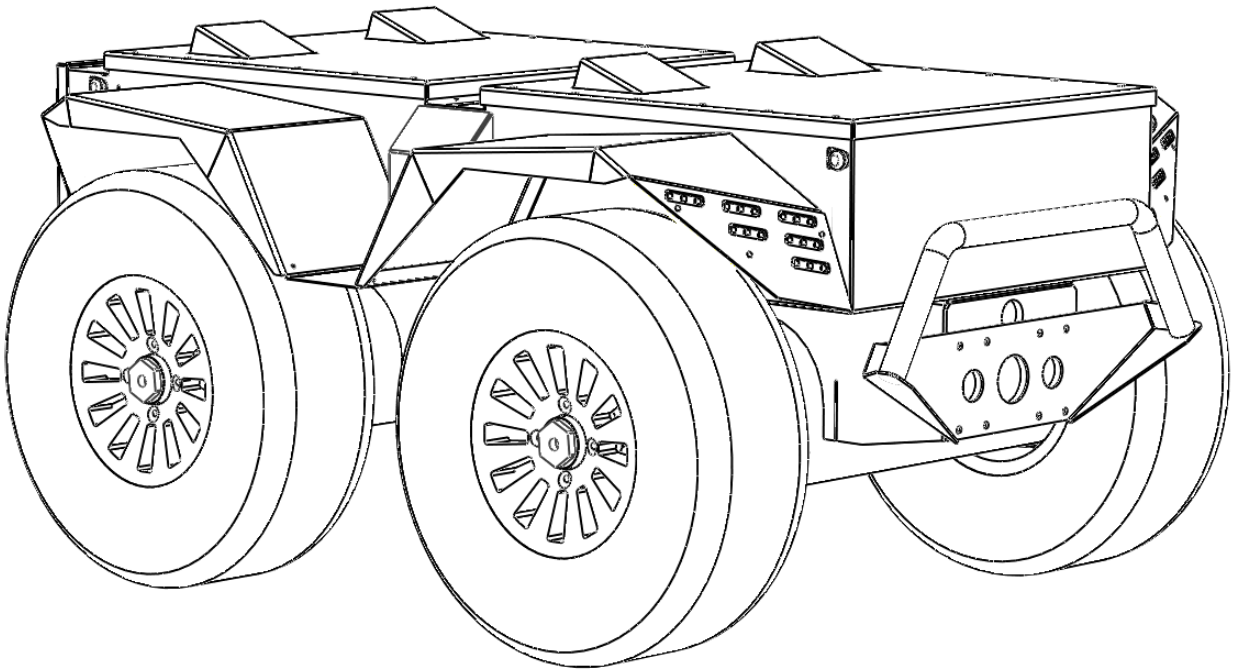
CLEARPATH ROBOTICS™



GRIZZLY

ROBOTIC UTILITY VEHICLE

USER MANUAL

CONTENTS

INTRODUCTION

Clearpath Robotics Grizzly is a rugged and easy-to-use Robotics Utility Vehicle (RUV) for rapid prototyping applications. In this guide, you will find information about the setup, operation, and maintenance of your Grizzly RUV.

What's Included

Included with each Grizzly are the following:

- 1 x Clearpath Robotics Grizzly
- 1 x 120 VAC wall charger
- 1 x Wireless controller
- 1 x Key set (2 keys)

Your Grizzly may also include additional sensors or infrastructure, depending on your customization choices.

What's Required

To simply drive Grizzly right out of the box, use the wireless controller as described in the Getting Started section on page 15.

To realize the full potential of Grizzly as a research platform, it will be desirable to interface with the onboard PC, using Robot Operating System (ROS). The onboard computers run Ubuntu Linux 12.04, and ROS Hydro. For maximum simplicity, a development machine should be the same; however, any version of Ubuntu supported by ROS Hydro will be adequate.

THE BASICS

This section provides an overview of the key specifications of the Grizzly platform.

Figure 1 and **Figure 2** give a tour of key Grizzly base components.

