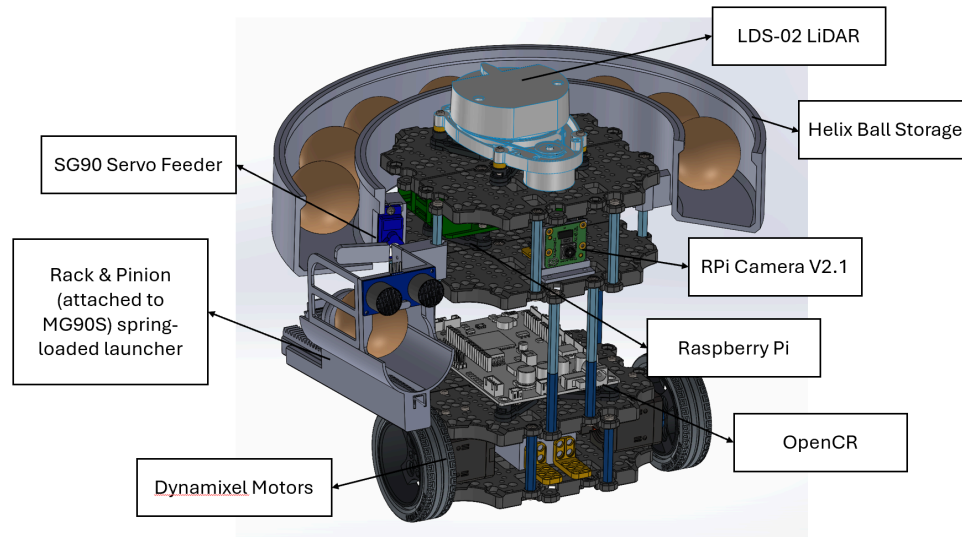


END-USER DOCUMENTATION

Autonomous Mobile Robot for Smart Warehouse Intralogistics

Section 1 - General System Description & Critical Data

A TurtleBot3 Burger-based AMR with a custom launcher payload. Its mission objective is to autonomously navigate an unknown warehouse environment, detect ArUco-marked stations, dock at delivery locations, and deliver ping-pong balls into static and dynamic receptacles within the mission time of 25 minutes. Bonus capability of multi-level delivery with elevator traversal via REST API.



<Turtlebot with Custom Payload CAD Model>

Parameter	Value
Model / Platform	TurtleBot3 Burger + Custom Payload (helix storage, launcher, camera, ultrasonic sensor)
Software Version	v1.0.0
Total Mass (g)	1364.1
Overall Dimensions (L x W x H)	214 mm x 280 mm x 192 mm
Centre of Gravity — X (forward +)	63.45mm (Origin: rear-left corner of Lower Base Plate at ground level)
Centre of Gravity — Y (up)	92.9mm (Origin: rear-left corner of Lower Base Plate at ground level)
Centre of Gravity — Z (right +, into robot)	95.28mm (Origin: rear-left corner of Lower Base Plate at ground level)
Battery	Li-Po 11.1 V, 1800 mAh (weight)
Compute	Raspberry Pi 4 + OpenCR 1.0
Sensors	LDS-02 LiDAR, RPi Camera Module V2.1, Ultrasonic Sensor (HC-SR04)
Drive	2 x Dynamixel XL430-W250
Launcher	Spring-loaded rack & pinion launcher with 1x SG90 and 1x MG90S 360 degree continuous servo motor
Ball Storage Capacity	9 ping pong balls (curved gravity-feed helix storage)
Mission Window	~25 minutes
Purpose	Autonomous warehouse intralogistics: explore unknown space, detect ArUco markers, perform docking, and deliver payloads to static and dynamic stations

Section 2 - Technical Guide

Subsystems:

Navigation (Dynamixel XL430 drive motors + SLAM), Sensors (LDS-02 LiDAR, RPi Camera for ArUco detection, Ultrasonic Sensor for Dynamic Delivery Receptacle detection), Computation (Raspberry Pi for ROS2 & Vision + OpenCR for motor control/IMU), Launcher (helix storage, SG90 servo gate, rack & pinion spring mechanism powered by MG90S servo).

