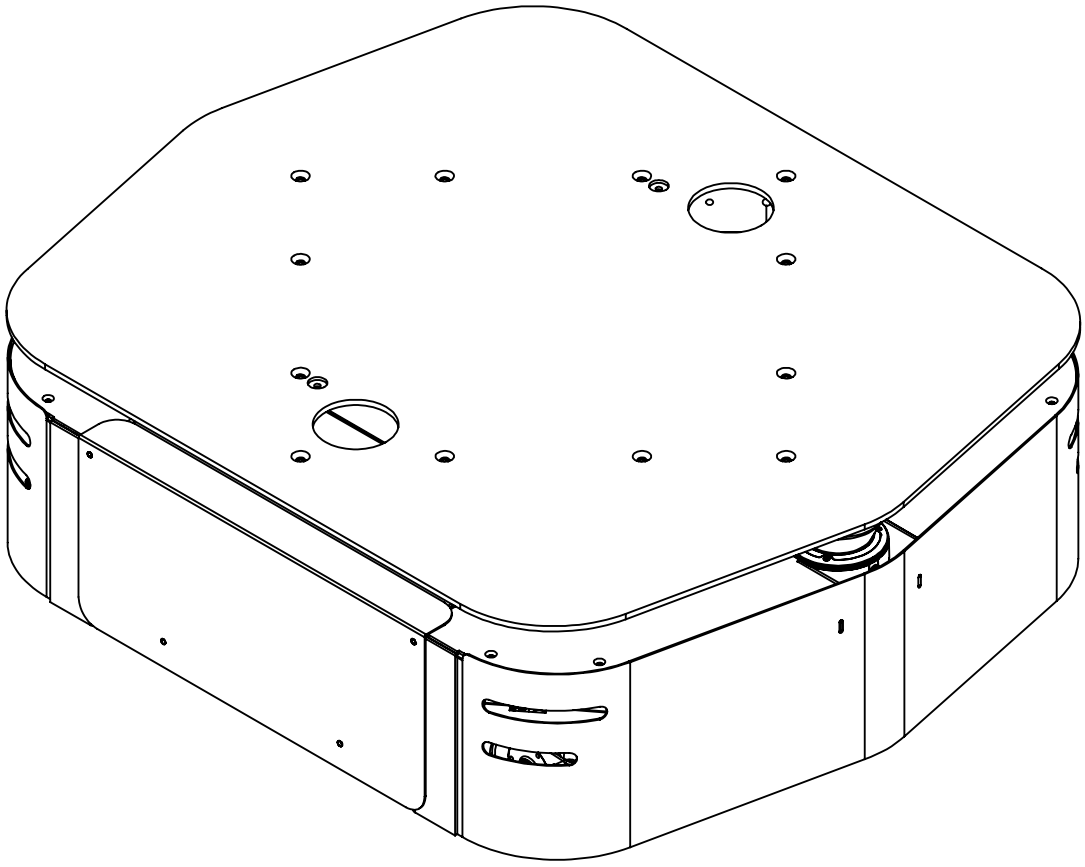
CLEARPATH ROBOTICS™



RIDGEBACK

OMNIDIRECTIONAL PLATFORM

USER MANUAL

CONTENTS

1 INTRODUCTION

Clearpath Robotics Ridgeback is a sturdy omnidirectional platform designed to move manipulators and other heavy payloads with ease. This guide contains information about the setup, operation, and maintenance of your Ridgeback.

1.1 What's Included

Included with each Ridgeback are the following:

- 1x Ridgeback
- 1x Battery Pack
- 1x Universal battery charger
- 1x Sony Bluetooth controller
- 1x Ridgeback User Manual
- 1x Onboard Mini ITX Computer with ROS Platform
- 1x Hokuyo UST-10LX forward facing LIDAR

1.2 Expansions

To expand the capabilities of Ridgeback, consider the following integrated packages offered by Clearpath Robotics:

1.2.1 Baxter Package

The Baxter Package includes an adjustable podium mount, power system tie-ins and communication for Baxter, enabling the robot to be integrated in under 30 minutes. Easily coordinate behaviours between Ridgeback and Baxter with full ROS, Gazebo Physics Simulator, RViz and MoveIT! Motion planner support.

