THREOD

SYSTEMS

EOS C VTOL

UAV OPERATOR GCS SOFTWARE MANUAL

Software Revision: 2023-02Document Number: 502-204-102798-01-2023-02

This page was intentionally left blank

STATEMENT OF CONFIDENTIALITY NONDISCLOSURE

This document contains proprietary and confidential information. All data submitted is provided in reliance upon its consent not to use or disclosure any information contained herein except in the context of its business dealings with Threod Systems. The recipient of this document agrees to inform present and future employees of the organization who view or have access to its content of its confidential nature.

The recipient agrees to instruct each employee that they must not disclosure any information concerning this document to others except to the extent that such matters are generally known to and are available for use by the public. The recipient also agrees not to duplicate or distribute or permit others to duplicate or distribute any material contained herein without Threod Systems OÜ express written consent.

Threod Systems retains all title, ownership and intellectual property rights to the material and trademarks contained herein, including all supporting documentation, files, marketing material and multimedia.

BY ACCEPTANCE OF THIS DOCUMENT, THE RECIPIENT AGREES TO BE BOUND BY THE AFOREMENTIONED STATEMENT.

This page was intentionally left blank

TABLE OF CONTENTS

REORD OF REVISION

Software Revision No.	Content	Date
2023-01	First release	03.2023
2023-02	Updated 11.2, Added Annex 7	06.2023
2023-03	Status bar & other UI changes	12.2023

This page was intentionally left blank

TABLE OF FIGURES

LIST OF TABLES

1 ABBREVIATIONS AND ACRONYMS

AE	:	Automatic exposure
AF	:	Auto focus
AGC	:	Automatic gain control
AGL	:	Above Ground Level
AMSL	:	Above Main Sea Level
Beidou	:	GNSS constellation operated by the People's Republic of China
CLAHE	:	Contrast Limited Adaptive Histogram Equalization
EO	:	Electro optical TV camera
FFC	:	Flat-Field Correction
Galileo	:	GNSS constellation operated by the European Union
GCS	:	Ground Control Station
GLONASS	:	GNSS constellation operated by the Russian Federation
GND	:	Ground Speed
GNSS	:	Global Navigation Satellite System
GPS	:	GNSS constellation operated by the USA
HDTV	:	High-definition image with a resolution of 1920x1080 pixels
HE	:	Histogram Equalization
IAS	:	Indicated Air Speed
IFC	:	In-Flight Failsafe
INS	:	Inertial Navigation System
ISR	:	Intelligence, Surveillance, Reconnaissance
LD	:	Laser (target) designator
LRF	:	Laser range finder
LWIR	:	Long Wave Infrared Camera
LUT	:	Look Up Table
MS	:	Mission Software
MWIR	:	Medium Wave Infrared Camera
NIR	:	Near infra-red
OSD	:	On-screen display
PFC	:	Pre-Flight Failsafe
PIP	:	Picture-in-picture
POI	:	Point of Interest
REL	:	Relative (flight) altitude of UAV above launch location
SBAS	:	Satellite-based augmentation system, a technology to enhance GNSS accuracy
UTC	:	Coordinated Universal Time
VSS	:	Video Server Software

This page was intentionally left blank

2 SAFETY

When operating EOS C UAS Ground Control Station (GCS) software it is critical to maintain situational awareness at the UAV operating site when arming, disarming the UAV and/or initiating take-off or landing sequence.

Special attention needs to be taken to provide safe operation of the EOS C UAV when landing in a remote area or making changes prior take-off or landing.

EOS C is piloted by Threod Systems autopilot enabling the UAV operator to plan and execute flight missions through point and click method.

This page was intentionally left blank

3 WARNINGS, CAUTIONS AND NOTES

UAVs of any kind are dangerous and can cause serious injury. Please read, understand, and follow the cautions and instructions.

Throughout the manual warnings and cautions are used to highlight various important procedures. They are defined as:

⚠ WARNING

AN OPERATING PROCEDURE, INSPECTION, REPAIR OR MAINTENANCE PRACTICE, WHICH IF NOT CORRECTLY FOLLOWED, COULD RESULT IN PERSONAL INJURY, OR LOSS OF LIFE.

CAUTION

AN OPERATING PROCEDURE, INSPECTION, REPAIR OR MAINTENANCE PRACTICE, WHICH IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE OR DESTRUCTION OF EQUIPMENT.

NOTICE

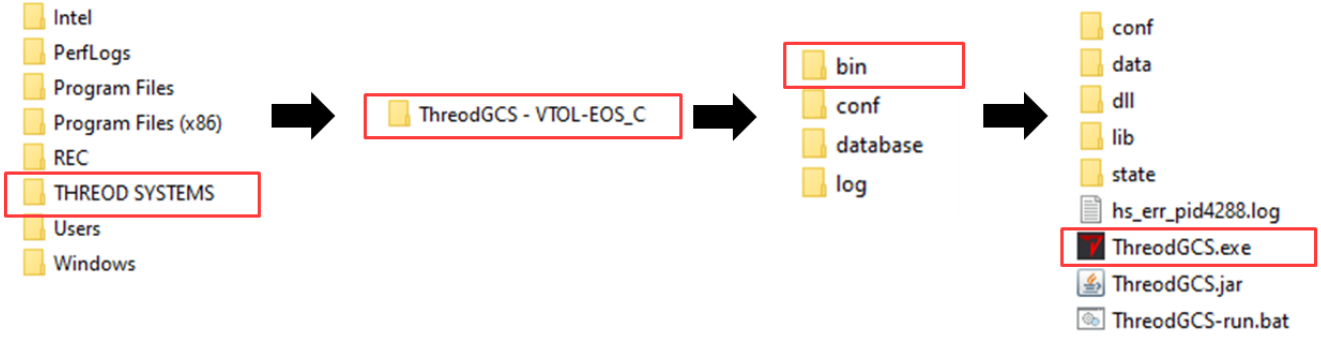
An operating procedure, inspection, repair or maintenance condition, etc., which is deemed essential to highlight.

This page was intentionally left blank

4 STARTING THE PROGRAM

To start using the EOS C UAV, open the **ThreodGCS shortcut** from the desktop.

The shortcut points to ThreodGCS.exe from **Local Disk (C:\ThreodSystems\ThreodGCS – EOS_C)**:



After activating software, you can choose whether the software is displayed in a single or dual monitor layout and the type of GDT. [1]

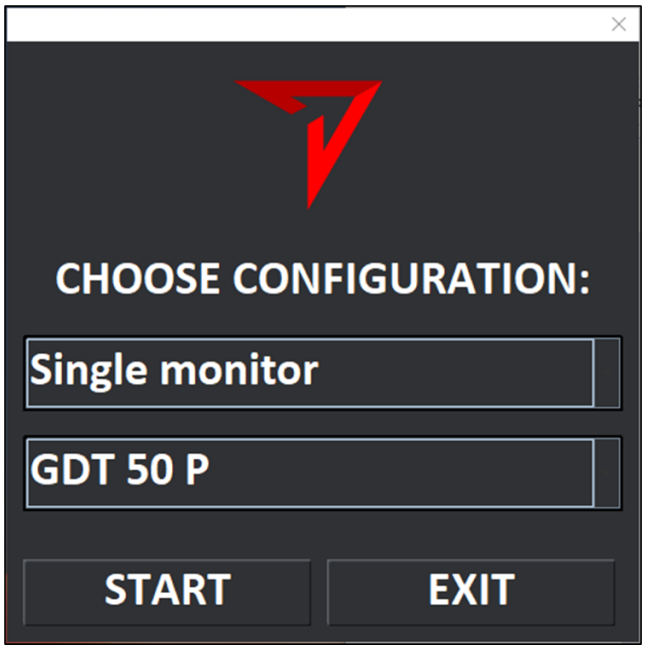


Figure 1 GCS software configuration window

[1] Not with all configurations.

4.1 LAYOUT

For all deployment scenarios there are options for single or dual monitor layouts. In single monitor layout all the information is displayed in one window.

For dual monitor setups the layouts provide a separate video window.

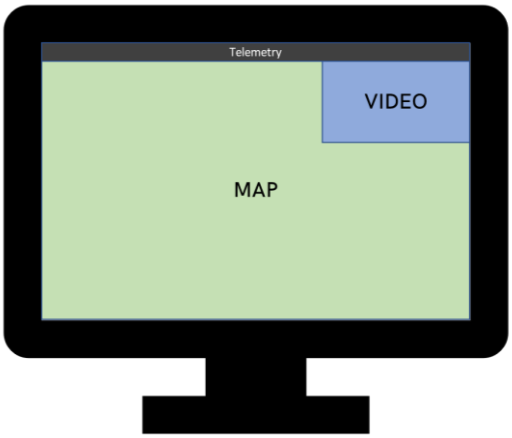


Figure 2 Single monitor

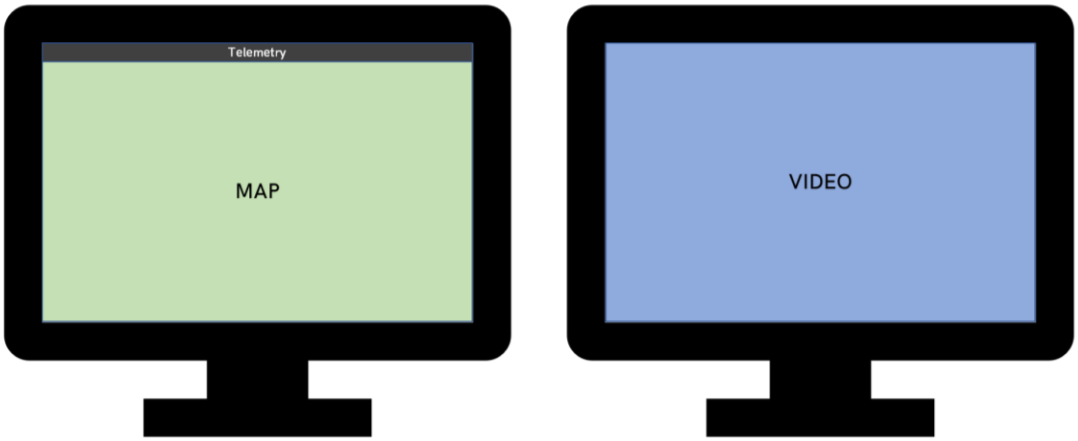


Figure 3 Dual monitor

4.2 GROUND DATA TERMINAL

Choose GDT with what will be connection created.

GDT 50 P	Selecting GDT 50 P, will show GDT camera video feed
GDT 4X4	Select it, when using GDT 4x4 and GDT 2x2

5 CONTROLLER

5.1 HANDHELD USB CONTROLLER

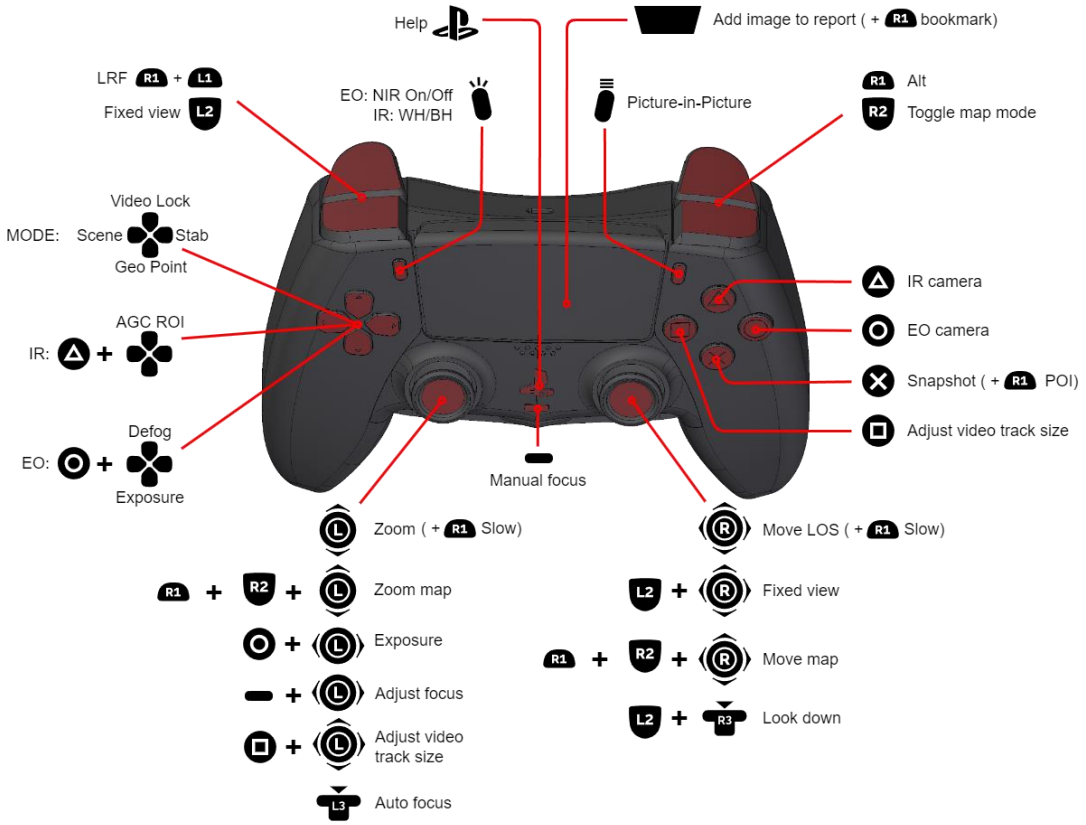


Figure 4 EOS C VTOL AUTO Mode Joystick Mapping

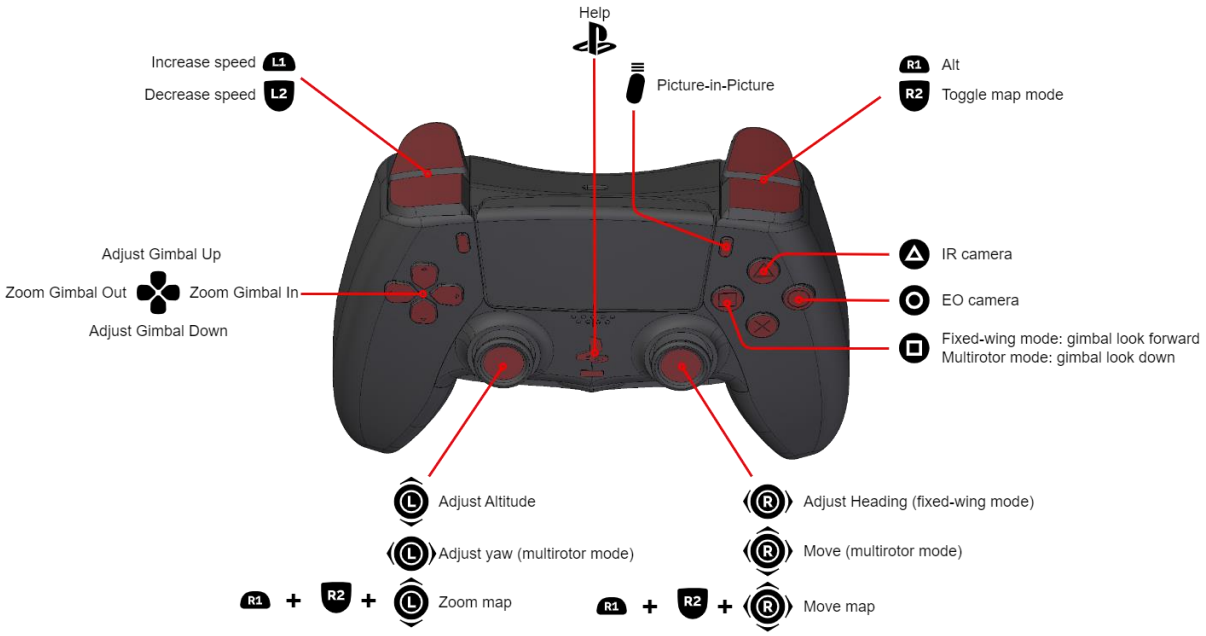


Figure 5 EOS C VTOL Guided Mode Joystick Mapping

6 USER INTERFACE

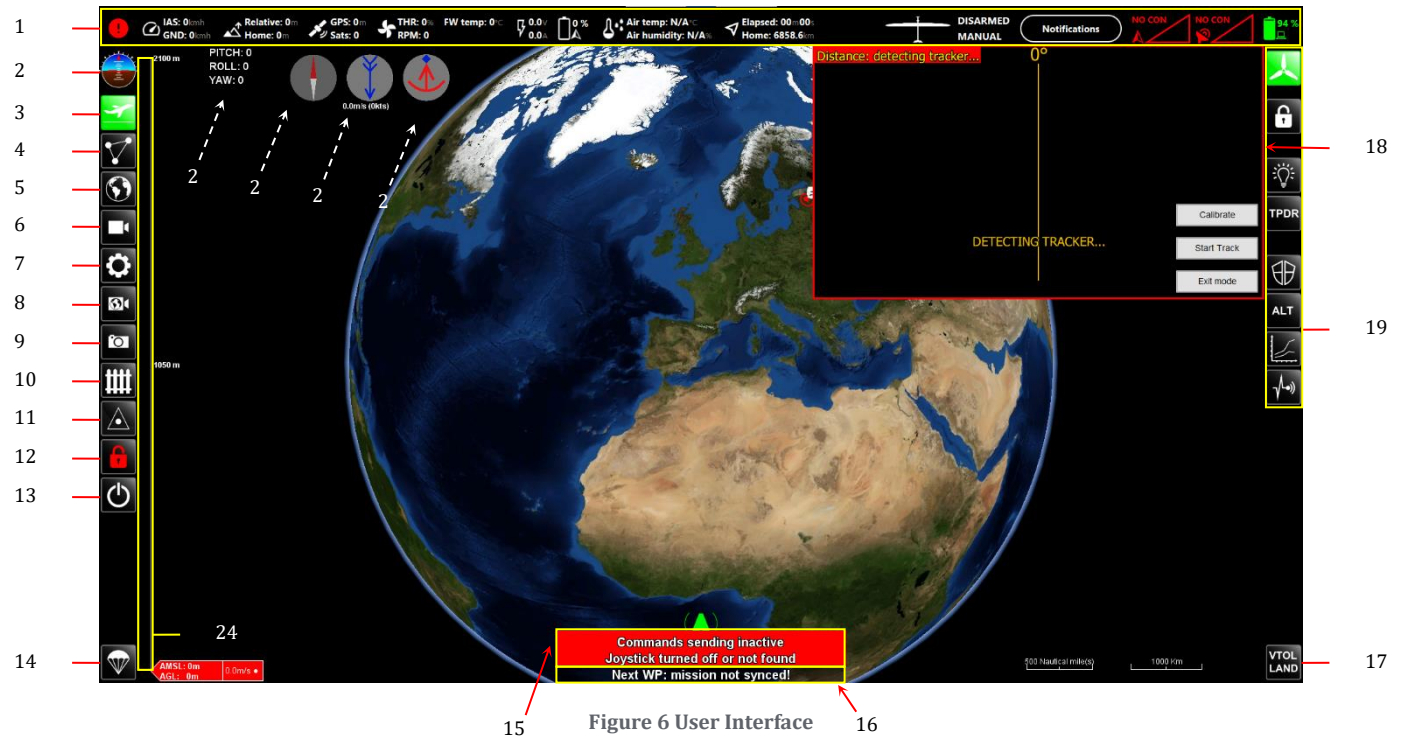


Figure 6 User Interface

NR	DESCRIPTION
1.	Status bar
2.	Artificial horizon
3.	Aircraft controls
4.	Waypoint editor
5.	Map controls
6.	Payload controls
7.	Settings menu
8.	Toggle screen priority
9.	Report tool
10.	Geofence
11.	Fire support interface
12.	Command sending activation
13.	Switch off program
14.	Switch off all motors/ Open parachute
15.	Command sending status/ Controls status
16.	Flight info: Playtime indicator/Next Waypoint distance, time/ Minimum LOS altitude
17.	VTOL LAND
18.	Video feed (UAV sensor or tracking antenna)
19.	Sub menu
20.	UAV axis indicators
21.	Map orientation indicator
22.	In-flight wind direction
23.	Tracker antenna direction and configurations
24.	Altitude bar with AGL & AMSL indication/ Altitude override

7 ENABLE/DISABLE COMMAND SENDING

Figure 7 Command sending activation

Enable command sending to control UAV.

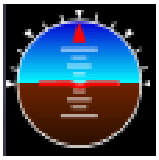
NOTICE

By disabling command sending you will still receive telemetry from UAV, but it isn´t possible to control the UAV[2]. After disabling command sending, it will activate TIME OUT counter in autopilot with a previously chosen option to either proceed to land or to continue mission.

[2] Precondition to continue receiving telemetry from UAV is to have good Line of Sight (LOS) between UAV and the Ground Data Terminal (GDT).

8 INDICATORS

8.1 GENERAL



The artificial horizon shows UAV rotation about both the longitudinal axis to indicate the degree of bank and about the lateral axis to indicate pitch. Can also be used for checking the internal configuration of the accelerometers. In addition, ROLL, PITCH & YAW values in degrees have been written out next to the artificial horizon.

The map orientation indicator shows map orientation related to North direction. Color RED indicating North and GREY indicating SOUTH. Feature is also used to orient map from 3D view back into 2D view with NORTH oriented on the top side of the screen.

The wind direction indicator is showing wind speed and direction measured from flight altitude (accuracy of measurement is improved when the UAV flies a full circle).

- The indicator icon is blinking if UAV is in pitot failsafe mode.

The GDT tracker indicator is showing ground data terminal direction and relation to UAV. UAV location related to the datalink is shown as blue diamond.

- Click to toggle between the tracker and gimbal video feeds.

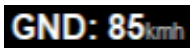
CAUTION

TRACKER MUST BE CALIBRATED TO UAV FOR DATALINK CONNECTION.
TRACKER CAN BE ADJUSTED BY TRIM WHILE UAV IS IN FLIGHT.

8.2 UAV PERFORMANCE

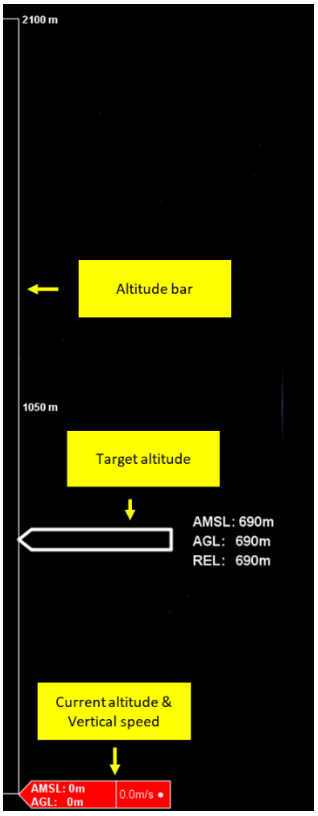
8.2.1 AIRSPEED

Aircraft speed is displayed in two values. Indicated Airspeed (IAS) and Ground Speed (GND).



Ground Speed is the horizontal speed of an aircraft relative to the ground. An aircraft heading vertically would have a ground speed of zero.
Indicated Airspeed is the speed of an aircraft relative to the air. Indicated airspeed is simply what is read off an airspeed gauge connected to a pitot static system.

8.2.2 ALTITUDE BAR



AMSL is flight altitude of the UAV Above Main Sea Level (AMSL) (barometrical).
AGL is flight altitude of the UAV Above Ground Level (AGL) (calculated according to map layer).
REL is Relative (flight) altitude of the UAV (barometrical).

Vertical Speed is the rate at which an airplane ascends or descends.

Current Altitude is present altitude of aircraft. By clicking on it and dragging up or down is possible to set Altitude Override.
Target Altitude is altitude where it aims.

Altitude Override. This function allows you to override the flight mission altitudes uploaded to UAV with a single altitude value. This function can be employed only while a flight mission is in progress and there is connectivity between UAV and the ground station. This will enforce the UAV to follow previously active mission flight profile.

NOTICE

Altitude override will be turned off by autopilot in case of landing sequence is initiated by UAV entering the loiter altitude waypoint.

CAUTION

IN CASE OF A FAILSAFE CONDITION, ALTITUDE OVERRIDE WILL BE DISABLED.

WHEN USING ALTITUDE OVERRIDE, BE AWARE WITH RADIO LINE OF SIGHT (RLOS). DISPLAYED AS MIN LOS ALT ON GCS'S SCREEN.

To activate Altitude override, drag current altitude tab to required altitude.

When Altitude override is active, target altitude will show Override.

Example picture shows that Vertical speed is 0.

After dragging current altitude tab, adjust value, or confirm it by clicking **SET OVERRIDE.** To cancel Altitude override, click DISABLE OVERRIDE.

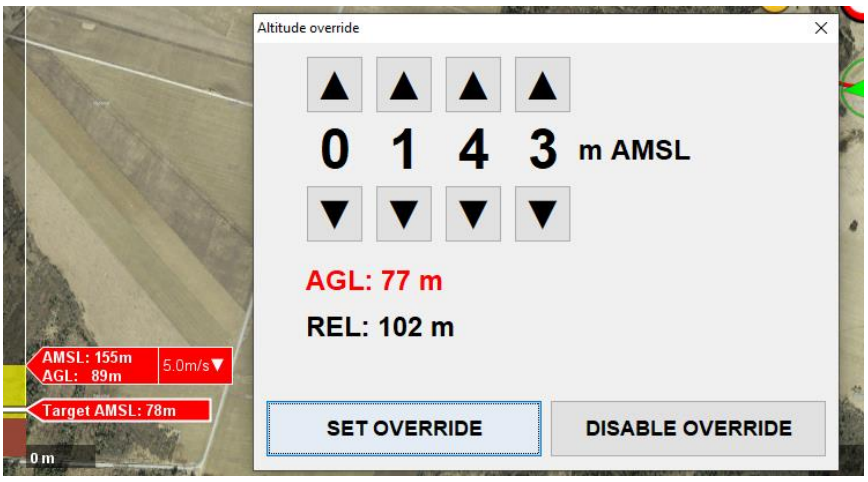


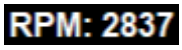
Figure 8 Altitude override window.

8.2.3 MOTORS

When in fixed wing flight mode then only fixed-wing motor parameters are shown as throttle value in percentage (%), Revolution per Minute (RPM, electronic count), temperature (°C) and current (A).

When in VTOL flight mode then the information about 4x VTOL motors and 1x fixed-wing motor values are depicted on status bar.

Throttle percentage shows motor (when in FW flight mode) or motors combined (when in VTOL mode with FW motor assisting) output.

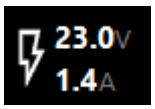


Revolutions per minute is the number of turns in one minute. It is a unit of rotational speed or the frequency of rotation around a fixed axis. On EOS C only fixed-wing motor RPM is depicted with an average of 2900-4000rpm when cruising in level flight.

Temperature is indicated on the status bar only for fixed-wing motor. It is normal that motor temperature will increase while platform is gaining altitude.

NOTICE

Every EOS C VTOL UAV is programmed to enter COOL DOWN MODE once FW motor temperature reaches 90 °C.

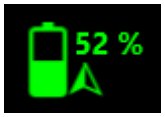


Current is indicated in amperes and always includes total value, both in FW and VTOL flight. When current from battery increases then battery **voltage** decreases and vice versa[3].

[3] Ohm's Law: Definition & Relationship Between Voltage, Current & Resistance

8.2.4 VOLTAGE

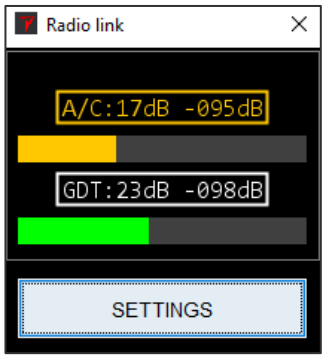
EOS C battery total voltage is indicated on top of the screen and in more detail can be seen when activating battery icon from underneath the main feature of aircraft controls.



EOS C remaining battery **capacity.**

8.2.5 DATALINK INDICATOR

EOS C UAS has a two-way datalink. Link indicator is showing datalink quality. Indicator bar has three different colours to provide information to UAV operator.



RED – Low signal level (SNR[4] ≤ 10 dB or no connection[5])

YELLOW – Medium signal level (20 dB < SNR > 10 dB)

GREEN – High signal level (SNR ≥ 20)

NOTICE

In case of interference a change of frequency is suggested. If communication plan allows change to new frequency applying bigger interval from the old problematic frequency. Changing frequency will take approximately 10-15 seconds. It is recommended to increase the failsafe time, but not over 60 seconds.

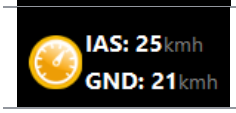
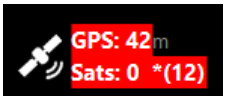
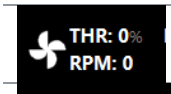
In case of critical signal level during flight it may be required to TRIM the 2-axis tracker for better LOS between UAV and GDT, if situation allows the increase of altitude may improve signal level. The further the UAV the more sensitive it is to move tracker direction using TRIM option.

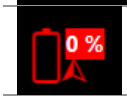
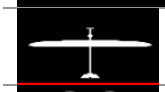
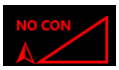
[4] Signal-to-Noise ratio (SNR) is a measure that compares the level of a desired signal to the level of background noise.

[5] No signal received from tracker module in last 4 seconds.

8.3 STATUS BAR

The status bar is the upper row of the flight information displayed about the UAV in Metric or Imperial units (configurable from settings) It is the primary real time information source about the system.

	Connection with aircraft OK (telemetry is received) • Click to open **datalink settings**
	No connection to aircraft (no telemetry is received)
	Default speed
	If pitot failsafe is active text “FAILSAFE” will be displayed together with target IAS (indicated airspeed), which is calculated/synthesized by autopilot.
	Manual speed override activated by user/pilot
	Automatic speed override activated by autopilot
	Relative (flight) altitude of the UAV (barometrical) • Click to **set altitude override** in meters. Home take-off altitude in AMSL. NB! If the payload doesn’t have the specific area’s DEM file to show the altitude, then this number indicates the uploaded mission’s home waypoint altitude.
	Altitude override activated indicator
	GPS (flight) altitude of the UAV (measured from sea level) Fixed satellite count/Satellites fixed on the UAV. For take-off it is required to have 6 satellites fixed. • Click to open settings window in ‘Technician’ tab where you can **turn GPS - ON/OFF.** Read more in page 118 TECHNICIAN WINDOW If GPS text is blinking this indicates an error (no 3D fix, not enough satellites or using GPS in autopilot is turned off) Sats is showing the **best available satellite count in brackets**. Best satellite count means it shows highest satellite count of the different existing GPS devices (if multiple) which match these criteria: have 3D fix, barometric altitude and GPS altitude difference is less than 1000m and last telemetry received for given GPS is less than 4 seconds ago. This is useful if you’re flying in a **GPS denied** area, start to fly back and want to know if or when to turn GPS back on for usage in autopilot instead of flying with INS
	Throttle percentage Revolutions per minute for the front motor
	Front motor temperature

	Battery voltage	Red	< 19.8V
	Battery amperage		
	Aircraft battery level shown as a percentage		
	Air temperature in Celsius	Red Yellow	< -19 || > 49 < 1 || > 39
	Air humidity as a percentage	Red Yellow	> 94 > 84
	Flight time elapsed		
	UAV distance from the ground station / home (waypoint)		
	Icon shown when aircraft in fixed-wing mode • Click to open flight mode options window		
	Icon shown when aircraft in multirotor mode • Click to open flight mode options window		
	Button icon and border colour is the equivalent of the most severe error • Click to expand notifications list		
	- INFO	White	Default
	- ALERT	Yellow	Proceed with caution
	- WARNING	Red	Error
	Aircraft link • Click to open **radio link** window		
	GDT datalink indicator • Click to open **radio link** window		
	Laptop battery level as a percentage		

8.4 FLIGHT INFO

At the bottom center area of GCS screen, user can monitor remaining playtime, loiter altitude rise/descend and time to next waypoint or back to home point.

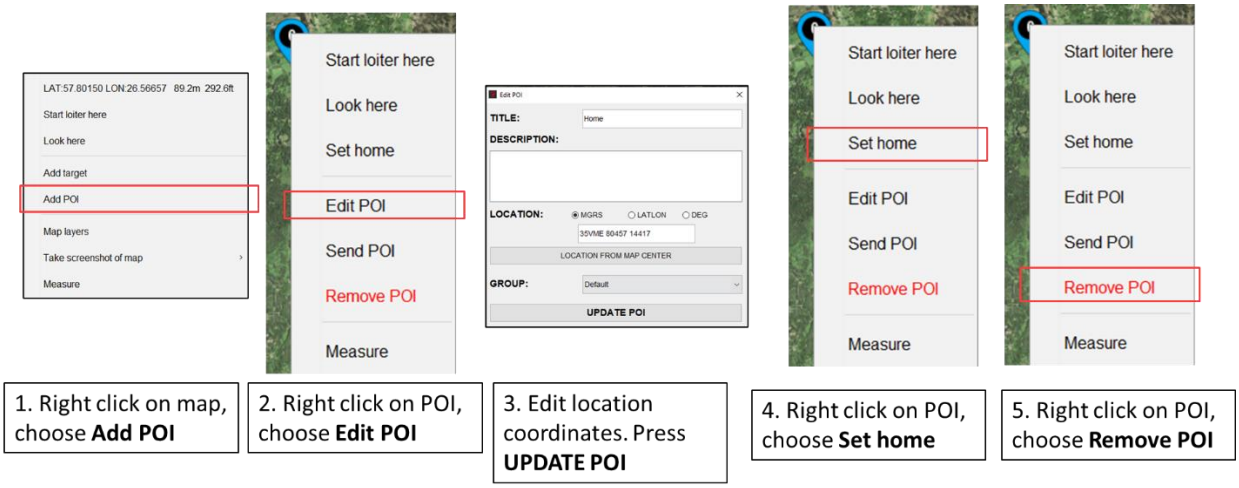
Figure 9 Flight info

- Will show text '(FAILSAFE, INACCURATE!)' next to playtime if UAV is in pitot failsafe mode currently

8.5 GROUND STATION LOCATION/ HOME POINT

	GDT 50 P has built in GPS and will show your ground station location /home point on map. After GCS software restart, software will memorise last location.
35.9km	UAV distance is measured according to your ground station location/ home point on map.

When using GDT 4x4 and GDT 2x2, user need to set GDT location manually. To set ground station/ home point manually:



1. Right click on map, choose **Add POI**
2. Right click on POI, choose **Edit POI**
3. Edit location coordinates. Press **UPDATE POI**
4. Right click on POI, choose **Set home**
5. Right click on POI, choose **Remove POI**

NOTICE

When using GDT 50 P and in a case, GDT might lose GPS due to jamming or spoofing. For that, after creating connection with aircraft and GDT calibration, set GDT location manually, in the same location! After restarting GCS software, GCS will use GPS coordinates again!

If GDT50 P GPS fails and cannot get coordinates, then Set home manually using POI.

9 CONFIGURATION

User can configure data link settings from configuration window by clicking on the UAV connection status indicator in the status bar.

Figure 10: UAV connection status indicator

9.1 PROFILE SETTINGS

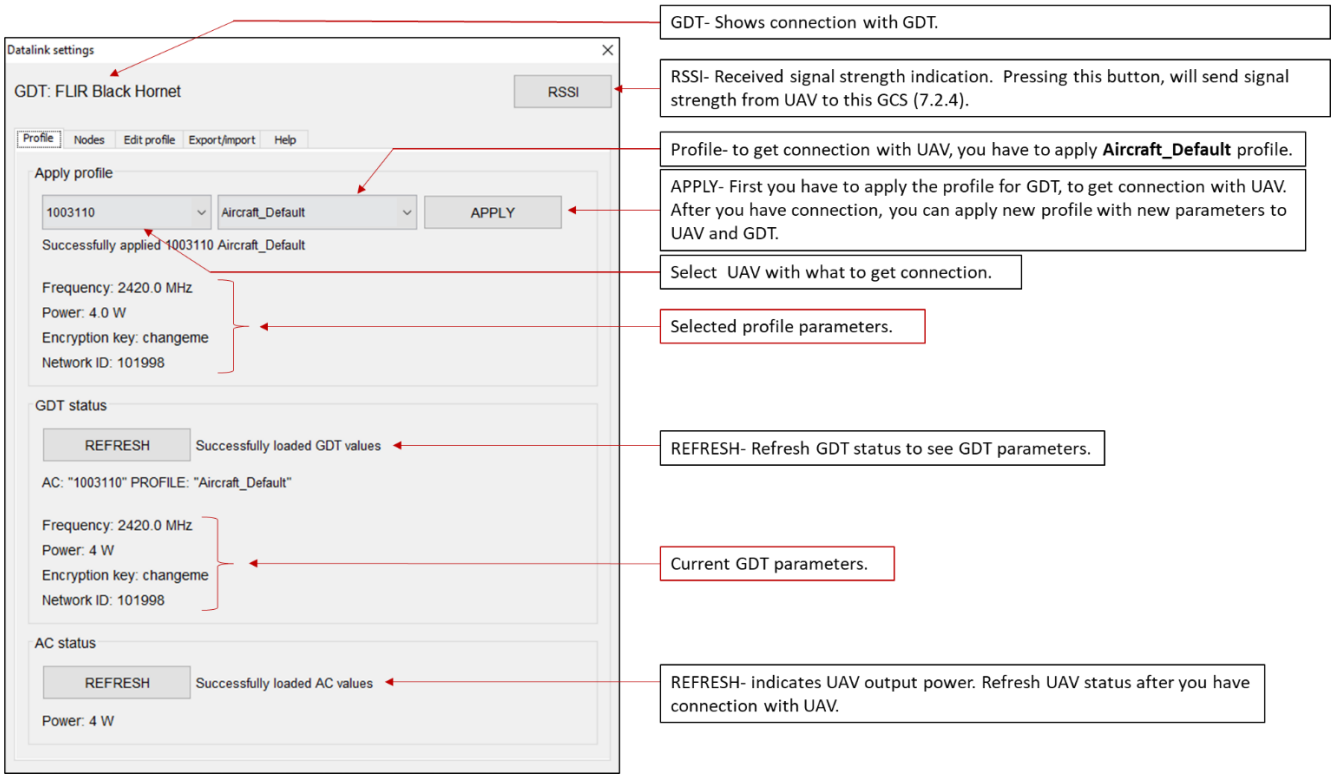


Figure 11 Datalink Profile management

To create connection with UAV, check ANNEX 1.

9.2 NODE TAB

Node TAB shows connection quality between radio pairs.

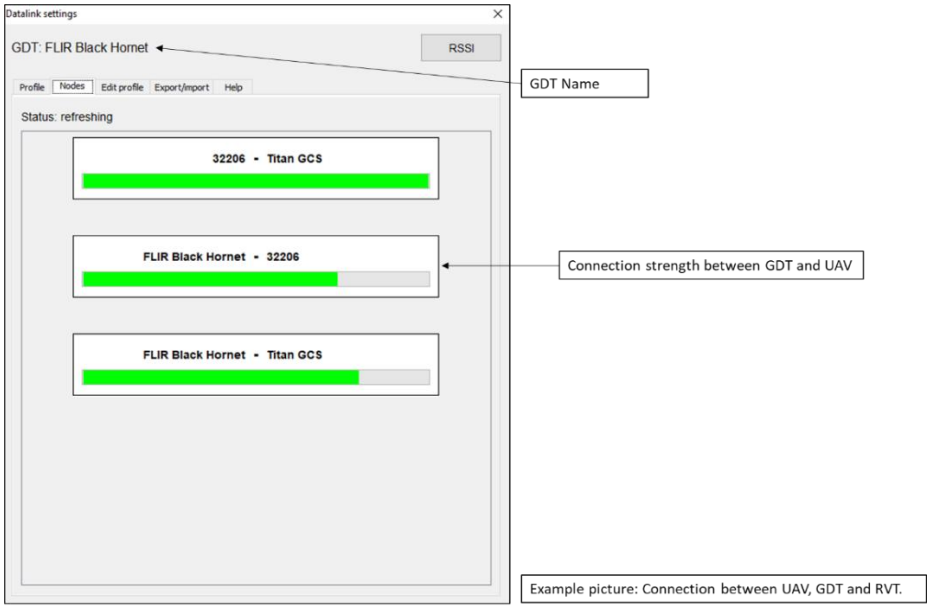


Figure 12 Node window

9.3 EDIT PROFILE

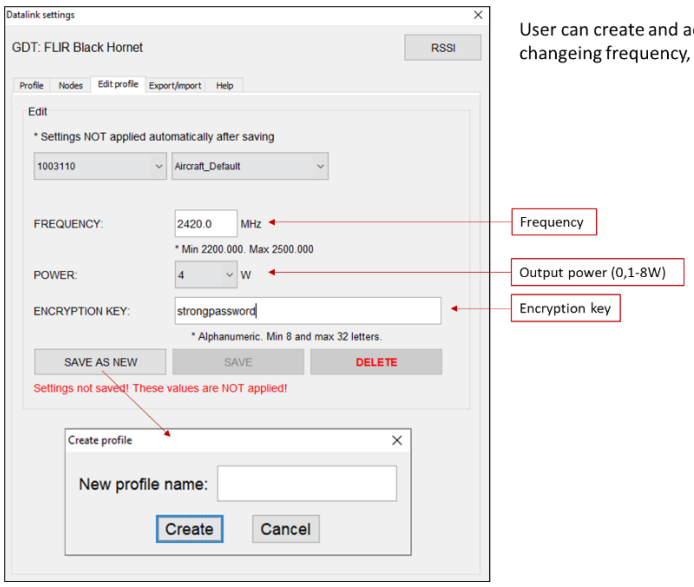


Figure 13 Datalink Edit profile management

To edit profile:

1. Select frequency.
2. Select output power.
3. Type encryption key.
4. Save as new profile.

9.4 EXPORT/IMPORT PROFILE

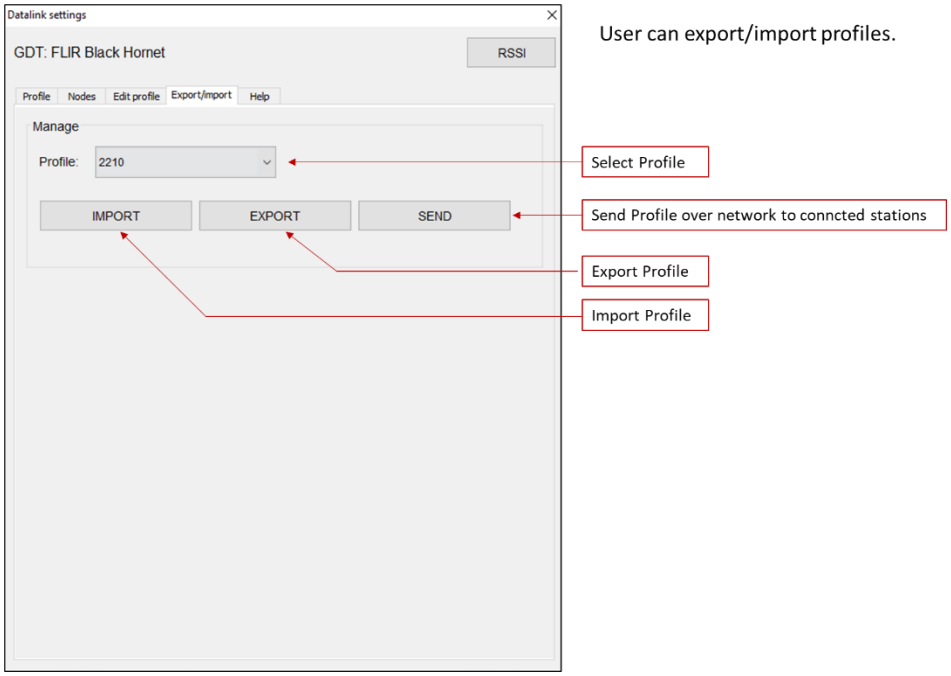


Figure 14 Datalink Export/Import management

Profile files are saved as **.json** files.

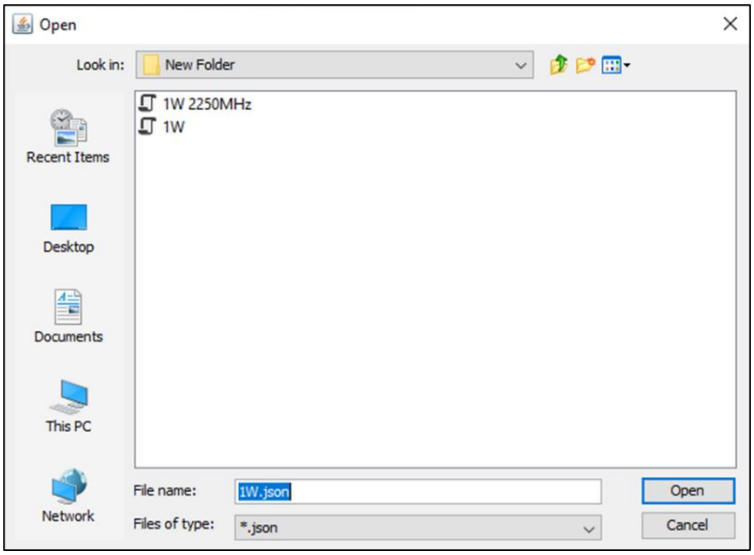


Figure 15 Import/export profile

9.5 DATALINK HELP TAB

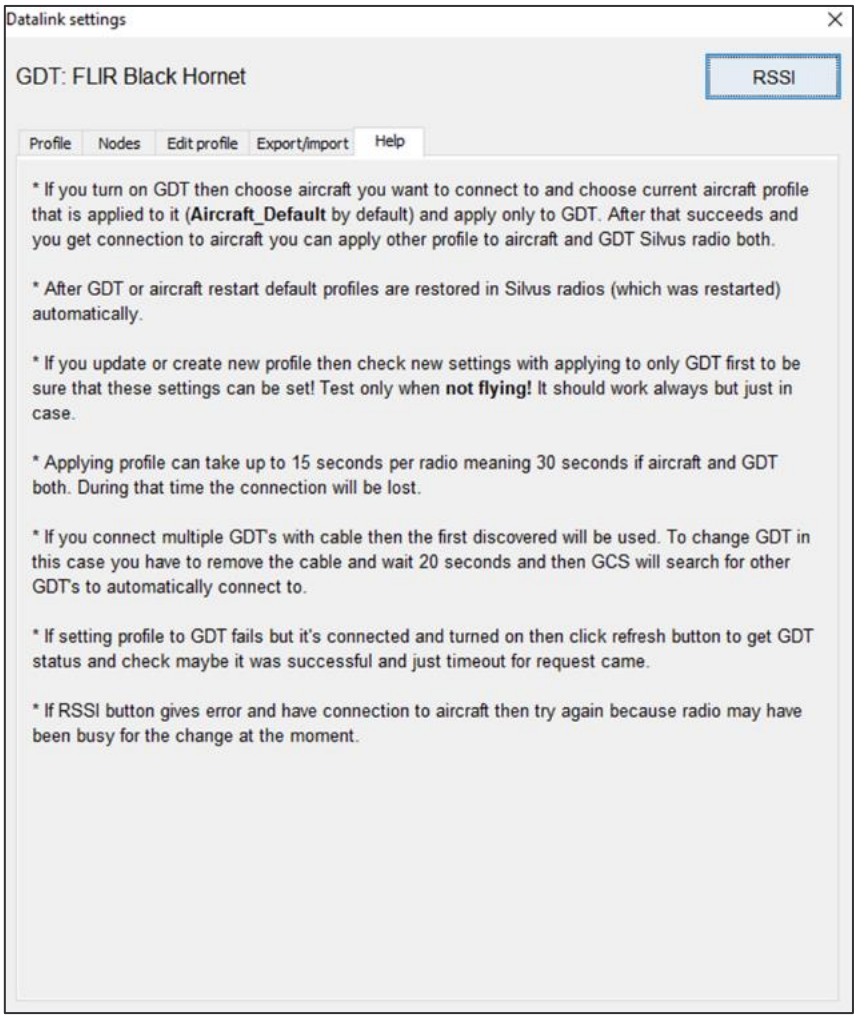


Figure 16 Datalink Help window

10 TRACKER CONFIGURATION

The tracker camera shows where the tracker is currently looking at. If tracker is set and calibrated to track the UAV it continuously steers the UAV by changing its angle and direction.

Setting tracker to follow UAV:

1. Power on Tracker (502-516-116610 Ground data terminal User Manual)
2. Configure tracker, by applying UAV default profile (paragraph CONFIGURATION 9.1)
3. Power on UAV
4. Set tracker crosshair onto UAV prior the launch
5. Activate CALIBRATE
6. Activate START TRACK (expect the crosshairs to tilt upward after activation).

Tracker camera GUI is showing to operator the direction and the angle of the UAV location from the tracker.

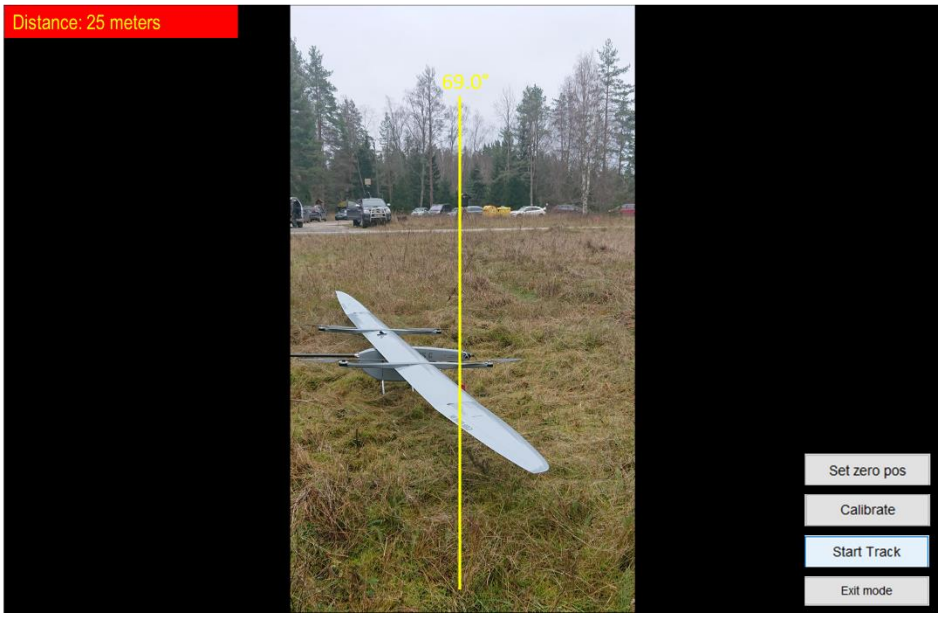


Figure 17 Tracker camera interface

CAUTION

UAV MUST BE ON THE CROSSHAIRS (VERTICAL ACCURACY IS CONSIDERED PRIMARY).

UAV MUST BE AT LEAST **15 METERS** AWAY FROM TRACKER. FOR DISTANCE FLIGHT, TAKE AIRCAFT FURTHER AWAY FOR ACCURATE CALIBRATION.

GREATER OFFSET FROM CROSSHAIRS MEANS LOWER LINK QUALITY.

WHEN PERFORMING POWER CYCLE TO THE GCS THEN ACTIVATE “START TRACK” AGAIN. AFTER POWER CYCLE GIMBAL COORDINATE ACCURACY MAY NOT BE PRECISE.

IN CASE GCS SW FREEZES OR CLOSES WHILE IN FLIGHT THEN AFTER REACTIVATING GCS SW IT IS NECESSARY TO PUSH “START TRACK” FROM THE TRACKER SCREEN.

User can configure tracker settings by clicking on tracker indicator icon. Tracker settings must be configured before flight. When employing “START TRIM” in flight it is necessary to activate “END TRIM” after connectivity has been improved. In case trimming was unsuccessful it is advisable to activate “RESET TRIM”, this will reset the previous trim setting.

Figure 18 Tracker configuration

TRIM is to make minor adjustments on the calibration. For example, if the user notices in flight offset of the tracker. **RESET** will reset previously trimmed values.

CAUTION

IF TRACKER IS NOT SET TO TRACK AFTER CALIBRATION, THEN DATA LINK CAN BE LOST AFTER UAV LAUNCH DUE TO UAV LEAVING FROM TRACKER COVERAGE.

HANDOVER AND TAKEOVER PROCEDURES MUST BE COORDINATED IN DETAIL BETWEEN THE CONTROLLING AND NEXT TO BE CONTROLLING OPERATOR.

NOTICE

For calibration, UAV and GDT must have GPS fix.

Tracker line (50km) is drawn on map where tracker is pointing currently if tracker is chosen/configured to be used and distance texts are drawn along the tracker line. In higher altitude text is drawn in 5km steps and in lower altitude it's every 1km steps. Tracker line is red when tracking is not started and black if it is tracking.

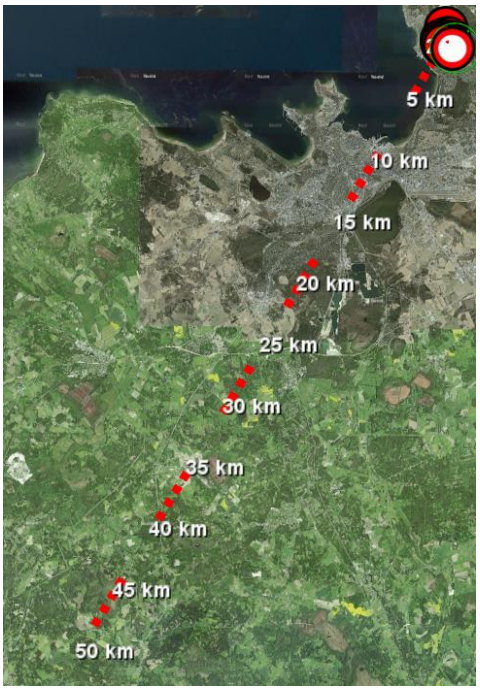


Figure 19: Tracker line (not tracking)

Figure 20: Tracker line (tracking)

10.1 AZIMUTH CALIBRATION

Use Azimuth calibration for GDT calibration when Aircraft is not in visual range.

Tracker azimuth can be calibrated in two ways:

1) Orienting tracker onto UAV by using camera crosshair. Press CALIBRATE. After calibration, Click START TRACK for tracking.
2) Point tracker on the direction what you know on the map. Then make right click on the same spot on the map and select: “Calibrate tracker with this position”. After calibration, Click START TRACK for tracking.

Figure 21 Azimuth calibration on the map

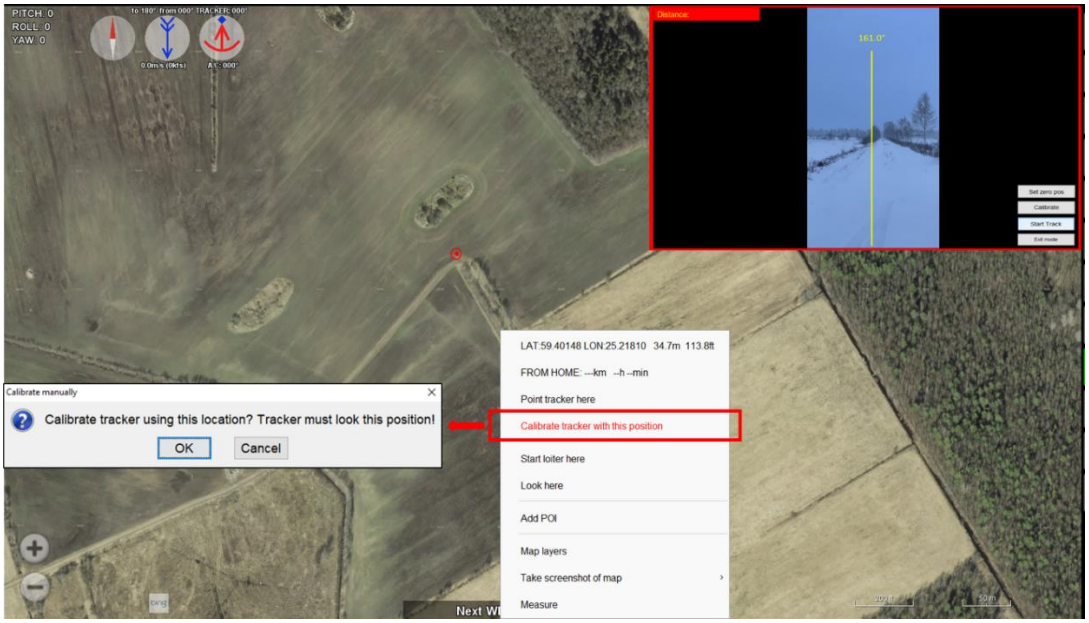


Figure 22 Azimuth calibration with right click on the map

11 UAV CONTROLS

Aircraft controls.

11.1 ACTIVATION OF MOTORS

When employing this icon in VTOL configuration the 4 VTOL motors will be activated and the UAV will take-off to a preplanned transition altitude and after reaching designated value it will continue flight in relying on forward motor only. Waypoints must be synced with autopilot and aircraft needs to be armed to activate motors.

During the flight, you cannot deactivate motors. Except when UAV is flying to landing waypoint or is already in landing waypoint. By pressing this button during the flight, it will ask to proceed to land or to closest Fail-safe waypoint.

To stop motors during the flight, press Emergency stop button.

⚠ WARNING

STOPPING MOTORS IN VTOL FLIGHT WILL RESULT IN UNCONTROLLED DESCEND AND CRITICAL DAMAGE TO THE UAV. IF MOTORS ARE STOPPED WHEN UAV HAS NO HORIZONTAL SPEED EMERGENCY THEN PARACHUTE MAY NOT HAVE ENOUGH TIME TO PROPERLY BE DEPLOYED.

11.2 ARM/DISARM

To arm and disarm UAV. Disarm is allowed only when landing or landed.

⚠ CAUTION

WHEN UAV IS ARMED THEN THE ESC (ELECTRONIC SPEED CONTROLLER) STOPS MAKING BEEPING SOUND WHICH NOTIFIES THAT IT IS NOT SAFE TO BE NEAR THE UAV.

11.3 EMERGENCY STOP, PARACHUTE

Emergency stop button will automatically stop fixed wing motor or VTOL motors if in VTOL mode and deploy emergency parachute.
When aircraft is without parachute, then stopping motors works with same logic, as described above.

Figure 23 Emergency stop

11.4 VTOL LAND

Activating this button, will turn UAV into VTOL mode for landing! Suggested for emergency use only. Operator can create new landing point. When VTOL LAND is pressed and CONFIRMED, system will create a landing spot 5 seconds in front of the aircraft's nose, from the place, where it was confirmed. It is also possible for the operator to drag the EMERGENCY landing point on map to desired location.

When pressed in Guided mode, it will turn the aircraft from fixed-wing into multirotor mode.

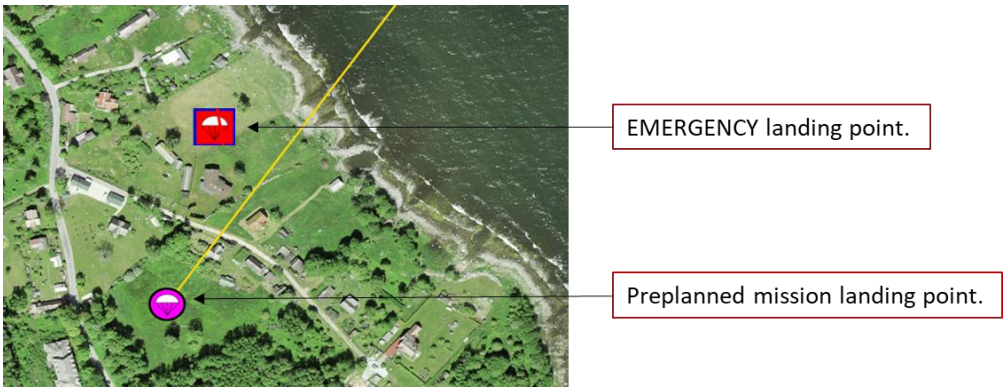


Figure 24 Emergency landing point

CAUTION

BY CREATING VTOL LAND, OPERATOR MUST DO EVERYTHING, THAT THE NEW LANDING POINT IS SAFE FOR LANDING!

WHEN DRAGGING VTOL LAND POINT INTO NEW LOCATION, BE CAREFULL WITH SIDEWINDS OVER 5 M/S! NEVER DRAG NEW LANDING POINT IN THE BACK OF AIRCRAFT!

AFTER LANDING; RESTART SOFTWARE!

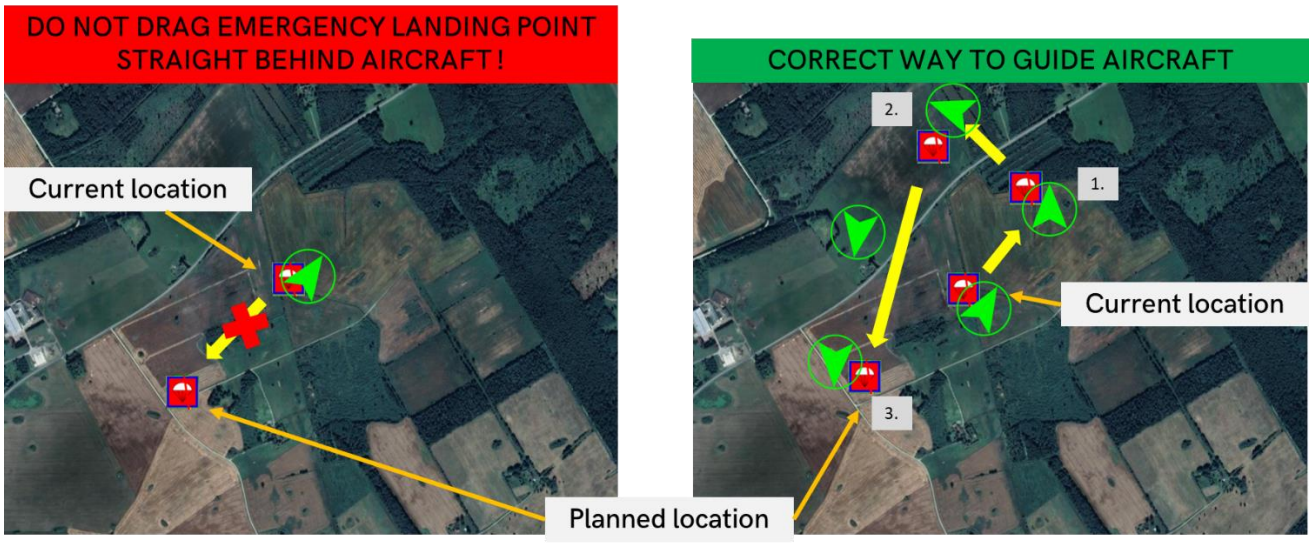


Figure 25 Emergency landing point

11.5 LIGHTS

Operator can switch ON and OFF navigation, IR and anti-collision lights (strobe).

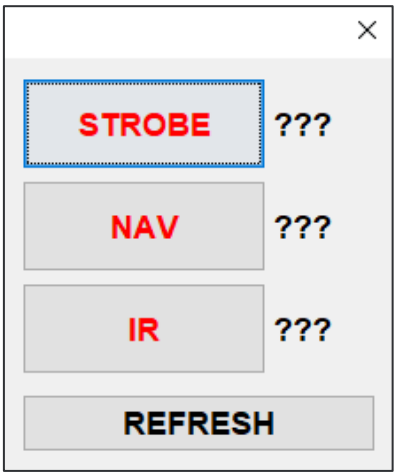


Figure 26 Lights

NOTICE

Labels are displayed red and lightning status is shown with question marks if datalink is disabled.

Refresh button will update the status of the lights (useful when taking over UAV control from another control station).

CAUTION

When STROBE light is ON and flashing, then it is NOT safe to approach the aircraft.

11.6 FAILSAFE

Fail-safe is applied when the UAV loses data transmission from the GCS. Make sure to always set the Safe altitude to a height that surpasses the highest obstacles in the operation area.

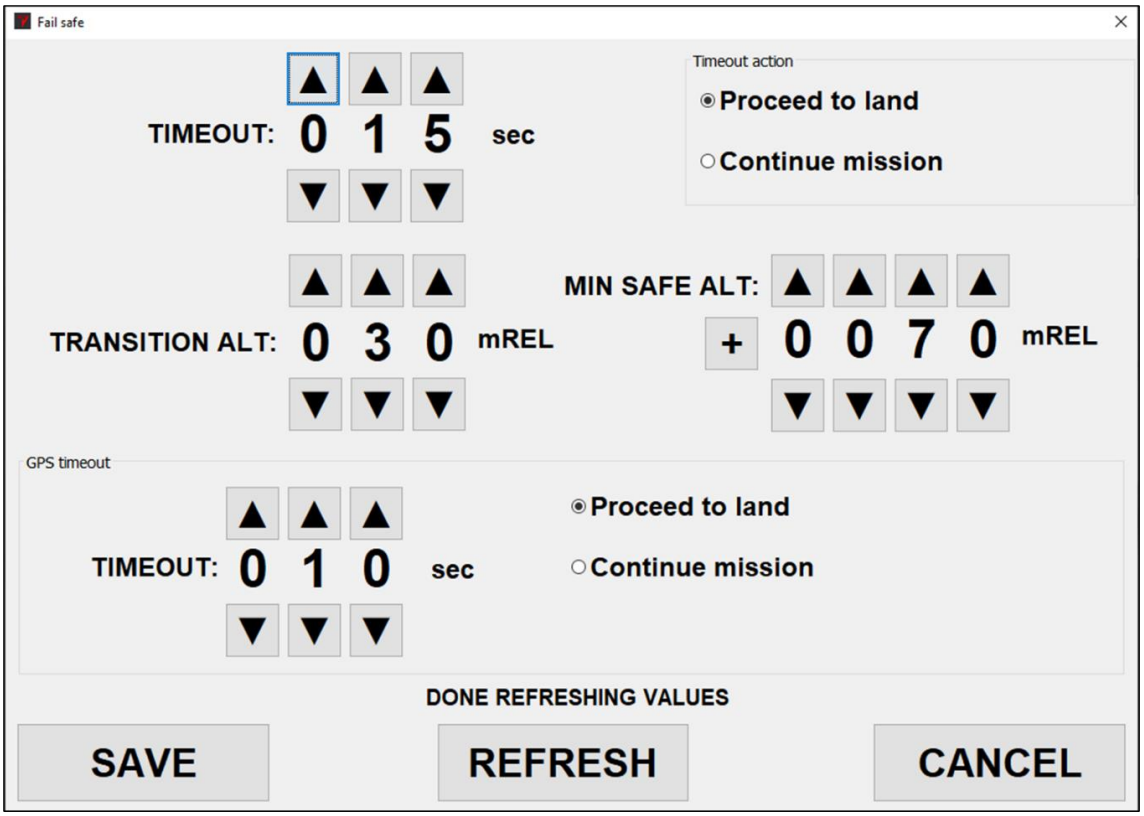


Figure 27 Failsafe menu

TIMEOUT	Is the period that the UAV will wait before commencing one of the two options on the right-hand side. Suggested 10-15 seconds to be used. 1-999 seconds can be inserted.
TRANSITION ALTITUDE	Sets altitude for take-off transition, from VTOL to fixed-wing. 10-100 m can be inserted.
MIN SAFE ALTITUDE	Will initiate VTOL motors if the UAV fails to follow planned flight profile and descends below stated altitude. In case the employment of VTOL motors has no effect (VTOL motor failure etc) and descend continues then emergency parachute is employed.6 -1000…+1000 mRel can be inserted.
Proceed to land	The time criteria for the UAV to wait for heartbeat packages from the GCS, once the specified time has passed, the UAV will navigate to the closest Failsafe waypoint if Failsafe points are activated and continue to the landing waypoint for transition. Without Failsafe waypoints, aircraft will fly straight to Loiter Altitude what is connected with landing waypoint.

