CanberraUAV Workshop Ground Control Stations

Feb 2017

Ground Control Stations

- Also known as GCS
- Communicate with the UAV
- Receive telemetry data
- Send commands to UAV

GCS –Introduction

- Telemetry Data
  - Data sent from UAV to GCS
  - Contains information about the current state of the UAV
    - Speed
    - Position
    - Altitude
    - System errors

GCS –Introduction

- Command data
  - Data sent from GCS to UAV
  - Can be
    - Flight commands (RTL, Goto waypoint)
    - Get/set flight parameters
    - Get/set mission waypoints

GCS –Introduction

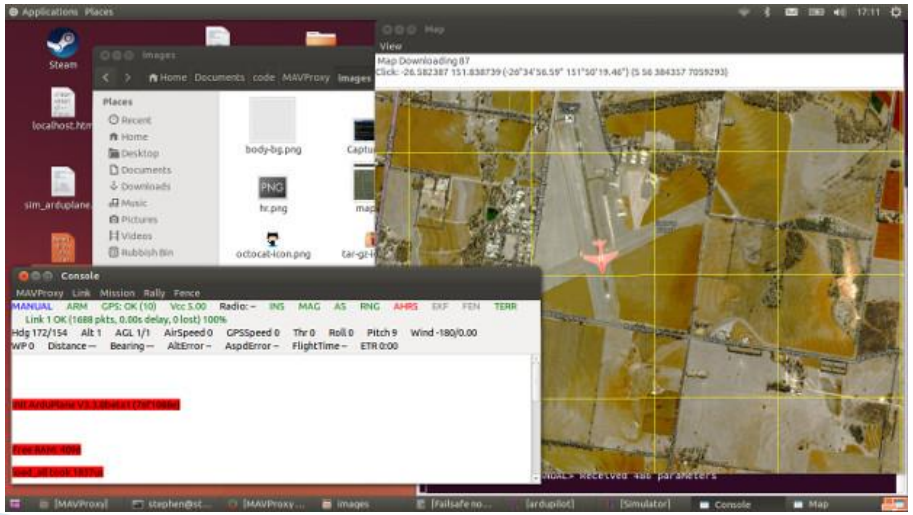
- A GCS Consists of
  - Communications Link
  - GCS Computer
  - GCS Software
  - Other accessories – live video feed, tracking antenna, DGPS base station, etc as required

GCS – Software Options

- Most GCS software is run on laptops
- Different options depending on
  - Which flight controller is used
  - GCS Operating System
  - Require features
- Open source and commercial offerings

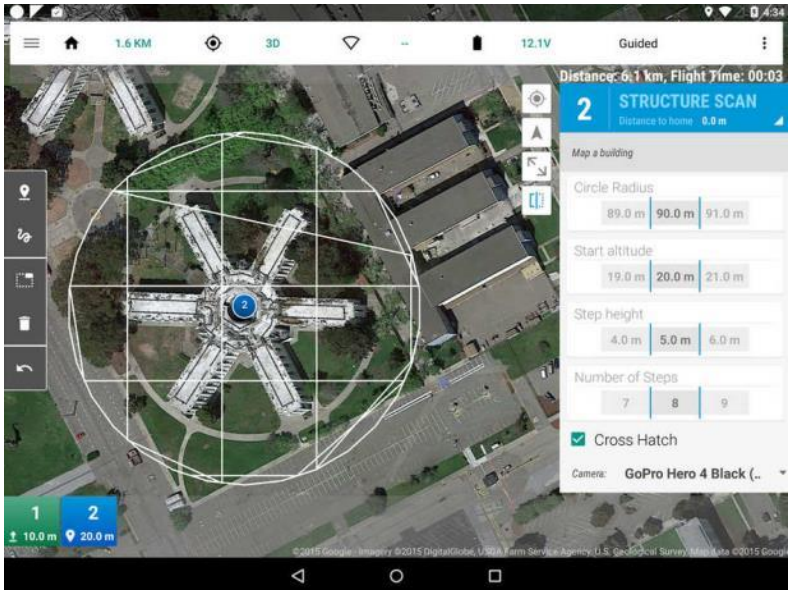
GCS – Software Options

Software	Runs on Linux	Runs on Windows	Runs on OSX
Mission Planner		YY	Y
MAVProxy	YY	Y	
APM Planner 2	YY	YY	YY
Qground control	Y	Y	YY
UgCS	YY	YY	YY



