion batteries. Always disconnect power before contacting any electrical components.
	Indicates components with potential for damage from electro-static charges. Always use caution when handling ESD sensitive parts.

Important safety information

Table of important safety information

General hazards	

	• Always maintain a safe distance from MARC when in motion. You risk being hit, run over, or trapped if you do not maintain a safe perimeter during operation.
	• Human traffic must yield right-of-way to MARC autonomous products.
	• Ensure proper mounting of loads during use. See **Loading MARC safely** on page on page **59**.
	• Danger of personal injury from overturning robot or falling load.
	• All accessories and loads mounted on top of the robot should be fastened correctly and meet specifications.
	• Do not drive the vehicle irresponsibly.
	  ○ There is danger of personal injury and/or damage to the robot.
	  ○ The robot should not be driven over edges or in other ways operated irresponsibly.
	• Always maintain a minimum 3-foot distance from MARC when robot is in motion.
	• Do not use the robot to transport people
	  ○ There is risk of personal injury and/or damage to the robot.
	  ○ This will revoke compliance with the standard **EN 1525 Safety for Unmanned Trucks**.

	• Indoor use only
	  ○ The robot is made for indoor use only and should never be used outdoors.
	• Avoid small objects on the floor in the robot's area.
	  ○ There is risk of property damage and/or damage to the robot.
	  ○ The robot cannot detect some obstacles at a height of .75” (20 mm) or lower and may run over small objects. It is designed to detect and avoid obstacles taller than 1.5”.
	  ○ For obstacles in between .75” and 1.5”, it may depend upon the material, size, and color of the obstacle if the robot will identify it or not.
	• The robot should not be moved to a different floor of your facility. If you are using MARC on the first floor and transport it to another floor, it will not be able to navigate properly. Always reset the destinations and create a new map when using it on a different level.
	• The robot will go around objects that are not part of the map, but this may influence the efficiency of the planned route.
	• The ambient temperature in the robot's environment should be between 5°C / 41°F and 45° C / 110°F for operation of the robot or charging the battery pack.
	• Avoid exposure of the robot to excessively humid or extremely dry environments.
	  ○ The ambient humidity in the robot's environment must be within 0~85% RH (without condensation).
	• This equipment is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities, or lack of experience and knowledge, unless they have been given supervision or instruction concerning use of the appliance by a person responsible for their safety. Children should be supervised to ensure that they do not play with MARC. Failure to do so may cause an accident or injury.
	• Certain reflective objects can confuse the laser system and can cause the product to think there is an object in its way when there is not. These objects can include items with a chrome finish, mirrored surfaces, and other similar objects with a highly reflective finish.

	• Only operate on even, clean and dry surfaces.
	  ○ Avoid gradients (ramps etc.) on the route.
	  ○ There is risk of personal injury and/or damage to the robot.
	  ○ Wet and uneven surfaces may cause the robot to skid.
	• Do not overload the robot.
	  ○ There is risk of personal injury and/or damage to the robot.
	  ○ The maximum payload for MARC:
	  ▪ In autonomous operation: 100 kg or approximately 220 lbs. combined across both shelves.
	  ▪ In manual push mode: 225 kg or approximately 500 lbs.
	  ○ Individual shelves must never be loaded over 55 kg or approximately 125 lbs while moving.

	○ If exceeded, it may cause overturning, falling load and damage to the robot. ○ See also **Loading MARC safely** on page on page **59**. • Turn off the main power and remove battery before attempting any troubleshooting or repair. • While mapping do not push the cart at speeds greater than 1.3M/second (3 MPH) to allow for accurate data. • Do not use the cart to tow or push any other item. ○ For example, do not attach a trailer, broom, or plow to the cart. • Do not try to manually push or move the cart in any way while it is moving on its own.

Lithium-ion battery use, storage and safety

Lithium batteries are power sources with high energy content and are designed to represent the highest possible degree of safety.

	Potential hazards
	Lithium-ion battery packs may get hot, explode, or ignite and cause serious injury if they are abused electrically or mechanically. Observe the following precautions when handling using and storing lithium-ion batteries: • Never leave power on to battery when not in use. • Never short-circuit or connect loads other than the intended system to the battery. • Do not connect with false polarity. • Do not expose to temperature beyond the specified temperature range or incinerate the battery. • Do not crush, puncture, or disassemble the battery. The battery contains safety and protection devices, which, if damaged, may cause the battery to generate heat, explode or ignite. • Do not allow the battery to get wet. • In the event the battery leaks and the fluid gets into a person's eyes, do not rub the eye. Rinse well with water and immediately seek medical care. If left untreated, the battery fluid could cause damage to the eye. • Use only the original charger, and always follow the instructions from the battery manufacturer. • Disposal: The U.S. Environmental Protection Agency (EPA) does not regulate the disposal of batteries in small quantities. While there are no federal regulations for disposal of lithium-ion batteries, many individual states or localities have established their own guidelines for battery disposal and should be contacted for any disposal guidelines that they may have.
	Lithium-ion batteries are presently the most commonly used energy storage devices on motorized equipment. Learning how to maintain lithium-ion batteries can not only prolong battery lifetime but also protect your device from potential damage. • **Charge new batteries** It is not necessary to charge over 12 hours when first used. When a device powered by batteries is purchased, sellers will usually tell us the batteries must first be charged 12 hours before using. This is unnecessary. Unlike common Ni-CD or Ni-MH batteries, most lithium-ion batteries are activated before leaving the factory. Due to their low self-discharge, it is unnecessary to charge lithium-ion batteries for such a long cycle when new. Lithium-ion batteries are ready for use when the charger indicates so, and they will reach their best capacity after 3 or 5 charge/discharge cycles. • **Use appropriate chargers** Original MūL Technologies chargers are the only ones supported by MūL. Using any other chargers can lead to shorter running times, premature battery failure, fire or explosions. • **Avoid overcharging** Over charging may let the battery's interior rise to a high temperature which is bad for both the battery and the charger. Simply charging to 'full' is good enough and will increase the life of the battery and charger. • **Avoid touching metal contacts** All contacts on batteries need to be kept clean for best performance. When carrying batteries around, do not let the contacts touch metal objects such as keys; this could cause a short circuit, damaging the battery or potentially resulting in a fire or explosion. • **Avoid using often in high or low temperature environments** Lithium-ion batteries have optimal working and storage temperatures. If they're continually used in extreme temperature environments, this will negatively affect battery use time and useful life.

Intended use of MARC carts

The MūL Technologies MARC autonomous cart products are tools that help you optimize efficiency. MARC eliminates the steps taken that add no value while working alongside employees. They are not intended to be used in any manner outside the scope of this manual. The below list provides general example use applications. It is limited and should not be considered comprehensive.

All MARC systems are intended to be used in indoor industrial environments where access for the public is restricted.

The MūL Technologies MARC system is designed;

- for indoor use only.
- for use only on solid, stable, non-moving areas. It is not designed for ships, moving vehicles or similar modes of transportation.
- for climate-controlled areas between 41°F and 110°F (5°C and 45°C).
- for use in dry conditions only.
- for use on a single level – no elevators or lifts.
- for use in areas where the floor is free of objects smaller than 1.5” (40mm) from ground level.
- for use on flat, level, surfaces with no ramps, inclines or transitions.
- to carry only secured liquid materials.
- to carry only non-hazardous materials.
- to operate in areas with at least 24” clearance on both sides for a total width of approximately 6 feet. Aisles or paths with a width less than 6 feet may prevent proper path planning and cause MARC to abandon its route.

One of the most important steps in achieving a safe installation of any autonomous robot is to complete a thorough risk assessment. Since every facility presents unique issues and risks, it is critical that the individual or organization that is implementing MūL Technologies MARC automated products complete this assessment based on their own facility.

Considerations for this assessment include in part;

- foot traffic and moving equipment must maintain a minimum 3-foot distance from autonomous MARC products when robot is in motion.
- human traffic must yield right-of-way to MARC autonomous products.
- low hanging objects or obstructions that are above the sight line of MARC.
- small items on the floor that may be missed by MARC’s sensors.
- high value items that are transported by, or in the area of, MARC products.
- dangerous materials transported by, or in the area of, MARC products.
- placement of ladders, scaffolds, metals carts or similar equipment in the robot's work environment.
- consideration of the general environment for safety issues prior to deploying MARC products.

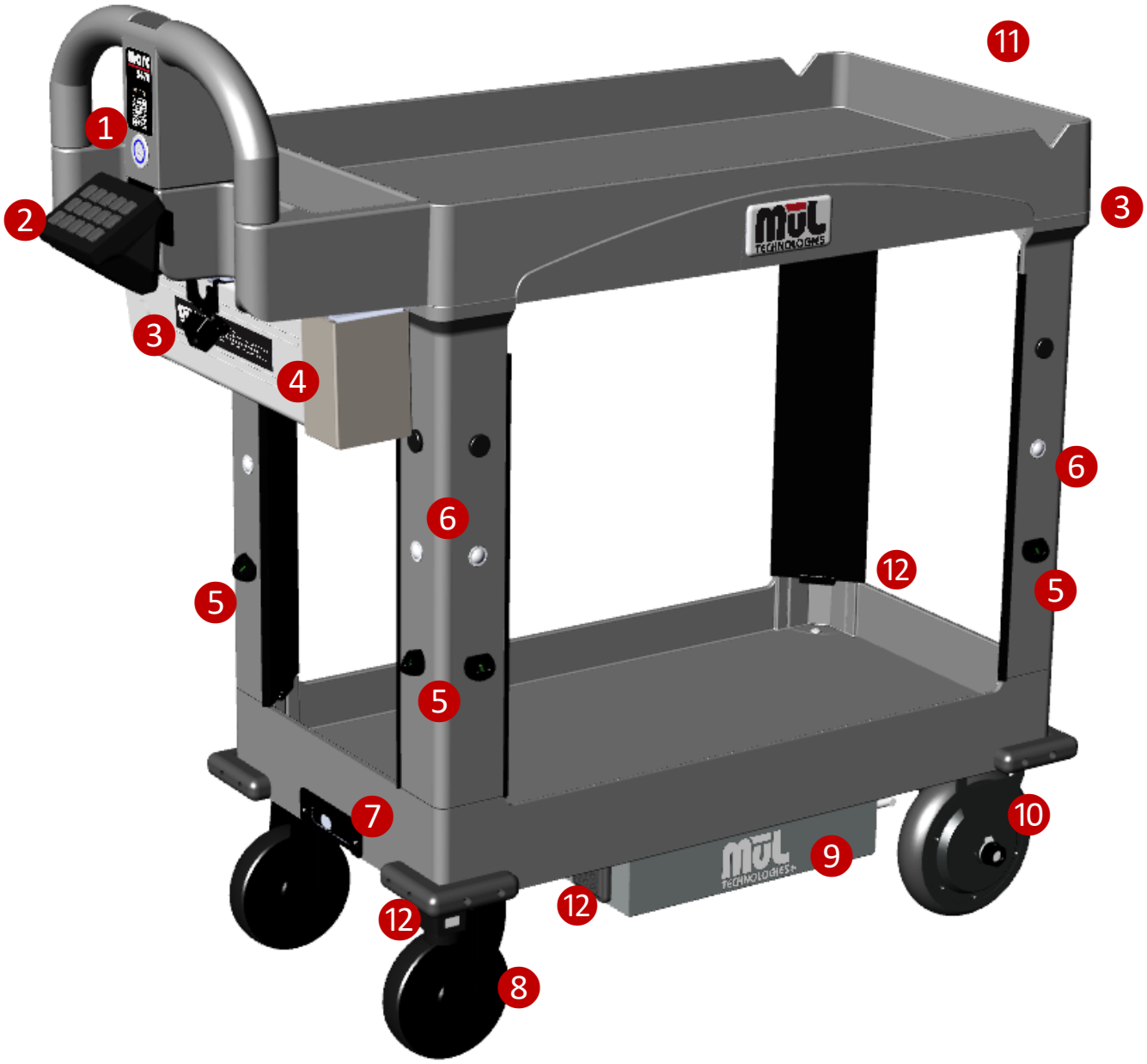
We recommend that guidelines in ISO 12100, EN 1525, ANSI B56.5 or other relevant standards be used to complete the risk assessment. EN 1525, clause 4 contains a list of significant hazards, hazardous situations and events which can be used as further reference for consideration.

MARC products must not be modified in any way. MūL Technologies will not be responsible for damage caused by products that have been altered or modified.

MūL Technologies is not responsible for any damages caused to MARC products or accessories, or any other equipment due to programming errors or malfunctioning of MARC robots.

MARC 5 Series hardware features overview

MARC robots have been developed with simplicity in mind.



#	Feature
1	Power button (also serves as emergency power-off button)
2	15-button EZ-Go Navigation panel
3	High power LED blue light movement indicator (2 total, 1 each end)
4	Battery assembly (including ON/OFF key switch)
5	Proximity sensors (8 total, 2 each side)
6	LED status indicators (8 total, 2 each side)
7	High resolution 3D depth camera (2 total – front and rear)
8	Free turning rear wheels
9	RCP (Robotic Cart Platform) module
10	Drive wheels
11	Emergency stop button (on front of cart – not shown in image)
12	LiDAR units (3 total)

MARC 5 Series software features overview

The AI-driven self-navigation and safety system utilizes advanced technologies such as 360° LiDAR, 3D depth cameras, and proximity sensors to navigate and avoid obstacles in real-time, ensuring safe and efficient operation in dynamic environments. It differentiates between static objects like walls and dynamic objects like people, enhancing efficiency in busy environments, and operates autonomously without requiring any operator involvement or external system.

AI-Driven Self-Navigation and Safety

- Utilizes 360° LiDAR, 3D depth cameras, and proximity sensors to navigate and avoid obstacles in real-time.
- Ensures safe and efficient operation in dynamic environments, preventing collisions and continuously monitoring surroundings to avoid hazards.
- Integrates AI for optimizing map creation, route planning, navigation, and optimal traction control.
- Intelligent acceleration and deceleration for increased efficiency

AI-Based Learning and Adaptation

- Learns from operational experiences and adapts to environmental changes.
- Improves navigation strategies and operational efficiency over time through continuous learning.
- Differentiates between static objects like walls and dynamic objects like people, enhancing efficiency in busy environments.
- Operates autonomously without requiring any operator involvement or external system.

AI Efficiency and Collision Avoidance

- Continuously refines performance based on accumulated data.
- Optimizes routes and tasks for increased productivity, reducing errors and downtime with adaptive learning.
- Predicts potential collisions before they occur and makes real-time changes to avoid collisions or shifting of the payload.

Built-in AprilTag capabilities

- AprilTags can be used to help MARC carts stay on track in highly dynamic environments. See **Using optional AprilTags** on page **52**.

About the Optional Software Package (OSP)

The 5 Series MARC products offer an additional Optional Software Package (OSP) that adds extended functionality. This OSP is included with all new 5 Series carts shipped and is licensed for an extended demo period from the date of purchase for no fee. This allows additional time for you to decide whether you find value in the extra features. If not, you do not need to renew the OSP package and you can still use your MARC carts without it.

The chart below is a high-level overview of the things that are included in the base cart or the cart with the Options package.

Feature	With OSP	Without OSP
Available destinations	20 total	10 total
Looping mode	Available	Not available
Power Assist Mode	Available	Not available
Language packs	All available	English only
Precise Mode	Available	Not available
Ability to lock programming	Available	Not available
Statistics screen	Available	Not available
Custom button text	Available	Not available

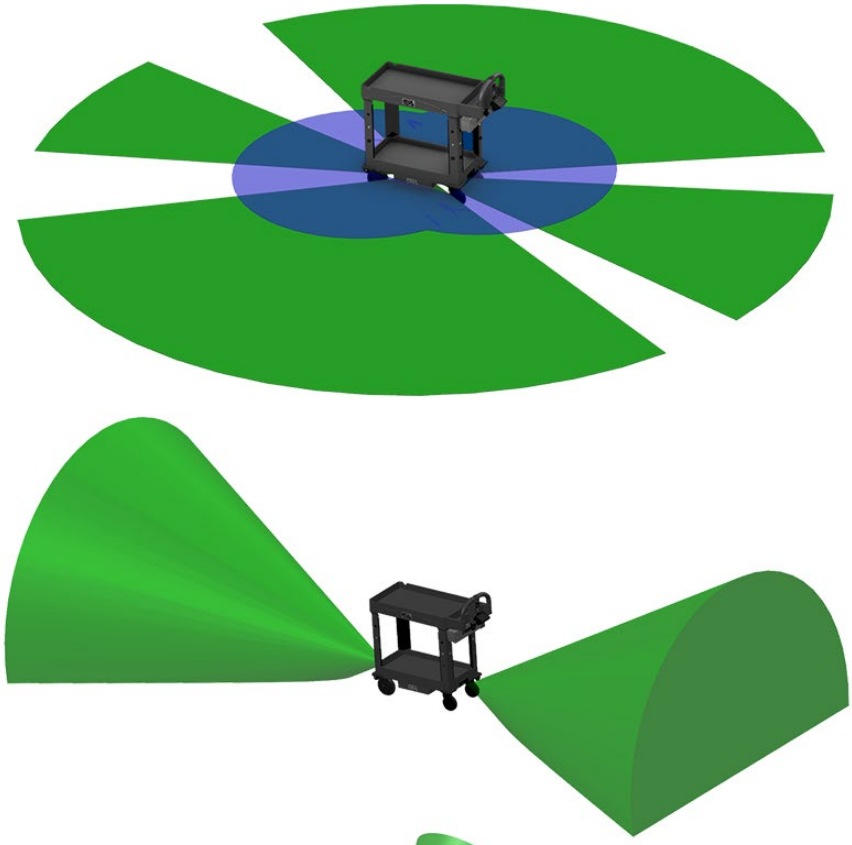
Please visit multechnologies.com/options (or use QR code below) or reach out to your salesperson for the latest details on the Options package.

To learn more and or to check / renew an Options Package, visit the MūL web site at multechnologies.com/options or scan this QR code to visit the site directly.

System and sensor overview

Combination of 3D cameras, lasers and proximity sensors create a complete view

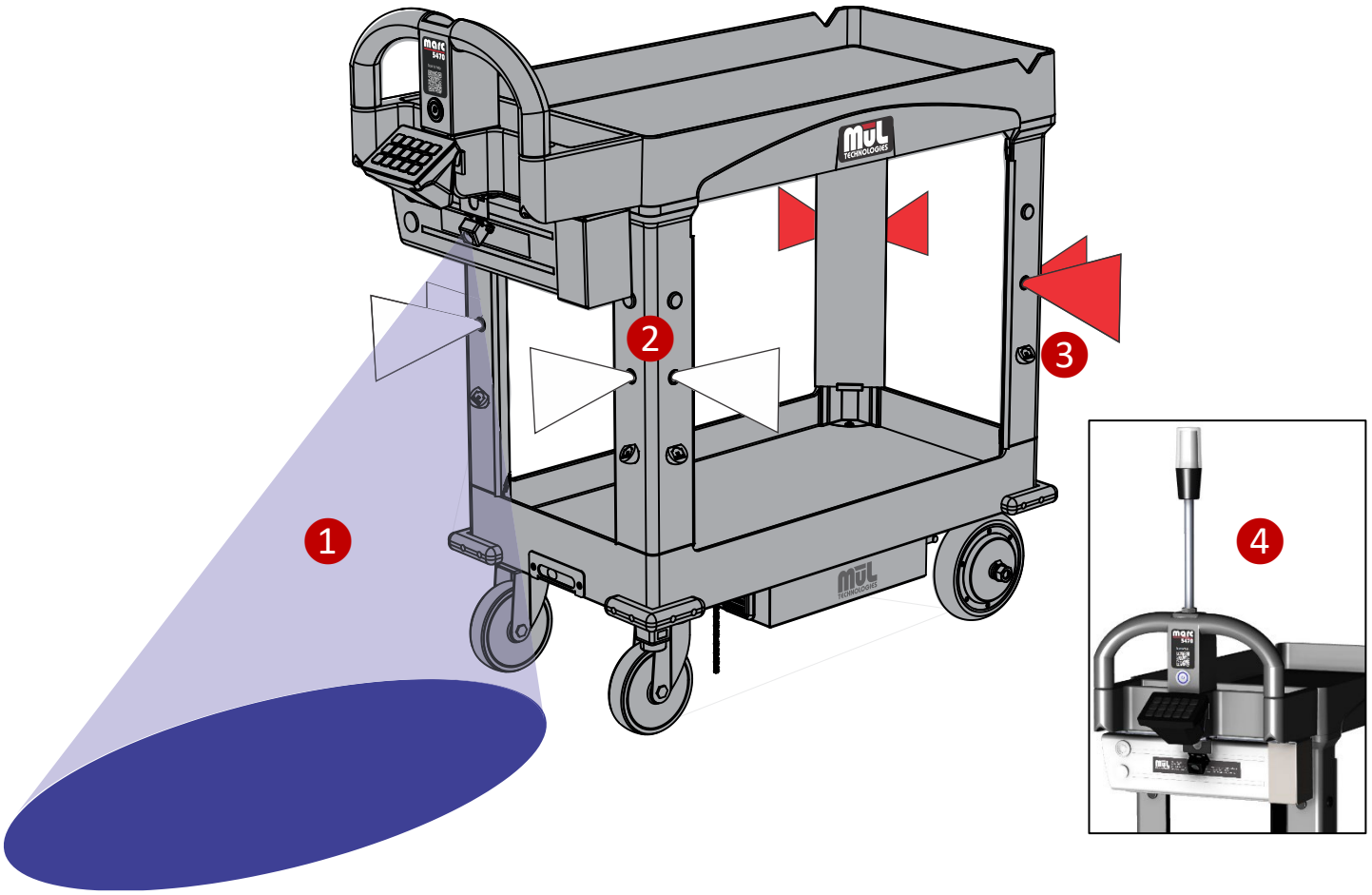
- Two high resolution 3D depth cameras allow MARC to build accurate maps, see at extreme angles, and operate safely.
- 3 independent LiDAR units scan the environment in real-time to build a completely independent map that is used to navigate through an ever-changing facility.
- 8 proximity sensors create an anti-collision system with 360° view of the area near the cart.
- Additional encoders track distance traveled, speed and turning data.
- Internal 3-axis digital gyroscope combined with a 3-axis accelerometer for measuring tilt, acceleration, and shock.



Sensor parameters

- Main LiDAR scans 360° at 32000 samples per second measuring at a distance of 25m with 1° angular resolution and 13mm distance resolution.
- Auxiliary LiDAR (X2) scans 270° at 4500 samples per second measuring at a distance of 3m with 1° angular resolution and 15mm distance resolution.
- 8 proximity sensors with 1m range and 1mm distance resolution.
- Dual 3D cameras with up to 1280 × 720 active stereo depth resolution at up to 90 fps.
- Active IR stereo depth technology with a field of view of 87°±3° × 58°±1° × 95°±3°.

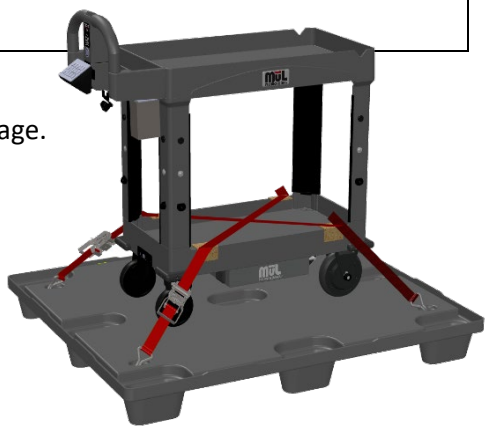
Visibility during movement – LED indicators



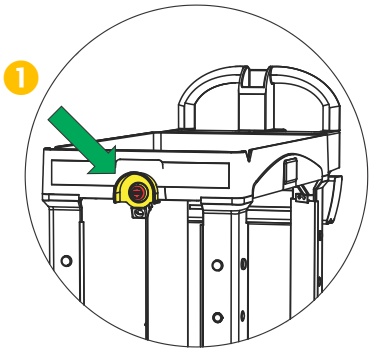
#	Feature
1	High power blue LED indicates movement toward the light. There are two blue LEDs – one in front and one in back. The LED light that is illuminated is indicating movement in that direction.
2	LED indicator lights on the legs are used for several different indicators. While the cart is in autonomous motion, the white lights also indicate movement in that direction. Consider it analogous to headlights and taillights on a road vehicle. For additional information on the meaning of LED colors and combinations, see **Table of LED indicator cues** on page **60**.
3	While the cart is in autonomous motion, the red lights indicate movement away from those lights. Consider it analogous to headlights and taillights on a road vehicle.
4	Optional flashing LED light tower can be used for greater visibility.