[6] Emergency parachute is used when available.

Continue Mission	Specifies the UAV to continue with the mission after link loss until achieving the last waypoint or another failsafe condition (e.g., battery critical, cannot maintain altitude, autopilot termination due to mechanical or electronic failure). the status bar and provides additional details.
GPS timeout	Is the period that the UAV will wait after losing GPS signal before commencing the action chosen on the right-hand side. Suggested value is 10-15 seconds. 1-999 seconds can be inserted.
SAVE	Send failsafe info to aircraft.
REFRESH	Receive confirmation from aircraft, that values got saved.

NOTICE

Fail-safe actions can be only saved if the datalink between GCS and UAV is established, refresh button is for confirming the proper values got saved.

11.7 SPEED OVERRIDE

This function allows the user to change the UAV speed when deemed necessary. For example, when following a target. The speed can be set back to normal value by pressing DEFAULT. 60-90 km/h (17,5- 25 m/s) can be inserted.

Speed override dialog is opened by clicking on the speed section in the status bar now.

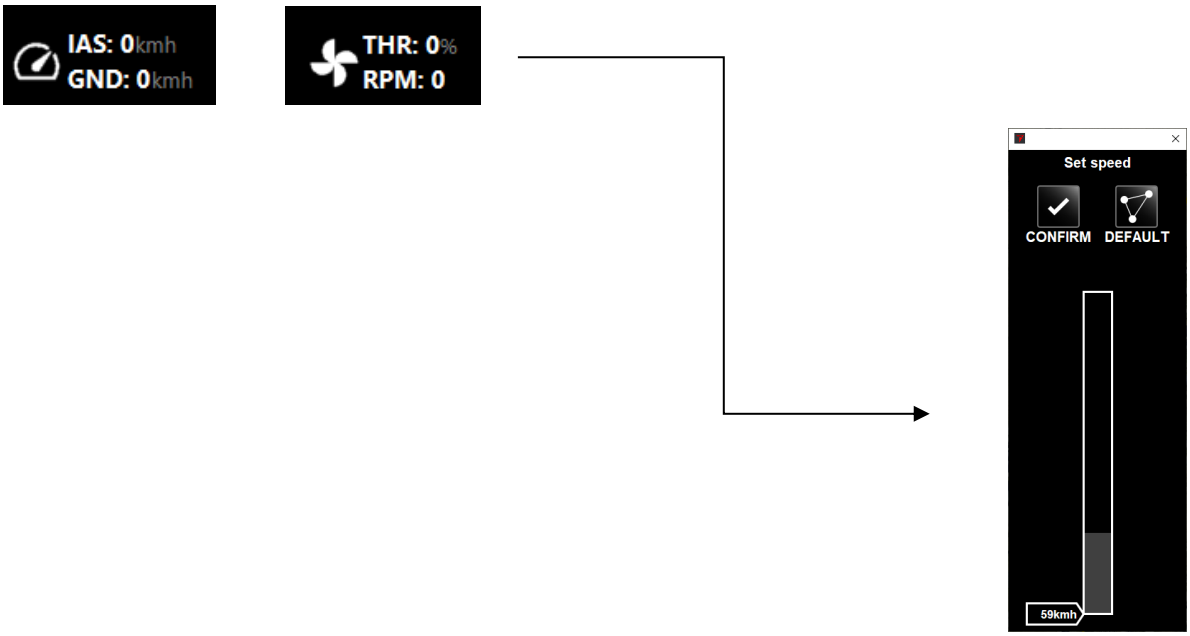


Figure 28 Speed override

NOTICE

SPEED OVERRIDE will be deactivated by autopilot:

- When aircraft enters Loiter Altitude waypoint (for example, loiter down before Landing waypoint 12.2.4).
- When aircraft enters Loiter Time Waypoint LOITER TIME WP12.2.5.
- When autopilot wants increase IAS, due to high wind, in a situation where set SPEED OVERRIDE is smaller than the speed what Autopilot would like to set.
- When activating MANUAL LOITER, or adjusting MANUAL LOITER location.
- When FAIL SAFE timeout is activated.

W AV then there is no option to change UAV speed as prior making a change it is required to obtain saved minimum and maximum speed values from the autopilot.

Figure 29 Speed override

CAUTION

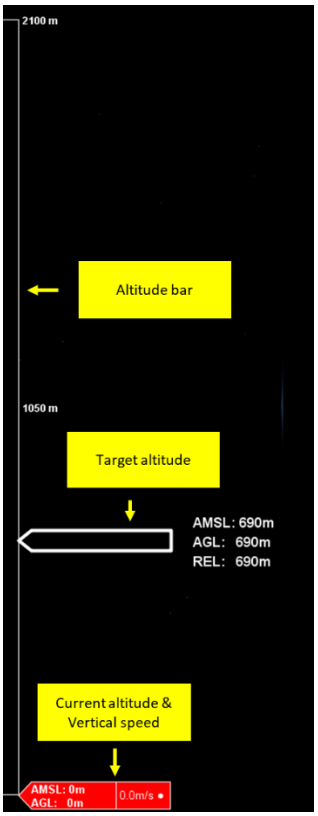
WHEN UAV IS PROCEEDING TO LANDING WAYPOINT, DO NOT ACTIVATE SPEED OVERRIDE!

Battery drainage is faster/flight time shorter!

1. The battery consumption can be up to 50% more rapid when flying at full speed.
2. Using speed override is not advisable during very turbulent weather conditions.
3. It is recommended not to use speed override when the GPS is off and the pitot failsafe is active.
4. When using speed override, pay more attention to altitude.
5. At high speeds, the aircraft may not descend from thermals[7] because the pitch is significantly limited by G-forces to prevent wing damage.
6. Speed override increases vibration in the aircraft and results in poorer video quality.

[7] Thermals are created by the uneven heating of Earth's surface from solar radiation, and they are an example of convection, specifically atmospheric convection. Glider pilots often utilize thermals for lift during flight. When soaring, these warm updrafts allow birds and gliders to ascend to higher altitudes without engine power. (Glider Flying Handbook published by the Federal Aviation Administration)

11.8 ALTITUDE OVERRIDE



AMSL is flight altitude of the UAV Above Main Sea Level (AMSL) (barometrical).
AGL is flight altitude of the UAV Above Ground Level (AGL) (calculated according to map layer).
REL is Relative (flight) altitude of the UAV (barometrical).

Vertical Speed is the rate at which an airplane ascends or descends.

Current Altitude is present altitude of aircraft. By clicking on it and dragging up or down is possible to set Altitude Override.
Target Altitude is altitude where it aims.

Altitude Override. This function allows you to override the flight mission altitudes uploaded to UAV with a single altitude value. This function can be employed only while a flight mission is in progress and there is connectivity between UAV and the ground station. This will enforce the UAV to follow previously active mission flight profile.

NOTICE

Altitude override will be deactivated by autopilot:

- When aircraft enters Loiter Altitude waypoint (for example, loiter down before Landing waypoint 12.2.4).
- When in flight FAIL SAFE condition is activated, Paragraph 19.3.

CAUTION

IN CASE OF A FAILSAFE CONDITION, ALTITUDE OVERRIDE WILL BE DISABLED.

WHEN USING ALTITUDE OVERRIDE, BE AWARE WITH RADIO LINE OF SIGHT (RLOS). DISPLAYED AS MIN LOS ALT ON GCS'S SCREEN.

- When Altitude override is active, target altitude will show Override.

- Vertical speed is 0.

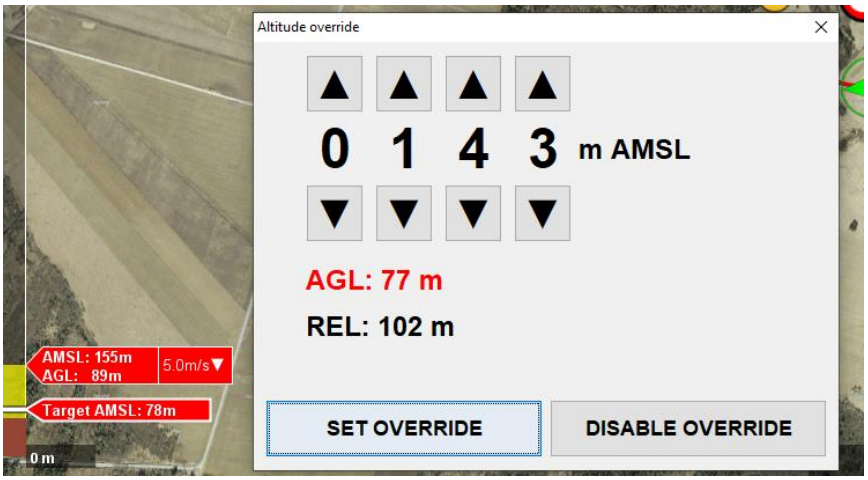


Figure 30 Altitude override window.

11.9 ALTIMETER SETTINGS

An altimeter or an altitude meter is an instrument used to measure the altitude of an object above a fixed level. The measurement of altitude is called altimetry.

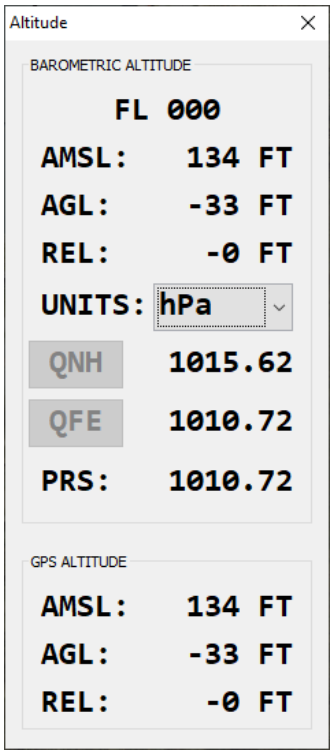


Figure 31 Altimeter settings

QNH Is an aeronautical Q code. Indicating the atmospheric pressure adjusted to mean sea level. It is a pressure setting used by pilots, air traffic control (ATC), and low frequency weather beacons to refer to the barometric setting which, when set on an aircraft's altimeter, will cause the altimeter to read altitude above mean sea level within a certain defined region.

QFE Refers to the altimeter setting that will cause the altimeter to read the height above a specific aerodrome or ground level, and therefore read zero on landing.

FL 000 Flight level is measured based on standard pressure. Values are indicated counting only first three digits. 10000 feet is indicated FL 100.

CAUTION

RELATIVE ALTITUDE (REL) IS AN ALTITUDE ABOVE LAUNCH LOCATION: IT IS NOT ALTITUDE ABOVE GROUND LEVEL.

11.10 FLIGHT PARAMETERS CHART

Chart can show flight parameters. Chart will be shown in separate window and can be opened by clicking on button in flight buttons section. In first opening automatically shows engine RPM, relative altitude, and air speed.

Timeframes for chart user can select are: 1min, 2min, 5min, 10min and 30min. User can select from checkboxes which parameters to show on chart.

Selecting from 30min to 1 min to 30min will not lose values (will not lose 29min of values in the example).

Extra features that are available with used chart library: create picture of the chart and export data on chart in CSV format.

Window is resizable - when resizing the chart size will change also. It has min size defined that control buttons/checkboxes will not be lost.

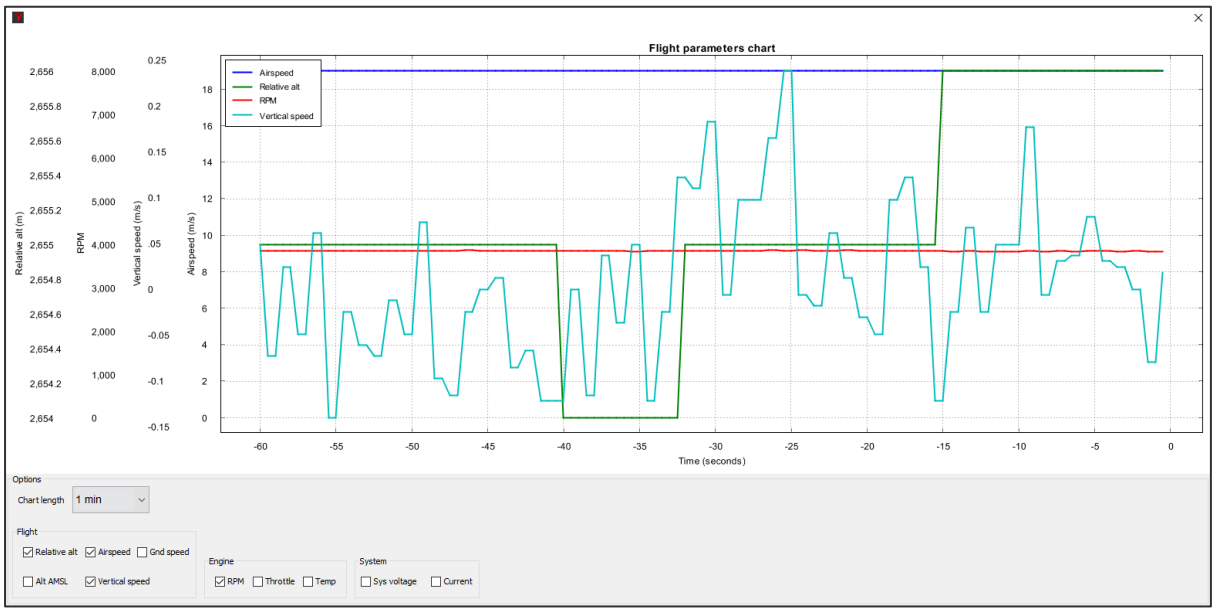


Figure 32 Flight parameter chart

11.11 SENSOR STATUS WINDOW

Sensor status window gives UAV operator a clear overview in one view (window) that indicates the status and health of all sensors/system components.

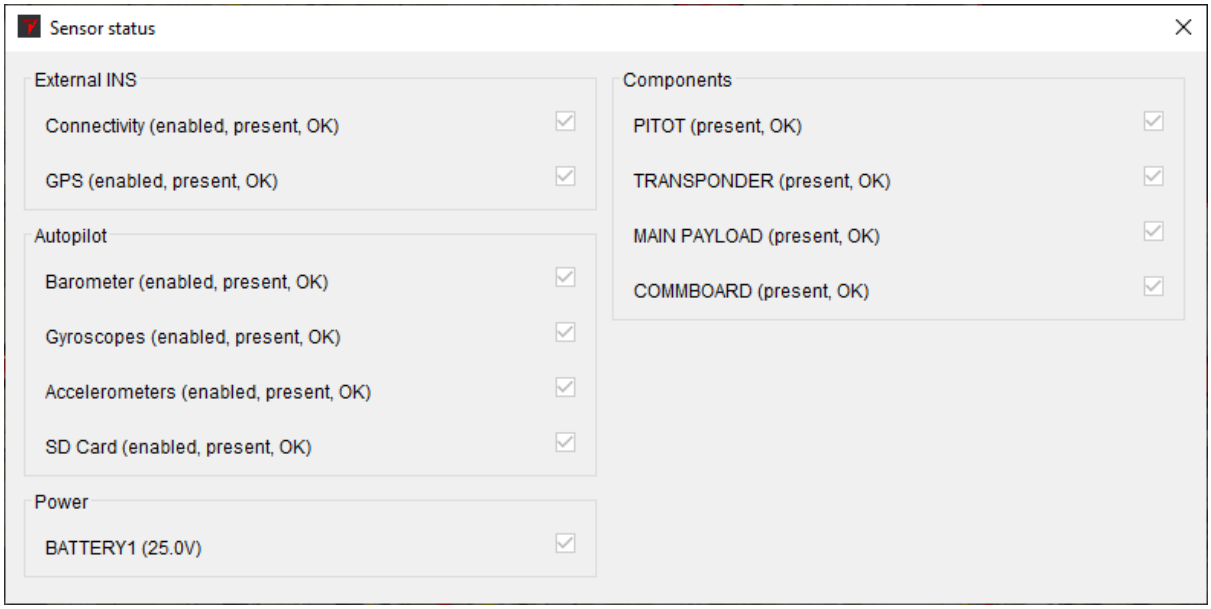


Figure 33 Sensor status window when no connectivity with UAV

NOTICE

Failures are indicated in red (also when no connection established with UAV).

UAV cannot ARM when one of the following is red or battery voltage is below 22 volts:

Connectivity, GPS, Barometer, Accelerometers, SD Card, PITOT or COMMBOARD.

CAUTION

IF ANY OF THE FAILURE OCCURS DURING PRE-FLIGHT CHECKLIST, ABORT THE ACTIVITY, LOG INFORMATION TO MAINTENANCE BOOK AND TO FLIGHT LOGBOOK THEN CONTACT Threod Systems (support@threod.com).

External INS in the sensor status bar will show different GPS statuses depending on the aircraft's configuration:

- GPS 2 is the regular configuration: Gimbal GPS is primarily used (Figure 36)
- GPS 1 is the anti-jamming configuration: autopilot GPS is primary (GPS 1), and Gimbal GPS is secondary (GPS 2) (Figure 36)
- If no GPS is found, a message will appear "No enabled GPS found in system." (Figure 36)

The GPS will show different flags after numbering that give information about the sensor status.

- Enabled – The sensor is enabled in the autopilot
- Present – Sensor info is updated
- OK – Sensor info is valid

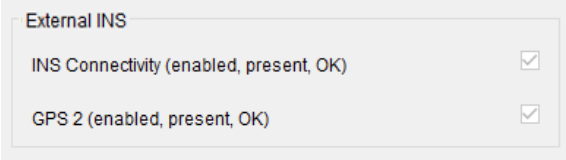


Figure 36 GPS numbering in regular configuration

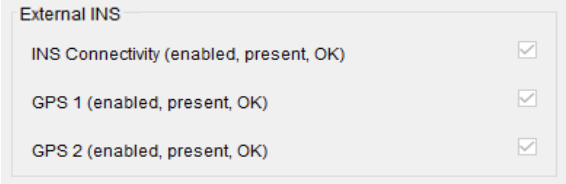


Figure 36 GPS numbering in anti-jamming configuration

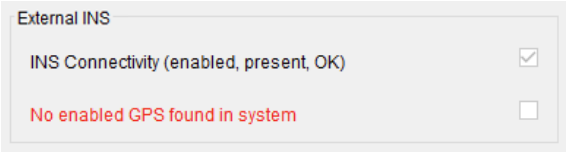


Figure 36 GPS numbering - GPS not found

NOTICE

It is not possible to manually change primary and secondary GPS.

The GPS communication diagram (Figure 122).

11.12 BATTERY

EOS C employs with two different battery size, 30Ah and 32 Ah LiPo battery. Inside battery is an integrated battery management system (BMS). It is necessary to engage refresh button to get up to date info.

- Click on battery voltage/current section to open battery info window.

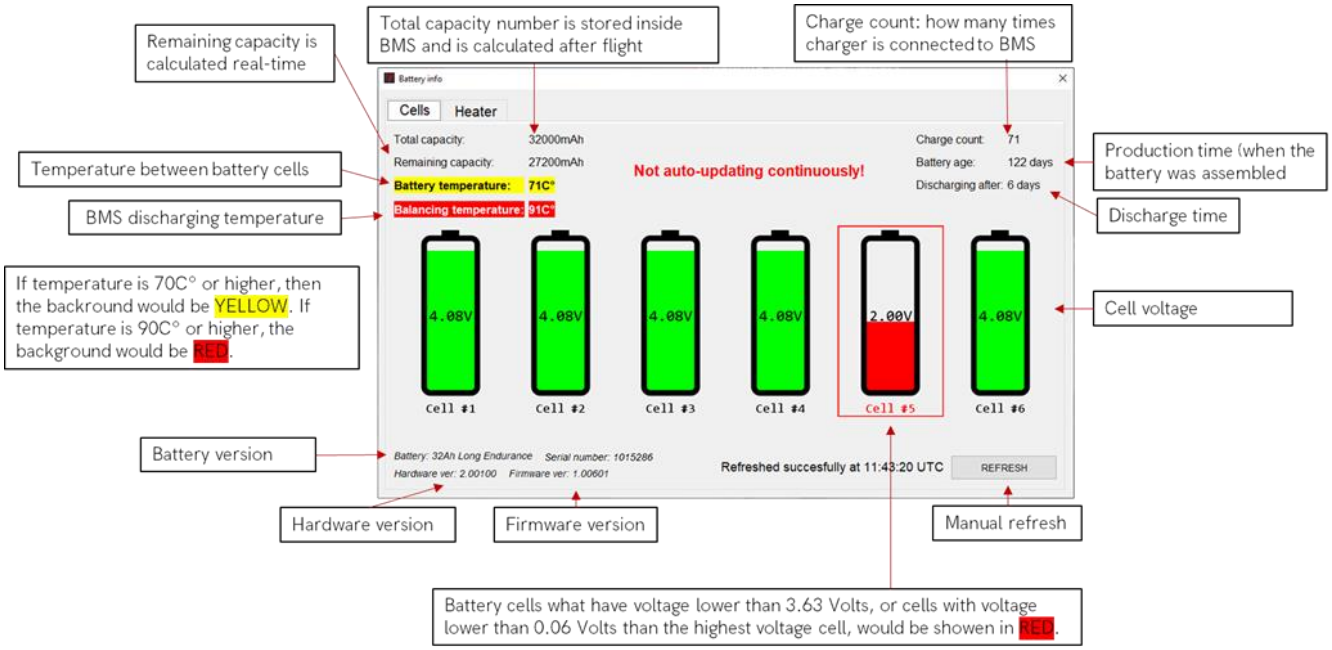


Figure 37 Battery info notifications

NOTICE

Battery usage is described in EOS C MAINTENANCE MANUAL.

CAUTION

BATTERIES IN RED INDICATE A BIG DIFFERNECE IN CURRENT BETWEEN THE DIFFERENT CELLS

11.12.1 BATTERY HEATER

Battery heating is to heat up or maintain battery cell temperature warm. Battery heating is automatically controlled by autopilot. Preheating is possible only with charger what has preheating functionality. Preheating goal temperature is 40°C. During the flight, battery is maintaining 18°C. When powering on aircraft, and battery inner temperature is lower than 18°C, then battery will be heated to 18°C. If heater window showing any about condition, it can be: Communication to heater controller has been lost, Battery does not have heater or BMS is dead.

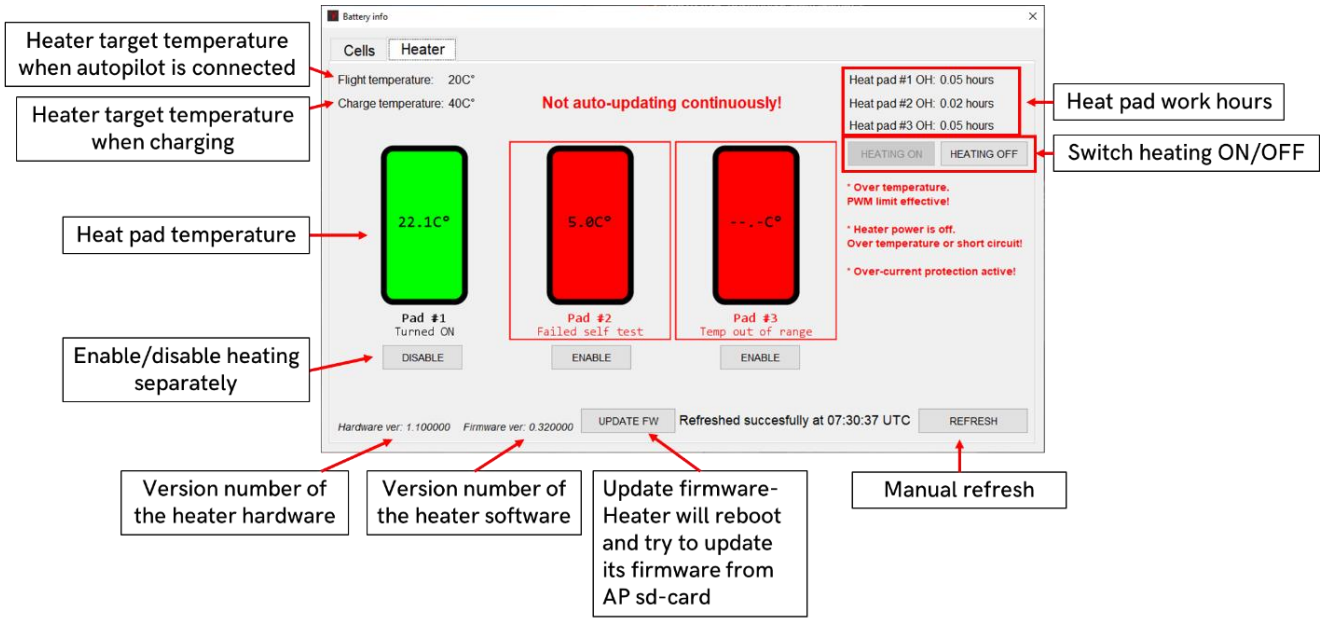


Figure 38 Battery heater window

Table 1 Heater notifications

Message	Description
Over Temperature. PWM (Pulse width modulation) Limit effective!	Recommended not to fly with that battery and contact Threod Support.
Heater Power is off. Over Temperature or short circuit!	Failure with heater controller.
Over-Current protection active!	Heater current consumption was higher than allowed.
Failed self-test	This error will be sent every 90 seconds if relevant heating pad power when tested was smaller than 20W (normal consumption).
Temp. out of range	Temperature is below -40 or over 200, which most likely indicates that its disconnected.

11.13 TRANSPONDER

Transponder is an automated transceiver in an aircraft that emits a coded identifying signal. the transponder sends a transponder code (or "squawk code", Mode A) or altitude information (Mode C) to help air traffic controllers to identify the aircraft and to maintain separation between planes. Mode S (Mode Select) is designed to help avoiding over-interrogation of the transponder (having many radars in busy areas) and to allow automatic collision avoidance. Mode S transponders are backward compatible with Modes A and C.

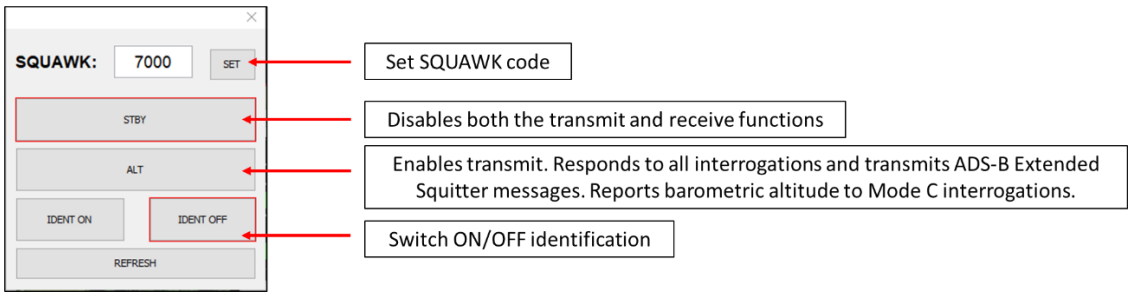


Figure 39 Transponder settings

Transponder needs to be configured via Wi-Fi adapter and mobile device application.

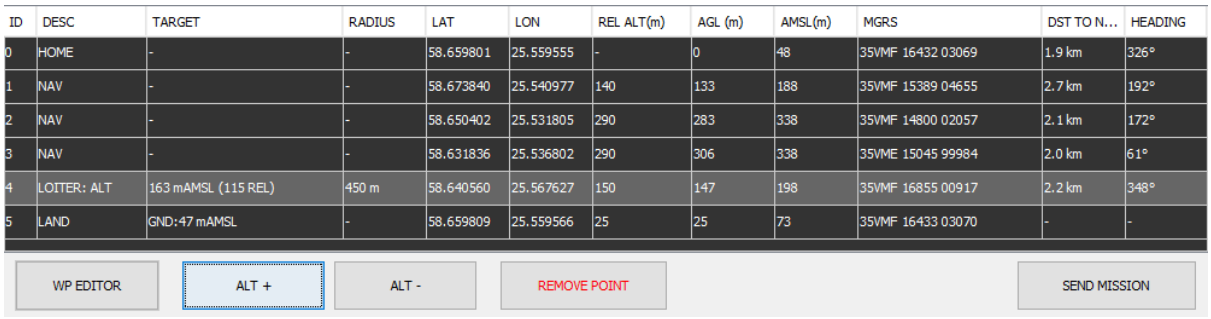
Contact with your local authorities for correct transponder settings!

12 WAYPOINTS

Waypoint editor.

12.1 WAYPOINT LIST

The detailed view of every added waypoint can be opened in a table when activating the Waypoints list option in the Mission Control sub-menu. This view provides a simple overview of the coordinates, altitudes, distance, heading and type of each waypoint.



ID	DESC	TARGET	RADIUS	LAT	LON	REL ALT(m)	AGL (m)	AMSL(m)	MGRS	DST TO N...	HEADING
0	HOME	-	-	58.659801	25.559555	-	0	48	35VMF 16432 03069	1.9 km	326°
1	NAV	-	-	58.673840	25.540977	140	133	188	35VMF 15389 04655	2.7 km	192°
2	NAV	-	-	58.650402	25.531805	290	283	338	35VMF 14800 02057	2.1 km	172°
3	NAV	-	-	58.631836	25.536802	290	306	338	35VME 15045 99984	2.0 km	61°
4	LOITER: ALT	163 mAMSL (115 REL)	450 m	58.640560	25.567627	150	147	198	35VMF 16855 00917	2.2 km	348°
5	LAND	GND:47 mAMSL	-	58.659809	25.559566	25	25	73	35VMF 16433 03070	-	-

Figure 40 Waypoint list

ALT + and **ALT -** will either increase or decrease altitude of all waypoints (not including loiter down target and land). Notice increase/decrease "by".

REMOVE POINT will delete point from the flight plan.

EDITOR will open waypoint editor.

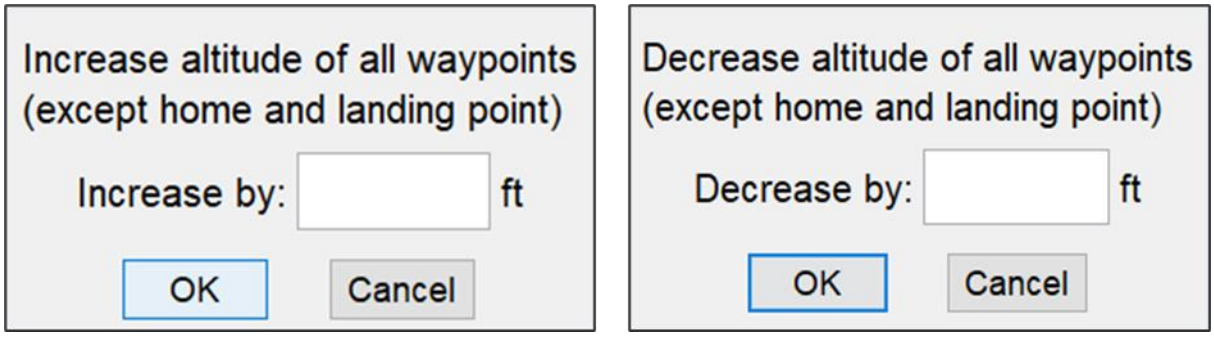


Figure 41 Increasing and decreasing WPs

12.2 WAYPOINT EDITOR

Waypoint editor applies to the selected waypoint and will act as a default for any waypoint created after that. The waypoint settings window allows the operator to assign waypoint types and add additional values to the waypoints that support it.

Operator can add, move, or delete waypoints by plotting crosshair in the center of the map or using written coordinates. Coordinate system can be either MGRS or Lat/Long format.

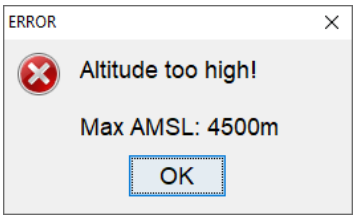


Figure 42 Maximum waypoint altitude warning

NOTICE

Maximum altitude for the waypoint can be 4500 meters AMSL.

First Navigation waypoint cannot be Loiter altitude or Loiter time waypoint.

Loiter altitude waypoint must be set before landing point.

12.2.1 HOME WP

Home WP is the initial point for flight mission. It must be placed precisely (to get accurate RELATIVE values) to the take-off location. Autopilot will update the position and altitude automatically and operator can see the correct place after downloading the mission from autopilot. If operator moves the home WP, then AMSL altitude will be automatically changed so that it is on the ground level. This will not reset position and altitude in autopilot. After downloading from autopilot, you cannot drag HOME waypoint anymore. For that you need to erase mission plan.

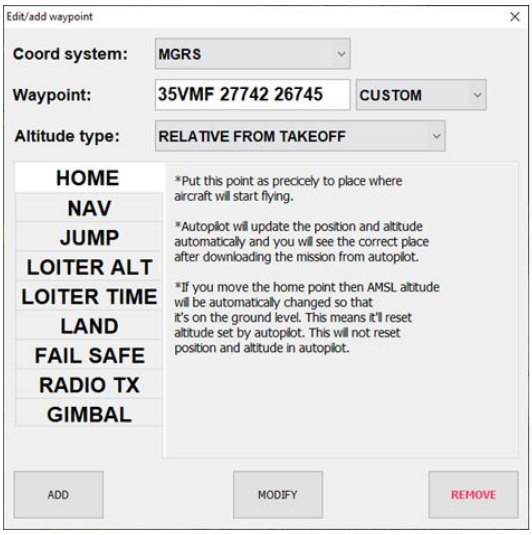


Figure 43 Home waypoint

12.2.2 NAVIGATION WP

Navigation WP is the most common point that UAV will use for flying. Navigation WP is defined by location and altitude.

WP is used as target location with coordinates and altitude. Whenever the autopilot detects inserted navigation waypoints, it will take each location and fly to it in sequence. The jump waypoint allows to point towards another waypoint regardless of ordering number.

Figure 44 Navigation waypoint

WP ALT is the altitude where UAV enters the point.

12.2.3 JUMP WP

Waypoints ID is the number of WP to where the UAV should proceed. If UAV arrives to named WP, it will take direction to defined WP.

Are used to create looped missions. A looped mission will continue until new commands are sent to the autopilot, the operator takes over control with the use of GUIDED mode or a failsafe condition is activated (e.g. empty battery).

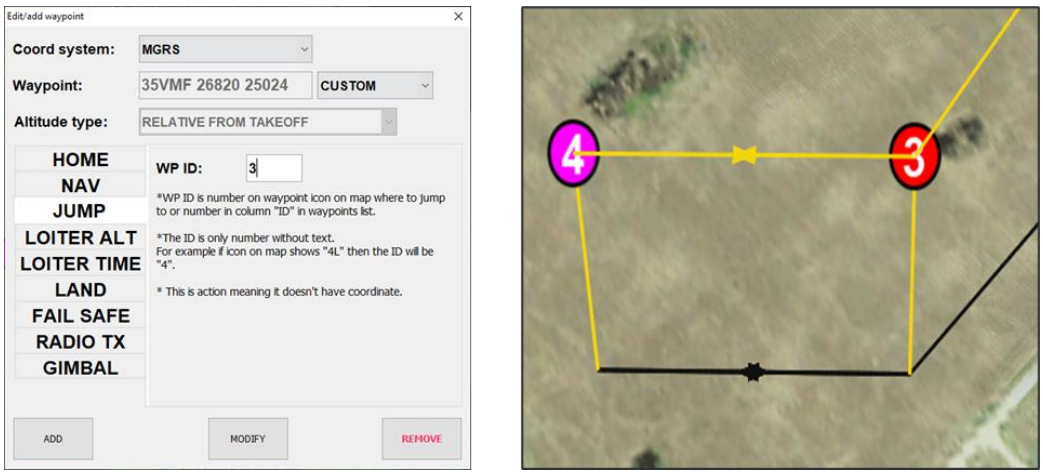


Figure 45 Jump waypoint

WP ID is waypoint number where it will jump to. (In the example picture it is from 4 to 3).

12.2.4 LOITER ALTITUDE WP

Loiter altitude is used when UAV must increase or decrease altitude inside of tight airspace, where normal climb/descent is not possible (mountains, ATC restrictions).

Before landing, there must be Loiter altitude WP created, to ensure flying to the Landing WP in safe altitude. In loiter down the descent starts at the centre of the loiter, not where the UAV entered the loiter.

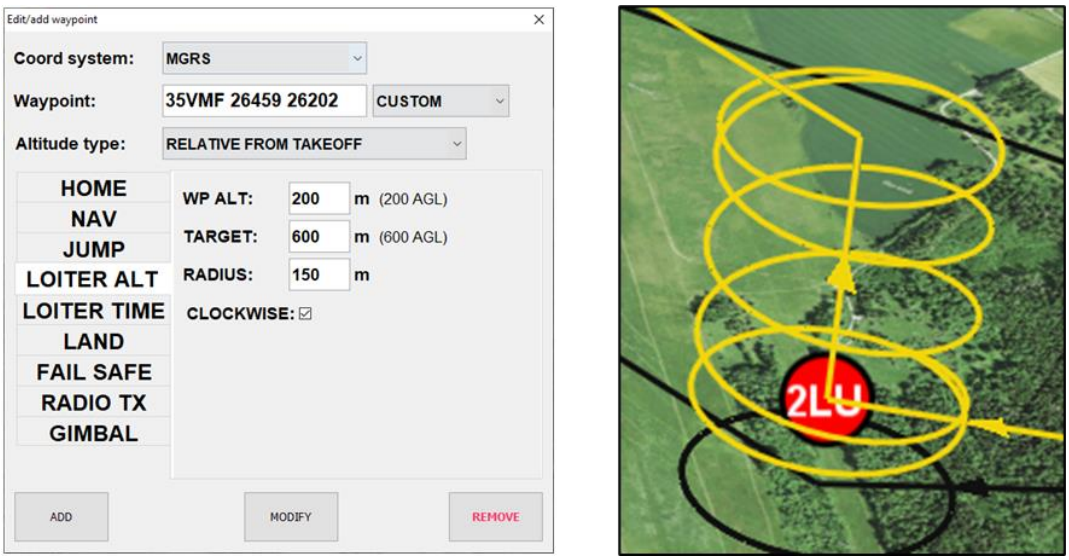


Figure 46 Loiter altitude waypoint

TARGET is the altitude where UAV leaves the loiter on the furthest point opposite to exit direction.

RADIUS define the lateral limits of the circle. Minimum value 150 meters.

CLOCKWISE without a tick in the box, the loiter is anti - clockwise.

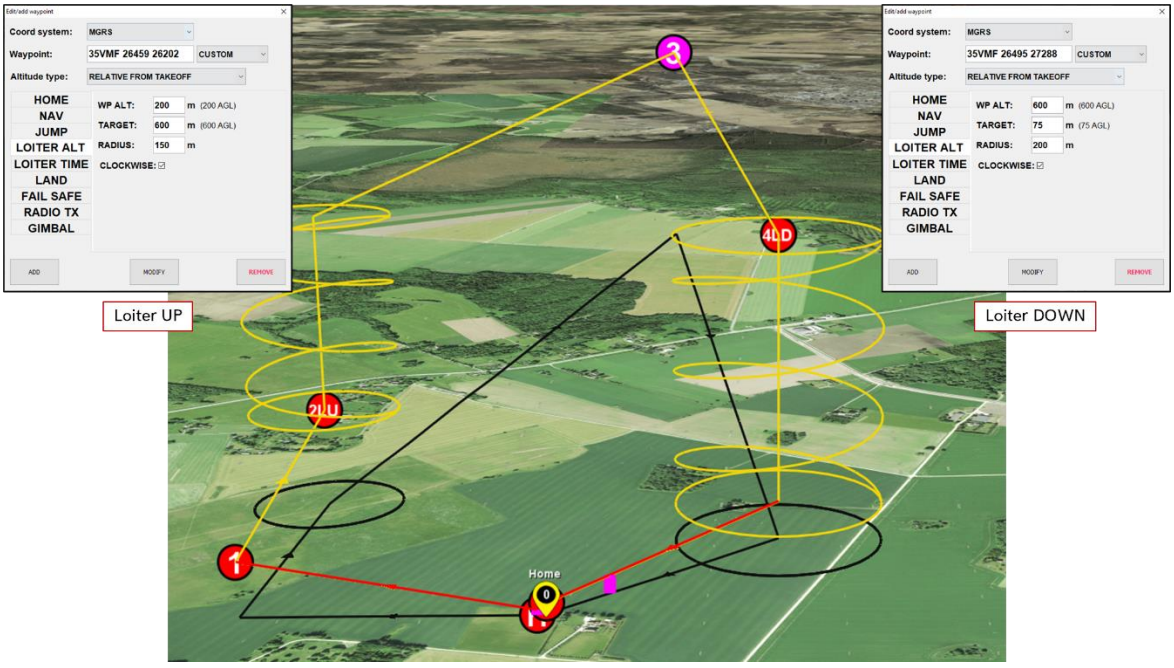


Figure 47 Loiter altitude usage

NOTICE

Altitude override will be turned off by autopilot in case of landing sequence is initiated by UAV entering the loiter altitude waypoint.

12.2.5 LOITER TIME WP

Operator can set loiter WP with specific time, shape, and position.

Orientation (direction) will set the direction of the loiter for figure 8, circle and racetrack.

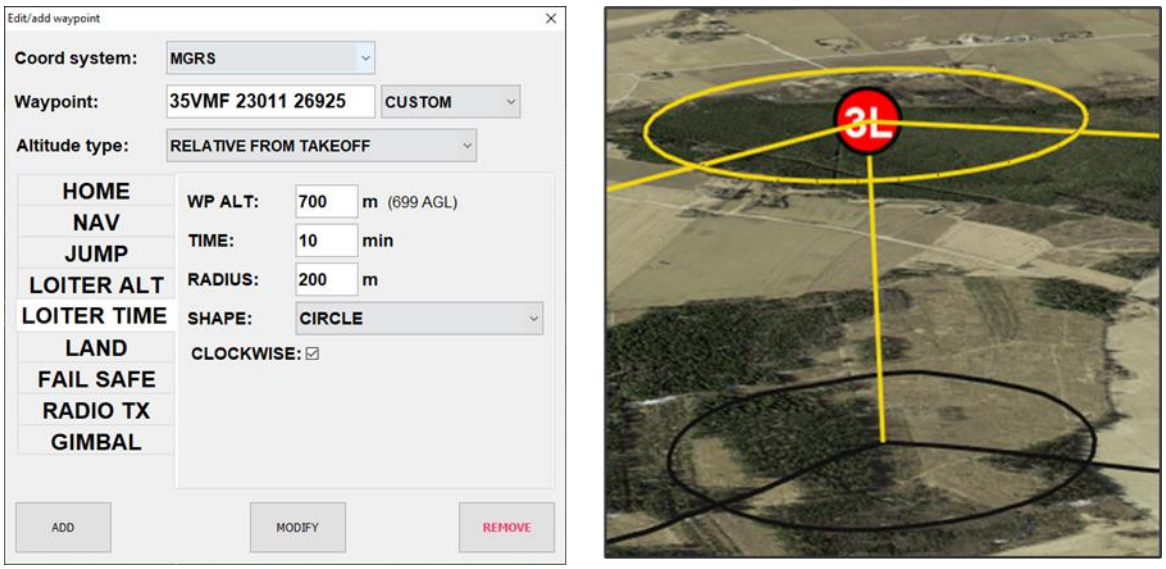


Figure 48 Loiter time waypoint

TIME is how long it stays in loiter.

SHAPE there are 3 types: circle, racetrack and figure 8.

ANGLE is for loiter shapes racetrack and figure 8. Choose from 0 and 45 degrees.

LENGTH define loiter figure size.

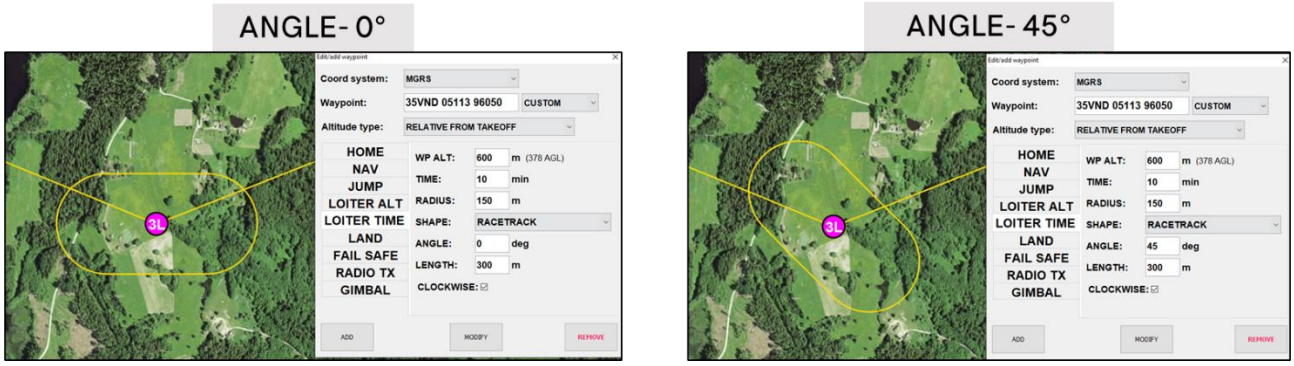


Figure 49 Loiter time/angle example

12.2.6 FAIL-SAFE WP

If fail safe action is selected as proceed to land, then UAV flies to nearest fail-safe WP. If fail-safe is not activated, then it acts as ordinary navigation WP.

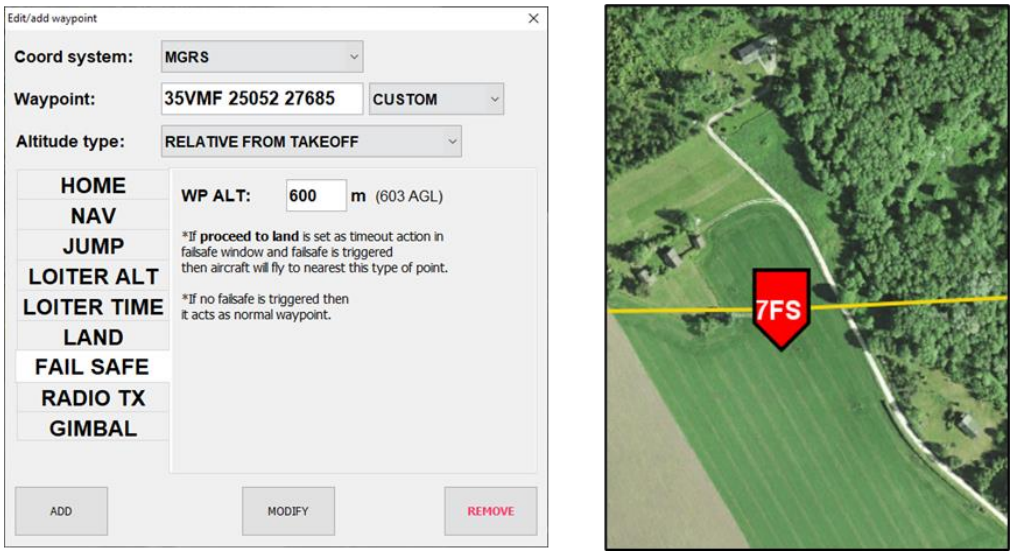


Figure 50 Fail safe waypoint

12.2.7 LAND WP

Land waypoint is the last waypoint for the mission. Before land waypoint, there MUST be a loiter ALT waypoint planned.

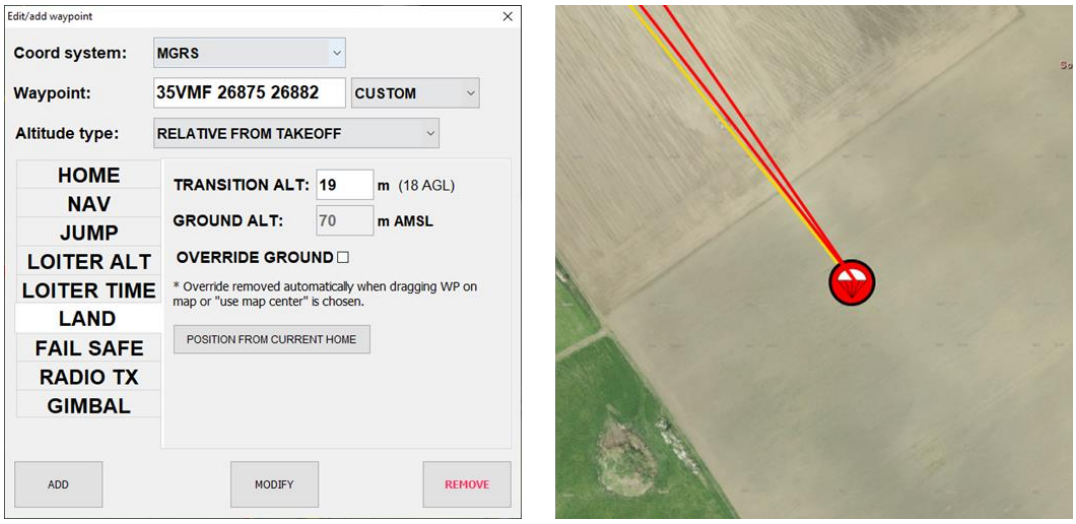


Figure 51 Land waypoint

TRANSITION ALT is transition altitude for VTOL.

OVERRIDE GROUND is to insert ground altitude manually (AMSL). Used for different landing location.

POSITION FROM CURRENT HOME by pressing this, it will take UAV HOME coordinates for landing waypoint. For this you need to have connection with UAV and UAV must be in take-off point. Without UAV connection or flying, it will set HOME coordinates.

12.2.8 RADIO TRANSMIT

With this action, it will enable or disable Aircraft radio transmission.

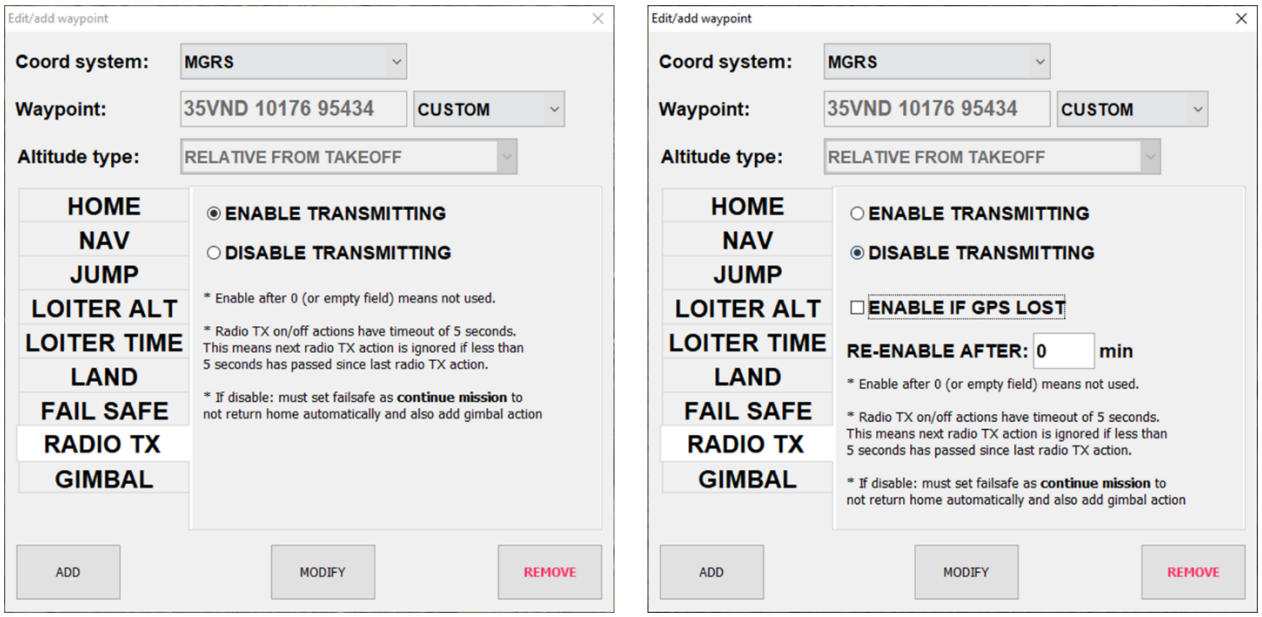


Figure 52 Radio Transmit action

ENABLE TRANSMITTING	Enables radio transmission
DISABLE TRANSMITTING	Disables radio transmission
ENABLE IF GPS LOST	When selected, it will activate radio transmission after GPS signal loss.
RE- ENABLE AFTER	After how many minutes later transmission will be enabled.

NOTICE

RADIO TRANSMIT can be re-edited only in Waypoint list!

CAUTION

FOR A FLIGHT WITH DISABLED RADIO TRANSMISSION, SHOULD BE COOSED “CONTINUE MISSION” FOR “TIME OUT ACTION” UNDER FAIL SAFE WINDOW.

12.2.9 GIMBAL ACTION

With this action Gimbal will hold specified angel or coordinates with specified Zoom and sensor. LOOK HERE blue cross is visible on map only when action point is selected and gimbal mode is LOOK AT LOCATION.

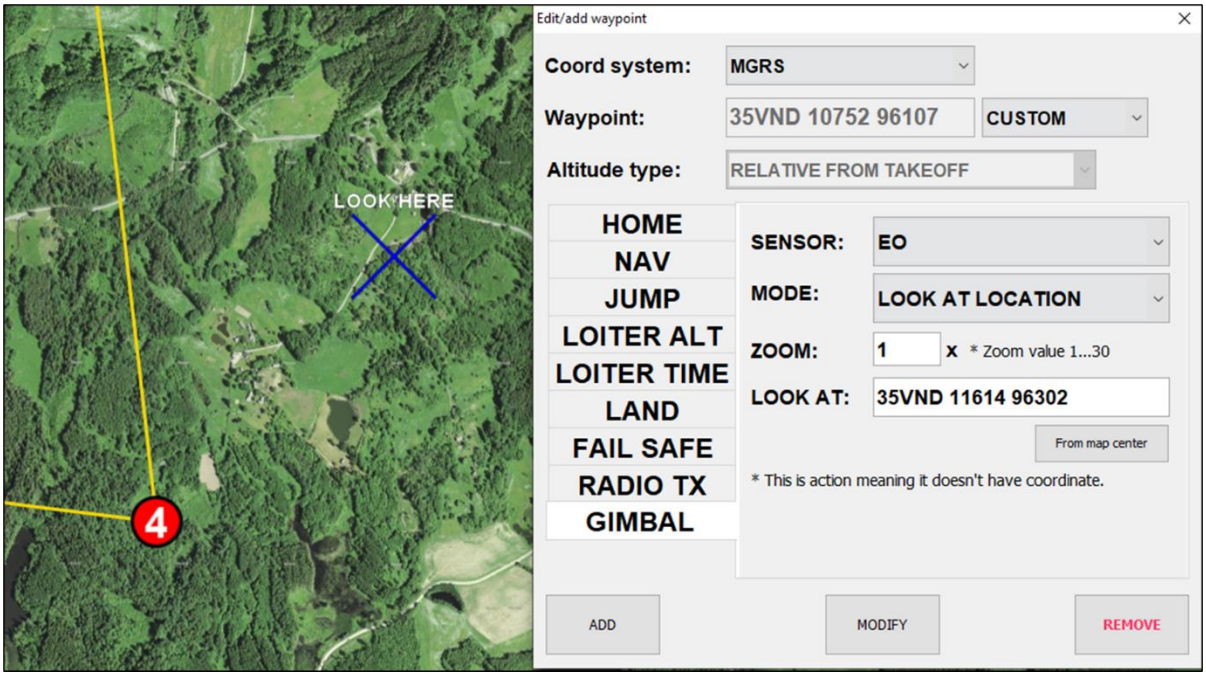


Figure 53 Gimbal action

SENSOR	Choose sensor EO/IR
MODE	Define gimbal angle. LOOK AT LOCATION (coordinates), LOOK DOWN, LOOK FORWARD 45°, LOOK LEFT 45°, LOOK RIGHT 45°
ZOOM	Sensor zoom: EO 1…30x, IR 1…8x
LOOK AT	Coordinates for LOOK AT LOCATION
From map center	By clicking this, will use Map center coordinates for LOOK AT LOCATION

12.2.10 TIME CALCULATION TOOL

The mission time estimate tool can be found in the waypoint menu. The tool gives an estimate of how long the maximum playtime and total flight time are. The calculation error rate may differ from real-time by 5-10%. The time estimation tool only uses a straight path in the calculation using three points: home-loiter-home (Figure 55). The calculation does not consider the mission route or other waypoints even if values are read from the mission. The calculation assumes the home point and landing point are the same. If multiple landing points are used, the calculation uses the first one. The mission time estimate tool's purpose is to plan missions ahead of time, before flying, and get estimated flight time and playtime. If the aircraft is already flying and mission time is calculated during flying, the total flight time is shown, not the remaining flight time.

Battery: The battery model influences flight time. It is presumed in the calculations that new batteries are used. The 30Ah battery is chosen by default. In case the battery is 32Ah Long Endurance with a heater, the box must be ticked and air temperature is chosen to get a more accurate result.
Airspeed: Default airspeed is 60 km/h and max airspeed is 90 km/h. The higher the speed, the shorter the flight time.
Loiter distance: The perimeter of the loiter. If multiple loiters are in the mission, the calculation uses the furthest.
Azimuth to loiter: The azimuth from home point to loiter.
Home altitude: The home altitude that is measured in AMSL.
Transition altitude: The altitude from which the aircraft transitions in the home point from multirotor to fixed wing.
Cruise altitude: The highest used altitude should be entered.
Land transition altitude: The altitude from which the aircraft transitions from fixed-wing to multirotor before landing.
Wind: It is possible to choose wind speed and direction.

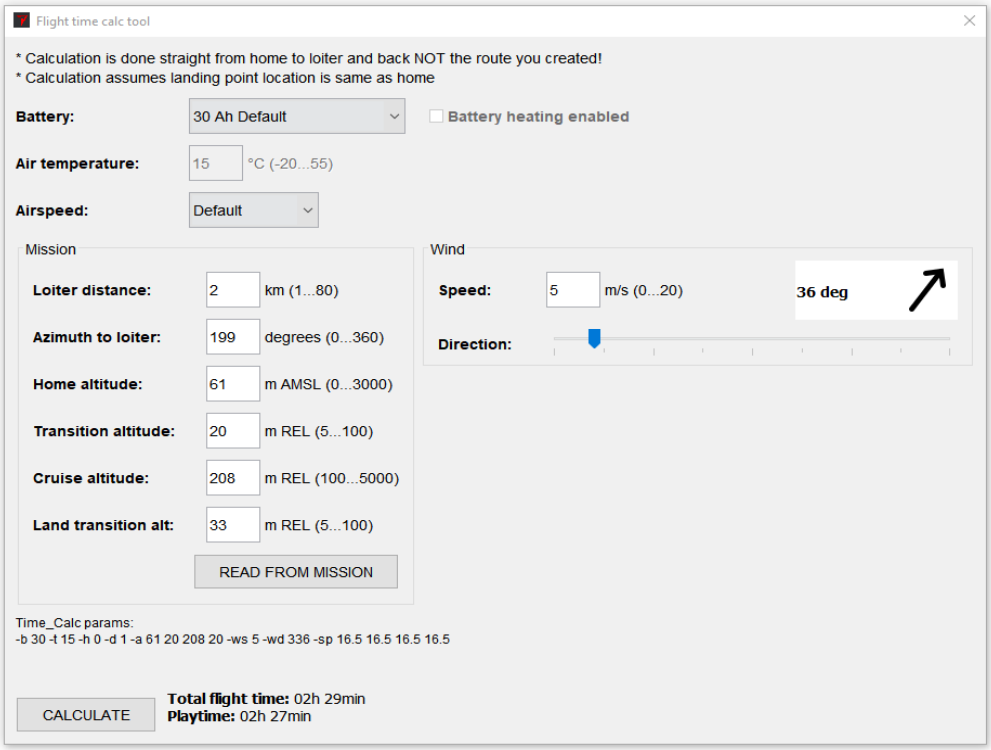


Figure 54 Flight time calculation tool

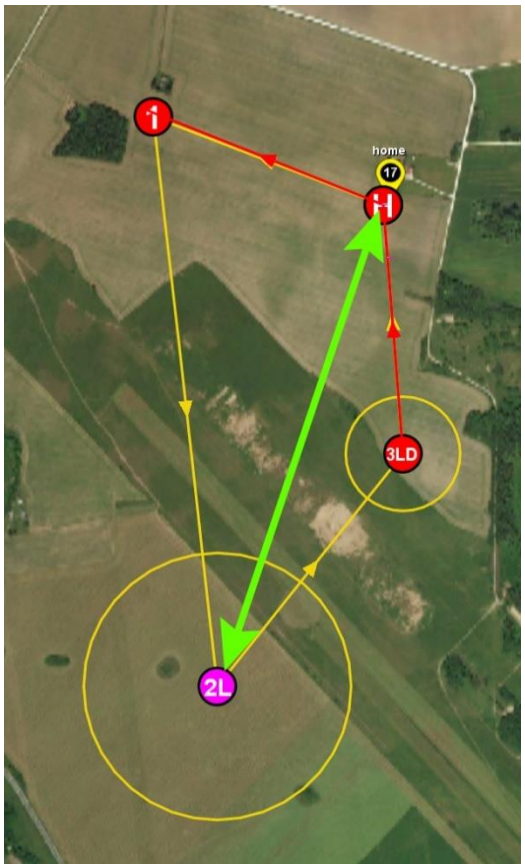


Figure 55 Mission route vs distance time calculation uses

12.2.11 ACTION WAYPOINT EXAMPLE

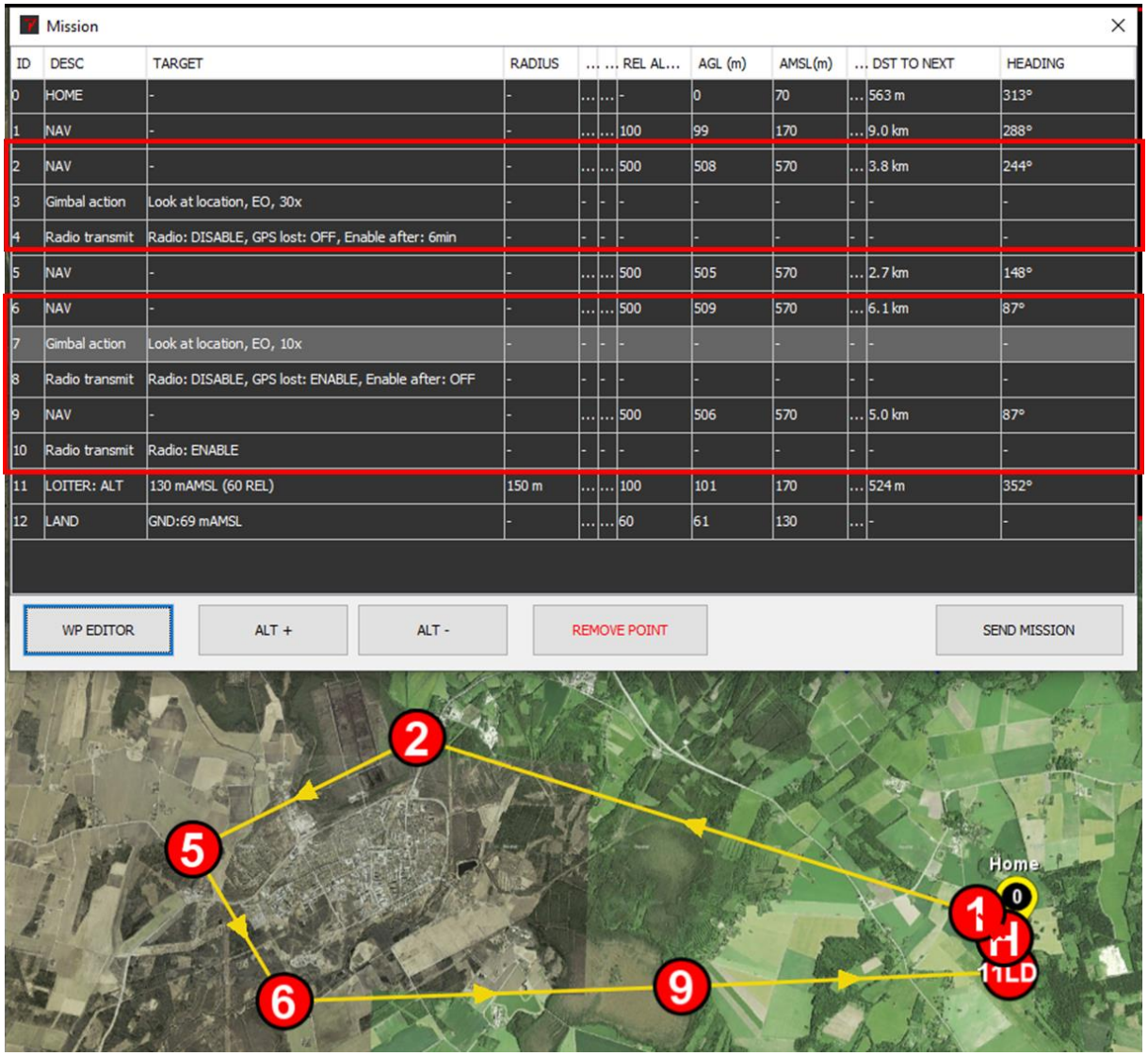
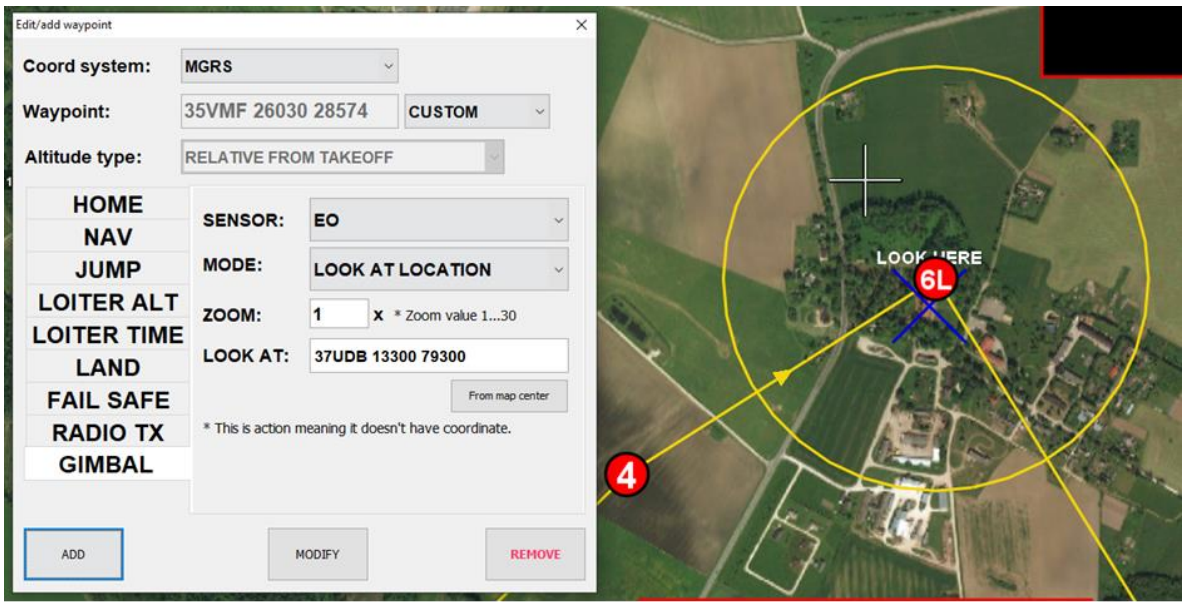


Figure 56 Action waypoint example

When Aircraft flies through 2nd WP, Gimbal will be set to EO sensor looking at specified coordinates. Radio TX will be disabled. No action with loss of GPS signal. Tx will be activated after 6 minutes.

