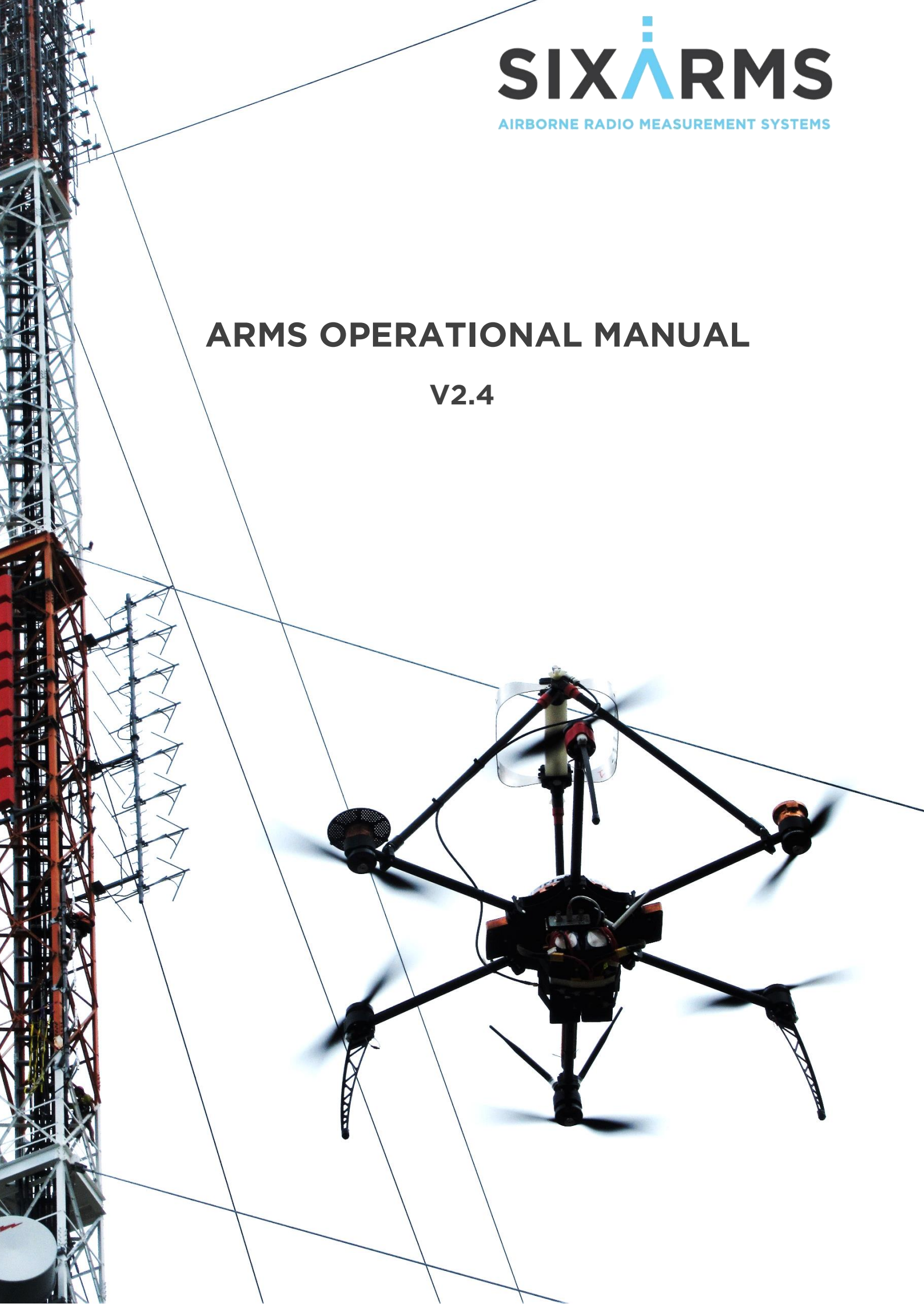
SIXARMS

AIRBORNE RADIO MEASUREMENT SYSTEMS

ARMS OPERATIONAL MANUAL

V2.4



DISCLAIMER

The use of this equipment should only be used by a professional Remote Pilot who is able to conduct the setup, safety and airborne operation of the RPAS. They should be familiar with ground control stations, waypoint planning and telemetry monitoring.

This operational manual details how to use the ARMS system to collect RF data used to analyse broadcast antenna systems, it is not a comprehensive RPAS flight guide. Experienced RPA operators should make use of their own operating procedures regarding the flight operations. Sixarms is not responsible for improper use of a RPAS.

Operations in excessively high RF environments is not recommended. Safe flight distances should always be adhered to.

Although autonomous missions are possible (depending on the flight controller used), the system is not fitted with an obstacle avoidance system and care should be taken when the RPA is operating in and around obstacles.

NOTE: The ARMS Receiver gets hot, during operation mounted on the RPA the device gets cooled via air movements, however, when testing on the bench, some cooling is required.

VERSION CONTROL

Version	Date	Major Changes
1.0	June 2017	First Release
2.0	April 2019	Revision to include IP radios and new Live Dashboard Settings
2.1	July 2019	Introduced Extra Flight Types with explanations
2.2	March 2020	Inclusion of DJI M200 RPAS setup for DE Flights
2.3	January 2021	Inclusion of Signal Generator and DJI Flight Planning
2.4	June 2021	Revised due to AMS Screen Changes

CONTACTS

SUPPORT
Sixarms Unit 2, 60 Township Drive West Burleigh, 4219, QLD, Australia support@sixarms.com

ACRONYMS

AltHold	Altitude Hold (Mode)
AUT	Antenna Under Test
DTV/DVB-T	Digital Television
ERP	Effective Radiated Power
FCS	Flight Controller System
FM	Frequency Modulation
GCS	Ground Control Station
GPS	Global Positioning System (WGS84 Datum)
HUD	Heads Up Display
IMU	Inertial Management Unit
INS	Inertial Navigation System
ITU	International Telecommunication Union
HRP	Horizontal Radiation Pattern
PIC	Pilot in Command
PosHold	Position Hold (Mode)
RC	Remote Controller
RF	Radio Frequency
RP	Remote Pilot
RPAS	Remotely Piloted Aircraft System
RTK	Real Time Kinematics
RTL	Return to Launch
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
VRP	Vertical Radiation Pattern
VHF	Very High Frequency

CONTENTS

1/ WHAT'S NEEDED

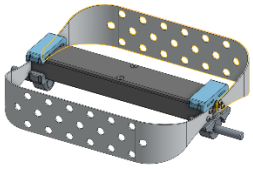
The ARMS (Airborne Radio Measurement System) consists of:

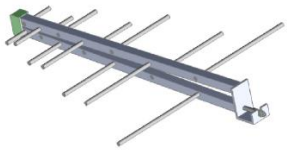
V1

V2

ARMS Receiver, Interconnecting Cable and Wi-Fi Antennas (if applicable)

RPA (including Ground Control Station), Telemetry/RC Control and optional RTK GPS System





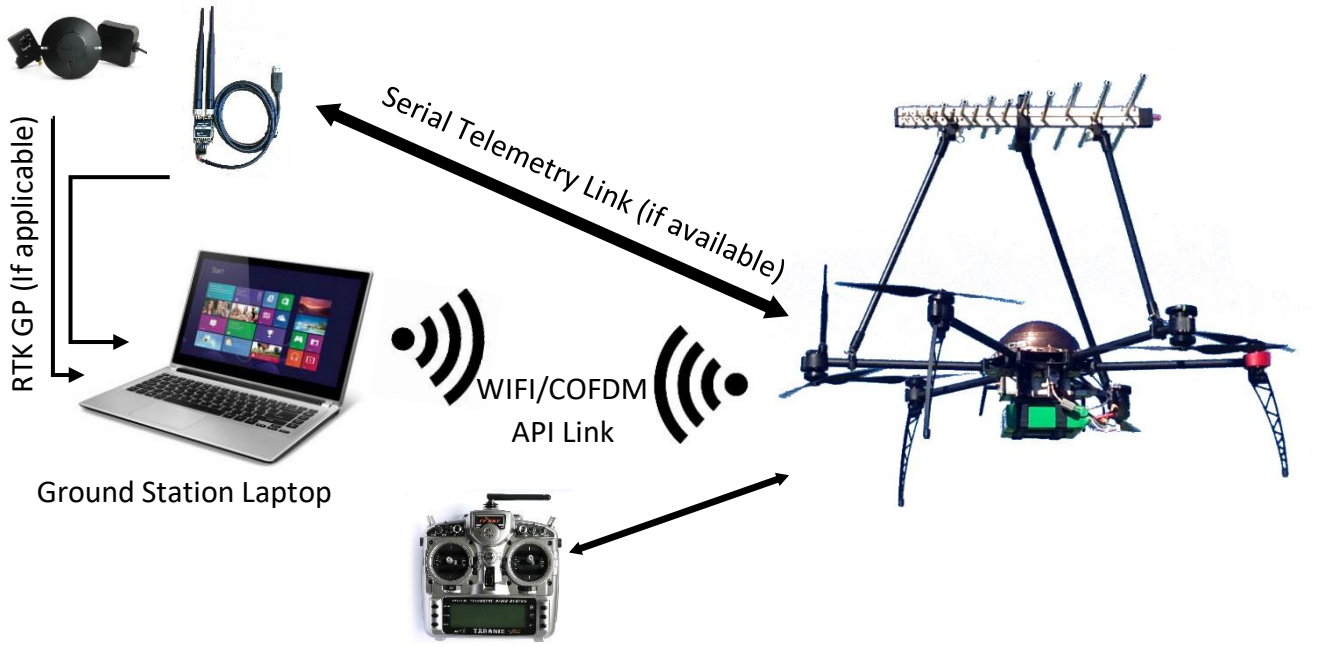
Receive Antennas

Antenna Mounting Components

Antenna Measurement Studio

2/ SYSTEM OVERVIEW

The following diagram shows the general connectivity of the ARMS.



The Sixarms ARMS units have been designed to be modular and still allow connectivity to all components. The ARMS receiver and CPU are mounted either in the mounting bay underneath the RPA electronics or above the electronics. This is connected via DB9 cable for power and connectivity to the Flight Controller of the RPA. It can easily be replaced/interchanged.

Similarly, all antenna systems are easily interchangeable with the current mounting system and polarisation is adjusted without much effort.

The system has been designed to perform antenna pattern verification as well as RF coverage validation.

3/ RPA SETUP

Please consult the appropriate RPA handbook for aircraft setup, specific notes on using the ARMS units with either ARDUPILOT and PX4 Mavlink compatible Flight Controllers or DJI M600, M200 and A3 Onboard SDK compatible flight controllers can be found in Section 8.

4/ AMS GUIDE

The Antenna Measurement Suite (AMS) has been designed to allow a streamlined workflow to capture valid RF data to assess transmission antenna systems. AMS allows for a systematic approach to the data collection by using Antenna Under Test (AUT) information to create flight profiles and assess the validity of collected data. Automated Reports allow for instant informed decisions to be made about the operation of the AUT.

4/1 INSTALLING AMS

Once licensed, Sixarms will provide the installation pack for AMS. This is recommended to be installed on:

1. Quad Core i3 or greater Laptop or Tablet
2. Windows 10 64-bit Operating System
3. Administrative Privileges
4. Minimum 4GB Memory and 64GB SSD/Hard drive
5. Dual USB 2.0 slots if using RTK and Serial Telemetry)

Installation will setup all packages to run AMS, including an SQL database component. If you have any issues with the installation, please contact Sixarms support (support@sixarms.com)

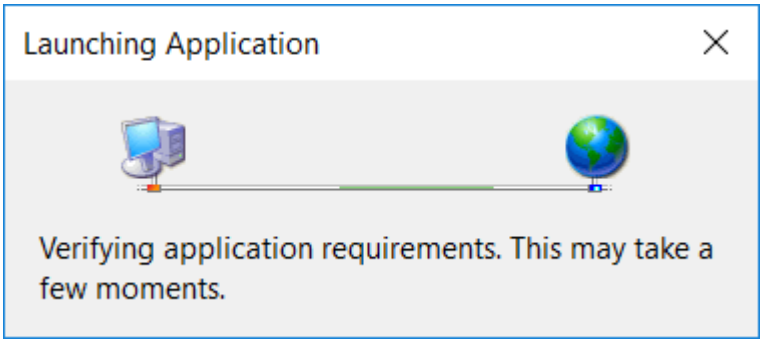
For Mavlink based vehicles, Mission Planner is also needed to connect to and monitor your RPA. Please consult http://ardupilot.org/planner/

For DJI based vehicles, currently an Android Phone running 'Litchi' is needed to initiate AMS generated flight plans. Please consult https://flylitchi.com/ for information on installation and usage.

If you are using our professional ground station, AMS and Mission Planner will already be installed and setup.

4/2 STARTING AMS

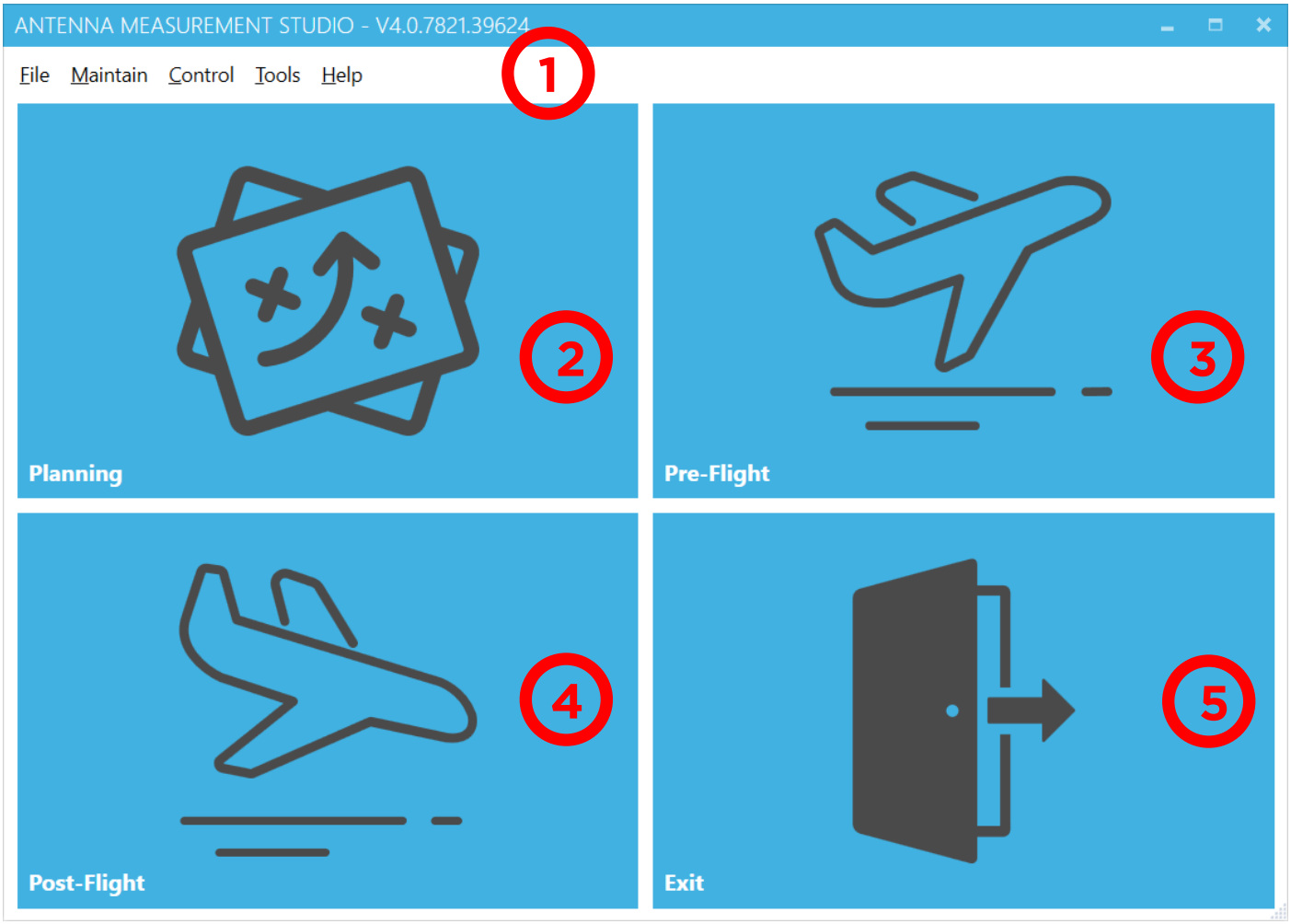
When clicking on the Antenna Measurement Studio on your Desktop, the software will check for updates (if you are connected to the Internet) and automatically update AMS to the latest version and then start.



On some PCs, an acknowledgement window is needed in order to continue the update process. This simply allows AMS access to the network settings of the PC.

4/3 MAIN SCREEN

The main screen is split into two areas. The menu items which help setup and customise parameters and the measurement section (which itself has 4 areas – Planning, Pre-Flight, Post-Flight and Exit). The menu options are able to be accessed at any stage during the measurement campaign while only one of the measurement sections can be accessed at a time.



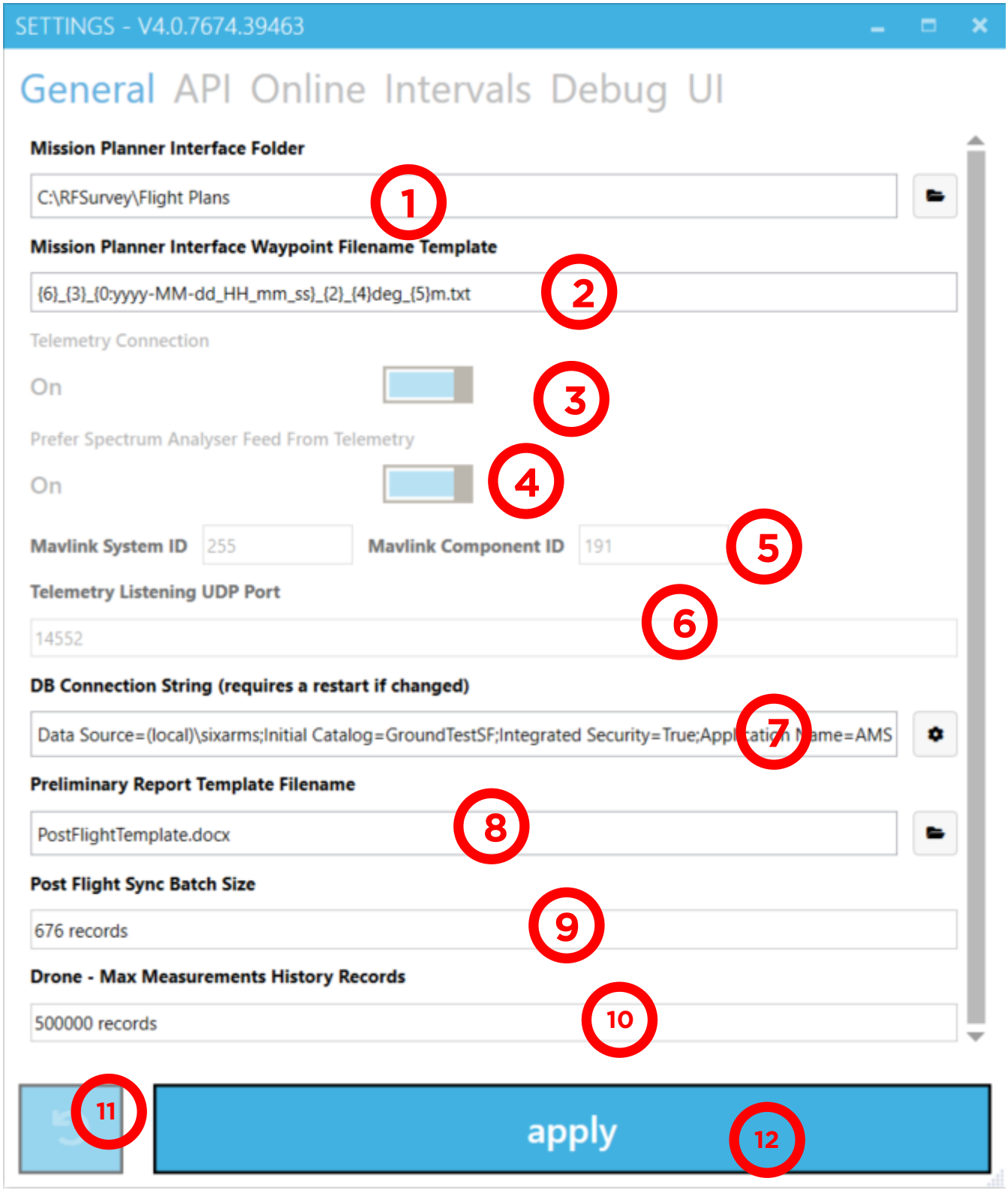
1/ **Main Menu Options**

2/ **Planning** Pre-Survey planning used to create measurement sessions

3/ **Pre-Flight** Pre-Flight checks, ARMS Receiver programming and data capture, flight path generation and live data display

4/ **Post Survey** Post Survey data synchronisation, exporting and preliminary report generation

4/4 FILE … SETTINGS … AMS … GENERAL



1/ **Mission Planner Interface Folder** Folder location to store generated flight plans

2/ **Mission Planner Interface Waypoint Filename Template** Filenames for generated flight paths

   i. {6} = Flight Type
   ii. {3} = Site Name
   iii. {0:yyyy-MM-dd_HH_mm_ss} = Date Time
   iv. {2} = Antenna Name
   v. {4} = Azimuth/Depression Angle
   vi. {5} = distance from antenna

3/ **Telemetry Connection** ON when using a serial modem (e.g. RFD868/900) for telemetry info. OFF when using an IP-based telemetry link (e.g. COFDM/Wifi)

4/ **Prefer Spectrum Analyzer Feed From Telemetry** ON when using a serial modem that has longer range than the API COFDM/Wifi.

5/ **Mavlink System ID and Mavlink Component ID** To identify the ARMS Rx to the Mavlink based Flight Controller

6/ **Telemetry Listening UDP Port** Listening port for telemetry info (either redirected from Mission Planner), or IP-based

7/ **DB Connection String** Specific DB setup for AMS. If changing to another database, a restart of AMS is needed. Use the settings button to swap databases. A restart of AMS is needed when changing databases. To create a new database, replace the string *Catalog=Ground* with *Catalog=NewDBname* then press apply.

8/ **Preliminary Report Template Filename** Preliminary report template location and filename. Used to customise preliminary reports

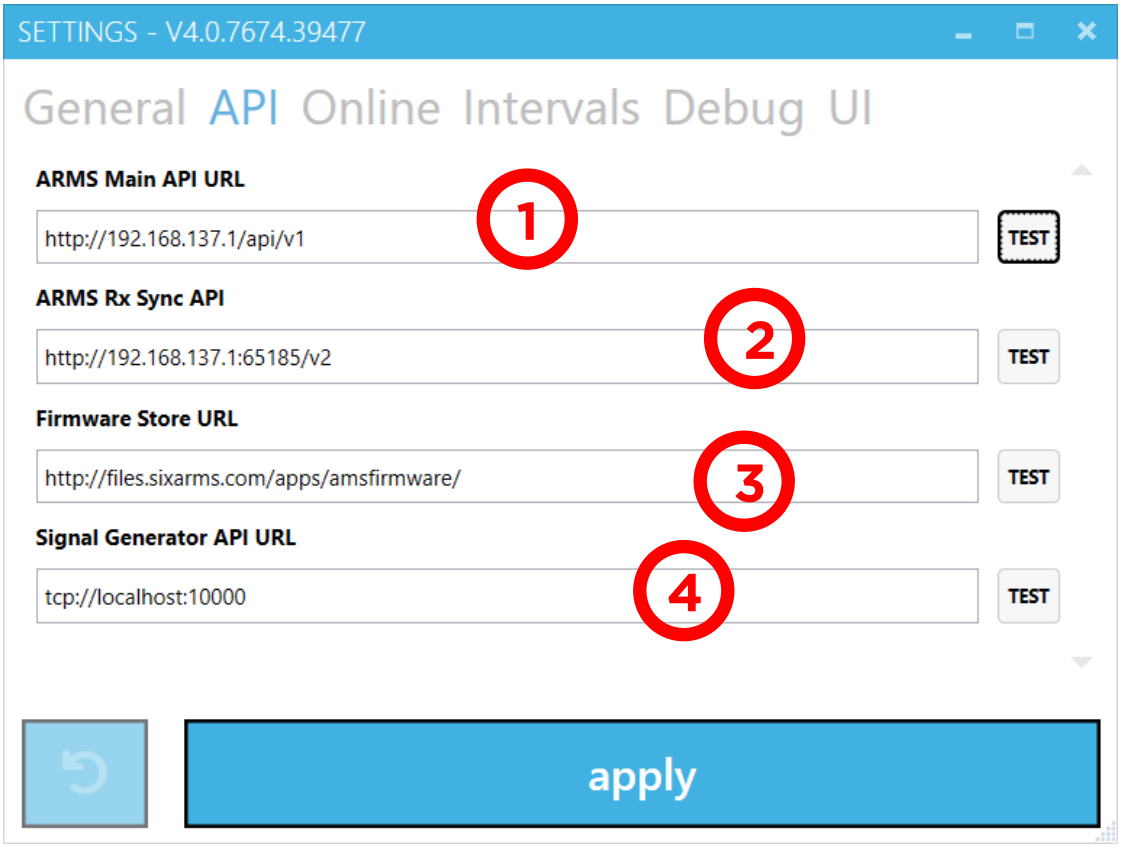
9/ **Post Flight Sync Batch Size** Determines the number of records to simultaneously sink after a measurement session. This can be customised to increase sync speed.

10/ **ARMS Rx – Max Measurements History Records** This sets the limit to the amount of readings on the ARMS Rx before AMS will prompt the user to remove those readings in order to keep the processing speed to a maximum.

11/ **Undo Button** Undo recent changes

12/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/5 FILE … SETTINGS … AMS … API



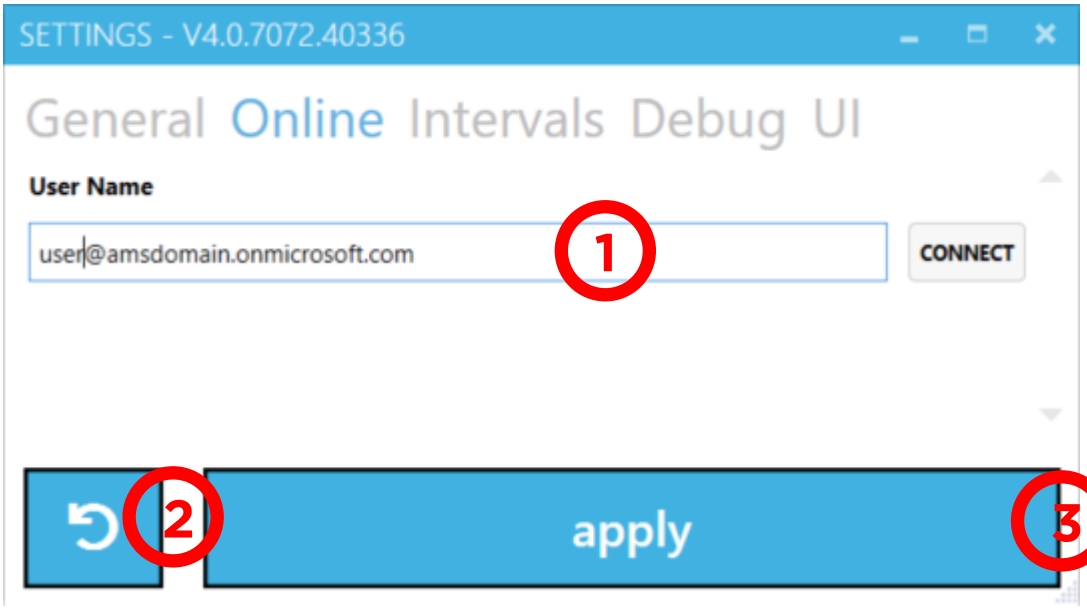
1/ **Main API URL** For communication and control of the ARMS Rx. Use the TEST button to check connectivity.

2/ **Sync API URL** For data synchronisation between the ARMS Rx and Ground Station. Use the TEST button to check connectivity.

3/ **Firmware Store URL** Location of firmware update list. Use the TEST button to check connectivity.

4/ **Signal Generator API URL** Location of Signal Generator Control API (if available).

