ANYMAL (GEN. D) //

Master Operator Training

Use ANYmal Safely and Efficiently

Zürich, 2022

Corresponding to Operator's Manual version 1.4, published 28.04.2022

All information is subject to change without notice.

ANYbotics

Introduction

- Who is Who?
- Schedule
- Support Systems
- Operator's Manual
- Product Description
- System Overview
- Hardware Interfaces

Who is Who?

Franklin Wu

Yoann Lapijover

Schedule

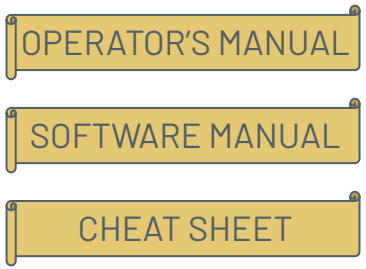
Proposed time: 4 sessions of 4 hours, including breaks.

Session 1	Session 2	Session 3	Session 4
Introduction	Environment Setup	Define Points Of Interest	Autonomous Charging
Safety Instructions	Record A Map	Plan A Mission	Inspection
Basic Operation	Draw The Waypoints	Autonomous Operation	Teleoperation
Operator Graphical User Interface			Service and Maintenance
Advanced Operation			

Support Systems

- Datasheet → Received with your ANYmal
  - Robot Name
  - Part and Serial Number
  - Hardware Configuration
  - Network Configuration Including IP, User Accounts and Passwords
  - Software Repository - PPA
- User material
  - Operator's Manual
  - Software Manual (deprecated)
  - Training Slides (this document)
  - Cheat Sheet
- Support request system
  - Product Support
  - General Enquiries
  - Feature Requests

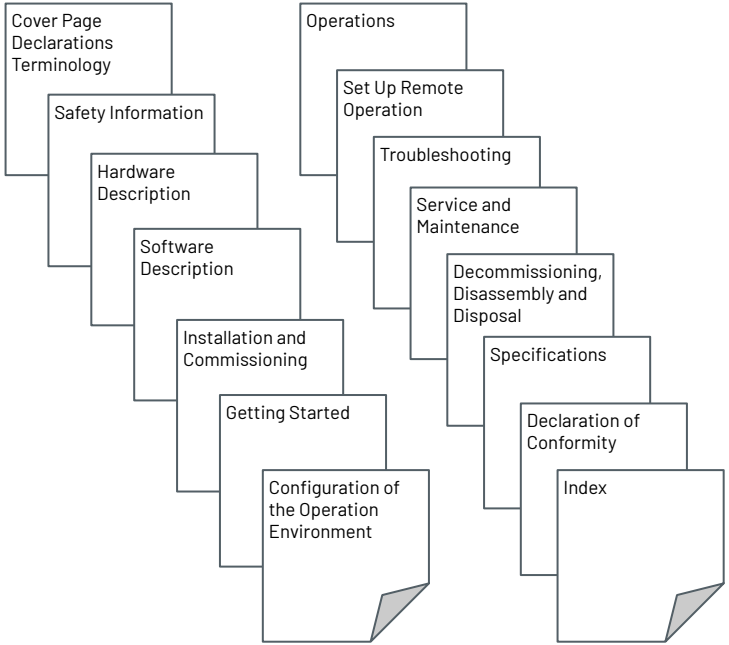
support.anybotics.com
(registration with company email needed)



Operator's Manual

OPERATOR'S MANUAL

IMPORTANT: carefully read and understand the safety instructions in the Operator's Manual before operating ANYmal.



Product Description

OPERATOR'S MANUAL Section 12

ANYmal Robot

Product Information

Found on robot label:

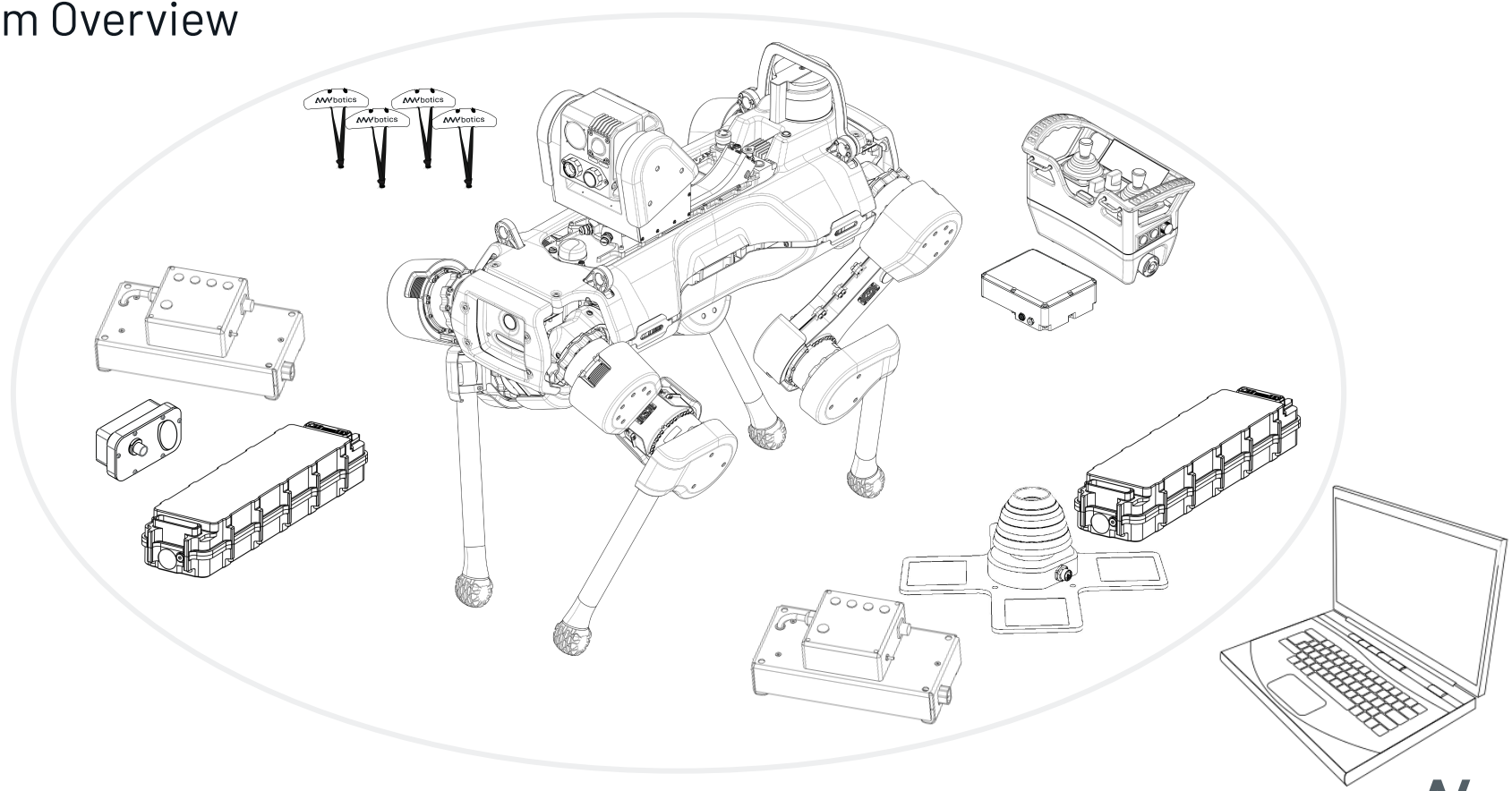
- Part Number
- Serial Number
- Name
- ...

Technical Specifications

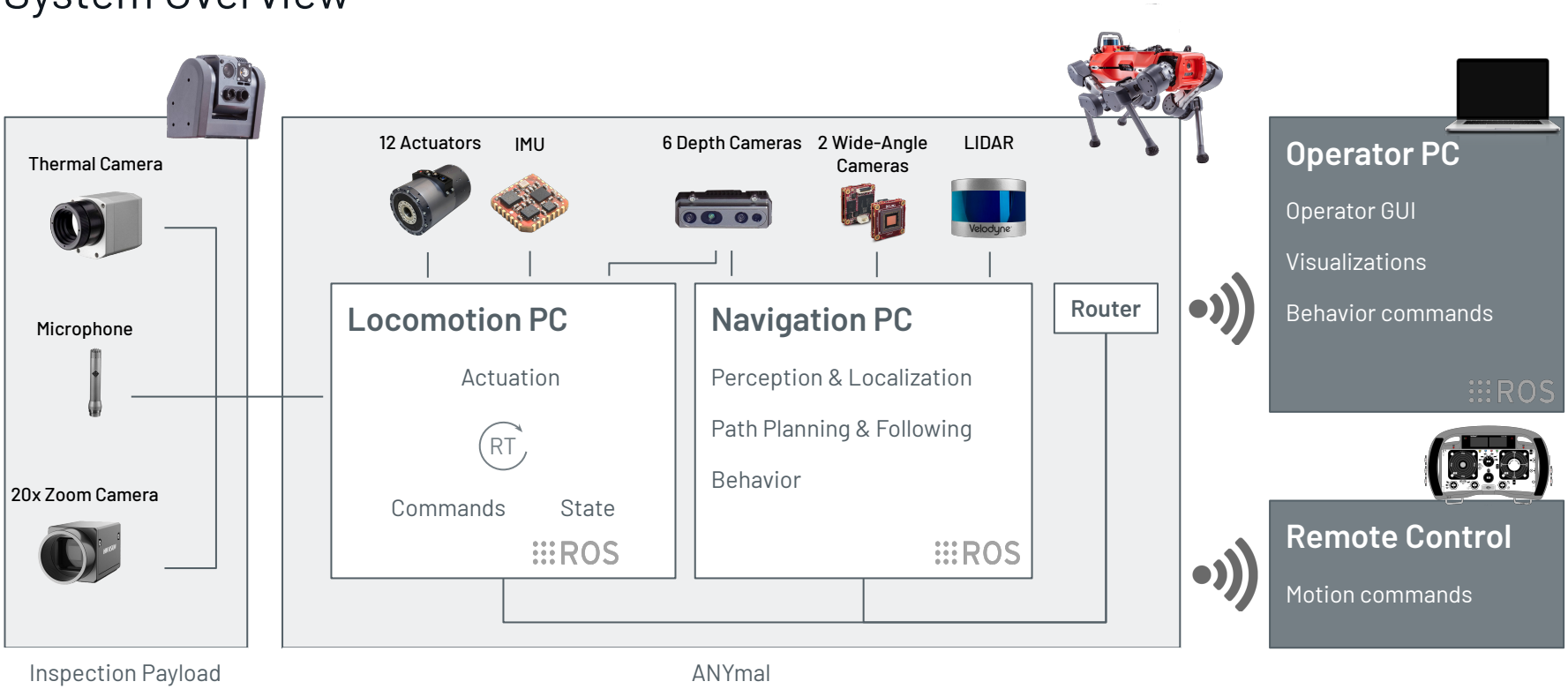
Found in Operator's Manual:

- Robot specifications
- Computers specifications
- Accessories specifications
- ...

System Overview

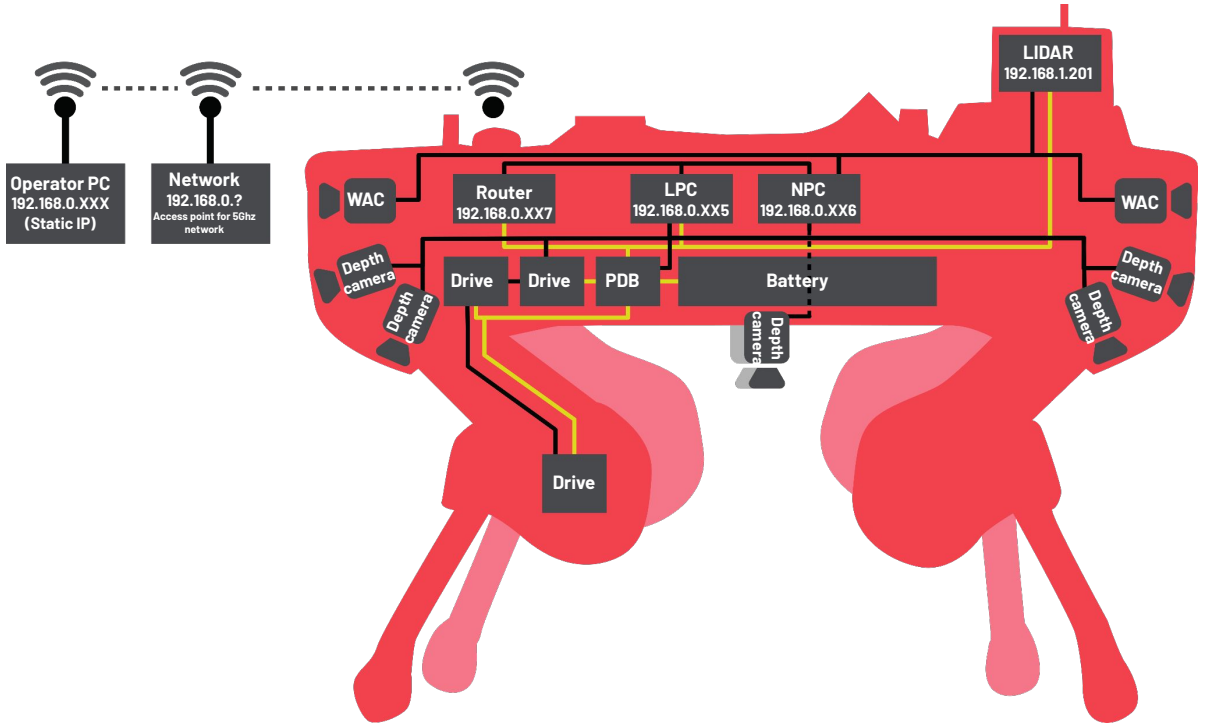


System Overview



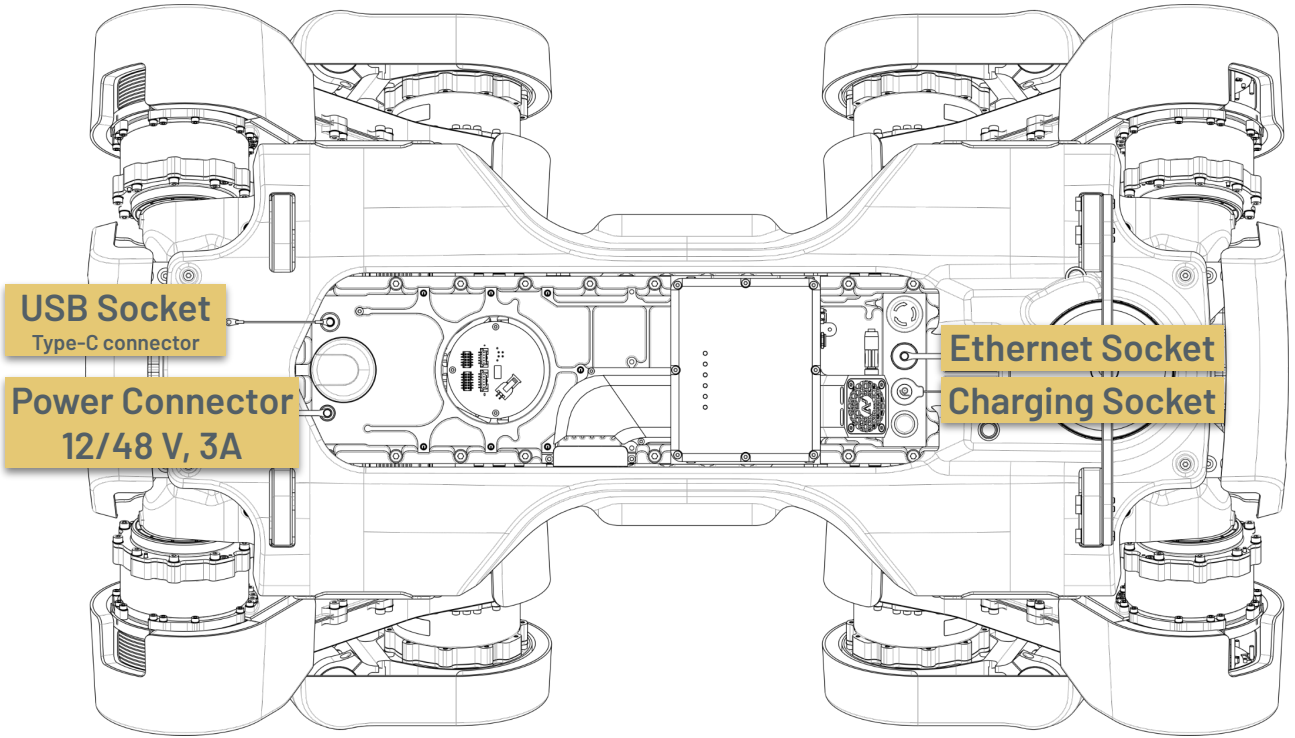
System Overview

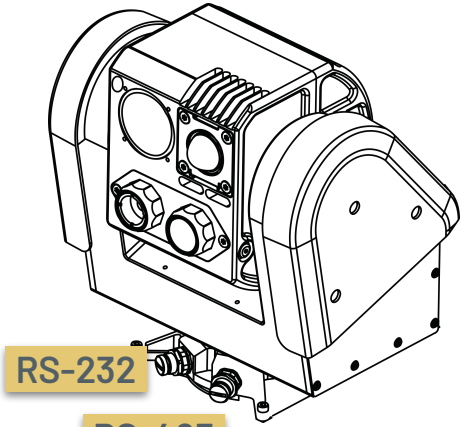
OPERATOR'S MANUAL Section 2.3.8



Hardware Interfaces

OPERATOR'S MANUAL Section 2.3.2





Safety Instructions

- Terminology
- Intended Use
- Main Risks and Mitigation Measures
- Safety Functions
- Checking the Safety Functions
- Robot Behaviors
- Organizational Measures
- Lifting the Robot

Terminology

OPERATOR'S MANUAL Section 1.1

USER

Entity that:

- uses the Robot for the intended use,
- is responsible for the personnel associated with the Robot operation,
- is subject to the legal responsibility for occupational safety,
- bears legal responsibility for the Robot during operation for the protection of the Master Operators, Operators, Bystanders or any third party.