In Waypoint 6, Gimbal will be set to EO sensor looking at specified coordinates. Radio TX will be disabled. When GPS signal will be lost, TX will be activated. If GPS was not lost, then Tx will be activated in waypoint 9.

Gimbal action for Loiter time or Loiter altitude waypoint, must be added to previous waypoint (in this picture 4th waypoint).



ID	DESC	TARGET	RADIUS	...	...	REL ALT(m)	AGL (m)	AMSL(m)	...	DST TO NEXT	HEADING
4	NAV	-	-	...	...	600	604	670	...	689 m	57°
5	Gimbal action	Look at location, EO, 1x	-	-	-	-	-	-	-	-	-
6	LOITER: CIRCLE	10 min	400 m	...	...	600	596	670	...	2.3 km	148°

Figure 57 Gimbal action for Loiter time

12.2.12 MISSION ROUTE LINE EXPLANATION

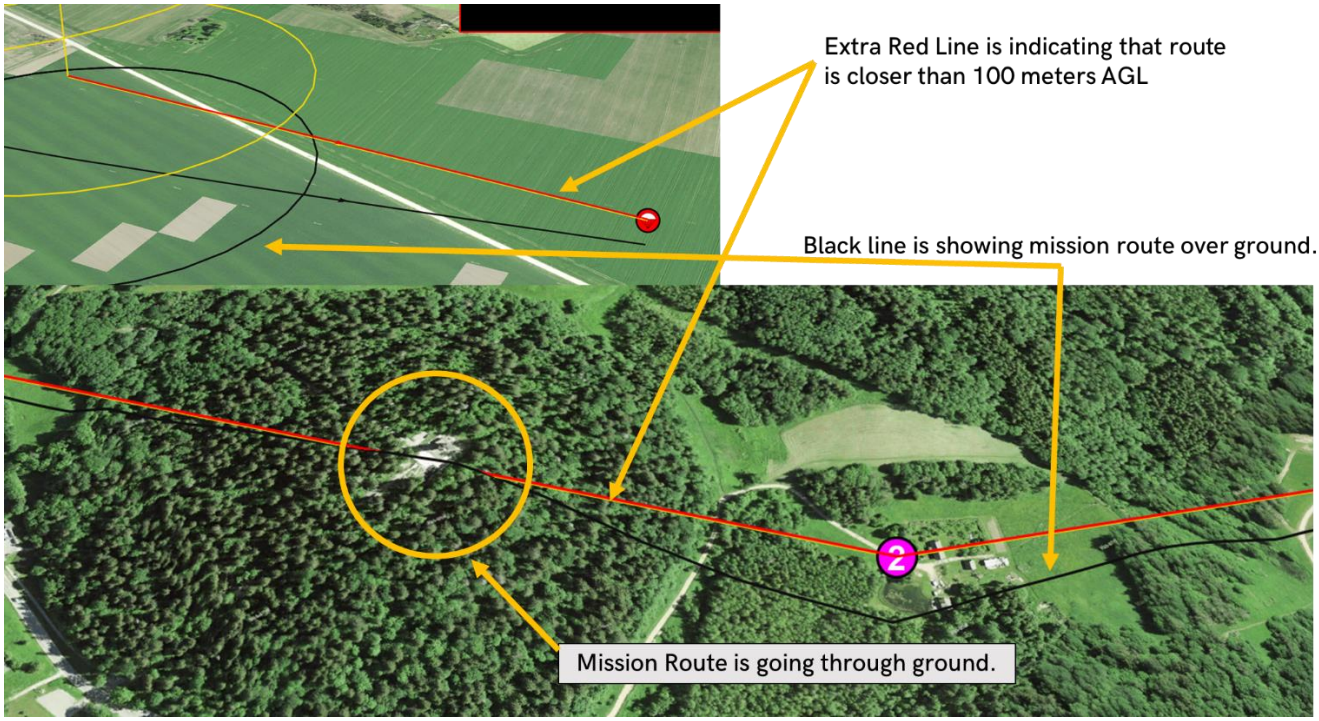


Figure 58 Mission route line explanation

12.3 WAYPOINT CONTROLS

ACTIVATE – Operator is able to move WPs on the map.

DOWNLOAD – Downloads the flight plan from UAV autopilot to GCS.

UPLOAD – Uploads the flight plan from GCS into UAV autopilot.

ADD WAYPOINT

REMOVE WAYPOINT

SAVE / LOAD / DELETE – Operator is able to save, load and delete previously saved flight plans.

DELETE – Will delete entire flight plan depicted on the map. Prior deleting system will request confirmation.[8]

ALTITUDE-ELEVATION RELATION CHART – Check the flight plan and waypoints relation to ground elevation.

Time CALC – Open flight time calc tool

[8] In case flight plan in use was deleted on the map it is possible to restore the plan by downloading flight plan from UAV autopilot.

12.4 ALTITUDE-ELEVATION RELATION CHART

Altitude relation chart is an assistive tool to check the flight plan and waypoints relation to ground elevation. Chart is used in mountainous regions mainly. Shall be checked before each flight.

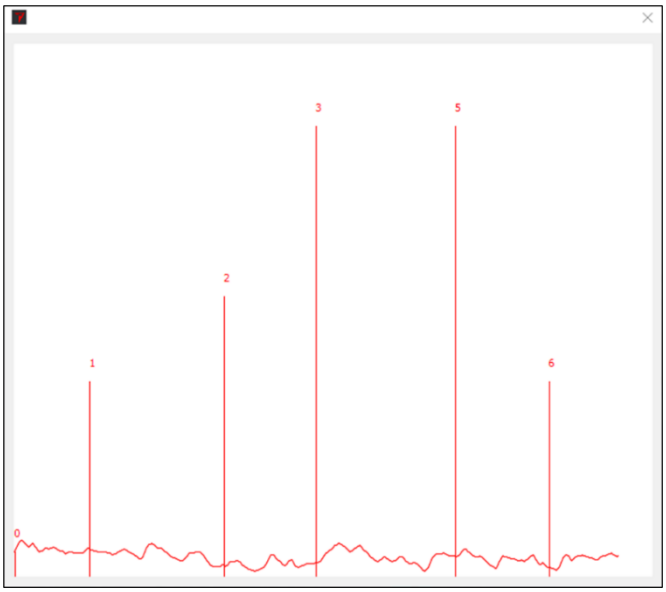


Figure 59 Altitude elevation relation chart

12.5 FLIGHT INFO

With right click on waypoint, you get Flight info. During the flight or pre-flight, it is possible to use Flight info tool. It will show estimated time to selected waypoint and distance.

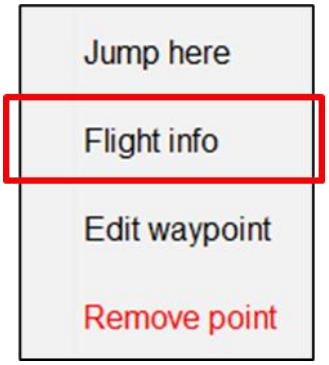
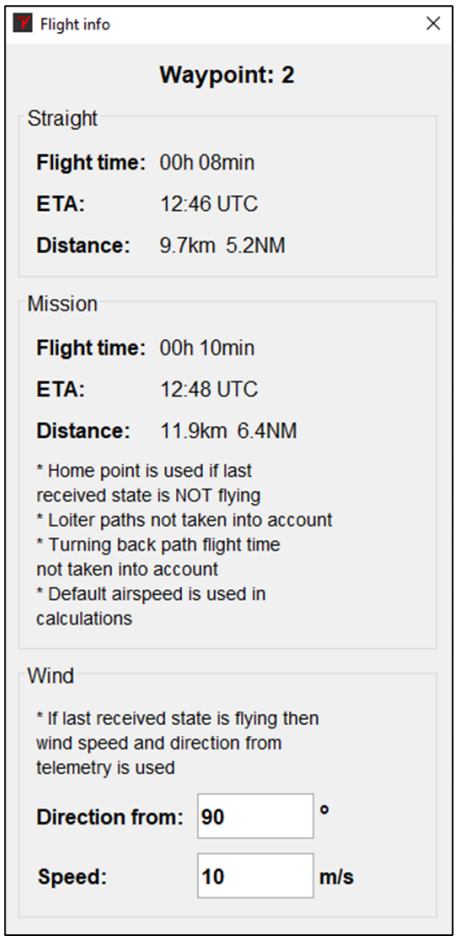


Figure 60 Flight info



Straight- shows direct flight values.
If aircraft is connected, then it will be from aircraft location to the selected WP.
Without aircraft connection it is from HOME WP to the selected WP.

Mission- shows flight values according planned mission.
If aircraft is connected, then it will be from aircraft location to the selected WP.
Without aircraft connection it is from HOME WP to the selected WP. When MANUAL LOITER is activated, then mission calculation is not available.

Wind- after GCS software start, is no telemetry received from aircraft. Then user can set wind direction and speed manually.

Figure 61 Flight info window

NOTICE

Inflight aircraft will use automatically measured wind direction and speed.

13 FLIGHT MODE

Open flight mode settings from the status bar[9]. Flight Mode[10] switches between GUIDED MODE[11] and AUTO MODE. Guided Mode is for emergency situations, options include **START LOITER**, **FLY TO HEADING** and **FLY BY CAMERA**.

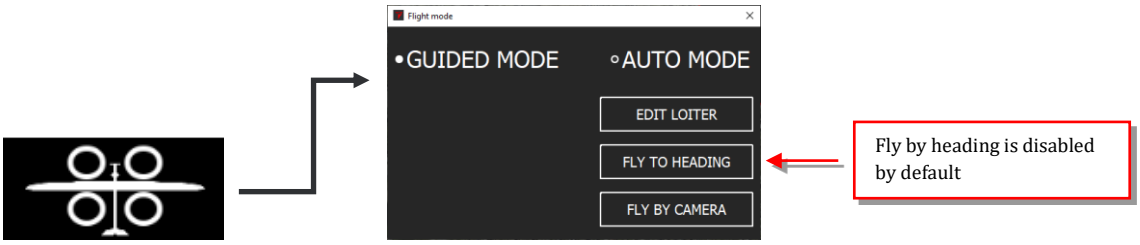


Figure 62: Flight mode window

13.1 QUICK LOITERING

Quick loitering allows you to create loitering point. You can create quick loitering point by choosing the quick loitering button or by clicking on the map and creating quick loiter. By choosing the button, it will create the loiter around UAV location.

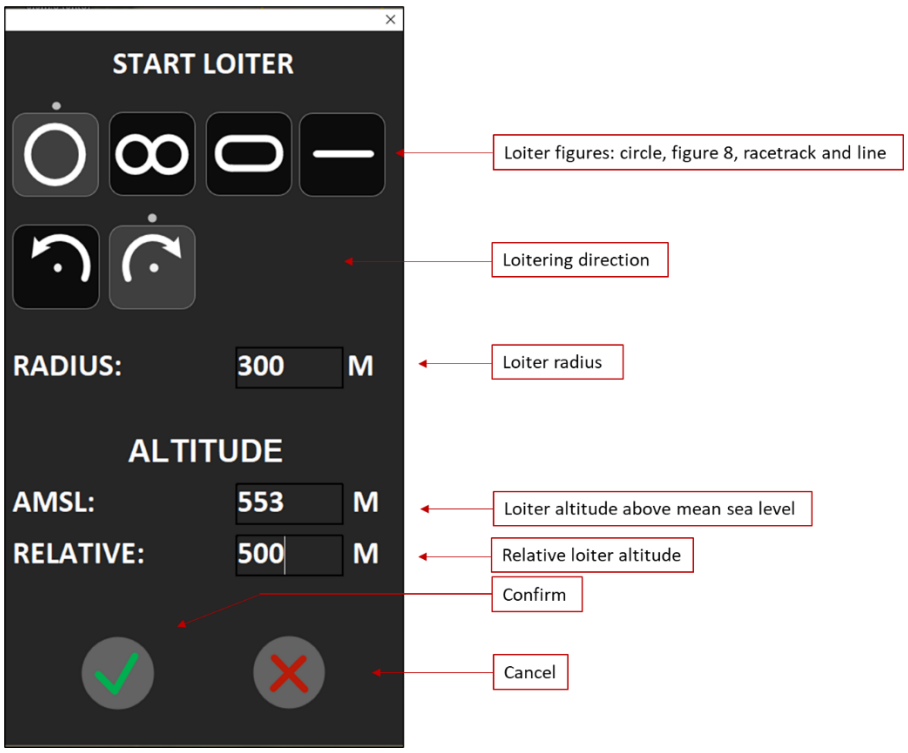


Figure 63 Quick loitering

[9] 2023-03 Release
[10] 2022-06-08 Update
[11] Chapter 21

NOTICE

Pay attention to given values and entry location.

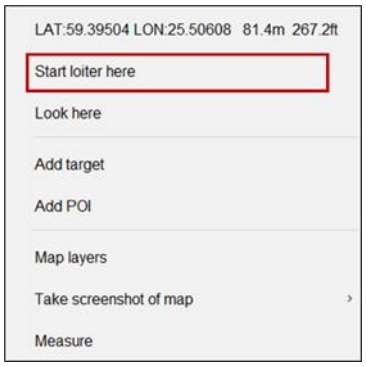


Figure 64 Creating loiter on the map

13.2 FLY TO HEADING

Is a function to route aircraft towards assigned heading and flight level required from the air traffic control or any other relevant authority.

To create Quick heading, you need to choose Distance or Time to fly Loiter. Loiter will be created with 500-meter radius. If you choose time, it will create Manual loiter into defined heading. Distance will be calculated in GCS taking into consider current wind speed/heading and set IAS. It will stay in this loiter until next command or after Playtime gets 0.

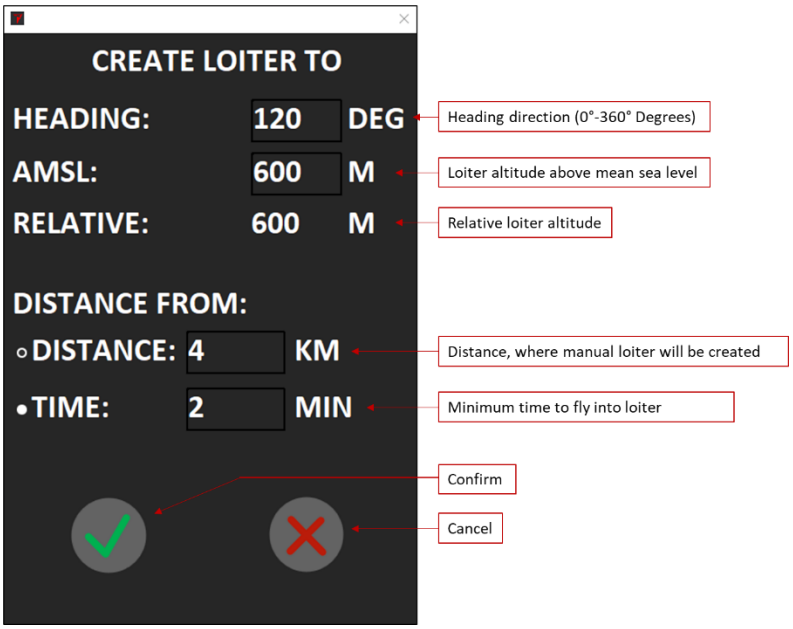


Figure 65 Quick heading

- NB! Feature must be enabled in configuration

NOTICE

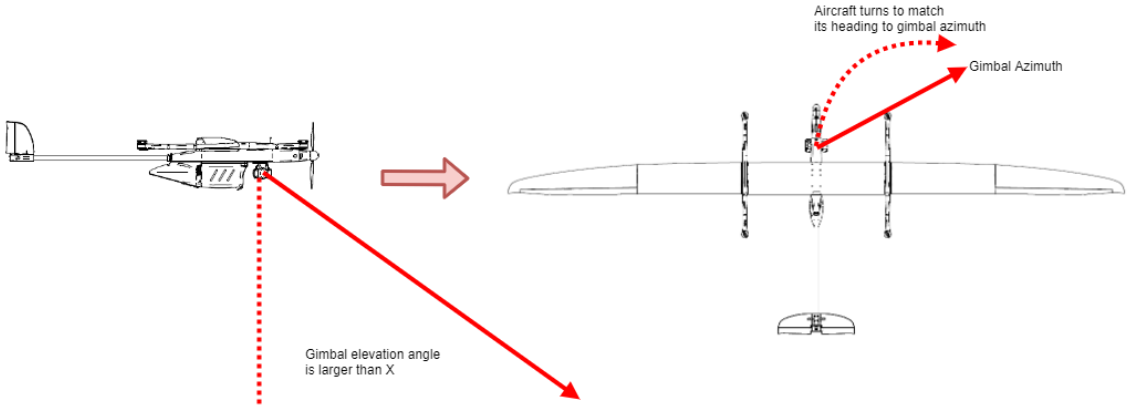
Pay attention to given values and entry location.

Altitude reference used in general aviation is mostly in AMSL.

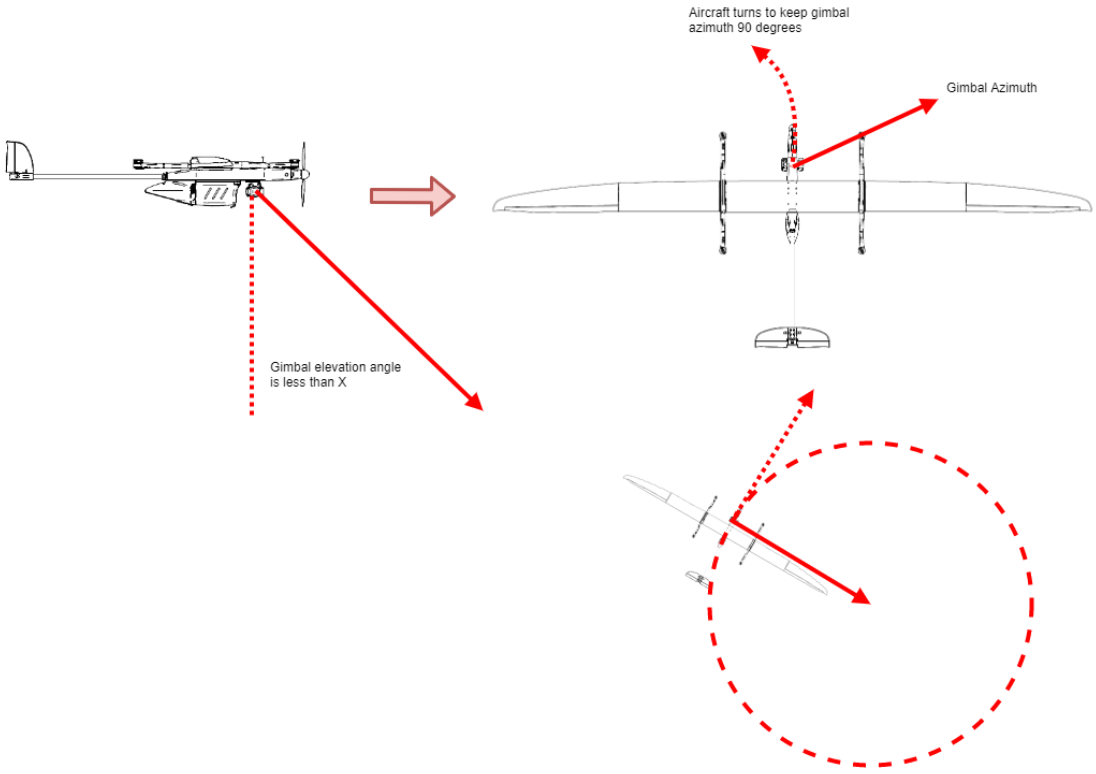
13.3 FLY BY CAMERA

Fly-by-camera is a flight mode where the aircraft flies where the gimbal (camera) is pointed to. This flight mode is independent of GPS navigation and can be used as a backup to navigate back home.

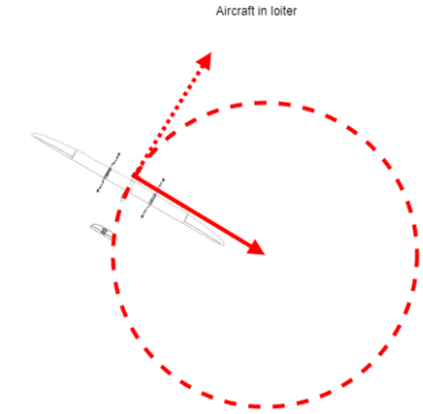
Flight direction is determined by gimbal azimuth. Limiting factor is gimbal elevation angle (tilt) - if the elevation angle is low, aircraft starts loitering around gimbal target. Gimbal tilt boundary is 45 degrees down where aircraft starts loitering.

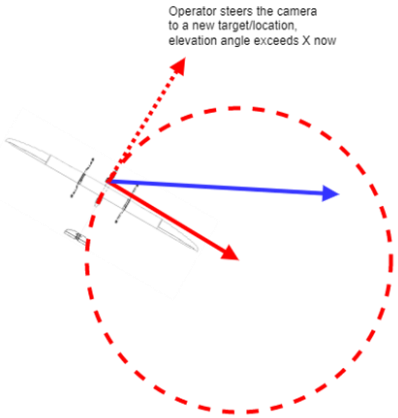


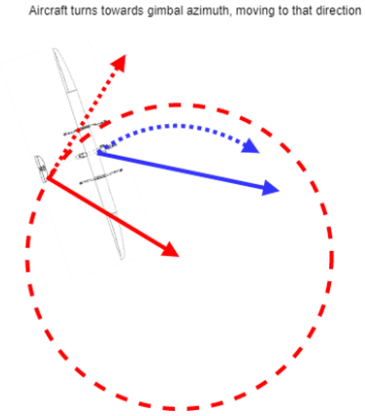
Aircraft turns to match gimbal azimuth when elevation is greater than X - this behaviour is the main component of fly-by-camera and target tracking and results the aircraft flying where the gimbal is pointing.

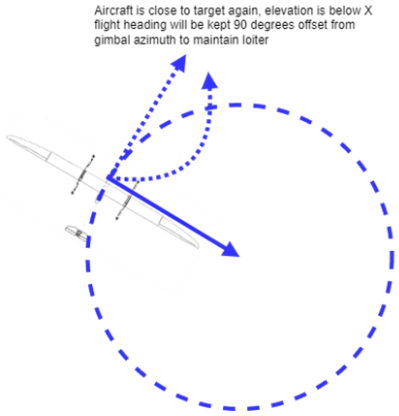


Aircraft enters loiter when gimbal elevation angle is smaller than X. User should be able to switch between left-hand and right-hand loiter.


Aircraft in loiter


Operator steers the camera
to a new target/location,
elevation angle exceeds X now


Aircraft turns towards gimbal azimuth, moving to that direction


Aircraft is close to target again, elevation is below X
flight heading will be kept 90 degrees offset from
gimbal azimuth to maintain loiter

14 MAP SETTINGS

Map controls.

14.1 MAP CONTROLS

CENTRE UAV will set UAV in the centre of screen and hold it.

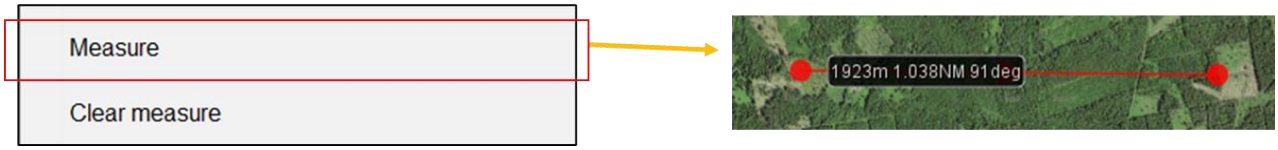
FOLLOW TARGET will set payload crosshair in the centre of screen and hold it.

GIMBAL ORIENT will keep map according to payload orientation.

MEASURING TOOL is displaying distance in nautical miles, kilometers, and angle in degrees.

Figure 66 Measuring tool

It is possible to use right click on map for measuring:



14.2 RADIO COVERAGE CALCULATION

RF area coverage calculator tool is meant to be used as an estimator for radio coverage, taking the elevation data into account. To configure, input as precise data as possible. Increase the flight altitude and/or antenna height to gain more area coverage. The max range is determined only by the desired distance and line-of-sight (LOS), (transmitter strength is not taken into consideration when using this tool).bb Max range is 100km.

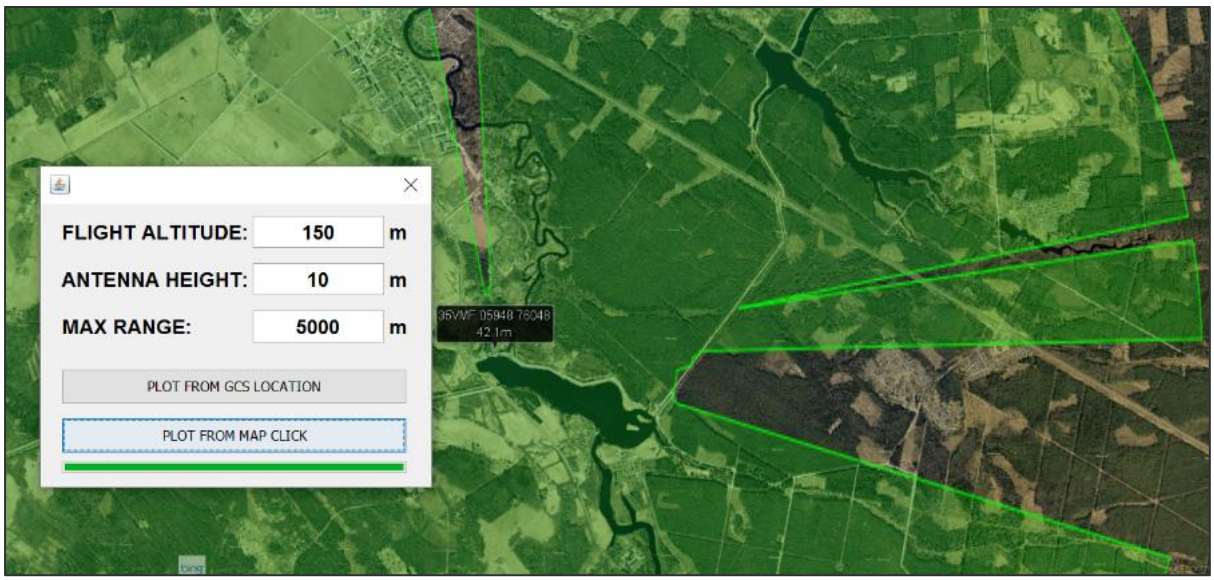


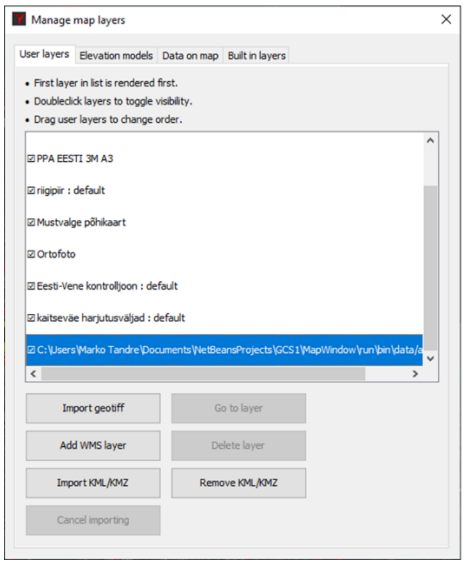
Figure 67 Radio coverage calculation

14.3 MAP LAYERS

A “Manage map layers” window will open that lets you enable or disable the layers and change their relative order. To enable or disable double click on the layer. To change the order, click and drag the layer to a different position.

14.3.1 USER LAYER

User layers window will present options that let you enable or disable the layers and change their relative order. To enable or disable double click on the layer. To change the order, click and drag the layer to a different position.



Import geotiff- Imports geotiff file

Add WMS layer- Adds WMS (web map server)

Import KML- Imports vector layers in Google Earth KML format

Go to layer- Go to layer

Delete layer- Deletes layer from the hard disk

Remove KML- Removes layer

Cancel importing- cancels importing

Figure 68 User layer management

User map layers are stored under C: folder in hidden folder ProgramData.

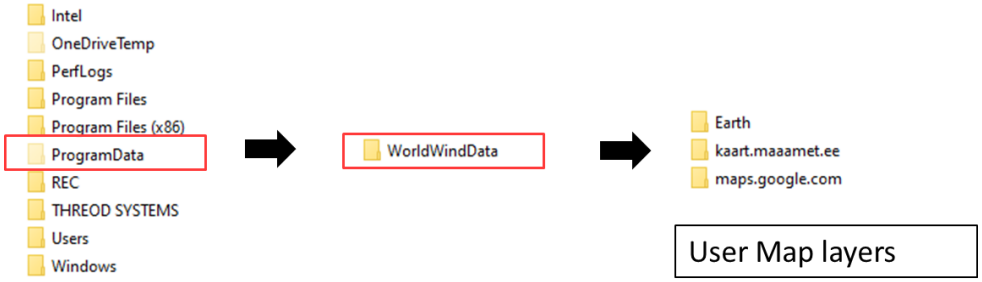


Figure 69 User map layers

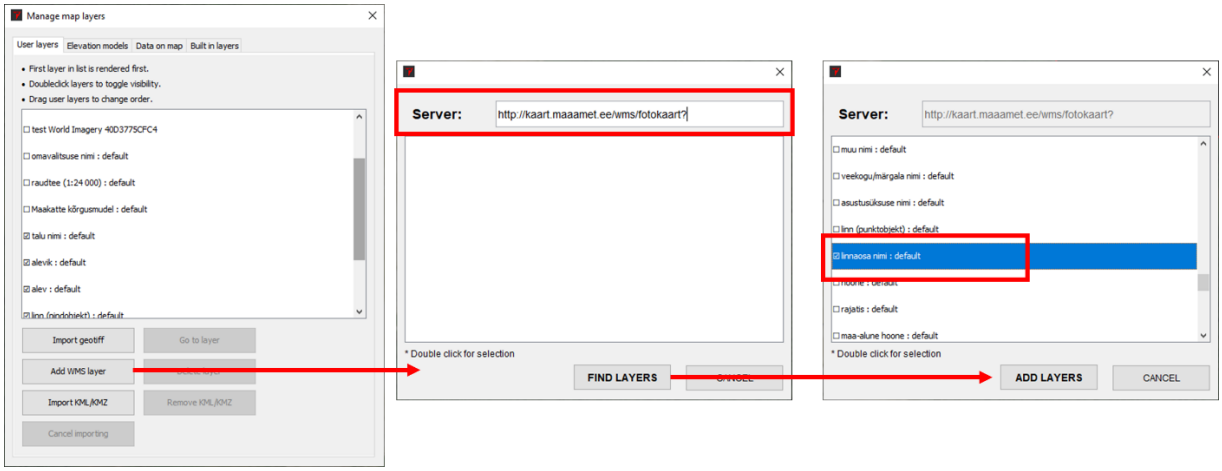


Figure 70 Example add WMS

14.3.2 ELEVATION LAYER

The elevation model shows installed elevation map layers. Selecting one or all layers will show on the map by colouring this area where it is.

A step-by-step guide on how to upload elevation models is thoroughly explained in the Orca-130 manual.

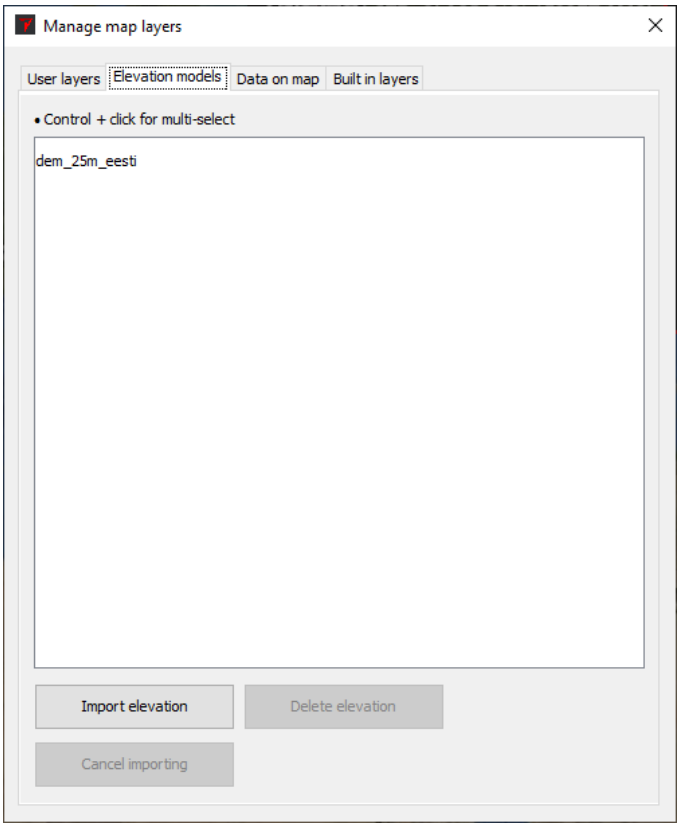


Figure 71 Elevation model management

14.3.2.1 GIMBAL ELEVATION REPORTING

NOTICE

Gimbal elevation reporting capability is only applicable to Orca 130, which has an elevation model feature and an updated autopilot. The Gimbal elevation reporting feature does not work with any other payload like Shark or Photo Payload. The radar must be enabled and working correctly for the feature to work as intended.

The aircraft flies using a barometer to measure pressure to calculate mean sea level altitude. A barometer measures atmospheric pressure: therefore, the aircraft's altitude directly depends on the accuracy of the pressure value. The atmospheric pressure changes throughout the day depending on location, weather, and altitude.

The aircraft calculates and saves the QNH value (atmospheric pressure at the mean sea level) on three occasions:

- After switching on, when the aircraft receives altitude information from the gimbal. This ensures that the aircraft location barometric altitude corresponds to the gimbal map altitude.
- Before landing, when flying from loiter down to the landing point, the autopilot recalibrates the barometer using the gimbal elevation model and radar readings to correct the barometric altitude of the landing point.

Compensation for barometric altitude inaccuracy works through the radar. The autopilot compares the aircraft's barometric altitude with the ground altitude value received from the gimbal's elevation model, which is added to the radar reading. In case the values are not identical, the QNH value is corrected (Figure 72). The corrected value is shown in the notification tab as "ERROR; [AP-1(200)] -> QNH adjusted to 10217/10 hPa."

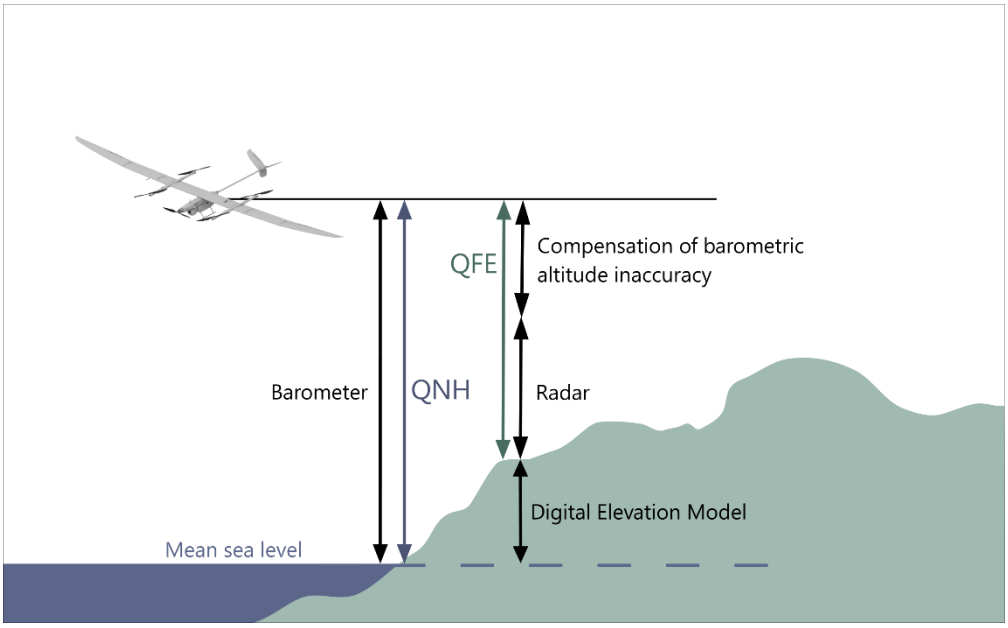


Figure 72 Gimbal elevation reporting for barometric altitude inaccuracy

The QNH value can be seen under the "Aircraft controls" in "ALT" (Figure 73).

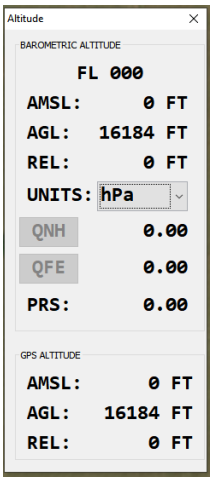


Figure 73 QNH value in Altitude bar

Radar not working: In case the radar is not working, it is recommended to land with a minimum of 30% reserve in the battery. Without the radar, the aircraft will land slower to ensure safety.

Endurance flight: The pressure change is likely after a long flight, especially in the mornings and evenings. Ensure the battery has an extra reserve and it is recommended to transition a little bit higher.

Mountainous area: When flying in a mountainous area, it is especially important to be extra careful while landing. The aircraft's pitch is usually 8-12° degrees to lose height and radar reads at a 45-degree angle. This means the radar does not start to avoid obstacles at the landing point as the radar simply measures elevation from another point (Figure 74). It is recommended to control the landing height, land higher, and have a bigger battery reserve.

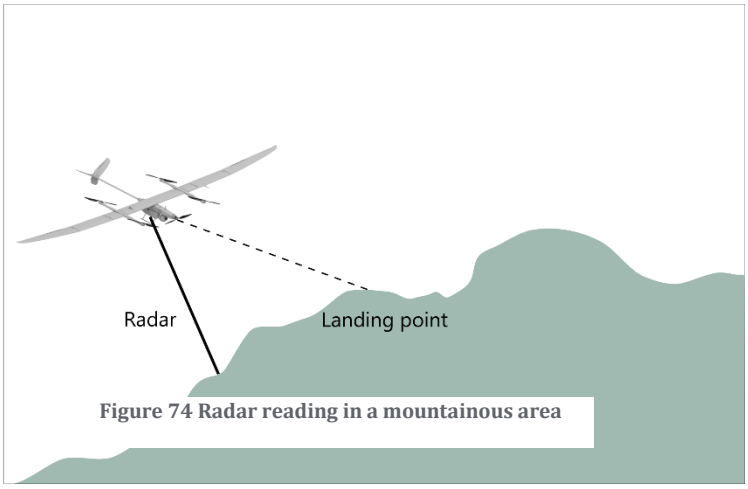


Figure 74 Radar reading in a mountainous area

Landing with imprecise elevation models and/or not updated pressure values: While landing when aircraft positioning and altitude reading is inaccurate, the aircraft can mistake large objects like houses or forest as ground. When the aircraft is landing, the aircraft will need a height of at least 10m above obstacles. If obstacles are higher or if the aircraft adjusts the forest as ground, the radar will start to avoid it and will give an error "*81; **Ground proximity alert $ m***". The aircraft will start to

correct the QNH value to try to keep a safe distance from it, giving a notification "*109;* ***QNH adjusted to $/10 hPa***". The aircraft is likely 10-15 m above the projected flight trajectory and may come land at a higher altitude. Keep a bigger battery reserve to ensure a safe landing. The aircraft may not send an adjusted QNH value when the pressure has not changed.

If the aircraft lands directly after the forest or a house, the aircraft has not had enough time to adjust the barometer and is likely at a much higher altitude and overshoots the targeted altitude (Figure 75). The QNH-adjusted value is added on top of the projected trajectory, resulting in a higher transition altitude. The aircraft will give a notification "*128;* ***Aircraft is $m over target altitude***". This is especially dangerous after a long flight or with an empty battery.
When **landing over the forest**, it is recommended to put the landing point at least 100m from the forest as it gives the barometer enough time to adjust the QNH value and land at the targeted altitude.

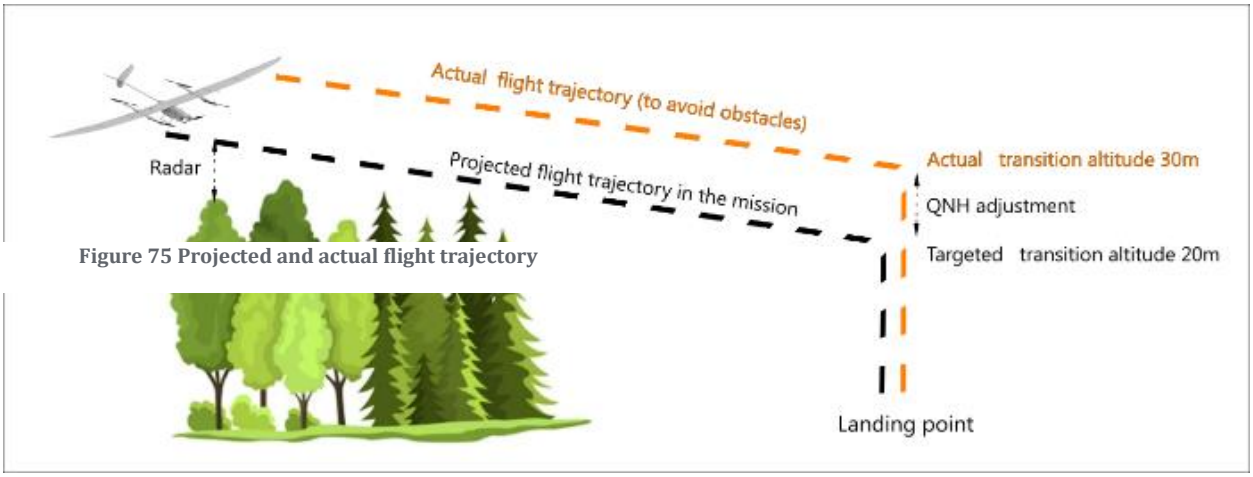


Figure 75 Projected and actual flight trajectory

Validating barometer values: In case the barometer reading seems incorrect, it is possible to validate the altitude readings by comparing two values. To control the values, the aircraft can be flying over the landing point or coming out of the loiter down. Flying over the landing point should be done only in good weather and when the area is clear of obstacles like houses or trees. The altitude must be approximately 60 m REL for the radar to start reading values. If the altitude is over 60 m REL, the values may not be accurate or the reading may not come through. Enable radar reading (Settings -> Technician -> Check "Update radar altitude continuously") and check if the radar value and relative altitude values are the same. **Caution! Uncheck "Update radar altitude continuously" when done comparing values.** If radar is updated continuously, sending commands may be impaired and commands may not upload to the aircraft!

If the digital elevation model is not available in the gimbal, it will not report any elevation data to the autopilot. This means that the target coordinates are calculated using the WGS84 ellipsoidal model of the Earth. This is a very inaccurate way of calculating the target location and those coordinates should be used with caution. The payload operator can tell that the elevation map is missing by looking at any point on the ground with the gimbal, the reported target altitude will always be zero. When the digital elevation model is not available in the gimbal, the GCS will give an error "***Altitude map database is enabled, but not detected. Ground altitude may be invalid***."

If gimbal elevation model information is not available, the aircraft will take ground altitude from the mission home point before take-off when the mission is uploaded. In this case, when landing, the barometer's new value is not saved and ground altitude info may be invalid. If the operator does not upload the mission before the flight, the autopilot will calibrate the previous flight, which is most likely inaccurate.

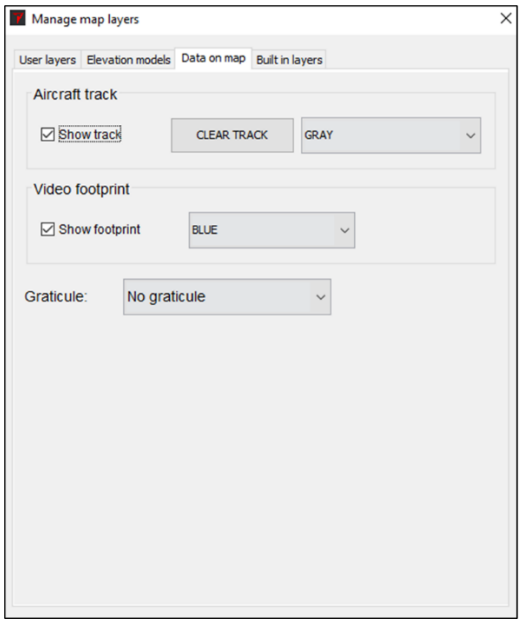
If the sending of the elevation map information ends before landing or it is missing, the barometer value is not refreshed during landing. In the worst-case scenario, the aircraft may land twenty meters higher or lower than planned in the mission. In this case, the aircraft depends on the radar to avoid obstacles on the ground, but it may not be possible to avoid taller trees or houses. Landing higher with at least 30% of the battery reserve is recommended. If the aircraft's battery runs out before it lands, it may lose control and crash.
If the gimbal is inoperational during the flight/landing it cannot report ground elevation data.

Gimbal and GCS use different elevation models. Elevation maps can differ in terms of resolution. Lower resolution (larger distance between grid points) has a lower accuracy than finer resolution maps which have a smaller distance between grid points. Differences between elevation map resolutions can create abnormalities in home point altitude during the mission upload and download processes. Namely when the ground elevations are calculated by gimbal and GCS from the elevation maps differ, aircraft AGL value can move above or below the ground as the two systems have a different understanding of the ground elevation (Figure 76). To avoid such abnormalities, the same maps should be used for the gimbal and GCS. To use the same map for the gimbal and GCS, the desired GeoTIFF file should be uploaded to the gimbal and imported by Mission Software, creating an elevation map in a suitable format for GCS. Read more about how to upload elevation models in the Orca 130 User Manual.

Figure 76 Elevation maps with different accuracy

14.3.3 DATA ON MAP

Data on map shows UAV track on map and allows to create graticule.



Show track- Activate aircraft track showing

Clear track- Erases aircraft track

You can change aircraft track color from dropdown menu.

Show footprint- Activate video footprint

You can change video footprint color from dropdown menu.

Graticule- Creates graticule on map

You can choose:

- MGS
- LATLON
- Degrees

Figure 77 Data on map management

14.3.4 BUILT IN LAYERS

Built in layer allows to activate by choosing between different built in layers.

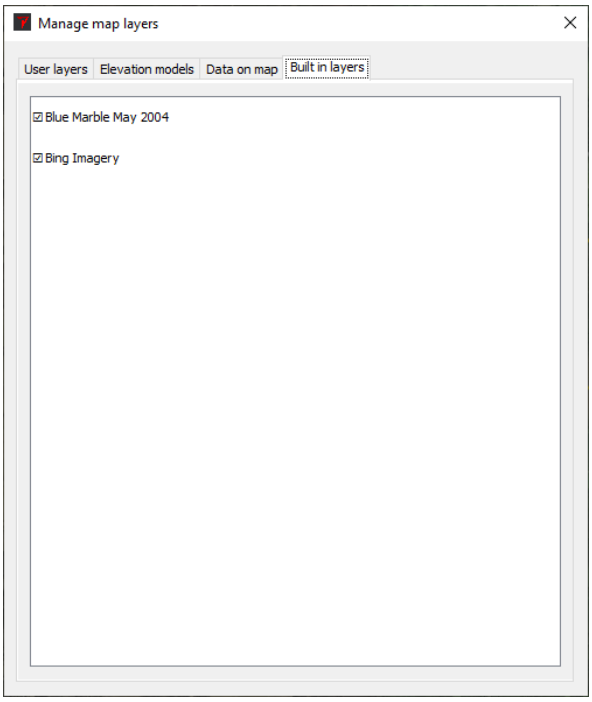


Figure 78 Built in layers management

14.4 POINT OF INTEREST

Point of interest is a specific location marked on the map.

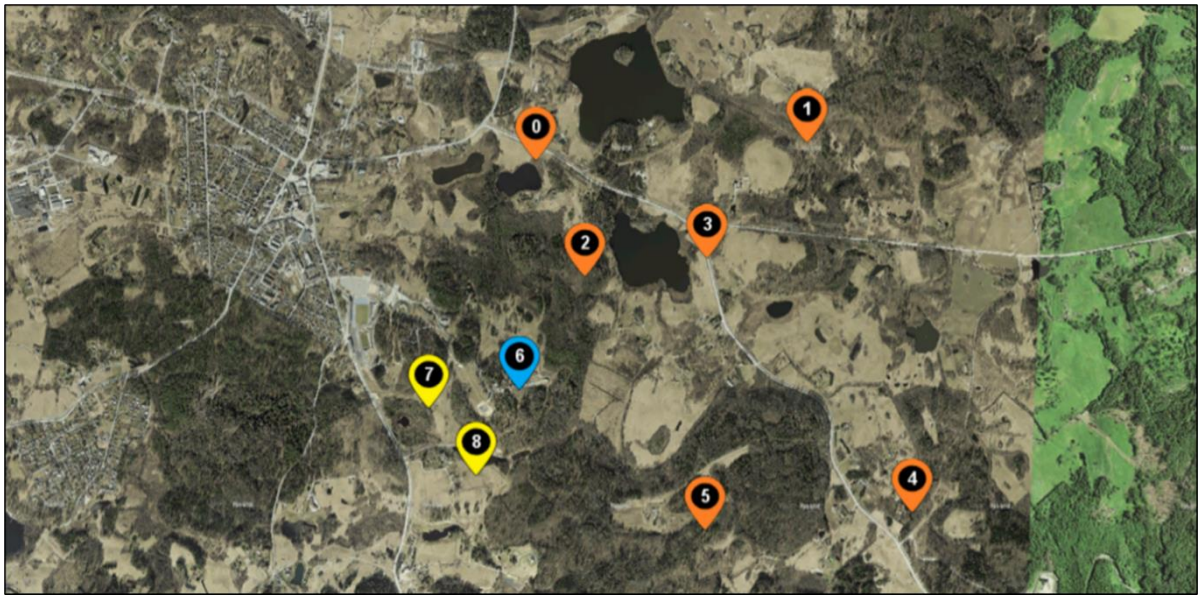


Figure 79 Point of interests

POIs can be added two ways. Either make right click on the map and select Add POI or use POI interface. All POI-s and groups will be restored after GCS restart.

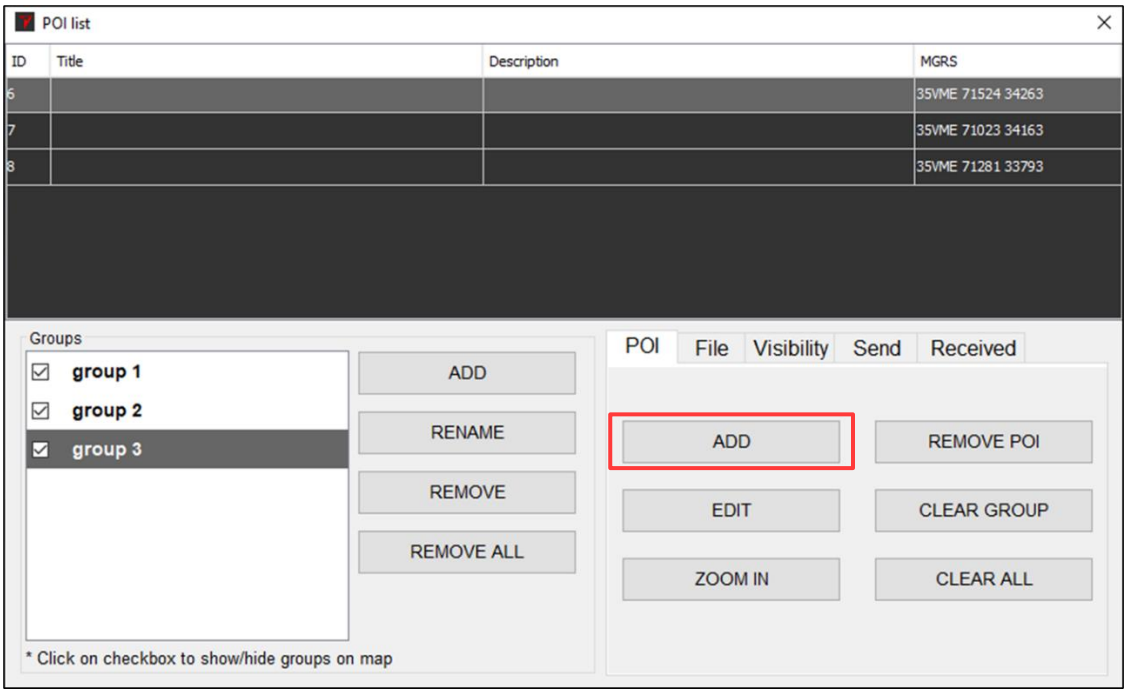


Figure 80 Adding POIs

If using POI interface window, then after selecting ADD, POI creator opens, and operator can create POI by including title, description, location, and specific group if required.

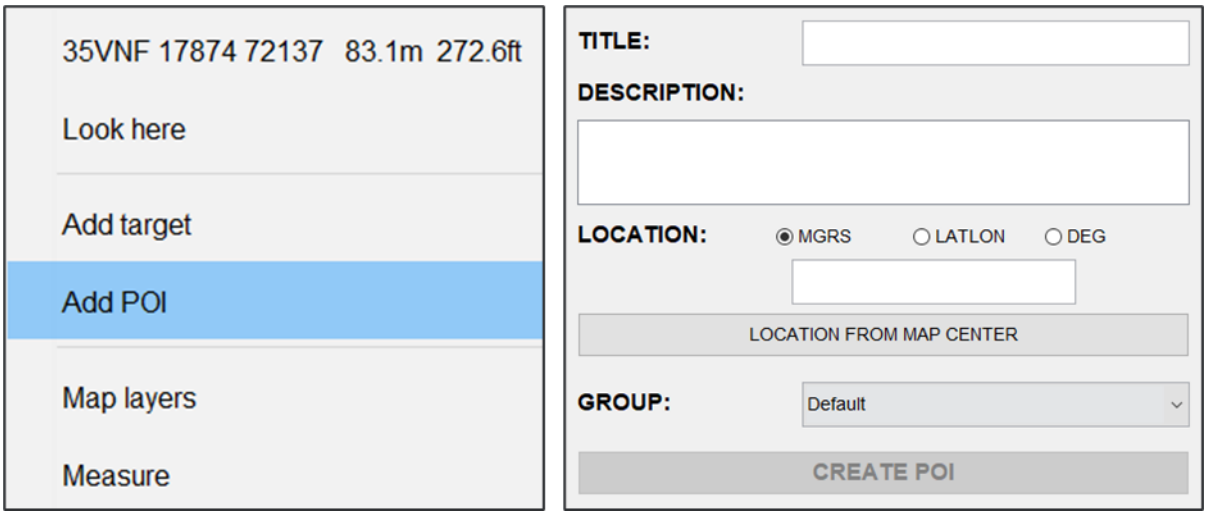


Figure 81 Creating POIs

User can edit POIs by making double click on the desired row on the table or selecting EDIT and do it from editing window.

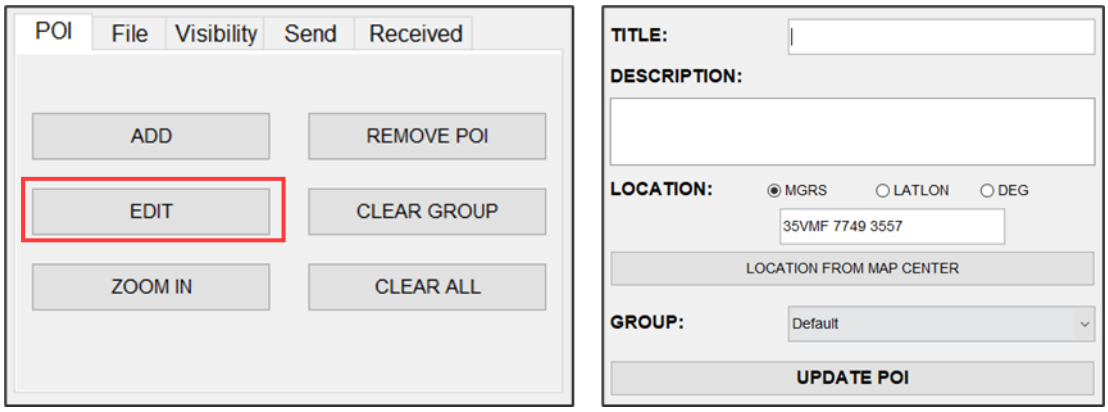


Figure 82 Edit POIs

POIs will be included to default group, if other not created. After group is created, operator can manage groups by either including new ones or removing existing by POI and entire group.

Existing POIs from default group can be included to new group by selecting EDIT and changing the POI group settings.

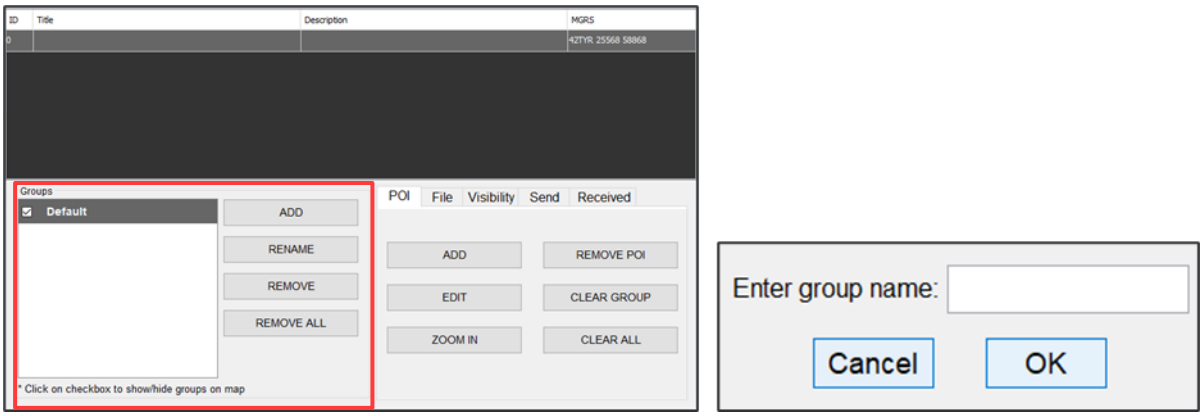


Figure 83 Group POIs

User can save POIs and entire groups to file and use them later by loading them from the saved file. File is saved to computer documents folder as. json type of files.

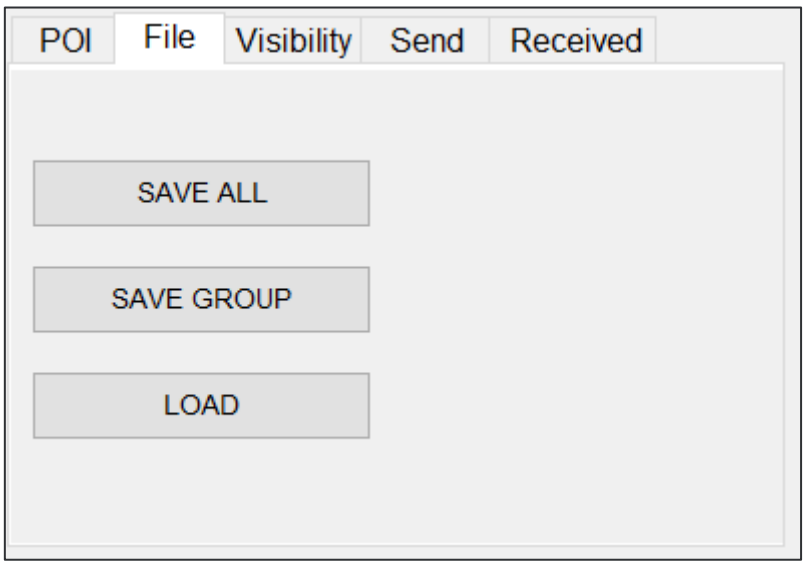


Figure 84 Save POIs

User can select the means of visibility of how the POIs are displayed on the map layer.

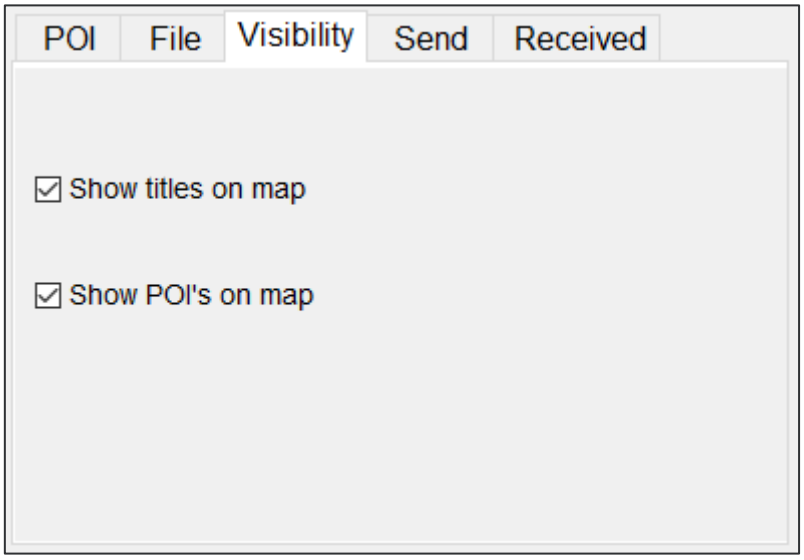


Figure 85 POI visibility settings

User is able to send and receive POIs to another user in UAV GCS software UI and Mission Software UI. POIs can be shared to all, users specified in groups or to direct recipient.

Received POI-s need to be divided into groups by user in order to distinguish those from other POI's, as those all look the same.

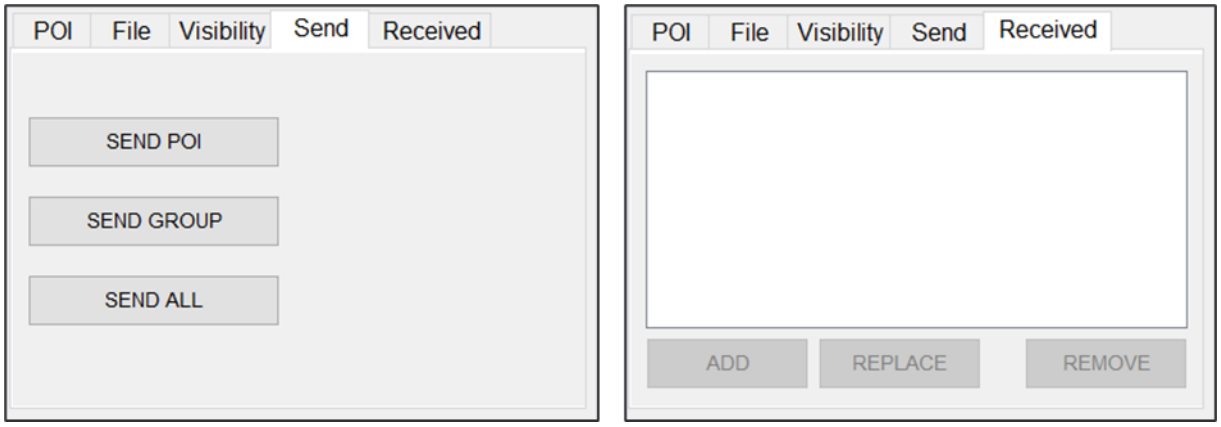
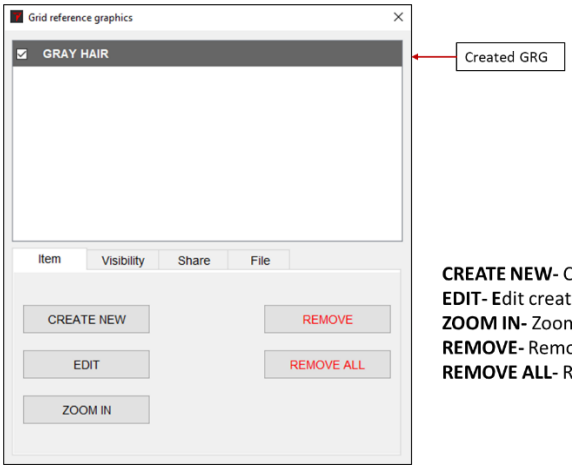


Figure 86 Send and Receive POIs

14.5 GRG- GRIDDED REFERENCE GRAPHIC

The Gridded Reference Graphic (GRG) solution allows you to create rectangular grids for use in partitioning geographic areas of interest. Gridded reference graphics can be used in a variety of operations, including search and rescue, cordon and search, and clearance operations. GRG will be restored automatically after starting up.

