

CanberraUAV

# Flight Operations Manual

UAV Outback Challenge 2014



[www.canberraUAV.org.au](http://www.canberraUAV.org.au)

# 1 Contents

2	Introduction .....	3
2.1	Version History.....	3
3	Roles and Responsibilities.....	4
3.1	Pilot .....	4
3.2	Assistant Pilot.....	4
3.3	Ground Control Lead.....	4
3.4	Ground Control Secondary .....	4
3.5	Camera and Imagery Control .....	4
3.6	Manual Antenna Tracker .....	4
3.7	OBC Liaison .....	4
3.8	Named Roles .....	5
4	Checklists .....	6
5	Flight Phases .....	11
5.1	Takeoff and cruise to search area (0:00 - 5:00) .....	11
5.2	Searching for Joe (5:00 - 35:00) .....	11
5.3	Joe Detected (35:00 - 40:00).....	11
5.4	Bottle Drop (40:00 - 45:00) .....	12
5.5	Return to Airfield (45:00 - 50:00).....	12
5.6	Landing (50:00 - 55:00) .....	12
6	Emergency Procedures .....	12
6.1	Loss of Datalink .....	12
6.2	Loss of GPS .....	12
6.3	Pixhawk Software crash (Failure of Autopilot software / Failure of SAS).....	13
6.4	Loss of engine power .....	13
6.5	Geofence breach.....	13
6.6	GCS Software failure .....	13
6.7	Commanded Destruction.....	13
7	Annexes.....	14
7.1	Waypoint ID's.....	14
7.2	Bushmaster Performance Info .....	17
7.3	Area Map.....	18
7.4	Ground Station Network.....	19

## 2 Introduction

This manual describes the operations of CanberraUAV in the Outback Challenge 2014 (OBC). This includes roles and responsibilities, mission phases and emergency procedures.

The aim is to document everything that is needed to be done during the OBC Search and Rescue Mission, so it can act as a reference point for team members.

It will also cover the OBC Scrutineering mission, with the relevant changes to waypoints and flight phases.

### 2.1 Version History

Version	Date	Comments
1.0	10/08/2012	Initial Version
2.0	19/08/2012	2012 OBC Final
3.0	01/08/2014	Changes to account for new airframe and setup for the 2014 OBC
3.1	08/08/2014	Cleaned up additional 2014 OBC changes
3.2	20/08/2014	Updated waypoint information and usage of Porter as airframe
3.4	04/09/2014	Various changes on feedback from 1 <sup>st</sup> All Up Test – updated waypoints, changes to airspeed calibration, labeling as to who does each checklist item.
3.5	09/09/2014	Add references to Bushmaster. Also added checklist item for fuel breather hose.
3.6	15/09/2014	Moved airspeed sensor calibration. Added radio range check and Lidar check

## 3 Roles and Responsibilities

### 3.1 Pilot

- Assembling the UAV (Wings, Tailplane, Hatches) and performing pre-flight checks
- The Pilot and the Assistant Pilot will be the only team members on/near the runway
- Flying the UAV in Manual or FBW mode. This may include takeoff, landing or during emergency procedures (when the UAV is circling Airfield Home and needs to be landed)
- The Pilot will have the final decision on manual takeover whilst the UAV is in RC range.

### 3.2 Assistant Pilot

- Assists the Pilot with their tasks
- Has a CB radio to communicate with the Ground Control Station
- Acts as a point of contact on the flight line during preflight checks
- If the Pilot is unavailable, performs their tasks
- The Pilot and the Assistant Pilot will be the only team members on/near the runway

### 3.3 Ground Control Lead

- Assist with GCS Setup
- Performs pre-flight checks of the Pixhawk and Imaging software
- Monitors overall progress of the UAV through all phases of the mission
- Issues commands to the UAV
- Confirms bottle drop

### 3.4 Ground Control Secondary

- Assist with GCS Setup
- If the Ground Control Lead is unavailable, performs their tasks
- Monitors the UAV's progress through the mission waypoints
- Ensures that the correct waypoints have been loaded
- Monitors the state of the UAV - altitude, speed, roll, pitch, etc
- During emergency situations, ensures the UAV diverts to the correct waypoint/loiter
- Monitors the time, ensuring the UAV will finish the search pattern within the allocated time limit. Watch ETR.