MASTER OPERATOR

Person that:

- must have been trained by ANYbotics in installing, commissioning, operating, maintaining, cleaning and troubleshooting ANYmal and instructing Operators and Bystanders,
- is enabled to carry out Robot operation, as well as certain maintenance and repair work in a professional and safe manner.

OPERATOR

Person that:

- must have undergone specialist training by Master Operators or ANYbotics,
- is enabled to carry out Robot operation, as well as certain maintenance and repair work in a professional and safe manner.

BYSTANDER

Person that:

- must have been instructed by Master Operators or Operators to safely share the workspace with the Robot.

Intended Use

ANYmal is to be used to perform autonomous, supervised or remote controlled inspection tasks in industrial environments by trained Master Operators and Operators.

Intended use includes compliance with all of the information in the Operator's Manual.

Any use that deviates from, or goes beyond the intended use, is considered misuse and can result in hazardous situations.

Carefully read and understand the Intended Use section of the Operator's Manual before operating ANYmal.

Main Risks and Mitigation Measures

ANYmal has been designed to be as safe as possible, but **some risks remain** and need to be considered when using the Robot.

Main Risks

Stairs: risk of falling onto a person or causing a person to fall down.

Elevated platforms: risk of falling onto a person or causing a person to fall down.

Unexpected movement: risk of kicking a person or crushing a body part.

Lithium-ion battery: risk of causing a fire.

Mitigation Measures

Technical measures

- Safety functions
- Robot behaviors

Organizational measures

Safety Functions

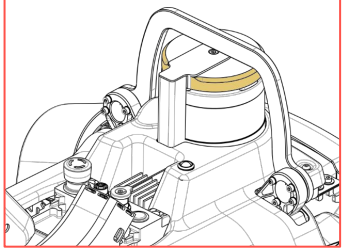
OPERATOR'S MANUAL Section 1.5

IMPORTANT: carefully read and understand the safety instructions in the Operator's Manual before operating ANYmal.

Danger zone active warning light

Located on top of the LIDAR sensor.

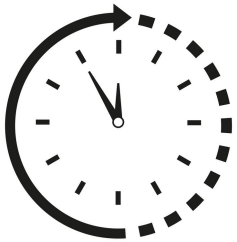
When the warning light is on, you must stay at least 2m away from the robot.



Delayed start with warnings

Enabling the actuators turns the danger zone active indicator on.

Everyone must leave the danger zone within 9 seconds or someone must press an emergency stop.



Operator GUI emergency stop

Located at the bottom of the Operator GUI.

Cuts power to the actuators. Actuators shut down, robot collapses.

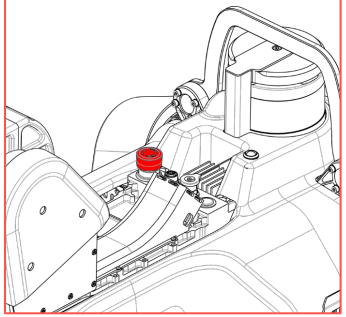
Only if connected to robot network.

Robot emergency stop

Located on top of the robot.

Cuts all power. Computers shut down, actuators shut down, robot collapses.

Use only as last resort.

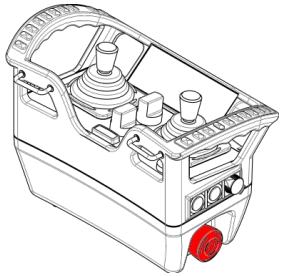


Remote control emergency stop

Located on the side of the remote control.

Cuts power to the actuators. Actuators shut down, robot collapses.

Only if transceiver mounted.



Emergency Stops Recap

3 LEVELS

Protective Stop

- Stops running controller.
- Robot freezes or collapses gracefully.

On remote control:

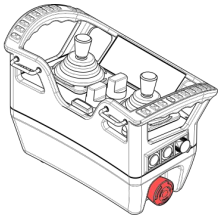
In Operator GUI:

Use to freeze momentarily.

Remote Control and Operator GUI Emergency Stops

- Disconnects power to all the drives.
- Robot collapses.
- Disengage to power on the drives.

On remote control:



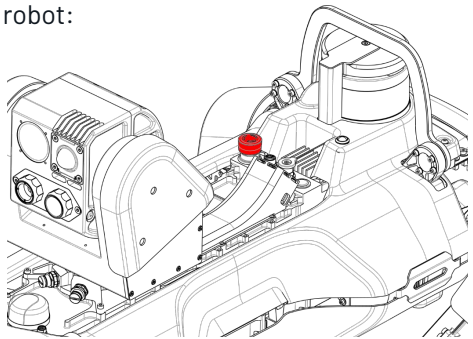
In Operator GUI:

Use to cut powers to the drives.

Robot Emergency Stop

- Disconnects all power sources.
- Powers off all the drives and computers.
- Robot collapses.
- Disengage to power on the robot.

On robot:



Use as last resort in case of imminent danger.

Checking the Safety Functions

OPERATOR'S MANUAL Section 10.2.1

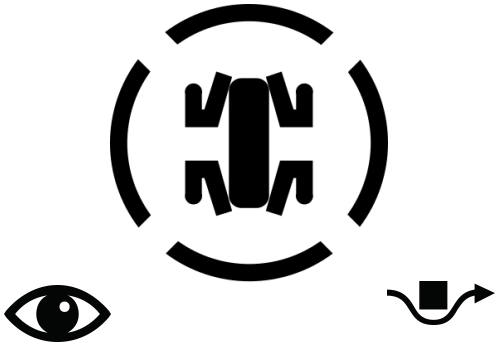
The safety functions need to be tested after maintenance tasks, after a fall, or once a year. Detailed instructions can be found in the Operator's Manual.

IMPORTANT: If a test is not successful, stop using the robot immediately and contact customer support.

Robot Behaviors

Collision Avoidance

Mechanism that helps the robot detect and avoid collisions with some obstacles in its way while operating manually.

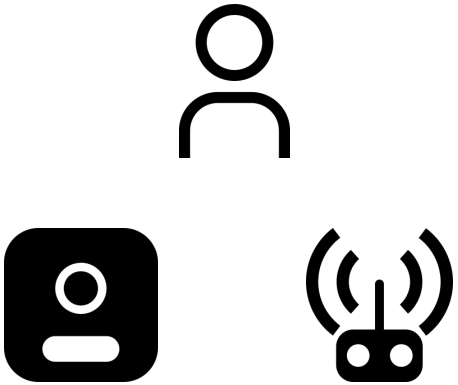


Battery Monitoring

Mechanism that warns the Operator and sends the Robot to rest at low battery to avoid collapsing.

Control Lease

Mechanism that ensures that the robot can only be controlled from one source.



Organizational Measures

Operator's Manual

Read the Operator's Manual and apply its instructions and best practices.

Risk Assessment

Perform a risk assessment for the specific environment and planned use of ANYmal.

PPE

Wear personal protective equipment.

Safety Distance

Keep a 2m distance to the robot when the actuators are powered (as indicated by the warning light).

Handling the Robot

Do not handle the robot when the drives are powered.

Elevated Platforms

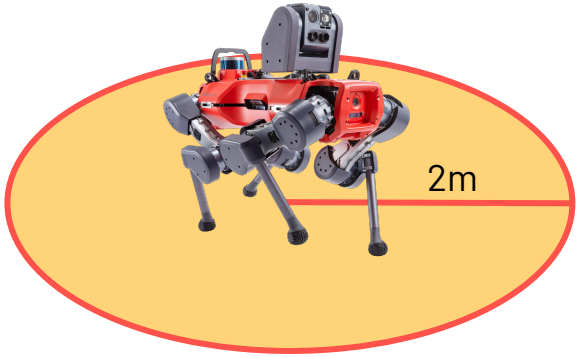
Ensure all elevated platforms used by the robot are equipped with guard rails.

Stairs

Do not use the robot on stairs when people are present.

Lifting the Robot

The robot must be lifted by 2 people at least, or using a crane.



Lifting the Robot

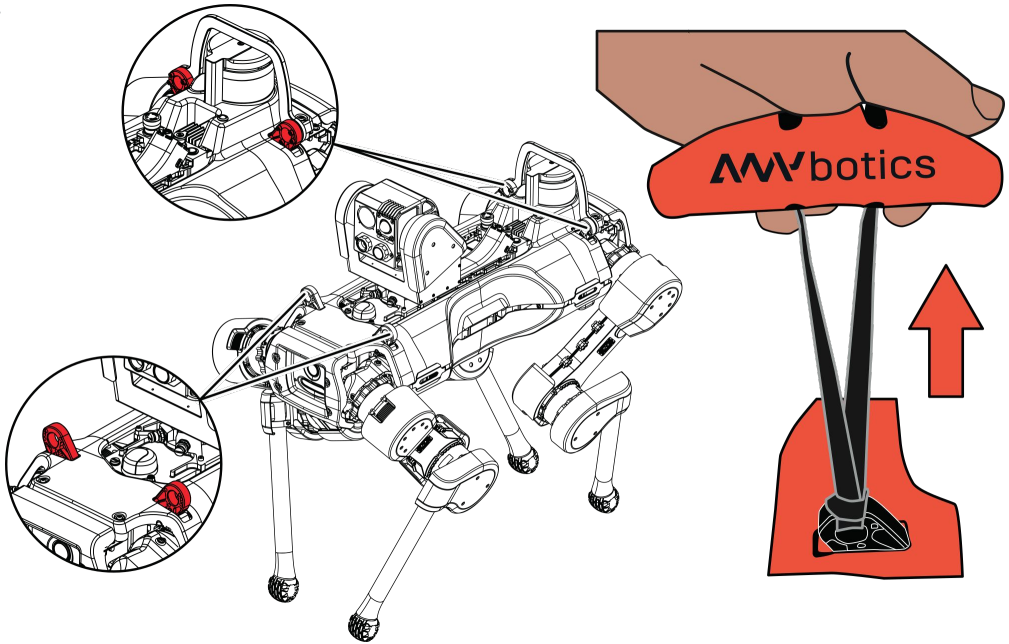
OPERATOR'S MANUAL Section 1.14

Only approach the robot once the danger zone active warning light is off.

Always use the 4 dedicated handles to lift the robot.

Attach the handles to the 4 hoist points.

Use at least 2 people to lift the robot.



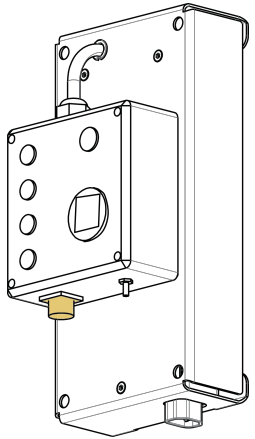
Basic Operation

- Battery Charging
- Battery Insertion
- Emergency Stops
- Starting the System
- Remote Control
- Basic Motions in Manual Operation
- Shutting Down the System

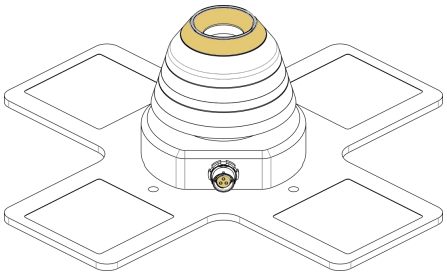
Battery Charging

OPERATOR'S MANUAL Section 8.1

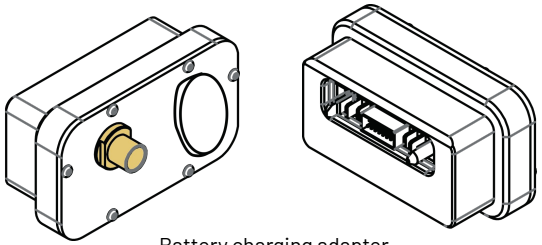
1. Connect the robot battery charger to a power supply and attach the charging cable.
2. Connect the charging cable to
   - The battery charging adapter - if the battery is outside of the robot.
   - The robot top connector - if the battery is inserted in the robot and the actuators are not powered.
   - The docking station - if the battery is inserted in the robot and the actuators are powered.
3. Connect the remote control battery charger to a power supply and insert the remote control battery.



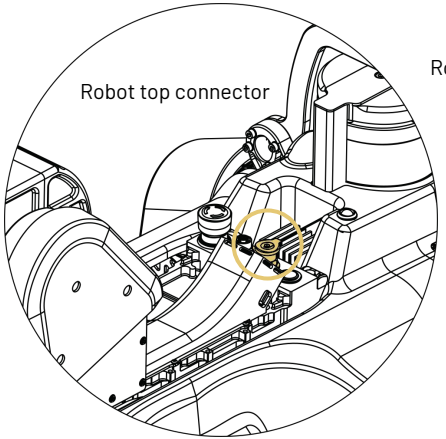
Robot battery charger



Docking station



Battery charging adapter



Battery Charging

OPERATOR'S MANUAL Section 2.3.18

LED INDICATORS

- Full: The battery is full or almost full.
- Charging: Current is flowing from the charger to the battery.
- Connected: The battery is detected. *Force Charging* can overrule this.
- Power: The charger is connected to a power source and switched on.

INSTALLATION

1. Select a dry, indoor environment with an ambient temperature between 0°C and 35°C, at least 2m away from any flammable object.
2. Mount vertically to a wall using the hole pattern.

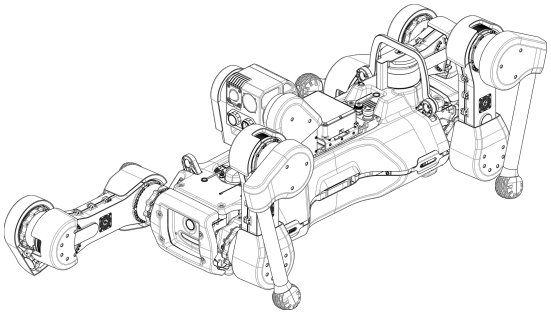
NOTE: The charger voltage display might indicate a different value than the battery charging adapter display.

Battery Insertion

OPERATOR'S MANUAL Section 8.1.2

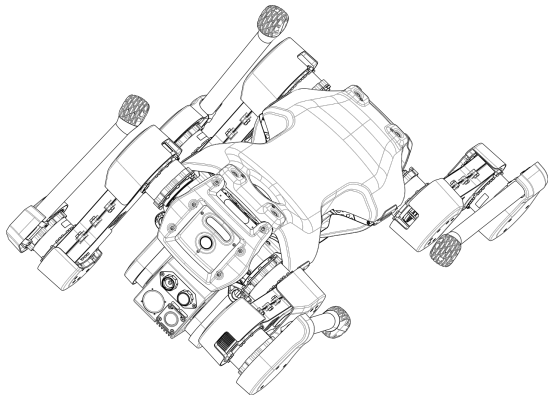
Position the legs

- Knees folded
- One side pointing upwards
- One side pointing outwards



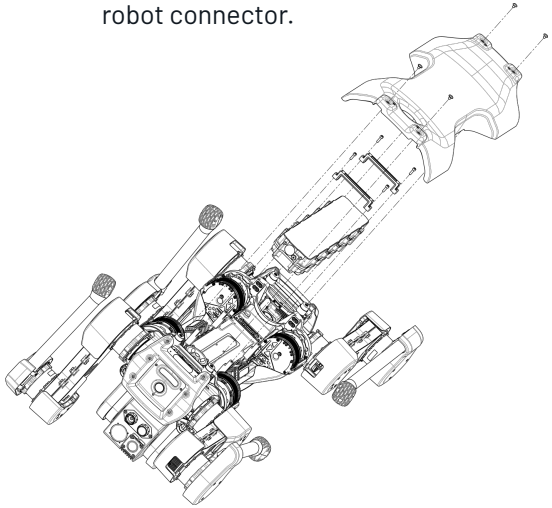
Flip the robot over

- Pull the knees all the way over until they touch the ground.



Unscrew the shell and clamps

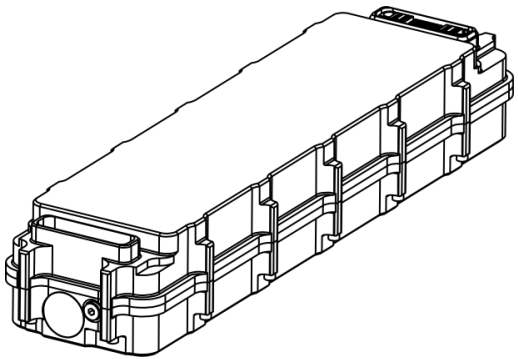
- Use hex screwdriver size 4 with a max torque of 0.5Nm.
- Align the battery connector with the robot connector.



Battery

OPERATOR'S MANUAL Section 2.3.17

- Enables ~1.5 h of mission time.
- Storage instructions must be followed.
- When swapping:
  - Shut down the robot.
  - Press the robot emergency stop button.
  - Disconnect the robot charging cable.