Unpacking and getting started

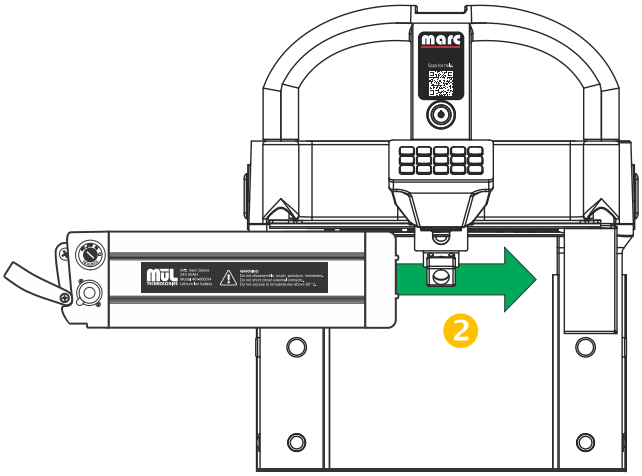
INFO	No tools are needed to unpack and start using your MARC cart!
	Remember to retain all the original packaging and shipping materials for MARC. These materials have been custom made to ship MARC units and are the best option for any future shipping needs of the system to avoid damage during shipment.

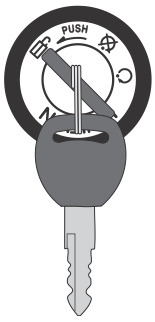


1. Place the unit on a flat, solid surface with space to move around the package.
2. Unlock container top by sliding yellow latch levers and lift / set top aside.
3. Unlock the container side by sliding the yellow latch levers.
4. Using two people, lift the outer cover upward and remove.
5. Loosen and remove the 2 ratcheting straps holding MARC to the pallet.
6. Using two people, lift MARC upward and remove from pallet.
7. Unbox the battery (packaged separately), making sure to remove the keys from the packaging.
    - Battery may need to be charged before use, please see **Charging the batteries** on page **49**.
    - Verify that the e-stop button has not been activated (pressed)(#1 below)
        - See #8 below for additional information on the e-stop button.
    - Insert key and verify the battery remains in the unlocked position.
    - Slide the battery onto the rails on the system battery holder (#2) and push it till engaged.
    - Turn the key to the “On” position (#3).
        - This will lock the battery in place and offer power to MARC.
        - To move from unlocked position to “Locked with power off” position, it is important to push the key inward slightly and then release slowly while turning the key to the next position.
    - For additional information, see **Inserting the battery pack into MARC** on page **51**.

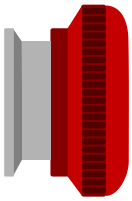
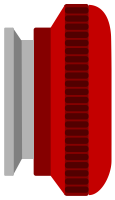


Check emergency stop button first!





8. Verify the Emergency Stop button (#1 above left) is not engaged. This can be found at the front of the cart (the end away from the handle). If engaged, turn the button in the direction of the arrows to reset – the button will pop out when disengaged.

	The emergency stop button is located on the end of the cart opposite the handle. This button is used to shut MARC off immediately when activated.
 Normal operation  Power disconnected	The emergency stop button is activated when pushed inward. The upper image on the left shows the button from the side when in a normal state. The lower image shows the button in an activated, or off state. The cart will not operate with the emergency stop button activated.

9. Press the power button just above the EZ-Go Navigation panel to turn on the cart.
10. **Note that boot time can be as long as 2 minutes** and is complete when the audio cue "Cart ready" is heard and the indicator LEDs are pulsing green.
11. **You are ready to use MARC!** Please read and understand this manual before use – while operation is simple, it is important to understand how MARC works. Continue next page to program your first locations.

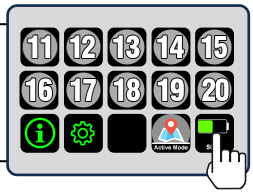
INFO	MARC should not be moved while it is starting up. The cart is ready for use when the cart announces, "Cart ready" and the LED indicators illuminate in a pulsing green pattern.
	As a best practice, move the cart to the area you wish to use MARC before powering up. This will reduce the amount of unnecessary mapping the system saves, since the mapping is constant while on. For more information on best practices, see **Best practices for mapping** on page **35**.
	For additional tips on using MARC, see **Best practices and tips for smooth operation** on page **43**.
	Each end has an emergency power-off option – the front has the red emergency stop button and rear the has the power button which also immediately powers down the unit.
	Note that any time MARC is powered off in Active Map Mode, it will need to be reprogrammed. For information on operating modes, see **Operating modes: Active Map and Fixed Map modes** on page **33**.

Programming your first destinations

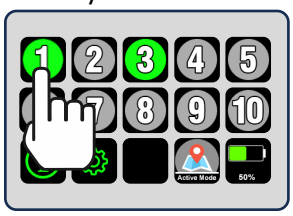
Now that you're ready to roll, let's give MARC a try!

1. If the cart is booted up and ready, go to step 5.
2. Turn the key switch to ON position.
3. Press the power button. If the cart does not power up, verify the emergency stop button is not engaged and disengage if needed (rotate clockwise with arrows until it pops out).
4. Wait for MARC to boot up, up to 2 minutes.
   - Cart is ready when audio cue "Cart ready" is heard and indicator LEDs are pulsing green.
   - Wherever MARC is physically located will be the destination when a button is programmed.
   - Speed between locations will be up to 1.0 m/second or 2.2MPH or less.
   - Start and end points should be a minimum of 1m (3 feet) from all stationary objects.
   - Entire route should include 6 feet of available space.
5. Press and hold any un-programmed station button (grey) for 3 seconds until you hear the double-beep sound.
   - In this example, we used "3." Station button will turn green, indicating programming completed.

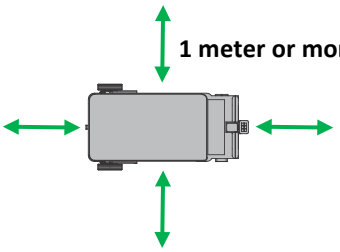
TIP: If you see the second screen, press the battery level button to return to the first screen with station buttons 1-10.



6. Using the handle, manually push the cart to a second location you wish to program as a destination.
7. Press and hold any un-programmed station button (grey) for 3 seconds until you hear the double-beep sound.
   - Use any unused station button 1-20 (in this example, we used "1").



TIP: For best results, program destinations more than 2 feet from any stationary objects.



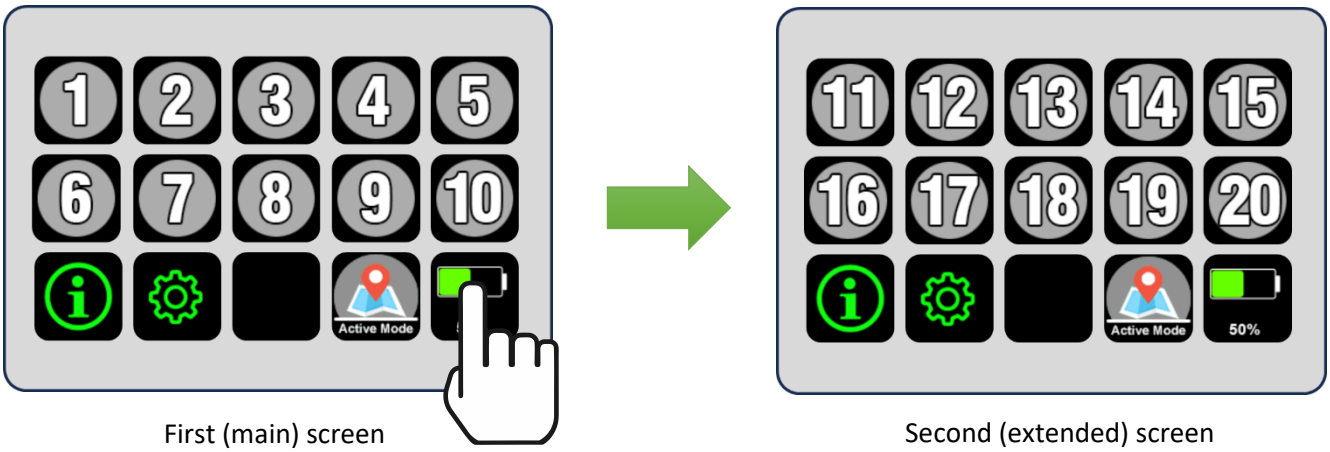
That's it! You have programmed MARC for 2 destinations in Active Map Mode and can put him to work. Press the station button for each programmed key (in our example 1 and 3), and MARC will travel to the location programmed for that button.

Additional tips:

- In Active Map Mode, MARC does not retain information when powered down or restarted. This is designed for a use case where MARC is a shared resource between multiple users.
  - You can also use MARC in Fixed Map Mode if you plan to use MARC in a specific area. See **Operating modes: Active Map and** Fixed on page **33** for more information.
- You can add a new destination at any time using any additional un-programmed (grey) station button.
- MARC will prioritize the path you took when programming destinations.
- You can *re*-program any station button by moving the cart to a new destination and pressing a pre-programmed button (green) for 3 seconds until you hear the double-beep. The current location replaces the previously programmed location.
- You can also remove a destination from a button without programming a new one. Hold the programmed button (green) 6 seconds until you hear a triple-beep. The button will turn grey and will no longer be associated with a destination.
- In Active Mapping Mode, you can also move your MARC system to any additional, non-programmed locations (for example, to get inventory items from shelves), and then tap one of the pre-programmed buttons to send MARC back to that location.

For detailed information on using the EZ-Go Navigation panel, see **EZ-Go Navigation system overview** on page **20**.

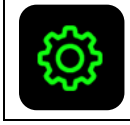
EZ-Go Navigation system overview



First (main) screen

Second (extended) screen

During normal operation, users can toggle between the first and second screens by tapping the battery button. Initially, this brings you to the second screen where destination buttons 11-20 are shown.

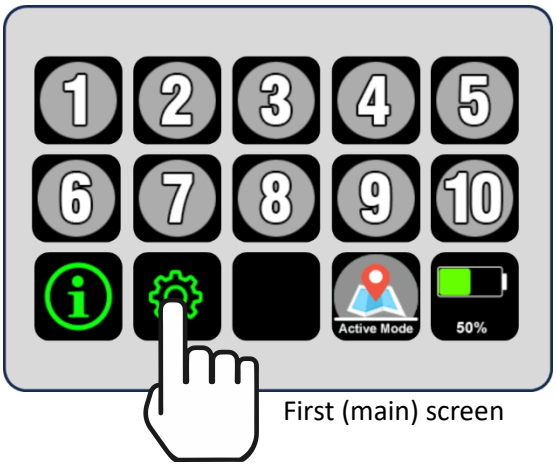
	Station buttons 1-20 (11-20 are on the second screen) display in grey when they are *not* programmed for a specific destination. Press and hold a grey button until you hear the double-beep indication (approximately 3 seconds) to program that station with the unit's current location. The button will then turn green indicating it is programmed.
	Station buttons 1-20 display in green when they are programmed for a specific destination. Tap these buttons to send the unit to its destination designated for the specific number pressed. The destination to which the cart is headed will also flash to indicate the location that it is travelling to.
	CLEARING: If you wish to clear a set location for a station button, press and hold the button for more than 6 seconds but less than 10 seconds until you hear the triple-beep indication. When released, the button will return to the grey color and no longer be associated with a destination.
	REPROGRAMMING: If you wish to set an already programmed button to the cart's current location, press and hold the button for approximately 3 seconds until you hear the double-beep indication. The cart's current location is then programmed for that numbered station button.
	Station buttons are Blue when the cart is in Looping Mode. For more information on Looping Mode, see **Operating modes: Looping Mode** on page **40**.
	The calibrate button is only available in Fixed Map Mode. The Calibrate function allows for reorientation of the mapped area in the instance that MARC becomes disoriented or is 'lost'. This can happen in a variety of scenarios, including for example if the cart hits a wet or slippery spot on the floor that causes the wheels to slip. Once MARC is in the designated location and orientation, press and hold the button for 3 seconds till you hear the double-beep tone. This will allow the map to realign to a known point of origin. To learn more about using the Calibrate function, see the section **Using the Calibrate Button functionality** on page **36.**
	The Info button displays pertinent system information and statistics. For details, see **System Statistics Overview** on page **32**.
	The settings button is used to access various cart options. See **Settings menu overview** on page **22** for additional information on settings menu.

	Under normal operating conditions, the bottom right button is reserved to display the battery's current charge status. This button also allows users to switch between the first and second screens.
 	The map button is used to save or erase the currently mapped area and indicate the current map status, either Active Mode (no saved map) or Fixed Mode (map has been saved). The button appears grey and is animated if there is currently not a saved map (Active Map Mode) and green when a map is saved (Fixed Map Mode). To save a map, press the button for 3 seconds till the double-beep confirmation is heard. The button will turn green and the audio cue "Map saved" will be heard. To erase the currently saved map, press the map button for 6 seconds until you hear the triple-beep tone. The button will turn grey, indicating the map has been erased, and the audio cue "Map erased" will be heard. This also removes all programmed locations. When a map is not saved (Active Map Mode), turning the cart off or rebooting will cause the currently mapped area to be deleted from the system. See **Operating modes: Active Map and Fixed** on page **33** for more information.
	A yellow check engine symbol indicates there is an urgent issue with the cart. It is still possible to operate the cart, but the issue should be addressed as soon as possible. For more information, see **Troubleshooting** on page **66**. Press the battery level indicator button to return to the main screen.
	A red check engine symbol indicates there is a critical issue with the cart. Autonomous mode and powered manual drive mode are both disabled when there is a critical issue. For more information, see **Troubleshooting** on page **66**.

	Tapping any button during movement will cancel the current route. If you tap the wrong location, for example, you can immediately press any key to cancel the route and then press the correct location button. This also acts as a safety feature, as pressing any button will cause the cart to stop.

Settings menu overview

The settings menu can be accessed by tapping the Settings icon on the EZ-Go Navigation panel.



First (main) screen

Settings screen

	The Settings button is used to access various options shown above. These include adjusting the volume, activating or deactivating Beep mode, Loop mode and adding or removing optional languages. This is also where you access Power Assist Mode and system lock features.
	The Volume submenu allows you to adjust the volume of your cart in 10% increments. Note that since it is a feature that adds safety, you can lock a specific level setting for volume. The volume (+) button increases the volume and the volume (–) button decreases volume in increments of 10%. When in the main screen showing the programmed location buttons, tap the settings button to access the settings screen with the volume submenu button. Click that to access the volume up/down buttons to adjust sound levels. Note the volume level controls all audible system notifications including the warning beep, and all are adjusted in unison. If the icons show a small padlock on the upper left, that indicates that the volume function has been locked and cannot be changed until the cart is unlocked using the code entered.
	MARC carts offer a safety beeping option, which when activated is heard while MARC is moving in autonomous mode. Warning beeps can be enabled or disabled using the single button, and current status is displayed on the button as grey when off, and green when active. To turn the beeping on, press and hold the button for 3 seconds till you hear the double-beep tone. The icon will turn green to indicate it has been activated. To turn off the beeping, press and hold the button for more than 6 seconds until the triple-beep sound is heard. The icon will turn grey to indicate beeping has been turned off.
	To turn Looping Mode on, press and hold the Looping Mode button for 3 seconds till you hear the double-beep tone. The icon will turn green to indicate it has been activated. To turn off looping mode, press and hold the button for more than 6 seconds until the triple-beep sound is heard. The icon will turn grey to indicate Looping Mode has been deactivated. For detailed information on using MARC carts in looping mode, see the section **Operating modes: Looping Mode** on page **40**.
	The grey padlock in an unlocked position indicates that the cart is currently not locked with a code. The green padlock in a locked position indicates that the cart is currently locked with a code. For detailed information on using the locking functionality, please see **Locking the MARC cart settings to prevent** reprogramming on page **24**.

	The Info button displays pertinent system information and statistics. For details, see **System Statistics Overview** on page **32**.
	Powered Assist manual drive buttons allow the user to operate the cart manually. The buttons will move the cart in the direction shown when pressed. **Use caution, as during manual movements all safety features of the cart are disabled**. When in the main screen showing the programmed station buttons, tap the settings button to access the second screen with the manual drive submenu. Click the joystick icon to access the arrow keys. For more information on using manual movement, please see the section **Powered Assist movement mode** on page **45**.
	 **WARNING: All safety features are disabled while using the powered manual movement mode.** The operator is responsible for safe movement of MARC in *any* manual movement mode. Great care must be taken while using powered manual movement mode.
	The language icon allows access to the various language options that are available. Note that the individual language icons are greyed out when disabled, and colored when enabled as shown on left. Each audio cue will be spoken in English (always) and then repeated in the additional languages that are enabled.
	Precise mode allows users to program MARC to use less of the available pathway to move. This mode toggles on or off by using the settings button. For more information on this mode, please see **Operating modes: Precise Mode** on page **38**.

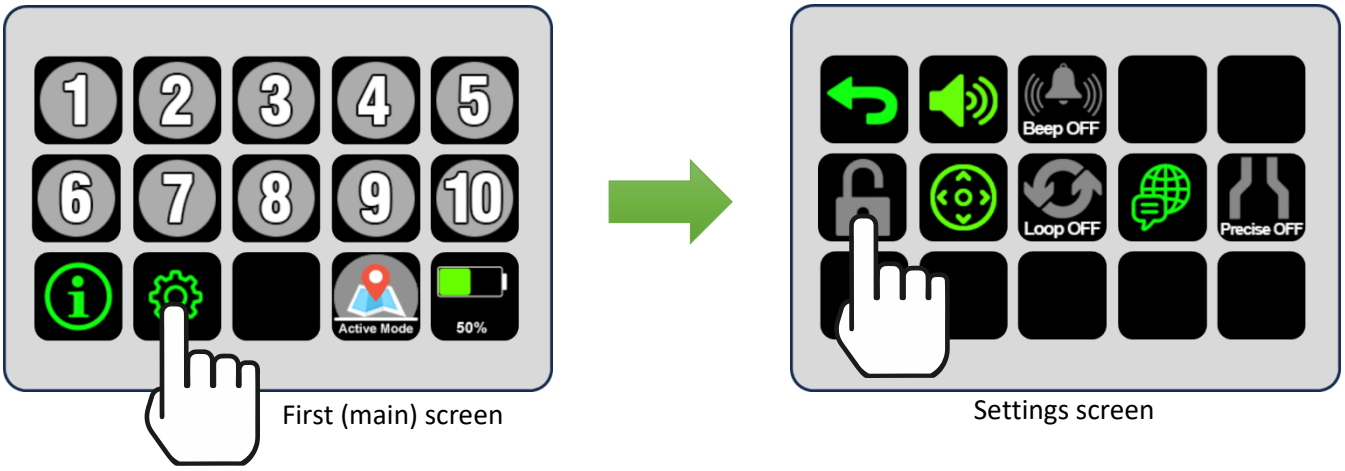
	Note that some settings can be locked to prevent access or reprogramming. When the cart is locked, these options will have a small padlock in the upper left corner indicating that they are only accessible if the cart is first unlocked. See **Locking the MARC cart settings to prevent** reprogramming on page **24** for more information on use of the locking feature.

	Some options are included in the Options Package and may require a current options package subscription. For more information on what is included in the Optional Software Package, please see **About the Optional Software Package (OSP)** on page **14**.

Locking the MARC cart settings to prevent reprogramming

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**

The settings menu can be accessed by tapping the Settings icon on the EZ-Go Navigation panel. Once on the settings screen, the code entry screen can be loaded by pressing the padlock button. The button may appear grey and unlocked (if the cart is not locked) of green with a locked padlock (if the cart is locked).

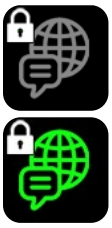
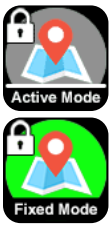


First (main) screen

Settings screen

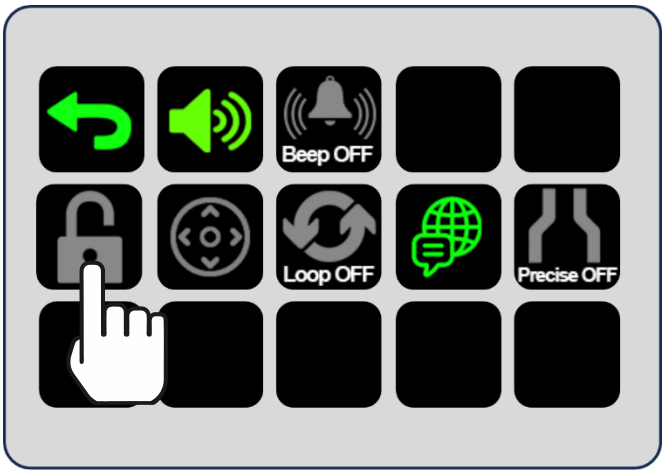
Some settings are automatically locked to prevent user changes. Others are locked in an enabled or disabled state. For example, all destination buttons are automatically locked in their current state, while the volume level submenu remains locked in either an on or off (accessible or not accessible) state – based on the status when the lock code is applied.

	**LOCK INDICATOR** The grey (Open) padlock indicates that the cart is not locked. All programming is available to users and all settings can be changed. The green padlock indicates the cart is locked and a code has been set. The code will be required to unlock the cart and change any settings. All other buttons will display the small padlock over the icon to indicate that the cart is locked, and those functions cannot be edited out of their current state (unless they are locked in an enabled state. See table below for more detail.
Features that will be affected by locking the cart include the following:	
	**DESTINATIONS** Destinations are locked in their current state. If the destination was not programmed, it cannot be used. If a destination is programmed, it will remain and cannot be updated or removed. This is true for all destination buttons. In order to update, add or remove destinations, the carts will need to be unlocked.
	**VOLUME** The grey volume submenu icon with a padlock indicates that the cart is locked and the volume adjustment buttons are not accessible. The green volume submenu icon with a padlock indicates that the cart is locked but the volume adjustment buttons remain accessible. In this scenario, volume levels can be adjusted by users.

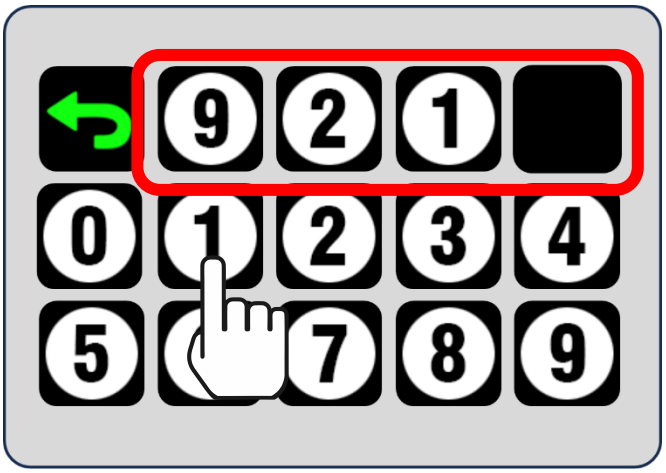
	**POWER ASSIST MODE** The grey power assist submenu icon with a padlock indicates that the cart is locked and power assist buttons are not accessible. The green power assist submenu icon with a padlock indicates that the cart is locked but the power assist buttons remain accessible. In this scenario, power assist buttons can be used to move the cart manually.
	**LANGUAGE PACKS** The grey language submenu icon with a padlock indicates that the cart is locked and language options are not accessible. The green language submenu icon with a padlock indicates that the cart is locked but the language options remain accessible. In this scenario, languages can be enabled or disabled.
	**MAP MODES** The grey (Active Map Mode) icon with a padlock indicates that the cart is locked and map cannot be saved. This allows the cart to be permanently in Active Map Mode. The green (Fixed Map Mode) icon with a padlock indicates that the cart is locked and the current map cannot be erased. This locks the cart into either Active Map Mode or Fixed Map Mode exclusively. Please see note below regarding rebooting while in Active Map Mode and while the cart is locked.
	**PRECISE MODE** The grey (Active Map Mode) icon with a padlock indicates that the cart is locked and map cannot be saved. This allows the cart to be permanently in Active Map Mode. The green (Fixed Map Mode) icon with a padlock indicates that the cart is locked and the current map cannot be erased. This locks the cart into either Active Map Mode or Fixed Map Mode exclusively. Please see note below regarding rebooting while in Active Map Mode and while the cart is locked.