### 3.5 Camera and Imagery Control

- Assist with GCS Setup
- Confirms the Camera is capturing correctly
- Monitors the camera capture and image processing
- Makes the call as to where Joe is located

### 3.6 Manual Antenna Tracker

- Assists with GCS Antenna Setup
- In the event of the automatic antenna tracker failing, they will point the antenna manually. Pointing directions will be given by Ground Control Lead

### 3.7 OBC Liaison

- Assist with GCS Setup
- Relays messages and queries between the OBC staff and GCS team
- Records Joe position and gives it to the OBC Staff

### 3.8 Named Roles

<b>Team Member</b>	<b>Role</b>
Jack Pittar	Pilot
Andrew Tridgell	Ground Control Lead
Stephen Dade	Ground Control Secondary
Matt Ridley	Camera and Imagery Control
Grant Morphett	Assistant Pilot
Chris Gough	Manual Antenna Tracker
Greg Oakes	OBC Liaison and Payload Master
Jono Parrot	General Help

## 4 Checklists

These checklists are to be performed before and during any flight with the CanberraUAV Bushmaster airframe and full GCS setup.

Item	Who?	Done?
<b>Before the Competition (the evening beforehand)</b>		
The full mission MUST be run in SITL beforehand to check for any typos with waypoints	GCS	
Confirm all batteries charged (avionics, ignition, GCS, RC Controller, CB radios)	GCS	
All GCS laptops charged and working correctly	GCS	
UAV avionics tested for basic functionality	GCS	
UAV and GCS equipment loaded in vehicles, along with spares and tools	UAV and GCS	
<b>Assembling the Bushmaster</b>		
CB radio active	UAV and GCS	
Assemble wings and unfold fuselage	UAV	
Check for physical damage to airframe	UAV	
Check all electronics present and connected (no unconnected cables)	UAV	
No physical damage to engine, propeller or avionics	UAV	
Confirm avionics and engine ignition batteries fitted and charged	UAV	
Confirm fuel tank full	UAV	
Centre of Gravity within limits	UAV	
Confirm water bottle correctly attached	UAV	
Area and runway clear of unnecessary personnel and debris	UAV	
Confirm air breather plug is in breather hose from header tank	UAV	
<i>Avionics power ON</i>	UAV	
<b>Assembling the Ground Station</b>		
Radio mast erected	GCS	
GCS table and chairs in correct position	GCS	
Shading assembled	GCS	

GCS laptops power and network connected	GCS	
Radios (900 MHz,5.8 GHz, 433 MHz both ends) and tracker power connected	GCS	
<i>Van Power ON</i>	GCS	
Internal LAN active	GCS	
Confirm radios, laptops and TV powered	GCS	
CB Radio placed in centre of GCS table	GCS	
All laptop software working correctly	GCS	
All Ground Station operators confirm their respective sections OK	GCS	
Tracking antenna pointing to UAV	GCS	
Confirm that 433 MHz tracker link is stable and a good SNR	GCS	
<i>Confirm that mission is a GO</i>	GCS	
<b>Pre-Engine start checks</b>		
Airspeed calibration – Put cover on airspeed sensor, disarm then arm the Pixhawk, wait for confirmation from GCS and remove cover	UAV and GCS	
Verify		
All servos and flight control surfaces responsive	UAV	
PIXHAWK running	GCS	
Odroid running	GCS	
RC radio link working	UAV	
Confirm GPS Lock (for both GPS modules)	GCS	
Confirm altitude lock (Pressure, GPS and Lidar)	GCS	
Pixhawk showing stable 5V power	GCS	
Gyros and Accelerometers calibrated and showing sensible values	GCS	
Compass calibrated and pointing in the correct direction	GCS	
Correct Pixhawk parameters loaded	GCS	
Confirm waypoint numbers for GPS loss, data loss failsafes are set in the Pixhawk parameters	GCS	
Confirm geofence loaded and active	GCS	

