

TECHNICAL MANUAL

Songbird

Manual Version 3.1

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Technical Manual for SONGBIRD v3

Manual Version 3.1

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*This manual is a part of the product. Please keep it throughout the lifetime of the UAV.
Please pass it on to any subsequent owner. Should you receive supplements, please ap-
pend them to keep this manual updated.*

1 INTRODUCTION

The SONGBIRD is a fixed-wing UAV (Unmanned Aerial Vehicle) with vertical takeoff and landing (VTOL) capability. It can be used to gather professional aerial imagery or other remote sensing data. Its modular design enables it to carry various payloads for surveying, mapping, security and surveillance, inspections, search and rescue, emergency deliveries and precision farming.

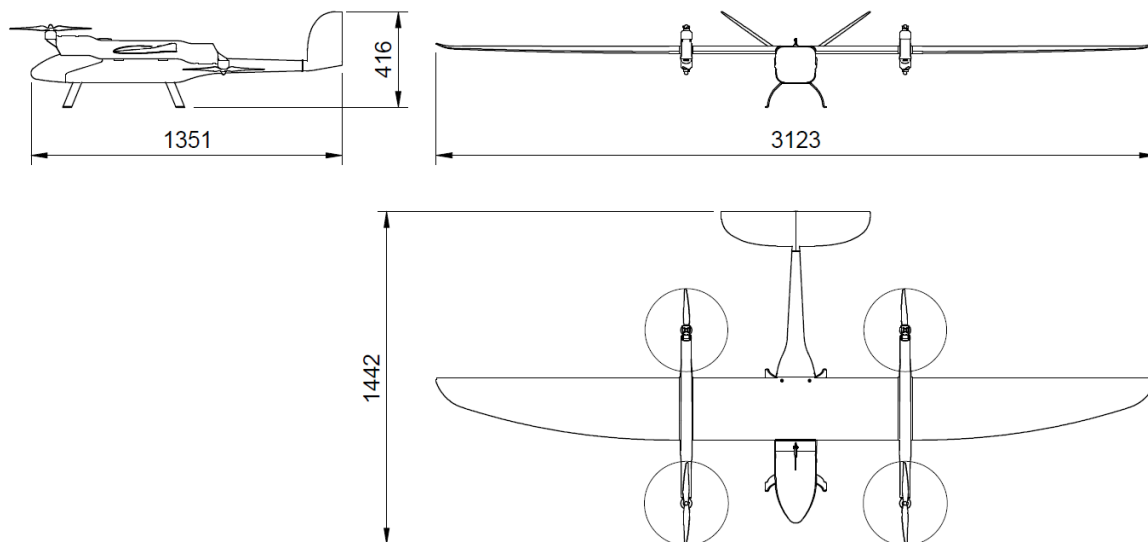
While the SONGBIRD has excellent horizontal flight properties, the VTOL feature reduces the risk of damage to the UAV and the payload at takeoff and landing. It also allows the SONGBIRD to be used in almost any location – no runway or other infrastructure is needed. It is designed to close the gap between costly full-size aircraft operation and simple multirotor drones which are easy to deploy but have very limited flight time and range.

Using the ground control software, the user can set up tasks that the SONGBIRD will carry out automatically, including takeoff and landing. The UAV can be controlled manually if desired. The SONGBIRD is available with two different propulsion setups (model 100 and model 150) which are both covered in this manual. The SONGBIRD 150 uses more powerful motors making it suitable for heavier payloads and/or high-altitude operation. It has a higher power consumption but may compensate for that by carrying additional batteries in the payload compartment.



The flight controller facilitates smooth transitioning between the COPTER mode (left image) and AIRPLANE mode (right image). Normally the COPTER mode is only used for taking off and landing, as extensive hovering will decrease the flight time of the SONGBIRD significantly. During a mission, the SONGBIRD may loiter (circle) over a point of interest in AIRPLANE mode.

2 SPECIFICATIONS



SONGBIRD 100

SONGBIRD 150

DIMENSIONS

Span Width:	3.1 m	3.1 m
Length:	1.4 m	1.4 m
Body Material:	GFRP, CFRP	GFRP, CFRP
Empty Mass:	6.8 kg	7.6 kg
Max. T/O Mass:	10.8 kg	14.0 kg
Typical Load Examples:	355 Wh (2.0 kg) Battery + up to 2.0 kg Payload	355 Wh (2.0 kg) Battery + up to 4.4 kg Payload or 710 Wh (4.0 kg) Battery + up to 2.4 kg Payload

SPEEDS

Min Airspeed (AIRPLANE Mode):	16.8 m/s (60 km/h)	17.5 m/s (63 km/h)
Max Airspeed:	28.0 m/s (101 km/h)	28.0 m/s (101 km/h)
Cruise Airspeed:	17.5 m/s (63 km/h)	19.0 m/s (68 km/h)
Wind (at Cruising-Altitude):	max. 14 m/s (50 km/h)	max. 15 m/s (54 km/h)
Wind (at Launch Site):	max. 6 m/s (22 km/h)	max. 7 m/s (25 km/h)

*SONGBIRD 100**SONGBIRD 150**PERFORMANCE*

Propulsion:	Four Electric Motors	
Installed Capacity:	3.8 kW	6.4 kW
Power Consumption (Hovering):	1.8 kW (at 9 kg TOM)	2.2 kW (at 11 kg TOM)
Power Consumption (Cruise):	280 W (at 9 kg TOM)	420 W (at 11 kg TOM)
Max. Flight Time & Distance:		
355 Wh Bat., no Payload	65 min (67 km)	55 min (59 km)
710 Wh Bat., no Payload	120 min (124 km)	100 min (109 km)
355 Wh Bat. + Payload*	50 min (51 km)	45 min (48 km)
710 Wh Bat. + Payload*	-	80 min (87 km)

*Payload example: Colibri camera + long range transmitter, powered by the flight battery

COMMUNICATION LINKS

Basic Setup:

Application & Range	VLOS Operation (Visual Line-of-Sight), 1-2 km
RC (Backup Manual Control)	2.4 GHz
Telemetry & Command	433 MHz
Direct Video Link	-

Advanced Setup (optional):

Application & Range	for BVLOS and/or live video operation, 5-10 km or up to 25 km with optional tracking antenna.
RC (Backup Manual Control)	433 MHz
Telemetry & Command	868 or 900 MHz
Direct Video Link	2.4 GHz

4G Cellular (optional):

Application & Range	Unlimited range within covered areas. Can be added to any other setup as telemetry, command and live video link.
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FEATURES

Autopilot:	Capable of Fully Automatic Missions, Auto Takeoff and Landing
Safety features:	Automatic Return to Launch Self-Stabilization

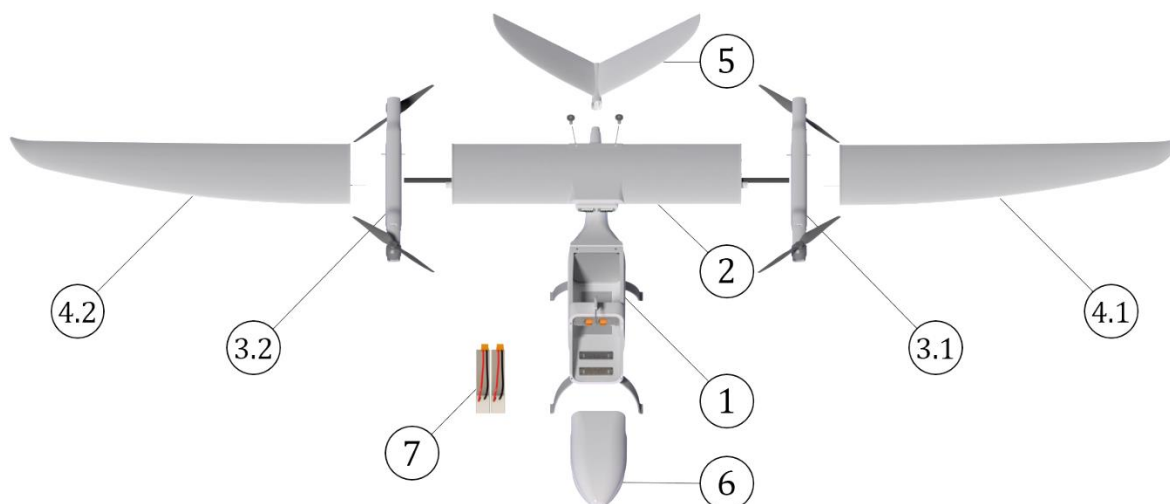
Geofencing

VTOL capability:	Yes
Operating Temperature:	-10 °C to 40 °C (preheat batteries to > 5 °C)
Operator Training:	Courses and Training Box (SONGBIRD operation in simulated environment) available

TRANSPORTATION

Transport box:	120 cm x 60 cm x 38 cm
Set up time:	< 10 min
Tool-free Assembly	Yes

3 SCOPE OF SUPPLY

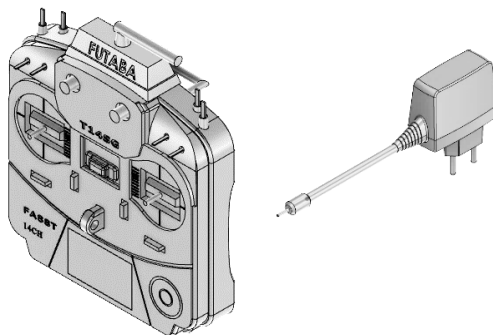


SONGBIRD - AIRFRAME

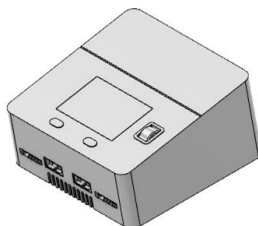
1	Fuselage
2	Wing – Middle Section with Knurled Screws
3.1	Motor Arm Left
3.2	Motor Arm Right
4.1	Wing – Outer Section Left
4.2	Wing – Outer Section Right
5	V-Tail
6	Nose
7	Flight Battery

ACCESSORIES

8 Transmitter with Charger



9 Charger for Flight Batteries



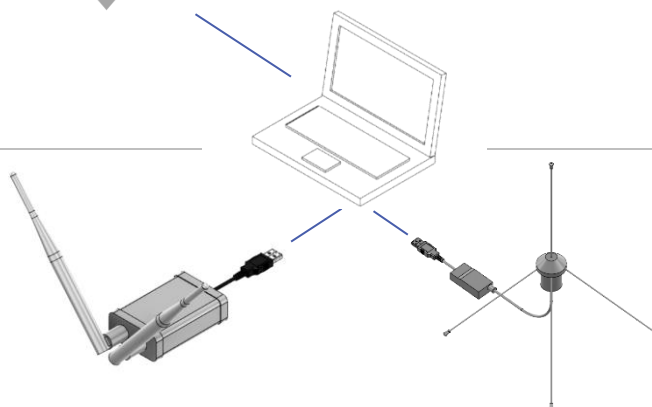
10 GCS Software



Download.

To be installed on any MS-Windows 10-computer.

11 USB Telemetry Module



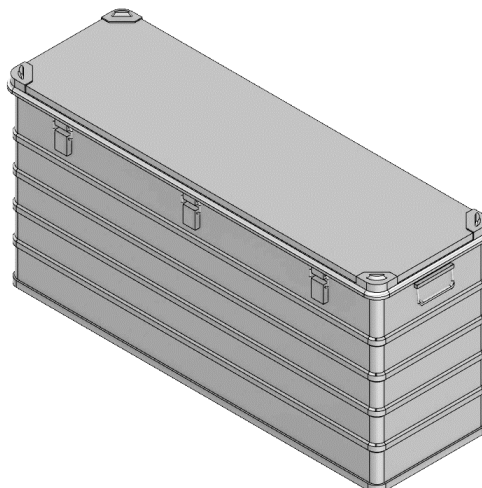
RFD 868/900 MHz

or

3DR 433 MHz

(According to your setup)

12 Transport Box



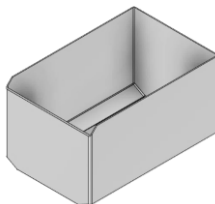
OPTIONAL EQUIPMENT

- 13 Ruggedized Laptop with Power Supply

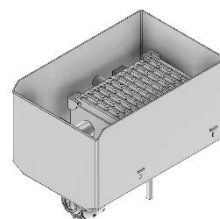


(GCS software pre-installed)

- 14 Payload Box, Outfitted According to Your Order



or

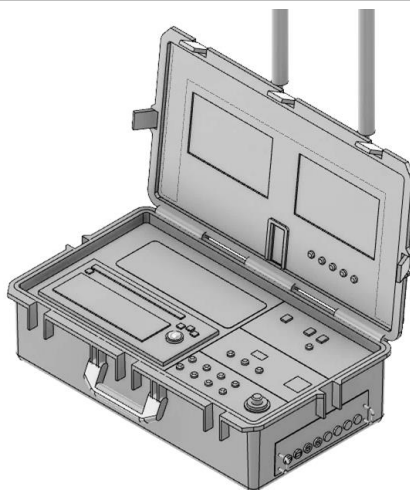


or ...

