CLEARPATH
ROBOTICS™

DINGO

UNMANNED INDOOR GROUND VEHICLE

USER MANUAL

CONTENTS

1 INTRODUCTION

Dingo is a lightweight and easy-to-use unmanned indoor ground vehicle for ROS Melodic, presented by Clearpath Robotics.

Dingo includes a standard internal PC, as well as basic IMU. Standard perception modules are available, including URDF and simulator integration, as well as demonstration applications.

There are two Dingo variants:

- Dingo-D: Uses differential drive and has two module bays, one of which must be a battery module; the second module is typically a computer module.
- Dingo-O: Uses omnidirectional drive and has four module bays, at least two of which are typically battery modules; the other modules may be computer modules or serve as expansion for other custom hardware.

Please inquire with Clearpath Robotics for details. See Contact on page 17 for contact information.

1.1 What's Included

Contained in your Dingo shipment are the following items:

- Dingo UGV (Dingo-D or Dingo-O variant)
- One or more 12V sealed lead acid (SLA) or 14.4V Lithium-ion batteries
- One or more 110/220V universal chargers for your batteries
- One Sony PS4 Bluetooth controller
- One Dingo User Manual

If you elected to purchase standard payload modules or custom integration services with Dingo, then additional equipment will be included per your specific configuration, plus further documentation as required.

1.2 Hardware Overview

Dingo's external features include the mounting pattern on the top trough cover, 98.4 mm diameter wheels (Dingo-D) or 101.6 mm diameter mechanum wheels (Dingo-O), human machine interface panel (HMI), top (yellow) fairings, and side access panels. The exteriors of Dingo-D and Dingo-O are shown in Figure 1 and Figure 2 respectively.

The HMI panel is shown in Figure 3, and includes from left: motor button, comms indictor, wifi indicator, battery indicator, and system power button.

To access Dingo's payload modules (computers or batteries), simply slide and remove the top (yellow) fairings. To access Dingo's MCU PCBA (for user power), remove the four M5 flathead screws from the top trough cover, and then remove the trough cover.

The interior of the Dingo-D is shown in Figure 4 and the interior of Dingo-O is shown in Figure 5 along with example payload modules.
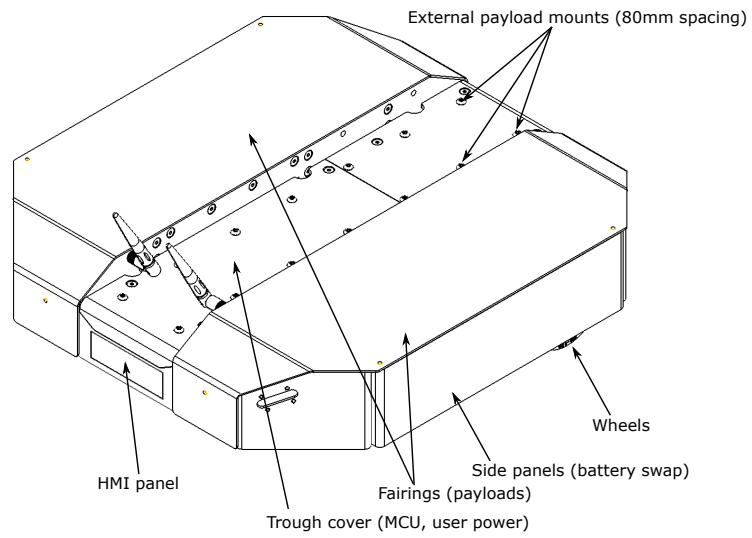
External payload mounts (80mm spacing)

Wheels

HMI panel

Side panels (battery swap)

Fairings (payloads)

Trough cover (MCU, user power)

Figure 1: Dingo-D exterior

External payload mounts (80mm spacing)

HMI panel

Side panels (battery swap)