Included Accessories:

- Baxter Mounting Podium
- 120/240V VAC power inverter

1.2.2 UR5 Package:

The UR5 Package includes mechanical mounting, integrated UR5 controller, power and communications for the Universal Robotics UR5 robot arm. It also includes a Robotiq 3-Finger gripper and a force torque sensor. Easily coordinate behaviours between Ridgeback and UR5 with full ROS, Gazebo Physics Simulator, RViz and MoveIT! Motion planner support.

UR5 Packages

Included Accessories:

- BUR5 robot arm
- 3 Finger 85 Robotiq gripper
- Robotiq FT 150 force-torque sensor
- BumbleBee stereo camera
- FLIR PTU D46-17 pan-tilt unit

1.3 Hardware Overview

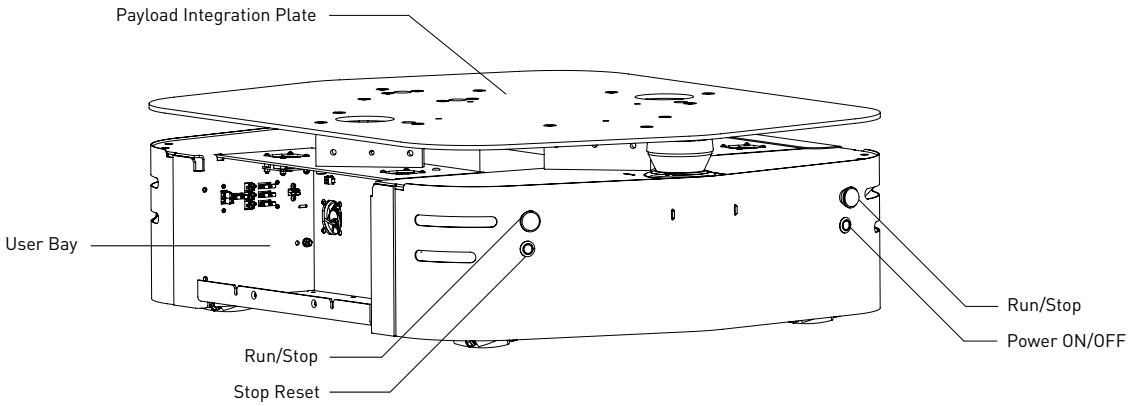


Figure 1: Ridgeback Hardware Overview

1.3.1 Rear Buttons

There are four push buttons located on the back of the Ridgeback: Stop, Stop Reset and Power ON/OFF. Each button is described in Table 1.

Power ON/OFF	Turns on/off the Ridgeback.
Stop (x2)	Stops the robot. Intended for use in emergency situtions.
Stop Reset	Allows Ridgeback to run again after Stop button has been pressed.

Table 1: Ridgeback Rear Buttons

1.3.2 User Bay

The User Bay provides access to the User Power electrical panel and additional space for stowing user equipment. The electrical panel can be used to power your payload structures. For more information on electrical payload integration, please see Electrical Integration on page 13.

1.3.3 Payload Integration Plate

The Payload Integration Plate provides a robust foundation for mounting payload stuctures such as Baxter, UR5/UR10 manipulation arms, or any other combination of sensors and manipulators. For more information and guidance on mounting payload structures ontop of Ridgeback, plage refer to Mechanical Mounting on 13.

1.4 System Architecture

1.5 Technical Specifications

Key specifications of Ridgeback are shown in Table 2.

External Dimensions (L x W x H)	932 x 793 x 298 mm
Weight	125 kg
Obstacle Clearance	18 mm
Max Payload	100kg
Max Speed	1.1 m/s
Drive Configuration	4 Independently driven omni-directional wheels
Operating Environment	Indoor
Battery Chemistry	Marine Grade AGM Sealed Lead Acid
Capacity	24 V 100 Ah
Operating Time	8 Hours max
Charge Time	5 Hours approx
User Power	5 V, 12 V, 24 VDC (fused at 10A each), option 120 VAC
Drive Power	200 W peak, 800 W continuous
Control Modes	Kinematic control (forward, sideways, rotaiton), individual wheel velocities
Feedback	Battery, gyroscope and accelerometer
Communication	Ethernet, USB 3.0, RS 232
Drivers and APIs	ROS Indigo, Gazebo, Navigation Support, MoveIt!