Figure 87 Example GRG



CREATE NEW- Creates new GRG grid
EDIT- Edit created GRG
ZOOM IN- Zooms in on the selected GRG
REMOVE- Removes selected GRG
REMOVE ALL- Removes all GRG-s

Figure 88 GRG Item

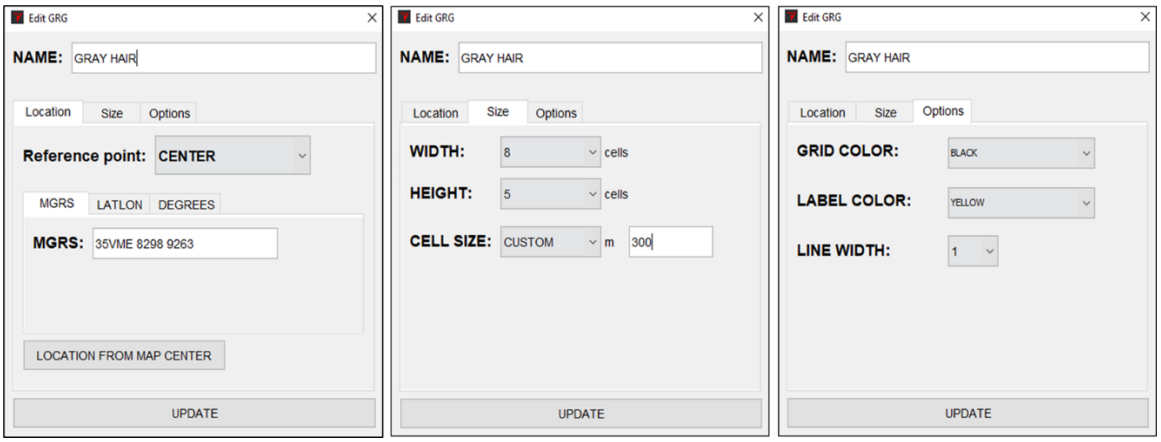


Figure 89 Edit GRG

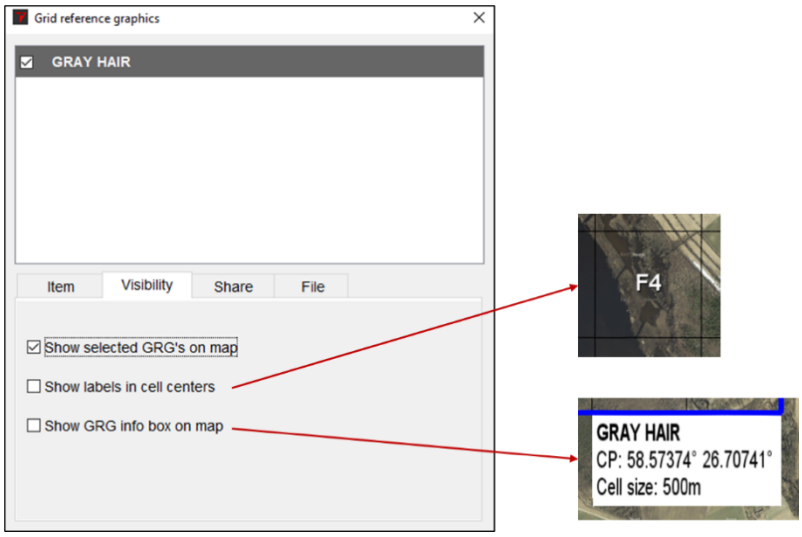
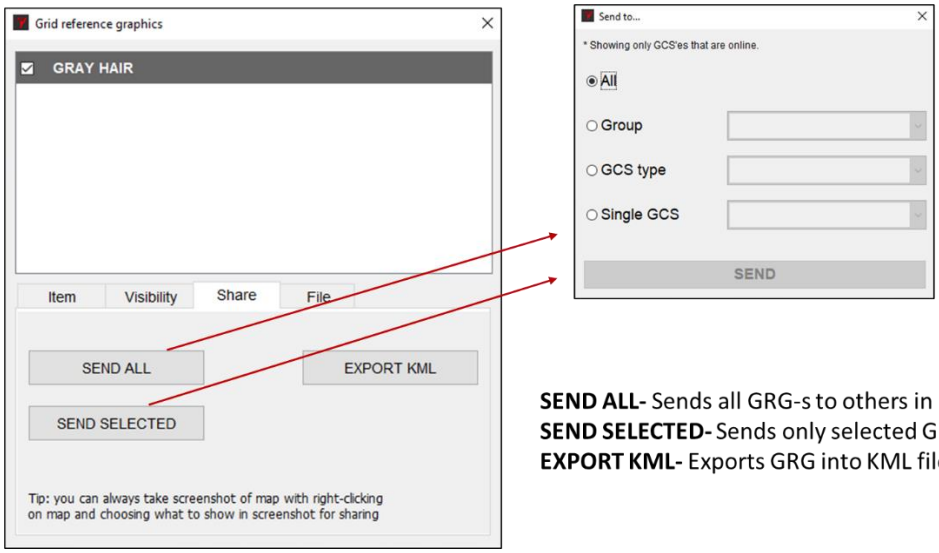
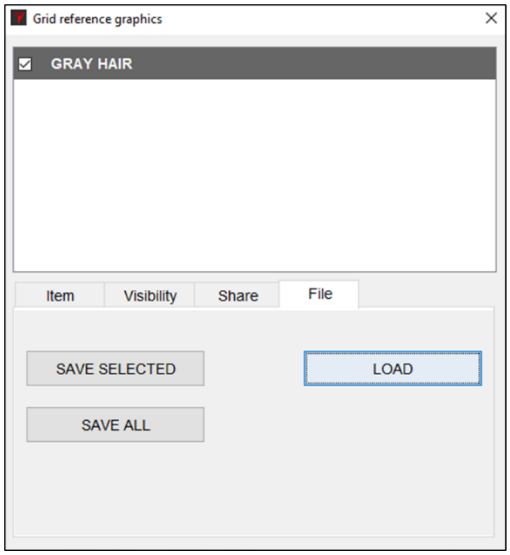


Figure 90 GRG Visibility



SEND ALL- Sends all GRG-s to others in network
SEND SELECTED- Sends only selected GRG-s to others in the network
EXPORT KML- Exports GRG into KML file (will not include info box)

Figure 91 GRG Share



SAVE SELECTED- Save selected GRG-s
SAVE ALL- Save all GRG-s
LOAD- Load GRG from computer

Figure 92 GRG File tab

15 PAYLOAD CONTROLS

- Open gimbal features:

Look pitot

Geolock

Scene steer

STAB

Look down

EO sensor

IR sensor

Increase track box size

Decrease track box size

Moving target indicator

Onboard recording

Payload settings

15.1 VIDEO SCREEN

The Video window displays the video feed transmitted by the gimbal. When no video image is received, a grey background is shown.

Once the video decoding starts, the video will be displayed. The last decoded frame is always shown. A red outline around the video window indicates that expected new frames have not been received frame in 0.5 second). This indicates that there might be a video link problem or connection to the gimbal signal has been lost.

Figure 93 Grey video screen (no signal)

Figure 94 Video display

15.2 ON-SCREEN DISPLAY

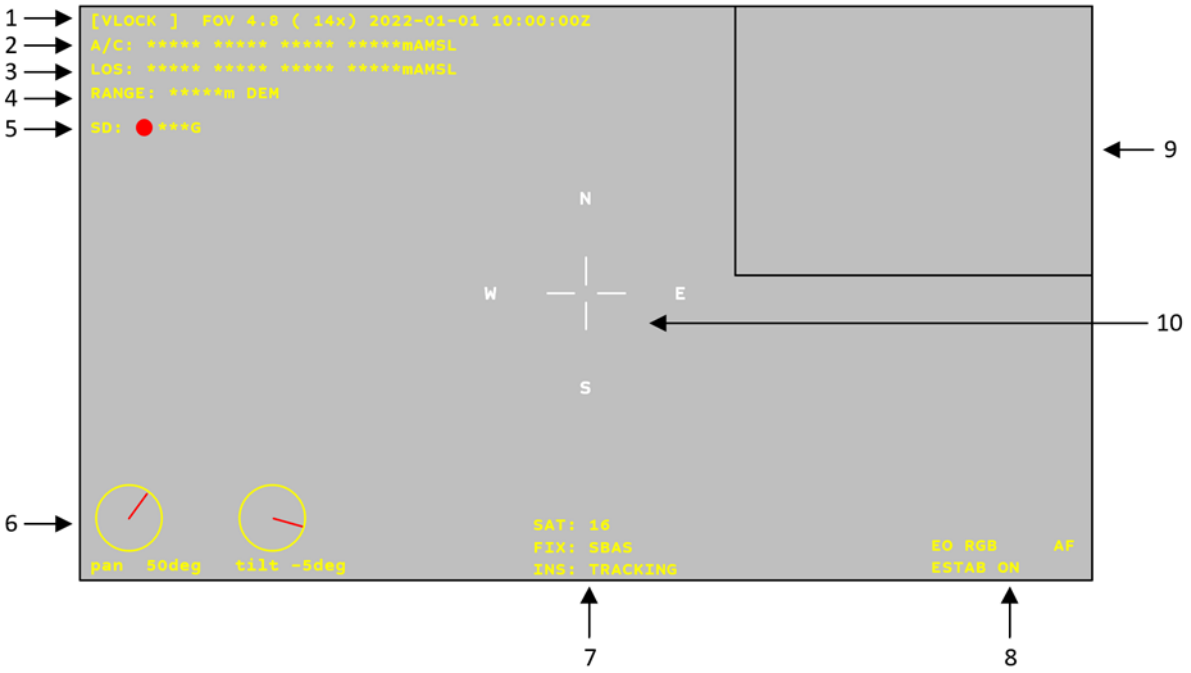


Figure 95 On-screen display (OSD)

Table 2 On-screen display (OSD)

Item	Description
1	Mode, field of view (FOV), zoom level, date, and time display INIT – Gimbal is initializing STAB – Gyro stabilized mode SCENE – Scene steering mode GEO – Geopointing mode ENCDRIVE – Fixed position mode, no stabilization
2	Aircraft coordinates and altitude above mean sea level
3	Line of sight (LOS) coordinates and altitude above mean sea level (target at crosshair)
4	Slant range from the camera to the target in meters. DEM indicates calculated distance using digital elevation model, LRF indicates measured distance using laser range finder
5	SD card remaining capacity and recording status
6	Pan and tilt positions
7	GPS and INS status SAT – number of satellites FIX – GPS fix quality INS – Attitude and position quality (tracking is indicated when measurements are nominal and in spec)
8	EO camera modes are RGB (full color) or NIR (near infrared). Focus modes AF (auto focus) or MF (manual focus) IR camera modes are WH (white hot) or BH (black hot) ESTAB ON/OFF indicates digital image stabilization status
9	PIP (Picture-in-picture) display of secondary camera
10	Target crosshairs indicating line of sight (LOS) and cardinal directions

15.3 SETTINGS USER INTERFACE

Payload settings

15.3.1 PLAYBACK

After flight Playback provides the user an option to review already saved video by scrolling it back and forward by 10- or 60-seconds interval. For more precise setup, use the scrolling bar to set the video. Playback works only with GCS recorded videos. For playback is needed **.ts** and **.index** files with same name.

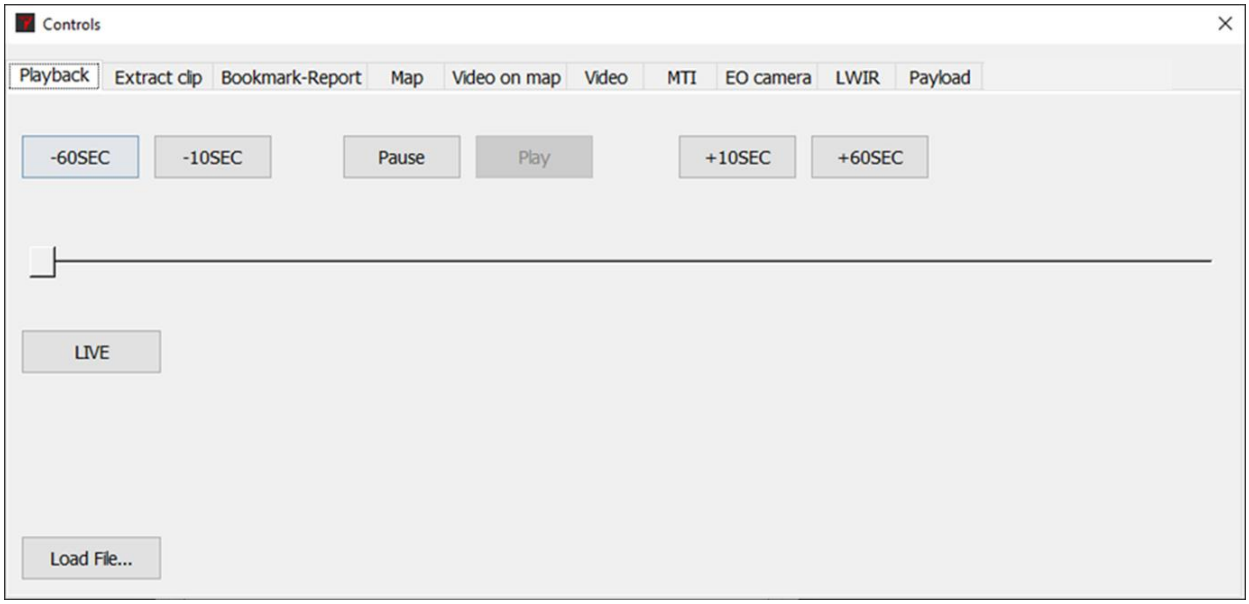


Figure 96 Playback settings

Playback can be used to view previously saved files by selecting Load File. During the flight playback is not allowed.

15.3.2 EXTRACT CLIP

When playing back recordings, the user can extract selected video clips by marking the beginning and end at the desired time.

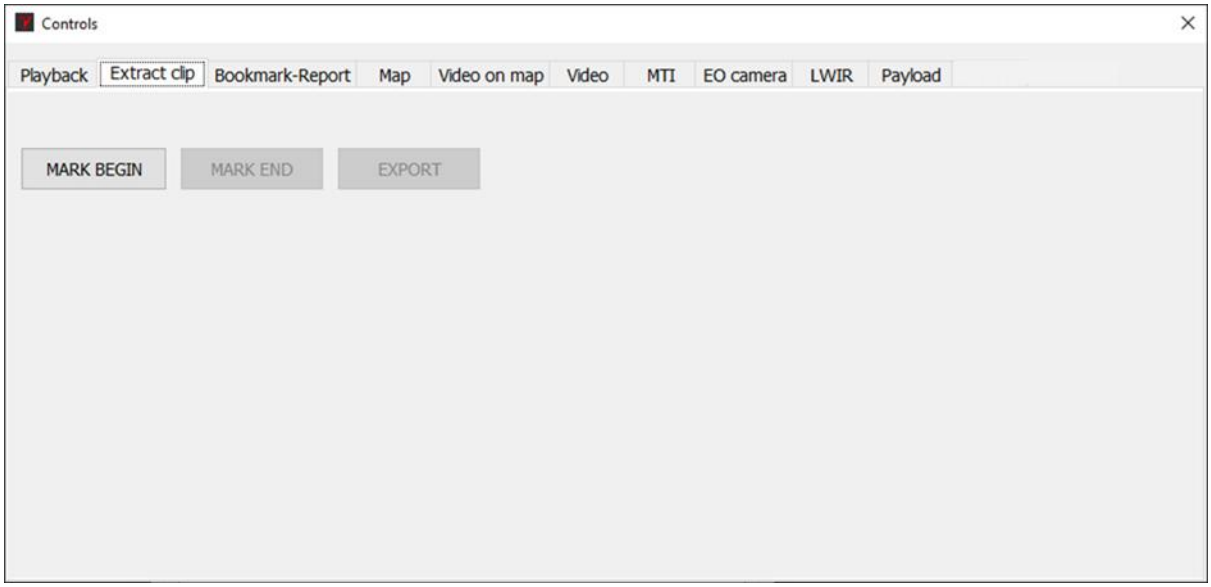


Figure 97 Clip extraction settings

MARK BEGIN	Marks the beginning of video clip.
MARK END	Marks the end of the video clip.
EXPORT	Export clip from the GCS.

15.3.3 BOOKMARK AND REPORT

Bookmark is used to save interests from the feed for later analyses. Operator can add or change bookmarks any time during the operations.

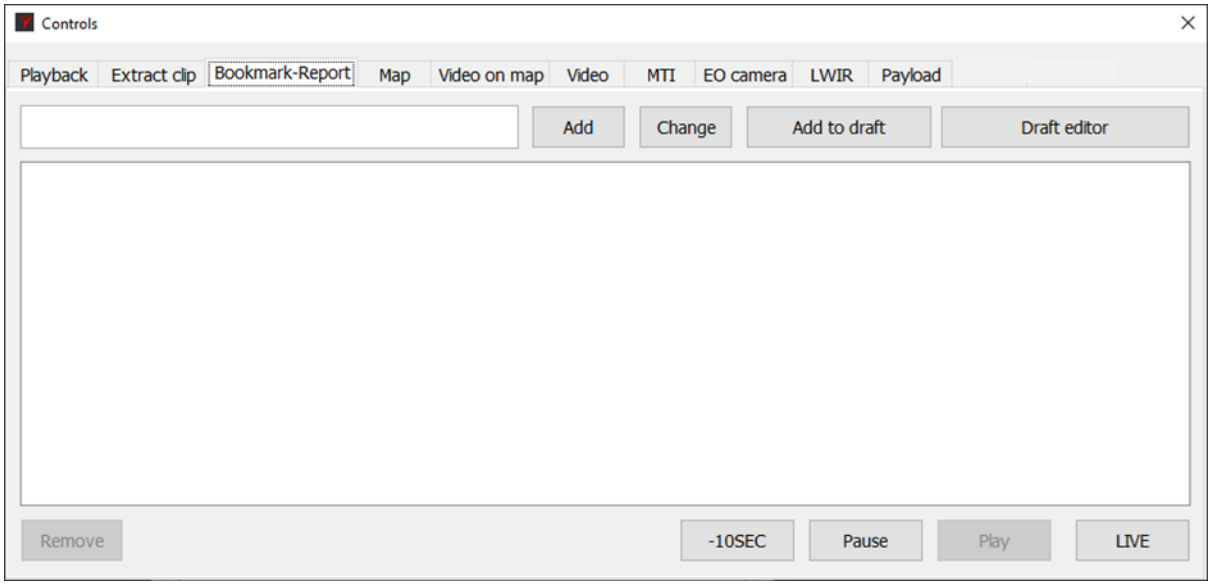


Figure 98 Bookmark and Report settings

Reports will be saved to: C/REC/REPORTS

Report file is labelled accordingly: day/time/filetype

Day	This is date of day when report was first created for example 5. January 2019 means folder is "190105". Time will be UTC.
Filetype	This is file type of generated report. Possible values: "WORD", "PDF" and "POWERPOINT".
ADD	Add Bookmark.
CHANGE	Select bookmark, change Bookmark name.
ADD TO DRAFT	Adds current screen picture into Report draft.
DRAFT EDITOR	Opens Report draft editing window
REMOVE	Select Bookmark, Remove it.
-10 SEC	Scrolls video 10 seconds back.
PAUSE	Pause Playback video
PLAY	Start video Play
LIVE	Switch to Live video

15.3.3.1 REPORT EDITOR

Report editor is an interface to customize initial reports before extraction. User can compile standard format report by entering required information. User can move images between drafts. If only one image in draft, then the old draft will NOT be deleted but just stays as draft with no images so that if there is info written by user in the draft it will not be lost.

User can start new draft from image if there are multiple images in current draft. This will create new draft and move the current image to the newly created draft. User can delete draft. User can delete image from draft.

Drafts list shows info about status of drafts: "no report created!", "no images!" or list of filetypes which reports are created in brackets after draft number. For example: "#1 (Word, PDF))".

Draft number is combination of month day number and draft number in that day.

User can open created reports folder(s) of selected draft by clicking "open selected report folder(s)" button. This is enabled only if any report for selected draft is created.

On top of the draft map the coordinates of the center of the map are shown.

Each draft can have multiple images. Each image can have its own description.

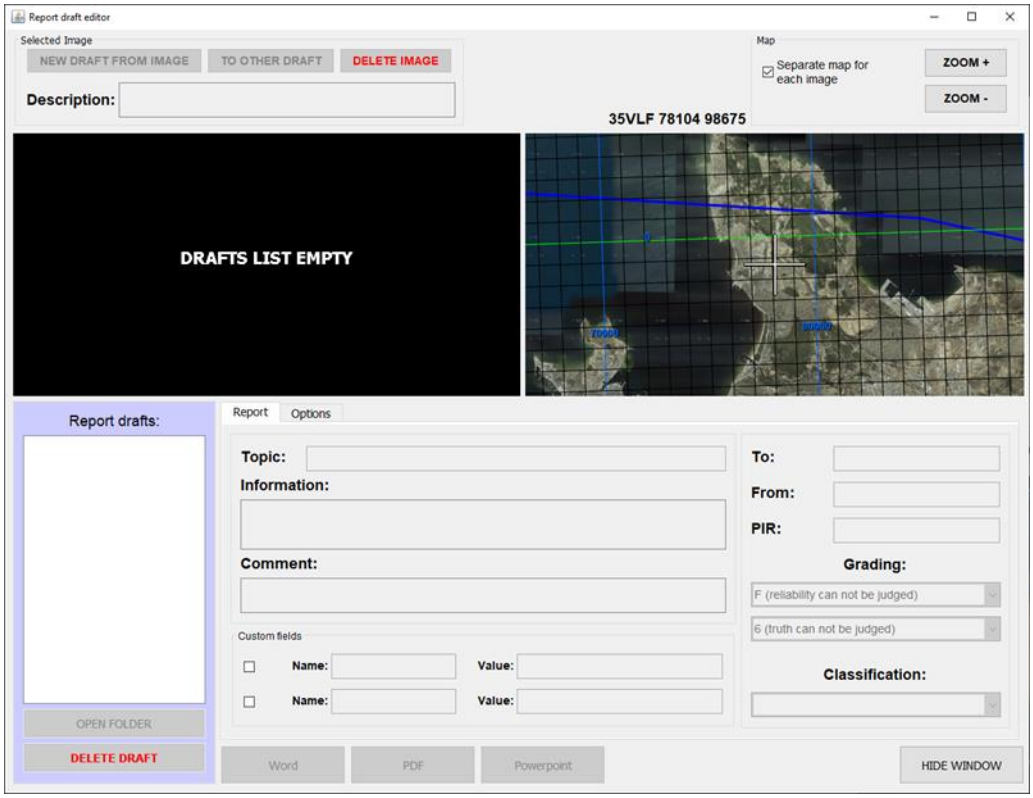


Figure 99 Draft editor window

15.3.3.2 REPORT FIELDS

TO	Each draft has own state for it. If new draft is created then last value is automatically used (even after GCS restart).
FROM	Each draft has own state for it. If new draft is created then last value is automatically used (even after GCS restart).

DTG	User can't change it. This is time when report was generated. Timezone is UTC.
TOPIC	Report title.
CLASSIFICATION	User defines the values. This is added to top and bottom of each page also if set. If new draft is created then last value is automatically used (even after GCS restart).
PIR	Priority Information Requirement
GRADING	This is standard which is combo of A-F and 1-6. This can be empty. If new draft is created then last value is automatically used (even after GCS restart).

SOURCE RELIABILITY GRADE		INFORMATION RELIABILITY GRADE	
A	completely reliable	**1**	confirmed by other sources
B	usually reliable	**2**	probably true
C	fairly reliable	**3**	possibly true
D	not usually reliable	**4**	doubtfully true
E	unreliable	**5**	improbable
F	reliability cannot be judged	**6**	truth can not be judged

DTG	Date Time Group
LOCATION	automatically set. If all images have own map then first image location otherwise the only map location.
INFORMATION	Information about the observation. Must be facts instead of assumptions.
COMMENT	Complier comment to report.
Custom field 1	user chooses if this is used and what is the name of the field. Each draft has own state for it. If new draft is created then last field name and visibility is automatically used (even after GCS restart).
Custom field 2	user chooses if this is used and what is the name of the field. Each draft has own state for it. If new draft is created then last field name and visibility is automatically used (even after GCS restart).
Imagery	map and image pairs. If one map for all images then only first images has map. Under the map location is written also. If each images has own map then image number is written under the map to which image it's meant to. Under image the image number is written.

15.3.3.3 REPORT OPTIONS

This section items apply to all drafts. States are saved meaning after GCS restart state is restored.

User can choose if report is created and some fields are empty then are those fields added to report or not. User can choose if date-time is put under each image or not in reports. Date-time timezone is UTC. User can choose in which coordinate system data is report: MGRS, LATLON or degrees.

User can add logo to report if needed.

Report number is generated automatically. This contains string prefix (from field "Report title prefix" that user defines and date and report number after that. Timezone is UTC.

Information origin - user defines where the info comes from. Default is "UAV gimbal".

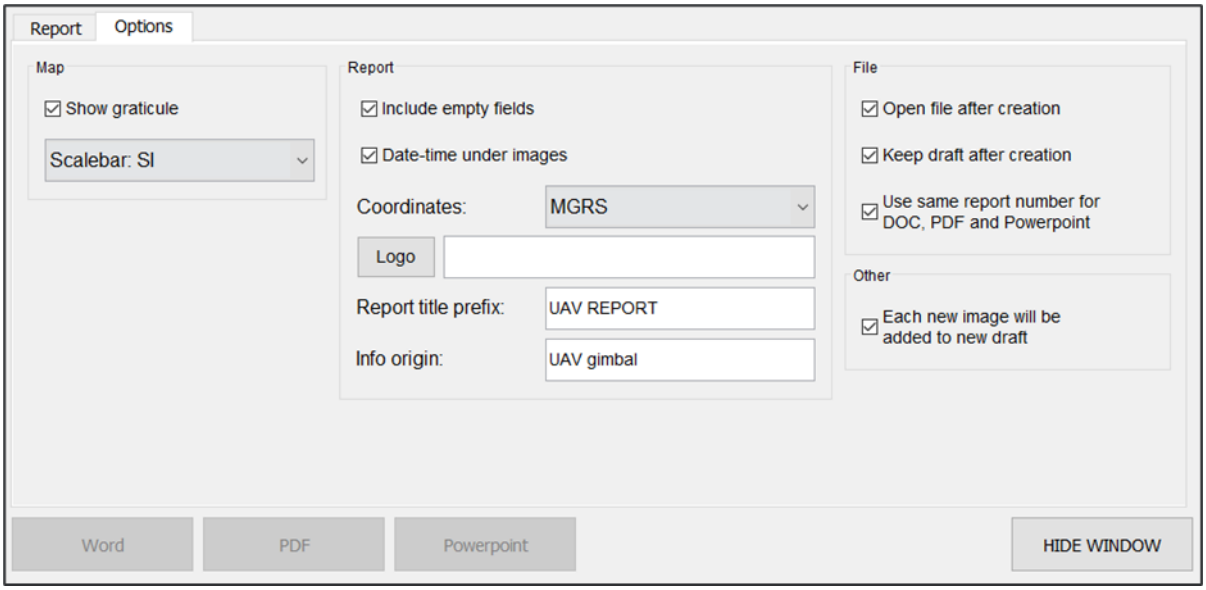


Figure 100 Report options

15.3.3.4 FILE GENERATION

This section items apply to all drafts. States are saved meaning after GCS restart state is restored.

User can choose if same draft creates different report numbers or same draft different report file types have same report number.

User can choose if after generating the report the generated report will be automatically opened or not.

User can choose if draft is automatically deleted after successful report creation or not.

If draft is kept after report generation then user can update generated filetype report. Technically all files will be deleted in the folder and new ones will be created.

FOR OFFICIAL USE ONLY

UAV REPORT 190828 - 10

TO HQ
FROM UAV
DTG 28 1048UTC AUG 19

TOPIC	Mingi topic
CLASSIFICATION	FOR OFFICIAL USE ONLY
PIR	NONE
INFORMATION ORIGIN	UAV gimbal Orca
INFORMATION GRADING	F6
DTG (event)	28 1048UTC AUG 19.....28 1048UTC AUG 19
LOCATION	35VMF 3997 7959
INFORMATION	Mingi info siin. Siin on natuke rohkem infot kirjutatud, et ikka oleks ikka mitmel real see ja näeks milline välja näeb mitmerealisena onju.
COMMENT	Mingi kommentaar siin
Custom name 1	Custom value 1
Custom name 2	Custom value 2

IMAGERY:

FOR OFFICIAL USE ONLY

FOR OFFICIAL USE ONLY

Location: 35VMF 4014 7990

Image: 2. 06APR19 UTC 10.22.56
Metsapiirkene paistab

FOR OFFICIAL USE ONLY

Figure 101 Generated report file

15.3.4 VIDEO

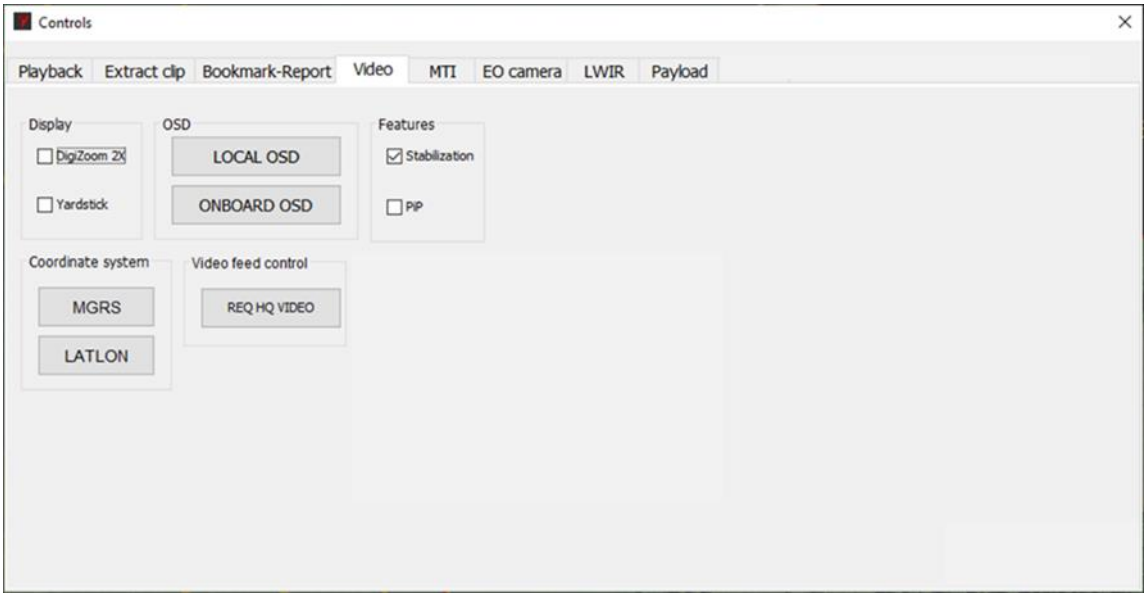


Figure 102 Gimbal video settings

DigiZoom 2x	Zooms the video digitally by a factor of 2. Zoom is performed in the ground software and does not affect the video stream coming from gimbal.
Yardstick	Enables the yardstick to take a position on the video overlay. The yardstick is a guide to assist with the estimation of distances on the ground.
MGRS	Switch the on-screen display coordinates in gimbal video to MGRS format.
LATLON	Switch the on-screen display coordinates in gimbal video to WGS84 decimal latitude/longitude format.
OSD	On screen display
LOCAL OSD	Metadata is not recorded on video.
ONBOARD OSD	Metadata will be recorded on video.
Stabilization	Switch on and off picture stabilization.
PiP	Activate Picture-in-picture
REQ HQ VIDEO	Request High Quality Video. Will activate video streaming to Mission software.

Figure 103 Yardstick on the video

15.3.4.1 MEASURING DISTANCES

To measure distance on the video feed, right click on the required measurement start location and choose “New measurement”. A red line will be shown with distance and angle information from the starting point to the location of the cursor (measurement info is updated continuously when moving cursor around the video feed). Affirm the measurement with the mouse click. Measurement that is performed on the video feed, will also be visible on the map.

Figure 104 Measurement on the video feed window

15.3.5 MOVING TARGET INDICATOR

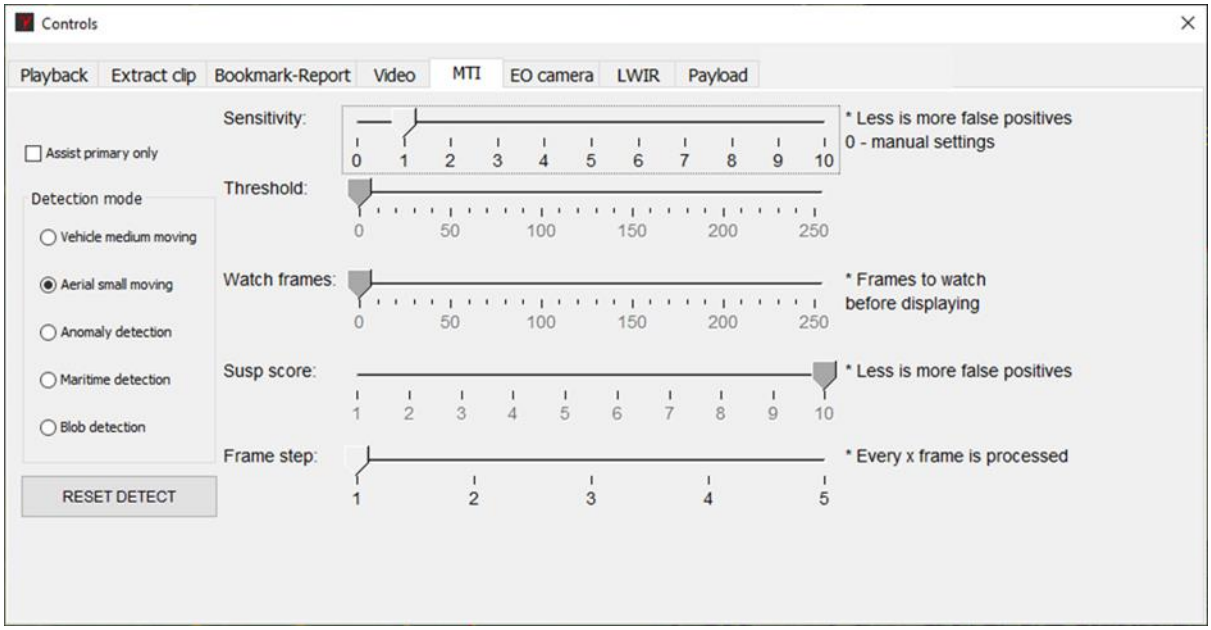


Figure 105 Moving Target Indicator settings

Assist primary only	Motion assist for primary target only if checked and all targets if not.
Sensitivity	The moving target indication sensitivity refers to the algorithm's threshold for deciding whether a particular candidate target is a moving target or a false positive.The smaller value, the more false positive indications. Except value 0, that will refere to default settings.
Threshold	It controls the threshold at which potential moving targets are generated.
Watch frames	After a potential moving target is generated by the moving target indication system, it is watched by the system for a number of frames. This controls the number of frames the system watches a moving target before displaying it.
Susp score	It controls the level at which we consider a track '"suspicious"'. Setting this value higher will result in more false positives.
Frame step	Step between frames. 1 processes every frame, 2 processes every other frame, etc.
Vehicle medium moving	This mode works best when finding moving vehicles in a moving scene. It works well from a moving aerial platform for finding vehicles that are typically 10 to 100 pixels long in the scene. It does not work as well at finding very small, very large, slow or erratically moving objects.
Aerial small moving	This mode works from a moving platform and can find small and slow, fast or erratically moving objects. It is capable of handling scene motion with frame to frame perspective change. It will lose objects that stop moving. This mode takes the most compute resource and is the most likely to run

	at less than full frame rate if other processing is also enabled(such as network video output).
Anomaly detection	This mode works from a moving or stationary platform and finds objects that are unique anomalies or outliers in the scene based on color and / or intensity.This mode doesn't require objects to be moving to be detected.
Maritime detection	This mode works from a moving or stationary platform and finds objects in a maritime environment such as ships or life jackets.
Blob detection	This mode works from a moving or stationary platform and finds objects that are light or dark compared to their surroundings. This mode doesn't require objects to be moving to be detected.

15.3.6 EO CAMERA

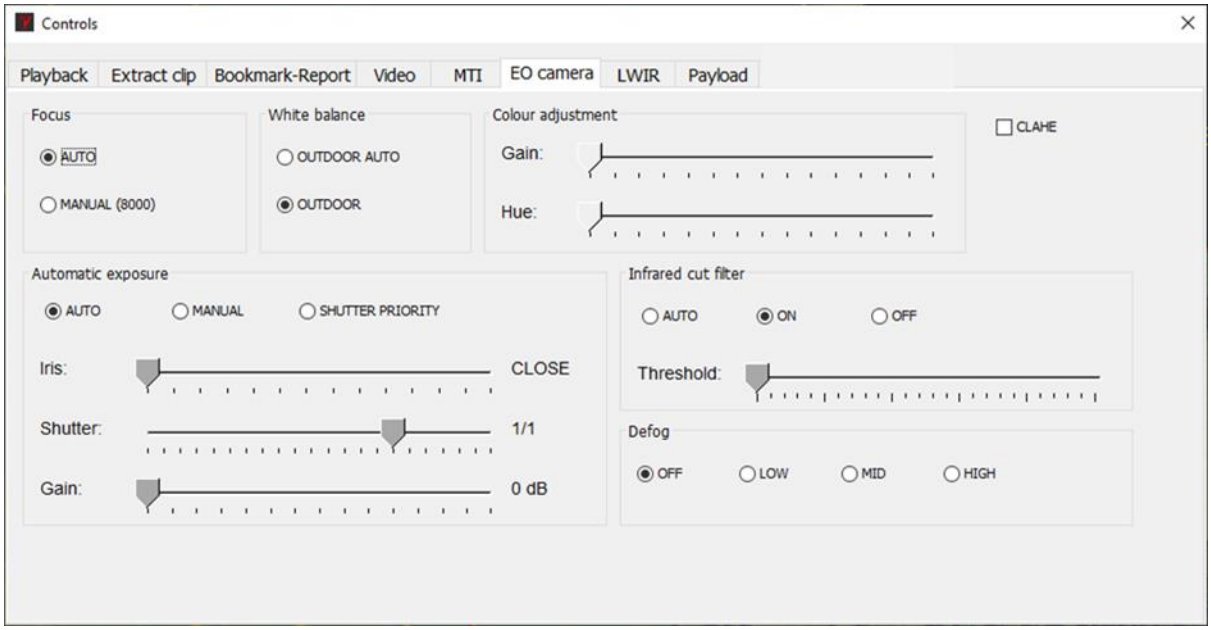


Figure 106 EO camera settings

CLAHE	Enable/disable contrast enhancement (contrast limited adaptive histogram equalization). Useful when objects could be hidden in shadows.

CAUTION

WHEN USING CLAHE IN SITUATION WHERE VIDEO FEED IS NOISY (LOT OF SMALL MOVEMENTS, MANUALLY SET HIGH GAIN, HIGH SHUTTER SPEED), IT WILL RAISE VIDEO DOWNLINK BITRATE. IN LONGER DISTANCES/LOW LINK QUALITY IT WILL CAUSE LINK LOSS.

FOCUS

AUTO (Focus)	Automatic focus mode. When zooming, the auto focus always tries to find best settings.

MANUAL (8000)	Manual focus mode. Operator can adjust focus using joystick. Useful when autofocus struggles to find optimal values.

WHITE BALANCE

OUTDOOR AUTO	Outdoor white balance with automatic adjustments.
OUTDOOR	Fixed outdoor white balance.

COLOUR ADJUSTMENT

Gain	Adjust color gain. Left is minimum value, right is maximum. Useful when there is little color in a scene. Adding color gain will produce more vibrant but artificial looking image.
Hue	Changes color hue. Useful when color adjustment is required depending on scene.

AUTOMATIC EXPOSURE

AUTO	Exposure settings are chosen automatically by the camera.
MANUAL	Exposure settings are selected by the operator.
Iris	Manually adjust how open or closed the iris is (aperture).
Shutter	Adjust shutter speed. Lower values will result in less image blurring but allow less light to be collected.
Gain	Adjusts how much the signal is amplified

EO camera has an internal infrared cutoff filter that can be automatically or manually controlled. ICR filter cuts off non-visible light in infrared spectrum to the image sensor in order to produce color-correct picture for visible spectrum. In low light conditions this filter can be removed to increase the sensitivity of the camera. When the ICR filter is off, the image is black and white and camera is in low-light or night mode.

INFRA-RED CUT FILTER

AUTO	Camera turns the ICR filter on/off automatically depending on light conditions and threshold value
ON	ICR filter is on (normal mode)
OFF	ICR filter is off (low light mode)
Threshold slider	adjust automatic ICR filter on/off threshold

DEFOG

OFF	No defog filtering
LOW	Low level of filtering
MID	Medium level of filtering
HIGH	High level of filtering

15.3.7 THERMAL CAMERA (LWIR)

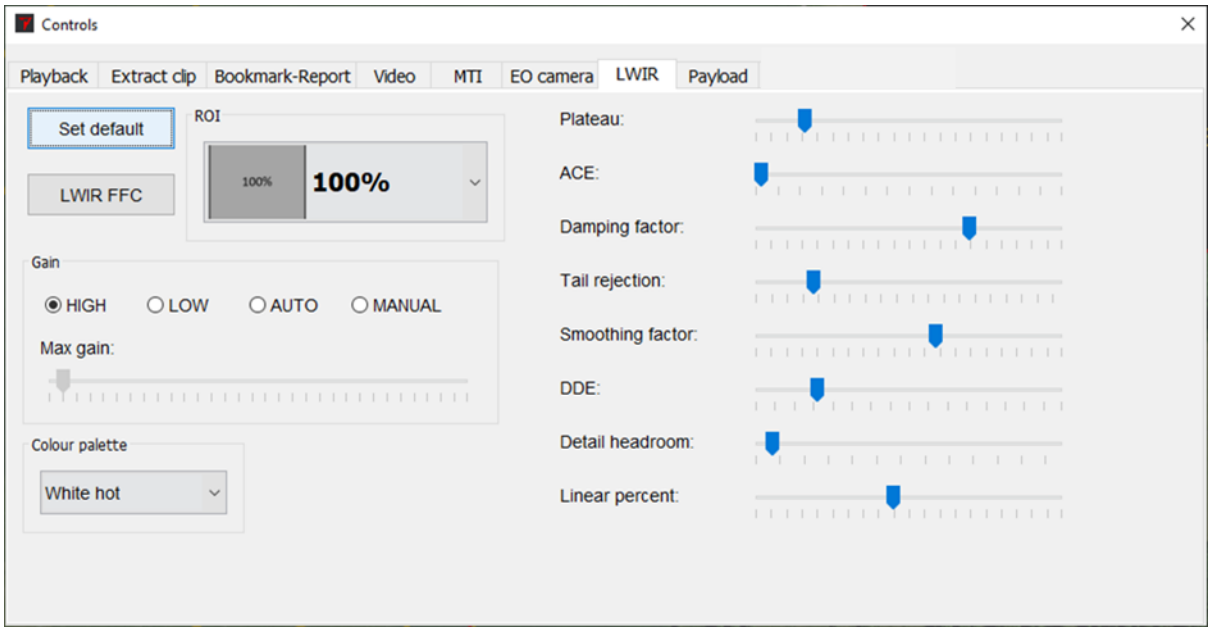


Figure 107 LWIR thermal camera settings

Image enhancements for LWIR camera.

Set default	Sets the default configuration of the camera
LWIR FFC	Performs shuttered Flat Field Correction

Automatic Gain Control/Digital Detail Enhancement (AGC/DDE)

Gain	AGC Maximum gain.
Damping	Speed of AGC response
Linear	Linear percent adjust how accurately to represent objects temperature
Plateau	Adjust histogram equalization mapping
Tail	Tail rejection determines the percentage of the ignored histogram tails
DDE	Digital Detail Enhancement level

ACE Adaptive Contrast Enhancement level

Smoothing factor Changes the attenuation and enhancement levels of DDE

COLOUR PALETTE

Change Colour palette between BLACK HOT or WHITE HOT.

AGC ROI

AGC (automatic gain control) algorithm takes the maximum and minimum values of camera output signal and scales the whole image to fit in the visible range (0…255). ROI (region of interest) selects the area of camera image where the algorithm looks for the maximum and minimum values.

Smaller ROI close to the target will provide better details of the target area while reducing the details of surroundings.

15.3.8 PAYLOAD

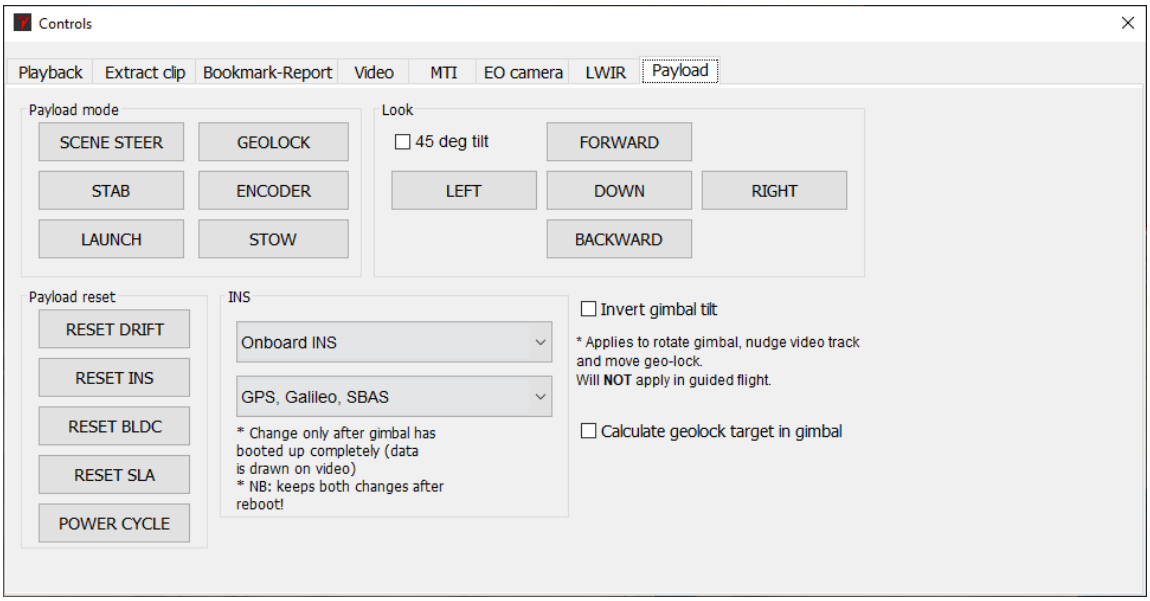


Figure 108 Payload settings

PAYLOAD MODES

SCENE STEER In scene steer mode, the user can pan/tilt the gimbal using right joystick and zoom the camera using left. In scene steer mode, the gimbal always uses image processing to keep the current view in the center. This means that, no matter how the UAV moves the gimbal targets the same location.

STAB In stabilization mode, the user can pan/tilt the gimbal using right joystick and zoom the camera using left. The gimbal will stabilize relative to the UAV movements to keep the image stable however it is not fixed to any specific location and drifts as the UAV moves.

LAUNCH When the Launch mode is activated, the Orca gimbal changes the heading to the left (pan 270 degrees, tilt 0 degrees) and actively tries to keep its orientation fixed with its motors.

GEOLOCK This gimbal mode allows the gimbal to target a specific coordinate instead of visual information. The targeting can be activated during flight by clicking on the map. Click on the GeoLock icon to enable this mode. Enabling the GeoLock mode will send coordinates of the target area to the UAV. To retarget right-click on the map to change the target area.

ENCODER In encoder mode gyroscopic stabilization is disabled and the gimbal will move to commanded angles relative to the airframe as adjusted by the joystick.

STOW Mode is used during the landing of the aircraft. When landing the UAV, the gimbal turns the objective rearward (pan 180 degrees, tilt maximum up). It protects the gimbal camera lenses from harm during a landing.

LOOK PITOT In look pitot mode the gimbal will look to the right and zoom in 4,3x on the pitot. The mode works best with EO. Mode is used to ensure the pitot tube is not blocked or iced. When "look pitot" mode is activated the video stabilization is turned off and the payload is in encoder mode. When exciting pitot mode, ensure video stabilization is on, under settings.

In case of icing, it is recommended to turn ON the pitot failsafe, keep looking pitot until the end of the flight, and return home instantly. If the pitot is iced GND and IAS values are not correct and correlated. Usually, GND values are too high or low compared to IAS.
After landing make sure to dry the pitot thoroughly for at least 24h at 20-30°C degrees and humidity should not be higher than 50%. On the next flight, the transition from multirotor to fixed-wing higher if possible with a recommended altitude of 35m.

LOOK

The gimbal can be commanded to look at a specific orientation with regards to the physical mounting platform.

FORWARD Gimbal moves to 0 degrees pan and 0 degrees tilt

BACK Gimbal moves to 180 degrees pan and 0 degrees tilt

LEFT Gimbal moves to 270 degrees pan and 0 degrees tilt

RIGHT Gimbal moves to 90 degrees pan and 0 degrees tilt

DOWN Gimbal moves to 0 degrees pan and 90 degrees tilt

For the FORWARD, LEFT, RIGHT and BACK orientations there is an option to rotate the gimbal by +45 degrees (down) in the tilt axis by selecting the checkbox from the user interface. The change

will only take effect on the next fixed view mode change. Active orientation is displayed for the user on the gimbal mode indication are on the overlay.

The VLOCK mode enables the user to track a visible moving or stationery targets. The mode can be enabled by either clicking with a mouse on the video image window or pressing the "VIDEOTRACK" button on the joystick. After activation a red box will appear on the image. The box designates the tracked object. The size of the box can be adjusted from the user interface, by pressing the button "+" to enlarge the track box and "-" to reduce the size of the track box. The tracking box should be adjusted ca 10% larger than the object being tracked. During video tracking the gimbal constantly adjusts its pan and tilt angles to keep the selected target in the middle of the image.

If the target is lost after activation, the gimbal will switch to SCENE STEER mode automatically.

Switching to any other mode from video-tracking will turn off the video tracking functionality and the red tracking box will disappear.

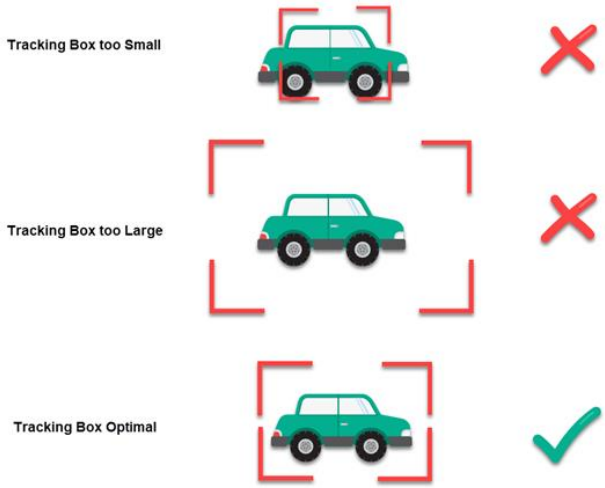


Figure 109 Tracking types

Payload reset	
RESET DRIFT	Will reset gimbal drift. To be performed when excessive drift is experienced in stabilized operation mode. It is required for the gimbal to be stationary during this process.
RESET INS	Will reset onboard INS. Use it when issues with satellites.
RESET BLDC	Will reset Gimbal motors. Use it when issues with gimbal movement.
RESET SLA	Reset onboard Video Processor.
POWER CYCLE	Restarts the whole gimbal
ONBOARD INS	Uses Gimbal INS for range and coordinate calculations
THREOD Autopilot	Uses Aircraft INS for range and coordinate calculations
CHOOSE INS SOURCE, CONSTELLATIONS	Can choose only if onboard INS is selected to be.

	Global Navigation Satellite System (GNSS) provides global coverage. Examples of GNSS include Europe's Galileo, the USA's NAVSTAR Global Positioning System (GPS), Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) and China's BeiDou Navigation Satellite System.
INVERT GIMBAL TILT	If checked then right joystick stick up-down is inverted. Applies to rotate gimbal, move video track box and move geo-lock position
CALCULATE GEOLOCK TARGET IN GIMBAL	Choose if calculating new geolock target (moving geolock target with joystick in geolock mode) is made in GCS or gimbal. NB: gimbal must have elevation map for the area to calculate correctly if chosen to calculate in gimbal!

16 GCS SETTINGS

16.1 SETTINGS

Operator can configure general settings under first submenu.

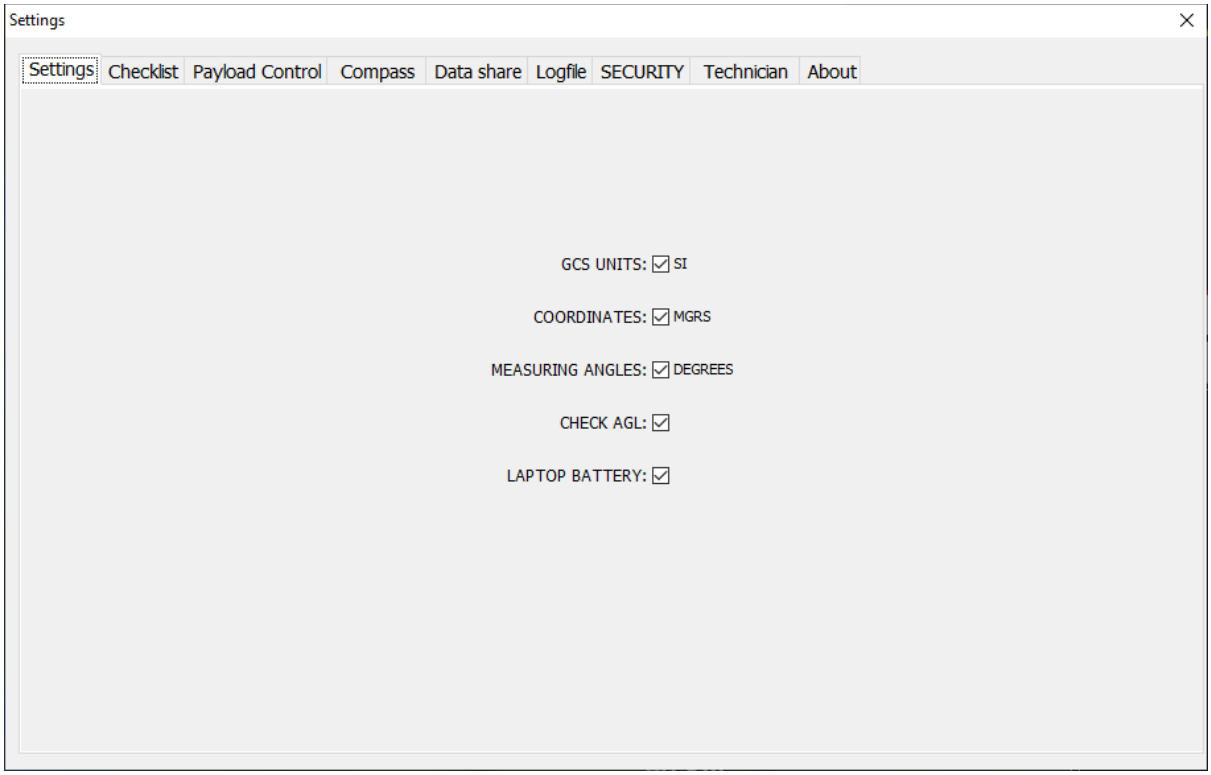


Figure 110 Settings menu

GCS UNITS	Operator can select between metric (SI) and imperial unit (knots and feet) systems.
COORDINATES	Operator can select between MGRS and LAT/LONG coordinates.

MEASURING ANGLES	Operator can select between MILs and degrees.
CHECK AGL	Automatic check for flight path compared with AGL values.
DTG IN STATUSBAR	Show date time group (DTG) in status bar.
AC POSITION IN STATUSBAR	Show aircraft (AC) distance to GDT and aircraft coordinates.
LAPTOP BATTERY	Show laptop battery charge.

NOTICE

Marked checkbox enables reference shown on the list.

16.2 CHECKLIST

Menu provides operator a selection of functions to perform UAV preflight checks on servo mechanism, impeller and motors.

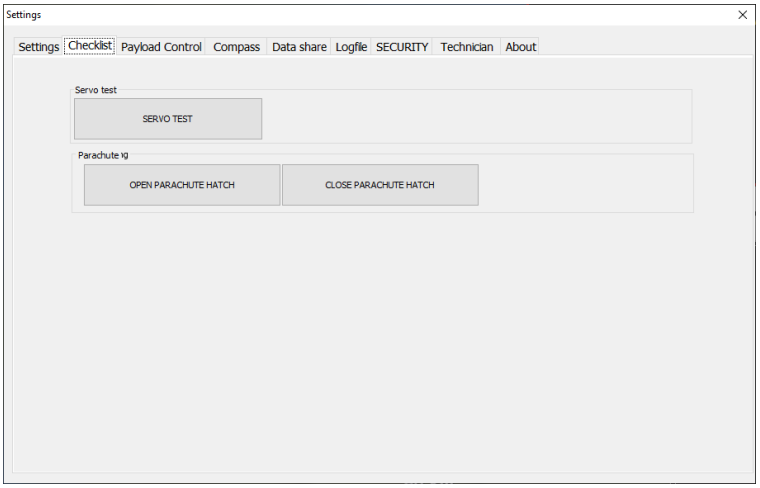


Figure 111 Checklist functions

CAUTION

WHEN OPENING PARACHUTE HATCH, YOU SHALL CHECK THE SERVO MOVEMENT AND ALSO HOLD PRESSURE ON THE HATCH, TO PREVENT PARACHUTE FROM DROPPING OUT.

CAUTION

CHECK SERVO MOVEMENT DIRECTION BEFORE THE TEST, TO PREVENT FINGERS GETTING STUCK BETWEEN THE BODYSHELL AND SERVO ARM.

16.3 PAYLOAD CONTROL

Duplicates the functions of the hand control. Operator can pan/tilt, zoom in/out payload cameras, change sensors without additional equipment.

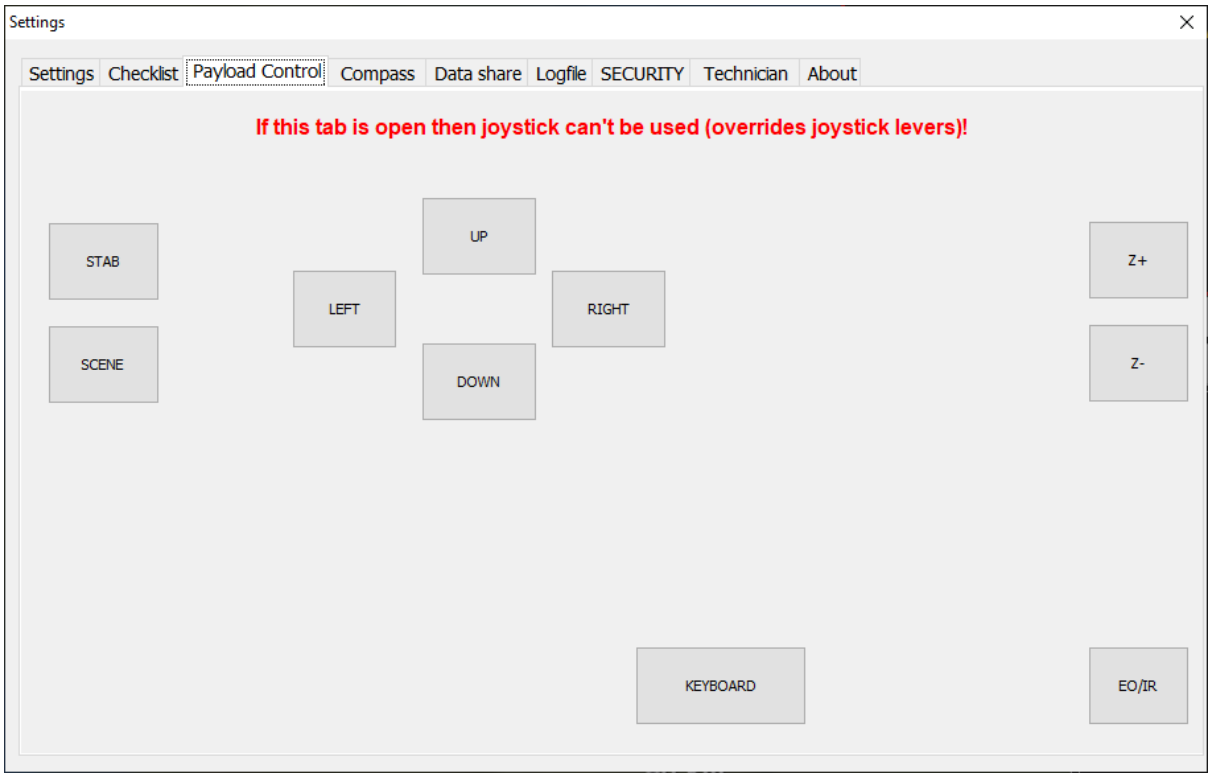


Figure 112 Payload control

NOTICE

If payload control tab is opened, hand controller joystick functionality will be slower, because software and controller both are sending values.

16.4 COMPASS

Aircraft has built-in INS (inertial navigation system). It is necessary to calibrate INS and Compass in Autopilot. The autopilot automatically calculates the declination value at the location from the first valid GPS coordinate. The user does not need to write the magnetic declination manually if the values are correct. It is important to check the values:

- When changing countries, make sure the magnetic declination is correct.
- When changing continents, it is essential to calibrate the compass.
- In case there is no notification before take-off. The magnetic declination values must be refreshed.

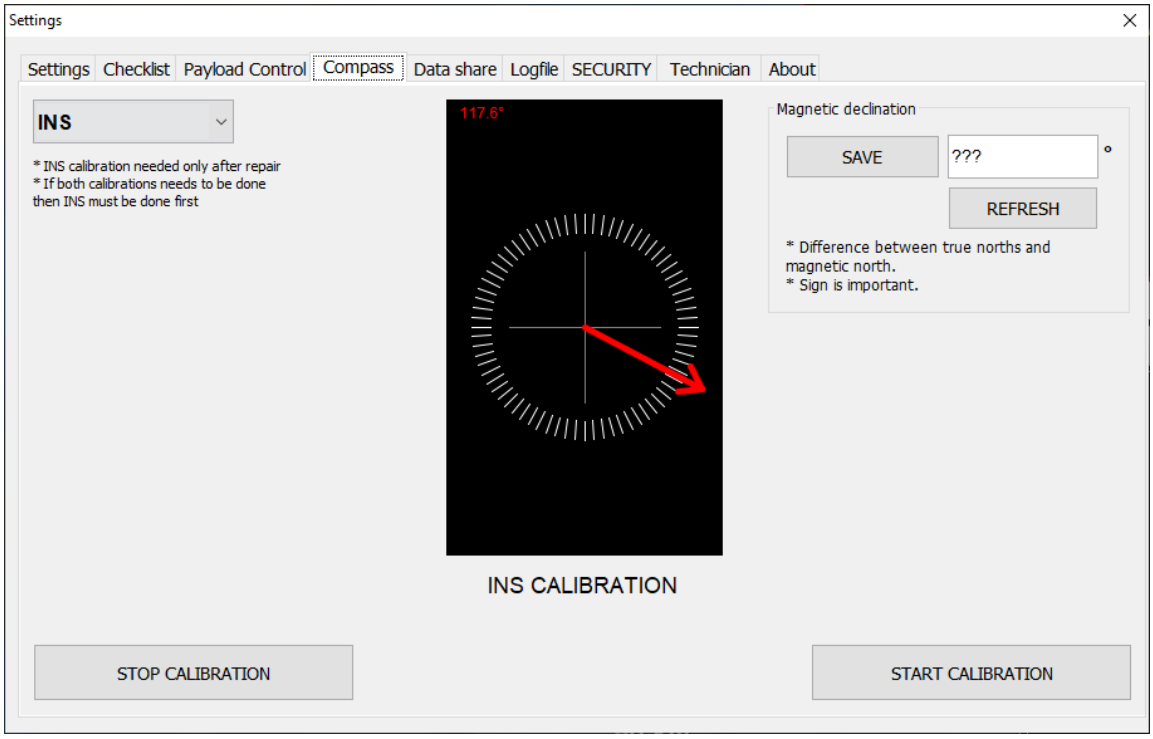


Figure 113: Compass calibration window

- Check INS/Compass calibration from EOS C MAINTENANCE MANUAL.

NOTICE

Safe distances for compass calibration:

- 15 cm minimum: Metal rim glasses, pen/pencil, metal watch band, pocketknife, metal zipper/buttons, belt buckle, batteries, binoculars, cell phone, keys, camera, camcorder, survey nails, metal tape measure.
- 50 cm minimum: Clipboard, data collector, computer, GPS antenna, 2-way radio, handgun, hatchet, cell phone case with magnetic closure.
- 2 m minimum: Bicycle, fire hydrant, road signs, sewer cap or drain, steel pole, ATV, guy wire, magnets, chain-link fence, bar-wire fence, data collectors that use a magnet to hold the stylus.
- 5 m minimum: Electrical box, small car/truck, powerline, building with concrete & steel.
- 10 m minimum: Large truck, metal building, heavy machinery.

16.5 DATA SHARE

Operator can configure GCS networking information by editing groups and node names that will be shown to other network users.

All new values must be saved. If selecting reset current values, name and group information will be set as default. Default value is showing GCS type and operating position.

Other network user node names, status, group, and network information is shown in list below.

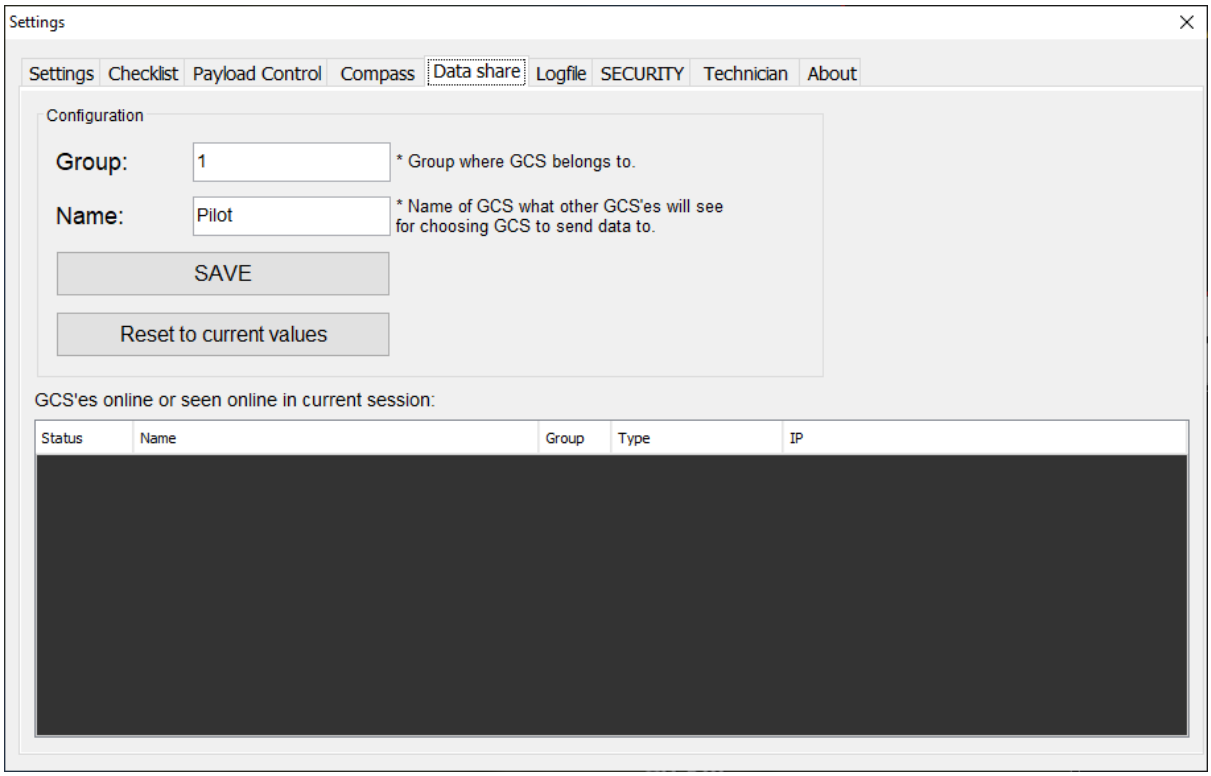


Figure 114 GCS Messaging

NOTICE

Pay attention on node activity status. List will show nodes present or seen in past.

Over Data share is possible send:

- POI (points of interest)
- Mission – 2nd pilot cannot receive it
- Manual loiter – 2nd pilot cannot receive it
- Fire support Target
- GRG (gridded reference graphic)[12]
- Custom radio profile

16.6 LOGFILE

To protect the log files stored on the UAV, all saved logs can be encrypted using AES-256-CBC IV 0. To access the encrypted log files the user needs to decrypt these files first. This can only be done with the GCS that has the appropriate decryption key. The key is stored in the configuration file of the GCS software (conf\ conf_fixedwing_override.toml). Key length is 32 bytes and it is stored in hexadecimal numbers (0...9 A... F). One byte is two characters ex: 1F. For maximum security, use random password generator to generate the key.

- GCS will delete automatically logs older than 90 days on startup to free up hard drive space and also older logs are not relevant anymore.

