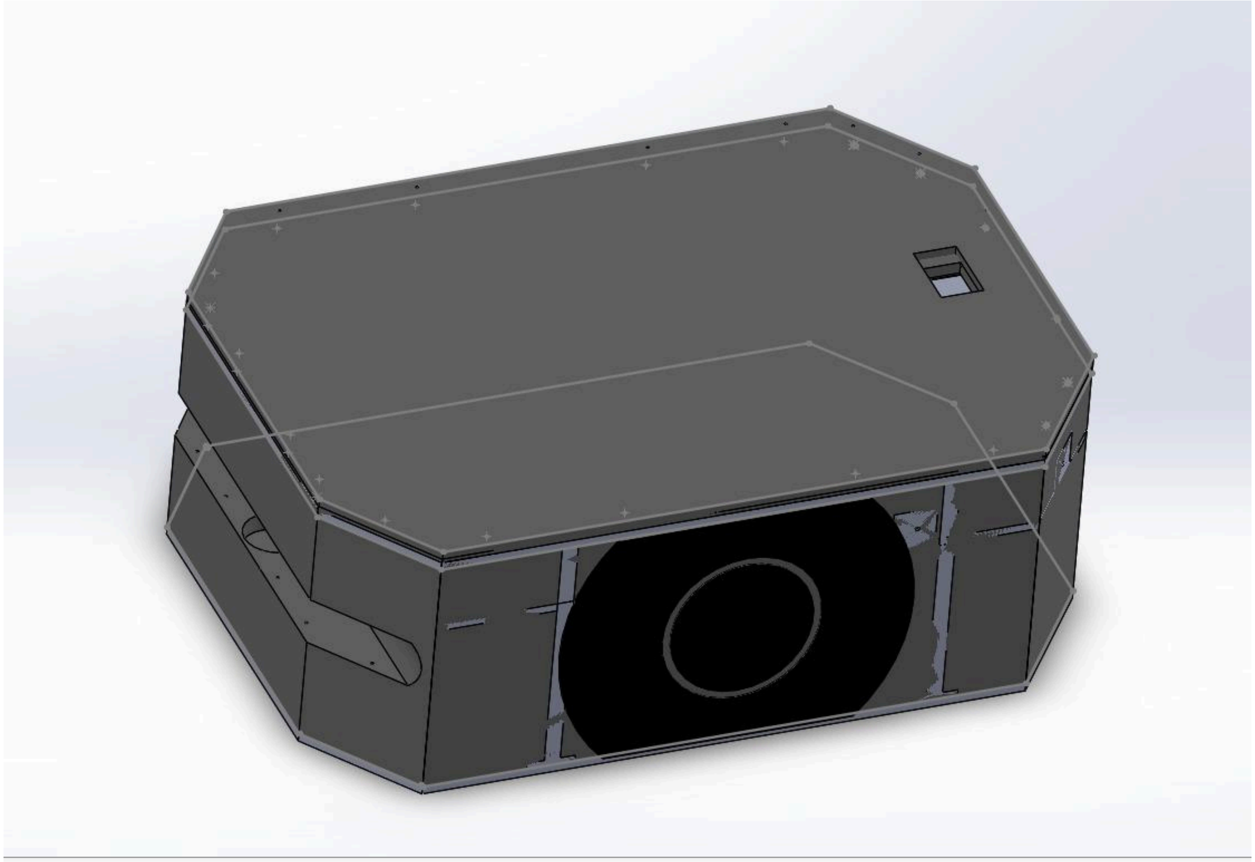
AMR CONTROLLER



User’s Manual

Precision Navigation | Intelligent Control | Seamless Autonomy

This document serves as a comprehensive guide for configuring, operating, and maintaining the AMR Controller. Designed for reliability and adaptability, the controller enables advanced path planning, obstacle avoidance, and seamless autonomous mobility. Whether for research, industrial automation, or field robotics, this manual ensures users have the tools and knowledge to unlock the full potential of the system.