Fairings (payloads)
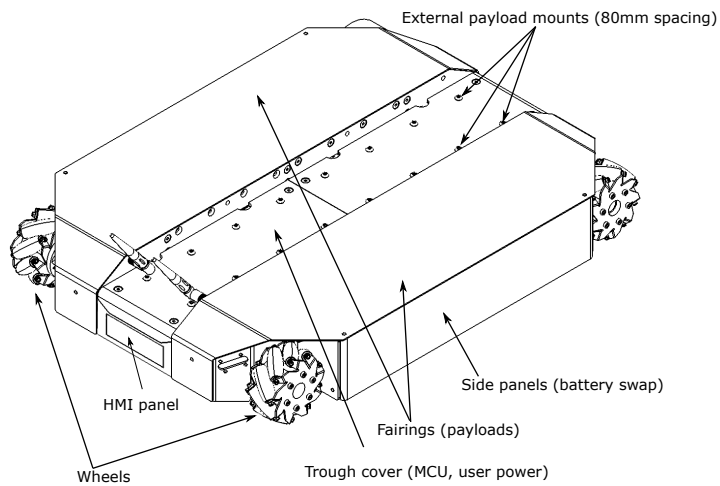
Wheels

Trough cover (MCU, user power)
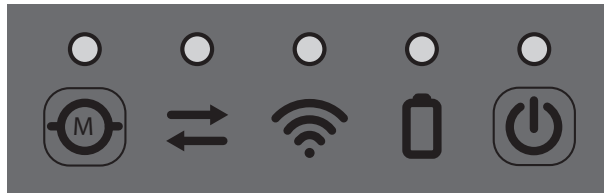
Figure 2: Dingo-O exterior

Figure 3: HMI panel.

Dingo-D will contain one battery module (Sealed Lead Acid or Lithium Ion) and Dingo-O will contain one or more battery modules. Batteries can be installed and removed by removing the corresponding side access panel and sliding the battery in or out as needed.

Dingo does provide an optional shore power connection to allow the system to be powered without requiring batteries to be present. Note that when shore power is connected, the motors are disabled and it is not possible to drive the Dingo; however, all other electronics (computers, sensors, etc) will remain enabled.

1.3 System Architecture

Like many ROS robots, Dingo is built around an x86 PC running Ubuntu, paired with a 32-bit MCU. The MCU handles I/O, power supply monitoring, and motor control, as well as supplying data from the integrated IMU. The communication channel between the MCU and PC is a Gigabit Ethernet connection.

The key topics which comprise Dingo's ROS API are given in Table 1.

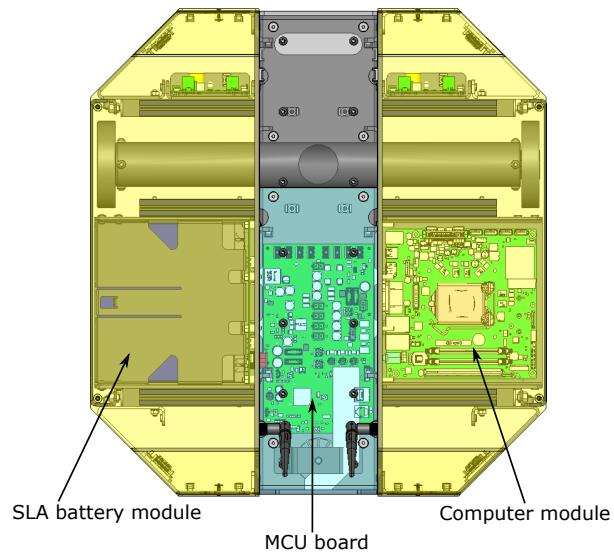| Topic	Message Type	Purpose
/cmd_vel	geometry_msgs/Twist	Input to Dingo's kinematic controller. Publish here to make Dingo go.
/odometry/filtered	nav_msgs/Odometry	Published by robot_localization, a filtered localization estimate based on wheel odometry (encoders), and integrated IMU.
/imu/data	sensor_msgs/IMU	Published by imu_filter_madgwick, an orientation estimate based on Dingo's internal IMU unit.
/mcu/status	dingo_msgs/Status	Low-frequency status data for Dingo's systems. This information is republished in human readable form on the diagnostics topic and is best consumed with the Robot Monitor.