2.4 GHZ VIDEO GROUND OPTIONS

(for 4G video use any computer with internet access and the GD video player software)

- 15 Combined Ground Station



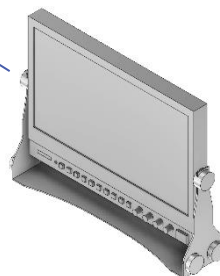
Incl. computer (left screen) and video receiver (right screen)

- 16 Standalone Video Receiver



(To be connected to any monitor with SDI-interface. Requires a separate Computer to run the GCS)

- 17 Video Monitor, Suitable for Video Receiver

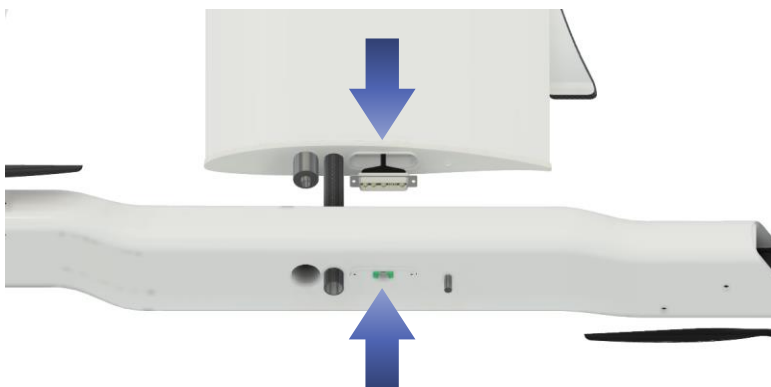


4 ASSEMBLY

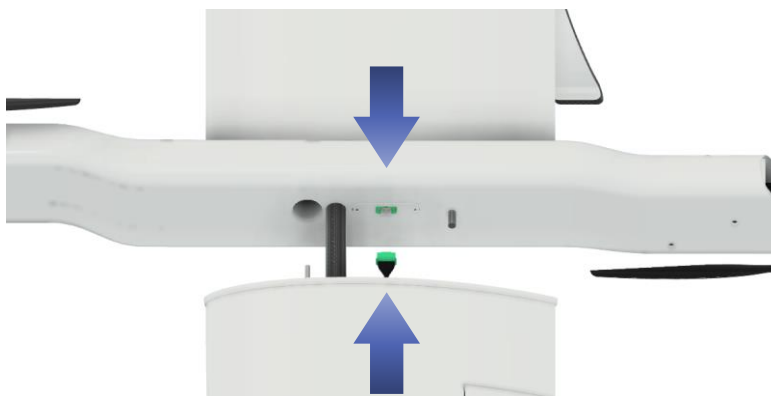
1. Place the payload box inside the fuselage. For training purposes, you can also use an empty box.
2. Place the middle section of the wing (part no. 2) on the fuselage (part no. 1) and push it forward, connecting the plugs. Then secure it using the two knurled screws.



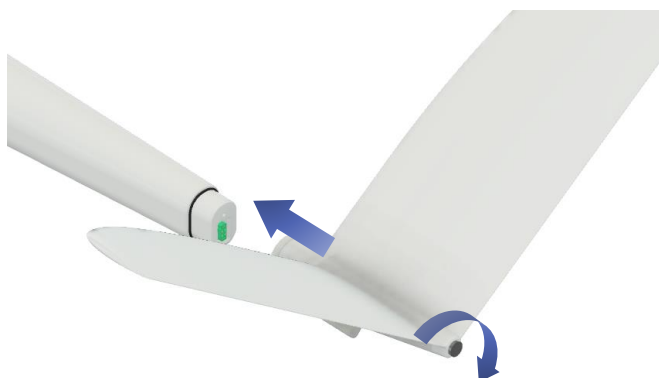
3. Slide the motor arms (parts 3.1 and 3.2) onto the carbon tubes of the middle wing and connect the plug. (In some versions this plug is fixed and will connect automatically). Make sure to also align the small anti-torsion pins of the arms with the corresponding holes in the middle section of the wing (part no. 2). Repeat for the other side and keep in mind that the UAV may tip over when just one arm is attached.



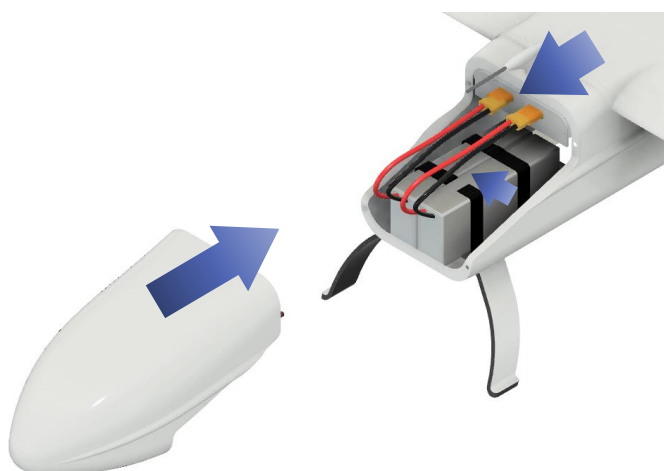
4. Attach the outer wings (Parts 4.1 and 4.2) by connecting them in the same way as the motor arms. After they are pushed all the way in, the locking mechanism will hold the wings and the motor arms in place.



5. Plug the v-tail (Part No. 5) onto the tail boom and secure it using the knurled screw in the back of the v-tail. Ensure that the v-tail is free of play after tightening the screw.



6. Place the battery (part no. 7) on the plate in the front of the fuselage. Tighten the Velcro straps to secure it. For your safety and to save energy, it is recommended to connect the battery just before flight, according to the preflight checklist. Plug in both yellow connectors and verify tight fit.



Stay clear of the propellers and ensure that nobody will arm the motors while people are near the UAV.

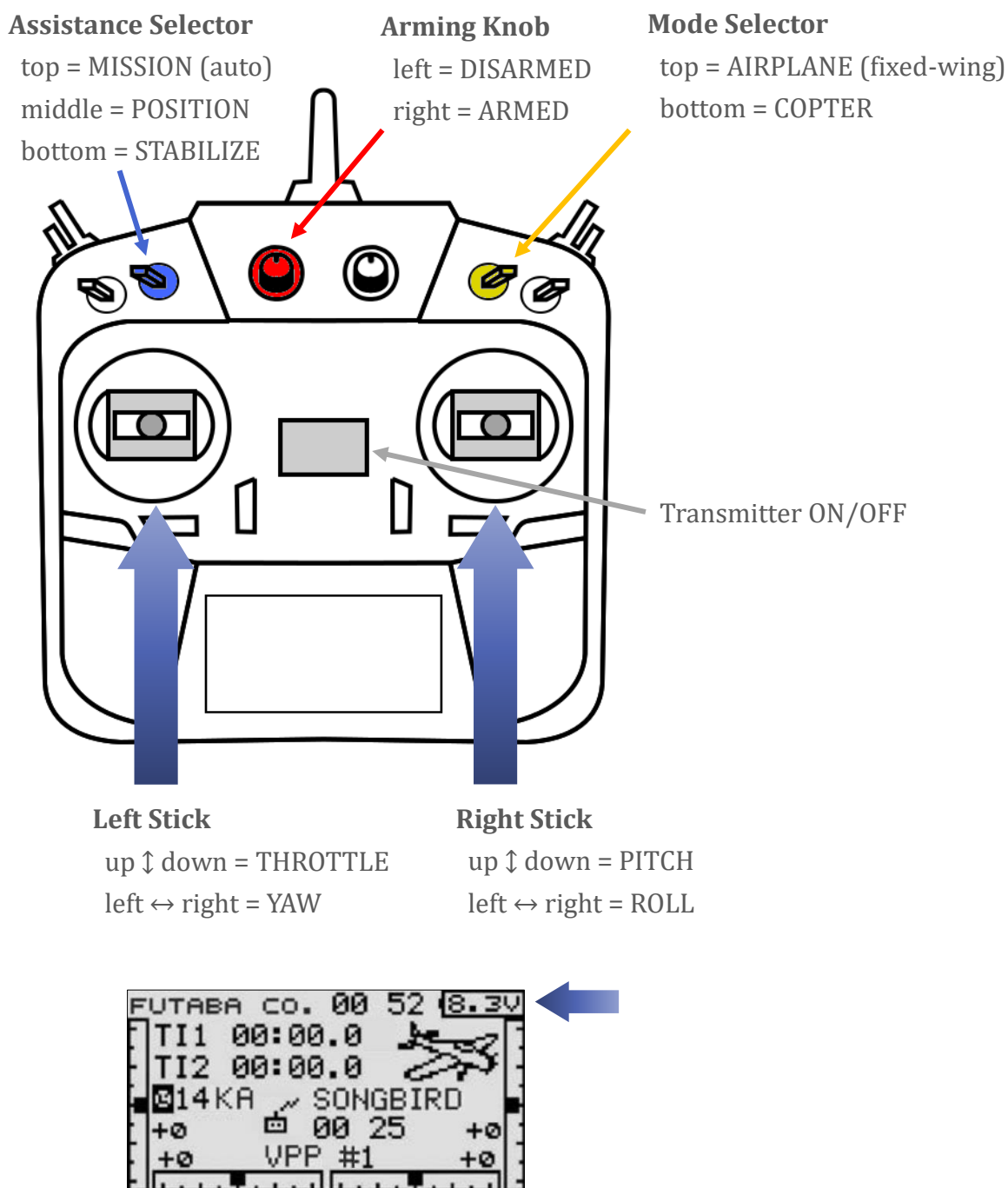
7. Then the nose (part no. 6) can be attached by pushing the plastic knobs of the nose into the designated cavities of the fuselage.

To prepare the ground station, follow these steps:

1. Connect the USB-plug of the telemetry module (part no. 11) to the GCS computer (part no. 13, 15 or your own computer).
2. Launch the Ground Control Station Software. You are ready to connect to the UAV. For instructions on how to use the software, see chapter 8.
3. When using live video: Connect the Antennas to the receiver and turn it on (in case of 2.4 GHz video) or launch the Germandrones video player on any computer with internet access (in case of 4G video), enter the login data provided by Germandrones and click “connect”.

5 THE TRANSMITTER

Please familiarize yourself with the transmitter before flying the SONGBIRD as described in the subsequent chapters. It is advisable to use the Germandrones training box and take part in a personal introductory course.



Please use the provided charger to keep the transmitter's battery above 7.6 V. The voltage can be seen in the upper right-hand corner of the display.

6 BASIC FLIGHT OPERATION

Caution!

This chapter will guide you through the main phases of a flight. Before you continue, please verify that the SONGBIRD is set up correctly, as described in chapter 4 and ensure that all conditions for safe operation are met (see chapter 12). It is strongly recommended to use the Checklists provided in the annex to monitor all preparations.

Arming

1. Complete the preflight Checklist (provided in the annex). This will help you to verify that the flight is correctly prepared. When finished, the UAV is ready for flight and the transmitter should be set to **POSITION** and **COPTER** Mode.
2. **Arm the motors** by turning the Arming Knob on your transmitter to the full right position. The motors will start spinning at low RPM. Verify that all four motors are running.

You can now continue manually or start an automatic flight.

Manual Takeoff

After arming you can take off manually with the SONGBIRD. Pay attention to possible signs of a defect (unstable flight, unusual noise etc.). For your own security do not proceed in case of such behavior.

When the THROTTLE stick is centered in POSITION and COPTER mode, the UAV will try to maintain the current altitude. Thus, you need to briefly move the THROTTLE stick to a position above center to lift the SONGBIRD off the ground.

You are now flying in COPTER mode. You can move the aircraft around using the control sticks. For an overview of all possible inputs and mode selections, refer to chapter 7.

Manual Landing

Descend in COPTER Mode by moving the THROTTLE stick down. After touchdown reduce the THROTTLE to minimum and disarm the UAV by turning the Arming Knob to the full left position. The motors will come to a stop.

Note: You may have to wait for a few seconds until the system has verified the landing (indicated by reduced motor-RPM) before disarming will be allowed. If disarming was unsuccessful because the input was made too soon, move the knob to the right and to the left once more. Three seconds after successful landing detection, the system will disarm automatically.

Automatic Flight

In most scenarios, you will want to conduct an automatic mission.

After successful arming (all propellers spinning at low RPM), you can directly switch the Assistance Selector to MISSION. The Songbird will now take off, fly along the given waypoints and land eventually. This includes automatic transitioning between COPTER and AIRPLANE mode, which is defined by the Takeoff and Landing waypoints (see chapter 8). Disarm the system after landing by turning the Arming Knob back to the left.

This mode only works if a mission has been predefined (chapter 8).

7 FULL FLIGHT CONTROLS OVERVIEW

In this chapter, you will find complete information on controls and the UAV's behavior in each mode. It covers all actions that the remote pilot can do with the Futaba transmitter. Note that some different actions can be performed via the Ground Control Station (chapter 8).

7.1 Manual Controls (POSITION)

The following explanations assume that the **Assistance Selector** is set to **POSITION** (recommended). For other options see chapter 7.2.

COPTER Mode:

When the SONGBIRD is airborne and COPTER mode is set, the UAV will hold its altitude and GPS-position. Only if an input is given by moving a stick (or both) away from its center-position, the SONGBIRD starts moving. The moving speed depends on the amount of stick deflection; however, the maximum speeds are limited by the software to ensure safe maneuvering. Use COPTER mode for manual takeoffs and landings, as described in chapter 6.

The controls are as follows:

<i>LEFT STICK</i>	<i>INPUT</i>	<i>RESULT</i>
	THROTTLE ↑ above center	gain altitude
	THROTTLE ↓ below center	lower altitude
	YAW → right	change heading clockwise
	YAW ← left	change heading counterclockwise
<i>RIGHT STICK</i>	<i>INPUT</i>	<i>RESULT</i>
	PITCH ↑ above center	move forward
	PITCH ↓ below center	move backwards
	ROLL → right	bank right to move sideways
	ROLL ← left	bank left to move sideways

Note: If GPS-lock is lost, the UAV can hold the altitude but not the position anymore. The pilot may notice a tendency to drift away in such case and should counteract.

Keep the nose pointed into the wind during copter mode, especially in windy conditions (use the YAW control). Aerodynamic forces will always act on the aircraft and it may become unstable with strong wind from the side or the back.

AIRPLANE Mode:

This mode can only be set when the SONGBIRD is already airborne, as it is not designed for takeoffs or landings in AIRPLANE mode (the process of changing flight modes is explained in the section below). In this mode, the UAV behaves much like a fly-by-wire controlled aircraft. If all sticks are left in their center position, the flight controller will maintain the current track and altitude. The throttle is adjusted automatically to maintain a normal operating speed even during climbs or descents. It is therefore not recommended to lower the airspeed manually, even on a descent. Nevertheless, the target airspeed may be changed temporarily by moving the throttle stick away from its center position.

Stick inputs are used to change the attitude as follows:

LEFT STICK	INPUT	RESULT
	THROTTLE ↑ above center	raise airspeed temporarily
	THROTTLE ↓ below center	lower airspeed temporarily
	YAW → right	no function (automatic rudder)
	YAW ← left	no function (automatic rudder)
RIGHT STICK	INPUT	RESULT
	PITCH ↑ above center	sink
	PITCH ↓ below center	climb
	ROLL → right	turn right
	ROLL ← left	turn left

Note: The pitch- and bank-angles are limited by the flight controller for safety reasons. This also limits the maneuverability of the songbird. The remote pilot must fly foresightful and avoid rapid maneuvers. Please pay special attention to having enough space for avoiding obstacles when using this mode. Also remember that the UAV never stops moving in AIRPLANE mode and therefore continuous attention from the remote pilot is needed.

