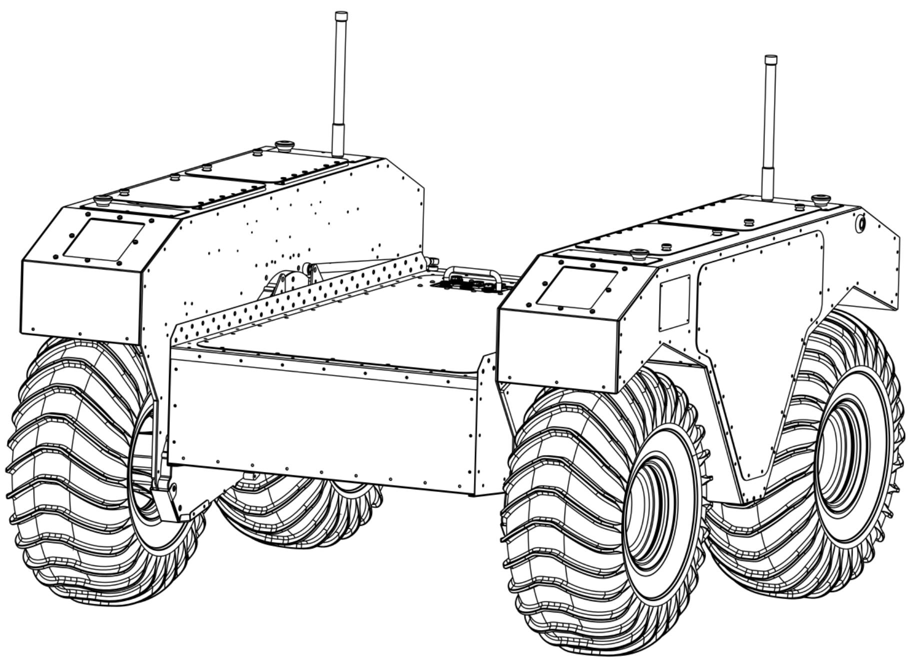
UDOH03 WARTHOG



UNIQUELY INTEGRATED PLATFORM

CUSTOM ROBOT QUICKSTART GUIDE

1 FROM THE DESK OF THE ROBOTSMITHS

Thank you Universidad de O'Higgins for your Warthog order! As part of the integration, we have prepared this quick reference memo for you and your team detailing your specific package.

2 SAFETY WARNING

Use of an autonomous robot is inherently dangerous. Please take time to locate the Red E-STOP buttons on each side of the front and rear of the Warthog. The E-STOP buttons and the Wireless E-STOP are used to stop the Warthog movement, but DO NOT control power to the payloads.

3 SYSTEM OPERATIONAL TIPS

For best battery performance and life, it is advised that the batteries be charged immediately after use. If the vehicle begins halting unexpectedly, or if the lights change to yellow, doing one or more of the following may improve performance:

- Reducing motor power draw by lowering acceleration, turning in place less, or limiting the grade of terrain being traversed.
- Reducing peripheral power draw by unplugging or otherwise shutting off devices which are not in use.