Table 1: Dingo ROS API Topics

SLA battery module

MCU board

Computer module

Figure 4: Area inside Dingo-D, with example modules

Li-Ion battery module   SLA battery module

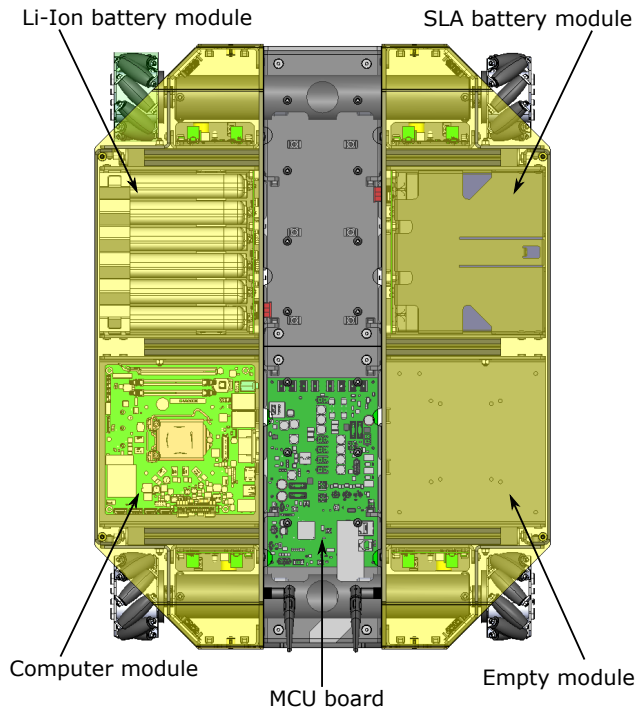Computer module   Empty module

MCU board

Figure 5: Area inside Dingo-O, with example modules

2 GETTING STARTED

The first step is to power up your Dingo and have some fun driving it around! If you've just unpacked Dingo from its packaging, you may need to open it up and connect the battery.

Press the power button ⏻ on Dingo's HMI panel. The LEDs should show a test pattern, after which you will wait about 30 seconds for the internal PC to finish booting up.

When the comms LED (⇄) is green, this signals that the PC is finished booting up, and that the PC and MCU are in communication. At this point, press the PS button on the Sony Bluetooth controller to sync the controller to Dingo. Once the blue LED on the top of the controller goes solid, you're paired and ready to drive. Hold the L1 trigger button (deadman switch), and push the left thumbstick forward to drive the Dingo. For full speed mode, hold the R1 trigger. See Figure 6 for the Sony PS4 controls layout.

Deadman Switch [L1]   Turbo [R1]
                                       Full Speed Mode

Steer
Forward/Backward
Dingo-D: Yaw Left/Right
Dingo-O: Planar Left/Right
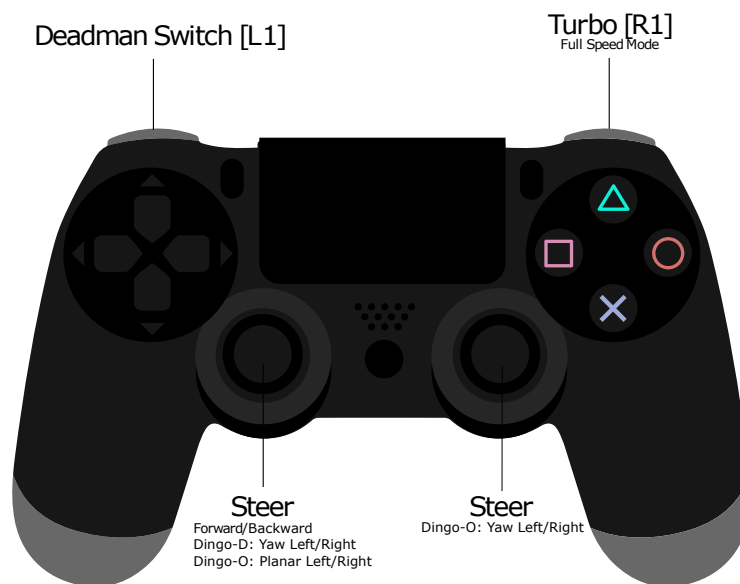
Steer
Dingo-O: Yaw Left/Right