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1.Introduction

Overview of the robot

This user manual serves as a comprehensive guide for professionals involved in the deployment, operation, and maintenance of an Autonomous Mobile Robot (AMR) controller within industrial environments. It is specifically tailored for engineers, system designers, technicians, and facility managers with a background in factory automation and robotic control. The manual begins by introducing the AMR's intended functionality, key features, and operational scope, emphasizing its use in structured indoor settings such as warehouses and logistics centers. It outlines critical safety information, including emergency protocols, risk mitigation strategies, and personal protective equipment guidelines to ensure safe interaction with the system. Detailed instructions are provided for powering the robot on and off, battery handling, and recovery procedures. Additionally, the document covers routine maintenance schedules, visual inspections, and component replacement to ensure optimal performance and longevity. A dedicated troubleshooting section addresses common issues and recovery steps, along with guidance on when to contact technical support. The system specifications section details mechanical, electrical, and environmental parameters essential for deployment planning. This manual does not include every software configuration step but references other documentation for those tasks. By following the guidelines within this manual, users can safely and efficiently integrate the AMR into their operations while ensuring compliance with industrial standards and best practices.pose of the manual.

Intended users

This manual is intended for qualified professionals with expertise in factory automation (FA) and robotic control systems. The intended audience includes:

- Engineers and decision-makers responsible for the implementation of automation solutions
- System designers involved in the development of FA architectures
- Technicians tasked with the installation, commissioning, and servicing of automation equipment
- Facility managers overseeing the operation and maintenance of automated systems and infrastructure

2.Safety Information

General safety warnings

1. The end-user is responsible for ensuring that the AMR operates strictly within its specified capabilities, intended applications, and designated environments.

2. A task-specific risk assessment must be carried out by the end-user, and relevant safety measures must be implemented in compliance with local safety regulations.

3. It is the end-user’s duty to ensure that the AMR’s design, deployment, and usage align with applicable local standards and legal obligations.

4. The end-user is responsible for conducting a thorough risk assessment to identify and mitigate hazards introduced by the payload.

5. The user must confirm that the AMR remains stable with any attached payloads, structures, or accessories during operation within the defined environment.

6. When transporting containers with liquids or non-solid materials, the end-user must account for the impact of shifting contents on the AMR’s stability.

7. It is the end-user’s responsibility to ensure the payload is securely fastened to the AMR.

8. Payload movement during transport must not compromise the AMR’s balance or operational safety.

9. Operating the AMR on non-compliant inclines may result in tipping and serious crush injuries.

10. No functional modifications are permitted unless followed by a complete risk assessment.

11. Unauthorized modifications may compromise the AMR's safety and performance.

12. After any modification, the end-user must verify that all safety features remain operational.

13. All unpacking procedures must be conducted with proper tools and adherence to safety instructions to avoid personal injury or property damage.

14. Avoid exposing the AMR to rain, high humidity, or any form of moisture, as this may compromise its functionality.

15. Do not operate the AMR in hazardous environments, such as areas containing flammable gases, explosive vapors, or oil mists.

16. Prevent the AMR from entering designated emergency evacuation routes or zones used by emergency personnel.

17. During workspace map development, ensure that objects extending beyond the AMR's laser scan range—either overhead, below, or to the sides—are clearly marked as restricted zones to reduce the risk of collision.

18. Failure to define and physically secure dangerous zones may result in serious injury or damage to the AMR during operation.

19. Physical barriers must be both detectable by the AMR's sensors and structurally capable of stopping the AMR at full payload and top speed.

20. Operating the AMR in conditions that exceed its ingress protection rating can result in system failure or malfunction.Never attempt to remove the battery while the AMR is powered on; always ensure the system is completely powered down before handling the battery.

21. The AMR is optimized for operation on smooth indoor surfaces; although it can traverse minor steps or gaps, doing so repeatedly or at high speed can significantly reduce the lifespan of its drive components.

22. Only trained and authorized personnel who have thoroughly reviewed this manual should perform manual movement or operational adjustments on the AMR.

23. Cleaning frequency should be determined based on the system's operational intensity, environment, and usage; high-dust or high-traffic environments may require more frequent cleaning.

24. When cleaning the charging contacts, use only isopropyl alcohol—avoid any other solvents or chemicals, as they may damage surrounding surfaces or sensitive components.

25. Do not operate the AMR on soft surfaces such as carpet.

Emergency stop and hazard zones

The robot is equipped with an emergency stop button. This is a critical safety device designed to bring the AMR to an immediate and safe halt in the event of a hazardous situation.

To activate the emergency stop:

1. Press the emergency stop button. The button will latch in the depressed position.
2. Confirm that the AMR has come to a complete stop.

