AutoRally Platform Operating Procedures

Version 1.3, February 2017, Georgia Institute of Technology

Contents

1 Getting Started

This document describes how to operate an AutoRally platform. Starting from an assembled AutoRally chassis and compute box, you will learn how to operate the platform under autonomous and manual control, perform a pre-run preparations and final configuration at the test site, power on the platform, and run the core AutoRally software. Read through this entire document before operating an AutoRally platform.

The Operating Procedures document assumes that you have constructed and configured an AutoRally chassis and compute box. Complete AutoRally platform build and configuration information can be found at the AutoRally platform instructions and the AutoRally Wiki. In addition to the platform, this document assumes you already have the required Base Station/misc equipment listed in AutoRally Parts List.

The platform is controlled with a standard RC transmitter or by the on-board computer. Seamless remote switching between autonomous and manual control is done with a switch on the transmitter. The last channel on the transmitter, controlled by another button, is a remote run-stop. It controls a live-man relay on the chassis that sits between the throttle signal and electronic speed controller (ESC).

The AutoRally platform is an accessible research testbed, but it can cause serious injury and damage if operated in an unsafe manner. Only operate in an access-controlled space where the operator can maintain line-of-sight visibility to the platform at all times.

This document is best viewed in color.

1.1 Battery Safety

Follow all manufacturer provided instructions for safe battery handling.

When connecting batteries always ensure that the ground and positive wires (black and red) of the battery do not touch each other. Physical contact between positive and ground of the battery will cause a power short and permanently damage the batteries and surrounding components.

Avoid all contact between battery wires and the aluminum compute box. The compute box is grounded so any contact with battery leads can short the batteries, potentially through electronics, and will permanently damage the batteries and any components involved in the short. Batteries not in use/connected to anything must have protective battery plugs on wire ends.

When not in use, batteries must be stored inside of LiPo sacks.

1.2 Wire Connector Safety

When connecting and disconnecting electrical connections, always apply force to the connectors directly, not to the wires. Pulling and pushing the wires will damage the wires and cause connections to fail prematurely. When disconnecting electrical connections, pull in a straight line, do not twist or apply torque to the connections.

1.3 Resources and Useful Links

- AutoRally platform instructions
- AutoRally Wiki
- AutoRally Platform Configuration
- Configuring IP Addresses for the AutoRally Platform
- Product manuals and datasheets in `manuals/`

2 Component Operation

2.1 Transmitter

Parts

- Futaba 4PLS transmitter

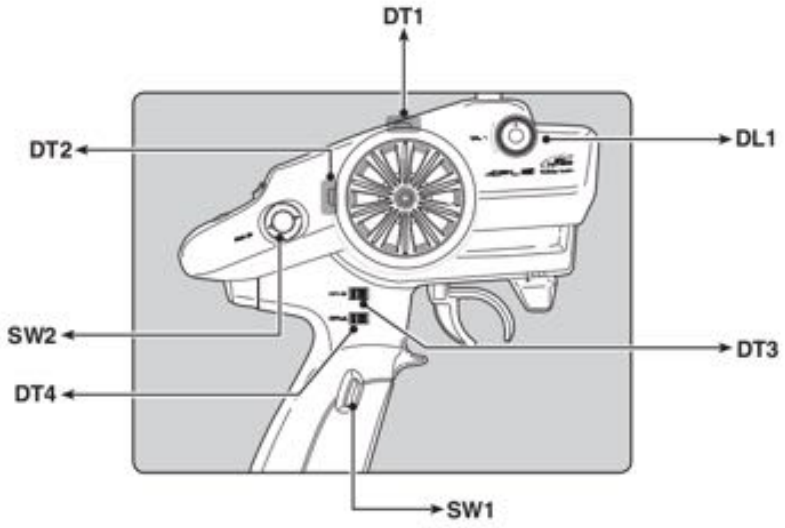


Figure 1: Transmitter diagram

SW2 is used to switch between manual and autonomous mode. In manual mode only the human operator can control the platform using the transmitter. In autonomous mode the human can still control the platform using the transmitter if no higher priority controllers are running. Refer to the Controlling the AutoRally Platform Wiki Pagefor more information on how the servo controller works.

Figure 2: Left: Autonomous mode. Right: Manual mode

SW1 is used to enable motion. When SW1 is disabled, robot motion is disabled in both autonomous and manual control. You can still control steering when motion is disabled via SW1.

If the platform is moving when motion is disabled, the platform will coast to a stop.

Figure 3: SW1 enables and disables throttle control.

Figure 4: The wheel controls steering.

Figure 5: The trigger controls throttle, rear brake, and reverse functionality.

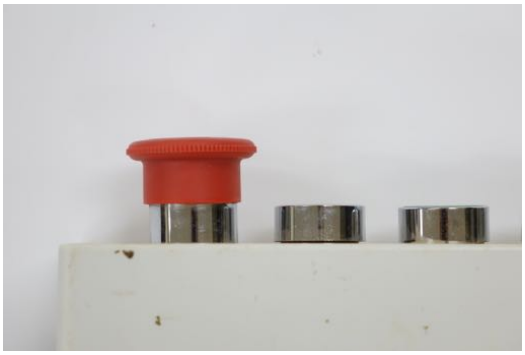
2.2 Run-Stop Box

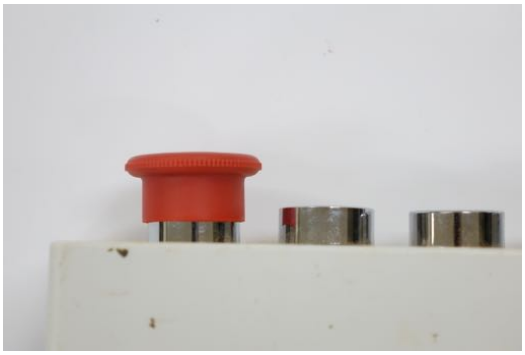
Parts

- Run-stop box

The following is a picture of the run-stop box and operation details:

The red mushroom button and the red momentary switch disables motion through software to stop the platform completely in case of emergencies.To re-enable motion, ensure that the mushroom is released by twisting in the direction indicated on the button and that the green button is pressed.**The Run-Stop Box only affects throttle control in autonomous mode.**





The green momentary switch of the run-stop box enables motion for the platform.