Figure 6: PS4 Controls Layout

If you're not seeing any action, check Contact on page 17 to get in touch with support.
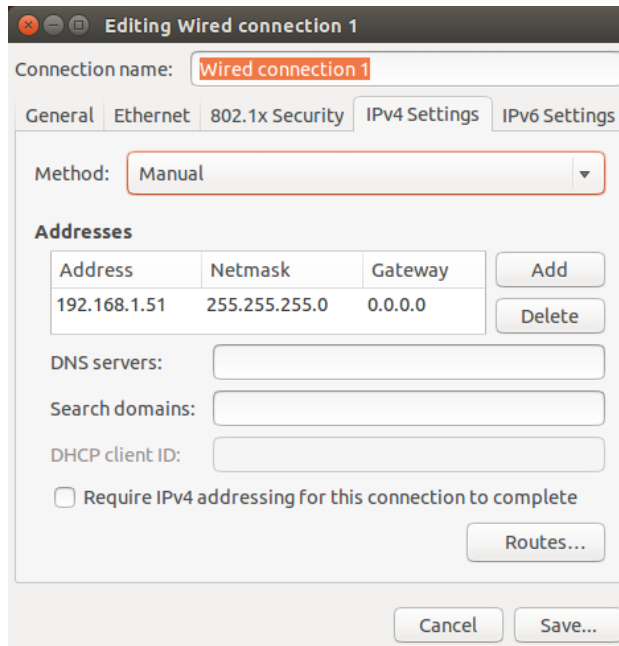
2.1 Wireless Access

To get Dingo connected to your local wifi, you must first access the internal computer using a wired connection. Open the chassis, lower the computer tray, and connect to the network port labeled `STATIC` with a standard ethernet cable.

2.1.1 Static IP Configuration

Set your laptop's ethernet port to a static IP such as `192.168.131.51`. To do this in Ubuntu, follow the steps below:

1. Click on the Wifi icon in the upper-right corner of your screen, and select **Edit Connections**

2. In the **Network Connections** window, under **Ethernet**, select your wired connection and then click **Edit**

3. Select the **IPv4 Settings** tab and then change the **Method** to `Manual`

4. Click the **Add** button to add a new address

5. Enter a `192.168.131.51` as the static IP under the **Address** column, and enter `255.255.255.0` under the **NetMask** column, and then select **Save**

Figure 7: Static IP Configuration

2.1.2 Connect to Dingo via SSH over ethernet

The next step is to connect to Dingo via SSH. To do so execute the following in a terminal window:

```
ssh administrator@192.168.131.1
```

You will be promoted to enter a password. The default password is `clearpath`.

2.1.3 Connect Dingo to Wireless Network

Now that you're connected via SSH over a wired connection, you can setup Dingo to connect to a local wifi network. To do this, you will use the wireless interface configuration daemon (WICD) - a preinstalled network manager.

In a terminal window, execute the following command:

```
wicd-curses
```

You should see a browsable list of networks which the robot has detected. Use arrow keys to select the one you would like to connect to, and then press the right arrow to configure it. You can enter your network's password near the bottom of the page, and note that you must select the correct encryption scheme; most modern networks use WPA1/2 Passphrase, so if that's you, make sure that option is selected. You also likely want to select the option to automatically reconnect to this network, so that Dingo will be there for you on your wireless automatically in the future.

When you're finished, press **F10** to save, and then **C** to connect. Dingo is now connected to wifi!

While you're still wired to Dingo, you'll need to identify the IP address of Dingo's wireless connection.

In a terminal window, execute:

```
ifconfig
```

A list of network connections will be displayed within the terminal. Locate the wireless network and make note of its IP address. Now that you know Dingo's wireless IP address, you may now exit the ethernet SSH session by executing `exit`.

Remove the ethernet cable and close up Dingo. Now you can SSH into Dingo over the wireless network. To do so, execute:

```
ssh administrator@<IP_OF_DINGO>
```

SSH sessions allow you to control Dingo's internal computer. You can do various things such as download packages, run updates, add/remove files, transfer files etc.

2.2 Remote ROS Connectivity

To use ROS desktop tools, you'll need your computer to be able to connect to Dingo's ROS master. This will allow you to run ROS commands like `rostopic list`, `rostopic echo`, `rosnode list`, and others, from a remote PC and the output will reflect the activity on Dingo's ROS master, rather than on your own machine. This can be a tricky process, but we've tried to make it as simple as possible.

In order for the ROS tools on your computer to talk to Dingo, they need to know two things:

- How to find the ROS master, which is set in the `ROS_MASTER_URI` environment variable, and
- How processes on the other computer can find your computer, which is the `ROS_IP` environment variable.