Confirm failsafe termination action is set to "42"	GCS	
2x Radio links active and working (with a decent SNR value)	GCS	
Ensure flight mode FBWA	UAV and GCS	
Check the Odroid has enough free SSD space	GCS	
Flaps set to 0	UAV and GCS	
<i>Wait for permission to start engine</i>	UAV	
<b>Post-engine start Checks</b>		
Engine running nominally	UAV	
Radio range check		
Confirm IMU gives the correct orientation (during taxi)	GCS	
Start camera capture	GCS	
<i>Taxi to runway</i>	UAV	
<i>Wait for takeoff permission</i>	UAV	
<b>Pre-takeoff Checks</b>		
UAV pointed accurately down runway	UAV	
Radio, Pixhawk show no errors or issues	GCS	
Check Pilot is ready for manual takeover	GCS	
<i>Switch to AUTO and takeoff (wp set 1)</i>	UAV	
<b>Post-takeoff Checks</b>		
Climb rate good	UAV and GCS	
Airspeed good	UAV and GCS	
Plane turning to waypoints	GCS	
Camera capture good	GCS	
Radio, Pixhawk show no errors or issues	GCS	
<b>Search Area (Cruise) Checks</b>		
Image detection working	GCS	
Radio, PIXHAWK show no errors or issues	GCS	
UAV is navigating through waypoints well	GCS	

<i>Joe found</i>	GCS	
<i>UAV loitering in centre of search area or at Joe location</i>	GCS	
<b>Pre drop Checks</b>		
Joe position written down and confirmed with OBC Staff (click on map, MAVProxy console -> menu -> Show Position)	GCS	
Pre-drop and drop waypoints moved to Joe position (click on map and type in <code>movejoe</code> )	GCS	
Command UAV to fly over Joe ( <code>wp set 15</code> )	GCS	
<i>OBC Staff give permission to drop bottle</i>	GCS	
Switch to drop waypoints ( <code>wp set 20</code> )	GCS	
UAV navigating to drop points	GCS	
<i>Confirm bottle dropped</i>	GCS	
<i>UAV returning to airport (<code>wp set 31</code>)</i>	GCS	
<b>Return and Approach Checks</b>		
Radio, Pixhawk show no errors or issues	GCS	
Pilot and Assistant Pilot returning to near runway	GCS	
<i>Landing permission given by OBC staff</i>	GCS	
UAV starting to lose altitude and airspeed as required	GCS	
UAV in sight of Pilot	UAV	
UAV lined up with runway and glideslope	UAV and GCS	
<i>UAV lands</i>	UAV	
<i>Pilot takeover where needed for manual landing</i>	UAV	
UAV engine shutdown	UAV	
<b>Shutdown and Packup Checks</b>		
UAV recovered and returned to GCS by Pilot and Assistant Pilot	UAV	
UAV ignition power shutdown	UAV	
GCS confirms all flight data recorded	GCS	
UAV avionics shutdown	UAV	
GCS power shutdown	GCS	

GCS packup	GCS	
UAV packup	UAV	

## 5 Flight Phases

### 5.1 Takeoff and cruise to search area (0:00 - 5:00)

- Takeoff may be automatic or manual, depending on weather conditions and how confident we are feeling.
  - For automatic takeoff, the GCS needs the following inputs:
    - RX Transmitter: Flight mode AUTO
    - GCS: `wp set 1`
  - For manual takeoff, allow the pilot to set to FBWA mode. After takeoff and when the UAV is at least 50m off the ground, track directly to the EL1 (Entry lane 1) point. The GCS will need the following inputs:
    - `wp set 2; auto`
- The UAV should reach a target altitude of 100m AGL early into the flight. Note the terrain tracking will alter the UAV's altitude AMSL.
- While the UAV is tracking to EL1, ensure that:
  - The UAV manoeuvres correctly (good parameters)
  - GPS has a solid lock (can we check for a signal strength / # of satellites locked?)
  - SNR on both radios is acceptable
  - Camera is showing good quality images
- Make a note of the wind speed/direction - this will affect our bottle drop waypoint
- The Odroid's MAVProxy instance and image processing software should be monitored for any errors and restarted if necessary