Important Safety Notes :

- The emergency stop button is for emergency situations only. Do not use it for routine stops.
- Regularly inspect the emergency stop button to ensure it is unobstructed, functional, and easily accessible.
- Ensure all personnel in the vicinity of the AMR are familiar with the location and operation of the emergency stop button.
- Do not attempt to bypass or override the emergency stop circuit.
- The emergency stop circuit is a safety-rated circuit. Any modification or repair must be performed by qualified personnel only.
- After an emergency stop activation, a thorough inspection of the AMR and the surrounding area should be conducted to determine the cause of the emergency and to prevent recurrence.

The following hazard zones may be present in the AMR's operational area:

- Crushing/Pinch Points: Locations where a body part could be trapped between the AMR and other objects (e.g., walls, machinery, other AMRs).
- Impact Zones: Areas where the AMR could collide with personnel or other equipment.
- Path of Travel: The planned and potential routes of the AMR. This zone needs to be considered, as the AMR may deviate slightly from its planned path due to sensor limitations or dynamic obstacle avoidance.
- Load Zones: The area surrounding the AMR where the payload could shift, fall, or otherwise create a hazard.
- Restricted Areas: Zones where AMR access is prohibited for safety reasons (e.g., areas with unstable structures, very high temperatures, or dangerous materials).

Proper PPE and lifting instructions

The following guidelines must be adhered to when lifting the AMR to prevent personal injury and/or equipment damage.

General Precautions:

- If the AMR must be lifted, ensure that an adequate number of personnel are available to handle the weight, or use a mechanical lift.
- Personnel involved in manually lifting the AMR must employ proper lifting techniques to avoid muscle strain or back injury.
- Lifting straps must be attached in a manner that ensures even weight distribution. Uneven weight distribution during lifting operations can cause the AMR to shift or become unstable, potentially leading to injury or damage.
- Verify that any equipment used for lifting, including but not limited to straps, hoists, and cranes, is appropriately rated for the weight of the AMR. It is the end user's responsibility to inspect and confirm the suitability of lifting equipment and to apply appropriate safety factors prior to lifting.
- Exercise extreme caution when placing the AMR back on the floor after lifting. Ensure all safety precautions are in place to prevent personal injury and/or property damage.

Safe Lifting Points:

The AMR may be safely lifted from the following points:

- Load-bearing T-slotted extrusions located in the payload bay.
- Caster mounting points.
- Any area on the underside of the steel chassis that is not a sensor location.

Prohibited Lifting Points:

To prevent damage to the AMR, do *not* lift from the following points:

- Any of the AMR skins (outer panels).
- Any part of the chassis that contains a sensor component.

3.System Overview

Intended use

The Autonomous Mobile Robot (AMR) is intended for operation within indoor, industrial environments and under the supervision of trained personnel. Suitable deployment areas include structured or semi-structured settings such as warehouses, distribution centers, and logistics facilities, where access by the general public is restricted.

Deployment of the AMR is strictly limited to applications where comprehensive risk assessment has been conducted and appropriate mitigation strategies have been implemented to protect personnel and equipment.

The AMR is not designed for use in the following environments:

- Outdoor or uncontrolled spaces without thorough risk analysis
- Locations accessible to the general public
- Areas containing life-support or critical medical systems
- Residential or domestic settings

Despite its advanced safety features, the AMR must be integrated into workflows with careful consideration of operational hazards and environmental conditions.

Note that the method of loading or unloading payloads onto the AMR is not provided by the manufacturer. It is the sole responsibility of the end user to conduct a complete, task-specific risk assessment and to ensure that payload handling is carried out safely.

Commissioning and operation of the AMR must be performed in strict accordance with the procedures outlined in this manual.

AMR key features and capabilities

The Autonomous Mobile Robot (AMR) described in this manual incorporates a robust integration of mechanical design, sensor technology, and advanced localization algorithms to achieve intelligent, adaptive mobility in industrial environments. Each component and feature is carefully engineered to ensure reliable operation, real-time responsiveness, and safe interaction within dynamic workspaces.

One of the fundamental features of the AMR is its four-wheel platform architecture, which includes two independently driven wheels and two passive caster wheels. This differential drive configuration provides a balance between maneuverability and mechanical stability, enabling precise navigation even within confined indoor environments. The chassis is optimized for carrying a payload of up to 5 kg, ensuring consistent performance during transport tasks without compromising on structural integrity or safety.