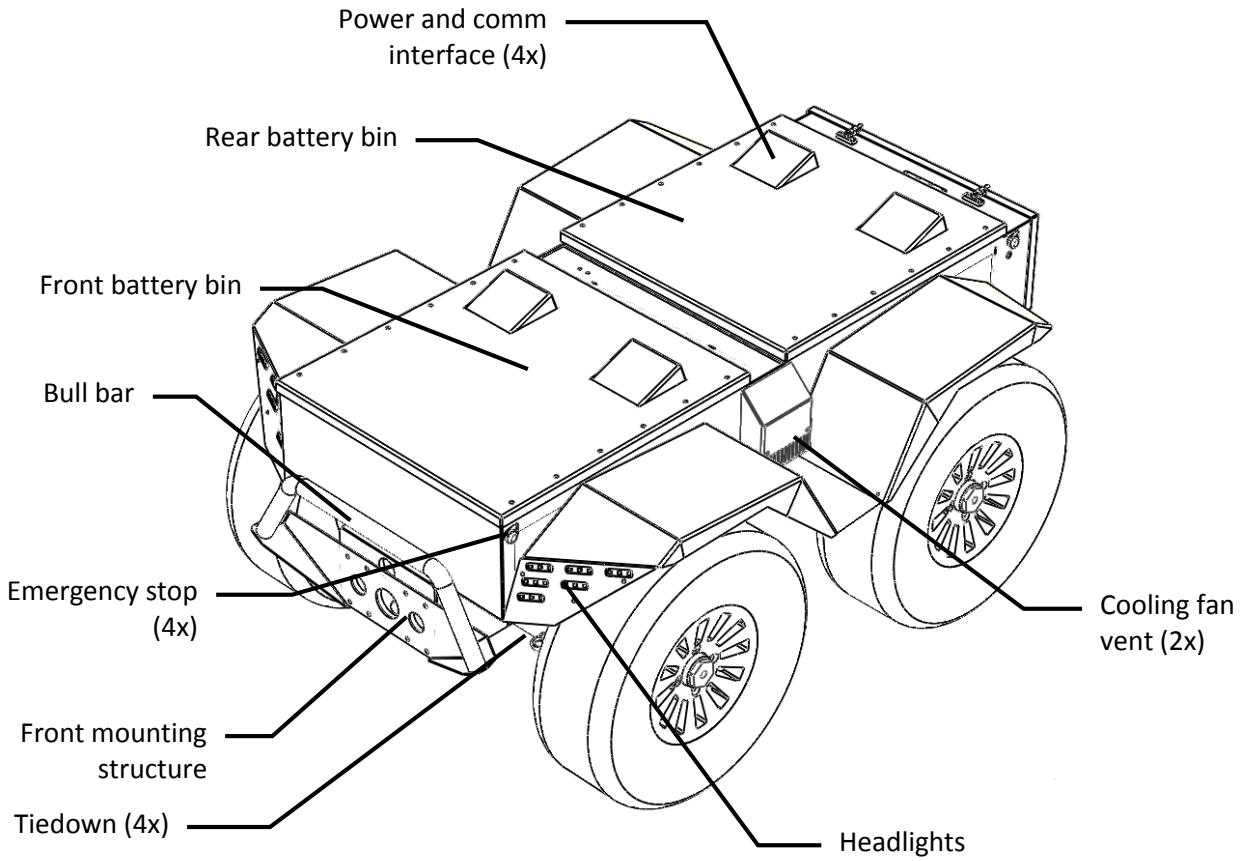


Figure 1: Grizzly at a Glance (Front View)

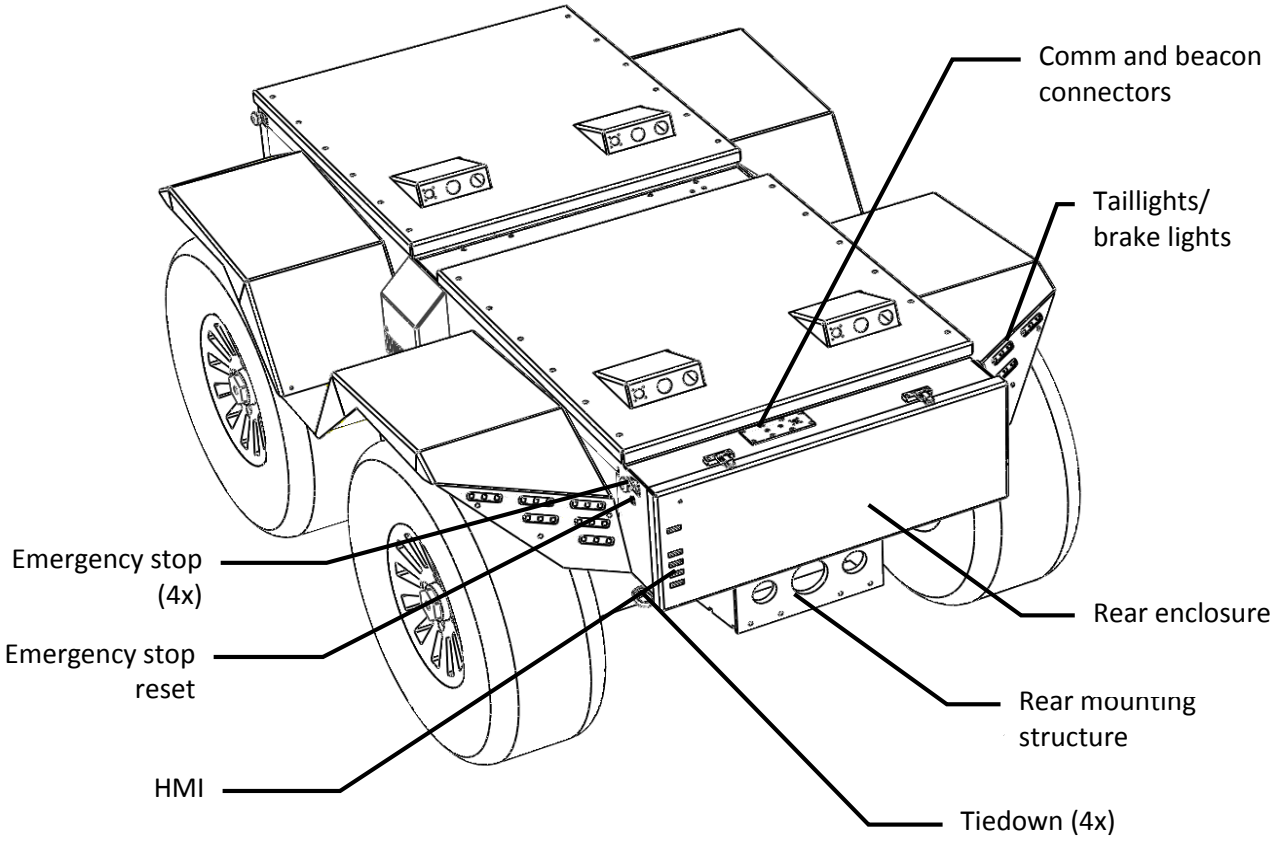


Figure 2: Grizzly at a Glance (Rear View)

Hardware Architecture

Figure 3 gives an overview of the standard devices which make up Grizzly. This diagram is provided to aid the user in understanding how Grizzly is architected. Details of the power system (including the relays and emergency stop system) are not shown.