### 5.2 Searching for Joe (5:00 - 35:00)

- Both radio links will be stretched to its limits during this section. Keep a very close eye on it
- If the Camera GCS and GCS Lead are confident that Joe has been found part-way through the mission, we may decide to abort the search pattern and go directly for the bottle drop (with the organiser's permission).
- The GCS Secondary should keep a monitor on any potential geofence breaches, in addition to tracking the correct waypoints. It should be noted if a particularly strong crosswind is attempting to blow the UAV off course.

### 5.3 Joe Detected (35:00 - 40:00)

- As soon as we decide to tell the organisers where we think Joe is, the GCS Lead should immediately set up the cross-loiter and bottle drop waypoints. This is performed by clicking on the main map as to Joe's location and then typing in "`j oemove`" in the console, which will move all the appropriate waypoints.
- After the waypoints are laid in, the GCS Lead should change the loiter waypoints to be over Joe's position.
- While we wait for the organisers, the UAV should continue the search pattern. If it finishes the pattern, it will loiter over the middle of the search area for 10 minutes and then return to the airport.
- To command the UAV to cross-loiter over Joe:
  - `wp set 15`

## 5.4 Bottle Drop (40:00 - 45:00)

- The GCS Lead will order a waypoint jump to the bottle jump points.
  - wp set 20
- The GCS Lead will count down time to bottle drop
- The GCS Secondary will confirm the bottle drop mechanism activation
- The UAV will then go back to the cross-loiter over Joe in order to get a confirmation of the bottle on the ground

## 5.5 Return to Airfield (45:00 - 50:00)

- To command a return and landing to the airfield, use
  - wp set 31
- Keep a general eye on the UAV - tracking to airfield, etc
- Ensure the OBC staff have given us permission to approach and land the UAV – preferably whilst just entering the exit lane
- When getting close to the airport, the UAV should start descending and slowing down – the GCS Lead and GCS Secondary should keep a close eye on this to ensure the UAV is on the correct glideslope.

## 5.6 Landing (50:00 - 55:00)

- Landing may be automatic or manual, depending on weather conditions and how confident we are feeling.
  - In automated mode, the GCS Secondary will keep a careful eye on the speed and altitude of the UAV
  - The Pilot will confirm when the UAV is in visual range
  - If, at any point during the landing, we are not confident in the auto landing the pilot will manually take over in FBWA mode (only if the UAV is in visual range though)
  - During a manual landing, the GCS Secondary will call out the speed and altitude for the pilot.

# 6 Emergency Procedures

## 6.1 Loss of Datalink

- Occurs if the both datalinks are lost (no heartbeat) for more than 10 seconds
  - If combined with a loss of GPS, the UAV must terminate
  - If the RC link fails during manual flight, the UAV must terminate
- The UAV will fly to the Comms Hold waypoint (at 400ft (120m) AGL / 1900ft AMSL) and loiter for 2 minutes
- The UAV will fly to the Airfield Home waypoint (at 400ft (120m) AGL / 1900ft AMSL) and loiter for 2 minutes whilst manual recovery is attempted
- If the datalink is not re-established in this time, the UAV will terminate
- We are allowed a maximum of 2 datalink losses during the mission
- On the third datalink loss, we are to fly directly to the Airfield Home waypoint and land or terminate

## 6.2 Loss of GPS

- If the both GPS modules report a loss of lock, the mode will be activated immediately
- The UAV will loiter around the point of GPS lock loss (via dead reckoning) for 30 seconds
- The UAV will navigate to the Airfield Home waypoint (via dead reckoning)
- When at Airfield Home, RC control will be established and the UAV landed, otherwise flight termination
- We are allowed a maximum of 1 GPS loss during the mission
- On the second loss of GPS lock, the UAV will navigate to the Airfield Home waypoint (via dead reckoning) for landing