To facilitate environmental awareness and real-time obstacle avoidance, the AMR is equipped with a high-precision Light Detection and Ranging (LiDAR) sensor. This sensor continuously scans the robot's surroundings, generating a dense point cloud representation of obstacles and environmental features. The real-time feedback from the LiDAR system enables the AMR to dynamically detect objects in its path and adjust its trajectory as necessary, thereby enhancing its autonomous decision-making capability and ensuring safe operation without human intervention.

A cornerstone of the robot's autonomous functionality is its use of a Simultaneous Localization and Mapping (SLAM) algorithm, developed in C++ and grounded in the theoretical principles of probabilistic robotics. SLAM enables the AMR to build a coherent map of its environment while concurrently estimating its own position within that map. This is achieved through the fusion of sensor data (primarily from the LiDAR) with motion estimates, allowing the AMR to self-localize even in GPS-denied environments. The SLAM system supports loop closure detection, error correction, and map refinement, all of which contribute to high-accuracy path planning and long-term autonomy.

Together, these features enable the AMR to operate effectively as an intelligent, mobile unit within structured or semi-structured indoor facilities. Its mechanical robustness, perceptual awareness, and autonomous mapping capabilities make it an ideal solution for modern logistics, warehousing, and industrial automation tasks.

Major components

This section describes the primary components of the Autonomous Mobile Robot (AMR). These components work in conjunction to provide the AMR's navigation, motion, and control capabilities.

1. Chassis

- Description: The chassis serves as the structural foundation of the AMR system. It is a robust framework that provides the necessary rigidity and strength to support all other operational components. The chassis is engineered to withstand mechanical stresses encountered during movement and operation.
- Material and Construction: Constructed from steel, the chassis incorporates strategic reinforcement points at high-stress junctions. Gussets are added at the motor mounting areas to prevent flexing during rapid acceleration and deceleration.
- Key Features:
  - Pre-drilled mounting holes with pressed-in threaded inserts simplify component attachment and facilitate future modifications.
- Dimensions: 963mm × 690mm × 333 mm

2. Motors

- Description: The AMR utilizes closed-loop stepper motors to provide precise and controlled movement.
- Specification: The AMR is equipped with 24HS40-5004D-E1000: 4.0Nm Closed loop stepper motor and CL57T V41 Driver, selected based on the torque requirements of the system.

3. Lidar

- Description: Lidar (Light Detection and Ranging) is a crucial sensor used for environmental perception and navigation.
- Specification: The AMR uses the RPLiDAR S2L.
- Key Features:
  - 360° scan capability.
  - 0.12° angular resolution.
  - Provides a balance of performance and price.

4. Microcontroller (MCU)

- Description: The Microcontroller Unit (MCU) is responsible for executing the motor driving tasks. It receives movement signals from the processor and translates them into control signals for the motor drivers.
- Specification: The AMR incorporates the ATmega32U4, an 8-bit AVR microcontroller developed by Atmel.
- Key Features:
    - High-performance RISC architecture.

5. Inertial Measurement Unit (IMU)

- Description: The Inertial Measurement Unit (IMU) is used for sensing the AMR's orientation, motion, and rotation.
- Specification: The AMR uses the BNO055.
- Key Features:
    - Affordable and easy to integrate.
    - Provides reliable performance for orientation tracking and motion sensing.
    - On-board sensor fusion, which simplifies data processing.

6. Processor

- Description: The NVIDIA Jetson Nano serves as the high-performance computing core of the AMR, responsible for advanced data processing, decision-making, and high-level control. This System-on-Module (SOM) integrates a powerful processor, memory, and interfaces, enabling it to execute complex algorithms essential for autonomous navigation and operation.

- Key Features and Functions:
    - High-Performance Computing: Delivers substantial processing power in a compact and energy-efficient form factor.
    - GPU Acceleration: Leverages the GPU to accelerate computationally intensive tasks, crucial for autonomous navigation.
    - Sensor Data Processing: Processes and interprets data from the lidar, IMU, and other sensors to perceive the environment.
    - Path Planning and Control: Executes algorithms for path planning, obstacle avoidance, and motion control, enabling the AMR to navigate autonomously.
    - Communication: Facilitates communication with the motor controllers, other onboard systems, and external devices.