4/6 FILE … SETTINGS … AMS … ONLINE

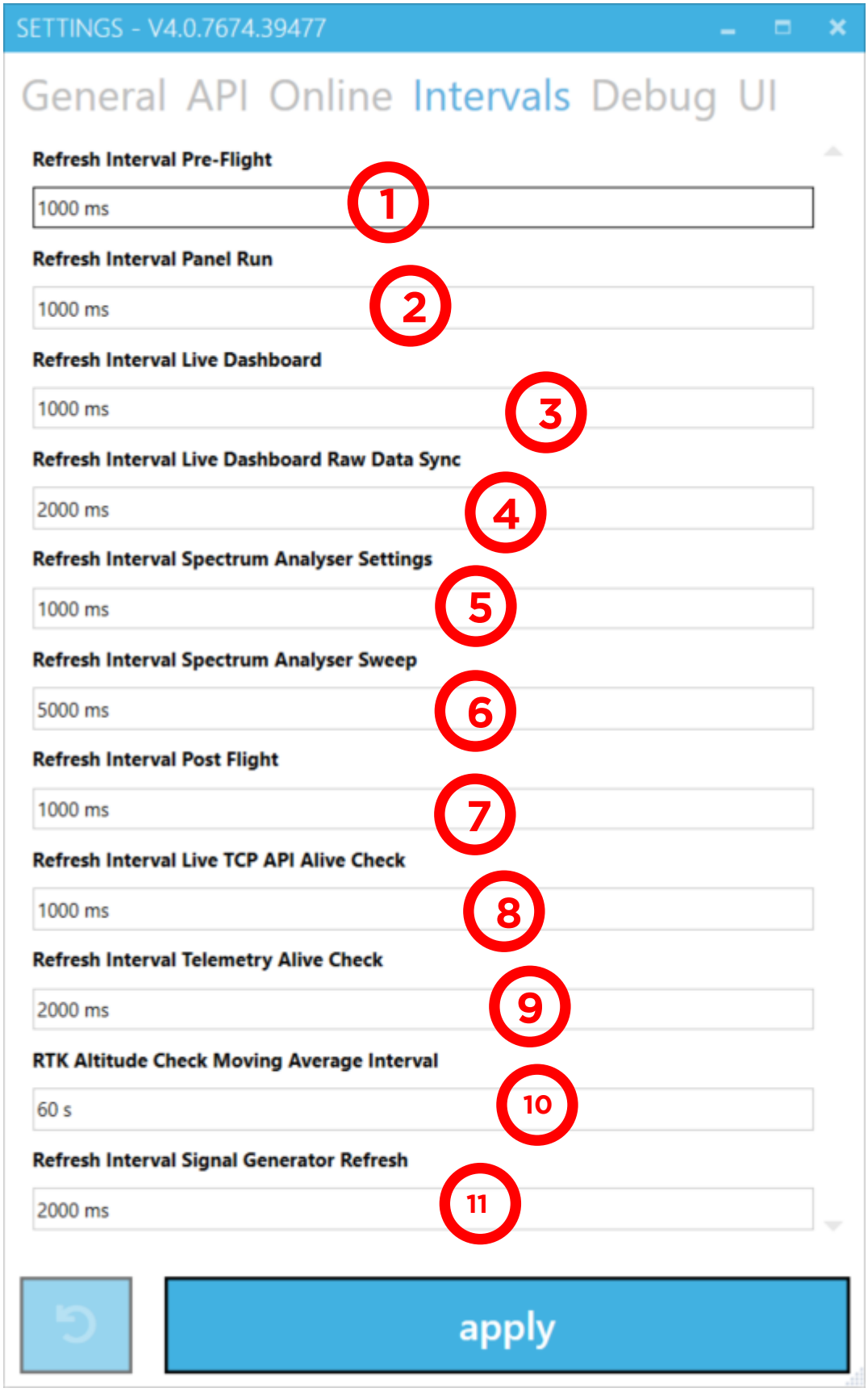


1/ **User Name** User name for online services such as database backup and data analytics (future). Use the connect button to test connectivity. You will need to contact Sixarms Support to create your account before this functionality can be used.

2/ **Undo Button** Undo recent changes

3/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/7 FILE … SETTINGS … INTERVALS



1/ **Refresh Interval Pre-Flight** This determines the update rate for all data related to the Pre-Flight Verification Screen

2/ **Refresh Interval Panel Run** This determines the update rate for all data related to the Panel Run Screen

3/ **Refresh Interval Live Dashboard** This determines the update rate for all data shown on the Live Dashboard Screen.

4/ **Refresh Interval Live Dashboard Raw Data Sync** Determines the rate at which background data syncing occurs (to minimise time during Post Flight data syncing. This only occurs of the Telemetry bandwidth is sufficient

5/ **Refresh Interval Spectrum Analyser Setting** This determines the update rate for the Spectrum Sweep Raw frequency vs amplitude plot (min 5 seconds)

6/ **Refresh Interval Spectrum Analyser Sweep** This determines the update rate for all data related to the Spectrum Analyser Settings Screen

7/ **Refresh Interval Post Flight** This determines the update rate for all data related to the Post Flight Synchronisation Screen

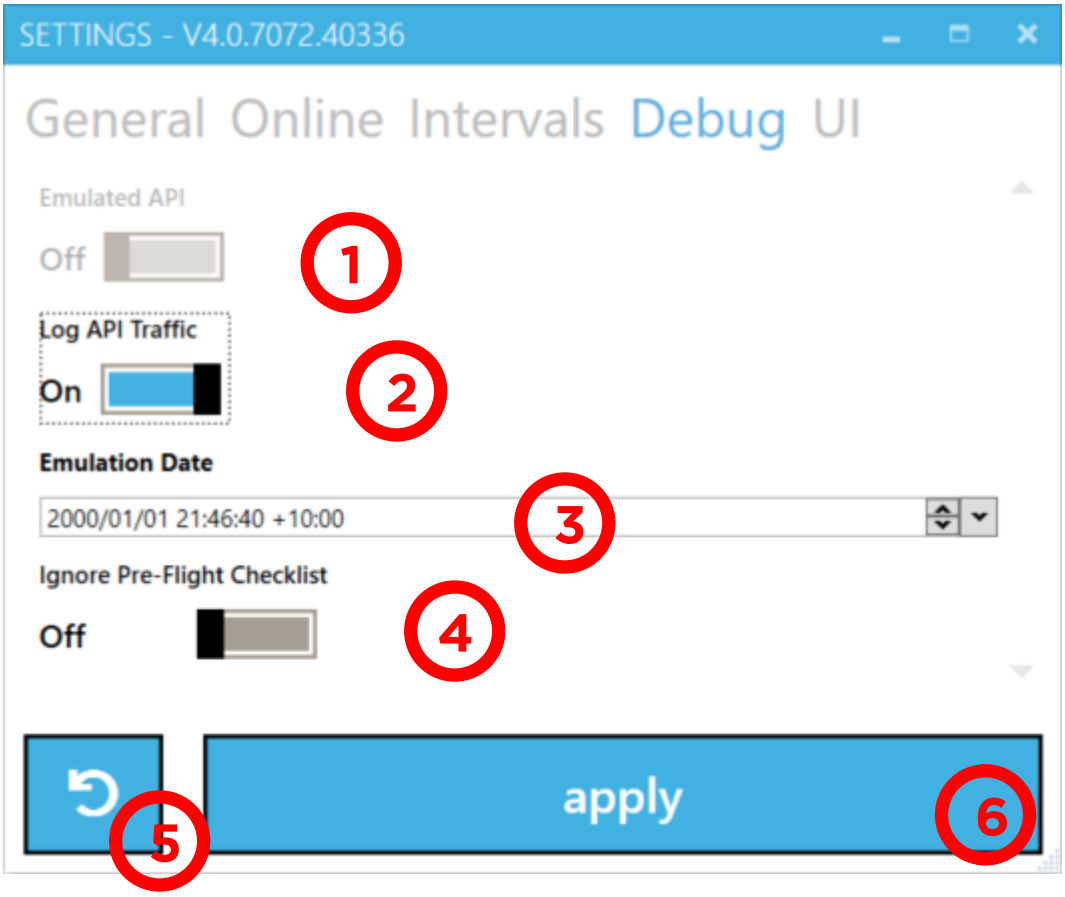
8/ **Refresh Interval Live TCP API Alive Check** This determines how often AMS checks to see whether the API link to the ARMS Rx is connected

9/ **Refresh Interval Live Telemetry Alive Check** This determines how often AMS checks to see whether the Telemetry link to the ARMS Rx is connected

10/ **RTK Altitude Check Moving Average Interval** Determines the time duration for a stable altitude reading (when RTK is needed) before engaging in the flight. This altitude check is important when measuring narrow beam width antennas and to test the stability of the RTK signal

11/ **Refresh Interval Signal Generator** This determines how often AMS checks the status of the Singal Generator (if applicable)

4/8 FILE … SETTINGS … DEBUG



1/ **Emulated API** Not used

2/ **Log API Traffic** Used for debugging

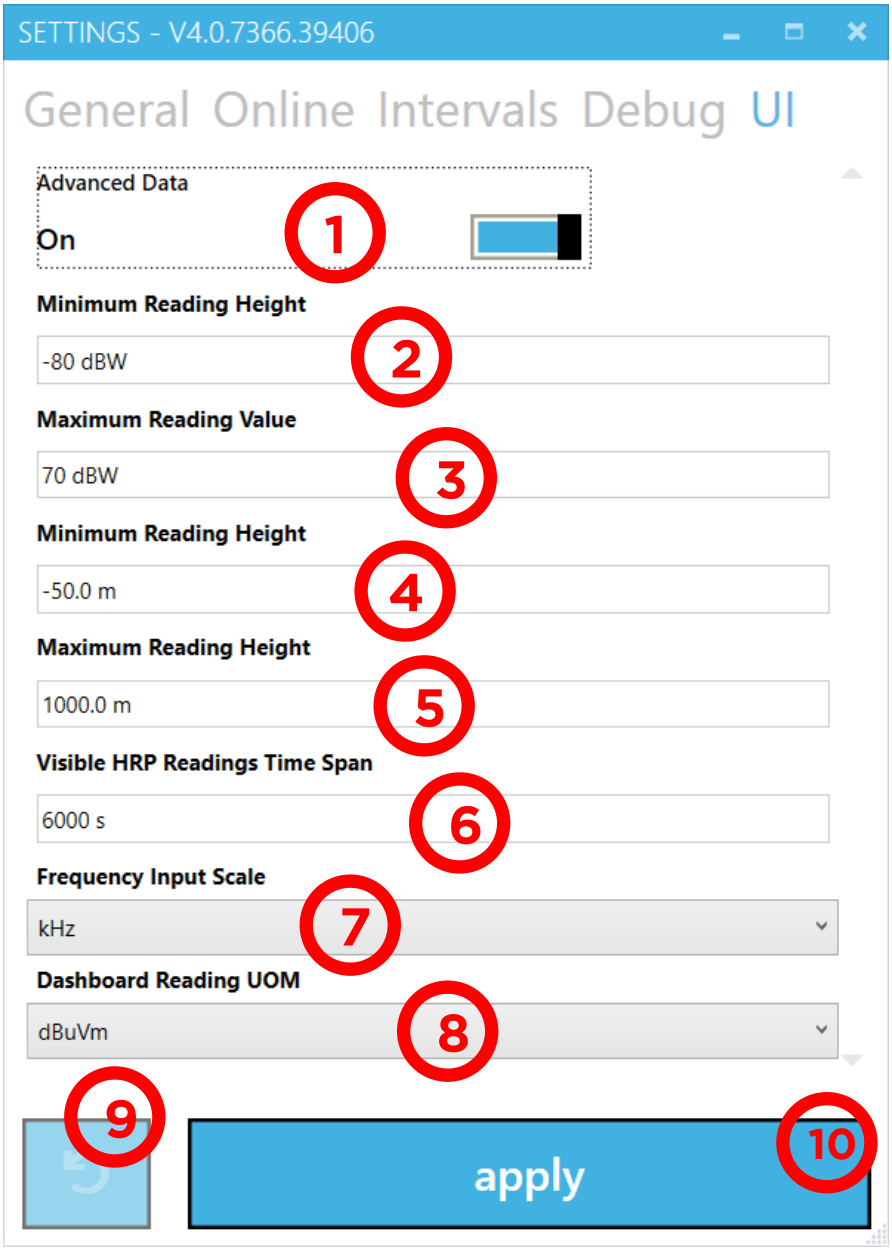
3/ **Emulation Date** Not used

4/ **Ignore Pre-Flight Checks** Used when testing functionality. This is needed to get from the Pre-Flight screen to the Start Run Screen (when testing e.g. indoors)

5/ **Undo Button** Undo recent changes

6/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/9 FILE … SETTINGS … UI



1/ **Advanced Data** Turned ON to see RAW dBm values on Live Dashboard Screen. Also turns slider functionality ON for plot customisation on the Live Dashboard Screen. This can also be set on the Live Dashboard Screen using the Settings button.

2/ **Minimum Reading Value** Set the lowest expected dBW Scale Reading

3/ **Maximum Reading Value** Set the highest expected dBW Scale Reading

4/ **Minimum Reading Height** Set the lowest expected Relative Flight Height (below take-off position)

5/ **Maximum Reading Height** Set the highest expected Relative Flight Height (above take-off position)

6/ **Visible Readings Time Span** After this set time, the plotted data starts to disappear.

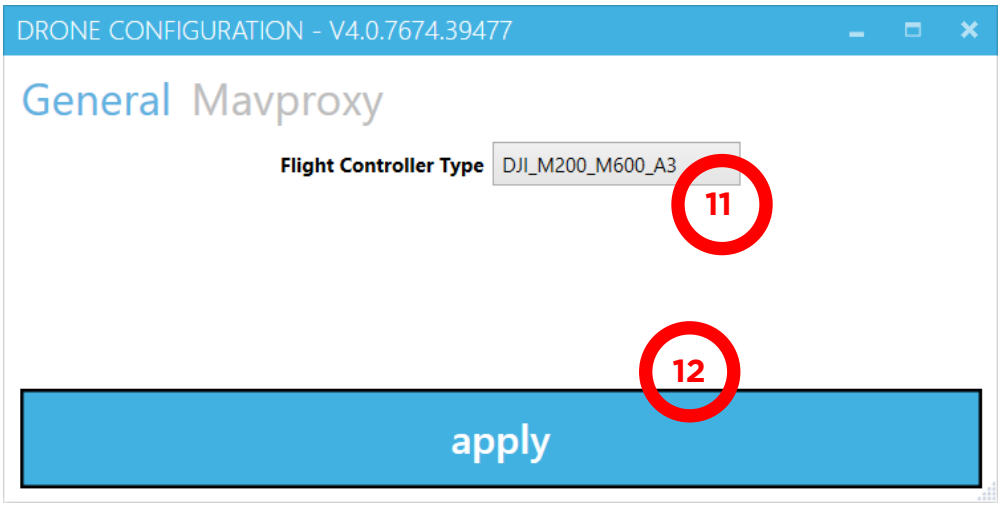
7/ **Frequency Input Scale** Choose default frequency units for AMS (useful when measuring low kHz signals). You can choose between kHz or MHz

8/ **Dashboard Reading Unit of Measurement** Choose between dBuV/m (Corrected Field Strength) or dBW (Corrected Radiated Power) for the default units shown on the Live Dashboard screen.

9/ **Undo Button** Undo recent changes

10/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

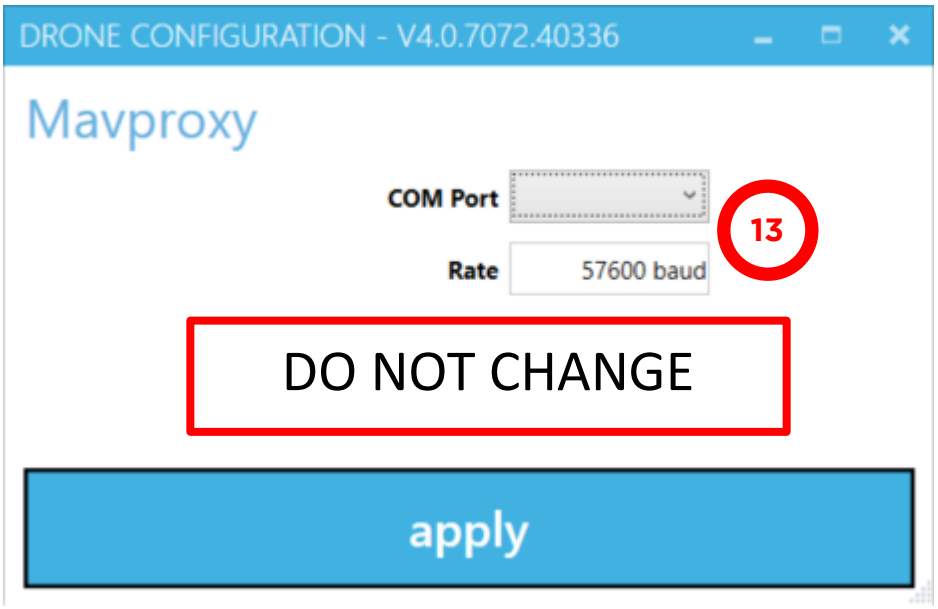
4/10 FILE … SETTINGS … ARMS … FLIGHT CONTROLLER CONFIGURATION … GENERAL



11/Flight Controller Type This setting describes the flight controller that the ARMS Rx is connected to. Currently the ARMS Rx supports connections to Mavlink based flight controllers (i.e. the Cube), DJI M210 v1 and v2, M300 RTK and DJI M600 (A3). In order to create the appropriate flight plan for the flight controller to execute, the correct flight controller needs to be chosen.

12/Apply Button Needs to be pressed whenever changes are made in order for them to be saved

4/11 FILE … SETTINGS … ARMS … FLIGHT CONTROLLER CONFIGURATION … MAVPROXY

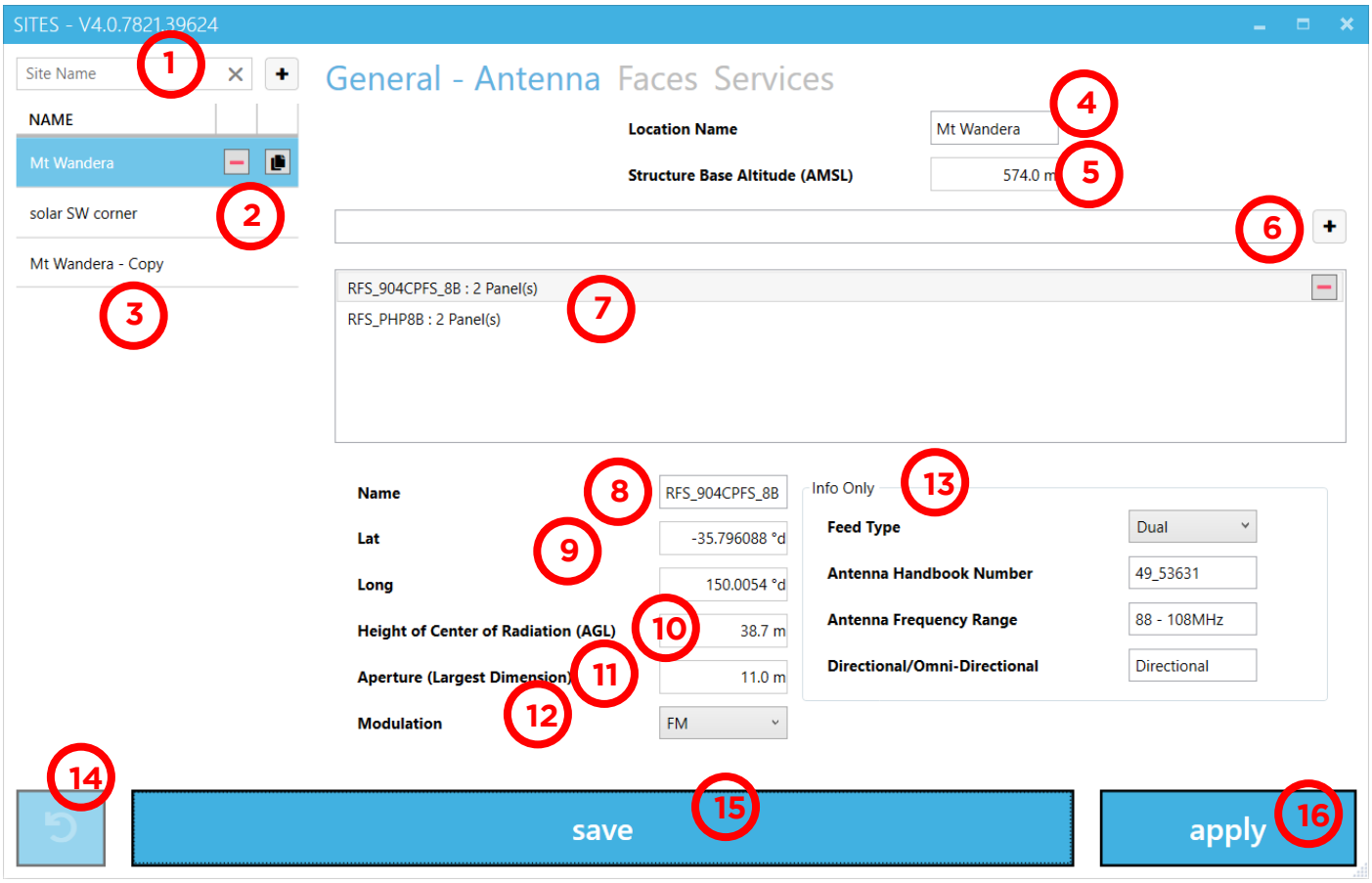


(Not needed when telemetry is disabled OR if using an IP-Based Radio Link OR using a DJI based flight Controller)

13/COM Port Setting This setting determines the port to which the Flight Controller is connected to the ARMS Rx. It will automatically find the ports used by the ARMS Rx and allow the user to select the correct port. This may need to be done after a firmware upgrade.

4/12 MAINTAIN ... SITES ... GENERAL-ANTENNA

This is the main entry point to establish a new site. The general methodology is to Establish Antennas -> Add Faces/elevation slices to the Antennas -> finally, Add services to the Antennas.



1/ **New Location** Enter the Location Name and press the + button to create a new site entry

2/ **Clone or Delete** Clone or Delete a site from the database

3/ **Existing Locations** Lists all sites in the current database

4/ **Location Name** Set the name of the Project/Location (Could use a combination of Site IDs, Names, Client, etc)

5/ **Structure Base Altitude** The altitude of the base of the supporting structure in meters above sea level. This needs to be as accurate as possible in order to measure accurate depression angles. For planning, using Google Earth Altitude is recommended. This is the height of the earth surface directly below the antenna you are testing.

6/ **New Antenna** Press to create a new antenna system for the location

7/ **Antenna List** Current Antennas installed on that location

8/ **Antenna Name** Set the name of the Antenna (Could use a combination of Manufacture, Model, etc)

9/ **Antenna Coordinates** The Latitude and Longitude decimal degrees (WGS84) for the Antenna Location

10/ **Centre of Radiation Height** This is the height of the centre of radiation of the antenna. It's the height above ground level in meters. The accuracy of this data determines the depression angle accuracy.

11/ **Antenna Aperture** The largest dimension of the antenna under test. This is used to determine the radiated Far-Field distance

12/ **Modulation** Select the modulation type for the service being measured. These are defined in MAINTAIN…MODULATION LIST. Examples could be AM, FM, DVBT, ATSC, DAB, Digital Radio, etc)

13/ **Info Only Section** Not used in any calculations, but provided for inclusion in the Automated Preliminary Report

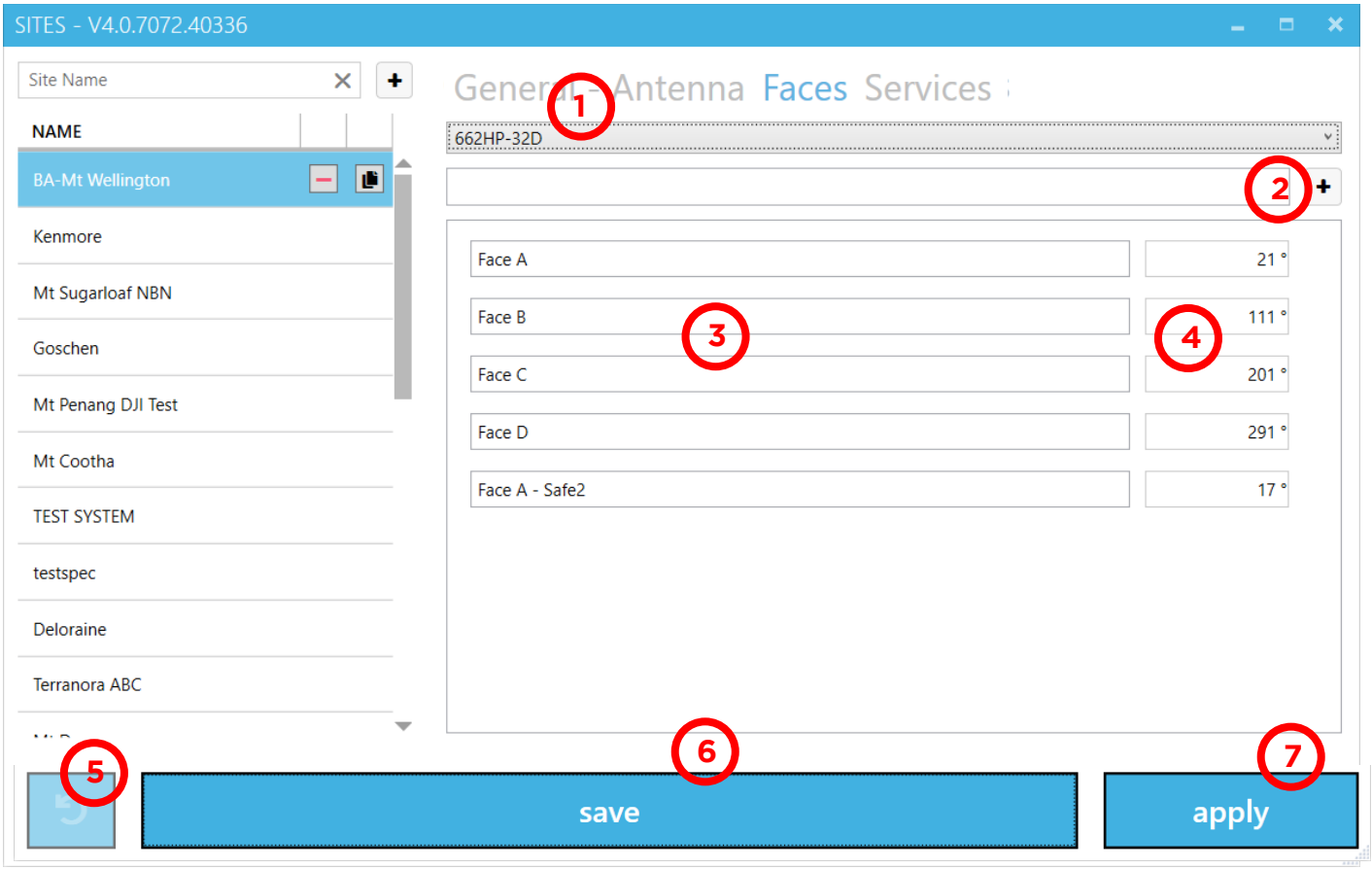
14/ **Undo Button** Undo recent changes

15/ **Save Button** Save current settings without leaving the page

16/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved. Once pressed the data is saved and the page closes

4/13 MAINTAIN ... SITES ... FACES

Define the elevation slices/faces that are needed to be measured. With panel antennas, it is good practice to fly the elevation slice at each of the panel bearings. If measuring a simple omnidirectional antenna, then a single elevation slice may suffice.



1/ **Antenna List** Dropdown menu to select previously generated site antennas

2/ **New Elevation Slice** Enter a name for the elevation slice. Usually denoted by a Face name or azimuth direction

3/ **List of Elevation Slices Name** List of current Faces/Slices associated with a specific antenna

4/ **Azimuth Info** The azimuth that the elevation slice will be measured at in degrees

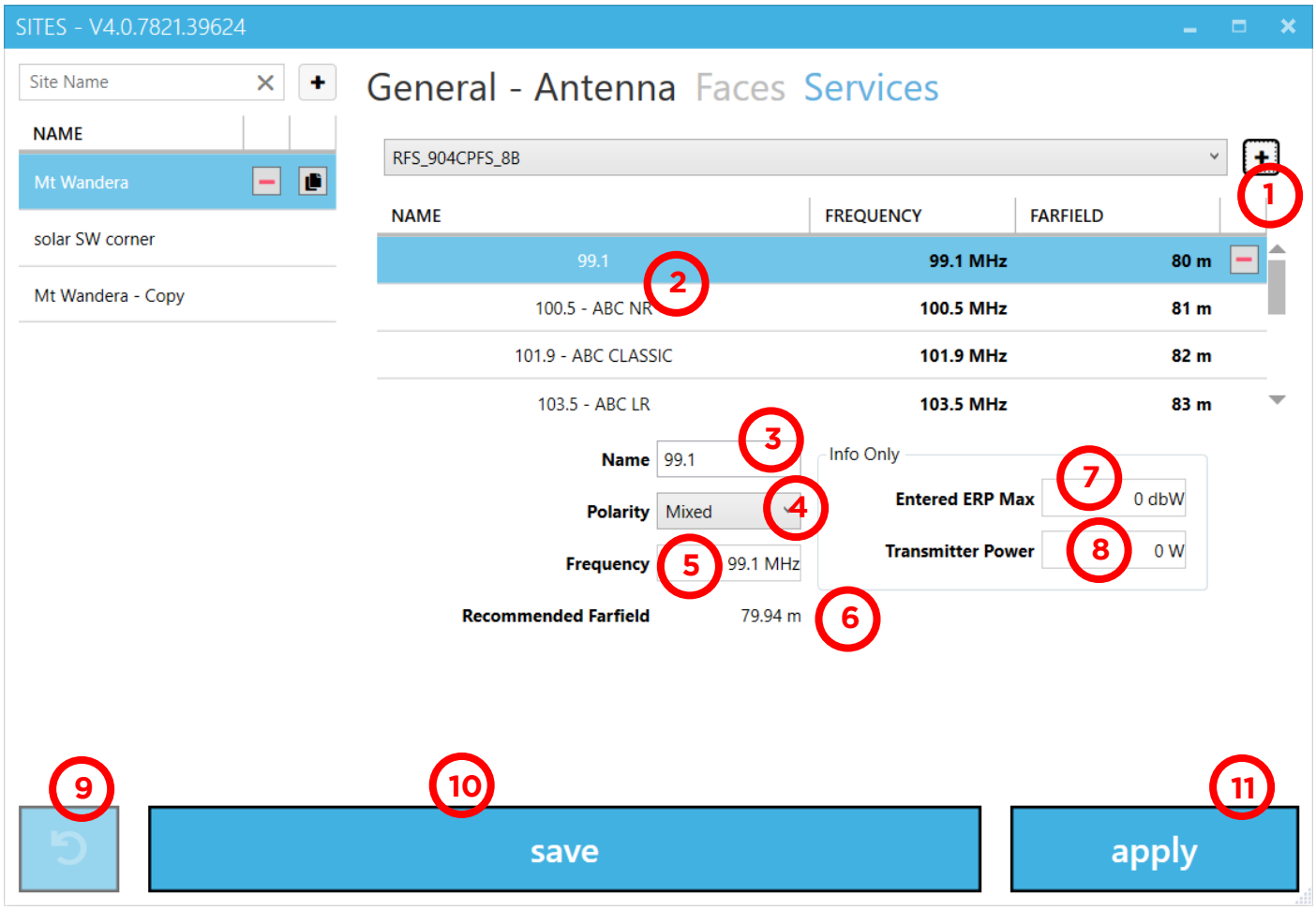
5/ **Undo Button** Undo recent changes

6/ **Save Button** Save current settings without leaving the page

7/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved. Once pressed the data is saved and the page closes

4/14 MAINTAIN ... SITES ... SERVICES

Enter all services operating on the selected antenna. All parameters such as frequency, bandwidth, modulation and polarity should be completed.



