

JACKAL

UNMANNED GROUND VEHICLE

USER MANUAL

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1 INTRODUCTION

Jackal is a rugged, lightweight, fast, and easy-to-use unmanned ground vehicle for ROS Indigo, presented by Clearpath Robotics.

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

Please inquire with Clearpath Robotics for details. See Contact on page 13 for contact information.

1.1 What's Included

Contained in your Jackal shipment are the following items:

- Jackal UGV
- 270 watt-hour lithium battery pack
- 110V/220V universal charger
- Sony Bluetooth controller
- Jackal User Manual

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

1.2 Hardware Overview

Jackal's external features include the mounting pattern on the lid panel, 190 mm diameter wheels, human machine interface panel (HMI), and lid panel latches. The HMI panel is shown in Figure 1, and includes from left: motor button, comms indicator, wifi indicator, battery indicator, and system power button.

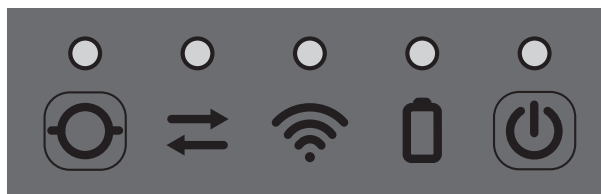


Figure 1: HMI panel.

Incomplete Feature

Note that as of the 0.1 firmware, Jackal's HMI indicators and motor enable/disable button are non-functional. Please expect an update in the near future to correct this.

To access Jackal's interior, actuate the latches under the front end of the lid, on the opposite end from the HMI. When you lift the lid, you will see Jackal's onboard Li-Ion battery pack, and its two connectors. The large

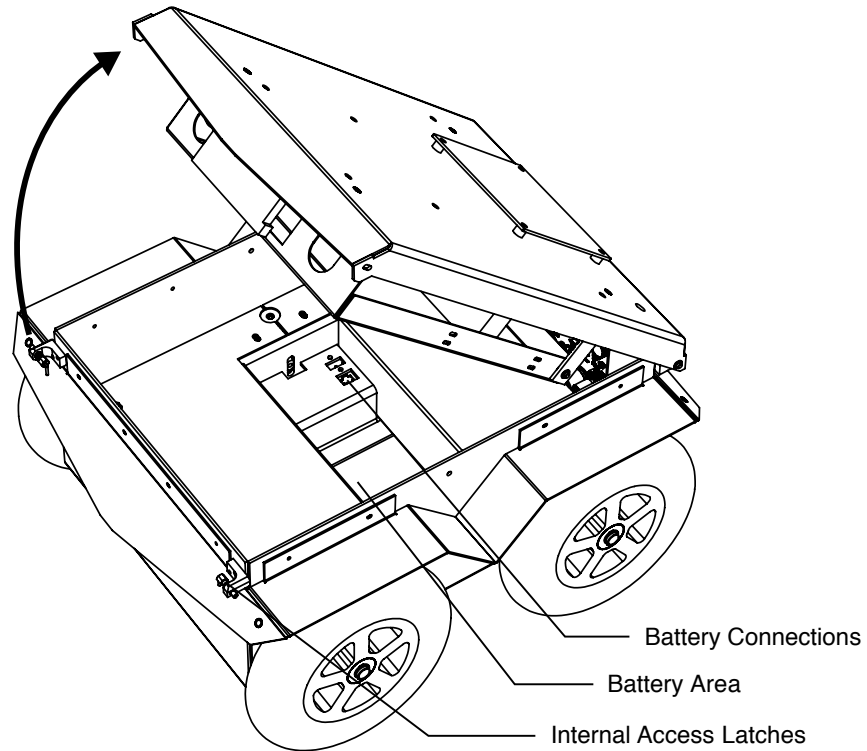


Figure 2: Battery area inside Jackal.