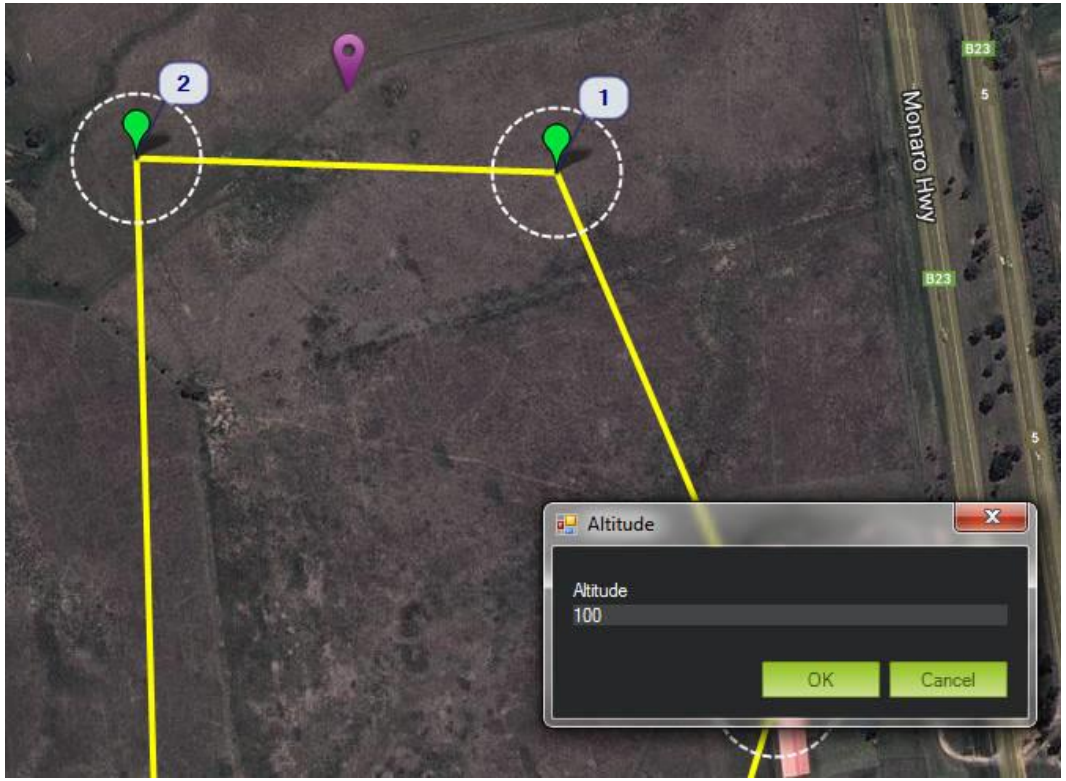
GCS – Software Options

Software	Runs on Android	Runs on iOS
Tower	YY	
MAVPilot		YY
SidePilot		YY
AndroPilot	YY	



GCS – Software Options

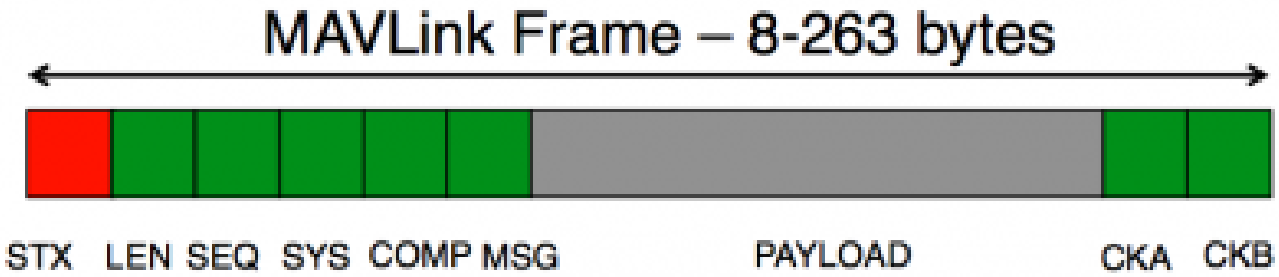
- Compatibility and features vary widely between GCS programs



GCS – MAVLink

- Micro Air Vehicle Link
- Standardised protocol for most open-source flight controllers
  - Though some flight controllers may have extra MAVLink messages
- Efficient and low datarate
- Includes CRC to ensure validity of data
- 3 versions – 0.9, 1.0, 2.0
- Arduplane can use 1.0 or 2.0 (default 1.0)

GCS – MAVLink



Byte Index	Content	Value	Explanation
0	Packet start sign	v1.0: 0xFE (v0.9: 0x55)	Indicates the start of a new packet.
1	Payload length	0 – 255	Indicates length of the following payload.
2	Packet sequence	0 – 255	Each component counts up his send sequence. Allows to detect packet loss
3	System ID	1 – 255	ID of the SENDING system.
4	Component ID	0 – 255	ID of the SENDING component.
5	Message ID	0 – 255	ID of the message – the id defines what the payload "means" and how it should be correctly decoded.
6 to (n+6)	Data	(0 – 255) bytes	Data of the message, depends on the message id.
(n+7) to (n+8)	Checksum (low byte, high byte)	ITU X.25/SAE AS-4 hash, excluding packet start sign, so bytes 1..(n+6)	

GCS – MAVLink

GPS_RAW_INT (#24)

The global position, as returned by the Global Positioning System (GPS). This is NOT the global position estimate of the system, but rather a RA estimate. Coordinate frame is right-handed, Z-axis up (GPS frame).