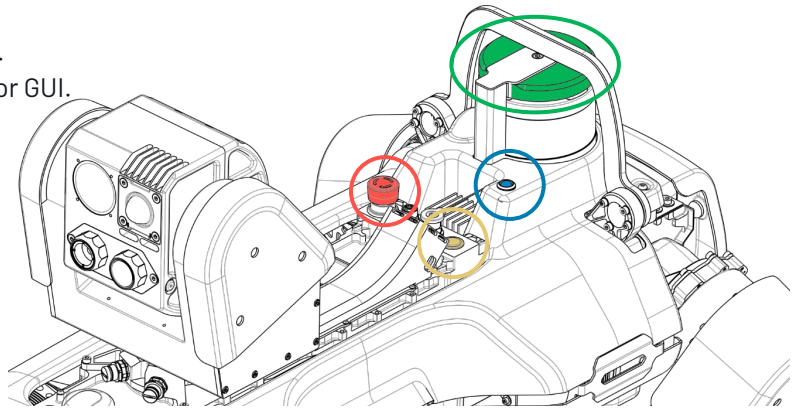


Specifications	
Mass	5.6 kg
Dimensions	466 x 136 x 78.1 mm
Voltage Range	31.2 V to 50.4 V
Capacity	932.4 Wh
Full charge	3h
Quick charge (70%)	2h
Ingress Protection	IP67, when connected to the robot

Starting the System

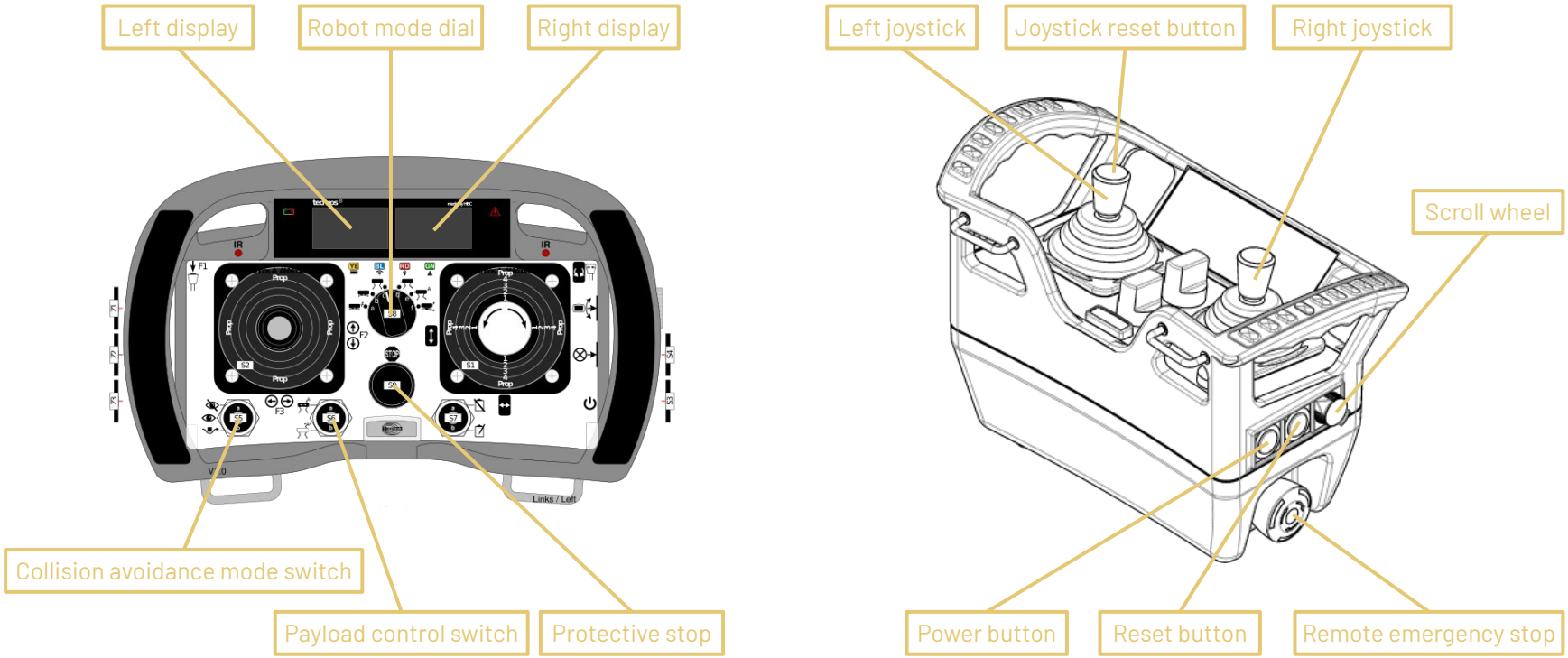
OPERATOR'S MANUAL Section 4.5

1. Make sure the feet of the robot are below its hips and that the robot emergency stop is released.
2. Press and hold the robot power button. The status light starts blinking blue.
3. Release the robot power button when the status light turns off.
4. Power on the remote control.
   a. Release the remote control emergency stop.
   b. Press short then press long on the start button, then release.
5. Power on the actuators using one of these options:
   a. Turn the remote control robot mode dial to Rest, Stand or Walk.
   b. Enable the actuators through the `Power` panel of the remote control.
   c. Enable the actuators through the `Power System` panel of the Operator GUI.
6. The danger zone active warning indicator turns on.



Remote Control

OPERATOR'S MANUAL Section 2.3.20



Remote Control Robot Mode Dial

OPERATOR'S MANUAL Section 8.3.9

Used to switch between the different robot control modes and gain or release control of the robot.

Stand on all legs.
Use to move the torso without moving the legs.

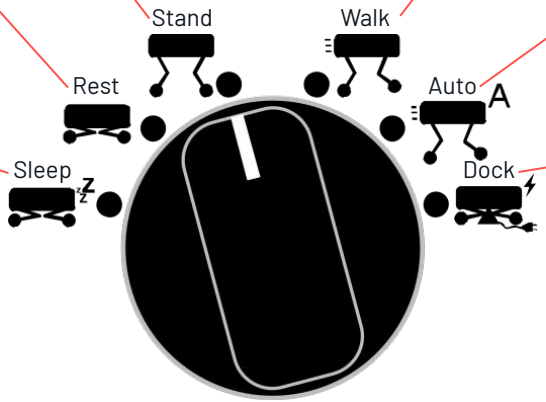
Stand on all legs, ready to walk.
Use to steer the robot around.

Lie down with actuators powered.

Switch the user interaction mode to Auto.
Use before launching a task or mission.

Lie down and shut down the actuators.

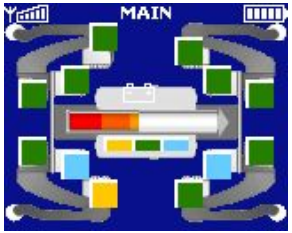
Navigate to the docking station (if localized), detect it and dock.
Use to recharge the battery autonomously.



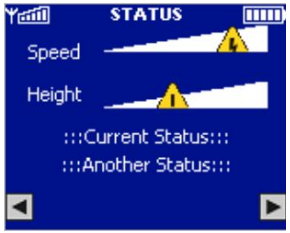
Remote Control Displays

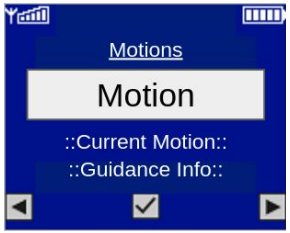
OPERATOR'S MANUAL Section 8.3.7

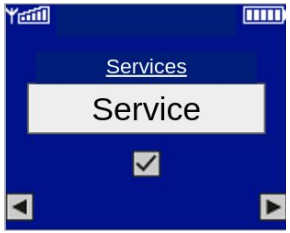
Left display: Shows information about the state of the robot and its systems.

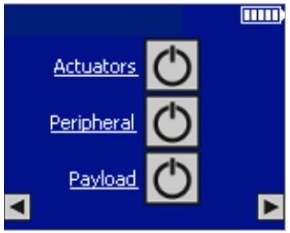


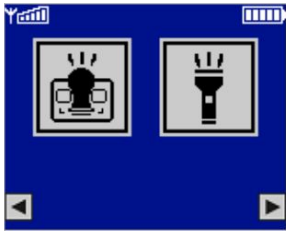
Right display: Shows six panels that can be accessed using the scroll wheel button. The panels display information and provide additional control options.











Remote Control Buttons and Switches

OPERATOR'S MANUAL Section 8.3

Scroll wheel: Used to access and select the different menus and options on the right display. Turn to navigate and press to select the highlighted option.

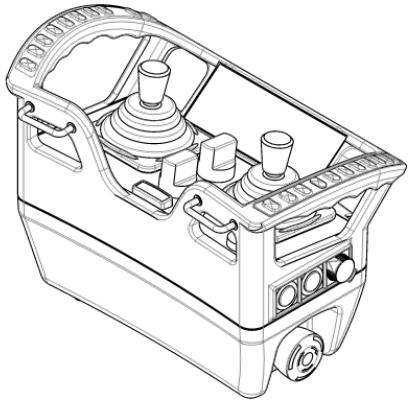
Reset button: Used to cancel a selection on the right display.

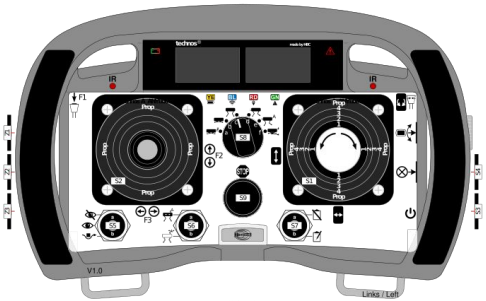
Power button: Used to turn on the remote control and clear warnings.

Collision avoidance mode switch: Used to select the robot reaction to obstacles. Use the top position to walk blindly into obstacles, the middle or bottom positions to stop in front of obstacles.

Inspection payload control switch: Used to select the left joystick behavior. Use the top position to control the robot body and the bottom position to control the pan-tilt unit.

Protective stop button: Used to trigger a protective stop.





Remote Control Warnings

Shock-Off

Triggered if the remote control registers a hard impact.

Zero-G

Triggered if the remote control is falling down or being thrown (triggered by measured accelerations).

Inclination

Triggered if the transmitter exceeds a certain angle of inclination for a specified time and/or is positioned upside down.

CONSEQUENCE: the remote control beeps and the displays show information about the warning.

SOLUTION: dismiss these warnings using the power button (press, then press and hold, like the start sequence).

Basic Motions in Manual Operation

How to Stand Up

1. Make sure the robot is on a relatively flat and smooth surface.
2. Turn the robot mode dial to Stand or Walk.

How to Walk

1. Turn the robot mode dial to Walk.
2. Use the right joystick to move forwards, backwards, sideways and to rotate.

How to Control the Torso

1. Turn the robot mode dial to Stand.
2. Use the right joystick to control the roll, pitch and yaw of the torso.
3. Switch the inspection payload control switch to robot body control (up).
4. Use the left joystick to move the torso up and down.

How to Control the Inspection Payload

1. Switch the inspection payload control switch to pan-tilt control (down).
2. Use the left joystick to move the the payload right, left, up and down.
3. Use the left joystick button to reset the payload position.

Basic Motions in Manual Operation

How To Stop In Front Of Obstacles

1. Switch the collision avoidance mode switch to stop-and-go (middle).
2. Walk the robot around and watch it stop in front of obstacles. For safety reasons, do not try to walk into people or damageable objects!
3. Notice how the robot stops in front of steps or small obstacles too.

How To Ignore Obstacles

1. Switch the collision avoidance mode switch to blind (up).
2. Walk the robot around and watch it go over the steps or small obstacles that previously stopped it.

Shutting Down the System

OPERATOR'S MANUAL Section 4.7

1. Switch to the Sleep mode using the remote control or Operator GUI.
   a. The danger zone active warning indicator turns off.
2. Shut down the remote control by pressing the remote control emergency stop.
3. Shut down the robot by pressing and holding the power button.
4. Release when the status light starts slowly blinking red.

Operator Graphical User Interface

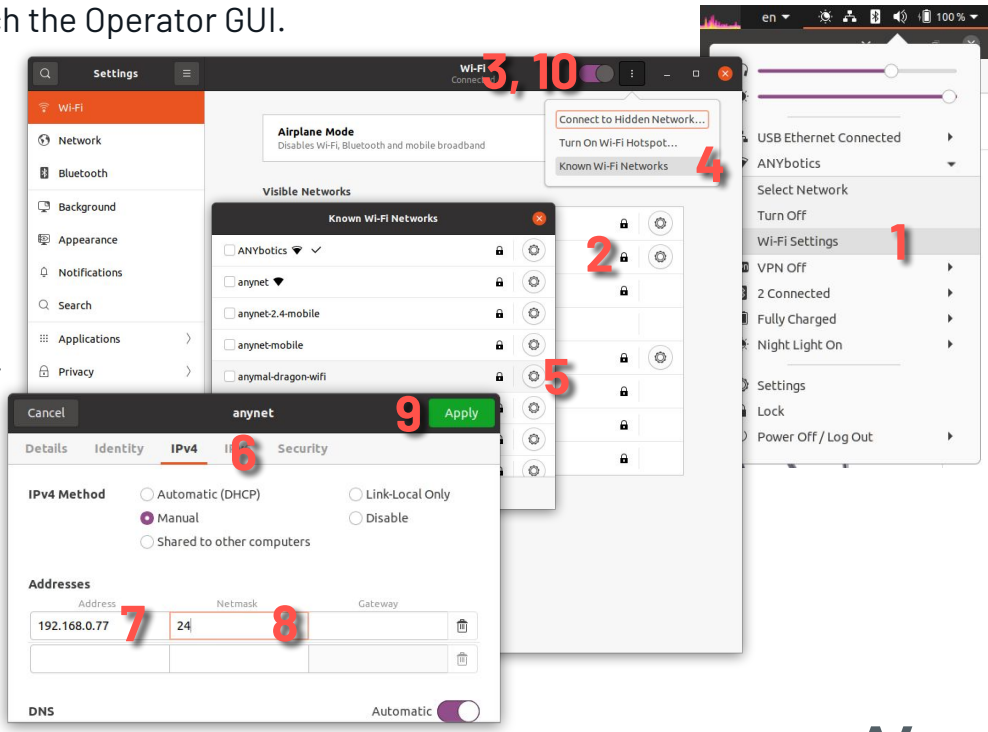
- ANYmal Network
- ANYmal Software Launcher
- General Overview
- User Interaction Popups
- Protective Stop and Emergency Stop
- Robot Control Panel
- Control Lease Panel

ANYmal Network

OPERATOR'S MANUAL Section 5.5

The OPC must be connected to the robot network to launch the Operator GUI.
This requires a static IP setup:

1. Open Wifi Settings on the operator computer.
2. Select the Robot network (<anymal-name>-wifi).
3. Turn the operator computer WiFi off.
4. Select the menu in the top right of the Wi-Fi Settings window and select "Known Wi-Fi Networks".
5. Select the gear icon next to the Robot WiFi network.
6. In the IPv4 tab, select the Manual toggle button.
7. Enter 192.168.0.xxx in the Address field. Replace xxx with a number between 1 and 255 that is different from the LPC, NPC and router IP addresses.
8. Enter 24 in the Netmask field.
9. Select Apply.
10. Turn the operator computer WiFi on.

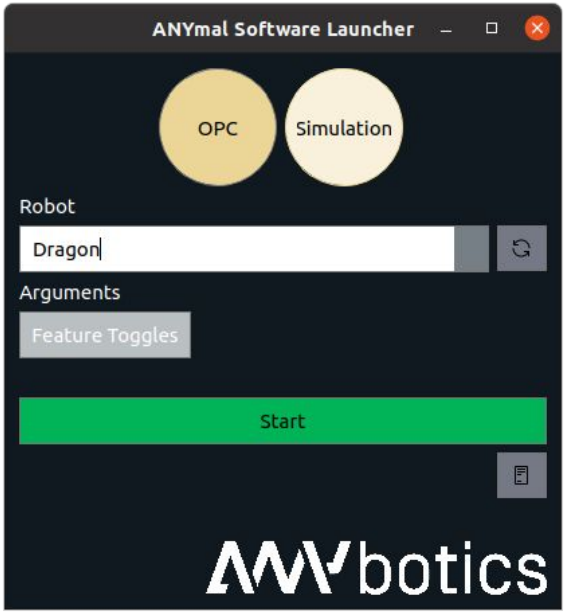


ANYmal Software Launcher - OPC

OPERATOR'S MANUAL Section 3.1

1. Connect the operator computer to the same network as ANYmal.
2. Launch the ANYmal Software Launcher application.
3. Select the OPC option.
4. Refresh the robot list and select one.
5. Click Start.
6. The terminal output can be visualized using the log button.

7. Use the Stop button to stop the software.

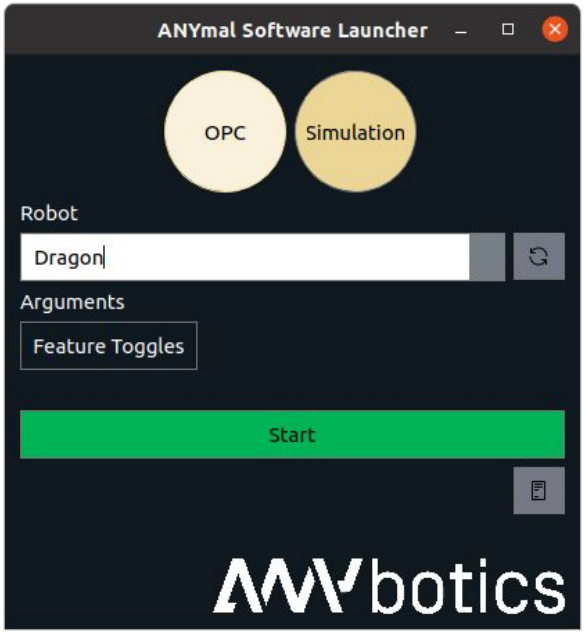


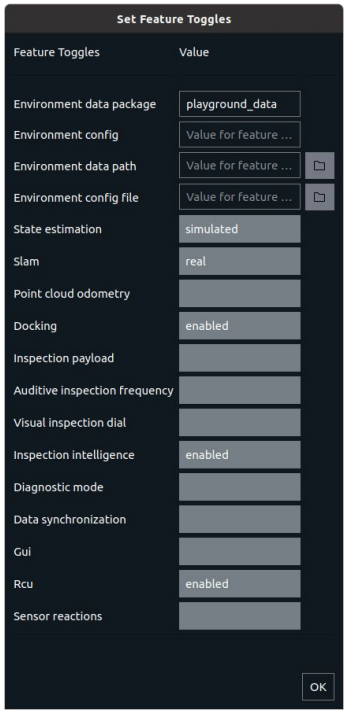
ANYmal Software Launcher - Simulation

OPERATOR'S MANUAL Section 3.1

1. Launch the ANYmal Software Launcher application.
2. Select the Simulation option.
3. Refresh the robot list and select one.
4. Open the Feature Toggles window.
5. Customize the simulation and click OK.
6. Click Start.
7. The terminal output can be visualized using the log button.