	Locking the MARC cart while in Active Map Mode (no saved map) can result in confusing situations. Since the destination buttons are automatically locked, and the cart maps and destinations are deleted when the cart is powered down (including for battery change or emergency stop button activation) the operator will not be able to use the cart after rebooting until it is unlocked. This is because reprogramming the cart will require the code to unlock the cart and make the destination buttons available.
	To lock the cart, first program everything the way you want it to remain. This means that mapping should be completed, destinations should be set

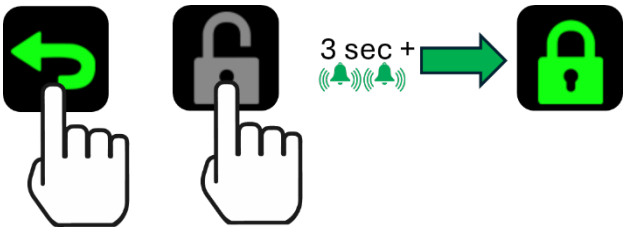
To set a lock code and lock the cart



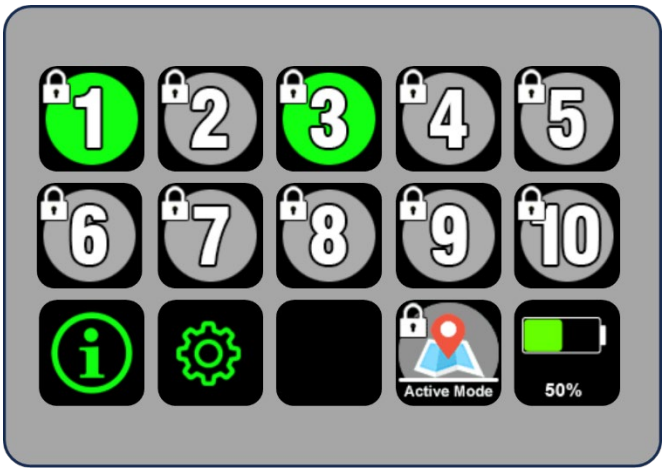
Choose the padlock icon to enter the code screen and enter your security code.



Enter the 4-digit numerical code you would like to use to lock the cart. Once the code is entered, tap the back arrow to return to the previous screen displaying the lock icon.



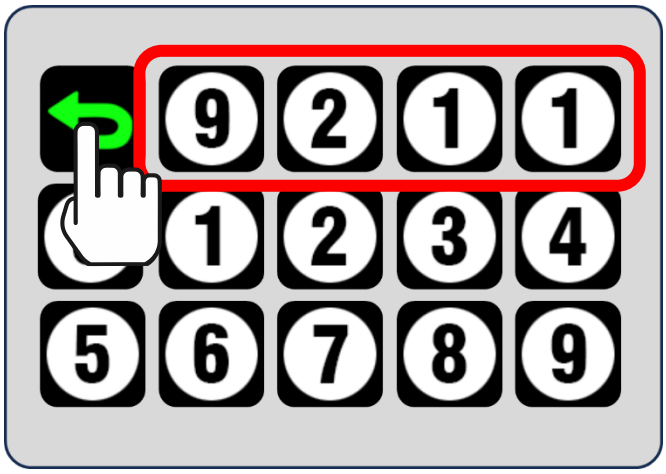
Press and hold the padlock icon for over 3 seconds till you hear the double-beep audio cue. When you release the button, the padlock will turn green and appear locked, indicating that the cart programming is now secured.



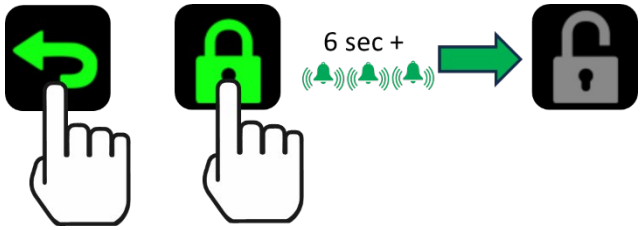
Once the cart has been locked, buttons will show padlock as indication that they cannot be changed till the cart is unlocked.

To remove a lock code and unlock the cart

Tap the settings icon. Choose the padlock icon to enter the code screen and enter your security code.



Enter the 4-digit code you used to lock the cart. Once the code is entered, tap the back arrow to return to the previous screen displaying the lock icon.



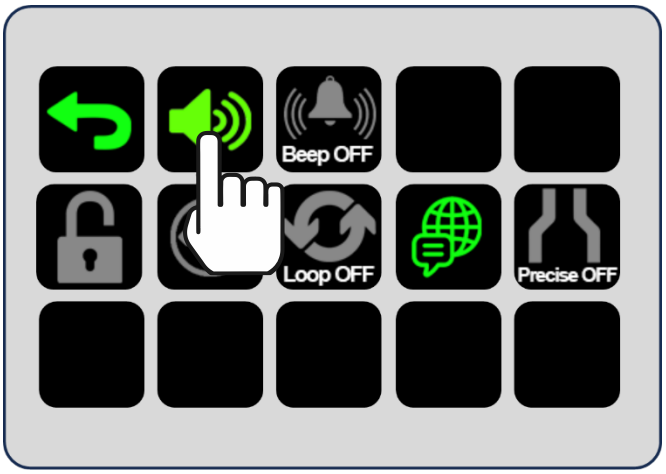
Press and hold the padlock icon for over 6 seconds till you hear the triple-beep audio cue. When you release the button, the padlock will turn grey and appear unlocked, indicating that the cart is now unlocked.

Once the cart has been unlocked, buttons will no longer show a padlock in the upper left as indication that they can be changed.

How to enable/disable and lock the volume settings submenu

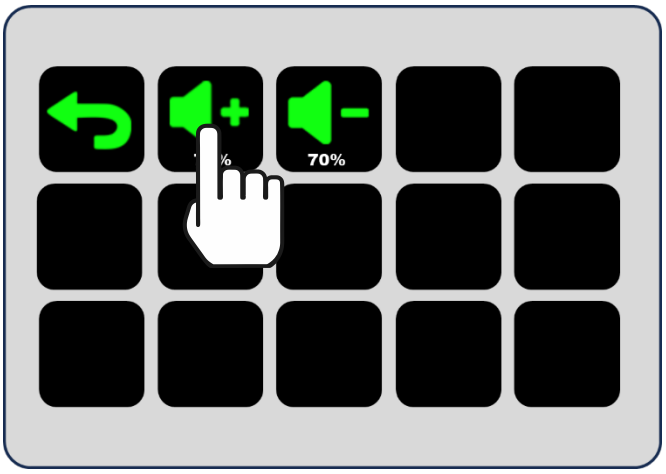
MARC carts can be locked for preventing users from changing certain settings. This includes the volume settings. If you want to ensure that the volume does not change from the desired setting, you can use the EZ-Go Navigation locking function to accomplish this. Note that some functions are automatically fully locked, and others are optionally part of the locking settings.

For full details on setting up a code and locking the cart, see **Locking the MARC cart settings to prevent** reprogramming on page **24.**

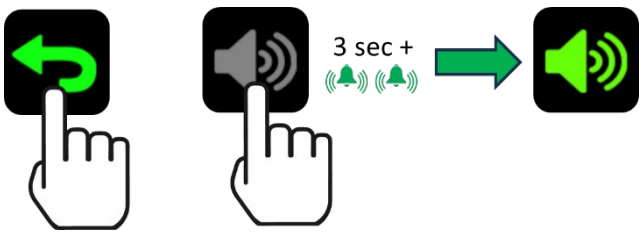


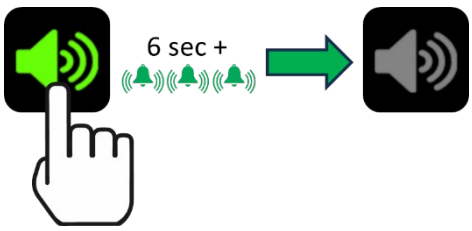
Once the Volume menu icon turns grey, you can now lock the cart and the volume adjustments will not be available to users. The volume level you set will remain until the cart is unlocked and the setting changed.

This can be verified by the grey (disabled) icon with the padlock (locked) displayed as shown.

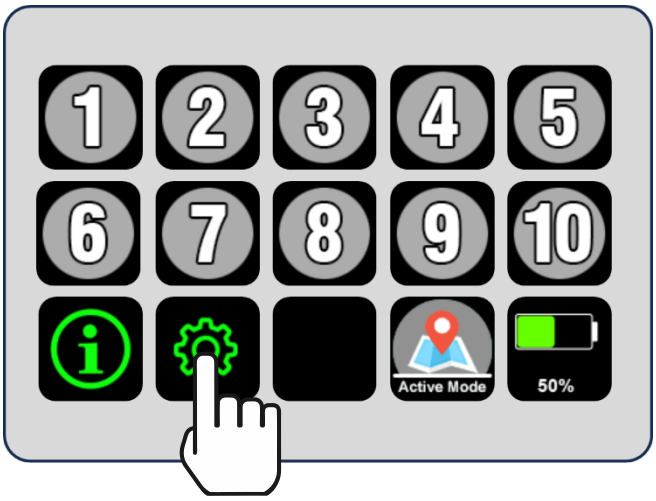


If the cart is locked, but the Volume submenu is still active, users will be able to adjust the volume whether the cart is locked or unlocked. In this case, the volume button will appear green with a padlock, indicating the cart is locked but the volume adjustments remain available. Users can adjust the volume as desired.



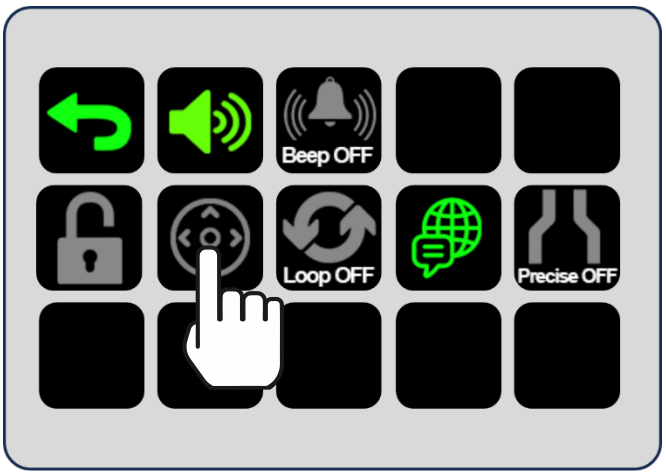


How to enable/disable and lock Power Assist Mode



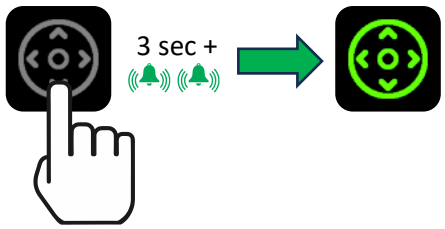
MARC carts can be locked for preventing users from changing certain settings. This includes the beep settings. If you want to ensure that the beep does not change from the desired setting, you can use the EZ-Go Navigation locking function to accomplish this. Note that some functions are automatically fully locked, and others are optionally part of the locking settings.

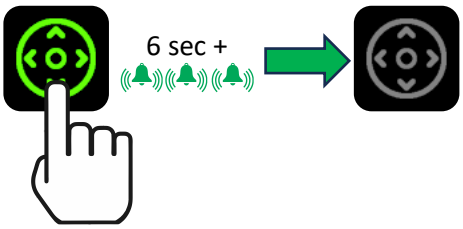
For full details on setting up a code and locking the cart, see **Locking the MARC cart settings to prevent** reprogramming on page **24.**



Once the Power Assist setting is set how you want it (accessible or not), you can lock the cart and the Power Assist function setting cannot be changed by users. If the setting is enabled (green) it cannot be disabled without unlocking the cart with the security code.

This can be verified by the green (enabled) or grey (disabled) icon with the padlock (locked) is displayed as shown.





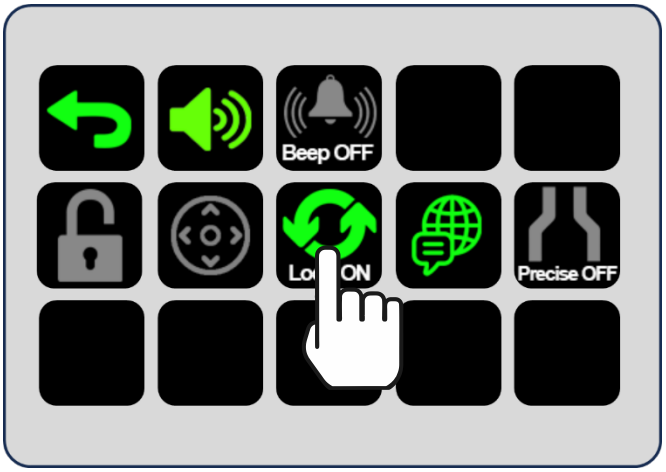
How to enable/disable and lock Looping mode setting

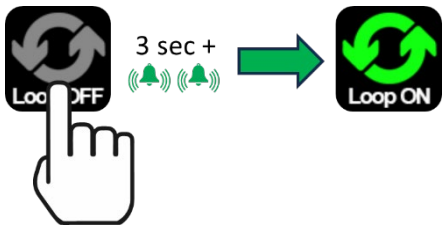
MARC carts can be locked for preventing users from changing certain settings. This includes the looping mode settings. If you want to ensure that the looping mode state does not change from the desired setting, you can use the EZ-Go Navigation locking function to accomplish this. Note that some functions are automatically fully locked, and others are optionally part of the locking settings.

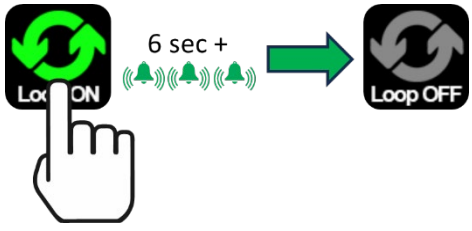
For full details on setting up a code and locking the cart, see **Locking the MARC cart settings to prevent** reprogramming on page **24.**

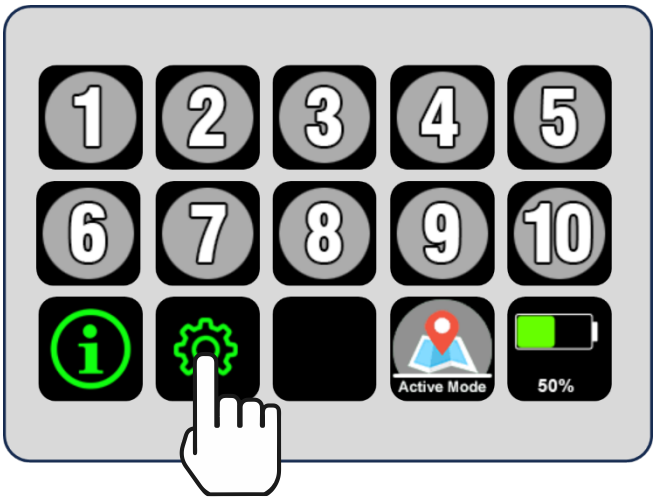
Once the Looping Mode is set how you want it (on or off), you can lock the cart and the looping mode setting will not be available to users. The cart will remain in looping mode until the cart is unlocked and the setting changed.

This can be verified by the grey (disabled) icon with the padlock (locked) displayed as shown.







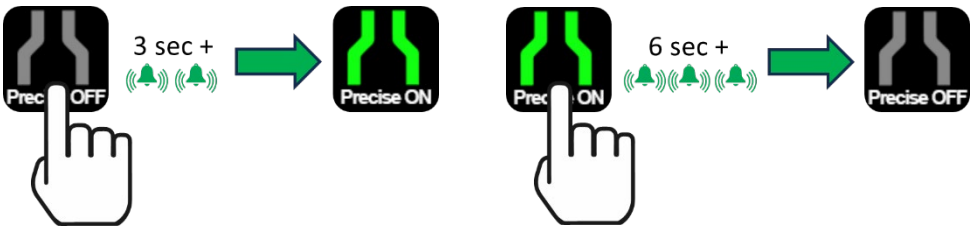


MARC carts can be locked for preventing users from changing certain settings. This includes the Precise Mode settings. If you want to ensure that the Precise Mode state does not change from the desired setting, you can use the EZ-Go Navigation locking function to accomplish this. Note that some functions are automatically fully locked, and others are optionally part of the locking settings.

For full details on setting up a code and locking the cart, see **Locking the MARC cart settings to prevent** reprogramming on page **24.**

Once the Precise Mode is set how you want it (on or off), you can lock the cart and the current state will be locked and not be available to users. The cart will remain in Precise Mode until the cart is unlocked and the setting changed.

This can be verified by the grey (disabled) icon with the padlock (locked) displayed as shown.

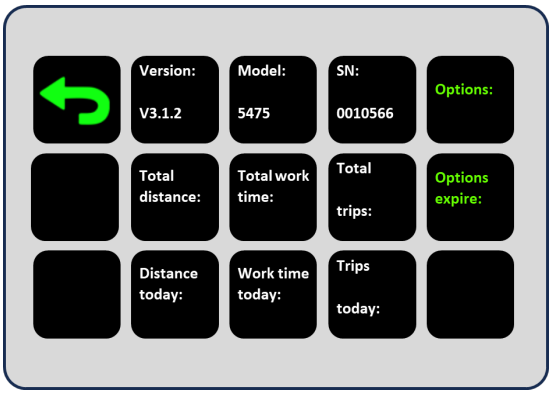


System Statistics Overview

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**

The statistics screen can be accessed by tapping the Info icon on the EZ-Go Navigation panel.

First (main) screen



Info screen

Version:	This is a string that indicates the current software revision that the cart is running.
Model:	This indicates the model number of the product.
SN:	This is the unique serial number of the unit.
Total distance:	This is the total distance travelled by the unit since it was put into service.
Total work time:	This is the total time in service for the unit since it was put into service.
Total trips:	This is the total number of trips travelled by the unit since it was put into service.
Distance today:	This is the total distance travelled on today's date.
Work time today:	This is the total time in service for the unit on today's date.
Trips today:	This is the total number of trips travelled by the unit on today's date.
Options:	Options package – enabled (active) or disabled (inactive). See **About the Optional Software Package (OSP)** on page **14** for additional information.
Options expire:	Expiration date for the Options package. See **About the Optional Software Package (OSP)** on page **14** for additional information.

INFO	The data shown in the info screen is intended to be permanent to each unique cart. In some situations, the data may be lost. This could include events such as RMA replacement units, replacement hardware installation or other service. In some cases, software updates or reinstallation may result in this data being lost.

Operating modes: Active Map and Fixed Map modes

MARC carts operate in two distinct mapping modes. It is important to understand the differences between these modes to ensure the most value for your unique scenario.

Depending on how you plan to use each MARC, you have options to most efficiently leverage the benefits of automation that will help you save the most time possible. Each mode of operation is described below.

Active Map Mode Overview

While in Active Map Mode, all areas MARC travels through will be added to its internal map. This means there are no 'predefined' areas where the unit is required to operate within. This mode is the best approach for ad-hoc shared use of the cart. Operators can use it for a specific task over a short period, then turn it off and let someone else use it for their specific task.

In Active Map Mode, MARC units will not remember mapped areas when they are powered down. This includes during a battery swap. To save the map, the Save Map button should be used, which then puts MARC into the Fixed Map Mode.

Fixed Map Mode Overview

Fixed Map Mode is the most efficient option when you plan to use MARC in a consistent area and can leverage the saved map for that area.

While in Fixed Map Mode, MARC units must be kept in their mapped area.

Once MARC is in Fixed Map Mode, the map will become saved permanently (until an "Erase Map" process is executed, or the software is updated).

The unit must now remain in the currently mapped area while operating, or the message "Out of mapped area" will be heard and the cart will need to be returned to the mapped area for use.

Optionally, the map can be erased, returning MARC to Active Map Mode. In this case, the mapping process will need to be redone.

 	The Save Map button is used to save the currently mapped area and used to indicate the current map status. The button appears grey if there is currently not a saved map (Active Map Mode) and green when a map is saved (Fixed Map Mode). To erase the currently saved map, press the map button for 6 seconds until you hear the triple-beep tone. The button will turn grey, indicating the map has been erased, and the audio cue "Map erased" will be heard. When a map is not saved (Active Map Mode), turning the cart off or rebooting will cause the currently mapped area to be deleted from the system.

Mapping Modes Comparison Chart

	Active Map Mode	Fixed Map Mode
Quickly use cart in varied areas – shared usage	X	
Ability to add to map as you move to new areas	X	
MARC can only be used in mapped area		X
Ability to retain map on power-off or restart		X
Ability to retain map during battery swap		X

Using MARC in Active Map Mode

MARC defaults to Active Map Mode from the factory and is indicated by the Save Map button appearing grey. Active Map Mode will remain in effect until the Save Map button is used to save a map. This results in the mode of operation moving from Active Map Mode to Fixed Map Mode.

Adding a new destination while in Active Map Mode.

Simply add the desired destination (current location) to an unused station button or reprogram an existing station button. Press the desired station button until you hear the double-beep confirmation tone.

Saving a map (move to Fixed Map Mode)

Press and hold the Save Map button until you hear the double-beep confirmation tone. MARC will also announce "Map saved". It may take some time to save the map depending on the size of the map. If you press a button during saving process, an audio cue will prompt "Saving map."

INFO	Do not move the cart while the map is being saved, as MARC is not actively mapping during the Map Save process. This may cause mapping errors and the appearance of a malfunctioning or lost cart.

Once you save a current map, you will be in Fixed Map Mode.

Using MARC in Fixed Map Mode

Whenever a map is saved (Save Map icon is green as shown), MARC is in Fixed Map Mode. Fixed Map Mode will remain in effect until the Save Map button is used to erase a map or the software is updated. This results in the mode of operation moving from Fixed Map Mode to Active Map Mode and all programmed locations will be erased.

INFO	Depending on the length of the mapped path, the map may take some time to save. If this is the case, an audio cue will mention that the map is taking a bit to save along with an estimated time remaining.

Adding a new destination while in Fixed Map Mode.

If the desired destination is within the area that has been mapped, you can simply add it to an unused station button or reprogram an existing station button. Press the desired station button till you hear the double-beep confirmation tone.

To add a new point outside of the existing map, MARC will need to be reprogrammed by erasing the map (moving to Active Map Mode) and remapping the area to include all desired locations and then saving the map (moving to Fixed Map Mode) after the mapping of the entire area is complete.

Moving MARC outside of mapped area in Fixed Map Mode.