Field Name	Type	
time_usec	uint64_t	Timestamp (microseconds since UNIX epoch or microsecon
fix_type	uint8_t	See the GPS_FIX_TYPE enum.
lat	int32_t	Latitude (WGS84), in degrees * 1E7
lon	int32_t	Longitude (WGS84), in degrees * 1E7
alt	int32_t	Altitude (AMSL, NOT WGS84), in meters * 1000 (positive fo addition to the WGS84 altitude.
eph	uint16_t	GPS HDOP horizontal dilution of position (unitless). If unkn
epv	uint16_t	GPS VDOP vertical dilution of position (unitless). If unknow
vel	uint16_t	GPS ground speed (m/s * 100). If unknown, set to: UINT16_
cog	uint16_t	Course over ground (NOT heading, but direction of movem
satellites_visible	uint8_t	Number of satellites visible. If unknown, set to 255

GCS – MAVLink

MAV_CMD

Commands to be executed by the MAV. They can be executed on user request, or as part of a mission script. If the action is used in a mis
1, Param 2, Param 3, Param 4, X: Param 5, Y:Param 6, Z:Param 7. This command list is similar what ARINC 424 is for commercial aircraft:

CMD ID	Field Name	
16	**MAV_CMD_NAV_WAYPOINT**	Navigate to MISSION.
	Mission Param #1	Hold time in decimal seconds. (ignored by fixed wing
	Mission Param #2	Acceptance radius in meters (if the sphere with this
	Mission Param #3	0 to pass through the WP, if > 0 radius in meters to p orbit. Allows trajectory control.
	Mission Param #4	Desired yaw angle at MISSION (rotary wing)
	Mission Param #5	Latitude
	Mission Param #6	Longitude
	Mission Param #7	Altitude
17	**MAV_CMD_NAV_LOITER_UNLIM**	Loiter around this MISSION an unlimited amount of ti
	Mission Param #1	Empty
	Mission Param #2	Empty
	Mission Param #3	Radius around MISSION, in meters. If positive loiter
	Mission Param #4	Desired yaw angle.
	Mission Param #5	Latitude
	Mission Param #6	Longitude
	Mission Param #7	Altitude

GCS – MAVLink

- There are MAVLink messages for sending/receiving parameters and missions
- Typically, a flight controller may only send some of the messages – depending on it's features, settings and current state

GCS – MAVLink

- MAVLink does include any encryption
  - Up to the user to implement in their communications link
- MAVLink 2.0 includes a “signing key”
  - 32-bit number
  - Flight controller will only accept commands from packet signed with this key
  - Disabled by default

GCS – Flight Planning

- Creating the waypoints to achieve the mission objectives

GCS – Flight Planning

- What is the mission objective?
  - Primary and secondary goals
  - Payload required
  - UAV required
- Most GCS software packages have a mission planning screen where you can drag-n-drop waypoints

GCS – Flight Planning

- Considerations
  - Takeoff/landing area
  - Hills/Terrain
  - Flight altitude
  - Mission length (km)
  - Weather (wind)
  - Communications coverage

GCS – Flight Planning

- If possible, run the mission in SITL beforehand, to ensure the waypoints are correctly laid out
- Some GCS software packages have auto-generation of waypoints for mowing-the-lawn surveys

Practical Session 1 (20min)