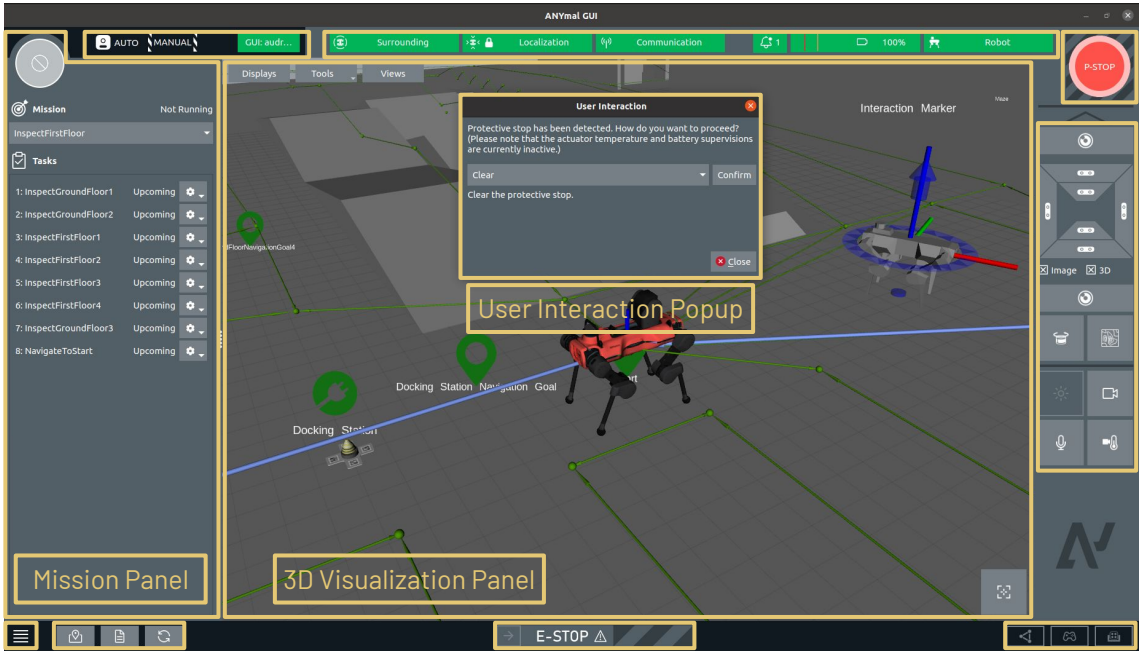
8. Use the Stop button to stop the software.





General Overview

OPERATOR'S MANUAL Section 3.2

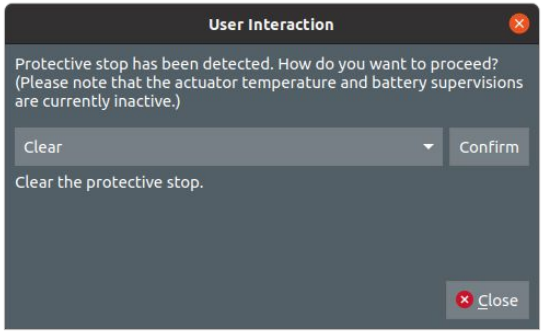


User Interaction Pop-ups

User interaction pop-ups appear when input from the operator is required.

This happens when the background supervision detects a threshold reached in the robot internal status:

- Actuator temperature too high (>65°C).
- Battery level too low (<20%).
- Protective stop engaged.



Protective Stop and Emergency Stop

OPERATOR'S MANUAL Section 3.2.5

The GUI protective and emergency stops are equivalent of the remote control protective and emergency stop.

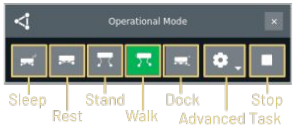
The protective stop stops the running controller. The robot freezes or collapses gracefully.

The emergency stop disconnects power to all the drives. The robot collapses.

Robot Control Panel

OPERATOR'S MANUAL Section 3.2.4

The robot control panel provides access to the operational mode panel, robot joypad and payload joypad.



OPERATIONAL MODE PANEL

- Use to switch between the available operational modes and launch advanced autonomous tasks.

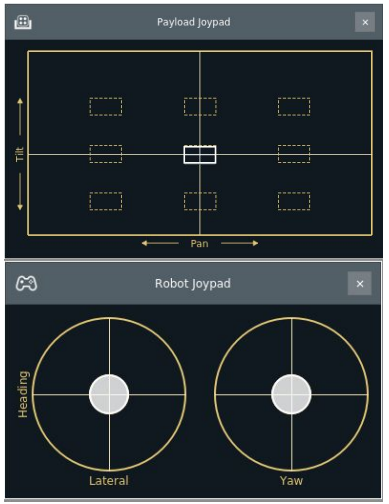
ROBOT JOYPAD

Left joypad:

- In walk mode, use to move the robot forwards, backwards and sideways.
- In stand mode, use to change the pitch and roll angles of the torso.

Right joypad:

- In walk mode, use to yaw the robot.
- In stand mode, use to change the yaw and height of the torso.



PAYLOAD JOYPAD

- Use to control the pan and tilt angles of the inspection payload.

Control Lease Panel

OPERATOR'S MANUAL Section 3.2.1

ANYmal can only receive commands from one source at a time. The control lease panel shows the current user interaction mode and GUI computer hostname.

The available modes are:

- None: ANYmal is ready to accept inputs from any source.
- Auto: ANYmal is operating autonomously.
  - Switching to *Auto* is only possible if the control has been explicitly released by the remote control. Some controls in the Operator GUI are unavailable in *Auto* mode.
- Manual: ANYmal is controlled manually from the Operator GUI or from the Remote Control.
  - Switching from *Auto* to *Manual* is possible at any point in time. Doing so will pause the ongoing autonomous behavior.

Advanced Operation

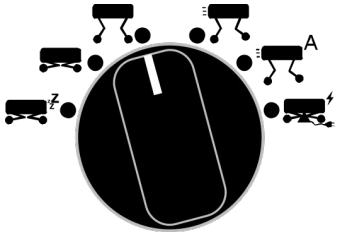
- Overview
- Motion States
- Motion Transitioner
- Fall Recovery

Overview

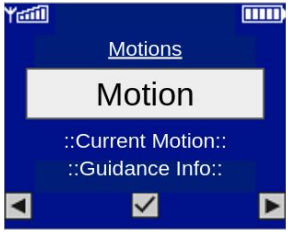
OPERATOR'S MANUAL Section 8.3.10

ANYmal's motions are controlled through motions states. Motion state commands can be sent using:

- the remote control robot mode dial,

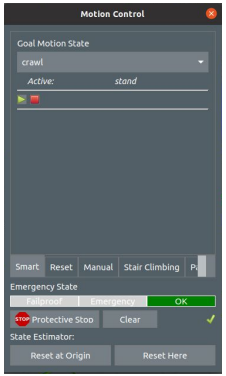


- the remote control *Motions* panel,



- the Operator GUI *Operational Mode* panel,

- the Operator GUI *Motion Control* panel.



Motion States

OPERATOR'S MANUAL Section 8.5.1.1

Rest

Lie down on the ground and lift the feet.

Do not push the Robot. It cannot step to recover balance.

Use only on smooth surfaces (±5 cm roughness), with up to 30° inclination.

Stand

Stand idle.

Do not push the Robot. It cannot step to recover balance.

Use only on smooth surfaces (±5 cm roughness).

Square Up

Move the legs into a stable symmetric configuration.

Do not push the Robot. It cannot step to recover balance.

Use only on smooth surfaces (±5 cm roughness), with up to 30° inclination.

Torso Control

Stand in place and allow the operator to control the torso using twist commands.

Do not push the Robot. It cannot step to recover balance.

Walk

Walk with a trotting gait without using sensor inputs.

Blind controller.

Intended for slightly rough terrain.

Do not use on stairs.

Motion States

OPERATOR'S MANUAL Section 8.5.1.1

Crawl

Walk with a trotting gait with the body close to the ground. This enables crawling under suspended objects.

Intended for use over slightly rough terrain ±5 cm.

Perceptive Walk

Walk with a trotting gait, using sensor input to react to small obstacles and uneven terrains.

Use over obstacles <=25cm high and stairs with <=20cm rise and 30° inclination.

Not suitable for negative obstacles. Use with care in bright or dark environments.

Stair Climbing

Climb up and down stairs.

Always climb up forwards and down backwards.

The Robot cannot turn or avoid obstacles on stairs.

Stairs must have <=45° inclination, >=21cm run and >=80cm width.

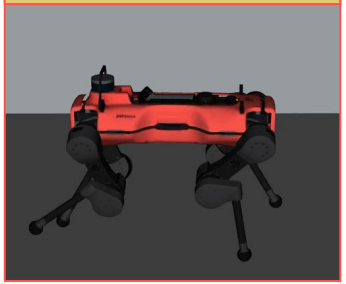
Run

Walk faster. Use only on clear flat terrain.

In development. Use with caution.

Do not use on rough terrain.

Cannot be used with navigation.



Walk to Pose

Walk to a commanded pose using a trotting gait. Used for docking.

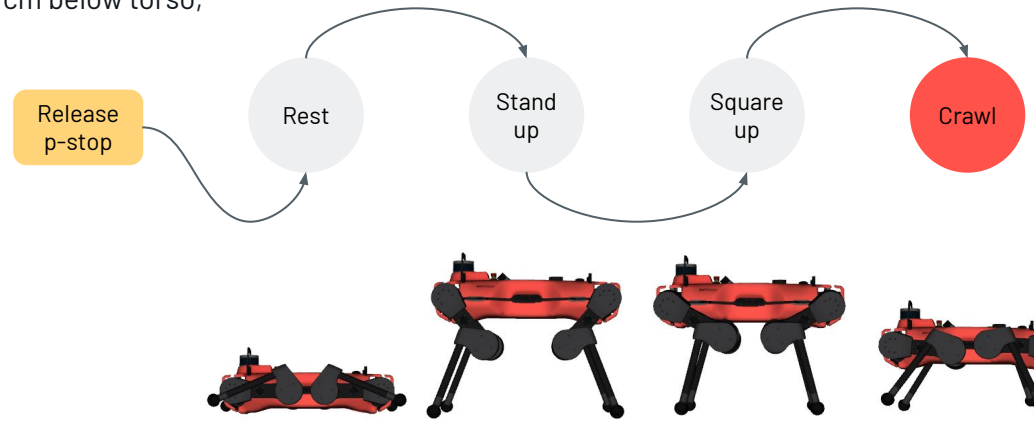
Not available in the Motion Control panel.

Motion Transitioner

The Motion Transitioner is a finite state machine which connects the different motion states via transitions.

It is initialized according to the robot status when the protective stop is released:

- lie_down: <3 feet in contact, <9 cm below torso,
- stand: all feet in contact, >35 cm below torso,
- mixed_configuration: stand and one joint >180°,
- oo_configuration: stand and all KFE and HFE joints >180°,
- stand_while_crawling: all feet in contact, 20-35 cm below torso,
- recovery: >2 feet in contact, >9 cm below torso,
- fallen: any other case.



NOTE: the motion state can be reset manually.

IMPORTANT: plan manual transitions carefully!

Fall Recovery

ANYmal can detect if the robot has unexpectedly fallen.
The motion transition from fallen to recovery is triggered automatically. However, the state fallen is only deduced after “manually” releasing the P-Stop.

- Obstacle detection is not active during fall-recovery.
- A square up is executed to transition between recover and stand.

WARNING: Expect a swift motion and ensure enough space!

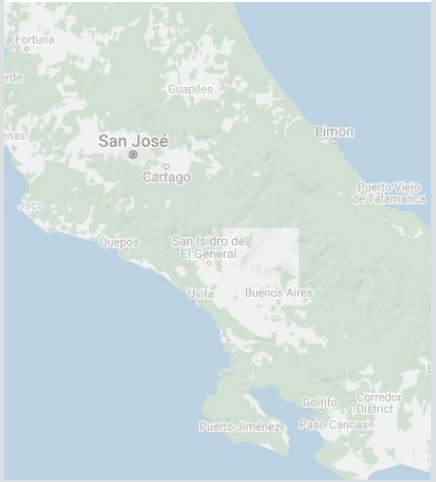
Environment Setup

- How to Approach a New Environment
- Environment Data Folder
- ANYmal Data Synchronisation
- Define The Default Environment
- Configuration Layers and Parameters

How to Approach a New Environment

1) MAP

Record 3D data covering the whole area.

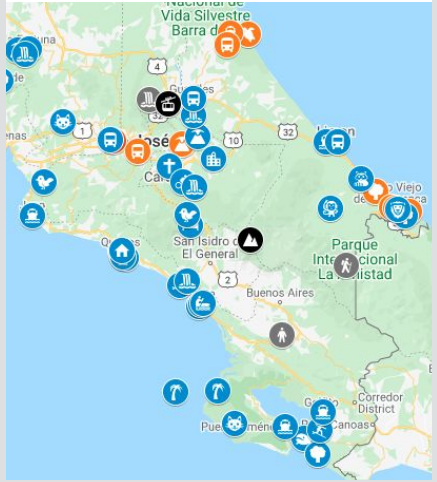


2) WAYPOINTS

Draw all the existing routes in the area, including their characteristics.

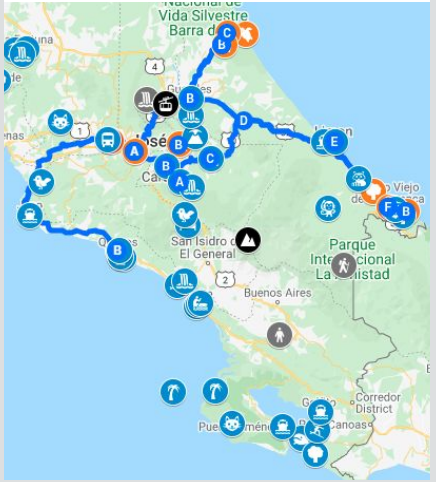
3) ENVIRONMENT

Spot the points of interest in the area.



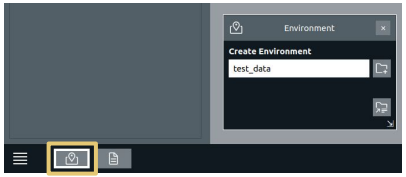
4) MISSION

Plan a multi stops journey across the area.



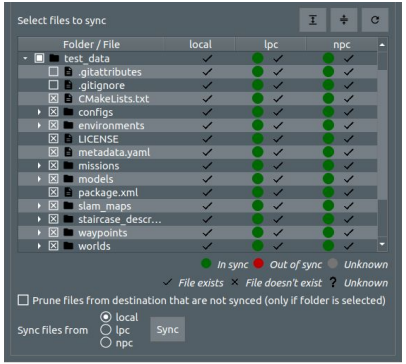
How to Approach a New Environment

1. Boot up the robot and start the Operator GUI.
2. Create a new environment folder on the LPC with the Operator GUI button.
3. Start a local ANYmal Data Synchronisation (ADS) ad-hoc server in a terminal.
4. Connect to the ADS server in the Operator GUI and synchronize the new environment folder from the LPC to the OPC and NPC.
5. Modify the configuration file on the LPC (`.ros/config.yaml`) to set the new environment as default and reboot the robot.
6. Create a map, waypoints, environment items (such as navigation goals or inspection points) and missions and save the files in the new environment folder.
7. Synchronize the environment folder from and to the robot with ADS to have the correct data available after a reboot.




```
linus@linus-ThinkPad-P52:~$ ads_local start
Starting
docker-compose_timescaledb_1 is up-to-date
docker-compose_timescaledb_1 is up-to-date
docker-compose_grafana_1 is up-to-date
docker-compose_ads-server_1 is up-to-date
Publishing ads.local on 192.168.0.212
```

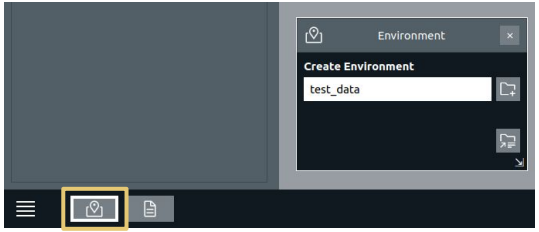
```
integration@anymal-dino-lpc: ~
launch:
  feature_toggles:
    environment_data_package: test_data
```



Environment Data Folder

```
test_data
├── configs
│   └── default.yaml
├── environments
│   └── environment.yaml
├── missions
│   └── test_mission.yaml
├── slam_maps
│   └── map.pb
├── waypoints
│   └── waypoints.json
├── worlds
│   └── world.world
└── ...
```

The environment data folder is used to keep together all the files related to a specific environment: map file, waypoints file, mission files, etc.



The *Environment panel* button in the Operator GUI is used to create a new environment data folder. The folder will contain the necessary structure and configuration. You will only need to replace the default example files as you progress through the environment setup.