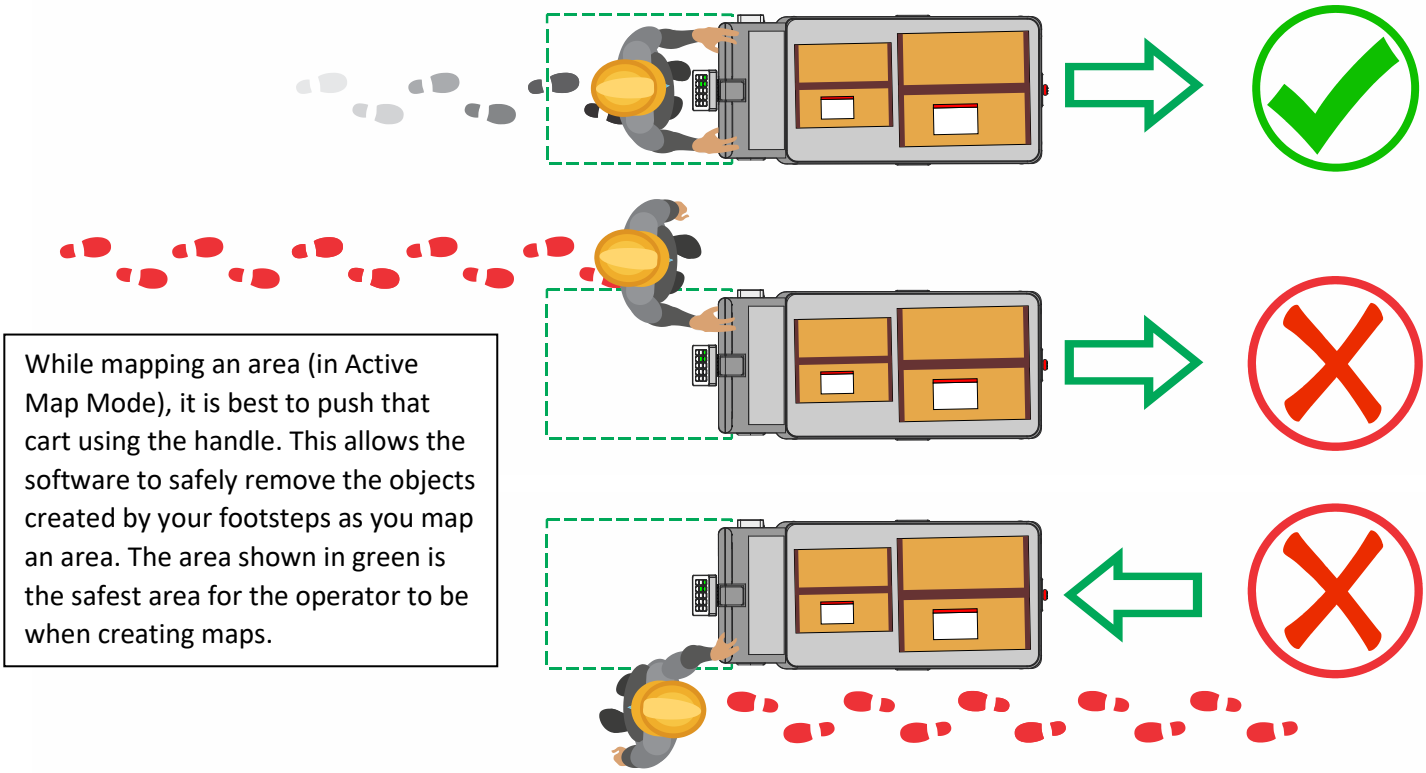
If MARC units are moved outside of the mapped area and the cart attempts to navigate to a destination or set a destination, the announcement "Outside mapped area" will be heard.

Once the cart is moved back into the existing mapped area, "Entering mapped area" will be heard and it will become operational.

Best practices for mapping

Mapping tips:

- When mapping a new area (Active Map Mode), it is beneficial to 'close the loop' and return to the same point mapping began. This allows for a more accurate map. MARC's software will be able to reference that initial point to straighten any areas that may have shifted during the mapping process.
- When initially mapping an area (Active Map Mode) and planning to save the map (Fixed Map Mode) for use in a single area, it is best not to have temporary objects in the area. Once the map is saved, those temporary items will be part of the permanent map. This may include, but not limited to, pallets of goods, parked or stationary forklifts, moveable staircases, similar large items, and people walking near the cart.
- When in Active Map Mode, be sure not to push MARC at speeds greater than 1.3m/sec (3mph) to avoid gaps in the map creation.
- When pushing the cart in Active Map Mode, only push from the handle side. Pushing from other sides or pulling the cart can cause lower sensor visibility and result in a reduced quality map. Objects may also be created based on the cart's view of your feet as you step.



While mapping an area (in Active Map Mode), it is best to push that cart using the handle. This allows the software to safely remove the objects created by your footsteps as you map an area. The area shown in green is the safest area for the operator to be when creating maps.

- When setting destinations, position the cart at least 1m (3 feet) away from any obstacle. This will generally prevent an abandoned route when returning to that destination.
- Never try to manually move or push the cart while it is moving autonomously, as this can cause the wheels to slip and thus interfere with the mapping alignment.
- Once the map has been created, be sure to limit the number of autonomous routes run prior to saving the map. Using the cart autonomously for numerous routes can result in a less effective map and may take longer to save the map and move to Fixed Map Mode.

Using the Calibrate Button functionality (Fixed Map Mode)

INFO	If you are using AprilTags, any pre-mounted AprilTag can calibrate the MARC cart simply by coming into view of the cart's cameras. When the cart sees on of the tags, the audio cue "Landmark detected" is heard. This is a simplified way to effortlessly calibrate MARC.

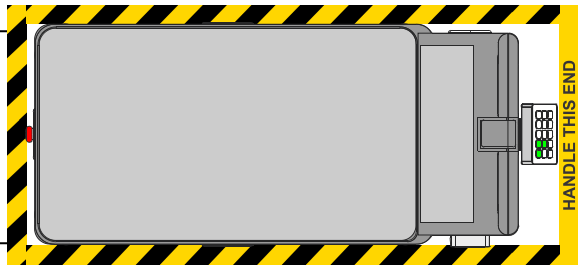
On occasion, like any autonomous robot, MūL robotic carts can become disoriented. This typically happens because of carts being moved while they are powered off – mapping cannot be done while power is off or the battery removed, and the cart is not actively mapping. Someone, for example, may move the cart during a battery swap.

In these instances, the Calibrate button can function as a 'reset' to a known location when in Fixed Map mode.

	Please note: The Calibrate button is automatically programmed when MARC is powered on or rebooted in Active Mapping Mode, which is the default when MARC is being programmed. Once the system is booted, the Calibrate button will automatically be set to the current location and orientation. Therefore, the cart should be booted in the known spot and orientation (similar to a parking spot) to allow calibration should it be needed. **In Fixed Map Mode:** Once the map has been saved (cart is in Fixed Map mode), the Calibrate button becomes operational and the calibration functionality is available. The only way to change the calibration location is to erase the map (return to Active Map mode) and reprogram the cart and saving the map. **Using the Calibrate button for reorientation (Fixed Map mode only):** Once the cart is moved to the known location and oriented properly, press and hold the Calibrate button till you hear the double-beep confirmation. The cart should now be correctly calibrated.

A tip for using the Calibrate functionality is to create a known 'parking spot' for a specific cart and use that as the physical Home location. Then, if the maps need to be realigned, the cart can be brought to that specific location in correct orientation and the Calibrate button pressed for 3 seconds until the double-beep confirmation is heard. Multiple carts utilized in the same area can share a common parking spot.

TIP: For best results using the Calibrate function, we suggest that you create a 'parking spot' for your robot. This will allow for simple use of the Calibrate functionality. Remember to have the cart parked and properly oriented when it is initially booted (in Active Mapping Mode) to set the parking spot location and orientation.



A few things to note about the Calibrate functionality:

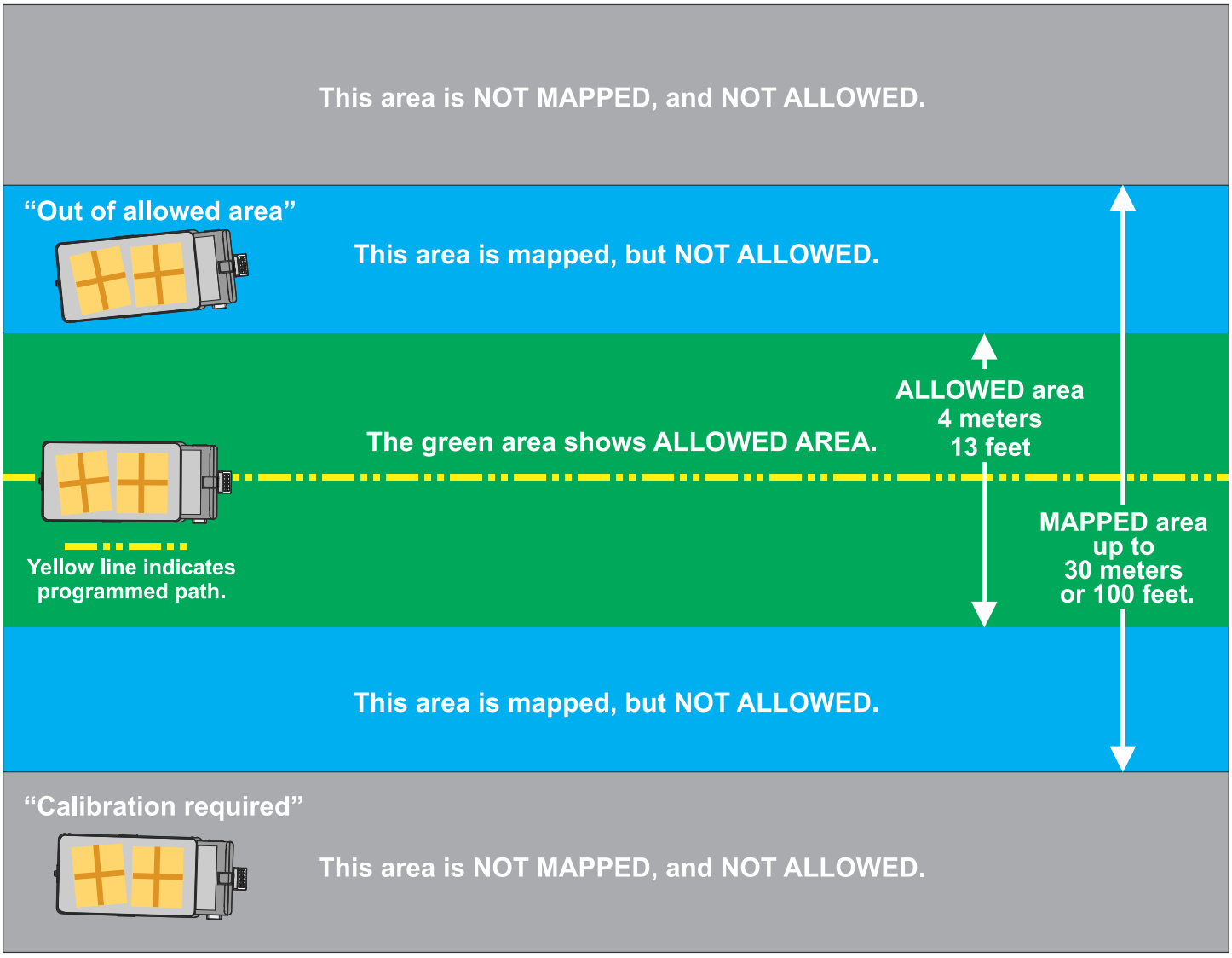
- The parking spot location is set automatically when the cart is booted initially in Active Mapping Mode. Once the unit is in Fixed Map mode, the parking spot location is saved, the Calibrate button will appear and the location will remain consistent.
- The physical parking spot location cannot be changed once it has been set, which is automatic.
- Note that any time a map is erased, the parking spot will automatically be set for the exact location the cart is in when the map erase process has completed.
- Be sure not to move the cart during the boot-up or map deletion processes.
- If the Calibrate button is used when the cart is not in the parking spot and oriented correctly, the cart will shift the map and will not operate properly.

Understanding Mapped Area and Allowed Area

Allowed Area:
This is an area that is 2 meters to the left and right (4 meters total) that the cart considers viable area to operate. Note that in Precise Mode, this area narrows to approximately 1 meter to the left and right (2 meters total).

Mapped but not Allowed Area:
The area shown in blue below is mapped by the LiDar and reaches significantly farther than the Allowed Area. In the diagram below, the blue area represents this portion of the map (not proportionately). This is an area that is up to 15 meters to the left and to the right of the Allowed Area. This is used to plot additional environmental objects that can be used by the robot to understand where it is. If the card is manually moved to this area, the audio cue “Out of allowed area” will be heard. The cart should be returned to the Allowed Area to continue operation.

Non-Mapped Area:
The grey out areas shown below represent the areas outside of the carts map. When the cart is in this area, it will give the audio cue “Calibration required”, meaning that the cart should be calibrated at the known home location and the Calibrate button pressed till the double-beep confirmation is heard.



Operating modes: Precise Mode

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**

MARC carts can operate in a mode where it is allowed to deviate from its path less. This can be handy for situations where you want the robot to operate in a narrower path. In this mode, the cart will be allowed to deviate less from the original path that was programmed.

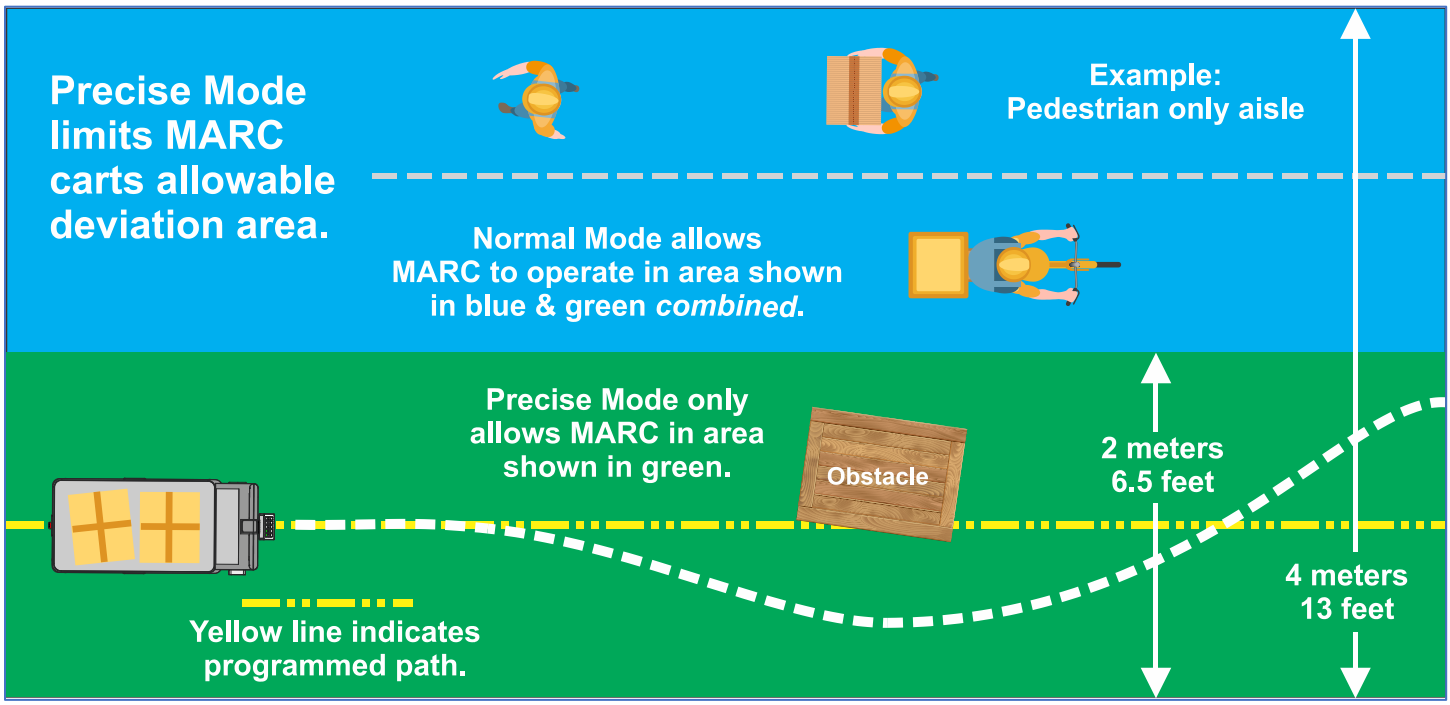
To toggle Precise Mode on and off, click the Settings button and then press and hold the Precise Mode button until you hear 2 beeps (to enable) or longer till you hear 3 beeps (to disable).

Overview of Normal Mode vs Precise Mode

Precise Mode is an option for scenarios where you want to confine MARC to a smaller width, more confined path. By default (with Precise Mode off), MARC carts are allowed to deviate a total of 4 meters (13 feet) while operating. This means 2 meters (6.5 feet) to the left or right of the originally programmed path.

When you activate Precise Mode, the MARC carts are allowed to deviate a total of 2 meters (6.5 feet) while operating. This means 1 meter (3.25 feet) to the left or right of the originally programmed path.

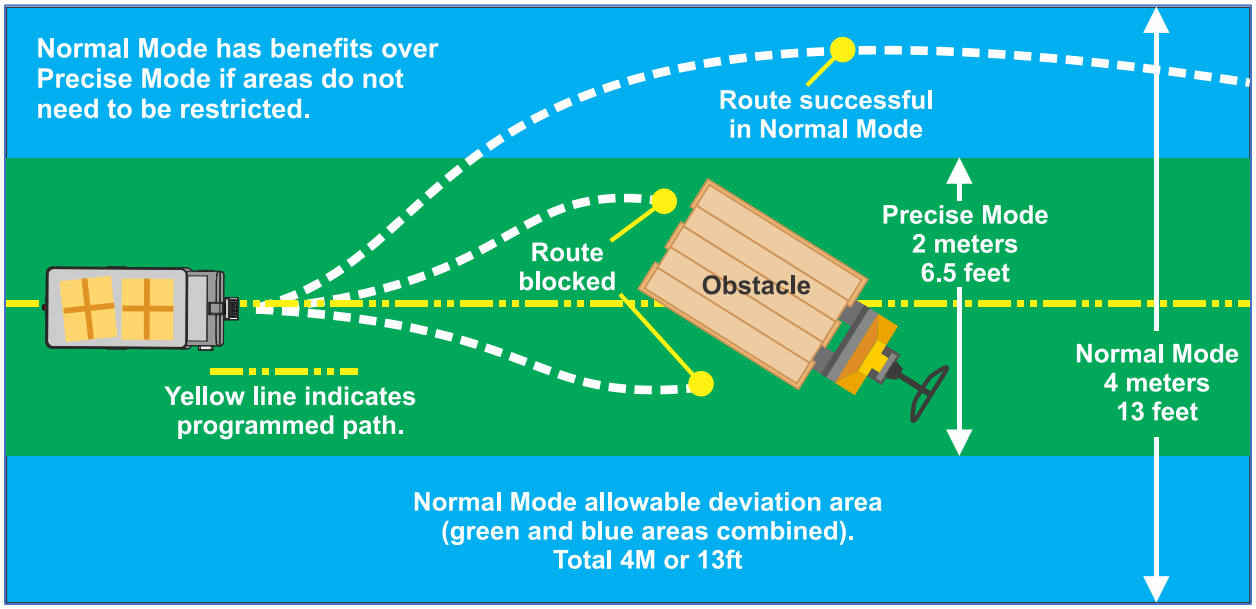
In Precise Mode, the cart considers a smaller width of deviation – 2 meters (6.5 feet) to be allowable for navigation. This can come in handy if you have a scenario where you do not want MARC carts to enter an area outside of that viable zone. In the example below, this is to prevent MARC carts from travelling into the pedestrian lane shown in blue.



Tips for using Precise Mode

Precise mode can be extremely beneficial for areas where it is desirable to keep MARC carts out of specific areas. These are often areas reserved for other types of traffic, for example pedestrians, bicycle lanes, or fork truck lanes.

With increased precision there may be times when the cart appears to have a path around an object (a pallet in the aisle, for example) but will not attempt to go around that obstacle. This can happen more readily in Precise Mode, since the cart is not allowed to deviate far enough from its path to get around the obstacle. The figure below is an illustration where an obstacle creates a blocked path in Precise Mode, while the cart in Normal Mode will not be blocked by the obstacle. Your unique use case may benefit from one mode or the other.



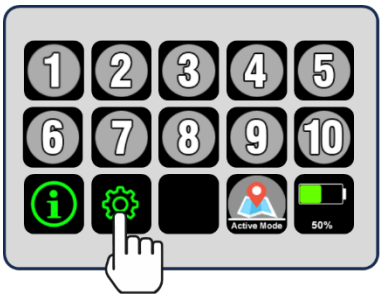
Additional considerations

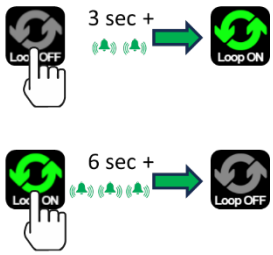
- For routes that have these more sensitive areas, Precise Mode is a great option to help keep MARC carts in more desirable 'traffic lanes'. If there are no such areas along the programmed path, it is suggested that Precise Mode not be enabled in order to offer the MARC carts as much flexibility of movement as possible.
- If a specific area of the facility is highly dynamic and the likelihood of an obstacle being placed on its path is high, over-map the area in order to enable the carts' ability to plan more flexible routes around obstacles. For example, in an aisle that has more flexibility, you can map down one side of the aisle, double-back in the middle and then map along the opposite side. This will tell the MARC cart that the whole mapped area is viable.
- While mapping, please be sure to maintain at least 3.5 feet from walls, shelving, fixtures or other objects. This can cause the allowable area to be overly constrained, which in turn can cause the cart to abandon its route more readily.
- Providing additional width while programming around corners will also increase the efficiency of MARC – especially when in Precise Mode. This creates a larger area around the corner for MARC to maneuver as it turns. Over mapping can also help in corners – again to 'widen' the viable path MARC carts are allowed to take.
- Precise mode does not affect the mapping process (in Active Map Mode). MARC will create the same map regardless of whether Precise mode is enabled or not.
- When there are multiple AMRs operating in common areas, it can be more efficient to plan non-overlapping routes. For example, you can utilize Precise mode to keep MARC moving in a "virtual lane" while other MARCs (or AMRs) move in adjacent virtual lanes.

Operating modes: Looping Mode

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**

MARC carts can operate in a mode where it moves sequentially between programmed destinations automatically. In this mode, all preprogrammed destinations are shown in blue. The cart will move through all programmed destinations in sequential order without user intervention. The cart will wait at each programmed destination for a preset amount of time. See **Adjusting the wait times when operating in Looping Mode** on page **41** for information on setting wait times. To send the cart to the next programmed destination sooner, the button for the next programmed destination (which will be animated) can be pressed. Any other programmed destination can also be pressed to resume Looping at that location. Looping mode is available in both Active Map mode and Fixed Map mode.





 	Looping mode is activated using the Looping Mode button. To activate Looping Mode, press and hold the button for a few seconds till the double-beep audio cue is heard. When the button is released, the looping icon will turn green to verify Looping Mode is activated. The programmed destination buttons will turn blue (instead of green) to indicate to operators that the cart is in Looping Mode and will operate automatically. To disable Looping Mode, press and hold the button till the triple-beep audio cue is heard. The Looping Mode icon will turn grey to indicate Looping Mode is not active. Note also that programmed destinations will turn green, indicating the cart is programmed but not in Looping Mode.
 	Programmed station buttons appear Blue when the cart is in Looping Mode. If the station buttons are blue and one of them is showing an animated clock hand, this indicates that the cart is actively looping and will automatically depart for the destination that is animated when the timer has expired. The cart will also announce “Going to next destination” 5 seconds before departure. The audio cue “Calculating” may then be heard and the cart will start travelling to the next sequential location in the loop programming. If the buttons are blue but none of the buttons are animated with a stopwatch image, this indicates that the cart is in looping mode, but not currently navigating. To initiate Looping mode, press one of the blue buttons to send the cart to the pressed station and continue operating in Looping mode. To hold cart where it is and pause looping mode, simply tap any button on the EZ-Go Navigation panel other than the button that is animated. The animated button (indicating the next destination) can be pressed to terminate the waiting cycle and send the cart on its way immediately.

Tips for using Looping Mode

- When the unit arrives at one of its loop destinations, it will be stationary during the waiting period. If you wish to send the cart to its next location before the timer expires, simply tap the button associated with the next destination in the process. The cart may then announce “Calculating” and begin movement.
- While in Looping mode, the current route can be cancelled by tapping any unprogrammed button on the EZ-Go navigation panel. This will also pause Looping Mode. If the cart was in waiting mode, the animated icon will change to solid blue and the audio cue “Looping Mode paused” will be heard. To restart Looping Mode, press the button of the next desired destination to restart Looping Mode at that chosen destination.

- If any unprogrammed button is tapped while the cart is moving between locations, Looping Mode will be paused. The cart will remain still until the next desired location button is pressed which reinstates Looping Mode and starts travel to the destination chosen.
- If the cart is pushed more than approximately 1 meter while in a waiting state in Looping mode it will cause Looping mode to be paused automatically.

Adjusting the wait times when operating in Looping Mode

Looping mode can be handy when you want to keep MARC moving through a pattern of locations without user input. When a MARC cart is in Looping mode, it will visit destinations in sequential order. By default, MARC will wait at each location for 1 minute. The wait time for each destination can be changed using the following process.

To access the Looping Mode Times setting, follow the login instructions in section **Accessing MARC's Web User Interface** on page **72**.