Table 2: Ridgeback System Specifications

1.6 Safety Considerations

1.6.1 General Warnings

Ridgeback is a rugged and high-performance vehicle. For the safety of yourself and others, always conduct initial experiments and software development with the vehicle raised off the ground. Place a wooden crate, a set of sawhorses, a sturdy storage tub, or any other solid flat structure having a height greater than 6 inches under Ridgeback to keep the wheels clear of the ground (“up on blocks”).

When starting out, favor slower wheel speeds. Ridgeback’s control loops can accurately maintain velocities as low as 0.1 m/s. Operating at such speeds will give you more time to react if things don’t go quite as you expect.

1.6.2 Stop Buttons

Two red Stop buttons are located on the back of Ridgeback. Power supply to Ridgeback's motor drivers is enabled by a normally-open relay, which is closed in series with the stop switch. When in Stop mode the Ridgeback will not drive. The commands received during stop are not buffered; Ridgeback will always act on the latest commands received. This means that if the commands are stopped before the Stop button is released, the Ridgeback will not move. If the commands are continued, Ridgeback will move at the speed commanded once the Stop is released.

Always ensure the Stop button is accessible at all times. Avoid mounting payloads that extend over the rear of Ridgeback and would occlude the Stop buttons.

1.6.3 Electrical System

Ridgeback is powered by two lead-acid (PbSO4) deep-cycle AGM batteries, similar to the type found in electric wheelchairs, golf carts, and other vehicles. Ridgeback's battery is capable of delivering 2000W. This gives Ridgeback motors their great performance, however, it is also enough power to cause severe bodily harm. Always use caution when operating Ridgeback to avoid personal injury or property damange. To ensure saftey, please observe the following precautions:

- Do not tamper with the plug attached to the battery.
- Do not tamper with the fuse panel, except to check and change the fuses, and to connect and disconnect the battery plug.
- Always replace fuses with the same type and rating to ensure continued protection against risk of fires
- Always disconnect the battery before performing maintenance on the robot
- Do not lay tools or other objects on top of the battery
- Do not move the robot while charging the battery
- Charge the battery only with the charger provided by Clearpath Robotics
- Please dispose of the batteries properly, or return the battery to Clearpath Robotics to do so

1.6.4 Lifting and Transport

- Ensure that Ridgeback is e-stopped when transporting short distances and powered off when transporting longer distances
- Do not push the robot at more than 0.5 m/s (1.6 ft/s) or damage to the motor controls may occur

1.6.5 Performance Recommendations

Included in Ridgeback are native software checks and limits to protect the vehicle. However, it is recommended to monitor the system's status during usage with `/diagnostics/rqt_robot_moitor`. It is also advised to have your software subscribe to the `/ridgeback/data/system_status` topic. This topic provides useful information regarding voltages, currents and temperatures of the system in the following form:

Voltages: [battery voltage, left motor driver, right motor driver]

Currents: [total draw, left motor driver current, right motor driver current]

Temperatures: [Left motor driver temp, right motor driver temp, left motor temp, right motor temp]

The total current draw does not include the motors drivers; it is the current consumed by the MCU and user power ports. Ridgeback's motors are rated to draw 8A continuous, but they will spike to several times this, particularly when traversing rough terrain and when turning on the spot. To reduce current draw, consider commanding wider-radius turns from your control software.

The temperature is measured in the motor drivers and on the motor casings; the coils inside the motor casings cannot be measured. Therefore, it is important to note that the temperature measured on the motor casings is a lagging indicator of the temperature of the coils inside the casing. Be aware of the delay in heat propagation on the motors during heavy use. The thermal limit of the system is 50□C, and the system will shut down if this limit is reached. Monitoring these fields over longer periods of operation will allow you to ensure that you are not putting excessive wear on the motors.

2 GETTING STARTED

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

Press the power button on the back of the Ridgeback. The LEDs should show a test pattern, after which you will wait about 30 seconds for the internal PC to finish booting up.