2.3 Compute Box

Parts

- Compute box

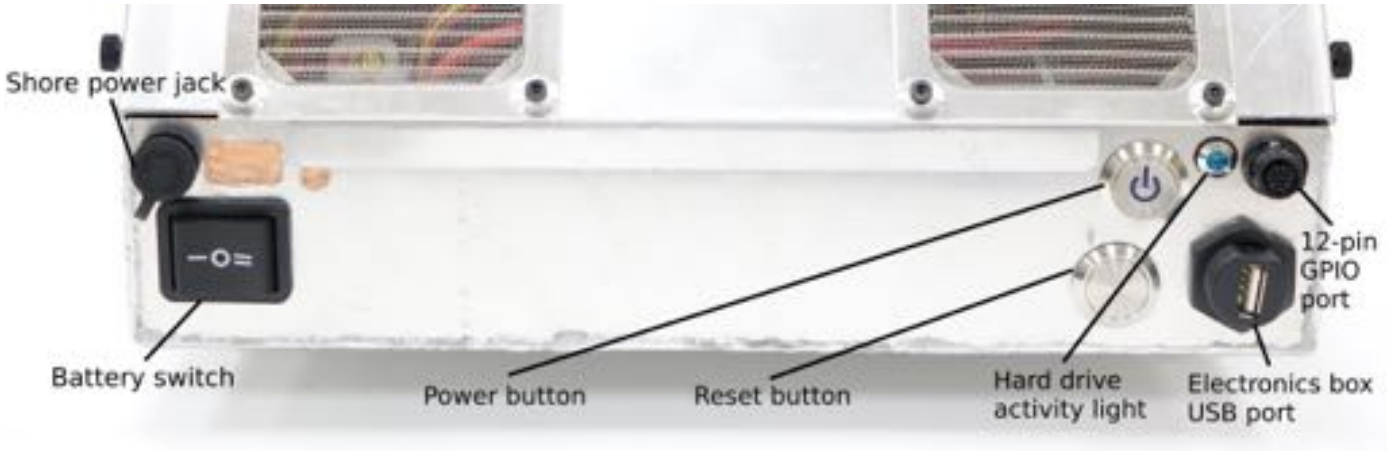


Figure 6: Labeled diagram of compute box back panel

2.4 Shore Power

Parts

- Shore power cable
- 24V MaxAmps power supply

Instructions

a. To use shore power, connect the shore power cable to the shore power connector located on the left side of the compute box, above the battery switch. **Do this after it is plugged into a power supply**

2.5 Compute Box Battery Switch

Parts

- Compute box

The three-way switch on the back of the compute box controls compute box battery operation. **The switch position does not affect shore power.**

Figure 7: Left: Position 0- battery power is turned off; Center: Position I- compute box runs on battery power; Right: Position II- Charge Mode for compute box battery is enabled.

3 Pre-run Preparations

3.1 Charge Batteries

Batteries must be supervised and kept in LiPo sack while charging.

Parts

- Hyperion EOS 720i battery charger
- 24V MaxAmps power supply
- Balance charge tab adapters
- 2 6.5mm red charge leads
- 2 6.5mm black charge leads
- Chassis batteries - LiPo 6500mAh 4S 14.8v HPI Baja Pair
- Compute box battery - LiPo 11,000mAh 6S 22.2v battery

Instructions

a. Connect the battery charger to power supply with 4mm banana plugs.

Connect the ground (black) wires first, followed by the positive (red) wires.

b. After charger is connected, connect power supply unit to a power source.

If you connect the charger to the power supply, *after* connecting power supply to a power source, it will produce a spark.

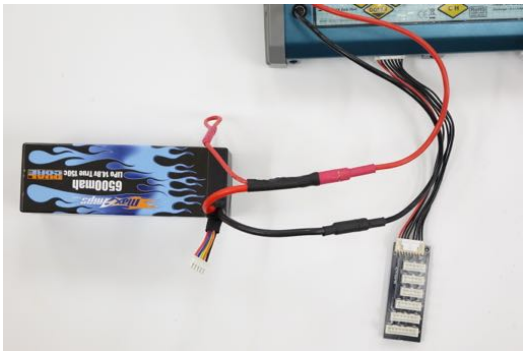
c. Plug all charge leads into charger according to lead color.


d. Connect the balance charge adapter to the charger.

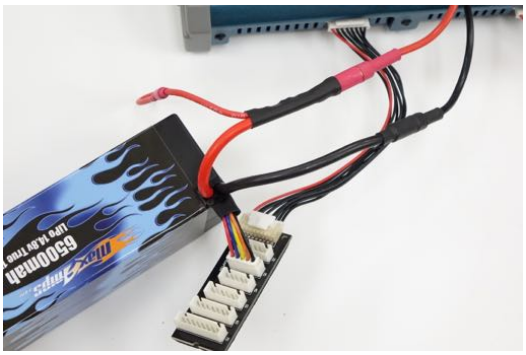

3.1.1 Chassis Batteries

Instructions

a. Connect the 6.5mm charge lead to the chassis battery. Begin with ground (black) and proceed with positive (red). Repeat for the second battery.



b. Connect the battery's balance tab to the appropriate connector on the balance adapter. Repeat for the second battery.



c. Select charging profile for the chassis batteries. If no profile exists, create one with the following settings.

Use the charger's manual in the `manuals/`folder as reference.

LiPo 4 cell, 14.8V battery

1C charge rate at **6.5A**

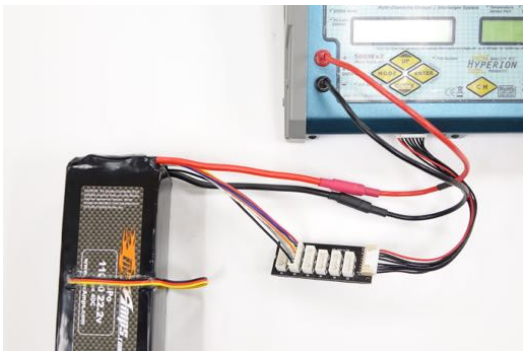
d. Select the **Sync** charge mode.

e. Charge batteries.

3.1.2 Compute Box Battery

Instructions

a. Connect compute box battery to charge leads and balance adpater.



b. Select charging profile for the compute box battery. If no profile exists, create one with the following settings.

Use the charger's manual in the `manuals/`folder as reference.

LiPo 6 cell 22.2V battery

1C charge rate at **11A**

c. Select the **Solo** charge mode.

d. Charge batteries.

3.1.3 Compute Box Battery While Installed In Compute Box

Only charge compute box battery with this method when testing outdoors with compute box battery installed in compute box.