1/ **New Service** Select a previously created antenna and press the + button to assign a new service.

2/ **Service List** List of current services assigned to the antenna

3/ **Service Name** Set the name of the service (Could be callsign, abbreviation, station name, etc)

4/ **Polarity** This is the polarity of the service being measured. Could be Horizontal, Vertical, Mixed, etc)

5/ **Frequency** The frequency of the service in MHz

6/ **Farfield** Calculated Farfield distance in meters based on Frequency and Aperture using $\frac{2D^2}{\lambda}$

7/ **Entered ERP Max** Estimated or Licenced ERP max in dBW. Used in the Preliminary Report

8/ **Transmitter Power** Operating power of service in Watts. Usually read from the Tx meter panel

9/ **Undo Button** Undo recent changes

10/ **Save Button** Save current settings without leaving the page

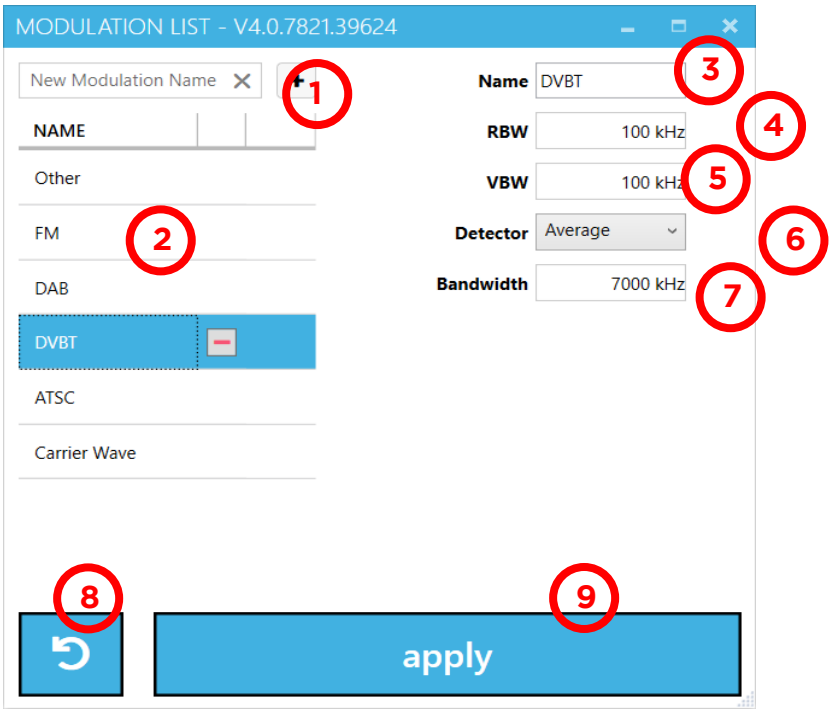
11/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved. Once pressed the data is saved and the page closes

4/15 MAINTAIN … MODULATION LIST

Define modulation types here. This create presets when measuring certain information. Contact support should you have difficulties defining the RBW, VBW and Detector for a 'new' modulation type. Some example recommendations are (may vary from country to country):

Modulation	RBW (kHz)	VBW (kHz)	Detector	Bandwidth
DVB-T	100	100	Average	6,7,8 MHz
DAB	100	100	Average	1.5 MHz
ATSC	100	100	Average	6 MHz
FM	120	5	Min-Max	200kHz
Carrier Wave	0.03	0.03	Average	100Hz
AM(CW)	0.03	0.03	Average	100Hz

Table 1: Recommended Spectrum Analyser Settings



1/ **New Modulation Type** Enter the name of the modulation and press the + to add

2/ **Current Modulation List** Shows current entered modulation and associated parameters

3/ **Modulation Name**

4/ **Resolution Bandwidth** The recommend setting for the RBW in kHz for this modulation type

5/ **Video Bandwidth** The recommend setting for the VBW in kHz for this modulation type

6/ **Detector Type** The recommend setting for the Detector Type for this modulation type (e.g. Average, Min-Max)

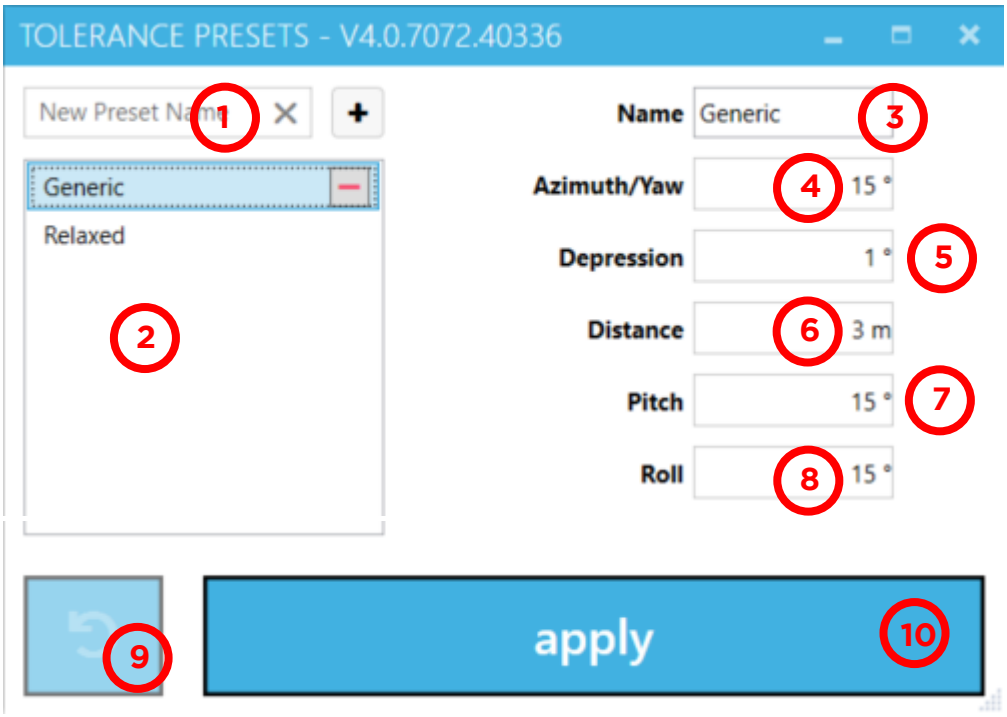
7/ **Bandwidth** The occupied bandwidth of the service in kHz

8/ **Undo Button** Undo recent changes

9/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/16 MAINTAIN … TOLERANCE PRESETS

Tolerance presets are used in determining the validity of a captured RF measurement sample. This is based on the heading, pitch, roll and distance of the drone.



1/ **New Tolerance Type** Enter the name of the tolerance and press the + to add

2/ **Current Tolerance List** Shows current entered tolerance options and associated parameters

3/ **Tolerance Name**

4/ **Azimuth/Yaw** The maximum tolerance used to classify a measurement point as Valid or Invalid based on the Azimuth and Yaw of the RPA

5/ **Depression Angle** The maximum tolerance used to classify a measurement point as Valid or Invalid based on the calculated depression angle

6/ **Distance** The maximum tolerance used to classify a measurement point as Valid or Invalid based on the distance from the RPA to the Antenna Under Test

7/ **Pitch** The maximum tolerance used to classify a measurement point as Valid or Invalid based on the Pitch of the RPA

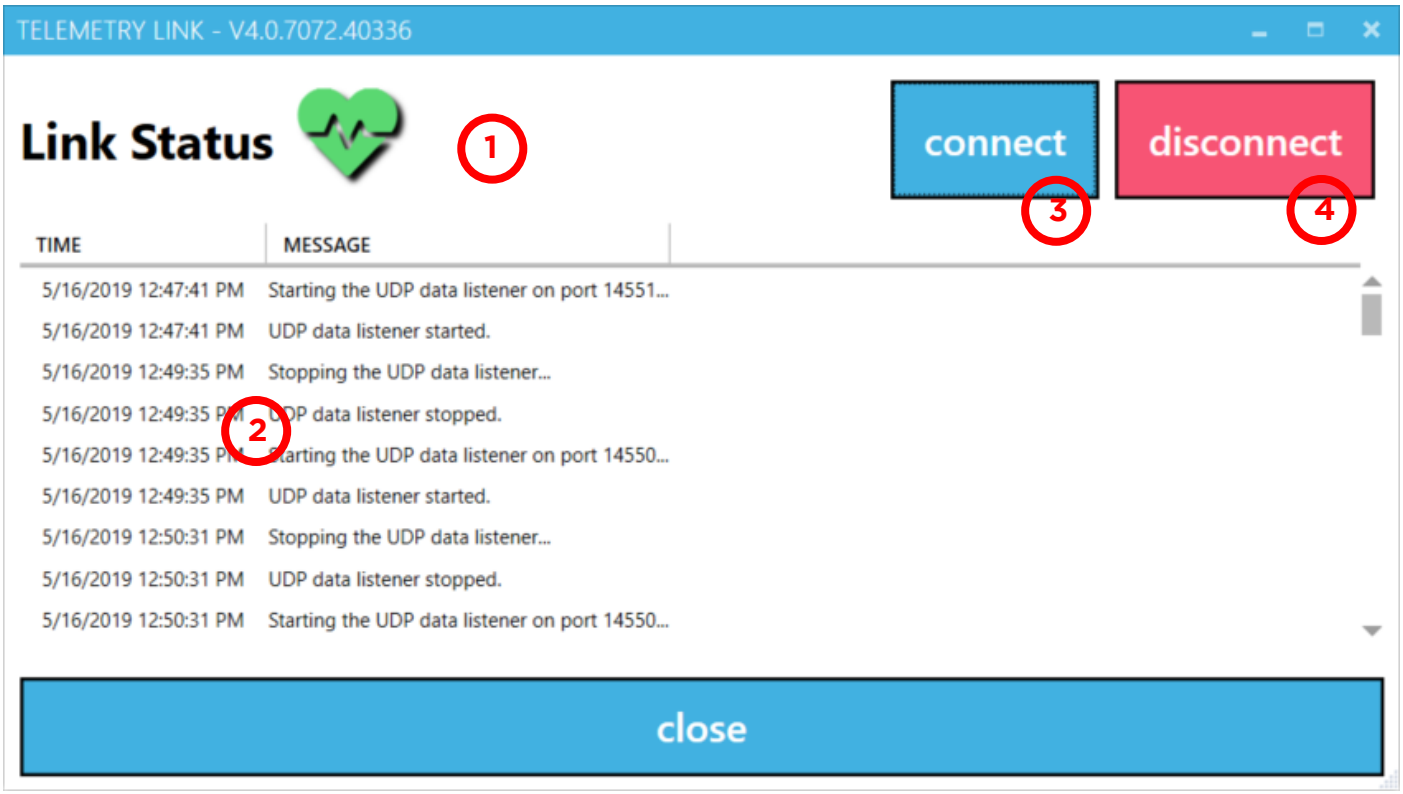
8/ **Roll** The maximum tolerance used to classify a measurement point as Valid or Invalid based on the Roll of the RPA

9/ **Undo Button** Undo recent changes

10/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/17 CONTROL … TELEMETRY LINK (IF AVAILABLE)

Controls the link status of AMS to the flight controller of the RPA. Used to monitor 'live' telemetry data from the RPA.



1/ **Telemetry Link Status** Display the current Telemetry Link Status (Green = Connection Established and Red = No Connection)

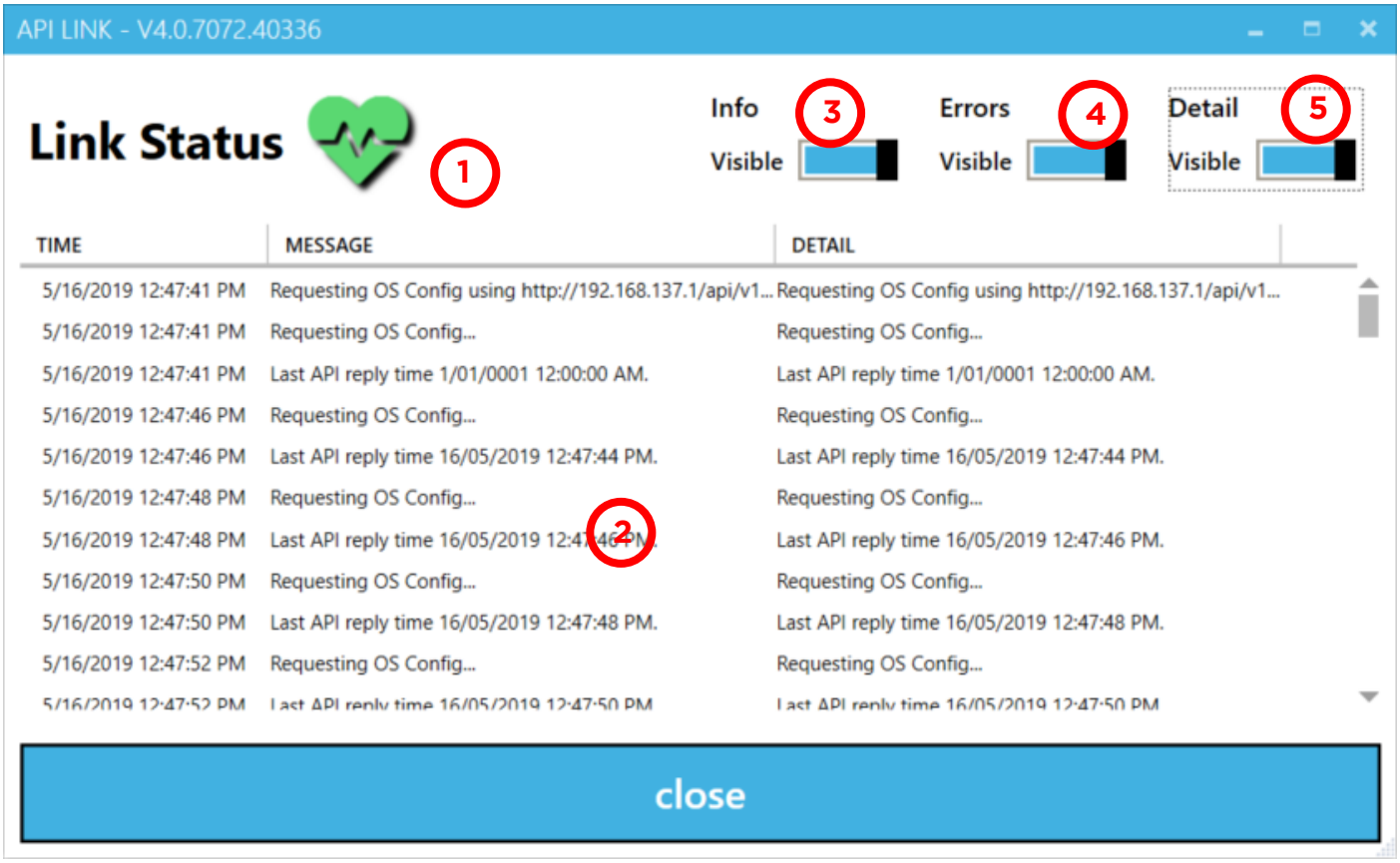
2/ **Telemetry Message Window** Shows current messages being passed from the RPA Flight Controller to the ARMS Rx then onto AMS. Messages can be sorted using the selected header

3/ **Connect** Connect to the Telemetry Port specified in the Settings menu

4/ **Disconnect** Disconnect the Telemetry from the specified port in the Settings menu

4/18 CONTROL ... API LINK (WIFI OR COFDM)

Controls the link status of AMS to the ARMS Rx.



1/ **API Link Status** Display the current API Link Status (Green = Connection Established and Red = No Connection)

2/ **API Message Window** Shows current messages being passed from the ARMS Rx to AMS. Messages can be sorted using the selected header

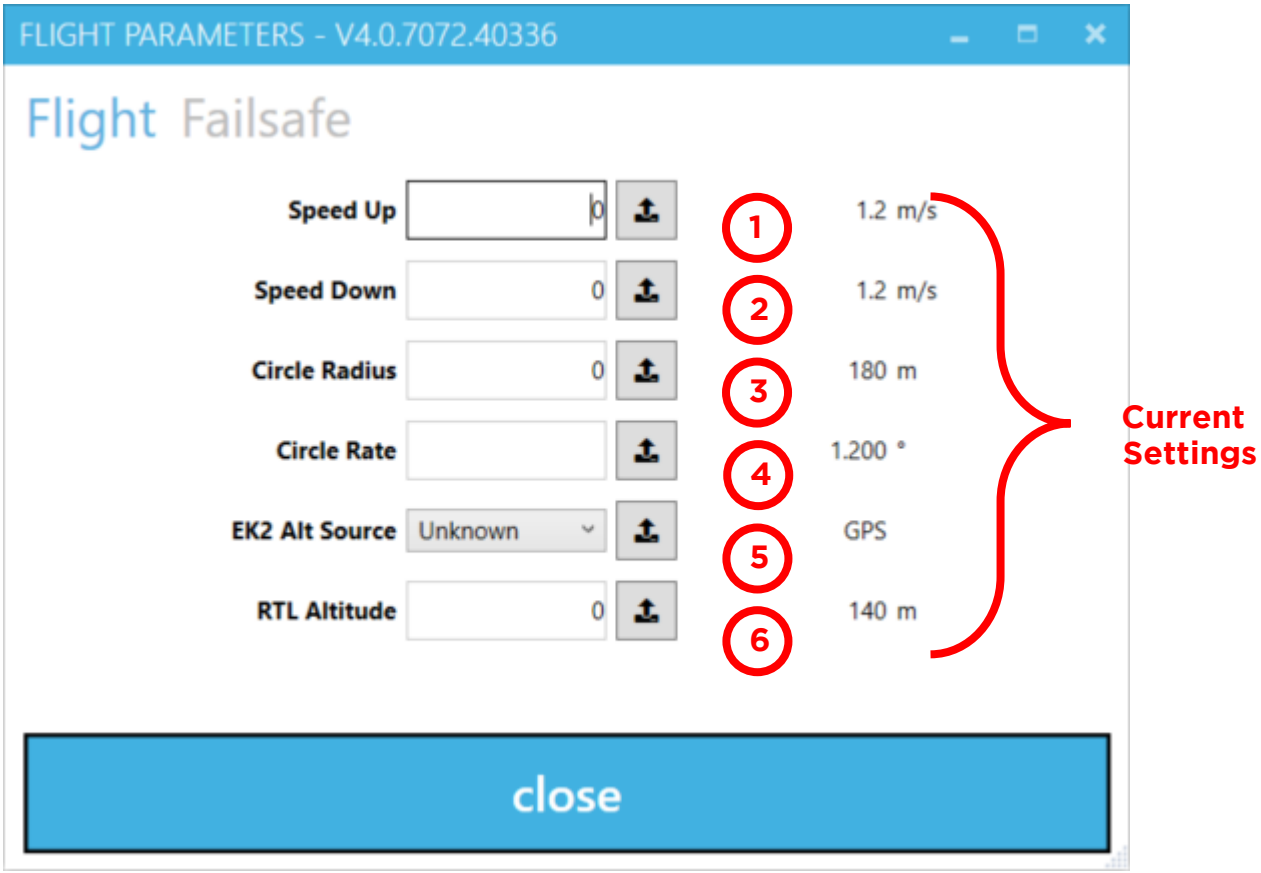
3/ **Info Visible** Toggle between Info being visible or not

4/ **Error Visible** Toggle between errors being visible or not

5/ **Detail Visible** Toggle between details being visible or not

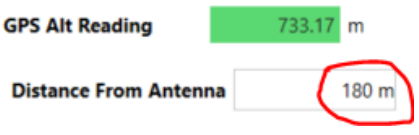
4/19 CONTROL … FLIGHT PARAMETERS … FLIGHT (ARDUCOPTER ONLY)

Controls commonly used flight parameters needed for successful measurement flights. These can also be changed in the Mission Planner software.



1/ **Speed Up** This setting controls the ascent rate of the RPA. For elevation slices, it is recommended to use 1 – 1.5m/s, but this depends on Spectrum Analyser sweep time and data resolution requirements

2/ **Speed Down** This setting controls the descent rate of the RPA. For elevation slices, it is recommended to use 1 – 1.5m/s, but this depends on Spectrum Analyser sweep time and data resolution requirements. To avoid Vortex Ring State, keep this setting less than 2m/s

3/ **Circle Radius** This setting controls the orbit distance around the antenna under test. This needs to match the setting in the PANEL RUN SCREEN 

otherwise the orbit and expected flight distances will not line up, cause invalid data to be displayed

4/ **Circle Rate** This setting controls the orbit speed of the RPA. For azimuth flights, it is recommended to use between 1 - 2°/s, but this depends on Spectrum Analyser sweep time and data resolution requirements

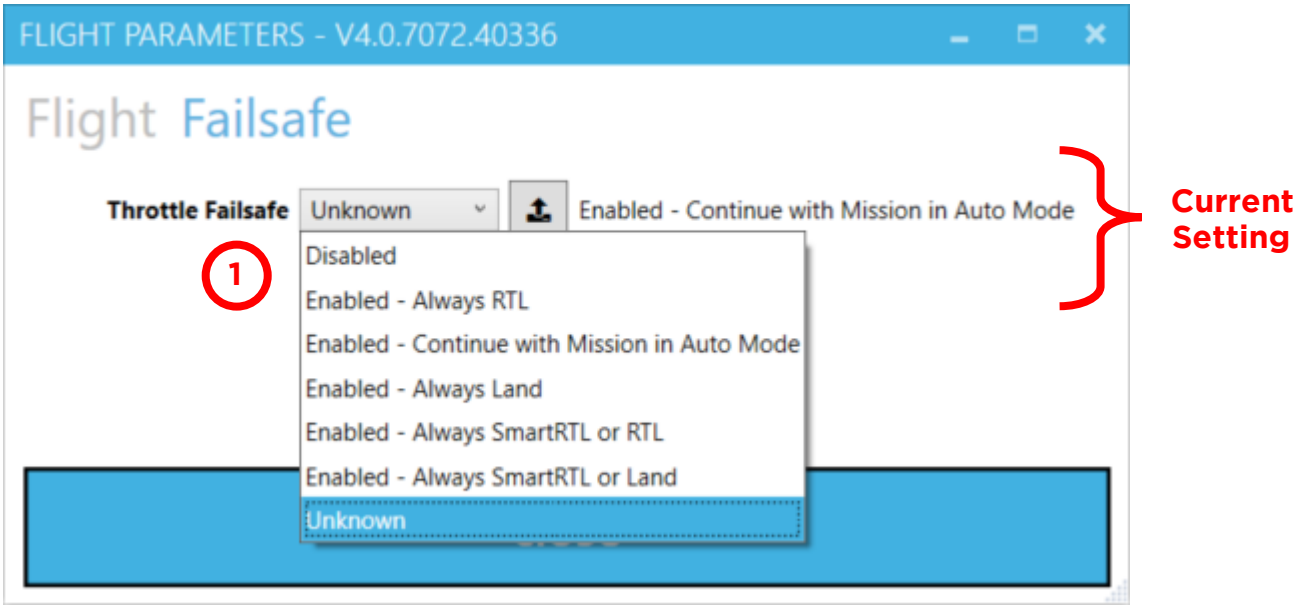
5/ **EK2 Alt Source** This setting specifies whether the RTK GPS or the Barometer are used as a flight height reference for the RPA. RTK GPS is used for greater accuracy in flight height

6/ **RTL Altitude** This setting specifies the height above take-off in meters that the RPA will return to home if instructed to or a failsafe is enabled.

Note that there is no APPLY button. After changing a value, press the button to change the value and monitor the current settings until the change is successful

4/20 CONTROL … FLIGHT PARAMETERS … FAILSAFE (ARDUCOPTER ONLY)

Define FAILSAFE parameters in the event that the Remote Control Signal is lost. Geofencing is not currently implemented in these controls. Head to Mission Planner should you need to implement a Geofence.

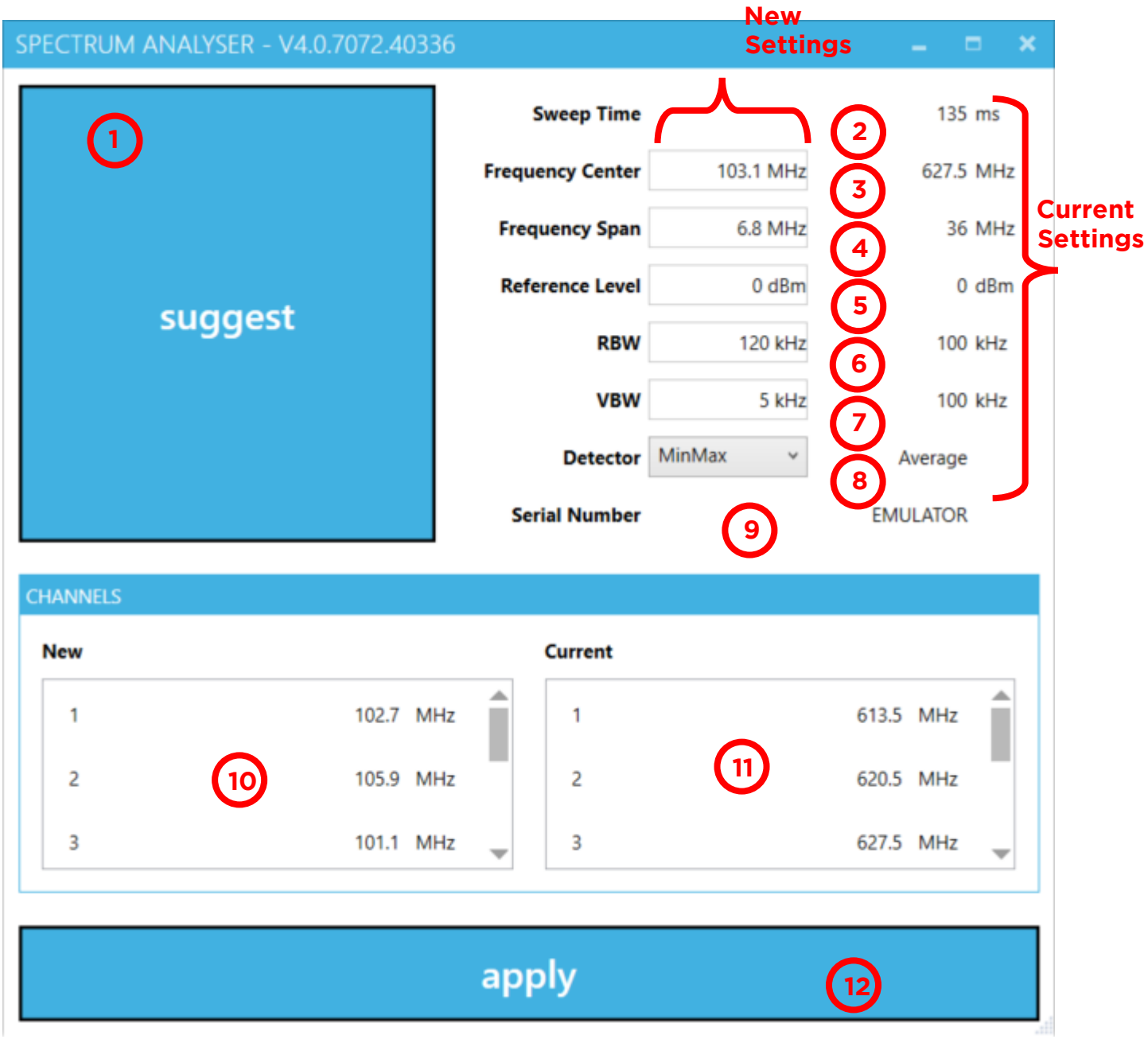


1/ **Throttle Failsafe** This setting allows the user to control what happens in the event the Remote Control signal is lost and a RC Failsafe occurs. Generally, “Continue with Mission” is used but needs to be evaluated on a site by site basis

Note that there is no APPLY button. After changing a value, press the button to change the value and monitor the current settings until the change is successful

4/21 CONTROL … SPECTRUM ANALYSER

AMS is able to setup and control the ARMS Rx based on setting defined within the session. The option to set the spectrum analyser manually is also available.



1/ **Suggest Button** This button suggests the settings for the sweep. It's based on the services being measured to calculate the centre frequency and span. The default is usually a good starting point.