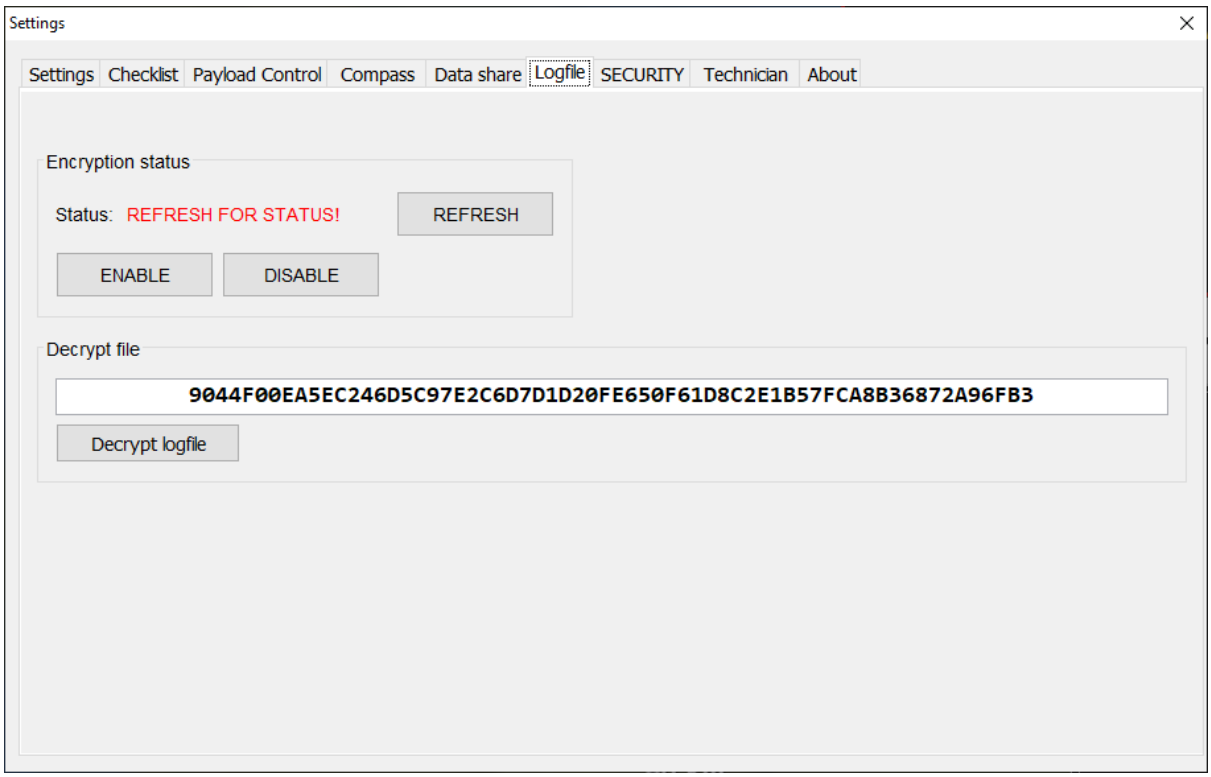


Figure 115 Logfile decryption

[12] GRG not implemented in Mission Software

EXAMPLE:

9044F00EA5EC246D5C97E2C6D7D1D20FE650F61D8C2E1B57FCA8B36872A96FB3

To decrypt logs, press the **Decrypt logfile** button.

Once the decryption process has ended, the decrypted file is saved in the same folder with the original.

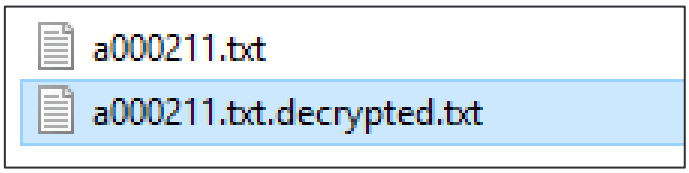


Figure 116 Decrypted logfile

NOTICE

Encryption status must be chosen before take-off. If you ENABLE or DISABLE it to the opposite during the flight, then you will break autopilot logfile.

The flightlogs will be stored on the UAV autopilot SD memory card. The files are categorized in the folders by dates. The prefixes determine the type of log captured.

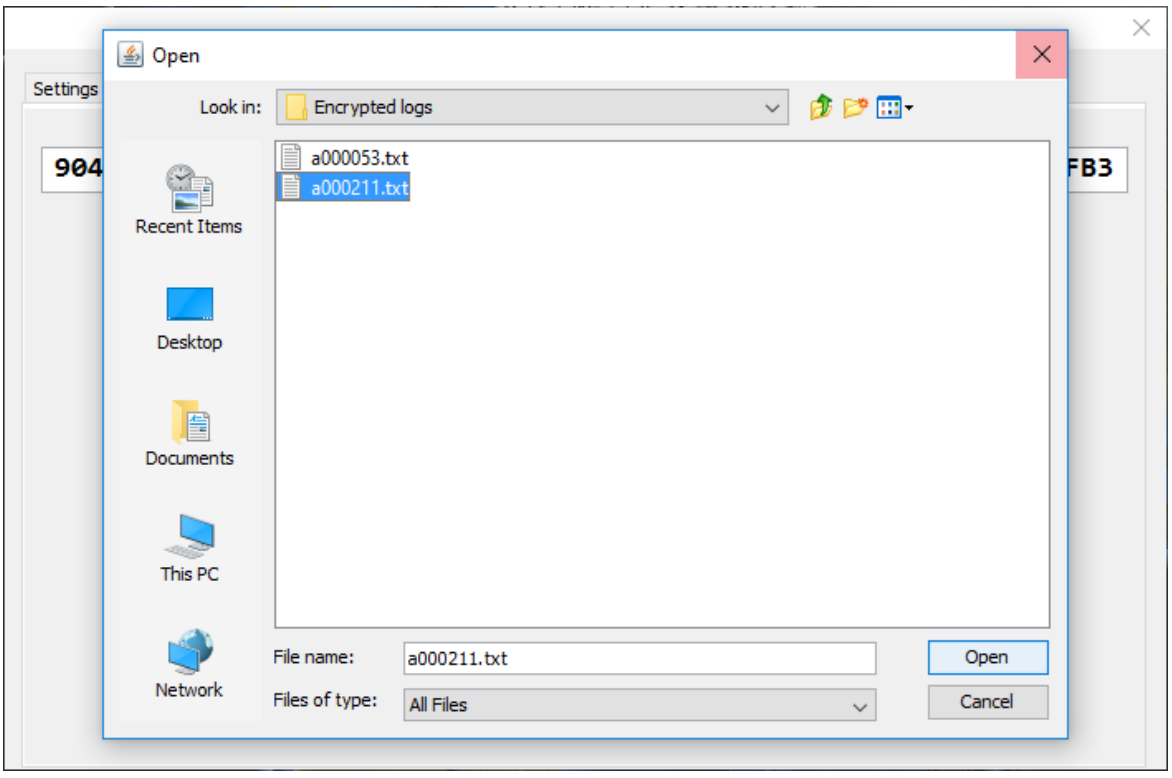


Figure 117 Decrypted logfiles folder

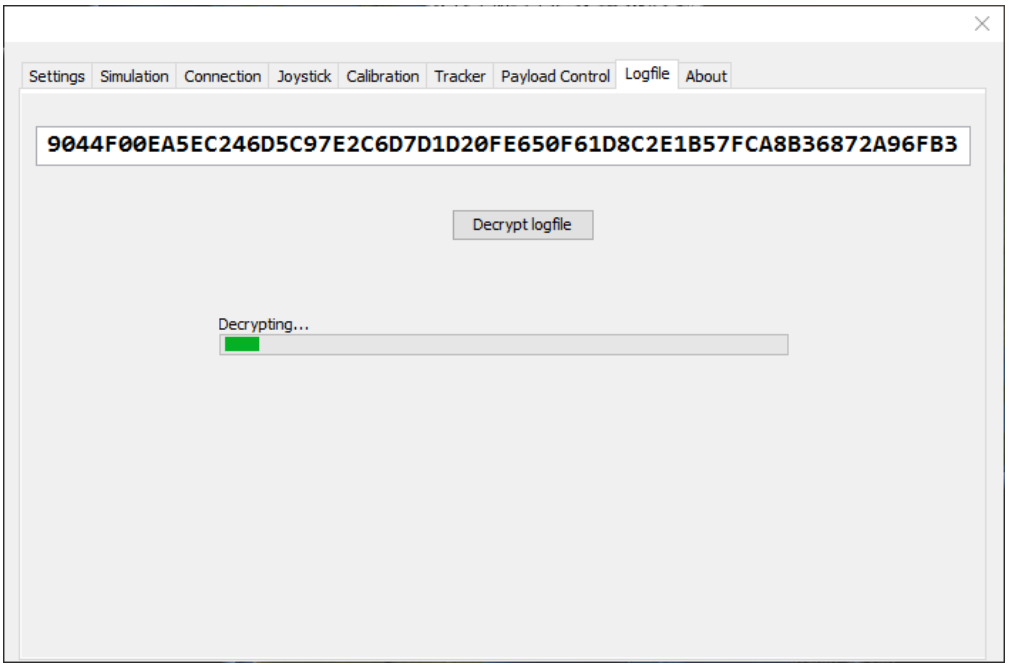


Figure 118 Decrypting

16.7 SECURITY WINDOW

With connected aircraft it is possible to erase over the air autopilot SD card and gimbal SD card.

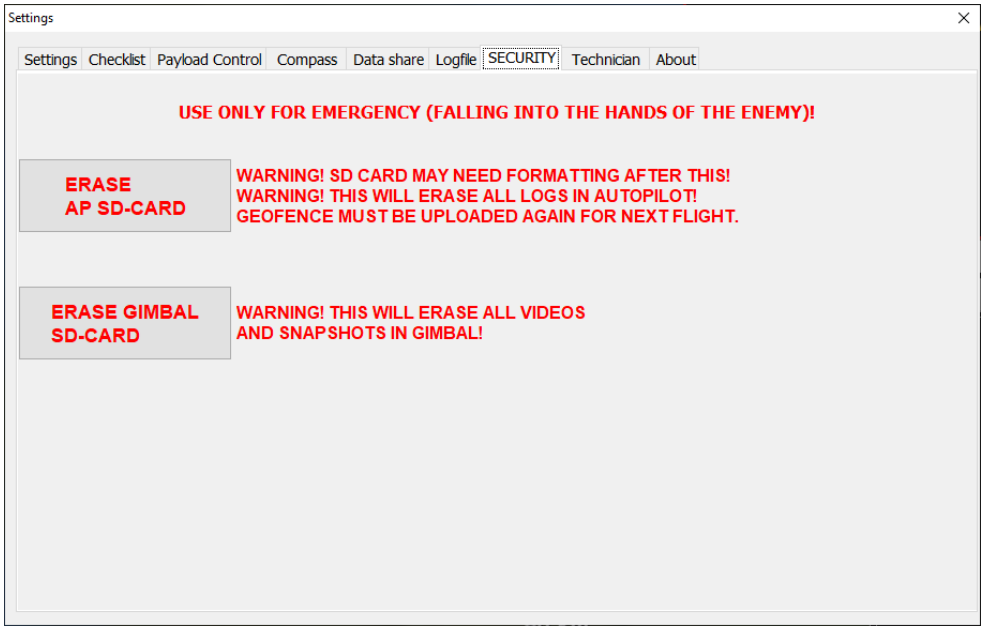


Figure 119 Security window[13]

NOTICE

After Erasing AP SD-card, it is required to format AP SD-card

[13] 2022-06-09 Update

16.8 TECHNICIAN WINDOW

The technician window allows the user to review UAV parameters for remote assistance from the technician.

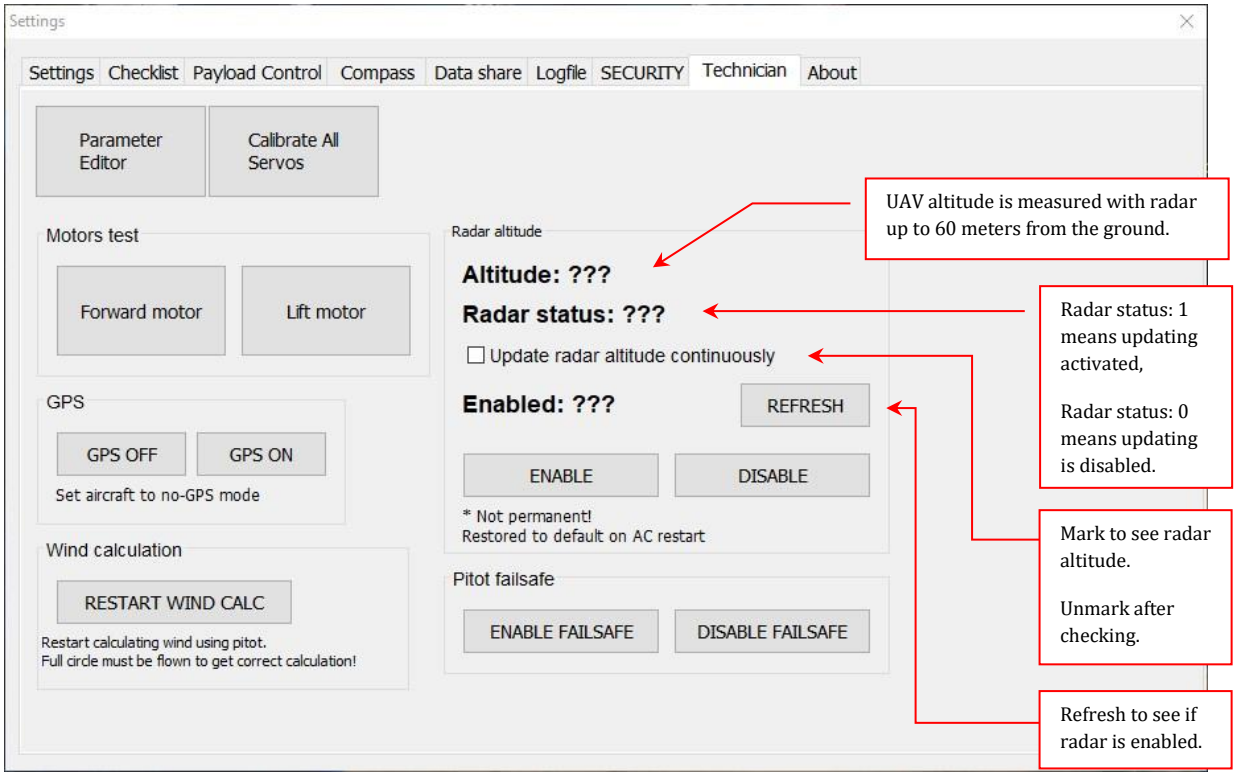


Figure 120 Technician window

Motors test - To test aircraft motors, **ARM** aircraft.
Forward motor- Accelerates forward motor to maximum throttle and stop it.
Lift Motors - Will spin each motor for 1 secund.

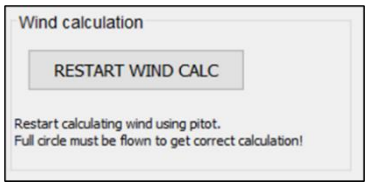
NOTICE

ARM UAV to perform FORWARD MOTOR or LIFT MOTOR test. After test DISARM UAV.

When using VTOL wing type, run forward test only on specifically dedicated bench!

CAUTION

WHEN PERFORMING MOTOR TESTS, MAKE SURE THAT IT IS SAFE AND PROPELLERS CAN SPIN FREELY!



Wind calculation[14]
RESTART WIND CALC- when due to GPS lost, user has used OVERRIDE AIRCRAFT POSITION, then autopilot will not automatically start wind calculations. To activate wind calculation, aircraft needs correct GPS signal. After that click RESTART WIND CALC and make full circle in the air.

To view parameters, select **Parameter editor** and **LOAD FROM AP**.

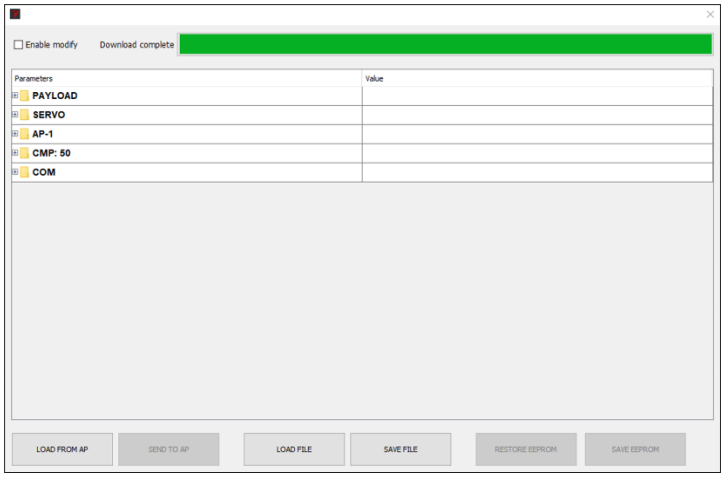
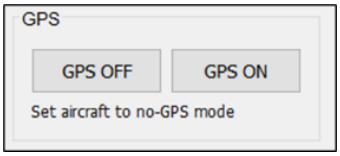


Figure 121 Loading AP parameters

Press **Calibrate All servos** if you got error message about servos, but all servos movement is correct and they can move freely. Calibrating all servos is needed, when replacing wing tip or tail boom with a new part.

16.8.1 GPS ANTI-JAMMING



GPS[15]
GPS OFF- Turns off GPS signal usage.
GPS ON- Turns on GPS signal usage.

If GPS is jammed or spoofed, the user can switch off GPS signal usage. Before landing, if the GPS signal is not restored, it is advised to switch the GPS OFF. If the GPS stays on during landing and the aircraft receives a GPS signal, it will try to match it with the mission plan. Since the GPS values will not match, the aircraft starts heading toward the mission plan. This is especially dangerous with an empty battery.

[14] 2022-08-17 Update
[15] 2022-08-10 Update

The anti-jamming configuration weighs 250 grams and consumes 6W of power which will make endurance flight time shorter. The position accuracy after bootup can fluctuate up to 20m from the actual location, and altitude can fluctuate ±25m within the first 10 minutes. The GPS accuracy gets better during the flight.

Gimbal's maximum satellite count is 16, while GPS's is 29. If the constellation is changed the gimbals satellite count will disappear and the aircraft is very sensitive to jamming, tracking is imprecise, and the geolock is not working. When coming out of alignment, it is imperative to make dynamic flight – a lot of turning with small distances like loitering the number 8 & changing altitude 100-200m.

In case of resetting:

- Reset INS – will give an error "GPS0 fix lost". Orca will go out of alignment, and the geolock is not working. The aircraft will start using secondary GPS and the satellite count will change.
- Power reset – will lose GPS if it is an anti-jamming configuration.
- BLDC & SLA reset – will not lose GPS.
- Comboard reset – will lose the GPS, but the aircraft will keep on flying.

If GPS is enabled manually:

1. An error will occur "GPS loss timeout expired".
2. If GPS is manually turned off, it is important to check failsafe parameters and adjust them if needed.
3. The sensor status will show "No enabled GPS found in the system"
4. If the gimbal has GPS satellites and GPS is enabled manually, there is no change within the gimbal.

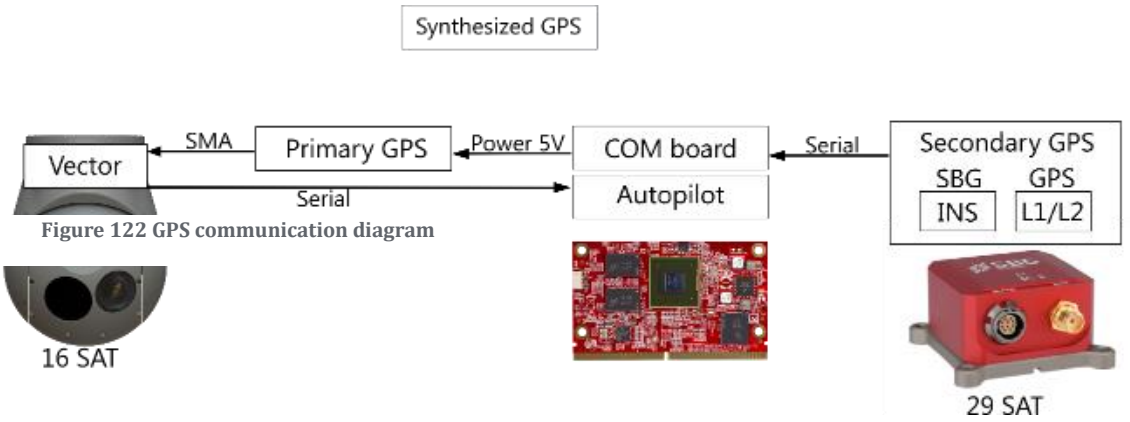


Figure 122 GPS communication diagram

NOTICE

GPS anti-jamming is only available with an integrated Anti-Jamming module and at least with Release 2 updated gimbal and autopilot.

The anti-jamming module is in the fuselage. It is imperative to handle the fuselage with care:

- Do not add any pressure on the top of the aircraft.
- Do not place aircraft upside down on hard surfaces. If needed to place the aircraft upside down it is recommended to either add a cushion before placing the aircraft on a hard surface or let another operator hold the fuselage.
- The antenna cannot be covered or fixed with carbon or aluminium tape. If needed, glass fiber and epoxy can be used for fixing.
- Do not keep objects close that disturb the signal.

EOS C UAV with a long Y tail and empty landing compartment's tail can be switched with EOS C UAV with an anti-jamming configuration.

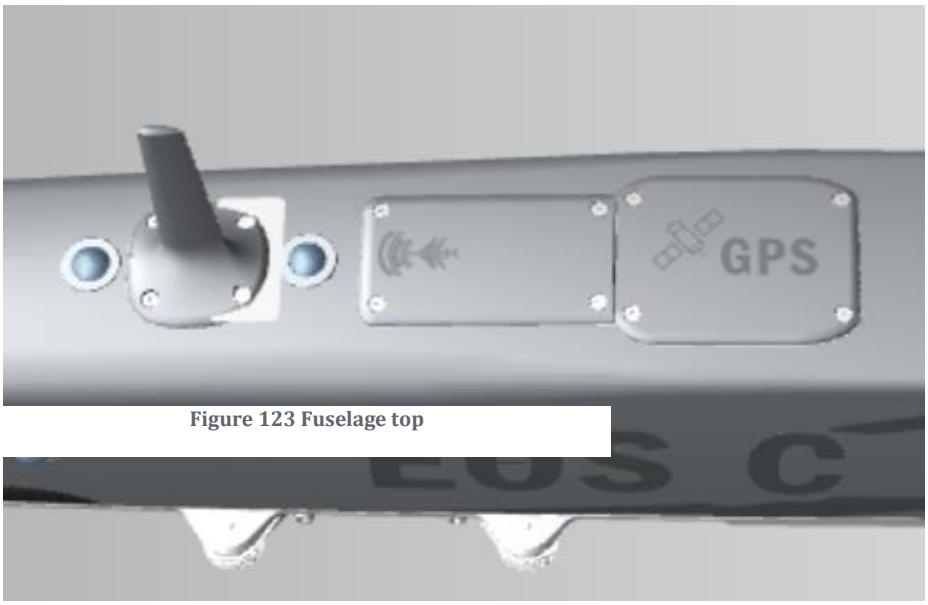


Figure 123 Fuselage top

16.8.2 PITOT FAILSAFE

A Pitot tube is a device used to measure the airspeed of an aircraft relative to the surrounding air. the Pitot tube provides an estimation of the aircraft's indicated airspeed (IAS) by measuring the difference between static and dynamic pressure in the airflow. In failsafe mode, the airspeed is calculated using the aircraft's position and the engine's power.

Pitot failsafe is used when the pitot is iced or blocked by particles like water, sand, or dust. If the aircraft's wing is already iced, the pitot will be iced shortly after. The pitot tube can be looked at by the "Look Pitot" button or by manually handling the gimbal. When the pitot cannot measure airspeed correctly the IAS value will be significantly smaller compared with GND.
For example, the aircraft is flying steadily at a fixed altitude (does not apply to take-off and landing), and the IAS shows 50 km/h, GND 100 km/h even though the wind speed is only 1 m/s. The aircraft will want to reach the desired airspeed and will push the throttle to 100%, amperage usage will be very high, and pitch will be -10…-15 degrees. It is recommended to ENABLE the pitot failsafe and to land as soon as possible. The failsafe is under Settings -> Technician.

In case the pitot cover is left on, there are three different scenarios of what the operator can do. In each scenario, the operator can change to guided mode and land manually. During take-off, it is imperative to ensure that speed and altitude are increasing. One operator must always observe the aircraft's indicators.

What to do if the pitot cover is left on:

1. **Do VTOL LAND immediately if you notice the pitot cover was left on.**
   1) While doing VTOL LAND the landing point can be dragged to another spot if the aircraft's height is 60-100 m. In case the aircraft's height is under 60 m, the landing point should not be changed. The aircraft can also be landed manually, using guided mode.
   2) After landing, check the propeller for damage, reboot the aircraft, THEN remove the pitot cover. The battery can be changed if an endurance flight is planned.
   3) The GCS will show the landing point with an icon until take-off or GCS is closed.

2. **The aircraft will do VTOL LAND automatically**
   1) The aircraft will fly approximately 100…400 m (depending on the wind), until noticing it cannot reach the desired airspeed. The aircraft will give errors "***VTOL transition timeout, disabling fixed wing mode***" and "***VTOL switched to rotary wing only mode***" meaning the aircraft is not trying to transition and will be in rotary wing mode.
   2) The aircraft starts to fly 5 m/s GND toward the landing point. Most of the time the aircraft will not turn its nose directly towards the landing point but will still move towards it.
   3) In case the wind is over 5-6 m/s it is recommended to do VTOL LAND immediately if the area is clean. It is important to observe battery voltage and amperage. In case of strong wind, the aircraft can overshoot the landing point and, while trying to catch it, can use up too much battery and crash.
   4) It is imperative to switch the battery before the next take-off.
   5) Gimbal can still be used during VTOL LAND.

3. **The aircraft is in VTOL LAND mode but the operator lands manually in guided mode**
   1) If the operator chooses to land in guided mode, the LANDING POINT must be always at the **front** of the aircraft. The landing point location can be changed but must always remain in front of the aircraft. The aircraft will land at a speed of 2-3 m/s. The joystick buttons must be held down until the aircraft is disarmed.

16.9 ABOUT

This is informative board where operator can see latest changes, updates and bug fixes. Information is available with every software update.

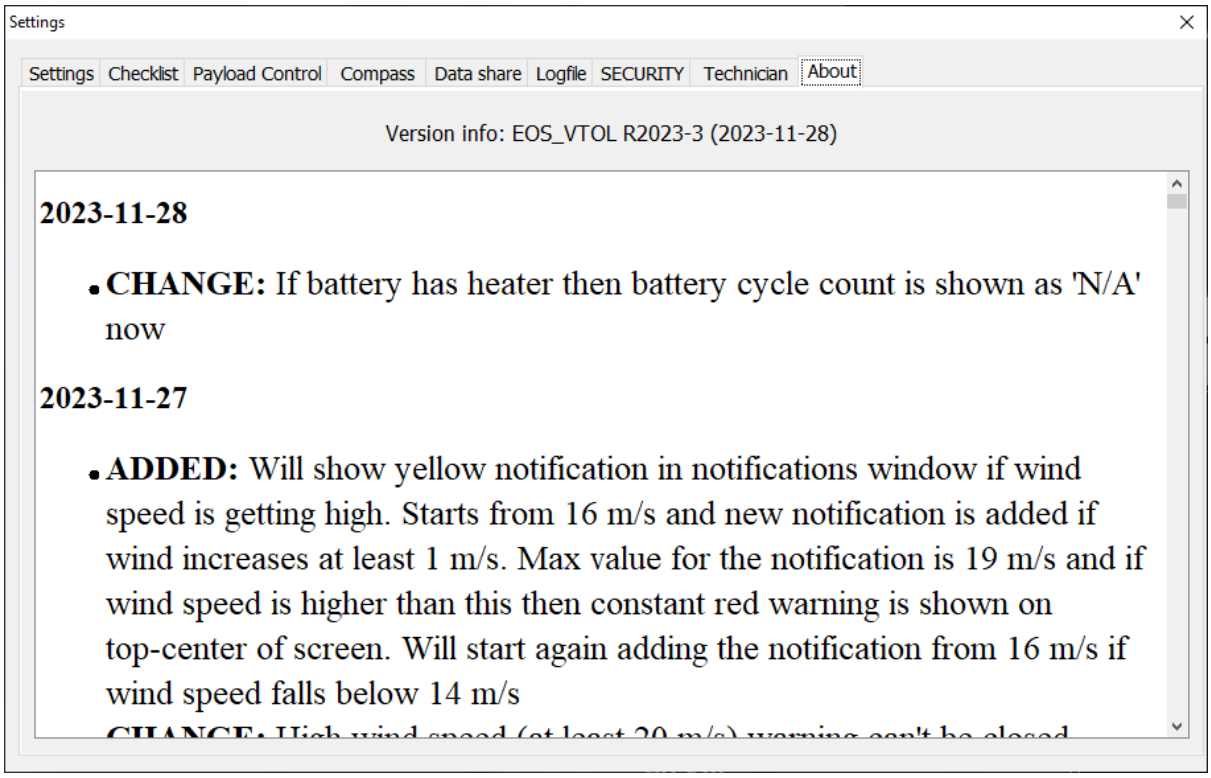


Figure 124 Version history

17 GEOFENCE

Geofence is a feature of the autopilot where the operator can define polygons or paths that the aircraft shall not cross. This allows the operator to specify enclosed “boxes” which the aircraft is unable to leave or “boxes” where the aircraft is unable to enter. It is possible to create combinations of both. Last GEOFENCE will be restored automatically after start up.

Geofence is active only in AUTO mode! When the aircraft is switched to GUIDED mode no geofence checks are preformed and the operator is in full control.

Geofence is created, configured, uploaded and saved using the Geofence Editor.

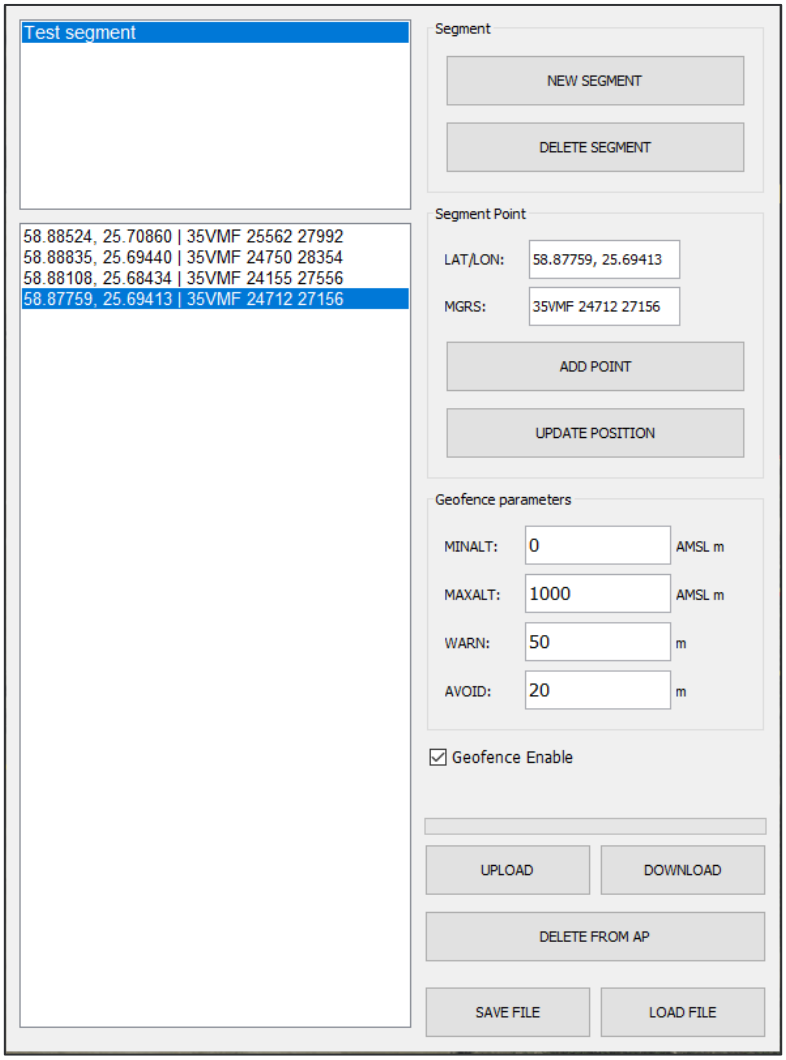


Figure 125 Geofence editor

Geofence consists of segments. Each segment has points which define the polygon or path. All segments must have different names! Create a new segment by clicking on **New Segment**.

Segment is defined by the line(s) between two or more points. Known coordinates can be entered from **Segment Point** section on the editor by entering coordinates in desired format and selecting

ADD POINT, or manually marked by making right click on preferred location on map and selecting **Add new point**.

Figure 126 Geofence point selections

Add new point	adds new point to the segment.
Close path	closes the path. Closed path terminates at the beginning effectively creating a polygon.
Open Path	Opens the path. Open path terminates at the last point.
Remove points	Make right click on desired point to remove it.

Point location can be changed from the editor by making updating point active from the point list and entering coordinates in desired format and selecting **UPDATE POINT.**

NOTICE

If geofence point(s) must be updated after the activation, segment must be up and downloaded again.

User is able to define **Geofence Parameters** by minimum and maximum altitude.

WARN	Distance where the user receives the notification that UAV is closing too close for the geofence. Notification is shown in notification window and marked yellow.
AVOID	Distance where the UAV starts avoiding marked line. Notification is shown in notification window and marked red..

CAUTION

MINIMUM DISTANCE FOR WARNING IS 1.5 NM AND 0.5 NM FOR AVOID NOTIFICATION.

After segment has been defined, mark **Geofence Enable**, **UPLOAD** it to UAV autopilot and **DOWNLOAD** it to activate. After download from autopilot, will be renamed into “SEGMENT 1”, “SEGMENT 2” etc.

To delete segment, unmark **Geofence Enable** and select **DELETE FROM AP**.

User can pre-plan segments by selecting **SAVE FILE** and have them for later use by selecting **LOAD FILE.**

It is possible to create overlapping or wholly enclosed segments inside other segments. Above example could be used in a scenario where the outer polygon defines the area where the aircraft is permitted to fly in. The smaller segment defines a region where the aircraft shall not go to (obstacle, restricted area, flight activity etc).

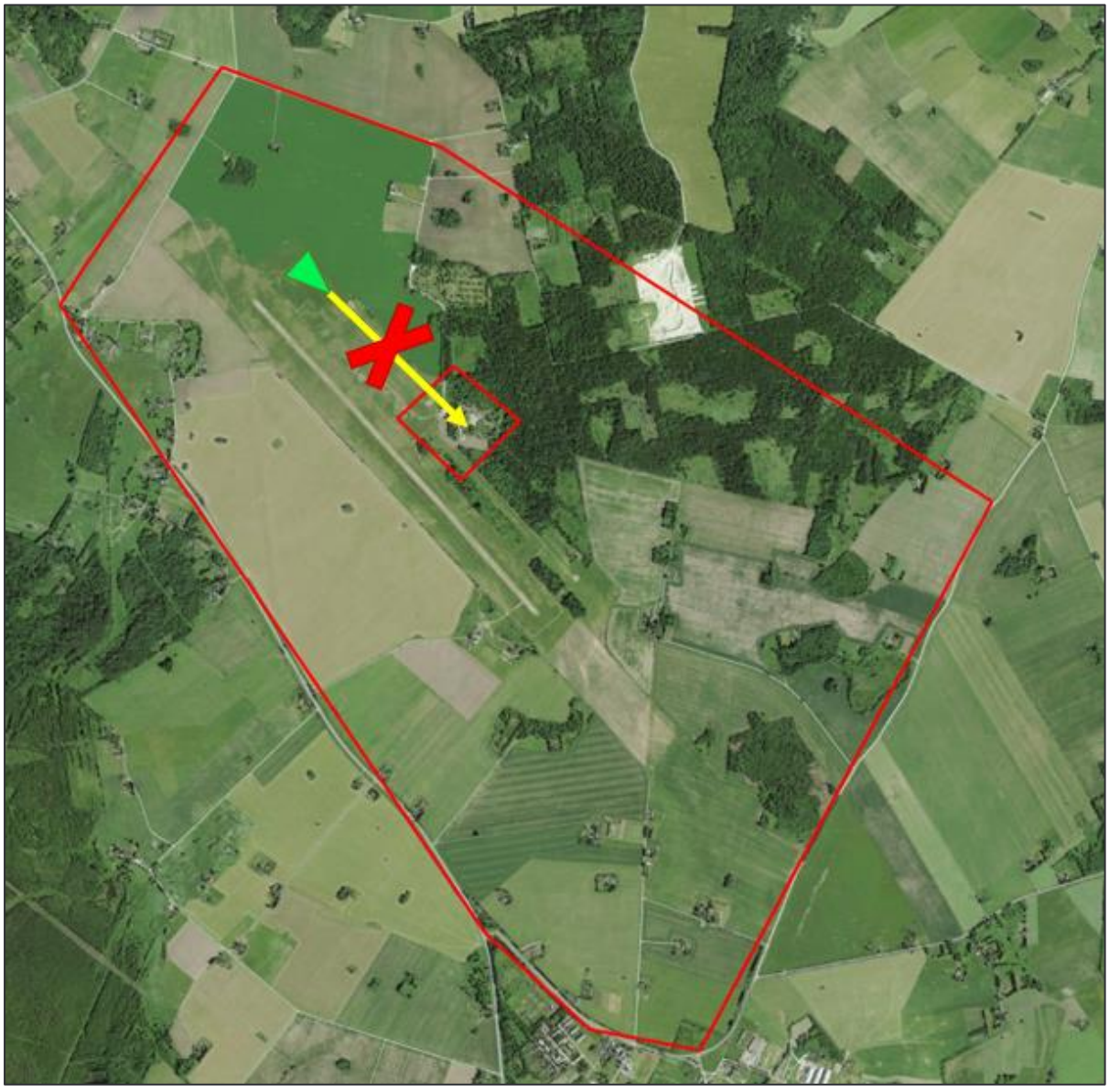


Figure 127 Geofence segment inside another segment

In the below geofence example there are two polygons defined. An outer polygon for the area where the aircraft is permitted to fly and a smaller restricted area where the aircraft is not permitted to enter. When the operator calls the aircraft from WAYPOINT 4 to pre-landing loiter down at WAYPOINT 8L, the autopilot first starts to fly directly towards 8L. Upon reaching WARN distance from the restricted area an error message is sent to the operator. When AVOID distance is reached, the autopilot executes

an avoidance manoeuvre and then proceeds again to 8L. Avoidance manoeuvres are executed until the aircraft is clear to proceed to 8L.

This type of geofence planning is also useful for emergency situations where LINK LOSS or other errors force the autopilot to abandon mission and execute an automatic return to landing point. If there are some areas where the aircraft is not allowed to fly at, they shall be defined with geofence editor and the aircraft will fly around them.

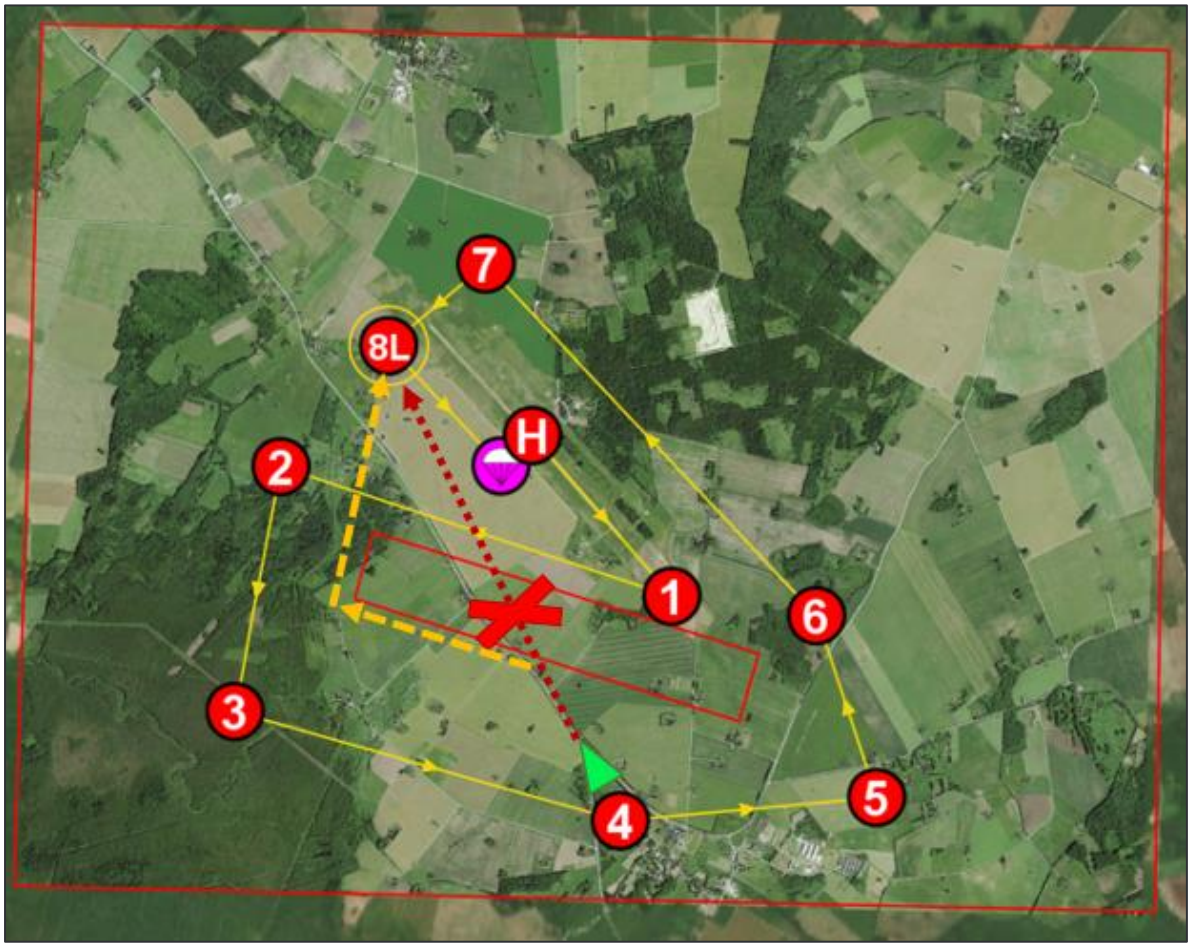


Figure 128 Geofence example

18 FIRE SUPPORT

Fire support targets

Fire support can be conducted with the ORCA gimbal. Fire correction is performed by observing and marking a missed target shot by an artillery shell and calculating the necessary adjustments for the artillery to hit the target with subsequent shots fired.

The operator can manage the target list, generate call for fire and calculate fire adjustments. If there is an FDC element integrated into network CFF can be sent directly over network. The system can create fire mission text that can be read out over the secure communications network.

18.1 TARGET LIST

Targets list manages all the targets. You will see all the targets in the list that contains ID (unique number generated automatically, not shown on map), target name, MGRS coordinates, type (point, linear, area), length (if it's type is not point), width (if it's type is area), attitude (in mils and if it's type is not point) and altitude.

Target can be selected by clicking on the target in the list or by clicking on target name on map (NB target name not the boundaries of the target!).

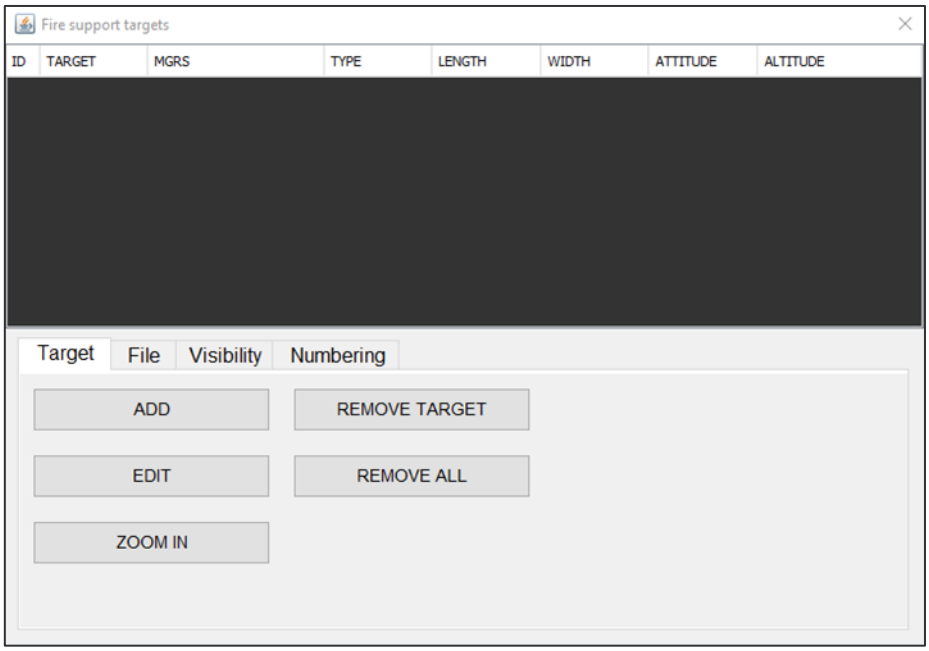


Figure 129 Fire support Target List window

Clicking on the "REMOVE TARGET" button will delete the selected target. A confirmation will be requested if any target was selected.

Clicking on the "REMOVE ALL" button will delete all the targets. A confirmation will be requested to complete the action.

Clicking on the “ZOOM IN” button will center the selected target on the map and zoom in with an animation.

Clicking on the “EDIT” button will open the target editor which is the same as the target creation window except that the “CREATE TARGET” button is replaced with an “UPDATE TARGET” button.

New targets are defined either by right-clicking on the map and choosing the required target type (point, linear, area) and selecting “Add target” (Figure 130 Fire support Target menu - Add target) or by entering it manually from the new target creation window (Figure 131 New Fire support Target) which is opened by clicking the “ADD” button under the “Target” tab in the targets list window (Figure 129 Fire support Target List window).

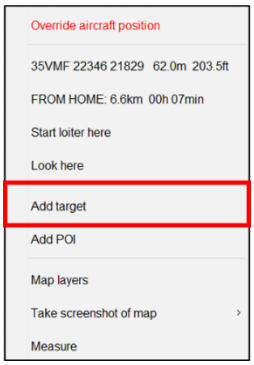


Figure 130 Fire support Target menu - Add target

To add a new target from the map, click the required target position on the map. The target is created when the target type is selected as “point”.

To add a linear target from the map, click the first location on the map (first point of the target) and then click on the second location to define the end of the target. After the second click the target is created. Prior to performing the second click, while moving the mouse on the map, the target is constantly updated on the map and the length is updated in 100m steps and the angle in 100mil steps. The second click must be a right mouse click to finish the target creation. The minimum length of the target is 100m.

To add an area target from the map, click the first location on the map to position the corner of the target. The second right mouse click is defining the angle of the target and length of one edge. The third right mouse click is defining the length of the second edge. After the third click, the target is created. Both edges have a minimum size of 100m. Prior to the second click (when the angle and first edge is defined), 100m length is used for the second edge while moving the mouse on the map. The length is changed in 100m steps and the angle in 100mil steps.

18.2 MANUAL TARGET CREATION

The manual creation menu for a Fire support target is shown in Figure 131 New Fire support Target.

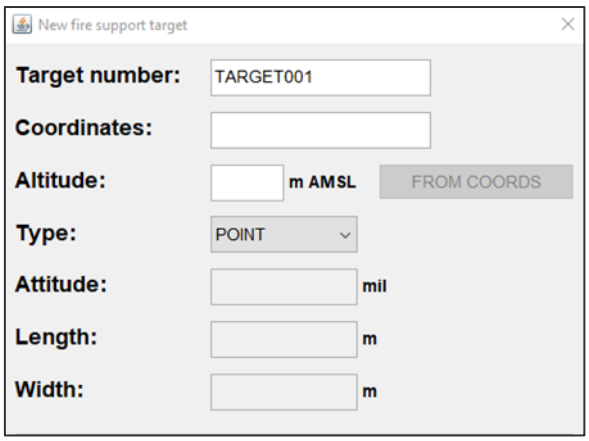


Figure 131 New Fire support Target

If this target creation window is opened, a white crosshair is drawn in the center of the map.

The Target number field is automatically pre-filled according to the target numbering rules defined by the user under the “Numbering” tab in the fire support target list window (Figure 137 Fire support Numbering menu). A Target number must be unique.

Clicking on the “FROM MAP CENTER” button will add the coordinate of the white crosshair to the coordinates field. The coordinates are the center point of the target.

Clicking on the “FROM COORDS” button will set the ground elevation of the target position to the altitude field. This button is only enabled if a valid coordinate exists in the coordinate field.

The type selector sets the type of target, which can be point, linear or area (refer to paragraph 18.1for details regarding the target types).

The Attitude field sets the attitude (heading) of the target in mils and must be rounded to the nearest 100 mils. This field is enabled only if the target type is not set to point.

The Length field sets the target length in meters and must be rounded to the nearest hundred. This field is enabled only if the target type is not set to point.

The Width field sets the target width in meters and must be rounded to the nearest hundred. This field is enabled only if the target type is set to area.

Clicking on the “CREATE TARGET” button will create the defined target. This button is enabled only if all the enabled fields are filled and contain valid values. If the target length is smaller than its width, the two parameters will be swopped automatically, and the attitude recalculated. If the Attitude is larger than, or equal to 3200mil then 3200 will be subtracted from the value to scale it to between 0...3100mil.

18.3 FIRE SUPPORT TARGET TYPES

The following fire support target types exist:

1. Point Target type

The selected target will show a danger close area as a red filled area with the danger close radius value in meters shown on top of the danger close area circle (Figure 132 Fire support Target – Point). The danger close area radius can be changed by right clicking on the target name on the map and choosing “Set danger close radius”.

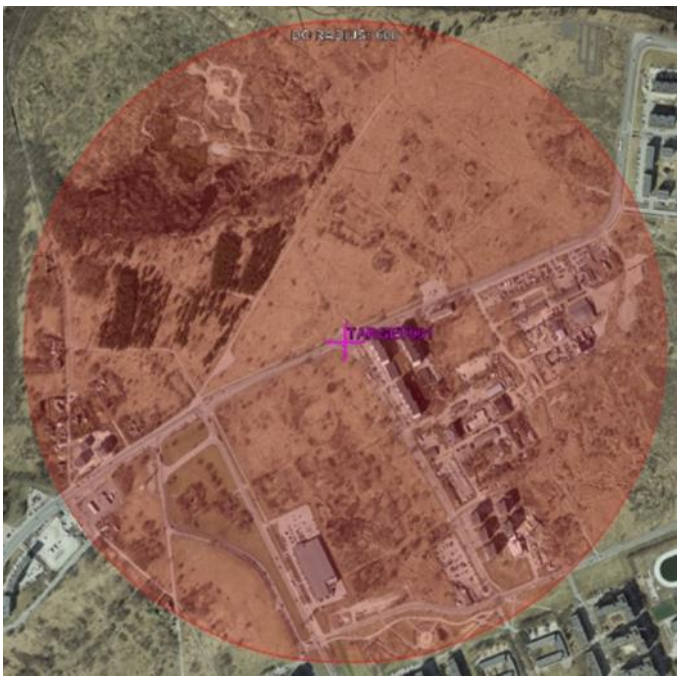


Figure 132 Fire support Target – Point

2. Linear Target Type

The selected target will show danger close area as a red filled area with the danger close radius value in meters on top edge. The danger close area radius can be changed by right clicking on the target name on the map and choosing “Set danger close radius”.

Figure 133 Fire support Target - Linear

3. Area Target type

The selected target will show the danger close area as red filled area with the danger close radius value in meters on the top edge. The danger close area radius can be changed by right clicking on the target name on the map and choosing “Set danger close radius”.

Figure 134 Fire support Target - Area

18.4 TARGET FILE OPERATIONS

The following section describes the file operations for the target system. (Refer to Figure 135 Fire support File menu)

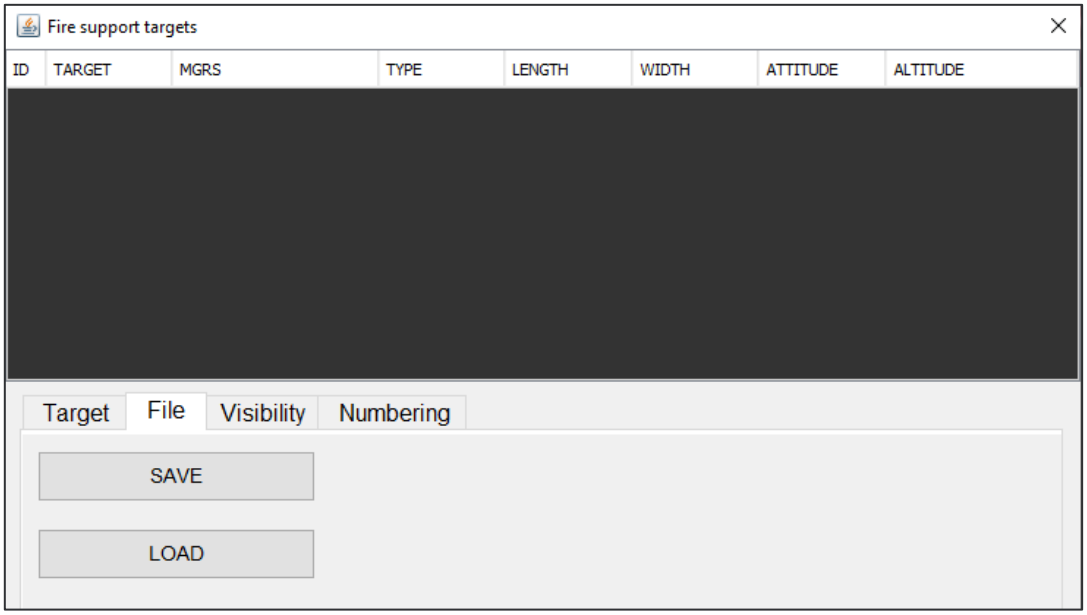


Figure 135 Fire support File menu

Clicking on the “SAVE” button will open the file save dialog for saving the targets to a file.

Clicking on the “LOAD” button will open the file load dialog box to select and load targets from a file. All the current targets will be removed from list when new targets are loaded.

18.5 TARGET VISIBILITY

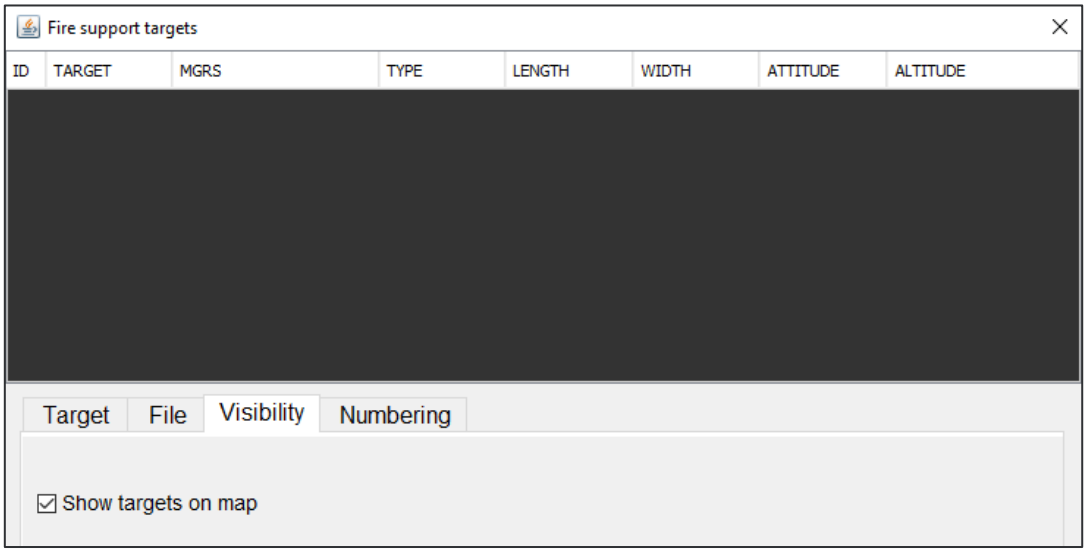


Figure 136 Fire support Visibility menu

If the “Show targets on map” checkbox is checked, the targets are shown on the map, otherwise all the targets are hidden on the map.

18.6 TARGET NUMBERING

This section describes the automatic target number generation rules when creating targets.

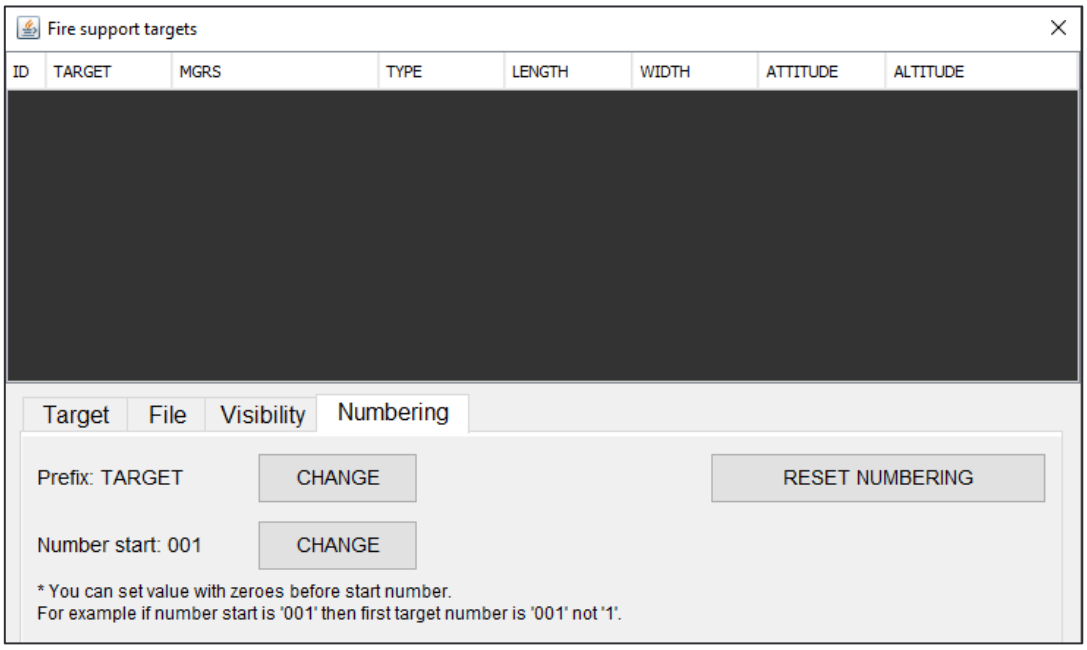


Figure 137 Fire support Numbering menu

The Target number can be changed at any time by editing the target data itself.

The automatically generated target number contains a text prefix and a number suffix which is the last target number value plus one. The number can also be set in the numbering menu if no targets exist in the targets list.

The number suffix operator can be padded with zeroes.

Examples:

- Prefix: “BB”. Number start: “001”. First target number: “BB001”.
- Prefix “BB”. Number start: “9”. First target number: “BB9”.
- Prefix: “BB”. Number start: “9”. Second target number: “BB10”.

Clicking on the “RESET NUMBERING” button will reset the numbering of the existing targets to default values according to the set rules.

Example:

- Prefix: “BB”. Number suffix: “01”.
- Target numbers in the list: “BB01”, “BB05”, “BB11”.
- After resetting the target numbering, the numbers in the list will be “BB01”, “BB02”, “BB03”.

18.7 CALL FOR FIRE (CFF)

The operator can generate “call for fire” data for reading it out over the communications radio or sending it over the network. To generate a “call for fire”, open the Firemission generation window by right clicking on the target name on the map and selecting the “Call for fire” menu.

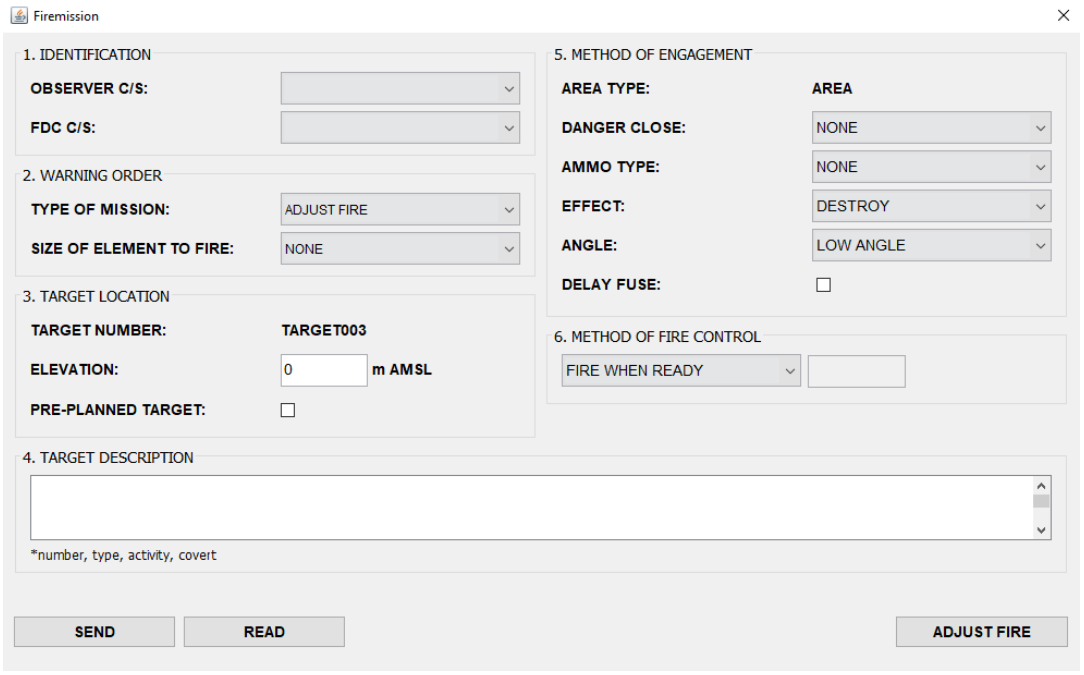


Figure 138 Fire mission description

All custom values for the following dropdown menus (where possible) are saved automatically and are restored after a GCS restart. The following is a description of the dropdown elements in the Fire Mission menu:

18.8 IDENTIFICATION

The Identification section consist of the following two drop-down menus:

- “Observer C/S”: Observer call sign selection. Can be user defined.
- “FDC C/S”: FDC call sign selection. Can be user defined.

18.9 WARNING ORDER

The warning order section consist of the following two drop-down menus:

- "Types of missions" (default):
  - Adjust fire
  - Fire for effect
  - Suppress
  - Immediate suppression

NOTICE

Custom types can be added by selecting "ADD NEW" from the list. Types can be deleted by selecting "DELETE SELECTED". (Only non-default types can be deleted.)

- "Size of elements to fire" (default):
  - 1 GUN
  - 2 GUNS
  - 3 GUNS

NOTICE

Custom elements can be added by selecting "ADD NEW" from the list. Elements can be delete by selecting "DELETE SELECTED". Only non-default elements can be deleted.

18.10 TARGET LOCATION

The target location section consists of the following items:

- "TARGET NUMBER": Shows the target number currently selected.
- "PRE-PLANNED TARGET": If this checkbox is selected, the target number is used for the fire mission instead of the coordinates. "PRE-PLANNED TARGET": If this checkbox is selected, the target number is used for the fire mission instead of the coordinates.
- "ELEVATION": The default value is the ground elevation, but it can be changed to any other value.

18.11 TARGET DESCRIPTION

A description can be entered in the "Target Description" box.

18.12 METHOD OF ENGAGEMENT

The method of engagement section consists of the following items and drop-down menus:

- "Area type": Type of target (point, linear, area) the fire mission is generated from.
- "Danger Close":
  - "YES"
  - "NONE" (means no danger close).
- "Ammo type":
  - NONE
  - HE
  - ILLUM
  - SMOKE

Custom ammo types can be added by selecting "ADD NEW" from the list. Custom ammo types can be deleted by selecting "DELETE SELECTED". Only non-default ammo type can be deleted. "NONE" means no ammo type requesting used and the default is used.

- "Effect":
  - Destroy
  - Neutralize
  - Harrass

Custom effects can be added by selecting "ADD NEW" from the list. Effects can be deleted by selecting "DELETE SELECTED". Only non-default effect can be deleted.

- "Angle":
  - "LOW ANGLE"
  - "HIGH ANGLE"

"LOW ANGLE" is the default for weapons. If this is selected, no information regarding the angle is sent.

- "DELAY FUSE": If this tick box is selected, a delay fuse request is added to the fire mission.

18.13 METHOD OF FIRE CONTROL

The method of fire control section consists of the following drop-down menu:

- "Method of fire control" (default):
  - Fire when ready
  - At my command
  - Time on target. (This enables the extra field next to dropdown).
  - Do not load

Custom methods can be added by selecting "ADD NEW" from the list. Methods can be deleted by selecting "DELETE SELECTED". Only non-default methods can be deleted.

18.14 ACTION BUTTONS

The following section describes the action buttons:

Clicking the “SEND” button will send the fire mission data over the network (if implemented and integrated.)

Clicking the “READ” button will generate the text for audio read-out from the given data (Refer to **Error! Reference source not found.**).

Clicking the “ADJUST FIRE” will open the fire adjustment window for the target (refer to section 0).

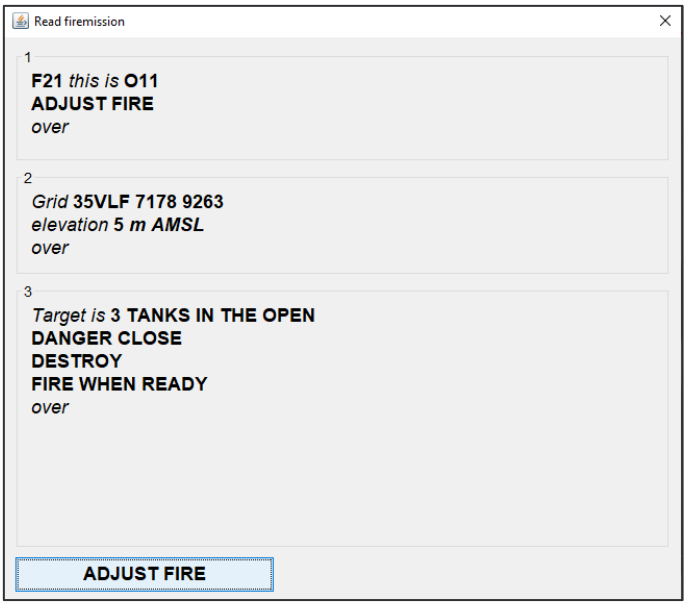


Figure 139 Fire support target reading

18.15 FIRE ADJUSTMENT

The window for the fire adjustment can be opened by right clicking on the target name on the map and selecting “Adjust fire”. It can also be selected from the fire mission generation window as described in section 18.14.