Manual Transition – COPTER → AIRPLANE:

If you want to change to AIRPLANE mode, climb to a safe altitude (at least 25 m above the ground or nearby obstacles is recommended).

The transition is done simply by switching the Mode Selector from the COPTER position to the AIRPLANE position. The motors will take a few seconds to rotate into the full forward position, thus picking up enough speed for safe flying in AIRPLANE Mode. Wait until this automated process is finished and then continue using the control sticks in the new mode.

Keep in mind that the SONGBIRD may lose a little amount of altitude in the process. Also make sure to have plenty of free space ahead of the aircraft to complete the transition.

Manual Transition – AIRPLANE → COPTER:

Before transitioning back to COPTER mode, it is recommended to align the aircraft against the wind and descend to an altitude of 25 m to 50 m above the ground.

To transition back to COPTER mode put all control sticks back to their center position and switch to COPTER mode. The motors will rotate into their vertical flight position. Wait for a few seconds until the flight controller has stabilized the SONGBIRD and continue to fly in COPTER mode. Consider that the UAV will move another 100 m to 150 m after initializing the transition before coming to a stop (depending on the wind conditions).

7.2 Comparison of the Assistance Options

The Assistance Selector (blue switch, seen in chapter 5) changes the amount of flight-support.

	COPTER MODE	PLANE MODE
POSITION <i>(recommended for manual flying)</i>	<p>The SONGBIRD will hold its position using the GNSS signal, unless stick inputs are given, as described above.</p> <p>It is advisable, to keep the nose pointed into the wind using the manual yaw control.</p>	<p>The SONGBIRD will maintain altitude, airspeed and flight direction unless control inputs are given.</p>
STABILIZE	<p>This is the most manual mode. The flight controller helps leveling the aircraft when the sticks are released but does not hold position or altitude. The songbird is much more agile.</p> <p><i>Note: As opposed to POSITION, the STABILIZE mode will not limit the sink rate. When landing descend carefully – keep in mind that the SONGBIRD is not designed for rapid retardation after a quick descent.</i></p> <p>You will likely need more than medium throttle to maintain altitude in this mode, which is important to keep in mind when taking over control from another flight-/or assistance mode.</p>	<p>In this mode, the Songbird behaves much like a normal model airplane. The controller will only aid by leveling the wings if the control sticks are released.</p>
MISSION	<p>Use this setting to carry out fully automatic flights. You cannot control the flight mode via the transmitter in this mode, as it is selected automatically according to the mission.</p> <p>It is, however, possible to switch between this and other modes in flight, as explained in section 7.3.</p>	

7.3 Switching Between MISSION and Manual Modes in Flight

It is possible to switch to MISSION when the Songbird is already flying. In this case, the Autopilot will immediately head for the currently active waypoint.

An exemplary use case is taking off manually to check the correct functioning of the aircraft and switching to MISSION mode a few meters above the ground. In this case, the flight controller will simply continue climbing (as the takeoff waypoint is still active) and conduct the mission. It is also possible to switch to the MISSION mode at any other time (e.g. after flying manually in AIRPLANE mode). Before doing so, activate the desired waypoint in the Ground Control Station (see Chapter 8). Note that otherwise the active waypoint may still be the takeoff waypoint which can cause the autopilot to descend back to the transitioning altitude in order to reach it.

You can also switch from MISSION to a manual mode (POSITION or STABILIZE). Beforehand, doublecheck the proper position of the Mode Selector – When taking manual control, the flight controller updates the flight mode to the current setting of the Mode Selector (COPTER or AIRPLANE) which can result in an immediate transition.

It is recommended to leave the Mode Selector on COPTER during automatic missions, since an accidental switch to this mode is normally acceptable while accidentally switching to AIRPLANE mode (especially close to the ground) can be dangerous.

If switched back to MISSION after a manual excursion, the flight controller will simply pick up the mission at the waypoint which was active before manual flight (unless it was changed via the Ground Control Station in the meantime).

Note: Only the takeoff and landing waypoints trigger an automatic transition. When entering an automatic mission somewhere in between (after flying manually in COPTER mode), it can be necessary to update the flight mode to AIRPLANE via the GCS.

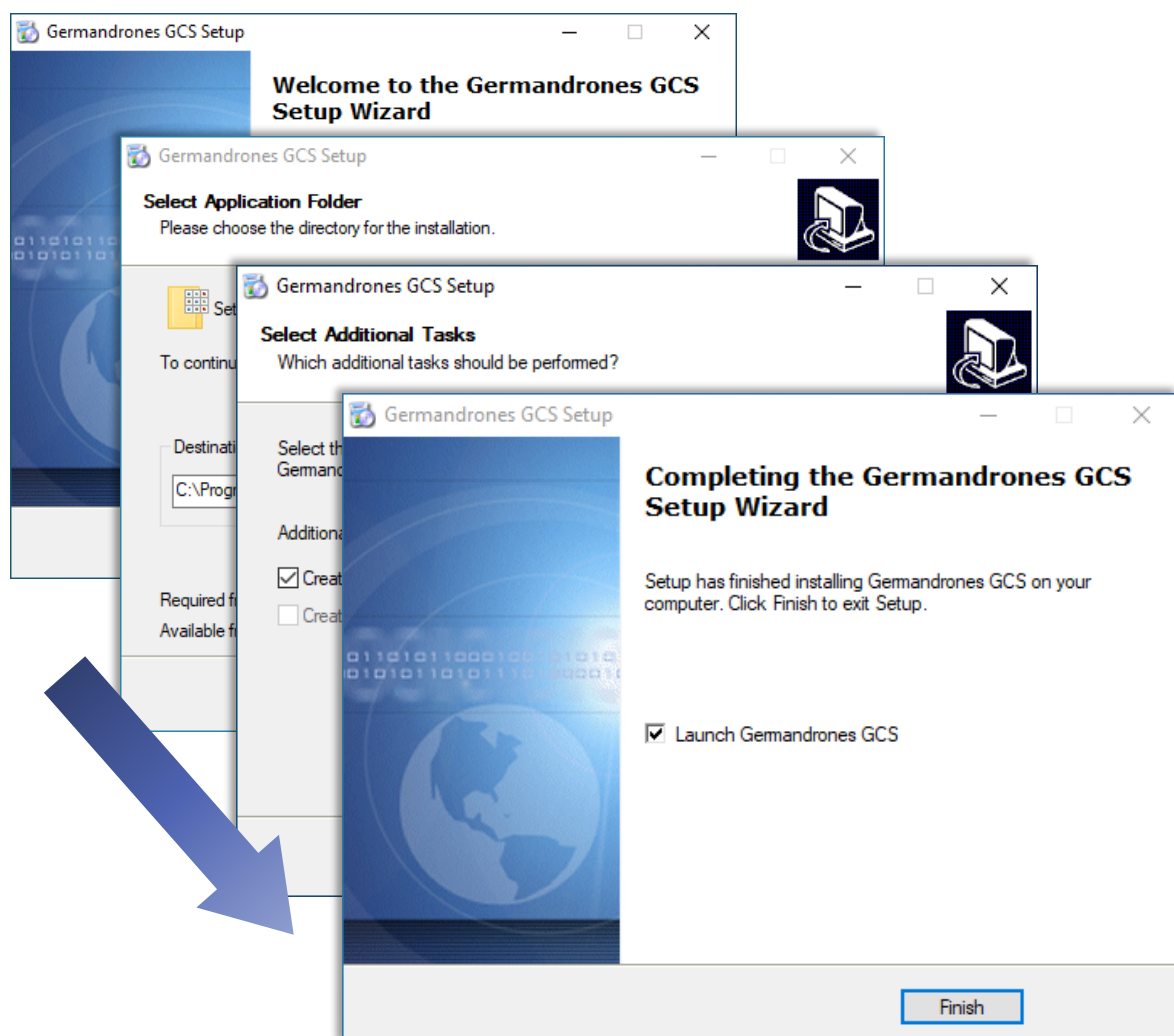
8 GROUND CONTROL STATION

The GCS (Ground Control Station) software, provided by Germandrones, can be installed on any Windows 10-computer, and can be utilized to set up missions, receive live data and even issue commands to the aircraft in flight.

In addition to its core functions, the GCS can be extended via the Germandrones SDK to communicate with the payload through the GUI, e.g. to control the camera. The bandwidth is restricted by the MAVLink protocol. The GCS may also be used to upload revised software and settings to the flight controller.

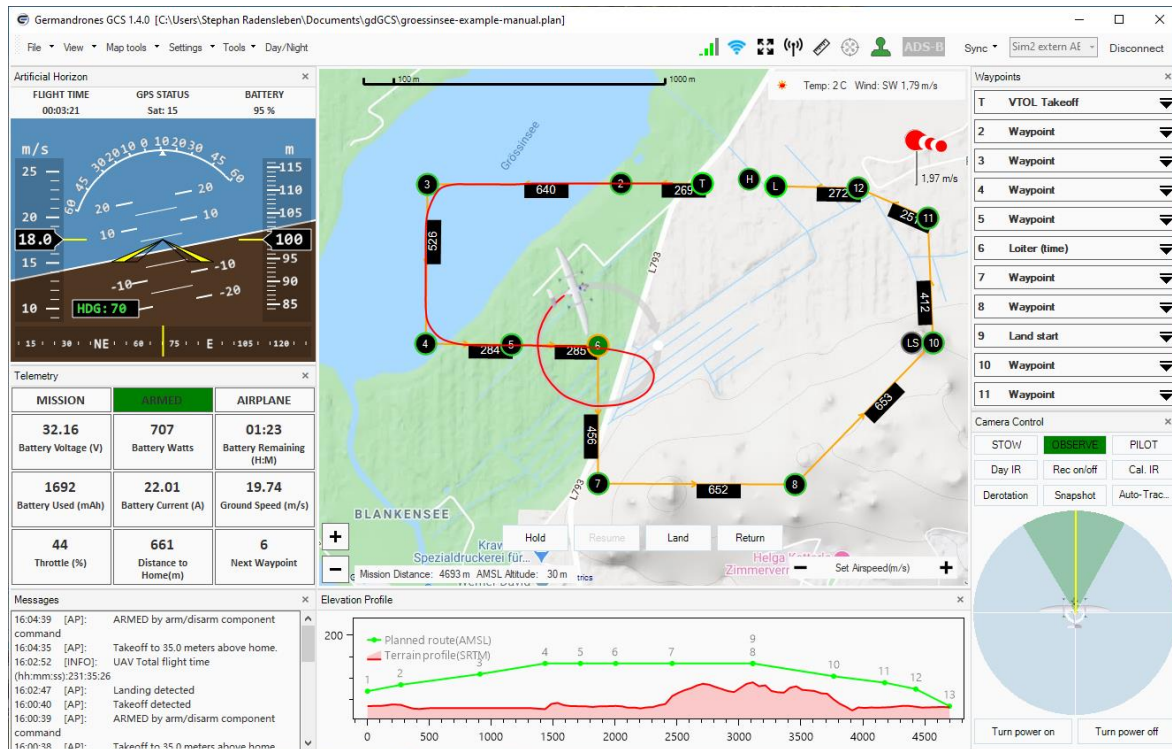
Software Installation

To install the GCS Software, run the provided installer file and follow the steps on the screen. Run the software after the installation finishes.



8.1 Introduction to the User Interface

After launching the GCS software, the main map appears with several widgets (dockable windows) arranged around it. To navigate in the map, you can drag or zoom in and out using the mouse or the + and – buttons at the bottom left. At the top right corner, the map contains an overlay with weather information. Please refer to chapter 9.5 for a detailed explanation of it.

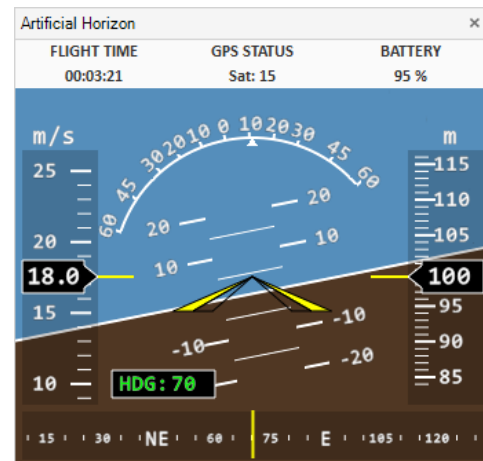


When preparing a mission, the GCS will be used to place waypoints and plan actions for the UAV. If an aircraft is connected and becomes armed, these functions will not be available anymore. Instead, the GCS will then be used to monitor the flight and issue live commands, if needed. The following widgets are available to help you with these tasks:

Artificial Horizon widget

This element visualizes the UAV's orientation in space. It combines several basic instruments to display the pitch and roll angles as well as the airspeed (left bar graph) and relative altitude (right bar graph). It also includes a compass at the bottom.

Flight Time, GPS Status and Battery percentage are always shown at the top of the artificial horizon widget.



Telemetry Data Widget

At the top, the following flight state information are displayed:

- Left: **Flight Mode** (e.g. POSITION, MISSION, RETURN...)
- Center: **Arming State** (ARMED, DISARMED)
- Right: **VTOL State** (COPTER, AIRPLANE, or TRANSITION)

Telemetry		
MISSION	ARMED	AIRPLANE
30,26 Battery Voltage (V)	695 Battery Watts	00:39 Battery Remaining (H:M)
4710 Battery Used (mAh)	23,00 Battery Current (A)	15,65 Ground Speed (m/s)
101 Wind Direction (Deg)	0 Radio RSSI	4,02 Pitch (deg)
46 Throttle (%)	819 Distance to Home(m)	5 Next Waypoint

Below, the Telemetry widget displays a thorough overview of the sensor data.

It can be customized by double-clicking on any field and selecting the display value from the pop-up window. Moreover, the grid size can be changed by right-clicking on any field and selecting "Change Column/Row count".