Autonomous navigation principles

The AMR integrates advanced hardware and autonomous navigation algorithms to create a versatile mobile platform capable of transporting payloads efficiently. Central to its operation is the use of Simultaneous Localization and Mapping (SLAM), which enables the AMR to map its environment and localize itself within that map in real time. This technology allows the AMR to navigate and perform tasks without requiring any modifications to the facility infrastructure. By continuously scanning its surroundings using onboard sensors such as the LiDAR , the AMR identifies physical landmarks and constructs a reliable internal representation of the environment.

SLAM empowers the robot to determine optimal navigation paths, updating its trajectory multiple times per second to ensure smooth, adaptive movement. When obstacles are encountered, the AMR autonomously adjusts its path-slowing, stopping, rerouting, or resuming its original course once the path clears. If rerouting is not possible, the AMR will safely terminate the task. Path planning is dynamically governed by constraints embedded within the internal SLAM map, which the AMR continuously refines through operation.

The AMR can function independently using its internal SLAM-generated map, especially in single-robot environments. However, in multi-robot scenarios, coordination via a central fleet manager may be required for efficient traffic handling. All localization and navigation parameters are maintained within the robot's core processing unit, eliminating the need for external path-modifying software.

Payload details and limits

The Robot is engineered to transport payloads with a maximum capacity of 5 kilograms, ensuring reliable performance for lightweight material handling applications. The robot itself has a total mass of 25 kilograms, inclusive of its structural frame, drive system, onboard electronics, and integrated sensors. This balanced weight-to-payload ratio supports stable and efficient operation within indoor industrial environments, while maintaining the necessary agility for autonomous navigation and maneuverability.

4.Maintenance and Cleaning

Maintenance schedule

Before performing any maintenance tasks on the AMR, it is important to read and fully understand the following information. Maintenance procedures described in this document must be carried out only by personnel who are properly trained, skilled, and authorized to perform such tasks. Ensure that the area where maintenance will take place is adequately secured and protected to prevent any interruptions from other AMRs. Access to this area should be restricted until maintenance is complete. For details on recommended maintenance intervals and specific tasks, please refer to the maintenance schedule in the table below.

Component	Maintenance Interval	Inspection
Emergency Stop Button	Weekly	Test for correct mechanical and functional response.
Motor Brushes	Every 3 months	Inspect for wear : assess length based on duration.
Drive and caster wheel threads	Every 3 months	Examine for wear,embedded debris or surface damage.
Caster Assemblies	Every 3 months	Apply lubrication to pivot and rolling components when needed.
Batteries	Every 6 months	Assess charge level,inspect for leakage,swelling or other damage.

5.Startup and Shutdown

Power-on sequence and the normal shutdown

The startup process of the robot begins by turning on the main power switch, which supplies power to all components including the Jetson Nano. Once powered, we establish a remote connection between our laptop and the Jetson Nano using VNC (Virtual Network Computing). This allows us to access the Jetson Nano's desktop environment wirelessly. After connecting, we compile the robot control program directly on the Jetson Nano and execute it. Upon execution, the robot initiates its mapping sequence, using its onboard sensors and localization algorithms to create an internal map of the environment. Once mapping is complete, the robot automatically returns to its initial starting position.

After the robot returns to the start point, we provide it with the destination coordinates through the user interface. The robot then navigates autonomously to the given location, utilizing the previously generated map for optimal path planning. Once it successfully reaches the destination, the program is terminated manually through the VNC interface. To ensure a proper shutdown and prevent any potential system or memory issues, we initiate the standard shutdown process of the Jetson Nano through the VNC connection, allowing the robot to power down safely and completely. This sequence ensures both the software and hardware components are handled correctly during startup and shutdown.

6.Battery and Charging

Manual charging method

To manually charge your GAONENG GNB 6S 22.2 V 5000 mAh pack with an external charger, first place the charger on a stable, non-flammable surface and select the Li-ion or Li-Po mode. Set the charge current to 0.5 C (about 2.5 A) for standard charging—or up to 1 C (5 A) if your charger and battery are rated for fast charging. Connect the charger's main output to the battery's XT60 plug, observing correct polarity (red to positive, black to negative). Then attach the balance lead to the charger's balance port, matching each pin to its cell position. Before starting, double-check that all connections are secure and that the battery is at or above room temperature (15–25 °C). Begin the cycle: the charger will first balance the cells, then bulk-charge until the pack reaches 25.2 V (4.2 V per cell), and finally taper the current in a balancing phase until each cell is equalized. Once the charger indicates "full" or "100 percent," power it off, disconnect the balance lead, then remove the XT60 plug. Store or install the battery only after it has cooled to ambient temperature. This approach ensures safe, balanced charging and maximizes the lifespan of your Samsung-based 21700 cells.