### 6.3 Pixhawk Software crash (Failure of Autopilot software / Failure of SAS)

- If no heartbeat is heard from the PIXHAWK for more than 1 second, this mode is activated
- Flight termination must be immediately activated

### 6.4 Loss of engine power

- The PIXHAWK will attempt to glide the UAV towards airfield home
- If within range, RC control will be attempted and the UAV landed at the airport
- The UAV will land as best it can within the mission boundary

### 6.5 Geofence breach

- If the Fence is breached, flight termination will be immediately activated
- This includes the height restriction of 3000ft (914m) AMSL (referenced to QNH)
- In the case of barometer failure (loss of pressure altitude), the GCS will be notified and the UAV will stay below 2000ft (609m) AMSL (1000ft below upper altitude limit), which is approximately 500ft (152m) AGL.

### 6.6 GCS Software failure

- If the main GCS laptop fails, this mode is entered into
- Same as loss of datalink mode

### 6.7 Commanded Destruction

- All radio transmitters will be turned off, and the UAV will terminate in accordance with the loss of datalink failure mode (it would return home)
- Will we instead send a terminate command to the UAV
  - `param set AFS_TERMINATE 1`

## 7 Annexes

### 7.1 Waypoint ID's

ID#	Name	Comments
0	Airfield Home	
<b>1</b>	<b>Auto Takeoff</b>	<b>Mission starts here (auto takeoff)</b>
2	Jump to Entry Lane 1 (22)	<b>Mission starts here (after manual takeoff)</b>
<b>3</b>	<b>Landing approach</b>	<b>Begin landing sequence</b>
4	Change to 23 m/s	
5	Change throttle to 20%	
6	Landing approach 2	
7	Landing	End of landing sequence (and mission)
<b>8</b>	<b>Comms Failure</b>	<b>Begin Datalink Failure - go to Comms Hold point</b>
9	Loiter 2 minutes	
10	Airfield home	
11	Loiter 2 minutes	Failsafe activated after this point
<b>12</b>	<b>GPS fail - loiter 30 secs</b>	<b>Begin GPS failure</b>
13	Airfield home	
14	Loiter (no time limit)	Failsafe activated after this point