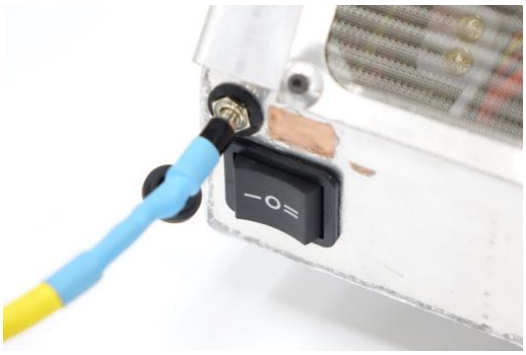
Parts

- Compute box w/ compute box battery
- Hyperion EOS 720i battery charger
- Shore power cable
- 24V MaxAmps power supply

Instructions

a. Connect shore power if the compute box will be running while charging the battery.

b. Set the compute box battery switch to position 0.

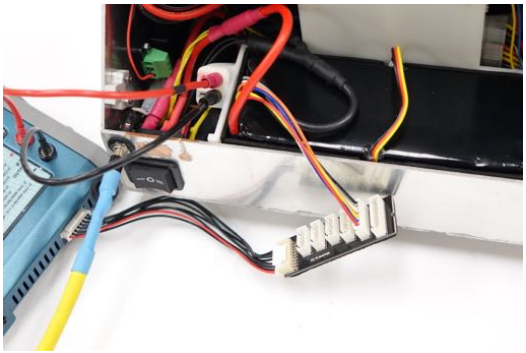


c. Remove the two thumb screws from the rear hinge panel of the compute box and open rear hinge panel to access compute box battery.

d. If present, disconnect the LiPo monitor from the compute box battery balance tab.

e. Connect the black charger lead to the ground (black) compute box battery charge connector located on the left side of the compute box battery holder. Connect the red charger lead to the positive (red) compute box battery charge connector.

f. Connect the balance adapter to the balance tab of the compute box battery.



g. Set the battery switch to position II (battery charge mode).

h. Select compute box battery profile on the charger.

i. Charge battery.

j. Set battery switch to position 0, disconnect charging leads and balance adapter, and secure compute box rear panel with two thumb screws.

k. Set battery switch to position I and disconnect shore power to return compute box to battery power.

3.2 Update Software

Instructions

a. Update your software and AutoRally software on the compute box and OCS computer.

b. Compile software on compute box and OCS.

c. Test all software launches and ensure they run as expected.

It is recommended to not update Ubuntu software packages unless you are prepared to debug issues that may arise.

3.3 Packing List

Make sure to bring the following items with you when you test. Refer to the appendix for pictures of items.

3.3.1 Equipment to operate the platform

- AutoRally Chassis
- AutoRally Compute Box
- Platform Body
- Futaba 4PLS Transmitter
- OCS Laptop
- 24V MaxAmps Power Supply
- Chassis Batteries in LiPo sacks
- Compute Box Battery in LiPo sack
- Battery Charger
- Shore Power Cable
- Wireless Access Point with PoE injector and power supply
- Run-Stop Box
- Base station GPS Setup(optional)

3.3.2 Equipment to operate the base station

- Monitors with HDMI and power cables
- Keyboards, Mice
- USB Hub
- Extension Cords
- Power Strips
- USB Extension Cables
- Ethernet Cables (minimum of 2)
- Spare screws, nuts, wire plugs, body pins, cotter pins
- Toolbox with all tools

Always pack extra supplies - "When in doubt, bring it out."

4 General Test-Site Setup

Parts

- Tables
- Monitors, keyboards and mice
- OCS computer with USB hub
- Shore power cable
- 24V MaxAmps power supply
- Extension power cables and power strips

Instructions

a. Set up the ground station on site (chairs, tables, large tent, etc.). Arrange the ground station in a layout appropriate for your setup.

b. Set up power with extension cords and power strips as necessary.

c. Set up the OCS computer and connect a powered USB hub.

d. Set up monitor, mouse, and keyboard for the compute box.

e. Connect the shore power cable to the 24V MaxAmps power supply. Connect ground (black) wire and positive (red) wire.

f. Connect the power supply to a power source with two power cords.

5 Operator Control Station (OCS) Hardware Setup

5.1 Wireless Access Point Setup

Parts

- Wireless access point (AP)
- Power over Ethernet (PoE) injector with power supply
- 2 Ethernet cables

Instructions

a. Mount the AP at an elevated position in the middle of your track.

b. Connect one Ethernet cable to the LAN1 (PoE) port on the AP.

c. Connect the other end of the same Ethernet cable into the AP/Bridge port of the PoE injector.

d. Connect the second Ethernet cable to the Network Port on the PoE Injector and the OCS computer.

e. Connect the PoE power adpater to the injector and the power source.

5.2 Run-Stop Box

Parts

- Run-stop box

Instructions

a. Connect both USB cables from the run-stop box to the OCS USB hub.

5.3 Base Station GPS Setup

This section is only necessary if you have a base station GPS.

Parts

- GPS RS320 receiver
- GPS Antenna (L1/L2 GPS, L-Band)
- GPS TNC-TNC antenna cable
- GPS DB-9 data cable
- GPS USB cable
- GPS power adapter
- OCS computer with USB hub

Instructions

a. Set up the antenna stand and mount the antenna.

b. Connect antenna to the RS320 reciever with the TNC-TNC antenna cable.

If your OCS machine does not have a serial port, connect serial to USB adapter to the DB-9 data cable.

c. Connect USB cable to Port A, DB-9 data cable to Port B on the RS320 receiver.

d. Connect the USB ends of these cables from the receiver to the USB hub of the OCS computer.

e. Connect power adapter to the Power port on the receiver. Plug adapter into a power strip.

f. Press the power button on the receiver to turn on the base station GPS.

6 Platform Setup

6.1 Battery Installation

6.1.1 Chassis

Parts

- AutoRally chassis
- Chassis batteries - LiPo 6500mAh 4S 14.8v HPI Baja Pair
- Baja series adapter
- Chassis battery velcro strap

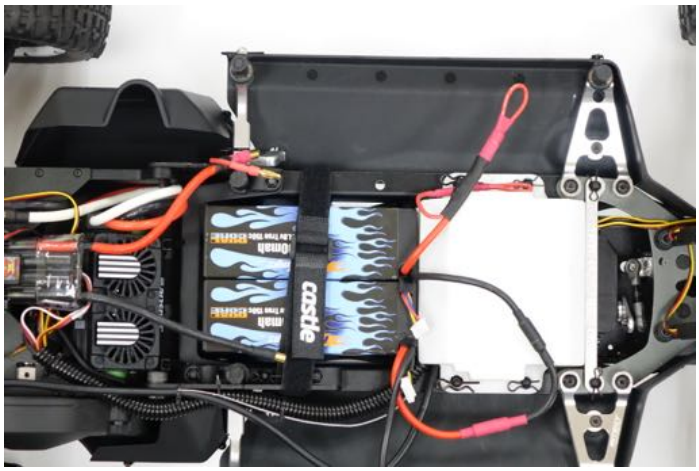
Instructions

a. Use the Baja series adapter to connect the ground lead of the chassis battery with the pre-charge circuit to the positive lead of the other chassis battery with the Baja series adapter.



b. Place the batteries in the chassis oriented with the battery wires next to the electronics box. Secure the chassis batteries in the chassis with the Velcro strap.