Battery replacement

1. Power off the AMR, disconnect all power sources, don appropriate PPE, and have the replacement battery and basic tools ready.

2. Remove the cover over the battery bay (typically secured by external fasteners), then unplug the XT60 connector and any auxiliary balance leads.

3. Lift out the depleted GAONENG pack, inspect the bay and connector terminals for debris or damage, and clean as needed.

4. Place the new battery into the bay, secure it with the original fasteners or straps, and reconnect the XT60 and balance/BMS leads, ensuring cables are clear of any moving parts.

5. Close and secure the battery bay cover, power on the AMR, check that the system recognizes the new pack's voltage and state-of-charge, and run a short load test to confirm stable operation and normal temperature.

Storage and overheating precautions

When handling the GAONENG GNB 6S 22.2 V 5000 mAh 10 C XT60 Li-ion pack—built around Samsung 21700 50S cells—it is critical to observe rigorous storage and thermal-management practices to ensure both safety and longevity, especially when the battery is integrated into an Autonomous Mobile Robot (AMR) controller. For storage, maintain the pack at a state of charge (SoC) of approximately 40–60 percent and store it in a cool, dry environment between 15 °C and 25 °C with relative humidity below 60 percent. Avoid exposing the battery to direct sunlight, rapid temperature swings, or environments exceeding 30 °C; if longer-term storage (over two weeks) is required, check the SoC monthly and top up as needed to maintain the recommended range. Store the pack in a fire-resistant container or cabinet—ideally a Li-ion safety bag—and segregate it from conductive materials to prevent accidental short-circuits. Never leave fully charged or fully depleted cells idle for extended periods, as extreme SoC states accelerate capacity loss and internal cell stress.

In operation, the GAONENG pack must be actively managed to prevent overheating: ensure that the AMR's battery compartment is well-ventilated and free of obstructions that can trap heat. Do not exceed the manufacturer's continuous discharge rating of 10 C (up to 50 A) without adequate thermal monitoring. Incorporate a battery management system (BMS) with individual cell voltage and temperature sensing; configure the BMS to cut off charging if any cell exceeds

45 °C or discharging if any cell surpasses 60 °C. Position thermal sensors adjacent to the cell group most prone to heat generation (often the central cells), and program the AMR controller to trigger a controlled shutdown or reduced-load mode when temperatures approach critical thresholds. After heavy use or high-current discharge cycles, allow the battery to cool to ambient temperature—below 35 °C—before re-charging. In the event of abnormal heat buildup, swelling, or electrolyte odor, immediately remove the battery from service, isolate it in a fire-resistant container, and follow your organization's hazardous-materials disposal procedures. By adhering to these storage and overheating precautions, you will maximize cycle life, preserve capacity retention, and safeguard both personnel and equipment.

7.Troubleshooting

Common issues and basic recovery steps

1. Low Battery and Charging Anomalies

   Issue 1: Failure to initiate charging sequence upon physical connection to the charging station.
   • Possible Cause: Degradation or contamination of the charging interface contacts
   • Recommended Action:
   – Inspect and clean the charging interface thoroughly to restore proper connectivity.

   Issue 2: Battery is critically depleted, preventing autonomous navigation to the charging station.
   • Recommended Actions:
   – Use external charging equipment to recharge the battery manually.
   – Physically relocate the AMR to the charging station and connect it directly.