2/ **Sweep Time** Displays the current sweep time of the Spectrum Analyser

3/ **Frequency Centre** Set the desired frequency in MHz

4/ **Frequency Span** Set the desired span in MHz

5/ **Reference Level** Settable between (+10 and -40dBm). If measuring high powered services, use 0dBm as a reference as well as suitable attenuation on the Front of the ARMS Rx. Greatest

sensitivity of the ARMS Rx is when the reference level is set to -40 (used when measuring week signals)

6/ **Resolution Bandwidth** Sets the required RBW in kHz for the services being measured

7/ **Video Bandwidth** Sets the required VBW in kHz for the services being measured

8/ **Detector Type** Sets the required detector type for the services being measured, options include:

i. Average

ii. Min-Max

9/ **Spectrum Analyser Serial Number** The serial number of the inbuilt spec an in the ARMS Rx

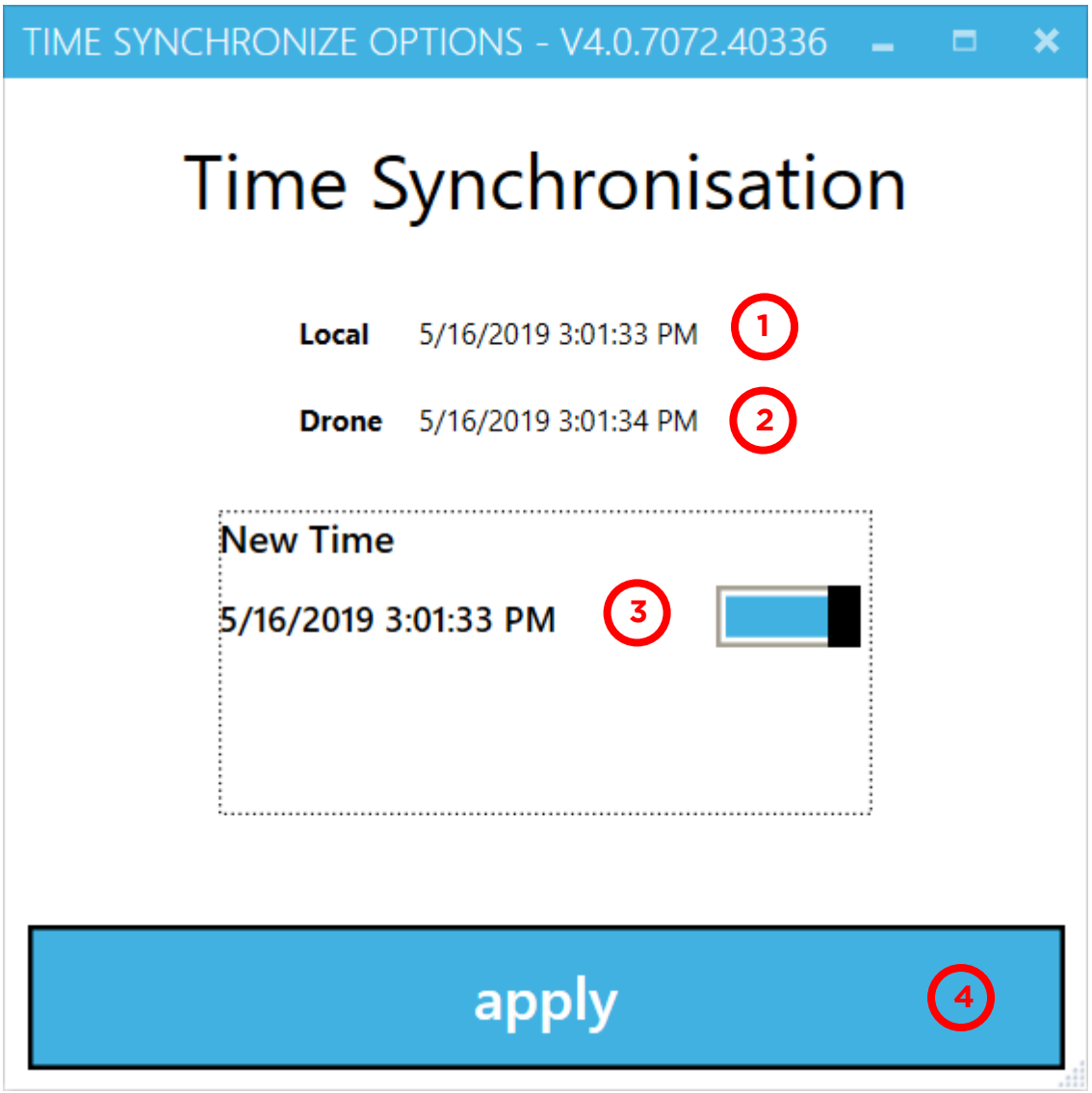
10/ **List of New Channel** Services to be programmed based on the selected Session

11/ **List of Current Channel** Services currently programmed in the ARMS Rx

12/ **Apply** Press Apply to program the Spectrum Analyser

4/22 CONTROL … TIME SYNC

The local time on the PC running AMS and the local time on the ARMS Rx should be in sync. This menu allows the times to be synchronised. Both PCs time may drift over time and will require resyncing.



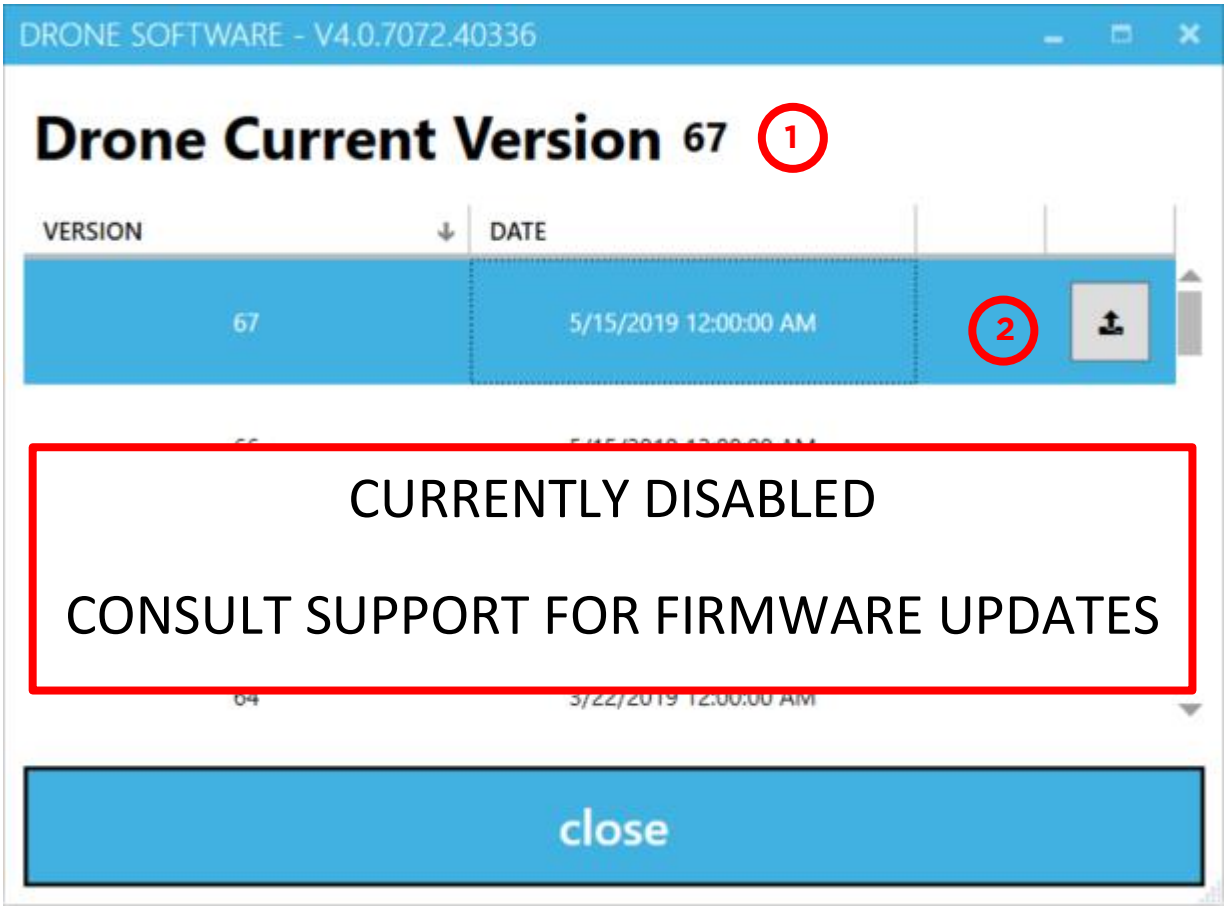
1/ **Local Time** The local time on the machine running AMS

2/ **ARMS Rx Time** The time on the ARMS Rx PC

3/ **New Time Toggle Switch** Toggle between setting the ARMS Rx time or the local machine

4/ **Apply** Press Apply to sync the time between AMS and the ARMS Rx

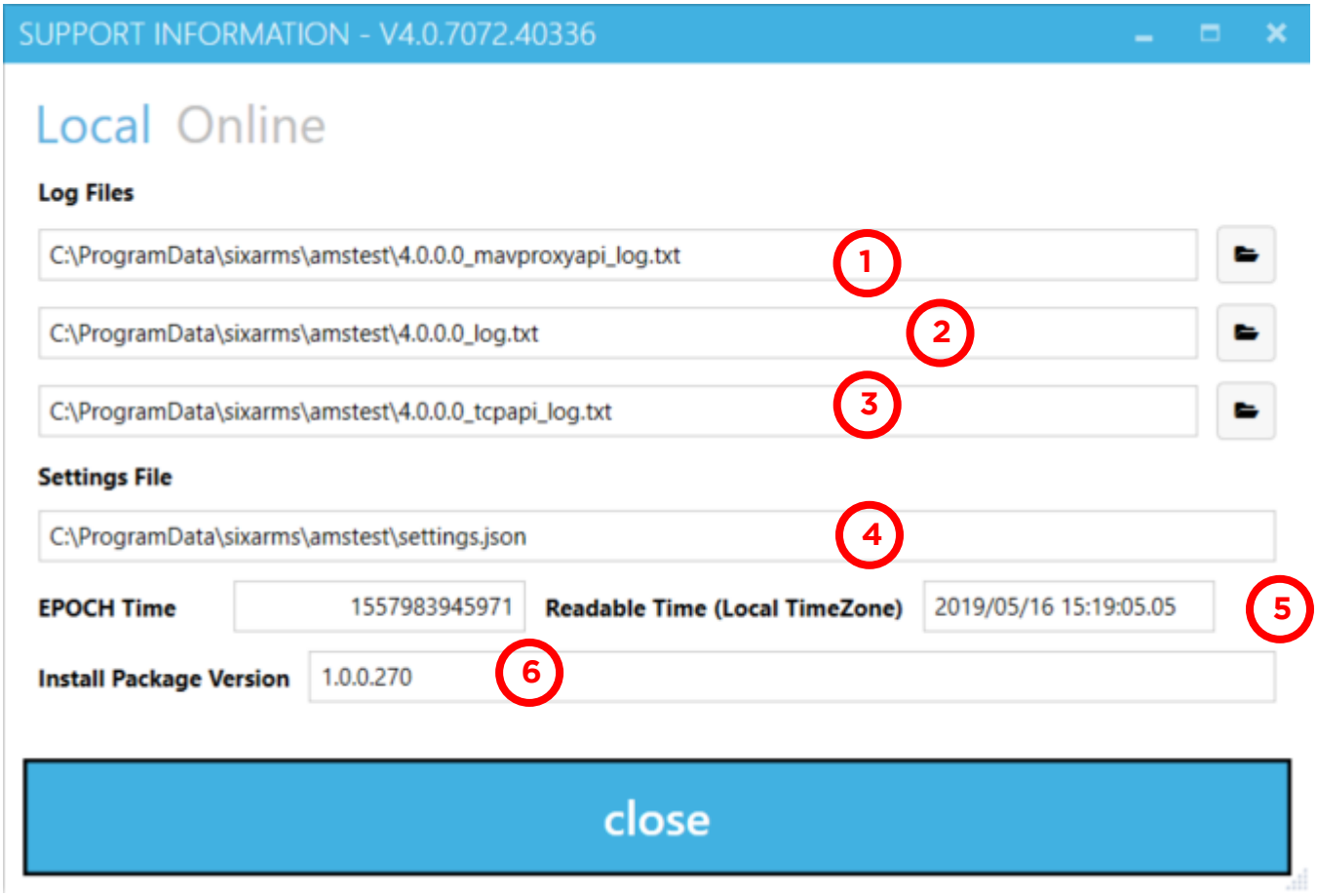
4/23 CONTROL ... ARMS Rx FIRMWARE (IF APPLICABLE)



1/ Current Firmware Version The current firmware on the ARMS Rx

2/ Download and Install Firmware Download and install the selected firmware version

4/24 HELP … SUPPORT INFO … LOCAL



1/ **Telemetry Log File** The location of the Telemetry Log File

2/ **Main AMS Log File** The location of the AMS Log File

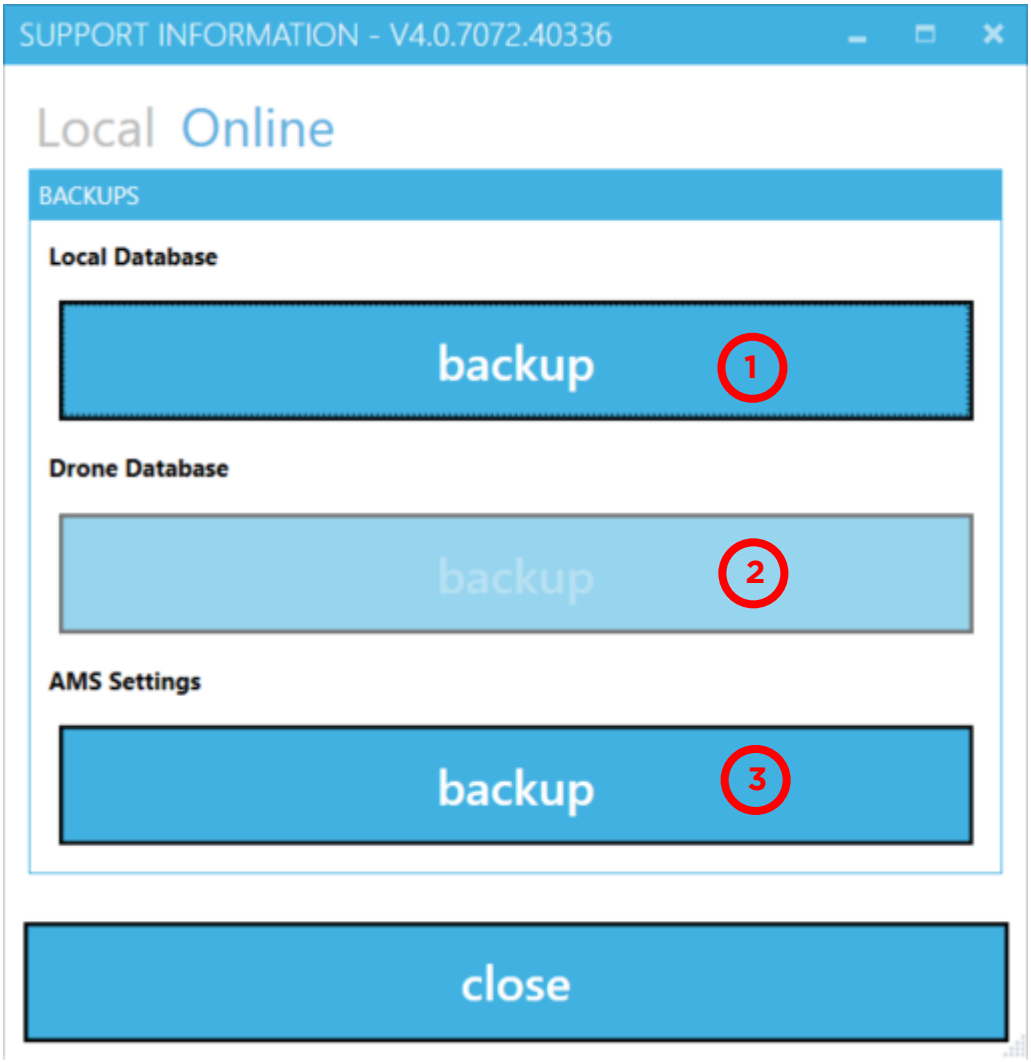
3/ **API Log File** The location of the API Log File

4/ **AMS Setting File** The location of the AMS Settings File

5/ **EPOCH Time Convertor**

6/ **Install Package Version** AMS Version Number

4/25 HELP … SUPPORT INFO … ONLINE



1/ **Backup the current AMS database** AMS performs an online backup of the current database

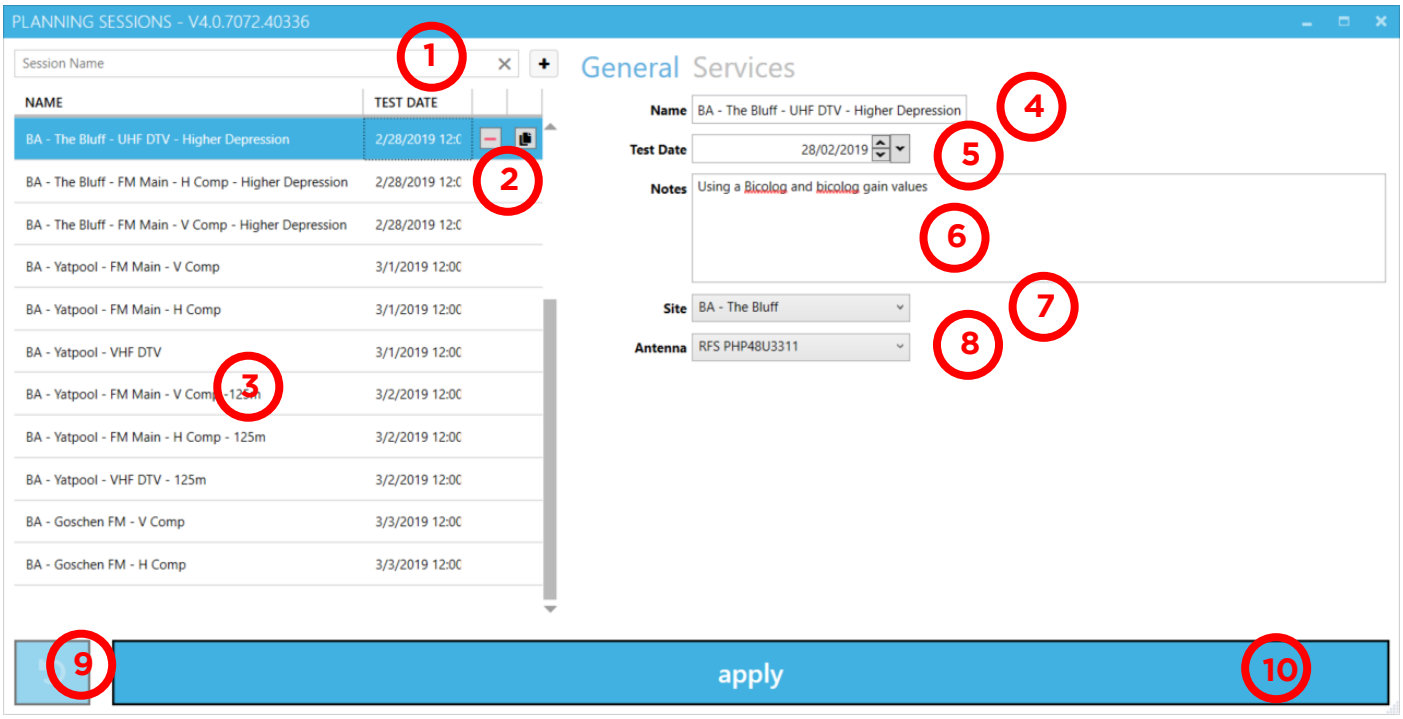
2/ **ARMS Rx Database** Not Yet Implemented

3/ **AMS Settings** AMS performs an online backup of the current settings

Note that your online username will need to be setup in File … Settings … Online

4/26 PLANNING ... GENERAL

Planning sessions are created to measure particular services from a particular antenna. Only one antenna under test can be chosen at a time. However, multiple services on that antenna may be measured in one planning session.



1/ **New Planning Session** Enter the Session Name and press the + button to create a new entry

2/ **Clone or Delete** Clone or Delete a Session from the database

3/ **Existing Sessions** Lists all Sessions in the current database

4/ **Session Name** Set the name of the Session (Site Names, Client, Antenna, polarisation, etc)

5/ **Time and Date of the Expected Measurements**

6/ **Session Notes** Allow the input of any notes concerning the session. This will get transferred to the preliminary report (e.g. Service 1 Tx fault during measurement)

7/ **Site** Select the Site that contains the antenna under test

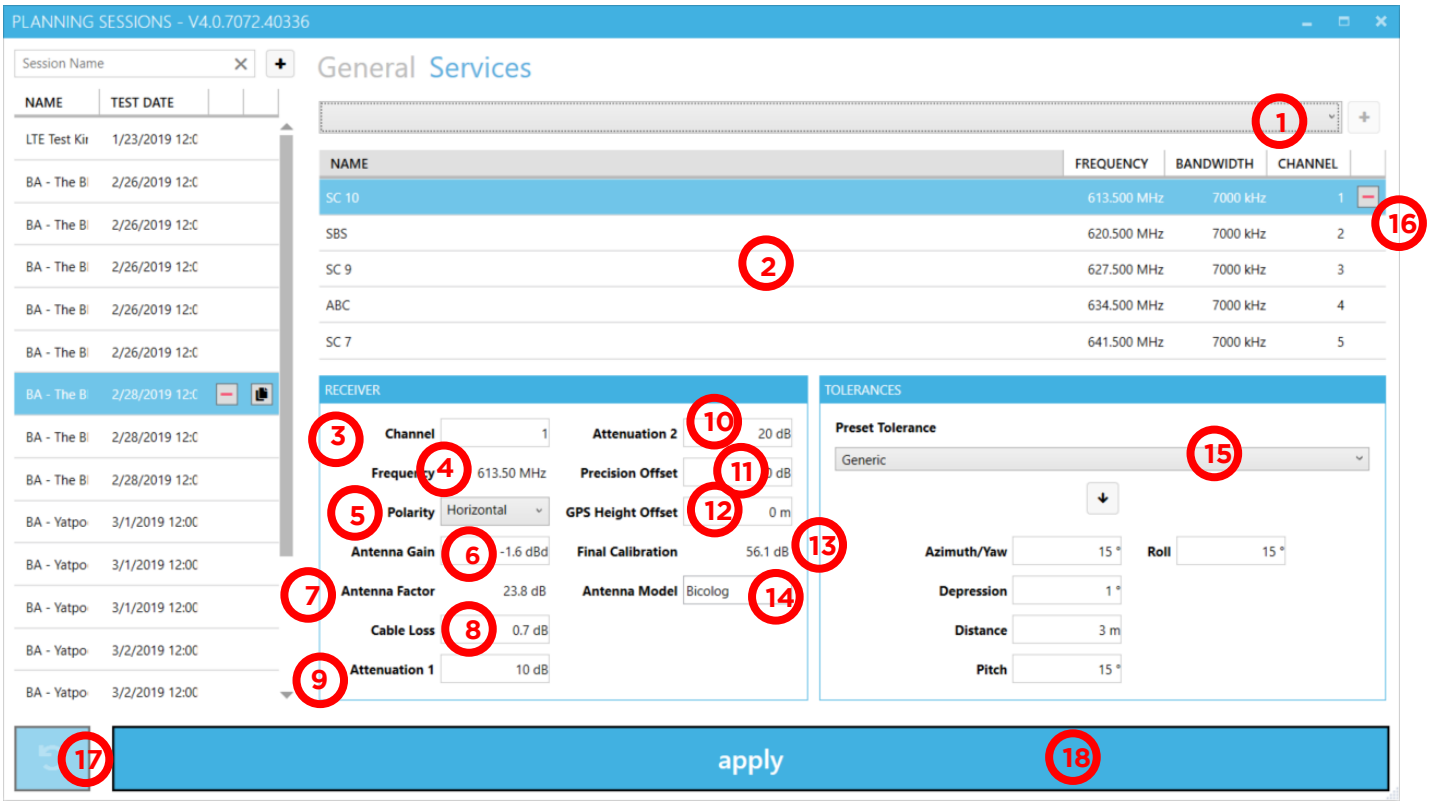
8/ **Antenna** Select the Antenna Under Test associated with that Site

9/ **Undo Button** Undo recent changes

10/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/27 PLANNING … SERVICES

Define all services for a chosen antenna that will be measured. Also, define the Rx antenna and calibration details and tolerance settings for all services.



1/ **Select Services** Select Services associated with the AUT and add to the session with the +

2/ **Service List** Current list of services to be measured

3/ **Service/Channel Number** Automatically assigned number

4/ **Frequency** Automatically assigned frequency based on Services setup

5/ **Polarity** This is the polarity of the Receive antenna attached to the ARMS Rx (e.g. could be Horizontal or Vertical if measuring Mixed Polarisation)

6/ **Antenna Gain** Enter the receive antenna gain value in dBd for the service frequency

7/ **Antenna (Dipole) Factor** Automatically calculated

8/ **Cable Loss** Inline cable loss in dB for the specific service

9/ **Attenuation 1** First inline attenuator in dB for the specific service

10/ **Attenuation 2** Second inline attenuator in dB for the specific service

11/ **Precision Offset** Used when comparing values to a higher end calibrated receiver

12/ **GPS Height Offset** Input the height difference from the GPS/Barometer to the Receive antenna. Used where higher accuracy depression angles are needed.

13/ **Final Calibration Factor** Sum of all contributing calibration factors

14/Receive Antenna Model Model or description of receive antenna used

15/Preset Tolerance Selection Select a predefined set of validation tolerances

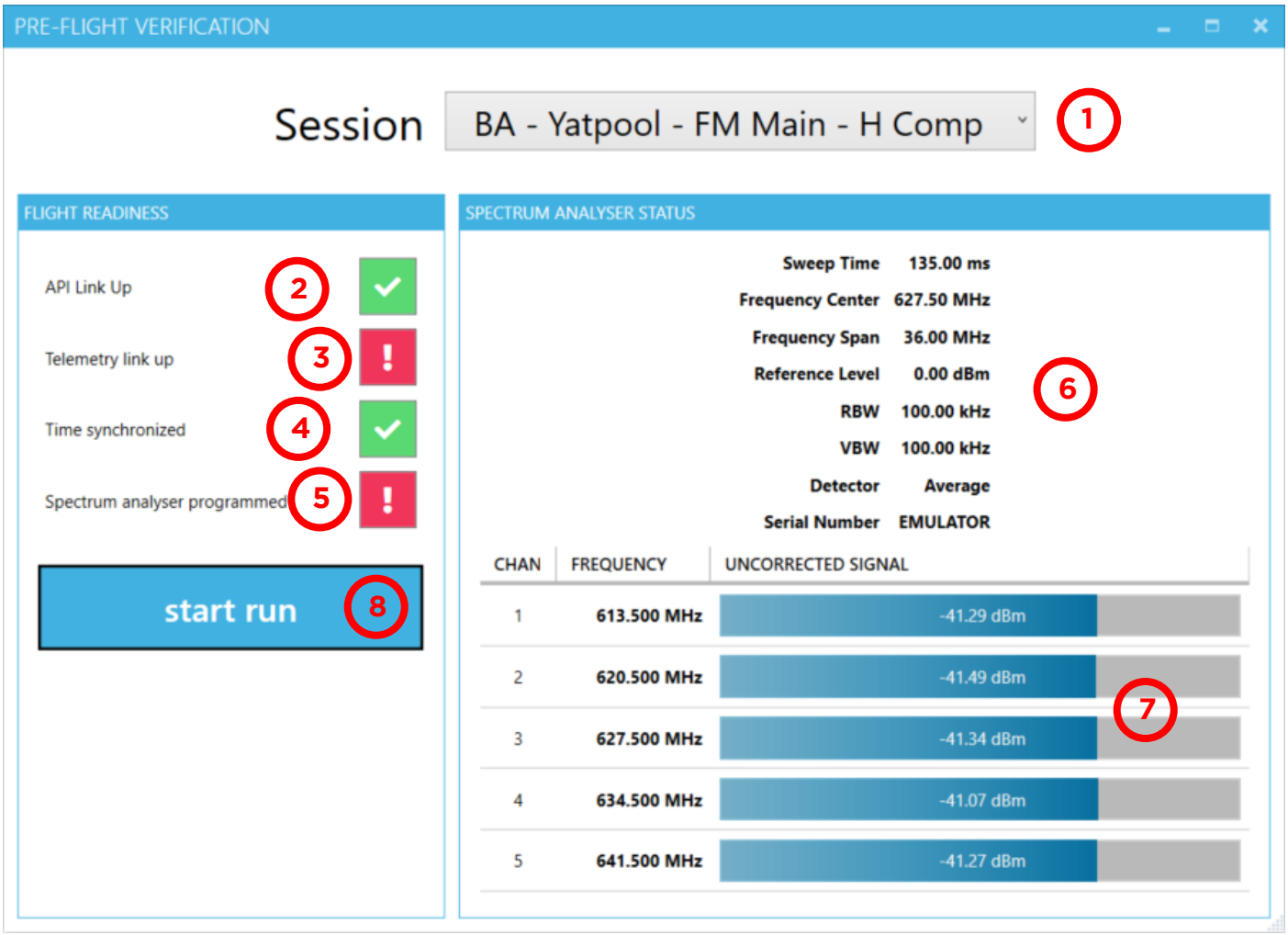
16/Remove Services Remove services from the current measurement list using the -

17/Undo Button Undo recent changes

18/Apply Button Needs to be pressed whenever changes are made in order for them to be saved

4/28 PRE-FLIGHT … VERIFICATION

This screen is used to verify that all settings and subsystems are working correctly. All check boxes should be green before starting the measurement. Select the session, program the spectrum analyser (confirm the readings are being displayed), check all boxes are green, then start the run



1/ **Session Selection** Select a pre-defined Session from the drop-down list

2/ **API Monitor** If the API link is UP then the box is a green tick. If the API link is DOWN then the box is a Red exclamation Mark. Clicking on the status box will take you to the API Link Screen

3/ **Telemetry Link Up Monitor** If the Telemetry link is UP then the box is a green tick. If the Telemetry link is DOWN then the box is a Red exclamation Mark. Clicking on the status box will take you to the Telemetry Link Screen

4/ **Time Synchronised Monitor** If the system time of the ARMS Rx and AMS match up then the box is a green tick. If the times don't match then the box is a Red exclamation Mark. Clicking on the status box will take you to the API Link Screen

5/ **Spectrum Analyser Programmed Monitor** If the ARMS Rx is programmed correctly for the selected session, then the box is green. If the session and the ARMS Rx differ, the box is Red. Clicking on the box will take you to the program spectrum analyser screen.