The suggested pattern is to create a file in your home directory called `remote-dingo.sh` with the following contents:

```
export ROS_MASTER_URI=http://cpr-dingo-0001:11311  # Dingo's hostname
export ROS_IP=10.25.0.102        # Your laptop's wireless IP address
```

If your network doesn't already resolve Dingo's hostname to its wireless IP address, you may need to add a corresponding line to your computer's /etc/hosts file:

```
10.25.0.101 cpr-dingo-0001
```

NOTE: You can verify the hostname and IP address of Dingo using the following commands during an SSH session with the onboard PC.

```
hostname
hostname -i
```

Then, when you're ready to communicate remotely with Dingo, you can source that script like so, thus defining those two key environment variables in the present context.

```
source remote-dingo.sh
```

To verify that everything is set up propelry, try running a few ROS commands, such as the standard visual ROS tools:

```
roslaunch dingo_viz view_robot.launch
rosrun rqt_robot_monitor rqt_robot_monitor
rosrun rqt_console rqt_console
```

If the tools launch, then everything is setup properly.

Please contact Clearpath Support if you need assistance in configuring remote access. For more general details on how ROS works over TCP with multiple machines, please see:

http://wiki.ros.org/ROS/Tutorials/MultipleMachines.

For help troubleshooting a multiple machines connectivity issue, see:

http://wiki.ros.org/ROS/NetworkSetup

2.3 Dingo Desktop Packages

To command or observe Dingo from your desktop computer, first set up a basic ROS installation. See the following page for details:

http://wiki.ros.org/melodic/installation/ubuntu

When your ROS install is set up, install the Dingo desktop packages:

```
sudo apt-get install ros-melodic-dingo-desktop
```

Once your remote access to Dingo's ROS master is configured (see options in subsection 2.2), you can launch rviz, the standard ROS robot visualization tool:

```
roslaunch dingo_viz view_robot.launch
```

From within rviz, you can use interactive markers to drive Dingo, you can visualize its published localization estimate, and you can visualize any attached sensors which have been added to its robot description XML (URDF).

Additionally from the desktop, you can launch the standard RQT Robot Monitor, which watches the diagnostic output from Dingo's self-montoring capabilities:

```
rosrun rqt_robot_monitor rqt_robot_monitor
```

3 APPS

When equipped with a laser scanner as is available in the Gazebo simulation, Dingo works with the standard ROS navigation stack. See http://wiki.ros.org/dingo_navigation.

4 CHARGING & BATTERY MAINTENANCE

When finished with the Dingo, press and release the power button ⏻ to power it off. Then remove the batteries for charging.

Dingo's batteries are charged outside the Dingo using the charger(s) provided.

Alternatively, if you have multiple batteries, you can hot-swap them one at a time. The system will remain operational while hot-swapping as long as there is at least one battery in the system or the system is connected to shore power prior to removing the batteries. Note that plugging in shore power will engage a motor stop and it is not possible to drive Dingo while connected to shore power.

The Sealed Lead Acid batteries have overcurrent protection in the form of an ATO fuse. The Lithium-Ion batteries include integrated protections against fault due to overcurrent, overdischarge, and short circuit. The batteries are rugged and designed for the demanding environments into which Dingo may be deployed.

However, please take note of the following:

- SLA batteries must be charged while in a 0 to 45 $^\circ$C range and discharged while in a -30 to a 60 $^\circ$C range.

- Li-Ion batteries must be charged while in a 0 to 50 $^\circ$C range and discharged while in a -20 to a 60 $^\circ$C range.

- The batteries must not be punctured or disassembled.

- The batteries should be dropped off or delivered to your local hazardous waste authority for disposal.

- When traveling with Dingo, consult your airline's restrictions regarding lithium batteries (if applicable). If possible, bring the batteries in your carry on luggage, where they will be subject to normal cabin temperatures and pressures.

Please contact Clearpath Robotics for additional information about Dingo's batteries or for information about purchasing additional batteries.

5 PAYLOAD INTEGRATION GUIDE

If you're wanting to attach custom hardware to Dingo, you'll have to take care of mechanical mounting, electrical supply, and software integration. This section aims to equip you with respect to these challenges.

5.1 Mechanical Mounting

External payloads can be attached to the 80 mm square mounting holes on Dingo's trough cover as shown in Figure 4 and Figure 5. The mounting holes come with M5 screws pre-installed. You may mount your hardware directly onto the trough cover or you may design and mount a new plate to the trough cover and secure it to the trough cover using M5 screws.