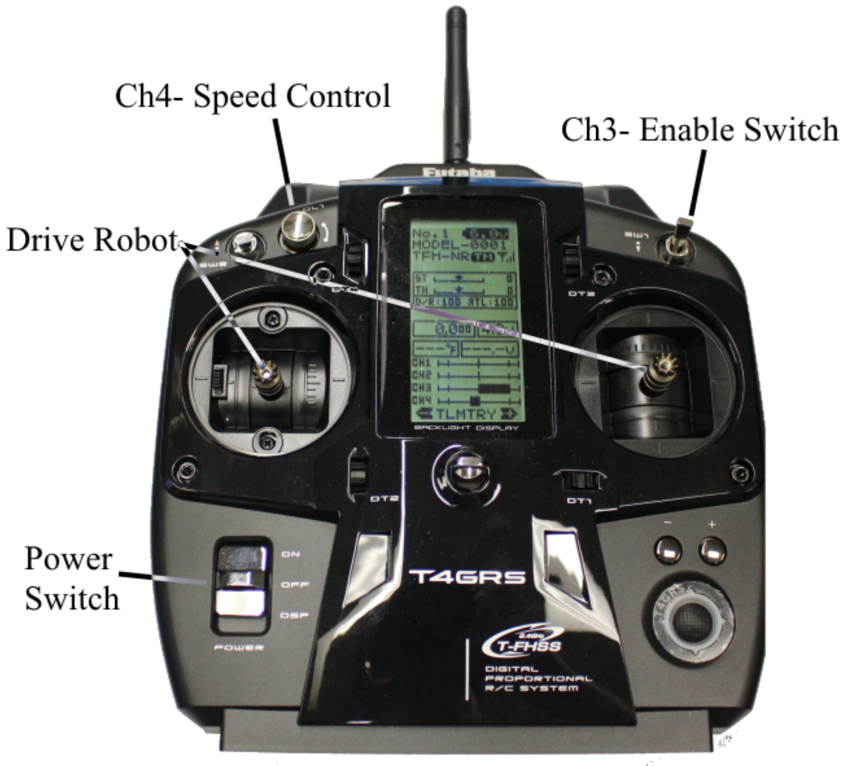
Your Warthog's battery can be charged by plugging its terminals into the included charger. Simply open the latch on the rear left of the Warthog and plug the charger's Anderson connector into the Warthog's. A light on the top of the charger will illuminate to indicate charging is taking place. When the charging light turns off, the battery is fully charged!

4 GETTING STARTED

Your system has been configured to allow you to get started immediately after receipt. Follow these instructions to get moving:

1. Turn on the Warthog using the big red switch on the rear of the robot.
2. Release all emergency stop controls on the Warthog. The lights should illuminate red on the rear two windows of the robot, and white on the front two windows.
3. Release the e-stop condition on the wireless e-stop controller.

4. Use the Futaba remote to control Warthog's motion. Use the two joysticks to drive the Warthog while holding CH3's Enable Switch. If the Enable switch is released, the robot will stop moving. Ch4 is the Speed Control knob. Turning CH4's knob counter-clockwise will lower the speed of the Warthog, while turning the knob clockwise will raise the speed.



5 NETWORK INFORMATION

Parameter	Value
Robot Static IP	192.168.131.1
Robot Hostname	cpr-w200-0065
User Name	administrator
User Password	clearpath
Secondary PC Static IP	192.168.131.5
Secondary PC Hostname	cpr-w200-0065b
Secondary PC User Name	administrator
Secondary PC User Password	clearpath
ROS Version	Noetic
Serial Number	W200-0065
Velodyne IP	192.168.131.20
SwiftNav Rover IP	192.168.131.31
SwiftNav Base Station IP	192.168.131.30
Microhard Radio IP	192.168.131.51
Microhard Radio Username	admin
Microhard Radio Password	clearpath
Access Point Radio IP	192.168.131.52
Access Point Radio Username	admin
Access Point Radio Password	clearpath1
Access Point Wifi SSID	UDOH03_Router
Access Point Wifi Password	clearpath
Base Station Radio IP	192.168.131.50
Base Station Radio Username	admin
Base Station Radio Password	clearpath
Base Station SSID	UDOH03 Base Station

6 BASE STATION

Your robot is equipped with a portable high-powered Wifi Base Station. This base station may be used in your lab or anywhere in the field as a long-distance wifi access point for communicating with your robot. Your robot has been configured to connect with this base station by default.

To set up the Base Station, find a suitable and stable location to set up the base station tripod. Mount the Base Station to the tripod by threading the tripod's mounting screw to the Base Station's threaded mounting hole.

If necessary, open the Base Station enclosure and plug in the battery. If you are working in a lab environment, you may optionally connect the Base Station's Ethernet port to a live Internet connection. This will grant the robot (and any other computers connected to the Base Station via wifi) access to the internet.

Some corporate network infrastructures may not permit an unauthorized access point. If this is the case at your location, please contact your IT administrator for assistance with connecting the Base Station to your intranet.

Turn on the Base Station by pressing the silver button located on the side. After a few minutes the Base Station will begin broadcasting its SSID. At this point you may turn on your robot, and connect to the base station using any other external computers. Your computer will be granted an IP address in the same subnet as the Base Station and robot, allowing you to communicate with the robot easily.