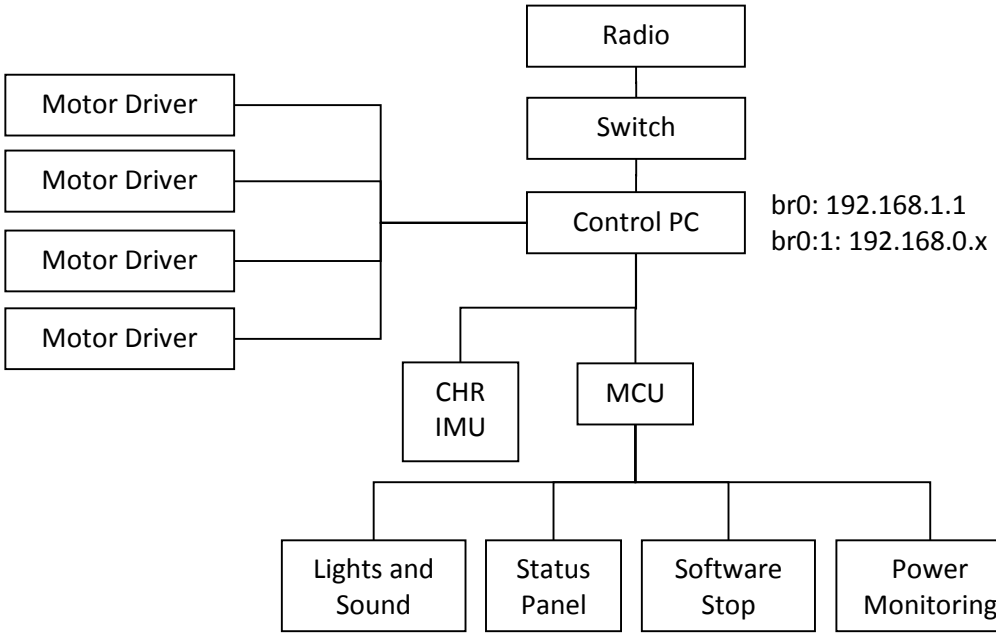


Figure 3: Grizzly Architecture

The eth0 interface on the Control PC is split into two "virtual interfaces". One has a static IP of 192.168.1.1, interfaces with the onboard sensors, and is the ROS master. The second has an IP in the 192.168.0.*x* range, with the IP being assigned via a DHCP server on a radio. If Grizzly is configured with a base station, the DHCP server is on the base station radio and the onboard radio serves as a bridge. If Grizzly is configured to host its own network, the DHCP server is on the onboard radio.

When additional PCs are plugged into the onboard Ethernet network, they will be assigned IPs by the DHCP server in the 0.*x* range. If it is desired for them to participate in the ROS network, they should be set up to have static IPs on the 1.*x* subnet.

Status Indicators

The lights on the Grizzly HMI panel (**Figure 4**) indicate vehicle status. These patterns are described in **Table 1**.

Light	Status	Description
Autopilot (blue)	Off	**Future Use/Reserved**
Position Lock (blue)	Off	**Future Use/Reserved**
Network Error (yellow)	Flashing	**ROS not online.** The MCU is currently not connected to the ROS network. If the system has just been powered on, this may take roughly 30 seconds to clear.
	Off	**ROS OK.** The MCU has connected to the ROS network.
E-Stop Status (red)	Flashing	**Emergency stop active.** At least one emergency stop condition has been met.
	Double Flash	**Reset required.** The emergency stop condition has been cleared, but the reset button needs to be pressed.
	Off	**No emergency stop detected.**

Table 1: Grizzly Status Indicators

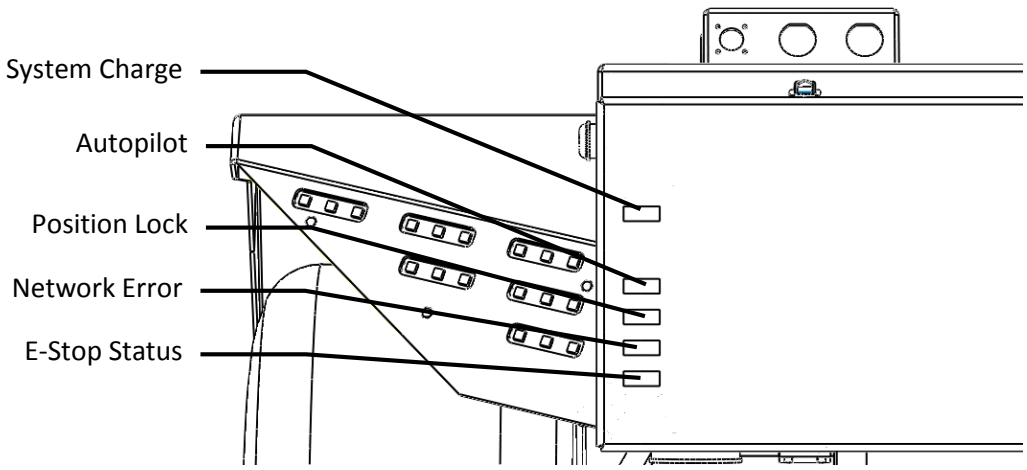


Figure 4: Rear HMI

Wireless Controller

Grizzly ships with a simple one-handed Bluetooth controller integrated as a means of manual control. The range has been tested to 50 meters LOS, but environmental factors such as ambient Wi-Fi signals or physical obstructions may negatively impact this range. The "System Enable" trigger must be depressed at all times for the wireless controller to operate.