Display this				
<input type="checkbox"/> Air Speed (m/s)	<input type="checkbox"/> ClimbRate (m/s)	<input type="checkbox"/> LTE Remote Noise	<input type="checkbox"/> Radio Noise	<input type="checkbox"/> Time in Air (H:M:S)
<input type="checkbox"/> Altitude ABS (m)	<input type="checkbox"/> Distance Sensor (m)	<input type="checkbox"/> LTE Remote RSSI	<input type="checkbox"/> Radio Remote Noise	<input type="checkbox"/> Time in Air (sec)
<input type="checkbox"/> Altitude AGL (m)	<input type="checkbox"/> Distance to Home(m)	<input type="checkbox"/> LTE RSSI	<input type="checkbox"/> Radio Remote RSSI	<input type="checkbox"/> Traveled Distance (m)
<input type="checkbox"/> Altitude Relative (m)	<input type="checkbox"/> Estimated Distance (m)	<input type="checkbox"/> LTE RxErrors	<input checked="" type="checkbox"/> Radio RSSI	<input type="checkbox"/> Vertical Speed (m/s)
<input type="checkbox"/> Battery Current (A)	<input type="checkbox"/> GPS Status	<input type="checkbox"/> Next Waypoint	<input type="checkbox"/> Radio RxErrors	<input type="checkbox"/> Wind Direction (Deg)
<input type="checkbox"/> Battery Percentage (%)	<input type="checkbox"/> Ground Course (deg)	<input type="checkbox"/> Payload Battery Current (A)	<input type="checkbox"/> Roll (deg)	<input type="checkbox"/> Wind Velocity (m/s)
<input type="checkbox"/> Battery Remaining (H:M)	<input type="checkbox"/> Ground Speed (m/s)	<input type="checkbox"/> Payload Battery Used (mAh)	<input type="checkbox"/> Sat Count	<input type="checkbox"/> Yaw (deg)
<input type="checkbox"/> Battery Used (mAh)	<input type="checkbox"/> Latitude	<input type="checkbox"/> Payload Battery Watts	<input type="checkbox"/> Target Airspeed	
<input type="checkbox"/> Battery Voltage (V)	<input type="checkbox"/> Longitude	<input type="checkbox"/> PDB Temperature(C)	<input type="checkbox"/> Target Altitude	
<input type="checkbox"/> Battery Watts	<input type="checkbox"/> LTE Noise	<input type="checkbox"/> Pitch (deg)	<input type="checkbox"/> Throttle (%)	

Message Widget

Messages		
14:16:01	[AP]:	Takeoff to 35.0 meters above home.
14:16:00	[AP]:	[logger] file: rootfs/fs/microsd/log/2020-07-28/1
14:15:33	[INFO]:	Aircraft total flights: 308 times.
14:15:33	[INFO]:	UAV Total flight time (hh:mm:ss):212:15:11
14:15:33	[INFO]:	Aircraft battery capacity detected: 20000 mAh
14:15:33	[INFO]:	Aircraft cruise airspeed is 18 m/s
14:15:31	[INFO]:	Firmware version 6438a42

The Message widget is used to display incoming text notifications and warnings.

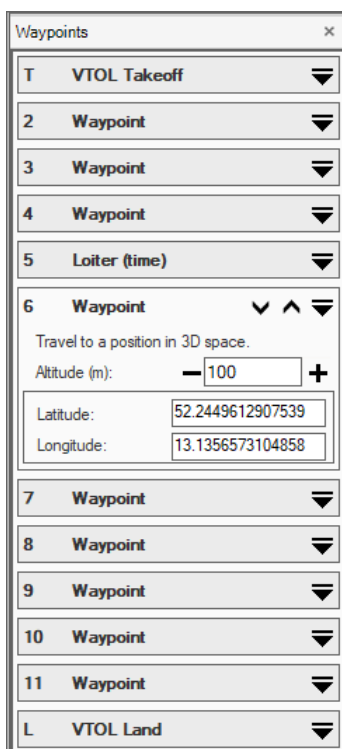
Confirmation notifications will be displayed regarding changes of air-speed, loiter radius and altitude, etc.

After the local time on the left, the source of a message is indicated in square brackets:

- [AP]: Messages from the SONGBIRD's autopilot
- [INFO]: Information generated by the GCS
- [GCS]: (Error) Messages from the GCS
- [WARN]: Warnings from the GCS.
- [#id]: Messages from additional components by #id. Example: [191]: LTE: 35,71 MB of 1 GB 22 days

Waypoint Widget

As waypoints are added to a mission, they appear in the waypoints list. Left-click on an



The Waypoints widget displays a list of mission waypoints. The list includes:

- 1 VTOL Takeoff
- 2 Waypoint
- 3 Waypoint
- 4 Waypoint
- 5 Loiter (time)
- 6 Waypoint (selected)
- 7 Waypoint
- 8 Waypoint
- 9 Waypoint
- 10 Waypoint
- 11 Waypoint
- 12 VTOL Land

The selected waypoint (6) is expanded to show configuration options:

- Travel to a position in 3D space.
- Altitude (m):
- Latitude:
- Longitude:

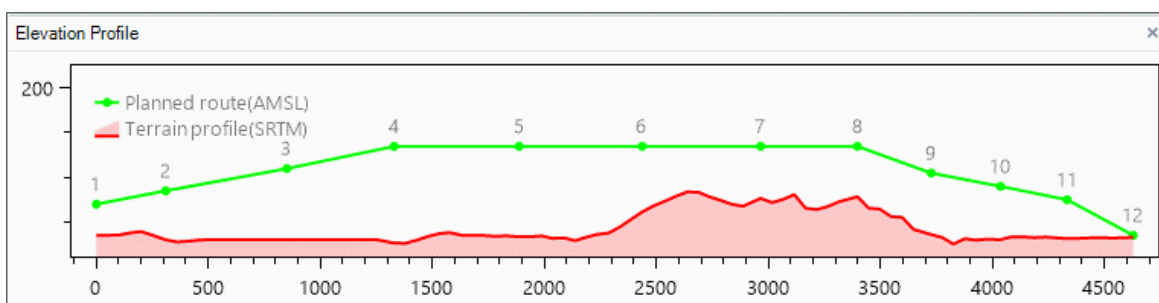
entry to expand it, enabling you to modify parameters such as altitude, radius (in case of a Loiter waypoint), etc.

The waypoint order can be rearranged by clicking on the “up” or “down” icons. The solid chevron button on the right opens a menu that lets you insert or delete waypoints.

Double-click on a waypoint to change its type. Some command types have no actual location but will dock to the previous waypoint in each case, such as “change speed” and “camera trigger distance”.

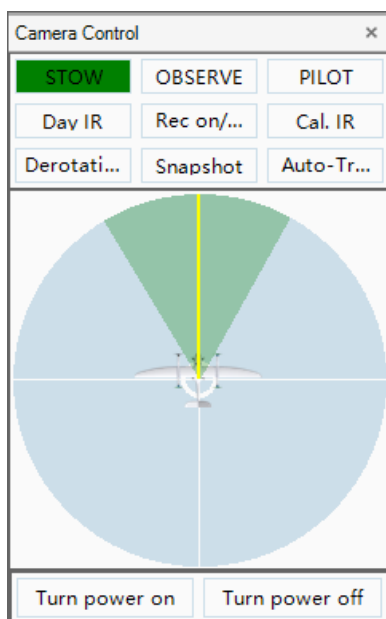
Elevation, Battery- and Airspeed Plot

The elevation profile is used to revise the planned mission altitude. The red solid plot displays the averaged landscape relief (based on SRTM data from the internet). Note that these data have a limited resolution and do not include obstacles like buildings, trees, power poles etc. The green plot displays the navigation waypoints. The horizontal axis displays the travel distance (in m) and the vertical axis shows the altitude above MSL (in m).



It is also possible to display a **Battery Plot** and **Airspeed Plot** by selecting them from the **View**-menu. These will help to monitor battery health and airspeed sensor calibration, respectively. For more information on these, see chapters 10 and 0.

Camera control



The Camera Control widget can be used in conjunction with a live gimbal camera. The display shows the orientation of the camera relative to the aircraft.

The buttons at the top can be used to toggle different camera functions (currently supporting NextVision cameras). For detailed information on these, please refer to the NextVision documentation.

8.2 Preparing a Mission



If necessary, you can clear existing waypoints by selecting **Plan new mission** in the **File** menu. Select a tool from the toolbar on the left-hand side of the map and **double-click** in the map to place waypoints in the desired location. Waypoint positions may be changed by clicking and dragging them with the mouse.

The following types of waypoints are available from the toolbar:

Takeoff

The first command in a mission must be the **Takeoff**. If no waypoints have been issued yet, the VTOL Takeoff tool will be used by default. Its altitude, which can be set in the Waypoints widget, represents the altitude (relative to the ground where the SONGBIRD is armed) at which the UAV will perform a transition to AIRPLANE mode. By default, this is set to 35 m. It is recommended to set this no lower than 25 m above the ground or nearby obstacles.

Note: Upon takeoff, the SONGBIRD will always climb straight up, independent of its placement. Rather than directly above, the takeoff waypoint should be set approx. 50-100 m

ahead of the actual takeoff position as it will define in which direction the UAV will align itself during the transition. See section 8.4 for an example.

All waypoint altitudes relate to the arming location. During the planning process, the terrain altitude at the takeoff waypoint stands in for it. Keep this in mind in case your actual arming altitude will differ significantly, for example in mountainous terrain.

Navigation Waypoints

After the takeoff point, you can begin adding regular navigation waypoints to create a flight path. Every additional waypoint will use the previous altitude by default, but it can be modified in the waypoints list. After the takeoff, create a path climbing to your cruise altitude. When creating the flight path allow for sufficient maneuvering space and avoid steep climbs or descents.

Loiter

These waypoints are optional – the UAV will fly circles (loiter) at their location. In the Waypoints widget you can set the altitude and time (in seconds) after which the UAV will head for the next waypoint. You can also set the loiter radius in the list or simply by dragging the handle button of the loiter circle in the map. By selecting the checkbox “Loiter 8 shape” the UAV will follow a figure-eight-pattern instead of a circle. In this case it is recommended to set the radius to at least 200 m to allow for a proper flight path.

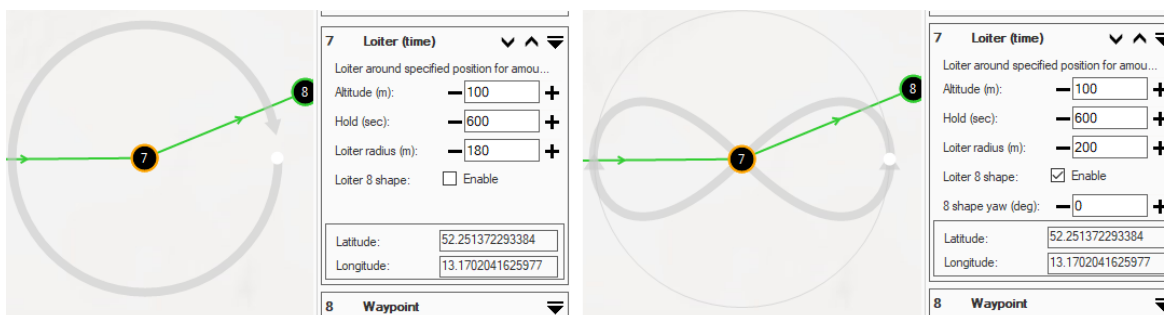


Photo Missions

Use the optional tools **Survey** or **Corridor** to generate flight patterns. To add such pattern to the mission, double-click on the map to place a polygon (or a corridor, respectively).

Photo patterns can be modified by dragging the solid white vertices. To add a new polygon vertex, click on a hollow circle. Right-clicking on a vertex will remove it.



The flight path will be created within the polygon based upon a variety of parameters, which can be edited in the corresponding entry in the Waypoints widget.

You can set the altitude, angle, and distance between the lines. The trigger distance specifies at which interval a camera trigger signal is sent to the payload. Define a turnaround distance to make the UAV fly past the border of the polygon before turning around. This will help keeping photos aligned even near the border. For best results, you may need at least 150 m – but it also depends on the lane separation. The lane separation parameter can help avoiding sharp turns and optimizing the flight path by skipping a certain number of lines at each pass. Selecting a camera preset is optional and can help choosing appropriate parameters. Use the Switch Start Position button to toggle the entry point of the pattern.

12 SURVEY

Area scan pattern.
Altitude (m): +
Angle (deg): +
Spacing (m): +
Trigger distance (m): +
Turnaround (m): +
Airspeed (m/s): +
Lane separation: +
Camera preset:

Switch start point

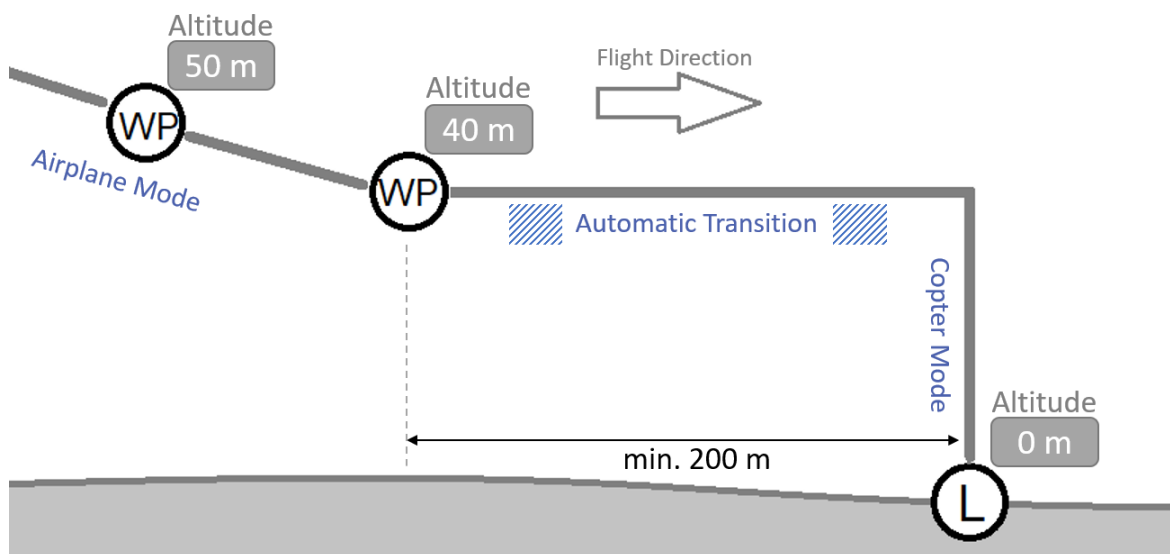
The Corridor tool offers a very similar set of parameters. As opposed to the Survey, it is based on a line to be tracked at different lateral offsets at each pass.