   The Velcro strap should run between the walls of the chassis, across the top of the batteries.



6.1.2 Compute Box

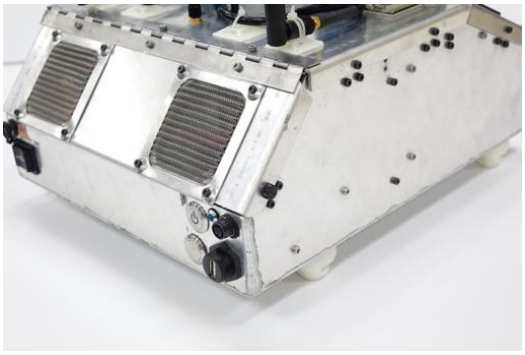
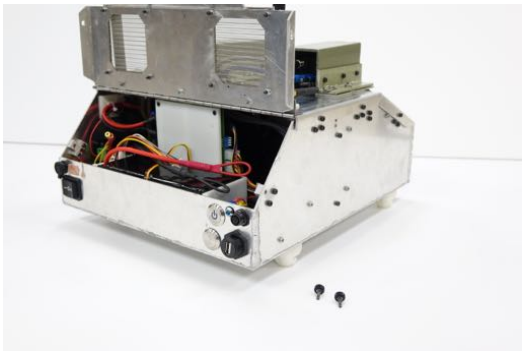
Parts

- Compute box
- Compute box LiPo 11,000mAh 6S 22.2v battery
- LiPo monitor

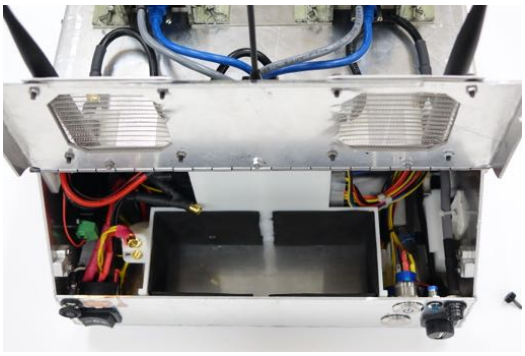
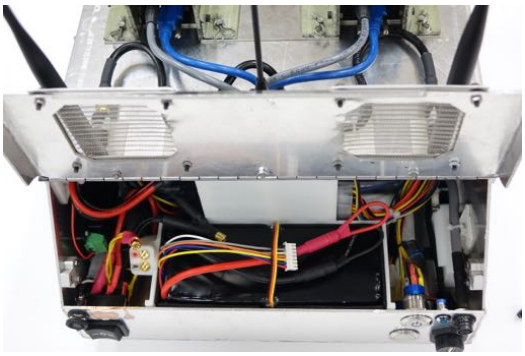
Instructions

a. If compute box is mounted on the chassis, remove it from the chassis.

b. Remove the two thumb screws that secure the back panel and open the rear hinge panel to expose the compute box battery slot.

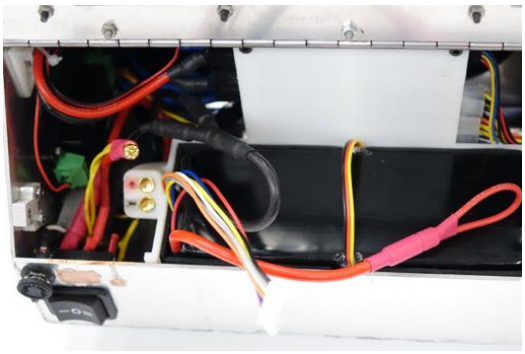
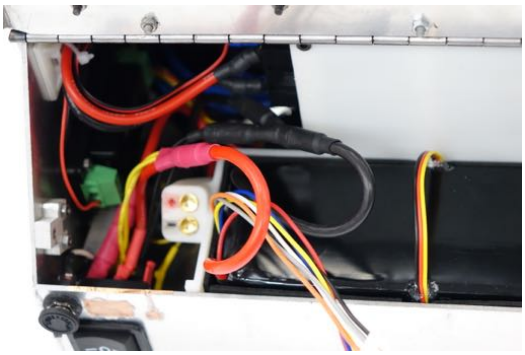



c. Install the compute box battery in the compute box battery slot with the leads oriented to the left.

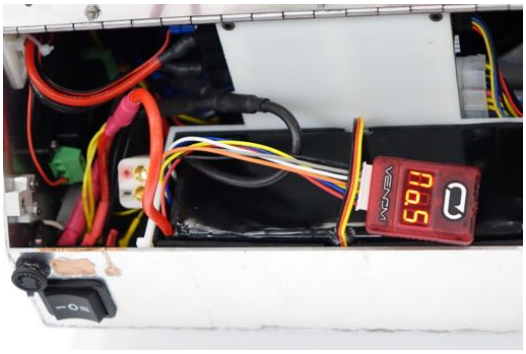



d. Verify that the compute box battery switch is set to position 0.

e. Connect the 6.5mm ground (black) wire of the battery to the 6.5mm ground connection of the compute box. Connect the 6.5mm positive (red) wire of the battery to the 6.5mm positive connection of the compute box.

f. Install a LiPo monitor on the balance tab of the compute box battery.



g. Close rear hinge panel and re-install thumb screws on rear side of compute box.


6.2 Powering the Chassis

Parts

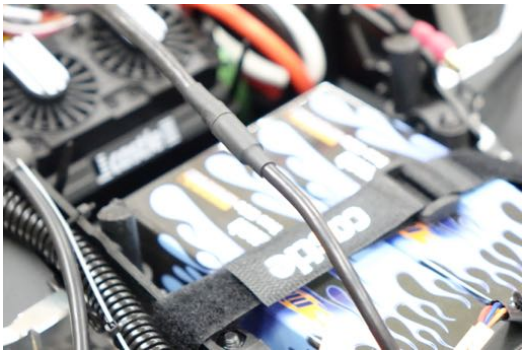
- Futaba 4PLS transmitter
- AutoRally chassis with batteries installed
- 2 LiPo monitors