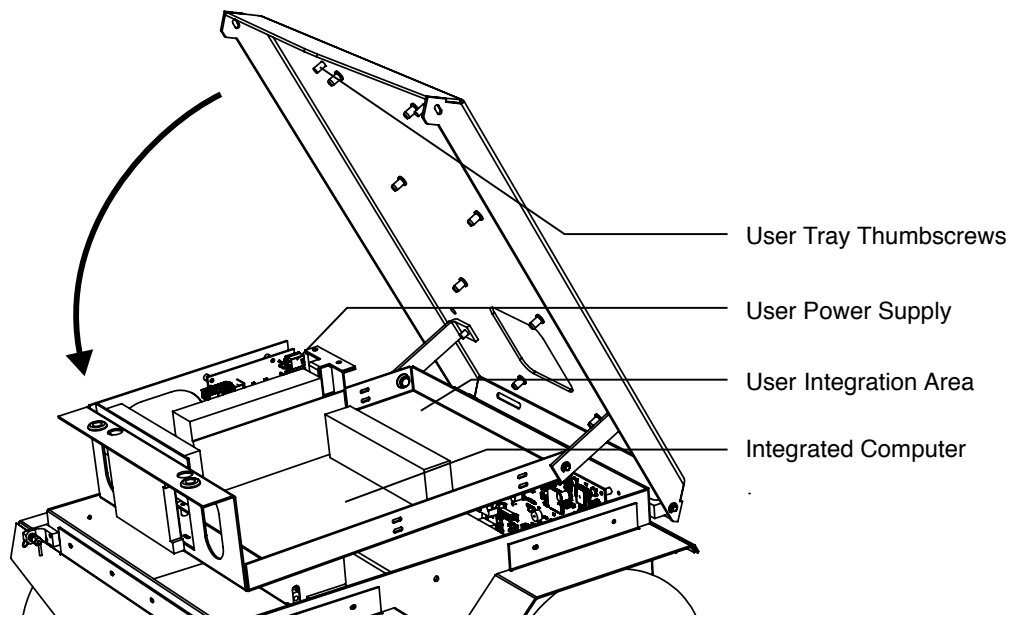


Figure 3: Computer and user tray.

Anderson Power Pole connector is to supply power to Jackal and must be connected in order for Jackal to operate. The smaller white Molex connector allows the battery pack to be charged inside Jackal while Jackal is powered off. It is recommended to connect both. The interior components of Jackal are labeled in Figure 2.

Finally, you may undo the thumbscrews which hold Jackal's computer tray to the lid. The tray lowers, revealing Jackal's onboard Mini-ITX PC, user power supplies, and internal user hardware mounting area. Please see Figure 3 and Figure 4 for the components of the tray and user power supplies. Note that the fused user power is available as four-pin Molex connectors, or a plug-in screw terminal block. For more information on integrating payloads electrically, see subsection 5.2, Electrical Integration.

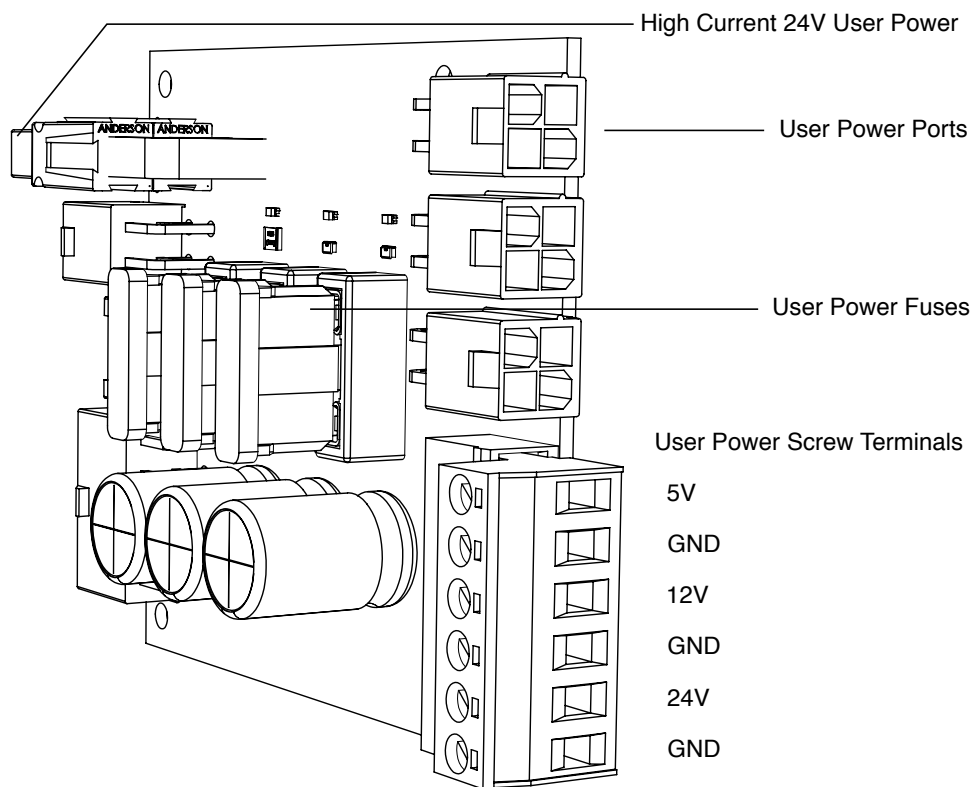


Figure 4: User power supply.

1.3 System Architecture

Like many ROS robots, Jackal is built around an x86 PC running Ubuntu, paired with a 32-bit MCU. The MCU handles IO, power supply monitoring, and motor control, as well as supplying data from the integrated IMU and GPS receiver. The communication channel between the MCU and PC is a Full Speed USB connection, with the MCU operating as a standard serial CDC device.

The communication protocol used is roserial. An instance of the `roserial_server` serial node is embedded in the `jackal_base` node, where it is connected to Jackal's kinematic controller.

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

Incomplete Feature


Note that due to USB stability problems with Navsat and IMU output enabled, these outputs have been temporarily disabled in the 0.1 firmware release. When further testing has been completed, an update will be released to enable these functions.