Press the PS/P3 button on the Sony Bluetooth controller to sync the controller to Ridgeback. Once the small red LED on the controller goes solid, you're paired and ready to drive. Hold the L2 trigger button, and push the thumbstick forward. For full speed mode, switch to the L1 trigger.

If you're not seeing any action, check Contact on page 13 to get in touch with support.

2.1 Wireless Access

To get Ridgeback connected to your local wifi, you must first access the internal computer using a wired connection. Open the User Bay, and connect to one of the the network ports with a standard ethernet cable. Now, set your laptop's ethernet port to a static IP such as `192.168.1.51`, and connect via SSH to `administrator@192.168.1.1`. The default password is `clearpath`.

Once connected via wire, execute `wicd-curses` to enter the text/curses UI to the wireless interface configuration daemon (WICD). Within the text UI, you can configure which wireless network you'd like Ridgeback to connect to upon system startup.

When the wireless link is established, remove the network cable, re-establish your SSH session over wireless, and close the Ridgeback User Bay.

2.2 Remote ROS Connectivity

Now that Ridgeback is on the wireless, you can access it via SSH or as a remote ROS master. Note that in the default configuration, the background job running on Ridgeback launches with the `robot_upstart` package, which is configured to set the ROS_IP environment variable to the static IP of the em1 ethernet port, by default `192.168.1.1`.

What this means is that in order for a workstation to communicate with Ridgeback over wireless, you may need to change one of three things:

1. If you're confident that Ridgeback will be operated only where it is connected to wifi, you could set `robot_upstart` to start the background ROS job only once wifi connects. To change this, run:

```
rosrun robot_upstart install ridgeback_base/launch/base.launch \
--job ros --interface wlan0
```

2. If you're confident that your network will resolve hostnames correctly, you could change the generated ROS start script (in `/usr/sbin/ros-start`) to set the `ROS_HOSTNAME` env var rather than `ROS_IP`.

3. Finally, you can add a static route to your workstation which will route requests from 192.168.1.1 to Ridgeback's real wireless IP on your network. An example of this configuration:

```
sudo apt-get install ros-indigo -robot-upstart
export ROS_MASTER_URI=http://192.168.1.1:11311
export ROS_IP=$(rosrun robot_upstart getifip wlan0)
sudo route add -net 192.168.1.1 netmask 255.255.255.255 gw $ROS_IP
```

These commands would be executed on your own machine.

Please contact Clearpath Support if guidance is required in selecting and executing a remote access strategy. 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 Visualizing Ridgeback

GAZEBO or MOVEIT?

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

http://wiki.ros.org/indigo/Installation/Ubuntu

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

```
sudo apt-get install ros-indigo -ridgeback -desktop
```

Once your remote access to Ridgeback's ROS master is configured, you can launch rvis, the standard ROS robot visualization tool:

```
roslaunch ridgeback_viz view_robot.launch
```

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

Additionally from your desktop, you can launch the standard RQT Robot Monitor, which watches the diagnoztic output from Ridgeback's self-monitoring capabilities:

```
rosrun rqt_robot_monitor rqt_robot_monitor
```

3 CHARGING AND BATTERY MAINTENANCE

Ridgeback uses two 8A31DTM Group-31 lead-acid (PbSO4) deep-cycle AGM batteries mounted low in the chassis. They provide an output of 24Vdc (nominal) and 100Ah of capacity and also serve as ballast to help keep the centre of gravity of the robot low, even with payloads mounted atop it.

Ridgeback has an internal charger. All that is required to charge Ridgeback is to open the User Bay access panel, locate the charger power cord and plug it into any 100-240Vac, 50/60Hz mains outlet. The robot can be turned ”on” though we recommend against driving the robot when the battery is charging.

If Ridgeback’s batteries need replacement they’re accessible by removing the top-plate and the insulator cover. Before performing any service or maintenance to the robot the battery pack must be fully disconnected. The batteries weigh approximately 33-kg (73-lbs) each so use all necessary care and caution when lifting the batteries out of the chassis. Please contact Clearpath Robotics regarding replacement batteries.