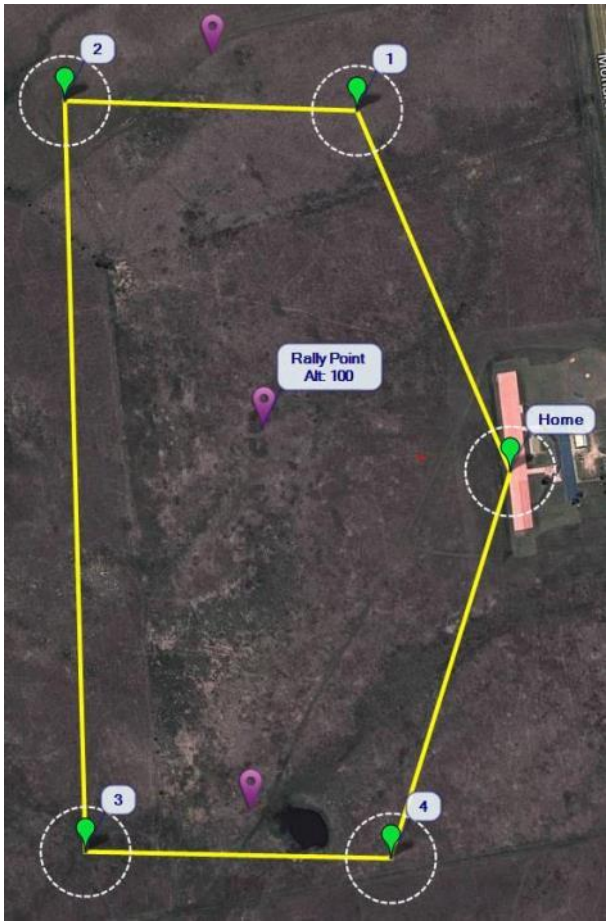
- Create a mission that:
  - Perform an aerial survey of the Snowy Hydro base
- Considerations:
  - Takeoff/landing at CMAC
  - Landing will be manual
- Create the mission, run in SITL
  - `cd ./ArduPlane`
  - `../Tools/autotest/sim_vehicle.py`
- Two options for GCS tool to use for mission planning (choose one)
  - Connect Mission Planner via UDP, port 14550
  - Use `module load misseditor` in MAVProxy

GCS – Advanced Planning

- Geofences
  - A single closed polygon
- UAV will turn back if it crosses outside of the polygon
  - Note that the UAV's inertia may send it beyond the fence for a short period

GCS – Advanced Planning

- Rally points
  - Instead of a single Home point, have a set of rally points
  - On RTL, the UAV will head to the nearest rally point



GCS – Advanced Planning

- Terrain Following
  - Terrain data stored on Pixhawk's SD card
  - Arduplane will look at this database to estimate it's AGL
  - Available in AUTO, RTL and other flight modes. Will maintain a constant height above ground
  - Set `TERRAIN_ENABLE` to `1` and `TERRAIN_FOLLOW` to `1`
  - Note the datasource is the SRTM data, so is only accurate to 20m

GCS – Post flight analysis

- Two types of logfiles
  - GCS – saved copy of MAVlink stream (tlog)
  - APM – saved on SD card (bin)
- Bin log has more messages at a faster rate
  - Generally the preferred log when analysing a flight
- Tlog is on the GCS, so can be used if the UAV goes missing or is destroyed
  - Still worth searching the crash site for the SD card!