Once logged in:

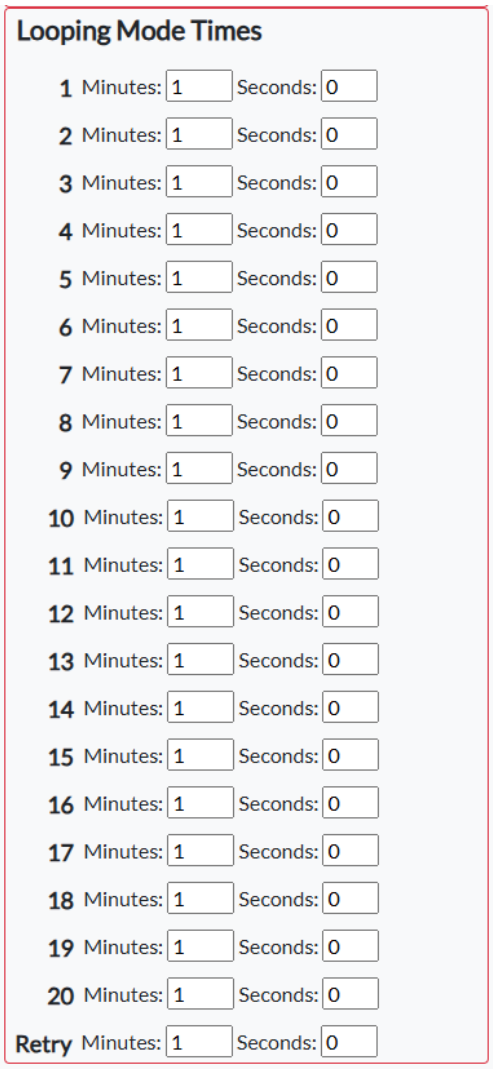
All locations will be shown in the list labeled "Looping Mode Times".

- See image (next page) for overview of this screen.

Change the times in minutes and seconds for the wait time at each desired destination.

- Note that once values are entered, they are saved automatically.
- Setting a 0 minute, 0 second delay will result in no delay.
- Setting the number to a very high number will result in pausing 'indefinitely'. This can be handy if one of the destinations requires a task to be performed. Maximum time settings is 10 hours.
- The default settings for all wait times is 1 minute.

Once times are set up the way you want them, exit the page – everything is ready to go!



← Under **Looping Mode Times**, each destination (1-20) is listed with a time value to the right. This value represents the amount of time M ARC will stop at the specified destination before planning a route to the next destination.

In Looping mode, if MARC comes to an obstacle blocking its path, it will retry to resume a route to its destination repeatedly. The **Retry** value is the amount of time it waits before trying again.

←

INFO	Helpful NOTES for **Retry** functionality. - It only applies to Looping mode. - It will keep retrying until it reaches the destination or runs out of power. ○ The default wait time is 1 minute. - The destination where MARC is trying to go before its path was blocked will have an animated timer icon so you can send it to the destination it was attempting to reach. - If the route is cleared before the retry time expires the user can press any set destination button to have MARC travel to that destination.

Best practices and tips for smooth operation

General tips:

- Avoiding intersecting or overlapping routes with multiple MARCs when possible, especially if the routes have pinch points or shared narrow passageways.
- Utilize the beeping feature to alert people near MARC's presence during autonomous operation.
- If you are using MARC in a specific area (in Fixed Map Mode), it is important not to move MARC outside of that area. You may want to include a 'parking spot' for MARC in the initial mapping to have a consistent place to put MARC when temporarily not in use. See Using the Calibrate Button functionality (Fixed Map Mode) on page 37.
- When in Fixed Map Mode, MARC should not be moved significantly while powered down, as this may cause confusion when the unit is powered back on. If the cart is moved while off, it should be returned to the same location when powered back on. This includes during powered-off storage, battery swapping, or any other time the unit is powered off or the battery is removed or turned off.
- The area where MARC units are stored should have fixed objects nearby. Since the cart needs to recognize where it is, if the environment has changed while the cart was turned off or rebooted, it may become confused.
- When transporting heavy payloads, the cart may coast a short distance while coming to a stop.
- In large open areas the cart may become disorientated. This may present itself as an abandoned route or the cart pausing. Returning the cart to an area with distinct obstacles will allow the cart to orientate itself.
- Well defined areas include multiple distinct fixed objects, for example an inner walled corner or permanent shelving. More fixed objects in the area will result in higher consistency.
- In order to match and navigate a mapped area, the cart will need to identify objects nearby. It may require less than 10 feet (3 meters) of distance between the cart and multiple fixed objects to properly orient itself. Large, open areas may not provide sufficient data for the cart to recognize its surroundings.
- Depending on your specific environment, you may find areas where the drive wheels of your MARC cart may slip. Since there are encoders embedded in the wheels, this can cause the map to shift and the cart to appear confused. This can be experienced when the cart is empty as well. To help reduce the propensity of slipping, you can add 10-20 pounds of extra weight over the drive wheels (on the lower shelf) to assist when MARC is not loaded.
- Since MARC carts use various fixed objects along its programmed path to continuously realign itself, in highly dynamic areas where objects are always changing, using AprilTags is often very beneficial. See **Using optional AprilTags** on page **52**.

What to expect during normal operation

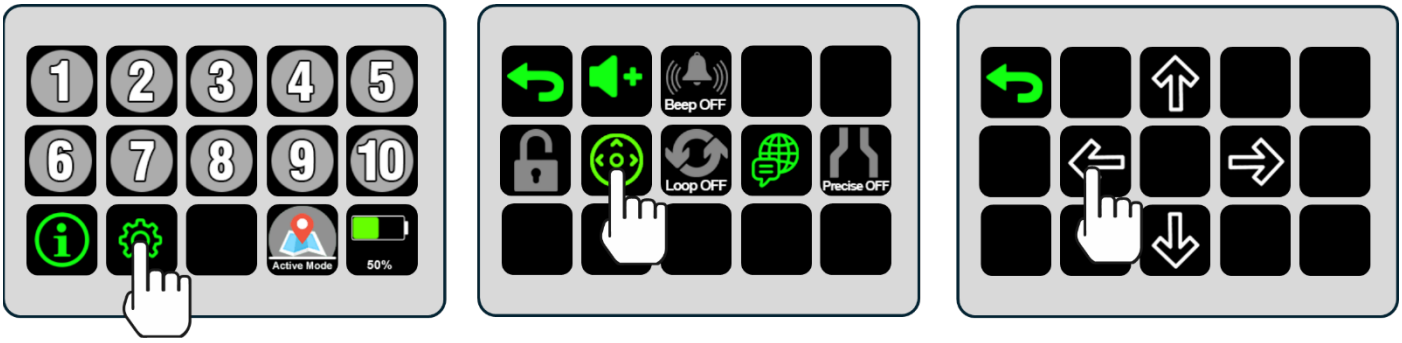
MARC products were designed to take extremely complex technology and make it simple to use. The simplicity allows users to easily and quickly engage the use of these carts and speed adoption for a speedy ROI.

Here are some things to expect during normal operation along with some best practices.

- The cart will show white LEDs in the direction it is travelling (similar to headlights) and red LEDs in the opposite direction (similar to taillights). Once the cart has arrived at a destination, the LEDs return to pulsing green.
- MARC units are capable of navigating through some narrow passageways, but it is recommended that the minimum width of open space along the entire programmed path be at least 6 feet.
- The cart may speed up and slow down frequently when travelling between destinations. This is normal behavior as the mapping and route planning software is continuously looking for the best possible route. The cart may also back up, rotate and/or turn around during normal operation.
- The cart will prioritize the path that was used during programming. If you have an area that you prefer the cart to avoid, do not use that path during the mapping (programming) process. Any areas you do not take MARC while in Active Mapping mode are considered no-go or keep out areas.
- Even though the cart can not be used on inclines or declines, there is a tilt sensor that will cause the operation to halt. At approximately 10°, the tilt sensor will automatically stop motion and wait for user intervention. This is by design and is a safety feature. An over-tilt red check engine light will be displayed until the user moves the cart back to a flat surface.
- The cart has been programmed to come within 1 meter of the destination. Within the 1m arrival, orientation of the cart may be different than when it was initially programmed or when it was last at the destination. The point of origin is the center point between the 2 drive wheels.
- If the cart encounters an obstacle that blocks its path, a tone will be heard, and the LED indicator lights will be bright white as it attempts to recalculate a path.
- As the cart moves toward its destination, it may encounter obstacles or path constraints that require it to recalculate its route. This process might involve reversing several meters or executing a wye turn. If the cart is unable to proceed and remains stationary for approximately 90 seconds, it will signal that the route has been abandoned. The cart will announce “Route abandoned,” and its indicator LEDs will pulse orange. This audible message will repeat every 30 seconds until the operator resolves the issue. Additionally, the numbered station button corresponding to the intended destination will begin flashing
- If the battery charge is low, the cart will indicate the current levels as follows:
    - For battery levels below 20%, it will say “Battery low” and will repeat this message every 30 seconds.
    - For battery levels below 10% the indicator LEDs will cycle between red, green and blue and the cart will continue to announce “Battery low.” Note that other indication colors and sequences will not be shown when the critical battery status is reached.
    - In both battery warning states, the cart can still be used. When the battery is completely discharged, the cart will shut down completely.
    - When MARC is powered down in Active Map Mode, destination and mapping information will be lost. Rebooting MARC in Active Map Mode, including after changing the battery, will require remapping and saved destinations to be reprogrammed.
    - Pressing the battery button for more than 3 seconds will silence the battery low audio cues.
- The cart will generally not explore unknown areas. However, you may find the cart will take a path within the allowed area that you were not expecting. If during the scanning of your facility the cart senses an alternative path that has been mapped is shorter, it may take that alternate path.
- When multiple MARC units are in the same area, you may notice they occasionally interact strangely. This is normal behavior since both are considered dynamic obstacles and are trying to avoid each other in a safe manner.

Powered Assist movement mode

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**



DANGER	All safety features are disabled while using the powered manual movement mode. Operator is responsible for safe movement of MARC in powered manual movement mode. Great care must be taken while using powered manual movement mode.

Powered Assist mode allows the user to control the cart motion manually if needed. To enter this mode, press the from the main screen, and then the Power Assist button.

	Pressing the left arrow turns MARC toward the left until the key is released. Note the handle end of the cart will move to the right to accommodate a left turn.
	Pressing the up arrow key moves the cart forward (away) until the key is released.
	Pressing the right arrow turns MARC toward the right until the key is released. Note the handle end of the cart will move to the left to accommodate a right turn.
	Pressing the down arrow key moves the cart backward (toward) until the key is released.
	It is acceptable to press either a forward or reverse arrow key simultaneously with either a left or right arrow key to move the cart at various angles.
	If the Power Assist button is grey, the function is not enabled. To enable, press and hold the button for 3+ seconds till the double-beep confirmation is heard. The button will turn green to verify.
	If the Power Assist button is grey and displays a small padlock, the function is not available. To make this function available, the cart will first need to be unlocked.
	Pressing the back arrow key while in Power Assist mode returns MARC to the settings screen.

INFO	The sequential beep tones will sound during Power Assist mode. These can be ignored while operating the cart via the arrow keys.

Using custom text on destination buttons

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**

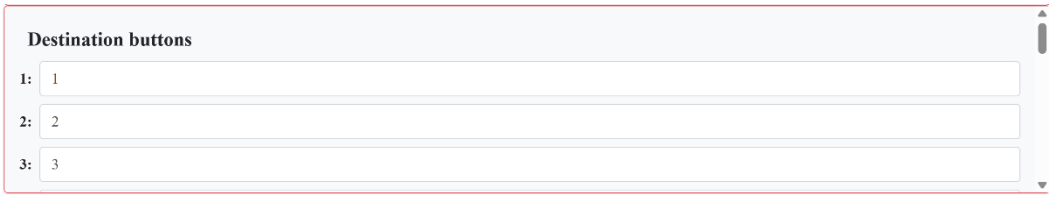
In some instances, it may be handy to use custom text for the destination buttons.

To edit the custom button text, first follow the instructions in the section **Accessing MARC's Web User Interface** on page **72**.

Once logged in, use the "Destination buttons" section to edit the text shown on specific buttons. Edits made will preview live on the buttons, and when you exit the text entry box, your changes will remain.

Note that the bold number on the left (numbered 1-20) are the default values for the buttons.

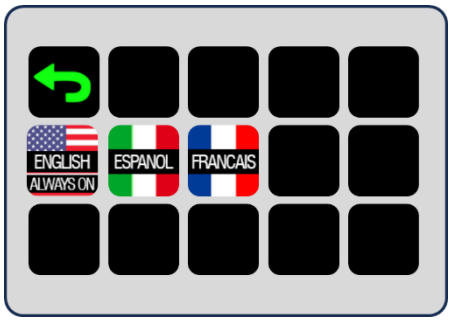
To access the text box for additional buttons, use the scroll bar on the right.



INFO	Note that some special characters (including non-English characters) are supported for button text. These can be copied/pasted into the text field or entered using ALT codes.

Language Settings

INFO	This function is part of the Optional Software Package. Please see **About the Optional Software Package (OSP)** on page **14.**



The language menu allows users to add audio cues in various languages. To enter the language options screen, press the settings button from the main screen, and then the Languages button.

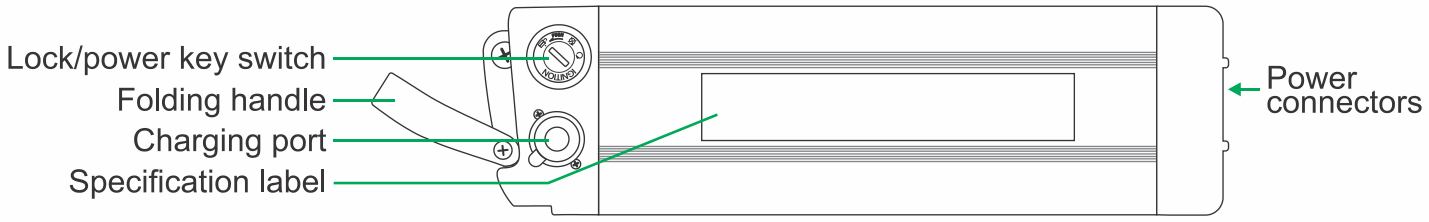
	The leftmost icon is English, which is always enabled. The other languages are optionally toggled on or off. Like most function in the menu, you can press for 3+ seconds till you hear a double-beep cue to enable a language, or for 6+ seconds till you hear the triple-beep to disable. When multiple languages are enabled, the spoken word audio cues will be played sequentially. When you see the small padlock icon over the language buttons, this indicates that the current language settings are locked and cannot be changed till the cart is unlocked.
	Pressing the back arrow key while in Language options returns MARC to the settings screen.

Using MARC battery packs

WARNING

Lithium-ion battery packs may get hot, explode or ignite and cause serious injury if they are abused electrically or mechanically.
Observe the following precautions when handling using and storing lithium-ion batteries:

- Never leave power on to battery when not in use.
- Never short-circuit or connect loads other than the intended system to the battery.
- Do not connect with false polarity.
- Do not expose to temperature beyond the specified temperature range or incinerate the battery.
- Do not crush, puncture or disassemble the battery. The battery contains safety and protection devices, which, if damaged, may cause the battery to generate heat, explode or ignite.
- Do not allow the battery to get wet.
- In the event the battery leaks and the fluid gets into a person's eyes, do not rub the eye. Rinse well with water and immediately seek medical care. If left untreated, the battery fluid could cause damage to the eye.
- Use only the original charger and always follow the instructions from the battery manufacturer.
- Avoid leaving fully charged batteries connected to energized chargers for extended periods.
- Avoid discharging batteries below 5% of total capacity.
- Avoid charging at temperature extremes. The optimal temperature range for lithium battery charging is room temperature (68-77° Fahrenheit or 20-25° Celsius).
- Avoid storing the battery pack in a discharged state. For long term storage (greater than 1 week) maintain 50% charge capacity. Remember that batteries drain naturally – even in storage.



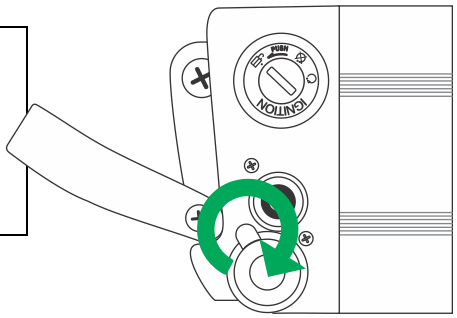
WARNING

To prevent possible damage, use only use genuine MūL Technologies batteries and chargers. Using batteries other than MūL Technologies approved batteries could result in dangerous situations and cause injury or fire. Always use caution when working with batteries.

Charging the batteries

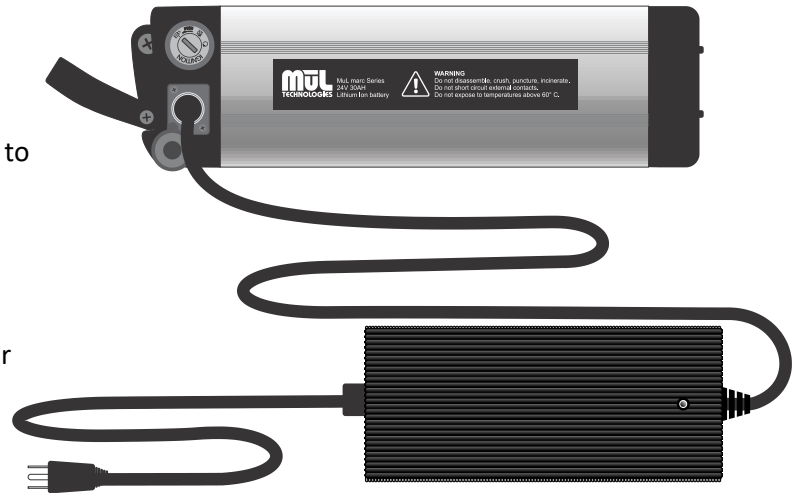
MūL Technologies battery packs and chargers are designed for use in MARC products exclusively. The battery packs are designed to offer many hours of service and have a charging life of over 800 cycles.

INFO	The charging port cover rotates to open. Lifting the cover too high may result in damage. When accessing the port, be sure to lift the cover gently and rotate the port cover to allow charging cable to be inserted as shown at right.



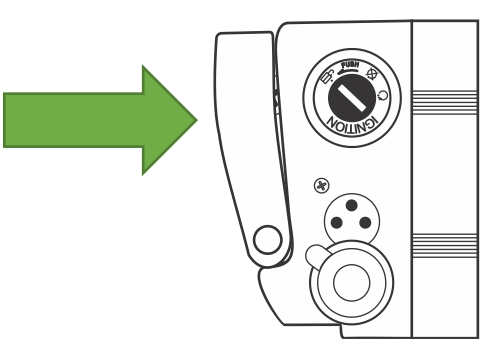
Charging procedure:

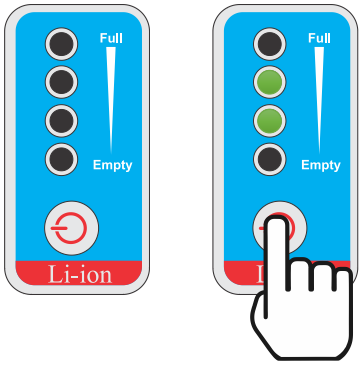
1. Verify the charger is not plugged into a wall outlet.
2. Place battery and charger on flat, stable non-flammable surface.
3. Ensure battery is in the OFF position with the key removed.
4. Gently lift and turn the charging access port cover to expose the charging port.
5. Insert the MūL Technologies battery charger connector into the charging port.
6. Plug the charger into a standard wall outlet.
7. Charging is complete when the green LED indicator is on solid.
8. Unplug the charger from the A/C outlet.
9. Remove the charger cord from the battery.
10. Reinstall battery into MARC system.

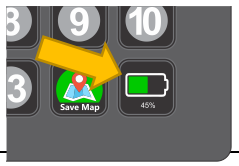


WARNING	The battery can be charged while installed in MARC. You must ensure that the same steps are followed in order and verify the battery's keys have been removed.
	Always plug the charger cable into the battery port before plugging the charger into an A/C outlet to avoid risk of damage to battery and charger.

Checking the battery's charge level:
The battery charge level indicator can be found on the exposed end of the MūL Technologies MARC battery when installed in MARC. To check if a battery is charged, press the button with the power symbol. While depressed, the charge LEDs will light on the power scale and indicate the battery's current charge level.
Please note that the status LEDs are not operational while the battery is actively being charged.



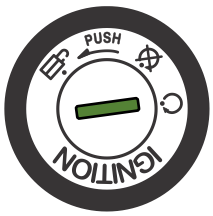




INFO	While MARC is running, the battery status is also shown on the EZ-Go Navigation panel.

Locking and unlocking battery packs

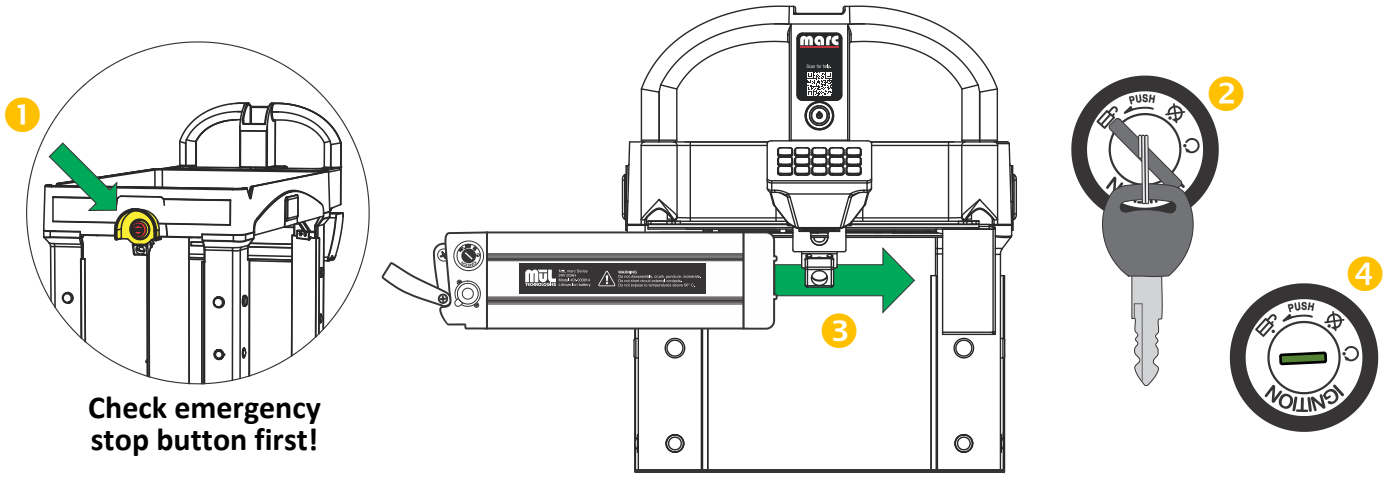
Using the keyed battery switch:

 Unlocked 	Indicates the battery pack is ready for removal or insertion. No power is supplied in this position and the battery slides freely into the battery bracket. **NOTE**: To move from unlocked position to “Locked with power off” position, it is important to push the key inward and then release slowly while turning the key to the next position.
NOTE: Push key in 	NOTE: To move from unlocked position to “Locked but off” position, it is important to push the key inward and release as the key moves to the next position.
 Locked, but off 	Battery is inserted and secured in position but is not supplying power. This is the mode the cart can be stored during longer durations of non-use.
 Locked and on 	Battery is inserted and secured in position and is supplying power to the system. This is the normal setting during use.

Inserting the battery pack into MARC

To insert a battery pack into MARC, follow these steps:

- Make sure the battery is charged. You can check this by pressing the button on the battery level indicator.
  - See **Charging the batteries** on page **49**.
- Check to verify that the emergency stop button is not activated (❶ in figure below).
- Ensure the key switch is in the unlocked position. (❷ in figure below).
- Guide the battery slots to the battery rail on MARC and slide in (❸).
- Slide battery until the power connectors are snug.
- Flip the foldable handle upward.
- Turn the key to locked position, being sure to press key in and slowly release it as you turn it.
  - If you are going to use the cart immediately, insert and turn the key to powered **ON** position (❹), and press cart power button (above the EZ-Go Navigation panel) to boot up the cart. This process takes up to 2 minutes and ends with an announcement, “Cart ready” and LEDs pulsing green.
  - Leaving the key in the locked-but-off position is appropriate for storage.