The battery pack is rugged and designed for the environments into which Ridgeback may be deployed. However, please take note of the following:

- The batteries and/or robot must not be stored or operated above xx◦C or below yy◦C. (MPa - insert proper temps here)
- If the robot is to be stored for any length of time it should be in a cool, dry location. The batteries should be fully charged and periodically maintained at full charge to ensure a long service life.
- The batteries must not be punctured or disassembled.
- The batteries should be disposed of pursuant to your local regulations regarding electrical and/or hazardous waste
- If it is necessary to ship Ridgeback contact Clearpath Robotics for shipping information regarding the batteries.

Please contact Clearpath Robotics for additional information about Ridgeback’s battery or for information about purchasing replacement batteries.

4 PAYLOAD INTEGRATION GUIDE

If you want to attach custom hardware to Ridgeback, you will have to take care of mechnical mounting, electrical supply, and software integration. This sectoin aims to equip you with respect to these challenges.

4.1 Mechanical Mounting

The payload integration plate can be used to mount external payloads ontop of the Ridgeback. The plate is made of aluminum, which provides a level of robustness to support payloads up to 100 kg (220 lbs). Ridgeback's battery packs are positioned low in the chasis and slightly rearward of center of the robot to balance the weight distribution when mounting front-facing manipulator payloads. To minimize the possibility of tipping over, payload structures should always be mounted as close to center as possible.

4.1.1 Payload Mounting Holes

Located towards the front-end of the mounting plate are two 5/8"-11 screw holes for mounting Baxter, UR5/UR510 manipulator arms, or any other payload structure. These holes are indicated in Figure 2. If you purchased the Baxter or UR5/UR10 package from Clearpath Robotics, Ridgeback will come with the required hardware adapaters and two 5/8"-11 Socket Head Cap Screws to securely mount the payload structure to the plate.

4.1.2 Cable Passthroughs

The two larger holes on the left and right side of the plate allow you to pass electrical wires and cables from the mounted payloads into the encolsed User Bay and the PC Bay. Electrical wires should always pass through the provided plastic grommets to protect against cutting and abrasion.

4.2 Electrical Integration

The three white Molex user power receptacles located in the User Bay and shown in Figure 3 are capable of supplying 5Vdc, 12Vdc, and unregulated battery voltage (approximately 24Vdc) for powering Ridgeback's payloads. See the illustration for the pin assignments. The total draw allowed on each rail is 5-amps. The mating connector for these Molex Mini Fit Jr (tm) receptacles is 39-01-2040, available at Digikey (part number WM3701-ND.) Ensure you select the contact appropriate for the gauge of wire used.

The single red and black Anderson connector pair provides unregulated battery voltage (approximately 24Vdc) at up to 20-amps peak. The mating parts are Anderson PP45 Power Pole (tm) 1327 (red housing), 1327G6 (black housing) and 261G2-LPBK (contacts.) These components are readily available at Mouser.com.

The rails on the User Bay Power board are protected against short circuit by fuses. See the illustration for the fuse locations and purposes.