Pre-Mission Start Procedure

	Steps
1	Load ping pong balls into storage and push the rack all the way forward. Ensure the launcher mechanism is properly loaded and no jams are present.
2	Ensure all connections are secure.
3	Power on the robot via the OpenCR switch.
4	Establish a remote connection by SSHing into the TurtleBot.
5	On a Remote PC – execute the main launch command to launch the TurtleBot.

Mission Flow (6 phases):

Step	Phase	Description
1	System Initialization	Initialise LiDAR, camera, and control nodes. Begin SLAM mapping of the environment.
2	Explore & Map	Frontier-based exploration to map unknown regions while avoiding obstacles.
3	Target Search	Navigate explored space while scanning for ArUco markers representing delivery stations.
4	Docking Approach	Navigate toward the detected marker and align using camera pose estimation.
5	Station A (Static Delivery)	Dock at a static receptacle. Dispense exactly 3 balls in sequence using the launcher.
6	Station B (Dynamic Delivery)	Track moving receptacle using ArUco + ultrasonic sensor. Dispense balls when the target is within the threshold.
7	Level 2 Access (Elevator)	Robot identifies the elevator lobby, digitally calls the lift via REST API, and travels up the lift onto the second floor safely to continue the mission

Key Specification:

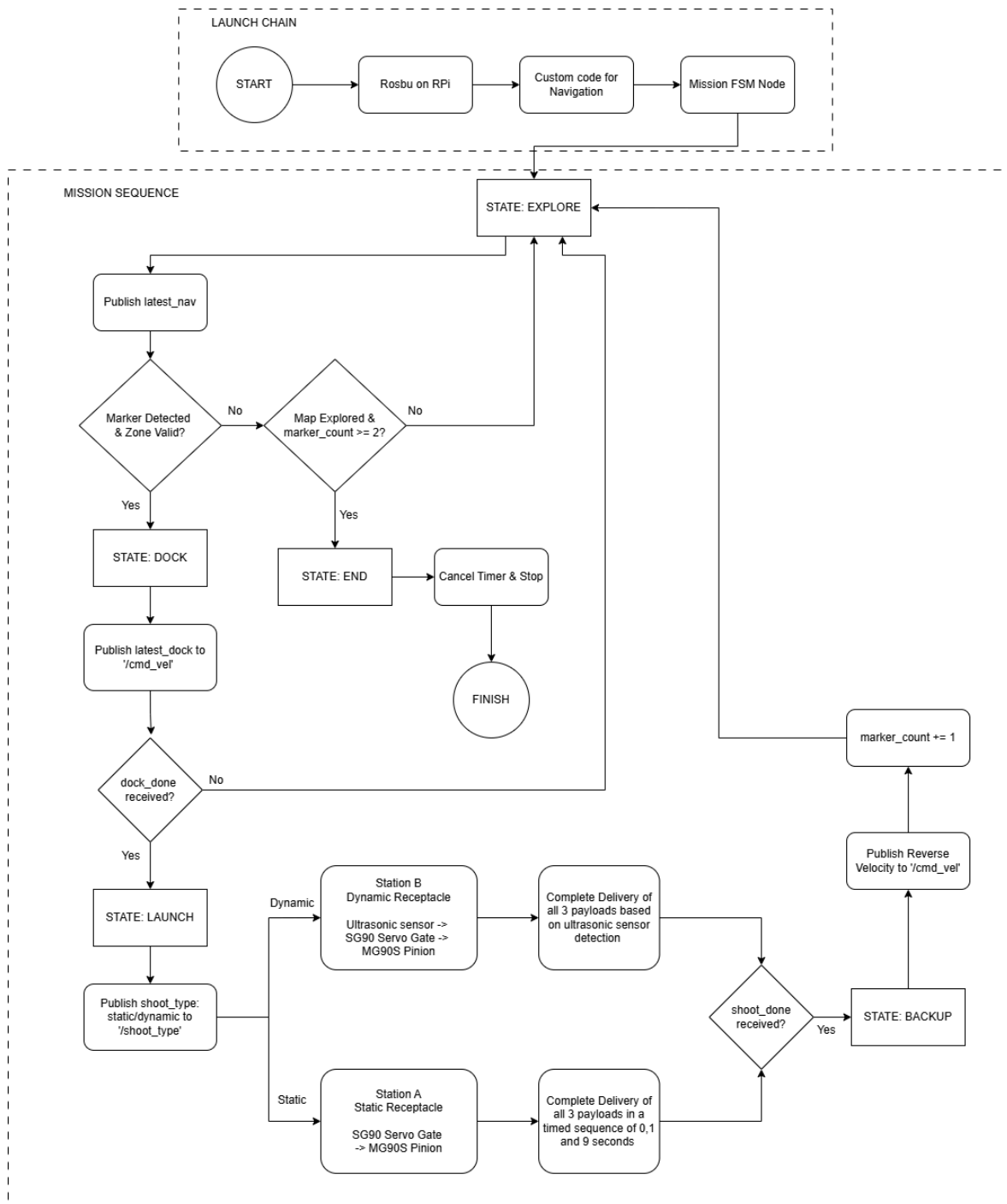
High-Precision Mapping: The robot maps the environment reliably for navigation and obstacle avoidance.