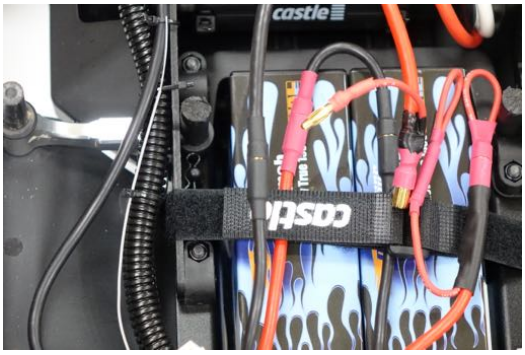
Instructions

a. **It may be beneficial to confirm the software is operating correctly before continuing with powering the chassis to prevent draining the batteries unnecessarily.**

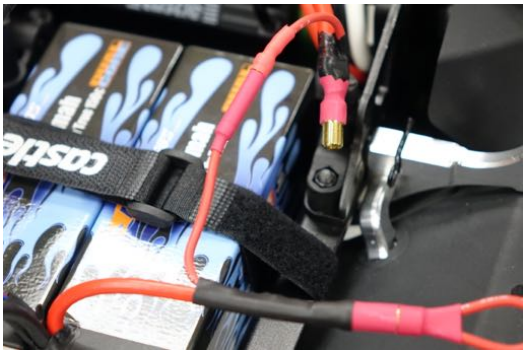
b. Turn the transmitter on. Reference the Transmitter Operation diagram in the Getting Started section or the transmitter manual for transmitter functionality.

c. Connect the 6.5mm ground (black) wire of the battery to the ground wire of the ESC.



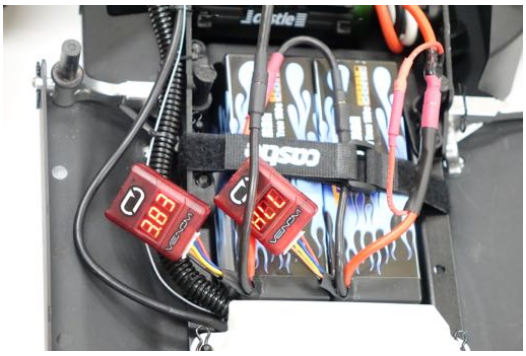


d. **Complete the next two steps quickly so that the pre-charge circuit does not overheat.** Connect the 4mm positive (red) pre-charging wire from the battery to the corresponding 4mm positive wire on the ESC.



e. Connect the larger 6.5mm positive (red) wire from the battery into the corresponding 6.5mm positive wire on the ESC.

f. Install a LiPo monitor onto the balance tab of each chassis battery.



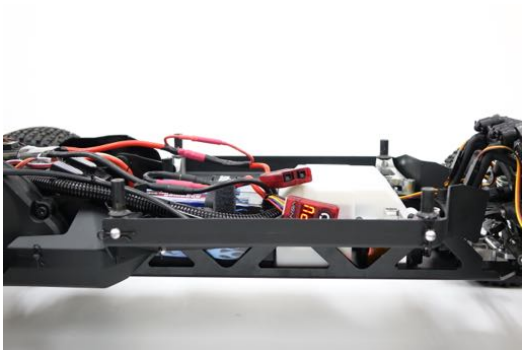
6.3 Mounting the Compute Box

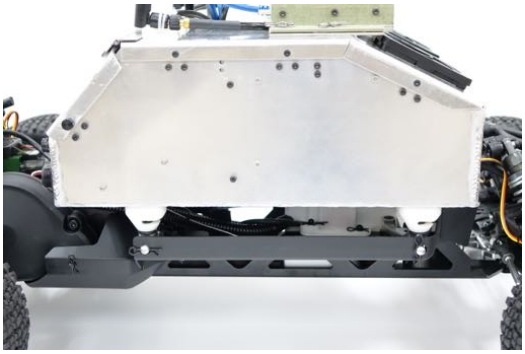
Parts

- Compute box with battery installed
- Chassis with battery installed
- Large body clips

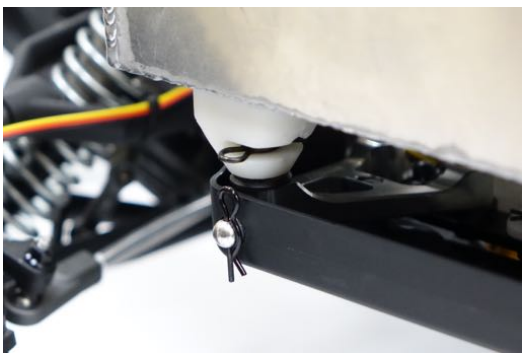
Instructions

a. Mount compute box to chassis by lining up the four chassis mounts on the compute box with the chassis body mounts. Push the compute box down so that the compute box chassis mounts fully cover the body mounts.





b. Secure compute box to chassis by pressing a large body clip through each of the four compute box chassis mounts and into the chassis body mounts.



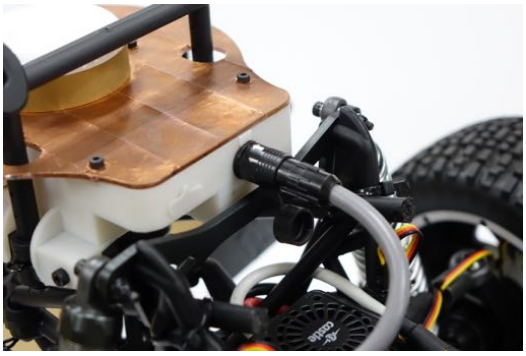
6.4 Data Connections

Parts

- AutoRally platform
- 12-pin GPIO cable

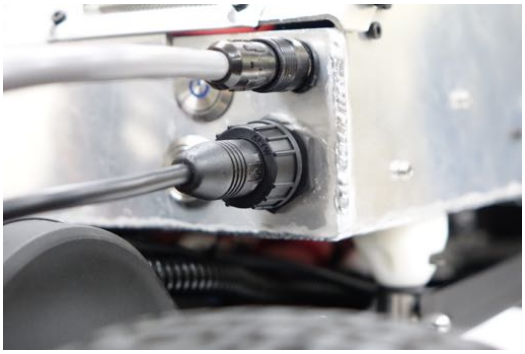
Instructions

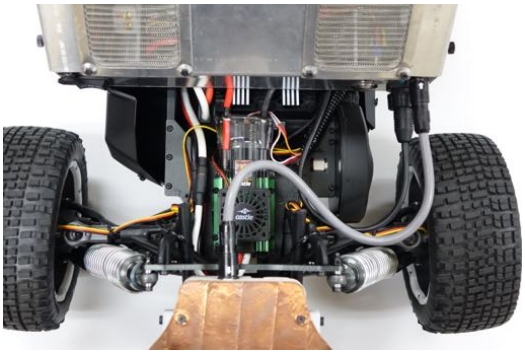
a. Connect one end of the 12-pin GPIO cable to the GPS box.



b. Connect the other end of the 12-pin GPIO cable to the 12-pin GPIO jack on the back of the compute box.

c. Connect the electronics box USB cable to the USB port on the back of the compute box and screw in the protective jacket.