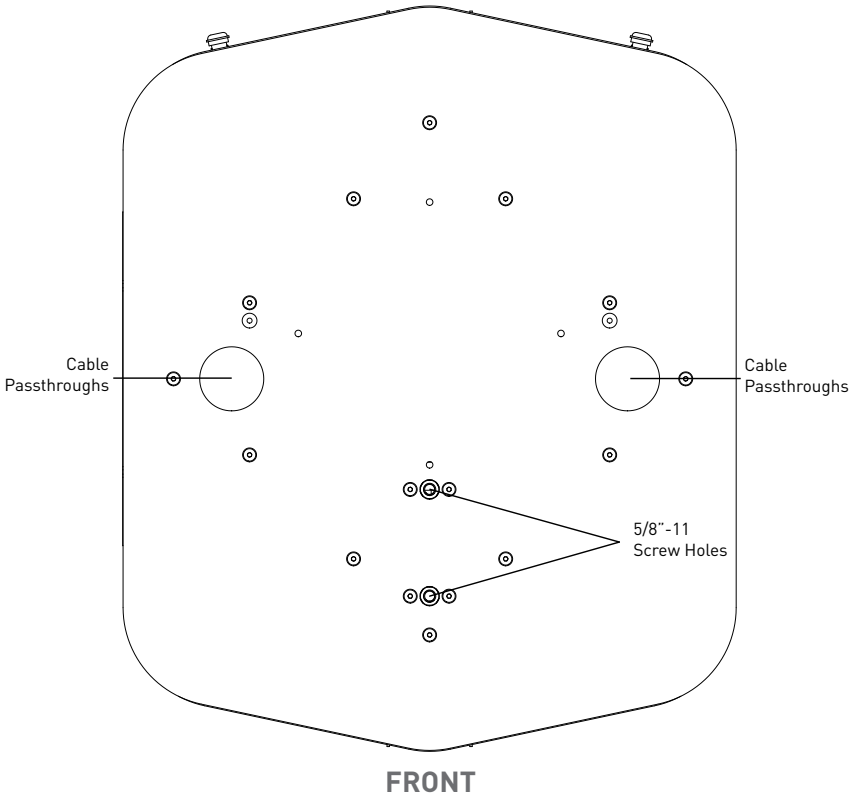


Figure 2: Ridgeback Payload Integration

WARNING: For continued protection against risk of fire, always replace fuses only with those of the same type and rating.

CAUTION: The unregulated battery output may range from as low as 20Vdc up to 30Vdc or more depending on the state of charge of the battery pack and the electrical loading on the system. Ensure any accessories connected to that rail are able to deal with unregulated battery voltages.

4.3 Software Integration

ROS has a large ecosystem of sensor drivers, some of which include pre-made URDF description 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 Ridgeback, which will include simulation, visualization, and driver support. However, we will happily assist you in

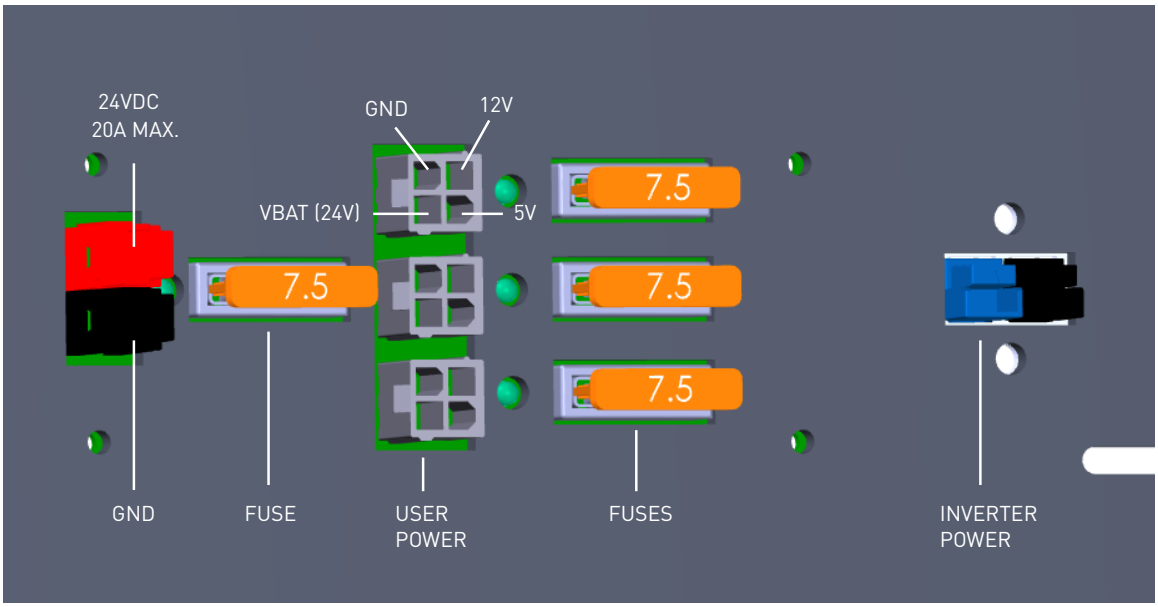


Figure 3: Ridgeback Power User Panel

integrating your own devices as well.

5 CONTACT

Clearpath is committed to your success with Ridgeback. 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 Ridgeback 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.

Ridgeback is designed not to require regular maintenance. As it is a newer product, Clearpath appreciates your patience as we understand its weak-point components and fill out the appropriate care instructions for the platform.