The Base Station battery will last for about 6 hours on a full charge. It is a good idea to change the battery as soon as you are finished using the base station, so that you always have a fresh battery ready to go.

Base Station settings may be altered by connecting to it via wifi, then entering its IP address into a web browser. These settings are available in the Network Information section earlier in this document.

7 WIRELESS ACCESS POINT

The wireless access point built into your robot is a convenient way to communicate with your robot without requiring a connection to wifi infrastructure in your location. Simply turn on the robot, and connect to the SSID being broadcast by the robot's access point. The SSID and login information are available in the Network Information section of this document.

Once connected to your robot's access point, your computer will be granted an IP address via DHCP. It should now be possible to communicate with the robot's onboard computer and payloads.

Should you need to change any settings on the AP, connect to it as usual via wifi. Then, enter its IP address into a web browser on your computer.

To connect your robot to the internet, plug a live internet connection into the WAN port on the access point. The robot and any connected computers should then be granted access to the internet.

Some corporate network infrastructures may not permit an unauthorized access point. If this is the case at your location, please contact your IT administrator for assistance with connecting the Base Station to your intranet.

8 MICROHARD RADIO

The Microhard is a powerful long-range wifi radio. It has been configured to act as a client, and will automatically connect to the base station on power up.

Its settings may be accessed by connecting to the Base Station via wifi, then entering the Microhard's IP address into a web browser. Its IP and login information are available in the Network Information section.

9 POE NETWORK SWITCH

Your robot is equipped with an active PoE (Power over Ethernet) network switch. Its purpose is to provide power and communications to one or more onboard payloads.

Any IEEE802.3af/at compliant devices may be connected to a PoE port on this switch.

Non-PoE devices may also be connected to this switch without harm. However, use caution when connecting passive PoE devices as they may not be compatible.

10 WIRELESS

To set up the wireless communications on your Warthog, you must first establish a wired connection. Using an Ethernet cable, connect your computer to an Ethernet port on the Warthog's computer via the top plate, and set a static IP on your computer to 192.168.131.19 (for example). If there are no free ports you may temporarily disconnect one of the payloads. SSH into the robot computer with:

```
ssh administrator@192.168.131.1
```

Enter the login password when prompted. Once you have successfully logged in, you can connect the robot's computer to a desired wireless network.

You can connect your robot to a desired wireless network using Netplan.

Simply create a file called 60-wireless.yaml inside of the /etc/netplan folder on your robot's computer. Copy and paste the contents below into the file, and make sure to modify the wireless interface, SSID, and password fields.

```
network:
  wifis:
    # Replace WIRELESS_INTERFACE with the name of the wireless network device, e.g. wlan0 or wlp3s0
    # Fill in the SSID_GOES_HERE and PASSWORD_GOES_HERE fields as appropriate. The password may be included
         as plain-text
    # or as a password hash. To generate the hashed password, run
    #  echo -n 'WIFI_PASSWORD' | iconv -t UTF-16LE | openssl md4 -binary | xxd -p
    # If you have multiple wireless cards you may include a block for each device.
    # For more options, see https://netplan.io/reference/
    WIRELESS_INTERFACE:
      optional: true
      access-points:
        SSID_GOES_HERE:
          password: PASSWORD_GOES_HERE
      dhcp4: true
      dhcp4-overrides:
        send-hostname: true
```

Once you have saved the file, you will then need to apply your new Netplan configuration and bring up your wireless connection by running:

```
sudo netplan apply
```

More advanced networking examples, including configurations for accessing a wifi network requiring WPA Enterprise credentials, can be found here:

https://netplan.io/examples/

You can verify that your robot is connected to a wireless network by running:

```
ip a
```

This will show all active connections and their IP addresses, including your robot's connection to the desired wireless network, and the IP address assigned to the robot's computer.

You may continute working on the robot via the wired connection, or disconnect the Ethernet cable and connect to it via wifi instead. When connecting to the robot computer by wifi, it should be accessible via its hostname:

```
ssh administrator@cpr-w200-0065
```

If you are having trouble establishing or maintaining a reliable wifi connection, please contact your network administrator. Some building wifi infrastructures require special permissions to be granted before a connection is allowed.