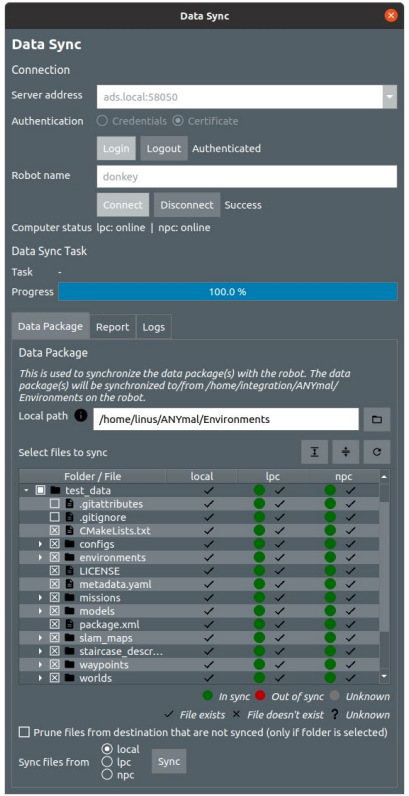
ANYmal Data Synchronisation

The ANYmal Data Synchronization system facilitates data transfer from and to your ANYmal:

- Update environment data packages.
- Archive and download mission reports.
- Access log files from the robot.

TLS-encrypted communication between either:

- Global infrastructure server (opt-in):
  - Set feature toggle `data-synchronization` to `enabled`
  - Address: `data-sync.anybotics.com:58050`,
- Local infrastructure server (to be setup),
- Local ad-hoc server, started on the OPC
  - Set feature toggle `data-synchronization` to `ad-hoc-only`
  - Address: `ads.local:58050`



Ad-Hoc Data Synchronisation Server

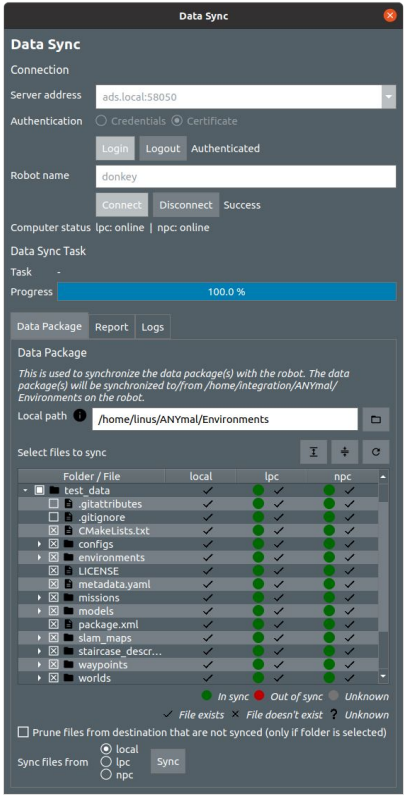
CHEAT SHEET

An ad-hoc ADS server is a quick way to synchronize environment changes (map, waypoints, etc.) between the OPC and the robot. It can work together with a global server or standalone.

1. Install and start ADS on the OPC.
2. Add the address in the Operator GUI and press *Login*.
3. Enter the robot name (in lowercase) and press *Connect*.
4. Refresh the file list to see changes.
5. Select the source to synchronize from.
   - Usually everything is sourced from the OPC, except for the map which is saved to the NPC.
6. Select the files to update and press *Sync*.

Server + Client

Clients

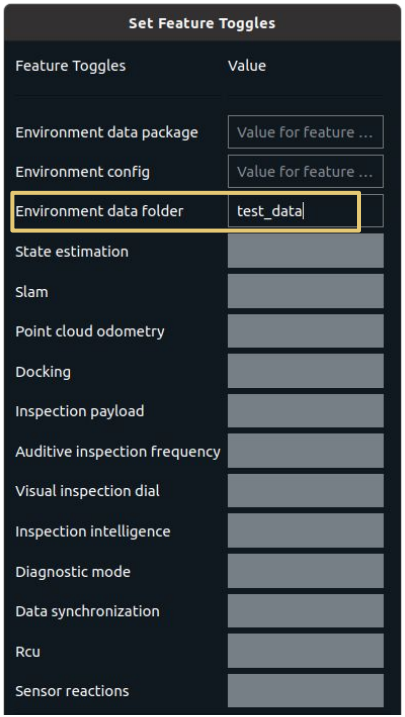


Define The Default Environment

The folder structure together with the specific config file enable the environment to be loaded by default at startup:

- In simulation, set the environment in the Feature Toggles.
- On the robot, set the environment in the file `.ros/config.yaml`.

```
  GNU nano 4.8                          .ros/config.yaml                          Modified
launch:
  feature_toggles:
    environment_data_folder: test_data
```



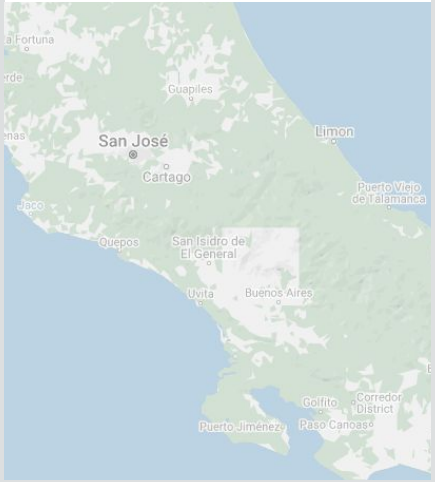
Record A Map

- Introduction
- Sensors
- How To Map A New Area
- How To Align The Map
- How To Localize In An Existing Map

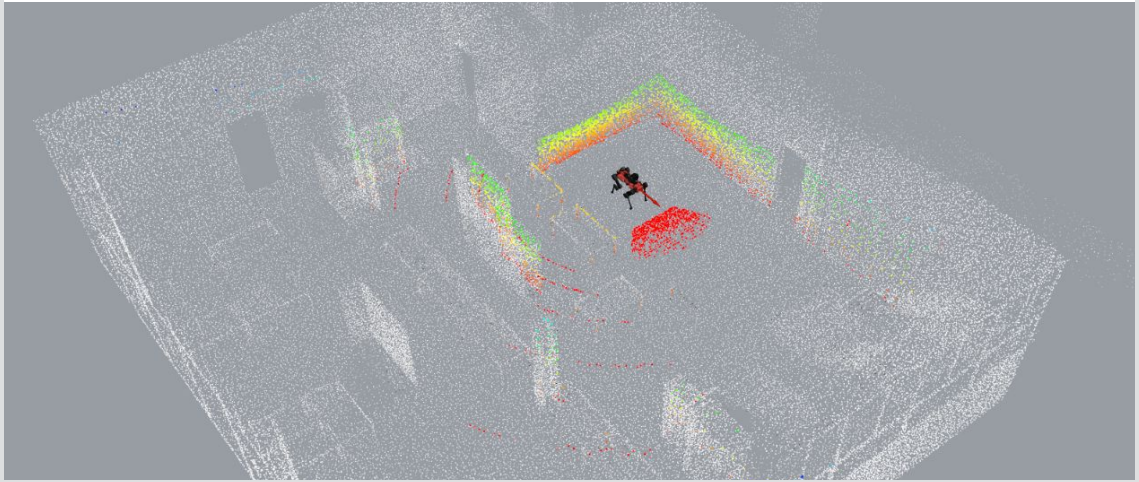
How to Approach a New Environment

1) MAP

Record 3D data covering the whole area.

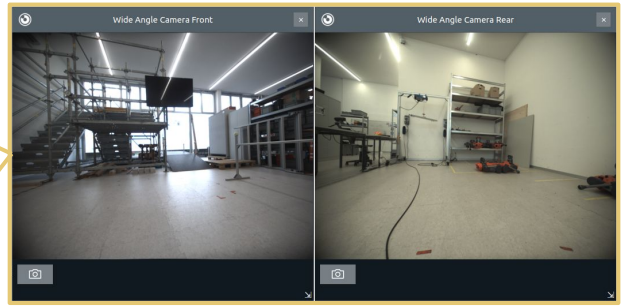


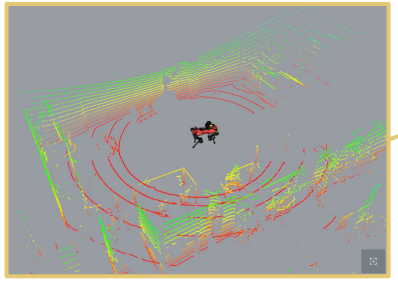
The Simultaneous Localization and Mapping (SLAM) system builds large reference maps and localizes ANYmal with high accuracy over long distances.

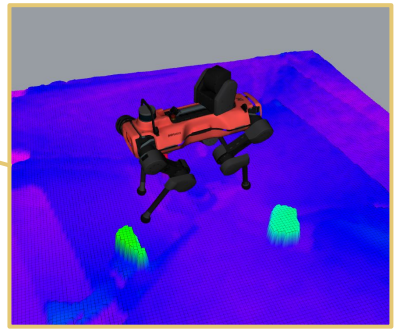


Sensors

OPERATOR'S MANUAL Section 3.2.3





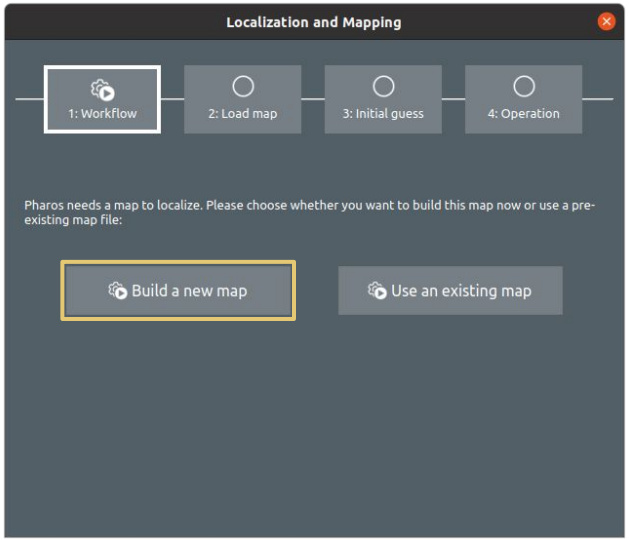


How To Map A New Area

OPERATOR'S MANUAL Section 6.5.1

Open the *Localization* panel and follow the workflow:

1. Click *Build a new map*.
2. Steer ANYmal around to incrementally build the map.
3. Click *Visualize map* to monitor the result in the visualization window.
4. Make sure the *Fixed Frame* is set to *map*.
5. Save the map:
   a. Enter the absolute file path (on NPC).
   b. Click the *Save* button.



The Operator GUI needs control to open the *Localization* panel, launch the mapping session and visualize the map. The remote control needs control to steer the robot and walk around.

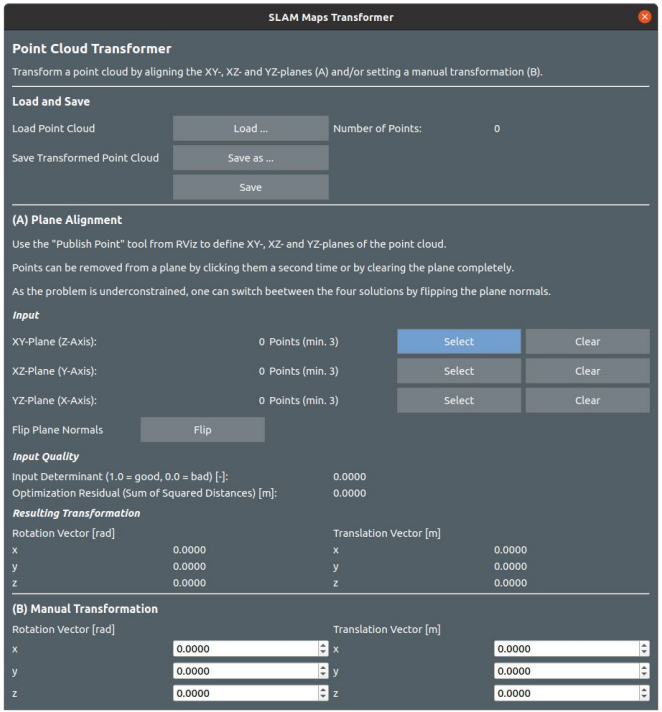
How To Align The Map

OPERATOR'S MANUAL Section 6.5.2

The SLAM maps transformer allows the repositioning and reorienting of point clouds. This can make the map more convenient to use as a base for creating waypoints, and nicer to visualize.

USAGE

1. Load a point cloud.
2. Use Section A for automated plane detection:
   a. Disable the Transformed Point Cloud in the displays list.
   b. Select at least 3 points on each plane using the Publish Point tool in RVIZ.
   c. Disable the Input Point Cloud and enable the Transformed Point Cloud in the displays list to see the result.
   d. Flip plane normals if needed.
   e. Save the transformed point cloud using the Save button.
3. Alternatively, use Section B to manually enter transformation values.
   a. Enter the rotation and translation values.
   b. Disable the Input Point Cloud in the displays list to see the result.
   c. Save the transformed point cloud using the Save button.

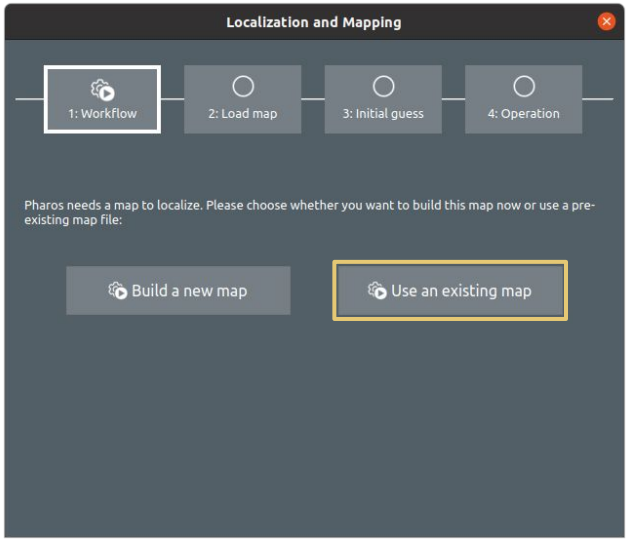


How To Localize In An Existing Map

OPERATOR'S MANUAL Section 8.6.3

Open the *Localization* panel and follow the workflow:

1. Click *Use an existing map*.
2. Enter the absolute file path (on NPC) and click *Load*.
3. Provide an initial guess:
   a. Click *Try Place Recognition*.
   b. If it does not work, provide a manual guess using the *Interaction Marker*.
4. Enable *Localization*.



Draw The Waypoints

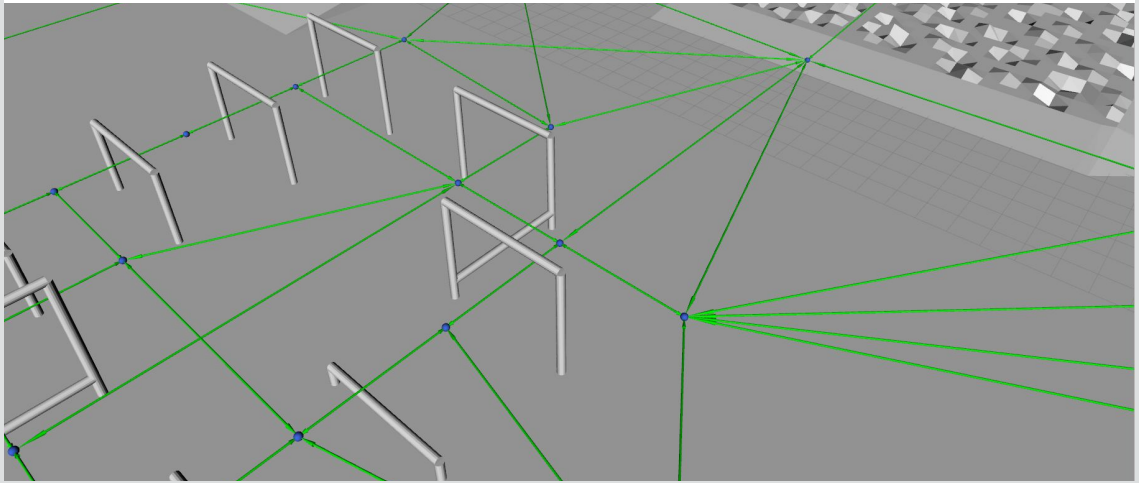
- Introduction
- The Waypoints Graph
- Path Follower
- Path Follower Modes
- Waypoints Editor

How to Approach a New Environment

2) WAYPOINTS

Draw all the existing routes in the area, including their characteristics.

The waypoints graph is a representation of the paths ANYmal can take in the environment.



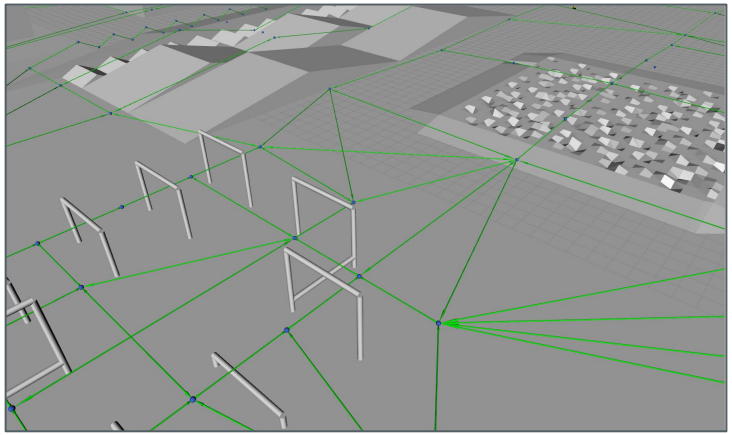
The Waypoints Graph

OPERATOR'S MANUAL Section 6.6

The waypoints graph consists in:

- a list of nodes (waypoints) and edges (that connect the nodes),
- a description of which motion state, path follower and path follower mode is used where.