7 Software Configuration

The platform should already be configured with the AutoRally Platform Configuration.

7.1 System Boot

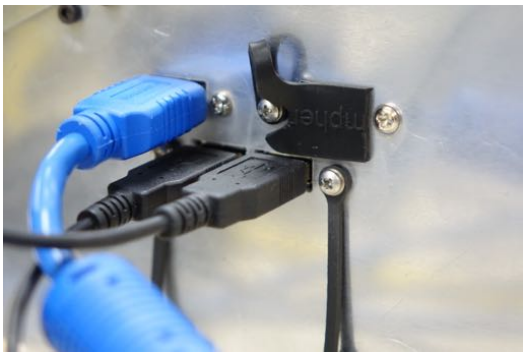
Parts

- Compute box
- Monitor, keyboard and mouse setup

Instructions

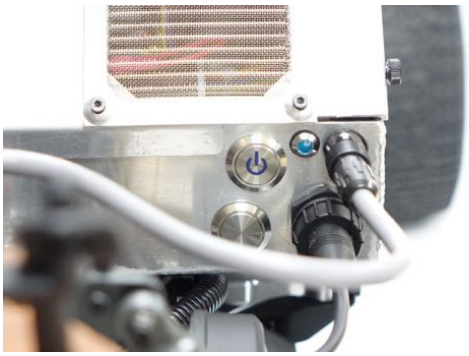
a. If desired, connect the monitor and keyboard to the compute box. **The display drivers may not load if a monitor is not plugged in on boot. To connect a monitor after booting, ssh into the compute box and run the command:**

```
sudo service lightdm restart
```



b. Apply power to the compute box with either shore power or battery power.

c. Turn on the compute box by pressing the power button on the rear panel of the compute box.



d. Turn on the OCS computer.

e. Ping the AutoRally platform from the OCS computer to confirm network connectivity. If network connectivity fails, refer to the Configuring IP Addresses for the AutoRally Platformpage.

7.2 Launch Core Software

Instructions

a. In a terminal window on the OCS computer, source the configuration file for the AutoRally platform you will control. **If you've already set up an alias for the platform during the AutoRally Platform Configuration, use the alias instead.** Verify that the output from the configuration script shows the expected values, i.e. that the correct chassis and cameras were detected. **This step must be done in every new terminal window.**

b. Launch the core software for the platform from the terminal you just configured on the OCS computer with the command:

```
roslaunch autorally_core autorally.launch
```

c. Launch the cameras in another terminal window on the OCS computer with the command:

```
roslaunch autorally_core cameras.launch
```

d. Verify the cameras are publishing data correctly with either the OCS or the rqt_image_view tool:

- In the OCS, open the video tab, click refresh, and select a topic. Or,
- launch the rqt_image_view tool with the command below, click refresh, and select a topic.

```
rqt_image_view
```

e. The topics to view are the /left_camera/image_raw and /right_camera/image_raw topics. **Use the compressed versions when connected over the network, /left_camera/image_raw compressed and /right_camera/image_raw compressed respectively.**

f. If the images do not show, in the System Info tab in the OCS, check the camera_nodelet_manager: /CameraTrigger. Verify the triggering rate requested and the actual triggering rate are their expected values. If there is an issue with the triggering, triggering can be disabled. Launch the dynamic reconfiguring tool with the command:

```
rosrun rqt_reconfigure rqt_reconfigure
```

g. In the tool, select left_camera_nodelet on the left and scroll down to the bottom. Uncheck the box labeled enable triggering. Repeat this process for right_camera_nodelet.

h. If desired, record data with rosbags. Refer to the ros documentation to record the desired topics. **Recording raw image topics takes a large amount of memory. Consider only recording the compressed images.**

7.3 Time Synchronization

Instructions

a. Locate the Diagnostic Messages display in the System Info tab of the OCS GUI. Verify that the GPS has signal by looking at the GPGNS GPS mode indicator value in the diagnostic entry of **gpsRover:/gpsRover/primaryPort** and ensuring that it displays "R-RTK fixed integer converged". This may take some time depending on your location and equipment. **Any GPS fix type (RTK, differential, or automatic) is sufficient to continue with the time synchronization process.**

b. This step is performed on the AutoRally compute box. **You can SSH into the AutoRally compute box from the OCS computer or use the monitor, keyboard, and mouse**

connected to the compute box. Synchronize compute box system with GPS time with the following commands in a terminal window:

Configure the USB port gpsd will use to communicate with the GPS.

```
stty 115200 < /dev/arGPSroverPortB
```

Launch `gpsd`

```
sudo gpsd /dev/arGPSroverPortB -n
```

c. On the compute box, verify that `chrony` is synchronizing the compute box system time with GPS time with the following commands:

Start the `chrony` client.

```
chronyc
```

Chrony client command that lists the time sources that the chrony daemon synchronizes itself to.

```
sources
```

d. Repeat step c on the OCS computer to verify that OCS system time is synchronizing to the compute box system time.

e. Wait until the clocks are synchronized. Synchronization is achieved when one of the `pps` sources has a asterisk next to a pound symbol). On the OCS, a caret is displayed instead of an asterisk next to a pound symbol.

If the OCS computer does not appear to be synchronizing its clock with the compute box, restart the OCS computer.

7.4 Launch Base Station Software

Instructions

a. Launch the base station software on the OCS computer in a configured terminal with the command:

```
roslaunch autorally_core baseStation.launch
```

b. Use the OCS GUI to verify that all nodes/software are functioning properly. Then disconnect the monitor, keyboard, mouse, etc. from the platform.

c. Plug all exposed compute box panel connections before placing the platform on the track. Place the platform on the track, with the car body secured on the platform with body pins.

8 Driving Controls

Reference the Transmitter Operation subsection under the Getting Started section for detailed information about operating the transmitter.

8.1 Manual Controls

Parts

- Futaba 4PLS transmitter
- Powered AutoRally platform

Instructions

a. Enable motion with SW1 on the transmitter grip.

b. To operate the AutoRally platform with the transmitter in Manual mode:

Steering: rotate the wheel on the transmitter

Throttle: pull the trigger toward the transmitter grip

Brake: push the trigger away from the transmitter grip

8.2 Autonomous Control

Instructions

a. Enable motion with SW1 on the transmitter grip.

b. Set the Manual/Autonomous control switch on the transmitter to Autonomous mode.

c. Enable motion within the OCS window by pressing the large "Enable Motion" button.

d. Enable motion on the run-stop box by releasing the red mushroom button, followed by pressing the green button. Verify that motion is enabled by checking that the RunStop Motion Enabled button of the OCS is green. Refer to Run-Stop Box Operation for run-stop box details.

e. The system is now ready to be controlled autonomously.