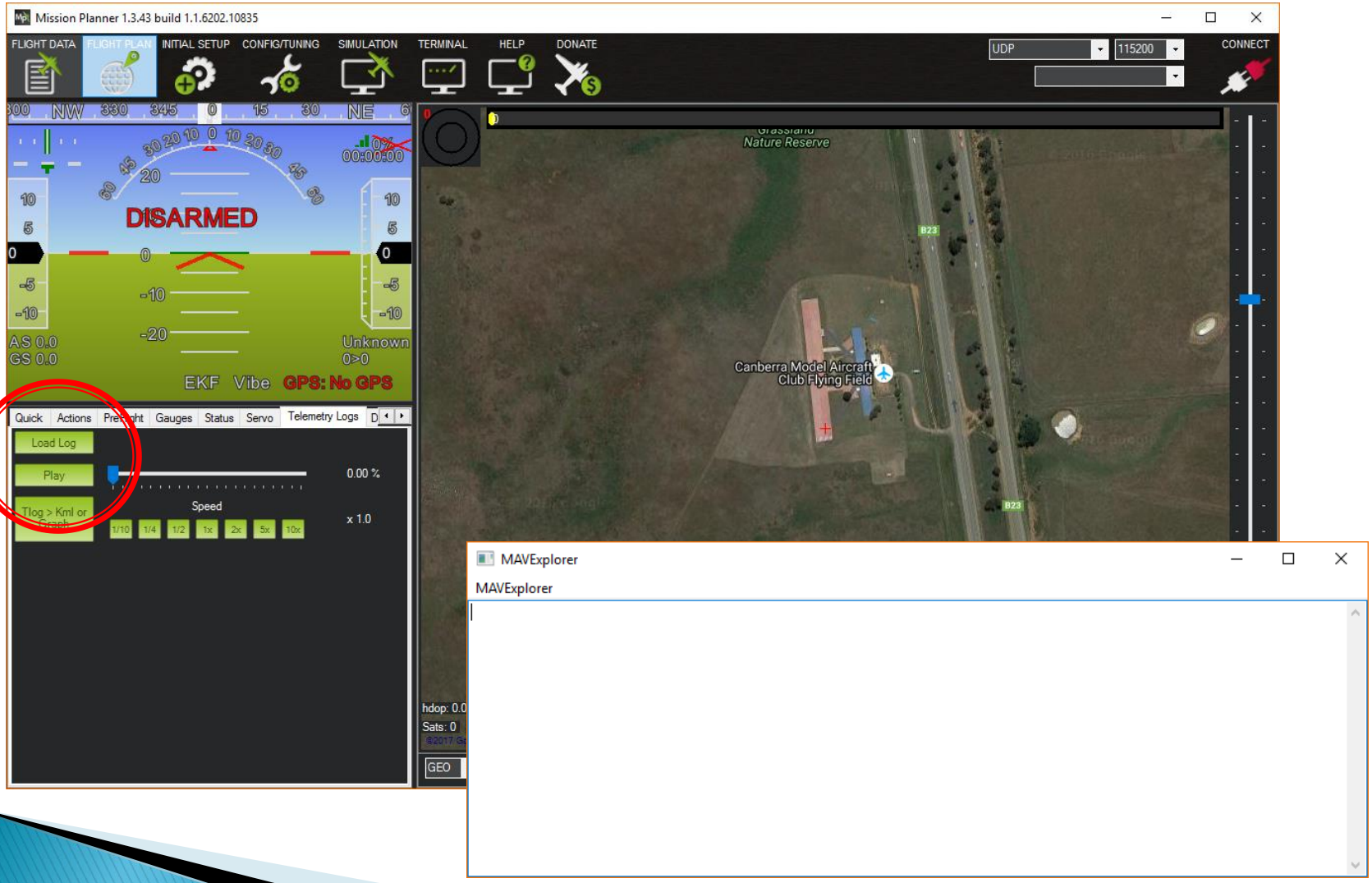
GCS – Post flight analysis

- Tlogs are stored in:
  - Mission Planner
    - C:\Program Files (x86)\Mission Planner\logs
  - MAVProxy
    - Same folder that MAVproxy was run from (unless using the --aircraft option)

GCS – Post flight analysis

- Most flight analysis tools will work with both bin files and tlog files
- Popular Flight Analysis tools:
  - Mission Planner
  - MAVExplorer (part of MAVProxy)