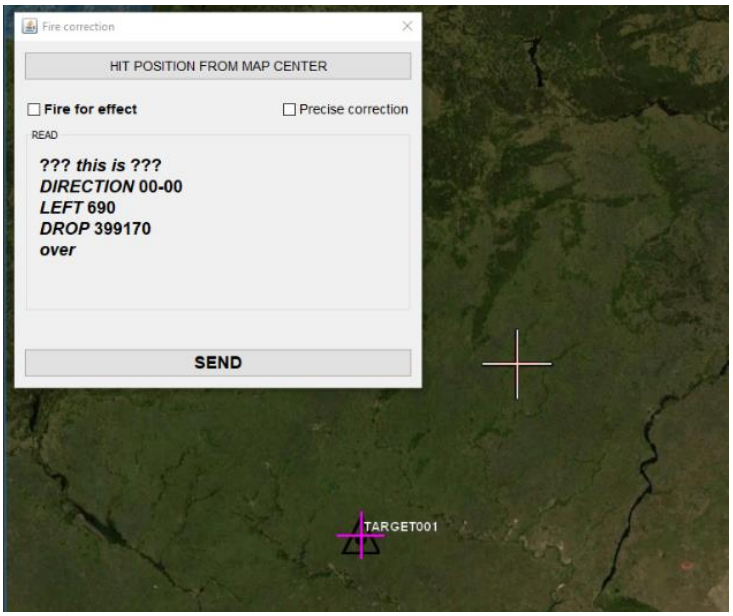


Figure 140 Fire Adjustment

Once the window is open, a white crosshair is drawn in the center of the map and a virtual observer position is created on the map from where the fire adjustment is calculated.

The “READ” section in the fire correction window is filled automatically with text for the adjustment. If the impact point is set and the question marks are replaced with the call signs, the read-out can be generated for that target by the fire mission system.

For a point target, a 50m x 50m rectangle is drawn around the target for determine is any adjustment is needed for normal fire.

The calculations for the fire adjustments are rounded to tens as per the standard.

If the checkbox “Precise correction” is selected, the calculations are not rounded and has a precision of 1 meter.

The impact point is drawn as a red cross on map.

The impact point can be set either by clicking “HIT POSITION FROM MAP CENTER” in which case the coordinates of the white crosshair are used or by right clicking on the map and selecting “Set hit position here”.

Clicking on the “SEND” button will send the fire adjustments over the network (if implemented and integrated into the system).

When the checkbox “Fire for effect” is selected, the text “FIRE FOR EFFECT” is added to the “READ” section.

18.16 FIRE ADJUST ON VIDEO

For quick fire adjustment, right click on video feed. Select Quick adjust fire.

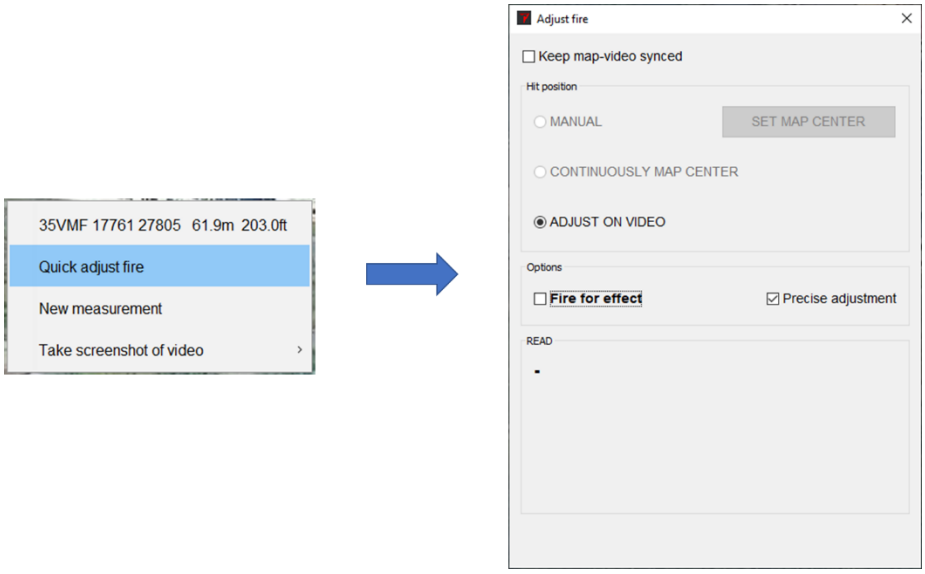


Figure 141 Quick adjust fire

Click on target. Target will be marked with BLACK cross.

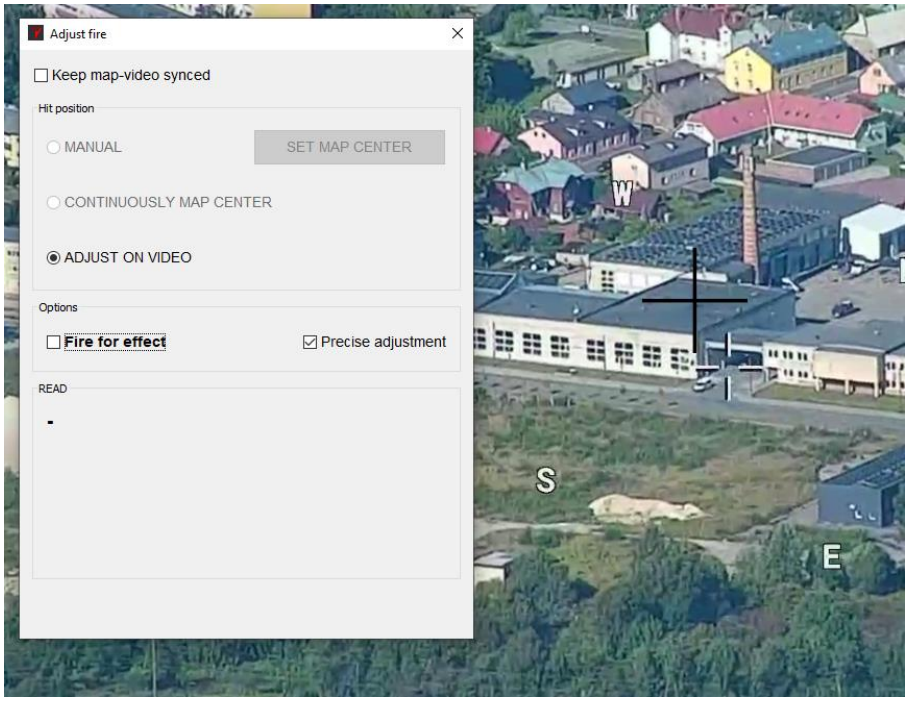


Figure 142 Select target

Click on hit point (where rounds hit). Hit point will be marked with RED cross.

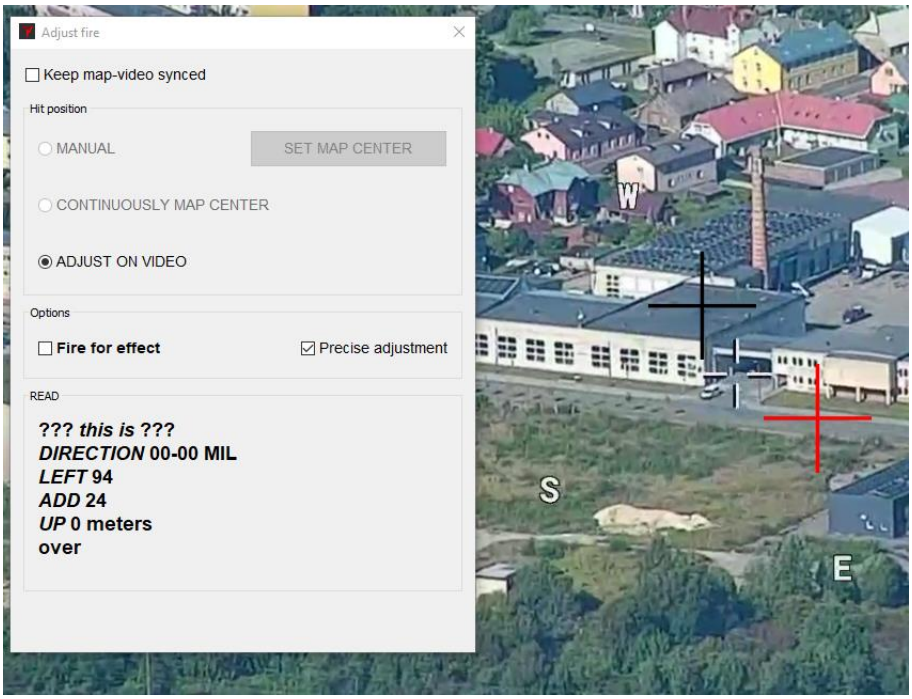


Figure 143 Hit point

19 FAILSAFE PROCEDURES

19.1 OVERVIEW

Eos C aircraft implements several automatic and some user configurable fail-safe procedures for increased safety and survivability.

Emergency return to home procedure is present for data link signal loss. The timeout (recommended 10-15 seconds) for return to home function is set by the operator before or during the flight.

When two emergency conditions (GPS signal loss and data link signal loss) are detected an autonomous return to home with inertial and magnetic sensors is performed by the aircraft after a timeout value is exceeded.

Feature GPS timeout is selectable in the range of 1-999 seconds.

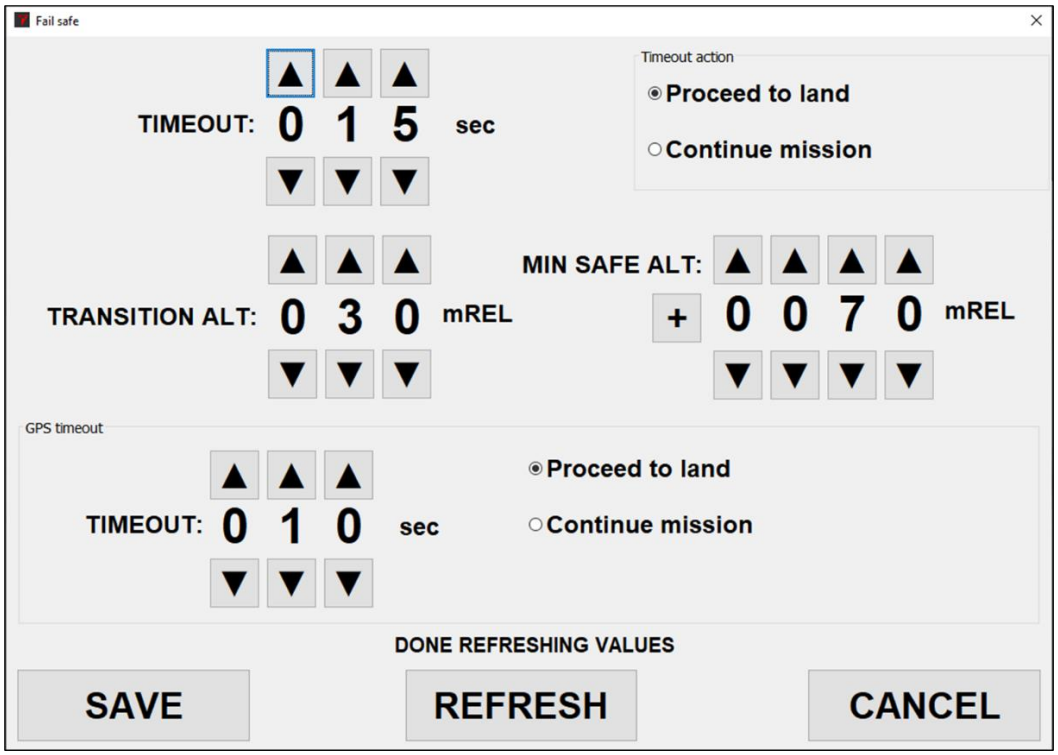


Figure 144 Failsafe configuration in GCS

19.2 PRE-FLIGHT FAILSAFE CONDITIONS

Pre-flight fail-safe prevents the operator from taking off when critical failures are present in the aircraft systems.

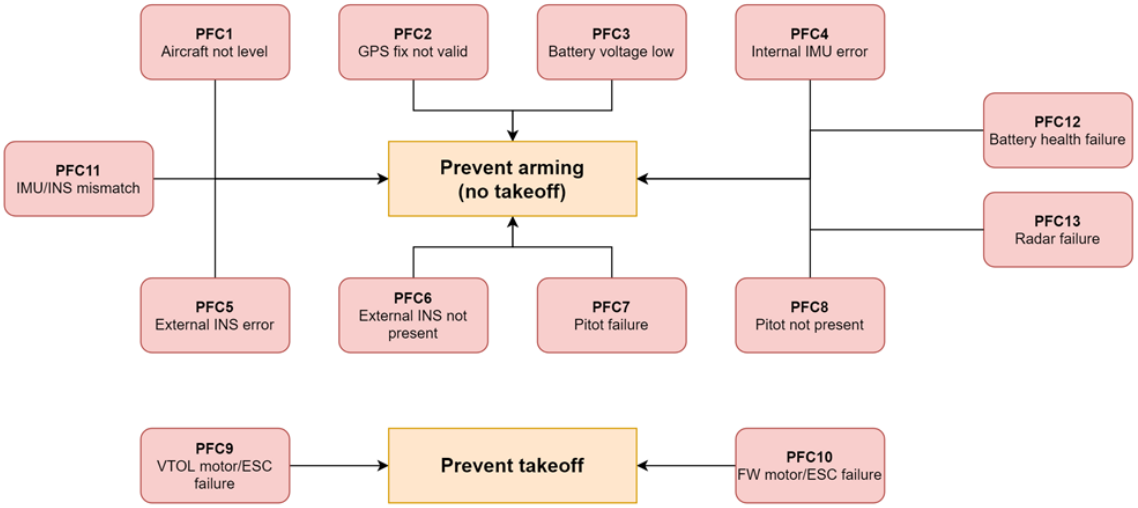


Figure 145 Pre- flight fail-safe conditions that prevent take-off

Table 3 Pre-Flight Failsafe (PFC) Conditions

CONDITION	DESCRIPTION	EFFECT
PFC1 – Aircraft not level	Aircraft combined roll/pitch angle must not be higher than value given in variable COPT_ROLL_A_MAX. If it is not, arming will fail with error message #57, Arm request rejected, airframe not level enough	Prevent arming
PFC2 – GPS fix not valid	Prevent arming when GPS fix is not valid or when there is less than P_ARM_REQ_NSAT satellites in solution. If there isn't, arming will fail with error message #52;Arm request rejected, insufficient GPS quality	Prevent arming
PFC3 – Battery voltage low	Prevent arming when battery voltage is below P_VOLTAGE_NOFLY. Arming would fail with error message 76;Too low voltage to fly, cannot arm	Prevent arming
PFC4 – Internal IMU error	Prevent arming when autopilot internal IMU (Internal Measurement Unit) chip is not operational. Autopilot would not get past INITIALIZING state if IMU is not functional, there will be no servo outputs. There will be periodic error message 75;Autopilot IMU not operational, maintenance needed	Prevent arming
PFC5 – External INS error	Prevent arming when the external INS (Internal Navigation System) is connected but not operational. Error message: 11060;INS General Fault: $	Prevent arming
PFC6 – External INS not present	Prevent arming when external INS is enabled but not present. Error message: 74;INS or magnetometer information is not present, cannot arm	Prevent arming
PFC7 – Pitot failure	Prevent arming when pitot reports error. Messages: 11057;I2C Pitot 1 error, status $ and 11058;I2C Pitot 2 error, status	Prevent arming

PFC8 – Pitot not present	Prevent arming when pitot is not connected/detected. If pitot failsafe is force enabled (parameter FS_PITOT_ENA value is 2), then it will allow flying, but will send still error message. Messages: 72;Pitot sensor info is missing, cannot arm or 73;Pitot sensor info is missing, using pitot failsafe to fly	Prevent arming
PFC9 – VTOL motor/ESC failure	Prevent take-off when any VTOL ESC (Electronic speed controller) reports an error. Errors may appear only when the motors are turned on and rotating. Autopilot spools up VTOL motors slowly, checks for RPM feedback and any errors, when all good, proceeds to take-off. Error messages: 82;Not all lift propellers are rotating, cannot start or 86;Aborting take-off due to engine errors	Prevent take-off
PFC-10 FW motor/ESC failure	Prevent take-off when fixed wing ESC reports an error. Errors may appear only when the motor is turned on and rotating. Autopilot takes off in VTOL mode, starts transition, checks for RPM feedback and any errors, when all good, proceeds to transition to fixed wing. If RPM is below FS_ENG_MIN_RPM or any engine errors, it will proceed to land. Message: 87;Not all forward propellers are rotating, aborting take-off	Prevent take-off
PFC-11 IMU/INS mismatch	If External INS and Internal IMU attitude is off by 1% prevent arming. Message: 79;aircraft needs more time to stabilize, cannot arm. Try again shortly.	Prevent arming
PFC-12 Battery health failure	If voltage of battery cells is off by 0.2V prevent arming. Message: 88;Battery cells voltage too different, cannot arm	Prevent arming
PFC-13 Radar failure	If Radar Altimeter is enabled by parameter SENS_GND_ENA, but radar data is not present, arming of the aircraft fails. Message: 45;Landing sensor inoperable	Prevent arming

19.3 IN-FLIGHT FAILSAFE CONDITIONS

In-flight failsafe ensures correct automated action is enforced by autopilot even in lost link profile.

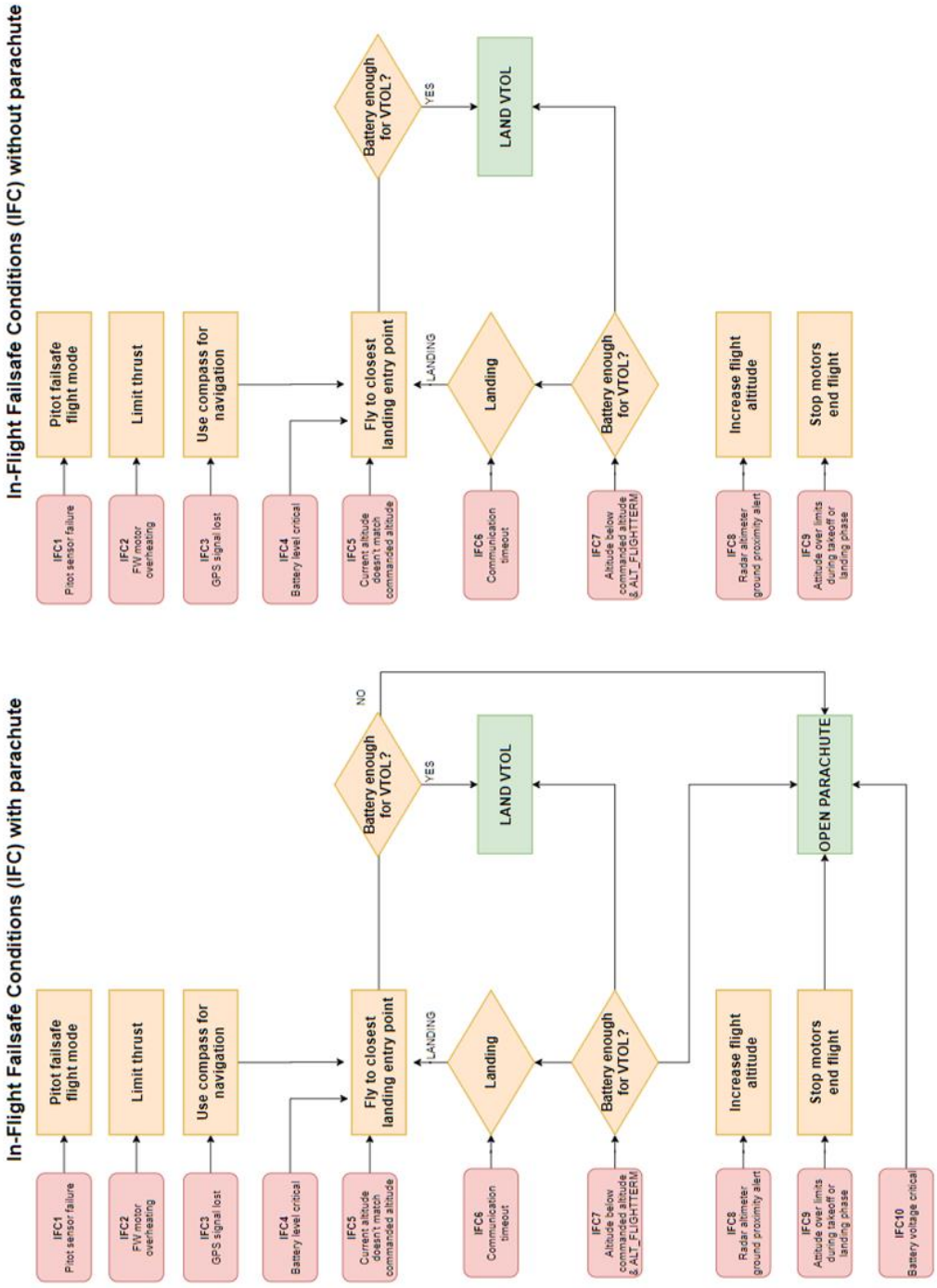


Figure 146 In-flight fail-safe procedures for increased safety and survivability

Table 4 In-Flight Failsafe (IFC) Conditions

CONDITION	DESCRIPTION	EFFECT
IFC1 – Pitot sensor failure	Pitot sensor error detected. Enter failsafe flight mode which is able to fly without pitot readings. Message: 60;Pitot sensor failure detected, activating failsafe. In pitot failsafe mode, airspeed is calculated from aircraft pitch and engine power.	Alert, flight mode change. Fly with GPS/Ground speed
IFC2 – FW motor overheating	If engine maximum allowed temperature is set (variable P_ENG_MAX_TEMP) and temperature data is available, then autopilot will reduce aircraft maximum pitch when approaching to set temperature. Aircraft starts to reduce maximum pitch when engine temperature is 10 degrees less than parameter value, and if engine temperature continues to rise, then it will lower maximum pitch until zero, when engine temperature reaches P_ENG_MAX_TEMP or exceeds it. Message: 80;Motor temperature near limits, $ degrees, climb performance reduced.	Limit performance
IFC3 – GPS signal lost	Use compass and dead reckoning to navigate back home or to landing point in case of GPS signal loss. Message: 24;GPS fix lost, AUTOPILOT is running on ESTIMATED coordinates	Navigation accuracy low
IFC4 – Battery level critical	Estimate the amount of energy contained in the battery pack (if no info from BMS, the autopilot will estimate internally) and calculate how much energy it takes to perform a landing in the closest landing point. Message: 31;Voltage level critical, aborting mission.	Proceed to land
IFC5 – Current altitude does not match commanded altitude	Autopilot monitors the current altitude and its commanded altitude. When the actual altitude is below the commended altitude threshold, perform landing. Message: 30;Cannot maintain altitude, aborting mission	Perform landing
IFC6 – Communication timeout	When user defined communication timeout threshold is exceeded execute one of the following actions (set by the user): continue mission, proceed to land, return to home	Continue, land or return to home
IFC7 – Altitude below commanded and minimum safe altitude	Works together with IFC5. When minimum safe altitude threshold is exceeded, perform instant landing regardless of aircraft location. Message: Message: 30;Cannot maintain altitude, aborting mission	Land immediately
IFC8 – Radar altimeter ground proximity alert	Aircraft will prevent flying closer to the ground than specified in the SENS_GND_MINALT parameter. Message: 81;Ground proximity alert $ m	Prevent decent below limit
IFC9 – Attitude limits exceeded	When attitude (combined roll and pitch) goes over 45 degrees during final landing phase or in take-off phase, stop all motors. This check is meant to address situation, when aircraft get stuck during start or some of its engines fail during take-off or if it lands in unstable surface and tips over.	Stop motors
IFC10 – Battery voltage critical	When battery voltage is critical, proceed to land. When battery voltage is below abort (no further flight possible) stop motors and open parachute.	Perform landing

19.3.1 FAILSAFE POINTS

Failsafe points allow the operator to define alternate routes to fly to landing sites. If defined, the closest failsafe point to the aircraft is chosen when an automatic proceed to land event is triggered.

Using failsafe points in mission planning allows the creation of multiple landing sites and/or flight paths that navigate around, above or below airspace restrictions.

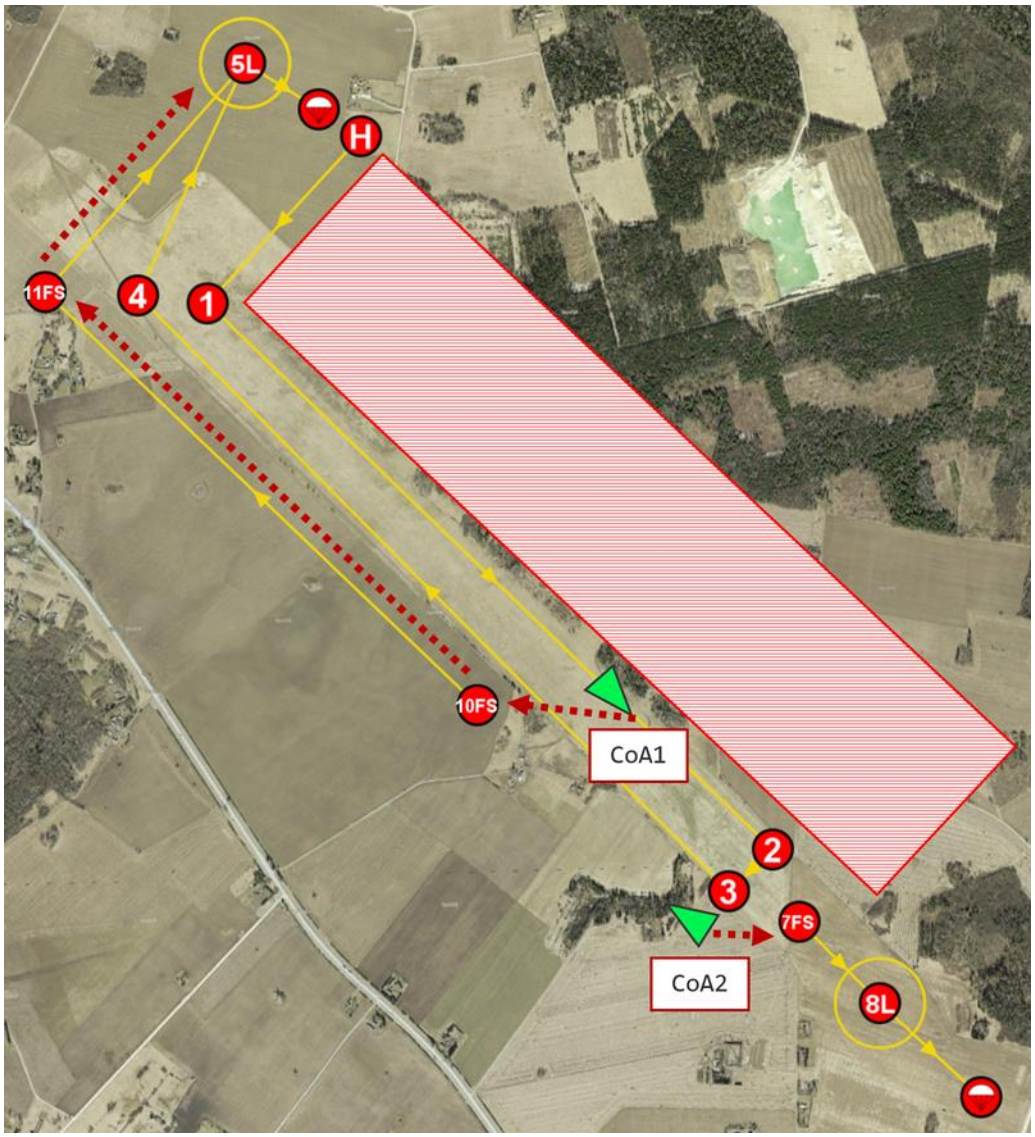


Figure 147 Scenario 1 – simple failsafe routes

An example of the simple failsafe routes are given in Figure 147 above creates two failsafe routes using failsafe points. First route 7FS->8L defines an alternate landing site. Second route 10FS->11FS->5L defines a route to the default landing site that avoids crossing the prohibited airspace (red box in north east sector).

When the aircraft enters a failsafe condition close to 10FS or 11FS it will choose this route to proceed to landing (Course of Action 1). When the aircraft is closer to the 7FS it will land at the alternate site (Course of Action 2).

Failsafe points provide a flexible way to adapt a mission to any kind of operational environment.

Figure 148 Scenario 2 - no failsafe routes, single landing site

Next example given in Figure 148 above presents a mission where no failsafe points are defined. In every case when an error triggers a return to land action, the autopilot proceeds to 8L pre-landing loiter down waypoint. In this specific example this behaviour always violates the NO-FLY ZONE thus illustrating the need to use failsafe landing points for mission planning.

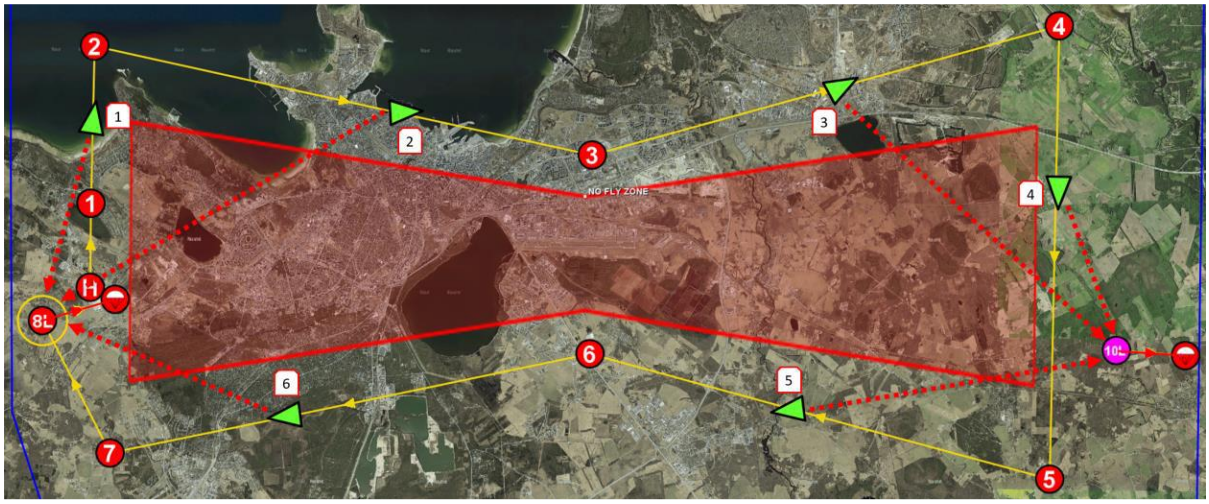


Figure 149 Scenario 3 - no failsafe routes, two landing sites

This example given in Figure 149 above presents a mission where no failsafe points are defined. There are two separate landing sites defined. The autopilot will choose the closest loiter down point that precedes a landing point if an error occurs. CoA 1, 2 and 6 will trigger the autopilot to fly to 8L and CoA 3, 4 and 5 trigger it to fly to point 10L. This method may be useful in simple cases but as it does not allow to plan any points between the loiter down and landing point (loiter down must always be followed by a landing point), its use is limited compared to the failsafe points.

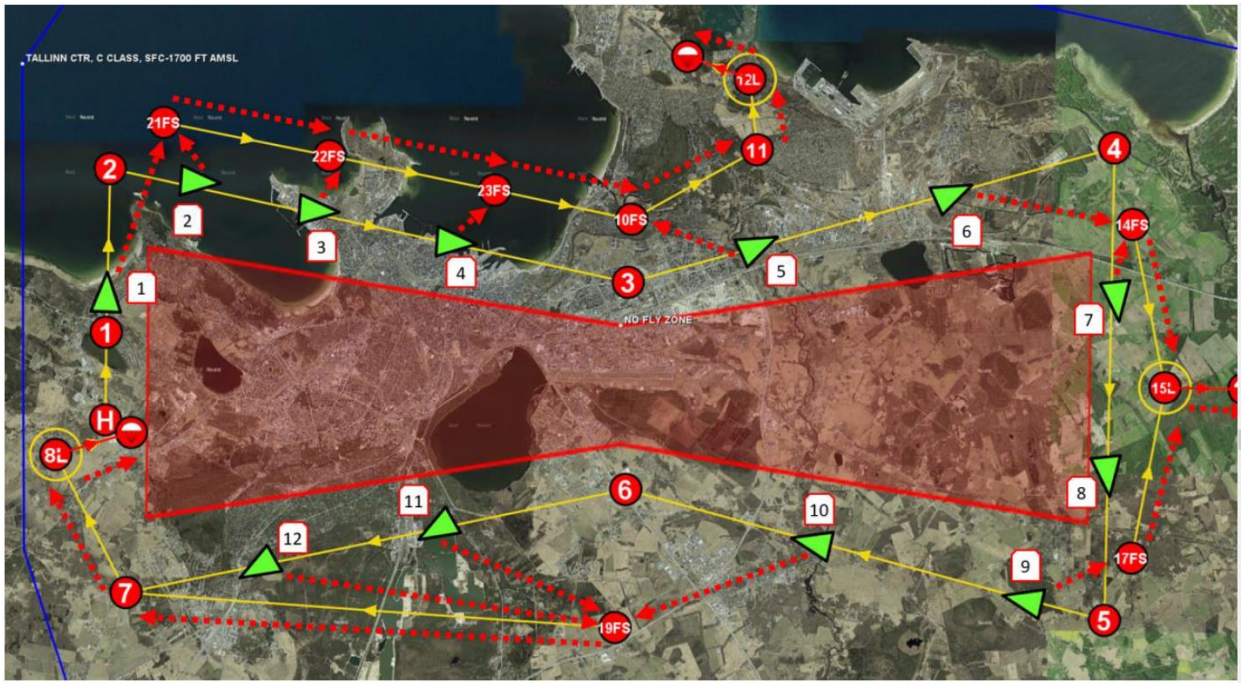


Figure 150 Scenario 4 – complex failsafe routes

Mission

ID	DESC	TARGET	RADIUS	LAT	LON	REL ALT(m)	AGL (m)	AMSL(m)	MGRS	DST TO ...	HEADING
0	HOME	-	-	59.401233	24.556642	-	0	24	35VLF 61280 87277	2.7 km	0°
1	NAV	-	-	59.425671	24.556783	200	202	224	35VLF 61388 89997	5.1 km	0°
2	NAV	-	-	59.471406	24.558332	500	524	524	35VLF 61663 95085	16.5 km	102°
3	NAV	-	-	59.440098	24.842752	500	471	524	35VLF 77660 91042	15.6 km	74°
4	NAV	-	-	59.477462	25.109369	500	503	524	35VLF 92896 94742	14.7 km	182°
5	NAV	-	-	59.345648	25.102958	500	478	524	35VLF 92114 80078	15.4 km	286°
6	NAV	-	-	59.382309	24.841481	500	491	524	35VLF 77380 84612	15.8 km	259°
7	NAV	-	-	59.353039	24.568308	500	500	524	35VLF 61746 81889	4.8 km	333°
8	LOITER: ALT	74 mAMSL (50 REL)	800 m	59.391474	24.529470	500	502	524	35VLF 59698 86248	2.4 km	73°
9	LAND	GND:15 mAMSL	-	59.397764	24.570887	35	43	59	35VLF 62075 86862	-	-
10	FAIL SAFE NAV	-	-	59.457678	24.844551	500	508	524	35VLF 77826 92996	4.5 km	60°
11	NAV	-	-	59.477103	24.913382	500	498	524	35VLF 81794 95034	2.2 km	355°
12	LOITER: ALT	74 mAMSL (50 REL)	800 m	59.496815	24.909377	500	515	524	35VLF 81636 97236	2.1 km	290°
13	LAND	GND:19 mAMSL	-	59.503104	24.875237	35	38	59	35VLF 79726 97997	-	-
14	FAIL SAFE NAV	-	-	59.456076	25.119260	500	494	524	35VLF 93389 92345	5.2 km	169°
15	LOITER: ALT	74 mAMSL (50 REL)	800 m	59.410513	25.136493	500	487	524	35VLF 94223 87245	2.5 km	91°
16	LAND	GND:30 mAMSL	-	59.410029	25.179787	40	34	64	35VLF 96679 87123	-	-
17	FAIL SAFE NAV	-	-	59.363005	25.117857	500	475	524	35VLF 93016 81986	5.4 km	11°
18	JUMP	ID: 15	-	-	-	-	-	-	-	-	-
19	FAIL SAFE NAV	-	-	59.343780	24.835665	500	495	524	35VLF 76910 80333	15.2 km	275°
20	JUMP	ID: 7	-	-	-	-	-	-	-	-	-
21	FAIL SAFE NAV	-	-	59.484388	24.587873	500	524	524	35VLF 63389 96469	5.2 km	101°
22	FAIL SAFE NAV	-	-	59.475238	24.678804	500	524	524	35VLF 68502 95267	5.2 km	101°
23	FAIL SAFE NAV	-	-	59.465792	24.769548	500	524	524	35VLF 73606 94040	4.3 km	101°
24	JUMP	ID: 10	-	-	-	-	-	-	-	-	-

WP EDITOR | ALT + | ALT - | REMOVE POINT

Figure 151 Scenario 4, table view

Table 5 Failsafe points scenario 4, Courses of Action (CoA)

COA	ROUTE	DESCRIPTION
1	**21FS**->22FS->23FS->10FS->11->12L->LAND	Closest landing route starts with 21FS. Continue the chain of waypoints as defined with sequence and jump (23FS jumps to failsafe point 10FS) commands.
2	**21FS**->22FS->23FS->10FS->11->12L->LAND	Closest landing route starts with 21FS. Continue the chain of waypoints as defined with sequence and jump (23FS jumps to failsafe point 10FS) commands.
3	**22FS**->23FS->10FS->11->12L->LAND	Closest landing route starts with 22FS. Continue the chain of waypoints as defined with sequence and jump (23FS jumps to failsafe point 10FS) commands
4	**23FS**->10FS->11->12L->LAND	Closest landing route starts with 23FS. As failsafe point 23FS includes a jump command to waypoint 10FS, jump there when 23FS is reached and continue to navigation point 11 as defined in the route.
5	**10FS**->11->12L->LAND	Closest landing route starts with 10FS. Continue the chain of waypoints as defined in the mission and proceed to land.
6	**14FS**->15L->LAND	Closest landing route starts with 14FS. Continue the chain of waypoints as defined in the mission and proceed to land.
7	**14FS**->15L->LAND	Closest landing route starts with 14FS. Continue the chain of waypoints as defined in the mission and proceed to land.
8	**17FS**->15L->LAND	Closest landing route starts with 17FS. Continue the chain of waypoints as defined in the mission and proceed to land.
9	**17FS**->15L->LAND	Closest landing route starts with 17FS. Continue the chain of waypoints as defined in the mission and proceed to land.
10	**19FS**->7->8L->LAND	Closest landing route starts with 19FS. Continue the chain of waypoints as defined in the mission and proceed to land.
11	**19FS**->7->8L->LAND	Closest landing route starts with 19FS. Continue the chain of waypoints as defined in the mission and proceed to land.
12	**19FS**->7->8L->LAND	Closest landing route starts with 19FS. Continue the chain of waypoints as defined in the mission and proceed to land.
13	H->1->2->3->4->5->6->7->8L->LAND	No failsafe action occurred during the flight; mission

19.3.2 BATTERY AND FLIGHT TIME ESTIMATION

Autopilot always monitors the battery charge level, windspeed, wind direction, altitude and energy needed to fly back to a landing site and perform a VTOL landing plus a safety margin.

To achieve this the autopilot tracks the closest failsafe return waypoint, if available, or nearest landing waypoint and its associated loiter down waypoint and will calculate power needed to fly there from aircrafts current location. If return power needed plus a safety margin exceeds remaining battery capacity, it will direct aircraft to nearest failsafe or landing waypoint preceding loiter down waypoint. It will also give error 31; Voltage level critical, aborting mission.

This feature reduces the probability of operating in conditions where the aircraft is unable to return to home and land safely.

20 GPS DENIED ENVIROMENT

In IMU and magnetometer-based navigation mode the aircraft uses the inertial orientation and magnetic sensors combined with barometric pressure and pitot airspeed data to calculate its approximate location. This mode is primarily used for returning home or proceeding to emergency landing location. When the pilot so chooses, the aircraft can continue its mission in this mode as well. The operator can use the camera throughout the flight.

When flying without GPS, it is possible to override aircraft current position. Aircraft overrides it if no GPS currently. Can be set from map context menu option **Override aircraft position**.[16] When employing **Override aircraft position**, then the autopilot will recalculate the wind speed and direction, those values will be stored until next adjustment. When GPS signal will come back, then activate wind calculations (16.8 TECHNICIAN WINDOW on page 118).

In GPS denied environment flight time calculations are inaccurate and not reliable. Pilot must assess flying conditions and constantly monitor battery values to safely return home and land. It is recommended to have a bigger battery reserve room than estimated playtime calculation shows.

Aircraft position can be overridden in two ways:

- Based on aircraft's current position
  - Sets the aircraft's current position at the location clicked (where the context menu was opened) – wait until aircraft is right over this location.
- Using gimbal target
  - Map context menu has option 'Override aircraft position - gimbal target' which tells where gimbal is currently pointing and calculates aircraft position from this.

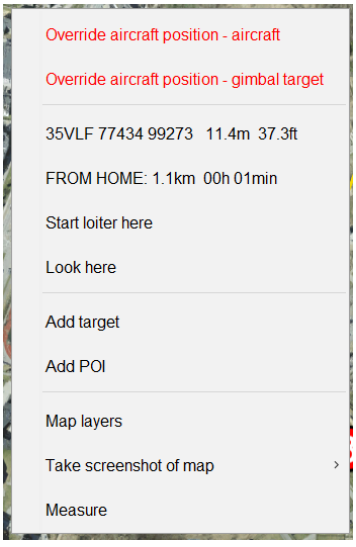


Figure 152: Map context menu - override aircraft position

CAUTION

IN GPS DENIED ENVIROMENT PLAYTIME IS NOT ACCURATE! LEAVE BIGGER BATTERY RESERVE TO RETURN HOME SAFETLY.

[16] 2022-08-10 update

21 GUIDED MODE

Guided mode is mostly used in emergency cases, where GPS is lost and EOS needs to be flown back home manually. Mode can be activated from the left side of the screen, choosing FLIGHT MODE.

Open the flight mode window from startus bar by clicking on the UAV's current state icon. From the appearing window operator can choose Guided Mode or Auto Mode

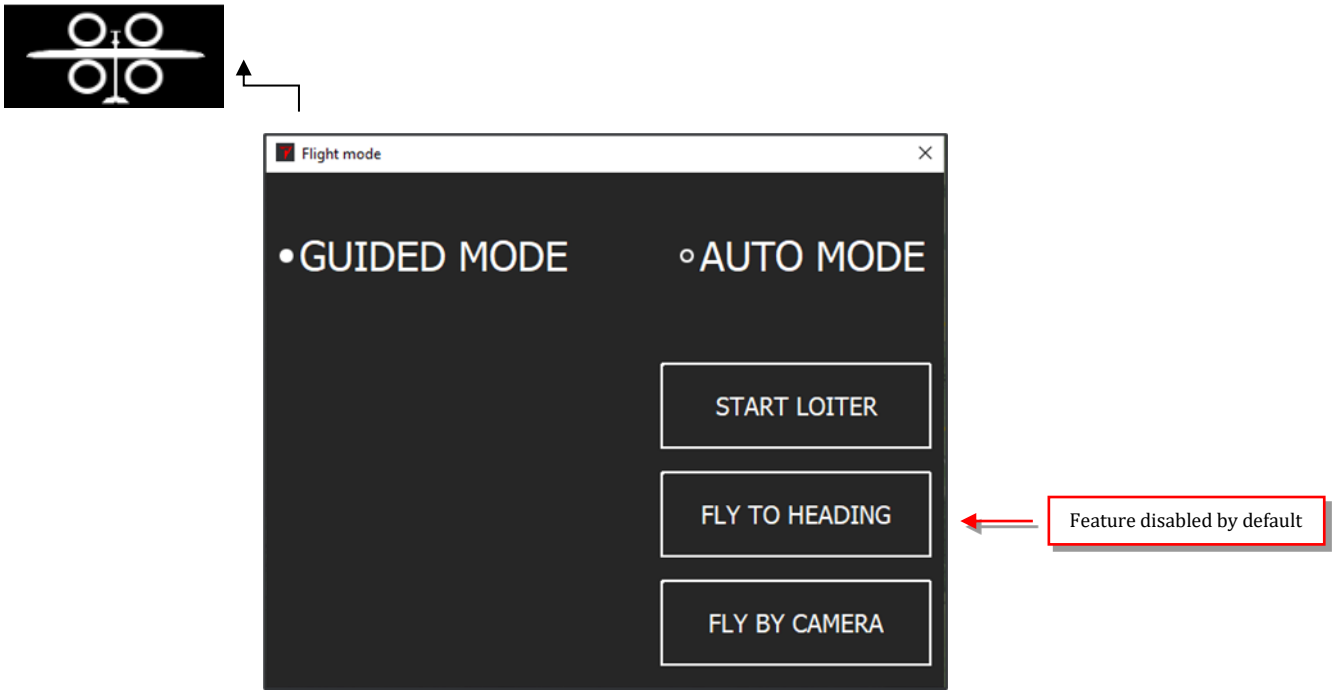


Figure 153: Flight mode window

When switching from Guided mode to Auto mode, it will create MANUAL LOITER around aircraft with default radius 200 meters.

There are 2 flight modes in guided mode. Fixed-wing and VTOL. In the case if GPS signal is lost or operator needs to alter landing spot before landing etc. If Guided mode is chosen from Flight mode menu (or from older HGCS Guided mode button) then flying will continue manually. Aircraft will maintain the last assigned altitude and using the joystick controls the operator can steer the heading (Roll control) with Right joystick and change altitude with Left joystick while in fixed-wing mode. The logic of altitude control is so, that moving joystick down, will give the aircraft AP to reduce the selected altitude and this will be visible on the Altitude override bar on the left side of screen. The same logic applies, when altitude is increased with joystick moved upwards.

When approaching the landing area and operator wants the plane state to change from Fixed-wing into VTOL, then VTOL LAND shall be pressed. EOS will then turn into multirotor for landing. In VTOL mode joysticks have few more functions available. Adjusting Yaw with left joystick is limited to turning the plane nose to the wind. Right joystick will move the EOS to the left and right instead of turning (Roll), which was used in fixed-wing mode. Moving Right joystick up/down will move forward and backward. All controls shall be handled with care and all movement has to be smooth. Operator shall never keep R joystick controls in max position for more than 2-3 seconds. L joystick can be kept in full

travel (for landing specially), as otherwise process will take too much time and battery health always must be considered.

In case link loss happens during VTOL GUIDED mode, the aircraft will land after 10 seconds automatically regardless of chosen failsafe options.

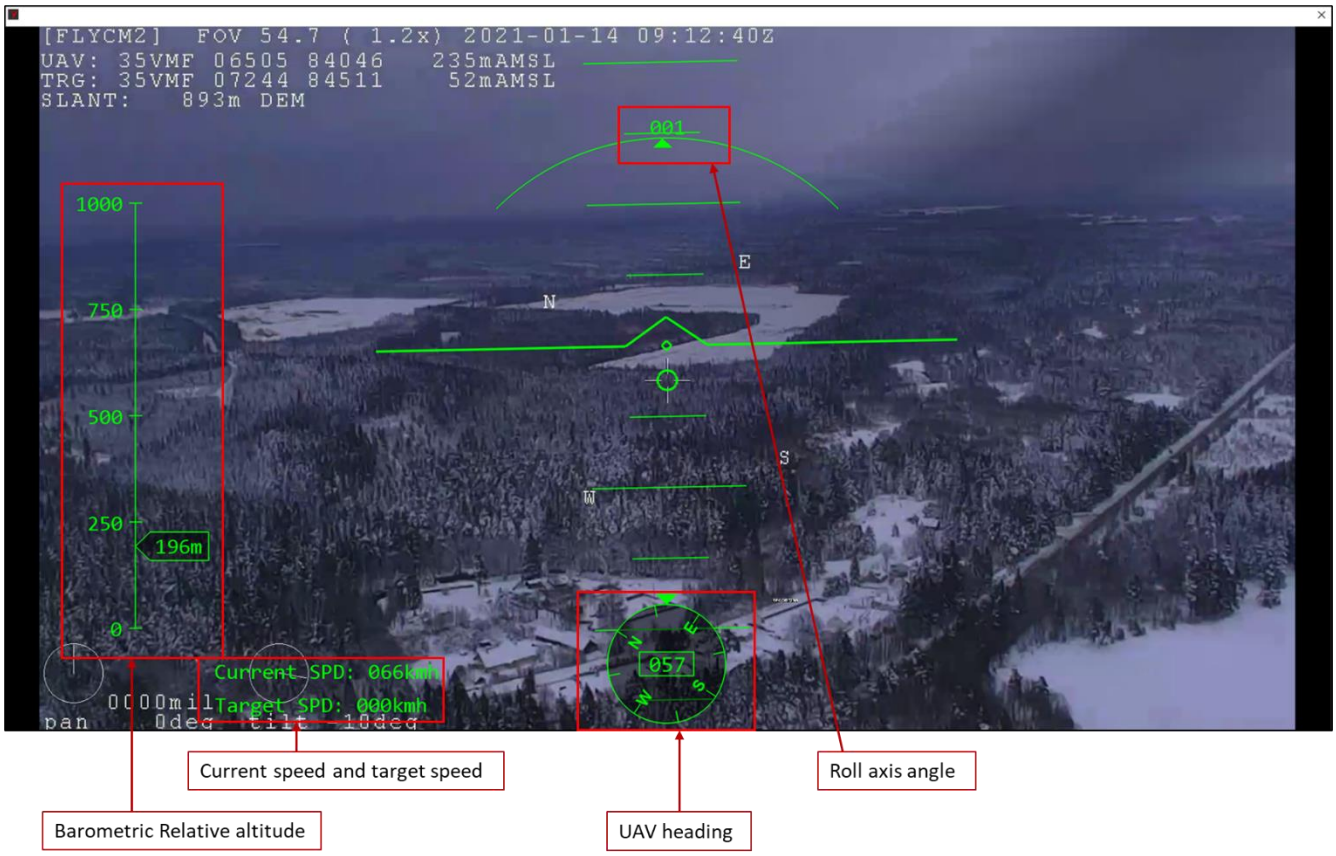


Figure 154 Fixed wing guided mode camera view

21.1 GUIDED MODE CONTROLS

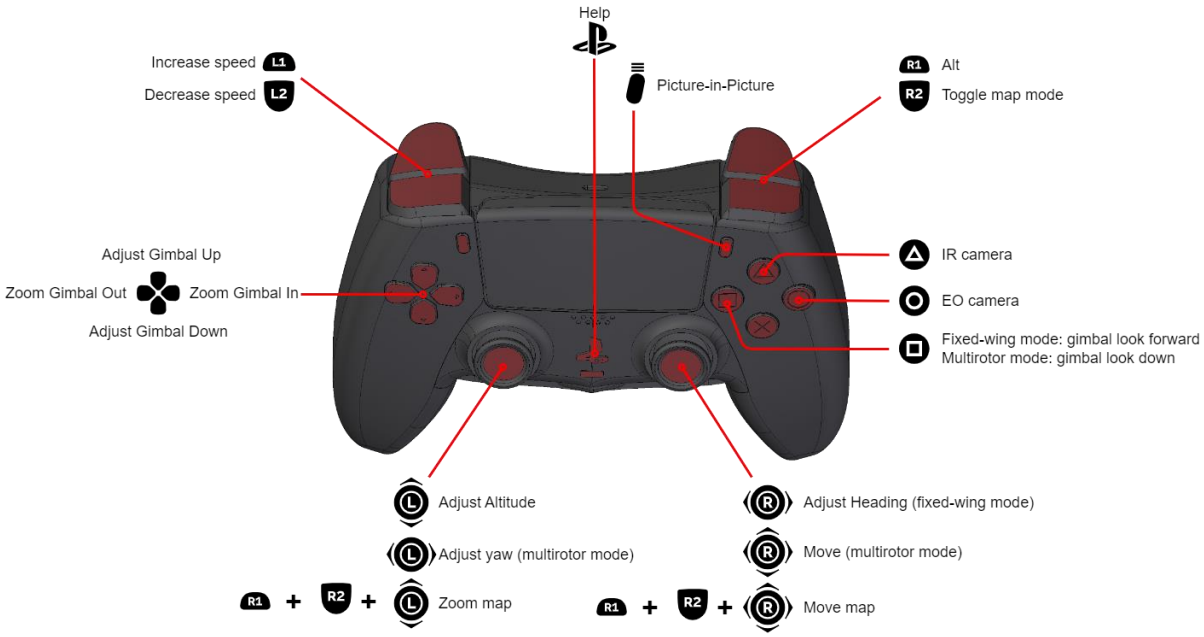


Figure 155 Guided mode Control for PS5 controller

CAUTION

RIGHT JOYSTICK SHALL NEVER BE USED IN MAXIMUM POSITIONS FOR MORE THAN 2-3 SECONDS. IT MIGHT UNSTABILIZE THE AIRCRAFT, SPECIALLY WHEN CLOSE TO GROUND.

NOTICE

Left joystick shall be used with full travel for altitude reducing, to keep the landing process time minimum. Special attention needed when battery is used for longer time before landing.

22 GCS VOICE APPLICATION

Threod communication system allows to use voice communication between ground units.

For use, activate Threod voice application TaCom.

Figure 156 TaCom application

NOTICE

Make sure that you have only one activated TaCom application.

After activating TaCom application you will have Push To Talk (PTT) button on the screen.

Figure 157 TaCom Push To Talk button

To talk over TaCom, press the button PTT (it will turn red).

Second option is to press ALT button on keyboard.

23 WARNING AND ERROR MESSAGES

System warnings are shown on top of the main screen as follows:

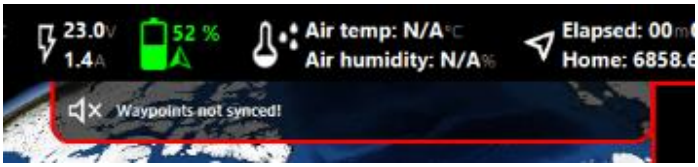


Figure 158: Waypoints not synced warning

Table 6 GCS software system warnings

	Message	Description	Causes	Action
1	GDT BATTERY LOW	GDT battery/power supply voltage low	Battery or power supply voltage lower than 20 volts	1.Change or charge the battery. 2.Check battery charger.
2	Waypoints not synced!	Waypoints in GCS software are not synced with autopilot	Operator has modified waypoints but not uploaded/synced them	Upload or sync changed waypoints
3	Aircraft link noise/jamming	Noise is detected on aircraft datalink	Jamming is present in aircraft vicinity; other transmitters are present on operating frequency in aircraft vicinity	1.Increase data link power, change frequency 2.Avoid the area
4	GDT link noise/jamming	Noise is detected on GDT datalink	Jamming is present in GDT vicinity; other transmitters are present on operating frequency in GDT vicinity	1.Increase data link power, change frequency 2.Avoid the area
5	Aircraft link loss	Lost communication with aircraft data link	No signal received from aircraft in last 4 seconds.	1.Check, is GDT tracking. 2.Wait until aircraft comes back to LOS.
6	GDT link loss	Lost communication with aircraft data link	No signal received from GDT in last 4 seconds.	1.Check, is GDT tracking. 2.Wait until aircraft comes back to LOS.
7	GDT turned off or cable disconnected!	Lost communication with radio module	No signal received from radio module in last 2 seconds	1.Check, is GDT powered on 2.Check GDT battery 3.Check cabling
8	Connection to tracker lost	Lost communication with tracker module	No signal received from tracker module in last 4 seconds	1.Check GDT battery 2.Check cabling 3.Restart tracker
9	Connected radio not installed to tracker	Lost communication with tracker module	Radio module cannot communicate with tracker module	1.Check that radio module is correctly attached to tracker module 2.check that only one radio/tracker is connected to GCS 3.Remove GDT cable from GCS and reconnect after 20 seconds.
10	High wind speed	Wind speed is higher than 20 m/s.	Pitot measured wind speed 20 m/s.	1.Descend aircraft. 2.Cancel mission

Warnings inside the red box indicate a critical issue is present. More detailed information can be found in error list.

24 NOTIFICATIONS

- Click on the notifications button to open the list from the status bar.

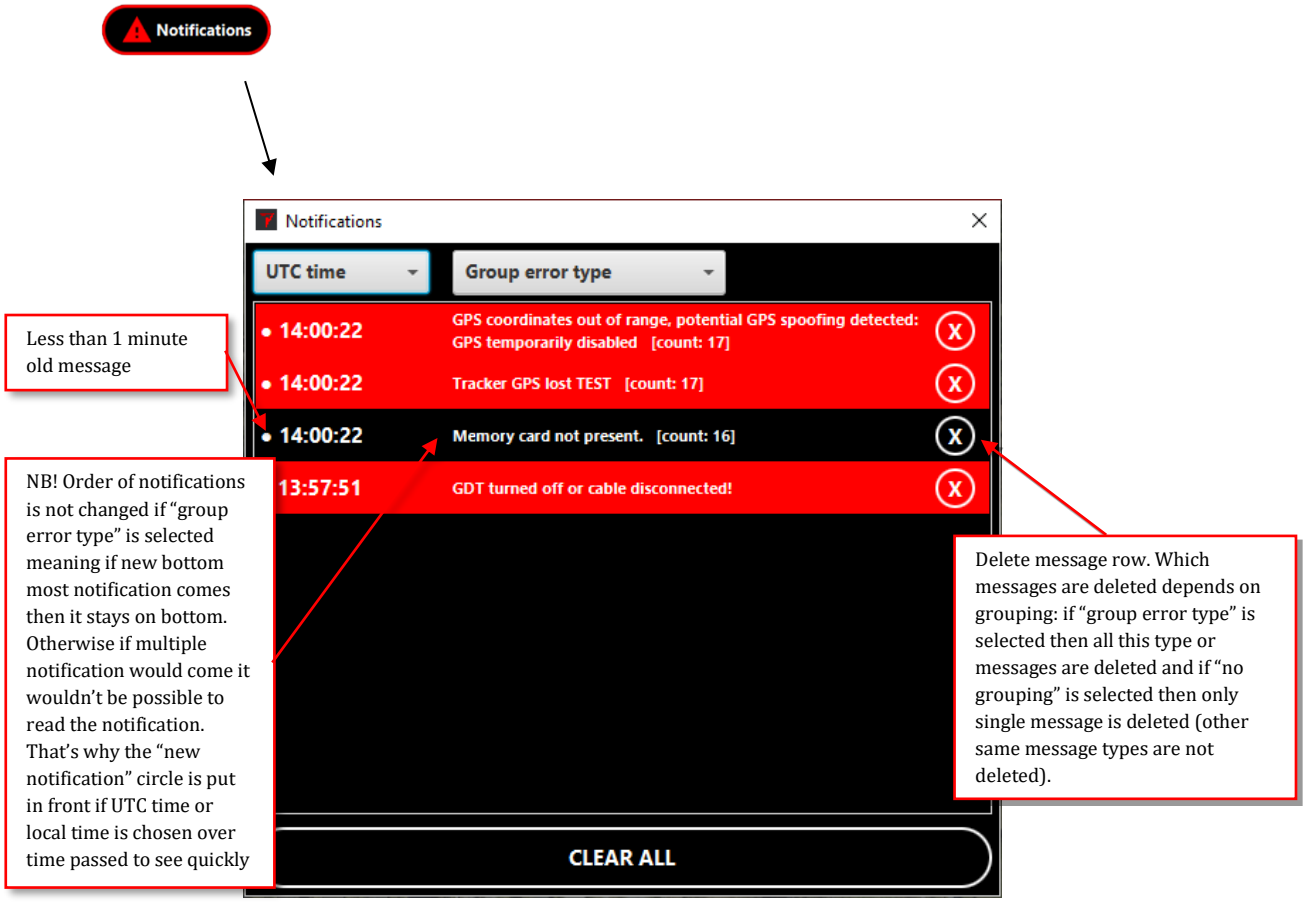


Figure 159: Notifications window

- It's possible to set which time is shown for errors (UTC, local time, time passed) and how errors are grouped (error type, consecutive type, no grouping).
- If UTC or local time is selected then a white dot is shown next to the time, meaning - this message is less than 1 minute old.

- On a GCS startup and when aircraft restart is detected a black screen is shown as gimbal video until video feed is received. A button to request video (high quality) feed is shown in the lower left corner of the video window.

Figure 160: Waiting for feed

- More serious errors are shown in the top-center of the window. You can mute the error sound for all currently visible errors. If a new type of error appears the error sound will play again. If you clear the notifications list in the notifications window and same error appears again the error sound will also play again.
- You can remove some errors separately from the error view. If you clear the notifications list in the notifications window and the same error appears again then it'll appear in errors view again also.
- If the error is from the autopilot, an error description is shown

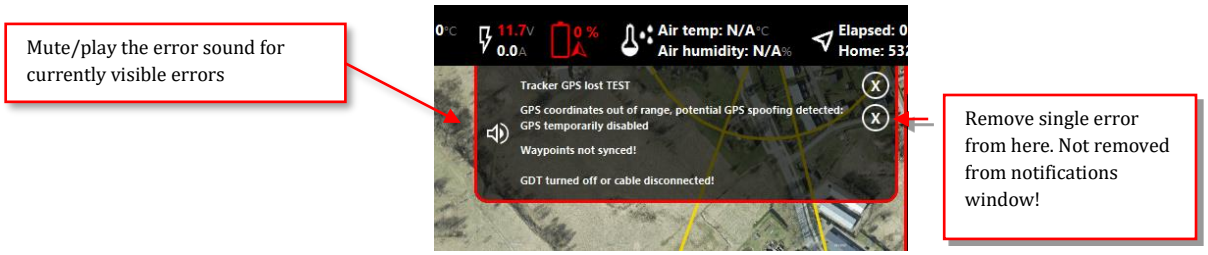


Figure 161: Single error notification

List of system warnings to notify UAV operator about malfunctions:

Table 7 GCS error messages

ID	GCS String	Description	Cause	Action
1	Active GPS nr $ fix lost.	Currently used GPS receiver number $ has lost its signal	Jamming, GPS receiver fault	Caution advised; loss of all GPS signals may be imminent
2	Inactive GPS nr $ fix lost.	Currently not used GPS receiver number $ has lost its signal	Jamming, GPS receiver fault	Caution advised; loss of all GPS signals may be imminent
3	ALL GPS'es have lost GPS fix	All available GPS receivers have lost signal. Autopilot uses INS information for navigation.	Jamming, GPS receiver fault	Start GPS loss procedures (fly away from the area using INS, switch to GUIDED mode if required)
4	Parameters save to memory card failed	Unable to save settings to SD-Card	Check if SD-Card is present, replace if faulty Format SD card	Check if SD-Card is present, replace if faulty
6	Pilot is not configured. Parameter save needed.	Autopilot settings are incorrect	Autopilot parameter memory corrupted	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
7	Parameters corrupted. Please review and save.	Autopilot settings are incorrect	Update failure, autopilot fault	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
9	Mission corrupt. Please review and save.	Autopilot settings are incorrect	Update failure, autopilot fault	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
10	EEPROM not present or malfunctioning.	Autopilot hardware fault	Hardware issue, damaged autopilot	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
11	Memory card not present.	SD-Card not detected	SD-Card not inserted, faulty SD-Card	Insert supplied SD-Card into autopilot. Logging disabled if no SD-Card present.
13	Parameter autosave initiated.	Autopilot has saved current parameters into permanent memory	Automatically done after 5 minutes of flight	No action needed
ID	**GCS String**	**Description**	**Cause**	**Action**

14	Lost CAN connection to component $	Autopilot lost connectivity with a sub-system in the aircraft. Message repeated periodically. If not repeated, connection is restored.	Sub-system failure, cable fault **2** – Pitot sensor not functional, no airspeed data available **100** – Video payload not functional **101** – Photo payload not functional 154 – Video payload retract mechanism not functional **10** – Front section (engine) controller fault, no control over throttle, engine, parachute, airbag **21** – Left wing controller fault, aileron not functional, nav light not functional **22** – Right wing controller fault, aileron not functional, nav light not functional **30** – Rear section (tail) fault, ruddervators not functional, backup GPS not functional, nav light not functional **201, 202, 203** – Autopilot 1, 2, 3 not functional **240** – Communication module not functional	Restart aircraft. If Error remains, contact with Threod Systems. SUPPORT@THREOD.COM
15	CAN component $ not responding	Autopilot lost connectivity with a sub-system in the aircraft. Message repeated periodically. If not repeated, connection is restored.	Sub-system failure, cable fault **2** – Pitot sensor not functional, no airspeed data available **100** – Video payload not functional **101** – Photo payload not functional **154** – Video payload retract mechanism not functional **10** – Front section (engine) controller fault, no control over throttle, engine, parachute, airbag **21** – Left wing controller fault, aileron not functional, nav light not functional **22** – Right wing controller fault, aileron not functional, nav light not functional **30** – Rear section (tail) fault, ruddervators not functional, backup GPS not functional, nav light not functional **201, 202, 203** – Autopilot 1, 2, 3 not functional **240** – Communication module not functional	Restart aircraft. If Error remains, contact with Threod Systems. SUPPORT@THREOD.COM
ID	**GCS String**	**Description**	**Cause**	**Action**

24	GPS fix lost, AUTOPILOT is running on ESTIMATED coordinates	All available GPS receivers have lost signal. Autopilot uses INS information for navigation.	Jamming, GPS receiver fault	Start GPS loss procedures (fly away from the area using INS, switch to GUIDED mode if required)
28	Increasing airspeed due to wind speed	Autopilot has estimated that the windspeed is higher than flight speed, will compensate by increasing flight speed	Windspeed is higher than flight speed	Caution, strong winds!
29	Heartbeat timer expired, aborting mission	Autopilot has not received any messages from a GCS	Autopilot is not receiving commands but is able to transmit. All GCS software instances are in INACTIVE mode (not sending commands)	Ensure that at least one GCS software instance is controlling the aircraft and sending commands is active. If still getting the same message, prepare to receive the aircraft as it proceeds to land automatically.
30	Cannot maintain altitude, aborting mission	Autopilot has detected that the aircraft is unable to maintain given altitude	Engine failure, throttle servo failure, engine underpowered, control surface failure, altitude sensor failure	Aircraft proceeds to land, if unable to reach landing site, will deploy parachute upon reaching pre-set FLIGHT TERMINATION value
31	Voltage level critical, aborting mission	System voltage below normal	PMU failure, short-circuit in cabling, sub-system failure causes excessive power draw from the system	Prepare to receive the aircraft as it proceeds to land automatically
32	Magnetometer nonoperational	Magnetometers not sending data	Magnetometer faulty or disconnected	You can fly, but heading information may be inaccurate
35	Parameter restore from EEPROM failed			
36	Airspeed sensor error too big $	Autopilot has detected a fault in the airspeed sensor	Faulty airspeed sensor or incorrect configuration	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
38	Pitot sensor values differ more than $ m/s	Autopilot has detected a fault in the airspeed sensor	Pitot sensors values differ too much	If it happens during pitot test, then you may want to me more gentle next time. If happens during flight, then you may want to replace pitot sensor module.
39	lost pitot sensor $ data	Autopilot has detected a fault in the airspeed sensor	One of the pitot sensors is malfunctioning	Replace Pitot sensor module
40	lost all pitot sensors data	Autopilot has detected a fault in the airspeed sensor	Connection lost to pitot module.	If flying, then you may want to deploy parachute.
44	delayed start due to gps position mismatch	Autopilot has detected sudden jump in GPS location and waits for location to stabilize before taking off	Either GPS signal is low, or It may happen, that when GPS gains access to more satellites, then its location will shift at that moment.	Wait, to receive more GPS satellites.