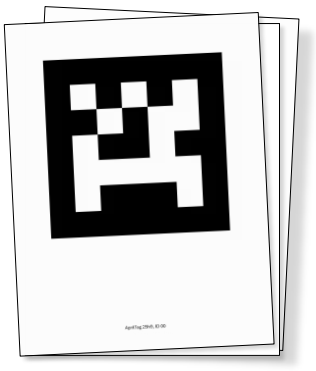


INFO	Batteries should not be stored in very hot or very cold conditions, or to be subject to conditions of high moisture. They also should not be stored in a fully discharged state.
	Store your battery between 15 °C (59 °F) and 25 °C (77 °F) in a dry area.
	If your battery pack is not in use for an extended period of time, it is imperative that you charge the battery pack before storage and then charge the battery pack once a month to prevent deterioration.

Using optional AprilTags

With any robot, precise navigation and localization are crucial for the effective operation of autonomous systems. AprilTags, a simple type of fiducial marker system, have emerged as a reliable and efficient solution for enhancing robotic guidance. These visual markers, easily detected and recognized by a camera, provide valuable positional information that can be utilized to guide robots with high accuracy.

Not all environments require the use of AprilTags – they are an option in MARC 5 Series robots to offer an option for those using MARC in environments that are challenging to map consistently.



AprilTags are a form of two-dimensional barcodes designed for reliable detection and identification by computer vision systems. They consist of a black-and-white square grid with a unique pattern that encodes a specific identifier. This identifier can be decoded by a camera and associated algorithms to determine the tag's position and orientation relative to the camera's viewpoint. The simplicity and robustness of AprilTags make them ideal for various applications in robotics and automation. Note that AprilTags offer a convenient way to recalibrate a MARC cart should it become disoriented. The calibration process (see Using the Calibrate Button functionality (Fixed Map Mode) on page 36) can be replaced by any pre-mounted AprilTag coming into view of the cart's cameras. When the cart sees one of the tags, the audio cue "Landmark detected" is heard. This is an effortless way to calibrate MARC.

Starting with the MARC 5 Series products, the functions needed for AprilTags use are included in the hardware (3D cameras) and software. While there are specific requirements for using AprilTags, the system is ready to go. AprilTags can help MARC localize in environments that are challenging to keep aligned.

Though everyone's facilities and situations are different, here are some areas where AprilTags shine:

- Highly dynamic environments with few static objects in the area.
- Areas that are very similar to other areas – for example the aisles in a warehouse.
- Areas where the drive wheels may slip regularly – extremely dusty or wet areas, for example.
- Programmed paths that are significant in length between destinations.
- Other environmental areas where MARC carts appear to be getting 'lost' with consistency.

AprilTags are visual markers that consist of a unique black and white pattern that cameras can easily recognize and use to determine the tag's 3D position and orientation in relation to the camera.

How AprilTags work:

- **Tag Detection:** Cameras identify the unique black and white pattern of an AprilTag.
- **Pose Estimation:** The software uses the pattern to calculate the tag's 3D position and orientation relative to the camera, including angle and distance.
- **Localization/Navigation:** By knowing the tag's position and the camera's position, the robot can quickly calculate its own position and orientation more accurately.

Benefits of Using AprilTags:

- **Accuracy:** when mounted properly, AprilTags provide accurate and reliable pose estimation.

- **Robustness:** Because of the simplicity and high contrast, they can be detected in various lighting conditions.
- **Simplicity:** The system is relatively easy to implement and use.
- **Flexibility:** AprilTags can be used in a wide range of applications.
- **Real-time Processing:** They allow for fast and efficient detection and processing.

AprilTags must be affixed to static, fixed objects so that their location is consistent. If tags are printed on flimsy material, are moved around or are blocked from view, they can be ineffective.

MARC uses AprilTags to assist with:

- **Mapping**
  AprilTags can assist in the mapping process (while in Active Map Mode) when programming a path. For example, if an AprilTag is located at the start, then when MARC is pushed back to the start area and sees the AprilTag for a second time it will more accurately align the map.
- **Navigation**
  MARC carts can use AprilTags placed in the environment to navigate predefined paths or avoid obstacles. By continuously detecting and decoding the tags, MARC can adjust trajectories and ensure accurate movement.
- **Localization**
  AprilTags can serve as landmarks for MARC to determine the current precise location within an environment. This allows MARC to continuously realign its map to the environment precisely.

Since environments can vary infinitely, AprilTag capabilities offer an additional tool to keep MARC moving efficiently and offering the best possible return on your investment.

Enabling AprilTags with MARC's Software

To integrate AprilTags with the robot's control system, follow these steps:

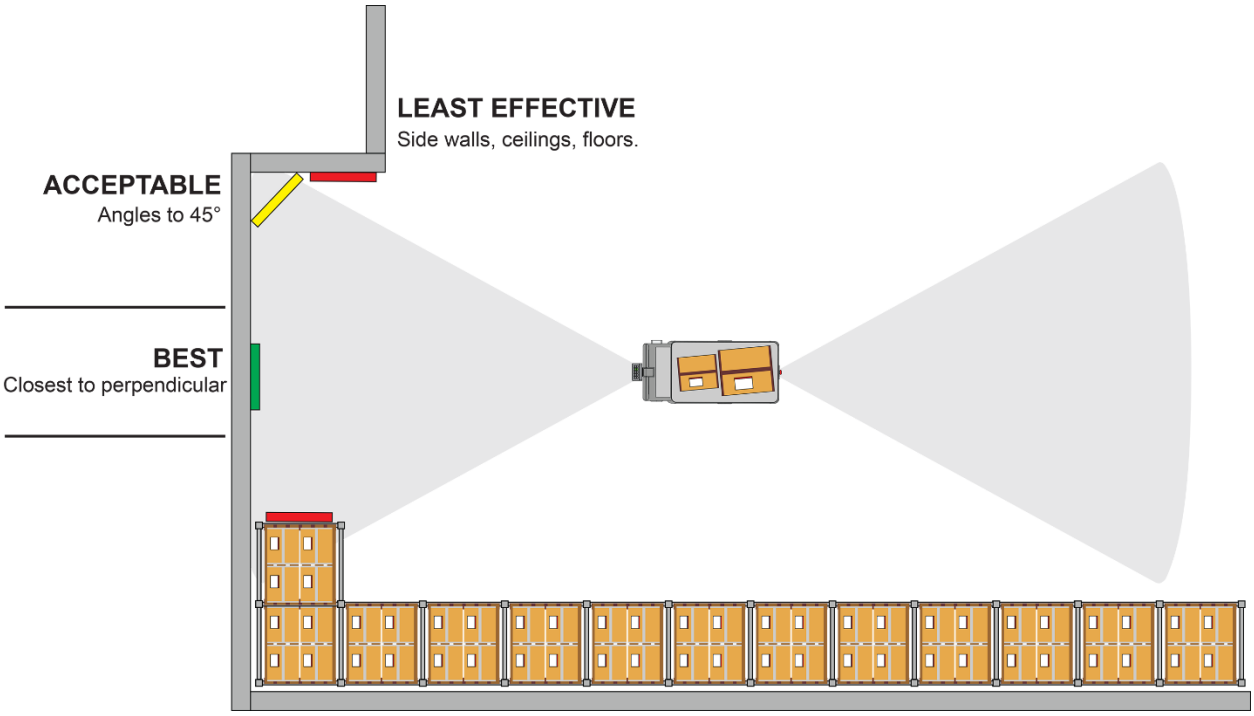
- Log in to your MARC cart's Web User Interface. Directions for this can be found in section **Accessing MARC's Web User Interface** on page **72**.
- Once logged in to the Web User Interface, you will see the section labelled "Enabled AprilTags". Note that each individual AprilTag you plan to use must be enabled by number to let MARC know to look for and use that specific tag.
- Once the 'enabled' box is checked for a specific tag number, that tag will be recognized by MARC carts. Note that you can use the same tag for more than one MARC unit, and different MARC units can have different tags enabled.
- Please follow the guidelines and best practices outlined below.

Best Practices for Implementing AprilTags

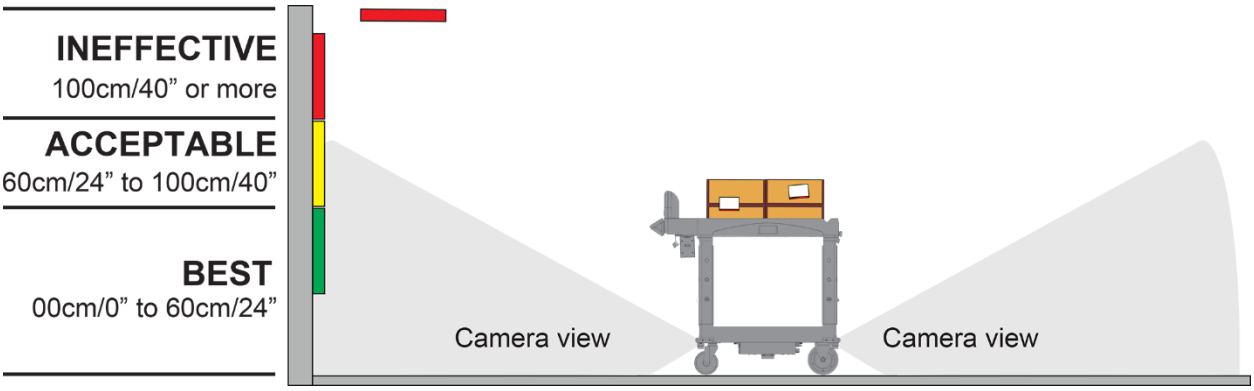
While AprilTags offer significant advantages in robotic guidance, certain challenges and considerations must be addressed:

- To be effective, tags require that they be very flat (for example against a surface) and securely mounted to prevent bending, twisting or other distortions. Do not cover any area of the surface of the tags. Do not cut the tags to smaller sizes. Do not obstruct any part of the sign with tape or other mounting materials. Do not drill additional holes in the tags.
- All tags must remain clean and without blemishes or smears that change the overall pattern.
- Steer clear of areas where other dynamic or static objects might block the camera's view of the tags. In order to help MARC navigate, tags must be visible to the 3D cameras front and back.
- Lighting Conditions: Variations in lighting can affect the detection accuracy of AprilTags. Ensuring consistent and adequate lighting is crucial for reliable performance.
- Tag Placement: The placement of AprilTags within the environment should be carefully planned to ensure they are within the camera's field of view and not obscured by obstacles.
- Tag Positioning: When considering the areas where MARC will see the AprilTag placards, consider how they can be closest to the center of the camera's view, and as close as possible to perpendicular to a line from the camera to the placard. The 'flatter' the camera sees the AprilTag, the better.

  View of camera field of view from above:



- The same applies for vertical height: for optimal effectivity, AprilTag placards should be mounted below 60cm/40" for the highest visibility. Note that this maximum is measured from the floor to the top of the placard.



- Each time an AprilTag is recognized the audio cue “LandMARC detected” is played. A lack of this audio cue playing while a tag is in view indicates the AprilTag was not detected as expected. This is a handy way to verify that a tag has been implemented correctly.
- In certain more complex scenarios, MARC carts can benefit from multiple AprilTags within view of a camera simultaneously. For example, using multiple tags would be recommended for an area prone to MARC carts becoming 'lost' (mis-localized) even when a single AprilTag is present.

Potential Environmental Challenges While Using AprilTags

While AprilTags offer significant advantages in robotic guidance, certain challenges and considerations must be addressed:

- Lighting Conditions: While the high contrast of the codes is helpful, variations in lighting can affect the detection accuracy of AprilTags. Ensuring adequate lighting is crucial for reliable performance. This would include conditions that are too bright (for example sunlight shining through a skylight onto an AprilTag) as well as too dim or dark.
- Tag Placement: The placement of AprilTags within the environment should be carefully planned to ensure they are within the camera's field of view and not obscured by obstacles.
- Temporary Objects: In highly dynamic environments, items may be left in areas that they are not normally in. It's important that workers in the robots' area of operation understand not to leave items blocking the cart's view of the AprilTag placards.

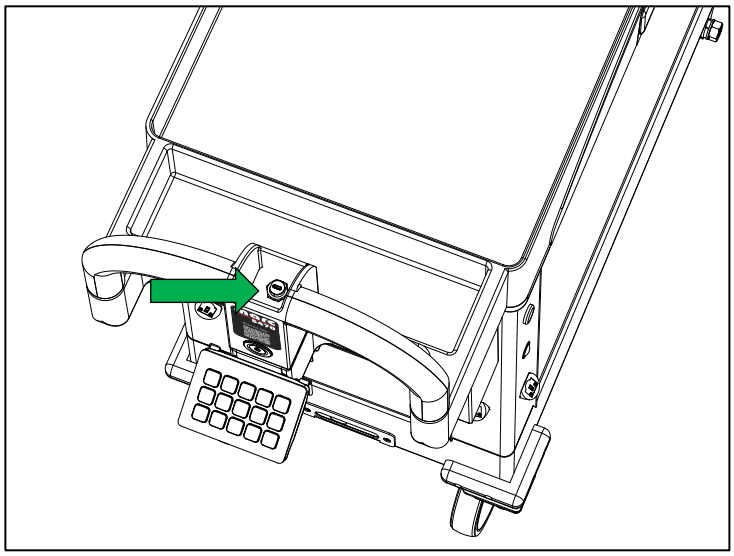
Since use of AprilTags is optional based on unique environmental requirements, detailed documentation is maintained separately. To review the latest available documentation, visit www.multechnologies.com/apriltags or using the QR code to the right.

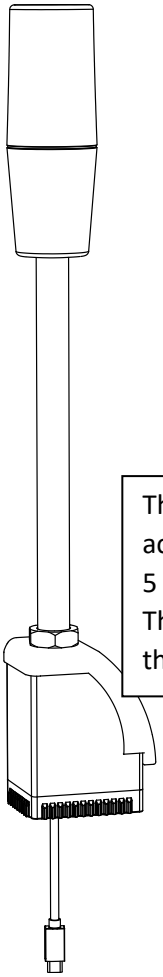
Complete high-quality sets of plastic AprilTag can easily be purchased on the MūL Shop at https://shop.multechnologies.com/

INFO	While in Active Mode, AprilTags aid in creating an improved map. However, while in Fixed mode AprilTags aid in autonomously calibrating MARC within a previously created map. AprilTags will not improve the map once in Fixed mode, nor will they localize MARC while in Active mode.

Using the USB-C accessory port

The 5 Series MARC carts include a USB-C port that is accessible through the open area at the center of the handle as shown on right.





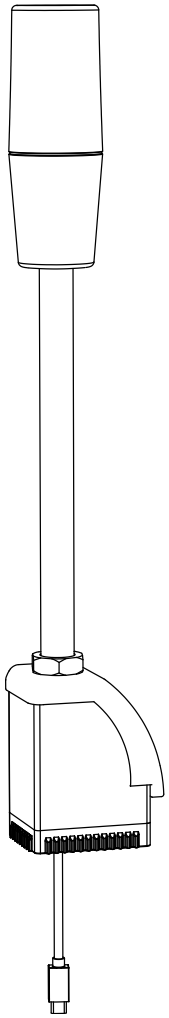
The LED light tower is an optional accessory that you can purchase for the 5 Series MARC carts for added visibility. This accessory also uses the USB-C port that is present in the cart handle.

The USB-to-LAN adapter kit that was included with you MARC can be connected to the USB-C port in the handle.

In the case you need to interface with the cart itself, this adapter kit will greatly speed up the data transfer process. See **Using the USB-C to LAN adapter kit** on page **58**.

INFO	
	This port is not a standard USB port and can only be used with the MūL Technologies accessories that are specifically designed to work with this port.
	The USB-C port cover should be secured whenever the port is not in use.

Using the optional LED tower

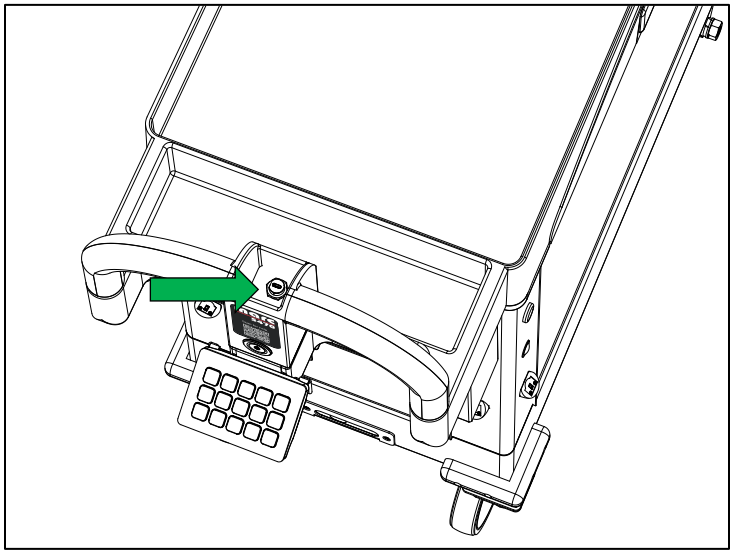


One of the optional accessories available for your MARC cart is the LED light tower. This light tower offers a higher level of visibility as your cart moves through the facility.

The light tower communicates several statuses, including:

- Green when MARC is ready for the next task.
- Flashing blue during autonomous movement.
- Red is the case of a critical error.

To use the LED light tower

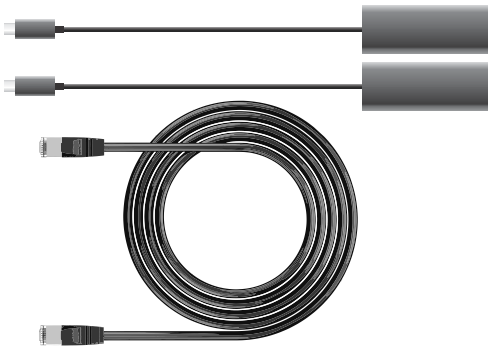


1. Ensure the MARC cart is powered off.
2. Plug the USB-C end of the assembled cable into the USB-C port located in the handle of the cart as shown on right. There should be a protective cap secured over the port. Twist this counter-clockwise to remove and tuck aside.
3. Plug the USB-C cable from the LED light tower into the USB-C port.
4. Carefully tuck the extra wire into the base of the LED light tower and slide the assembly snugly down into the cavity on the cart.
5. Power up the MARC unit.
6. The LED light tower should now operate.

INFO	**This port is not a standard USB port and can only be used with the MūL Technologies accessories that are specifically designed to work with this port.**
	The USB-C port cover should be secured whenever the port is not in use.

Using the USB-C to LAN adapter kit

Your MARC product came with a USB-C to LAN connection kit to help speed connections to the MARC carts.



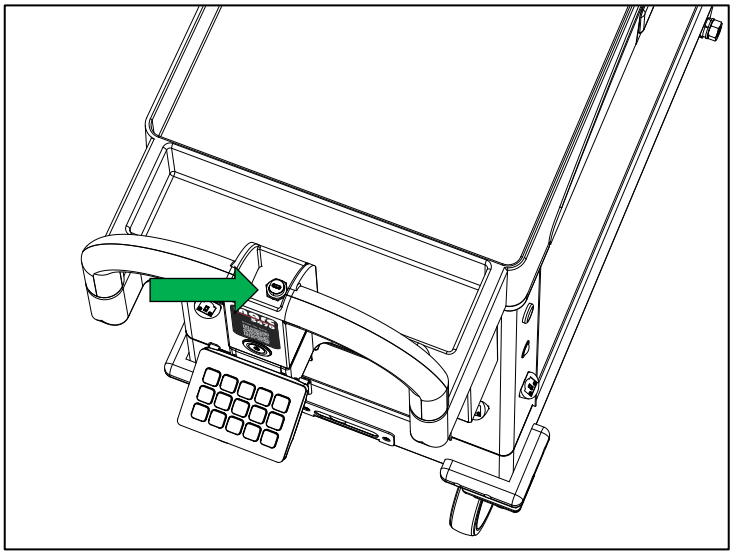
This includes several scenarios that require data transfer, including:

- Software updating
- Accessing and changing certain optional settings
- Data logging (for service requests)

INFO	The USB-C cables should be connected prior to powering the cart.
	The data kit includes two USB-C to LAN adapters. If you have a device (typically a laptop) that has a built-in LAN port, you do not need to use one of the USB-C to LAN adapters.

To use the adapter kit

1. Ensure the MARC cart is powered off.
2. Begin by connecting the included LAN cable (or a longer replacement, if desirable) to one of the included USB-C to LAN adapters.
3. Plug the USB-C end of the assembled cable into the USB-C port located in the handle of the cart as shown on right. Please note that if you have the optional LED light tower installed, it will need to be removed and disconnected. If there is not LED light tower, there should be a protective cap secured to the top of the port. Twist this counter-clockwise to remove and tuck aside.
4. Depending on your device specifically, plug either the LAN cable or USB-C cable into the device you are using to connect.



5. Power on the MARC cart.
6. Follow the directions for completing the operation you are intending to execute.

INFO	**This port is not a standard USB port and can only be used with the MūL Technologies accessories that are specifically designed to work with this port.**
	The USB-C port cover should be secured whenever the port is not in use.

Loading MARC safely

Important loading guidelines:

- Total load should not exceed 220 pounds / 100 kilograms during autonomous operation.
- Tall loads may strike low hanging objects above or become unstable and tip.
- Load height should not exceed 60 cm / 24 inches above surface of top shelf.
- Loads must not overhang the edges of shelf surface in any direction.
- Do not transport items that have the potential to roll or shift during movement.
- Do not transport hazardous materials.
- Do not transport open liquids.
- Avoid top-heavy loading. Place heavier loads on the bottom shelf.

Additional tip:
When loading MARC, always place more of the weight over the drive wheels, as shown below. This will reduce the risk of the wheels slipping, which can cause the cart to become disoriented. If wheels slip when cart is empty, consider using a 10–20-pound weight over drive wheels on lower shelf to reduce slipping.

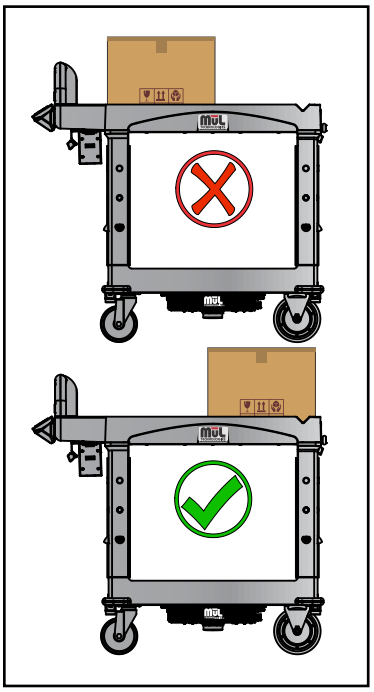


Table of LED indicator cues

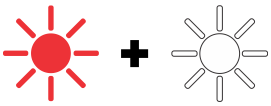
	Pulsing green	MARC is ready to accept commands.
		Normal movement – Visible white LEDs mean the cart is heading toward you (headlight) while visible red LEDs mean the cart is moving away from you (taillight).
	Pulsing orange	Impedance to movement; path blocked, route abandoned. Audio cue “route abandoned” will also be heard repeatedly.
	Flashing red	Red check engine light, indicating a major failure. Intervention required.
	Solid green	Command Received.
	Solid yellow	System is booting up. Also used to indicate yellow check engine light is active during operation.
	Solid white	MARC is calculating a route.
		Cycling of red-green-blue indicates critical battery charge level (includes audible warnings as well).

Table of audio indicator cues

MARC uses several audio cues to indicate statuses for several areas. These include system health, confirmations of programming change and warnings.

The single, double- and triple-beep tones are used as confirmations of various button press functions. Many functions are enabled/disabled through these button presses, including the programming of destinations.

For these functions, the simple programming looks like this:

Most functions are *executed* with a quick tap.

Most functions are *programmed* with a 3+ second press. Confirmed by double-beep.

Most functions are *deprogrammed* with a 6+ second press. Confirmed by triple-beep.

If the cart is locked with a code, functions displaying the small padlock icon cannot be changed without first unlocking the cart. See **Locking the MARC cart settings to prevent reprogramming** on page **24**.

Beeping tones	
Single beep	This sound is confirmation a button has been pressed.
Double beep	Medium length button hold confirmation (3+ sec) indicating function programming was successful. The button will also turn green for most functions. A double beep tone also indicates that a map has been saved.
Triple beep	Long button hold confirmation (6+ seconds) indicating removal of current programming of station button. The button will turn grey. A triple beep tone also indicates that a map has been deleted.
Triple multi-tone beep	Obstacle in path or recalculating route to destination.
Spoken audio cues (only English shown)	
“Arrived”	Cart has arrived at the destination.
“Battery low”	Battery charge level is low (repeats in 30 second intervals). Critical battery level also includes LED lights alternating colors (red, green, blue).
“Calculating”	This audio cue indicates the route is being planned and movement will begin momentarily.
“Calibrating”	The calibration command is being executed.