Note that the survey and corridor functions do not generate takeoffs or landings. Those must be defined by the user as usual.

During the upload of complex mission items such as SURVEY or CORRIDOR, waypoints are generated automatically. Always download such missions after uploading, to ensure having an exact copy of the actual mission in the GCS.

Landing

A **Land** waypoint is needed at the end of a mission (the altitude of this waypoint is ignored – the UAV will automatically descend until it touches the ground). The transition altitude is defined by the altitude of the previous waypoint because the UAV will maintain it until initiating the vertical descent, hovering above the landing waypoint. The image illustrates the altitude profile in a typical landing approach.



You can select the ruler tool from the top menu bar, to display the distances between waypoints. Also, avoid sharp turns or steep descents prior to the landing and ensure that there is sufficient free space at the desired transitional altitude.

To give the flight controller enough space for proper alignment and transition, allow for at least 200 m between the last regular waypoint and the landing.

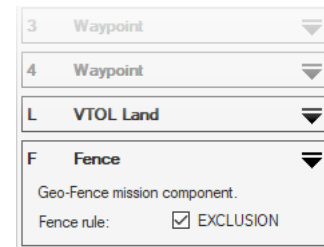
In most cases, you want to **land at the takeoff location**. This can be done by checking the option “Land at Takeoff”. This tells the flight controller to ignore the coordinates of the landing waypoint and use the arming location instead. It is advisable, to place the landing waypoint in a realistic position nevertheless to get a good preview and correct results from the built-in mission checker.

40	Waypoint
41	Waypoint
42	Waypoint
L	VTOL Land
Transition to VTOL and land.	
Altitude (m):	- 0 +
Continue mission?	<input type="checkbox"/>
Land at Takeoff	<input checked="" type="checkbox"/>
Set at UAV position	
Latitude:	50.8770370483398
Longitude:	13.4200248718262

Geofence

Use this tool to define Geofences either as a circle or polygon (right-click on the tool to toggle the modes). Drag the markers to modify the zone. Click on one of the hollow markers to add a new corner to a polygon.

The geofence tool will create an inclusion zone by default (it is forbidden to leave the area). It can also be used to mark an exclusion zone (it is forbidden to enter a certain area). The type of zone can be selected in the geofence's entry in the Waypoints widget. When a Geofence is violated, an Emergency Action can be triggered. The options are explained in chapter 8.9.



Instead of defining the geofence through markers on the map, it can also be generated automatically at a certain distance around your home (takeoff) location by selecting values for its radius and altitude in the geofence section of the Emergency Actions menu. See section 8.9. for further information.

Note:

When the UAV is placed in a forbidden zone, the autopilot will refuse to take off to a mission, independent of the current Emergency Action settings (section 8.9).

8.3 Connecting & Uploading

To establish a connection between the GCS and the UAV, plug the USB Modem into the GCS computer and turn on the aircraft. The USB module will be recognized by Windows as a COM port. Select it from the drop-down menu in the upper right-hand corner and click Connect. (If you have multiple COM ports and are unsure which one to choose, try to observe which one is added as the telemetry module is plugged in or try the “Auto” recognition.)



If you order another kind of data link (e. g. 4G), you will receive supplementary instructions on how to set up a new connection profile.

Once connected, the Software will begin downloading parameters from the aircraft (including the last mission if no waypoints have been placed in the map view). When this process is done, the gauges in the GCS will display live data from the UAV.

Every time you make changes, an orange blinking reminder “Upload Mission” will appear at the menu bar. Click in it to upload your mission to the UAV. Alternatively, you can click on **Sync** and choose **Upload Mission** or **Download Mission** at any time.

Only one mission file at a time can be stored in the aircraft’s memory.

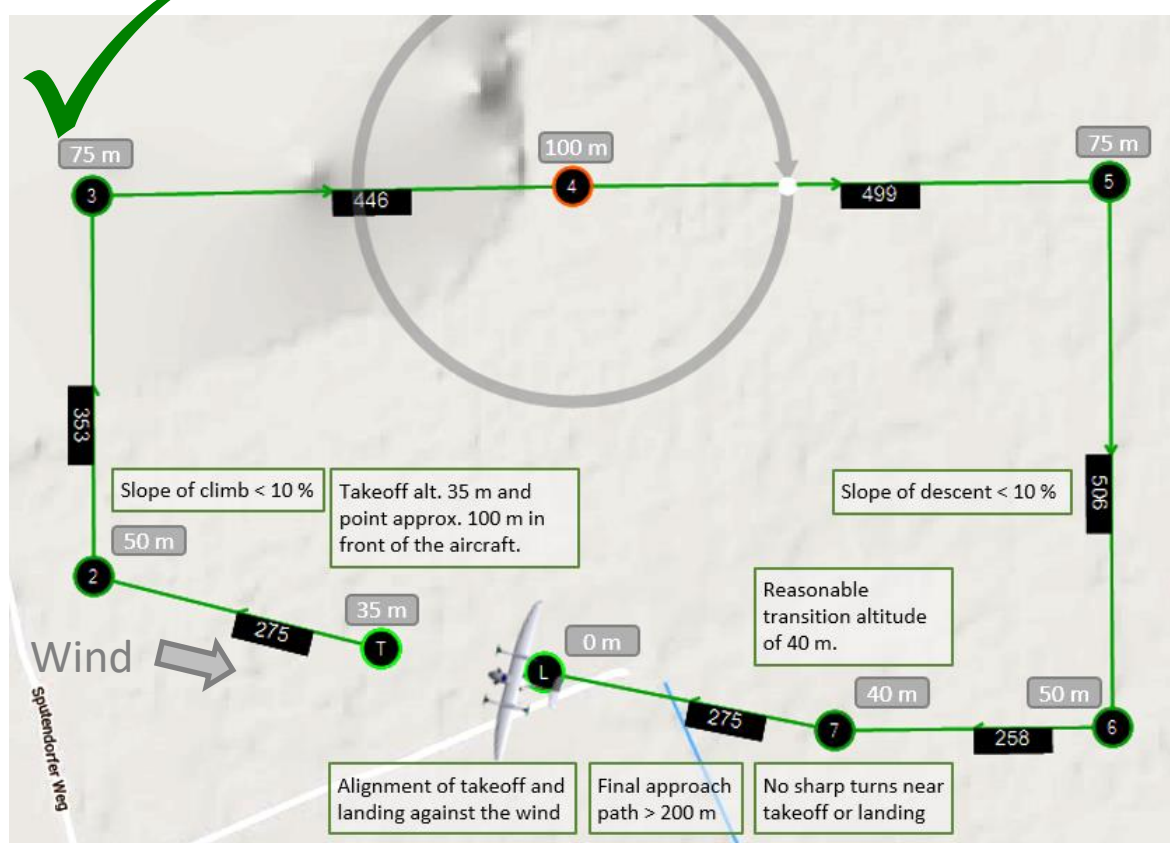
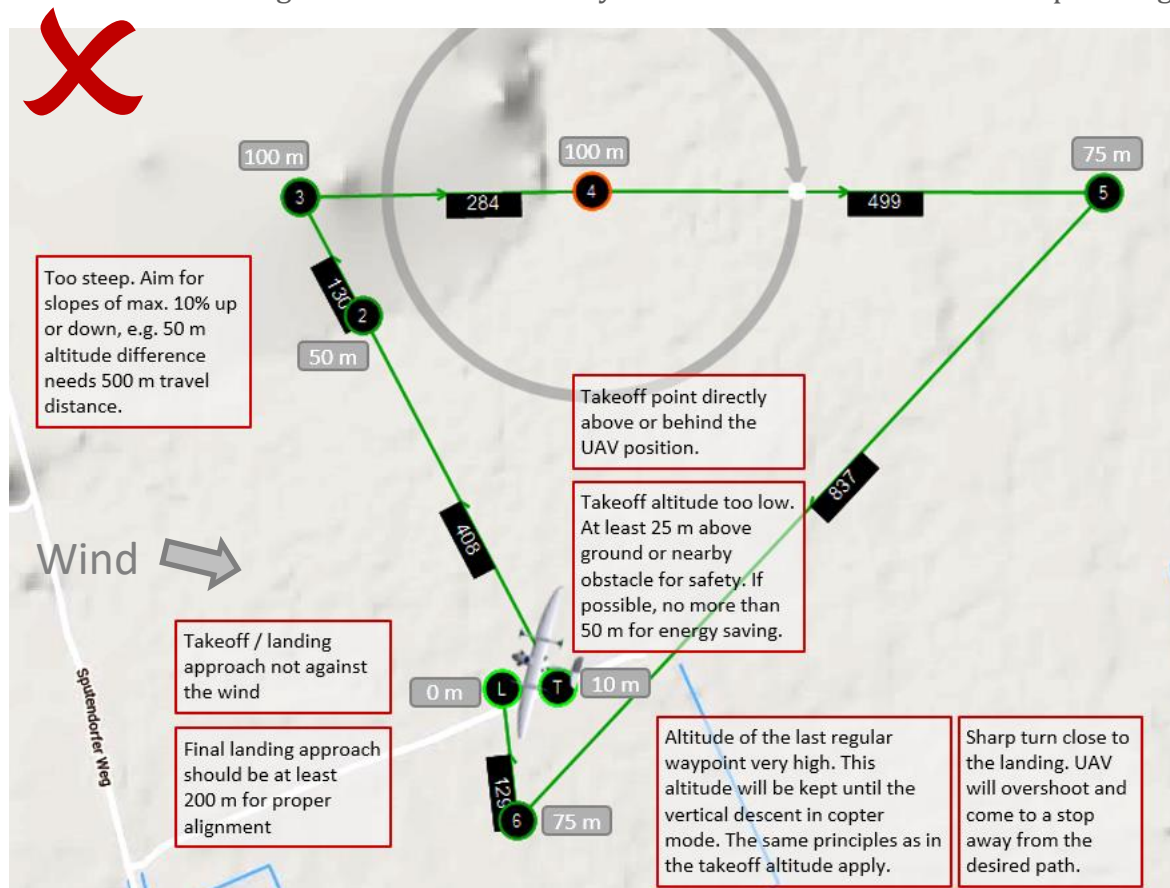
You can store mission drafts on the ground station computer’s hard drive using the **File** menu and selecting **Save Mission**. Choose **Open Mission** to retrieve a previously saved mission file.

Note: It is possible to connect multiple ground stations to one UAV. They can all monitor the flight data and issue commands; there is no hierarchy – the aircraft will execute all commands from any ground station connected. Therefore, the operators should agree on their respective roles before the flight. To keep unauthorized persons from connecting to the aircraft, most telemetry options can be delivered with an AES encryption.

When using both, 4G and a direct link telemetry option in the same aircraft simultaneously (hot redundancy) you can run multiple instances of the GCS on the same computer. You cannot establish more than one connection in a single instance of the GCS.

8.4 Best Practices in Mission Planning

Please view the images below for a summary of the dos and don'ts in mission planning:



What if takoffs and landings against the wind are not possible?

- If the surroundings do not allow a takeoff climb against the wind:

The SONGBIRD must always be placed facing the wind. However, the takeoff-waypoint can be located in another direction. In this case, the SONGBIRD will climb in COPTER mode facing the wind and reorient itself prior to the transition.



- If the surroundings do not allow a landing approach against the wind:

Some deviation from the ideal direction is acceptable:

- Wind at transition altitude 4 m/s or less: Up to 90°.
- Wind more than 4 m/s: Up to 45°.

During an automatic descent in COPTER mode, the SONGBIRD will turn and point the nose into the calculated wind. However, the transition can be destabilized by strong wind from the side or from behind.

8.5 Flight Supervision

To receive telemetry data and send commands during the flight, a connection between the GCS and the UAV must be established (as explained in section 8.3).

Some important data to monitor in a flight are:

- **Attitude:** In normal operation the UAV's bank angle (as seen in the artificial horizon) should be no more than 45° during turns in AIRPLANE mode and no more than 20° in the COPTER mode. The pitch angle should always be less than 20° up or down and less than 10° in steady cruise flight. A deviation from these values can indicate a malfunction or unsuitable environmental factors. Consider aborting the flight depending on the circumstances.
- **Altitude:** Is it safe? Does the UAV meet the altitude that was expected during mission planning? You can use visual references to back up this information, e.g. by simply

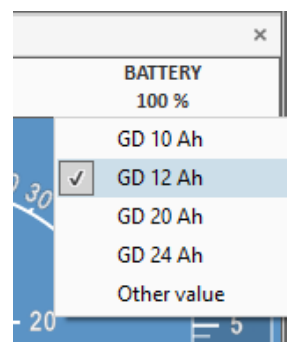
looking at the aircraft or the live video when available. In addition, the GCS will display a warning when the UAV is below 30 m above the ground in AIRPLANE mode (based on SRTM data). Please act quickly in this case, for example by switching to a manual mode, switching to COPTER, or changing the path using GUIDED mode. You can always use the GUIDED mode to change the altitude when necessary (see further below).

- **Battery status:** Monitor the remaining battery percentage with the indication at the top of the artificial horizon. Keep it above the minimum values recommended in section 9.4. Note that although some basic Emergency Actions can be preset, the flight controller cannot make educated decisions and ultimately the operator is responsible for safety.

The percentage is calculated from the current sensor's data. While the current sensing is very precise, the battery's status must be estimated based on the voltage in the beginning. As this can be inaccurate, it is important to only use fully charged batteries, especially for longer flights!

Moreover, the correct battery capacity must be set. To update it, click on the battery status and select the size, as indicated on the battery's label.

During flight, monitor the voltage and possibly the used capacity (available in the telemetry widget) as explained in section 9.4.