11 COMMUNICATING WITH THE ROBOT

Ensure the Base Station is turned on. Once it is broadcasting, connect to it via wifi.

To communicate directly with the robot PC, you can SSH in. It will be necessary to ssh into the robot for tasks such as installing, modifying or removing software and files on the robot. If this is your first time connecting to the robot, it will be necessary to connect an Ethernet cable between your own computer and an open port on the robot. Manually set your computer to the same subnet as the robot's IP address.

Note that you will not be able to use GUI tools such as rviz over an SSH connection:

```
ssh administrator@192.168.131.1
```

OR

```
ssh administrator@cpr-w200-0065
```

In order to use rviz and other visualization tools, you must declare the robot as master, and set the user computer IP. In a console on the user pc, type:

```
export ROS_MASTER_URI=http://cpr-w200-0065:11311
```

You should then be able to view a list of topics published by the robot with:

```
rostopic list
```

It will be necessary to declare the robot as master in every new terminal window, unless you change the master permanently in your ROS environment variables. If you are unable to connect with the robot via its hostname, your computer or network equipment may not be routing hostnames properly. In Ubuntu on your local computer, open your /etc/hosts file:

```
sudo nano /etc/hosts
```

Add the following line immediately below the line that contains 127.0.1.1, substituting in the robot's current wifi IP address. This address may be obtained by connecting directly to the robot via Ethernet, and using the "ifconfig" command. You may want to talk to your system administrator about giving the robot a permanent wifi address to ensure it always connects with the same IP address. You may also need to add an entry for the robot's secondary computer. The below example shows the setting if wired directly into the robot lan, or connected to the robot's wireless access point or base station.

```
192.168.131.1       cpr-w200-0065
192.168.131.5       cpr-w200-0065b
```

To ease communications between the robot and your computer, you can also add a similar entry in the robot's computer, pointing at one or more development computers.

12 SETTING UP YOUR WORKSPACE

To make full use of your new robot, your computer should have a matching version of ROS installed. For best results we recommend using a computer running Ubuntu natively, or in a VM.

Go to http://wiki.ros.org/noetic/Installation/Ubuntu for instructions on how to install ROS Noetic on your Linux computer.

Your ROS computer should also have the common software packages associated with your robot model. Once ROS is installed, use apt to install your robot-specific packages:

```
sudo apt-get install ros-noetic-warthog-desktop
```

There is a workspace installed in your robot for development and custom packages. You will likely want to be able to use these packages on your local machine. To do this, make a new folder on your local computer:

```
cd ~
mkdir catkin_ws && cd catkin_ws
mkdir src && cd src
```

Then copy all of the packages from the robot to your local machine

```
scp -r administrator@cpr-w200-0065:~/catkin_ws/src/* .
```

The ZED driver requires a GPU running nvidia CUDA to compile and run. It does not need to run on your remote computer; we only need it for the URDF and meshes it contains. Therefore, we can tell catkin to skip compiling the zed-ros-wrapper package. To do so, place a blank directory in the package root called "CATKIN_IGNORE."

```
cd ~/catkin_ws/src/zed-ros-wrapper
mkdir CATKIN_IGNORE
```

Now, make sure you have all of the dependencies needed to build these packages:

```
cd ..
rosdep update
rosdep install --from-paths src --ignore-src -r -y
catkin_make
source ~/catkin_ws/devel/setup.bash
```

13 GPU

The secondary computer in your robot has been equipped with a Graphics Processing Unit (GPU). Should you need to connect a monitor to the secondary computer, make sure it is connected to one of the ports on the GPU. To check whether the GPU is functioning properly, you can use the nvidia-smi utility:

```
nvidia-smi
```

The current driver version of your card should be listed in the top row.

14 FLIR A400 THERMAL CAMERA

The A400 thermal camera images cannot be viewed via ssh. Declare the robot as ROS Master, then from the command line:

```
rosrun image_view image_view image:=/rtsp2/image_raw compressed
```

The A400 image streams may also be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the desired "/image" stream (NOT /camera).

The A400's HTML control/settings page can be accessed by typing in the IP address of the camera in your computer's web browser (you will need to ensure your network adapter is on the same sub-net).