> **!** Though the remote stop button triggers the emergency stop loop, the wireless controller itself is not a substitute for an emergency stop and should not be relied on as such.

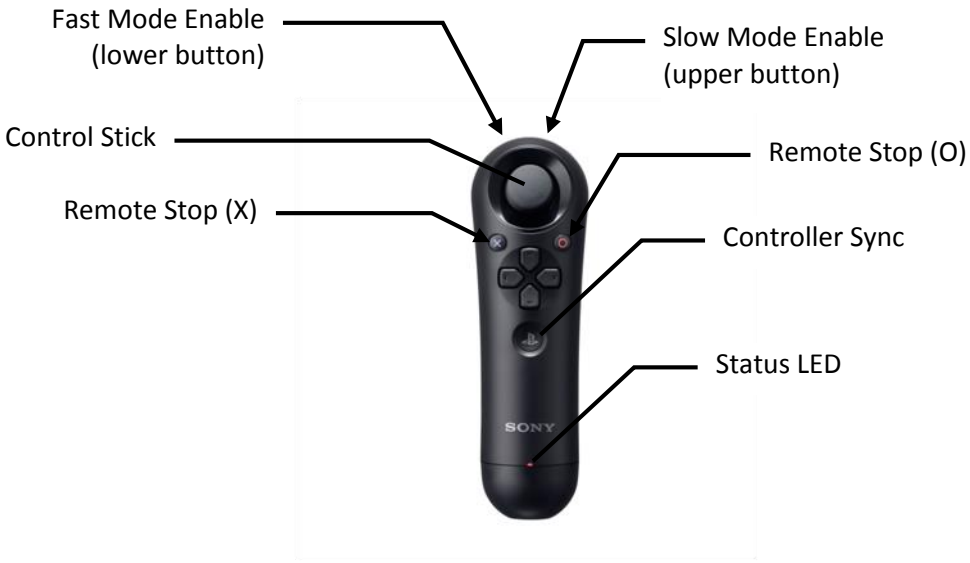


Figure 5: Wireless controller

Please see the Getting Started section for information on how to use the controller to operate Grizzly.

System Specifications

Key specifications of Grizzly are shown in Table 2. The "A" configuration is a high-speed model, while the "B" configuration is optimized for higher sustained torques. All specifications do not include additional payloads or sensing systems.

Dimensions	1.8 m length 1.3 m width 0.8 m height	69 in length 51 in width 32 in height
Curb Weight	A: 660 kg B: 910 kg	A: 1450 lb B: 2000 lb
Turning Payload	A: 350 kg B: 150 kg	A: 770 lb B: 330 lb
Climbing Payload	A: 600 kg B: 350 kg	A: 1400 lb B: 770 lb
Maximum Speed	A: 5.3 m/s B: 2.2 m/s	A: 12 mph B: 5 mph
Rated Drawbar Force	A: 3100 N B: 6230 N	A: 700 lbf B: 1400 lbf
Towing Runtime	A: 1.5 hr B: 3 hr	
Cruising Runtime	A: 6 hr B: 12 hr	
Maximum Incline	30° 60%	
User Power	5/12/24 V (48 V direct available with customization)	
Environmental	IP65 (Air inlet: IP54) -10 to +30° C	

Table 2: Grizzly System Specifications

SAFETY

Clearpath Robotics is committed to the safety of our users. Please be advised that Grizzly is experimental hardware designed for robotics researchers. It provides an unprecedented level of control at various levels of the software. When combined with the fact that the robot has a significant amount of power and force available, Clearpath Robotics cannot protect against risks created by unsafe use or modification of the robot.

> ! Unsafe operation may result in injury or death.

Take note of all safety labels on the vehicle before operation. Users are responsible for conducting their own safety evaluation of the robot and enforcing their own policies. Consult **Appendix B** in this document for a set of suggested lab guidelines.

Risk Reduction

Despite the safety features we have put into place, Grizzly is a large, fast-moving, high-powered robot which is designed for experimentation. The best way to ensure safety of life and equipment around Grizzly is to keep a safe distance, as defined further below.

Reporting

If you have any concerns about the safety of a Clearpath Robotics system or you witness a safety related incident, please contact Clearpath Robotics.

Email: safety@clearpathrobotics.com

Phone: 1-800-301-3863

Hazards

Much like an ATV or golf cart, the Grizzly presents a number of risks to users even during the course of normal operation. All users should familiarize themselves with the potential hazards of the system so they can anticipate and avoid them.

Each hazard carries with it potential consequences. Consequences can fall into one of the five following categories:

5	Severe: Chance of permanent disability or death
4	Major: Chance of disability in excess of 3 months
3	Moderate: Medical attention may be required
2	Minor: First aid may be required
1	Insignificant: Potential for minor cuts or bruises

Table 3: Hazard levels

The hazards currently identified are as follows:

Severity	Classification	Description	Suggested Avoidance
5	Impact	Impact with individuals.	When the robot is enabled, it should be assumed that it is always capable of accelerating, decelerating, or turning suddenly, potentially without being directed to do so by a human operator Always maintain a suitable safety distance (as defined above). Be very methodical in software testing. When possible, test behaviours first in simulation, on smaller robots, or with the vehicle on jackstands.
5	Crushing	Unexpected motion of vehicle from supports due to front axle moving around suspension joint.	Support front axle at two points if necessary to use as jack point.
4	Pinch point	Objects caught in space between tires and mudguards when the wheels move	Keep hands and other objects clear.
3	Electrical	Minor shock from power system after one or more batteries are removed.	The batteries are connected in parallel strings and power may remain live after some batteries are removed. Unless all battery strings are disconnected and the robot is not plugged in to a charger, assume that the robot is live.
3	Pinch point	Objects caught in space between front axle and vehicle frame	Keep hands clear.