The waypoints graph can be created and modified using the *Waypoints Editor*.

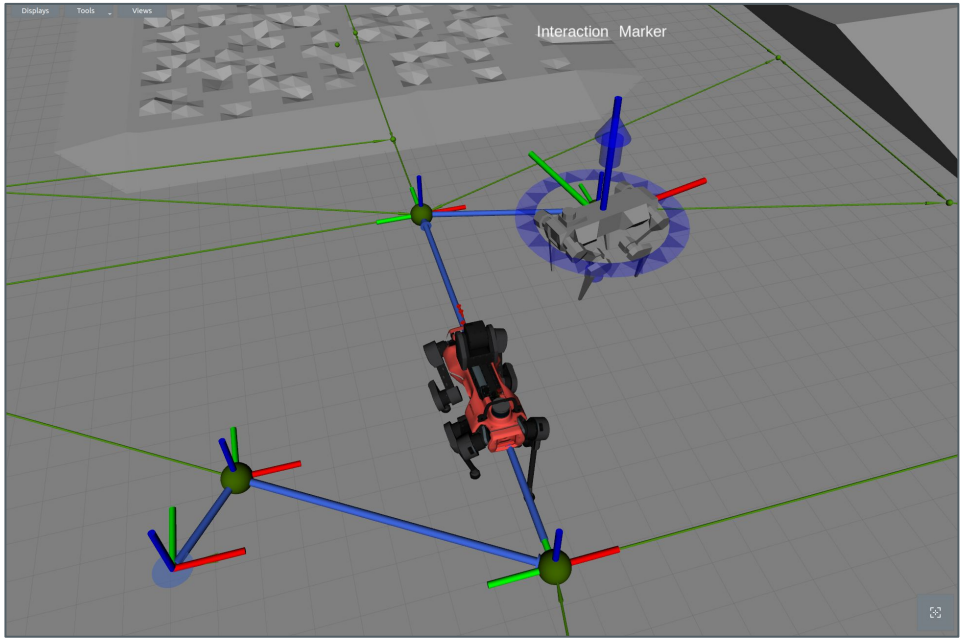


Path Follower

The path follower defines how closely versus optimally the robot follows the defined paths.

Available path followers are:

- Strict path follower [default]: strictly follows the calculated path, turns on the spot at nodes.
- Smooth path follower: follows the calculated path as closely as possible while minimizing the trajectory execution time. Can cut corners.



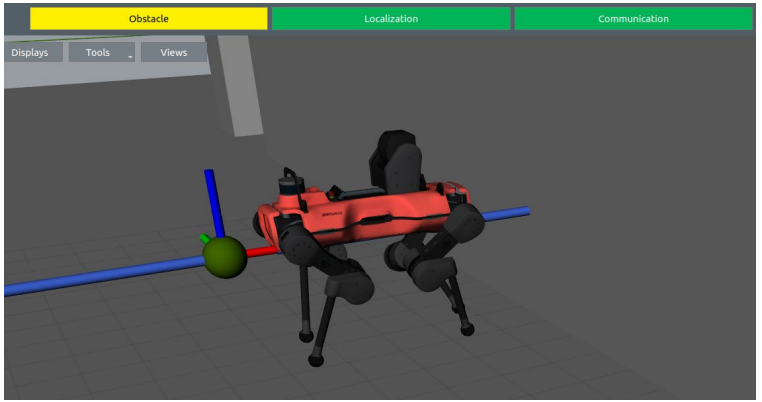
Path Follower Modes

OPERATOR'S MANUAL Section 8.5.2

The path follower mode defines how the robot reacts to obstacles on its way.

Available path follower modes are:

- Blind: does not detect obstacles and will run into them if on the path.
- Stop_and_go [default]: stops in front of static obstacles detected by the sensors, continues if the path clears up within the defined time [default=20sec].
- Avoid_obstacles: maneuver around obstacles detected by the sensors and then comes back to the path.



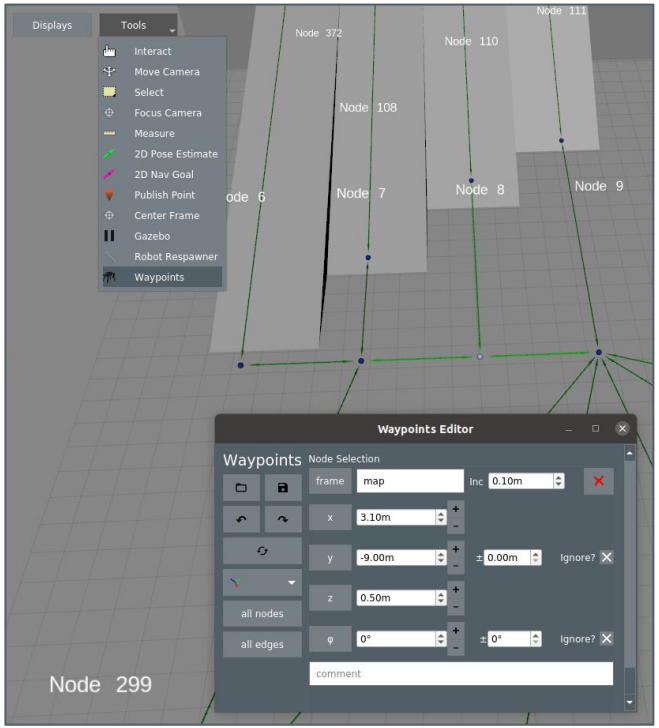
IMPORTANT: Modes other than *blind* should only be used in the *walk* motion state on flat terrain.

NOTE: Negative obstacles (cliffs) can only be detected if the bottom or the other side is visible.

Waypoints Editor

OPERATOR'S MANUAL Section 8.5

1. Open the Waypoints Editor in the menu options.
2. Select the *Waypoints* tool.
3. Optional: enable the SLAM display.
4. Place nodes in the environment by clicking on the visualization window or pressing the refresh button to get the current robot pose.
    a. Adjust their poses using the Waypoints Editor.
    b. Add tolerances if needed.
5. Connect the nodes with edges by clicking on a node and holding while moving the mouse. Release above another node (to connect them with an edge) or above empty space (to connect with a new node).
    a. Specify their motion states, motion parameters, path followers, modes and traversabilities using the Waypoints Editor.
6. Save to a file.



Tips:

- Select multiple nodes and edges by holding the Shift key and clicking the desired nodes and edges. They can then be modified simultaneously.
- Select all nodes or all edges using the *all nodes* and *all edges* buttons.
- Delete a node or edge by clicking the red cross or using the Remove mode.
- Unselect the bidirectional edge checkbox to modify an edge in one direction only.
- Select the *Interact* tool in the *Tools* list to drag nodes around.

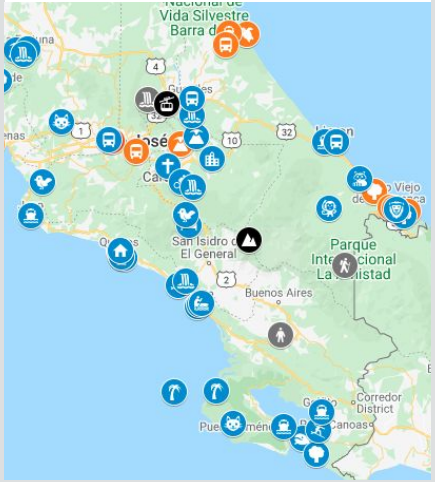
Define Points Of Interest

- Introduction
- Environment Objects
- Environment Setup

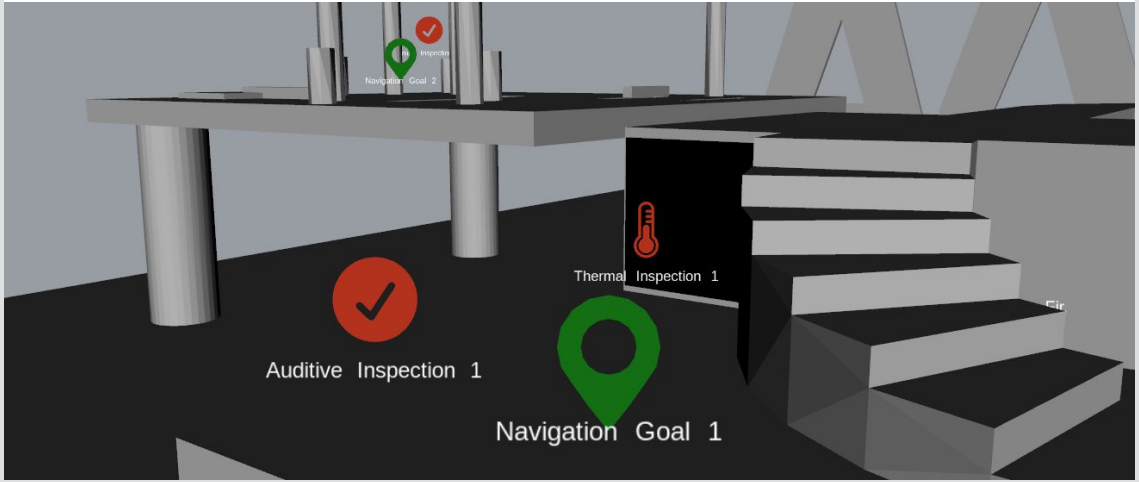
How to Approach a New Environment

3) ENVIRONMENT

Spot the points of interest in the area.



Environment objects are points of interest that the robot can interact with, such as inspection targets and navigation goals.



Environment Objects

Navigation Goal

Location to navigate to.

Simple Inspection

Object to visually or auditorily record without analysis.

Docking Station

Location around which to look for the charging station.

Intelligent Inspection

Object to visually inspect and analyse.

Thermal Inspection

Object to thermally inspect and analyse.

Environment Objects

Environment objects are points of interest that the robot can interact with through autonomous tasks:

- A navigation task requires a navigation goal.
- An inspection task requires an inspection point linked to a Navigation Goal by a navigation zone.
- A docking task requires a docking station and alignment Navigation Goals.

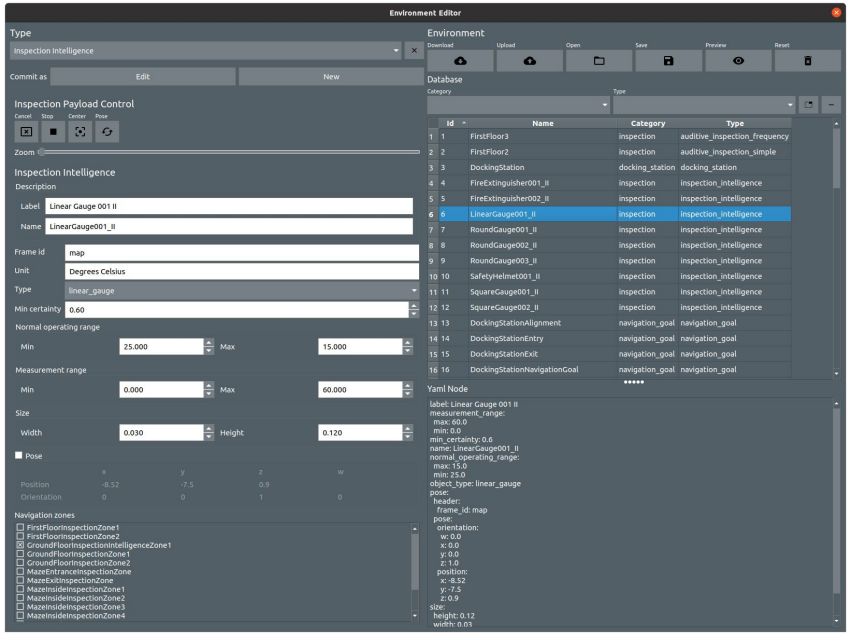
Environment Setup

OPERATOR'S MANUAL Section 6.7

Environment objects are created and managed using the *Environment Editor*, saved to a file in the data package and loaded to the parameter server. The *Environment Editor* is accessible through the Operator GUI Menu.

The objects loaded on the parameter server are listed in the *Database* after pressing the *Download* button.

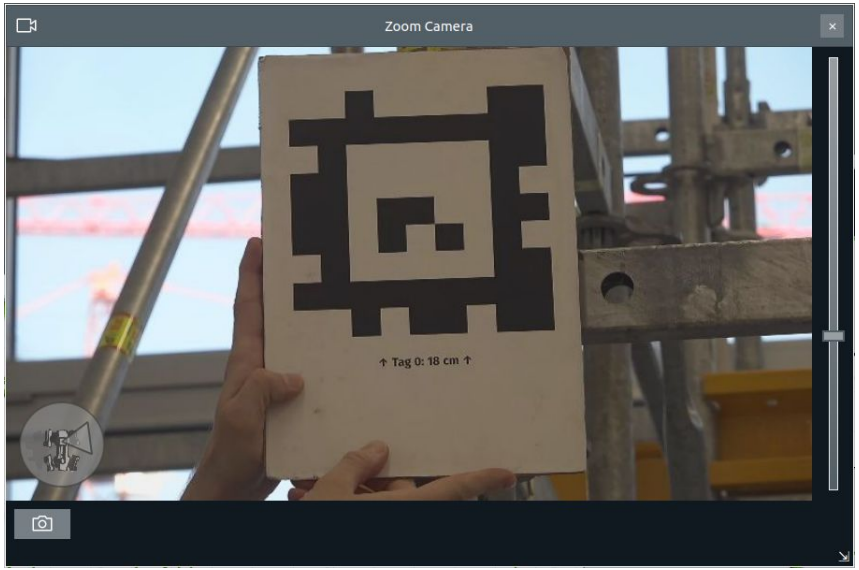
New and edited objects need to be loaded with the *Upload* button for direct use and saved to a file with the *Save* button for later re-use.



Environment Setup

Objects locations need to be recorded when the robot is localized in the environment.

- The location of a navigation goal is recorded using the current robot pose.
- The location of an inspection point is recorded using an *AprilTag*.



Environment Setup

OPERATOR'S MANUAL Section 6.7

Add a Navigation Goal

1. Walk the robot to the desired position.
2. Select the type *Navigation Goal* from the *Type* drop down menu.
3. Click the refresh *Pose* button to get the pose.
4. Fill in the label and tolerances.
5. Click the *New* button to add the navigation goal.

Add an Inspection Point

1. Walk the robot to the desired position and add a *Navigation Goal*.
2. Move the payload so that the zoom camera points towards the object to inspect.
3. Select the type *Navigation Zone* from the *Type* drop down menu.
4. Fill in the label.
5. Select a *Navigation Goal* to link it to.
6. Click the *New* button to add the *Navigation Zone*.
7. Select an inspection point (e.g. *Visual Inspection Simple*) from the *Type* drop down menu.
8. Fill in the label and size, select the camera type.
9. Get *Manual* control and launch the *Start Inspection Setup* task in the *Robot Control Panel*.
10. Hold the printed tag over the object to inspect.
11. Click the refresh *Pose* button to get the pose.
12. Click the *New* button to add the inspection point.

Adapt the Docking Station Pose

1. Walk the robot to the desired position.
2. Double click the *Docking Station Navigation Goal* in the *Database* list.
3. Click the refresh *Pose* button to get the pose.
4. Click the *Edit* button to edit the object.
5. Double click the *Docking Station* in the *Database* list.
6. Click the refresh *Pose* button to get the pose.
7. Tick the Pose checkbox.
8. Manually edit the *Position* so that the docking station is 0.5 to 1 m in front of the robot.
9. Click the *Edit* button to edit the object.

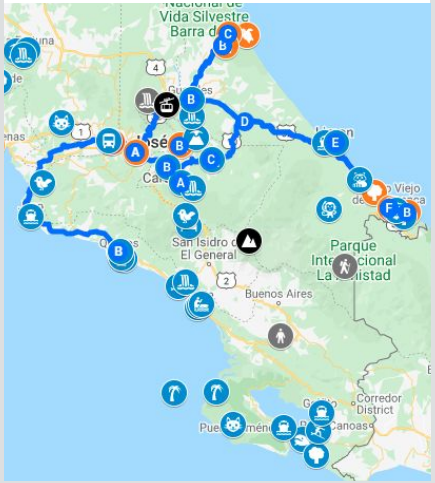
Plan a Mission

- Introduction
- Overview
- Mission Setup

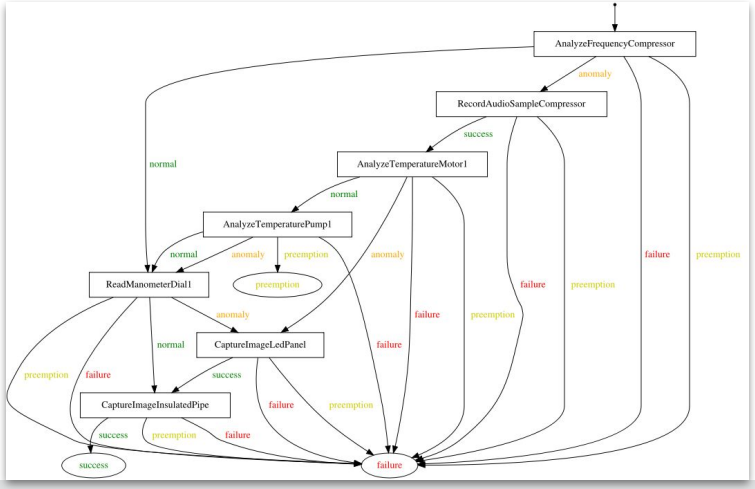
How to Approach a New Environment

4) MISSION

Plan a multi stops journey across the area.