15 FLIR CAMERA

The FLIR camera images cannot be viewed via ssh. Declare the robot as ROS Master, then from the command line:

```
rosrun image_view image_view image:=/camera/image_raw compressed
```

The FLIR image streams may also be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the desired "/image" stream (NOT /camera).

The camera settings can be configured on the fly using dynamic reconfigure. With the camera stream running in image_view or rviz, launch reconfigure from a new tab, and choose the "spinnaker_camera_nodelet" option from the menu:

```
rosrun rqt_reconfigure rqt_reconfigure
```

FLIR cameras are fixed focus. To fine-tune them for your application, you'll need to adjust the aperture, focus, and zoom (on some lens models) accordingly. Increasing the aperture (opening the iris wider) will allow more light onto the sensor, allowing it to operate in lower light conditions. But a wider aperture will also reduce the focal range. If you need a deeper focal range, try reducing the aperture and increasing the exposure in rqt_reconfigure to compensate.

The frame rate of the camera is affected by the acquisition_frame_rate value, as well as the exposure_time value. Setting the exposure time too high will reduce the achievable frame rate on the camera. In challenging lighting conditions it may be necessary to add auxiliary lighting in order to get a good balance of focal depth, exposure, and frame rate.

Any of the values that can be adjusted using rqt_reconfigure may also be pre-set in the camera launch file on the robot.

16 OCCAM 360 DEGREE CAMERA

The OCCAM 360 degree camera uses five individual cameras to generate a 360 degree view of its surroundings. The images from the five cameras may be viewed individually, or stitched together as a single image. Declare the robot as ROS Master, then from the command line:

```
rosrun image_view image_view image:=/omni_60_node/stitched_image0 compressed
```

The image streams may also be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the desired "/image" stream (NOT /camera).

The camera settings can be configured on the fly using dynamic reconfigure. With the camera stream running in image_view or rviz, launch reconfigure from a new tab, and choose the "spinnaker_camera_nodelet" option from the menu:

```
rosrun rqt_reconfigure rqt_reconfigure
```

The frame rate of the camera is affected by the number of other devices on the USB bus. For optimal performance, try disabling the launch files of sensors you don't need. You may also try adjusting the jpeg_quality parameter using rqt_reconfigure.

17 ZED CAMERA

The ZED camera generates both a pointcloud and live image streams. This data cannot be viewed via ssh. Declare the robot as ROS Master, then from the command line:

```
rosrun image_view image_view image:=/zed2_node/left/image_rect_color
rosrun image_view image_view image:=/zed2_node/right/image_rect_color
```

The ZED image streams may also be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the desired "/image" stream (NOT /camera).

The ZED Pointcloud may be viewed from within rviz by clicking "Add," selecting the "By Topic" tab, then choosing the "point_cloud/cloud_registered" topic.

Common parameters such as frame rate, image resolution, position tracking, and mapping options are all available in a common yaml file on the robot. It is located in ∼/zed_wrapper/params/common.yaml. Additional camera model-specific parameters are available in ∼/zed_wrapper/params/zed2.yaml.

18 VELODYNE LIDAR

The data produced by the Velodyne LIDAR is best viewed from within rviz, but you can check that it is publishing data using the hz command in ROS. The LIDAR should publish at a rate of about 10Hz or 20Hz, depending on the model:

```
rostopic hz /velodyne_points
```

The Velodyne will also publish a single-beam output to the /scan topic, at the same rate as the pointcloud:

```
rostopic hz /scan
```

Add Velodyne laser data to rviz by navigating to the "Sensing" sub-folder, and adding the relevant Velodyne topic to "LaserScan" and/or "PointCloud2."

19 UM7 IMU

The imu data may be checked by echoing the following topic:

```
rostopic echo /um7/imu/data
```

20 SWIFTNAV RTK GPS

The SwiftNav RTK GPS System is a powerful RTK GPS sensor solution. It consists of a Rover-mounted receiver and a fixed-position RTK Base Station receiver. The two receivers are linked via a two-way wifi to serial bridge which permits the Base Station to send RTK corrections to the Rover.

The SwiftNav receiver features a number of status LEDs which can be used to tell at a glance the status of the sensor.