3	Electrical	Minor shock from battery charger port (48 VDC nominal, fused at 30 A).	Keep hands and conductive objects clear.
2	Impact/ crushing	Objects being knocked over/crushed, ropes or cables being caught	Always be aware of objects which may be at risk within the test environment. Control the test environment.
2	Electrical	Venting of hydrogen gas from batteries into surroundings.	Keep robot in a well ventilated area when operating or charging.

Table 4: Specific hazards

If additional hazards are discovered beyond this list, please report them to Clearpath Robotics.

Safety Distance

Based on an assumed reaction time of 3 seconds and the kinematics of the vehicle, Clearpath suggests that a suitable safety distance (in meters) is 3 times the maximum vehicle speed in the forward/reverse direction and 2 times the maximum vehicle speed at the sides (**Figure 6**). Please see **Table 5** for specific examples.

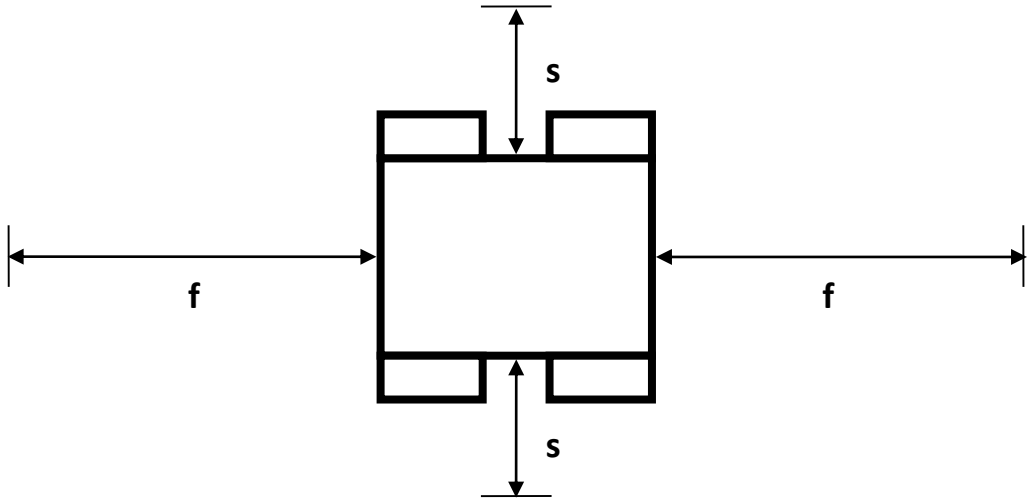


Figure 6: Minimum Safety Distance

Vehicle Max Speed	Forward/Reverse Distance (f)	Side Distance (s)
2.2 m/s / 8 km/h / 5 mph	7 m / 22 ft	4.5 m / 15 ft
5.3 m/s / 19 km/h / 12 mph	16 m / 52 ft	11 m / 35 ft

Table 5: Suggested Safety Distances

Though it is possible to limit the speeds further in software, the above suggestions should be used whenever new or unfamiliar software is being tested.

> ! Always maintain a safe distance from all robots. Never rely on proximity to the emergency stops of the robot as a substitute for this distance.

> ! The robot is capable of turning in place. Standing beside the robot may not be safe.

> ! Do not accompany Grizzly into a confined space.

Safety Features

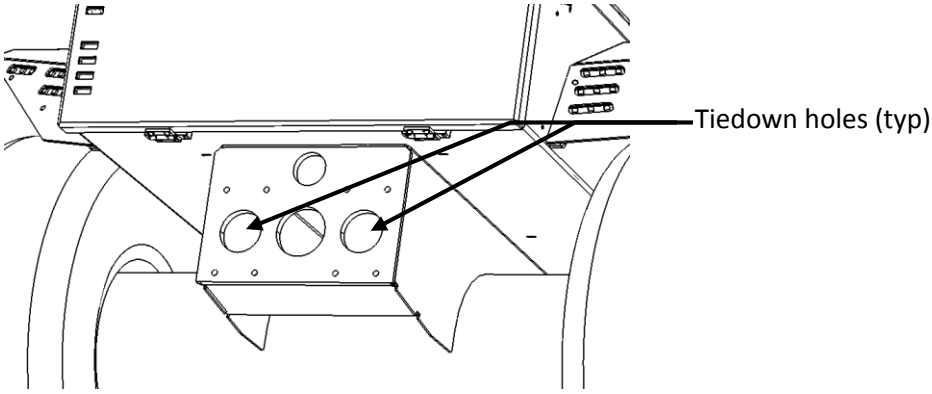
Grizzly has a number of built in safety features. These are no substitute for vigilance and proper test procedures.

- Four emergency stop buttons, each of which are hardwired to the motor power relays.
- Pre-relay monitoring of the emergency button state, with secondary software-triggered stop relay.
- Direct links between each motor controller and the motor power relays.
- Continual checks between motor controllers and the main control PC.
- Continual checks between the hardware control board and the main control PC.
- Continual robot integrity checks within internal software.
- Dedicated PC for robot speed control and monitoring.
- Fault detection on motor controllers, encoders, startup relays, and temperatures.
- Separate "reset" action mandatory to bring robot out of emergency stop state.
- Built-in pause before robot begins moving after it has stopped.
- Remote stop button on wireless controller (as configured when shipped).