5.2 Electrical Integration

Except for bus-powered USB cameras, most payloads have separate leads for power and data. Data connections may be brought through the openings in the trough cover and connected directly to the internal computer. Dingo's internal computer options support USB3 and Ethernet connectivity. With the performance PC, the PCIe Gen3 x16 slot may be used to supply a GPU or other attachements, as necessary.

Additionally, the internal mounting area may be used for an Ethernet switch, when attaching multiple Ethernet payloads, or for a PoE power injector as required.

The power lead may likewise be brought through the trough cover, and connected to the user power: unregulated battery power, regulated 12V power, or regulated 5V power. Remove the front trough cover by removing four flathead screws and locate the appropriate power connector on the MCU board. Refer to Figure 8 for the location of the user power connectors. Use DigiKey part WM3701-ND for connecting to 12V/5V power and DigiKey part WM10378-ND for connecting to VBAT power.
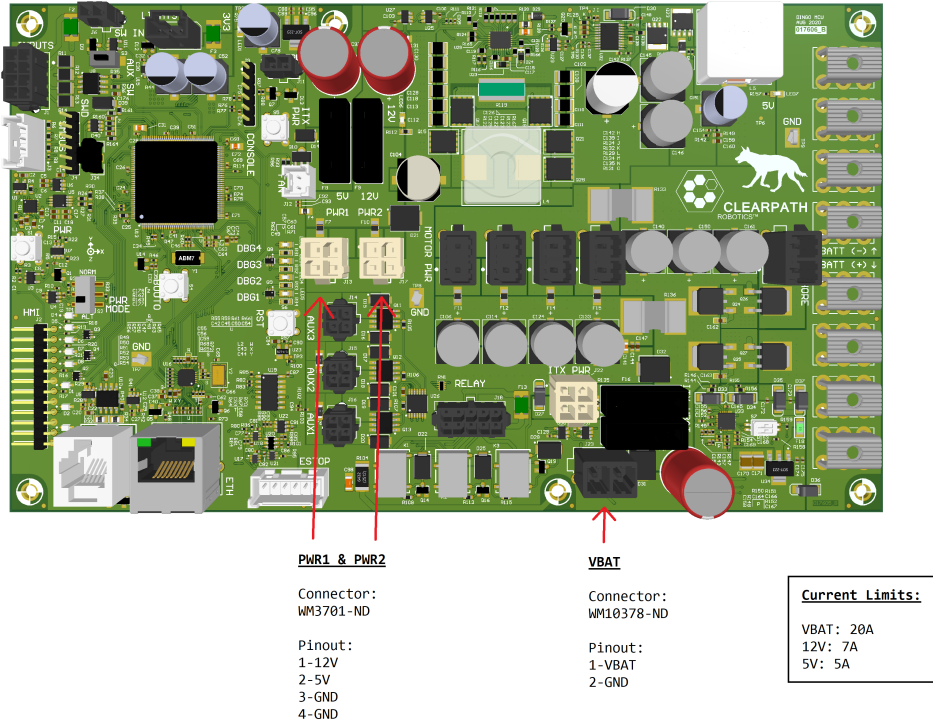
Figure 8: Dingo MCU and User Power

Route the power from the MCU board to the appropriate location, either to the internal payload modules or through the openings in the trough cover to the topside payload.

5.3 Software Integration

ROS has a large ecosystem of sensor drivers, some of which include pre-made URDF descriptions and even simulation configurations. Please see the following page on the ROS wiki for a partial list:

http://wiki.ros.org/Sensors

For the best experience, consider purchasing supported accessories from Clearpath Robotics for your Dingo, which will include simulation, visualization, and driver support. However, we will happily assist you in integrating your own devices as well.

6 CONTACT

Clearpath is committed to your success with Dingo. Please get in touch with us and we'll do our best to get you rolling again quickly: support@clearpathrobotics.com

To get in touch with a salesperson regarding Dingo or other Clearpath Robotics products, please email sales@clearpathrobotics.com.

If you have a an issue that is specifically about ROS and is something which may be of interest to the broader community, consider asking it on answers.ros.org. If you don't get a satisfactory response, please ping us and include a link to your question as posted there. If appropriate, we'll answer in the ROS Answers context for the benefit of the community.

Dingo is designed not to require regular maintenance. As it is a new product, Clearpath appreciates your patience as we continue to improve the platform.