6/ **Current Spectrum Analyser Settings** Shows the current ARMS Rx config

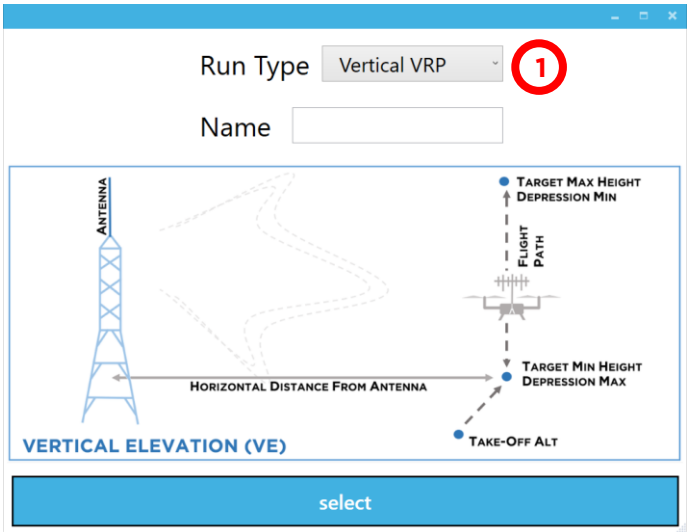
7/ **Signal Strength** Shows the programmed service and corresponding raw (uncorrected) channel power value in dBm

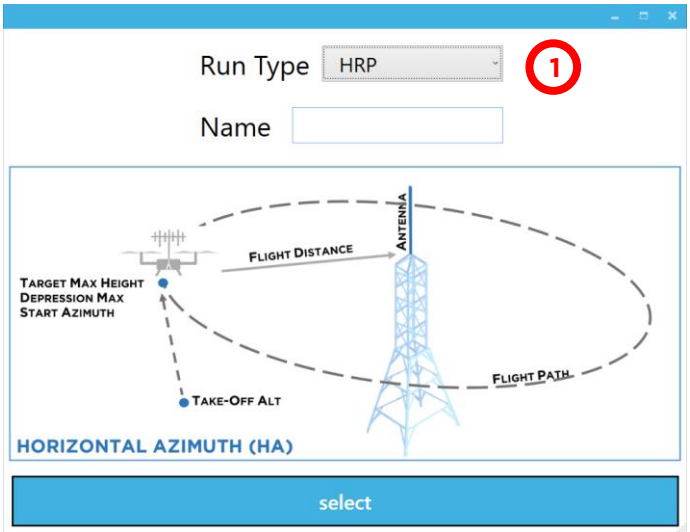
8/ **Start Run** Once all check boxes are green, click on the Start Run button to setup the flight paths and measurement types

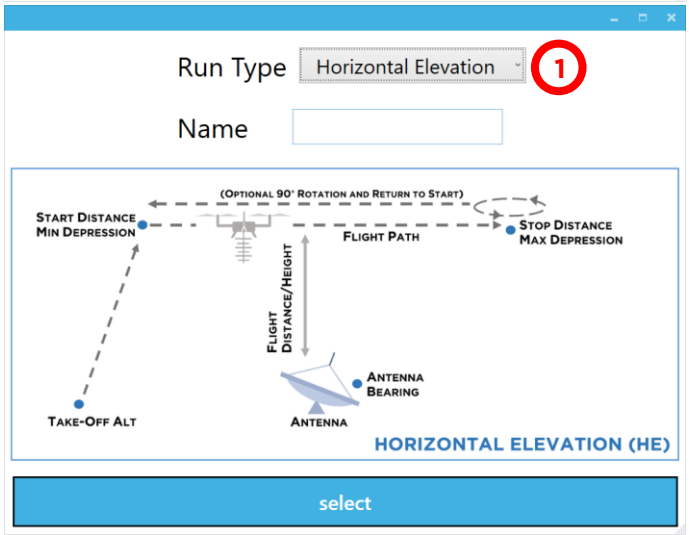
4/29 PANEL RUN (LICENCE DEPENDANT)

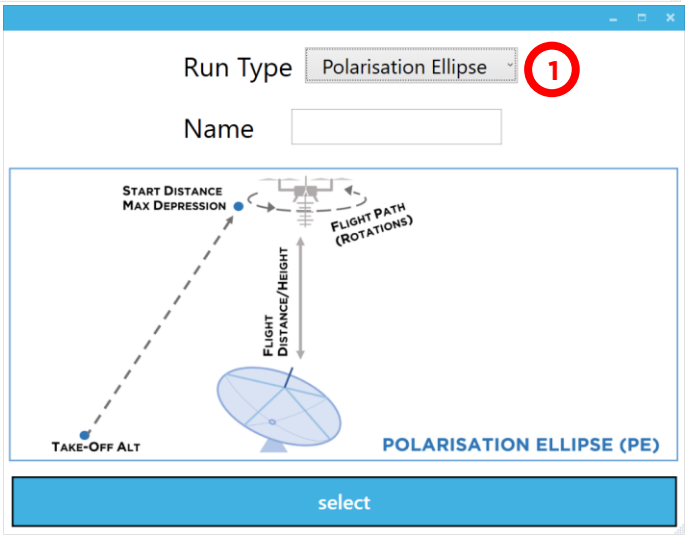
Define the flight type for the measurement run. This creates the flight path which is sent the RPA via Mission Planner. Take Off altitude is critical for accurate depression angles. If using RTK, wait for the GPS Alt Reading to turn green, then push that altitude to the Take-Off Alt. Start Recording is only enabled once a flight plan has been created. **Double check that values are as intended, before creating the flight plan!**

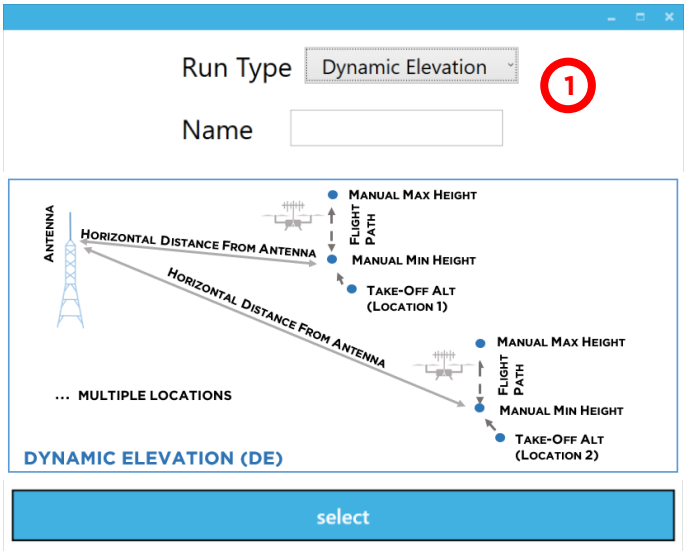
Different Measurement Runs/Flight Types include:

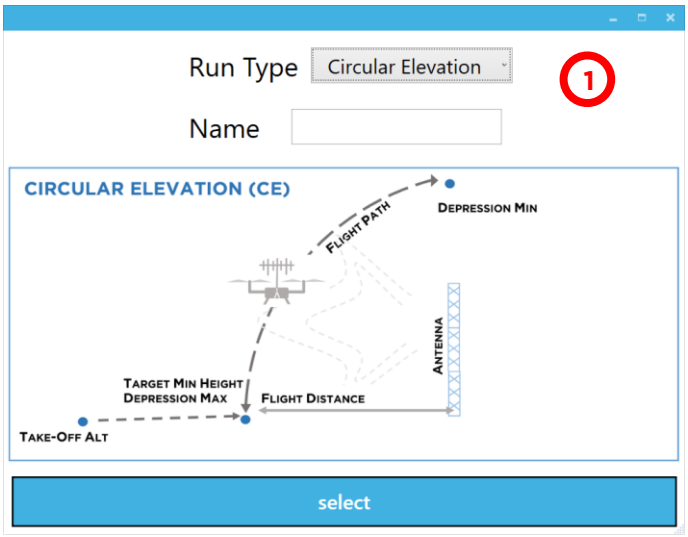


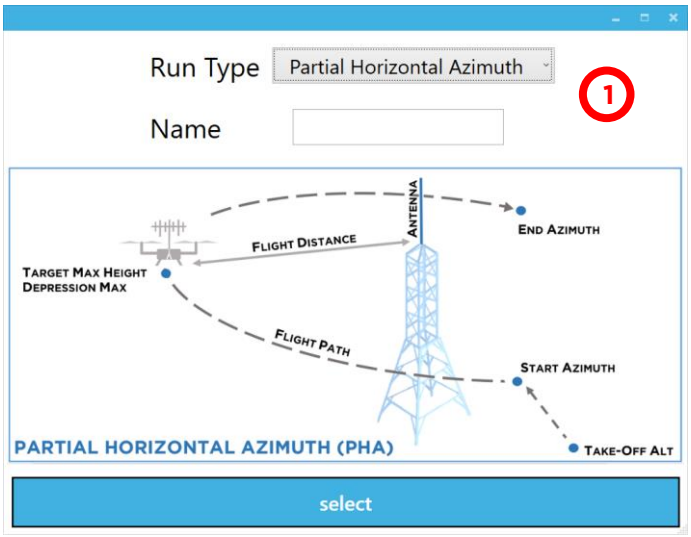


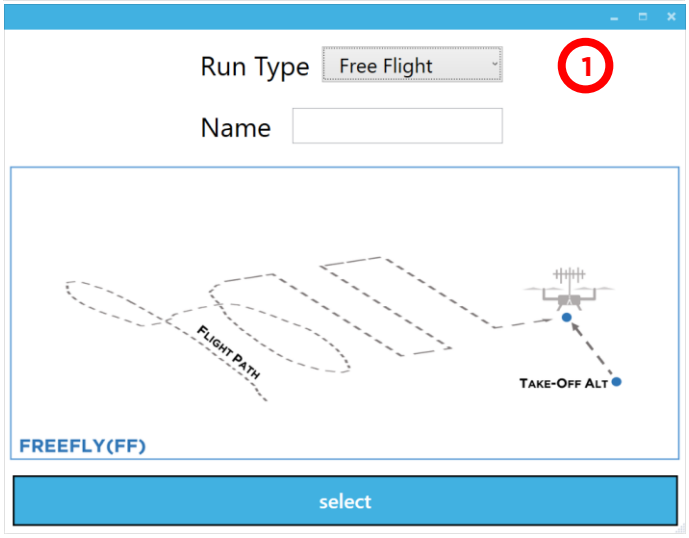










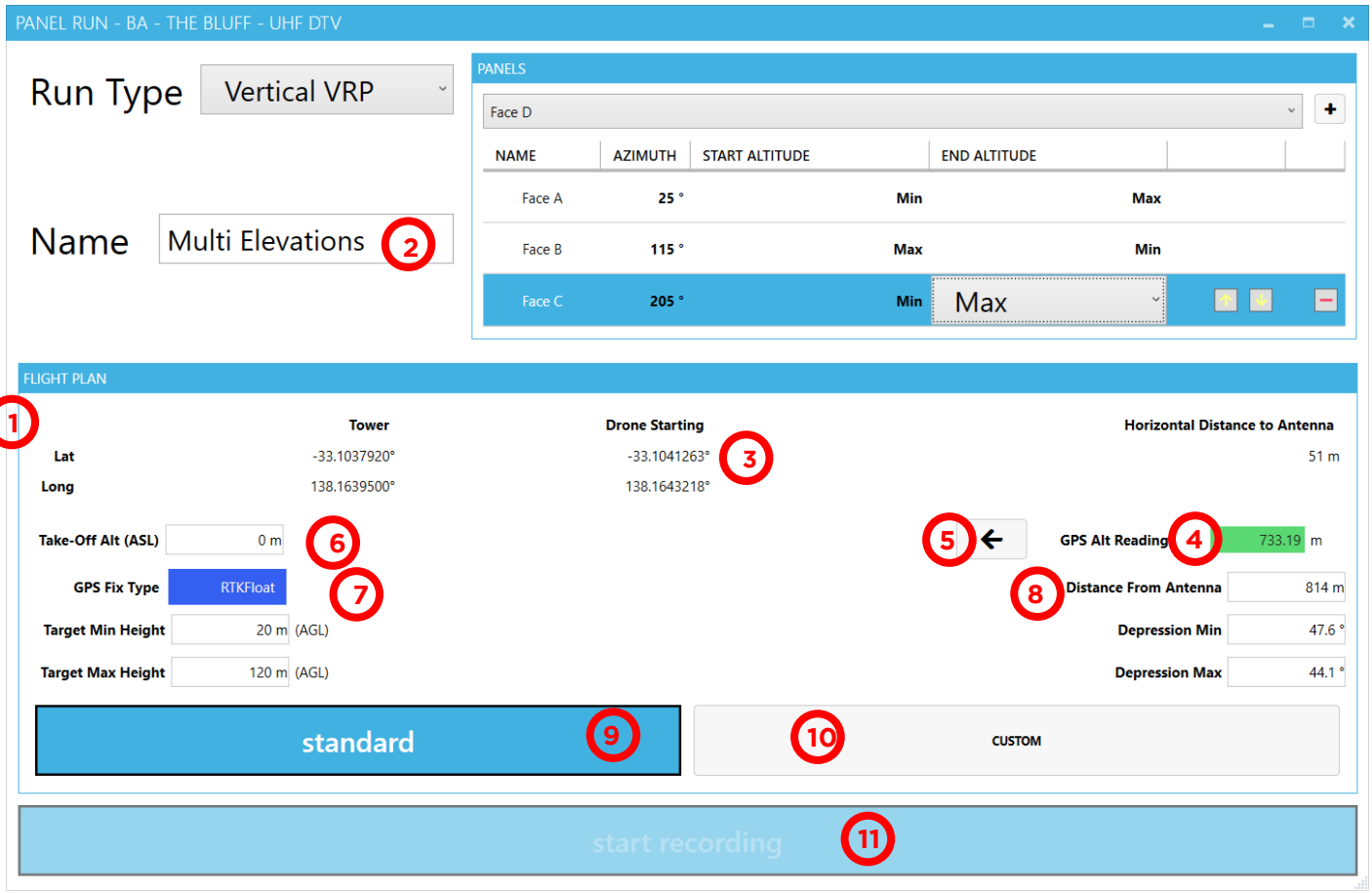


9/ **Run Type Selection** Select the type of run being performed. Options are:

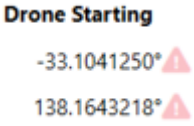
i. Vertical Elevation
ii. Horizontal Azimuth
iii. Circular Elevation (not yet implemented)
iv. Horizontal Elevation
v. Polarisation Ellipse
vi. Dynamic Elevation
vii. Freefly (partial implementation)

4/30 COMMON ELEMENTS FOR ALL FLIGHT TYPES

The following number information is relevant to all flight types.



1/ **Subsystem Faults** Faults with any of the components will be indicated with a flashing red triangle with an exclamation mark. Perform of battery reset on the RPA if the subsystems continually display this warning.



2/ **Name** Description of the Run being performed, practical name for the measurement run

3/ **Current RPA location** This shows the current GPS coordinates of the RPA as well as the distance from the RPA to the Antenna Under Test.

4/ **GPS Altitude Reading** This is the measured altitude of the RPA (using RTK or Barometer, depending on settings). Values are meters above sea level

5/ **Altitude Push** Once the altitude indicated in 4/ is stable, push this value to 6/ take-off altitude. This is essential as incorrect depression angles will be calculated if this step is missed

6/ **Take Off Altitude** It's important that the value in 4/ is pushed to this parameter once the altitude reading of the GPS/Barometer is stable. Use 5/ to assign the current altitude of the RPA to the Take-Off altitude (AMSL)

7/ **GPS Fix Type** The fix of the GPS may vary. For accurate RTK measurements, the GPS status should be either RTK Float or RTK Fix. Other options include:

i. No GPS
ii. Single (Yellow)
iii. Differential GPS (Orange)
iv. RTK Float (Blue)
v. RTK Fix (Green)

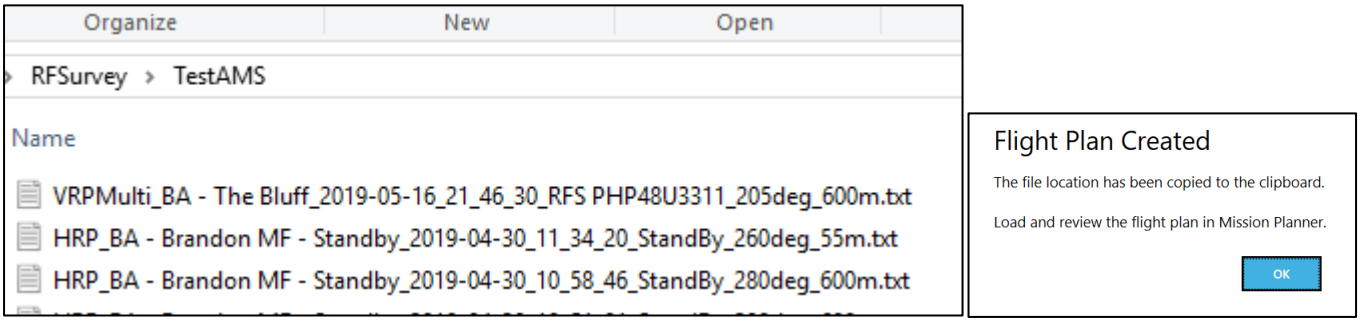
Note: Currently the GPS Fix Type is not implemented when using DJI Flight Controllers

8/ **Distance from Antenna** This value defaults to the calculated Farfield. It can be changed to any appropriate value. Beware that changing this value, changes the start and end height (which tries to automatically calculate itself based on depression angle min and depression angle max

9/ **Create Standard Flight Plan** Create the waypoint file for direct import into Mission Planner (for Ardupilot), DJI Litch (for M210) and DJI Pilot (for M300).

10/ **Custom Flight Plan** Create a custom flight plan (recommended if local obstacles need to be avoided as part of the flight plan)

NOTE: The created flight plan is saved in the directory indicated in the settings. Also, the Flight Parameters screen will appear at this stage. Confirm and set the appropriate values for the measurement run being performed.



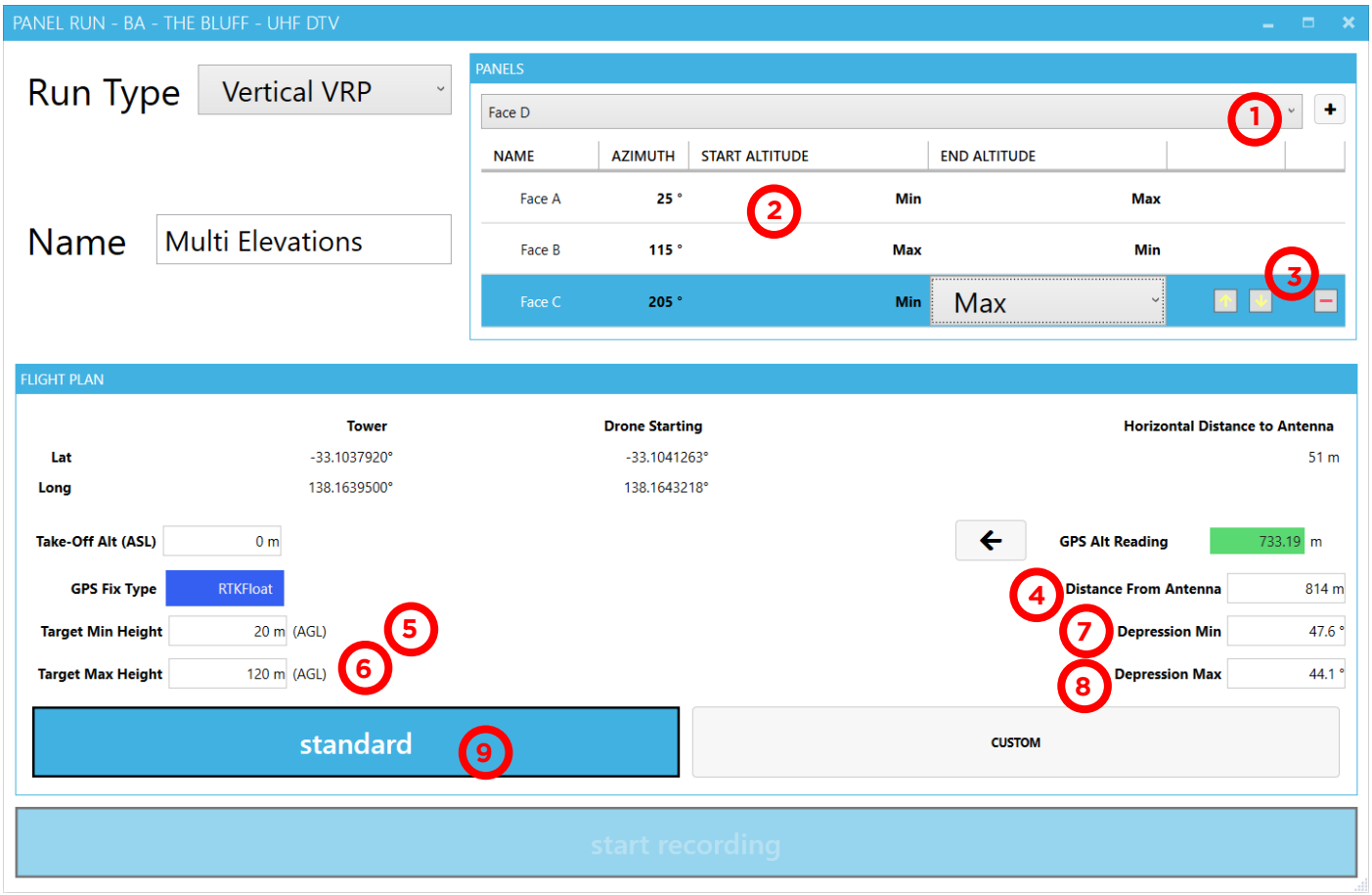
Use mission planner (or other RPA ground control) software to load the saved flight plan file. Confirm its functionality (modify if needed) and send the flight plan to the RPA. Please Consult Mission Planner section in the RPA manufacturers manual.

11/ **Start Recording** Start the recording session and open the Live Dashboard Display

Initiate Flight Plan via Mission Planner – It is recommended to take off and clear local obstructions before initiating the AUTO mode. Once the RPA is returning from its mission, the operator takes control to clear local obstructions and land. NEVER return to home at the height of the antennas. It is recommended to take off and return at heights very close to the ground to avoid the potential of flying in higher RF fields.

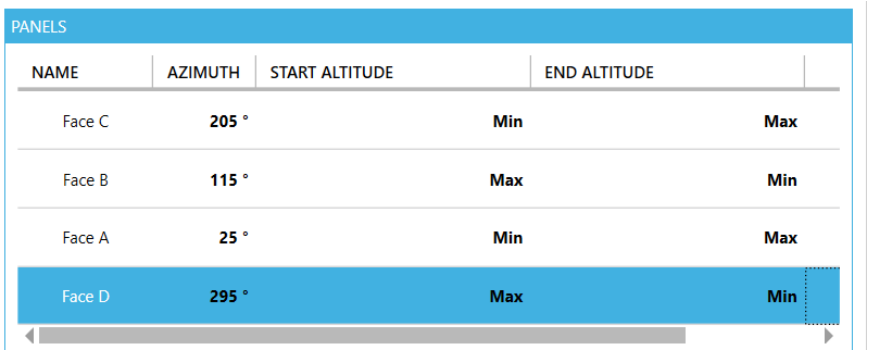
4/31 VERTICAL ELEVATION (VERTICAL VRP) - VE

The following flight specific inputs describes the creation of a VE flight path.



1/ **Face Selection** Select the Faces that will be used in the measurement run. Select and add multiple faces for a VRP run and a single start face for an HRP run

2/ **Flight Order** This list the order of the faces to be flown. Each face has a start and stop height. Min refers to the minimum height set in 9/ and max refers to the maximum height set in /10. E.g.



The example above shows the flight path to start at Face C (flying from Min height to Max height) then flying to Face B (flying from Max height to Min height) then flying to Face A (flying from Min height to Max height) and finally to Face D (flying from Max height to Min height).

3/ **Sort Order** Use the arrows to order which faces are flown in which order

4/ **Distance from Antenna** This value defaults to the calculated Farfield. It can be changed to any appropriate value. Beware that changing this value, changes the start and end height (which tries to automatically calculate itself based on depression angle min and depression angle max

5/ **Target Min Height** This is the height above take-off location in meters that indicates the start of the elevation run

6/ **Target Max Height** This is the height above take-off location in meters that indicated the end of the elevation run start

7/ **Minimum Depression Angle** This can be set to the min depression of the flight (positive depression angle is below the horizon of the COR of the AUT). Negative depression is above the horizon of the COR of the AUT

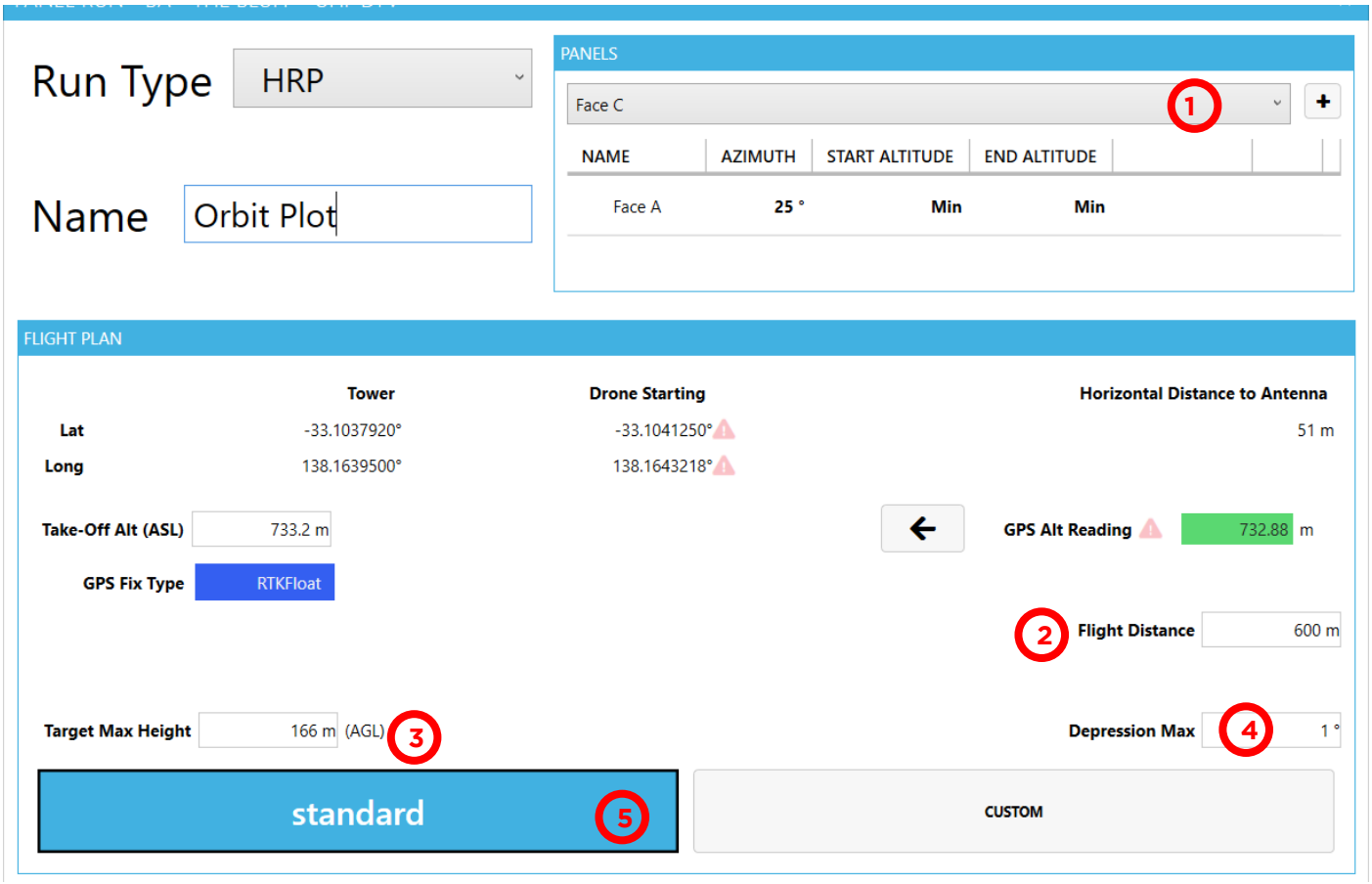
8/ **Maximum Depression Angle** This can be set to the max depression of the flight (negative depression angle is above the horizon of the COR of the AUT)

9/ **Create Standard Flight Plan** This button creates a standard flight path pattern for azimuth or elevation flights. For Vertical Elevation (VRP) flights, the standard flight plan is:

i. Fly to min start height (max depression angle)
ii. Turn around and face the AUT
iii. Ascend to max flight height (min depression angle)
iv. Descend back down to min start height
v. Return to Home

4/32 HORIZONTAL AZIMUTH (HRP) - HA

The following describes the inputs needed to correctly create an HA flight path.



1/ **Start Azimuth** Choose which Face/Azimuth to start and end the Azimuth flight.

2/ **Flight Distance** This value defaults to the calculated Farfield. It can be changed to any appropriate value. Beware that changing this value, changes the Target Max Height (which tries to automatically calculate itself based on Depression angle Max.