GCS – Post flight analysis

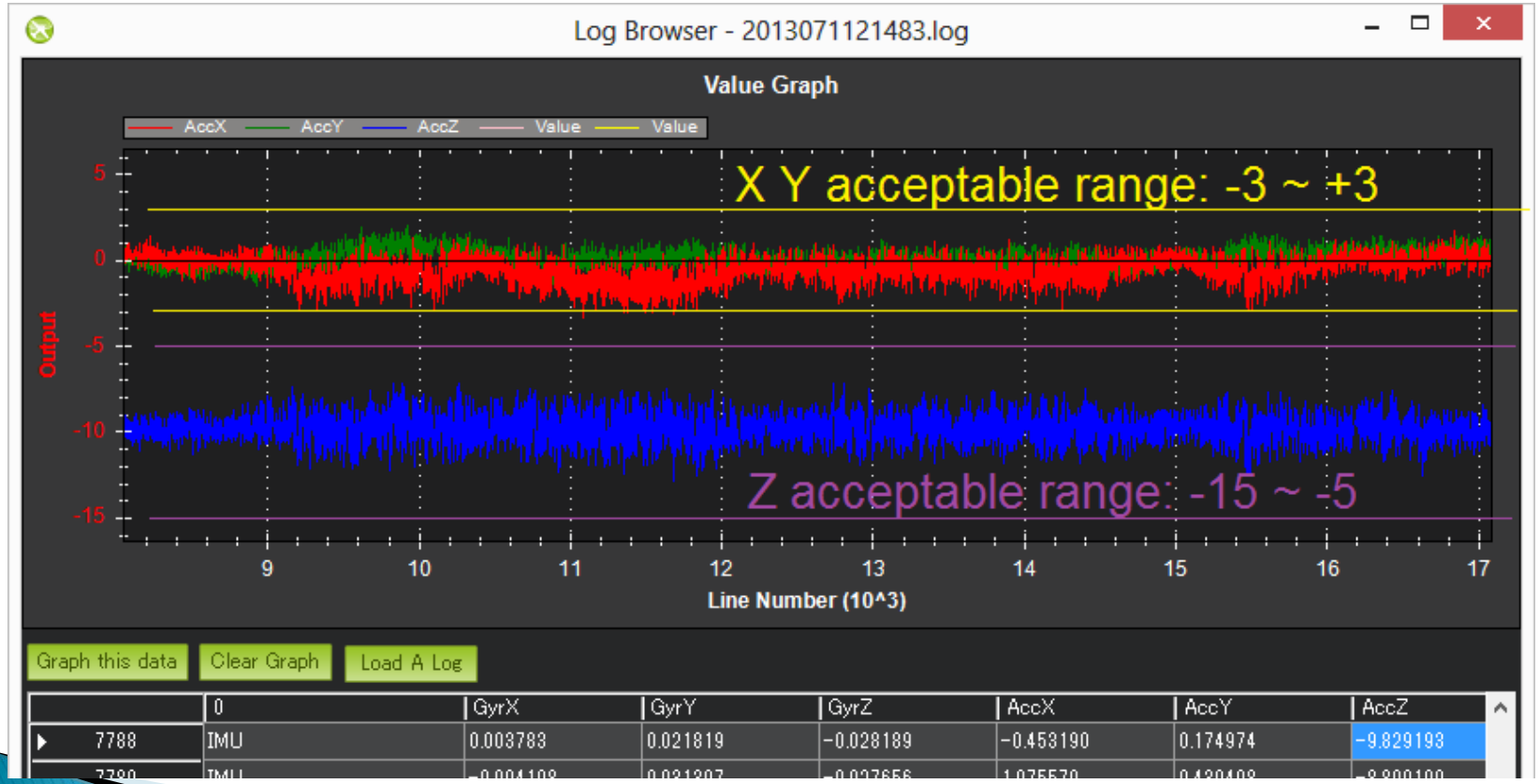


GCS – Post flight analysis

- Mechanical Failures
  - These appear in the log as a sudden divergence in the desired roll and pitch vs the vehicles actual roll and pitch