Transport

Observe the following when manually transporting the robot:

- Grizzly should be tied down with straps through **all four tiedown holes** using straps or chains that are designed for this purpose, rated for the vehicle's weight, and attached to appropriately spaced fixed anchors. There are two tie down holes through the front of the frame, and two on the rear of the frame.
- Place a tarp or other covering over the system to protect sensing equipment before transporting long distances or at high speeds.
- When transporting Grizzly on a trailer, follow the instructions on the trailer to ensure proper weight balance over the trailer tongue.



GETTING STARTED

You are ready to go! This section details how to get the Grizzly moving. Before enabling the system, ensure that you have secured the test environment as per your lab-specific guidelines. For an example of possible guidelines, please see **Appendix B**. Please note that it is not the responsibility of Clearpath to establish or enforce lab procedures; the guidelines are suggestions for your consideration.

Powering System

Grizzly is turned on via a key located in the rear enclosure. Begin by unlatching and opening the rear enclosure.

The key is located in the lower right corner of the enclosure. To only power the sensors and computers, turn the key clockwise to the "On" position. To power the system fully, including the motors, turn the key further clockwise to the "Run" position. To drive the Grizzly, ensure the key is in the run position.

The power LED adjacent to the key will turn on immediately, and the rest of the system under 5 seconds later. The main front and rear lights will turn on, the lights on the rear panel will flash briefly, and the cooling fans will turn on. In approximately 45 seconds, the "Network Error" light on the rear panel will turn off as ROS comes online. The fans should turn off slightly thereafter.

Close the rear door and reset all perimeter emergency stops. At this point, the "Emergency Stop" light on the rear panel should change from a single flash to a double flash. Reset the emergency stop condition by pressing the external reset button found on left side of Grizzly, towards the rear.

The system is now ready to drive!

Wireless Operation

Enable the wireless controller by pressing the Controller Sync button (**Figure 5**). The Status LED should begin blinking red.

Test connectivity by pressing the Remote Stop button on the controller. You should hear an audible click from Grizzly and the Emergency Stop light on the rear panel should begin blinking. As before, press the external reset button. You have confirmed connectivity!

To drive, hold the Slow Mode Enable trigger on the controller and slowly move the Control Stick away from centre. Once Grizzly detects an input, it will delay motion by two seconds, during which time it will flash the main lights and sound the buzzer to indicate that motion is imminent. This delay will occur after the system has not received a motion command for >10 seconds, or if it has been emergency stopped.

> ! Grizzly is capable of turning and accelerating quickly. Use caution.

SOFTWARE SYSTEMS

This section provides an overview of how to use the Grizzly onboard computers.

Network Infrastructure

Base Station Configuration

In this configuration, Grizzly connects to a fixed base station. The onboard Control PC receives an IP from the base station in the 192.168.0.*x* range. To connect to Grizzly, first connect to the network broadcast by the base station (SSID: CPR*XXX*, key: clearpath), and SSH into the robot.

```
# ssh administrator@192.168.0.x
```

The default password for the administrator user is "clearpath".

Self-Hosted Configuration

In this configuration, Grizzly hosts its own network. It has an IP of 192.168.0.1. The onboard Control PC receives an IP from the onboard radio in the 192.168.0.*x* range. To connect to Grizzly, first connect to the network broadcast by Grizzly (SSID: CPR*XXX*, key: clearpath), and SSH into the robot.

```
# ssh administrator@192.168.0.x
```

As before, the default password for the administrator user is "clearpath".

ROS Network

The onboard PCs in Grizzly use ROS to communicate internally and externally. ROS is launched on the control PC, with `ROS_MASTER_URI=http://192.168.1.1:11311`. This PC contains all of the main nodes responsible for vehicle control, and also launches sensor nodes on both the control and user PC.

When connected by SSH to the user or control PC, the ROS master is accessible by default. `rostopic list` will produce the full list of available topics. To restart the master, SSH in to the control PC from the user PC with `ssh administrator@192.168.1.1` and a password of "clearpath." Then, use the following commands to shut down and restart the master.

```
# sudo service grizzly-core stop
# sudo service grizzly-core start
```

If you would like the output from the system launch to be visible on the terminal, use `sudo /usr/sbin/grizzly-core-start` in place of `sudo service grizzly-core start`.

If ROS is launched from /usr/sbin instead of via the service, it may shut down when the terminal is closed. As well, the "ps3joy.py" program will need to be manually shut down via:

```
# sudo killall ps3joy.py
```

The robot base configuration has the following topics which can be used for control and monitoring:

Topic	Type	Purpose
/cmd_vel	geometry_msgs/Twist	Kinematic motion commands to Grizzly
/cmd_drive	grizzly_msgs/Drive	Per-wheel motion commands to Grizzly
/encoder	nav_msgs/Odometry	Dead reckoning feedback from Grizzly
/diagnostics	diagnostic_msgs/DiagnosticArray	System diagnostic output
/mcu/energy	std_msgs/Float32	Battery charge estimate
/mcu/estop	std_msgs/Bool	Emergency stop trigger
/mcu/status	grizzly_msgs/RawStatus	Raw status output from MCU
/motors/*/status	roboteq_msgs/Status	Raw status output from a given motor controller
/motors/*/feedback	roboteq_msgs/Feedback	Raw feedback from a given motor controller

Table 6: Base platform topics

The two most critical topics to be familiar with are `/cmd_vel` and `/mcu/estop`. To drive the robot from a ROS node, publish valid `Twist` messages on `/cmd_vel` at at least 10 Hz. To trigger the emergency stop relays, publish `True` to `/mcu/estop`. For an working example, look at `grizzly_teleop/nodes/teleop.py`.