9 What's Next

Refer to the AutoRally Wiki for tutorials about the AutoRally state estimator, waypoint follower, and constant speed controller.

10 Platform Shutdown

10.1 Software

Parts

- Running OCS computer
- Running AutoRally platform

Instructions

a. Shut down all software running and close out any terminal windows on the compute box and OCS computer.

b. Shut down OCS computer.

10.2 Compute Box

Parts

- Running compute box

It is very important to place connector caps on open connectors as you unplug batteries.
Instructions

a. Shut down the compute box by pressing the compute box power button.

b. Set the compute box battery switch to position 0 to disable battery power.

c. If compute box is running on shore power, remove shore power cable.

d. Disconnect the 12-pin GPIO cable from the GPS box and compute box.

e. Disconnect the electronics box USB cable from the compute box.

f. Remove monitor, keyboard and mice connections from the compute box.

g. Once all external connections to the compute box are removed, remove the large body pins from the chassis mounts and unmount compute box from the chassis.

h. Remove the two thumb screws from the rear hinge panel of the compute box and open rear hinge panel to access compute box battery.

i. Unplug and cap the positive connector of the compute box battery.

j. Unplug and cap the ground connector of the compute box battery.

k. Remove the compute box battery from the compute box and place it in a LiPo sack.

10.3 Chassis

Parts

- Running AutoRally chassis
- Battery plugs

Instructions

a. Unplug and cap the 4mm pre-charge connector.

b. Unplug and cap the 6.5mm positive (red) connector.

c. Unplug and cap the 6.5mm ground (black) connector.

d. Disconnect LiPo monitors.

e. Remove batteries from the chassis.

f. Remove the Baja series adapter.

g. Place batteries in protective LiPo bags.

h. Power off the transmitter.

11 Test Site Cleanup

Instructions

a. Disassemble Base Station GPS.

b. Disassemble Wireless Access Point setup.

c. Disassemble OCS computer.

d. Remove any monitors, keyboards, mice, wires, tables, etc. from the test site and pack up any other tools and equipment used.

12 In Lab Post-Run

12.1 Hardware Post-Run

Parts

- AutoRally chassis
- Compute box

Instructions

a. Clean dirt and debris off of platform. If there is dirt inside the compute box, blow it out with a compressed air can.

b. Clean compute box fan filters (located on the compute box lid). Refer to the Cleaning Fan Filter subsection at the end of this section for detailed instructions.

c. Remove and clean plastic under guard and engine guard from the chassis.

d. Inspect platform for loose screws, damaged parts, or any other mechanical or electrical issues. Pay special attention to:

   Cracks in chassis 3-D printed mounts

   Screws at the bottom of the chassis

   Damaged electrical connectors

   Rubber components in axle boots and shock boots

e. After removing batteries, make sure that they are stored in an appropriate place.

12.1.1 Clean Fan Filters

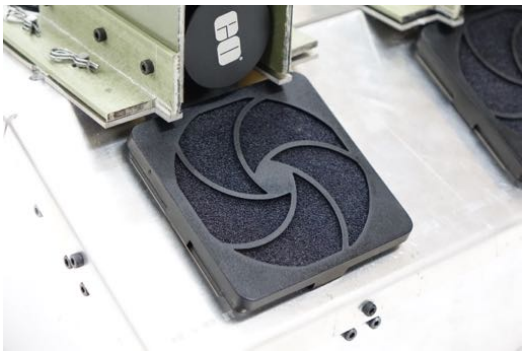
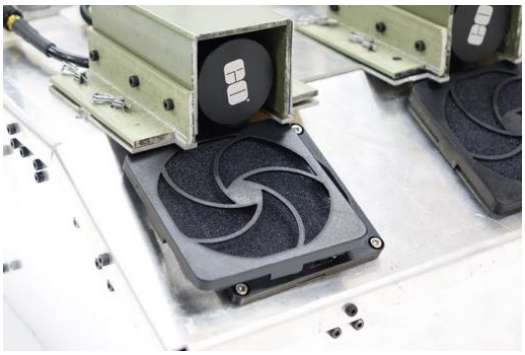
Parts

- Compute box
- Fan filter cover with fan filters
- Compressed air can (optional)

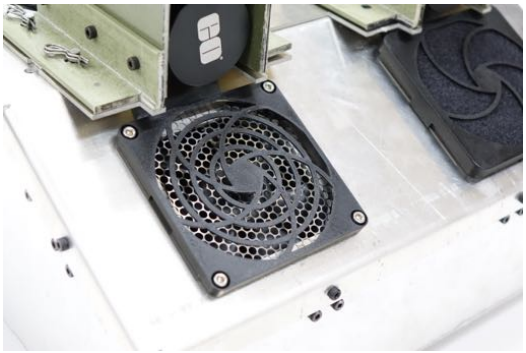
Instructions

a. Locate the fan filters on top of the compute box.

b. Release bottom, left, and right tabs of the filters cover by pulling up on them.

c. Slide filter covers sideways underneath camera covers to remove.



d. Remove and wash the filter in water, or by blowing out the dust with compressed air.

e. Reinstall filter and cover by reversing the above instructions.


12.2 Software Post-Run

Parts

- Compute box with monitor, keyboard, and mouse setup
- OCS computer

Instructions

a. Power up the AutoRally platform in lab.

b. Move all recorded data from the compute box.

c. Commit any changes made to software.

13 Appendix A: Test-run Checklist

13.0.1 Pre-run

- Charge the chassis and compute box batteries.
- Update software on the compute box and the OCS laptop.
- Perform a full distributed launch to ensure all the necessary hardware and software is working correctly.
- Pack all the necessary equipment.

13.0.2 Test-run

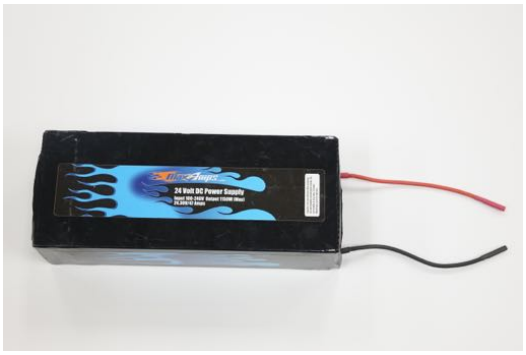
- Set up the ground station on site (chairs, tables, large tent, etc.).
- Set up the wireless access point.
- Set up the GPS base station.
- Install the chassis and compute box batteries.
- Mount the compute box.
- Attach the USB and the 12-pin GPIO cables to the compute box.
- Start the computer and launch the core software.
- Synchronize the computer clocks.
- Launch the base station software.
- Start the desired ancillary software.