3/ **Target Max Height** This is the height above take-off location in meters that the azimuth (orbit) flight is performed

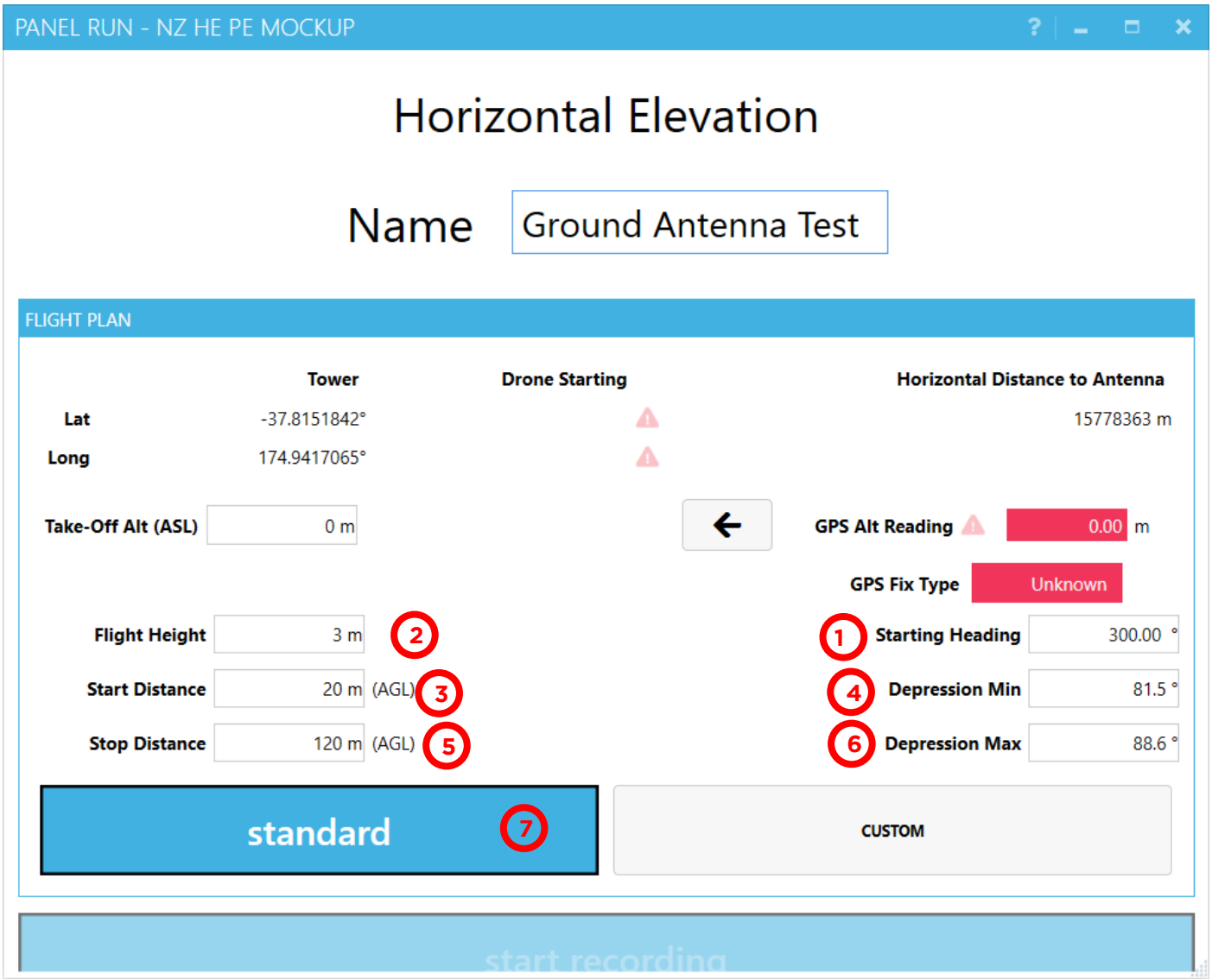
4/ **Maximum Depression Angle** This can be set to the max depression of the flight (negative depression angle is above the horizon of the COR of the AUT). Often this value is based on the results of a Vertical Elevation flight. Enter the desired depression angle to perform the orbit flight.

5/ **Create Standard Flight Plan** This button creates a standard flight path pattern for azimuth or elevation flights. For Horizontal Aximuth (HA) flights, the standard flight plan is:

i. Fly to height (depression angle) and distance of max signal
ii. Turn around and face AUT
iii. Perform Orbit flight
iv. Return to Home

4/33 HORIZONTAL ELEVATION - HE

The following describes the inputs needed to correctly create an HE flight path. HE flights are useful for measuring ground-based antennas. The standard flight path allows the measurement of co- and cross-polarisations in the same flight.



1/ **Start Heading** This is the bearing/Orientation of the ground based AUT.

2/ **Flight Height** This value defaults to the calculated Farfield. It can be changed to any appropriate value. Beware that changing this value, changes the Start and Stop Distances as well as Min and Max Depression Angles.

3/ **Start Distance** This is the horizontal distance from the AUT that the RPA will start the flight (related to Depression Min).

4/ **Depression Min** This is the minimum depression angle to start the flight (related to Start Distance).

5/ **Stop Distance** This is the horizontal distance from the AUT that the RPA will end the flight (related to Depression Max).

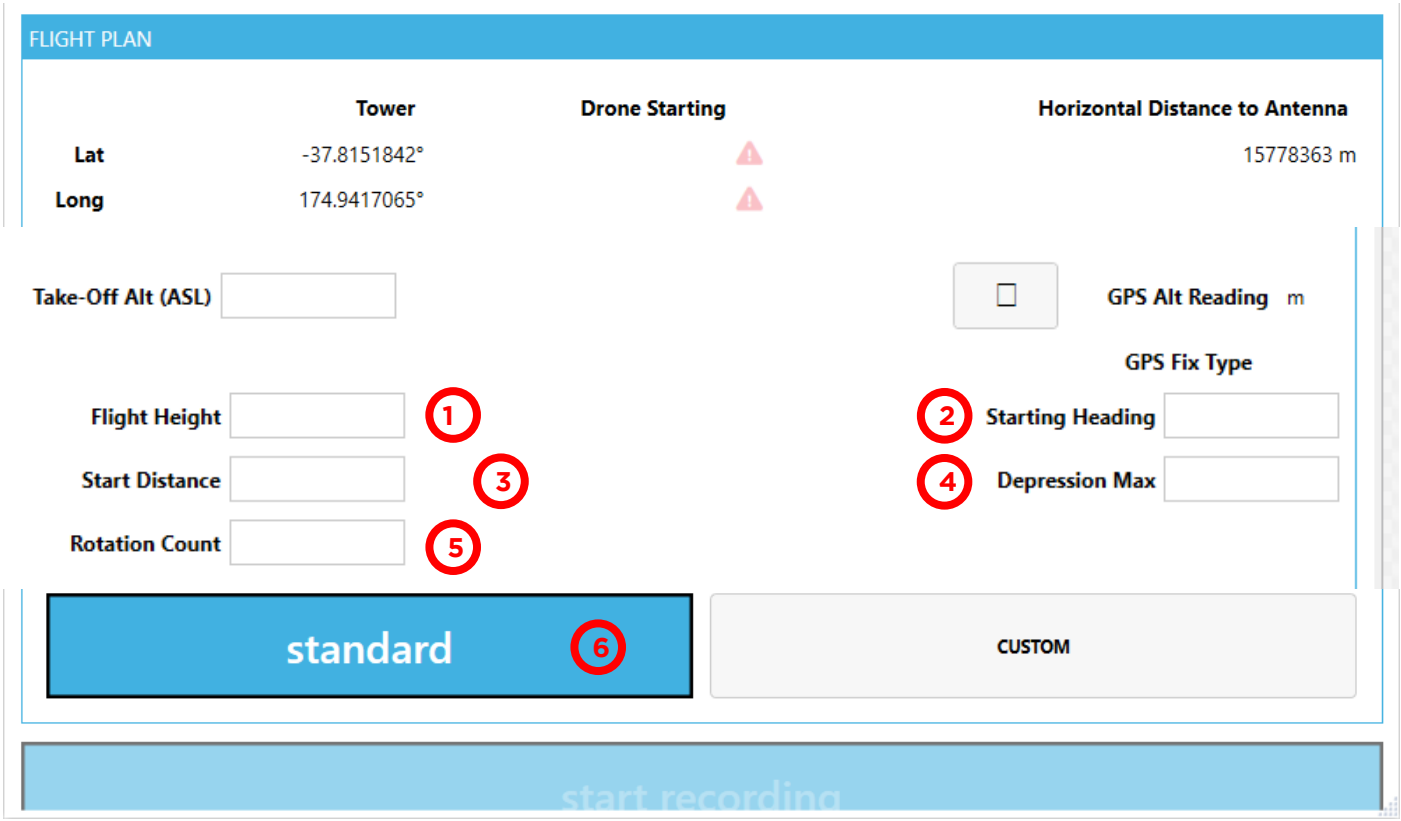
6/ **Depression Max** This is the maximum depression angle to end the flight (related to Stop Distance)

7/ **Create Standard Flight Plan** This button creates a standard flight path for the Horizontal Elevation (HE) flights, the standard flight plan is:

i. Fly to Flight height and Start Horizontal Distance (min depression angle)
ii. Point Antenna along Bearing of AUT
iii. Fly to Stop Distance (max depression angle)
iv. Rotate 90 Degrees
v. Fly back to Start Distance
vi. Return to Home

4/34 POLARISATION ELLIPSE (PE)

The following describes the inputs needed to correctly create an PE flight path. PE flights are useful for measuring ground-based antennas and their polarisation discrimination.



1/ **Start Heading** This is the bearing/Orientation of the ground based AUT.

2/ **Flight Height** This value defaults to the calculated Farfield. It can be changed to any appropriate value. Beware that changing this value, changes the Start and Stop Distances as well as Min and Max Depression Angles.

3/ **Start Distance** This is the horizontal distance from the AUT that the RPA will start the flight (related to Depression Max).

4/ **Depression Max** This is the maximum depression angle to end the flight (related to Stop Distance)

5/ **Rotation Count** This is how many rotations around itself the RPA will perform.

6/ **Create Standard Flight Plan** This button creates a standard flight path for the Polarisation Ellipse (PE) flights, the standard flight plan is:

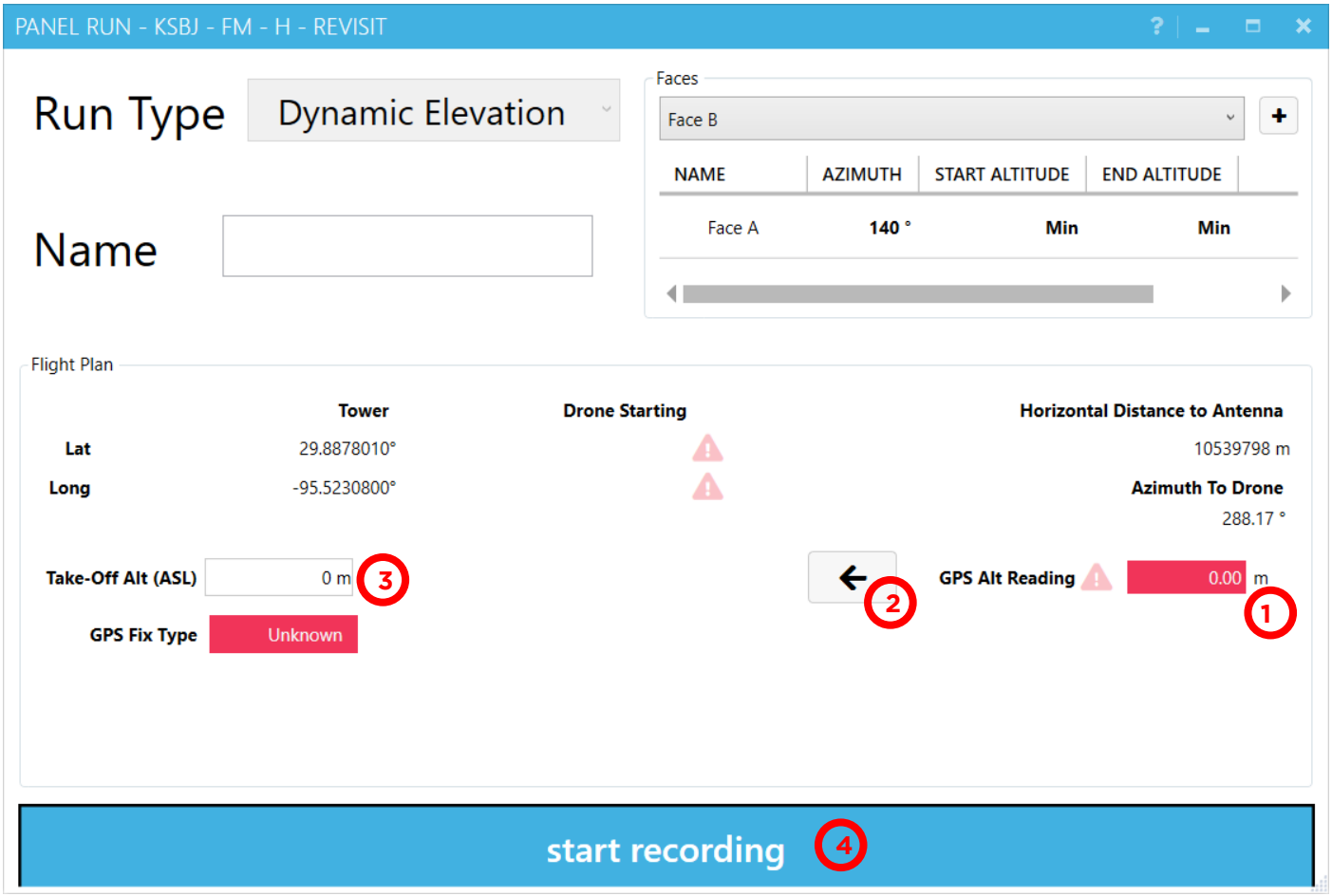
i. Fly to Flight height and Start Horizontal Distance (max depression angle). Usually at the maximum depression angle measured by an HE flight.

ii. Rotate RPA and rx antenna around itself for a x number of turns to get the full polarisation discrimination locus.

iii. Return to Home

4/35 DYNAMIC ELEVATION (DE)

The following describes the inputs needed to correctly create a DE flight path. DE flights are useful for measuring signal and layering characteristics in the desired coverage area. This is usually a Manually Controlled flight where the drone is pointed towards the AUT, takes off and flies vertically, then lands in the same location to complete the flight.



1/ **GPS Altitude Reading** This is the measured altitude of the RPA (using RTK or Barometer, depending on settings). Values are meters above sea level

2/ **Altitude Push** Once the altitude indicated in 4/ is stable, push this value to 6/ take-off altitude. This is essential as incorrect depression angles will be calculated if this step is missed

3/ **Take Off Altitude** It's important that the value in 4/ is pushed to this parameter once the altitude reading of the GPS/Barometer is stable. Use 5/ to assign the current altitude of the RPA to the Take-Off altitude (AMSL)

4/ **Start Recording** Start the recording session and open the Live Dashboard Display

4/36 INFLIGHT … LIVE DASHBOARD

After the flight plan has been loaded to the flight controller and all preflight checks are complete. Use the RC to take off, check RPA control, clear local obstacles, then initiated AUTO to carry out the flight path. While the RPA is flying to the first waypoint as well as in-between waypoints and on the way home after a mission, the RF measured readings will be RED. That is, they do not meet requirements to be a valid data point. This is normal behaviour. Once the RPA is in position to start a measurement run, the data will turn green. All data is synchronised and logged regardless of whether it is red (invalid) or green (valid). However, only green data is displayed on the Preliminary Reports.

1/ **Specific Service Plot** Indicates which service is being displayed

2/ **Measured Plot** This shows the measured data. Green data is VALID (within tolerance measurements) and Red data is INVALID (outside tolerance measurements)

3/ **Plot Customisation Sliders** These are available in the ADVANCED mode set in 6/, functionality includes:

i. Visible Range

ii. Seconds Per Grouping

iii. Moving Average Period Count

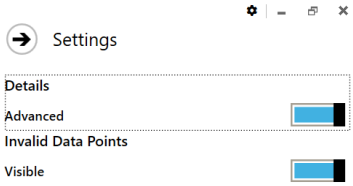
iv. Faded Points Opacity

v. Visible Points Period

4/ **Live Channel Power** Live correct channel power (ERP) in dBW and live raw uncorrected channel power in dBW is shown. Uncorrected values are enabled in the ADVANCED menu in 6/

5/ **RPA Telemetry Info** RPA monitoring parameters including distance and azimuth to AUT as well as battery and current drain

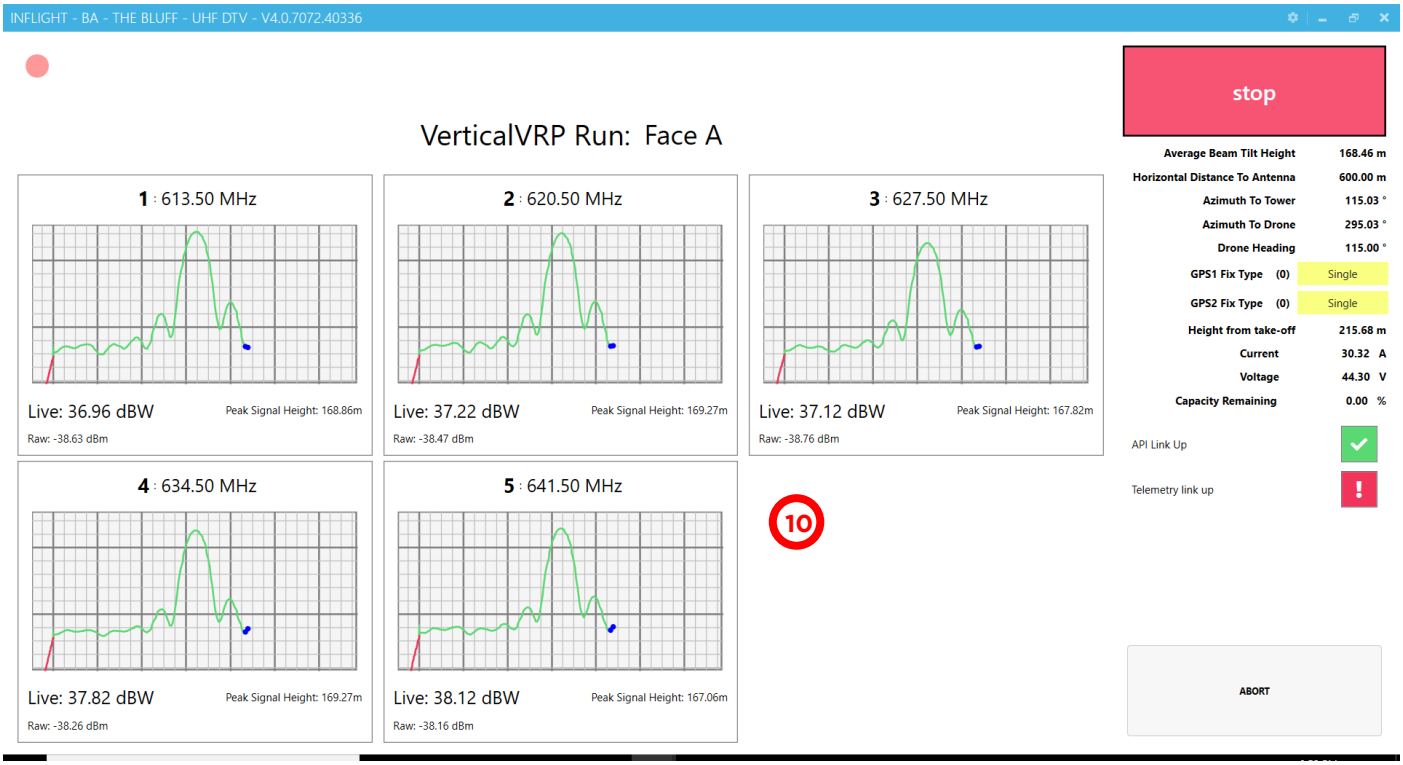
6/ **Live Dash Setting** Used to enable or disable ADVANCED mode, as well as a toggle switch to hide or show invalid data



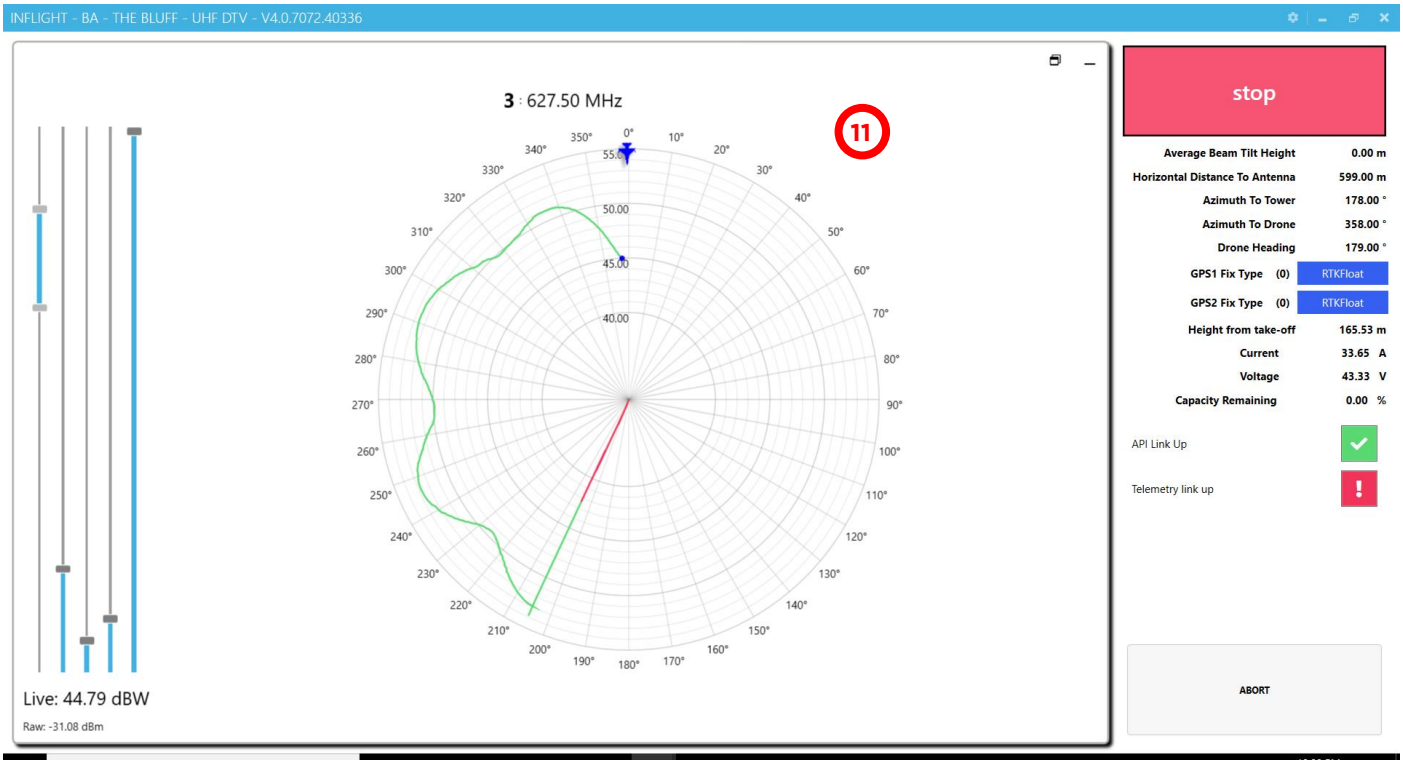
7/ **Stop Button** Once the measurement is complete, push the stop button to complete the measurement run. Failure to stop the measurement, may cause an issue with synchronisation of the measured data during the Post Flight Screen. If the measurement was setup incorrectly and you would like to terminate the flight, use the Abort button 9/

8/ **Peak Signal Height** Determines the height above take off that the maximum signal was measured (if performing VRP). This is used to set the height at which the HRP (orbit) is flown

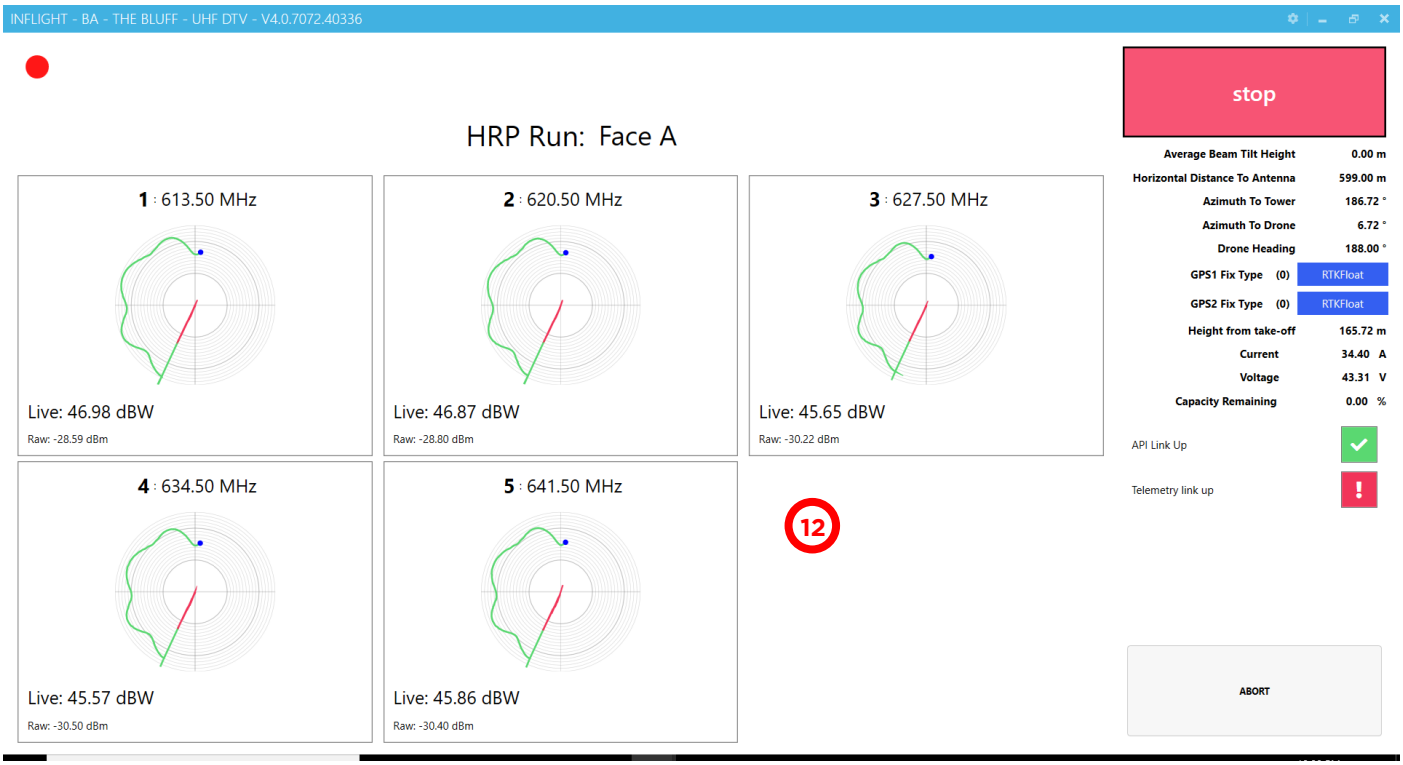
9/ **Abort Button** Is used if the measurement run had an error and the run needs to be restarted



10/ **Plot Overview** Shows the tracking of measurements for all services being measured



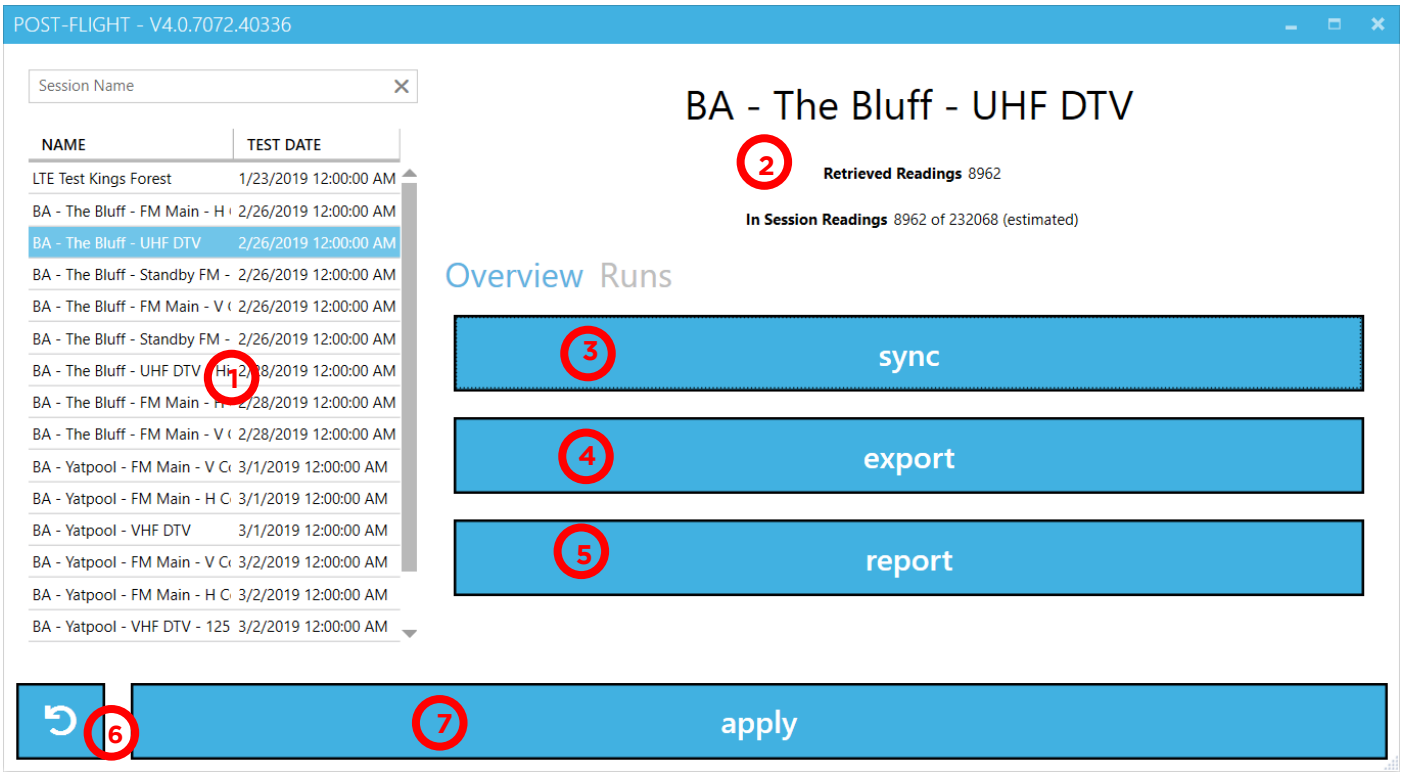
11/Measured Azimuth Plot This shows the measured data. Green data is VALID (within tolerance measurements) and Red data is INVALID (outside tolerance measurements)



12/Azimuth Plot Overview Shows the tracking of measurements for all services being measured

4/37 POST FLIGHT … OVERVIEW

Post flight synchronisation and analysis options.