2. AMR Start-Up Malfunctions

   Issue: AMR fails to begin the operational startup sequence
   • Initial Action:
   – Press the power OFF button
   – Inspect all electrical connections
   – Press and hold the power ON button for approximately 0.5 seconds, then release

   • Further Diagnostic Measures:
   – Check the battery's state of charge to ensure sufficient power for boot-up

3. Unexpected Operational Shutdown

Possible Causes:
- Loose or disconnected battery terminals
- Detected internal battery fault
- Critically low battery charge
- Electrical fault or short circuit at the USER PWR interface
- Malfunctioning Human-Machine Interface (HMI) panel or Operator OFF button
- Internal component failure or connection discontinuity

Recommended Actions:
- Inspect and address each of the above causes as applicable
- For internal component issues, contact technical support for assistance

4. Battery Electrolyte Leakage

Issue: Electrolyte leakage observed from the battery enclosure
- Immediate Action:

– Cease AMR operation immediately
– Secure the area and restrict access to unauthorized personnel

- Recommended Actions:

1. Wear appropriate Personal Protective Equipment (PPE)
2. Absorb leaked electrolyte using a dry, inert material (e.g., granular silica)
3. Decontaminate all affected surfaces thoroughly
4. Place the damaged battery in a sealed, non-reactive container
5. Dispose of all contaminated materials in compliance with local hazardous waste regulations

5. Ingress of Liquids

Issue: AMR has been exposed to liquid substances
- Recommended Actions:

– Immediately power down the AMR
– Remove all visible moisture and allow internal components to air dry fully

– Do not attempt to power on the AMR until it is completely dry and inspected for damage

When to contact support

- **AMR fails to start after following all power and connection checks:** This indicates a fundamental system malfunction beyond basic user-serviceable elements. It suggests a potential failure within critical internal hardware or core software that prevents the initiation of the AMR's operational state.

- **Charging does not initiate despite proper connection and clean contacts:** This signifies a potential fault within the power delivery or battery management systems. If physical connections and contact integrity are verified, the issue likely resides in internal charging circuitry, battery health, or communication protocols between the AMR and the charging apparatus.

- **AMR shuts down unexpectedly without clear cause:** Unpredictable operational cessation points to underlying instability within the system. This could stem from intermittent hardware faults, critical software errors, or unidentifiable power delivery issues that compromise the AMR's ability to maintain a stable operational state.

- **Hardware or internal components show signs of failure or damage:** Physical indicators such as unusual noises, visible damage (e.g., cracks, deformities), or non-responsive components directly suggest a compromise in the AMR's structural or functional integrity. Continued operation under such conditions could lead to further damage or safety hazards.

- **Battery leaks, swells, or shows signs of corrosion: T**hese are critical indicators of battery degradation and potential safety hazards. Electrolyte leakage, swelling, or corrosion can lead to thermal runaway, fire risk, and the release of hazardous substances, necessitating immediate cessation of use and careful handling.

8.Specifications

Mechanical specifications

Specification	Description
Dimensions	963mm × 690mm × 333 mm
Weight	The weight of the AMR without any load is 25 kg, and the maximum payload is 5 kg.
Chassis	Steel, 10mm thickness
Motor Specifications	The24HS40-5004D-E1000 is used as a 4.0Nm closed-loop stepper motor with rated current of 5.0A,Body length of 125mm,shaft length of 21mm,lead length of 300mm and D-Cut Shaft length of 15mm.
Speed	Maximum travel speed is 0.6 m/s and acceleration/deceleration is 0.6m/s^2.
Ground Clearance	1cm

Electrical Specifications

Specification	Description
Power Supply	Operating voltage is 22.2V, powered by a 6S1P Li-ion battery made from Samsung 21700 50S cells. The nominal voltage per cell is 3.7V.
Battery Capacity	The battery has a capacity of 5000mAh (5Ah), which is 111Wh (22.2V × 5Ah). Estimated run time depends on system power draw, typically ranging from 1 to 2 hours for light-duty AMRs.
Charging	Charging is done manually using a compatible charger. The standard charge rate is 1C (5A).
Power Consumption	During mapping, the robot draws 6.5A of current and consuming 105W of power. Under normal operation, with 20% of the time spent accelerating or decelerating and the rest at constant speed, it draws 3.5A and consumes 49W.
Battery Life	The battery is expected to support around 300 to 500 charge/discharge cycles under standard usage conditions before significant degradation.
LiDAR Power Requirements	The LiDAR operates at 5V, draws 0.5A of current, and consumes 2.5W of power

Processor Power Requirements	The Jetson Nano runs on 5V, requires 2A of current, and uses 10W of power.
Power Distribution	The Power Distribution Board supports a rated current of 60A and a maximum current of 120A for under 60 seconds, with XT60 pre-soldered connectors for the power module and battery.
Drive System	The CL57T V4.1 is used as a digital closed - loop driver for hybrid stepper motors . It supports 24-48V DC input and upto 8A peak current.