ID	GCS String	Description	Cause	Action
45	Landing sensor inoperable	Landing sensor is enabled in configuration but is not sending data.	Either autopilot configuration is wrong or there is landing sensor malfunction.	Cancel mission! Check radar settings (is it enabled). Before landing, make a overfly over your head and check visually altitude and adjust mission (landing altitude) before landing. Check battery voltage.
46	Autopilot SD-card has $ megabytes of free space	Autopilot reports how much free data is available on the SD-Card	Aircraft is turned on	Ensure there is enough free space left (logs consume about 70 Mb/hour)
47	Autopilot SD-card has less than $ megabytes free space	Autopilot reports that SD-Card free space is limited	SD-Card is getting full	Download logs, archive and clear logs from SD-Card to free up space
48	Pressure sensor not detected	Autopilot has detected that barometric altimeter is faulty	Barometric altimeter is not functioning, autopilot is damaged	Contact Threod Systems. Do not fly! **SUPPORT@THREOD.COM**
50	VTOL transition timeout, disabling fixed wing mode	Airframe has attempted transition to fixed wing mode but did not gain enough airspeed before timeout.	Forward motor malfunction	Cancel mission! Use VTOL LAND. Be cautious with wind direction!
52	Arm request rejected, insufficient GPS quality	GPS sees too few satellites for its output to be considered reliable.	Too little time for GPS to get proper fix, GPS signal weak or GPS malfunction.	Wait, to receive more stronger GPS signal. If this does not fix it, contact Threod Systems. Do not fly!
54	Too low altitude, disabling fixed wing mode	VTOL did descend uncommanded below ALT_FLIGHTTERM altitude	Battery empty, forward motor malfunction, airframe structural issues.	Re-route mission. Open parachute. Without parachute, use belly land.
57	Arm request rejected, airframe not level enough	Autopilot has detected, that aircraft is not horizontal enough to take-off.	Either aircraft is not horizontal or autopilot artificial horizon is out of sync	Adjust aircraft location or Contact Threod Systems.
58	Too low voltage, disabling rotary wing mode	VTOL flight is disabled because battery voltage is too low	Autopilot has detected, that remaining battery capacity does not allow safe VTOL landing	Re-route mission. Open parachute. Without parachute, use belly land.
59	Aircraft cannot control orientation, disabling motors	Aircraft disables its engines, because its pitch or roll is outside of safe limits	Airplane is about to roll over during take-off (one engine failure or because its attached to something) or landing (landed on uneven surface), so engines are disabled due to safety reasons.	During take-off, stop motors. Make clear that area is safe. During landing, stop motors! Contact Threod Systems. SUPPORT@THREOD.COM
60	Pitot sensor failure detected, activating failsafe	Autopilot has detected pitot sensor failure and activated failsafe flight mode	Either pitot sensor has malfunctioned, or pitot tubes are blocked by water or ice.	Cancel mission! Aircraft will continue flight without PITOT. Monitor RPM, angles (pitch, roll, yaw) and current.

ID	GCS String	Description	Cause	Action
61	Pitot sensor failure resolved, disabling failsafe	Autopilot has detected, that pitot sensor readings are reliable again and disabled failsafe	-	-
62	VTOL switched to fixed wing only mode	Rotary wing mode is disabled	Either operator or some error condition (which is reported by its own error message) caused VTOL mode to change	Re-route mission. Open parachute. Without parachute, use belly land.
63	VTOL switched to rotary wing only mode	Fixed wing mode is disabled	Either operator or some error condition (which is reported by its own error message) caused VTOL mode to change	Cancel mission! Use VTOL LAND. Be cautious with wind direction!
64	VTOL switched to automatic VTOL mode	this is default mode	This can be done only by changing autopilot parameter directly.	-
65	Landing sensor altitude issue, disabling radar altimeter	Autopilot disabled landing sensor because it determined, that landing sensor readings are unreliable	Landing sensor malfunction, dirt or moisture on aircraft body below lending sensor.	Cancel mission! Check radar settings (is it enabled). Before landing, make a overfly over your head and check visually altitude and adjust mission (landing altitude) before landing. Check battery voltage.
66	Aircraft has no pitot sensor data	Autopilot does not receive airspeed sensor data.	Airsoeed sensor has malfunctioned or is not connected to aircraft.	Cancel mission! Autopilot will put forward motor in maximum throttle.
67	Spin detected	Autopilot has detected spin condition.	Aircraft has detected spin condition and will transform to VTOL immediately to combat that	Cancel mission!
68	Spin condition over	Autopilot has detected, that spin condition is over.	Aircraft resumes normal flight	-
69	BMS reported error on command $	development feature	-	Contact Threod Systems. **SUPPORT@THREOD.COM**
70	BMS message $	development feature	-	Contact Threod Systems. SUPPORT@THREOD.COM
71	BMS is in error status $	BMS reports that it is in error status	BMS needs reset	Reset battery through Battery Insider.
72	Pitot sensor info is missing, cannot arm	Aircraft does not receive pitot information and therefore rejects arming	Pitot sensor is broken or not connected	Contact Threod Systems. SUPPORT@THREOD.COM
73	Pitot sensor info is missing, using pitot failsafe to fly	Pitot sensor info is missing, but aircraft is configured for pitot failsafe, and will still be able to fly	Pitot sensor has malfunction	Cancel mission! Autopilot will put forward motor in maximum throttle.
74	INS or magnetometer information is not present, cannot arm	Aircraft does not receive magnetometer information and therefore rejects arming	INS or magnetometer malfunction	Contact Threod Systems. SUPPORT@THREOD.COM

ID	GCS String	Description	Cause	Action
75	Autopilot IMU not operational, maintenance needed	Autopilot is broken	Autopilot component failure	Contact Threod Systems. SUPPORT@THREOD.COM
76	Too low voltage to fly, cannot arm	Aircraft battery is too empty to fly	Battery is not charged	Charge battery. Use charged battery.
77	Voltage too low to continue flight, terminating	Battery voltage has dropped to the point, where aircraft systems are about to lose power, parachute is deployed if installed	Battery is too empty to continue flying	Re-route mission. Open parachute. Without parachute, use belly land.
79	aircraft needs more time to stabilize, cannot arm. Try again shortly.	Aircraft sensors need more time to stabilize, aircraft cannot arm.	Aircraft had movement during power up, or GPS signal is jumpy.	Restart aircraft. Hold it stable when powering on!
80	Motor temperature near limits, $ degrees, climb performance reduced.	Aircraft engine is getting hot, aircraft is reducing engine load by decreasing climb angle.	Long climb in hot weather	Hold aircraft in level, by creating manual loiter, or use altitude override.
81	Ground proximity alert $ m	Aircraft is too close to ground and is taking actions to avoid it.	Its normal during launch, otherwise it indicates issues with mission planning, aircraft trajectory is too close to ground.	-
82	Not all lift propellers are rotating, cannot start	Autopilot has detected, that not all lift propellers spooled up during start, and aborted take-off.	Propeller may be stuck, motor malfunction	Check take-off area, clean it if needed. Or contact with Threod Sysstems. SUPPORT@THREOD.COM
83	Battery charge level $ percent	Aircraft has adjusted battery charge level based on battery voltage during power up.	This is normal message to indicate, whether battery is full or not.	-
84	Battery charge level adjusted $	Aircraft has adjusted battery charge level based on battery voltage during flight	This is normal message to indicate, that battery charge level was adjusted.	-
85	Battery size adjusted to match real performance	Aircraft has adjusted battery capacity based on aircraft current consumption and battery remaining voltage	This is normal message to indicate, that battery capacity was changed	-
86	Aborting take-off due to engine errors	One or more lift motors are not turning on take-off	Propeller stuck or motor malfunction	Check take-off area, clean it if needed. Or contact with Threod Sysstems. SUPPORT@THREOD.COM

ID	GCS String	Description	Cause	Action
87	Not all forward propellers are rotating, aborting take-off	Aircraft has detected, that forward motor is not turning	Forward motor malfunction	Contact Threod Systems. SUPPORT@THREOD.COM
88	Battery cells voltage too different, cannot arm	Battery is out of balance, aircraft ignores arming command	Battery is in disbalance and needs to be balanced or is faulty	Balance battery. Or contact with Threod Sysstems. SUPPORT@THREOD.COM
89	Battery health issue, cells voltage differs more than 0.2V	Battery is out of balance, battery health needs to be evaluated	Either battery is too empty or its broken	Balance battery. Or contact with Threod Sysstems. SUPPORT@THREOD.COM
90	BMS not responding	obsolete	-	-
91	BMS temperature $	BMS temperature is over 70 degrees - warning BMS temperature is over 90 degrees - error	Battery management system temperature is too high, land immediately and /or disconnect battery	Land immediately and /or disconnect battery. Contact Threod Systems. SUPPORT@THREOD.COM
92	BMS battery temperature $	BMS battery temperature is over 70 degrees - warning BMS battery temperature is over 90 degrees - error	Battery management system temperature is too high, land immediately and /or disconnect battery	Land immediately and /or disconnect battery. Contact Threod Systems. SUPPORT@THREOD.COM
93	BMS connector temperature $	BMS connector temperature is over 70 degrees - warning BMS connector temperature is over 90 degrees - error	Battery management system temperature is too high, land immediately and /or disconnect battery	Land immediately and /or disconnect battery. Contact Threod Systems. SUPPORT@THREOD.COM
94	BMS charge count $	Battery has had more than 180 charge cycles	test battery, reset charge count if ok	Contact Threod Systems. SUPPORT@THREOD.COM
95	Current sensor needs to be calibrated	Aircraft shows negative current when idle	Current sensor is faulty or needs to be calibrated	Contact Threod Systems **SUPPORT@THREOD.COM**
96	Motor temperature sensor out of range $	Motor temperature sensor value is lower than -50 or higher than 200 degrees celsius	Motor temperature sensor is disconnected or broken	Contact Threod Systems **SUPPORT@THREOD.COM**
97	Acceleration sensors are not calibrated	autopilot is brand new of has lost its configuration	Calibrate acceleration sensors	Contact Threod Systems. SUPPORT@THREOD.COM
98	Compass is enabled, but not calibrated	Compass calibration info is missing, dangerous to use	Calibrate compass	Calibrate compass!
99	IMU temperature drift is not calibrated	Autopilot is brand new or it has lost its configuration data	Calibrate IMU temperature drift	Contact Threod Systems. SUPPORT@THREOD.COM
100	License expired, cannot arm	Aircraft validity period has expired	request new validity code from Threod	Contact Threod Systems. SUPPORT@THREOD.COM

ID	GCS String	Description	Cause	Action
102	QNH Pressure $ out of range, check pressure sensor	Pressure sensor readings are out of range	Pressure sensor is most likely faulty . Replace autopilot	Contact Threod Systems **SUPPORT@THREOD.COM**
104	Descent speed too fast $ m/s	Aircraft cannot control its descent speed	Mechanical failure, battery empty or software issue	Cancel mission! Activate VTOL land if enough battery. If not, then plan parachute landing, without parachute, plan belly land. Contact Threod Systems. SUPPORT@THREOD.COM
105	Magnetometer calibration data invalid, please recalibrate	Magnetometer calibration data is out of range	Re calibrate magnetometer; if you get same error again, then replace.	Contact Threod Systems **SUPPORT@THREOD.COM**
106	Radar altimeter detected but not enabled	Radar altimeter is installed, but disabled	Most likely the altimeter failed during take-off and autopilot has disabled it. If you corrected the problem, then you need to enable it before system can use it.	Contact Threod Systems **SUPPORT@THREOD.COM**
107	Battery temperature below $ degrees	Battery is colder than optimal	Battery has been exposed to cold temperatures for long time	Take battery somewhere warm. Charge battery.
108	Battery temperature below $ degrees, battery performance reduced	battery is too cold to give maximum performance	Battery has been exposed to cold temperatures for too long	Take battery somewhere warm. Charge battery.
109	QNH adjusted to $/10 hPa	autopilot changed automatically QNH value prior to landing (can happen if ALT_AUTO_QNH = 2)	This is normal and indicates, that the logic that activates when ALT_AUTO_QNH = 2, is working	-
110	Engine full throttle performance too low, $ rpm	Motor cannot reach predefined RPM under full throttle	Motor is broken or propeller is out of balance (damaged)	Change propeller.
111	get_i2cdata free stack $	development feature	-	-
112	lost magnetometer $ data	one mangetometer data lost	magnetometer failed or its cable was disconnected	Restart aircraft. Or Contact Threod Systems SUPPORT@THREOD.COM
113	lost all magnetometers data	all mangetometers data lost	all magnetometers failed	Restart aircraft. Or Contact Threod Systems SUPPORT@THREOD.COM

ID	GCS String	Description	Cause	Action
114	Battery remaining capacity is below safe value	automatic battery capacity estimator has determined that remaining battery capacity is less than is required for safe flight	Battery is getting old	Cancel mission! Contact Threod Systems SUPPORT@THREOD.COM
115	BMS not responding	Autopilot in not able to communicate with battery management system	Battery management system interface may be broken	Contact Threod Systems SUPPORT@THREOD.COM
116	GPS loss timeout expired	GPS fix has been lost and GPS timeout has expired	GPS malfunction or jamming	Aircraft will proceed to land. Safe way is to cancel mission. Be prepared that GPS may come back. If it does not come back. Then switch GPS off. Prepare for Guided VTOL during land.
117	Battery critical, landing triggered	Aircraft has determined, that it does not have enough battery to continue flying in VTOL mode and triggered landing	Insufficient battery for VTOL flight. This error may happen, when plane converted to VTOL mode due to malfunction and is too far away to reach landing position.	Aircraft will make VTOL LAND.
118	Battery health issue, voltage did drop below $	Battery voltage did drop below safe level during flight.	Too old or too empty battery.	Cancel mission! Charge battery or Contact Threod Systems SUPPORT@THREOD.COM
119	Manual GPS coordinates out of range	This error comes, when operator tries to adjust aircraft position via GCS map if there is no GPS fix, but its unrealistic that the aircraft could have reached that position. Operator attempt to change aircraft position is ignored in this case and the error is sent.	Autopilot calculates wind direction and speed if operator gives manual position override, and the calculated wind had to be higher than AIRSPEED_HIGH, this is not allowed in order to filter out false locations.	Verify aircraft position on map and try again.
120	Potential GPS spoofing: GPS coordinate changed $ meters during 1 sec	This error comes, when GPS coordinate jumps suddenly, which can indicate spoofing.	Error is generated of GPS coordinate jumps more that 2xAIRSPEED_HIGH during 1 sec	Verify that aircraft location is reasonable; disable GPS if there is reason to believe that GPS coordinate is spoofed.
135	Communication issue with lift motor, channel $. Landing may be problematic.	This error denotes that there is no communication with the specified VTOL ESC.	1. Wire break in VTOL ESC feedback. Autopilot does not get information from the ESC but the aircraft is able to land vertically. 2. VTOL ESC is broken or PWM signal does not reach the ESC. In this case the aircraft is unable to land vertically. Left front motor -14 Right front motor -16 Right rear motor -17 Left rear motor -15	For airplanes with the parachute - do a parachute landing. For airplanes without the parachute - attempt VTOL landing or execute a controlled flight into the terrain (turn off radar, otherwise the aircraft will attempt VTOL landing when approaching ground).

ID	GCS String	Description	Cause	Action
136	Communication issue with forward motor, channel $	This error denotes that there is no communication with the forward motor.	1.Wire break in forward motor ESC feedback. Autopilot does not get information from the ESC. 2. VTOL ESC is broken or PWM signal does not reach the ESC.	Reduce altitude for safe VTOL LAND action.
137	Communication issue with servo, channel $	This error denotes that there is no communication with the specified servo.	Broken servo or feedback wire.	With control surface failure, airplane can continue flight. With parachute servo failure, execute a controlled flight into the terrain (turn off radar, otherwise the aircraft will attempt VTOL landing when approaching ground).
1002	BMS: Under-Voltage Cutoff Occurred	The Tiny BMS device provides battery Under-Voltage protection for cells under charge, discharge and idle states, based on each cell in series voltages measurement. Under-Voltage Fault is the BMS second level protection and always detected after the first level protection Fully Discharged Warning has been detected.	Discharged to much or battery is leaved on position a long time.	If the voltage is under 16v do not charge the battery anymore. Contact Thredo Systems, do not fly! For EOS BMS it is disabled
1003	BMS: Over-Voltage Cutoff Occurred	Note: Over-Voltage Cutoff must be always greater than Fully Charged Voltage. If the Over-Voltage Cutoff needs to be set out of range it is recommended at first set correct Fully Charged Voltage and then set Over-Voltage Cutoff value in this range.	Charger problem or BMS broken	If the voltage is more then 26.1v or higher Do not use that. Contact Thredo Systems, do not fly !
1004	BMS: Over-Temperature Cutoff Occurred	The Tiny BMS device provides over-temperature protection for cells under charge, discharge or idle states, based on cell temperature measurement (two external temperature sensor channels) and onboard temperature sensor measurement.	Disabled	Remove battery from EOS and cool it down, battery temperature is more then 90DegC
1005	BMS: Discharging Over-Current Cutoff Occurred	The Tiny BMS device provides over-current protection for cells under discharging, based on discharging current measurement.	Disabled	Recoverable over-current protection has been activated. Discharging current is higher than Discharge Over-Current Cutoff threshold.
1006	BMS: Charging Over-Current Cutoff Occurred	The Tiny BMS device provides over-current protection for cells under charging, based on charging current measurement.	Disabled	Recoverable over-current protection has been activated. Charging current is higher than Charge Over-Current Cutoff threshold.

1007	BMS: Regeneration Over-Current Cutoff Occurred	The Tiny BMS device provides over-current protection for cells under regeneration, based on regeneration current measurement.	Disabled	Not in use
1010	BMS: Low Temperature Cutoff Occurred	Fault condition recovers after BMS measured temperatures meets normal status conditions and Automatic Recovery time interval has been passed.		Recoverable under-temperature protection has been activated. Battery temperature is lower than -40°C. BMS goes back to normal status operation, if Charge Under-Temperature Warning also recovers, or goes to Charge Under-Temperature Warning status operation, if it was not recovered yet.
1011	BMS: Charger Switch Error Detected	Charger Switch (Dual Port mode) should be turned off, but BMS still measures charging current. Possible BMS internal FETs or relay / contactor damage	BMS broken	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**

ID	GCS String	Description	Cause	Action
1012	BMS: Load Switch Error Detected	Load Switch (Dual Port mode) should be turned off, but BMS still measures discharging / regeneration current. Possible BMS internal FETs or relay / contactor damage.	BMS broken	Contact Threod Systems, do not fly! **SUPPORT@THREOD.COM**
1013	BMS: Single Port Switch Error Detected	Single Switch (Single Port mode) should be turned off, but BMS still measures charging / discharging current. Possible BMS internal FETs or relay / contactor damage.	Not in use	-
1014	BMS: External Current Sensor Disconnected (BMS restart required)		Not in use	-
1015	BMS: External Current Sensor Connected (BMS restart required)		Not in use	-

1049	BMS: Fully Discharged Cutoff Occurred		Disabled	Recoverable under-voltage protection has been activated. At least one cell voltage dropped below Fully-Discharged Voltage threshold.
1055	BMS: Low Temperature Charging Cutoff Occurred	The Tiny BMS device provides charge under-temperature protection for cells under charge state, based on cell temperature measurement (two external temperature sensor channels) or onboard temperature sensor measurement.	Warning	Recoverable charging under-temperature protection has been activated. Battery temperature is lower than Low Temperature Charger Cutoff threshold
1056	BMS: Charging Done (Charger voltage too high)	BMS goes to the Fully Charged state and the SOC value is set to the 100 % value only if all three conditions are met: • The voltage of the all cells is at the Fully Charged voltage limit; • The cells imbalance is less than the Allowed Disbalance setting; • The charging current becomes lower than Charge Finished Current setting value.	Warning	-
1057	BMS: Charging Done (Charger voltage too low)	Charging process is stopped, due to low charger output voltage. SOC is not adjusted to 100 %	Warning	Try to charge again. Charger is broken. Contact Threod Systems
1097	BMS: System Started	Tiny BMS device powered up or restarted.	-	-
ID	**GCS String**	**Description**	**Cause**	**Action**
1098	BMS: Charging Started	Charger is connected and Charger Switch is	-	-
1099	BMS: Charging Done	Battery is fully charged. SOC adjusted to 100 %	-	-
1100	BMS: Charger Connected	Charger is connected.	-	-
1101	BMS: Charger Disconnected	Charger is disconnected	-	-
1102	BMS: Dual Port Operation Mode Activated	Tiny BMS is switched to Dual Port operation mode.	-	-
1103	BMS: Single Port Operation Mode Activated	Tiny BMS is switched to Single Port operation mode.	-	-
1115	BMS: Recovered From Over-Temperature Fault Condition	Over-temperature protection has been deactivated.	-	-

1116	BMS: Recovered From Low Temperature Warning Condition	Charging under-temperature protection has been deactivated.	-	-
1117	BMS: Recovered From Low Temperature Fault Condition	Under-temperature protection has been deactivated.	-	-
1118	BMS: Recovered From Charging Over-Current Fault Condition	Over-temperature protection has been deactivated.	-	-
1119	BMS: Recovered From Discharging Over-Current Fault Condition	Discharging over-current protection has been deactivated.	-	-
1120	BMS: Recovered From Regeneration Over-Current Fault Condition	Regeneration over-current protection has been deactivated (possible only in Dual Port operation mode).	-	-
1121	BMS: Recovered From Over-Voltage Fault Condition	Over-voltage protection has been deactivated.	-	-

ID	GCS String	Description	Cause	Action
1122	BMS: Recovered From Fully Discharged Voltage Warning Condition	Under-voltage (Fully-Discharged Warning) protection has been deactivated.	-	-
1123	BMS: Recovered From Under-Voltage Fault Condition	Permanent under-voltage protection has been deactivated.	-	-
1124	BMS: External Current Sensor Connected	External current sensor connected, initialized and in use.	-	-
1125	BMS: External Current Sensor Disconnected	External current sensor disconnected, BMS internal HALL current sensor is used.	-	-
10001	Commboard reset	Communication controller has rebooted	Software issue, electrical issue	Take note and report to Threod Systems
11003	watchdog reset detected	One of the servo control modules has been restarted	Software issue, hardware issue	Proceed to land, contact Threod Systems

11034	Servo $ movement failure detected	Servo is not moving freely	Servo is faulty, flight surfaces or parachute/airbag hatch levers are blocked Parachute servo - 7 Component 21 (WING-L) Left aileron servo - 5 Component 22 (WING-R) Right aileron servo - 5 Component 30 (TAIL-C) Left ruddervator - 1 Right ruddervator - 2	Proceed to land. Caution, some functions may not be available!
11045	ESC $ Error: motor blocked	Make sure propeller or motor is rotating freely	On ground something is hitting the propeller	Make sure every motor has the space to move freely
11046	ESC $ Error: H-Bridge break	ESC board is broken	-	Contact Threod Systems **SUPPORT@THREOD.COM**
11047	ESC $ Error: H-Bridge short circuit	Something is shorting out output phase cables.	-	Contact Threod Systems **SUPPORT@THREOD.COM**
11048	ESC $ Error: motor wire break	ESC has one or more motor phase cable break connection.	Broken pin or lose cable	Contact Threod Systems **SUPPORT@THREOD.COM**
11049	ESC $ Error: phase issue	-	-	-
11050	ESC $ Error: direction flag	-	-	-
11051	ESC $ Error: Overvoltage	ESC are getting more voltage then they can handle 30+volt	Battery voltage to high (overcharged)	Make sure the voltage on battery is right for the aircraft
11052	ESC $ Error: Undervoltage	ESC voltage is to low	Battery voltage is to low	Make sure battery voltage is OK
ID	**GCS String**	**Description**	**Cause**	**Action**
11053	ESC $ Error: Overcurrent	Current consumption is too high	Motor has been connected to ESC, when it was powered on.	Restart aircraft.
11054	ESC $ Error: MOS overheat	More then 130+ DegC	Motor is over worked	land immediately
11055	ESC $ Error: CAP overheat	More then 130+ DegC	Motor is over worked	land immediately
11056	ESC $ Error: Throttle stick wasn't bottom	PWM on the ESC is to high.	Software problem	Restart paircraft or Contact Threod Systems **SUPPORT@THREOD.COM**
11060	INS General Fault: $	Failed IMU health check.	-	Restart paircraft or Contact Threod Systems SUPPORT@THREOD.COM
11061	INS Aiding Fault: $	Failed IMU health check.	-	Restart paircraft or Contact Threod Systems SUPPORT@THREOD.COM

11062	INS Magn/ACC Fault: $	Possible fault or high vibration	-	Restart paircraft or Contact Threod Systems SUPPORT@THREOD.COM
11063	INS IMU Fault: $	Failed IMU health check.	-	Restart paircraft or Contact Threod Systems SUPPORT@THREOD.COM
11064	ESC $ MOS Temp +70C	Warning	Weather conditions. Too long time in VTOL mode. High altitude transition. Vibration. Mechanical issue.	When it reaches to+150C, it will cut-off motors. Cancel mission!
11065	ESC $ MOS Temp +90C	Critical	Weather conditions. Too long time in VTOL mode. High altitude transition. Vibration. Mechanical issue.	When it reaches to+150C, it will cut-off motors. Cancel mission!
11066	ESC $ CAP Temp +70C	Warning	Weather conditions. Too long time in VTOL mode. High altitude transition. Vibration. Mechanical issue.	When it reaches to+150C, it will cut-off motors. Cancel mission!
11067	ESC $ CAP Temp +90C	Critical	Weather conditions. Too long time in VTOL mode. High altitude transition. Vibration. Mechanical issue.	When it reaches to+150C, it will cut-off motors. Cancel mission!
11068	Radar SNR Low: $	Not in use	-	-
11069	Radar not operational	Power is off	Power cable broken	Contact Threod Systems **SUPPORT@THREOD.COM**
11070	FW MOTOR ESC MOS Temp High: $ C	Warning (Yellow 90°C) (Red 110°C)	Forward motor internal ESC is over heating	Yellow warning to be careful from overheating
ID	**GCS String**	**Description**	**Cause**	**Action**
11071	FW MOTOR ESC CAP Temp High: $ C	Warning (Yellow 90°C) (Red 110°C)	Forward motor internal ESC is over heating	Do not climb any higher. Control power consumption inflight.
11072	VTOL ESC 1 MOS Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode, go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.

11073	VTOL ESC 1 CAP Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.
11074	VTOL ESC 2 MOS Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.
11075	VTOL ESC 2 CAP Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.

ID	**GCS String**	**Description**	**Cause**	**Action**
11076	VTOL ESC 3 MOS Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.

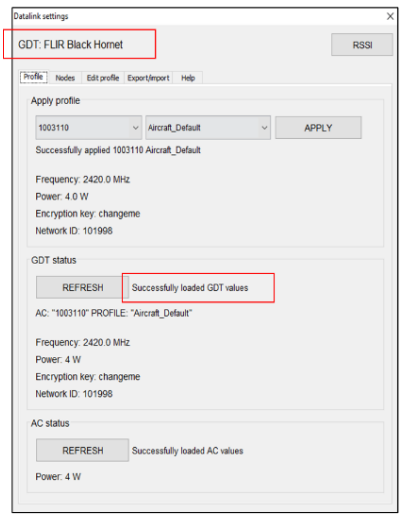
11077	VTOL ESC 3 CAP Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.
11078	VTOL ESC 4 MOS Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.
11079	VTOL ESC 4 CAP Temp High: $ C	Warning (Yellow 70°C) (Red 90°C)	• VTOL Transition or landing alt is too high • High alt fixed wing flight going into VTOL mode and flying back home. • Outer temperature is out of range	• Make sure power consumption is ok • If you are higher then allowed meters rel. and in VTOL mode go back into fixed wing • High winds and very warm weather conditions do not be in VTOL state to long.
11080	VTOL ESC FAULT (some are missing): $	All VTOL Booms needs to be connected	VTOL Boom is lose or not connected	Make sure connector istn broken (pins inside) Connector goes all the way in.
11081	Failed to save parameters to EEPROM: $	SD card broken.	-	Format SD card. If no help, change Autopilot SD card.

ANNEX 1 CREATING CONNECTION WITH UAV

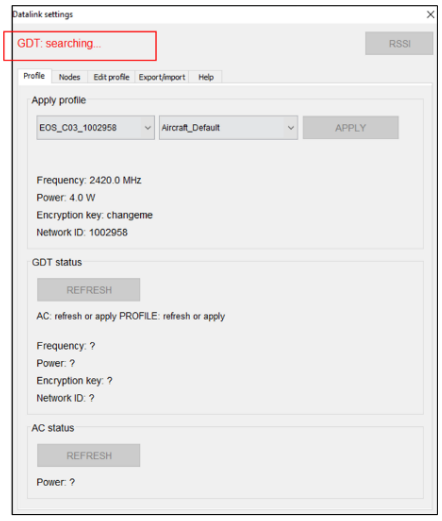
1. Power on GDT (Power up will take 1 minute)
2. Power on GCS and start GCS software
3. Power on UAV (Power up will take 1 minute)
4. Open Datalink settings by clicking on the UAV connection indicator at the top left corner of the screen

Figure 162: Connection indicator

5. Make sure you have connection with GDT

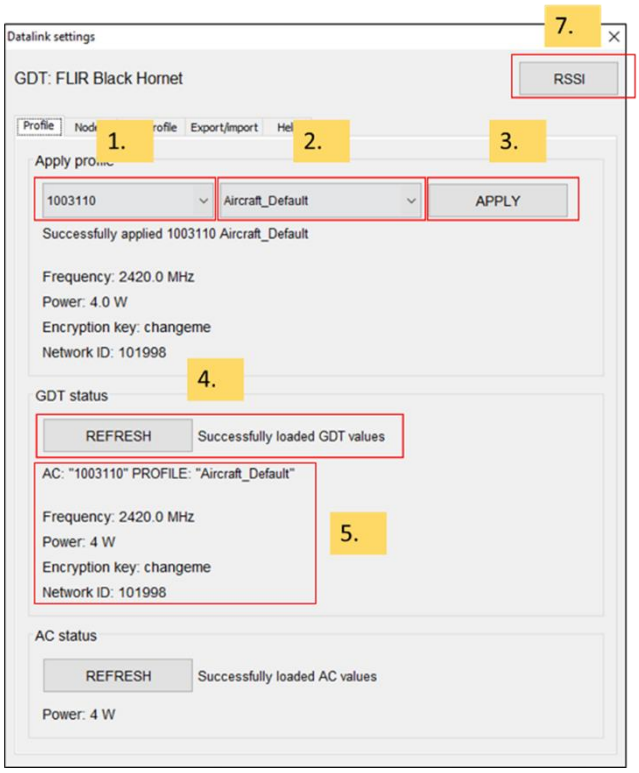


Connection with GDT

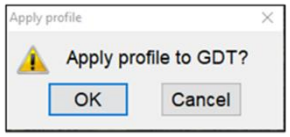


No connection with GDT

6. Apply UAV profile to GDT- will reboot GDT radio module (will take about 1minute)



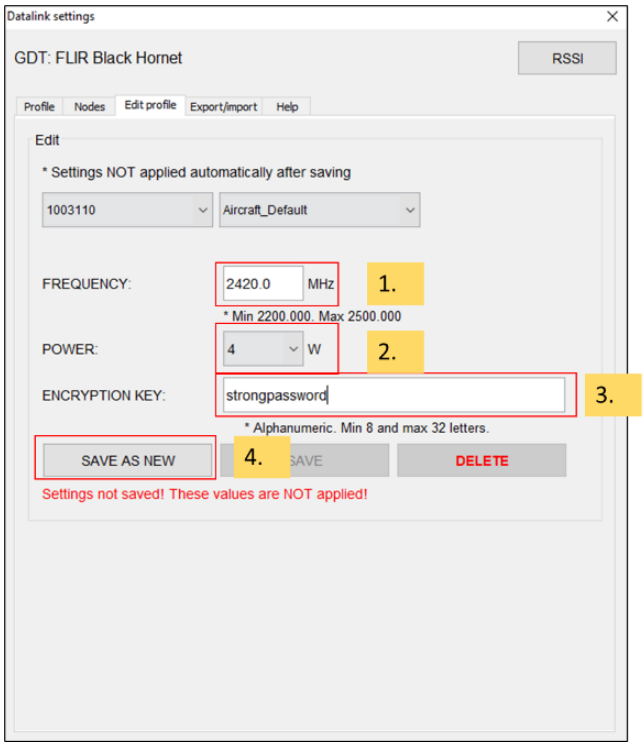
1. Select **UAV** what you powered on.
2. Select **Aircraft_Default** profile
3. Apply to **GDT**



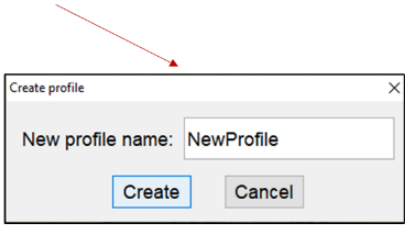
4. After reboot **REFRESH** GDT status and wait for **Successfully loaded GDT values**
5. Make sure you have correct values
6. You will get Green light in **Datalink telemetry indicator**

7. Press **RSSI,** you will get link quality

7. If needed, change profile (Frequency, Power, encryption key)



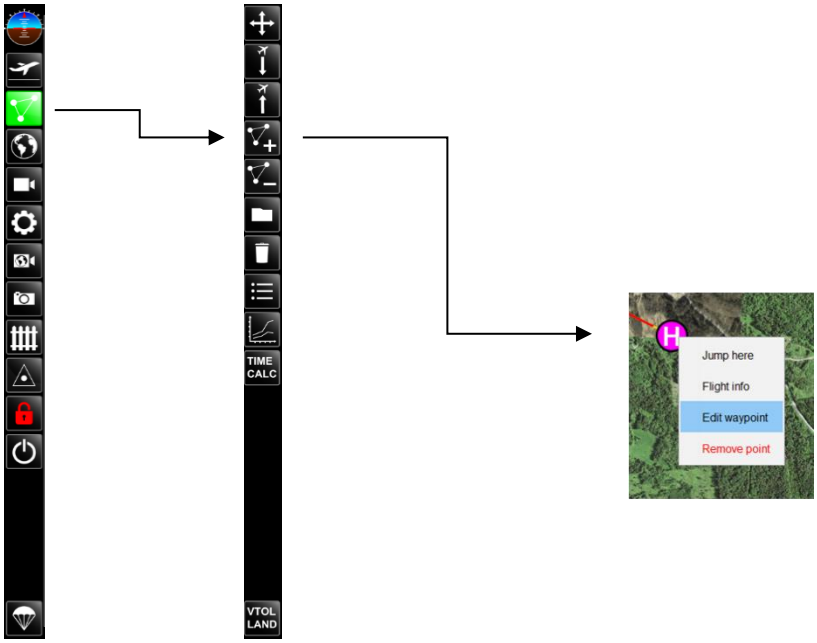
1. Enter **FREQUENCY**
2. Select output **POWER**
3. Enter **ENCRYPTION KEY**
4. **SAVE AS NEW**



8. Apply new profile

ANNEX 2 EXAMPLE MISSION

1. Add waypoints and edit



Needed waypoints:

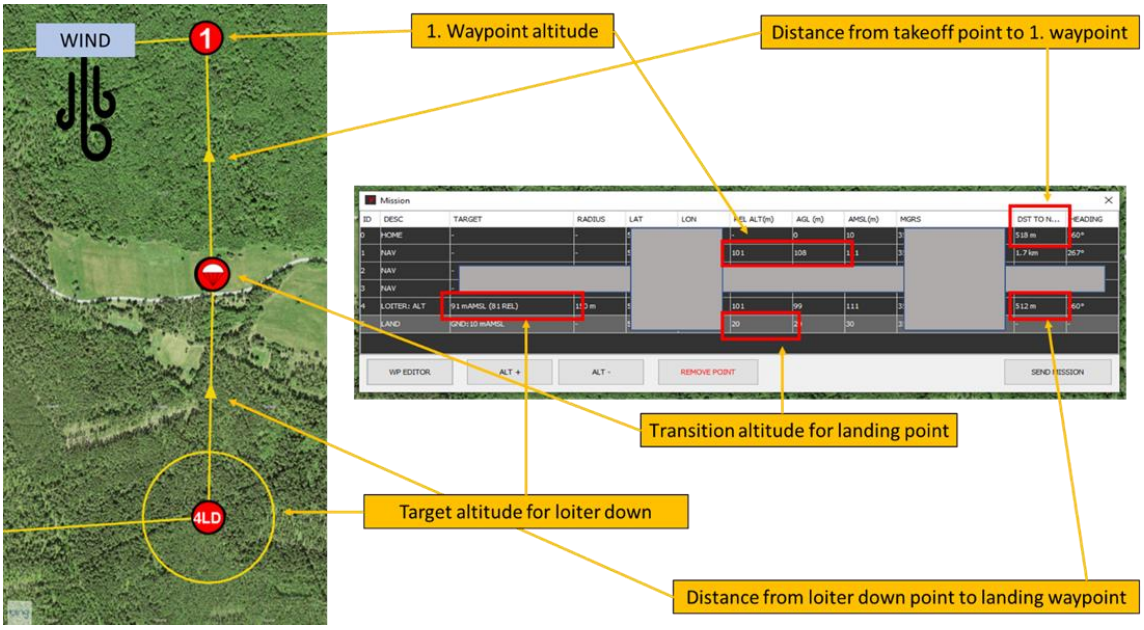
Home point for Take-off (HOME)

1st waypoint for taking off into head wind (NAV)

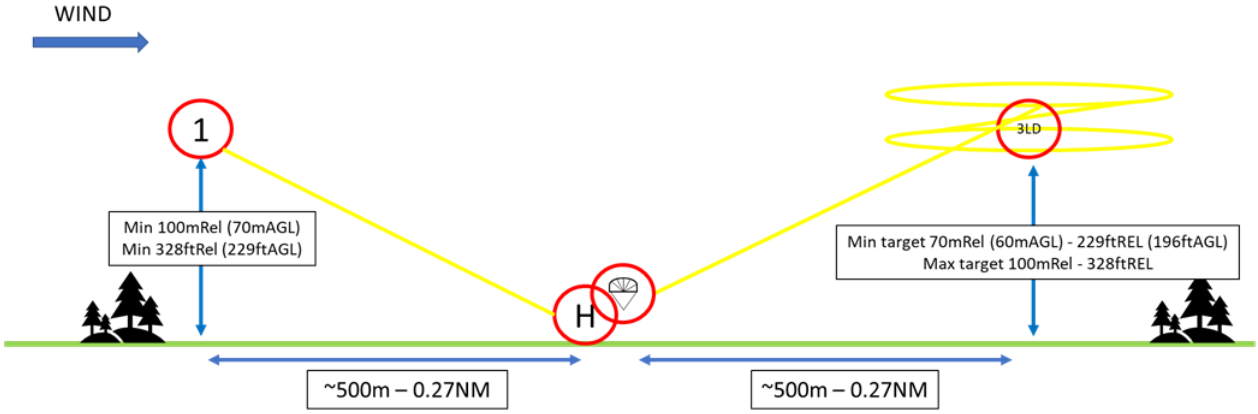
2nd waypoint for loiter down, before heading Landing waypoint (LOITER ALT)

Landing waypoint into head wind for landing (LAND)

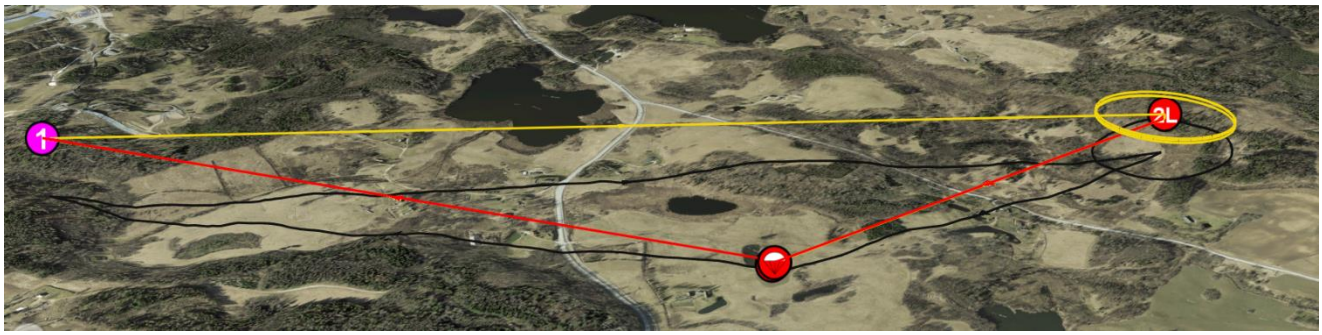
2. Plan your waypoints.



3. Take-off and landing profile criteria.

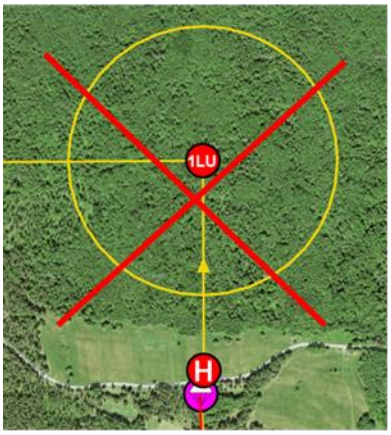


4. Check in different angel (to make sure, you are avoiding ground and obstacles)

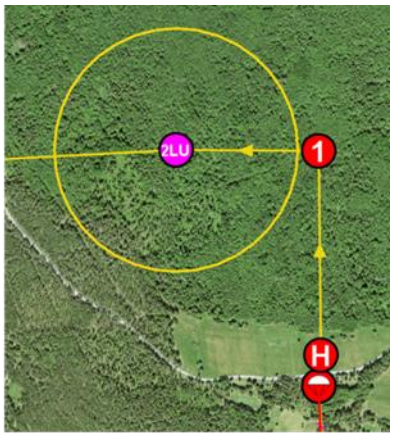


CAUTION

DO NOT USE LOITER UP IN 1. WAYPOINT. YOU MAY DAMAGE AIRCRAFT!



INCORRECT



CORRECT

WIND CHART

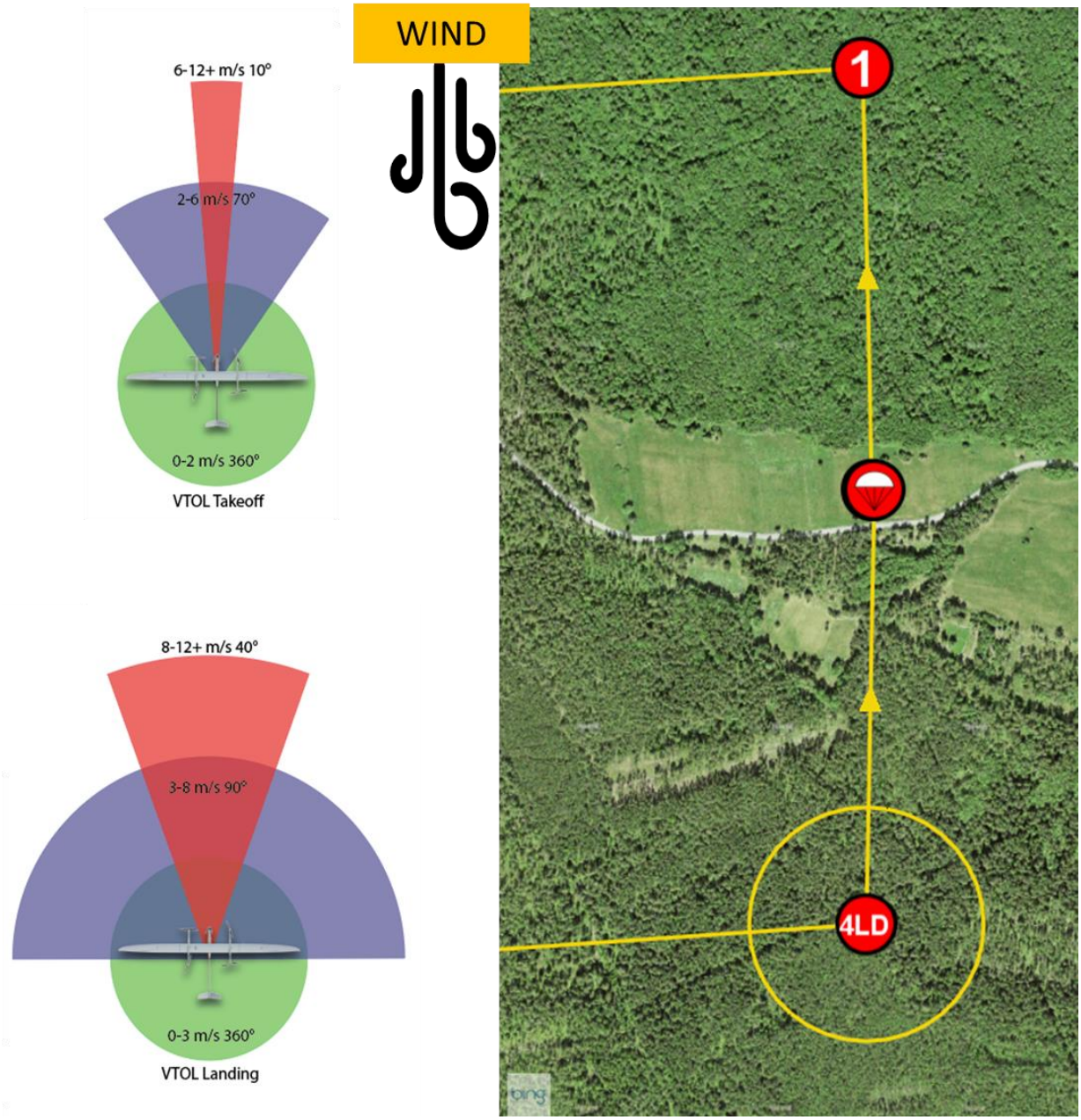


Figure 163 Wind chart for Eos C

ANNEX 3 ALTITUDE VISUAL DESCRIPTION

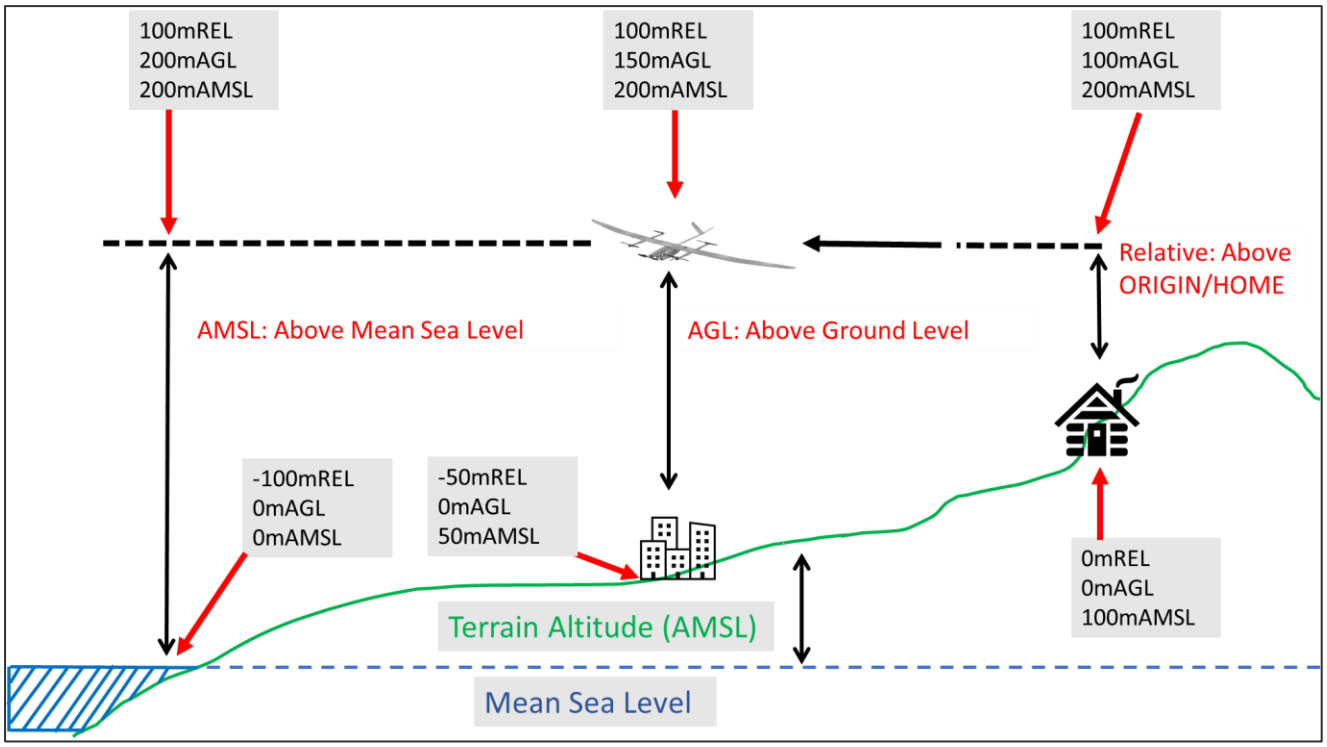


Figure 164 Altitude visual description

ANNEX 4 RUGGED CONTROLLER

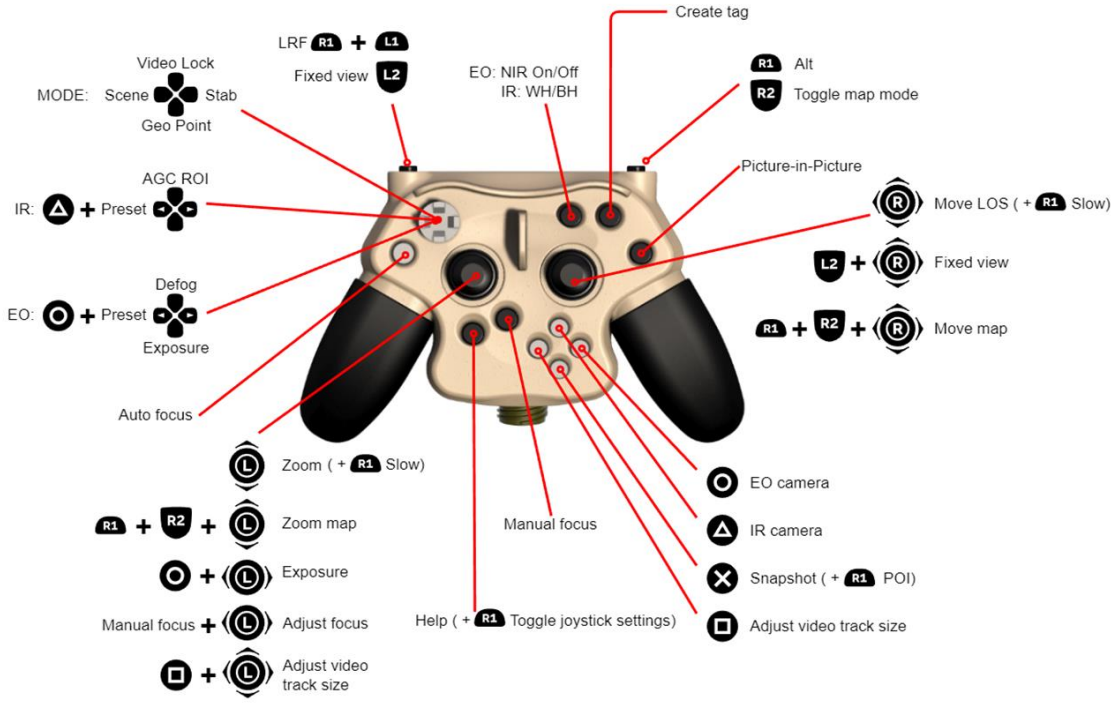


Figure 165 Rugged controller Auto mode layout

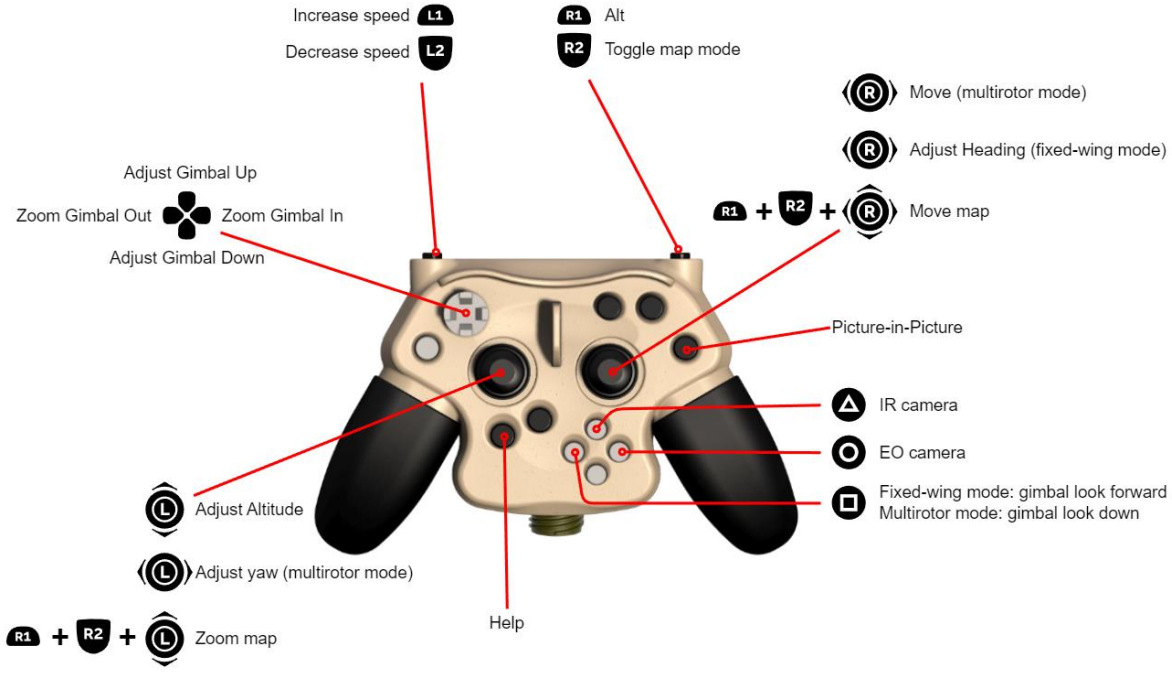
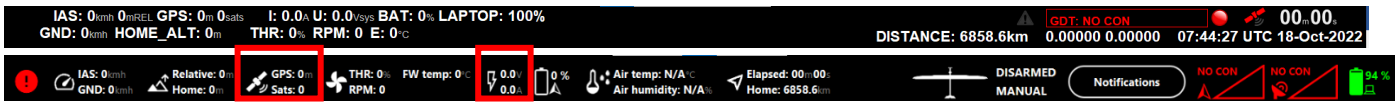
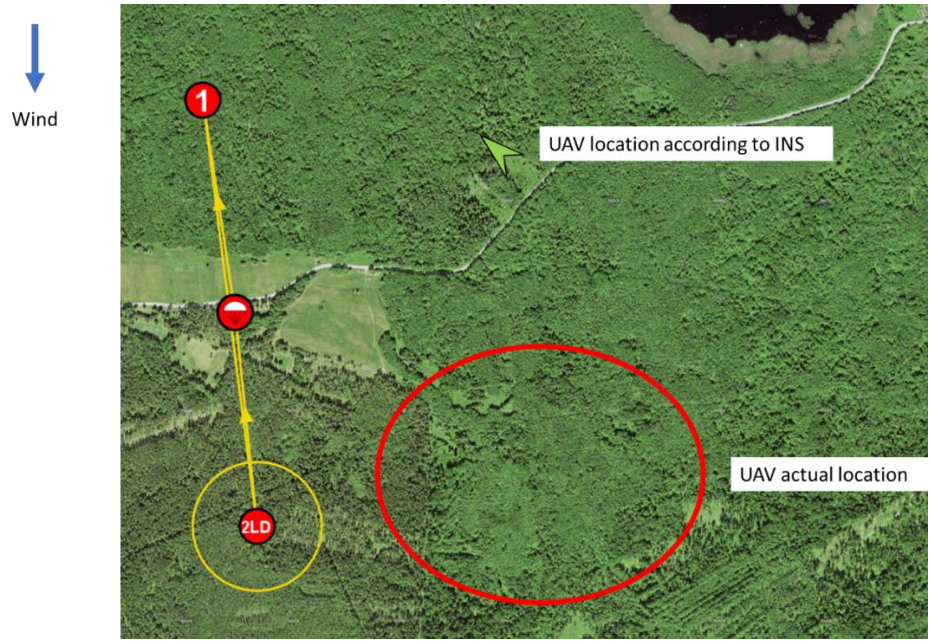


Figure 166 Rugged controller Guided mode layout

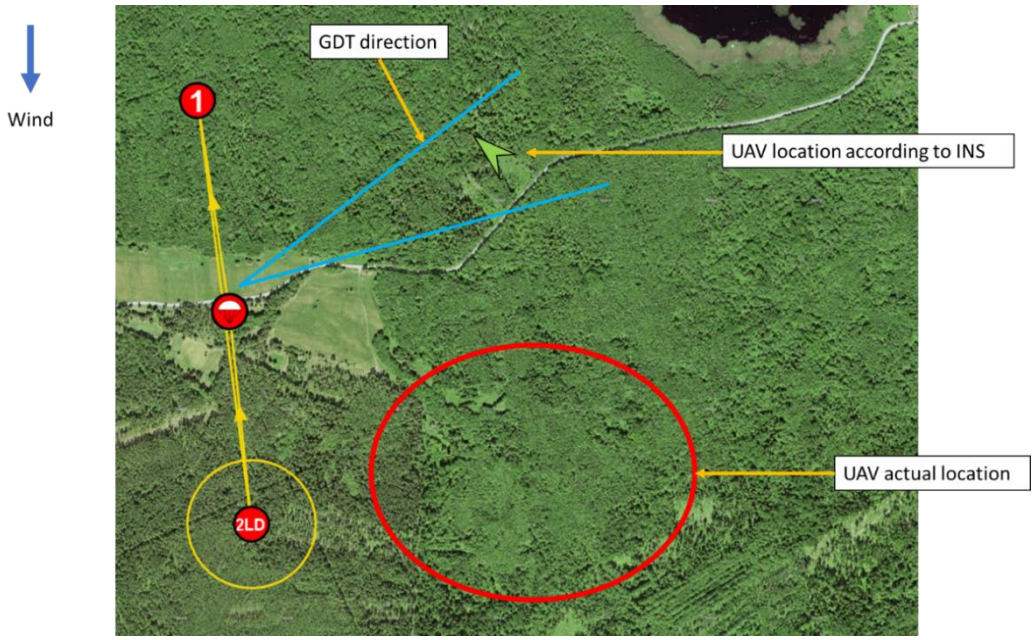
ANNEX 5 WITHOUT GPS FLIGHT



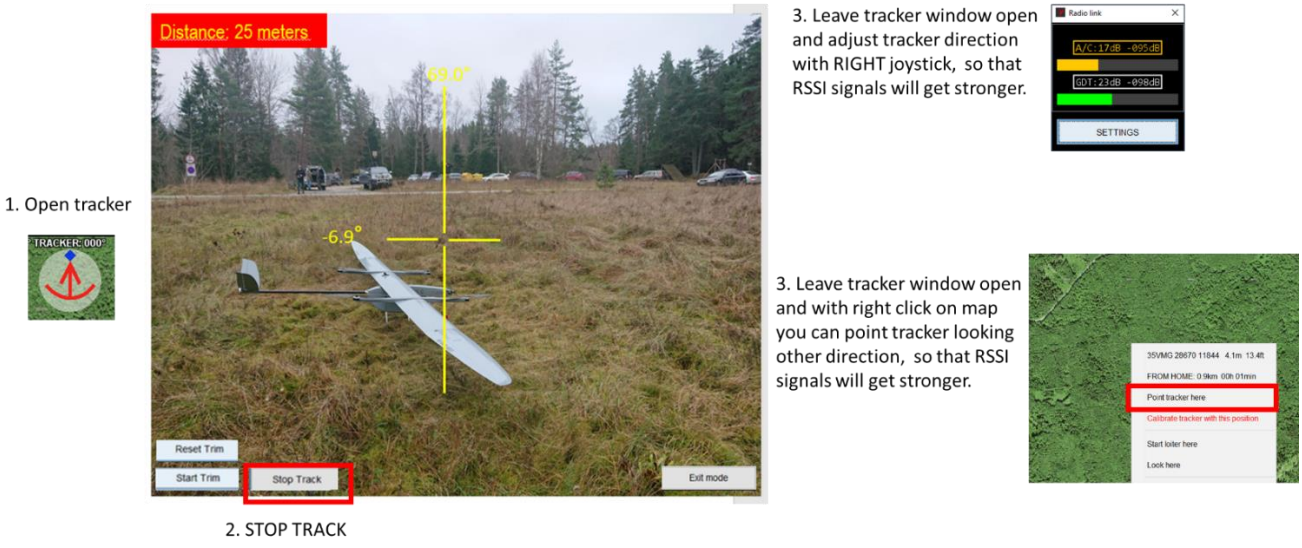
Without GPS aircraft is flying according to INS. Without GPS aircraft does not know the actual location. INS also gives feedback how fast and how far the aircraft has flown. But it does not know how much wind has blown it away. In that case aircraft reacts according to the worst scenario. Forward motor RPM will rise with increased battery consumption. Without GPS, autopilot will stop wind calculation, and this will reduce "PLAY TIME"!



In this situation, aircraft is still sending the location what it thinks, where it is. If you are using tracking antenna and it is tracking, then antenna is also looking on the coordinates, what aircraft thinks, where it is. What will happen is that you will lose communication with aircraft.



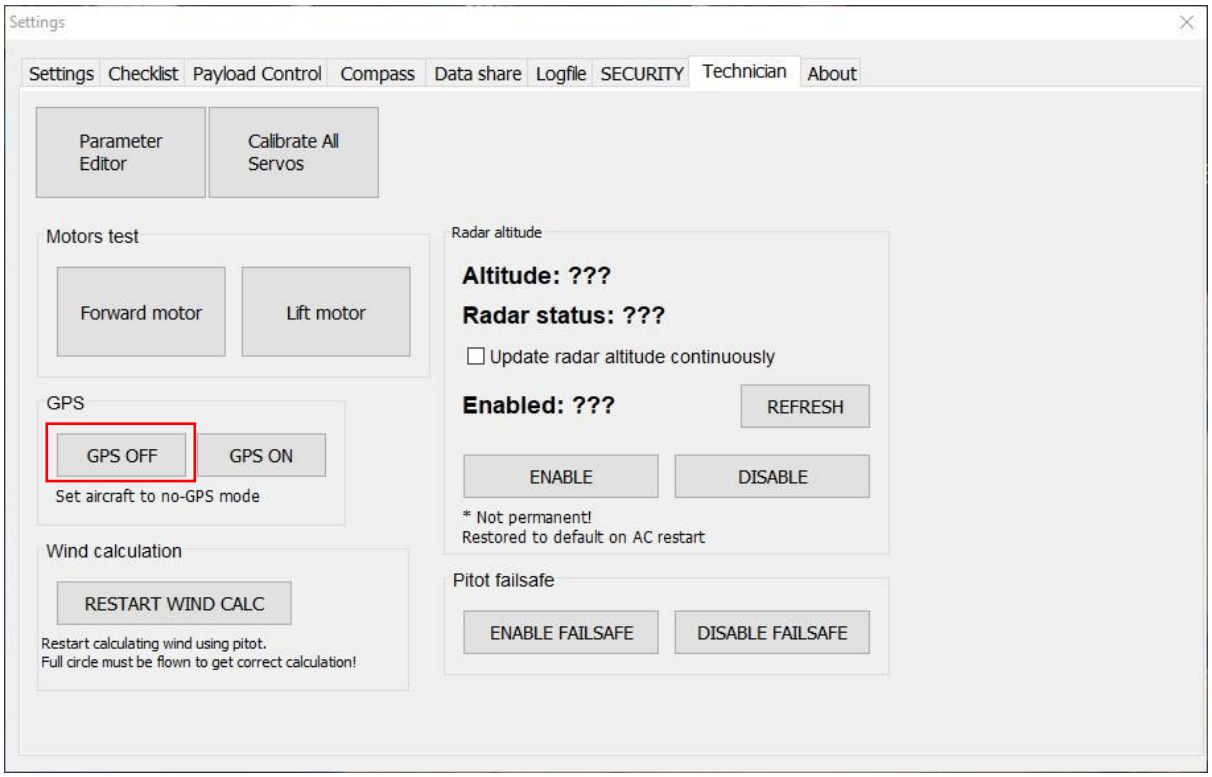
For situations where you have lost the GPS signal in aircraft, you need to stop tracking and adjust tracker direction so, that you will get stronger signal again. The fastest way is, STOP TRACK and physically turn whole tracker looking on the direction where aircraft is (keep in mind, that now you have lost tracker calibration also). The second option is to point tracker through the software.



HOW TO PROCEED TO LAND:

1. Switch aircraft into Fly-by Camera mode and guide the aircraft to your landing site.
2. If you can already recognise through video feed landing site, switch aircraft into Fixed-Wing Guided, and make a overfly from landing site in altitude of 100mAGL, to check, if GPS signal will come back. If you can see that the GPS is not coming back, switch GPS off, from settings. It will deactivate GPS for Autopilot.

In case when GPS signal will come back, or is spoofed, then the Autopilot is not using GPS signal!



3. **You need to have visual contact with aircraft, from the spot where you operate!** Align aircraft again facing into headwind. And proceed to land, on the same time descending (target altitude for landing around 50mAGL).

4. After aircraft has reached to landing site with target altitude around 50mAGL, Activate VTOL LAND. Aircraft will switch into MULTIROTOR GUUIDED MODE.

CAUTION

WITHOUT GPS AIRCRAFT CAN NOT HOLD ITS LOCATION, IT WILL START FLOATING IN THE AIR!

DO NOT MOVE AIRCRAFT BACKWARDS MORE THAN 5 SECONDS!

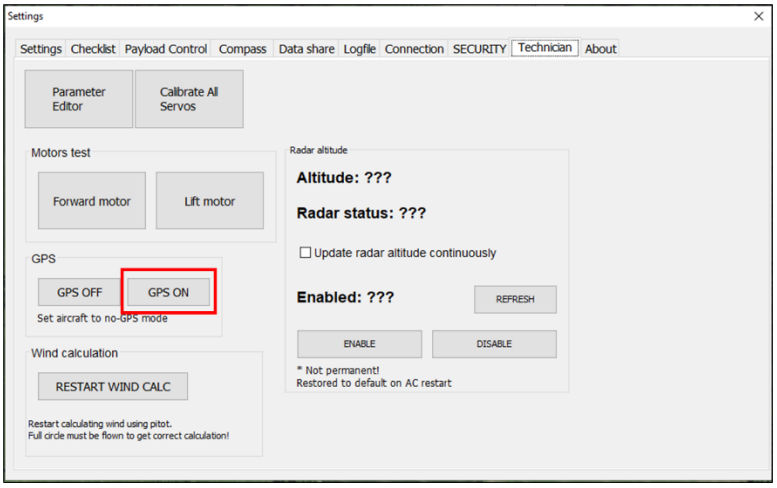
FROM THE ALTITUDE OF 5 METERS FROM GROUND, NO ADJUSTMETS WITH RIGHT JOYSTICK, HOLD AIRCRAFT SILGHTLY AGAINST THE WIND AND CONTINUE LANDING!

WHEN AIRCRAFT HAS TOUCHED THE GROUND, HOLD LEFT JOYSTICK STILL DOWN, UNTIL GCS SOFTWARE CONFIMRS THAT AICRAFT HAS BEEN DISARMED!