13.0.3 Post-run

- Shut down the compute box.
- Remove the chassis and compute box batteries.
- Disassemble the ground station.
- Clean the hardware including air filters.
- Upload testing data.

14 Appendix B: Parts

- 24V MaxAmps power supply



- 6.5mm battery cable adapters

- AutoRally chassis

- AutoRally mini-ITX compute box

- Baja series adapter

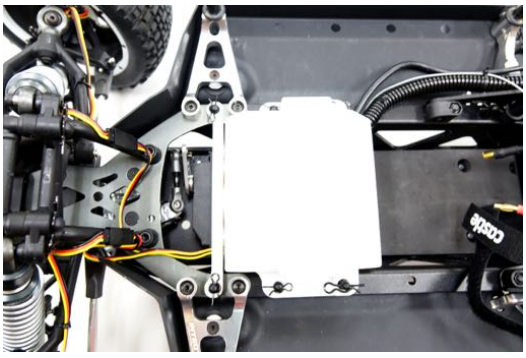
- Car body

- Cable plugs

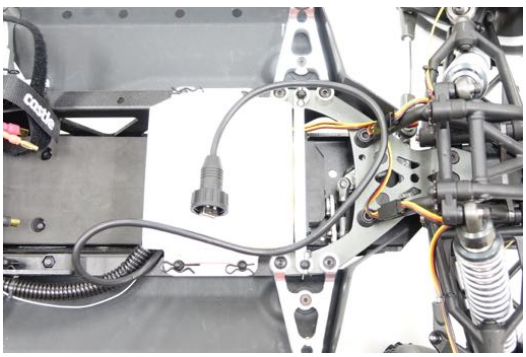
- Chassis batteries - LiPo 6500mAh 4S 14.8v HPI Baja Pair

- Compute Box battery - LiPo 11,000mAh 6S 22.2v battery

- Electronics box



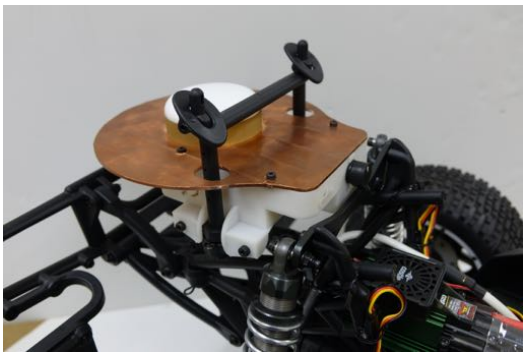
- Electronics box USB cable, waterproof Type A Male



- Futaba 4PLS transmitter

- GPIO 12-pin cable

- GPS box

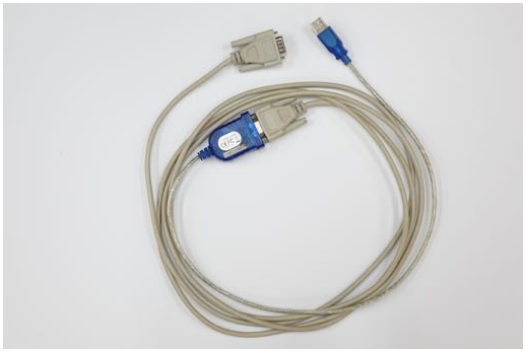


- GPS RS320 receiver

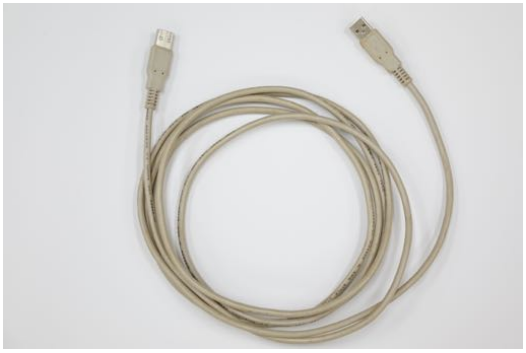
- GPS Antenna (L1/L2 GPS, L-Band)

- GPS TNC-TNC antenna cable

- GPS DB-9 data cable with serial to USB adapter



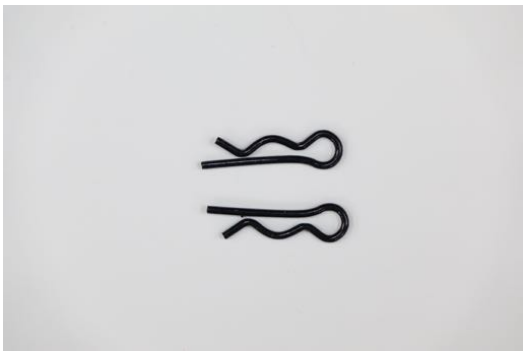
- GPS USB cable, Type-A to Type-A



- GPS power adapter

- Hyperion EOS 720i battery charger

- Large body clips

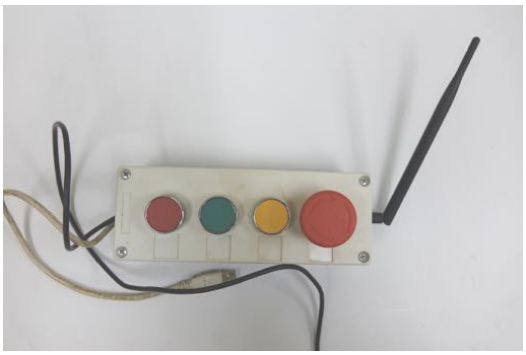


- LiPo monitor

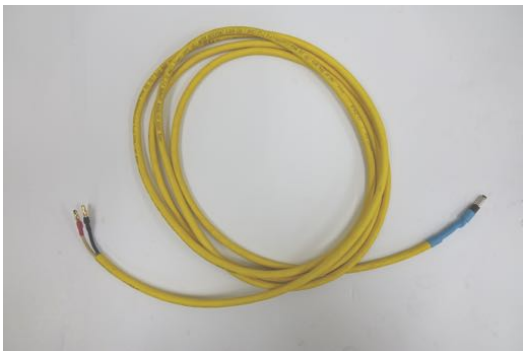
- Power over Ethernet (PoE) injector

- PoE injector power supply

- Run-Stop box



- Shore power cable



- Wireless Access Point (AP)

15 Appendix C: Revision History

Revision	Date	Author(s)	Description
1.1	July 2016	LP, AL, BG	created, version aligned with other documentation
1.2	September 2016	BG	Spelling fixes
1.3	February 2017	DP, JZ, BG	Streamlined procedure and added hints

16 Appendix D: Contributors

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