1/ **Session List** List of measured sessions in the database

2/ **Current Selected Session** Shows some details on the current selected session including session name and data count

3/ **Synchronise Data** Selecting this synchronises all data for that session. Synchronising data refers to downloading the high-resolution measured RF data from the ARMS Rx to the AMS application for the selected session. Synchronisation can also be performed in the Runs Tab for individual measurement runs

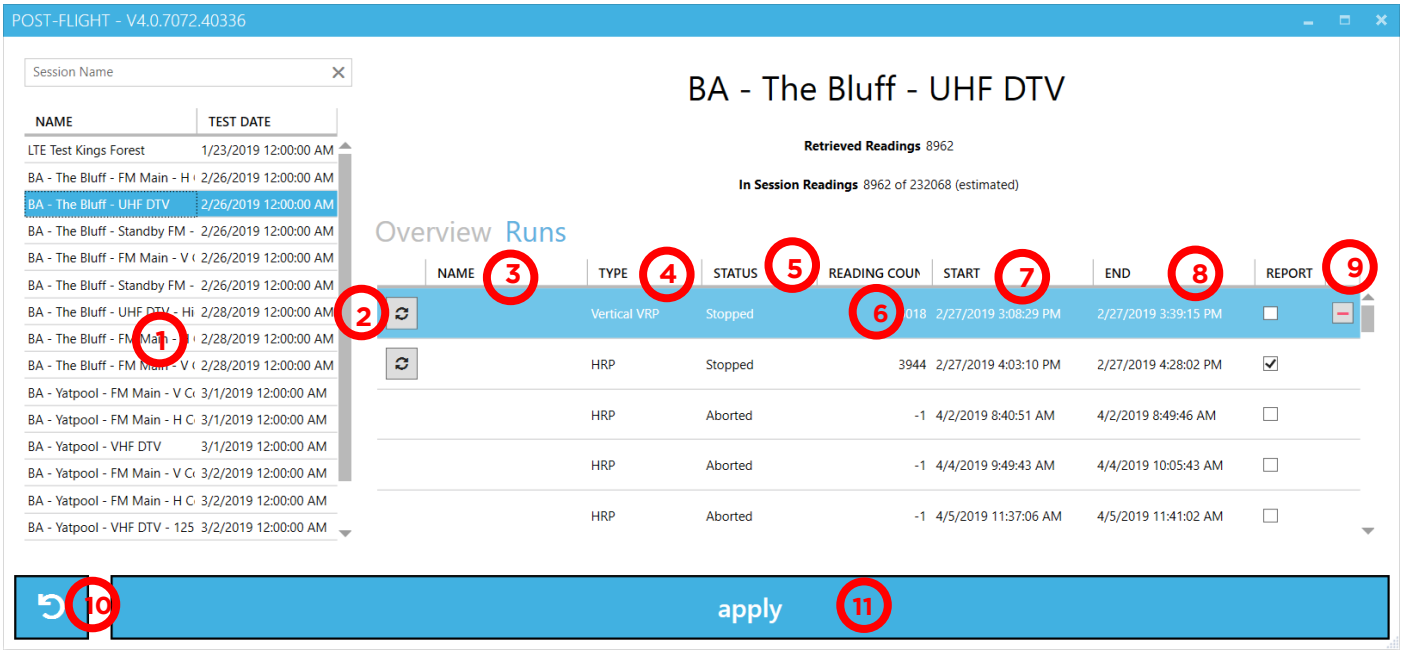
4/ **Export Data** Export the current session data to a predefined .xlsx file for further analysis if required

5/ **Create Preliminary Report** Produce a preliminary report for the current measurement session. Only Runs flagged with Report inclusion, will be included in the report. Report inclusion is set in the Runs Tab

6/ **Undo Button** Undo recent changes

7/ **Apply Button** Needs to be pressed whenever changes are made in order for them to be saved

4/38 POST FLIGHT … RUNS



1/ Session List List of measured sessions in the database

2/ Individual Sync Button Synchronise individual measurement runs

3/ Measurement Run Name The name given to that particular run. Same as the name defined in the PANEL RUN screen

4/ Run Type Measurement run type e.g. (HRP, VRP, etc, etc)

5/ Run Status The status of the measurement run. Values are:

i. Stopped – Signals a successfully complete measurement run

ii. Aborted – Indicates an aborted measurement run

iii. Blank – Indicates that either that measurement run has not been performed yet, or if there is a start time, that the measurement run experienced an issue and did not complete correctly

6/ Reading Count Indicated the number of synchronised measured datapoint associated with that measurement run. If the value is -1 then that indicates that no values have been synchronised for this measurement run

7/ Start Time The start date and time of the measurement run

8/ End Time The end date and time of the measurement run. If this is blank and the run is completed, an error occurred. Most likely, the STOP button was not pushed in the Live Dashboard Display (and the screen was closed down). Email support@sixarms.com if this occurs

9/ Report Inclusion Tick this box if you would like the selected measurement run included in the report. Remember to click APPLY to register your selection

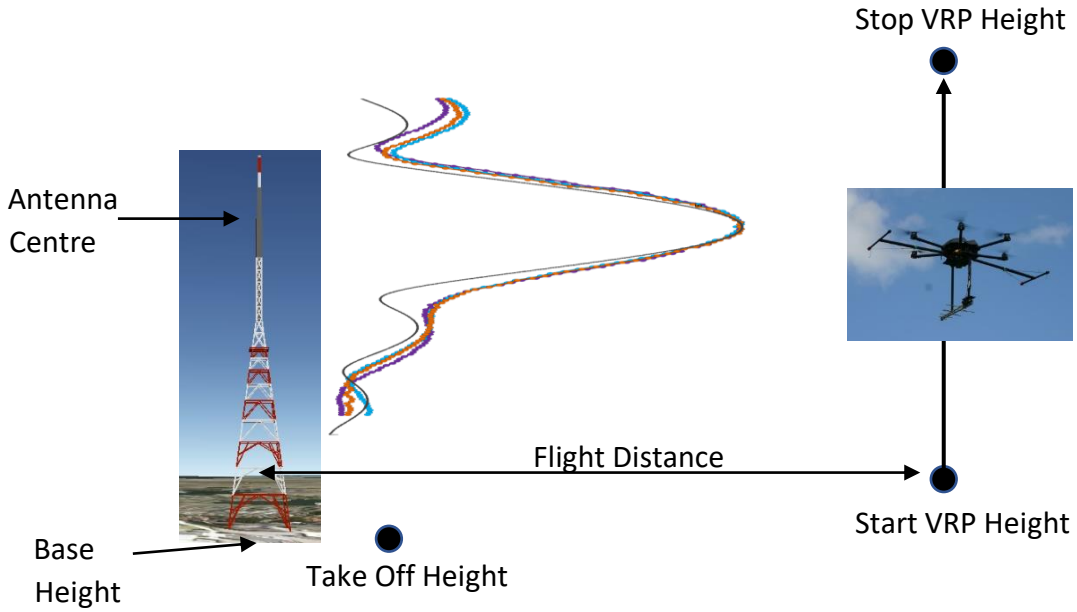
10/ Undo Button Undo recent changes

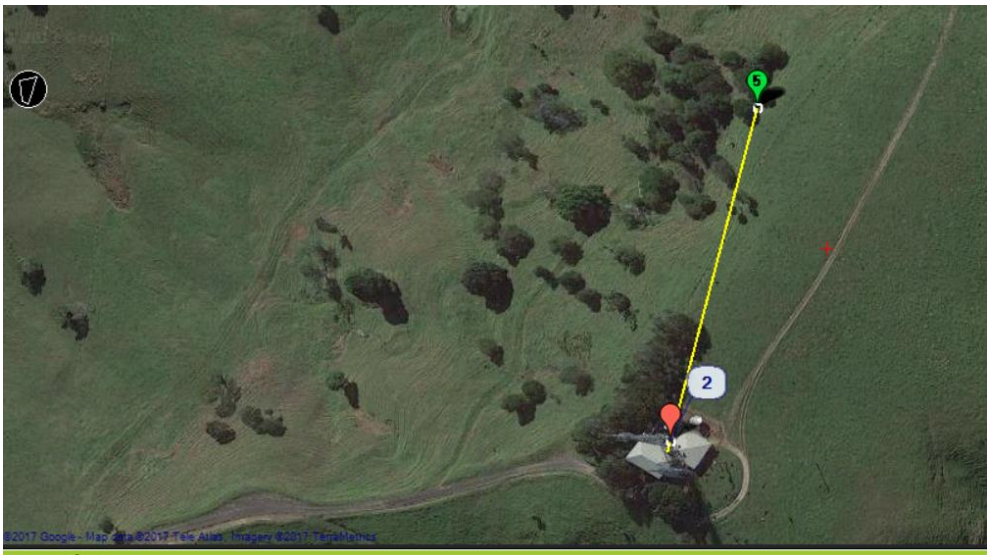
11/ Apply Button Needs to be pressed whenever changes are made in order for them to be saved

5/ FLIGHT PLANS (BASIC)

5/1 VERTICAL ELEVATION - VE

1. Take Off (5m above ground) – not included in Automatic waypoint generation
2. Fly to 1st Waypoint which is usually at the far field radius and Min Start Height.
3. Turn to face the Antenna Under Test
4. Wait 10 seconds to complete rotation
5. Climb vertically till Max End Height
6. Descend back to Min Start Height
7. Return to Launch





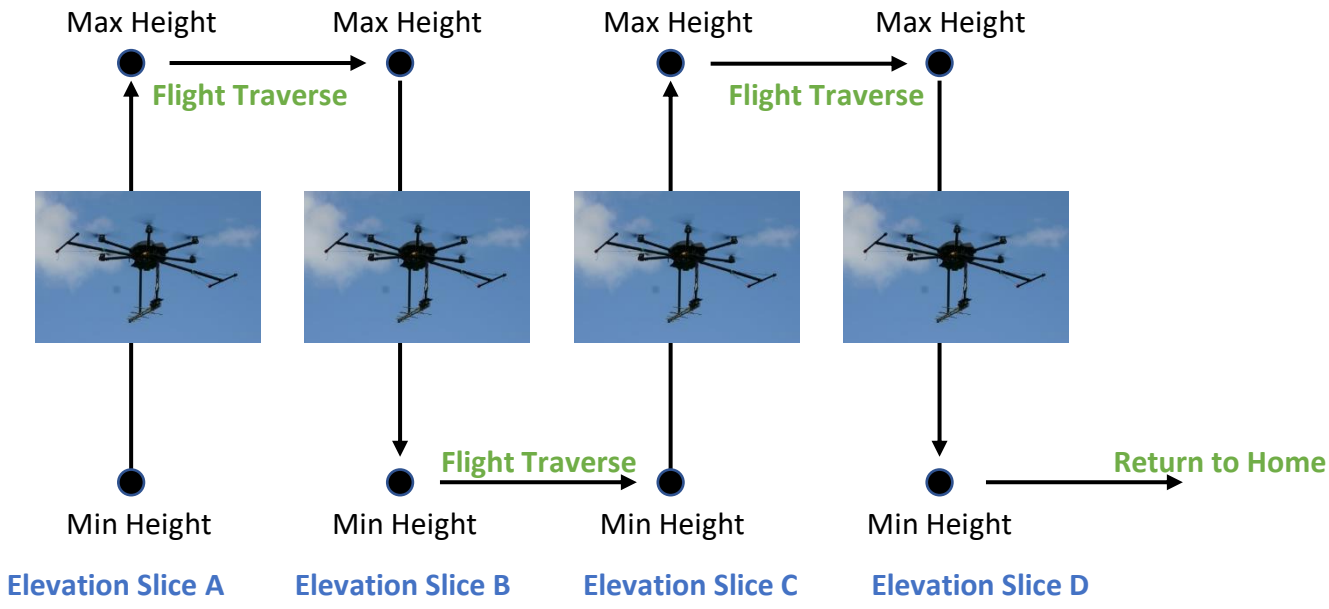
Waypoints

WP Radius 2 | Loiter Radius 2 | Default Alt 15 | Relative | Verify Height | Add Below | Alt Warn -15 | Spline

	Command	P1	P2	P3	P4	Lat	Lon	Alt	Delete	Up	Down	Grad %	Angle	Dist	AZ
1	WAYPOINT	0	0	0	0	-26.788602	152.918519	15	X			9.9	5.7	149.7	15
2	DO_SET_ROI	0	0	0	0	-26.789904	152.918137	40	X			0	0	0	0
3	LOITER_TIME	10	0	0	0	-26.788602	152.918519	15	X			-16.7	-9.5	149.7	15
4	WAYPOINT	0	0	0	0	-26.788602	152.918519	90	X			∞	90.0	0.0	180
5	WAYPOINT	0	0	0	0	-26.788602	152.918519	15	X			-∞	-90.0	0.0	180

5/2 MULTIPLE VERTICAL ELEVATIONS

AMS has the ability to allow multiple elevation slices to be flown in a single measurement run. It allows customization of start and stop heights for each slice.



Waypoints

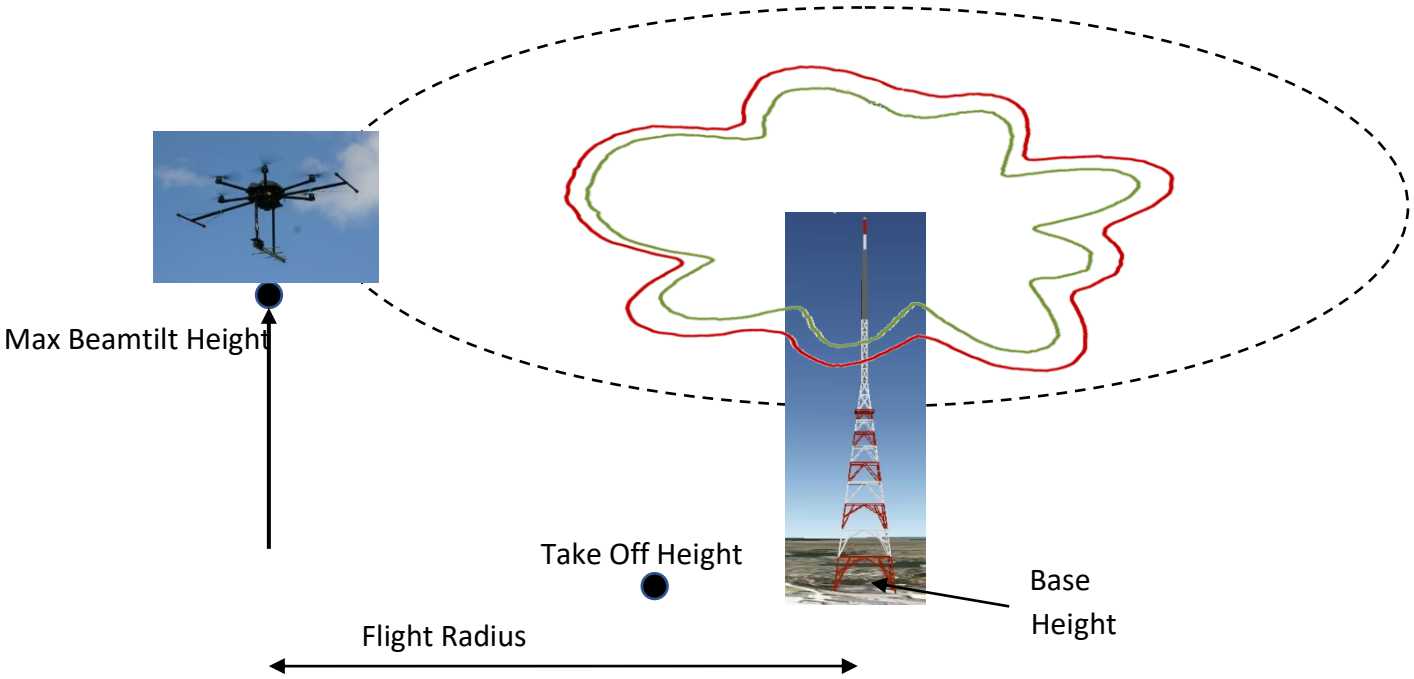
WP Radius 1 | Loiter Radius 45 | Default Alt 10 | Relative | Verify Height | Add Below | Alt Warn -10 | Spline

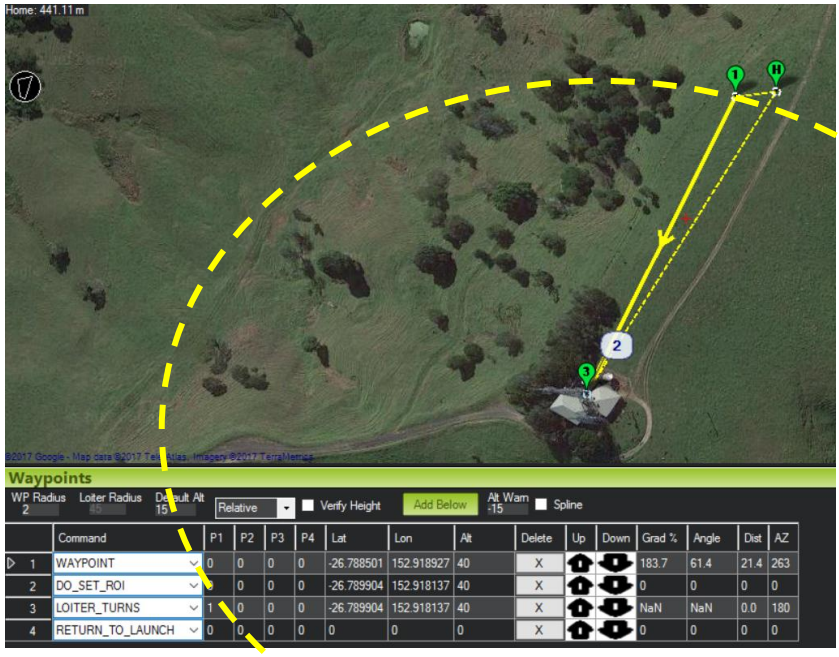
	Command	Dela				Lat	Long	Alt	Delete	Up	Down	Grad %	Angle	Dist	AZ
1	WAYPOINT	0	0	0	0	-33.108677	138.161231	40	X			6.8	3.9	583.3	210
2	DO_SET_ROI	0	0	0	0	-33.103792	138.16395	40	X			0	0	0	0
3	LOITER_TIME	10	0	0	0	-33.108677	138.161231	40	X			0.0	0.0	599.3	205
4	WAYPOINT	0	0	0	0	-33.108677	138.161231	280	X			∞	90.0	240.0	180
5	WAYPOINT	0	0	0	0	-33.10607	138.169782	280	X			0.0	0.0	847.6	70
6	DO_SET_ROI	0	0	0	0	-33.103792	138.16395	280	X			0	0	0	0
7	LOITER_TIME	10	0	0	0	-33.10607	138.169782	280	X			0.0	0.0	599.4	115
8	WAYPOINT	0	0	0	0	-33.10607	138.169782	40	X			-∞	-90.0	240.0	180
9	WAYPOINT	0	0	0	0	-33.098907	138.166669	40	X			0.0	0.0	847.6	340
10	DO_SET_ROI	0	0	0	0	-33.103792	138.16395	40	X			0	0	0	0
11	LOITER_TIME	10	0	0	0	-33.098907	138.166669	40	X			0.0	0.0	599.3	25
12	WAYPOINT	0	0	0	0	-33.098907	138.166669	280	X			∞	90.0	240.0	180
13	WAYPOINT	0	0	0	0	-33.101514	138.158119	280	X			0.0	0.0	847.5	250
14	DO_SET_ROI	0	0	0	0	-33.103792	138.16395	280	X			0	0	0	0
15	LOITER_TIME	10	0	0	0	-33.101514	138.158119	280	X			0.0	0.0	599.3	295
16	WAYPOINT	0	0	0	0	-33.101514	138.158119	40	X			-∞	-90.0	240.0	180
17	RETURN_TO_LAUNCH	0	0	0	0	0	0	0	X			0	0	0	0

5/3 HORIZONTAL AZIMUTH - HA

1. Take Off (5m above ground) – not included in Automatic waypoint generation
2. Fly to 1st Waypoint which is usually at the far field radius and Max VRP Height.
3. Turn to face the Antenna Under Test
4. Wait 10 seconds to finish turn
5. Fly in a circle at far field distance and max beamtilt height (make sure Flight Parameter Circle Distance is ser to the required radius before the flight)
6. Once completed Return to Launch (it will return at the max beamtilt height, so the operator will need to take control and lower the RPA to minimise exposure to higher RF fields

The HRP (if not complete for obstacle or battery reasons needs to be controlled by the operator to bring the RPA back).





5/4 HORIZONTAL ELEVATION - HE

Description to be added

5/5 POLARISATION ELLIPSE - PE

Description to be added

5/6 DYNAMIC ELEVATION - DE

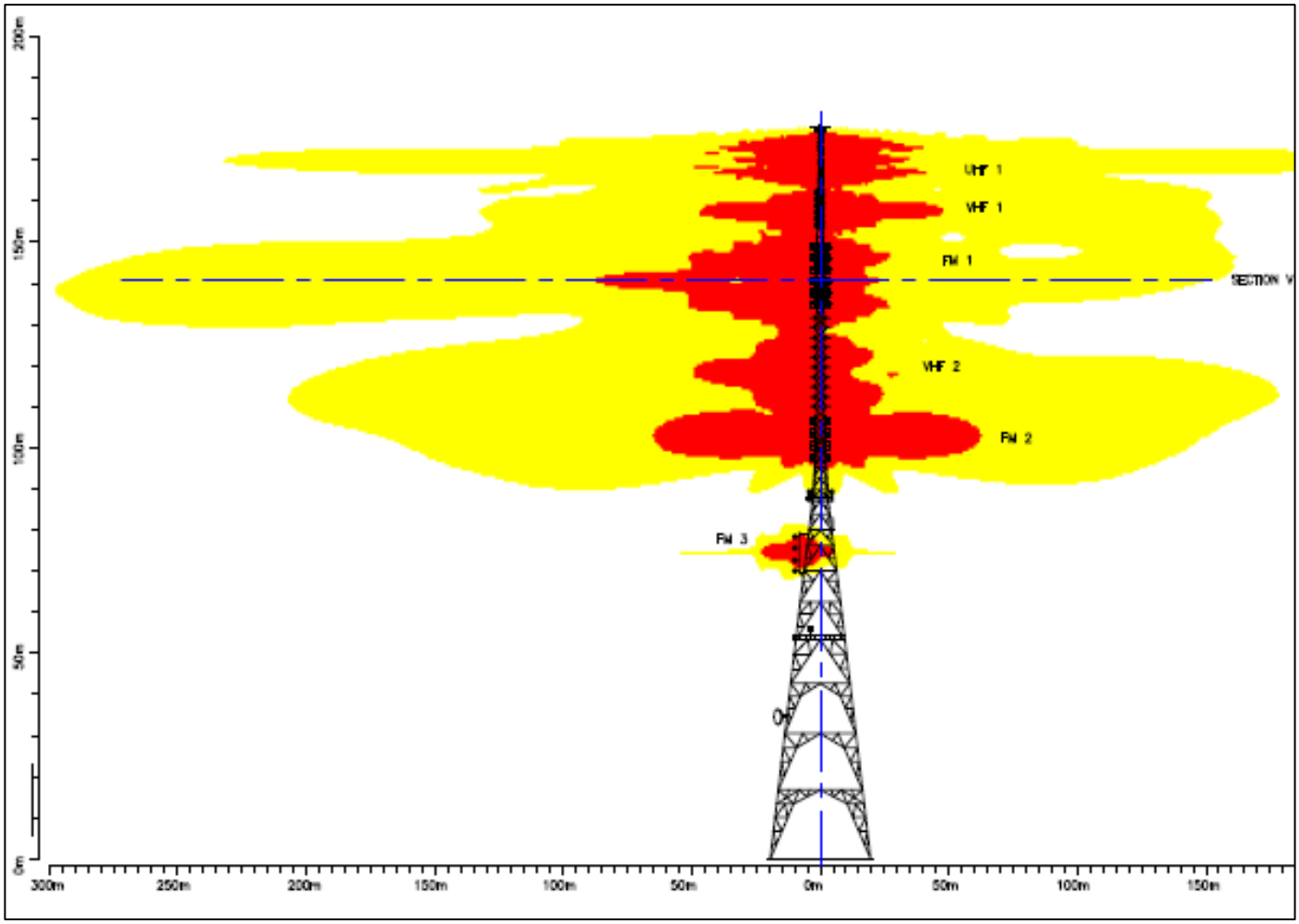
This is a manually controlled flight

1. Determine Take Off location and orientate drone towards AUT
2. Take Off (5m above ground)
3. Slowly ascend to desired maximum altitude while maintaining orientation towards the AUT.
4. Either
    a. At Max height, rotate the drone 90 degrees from current orientation (this will trigger the values on the descent to be invalid
    b. Maintain orientation and descend to the landing location
    c. Maintaining a static GPS location is important for consistency in data.

6/ HIGH RF EXPOSURE

Notes about high RF fields: The ARMS system is designed to be flown at distances further than the recommended far-field from the Antenna Under Test. Care should be taken when flying close to the antenna. Flying closer than recommended may cause issues with flight control. Always be ready to switch to "manual/Alt Hold" mode should an issue occur.

Typical Scenario



The RPA is not designed to be exposed to excessive RF fields. It has, however, been designed and shielded to be able to measure the far-field patterns of antenna systems. Field tests have shown the RPA to operate in fields more than 40V/m. A conservative approach would be to operate in fields of less than 20 V/m.

Both General Public (yellow) and Occupational (red) zones should be avoided when flying. As a rule of thumb, use 20 V/m as a reference to the maximum field to fly in.

7/ TYPICAL WORKFLOW (HORIZONTAL AZIMUTH AND VERTICAL ELEVATION USING ARDUPILOT RPAS)

7/1 PRE-SURVEY (OFFICE)

- Investigate survey site
  - Position, relation to hazards, airspace classification
  - Approvals needed?
  - Google Earth Coordinates (decimal degrees – WGS84)
- Investigate Antenna Under Test
  - Frequencies, Channels, Modulation
  - Aperture (greatest dimension)
  - Height above ground of the Centre of Radiation (AGL)
  - Supporting structure base altitude (AMSL)
  - Handbook Radiation Patterns
  - Number of panels (i.e. faces/elevation slices)
- Establish Site, Antenna and Service information in AMS
- Create a Planning Session in AMS

7/2 SURVEY (FIELD)

- Determine the best take off location for the RPA and setup in that location. Ideally only one take-off location is used per Session to avoid confusion relating to relative height differences.
- Survey the sky to determine the elevation and azimuth flight paths.

7/3 GROUND CONTROL SETUP

- Setup as per RPA operations manual (includes, telemetry, rtk, mavlink redirection)
- If using RTK, start the survey-in process
- Typical Setup shown below. Ground Station Pro has all components integrated into a single case

- Establish Take-Off and Landing locations

7/4 CONNECTING IT ALL

- Mount ARMS Receiver in the designated payload bay
- Connect both WIFI antennas to connectors marked W1 and W2
- Connect the interconnecting cable from the RPA to the ARMS Receiver (shielded DB9) connector. This connector supplies 12V to the ARMS Receiver as well as a connection to the flight controller.
- Install the antenna mounts on the RPA as per operating handbook.
- Secure the antenna in either vertical or horizontal polarisation.
- Connect and mount the RF coaxial cable from the antenna to the 50-ohm input of the ARMS Receiver (insert attenuation and secure cable, minimise the ability for the cable to vibrate)
- Power the RPA (the ARMS Receiver led will turn Orange when operating correctly and Green / No Led when there is an issue. It will vary on bootup but will settle after a minute or two.

7/5 TELEMETRY STREAM DUPLICATION (SERIAL LINK ONLY).

Mission planner has a function to duplicate the telemetry stream of the RPA. This needs to be enabled for AMS to function correctly. This is done by:

- Open Antenna Measurement Studio “AMS”, Navigate to “Control” then “Telemetry Link”. Click on “Connect”
- Go back to Mission Planner, press CTRL-F (this opens a new window), select “MAVLINK” then choose “UDP CLIENT”, tick Write, and press “Connect”. This will open a dialog box asking us where we want to redirect the telemetry info to. Type “127.0.0.1” press enter then type port “14550” press enter.

- Check that Telemetry data is being seen by AMS, there should be scrolling messages and the heart status is green not red. Close this window if needed.