External ROS Connection

To participate in the vehicle ROS network directly from a remote machine connected to Grizzly, first ensure that the machine has Ubuntu and ROS Hydro installed. Then, connect to the Grizzly Ethernet network and assign your machine a static IP in the 192.168.1.*x* subnet.

Execute the following commands to set up the ROS environment.

```
# export ROS_IP=192.168.1.mmm
# export ROS_MASTER_URI=http://192.168.1.1:11311/
```

Where *mmm* is the IP of the machine connected.

At this point attempt to list the available topics.

```
# rostopic list
```


Diagnostics

To access a comprehensive visual diagnostics output from Grizzly, run the following from a computer which has ROS_MASTER_URI and the network route set up properly, as described above in the **External ROS Connection** section.

```
# rosrun robot_monitor robot_monitor
```

Robot Internet Access

Base Station Configuration

To connect Grizzly to the internet via a base station, connect the WAN port on the base station to an external network.

Self-Hosted Configuration

To connect Grizzly to the internet when it is hosting its own network, connect the WAN port on the onboard radio to an external network.

MAINTENANCE

Grizzly is built for rugged, long-term use. However, there are steps that can be taken to maintain and extend the life of the platform even further.

Charging Grizzly

To charge Grizzly, perform the following procedure:

1. Open the rear enclosure.
2. Plug the included 48 V charger into a wall receptacle.
3. Connect the DC output cable from the charger to the terminal connector in the lower left corner of the rear enclosure.
4. When Grizzly is fully charged, the "Full Battery" indicator on the charger will illuminate. Unplug the charger from Grizzly.

> ! Always charge in a well-ventilated area with the charger's cooling fins well-clear of obstructions that may block airflow. Charger may be hot after charging.

The time required to fully charge the robot may be 10-15 hours depending on the state of discharge.

Charging Base Station

To charge the base station (if applicable), perform the following procedure:

1. Turn off and open the base station enclosure.
2. Unplug and remove the battery.
3. Plug the included 14.4 V NiMH charger into a wall receptacle.
4. Connect the base station battery into the charger.
5. When the base station battery is fully charged, the LED on the charger will turn green. Disconnect the battery from the charger.
6. Place the battery back into the base station and reconnect it.

Battery Pack

Grizzly uses multiple sealed lead acid battery cells, providing up to 20 kW-hours of charge. To maximize the lifetime, recharge immediately after use, and keep charged to prevent loss in capacity. Battery life expectancy is shown in Table 7 and shelf charge retention in Table 8.

Cycles	Depth of Discharge
200	100%
225	80%
500	50%

Table 7: Battery Life Expectancy

Shelf Time	Battery Charge
None	100%
1 month	92%
3 month	90%
6 month	80%

Table 8: Battery Shelf Life

Grizzly should never be used or stored in an environment exceeding 40 degrees Celsius (104 °F), and should always be charged at temperatures above freezing.

Fuses

The control electronics and payload power supplies are protected by an array of removable ATC/ATO blade-style fuses located on the right hand side of the rear enclosure. Replacements can be found at most hardware stores. Do not install fuses rated for more than the marked currents.

Tires

Tire pressure may change with temperature, and should be checked periodically with a pressure gauge. Checking, releasing pressure and inflating a tire are all done through the tire's inflation stem. Tire pressure should not exceed the ratings found on the tire, and lower pressure may be desired based on terrain requirements.

If a tire must be removed, first unfasten the four 14 mm M10 lugnuts that join the wheel to the axle hub, and slide it off the axle. When replacing, these screws should be tightened to 37 ft-lb [50 N-m] torque.

Tire Changing Instructions

Requires

- 1 x Trolley Jack
- 2 x Axle Stands
- 1 x Breaker Bar or Ratchet
- 1 x Torque Wrench
- 1 x 14mm Socket

Procedure

1. Ensure that the robot is powered off.
2. Place the trolley jack underneath the center of the axle tube (the front or rear axle tube, depending on the wheel to be changed). Note that the front axle can oscillate freely so care must be taken when lifting it. Jack the axle tube up until the wheels have been lifted off the ground, and the axle tube is high enough to insert the axle stands under.
3. Place one axle stand under each end of the axle tube, as close to each wheel as possible, taking care to align the V- or U-shaped contour of the axle stand with the curvature of the tube.
4. Slowly lower the jack and allow the axle tube to rest on the axle stands.
5. The wheel can now be removed. The wheel is attached to the hub with four standard metric ATV/UTV lug nuts (M10x1.5 thread with 14mm hex heads).
6. After installing the new wheel, it is recommended to hand tighten all four lug nuts and then torque them with a torque wrench to 50 Nm (37 ft-lb) in a criss-cross pattern.
7. The Grizzly can now be taken off the axle stands. Use the trolley jack in the same position as before to raise the robot. Then remove the axle stands and slowly set it back down on its wheels.

Fan Intake Filter

The cooling system on Grizzly includes a high powered fan on each side. Before each test, visually inspect the exterior grills for debris. On a monthly basis during operation or after a long period of inactivity, remove the two M5 flat head screws securing each grill with a 3 mm Allen key and inspect the filter. If clogged it can be removed and cleaned. The filter is attached using four M4 socket head screws that also use a 3mm Allen key. If the filter is cleaned with water, ensure it is dry before reinstalling it.

Rear Enclosure Seal

Periodically inspect the seal around the rear enclosure hatch for damage or wear.