In addition, you can bring up the **Battery plot** from the view menu. See chapter 10 for details.

- **Satellites:** The GPS status shows the amount of visible GNSS satellites. In normal conditions, it should be at least 12. Consider aborting the flight and expect unprecise navigation (both laterally and vertically) when the number of satellites becomes smaller.
- **Errors or warnings:** Monitor the display for such messages and act accordingly.

- **Flight mode:** Check if the aircraft is in the state that is expected, e.g. MISSION and AIRPLANE while carrying out a mission or POSITION and COPTER in a manual landing. If something was changed accidentally, you can click on the corresponding indication and select the mode. Note that manual modes can only be accessed via the transmitter.
- **Location:** Does the flight path meet the expectation? If not, check if the flight mode was changed or the wrong waypoint has been selected.
- **(Air)speed:** A proper airspeed is vital to avoid stalls or unstable flight. To verify the correct calibration of the sensor, occasionally check its readings for plausibility: Does it show any value other than 0 m/s on the ground? Does this approximately match the wind speed? In AIRPLANE mode, the indicated airspeed should be around 17 to 20 m/s. Does it approximately match the GPS based ground speed, considering the wind? The “Air-ground speed” plot can help comparing those data; it can be selected in the view menu.
- **PDB Temperature (Songbird 150 only)**

The heavier and more powerful setup can lead to overheating the PDB (Power Distribution Board). Normal takeoffs, landings and cruise flight are not affected by this, but excessive COPTER-flight or steep climbs (several minutes in a row) should be avoided.

To help you monitor the PDB’s temperature, this Songbird has been equipped with an additional sensor. If it is not yet displayed in the Telemetry widget, double-click on a field you wish to replace and choose “PDB Temperature”.

Please ensure that it does not exceed 100 °C. The temperature will generally rise when using COPTER mode or during steep climbs and will decrease in cruise flight or when the Songbird is landed.

8.6 Flight Guidance via Live Commands

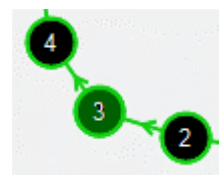
While it is not possible to upload a completely new mission in flight, there are several commands you can use to guide the aircraft when airborne:

Right-click in the map and select **Go to Location** or **Go to Location and PTC** (point camera here). This is referred to as **GUIDED** mode – The aircraft still flies and navigates automatically like in MISSION but not using the original mission path. Instead, the UAV will approach the selected location and begin to circle around it. The user will be prompted to select a radius for this. At the bottom right-hand corner of the map, buttons will now be displayed that allow you to change the altitude, airspeed, radius and to toggle between a circular holding pattern and an 8-shape with adjustable orientation.

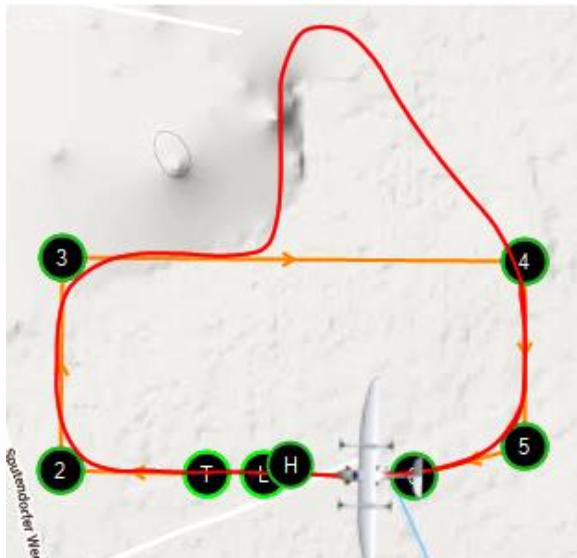
In MISSION mode you can modify the predefined flight plan by skipping waypoints or returning to previous ones. Simply click on a waypoint and confirm the prompt to choose it as the active one.

This can also be done when not in MISSION mode (e. g. GUIDED or during manual flight) in which case a prompt will appear, asking if you want to switch to MISSION directly or just save the selection for later.

Note: Independent of the flight mode, the active waypoint is highlighted in green in the map. Its number will also be displayed as “Next Waypoint” in the Telemetry widget.



Example use of the GUIDED mode:



The user wants to approach potential points of interest spontaneously. He has thus created a mission that contains all basic elements (takeoff, climb to cruising altitude, landing approach and landing). After reaching a safe altitude at waypoint no. 3, he switches to GUIDED mode by clicking on a point of interest further north. Later, he decides to return for the landing. To do this, he selects waypoint no.

4 of the predefined mission and activates MISSION mode once again. The UAV will resume the planned path at waypoint no. 4 and proceed to land.

Switching between automatic flight modes can also be done using the Quick Actions (see below).


Quick Actions



The Quick Action Buttons appear at the bottom of the map when a UAV is connected.

- The **Start Mission** button is visible then the UAV is disarmed. It will start the automatic mission (be sure that all preparations are done). After clicking “confirm” the UAV will arm and takeoff immediately, independent from the settings on the transmitter. For safety reasons, it is recommended to initiate Missions via the transmitter to include the remote pilot in the process.
- By pressing **Hold** during a mission, the UAV will start loitering (circling) around the current position at the same altitude. The radius can be changed using the button which appears on the bottom right in the map.
- Press **Resume** to continue the original mission. The UAV will pick up the flight path at the previously active waypoint.
- **Land** will cause the UAV to transition to COPTER mode and descend at the current location. As this will result in an unprepared landing and can cause damage, this function should only be used in an Emergency.
- **Return Home** will activate the RETURN mode manually whose main purpose it is to avoid loss of the UAV. The exact process is defined in the Emergency Settings (see section 8.9). To initiate a regular landing, the user should preferably use the normal mission path.

8.7 Top Menu & Settings



This section provides an overview of the many

more settings and options, most of which can be accessed through the menu bar in the upper left-hand corner of the GCS.

File Menu

The map can be cleared, and mission files can be saved or opened from the hard drive. Moreover, it is possible to export missions as a CSV file.

Map Tools

In the map tools menu, you can change the appearance of the map by selecting a map provider. You can also find the **Mission Checker** here. Run this tool to check the mission that is currently displayed in the map for potential problems. Note that this tool is designed to support the user but cannot guarantee a successful mission planning process solely.

Note: No special tool for prefetching map data is needed. Whenever a location in the map is viewed at a certain zoom level, those data are stored automatically and can be used offline later.

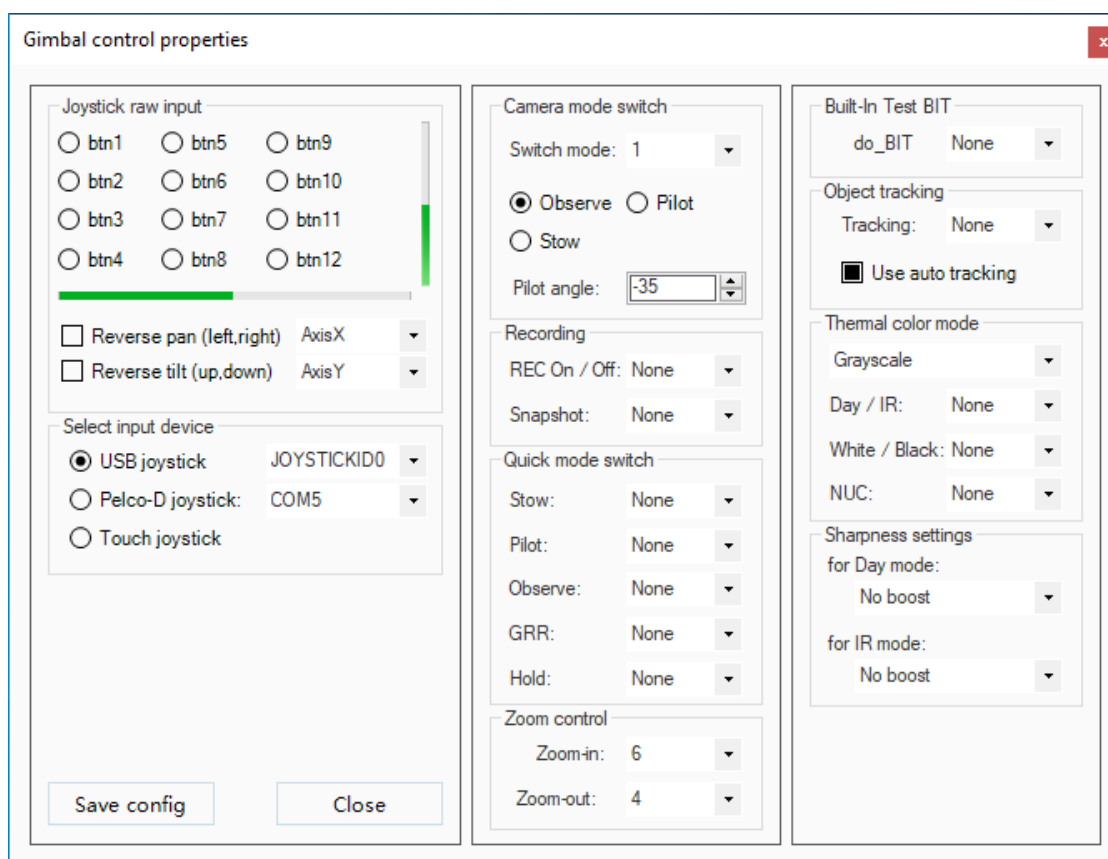
View Menu

Select widgets to be displayed. Widgets can be closed or moved by dragging their title bar. By dragging them on top of each other, some widgets can also be grouped to form one window with multiple tabs. The user can further adapt the user interface to his preferences by dragging the borders of the widgets to modify their respective sizes.

Gimbal Control Settings

This menu can be accessed from the **Settings** menu: The Ground Station (part number 15 in chapter 3) has a built-in joystick that comes preconfigured. In other cases, you may need to change some settings:

- Joystick Raw Input: On the left-hand side, set the joystick (or gamepad) axes which will be used. By pressing a button on a joystick, its channel becomes highlighted.
- Select Input Device: Select “USB Joystick” if a USB joystick or gamepad is used. Select “Pelco-D Joystick” if the Germandrones ground station’s built-in joystick is used.
- In the middle and right columns, you can (among other things) assign switches for various camera functions, adjust the tracking behavior and the appearance of the thermal mode.

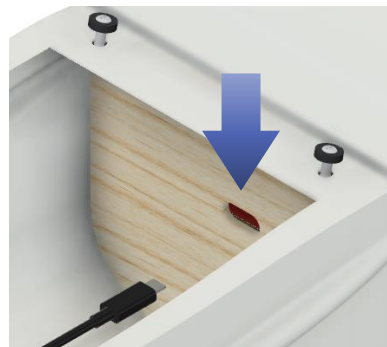


Emergency Actions can also be defined via the **Settings** menu. For a thorough explanation please refer to section 8.9.

Trigger camera trigger will manually trigger the camera. It can be used to confirm its correct functioning before a flight.

Hardware Update

1. To update the firmware, the SONGBIRD must be directly connected to the GCS computer via a Micro-USB cable. For your safety and convenience, use the fuselage only, without the other parts attached. Note that it must still be powered by the flight batteries.
2. Go to **Tools** and **Hardware Update** and select **Update Firmware** (Using the “Connect” button first is not necessary in this case). Select the Update file from the directory – please use files provided by Germandrones only.
3. Follow the steps described in the confirmation dialog box (unplug battery → click Confirm → plug battery back in).
4. After uploading the firmware, ensure all functions are working properly (servos, motors, no warning messages).
5. (Optional) Update the parameter file, if provided. Press the “Update Parameters” button and select the parameter file.
6. After the update finished, reboot the UAV (unplug the USB connector and battery, plug the battery back in, use radio telemetry).



Log Download

Connect the SONGBIRD via USB as shown under Hardware Update. Select the appropriate COM port from the top right menu and click connect (same process as connecting through a telemetry module, as described in section 8.2 – it is also possible to download logs via a telemetry unit, but this method is very slow.) Then go to **Tools** → **Download Log Files**. Click Refresh to obtain a list of all available logs and download the files you need.

There are several ways to evaluate logs in the ULog-format. Please contact Germandrones for access to our cloud tool.

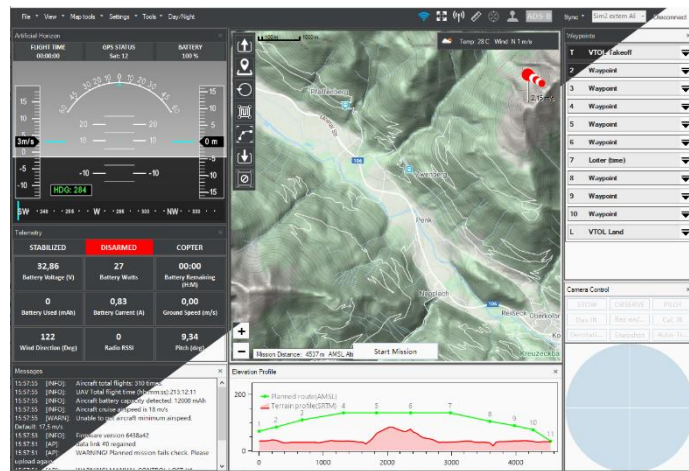
Geotagging

The Geotagging Tool can help you to add GNSS data to the EXIF header of photos taken during a mission. You can find it in the **Tools** menu.

GCS Updates

To access updates for the ground station software, go to **Tools** and select **Check for Updates**. The GCS should be disconnected from any UAV.

Day/Night Mode lets you toggle between a bright and a dark background version of the user interface.



8.8 Supportive Functions



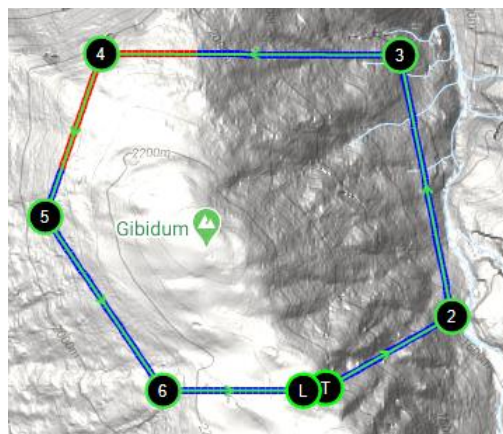
In addition to the controls for connecting a UAV to the GCS and up- or downloading mission files, some other functions can be accessed at the upper right-hand corner of the user interface.