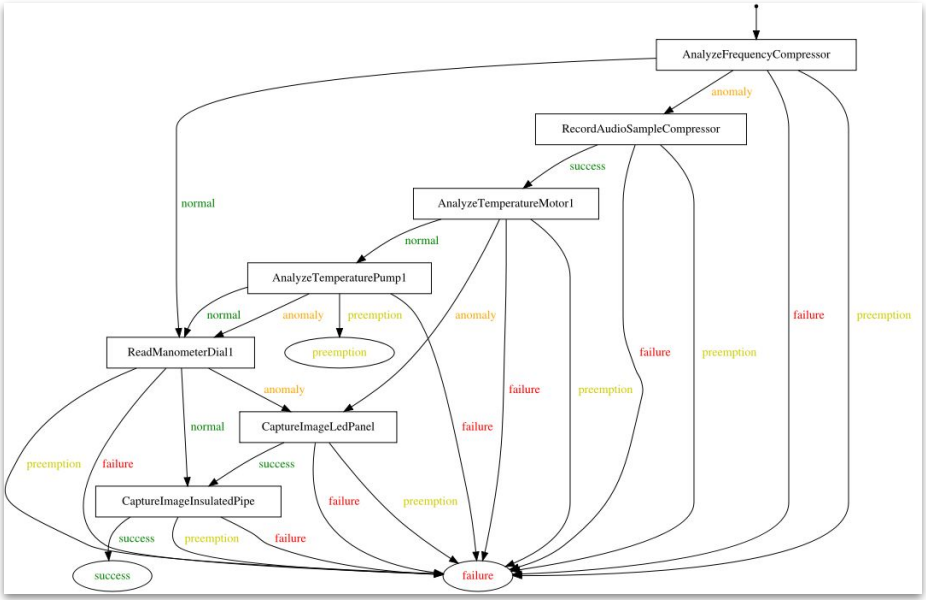
An autonomous mission defines a set of tasks to execute in a specific order depending on task outcomes.



Overview

ANYmal can execute a range of autonomous tasks and take decisions depending on the task outcomes.

Autonomous missions define the order of execution of tasks and the reactions to different outcomes.

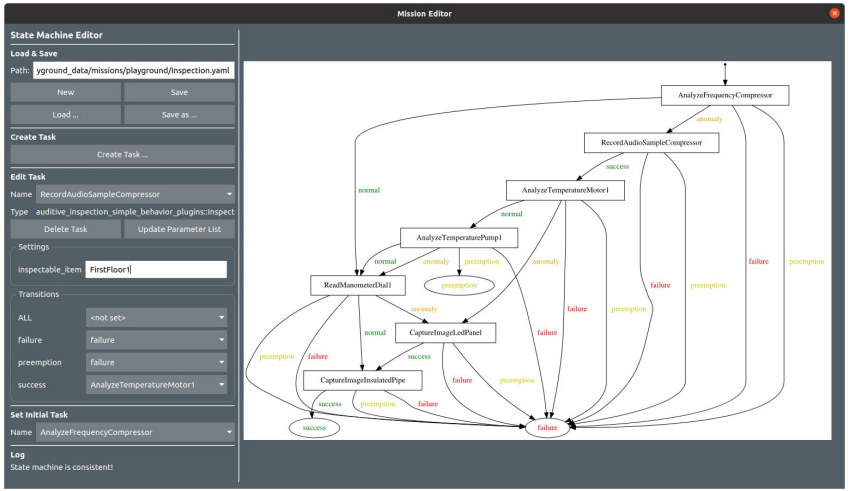


Mission Setup

OPERATOR'S MANUAL Section 6.8

Autonomous missions are created and managed using the *Mission Editor* and saved to a file in the data package on the OPC. The *Mission Editor* is accessible through the GUI Menu.

A new mission can be created using the *New* button, or an existing one can be loaded with the *Load ...* button. Completed missions can be saved with the *Save* or *Save as ...* button. A mission is ready to be saved when the *Log* contains no more error and states "State machine is consistent!".



Mission Setup

OPERATOR'S MANUAL Section 6.8

Add a Task

1. Click *Create Task ...*
2. Select the desired behavior plugin (e.g *navigation_behavior_plugins* or *xxx_inspection_xxx_behavior_plugins*).
3. Select the desired behavior (e.g. *ReactiveNavigation* or *Inspect*).
4. Fill in the name field.
5. Click *OK*.

Link the Corresponding Object

1. Select a task in the *Edit Task* dropdown list.
2. Set the *navigation_goal* or *inspectable_item* amongst those defined in the environment.
3. Repeat for all tasks.

Setup the Transitions

1. Select the initial task in the *Set Initial Task* dropdown list.
2. Select a task in the *Edit Task* dropdown list.
3. Set the transitions for each possible outcome using the *Transitions* dropdown lists.
4. Repeat for all tasks.
5. Check the result in the visualization.

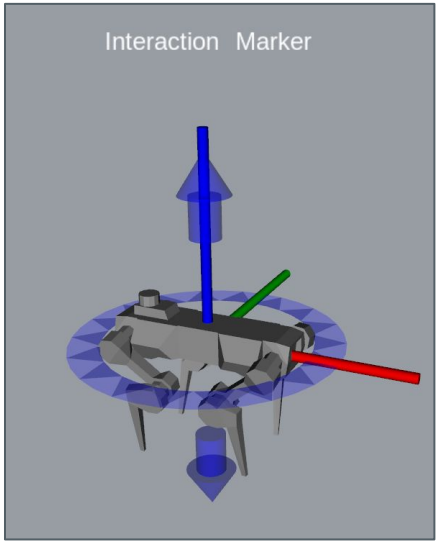
Autonomous Operation

- Interaction Marker
- Autonomous Tasks
- Autonomous Missions
- Global Replanning

Interaction Marker

OPERATOR'S MANUAL Section 3.2.6.1

The Interaction Marker allows interaction with the robot through the visualization window.
The red arrow indicates the front of the robot.



USAGE

- Click and hold the blue circle to move the marker around or rotate it.
- Click and hold the blue arrows to move the marker up and down.
- Right-click on the marker to access a context menu and
  - Reset the marker to the robot location.
  - Set a manual initial guess for localization.
  - Set a navigation goal.
  - Take a picture using an inspection payload camera.
  - Display the LIDAR point cloud.

Autonomous Tasks

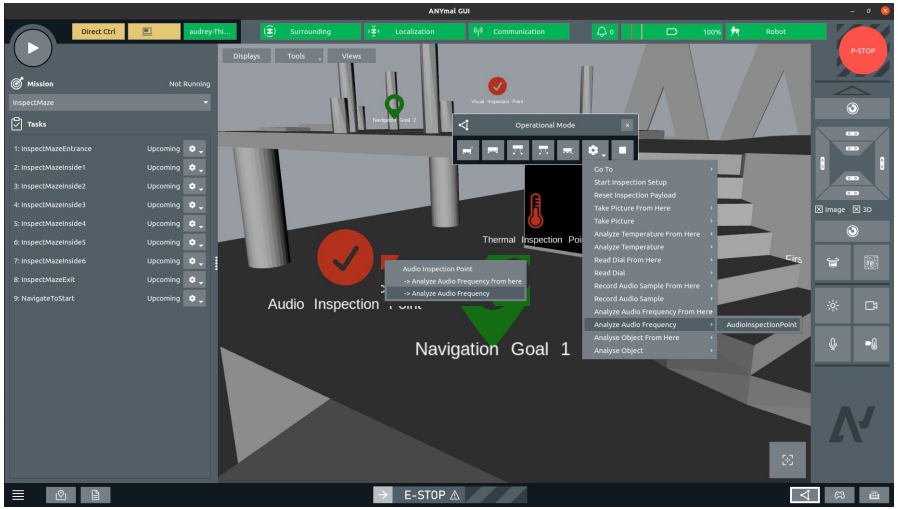
The robot can execute different types of tasks:

- Navigate to a goal,
- Inspect an object (visual, thermal, auditive),
- Dock,
- ...

Most tasks need a corresponding object with a location in the 3D robot environment.

Tasks can be launched through:

- the 3D visualization panel, clicking on the corresponding object,
- the operational mode panel, clicking on the advanced (gear) icon.



Autonomous Mission

Autonomous missions are controlled in the GUI mission panel.

A mission can be selected through the dropdown menu. The contained tasks are displayed in the *Tasks* list, and the expected robot path in the 3D visualization panel.

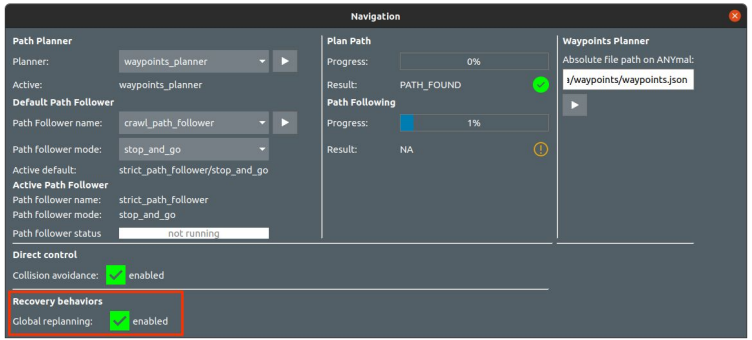
The mission is started, paused and resumed using the *Play* button.

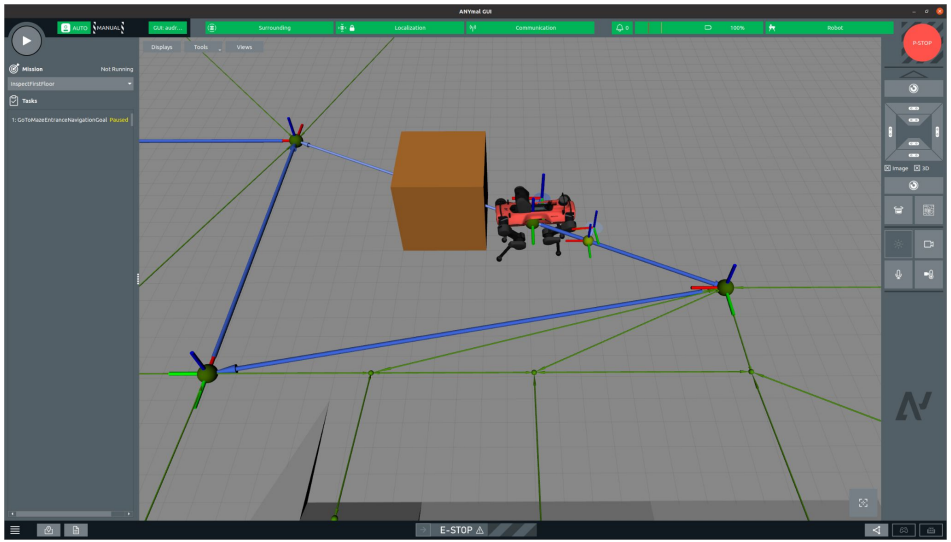
By default, the mission is started from the beginning and previewed assuming that all tasks succeed. The tasks settings offer other options.

In case of a critical event, ANYmal pauses the mission automatically and asks for operator input via a notification.

Global Replanning

Global replanning is a recovery behavior used when the planned path is obstructed by a persistent static obstacle. The robot cannot continue navigating towards the goal position and the recovery behavior replans an alternative path along the waypoints graph. Global replanning only happens in the "stop and go" path follower mode and is executed once the 20 second timeout expires.





Autonomous Charging

- Hardware Introduction
- Environment Setup
- Launching as a Task
- Using in a Mission

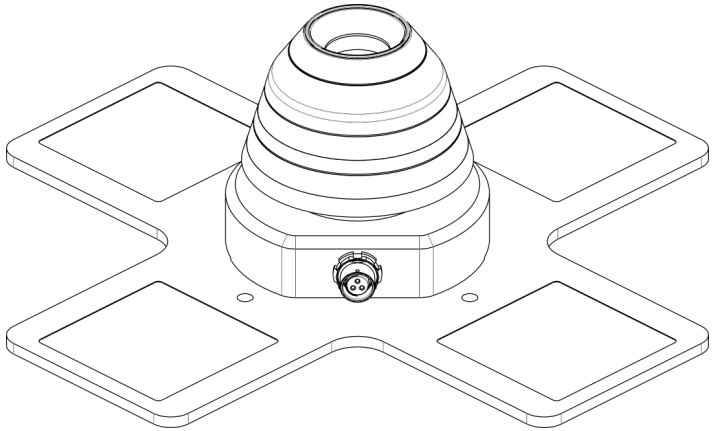
Hardware Introduction

OPERATOR'S MANUAL Section 2.3.19.1

The docking station is the accessory that enables the robot to autonomously recharge its battery. Its rings and AprilTags enable the robot to identify and localize the docking station.

INSTALLATION

1. Select a safe location protected from weather damage, away from evacuation routes and with adequate lighting.
2. Place the docking station on the floor, at least 0.5m away from walls and equipment.
3. Bolt the docking station to the floor using the holes in the base of the docking station.
4. Connect the charging cable from the battery charger to the docking station.



Environment Setup

Docking is an autonomous behavior which requires a specific docking objects in the environment setup.

Pre-made environment data packages contain the necessary objects. Only the locations of the *DockingStation* and *DockingStationNavigationGoal* objects need to be adapted.

	Id	Name	Category	Type
1	3	DockingStation	docking_station	docking_station
2	13	DockingStationAlignment	navigation_goal	navigation_goal
3	14	DockingStationEntry	navigation_goal	navigation_goal
4	15	DockingStationExit	navigation_goal	navigation_goal
5	16	DockingStationNavigationGoal	navigation_goal	navigation_goal

Launching as a Task

OPERATOR'S MANUAL Section 8.1.5

The docking action can be launched using one of the following methods:

- Remote control robot mode dial: turn the dial to *Dock*. 
- Operator GUI robot control panel operational mode: open the operational mode panel and click *Dock*. 
- Operator GUI 3D visualization marker: click on the *Docking Station* marker and select *Dock*.

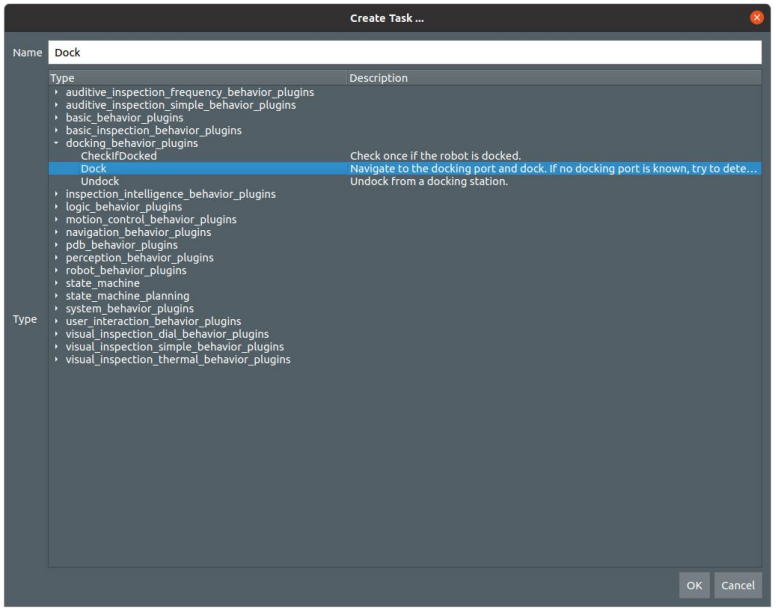
Launch when ANYmal is either localized or approximately 1 m away from the docking station.

The robot will navigate to the *Docking Station Navigation Goal* (if localized), then detect the docking station using its depth cameras, approach it and lie down to dock.

Using in a Mission

The docking action can be added as a task to a mission.

In *Create Task ...*, select *Dock* from the *docking_behavior_plugins*. No settings are needed.

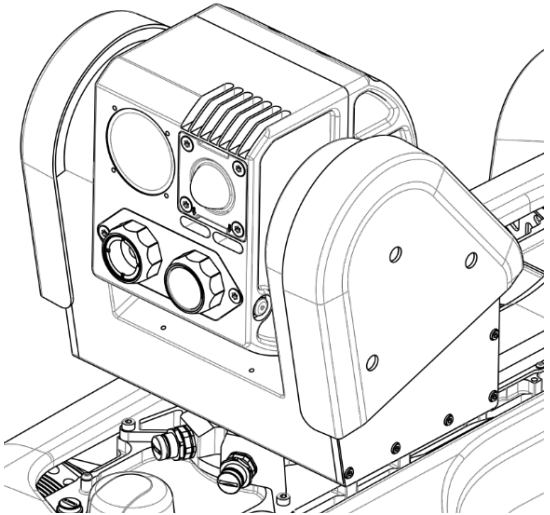


Inspection

- Hardware Introduction
- Operator GUI
- Inspection Monitor
- Mission Report
- Inspection Types
- Spot Light

Hardware Introduction

OPERATOR'S MANUAL Section 2.3.22

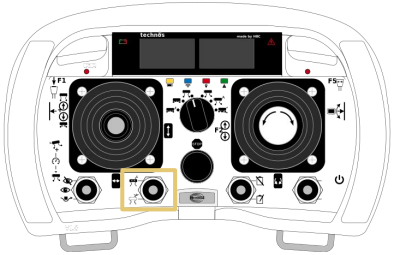


The inspection payload integrates multiple sensors mounted on a pan-tilt unit:

- Camera with 20x optical zoom,
- Thermal camera,
- Ultrasonic microphone,
- Spot light.