Topic	Message Type	Purpose
<code>/cmd_vel</code>	<code>geometry_msgs/Twist</code>	Input to Jackal's kinematic controller. Publish here to make Jackal go.
<code>/odometry/filtered</code>	<code>nav_msgs/Odometry</code>	Published by <code>robot_localization</code> , a filtered localization estimate based on wheel odometry (encoders), integrated IMU, and integrated GPS.
<code>/imu/data</code>	<code>sensor_msgs/IMU</code>	Published by <code>imu_filter_madgwick</code> , an orientation estimate based on Jackal's internal gyroscope, accelerometer, and magnetometer.
<code>/navsat/fix</code>	<code>sensor_msgs/NavSatFix</code>	Position fix from Jackal's built in GPS receiver.
<code>/navsat/vel</code>	<code>geometry_msgs/TwistStamped</code>	Velocity over ground according to the integrated GPS receiver.
<code>/cmd_drive</code>	<code>jackal_msgs/Drive</code>	Output from Jackal's kinematic controller, input to the motor controllers. Subscribe here for a lower-level look at what's going on.
<code>/feedback</code>	<code>jackal_msgs/Feedback</code>	High-frequency inputs from Jackal's encoders and motor current sensors.
<code>/status</code>	<code>jackal_msgs/Status</code>	Low-frequency status data for Jackal's systems. This information is republished in human readable form on the <code>diagnostics</code> topic and is best consumed with the Robot Monitor.

Table 1: Jackal ROS API Topics

2 GETTING STARTED

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

Press the power button  on Jackal'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.

Press the PS/P3 button on the Sony Bluetooth controller to sync the controller to Jackal. 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 Jackal 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. 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 Jackal 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 up Jackal.

2.2 Remote ROS Connectivity

Now that Jackal 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 Jackal 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 Jackal over wireless, you may need to change one of three things:

1. If you're confident that Jackal 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:

```
nosrun robot_upstart install jackal_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 Jackal'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 Jackal Desktop Packages

To command or observe Jackal 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 Jackal desktop packages:

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

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

```
roslaunch jackal_viz view_robot.launch
```

From within rviz, you can use interactive markers to drive Jackal, 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 Jackal's self-monitoring capabilities:

```
roslaunch rqt_robot_monitor rqt_robot_monitor
```

Incomplete Feature

Note that in the 0.1 release of the Jackal firmware package, the temperature sensors are not being published to ROS. The values appearing in the diagnostic output are not reflective of reality. Please expect a near-term update resolving this.

3 APPS

Upcoming Development

The use of the app launcher to run demonstrations such as from the `jackal_navigation` package is planned, but presently incomplete. The intent is ultimately to package Jackal's demos as Robot Apps or *rapps*, for ease of launch and getting started.

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

A standard outdoor GPS autonomy demonstration using Jackal's built-in sensing is planned, as well as a calibration app for the internal magnetometer.

4 CHARGING & BATTERY MAINTENANCE

Jackal's Li-Ion battery pack may be charged internal to the chassis—simply plug in the charger to the charge port located under the rear fender. Charging will occur when Jackal is powered down.

Alternatively, if you have multiple battery packs, you can easily lift the lid and remove the battery for external charging. When charging externally, remove the pigtail which adapts the charger to the platform's weather sealed charge port.

The battery pack is manufactured for Clearpath Robotics by AllCell Technologies. The pack includes integrated protections against fault due to overcurrent, overdischarge, and short circuit. The pack is rugged and designed for the demanding environments into which Jackal may be deployed.

However, please take note of the following:

- The pack must not be stored or operated above 60 °C or below –19 °C.
- The pack must not be punctured or disassembled.
- The pack should be returned to Clearpath Robotics for disposal, or to your local hazardous waste authority.
- When traveling with Jackal, consult your airline's restrictions regarding lithium battery packs. If possible, bring the pack in your carry on luggage, where it will be subject to normal cabin temperatures and pressures.

Please contact Clearpath Robotics for additional information about Jackal's battery or for information about purchasing additional packs.

5 PAYLOAD INTEGRATION GUIDE

If you're wanting to attach custom hardware to Jackal, 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

For external payloads, the recommended configuration is manufacture a metal or plastic bracket which attaches to the 120 mm square mounting holes supplied in Jackal's lid panel. The included thumbscrews use an M5 thread, if you wish to replace them with conventional fasteners. As an alternative to manufacturing a brand new plate, you may remove and modify one of the included ones.

For rear-facing or back-mounted payloads, it is also possible to replace (or drill into) the hatch panel which covers over access to Jackal's internal PC.

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 hatch and connected directly to the internal computer. Both of Jackal's internal computer options support USB3 and Ethernet connectivity. With the performance PC, the PCIe slot may be used to supply Firewire, Thunderbolt, or additional USB3 ports, 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 hatch, and connected to the User Power Board. Pull out the black terminal block, and use a small screwdriver to securely attach power leads to it. Confirm voltage and polarity before reconnecting the terminal block.

You may also choose to terminate your payload's power lead with the appropriate crimps and pins for the four pin Molex connector— this option may be more convenient if you expect to be adding and removing your payload from Jackal more frequently and would prefer not to be fiddling with the terminal block. Contact Clearpath Support for details about these parts.

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 Jackal, 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 Jackal. 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 Jackal or other Clearpath Robotics products, please email sales@clearpathrobotics.com.

If you have 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.

Jackal 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.