The **Telemetry Link Indicator** shows up to four green bars representing the signal quality received at the GCS. *For more detailed information, you can select “Radio RSSI” values to be displayed in the Telemetry widget. It ranges from 0 (no signal) to 255 (very strong signal). In addition, “Radio Remote RSSI” is the telemetry signal strength, received by the airborne unit.*

The **Internet Indicator** (blue symbol) shows you, whether the GCS is connected to the internet. This is needed to download map data, display weather information and establish a connection to UAVs running 4G telemetry.

The **Toggle Full-Screen** button lets you switch between windowed and full-screen mode (borderless window) of the GCS.

Turn on the **Radio Link Indication** to show the expected radio link quality depending on the flight route and the GCS home- (or takeoff) position. The planned route will be drawn in *blue* and *red* colors, where blue line means good radio link and red indicates parts where the radio connection may be lost. In the example the connection may be lost between waypoints 3 and 5.



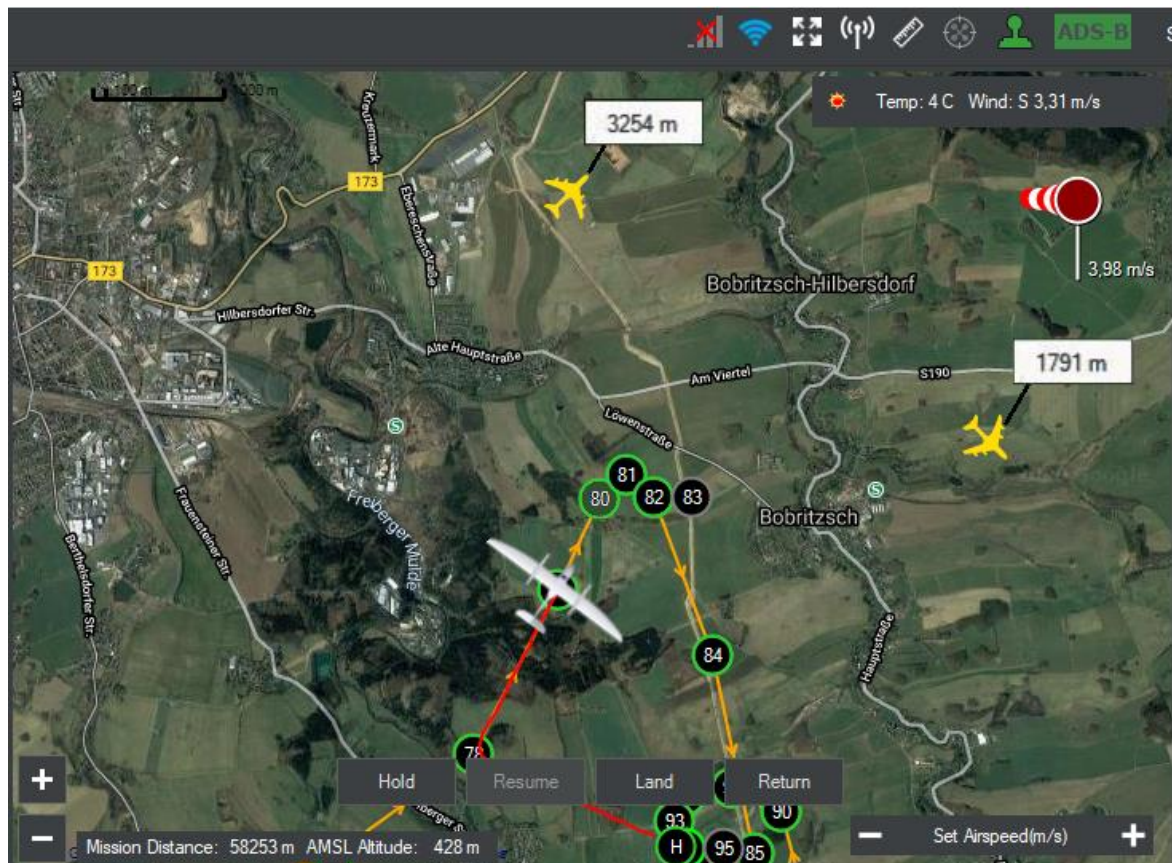
Note: This tool calculates the availability of a direct line-of sight based on terrain data and the projected altitude. It cannot take into account the transmission power, antenna setup or other obstacles and should thus be considered as a planning support only. Please watch the actual signal strength in flight.

The **Ruler Tool** displays the distance in meters between waypoints in the map. It helps with adequate path planning – especially when the area is not known, estimating distances based on the map view alone is difficult.

The **Map Centering** function moves the map to the UAV's coordinates when activated and keeps it in the frame when it moves. It is helpful for quickly finding the SONGBIRD in the map after establishing a connection.

The **Joystick Button** is used to activate or deactivate the joystick control of a gimbal camera.

The **ADS-B** function shows other aircraft in the map when using the optionally available ADS-B receiver that can be connected to the GCS via USB.



8.9 Emergency Actions

Emergency actions

Return home settings

☐ Return to arming position via direct path.
 ☒ Return to a planned mission landing.

Return home altitude (m): 100

Loiter Altitude (m): 45

RC loss action

☒ No Action, the current Flight mode is not changed.
 ☐ Switch to 'Loiter' mode.
 ☐ The 'Return' mode is activated.
 ☐ The 'Land' mode is activated.

RC Loss Timeout (s): 1

Telemetry loss action

☐ No Action, the current Flight mode is not changed.
 ☐ Switch to 'Loiter' mode.
 ☒ The 'Return' mode is activated.
 ☐ The 'Land' mode is activated.

Data Link Loss Timeout (s): 10

Low battery emergency actions

☐ Only display warning messages.
 ☐ The 'Return' mode is activated.
 ☐ The 'Land' mode is activated.
 ☒ A combination of the above.

Battery warning level %: 30

Battery action level %: 15

Battery emergency level %: 7

Geofence breach action

☐ No Action, the current Flight mode is not changed.
 ☒ Only display warning messages.
 ☐ Switch to 'Loiter' mode.
 ☐ The 'Return' mode is activated.

Max radius (m): 0

Max altitude (m): 0

Default airspeed settings

Mission cruise airspeed (m/s): 18,00

Apply Settings

Close

The Emergency Actions can be found under the Settings menu.

Return home settings

If the user or any of the emergency functions below triggers a “return home” action, it will be done according to these selections:

- **Return to arming position via direct path:** The UAV will climb to the “Return home altitude” specified in the field below if it is currently lower than this altitude. Otherwise, it will stay at its current altitude. If the UAV is far away from the home point

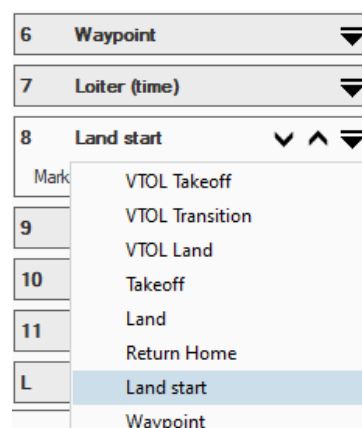
Ask yourself if this setting is appropriate in the current environment: When triggered anywhere, the autopilot will fly home straight, disregarding any obstacles, terrain or geofences. It does not obey the wind direction and should only be used in calm weather.

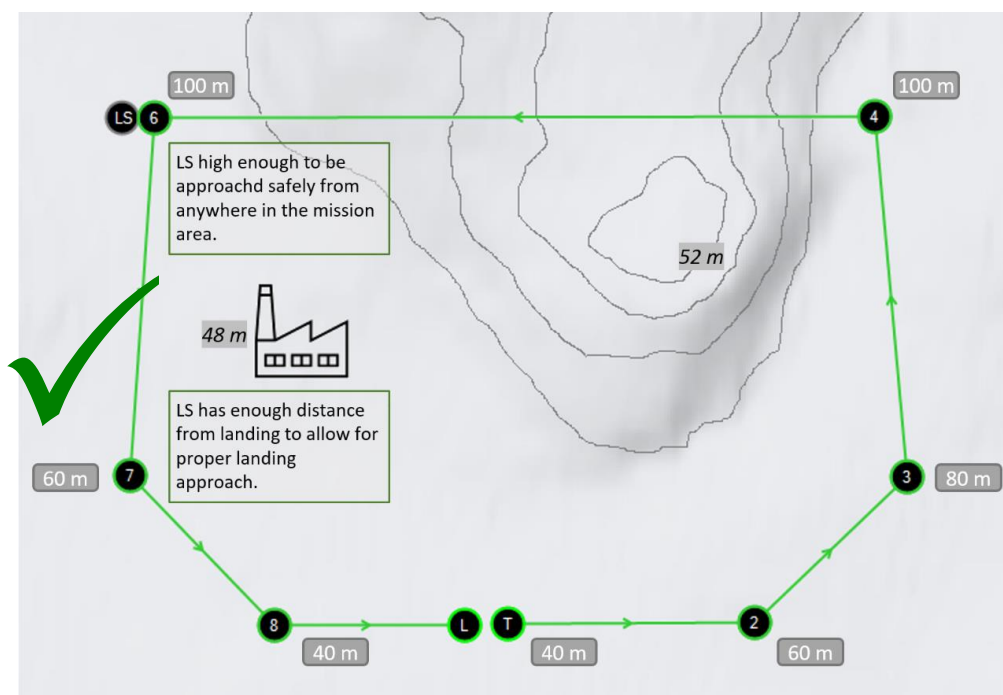
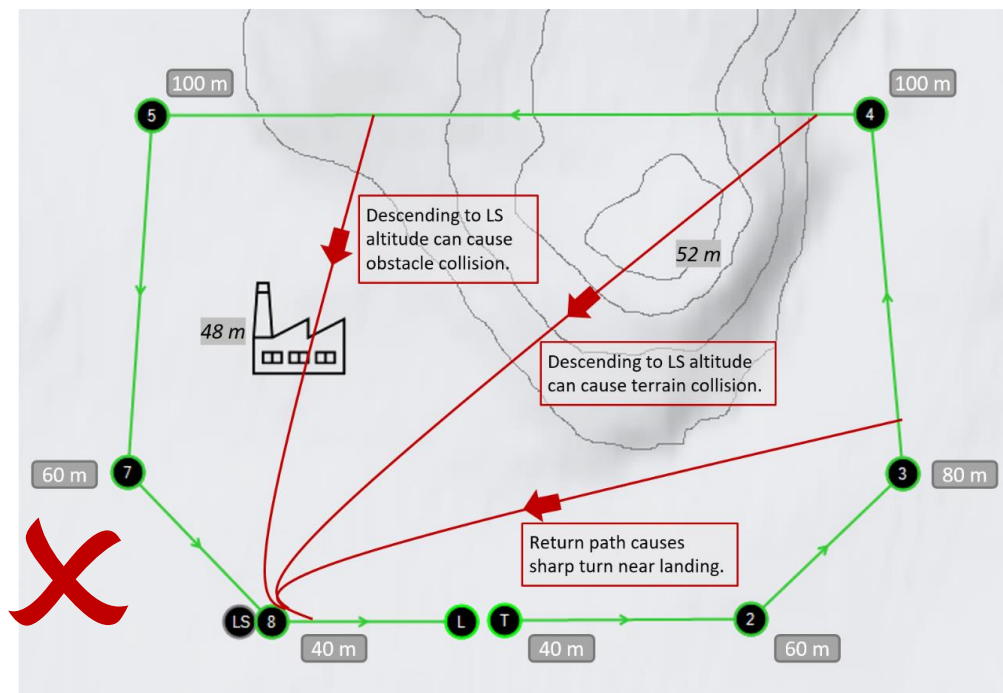
(which is defined as the last arming position), it will also do a transition to AIRPLANE mode if it is not already in this mode in order to travel home. It will then fly towards the home position in a straight line. When it comes close to the home point, it begins to loiter down to the “Loiter altitude” specified in the field below. Once this altitude is reached, a transition to COPTER mode is performed. After hovering to the correct home position (it usually has an offset at this point due to the radius of the loitering motion), the aircraft will land vertically at the arming position.

- **Return to a planned mission landing:** This return-home method uses the last part of the predefined mission path. It can be safer but requires an additional step in mission planning: You need to add one waypoint that you define as the beginning of your landing approach by right-clicking on or near it in the map and selecting “Add action here” - “**Land start**”. When the RETURN mode is triggered, the SONGBIRD will approach this waypoint and continue flying on the mission path until it has landed.

Think of the LS (land start) as a rally point in case of a problem. When placing it in the map, two things are important:

- The corresponding waypoint must be higher than all obstacles or terrain in the flight area, so that it can be safely approached from any point.
- It should not be too close to the actual landing. Otherwise, a sharp turn, the transition to copter and the alignment with the wind will all happen at the same time which can cause unsafe maneuvering.





Note:

- During the RETURN mode, Loiter waypoints will be treated as normal navigation waypoints.*
- If the mission path does not contain a Land start command and RETURN is activated, the flight controller will approach the landing directly, climbing to the Return altitude and transitioning without loitering to another altitude as it reaches the landing waypoint.*
- If RETURN is activated and the UAV has already passed the Land start marker, nothing changes; it will continue following the path to the landing point.*

Even when the RETURN mode is active, the user can overrule it by changing modes via the GCS or the transmitter as usual. In many situations it makes sense to let the autopilot bring the aircraft closer using the RETURN mode and take over control eventually.

RC Loss Action

The selected function will be triggered, when the connection with the RC transmitter has been lost for the duration specified under “RC Loss Timeout” (default: 1 second).

- **No Action**, the current Flight mode is not changed. Use this setting for BVLOS flights where an RC loss is expected, and the flight controller should continue the MISSION. Note that this setting makes sense only if you have a telemetry setup for a longer range, allowing you keep control over the aircraft via the GCS.
- **Switch to Loiter Mode**, will cause the aircraft to circle (when in AIRPLANE mode) or hover (when in COPTER mode) at the current location. This setting can be useful in manual flights as it grants the user time to take over control via the GCS when the RC connection is lost.
- **The Return Mode** is activated. It is recommended to set at least one of the RC loss and telemetry loss triggers to this setting to avoid the aircraft becoming uncontrolled at any time.