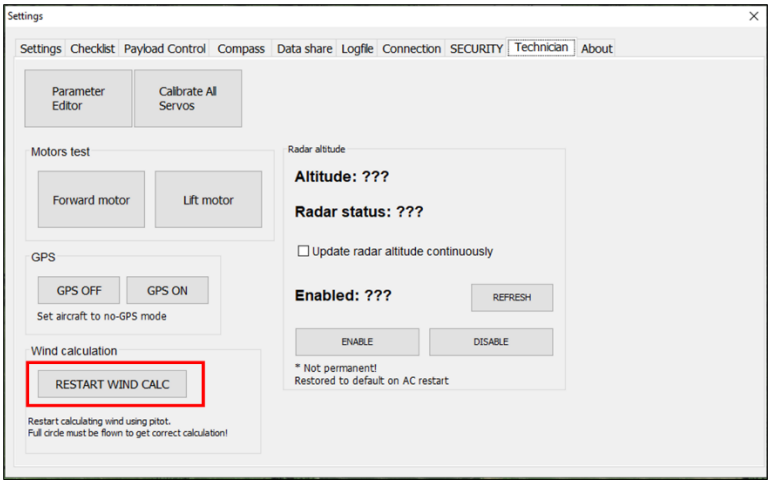
GPS SHOULD BE SWITCHD OFF FROM SETTINGS, DURING THE MULTIROTOR GUIDED LANDING!

IN CASE, WHEN GPS SIGNAL COMES BACK DURING THE FLIGHT:

1. Switch on GPS signal when it was disabled before.



2. Restart wind calculation by clicking RESTART WIND CALC. For that create manual loiter, and let the aircraft do full circle and you can continue mission.



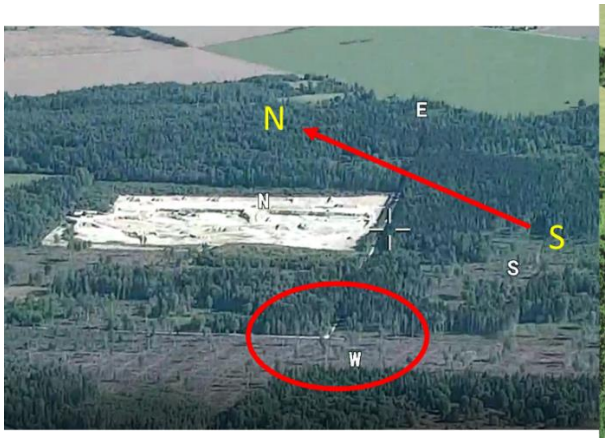
HOW TO ADJUST AIRCRAFT ACTUAL LOCATION DURING THE FLIGHT:

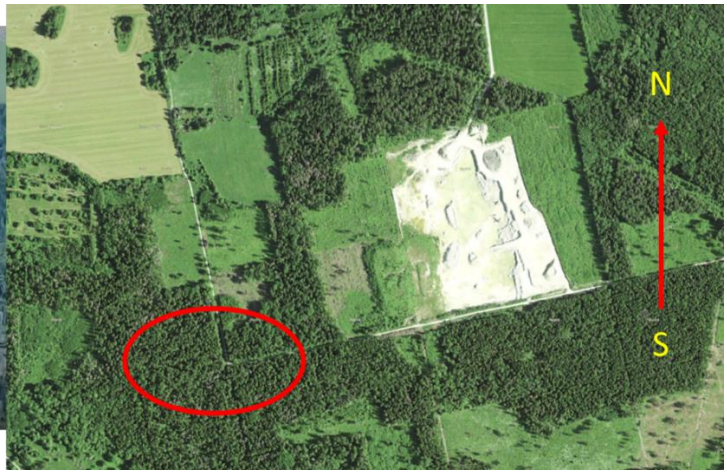
It is done through video feed.

1. **Based on aircraft position**

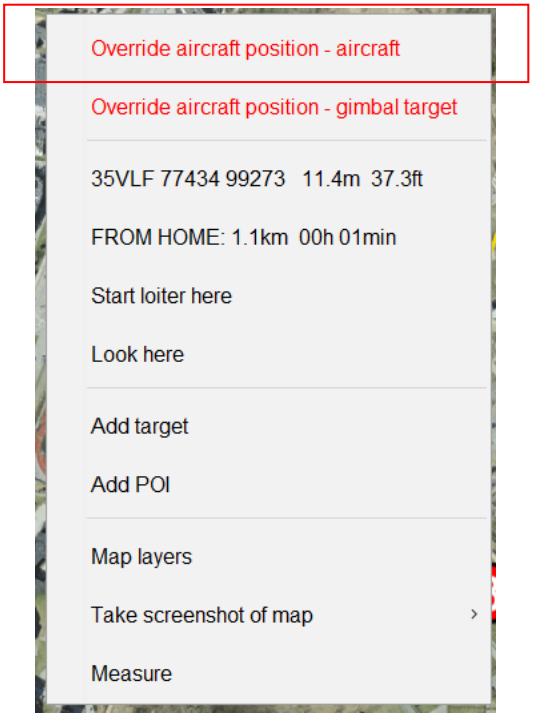
You need to recognize through video feed your actual location.

Find a recognizable landmark, for example, crossroad, building, field corner etc.



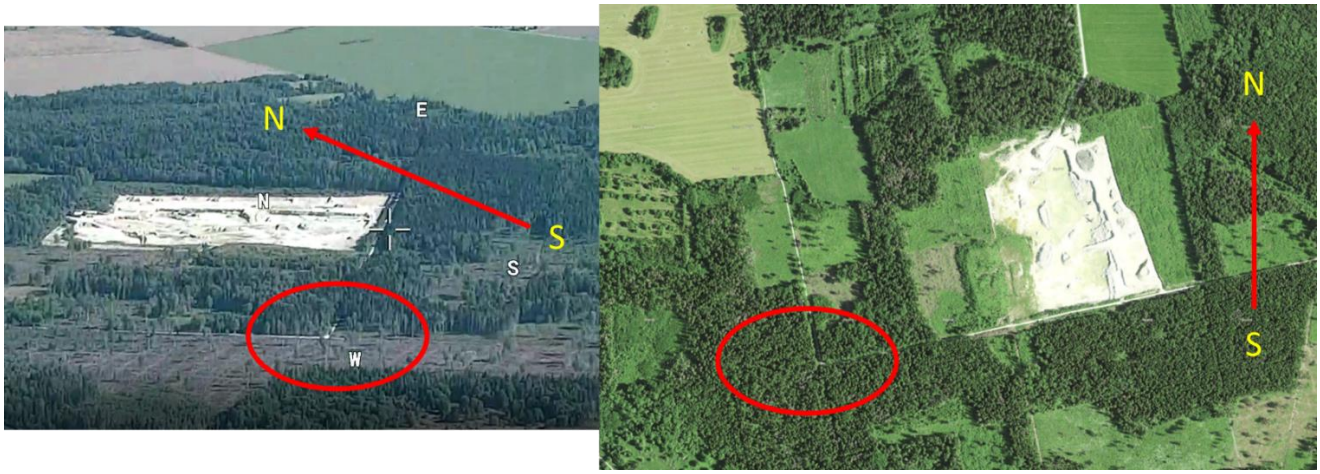


With manual loiter, guide the aircraft flying over location what you could recognize over video and map. Point the camera looking straight down (PAN 0° and TILT 90°). And on the time, when aircraft has reached to location what you have chosen. And the cross from video feed is looking at the point what you have chosen. Make a right click on the map and choose "Override aircraft position - aircraft"



2. **Based on gimbal target**
   You need to recognize the gimbal target location through the video feed.

   Find a recognizable landmark, for example, crossroad, building, field corner etc.



   Make a right click on the map (on the recognizable object of interest’ s location) and choose “Override aircraft position – gimbal target”.

ANNEX 6 INSTRUCTION: RVT VIDEO STREAMING WITH EOS-C VTOL

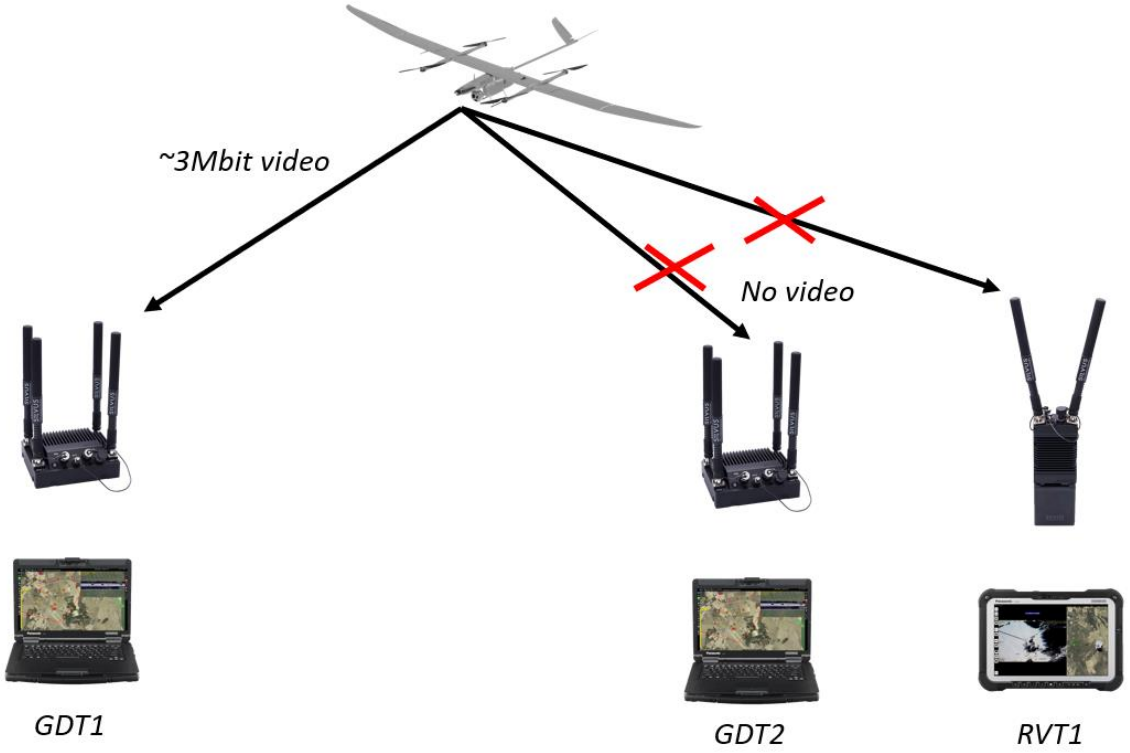
OVERVIEW

Eos C VTOL has two video streaming modes:

1. High quality downlink + very high quality SD card recording

In this mode a ~3Mbit video stream is sent to one of the GDT-s. All other GDT-s and RVT-s will receive no video at all. Secondary video stream is at 10Mbit with H.265 encoding and this is stored directly to the SD card.

Use this scenario when one ground control station needs live video stream and maximum quality on-board recroding is required.

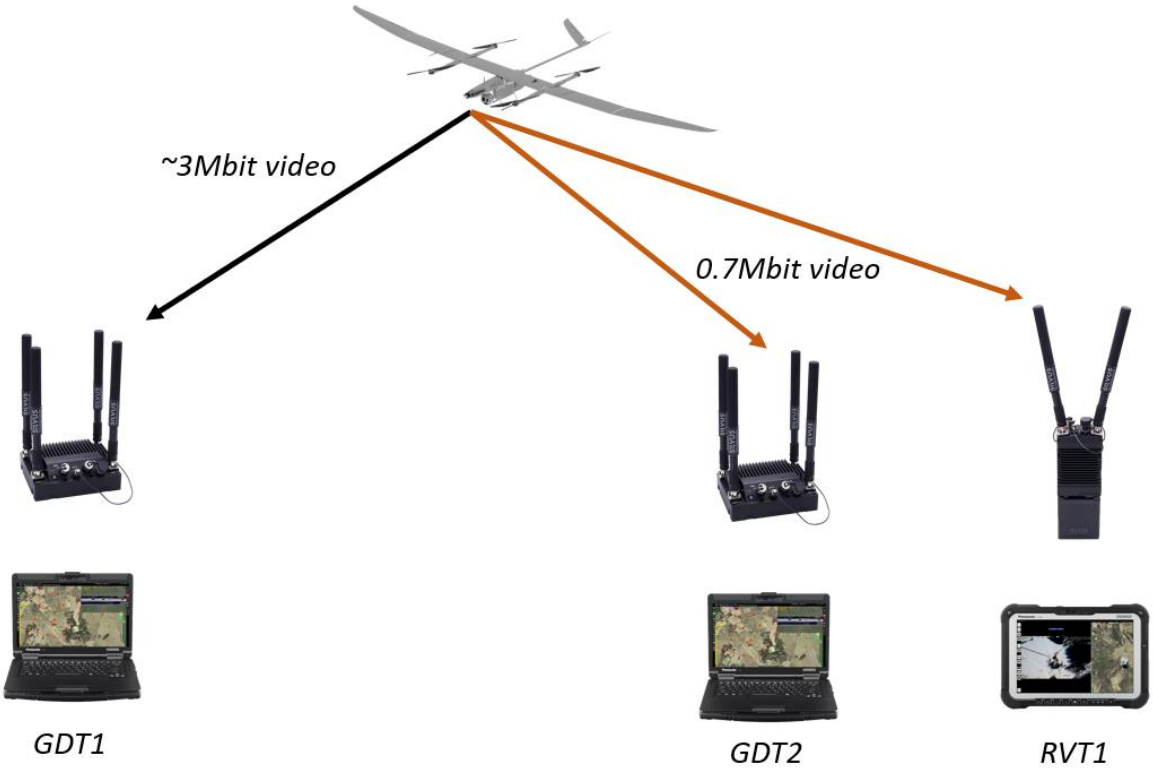


High quality downlink + very high quality SD card recording

2. High quality downlink + low bitrate RVT downlink

In this mode a ~3Mbit video stream is sent to one of the GDT-s. All other GDT-s and RVT-s will receive a low bitrate live video stream. In this case the main ~3Mbit video stream will be stored on the SD card.

Use this scenario when planning to use RVT-s and/or secondary ground control stations.

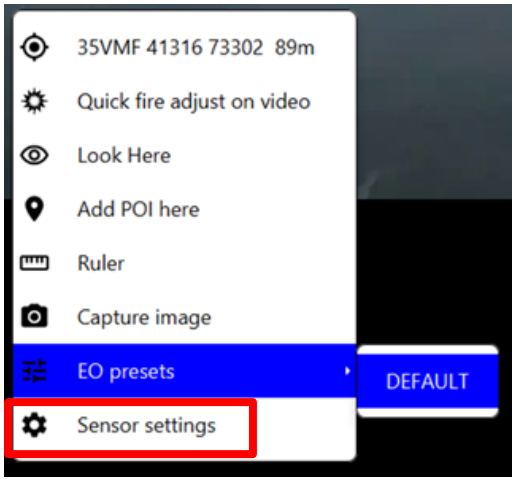


High quality downlink + low bitrate RVT downlink

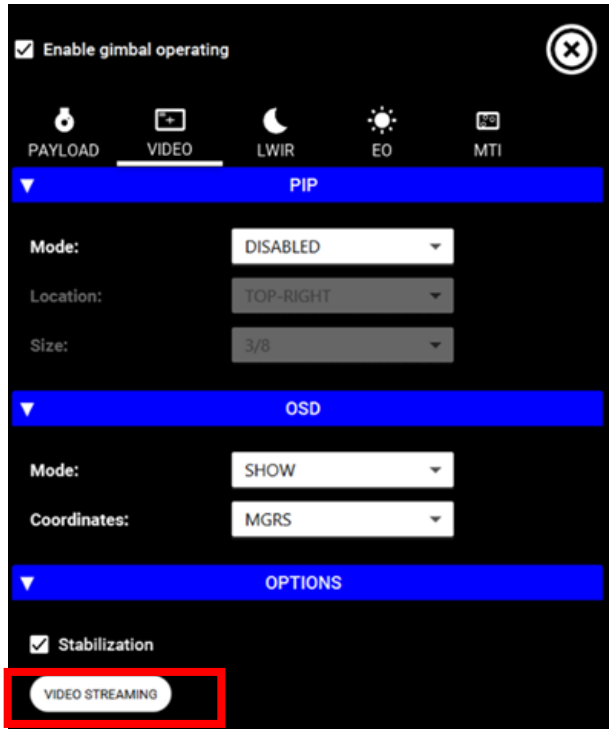
SELECTING BETWEEN OPERATING MODES

To configure the aircraft to use either mode 1 or 2 the operator must use Mission Software.

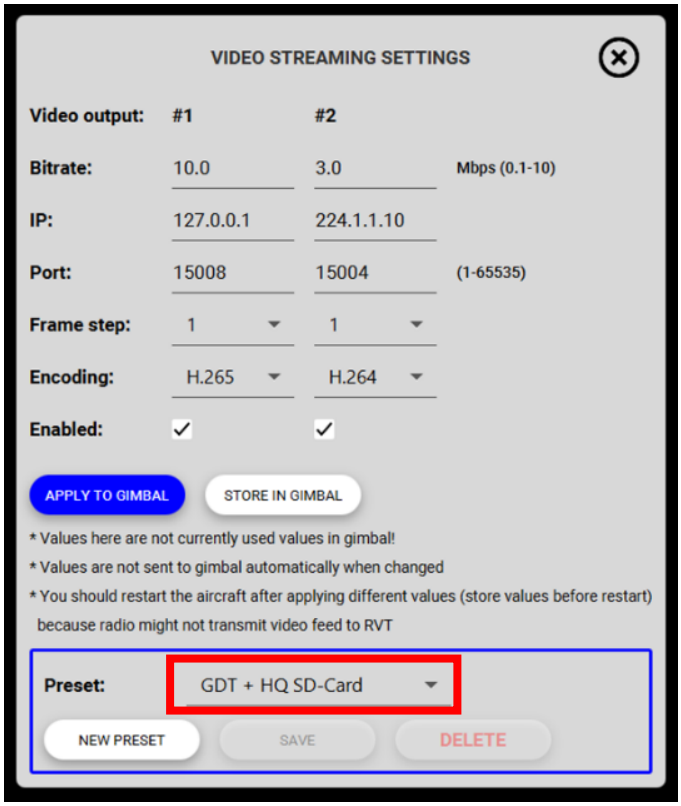
STEP 1 -Right click on the video display area (also works without the video being displayed) and select „Sensor settings“ option.



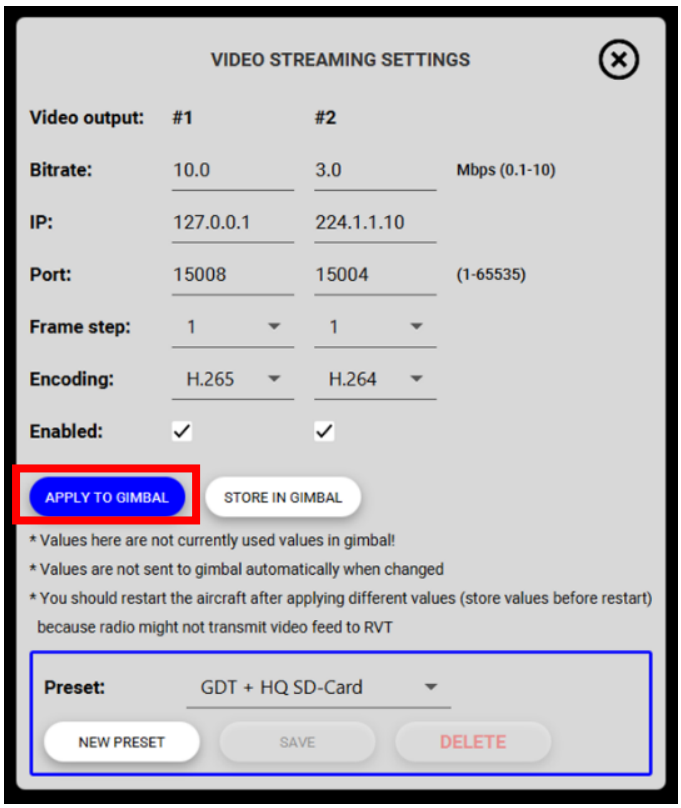
STEP2 – Click on the “VIDEO STREAMING” button.



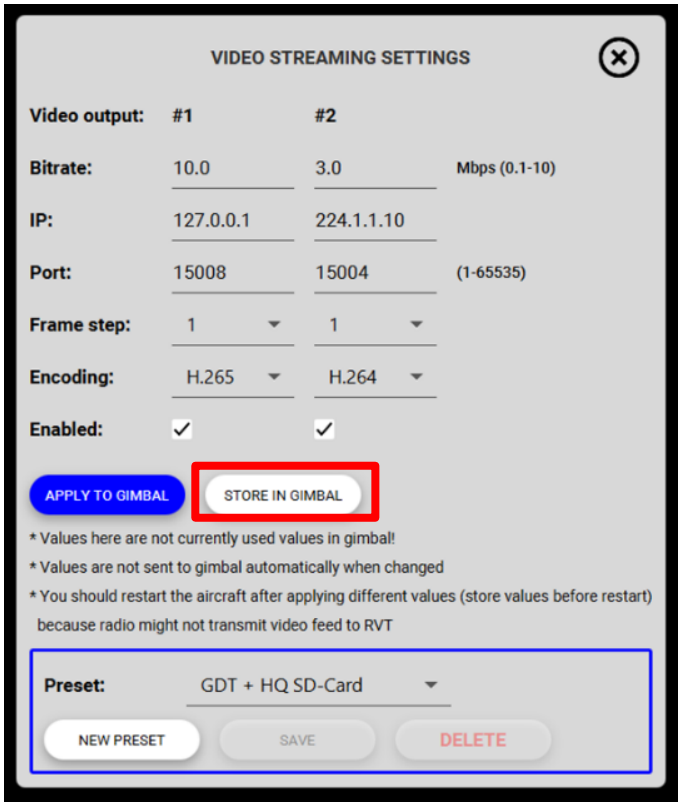
STEP 3 – From the dropdown menu select either GDT+HQ SD-Card (mode 1) or GDT + RVT (mode 2).



STEP 4 – Send the new configuration to the gimbal by pressing “APPLY TO GIMBAL” button.



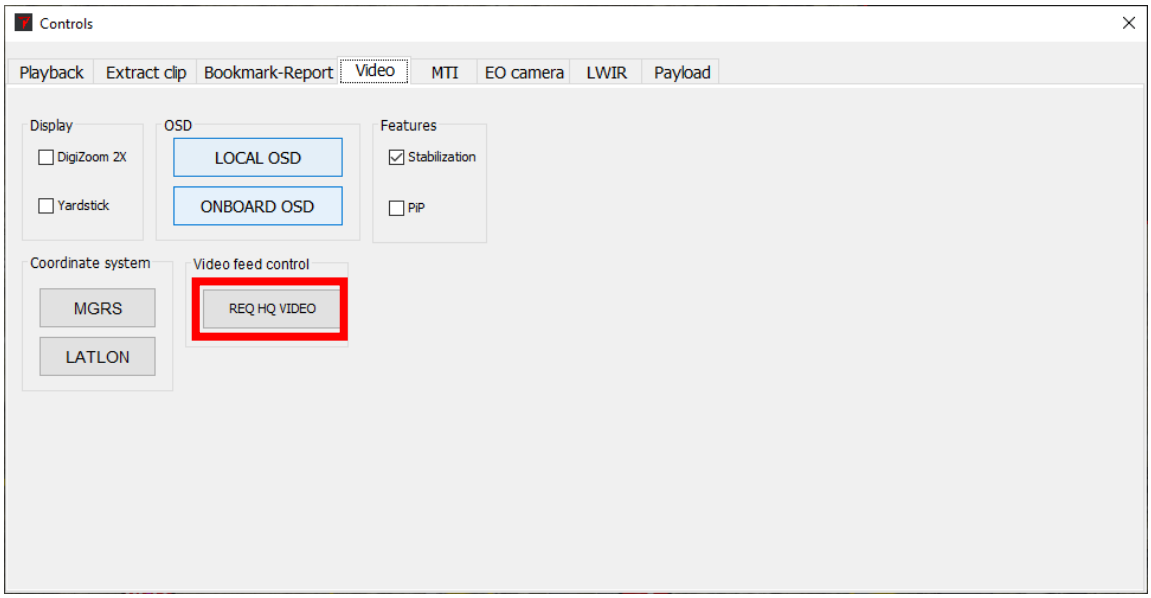
STEP 5 – Optionally click on the “STORE IN GIMBAL” button to permanently save the selected mode. In this case the gimbal recalls the selected settings after a power cycle.

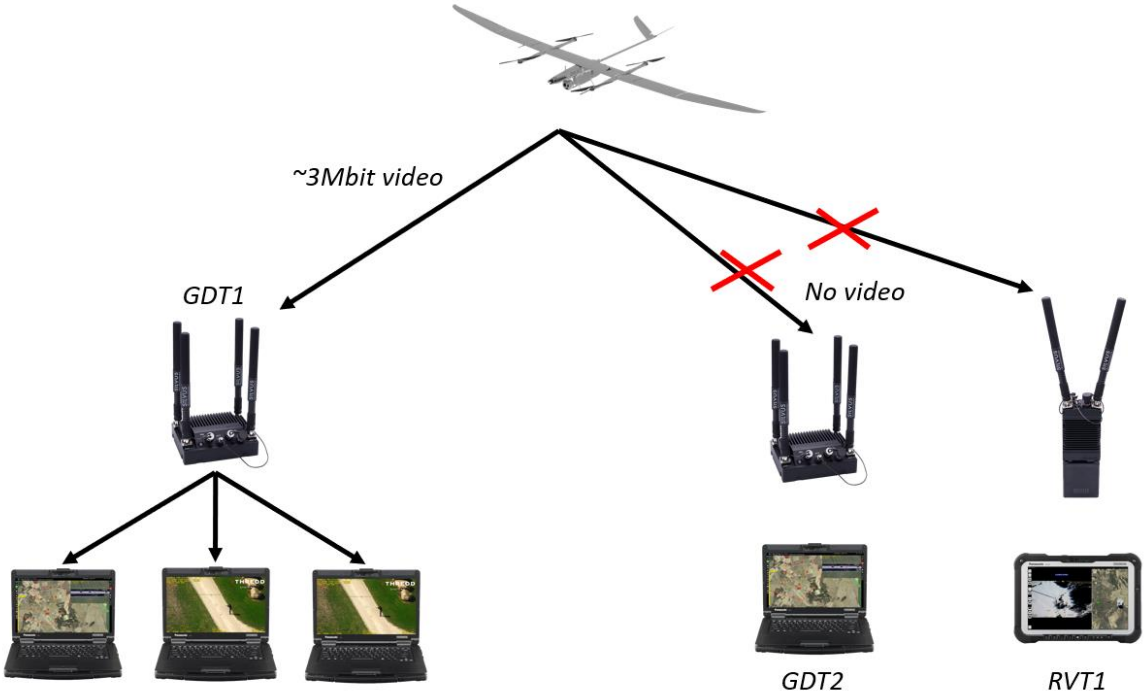


REQUESTING HIGH QUALITY VIDEO STREAM IN GCS

As the aircraft transmits the high quality video stream to only one GDT at a time, the operator must request the stream manually each time.

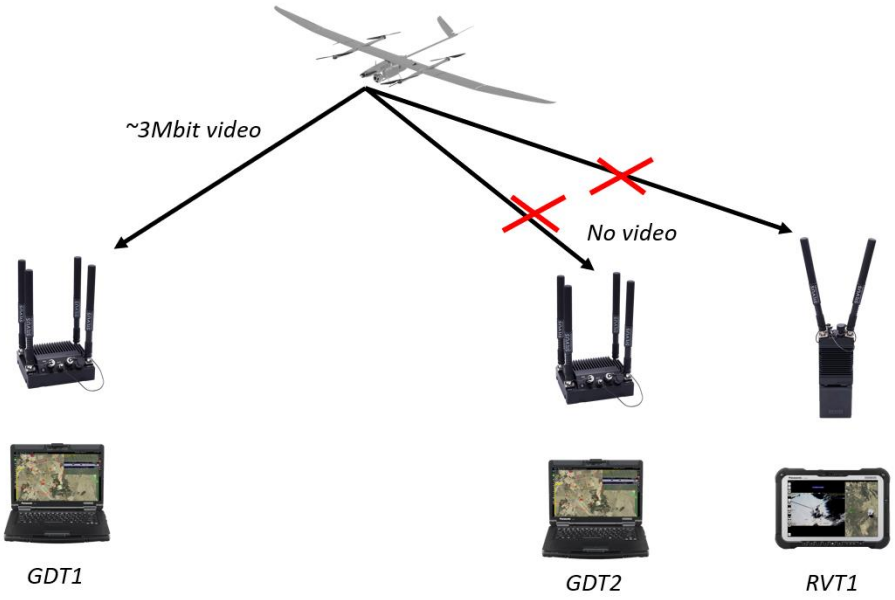
Requesting video is done in the ground control station software by the pilot. Navigate to the gimbal settings page and open the video tab. Click on the “REQ HQ VIDEO” button. This button will then configure the aircraft to send the video to the specific GDT that is connected to the computer which runs the pilot software. All computers connected to this GDT then receive high quality video stream.



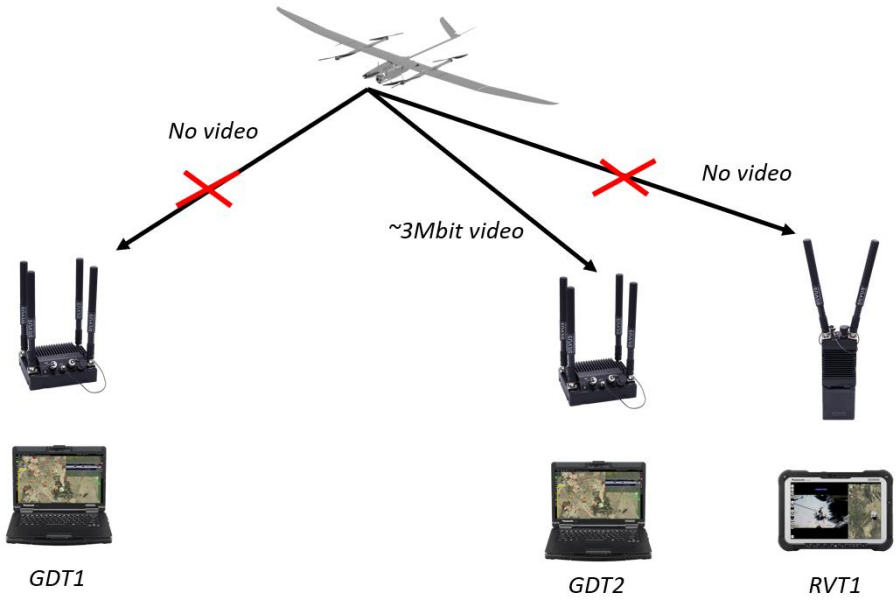


Video is sent to all computers connected to a GDT

Mode 1 – GDT+HQ SD-card

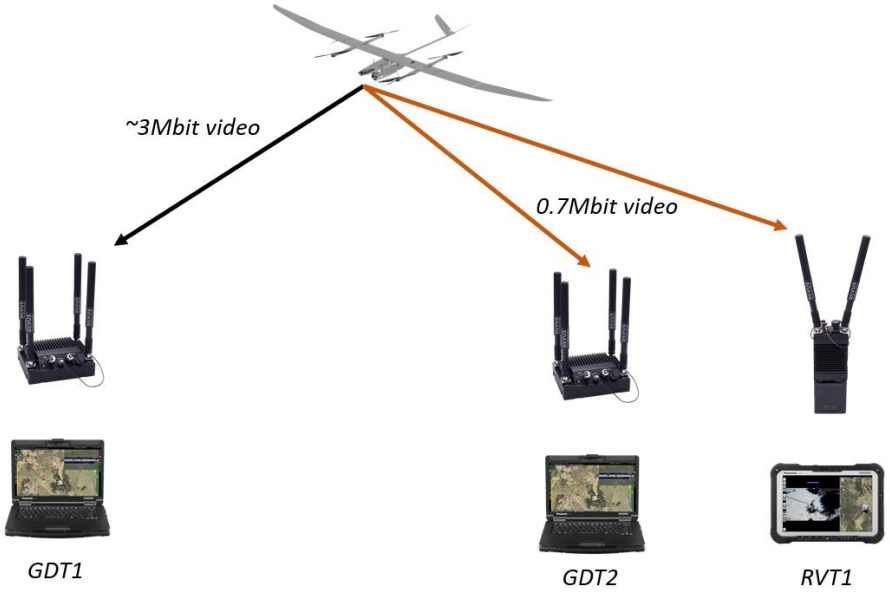


GDT1 requests HQ video stream, others see no video

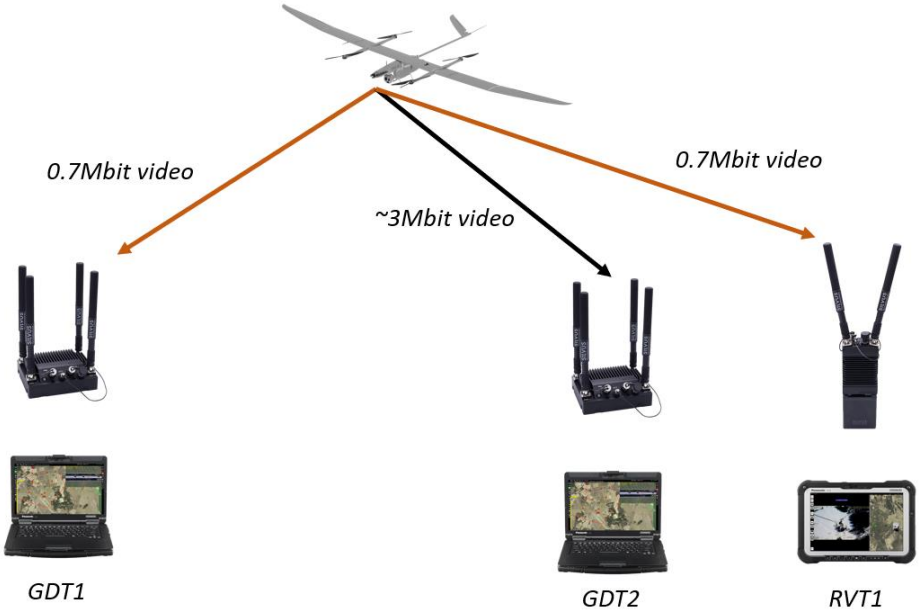


GDT2 requests HQ video stream, others see no video

Mode 2 – GDT+RVT



GDT1 requests HQ video stream, others see RVT low bitrate video



GDT2 requests HQ video stream, others see RVT low bitrate video

ANNEX 7 AERIAL PHOTO PAYLOAD

This function is designed for mapping missions but can also be used for other purposes. Creating a scan type flight path above an area is best achieved with the pattern flight tool available in the waypoint's menu.

To create aerial mapping mission, open Waypoint editor and choose Pattern creation.

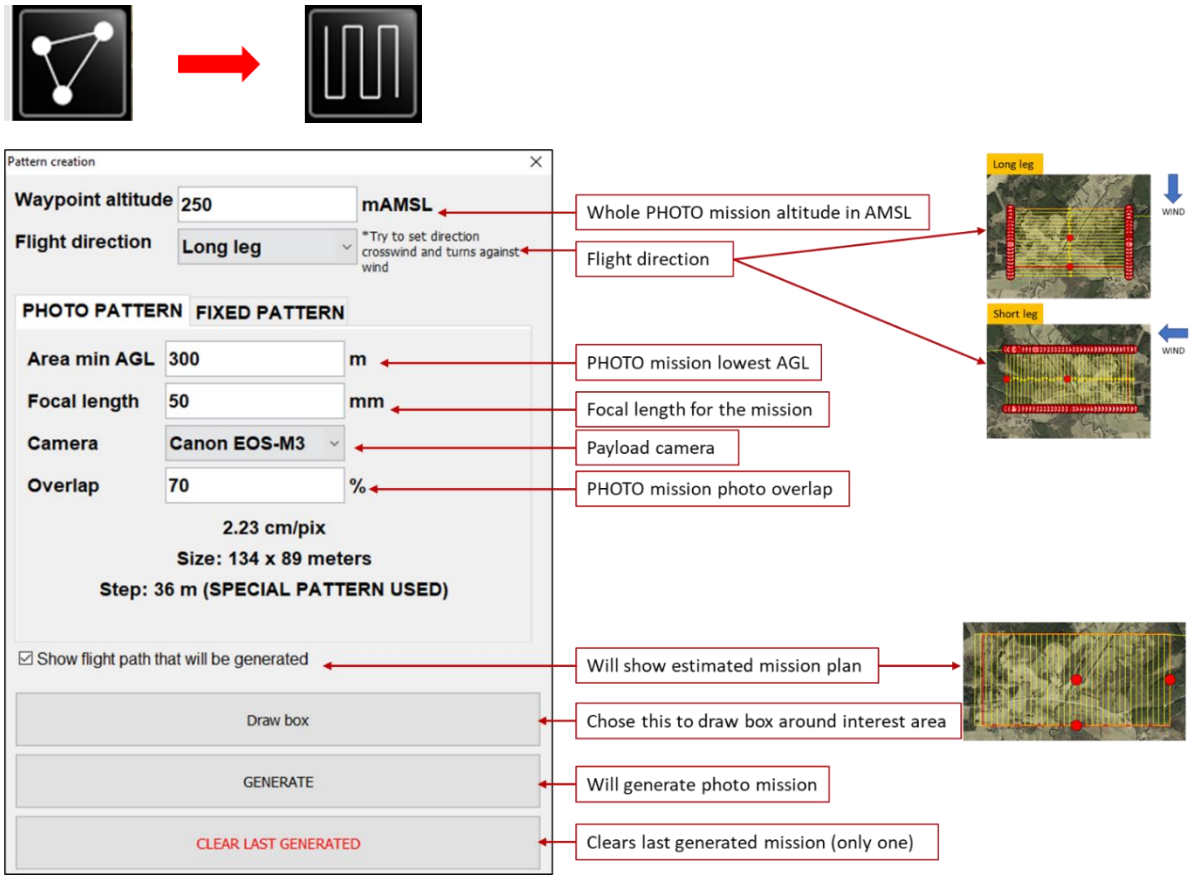


Figure 167 Mapping path tool (PHOTO PATTERN)

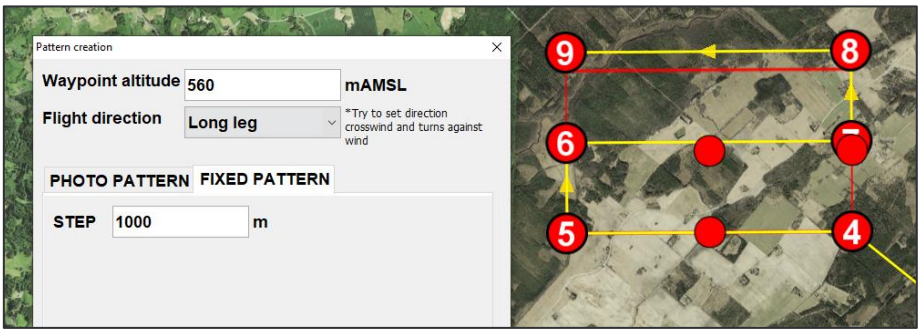


Figure 168 Mapping path tool (FIXED PATTERN)

Enter desired altitude and focal length of the lens. Enter desired overlap (20% is enough for good 2D stitching and coverage, more may be needed if 3D models are needed).

Area min AGL is to calculate flight pattern frequency to cover overlap.

To calculate correct values for the mission, use calculator. Download it from here:

https://support.pix4d.com/hc/en-us/articles/202560249-TOOLS-GSD-calculator

Click on Draw box to mark on the map scanning area. Point will be added starting from the first mouse click position.

Figure 169 Mapping box

Click on GENERATE to create the waypoints. Clear button will remove all scan pattern points but keep other waypoints of the mission intact. The software creates a scan pattern inside a defined area, the camera and overlap settings are used to specify the density of the scan paths. After mapping, pattern waypoints are created, continue flight planning as usual. CLEAR LAST GENERATED will delete last generated pattern. Not all of the patterns will be deleted, if GENERATE button was used multiple times before that.

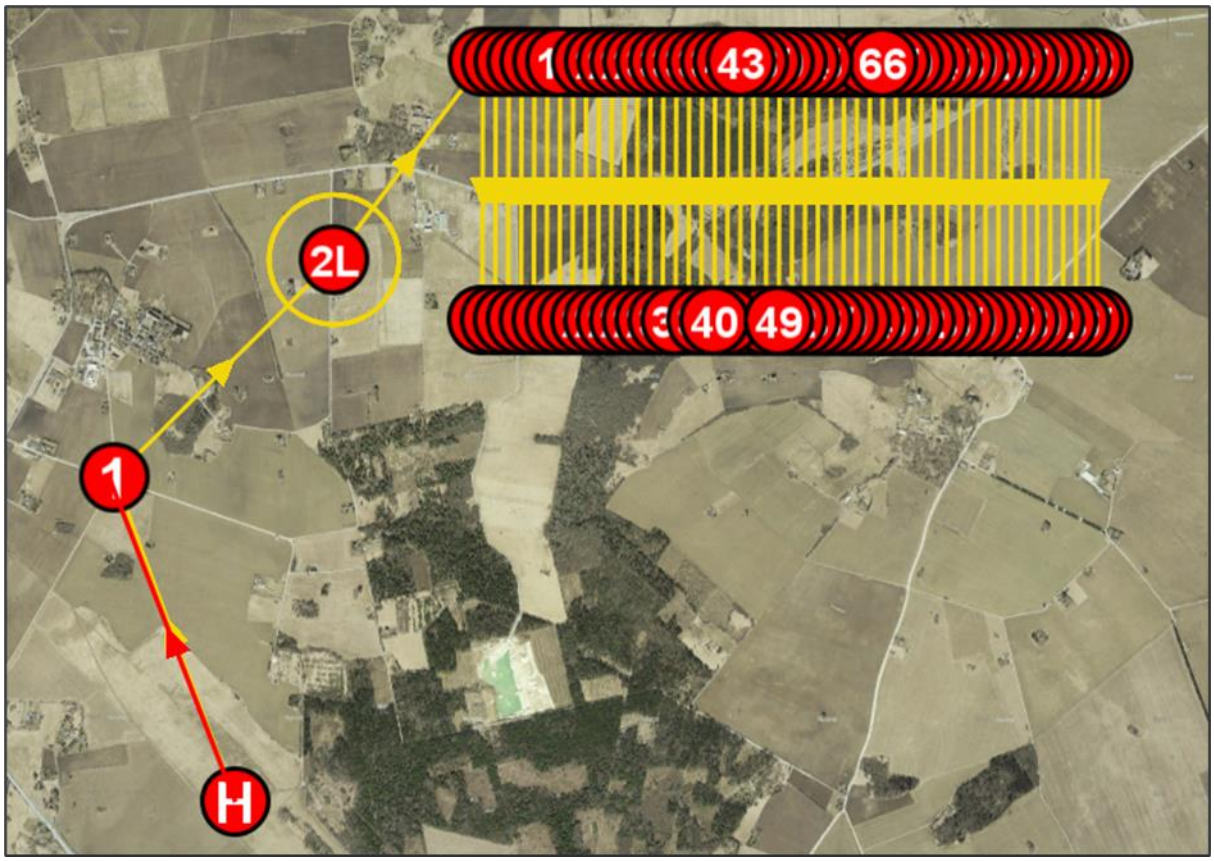


Figure 170 Generated mapping point

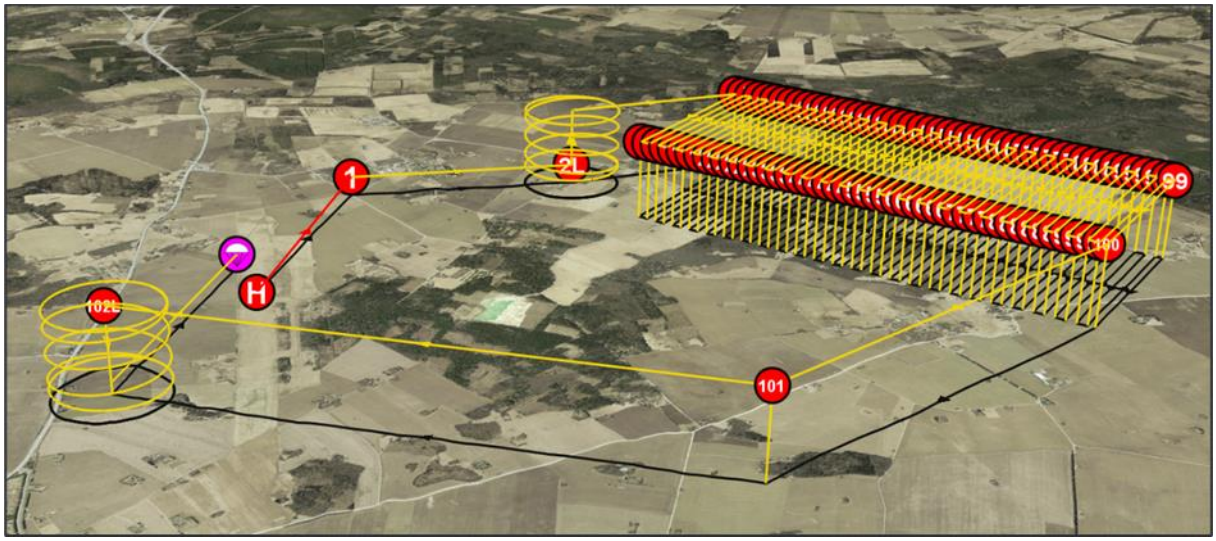


Figure 171 Example mapping flight path

Table 8 Mapping mission checklist

	Action	Check
1	Calculate focal length	☐
2	Plan mission (mapping mission must have side wind)	☐
3	Power on aircraft	☐
4	Change aircraft and GDT frequency	☐
5	After connection with aircraft, leave 1 minute pause and power on Payload	☐
6	REFRESH Camera status	☐
7	Unlock lens from transport position	☐
8	Set focal length and fix it	☐
9	Make sure that lens does not touch ground, remove lens cover	☐
10	REFRESH camera status and set Shutter speed	☐
11	Set payload in STOW position and take TEST SHOOT on ground	☐
12	Photo payload ready for take-off	☐
13	Take TEST SHOOT before mission at mission altitude	☐
14	START SHOOTING if test shoot was sharp	☐
15	After finishing mission in the interest area, STOP SHOOTING	☐
16	Make sure that gimbal is in STOW before landing	☐
17	After landing download last log file	☐
18	Copy Pictures from payload memory card	☐

Photo payload control

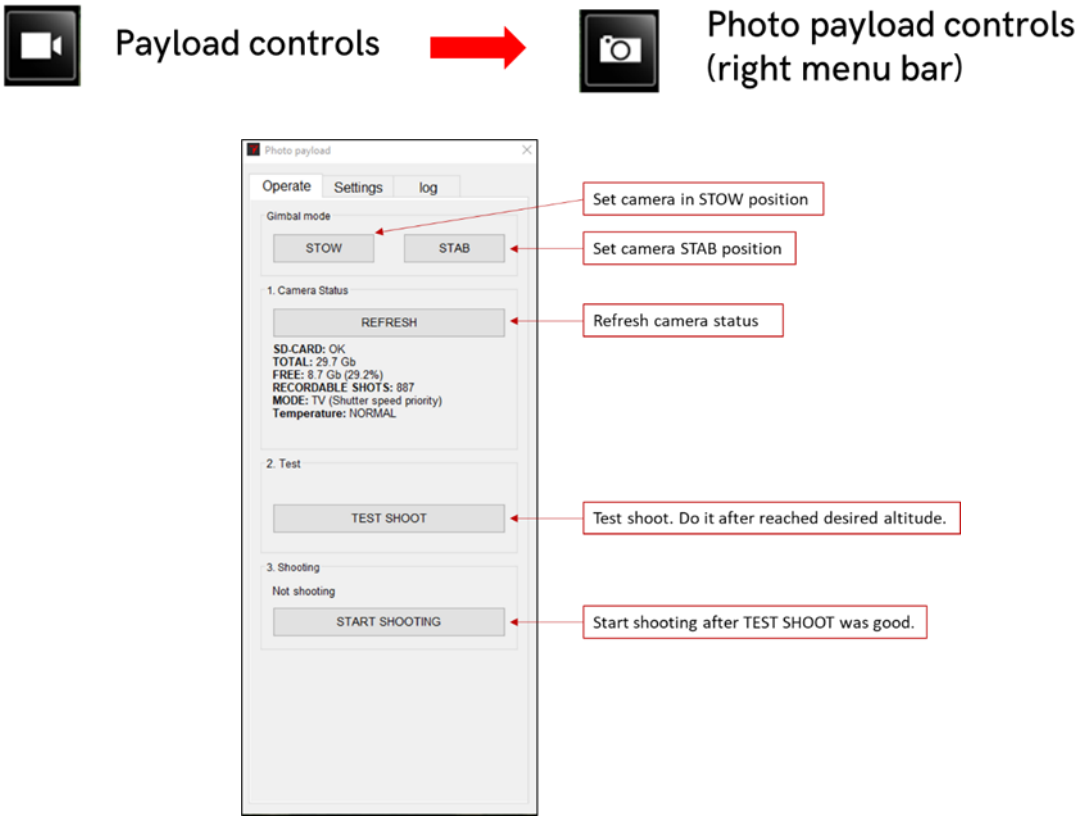


Figure 172 Photo payload operate settings

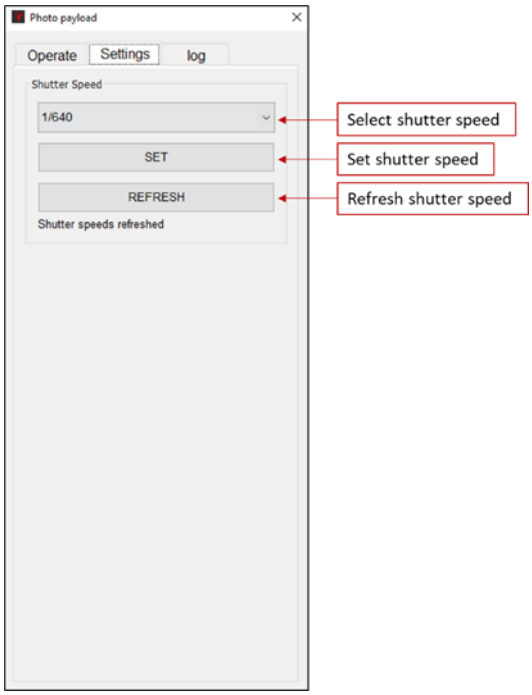


Figure 173 Photo payload settings

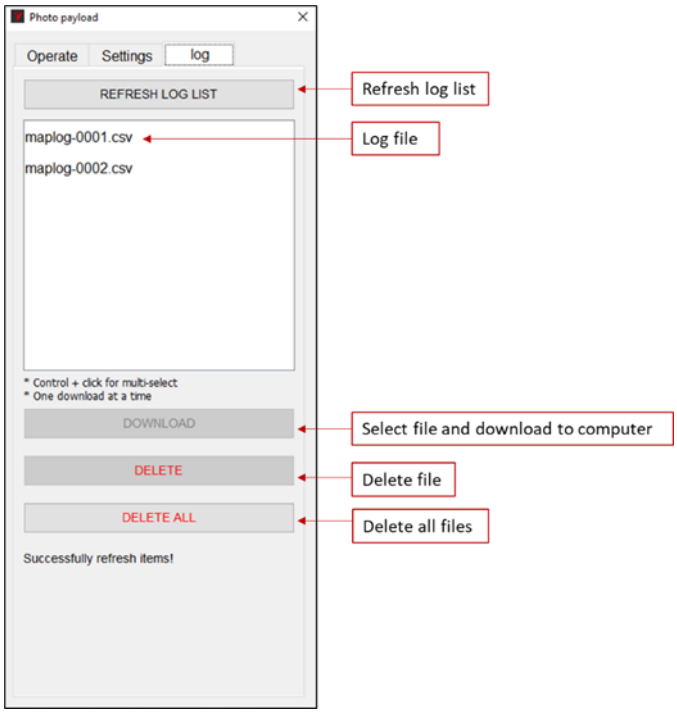


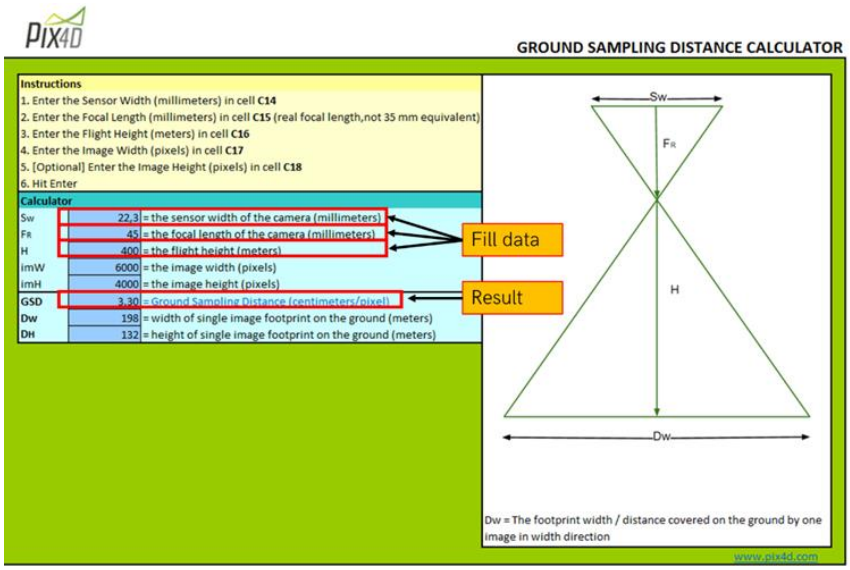
Figure 174 Photo payload log

Photopayload usage

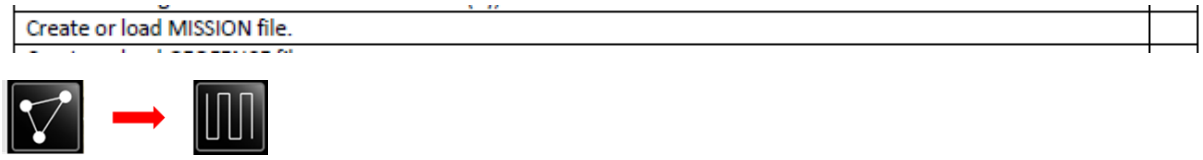
Steps are followed by ANNEX 7 Aerial photo payload, Table 8 Mapping mission checklist and combine with Flight Logbook.

1. Calculate focal length

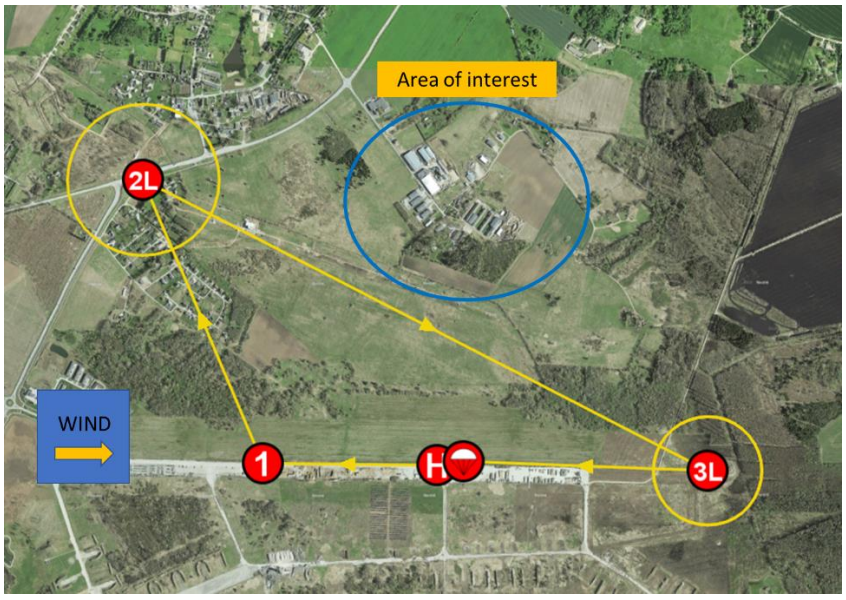
https://support.pix4d.com/hc/en-us/articles/202560249-TOOLS-GSD-calculator



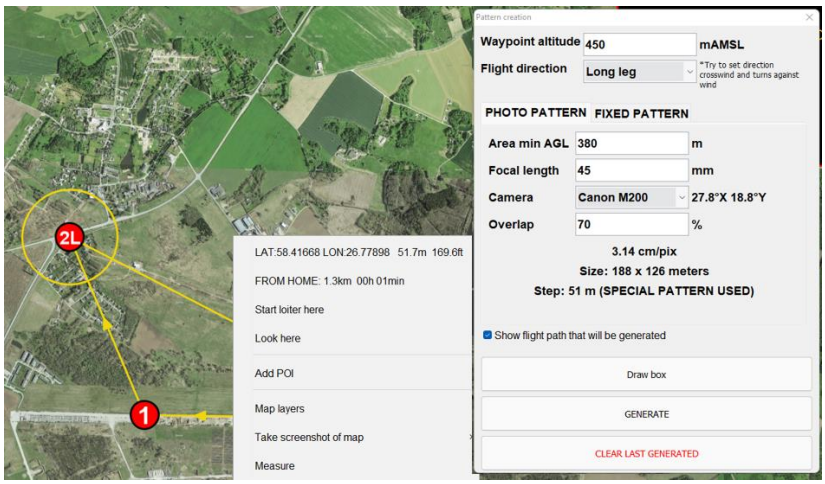
2. Plan mission



Plan/draw mission plan. 2nd waypoint is loiter up to gain altitude (for this example 400 mAGL). Pay attention to the wind direction.



With right click on map you can see ground altitude above sea level (In this example it is 51.7 mAMSL). Add this to mapping mission Waypoint altitude (~450 mAMSL).

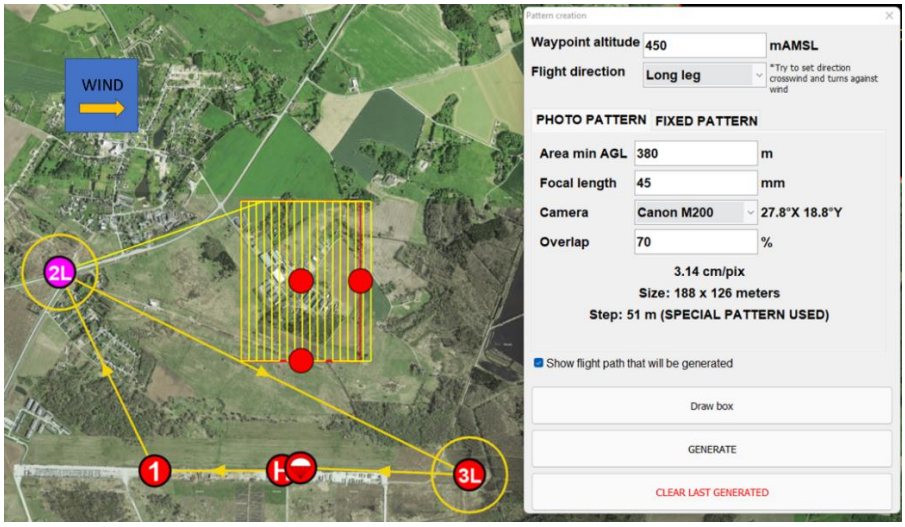


The minimum AGL of the area is defined by the highest elevation located in the interest area (in this example it is ~70 mAMSL). The area minimum AGL is necessary for mapping mission to ensure overlap.

Set overlap according to the following:

- 60% overlap in general cases.
- 80% overlap for agriculture fields and 85% overlap for forests and dense vegetation.

Click on the 2nd waypoint to continue the mission planning by drawing a box over the area of interest. To adjust the size and angle for the mapping mission, click on the red dots and edit. For the mission, cross wind is preferred as it provides equal ground speed between waypoints. Be prepared to adjust the mission profile over area of interest, based on weather conditions.



For next, click GENERATE, which will generate the mapping mission waypoints.

If GENERATE was clicked accidentally, click it once more. This will generate a second mapping mission over the previous. With CLEAR LAST GENERATED, the last generated mapping mission can be deleted.

3. Power on aircraft

Cover pitot, take the plane to safe take off area. Power on the plane. Wait for calibration.	

4. Create connection, change aircraft and GDT frequency

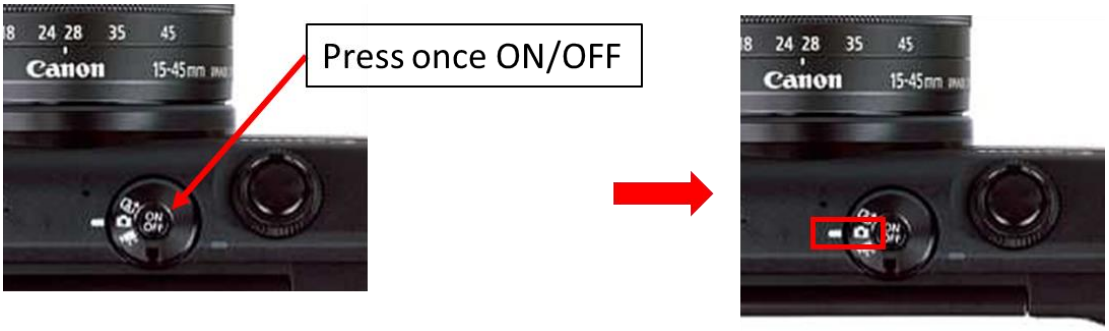
Create connection.	

It is necessary to change the frequency higher or lower from 2401-2495 MHz to prevent interference with the WIFI signal.

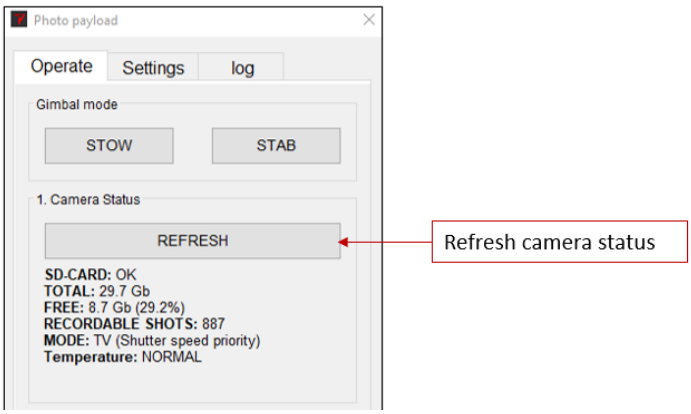
5. Power on Payload, select TV mode

Before powering on the APP, leave 1-minute pause, for Base Module to boot up after powering aircraft.

Check payload operation (both cameras, movement, functions, lenses).	



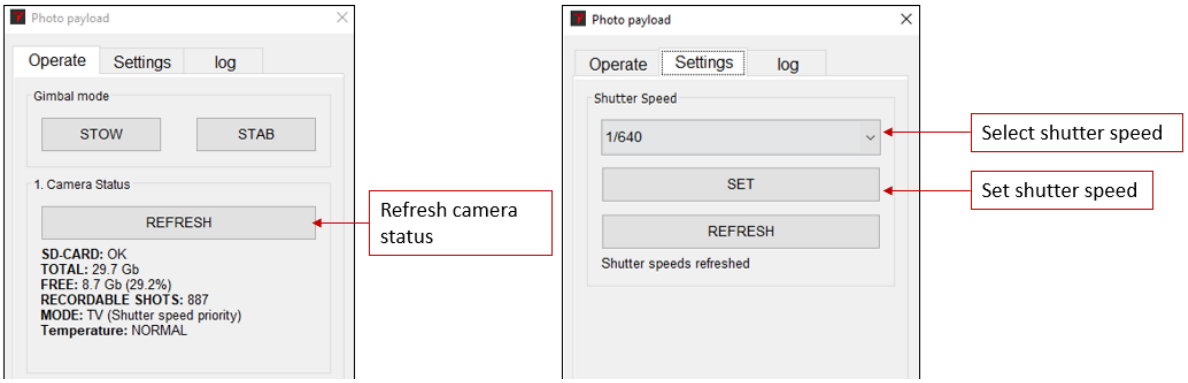
6. Check payload status



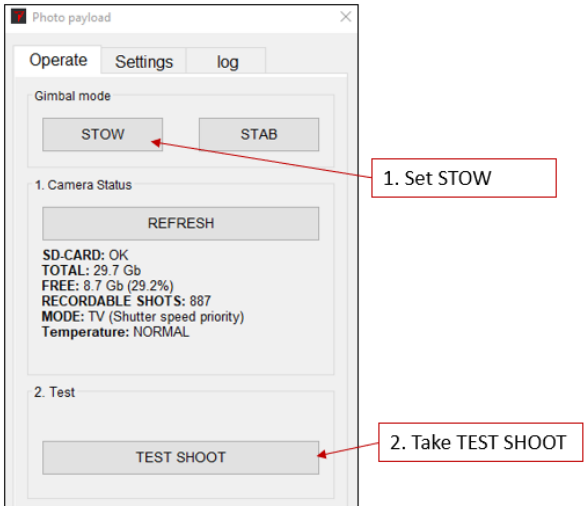
7. Unlock lens from transport position

8. Set focal length and fix it

9. Make sure that lens does not touch ground, remove lens cover
10. REFRESH Camera status and set Shutter speed



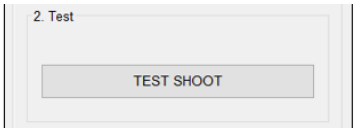
11. Set Payload in STOW position and take TEST SHOOT on ground



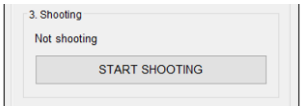
12. Payload ready for take-off

13. Take TEST SHOOT before mission at mission altitude

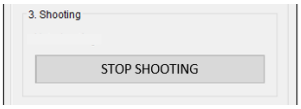
After reaching the mission altitude (in this example 400 mAGL), take a test shoot (it may be necessary to hold the aircraft in a MANUAL LOITER).



14. Start SHOOTING if TEST SHOOT was sharp

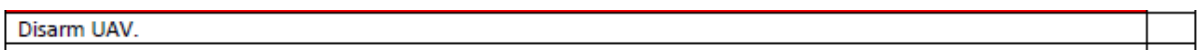


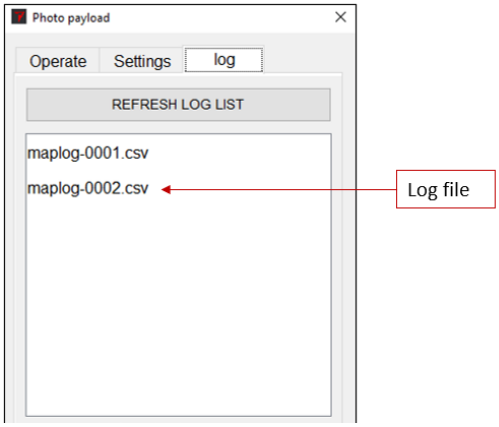
15. Stop SHOOTING, when mission is finished



16. Make sure that gimbal is in STOW position before landing

17. After landing download last LOG file





18. Copy picture from payload memory card

Emty SD cards and GCS (videos and logs).	

NOTES