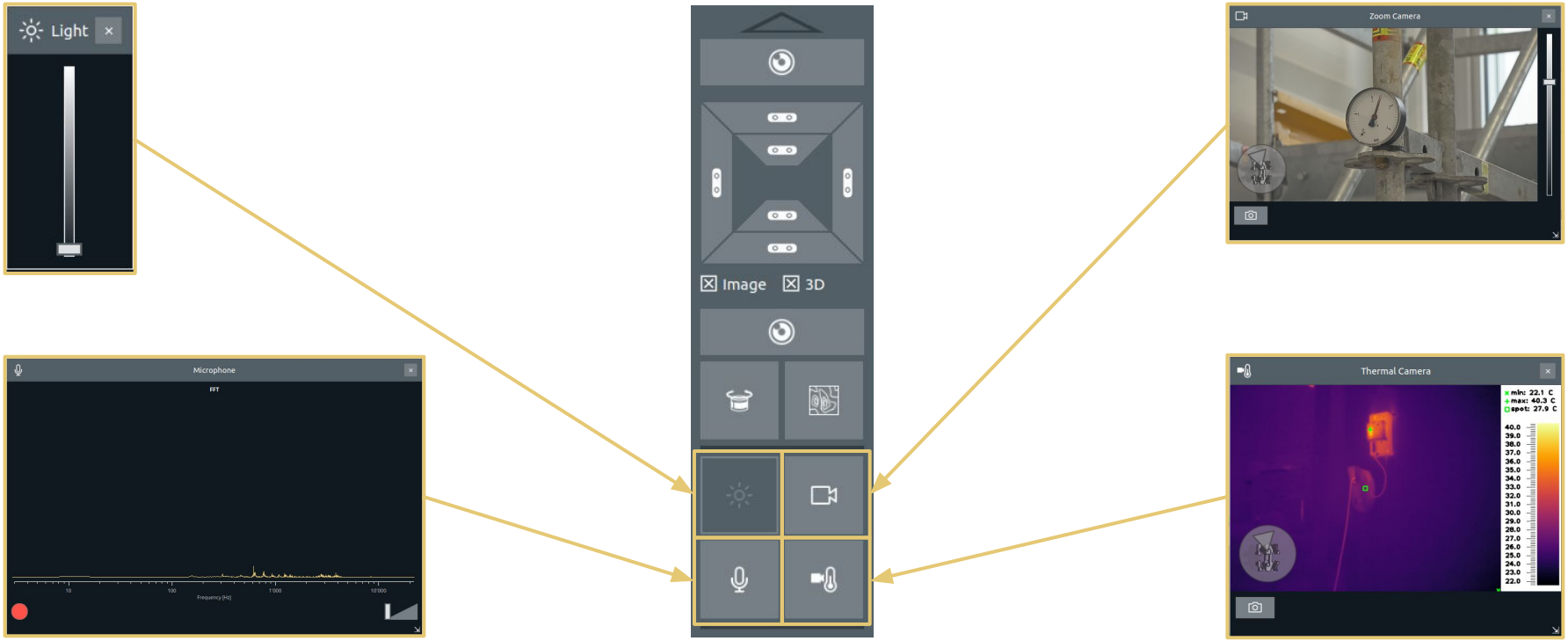
The inspection payload can be moved manually using the remote control:

- A toggle switch enables (down) or disables (up) the inspection payload manual control.
- The left joystick controls pan and tilt movements (if enabled).



Operator GUI

OPERATOR'S MANUAL Section 3.2.3



Mission Report

CHEAT SHEET

The mission report provides continuous reporting of tasks and events. It is available both as direct feedback in the GUI and as a saved document on NPC.

USAGE

- Saved in the `/home/integration/.ros/reports/<DATE>` folder of the Navigation Computer.
- Copy the report folder to the Operator Computer and open in Google Chrome through the terminal.

Mission Report: Example

CONTENT

- Event types:
  - Inspection outputs,
  - Mission information,
  - Safety-related information.
- Information included:
  - Occurrence time,
  - Severity level,
  - Event description,
  - Output value, if applicable,
  - Inferred status, if applicable,
  - Output file, if applicable.

MISSION REPORT ANYbotics

Location: Hagenholz

Date: 2021/09/10

Robot: ANYmal Dino

Time (hh:mm:ss)	Level	Event	Value	Status	File
06:55:58	INFO	Emergency stop has been detected and actuators are disabled. You can now approach safely to ANYmal. Disengage manually the Emergency Stop when it is considered safe.	-	-	-
06:57:10	INFO	Protective stop has been detected. How do you want to proceed? (Please note that the actuator temperature and battery supervisions are currently inactive.)	-	-	-
07:14:55	INFO	Selected 'Confirm'.	-	-	-
07:54:22	INFO	Starting mission 'Routine Inspection' ...	-	-	-
07:54:36	INFO	Navigating to 'Compressor Navigation Goal' ...	-	-	-
07:54:56	INFO	Successfully navigated to 'Compressor Navigation Goal'.	-	-	-
07:54:56	INFO	Inspecting 'Compressor Sound' from here ...	-	-	-
07:55:16	INFO	Successfully recorded audio sample of 'Compressor Sound'.	-	-	▶
07:55:17	INFO	Navigating to 'Manometer Navigation Goal' ...	-	-	-
07:56:03	INFO	Successfully navigated to 'Manometer Navigation Goal'.	-	-	-
07:56:04	INFO	Inspecting 'Manometer Dial' from here ...	-	-	-
07:56:17	INFO	Successfully read dial of 'Manometer Dial'. Certainty is sufficient: 0.97 >= 0.60. Reading is within expected operating range [0.00, 4.00].	2.36 bar	Normal	
07:57:13	INFO	Navigating to 'Pump Navigation Goal' ...	-	-	-
07:57:27	INFO	Successfully navigated to 'Pump Navigation Goal'.	-	-	-
07:57:27	INFO	Inspecting 'Pump Temperature' from here ...	-	-	-
07:57:30	WARN	Successfully analyzed temperature of 'Pump Temperature'. Certainty is sufficient: 1.00 >= 0.60. Reading is not within expected operating range [50.00, 90.00].	93.40 °C	Anomaly	
07:57:31	INFO	Navigating to 'Docking Station Navigation Goal' ...	-	-	-
07:57:40	INFO	Successfully navigated to 'Docking Station Navigation Goal'.	-	-	-

Inspection Types: Simple Visual Inspection

Purpose

Take a picture of a point of interest with the zoom or thermal camera.

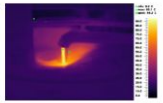
Usage

Properly lit environment needed for the zoom camera.

Dark environment is fine for the thermal camera.

Output

(Thermal) picture of the point of interest.

Time (hh:mm:ss)	Level	Event	Value	Status	File
10:52:00	INFO	Successfully took image of 'LEDs Panel'.	-	-	
10:52:17	INFO	Successfully took image of 'Insulated Pipe'.	-	-	

Inspection Types: Thermal Inspection

Purpose

Take a thermal picture of a point of interest.

Get the highest temperature in degree Celsius in the image.

Usage

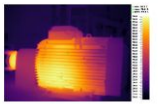
Works most reliably on surfaces with a dull dark color.

Shiny materials are generally problematic.

Output

Thermal picture of the point of interest

Value of the highest temperature in degree Celsius in the image.

Time (hh:mm:ss)	Level	Event	Value	Status	File
07:57:30	WARN	Successfully analyzed temperature of 'Pump 1'. Certainty is sufficient: 1.00 >= 0.60. Reading is not within expected operating range [50.00, 90.00].	93.40 °C	Anomaly	
08:01:17	INFO	Successfully analyzed temperature of 'Motor 1'. Certainty is sufficient: 1.00 >= 0.60. Reading is within expected operating range [0.00, 99.00].	76.01 °C	Normal	

Inspection Types: Dial Inspection

Purpose

Read and evaluate the indicated value on a round dial.

Usage

Choose a robot pose that avoids reflections on the dial.

Ensure only one dial is in the picture frame.

Ensure the dial has only one pointer.

Output

Value indicated by the pointer.

Certainty level.

Picture of the dial.

Status (within or outside of normal operating range).

Time (hh:mm:ss)	Level	Event	Value	Status	File
07:56:17	INFO	Successfully read dial of 'Manometer Dial 1'. Certainty is sufficient: 0.97 >= 0.60. Reading is within expected operating range [2.00, 2.50].	2.36 bar	Normal	
08:02:46	INFO	Successfully read dial of 'Manometer Dial 2'. Certainty is sufficient: 0.98 >= 0.60. Reading is within expected operating range [4.50, 5.00].	4.91 bar	Normal	

Inspection Types: Simple Auditive Inspection

Purpose

Record an audio sample of a point of interest in the audible or ultrasonic frequency range.

Usage

Get robot and microphone close to sound source.

Output

Audio recording at the point of interest.

Time (hh:mm:ss)	Level	Event	Value	Status	File
07:55:16	INFO	Successfully recorded audio sample of 'Compressor 1 Sound'.	-	-	

Inspection Types: Frequency Inspection

Purpose

Analyze the audio input for certain frequencies at a point of interest.

Can be used to detect a specific alarm sound.

Usage

Avoid using in an environment with loud background noise.

Output

Presence or absence of defined frequencies.

Time (hh:mm:ss)	Level	Event	Value	Status	File
07:55:16	INFO	Successfully analyzed frequency of 'Compressor 1'.	-	Normal	

Inspection Types: Inspection Intelligence

Purpose

Read and evaluate the indicated value on a round gauge, a square gauge, a linear gauge, a digital counter, an analog counter, a lever valve, a safety helmet or a fire extinguisher.

Usage

Choose a robot pose that avoids reflections.

Ensure only one object of that type is in the picture frame.

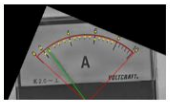
Output

Value indicated by the object.

Certainty level.

Picture of the object.

Status (within or outside of normal operating range).

Time (hh:mm:ss)	Level	Event	Value	Status	File
07:59:32	INFO	Successfully read the item 'Valve 1'. Certainty is sufficient: 1.00 >= 0.60.	1	Normal	
08:09:55	INFO	Successfully read the item 'Fire Extinguisher 2'. Certainty is sufficient: 0.84 >= 0.60.	1	Normal	
08:10:40	INFO	Successfully read the item 'Square Gauge 2'. Certainty is sufficient: 0.97 >= 0.60. Reading is within expected operating range [0.00, 10.00].	1.36 A	Normal	

Spot Light

OPERATOR'S MANUAL Section 1.17

The spot light enables inspection in dark environments.

USAGE

- The brightness can be adjusted using the slider in the sensors panel or in the inspection monitor.

Do not look directly into the spotlight mounted on the Inspection Payload!

Do not operate the spotlight without the collimator lens!

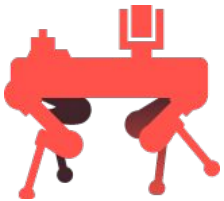
Teleoperation

- VPN Setup
- Operator GUI

VPN Setup

OPERATOR'S MANUAL Section 7.2

To connect to the robot outside of a local subnet, ANYmal's PCs can be accessed over a VPN tunnel if a server is available and set up.



Clients

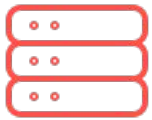
Private Key XXX
Public Key DEF
Address = 10.8.0.2/32

Endpoint
123.456.789:51820
Key ABC
AllowedIPs = 10.8.0.0/24

Private Key XXX
Public Key GHI
Address = 10.8.0.3/32

Endpoint
123.456.789:51820
Key ABC
AllowedIPs = 10.8.0.0/24

1. Install Wireguard on a server and on all clients (LPC, NPC, OPC).
2. Create keys and configs on all server and clients.
3. On the server, register each client.
4. Start Wireguard or enable system service.
5. Change to new IPs in the hosts file on the OPC.
6. Export your VPN IP as the ROS_IP environment variable.



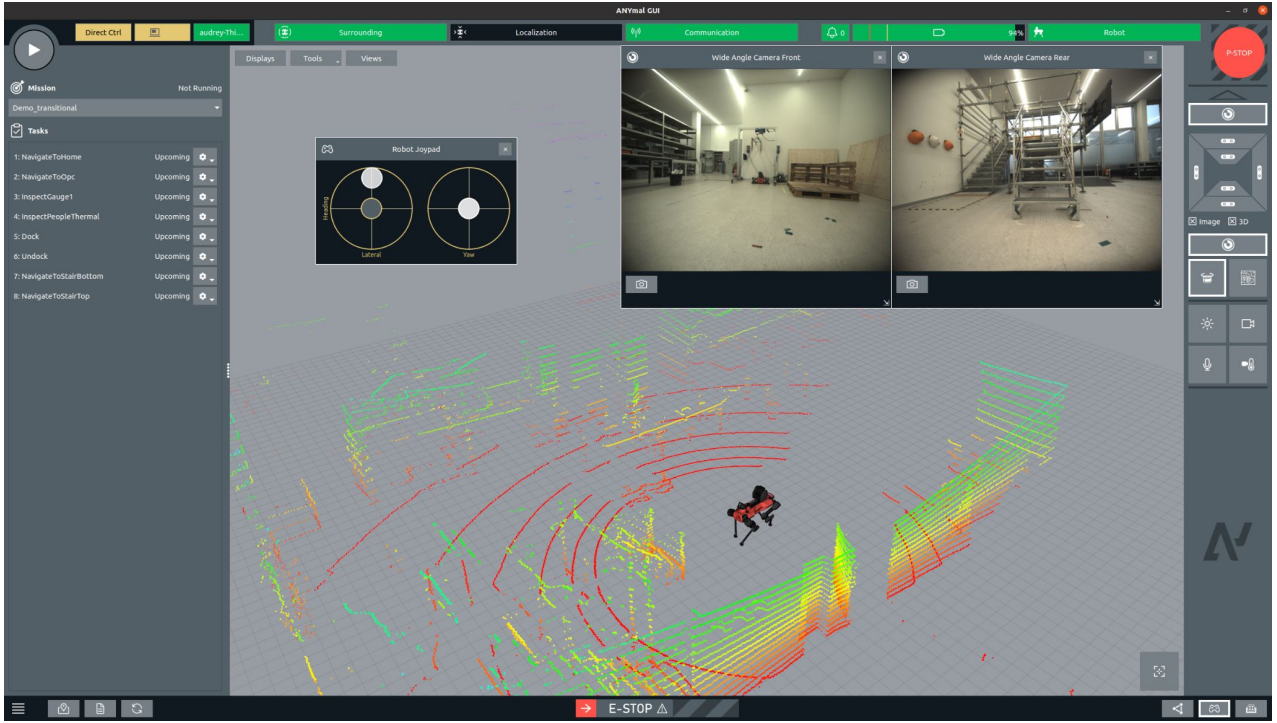
Server

Private Key XXX
Public Key ABC
Address = 10.8.0.1/24

Public IP 123.456.789

Operator GUI

OPERATOR'S MANUAL Section 1.11.11



ANYmal can be teleoperated through the Operator GUI, using the wide-angle cameras streams and digital joystick.

WARNING: the wide-angle cameras do not provide a 360° view. Be aware of blind spots and operate the robot accordingly.

Service and Maintenance

- Regular Inspection Checks
- Scheduled Inspection Checks
- Preventive Maintenance Tasks
- Parts Replacement
- Robot and Battery Storage

Regular Inspection Checks

OPERATOR'S MANUAL Section 10.1

The inspection checks below should be carried out prior to using the robot and regularly during extended periods of operation:

- Check for software and firmware updates.
- Check cleanliness of the sensor glass, joints and docking socket.
- Check for visible damage or wear on the robot body, battery, payload and hoist points.

Scheduled Inspection Checks

OPERATOR'S MANUAL Section 10.2

The inspection checks below should be scheduled and carried out every 3 months or after a fall or maintenance:

- Check the robot feet for damage and wear.
- Check the robot for damage.
- Check the cameras and lenses for damage.

The inspection checks below should be scheduled and carried out every 12 months or after a fall or maintenance:

- Test the safety functions.

Preventive Maintenance Tasks

OPERATOR'S MANUAL Section 10.3

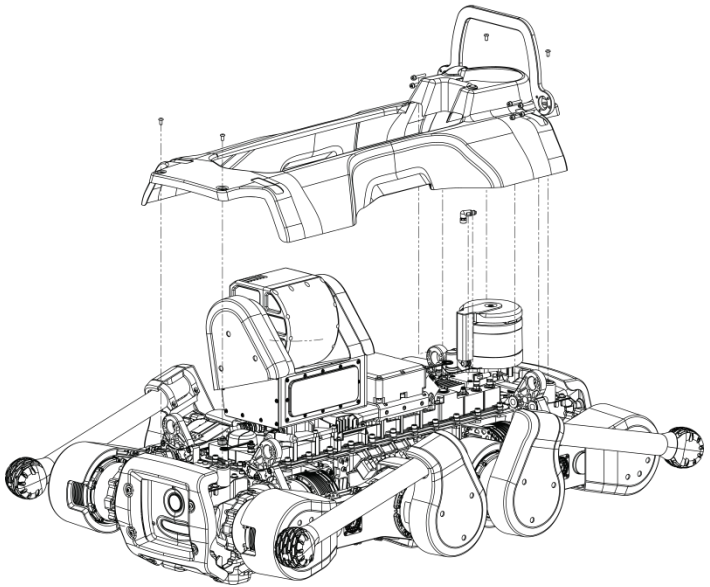
The maintenance tasks below should be carried out regularly, depending on the work environment:

- Clean the robot and sensors.
- Clean the fans and fan guards.
- Clean the docking socket.
- Clean the docking station.

Parts Replacement

Some parts of the robot may have to be replaced periodically when worn or damaged. The following parts can be replaced:

- the top shell,
- the bottom shell,
- the protectors,
- the feet,
- the rollover bar,
- the hoist points,
- the docking socket.



Robot and Battery Storage

OPERATOR'S MANUAL Section 10.5

How to Store the Robot

If stored for more than 1 month, remove the battery.

Store in a dry and secure location in the transport box.

Store between 10° and 30°C at 50% humidity.

If the robot has been stored for more than 1 month, check all safety functions before using it again.

How to Store the Robot Battery

Store the battery at room temperature in a dry environment.

Store the battery in a flame retardant container, separated from anything hazardous and away from direct sunlight or other heat sources.

Store the battery with a 50% to 70% charge. Recharge the battery every six months when not in use.

Thank you!

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