“Calibration required”	The cart has been moved outside of its saved map. To recalibrate, the cart must either see a known, enabled AprilTag or be recalibrated using the Home location and pressing the Calibrate button.
“Cart ready”	This audio cue indicates MARC has booted and is ready for use.
“Changing modes”	This audio cue indicates the map is being saved and a button was pressed/ignored.
“Entering Fixed Mode”	The map has been saved or the cart has started with a saved map.
“Entering mapped area”	MARC is in Fixed Map Mode and has now been pushed into a previously mapped area.
“Going to next destination”	While in looping mode, MARC will warn users that it will be moving to next destination prior to movement.
“Looping mode paused”	This will be heard when the cart is pushed more than approximately 1M while waiting at a programmed location. Once this audio cue is heard, Looping Mode will need to be reengaged by pressing one of the programmed buttons.
“Looping mode started”	Looping mode is enabled and autonomous movement started.
“Map deleted”	Deletion of the map is complete.
“Map is being deleted”	This audio cue indicates the map is being deleted and a button was pressed/ignored.
“Option package soon to expire”	This indicates that the cart’s Options Package is expiring soon. For more information, please see **About the Optional Software Package (OSP)** on page **14**.
“Out of allowed area”	MARC is in Fixed Map Mode and is not in the allowed area. For details on Allowed Area, please see **Understanding Mapped Area and Allowed Area** on page **37**.
“Out of mapped area”	MARC is in Fixed Map Mode and is not in the mapped area. Cart must be returned to mapped area, or the map must be erased and MARC reprogrammed for use elsewhere.
“Route abandoned”	Cart was unable to reach the destination. Generally, this would be caused by an object blocking MARC from reaching its destination.
“Route canceled”	A button was pressed by the operator (cancel process) while the cart was moving toward a destination. If a check engine light has been detected during a route, this can also result in the “Route canceled” cue without user intervention. This will then display the cause of the trouble light.
“Landmark Detected”	Indicates an April tag has been seen. For more information, see **Using optional AprilTags** on page **52**.
“Restarting Process”	A software issue was detected, and a process is being restarted.

INFO	If languages other than English are enabled, the voice audio cues will be played in each language that is enabled. English is always enabled, and will always be spoken first, followed by additional languages that are enabled. For more information on languages, see section **Language Settings** on page **47**.

Cleaning MARC

MARC systems are made from an extremely durable polypropylene material that will not leak, rust, chip, dent or peel, and will maintain a professional appearance for many years. The RCP unit (drive system) is made from very thick, strong powder coated steel enclosure to ensure protection of the electronics.

 WARNING	There are sensitive electronic components in MARC. • Make sure to disconnect and remove the battery pack prior to cleaning. • Never submerge any part of MARC. • Never spray liquids directly at any parts of MARC. • Never use harsh chemicals to clean any parts of the cart. • Never spray cleaner directly onto any electronic components, including the EZ-Go Navigation panel, sensors or LiDAR unit. Instead, spray a small amount of mild cleaner onto a rag or towel, then gently wipe the surface of the button area with the moist cloth.

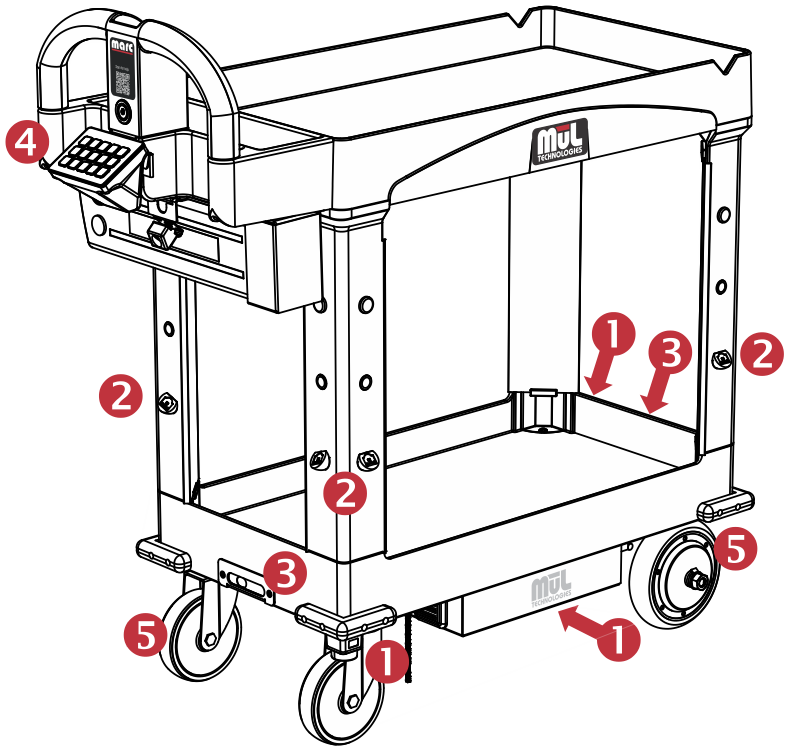
Here are some general tips for cleaning your MARC products:

- MARC is not waterproof and should not be sprayed directly or submerged.
- If using a household or industrial cleaner, be sure to test a small area to verify it does not damage the polypropylene material.
- Spray or dip a cloth into the cleaner and wipe the cart with a damp (not wet) cloth.
- For stubborn stains, consider using Mr. Clean Magic Eraser or similar product.
- If the drive wheels of MARC come in contact with liquids or any slippery materials, clean and dry the wheels to ensure MARC will have sufficient traction for the surface it operates on.
- The cameras and proximity sensors may accumulate dust and should be cleaned on a regular basis.

Cleaning the sensors and cameras:

- Air is the best non-contact method for cleaning dust and debris from the sensor and camera surfaces.
- A clean, soft, lint-free cloth can be used to gently wipe sensor, LiDAR and camera surfaces.
- Chemical cleaners other than alcohol wipes should not be used on electronic components or plastic mounting structures.

Preventative Maintenance



While your unique environment, including floor and air cleanliness, is the leading factor for maintenance you'll need, there are some simple preventative maintenance tips that will help you get the best results with MARC. These tips are described below.

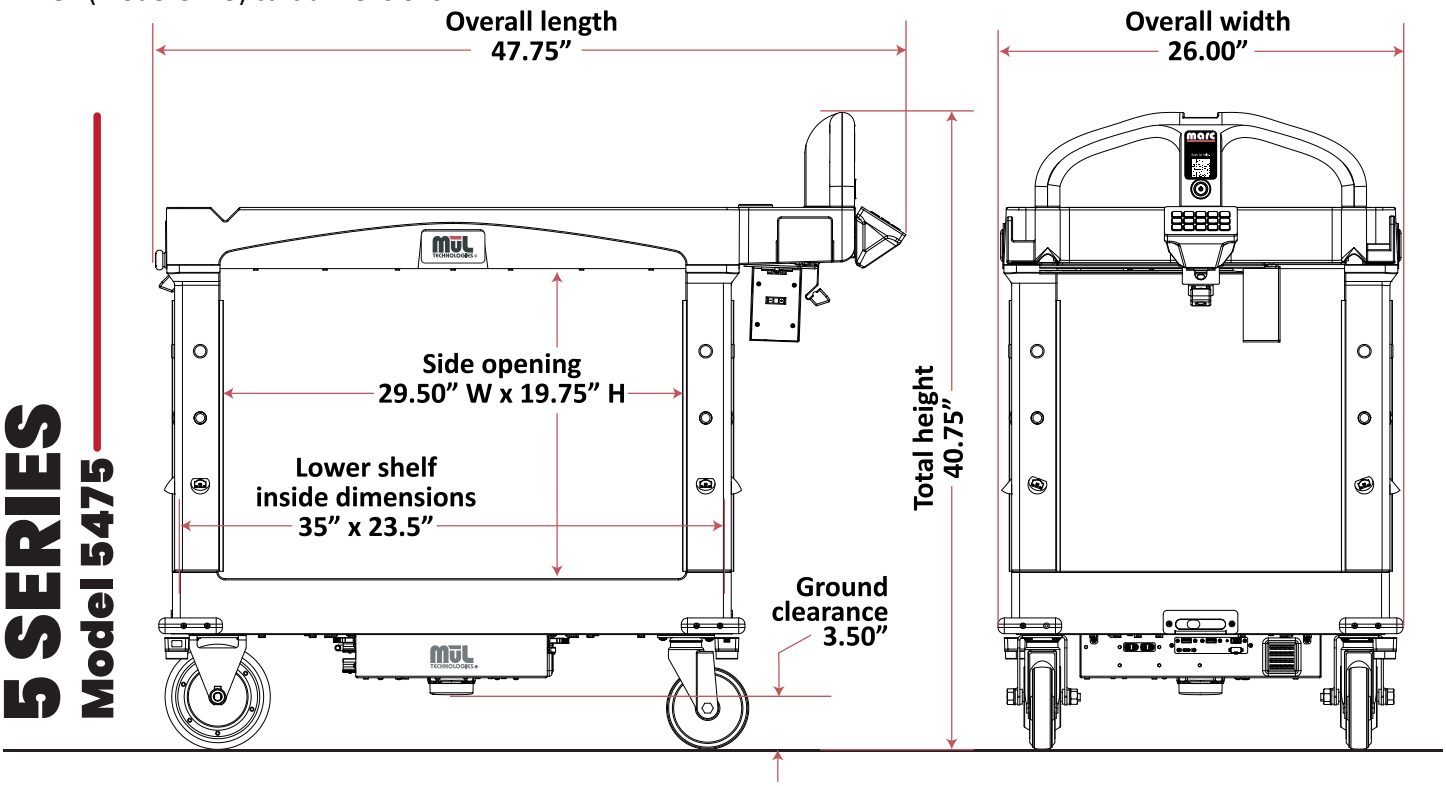
Recommended preventative maintenance processes:

1. **LiDAR (3 total, 1 centered under RCP, 1 front right and 1 rear left):**
   Clean with an air hose to remove dust as needed. As the LiDAR is a sensitive instrument with mechanical movement, use caution to not apply harsh chemicals as they can damage the LiDAR units' cover.
2. **Proximity Sensors (8 total, 2 each leg):**
   Clean daily with a canned air duster, lint free cloth or alcohol wipes. Note that fine dust and aerosol film buildup may not be visible. Wipe with alcohol wipes to remove fine dust and film buildup.
3. **3D cameras (2 total, 1 front and 1 rear):**
   Wipe with lint-free cloth or blow air, depending on the type of buildup. Never use chemicals or abrasive materials to clean camera lenses, as this may cause scratches or other damage to lens.
4. **EZ-Go Navigation Panel:**
   Wipe as need with a dry or moist lint free cloth. Do not spray directly or use cloth that is more than slightly wet. Do not use chemical cleaners, as they may fog the clear button covers.
5. **Wheels:**
   Wipe down as needed to remove debris that has built up on the wheels and inspect for embedded objects such as fasteners, stones, metal shavings or other debris from the floor. This includes both the drive wheels and the passive swivel wheels.

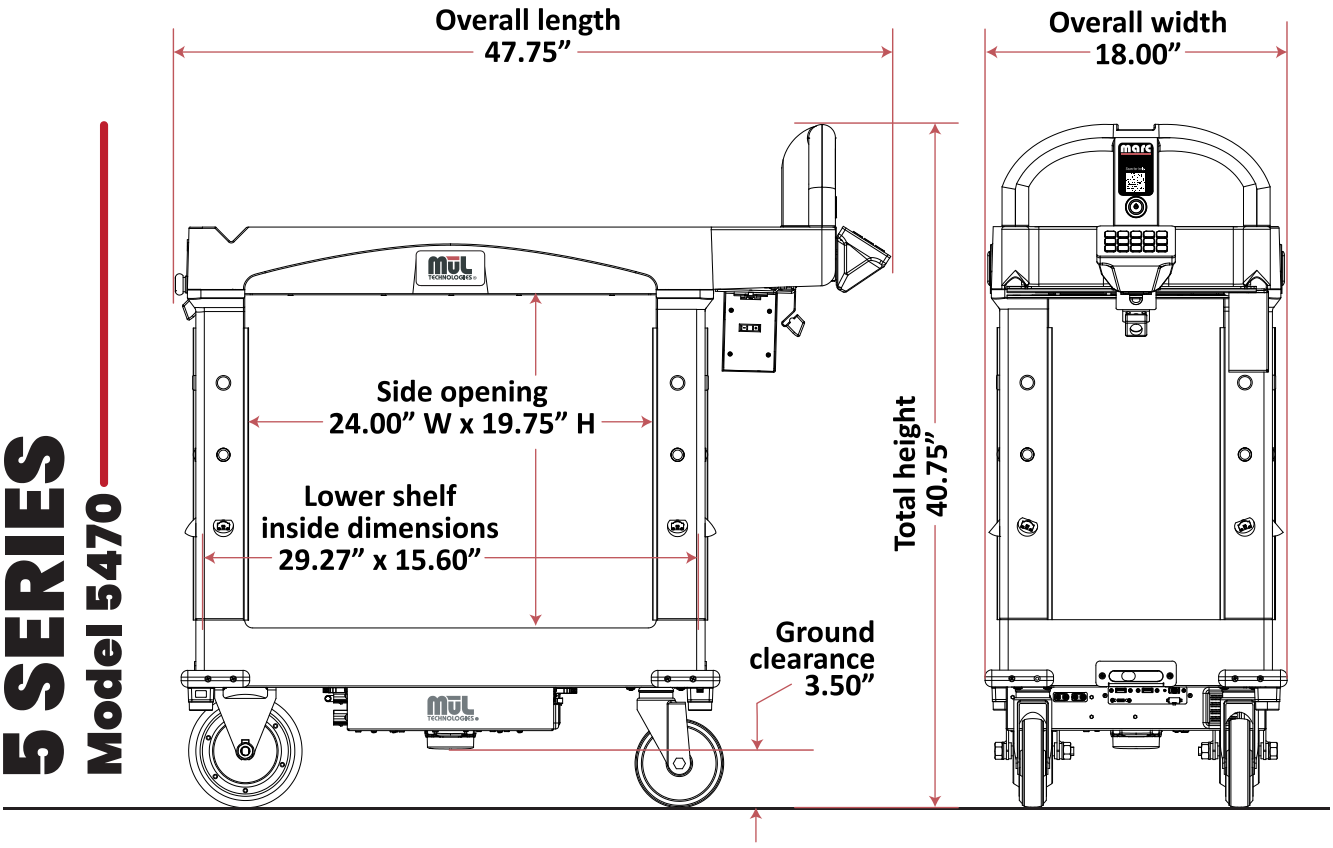
INFO	The frequency required for these maintenance items varies greatly from one facility to the next. Your specific environment will dictate how often you should perform these tasks.

MARC system dimensions

LARGE (model 5475) cart dimensions:



SMALL (model 5470) cart dimensions:



Troubleshooting

Problem	Things to try
After rebooting MARC, my preprogramed destinations are gone, and the buttons appear grey.	In Active Map Mode, this is by design; MARC does not retain maps or locations when powered down. Since programming is extremely easy, simply manually push MARC on the next route and reprogram the destinations. Note this includes powering down to change the battery. If you need the map and destinations to be saved, consider Fixed Map Mode. See **Operating modes: Active Map and Fixed** on page **33**.
Cart will not power up when power button is pressed.	Verify the emergency stop button located on the front of the cart is not engaged. Disengage button by turning in direction indicated by arrows until the button 'pops out'.
	Verify battery is inserted correctly and the key is in the "locked and on" position. See detailed information on using the battery properly in section **Inserting the battery** on page **51**.
	Verify your battery has a charge by pressing the charge indicator on the end of the battery. For detailed information, see section **Charging the batteries** on page **49**.
Red check engine light is illuminated. 	The red check engine light indicates a critical issue with the system. The cart will cease to operate until the issue is resolved. In the event there are multiple check engine lights, you can press the check engine button to cycle through them for review. Things that can cause the red light include: - Safety system inoperable - Cable disconnected below cart - Tilted cart Possible resolutions: - Reboot MARC system to see if indicator light is cleared. - Make sure the cart is on a level surface. See **Red (Critical) Check Engine light codes** on page **70**.
Yellow check engine light is illuminated. 	A yellow check engine light indicates an urgent issue with the system. The cart will continue to operate, but the issue indicated needs to be addressed. In the event there are multiple check engine lights, you can press the check engine button to cycle through them for review. Things that can cause the yellow light include: - Indicator LEDs disconnected or not functioning - Sensor blocked or unresponsive - Speaker not connected or malfunctioning - Battery system not communicating properly with system - Access point is not connected or malfunctioning - A cart sitting without power for multiple days may cause a yellow check engine light and a 0180 or 0190 error. Possible resolutions: - Reboot MARC system to see if indicator light is cleared. - See **Yellow (Caution) Check Engine light codes** on page **68**.

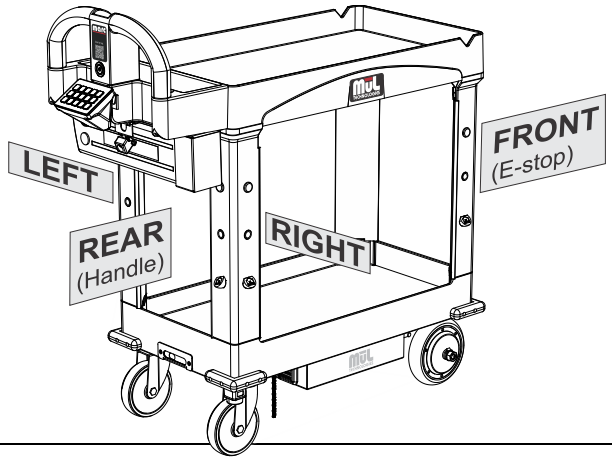
Cart stops and there are no indicator LEDs flashing or sounds.	Make sure the emergency stop button has not been pressed. If it has, reset it by twisting in direction shown by arrows. Verify your battery pack has sufficient charge. The cart may have encountered a large bump that set off the tilt sensor.
Pressed a station button but the cart did not move.	Verify the destination key you pressed has been set. Verify the destination is more than 1m away from the current location of the cart. Verify a red check engine light is not displayed. Verify the cart has an open path towards the destination. Verify you pressed the destination key for less than 3 seconds.
Cart did not reach the destination and announces, “Route Abandoned.”	The cart will stop when it is within ~1m of the programmed destination. Verify the destination is not blocked by obstacles and the path is open enough for the cart to navigate to the final destination. This condition can potentially occur anywhere along the defined path of the cart. If you encounter several instances of abandoned routes, it is possible that a cart reboot may solve the issue.
One of my set destinations is not correct.	Make sure that the cart has completely booted up. After you hear, “Cart Ready,” the cart will accurately set a destination. Make sure the cart is not moving when you set a destination. Make sure only one station button is pressed at a time to set a location.
I hear a noise coming from the cart while it is not moving.	If the cart is in the process of moving, it may be calculating the path for it to follow. It may also be moving a small amount as it adjusts the orientation of the cart. During these times it is normal for the cart to make a slight noise.
Cart seems confused or disoriented and cannot find destinations.	It is possible that the map software can ‘shift’ the map if the drive wheels slipped or were moving when the cart was still. This can cause the map to become disoriented. MARC is designed to be used on a flat, dry surface. It is also important not to move MARC units sideways or too quickly, as this may cause the wheels to slip. To use the Calibrate button function, please see **Using the Calibrate Button functionality (Fixed Map Mode)** on page **36**. If the map shifted and the Calibrate function did not resolve the issue, the cart should be powered down and restarted. Please note that the destination points will need to be reprogrammed if operating in Active Mapping Mode.

For the latest troubleshooting information, visit https://www.multechnologies.com/support or scan this QR code:

You can always contact the MūL Technologies team via email or phone to get assistance in resolving an issue. support@multechnologies.com or (262) 242-8830, option 2.

Yellow (Caution) Check Engine light codes

For the latest information, use this QR code to access our online information.



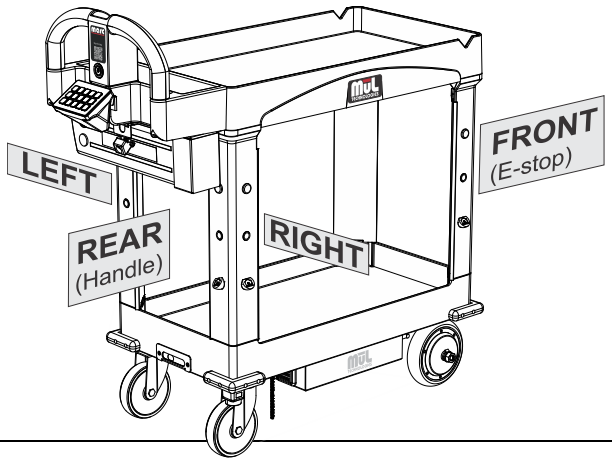
Yellow Check Engine light codes:

Code	Meaning	Comments
0000	LEDs missing.	The cart will operate normally but will not communicate direction or other status via the LED indicator lights.
0010	Battery pack missing.	The battery pack is not communicating its status to the mainboard. The battery can still be checked using the physical button on the battery itself. Please see section titled Using MARC battery packs.
1025	Distance sensor error (FL).	Front left distance sensor malfunctioning.
1026	Distance sensor error (FR).	Front right distance sensor malfunctioning.
1027	Distance sensor error (RL).	Rear left distance sensor malfunctioning.
1028	Distance sensor error (RR).	Rear right distance sensor malfunctioning.
1090	Access point error.	Access point missing or malfunctioning. MARC will perform normal operations, but the software update procedure will not function.
1100	Speaker error.	The cart will operate normally but will not communicate status via the audio cues.
1110	Weight sensor error.	Weight sensor missing or malfunctioning.
0180	CPA error	CPA encoder error.
0190	CPA localization error	CPA was unable to save previous movement while off.
2010	Battery error	Unable to communicate with battery.
2205	FL proximity error	The front, left proximity sensor may not be working or the cabling and/or circuitry connecting to the proximity sensor may not be working.

2206	FR proximity error	The front, right proximity sensor may not be working or the cabling and/or circuitry connecting to the proximity sensor may not be working.
2207	RL proximity error	The rear, left proximity sensor may not be working or the cabling and/or circuitry connecting to the proximity sensor may not be working.
2208	RR proximity error	The rear, right proximity sensor may not be working or the cabling and/or circuitry connecting to the proximity sensor may not be working.
2225	Side proximity sensor error FLS	The front, left, side proximity sensor may not be working or the cabling and/or circuitry connecting the proximity sensor may not be working.
2226	Side proximity sensor error FRS	The front, right, side proximity sensor may not be working or the cabling and/or circuitry connecting the proximity sensor may not be working.
2227	Side proximity sensor error RLS	The rear, left, side proximity sensor may not be working or the cabling and/or circuitry connecting the proximity sensor may not be working.
2228	Side proximity sensor error RRS	The rear, right, side proximity sensor may not be working or the cabling and/or circuitry connecting the proximity sensor may not be working.
2245	LED error FL	The front, left LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2246	LED error FR	The front, right LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2247	LED error RL	The rear, left LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2248	LED error RR	The rear, right LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2255	LED error FLS	The front, left, side LED may not be working or the cabling and/or circuitry connecting to LED may not be working.
2256	LED error FRS	The front, right, side LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2257	LED error RLS	The rear, left, side LED may not be working or the cabling and/or circuitry connecting to the LED may not be working.
2258	LED error RRS	The rear, right, side proximity sensor may not be working or the cabling and/or circuitry connecting to the LED may not be working.

Red (Critical) Check Engine light codes

For the latest information, use this QR code to access our online information.