Cleaning

After tests, wipe Grizzly down with a cloth. Do not clean with a pressure washer or hose with a solid stream nozzle. The Grizzly can be cleaned with a hose with a "mist" or "shower" nozzle, but avoid aiming the water directly at the air intake and exit grills located on either side of the robot.

Sensors

Consult the manufacturers' instructions for each integrated sensor for specific details on maintenance and servicing.

TIPS AND TROUBLESHOOTING

This section lists a few possible issues which may be encountered during the course of using Grizzly.

Observation	Issue & Resolution
"Stop and start" motion while using wireless controller	**System is at range limit.** Move closer to Grizzly, remove obstructions, or remove sources of 2.4 GHz wireless interference (such as Wi-Fi).
Vehicle is not moving and red light is on or flashing.	**System is in an emergency stop state.** Ensure key is in "Run" and rear door is closed. Release all emergency stops and press the reset button.
Vehicle is not moving and yellow light is flashing.	**Internal ROS network is down.** If it has been greater than 1 minute since system power-on, turn the entire system off and on again. If the problem persists, contact Clearpath Support.
Vehicle is not moving and there are no error conditions.	**No commands are being issued.** Refer to the **External ROS Connection** section for instructions on how to connect to the onboard ROS network. Use the "rostopic hz cmd_vel" command to verify that motion commands are being published by your software at a frequency of at least 10 Hz.
Emergency stop is active/not resetting, no stop buttons are depressed, and the rear door is open.	**Door safety switch triggered.** Close rear door and retry.
Emergency stop is active/not resetting, no stop buttons are depressed, and the rear door is closed.	**Key not in "Run" mode.** Turn key to "Run" and retry.
Emergency stop is active/not resetting and no other causes can be found.	**Internal critical error has occurred.** Refer to the **Diagnostics** section for instructions on how to retrieve detailed system information, and provide this information to Clearpath Support.

Can't ping onboard PC from remotely connected computer	**Network problem.** Ensure that the remotely connected computer is successfully connected to the Grizzly wireless infrastructure (ie, able to ping 192.168.0.1).
Unable to list, echo, or publish ROS topics from remotely connected computer	**ROS environment problem.** Ensure that the user laptop has a working ROS installation, including the Grizzly workspace. Ensure that ROS_MASTER_URI is correctly pointing to the Grizzly IP, ROS_IP is set to the user laptop's IP, and the network route is set up correctly (see the **External ROS Connection** section)
System fan is still on >1 minute after system power-on, and the system temperature is low	**Startup fault.** Turn the system key to "Off" and then back to "On" or "Run".
Both front wheels or both rear wheels are not responding.	**Internal "ANL" fuse blown.** Contact Clearpath Support for replacement instructions.
Sudden decrease in runtime by 25% or more.	**Battery module fuse blown.** Contact Clearpath Support for replacement instructions.

If you're having some trouble that you don't see here, or the suggested solution isn't working out, please get in touch so we can help you with it (see next page for contact details).

For more details on setting up multiple machines to work together in ROS, please see the following pages on the ROS wiki:

- http://www.ros.org/wiki/ROS/NetworkSetup
- http://www.ros.org/wiki/ROS/Tutorials/MultipleMachines

A. SERVICE AND SUPPORT

Clearpath Robotics is committed to your success and satisfaction. We are located in Kitchener, Ontario, and can accept phone calls from 9AM to 5PM EST Monday to Friday, at our toll-free number, or emails at any time. If you any questions or concerns, visit our support knowledge base for more information or to get in touch with our support team.

1-800-301-3863
support.clearpathrobotics.com

B: SUGGESTED LAB GUIDELINES

Please note that it is not the responsibility of Clearpath to establish or enforce lab procedures for any of our clients. The below guidelines are suggestions for your consideration.

Safety Officer

- The lab must appoint at least one Safety Officer
- The Safety Officer's contact information should be known by everyone in the organization who uses the Grizzly (including designers, developers, programmers, and end-users).
- The Safety Officer's contact information should be known to Clearpath Robotics.
- Details of the Safety Officer's roles and responsibilities are described in the Safety Officers page.
- The Safety Officer will remain informed of all known safety hazards and mitigations.
- The Safety Officer will ensure that all known mitigations are implemented in their organization.
- The Safety Officer will ensure that everyone involved with the products receives suitable safety training.
- The Safety Officer will report any safety incidents to Clearpath Robotics in a timely manner.
- The Safety Officer will work with Clearpath Robotics to further improve safety of their products.

Safety Policies

- All regular users must review and sign-off on the lab safety policy.
- All regular users shall review the user manual before use.
- Any tests must have at least two people present at the test site.
- The vehicle key shall be removed from the robot when not in use and left accessible only to authorized, trained individuals.
- The operator must stay within view of the vehicle when in operation.
- Refrain from modifying onboard safety systems.
- Refer to the user manual for maintenance instructions.
- Do not ride on the robot.
- Any outdoor driving of a robot in an in-use parking lot or any other area where motorized vehicles may expected to be present requires at least one individual to wear a reflective vest (when present in the lot) and take appropriate efforts to warn or divert vehicles not participating in the test.
- Reflective pylons must be set up in any part of the test area where vehicle traffic may occur during the time the test is going on.
- Supervise children, visitors, and anyone else who has not received appropriate training and signed-off on the safety policy.
- Verify all remote stop methods before test initiation and after any software change which may have altered remote stop behaviours. These procedures include but are not limited to: the remote stop button on the provided wireless remote control, timeouts within control software, and the software motor stop command.