Marker-Based Detection: The vision system detects ArUco markers for accurate docking.

Autonomous Operation: Fully autonomous system controlled by a finite state machine (FSM).

Reliable Delivery: Launcher mechanism delivers ping-pong balls consistently without jams.

Section 3 - System Architecture



The system is structured around a mission-level Finite State Machine (FSM) that coordinates exploration, marker detection, docking, and payload delivery.

Section 4 - Acceptable Defect Log

Items below are known imperfections that have been judged acceptable for mission operation.

ID	Description	Mission Impact	Operator Note
1	Minor cracks in 3D printed parts	None	Ensure functionality is not affected

Section 5 - Factory Acceptance Test (FAT)

Pre-mission checklist of factory checks.

#	Check Item	Test Done
1	Battery 11.1V / 1800 mAh charged & load verified	<input checked="" type="checkbox"/>
2	All frame layers & payload secured	<input checked="" type="checkbox"/>
3	LiDAR 360° FOV unobstructed	<input checked="" type="checkbox"/>
4	Both drive motors respond to test commands	<input checked="" type="checkbox"/>
5	The launcher mechanism operates without jamming	<input checked="" type="checkbox"/>
6	The storage system is loaded and feeding correctly	<input checked="" type="checkbox"/>
7	Camera operational; ArUco detection active	<input checked="" type="checkbox"/>
8	SLAM launches & maps on startup	<input checked="" type="checkbox"/>
9	The exploration algorithm generates valid paths	<input checked="" type="checkbox"/>
10	Docking accuracy within acceptable tolerance	<input checked="" type="checkbox"/>
11	Static delivery sequence successful (3 balls)	<input checked="" type="checkbox"/>
12	Dynamic delivery timing successful	<input checked="" type="checkbox"/>
13	FSM transitions correctly through all states	<input checked="" type="checkbox"/>
14	Electrical connections secure and stable	<input checked="" type="checkbox"/>
15	No overheating or abnormal system behaviour	<input checked="" type="checkbox"/>
16	Document pack ready	<input checked="" type="checkbox"/>

Section 6 - Maintenance & Part Replacement Log

Running record of maintenance operations and replacements of critical components.

Date	Component	Action / Reason	By
NIL	NIL	NIL	NIL