Red Check Engine light codes:

Code	Meaning	Comments
0033	Motor error (L)	The left drive motor is not responding and is not operational.
0034	Motor error (R)	The right drive motor is not responding and is not operational.
0043	Encoder error (L).	The left wheel encoder is not responding or is not operational.
0044	Encoder error (R).	The right wheel encoder is not responding or is not operational.
0050	IMU error.	The inertial measurement unit is used to prevent MARC from tipping and is required for safe operation but is not responding.
0070	Battery being charged while MARC is operational.	To prevent the cart from moving autonomously while the charging cord is attached, movement is disabled until the charger is removed.
1060	Cart tilted.	The cart experienced a tilt of greater than 10 degrees.
1130	Camera missing.	Front or rear high-definition depth camera is not responding.
1140	Digital board error.	The main communication board of MARC is not responding.
1150	LiDAR missing.	The laser measurement system has an error and is a critical part of MARC's ability to 'see' the world and to the map-creation process.
1160	Startup error.	The software has an issue. Please reach out to support for more information and troubleshooting assistance.
1980	Storage failure upon bootup	The system storage has experienced a failure during the cart boot-up process.
1990	Storage failure while running	The system storage has experienced a failure during normal cart operation.
1125	Circuit board error FL	The circuit board and/or cabling to the circuit board may not be working.

1126	Circuit board error FR	The circuit board and/or cabling to the circuit board may not be working.
1127	Circuit board error RL	The circuit board and/or cabling to the circuit board may not be working.
1128	Circuit board error RR	The circuit board and/or cabling to the circuit board may not be working.
1131	Front camera not communicating	The front, camera and/or cabling to the camera may not be working.
1132	Rear camera not communicating	The rear, camera and/or cabling to the camera may not be working.
1170	USB circuit missing TOP	The circuitry and/or cabling may not be working.
1261	LD_LIDAR_MISSING_F	The front, corner LIDAR and/or cabling to the camera may not be working.
1262	LD_LIDAR_MISSING_R	The rear, corner LIDAR and/or cabling to the camera may not be working.
1270	RCP firmware error	The circuitry and/or cabling may not be working inside the RCP.
2070	Battery is currently charging	While the battery pack charger is plugged in MARC cannot move autonomously.

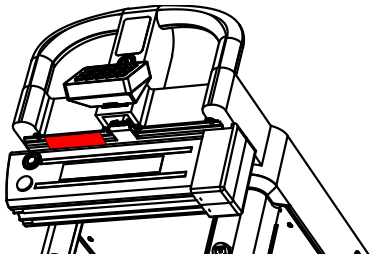
Accessing MARC's Web User Interface

INFO	The fastest, most efficient way to connect to your MARC cart is by using the USB-C to LAN adapter kit, since wired connections are faster and more reliable than wireless.
	Though it is possible that the update process can be successful using a variety of wireless devices, it is highly recommended that a Windows based laptop is used. Chrome or Microsoft Edge browsers also offer the best experience.
	Please note that upgrading the software will eliminate all mapping and programming. After the software update has been executed, all mapping will need to be redone, and destinations reprogrammed.

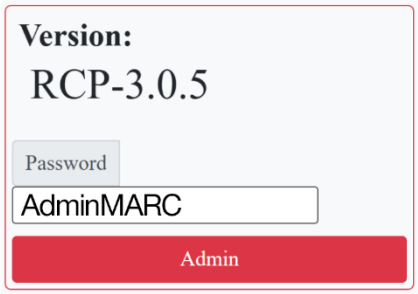
The MARC User Interface is a convenient way to see current settings, as well as make changes to several aspects of MARC's programming.

1. If you use the USB-C to LAN adapter kit, connect the adapter to the USB-C port prior to turning the cart on. See **Using the USB-C to LAN adapter kit** on page **58**.
2. The serial number of your MARC can be found using the INFO button, which can be found on the EZ-Go Navigation panel. Please see **System Statistics Overview** on page **32**.

   NOTE: If you are unable to use the info button for some reason, the serial number can also be found on the label attached to the metal battery bracket under the handle of the cart (shown in red at right).



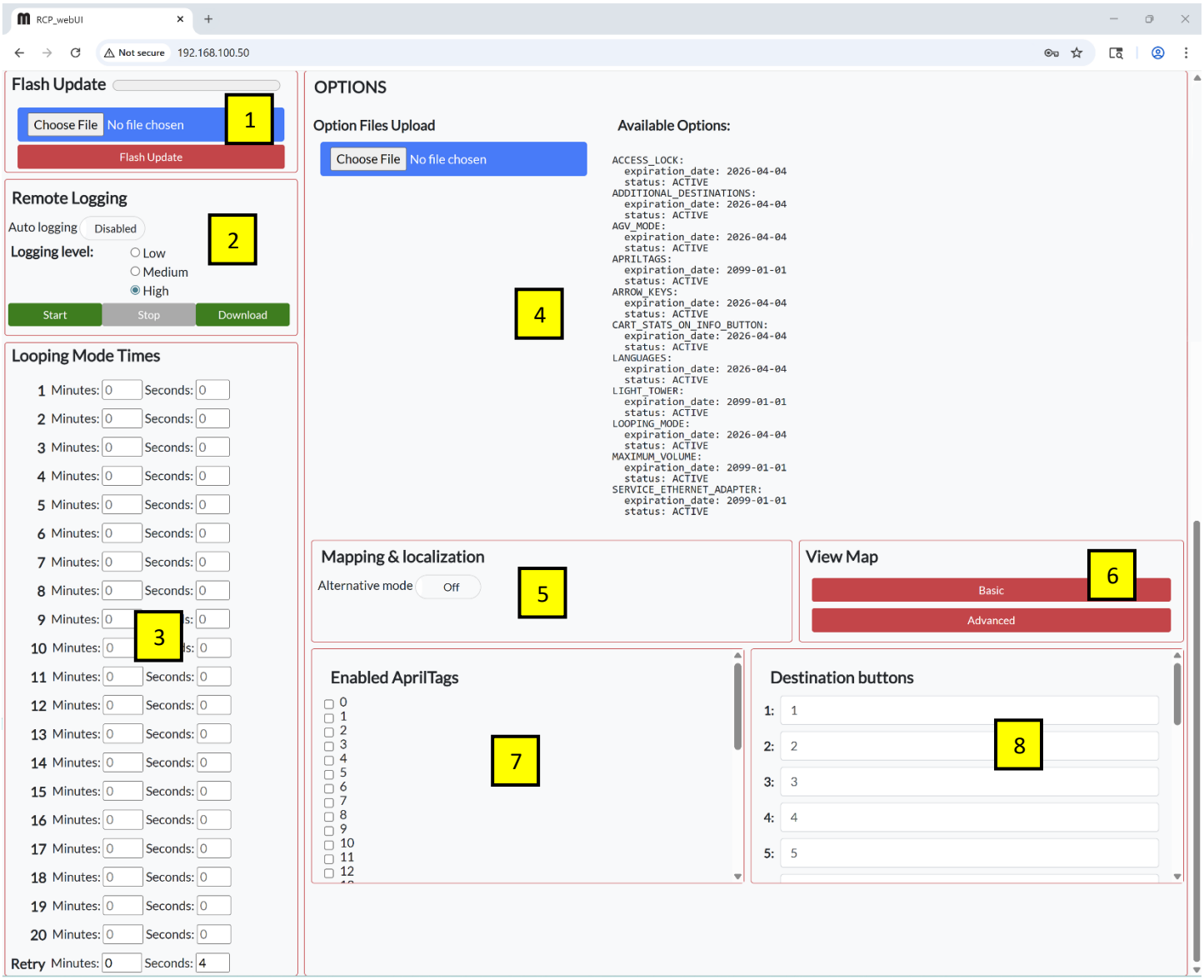
3. If you are connected using the USB-C LAN adapter kit, skip to step 5. Alternately, with a wireless computing device (e.g. laptop) and while within range (10 feet) of MARC, connect to your MARC's wireless network.
   - Closer is better, depending on your unique environment.
   - SSID will be MARCsetupXXXXX where XXXXX is the last five digits of the cart's serial number.
   - Click Connect for the SSID
   - Password is the same as the SSID used above.
4. Verify you have successfully connected to your MARC's wireless network.
5. Open a browser and go to http://192.168.100.50
6. Wait for the Version: section to populate with the current software revision and note revision if you are updating your cart.



INFO	The current revision of software installed on your MARC is shown at the top *prior to logging in* (in this example, 3.0.5). In some instances, it will say "Unknown" for a few moments.

7. Enter the password: **AdminMARC** and click the **Admin** button.

You should now see the screen shown:



Once you see this screen, you can continue to review current settings or make edits to the functions shown, including:

1. Software update panel (see **Updating MARC's Software** on page **78)**.
2. Remote logging interface panel
3. Looping Mode wait times adjustment panel
   See **Adjusting the wait times when operating in Looping Mode** on page **41**.
4. Optional Software Package (OSP) status and license upload panel
5. Mapping and Localization Alternative Mode toggle (Reserved for Technical Services)
6. Map view buttons (see **Viewing MARC's maps – see what it sees** on page **74**)
7. AprilTag data panel (see **Using optional AprilTags** on page **52**).
8. Destination buttons (custom text) programming panel
   See **Using custom text on destination buttons** on page **46**.

Once you are logged in, you can continue to the activity you were planning to program.

Viewing MARC's maps – see what it sees

With software version 3.0.9 or higher, your MARC cart includes a map visualization feature that helps you see where your cart has been and where it can travel. This optional tool helps you identify problem areas and understand how MARC sees your facility.

The map feature is not required for normal operation. Your MARC cart works perfectly well without ever opening the map view. This is a troubleshooting and diagnostic tool—use it when you need it, not as part of your daily routine.

How to Access the Map Feature

1. Log into your cart's web interface (see **Accessing MARC's Web User Interface** on page **72**)
2. You'll see two new map buttons (Basic Map for simple overview or Advanced Map for detailed sensor data)

Both map modes use the same access method; you simply choose which button to press based on what you need to see.

Basic Map Overview

Consider opening Basic Map view when:

- Your cart is traveling to unintended areas
- You want to verify your mapped area before saving
- You're troubleshooting navigation issues
- You want to ensure proper "loop closure" during initial mapping

Understanding What You See

The Basic Map display shows these key elements:

- **Cyan shaded area:** Where your cart can travel
- **Red squares:** Main center LiDAR sensor, obstacles creating "no-go" zones
- **Blue line:** Where you pushed the cart during mapping
- **Red line:** The path your cart plans to take autonomously
- **Green cart footprint:** showing MARCs current position
- **Arrow markers:** Programmed destinations displayed with a XYZ marker

How MARC Navigates Your Facility

Understanding the difference between the blue line and red line is key. The blue line simply shows where you walked with the cart during mapping—it's your historical path, nothing more. The cart will never just follow this blue line.

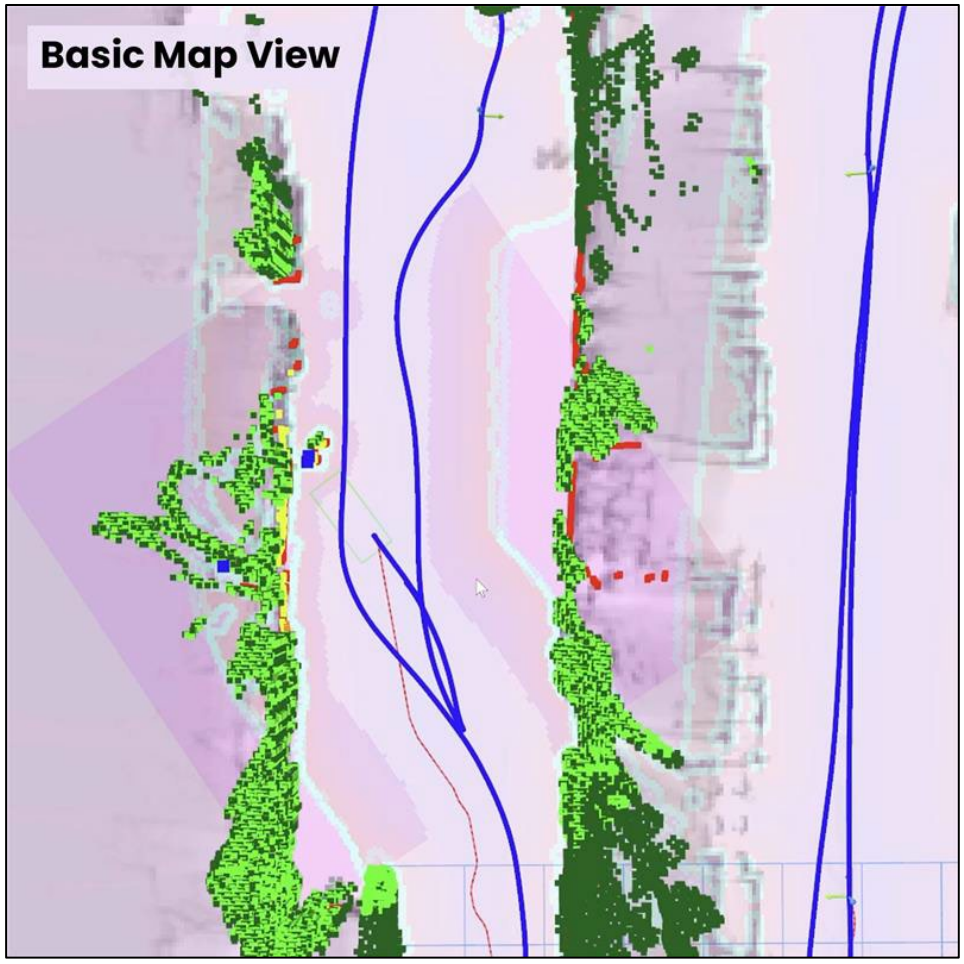
When you send your cart to a destination, it calculates the most efficient route through the allowed area. This is the red line, the cart's path. MARC will stay within the cyan allowed area and plan the quickest route, which may cut corners or take paths different from where you originally walked.

Common Problem It Solves

Sometimes customers report their cart travels where they don't want it to go. Often during mapping, someone moved an obstacle around - for example a forklift was blocking the path temporarily. When they pushed the cart to the side, they accidentally mapped that detour into the allowed area.

With Basic Map view, you can:

- See this detour immediately in the cyan allowed area
- Understand why the cart thinks it can use that path
- Identify areas you need to remap to exclude unwanted routes

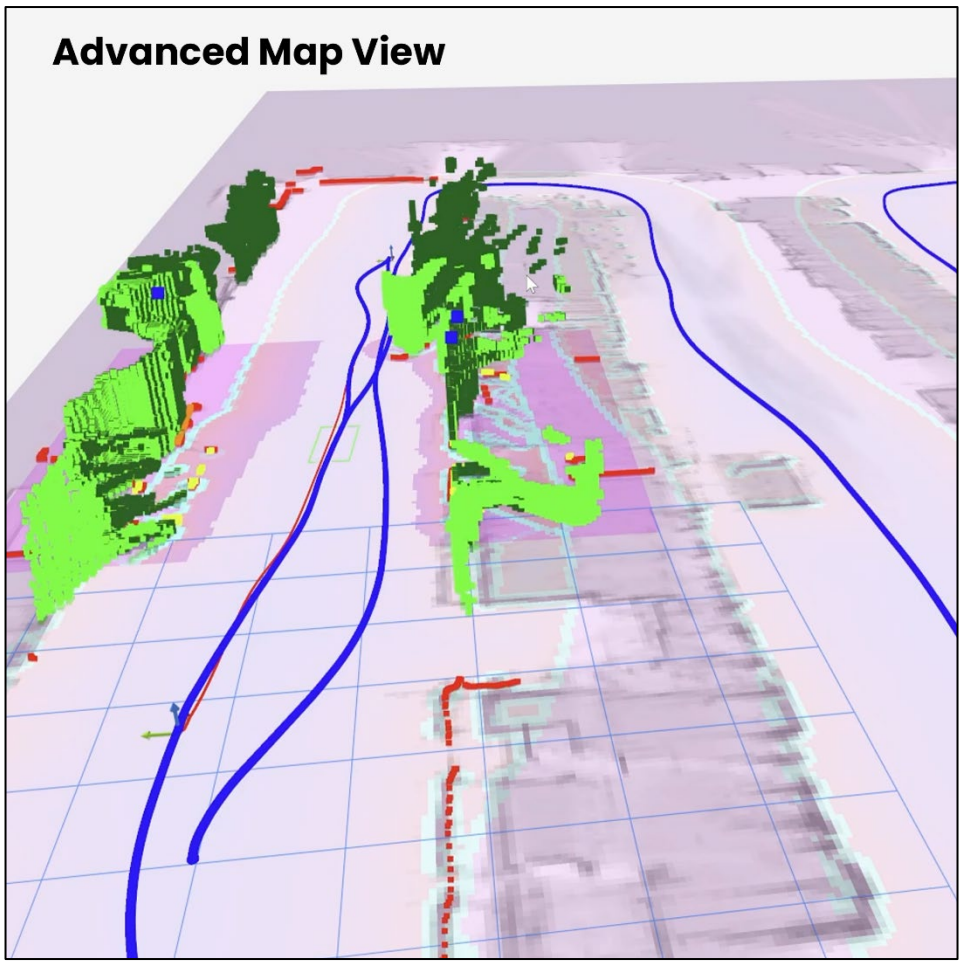


Navigating Basic Map View

- **Zoom:** Use two-finger pinch/scroll or mouse scroll wheel to zoom in and out
- **Pan:** Left-click and drag to move the map around
- **Rotate:** Right-click and drag to 3D rotate

Advanced Map Overview

Advanced Map view reveals what your cart is seeing through all its sensors in three dimensions. This can be handy to understand the carts vision and is not necessary for regular operation.



A more detailed view.

You'll see significantly more sensor data than you will in the Basic Map.

When to Use Advanced Map

Open Advanced Map view when:

- The cart stops moving unexpectedly
- You're diagnosing sensor issues
- You need to check for camera or LiDAR misalignment
- You want to verify what sensors are detecting during troubleshooting

Understanding the Display

	Green voxels	Camera data showing three-dimensional depth perception
	Dark green	This is the trail that builds behind you as you move around during mapping. It shows where the cart has been and what it has seen.
	Light green	This is temporary, real-time camera data that the cart is currently seeing in its immediate surroundings.
	Red squares	Main center LiDAR sensor, obstacles creating "no-go" zones
	Orange dots	Front corner LiDAR unit
	Yellow dots	Back corner LiDAR unit
	Blue squares	Proximity sensor detections
	Pink squares	Four meters by four meters local planning area where the cart performs short-range navigation
	Green outline	Shows MARCs current position

Navigation in Three Dimensions

Right-click and drag to rotate the view and examine obstacles from different angles. This helps you see overhead hazards like low-hanging shelves or identify if table legs are visible but tabletops are not.

The cart plans navigation in two dimensions but sees obstacles in three dimensions through its cameras. This is why the three-dimensional view helps you troubleshoot issues the cart might be experiencing.

Troubleshooting Common Issues

Sensor Contamination:

- Single green voxel where nothing exists generally indicates potential debris on camera lens.
- Blue squares with nothing nearby indicates possible debris on proximity sensors (even small items can trigger these).

Sensor Misalignment:

- LiDAR returns inside cart's footprint = Sensor bumped out of calibration
- Green data splashing on floor = Cart tilted or camera misaligned
- Straight red line on front of cart where there is no obstacle = LiDAR pointing at ground instead of forward

Navigation Problems:

If your cart stops moving when the path looks clear, check Advanced Map for sensor misalignment. You might see a sensor pointing at the floor, creating false obstacles that prevent the cart from moving.

About the Dark Green Trail

Don't worry about the dark green trail (dark green voxels) that follows you while mapping. It clears automatically when you press a destination button. Many users try to manually clear it by walking back and forth, just press any destination button instead. This data only matters when your cart is actively planning its route.

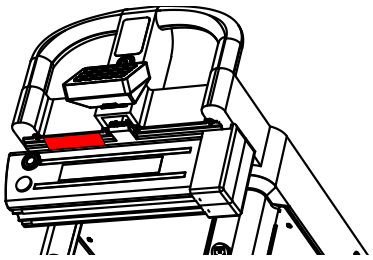
 INFO	These map views are diagnostic tools that exist to help you troubleshoot and understand how MARC navigates. Your cart is designed to work autonomously without monitoring the map. Use of these features when issues arise can be a handy diagnostic tool – but are not needed as part of normal operation.

Updating MARC's Software

If you have been instructed to update the software on your MARC system, here is the step-by-step process.

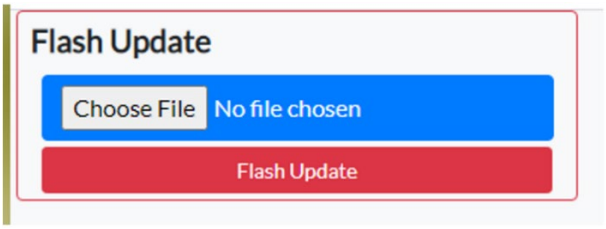
INFO	Updating the software on your cart will erase the current map and destinations. Please plan to reprogram the cart after the update has been installed.

1. Obtain the update package from MūL Technologies for your MARC.
2. If you use the USB-C to LAN adapter kit, connect the to the USB-C port *prior to turning the cart on*. See **Using the USB-C to LAN adapter kit** on page **58**.
3. Power on your MARC and verify your battery is at least 25% charged.
4. The serial number of your MARC can be found using the INFO button, which can be found on the EZ-Go Navigation panel.



NOTE: If you are unable to use the info button for some reason, the serial number can also be found on the label attached to the metal battery bracket under the handle of the cart (shown in red above).

5. Log in using the instructions in **Accessing MARC's Web User Interface** on page **72**, then return to this step.
6. Click on the **Choose File** button.

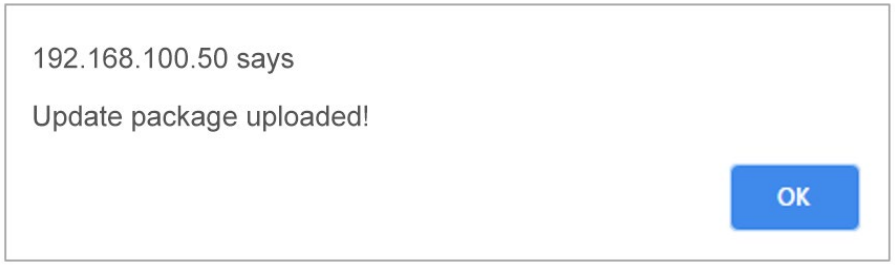


7. A file explorer window will pop up. Select the update package file you previously obtained from MūL Technologies and wait till you see the message "**Update package uploaded**." This can take several minutes to upload depending on connection strength and speed.

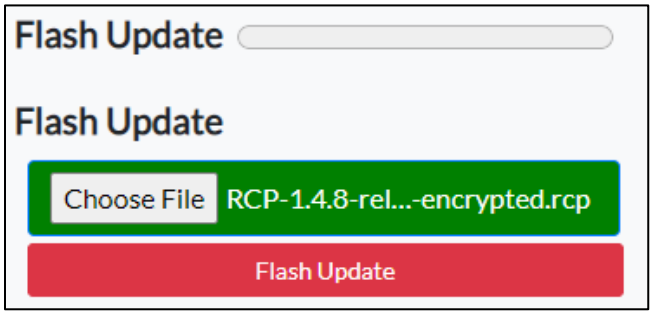
INFO	Since the updates are large, uploading can take several minutes. Once uploaded, you will see an acknowledgement and the **Choose File** box will turn green. At that point, click on **Flash Update** to begin the updating process. If the **Flash Update** is pressed early, an error will occur.

INFO	The device being used to connect and perform the update must remain near the cart being updated during the entire update process. If the device is moved away, powered off or otherwise disconnected the update process will halt and may leave the MARC unit inoperable.

8. After the file is uploaded, a pop-up box will indicate that the update package has been uploaded to your MARC.



9. Click OK and you will then see the selected file's name show up with a green background. If you do not see the file name and a green background, the file is still uploading or has failed unexpectedly.



10. Next, click on the Flash Update button to begin the updating. Depending upon the update this may take a few seconds to several minutes.
11. Once complete you will see a Success message box pop up.
12. **Power off your MARC, then back on**.
13. Verify your MARC successfully boots up.
14. Use the Info button to view the new version number to verify that the update was successful. See section titled **System Statistics Overview** on page **32** for details.

Software update error codes

If the software update process fails, these codes will help diagnose and correct the condition causing the error.

Code	Message	Comments
0	SUCCESS	The updating process was completed successfully.
1	FAILED_TO_VERIFY	There is an internal updating issue. Please contact the MūL Technologies team. You can contact the MūL Technologies support team via email or phone to get assistance in resolving an issue at support@multechnologies.com or (262) 242-8830, option 2.
2	FAILED_TO_DECRYPT	
3	FAILED_TO_EXTRACT	
4	FAILED_TO_INSTALL	

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