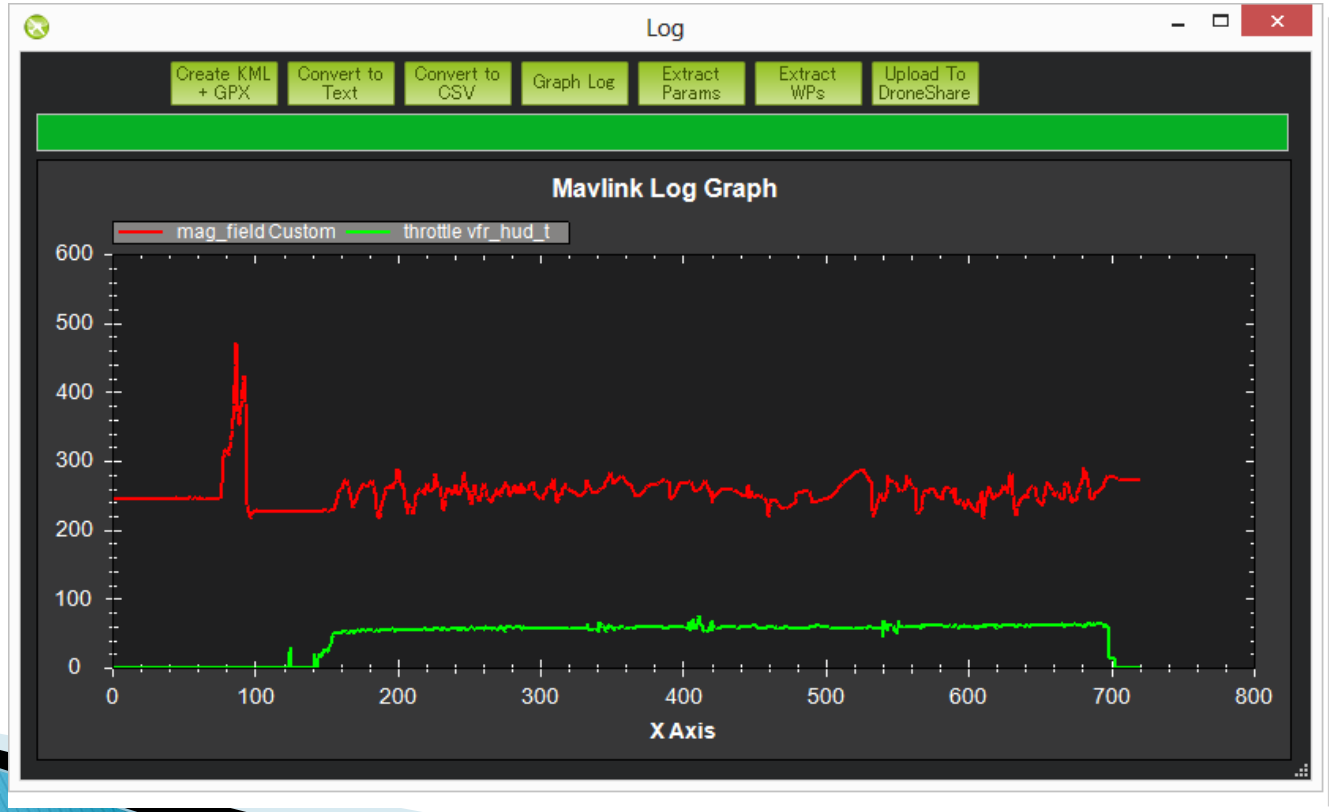
GCS – Post flight analysis

- Excessive Vibration



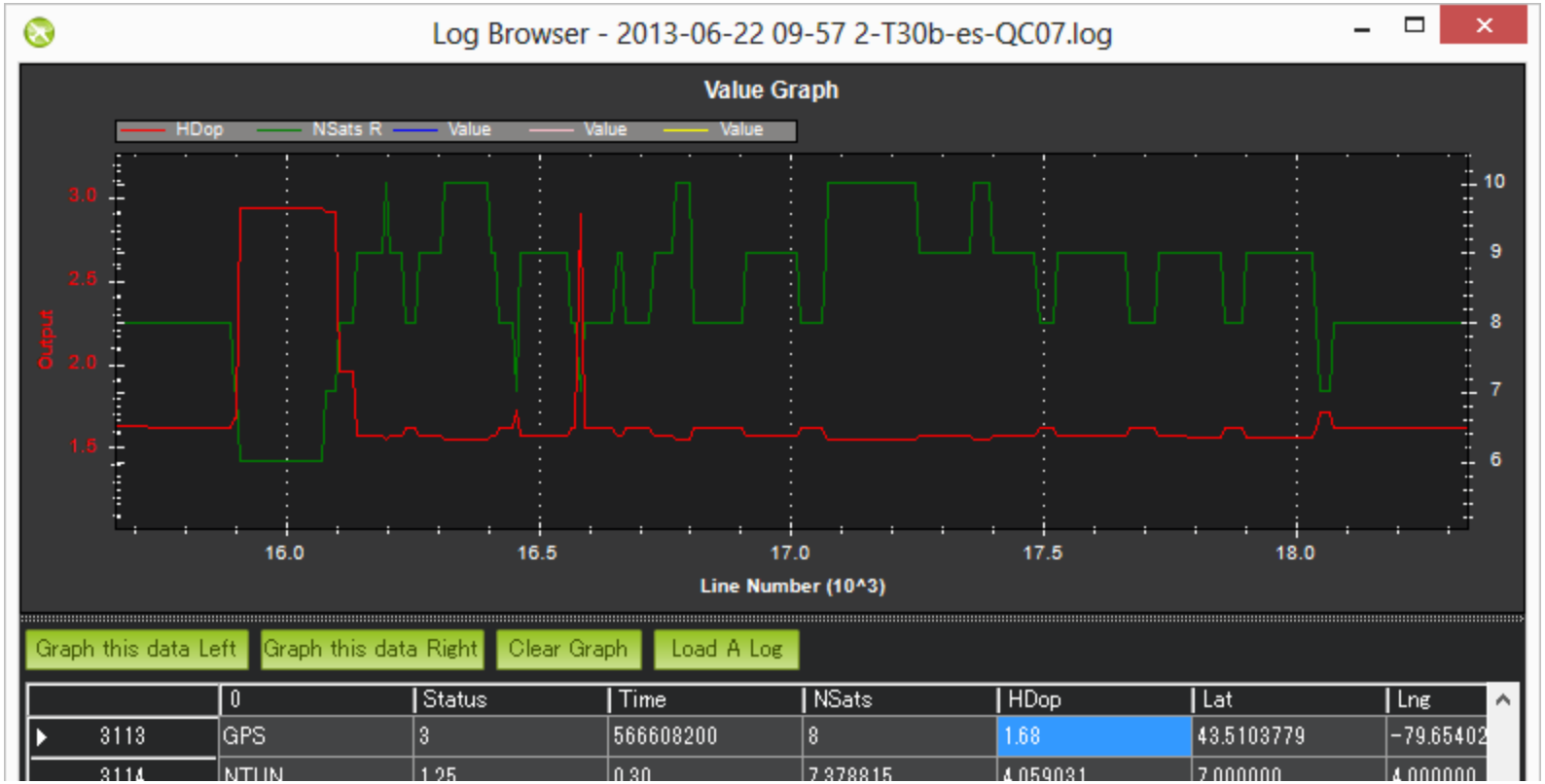
GCS – Post flight analysis

- Compass Interference
  - Look for patterns between `mag_field` and `throttle`



GCS – Post flight analysis

- GPS Glitches



GCS – Post flight analysis

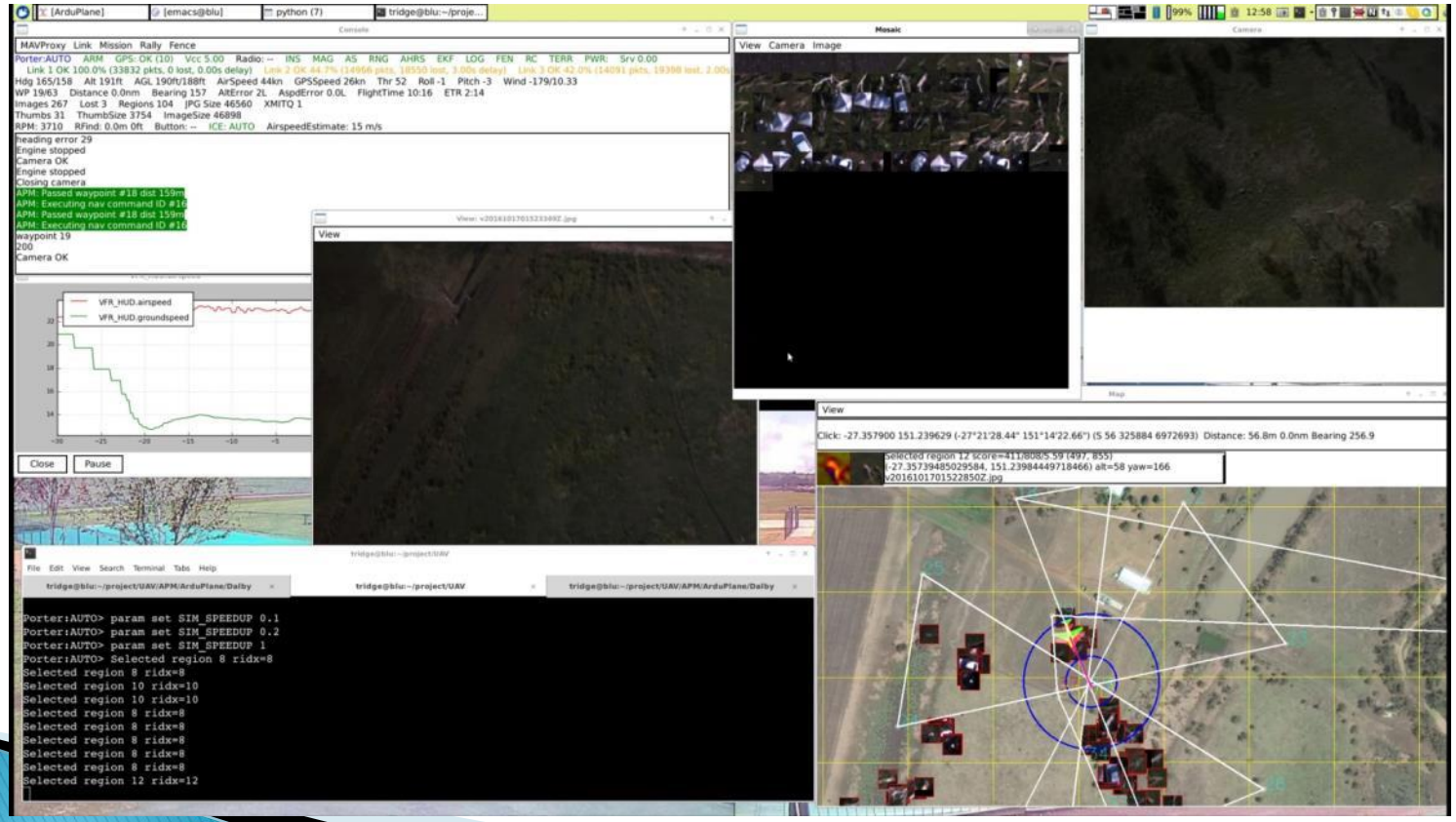
- Power brown-outs, if APM voltage varies by more than 0.15V, or goes below 4.7V

Practical Session 2 (20min)

- Logfile Analysis
  - Find a logfile generated by SITL(./ArduPlane/logs) for the bin file
  - For more interesting data: http://discuss.ardupilot.org/t/altitude-hold-and-stability/14536
- Two options for Analysis tool (choose one)
  - Mission Planner
  - MAVExplorer
- Check GPS
  - `GPS.Nsats` and `GPS.HDop` messages
- Check Vibration
  - `IMU.AccX`, `IMU.AccY`, `IMU.AccZ` messages

GCS – Inflight Monitoring

- APM outputs a lot of telemetry data
- How to watch all this in realtime?



GCS – Inflight Monitoring

- Decide which data is important
- May vary depending on mission phase
  - Speed, Altitude during takeoff and landing
  - Moving map during mission

GCS – Inflight Monitoring

- Things to typically monitor
  - Speed
  - Altitude
  - UAV Position (longitude/latitude) along with waypoints
  - Battery voltage
  - Telemetry link quality
  - Any error messages
- Anything that, if not detected in a short time, could result in a crash

GCS – Inflight Monitoring

- Have backup plans for common failure scenarios
- Practice!
  - In SITL
  - In test flights
- Consider having multiple GCS stations to split the workload

The End!

- Flight Planning
- Logfile analysis
- Inflight monitoring