Telemetry is automatically connected if using one of the COFDM (IP) Radios

7/6 CONNECTION TO ARMS RECEIVER (NON-COFDM)

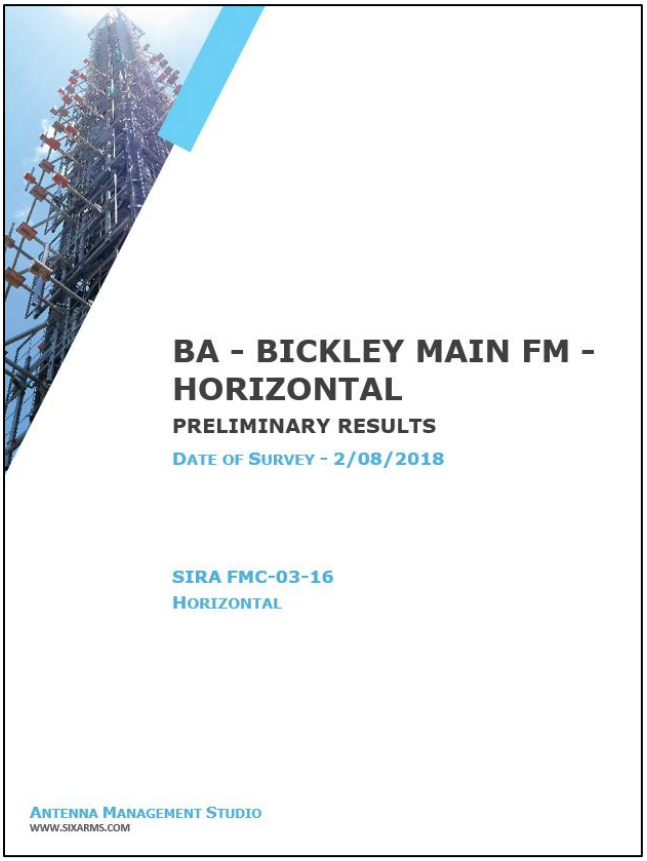
- Choose the “Sixarms” Wi-Fi hotspot and connect with “sixarmsconnect”. Check Auto connect.
- Go to “Control” then “AP Link” to determine whether your connection was successful, and we have communication with the ARMS Receiver. Heart status should be green not red.
- Go to “Pre-Flight” choose the session of interest, program the spectrum analyser by clicking on the red box, once programmed and all check boxes are green, click “Start Run”
- Configure and Load the flight plan, perform all safety checks and perform measurement flights.

7/7 DURING FLIGHT

- Monitor both the RPA flight parameters and the RF Measurement data with preference to the RPA flight characteristics

7/8 POST FLIGHT

- STOP the measurement run (if using WIFI as the API link, re-establish the link before pressing stop)
- Sync data, Create Preliminary Reports and Export Data if further analysis is needed.



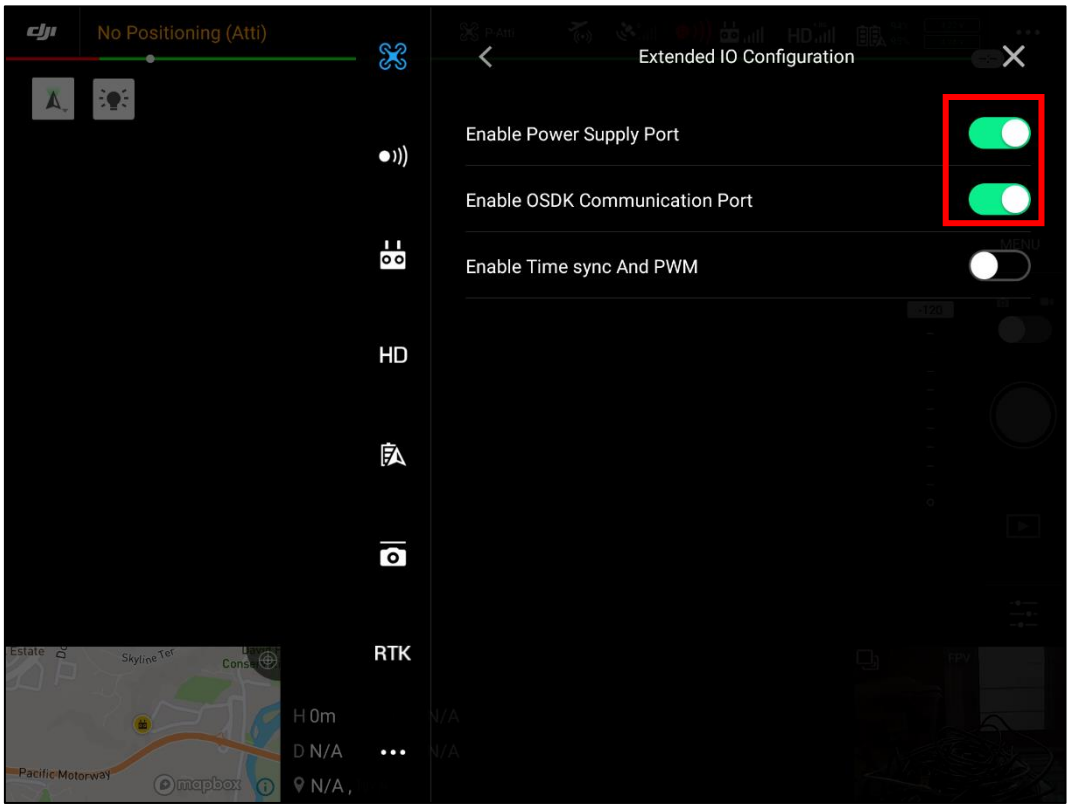
	A	B	C	D	E	F	G	H	I	J
1	TimeStamp	Lat	Long	Heading	Altitude	Pitch	Roll	RelativeH	Hdop	Vdop
2	2019-02-27 15:08:29.432	-33.1041	138.1643	162	733.01	-0.07908	-0.01466	-4.46	86	
3	2019-02-27 15:08:29.801	-33.1041	138.1643	162	733.02	-0.07911	-0.01467	-4.45	86	
4	2019-02-27 15:08:30.168	-33.1041	138.1643	162	733.03	-0.07918	-0.01474	-4.44	86	
5	2019-02-27 15:08:30.537	-33.1041	138.1643	162	733.03	-0.07924	-0.0148	-4.44	86	
6	2019-02-27 15:08:30.904	-33.1041	138.1643	162	733.03	-0.07922	-0.0149	-4.44	86	
7	2019-02-27 15:08:31.278	-33.1041	138.1643	162	733.03	-0.07929	-0.01499	-4.44	86	
8	2019-02-27 15:08:31.637	-33.1041	138.1643	162	733.03	-0.07932	-0.01504	-4.44	86	
9	2019-02-27 15:08:32.005	-33.1041	138.1643	162	733.03	-0.07932	-0.01498	-4.44	86	
10	2019-02-27 15:08:32.376	-33.1041	138.1643	162	733.02	-0.0794	-0.01481	-4.45	86	
11	2019-02-27 15:08:32.752	-33.1041	138.1643	162	733.01	-0.07954	-0.01481	-4.46	86	
12	2019-02-27 15:08:33.109	-33.1041	138.1643	162	733.01	-0.07959	-0.01484	-4.46	86	
13	2019-02-27 15:08:33.482	-33.1041	138.1643	162	733.02	-0.07962	-0.01493	-4.45	86	
14	2019-02-27 15:08:33.850	-33.1041	138.1643	162	733.03	-0.07958	-0.01495	-4.44	86	
15	2019-02-27 15:08:34.217	-33.1041	138.1643	162	733.03	-0.07971	-0.01496	-4.44	86	
16	2019-02-27 15:08:34.583	-33.1041	138.1643	162	733.03	-0.07976	-0.01489	-4.44	86	
17	2019-02-27 15:08:34.948	-33.1041	138.1643	162	733.05	-0.07959	-0.01452	-4.42	86	
18	2019-02-27 15:08:35.318	-33.1041	138.1643	161	733.05	-0.07864	-0.01296	-4.42	86	
19	2019-02-27 15:08:35.686	-33.1041	138.1643	161	733.05	-0.07836	-0.01186	-4.42	86	
20	2019-02-27 15:08:36.054	-33.1041	138.1643	161	733.05	-0.07836	-0.01185	-4.42	86	
21	2019-02-27 15:08:36.429	-33.1041	138.1643	161	733.05	-0.07832	-0.01158	-4.42	86	
22	2019-02-27 15:08:36.790	-33.1041	138.1643	161	733.05	-0.07883	-0.01241	-4.42	86	
23	2019-02-27 15:08:37.161	-33.1041	138.1643	162	733.06	-0.07964	-0.01426	-4.41	86	
24	2019-02-27 15:08:37.524	-33.1041	138.1643	162	733.06	-0.0798	-0.01452	-4.41	86	
25	2019-02-27 15:08:37.894	-33.1041	138.1643	162	733.06	-0.07975	-0.01421	-4.41	86	
26	2019-02-27 15:08:38.258	-33.1041	138.1643	162	733.07	-0.07973	-0.014	-4.4	86	
27	2019-02-27 15:08:38.633	-33.1041	138.1643	162	733.07	-0.07962	-0.01389	-4.4	86	
28	2019-02-27 15:08:39.005	-33.1041	138.1643	162	733.07	-0.07963	-0.0139	-4.4	86	
29	2019-02-27 15:08:39.378	-33.1041	138.1643	162	733.07	-0.07947	-0.01406	-4.4	86	
30	2019-02-27 15:08:39.733	-33.1041	138.1643	162	733.07	-0.07944	-0.01405	-4.4	86	
31	2019-02-27 15:08:40.104	-33.1041	138.1643	162	733.06	-0.07941	-0.01414	-4.41	86	
32	2019-02-27 15:08:40.475	-33.1041	138.1643	162	733.06	-0.0794	-0.01418	-4.41	86	
33	2019-02-27 15:08:40.838	-33.1041	138.1643	162	733.05	-0.0795	-0.01436	-4.42	86	
34	2019-02-27 15:08:41.206	-33.1041	138.1643	162	733.05	-0.07961	-0.01435	-4.42	86	
35	2019-02-27 15:08:41.578	-33.1041	138.1643	162	733.05	-0.07978	-0.01421	-4.42	86	
36	2019-02-27 15:08:41.947	-33.1041	138.1643	162	733.05	-0.07982	-0.01426	-4.42	86	
37	2019-02-27 15:08:42.312	-33.1041	138.1643	162	733.05	-0.07987	-0.01423	-4.42	86	
38	2019-02-27 15:08:42.679	-33.1041	138.1643	162	733.04	-0.07991	-0.01429	-4.43	86	
39	2019-02-27 15:08:43.051	-33.1041	138.1643	162	733.03	-0.07994	-0.01424	-4.44	86	

Overview | Readings | Chart1 | v1 | v2 | v3 | v4 | v5 | Run2202 | Run2203

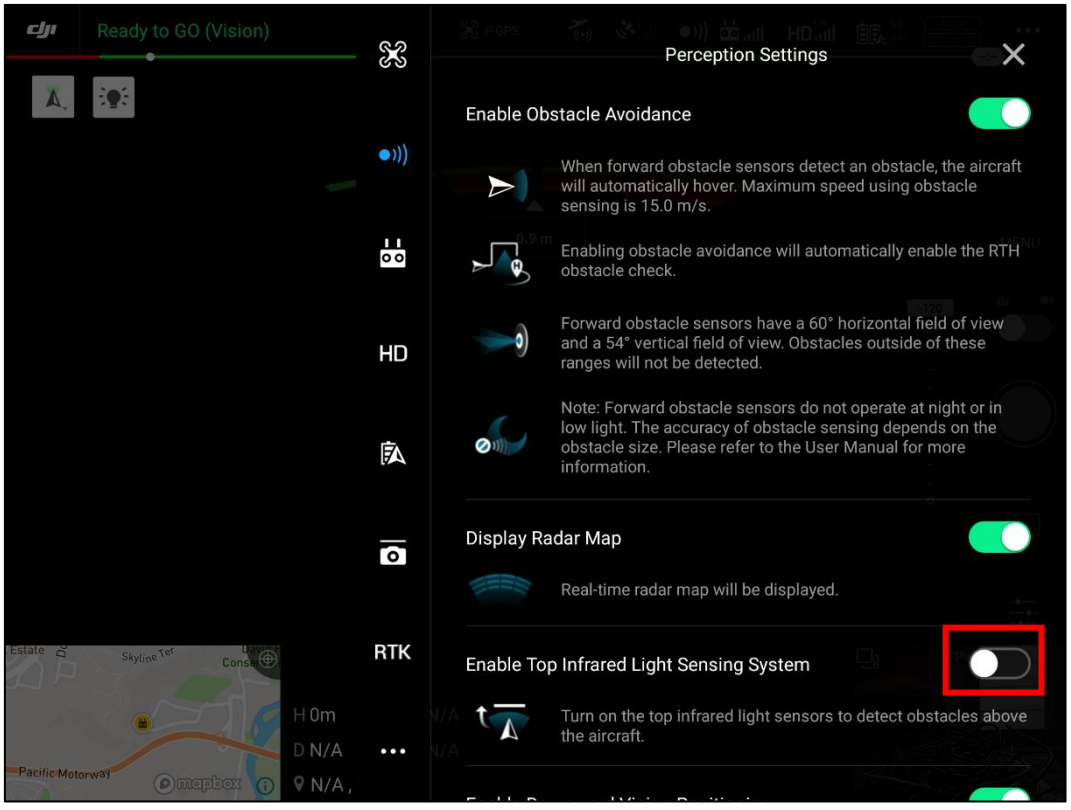
8/ TYPICAL WORKFLOW (DYNAMIC ELEVATION USING DJI M200 SERIES RPAS)

8/1 DJI M200 SETUP

- Open the DJI PILOT APP on CrystalSky device and configure as per below

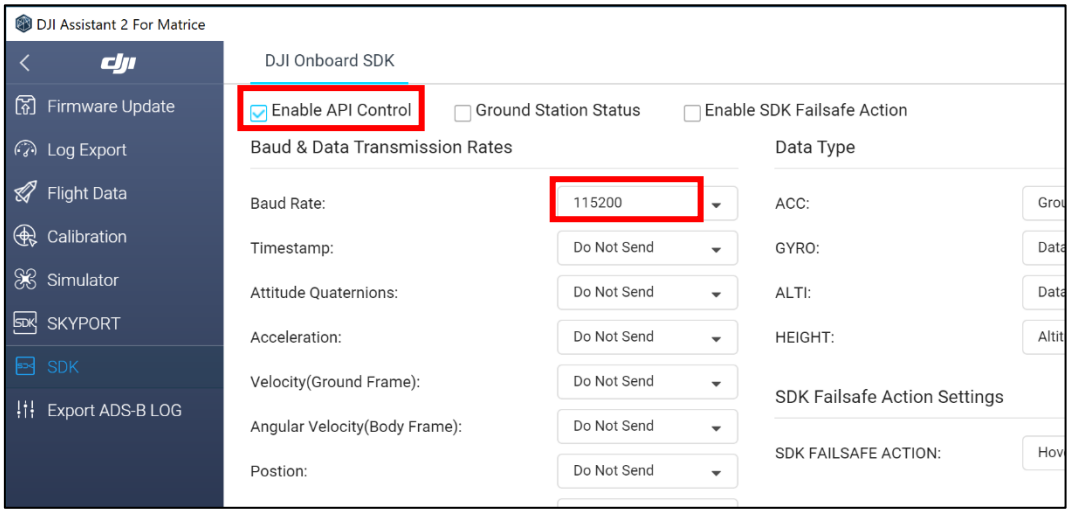


(enable Power Supply Port)



(disable Top Infrared Sensor – Due to ARMS Rx Mounting)

- Connect to DJI Assistant for Matrice and Configure as per below



(Enable API and Set Baud to 115200 – the other settings have no effect for the connection to the ARMS Rx)

NOTE: Every time the firmware is updated, this process will need to be repeated.

8/2 ANTENNA AND ARMS RX MOUNTING

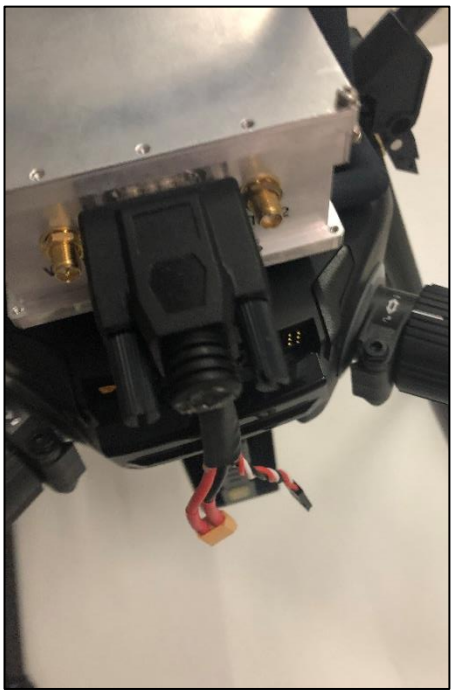
Install the Antenna Frame, Antenna and ARMS Rx as per below **BEFORE** powering on the M200 series drone.

Align Antenna Frame with M200 mounting holes

Secure 4 x M2.5 bolts

Insert Velcro Strap before ARMS Rx

Insert ARMS Rx and Velcro in Place

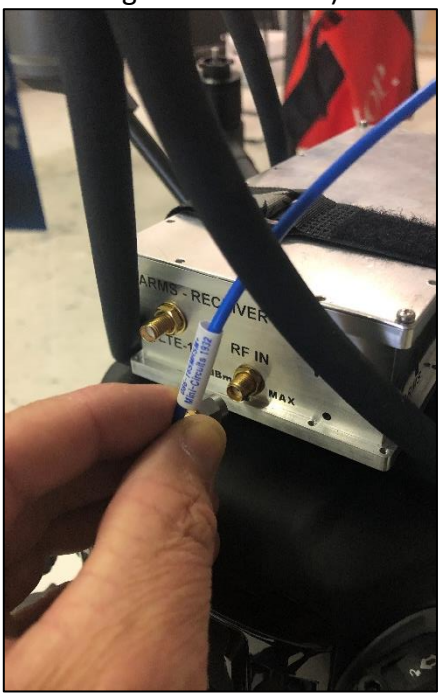


Connect DB9 Connector to ARMS Rx

Connect to DC and API (3rd from Right for M210 v2)

Mount Antenna and Secure

Attach RF Coax and Secure in place



Secure Coax on ARMS Rx (RF In) – add attenuation if needed

Suggested Coax Install Path

Suggested Rear Wifi Antenna Installation

Suggested Front Wifi Antenna Installation

WARNING: Do not use the antenna mount frame to pick up the M200 Series drone when the batteries are installed. It is not designed to support the total weight of the aircraft, batteries and payload.

8/3 PRE-SURVEY (OFFICE)

- Investigate potential measurement locations
    - Position, relation to hazards, airspace classification
    - Approvals needed?
    - Google Earth Coordinates (decimal degrees – WGS84)
- Investigate Antenna Under Test
    - Frequencies, Channels, Modulation
    - Aperture (greatest dimension)
    - Height above ground of the Centre of Radiation (AGL)
    - Supporting structure base altitude (AMSL)
    - Handbook Radiation Patterns (if applicable)
    - Number of potential DE measurement locations
- Establish Site, Antenna and Service information in AMS
- Create a Planning Session in AMS

8/4 SURVEY (FIELD)

- Determine the best take off location for the RPA and setup in that location. Ideally only one take-off location is used per measurement run to avoid confusion relating to relative height differences.
- Orientate drone to AUT. Start Measurement Recording in AMS.
- Manually climb to desired altitude observing the layering profile of the RF measurement data. Land
- Sync data and either EXPORT or Create REPORT.
- Repeat at next location

9/ SPECIFICATIONS

9/1 ARMS RX (AR9440)

Make and Model	OEM SA44B
Input RF	50 Ohms, Max
RF Frequency Range	1Hz to 4.4 GHz
Wide Dynamic Range	-151 dBm to +10 dBm
Resolution Bandwidths	0.1 – 259 kHz and 5 MHz
Relative Accuracy	0.25 dB
Absolute Accuracy	1.5 dB (signals less than 0 dBm)
Maximum Span for Channel Measurements per sweep	42 MHz recommended (varied performance after that)
Number of Channels Measured	Up to 10
Number of Channels Measured (Carrier Wave)	1
Temperature Range	-40 to 85 deg C

9/2 RFD868/900 TELEMETRY (IF APPLICABLE)

Frequency Range	902 - 928 MHz (USA) / 915 - 928 MHz (Australia) 868 MHz Europe
Output Power Range	10mW to 1W
Receive Sensitivity	>121 dBm (low data rates)
Power Supply	5V (800mA current at peak power)
Temperature Range	-40 to 85 deg C

9/3 COFDM 2.4 AIRCRAFT AND TELEMETRY (IF APPLICABLE)

Frequency Range	2.402 - 2.478 GHz
Output Power Range	Up to 1W
Receive Sensitivity	>99 dBm (up to 10Mbps)
Power Supply	7 - 30VDC
Temperature Range	-40 to 85 deg C

9/4 WIFI 2.4 AIRCRAFT (DJI DRONES)

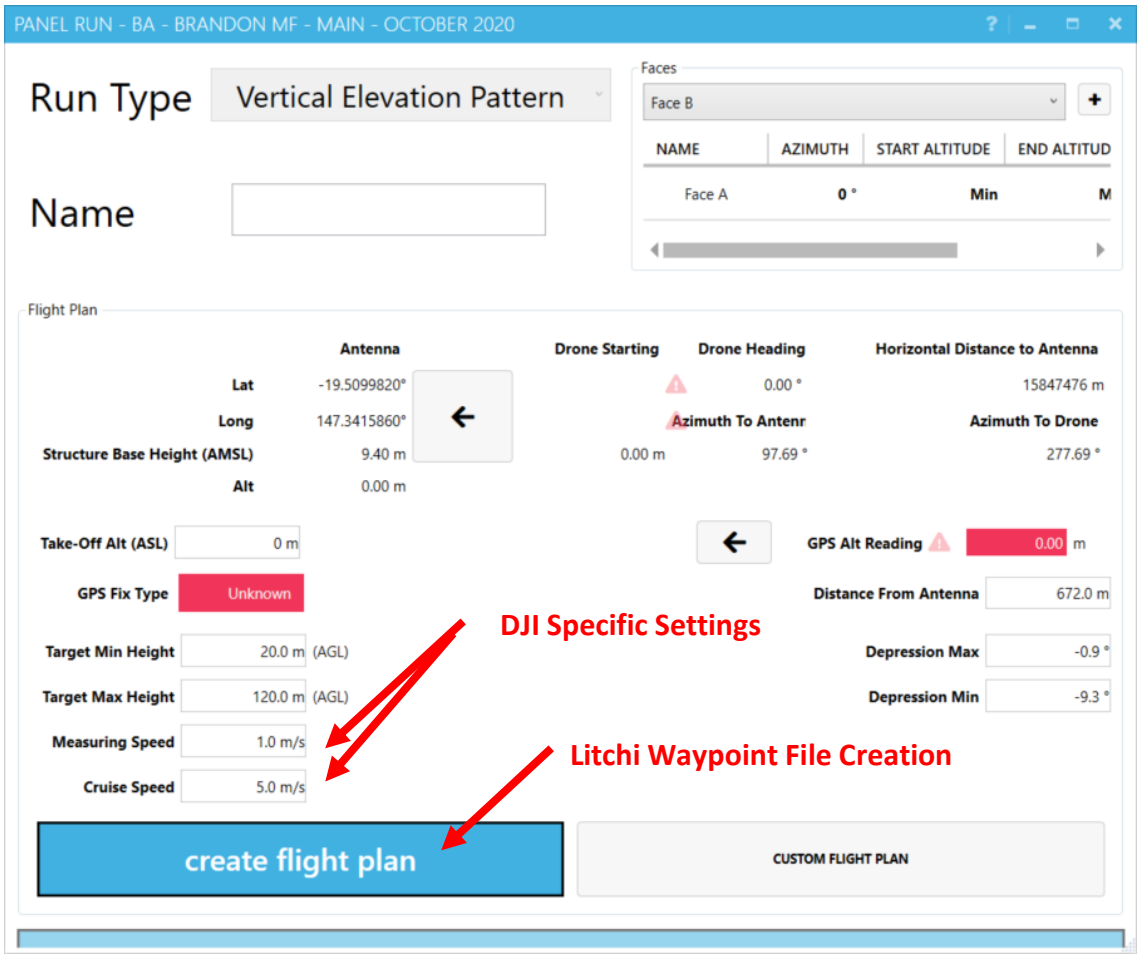
Frequency Range	2.402 - 2.478 GHz
Output Power Range	Up to 500mW
Receive Sensitivity	>72 dBm
Power Supply	7 - 30VDC
Temperature Range	-40 to 45 deg C

10/ LITCHI APP WAYPOINTS (DJI M210)

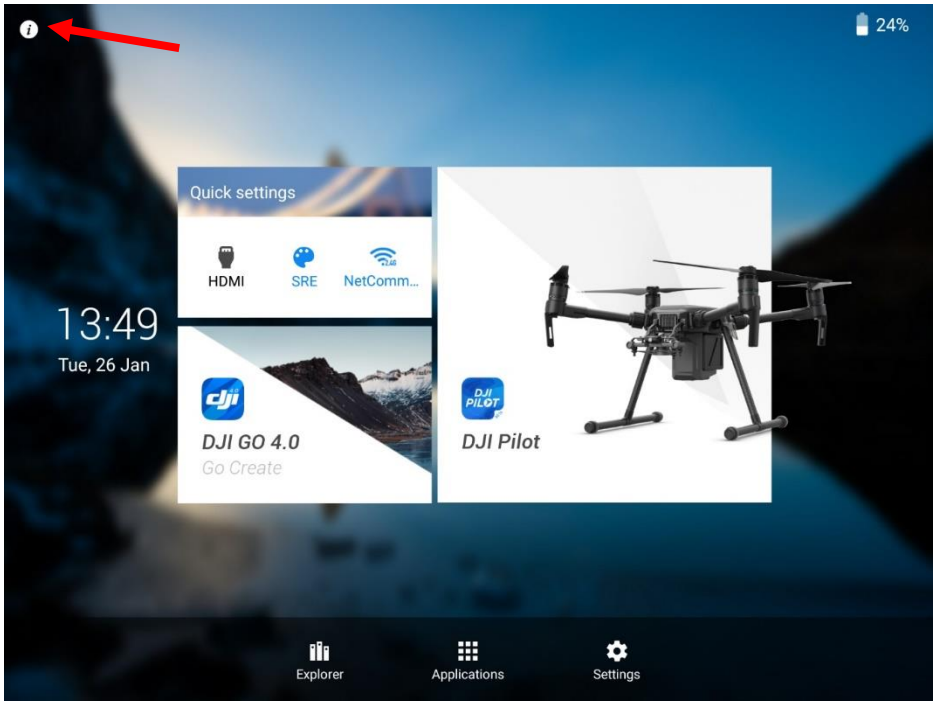
Antenna Measurement Studio is able to create custom flight plans for the DJI M210 v2 aircraft. However, this functionality requires the Litchi app to be installed on the device used for flying the machine.

If AMS is set to a DJI Based Flight Controller then the Litchi waypoint is automatically generated and if the device with litchi is plugged into the laptop running AMS, it will actually transfer the flight plan directly into Litchi.

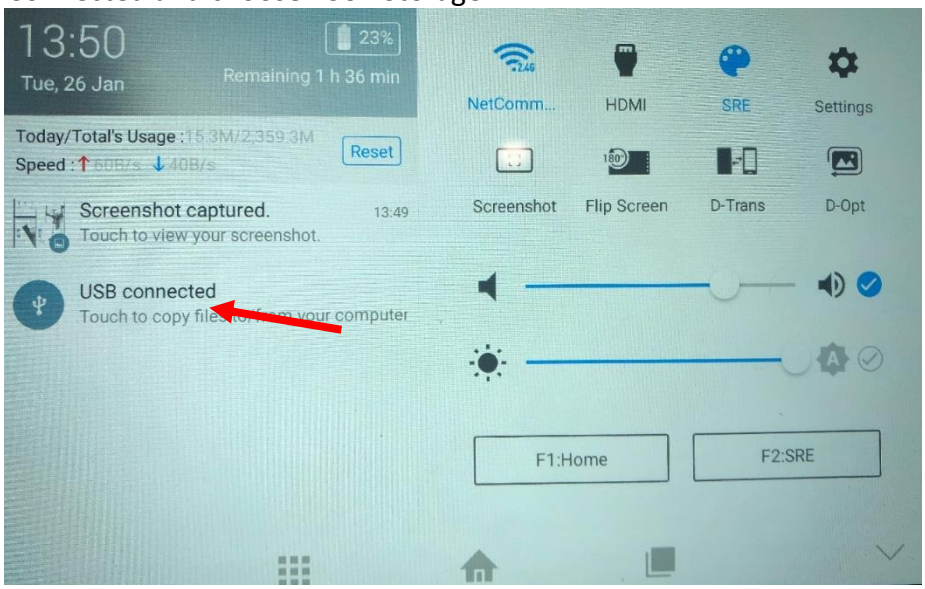
After creating the Standard Flight Plan in AMS … perform the following:



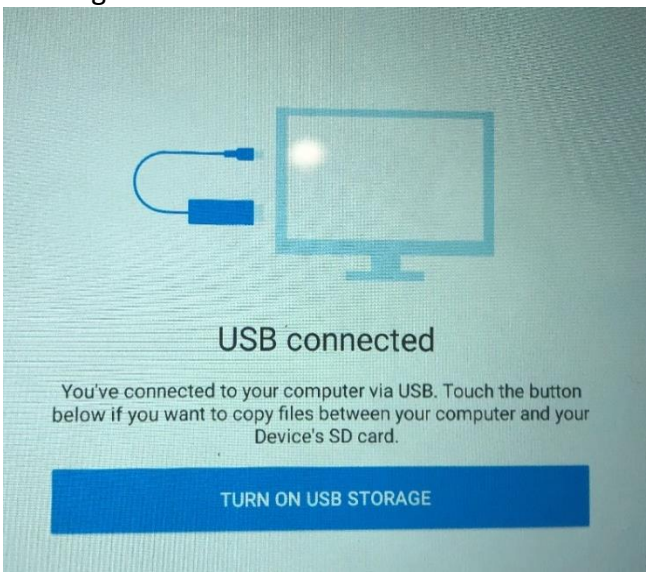
- Do not press ‘Create Flight Plan’ until all steps below are followed.
- Plug in a USB Type A to USB Micro from a free USB port on the laptop running AMS and the Device (Crystal Sky shown below). Navigate to the main screen and select the “i”



- Select USB Connected and choose “USB Storage”



- On the Crystal Sky you should get



(**Press Create Standard Flight Plan** … At this stage, AMS will copy the Waypoint File directly onto the Crystal Sky into the Litch application folder)

If this fails for any reason then you can manually copy the flight plan into the litchi folder.

- Open litchi, select the waypoint, confirm the flight path and parameters and execute flight when ready.