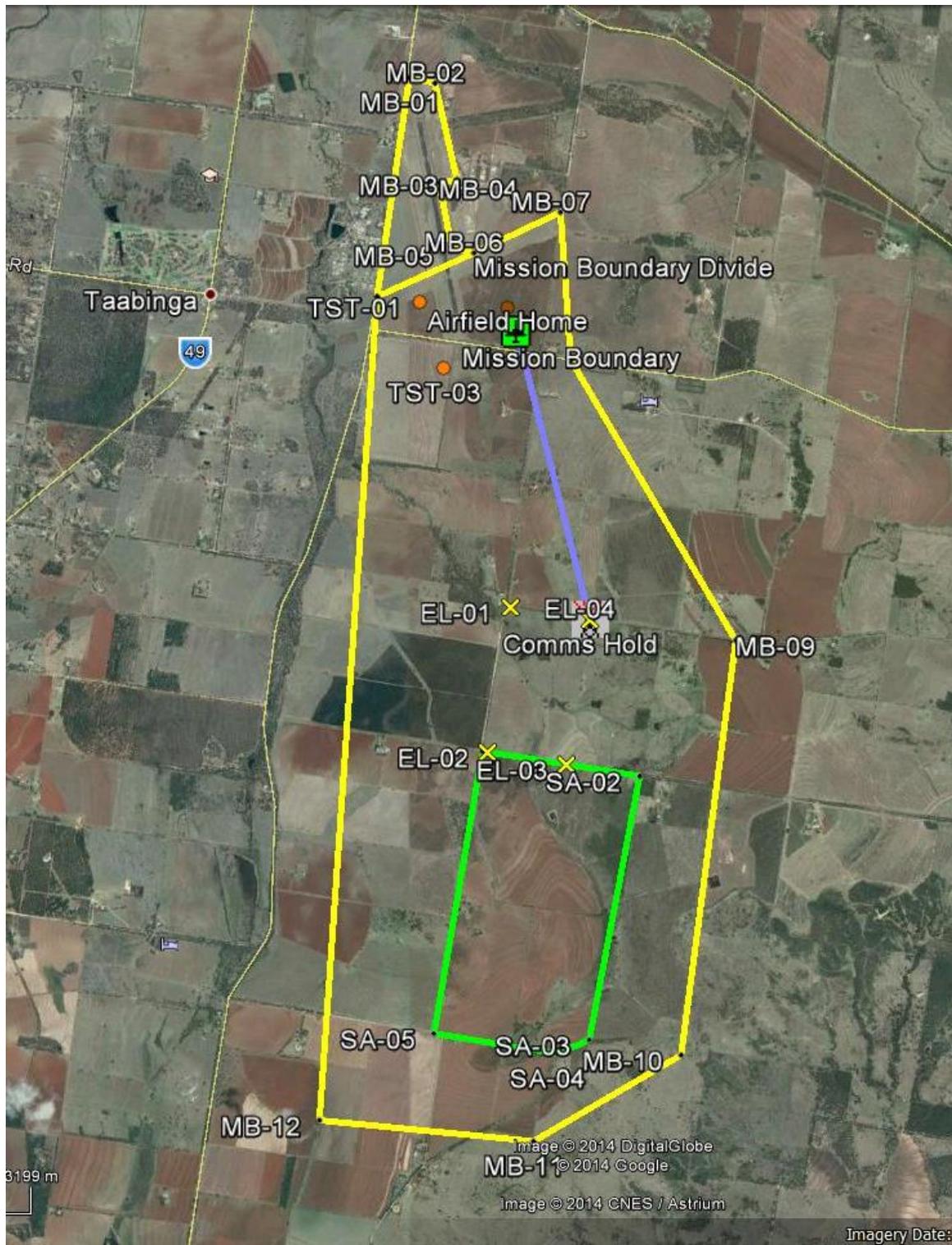
15	<b>Cross 1</b>	<b>Cross-loiter over Joe</b>
16	Cross 2	
17	Cross 3	
18	Cross 4	
19	Loop Cross	
20	<b>Joe approach</b>	<b>Begin Joe Drop</b>
21	Change to 20 m/s	
22	Joe Drop location	
23	Drop stage 1	
24	Delay	
25	Drop stage 2	
26	Change to 28 m/s	
27	Joe after	
28	Jump to cross-loiter (15)	End Joe Drop
29	<b>Entry Lane 1</b>	
30	Jump to search mission (34)	
31	<b>Exit Lane 1</b>	
32	Exit Lane 2	

33	Jump to landing approach (6)	
34	Search 1 (also Entry Lane 2)	Begin search
...		
83	Search 50	End search
84	Loiter in search area for 10 minutes	<b>At some point during this time, goto the Joe cross-loiter (15)</b>
85	Jump to exit lane (31)	

## 7.2 Bushmaster Performance Info

<b>Specification</b>	<b>Value</b>
Maximum Airspeed	64 kts (115 Km/h)
Cruise Airspeed	56 kts (100 Km/h)
Endurance at maximum airspeed	Estimated 60 minutes
Endurance at cruise airspeed	90 minutes
Maximum take off weight	20 Kg
Competition take off weight	15 Kg
Wingspan	2.6 m
Airframe length	2 m
Identifying marks	White with red trim
Aircraft planform and configuration	High wing tractor aircraft

### 7.3 Area Map



## 7.4 Ground Station Network

IP Addresses are statically assigned. All GCS computers should be in the 192.168.16.XXX range

Important IP Addresses:

Item	Address
Odroid	192.168.16.2
Rocket Radio on UAV	192.168.16.3
Rocket Radio on Ground Station	192.168.16.4
Tridge's Laptop	192.168.16.XXX
Steve's Laptop	192.168.16.30
Matt's Laptop	192.168.16.XXX

The MAXProxy server is on port 14550, on your IP address.