Solid Green	Power On
Flashing Yellow	Waiting for GPS Fix
Solid Yellow	GPS Fix Achieved
Flashing Red	Link Established Between Receivers
Flashing Blue	Floating RTK Solution
Solid Blue	Full RTK Lock

The SwiftNav GPS publishes to /piksi/navsatfix_best_fix. Note that the topic will only publish when a valid GPS fix has been achieved. When a full RTK lock has been achieved, the "Status" fields will change from a "1" to a "2."

```
rostopic echo /piksi/navsatfix_best_fix
```

Additional sensor data from the SwiftNav GPS receiver is available from other topics in the same namespace, such as:

```
rostopic echo /piksi/tracking_state
rostopic echo /piksi/debug/receiver_state
```

In order to achieve an RTK lock, it is necessary to update the "surveyed position" fields on the base station receiver. To do so, connect to the base station via wifi, and access the base station settings using the Swift Console application. On launch, choose "TCP/IP" and enter the IP address of the base station GPS receiver. Record the current Latitude, Longitude, and Height of the base station receiver (from the Solution tab) and transfer those values to the "surveyed position" fields in the Settings tab. It may be necessary to update these fields every time the Base Station is moved to a new location.

For more information on using the Swift Console, please see this link:

https://support.swiftnav.com/customer/en/portal/articles/2492795-swift-console

If the receiver appears to be having trouble achieving a good fix, the following steps may help:

- Make sure the robot has a clear view of the sky
- Move the robot away from tall objects such as buildings and trees
- Make sure no other payloads are partially or fully obscuring the GPS antenna
- Move potential sources of RF interference (such as USB3 cables or powerful radios) away from the antenna and antenna cable

21 VISUALIZING IN RVIZ

You can visualize your robot using rviz. To do so, you must first move a copy of any extra customizations from the robot into a workspace on your local computer (See “Setting Up Your Workspace.”) Then, source the workspace:

```
source ~/catkin_ws/devel/setup.bash
```

Declare the robot as ROS Master:

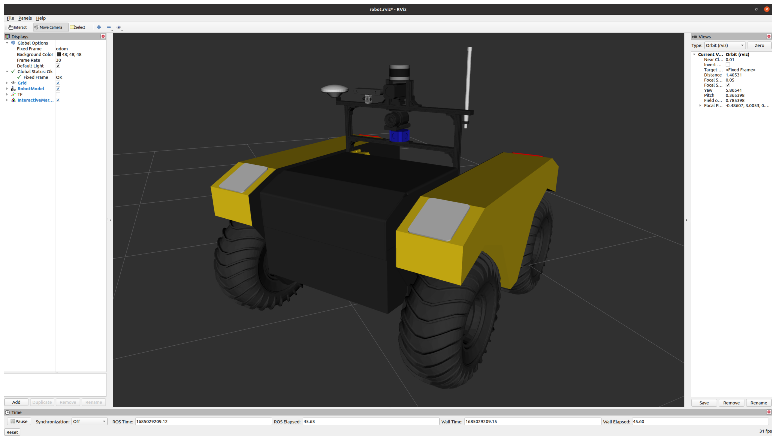
```
export ROS_MASTER_URI=http://cpr-w200-0065:11311
```

To view the robot's model in rviz:

```
roslaunch warthog_viz view_model.launch
```

To interact with the robot in rviz:

```
roslaunch warthog_viz view_robot.launch
```



You can rotate the model using your cursor, and zoom in or out by scrolling up or down. Strafe by holding down Shift and dragging the model. The robot itself may be driven directly from rviz by changing to interact mode. In this mode, arrows appear around the model. Drag the arrows to make the robot move.

Additional sensor topics may be added to the rviz interface by clicking the "Add" button in the bottom left, selecting "By topic," then choosing the desired topic from the list.

More information on rviz is available here: wiki.ros.org/rviz

22 ABOUT YOUR INTEGRATOR

This robot was integrated by Zac.

23 LEARNING

If you are new to using ROS, please visit our support page for information on how to get started using your new robot: support.clearpathrobotics.com

Please contact our support team directly at support@clearpathrobotics.com if you have any questions that aren't answered on our support page. For ROS-specific questions, we recommend visiting answers.ros.org, which we also keep an eye on.