- **The Land** mode is activated. It causes the UAV to transition to COPTER mode and descend at the current location. As this will result in an unprepared landing and can cause damage, this setting is not recommended in most conditions.

Telemetry Loss Action

These settings resemble the RC loss action settings. For details, please see above. The selected telemetry loss action is triggered when the connection has been lost for the duration specified under “Data Link Loss Timeout” (default: 10 seconds).

In most situations this should be set to Return mode.

Low Battery Emergency Actions

You can choose actions that will be taken at certain battery percentage levels (**warning** level, **action** level and **emergency** level), specified in the fields below.

- **Only display warning messages.** In many situations it can be safer to keep the full battery management authority to the user as the automatic actions defined below may otherwise interfere with the intentions of landing the aircraft in a certain way.

Even when battery action and emergency levels are reached, the flight controller will stay passive. This setting should not be used in BVLOS flights when a link loss must be anticipated.

- **The Return Mode** is activated when reaching the battery action level.
- **The Land Mode** is activated when reaching the battery action level. It causes the UAV to transition to COPTER mode and descend at the current location. As this will result in an unprepared landing and can cause damage, this setting is not recommended in most conditions.
- **A combination of the above:** The user will be warned when the battery warning level is reached. At the battery action level, the RETURN mode is triggered. If the

landing is not completed when the emergency level is reached, a transition to Copter and a direct landing is performed.

It is recommended to use “Only display warning messages” in most situations – concurrently the “Telemetry Loss” action should be set to “Return”. This prevents the Songbird from crashing due to an empty battery in case of a complete loss of communication while leaving a maximum authority over the battery management to the pilot/operator.

Remember that the remaining capacity calculation requires correct data about the installed battery (see chapter 8.5 for details).

The user is ultimately responsible for the battery management. Relying on the flight controller's emergency functions cannot guarantee absolute safety as the system has no sufficient situation awareness.

Geofence Breach Action

When the geofence is breached, a selection of these settings is performed:

- **No action** – this setting will ignore geofences.
- **Only display warning messages** – choose this setting to use the geofence for triggering a warning in the GCS display only.
- **Switch to Loiter mode**, will cause the aircraft to circle (when in AIRPLANE mode) or hover (when in COPTER mode) at the current location, waiting for further instructions.
- **The Return mode is activated.** When the geofence is breached, the flight controller will switch to RETURN mode. Keep in mind, that this causes the aircraft to approach the home or the land start point in a straight line. It may even fly directly through this or another geofence if it is in the way!
- The settings **max. radius** and **max. altitude** can be used to define a simplified geofence around the home point. This will be independent of other geofences that are defined in the mission. Set them to 0 to disable the function (default).

Note: The geofence is useful to avoid leaving the proper flight area when using the GUIDED or a manual mode. A geofence does not help to keep the aircraft on a MISSION path – if the navigational capabilities of the flight controller are somehow impaired, the same problem applies to reacting to the geofence.

9 FLIGHT PERFORMANCE

The following section provides an overview of the maximum payload mass that can be carried under any given circumstance and will show you, how much flight time and distance you can expect to achieve with a given payload. It also tells you what airspeed to choose.

9.1 Allowable Load

The maximum aircraft weight is dictated by the motors' ability to generate sufficient thrust for vertical flight under any given conditions. This is primarily influenced by the altitude above sea level and the temperature.

Note: The following tables refer to the location of takeoff and landing (COPTER mode). The conditions encountered during AIRPLANE-mode-flight are not decisive in this matter. The tables specify the maximum load, which is the combination of payload and battery.

SONGBIRD 100

MAX. LOAD IN KG – FIELD ELEVATION VS. TEMPERATURE

	< 0	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40 °C
100	4.0	4.0	4.0	4.0	3.8	3.6	3.5	3.3	3.1
250	4.0	4.0	4.0	3.8	3.7	3.5	3.3	3.2	3.0
500	4.0	4.0	3.8	3.6	3.4	3.2	3.1	2.9	2.8
750	3.9	3.7	3.5	3.3	3.2	3.0	2.8	2.7	2.5
1000	3.6	3.4	3.3	3.1	2.9	2.8	2.6	2.4	2.3
1250	3.4	3.2	3.0	2.8	2.7	2.5	2.4	2.2	2.1
1500	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	x
1750	2.9	2.7	2.5	2.4	2.2	2.1	1.9	x	x
2000	2.6	2.5	2.3	2.1	2.0	x	x	x	x
2250	2.4	2.2	2.1	1.9	x	x	x	x	x
2500	2.1	2.0	x	x	x	x	x	x	x
2750	1.9	x	x	x	x	x	x	x	x
3000	x	x	x	x	x	x	x	x	x
m MSL									

SONGBIRD 150

MAX. LOAD IN KG – FIELD ELEVATION VS. TEMPERATURE

	< 0	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40 °C
100	6,4	6,4	6,4	6,4	6,4	6,4	6,2	6,0	5,7
250	6,4	6,4	6,4	6,4	6,4	6,3	6,0	5,8	5,6
500	6,4	6,4	6,4	6,4	6,2	6,0	5,8	5,6	5,3
750	6,4	6,4	6,4	6,2	6,0	5,7	5,5	5,3	5,1
1000	6,4	6,4	6,2	5,9	5,7	5,5	5,3	5,1	4,8
1250	6,4	6,1	5,9	5,7	5,4	5,2	5,0	4,8	4,6
1500	6,1	5,9	5,6	5,4	5,2	5,0	4,8	4,6	4,4
1750	5,8	5,6	5,4	5,1	4,9	4,7	4,5	4,3	4,1
2000	5,6	5,3	5,1	4,9	4,7	4,5	4,3	4,1	3,9
2250	5,3	5,1	4,8	4,6	4,4	4,2	4,0	3,8	3,6
2500	5,0	4,8	4,6	4,4	4,2	4,0	3,8	3,6	3,4
2750	4,7	4,5	4,3	4,1	3,9	3,7	3,5	3,3	3,2
3000	4,5	4,3	4,1	3,8	3,7	3,5	3,3	3,1	2,9
<i>m MSL</i>									

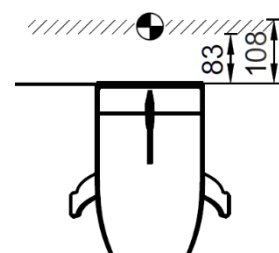
Note: The above tables refer to typical SONGBIRDS with empty masses of 6.8 kg (model 100) or 7.6 kg (model 150), respectively. To obtain the maximum gross weight (or “ M_{TOM} ”) add this to the mass from the above tables. Please consider this in case your SONGBIRD is heavier due to extra equipment or modifications.

Center of Mass

For stable flight characteristics, the center of mass must lie within 83 mm and 108 mm, measured from the center wing’s leading edge.



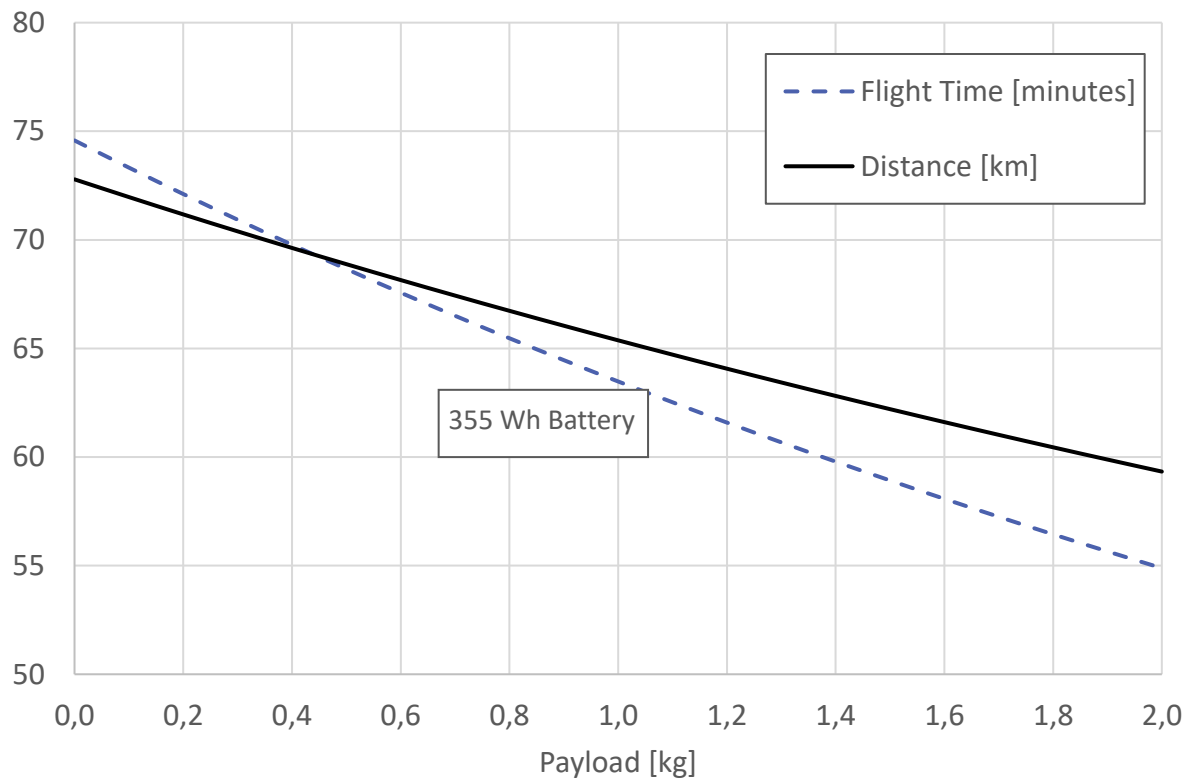
This requirement is met for any of the typical SONGBIRD, battery and payload combinations provided by Germandrones and verified for all setups that are delivered to a customer. Should you have any reason to assume that this has changed (due to modifications, repairs, etc.) please recheck the center of mass.



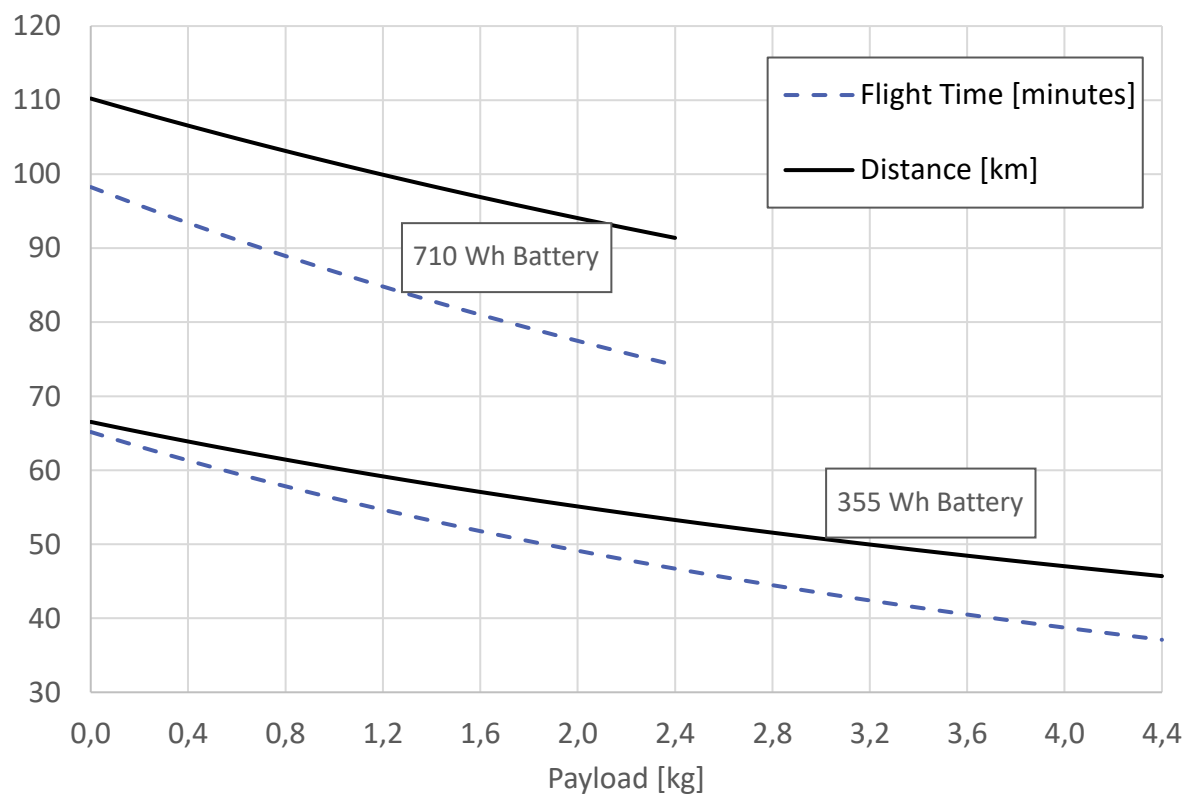
9.2 Flight Time & Distance

The following tables provide an indication of what flight time and distance can be achieved with certain setups.

SONGBIRD 100:



SONGBIRD 150:



Note: The above data originate from multiple flights in different conditions and represent an average. The actual performance depends on a variety of factors:

- *Wind can significantly decrease the distance over ground (see section 9.5).*
- *Environmental factors such as air density and temperature can impact the performance. Moreover, it is normal to see the power consumption change vividly as the flight controller reacts to thermals or turbulences. Therefore, the cumulative energy consumption can vary even between similar flights.*
- *The above data include typical sources of drag such as a gimbal camera payload and antennas. Any additional aerodynamic drag decreases the performance.*
- *The data do not include the additional power that some payloads draw from the flight battery! For example, a long-range HD video transmitter can draw up to 45 W and thus decrease the flight time and range by up to 12 %.*
- *For safety reasons, it is strongly recommended to leave some buffer capacity in the battery according to section 9.4.*

Long Missions

If the mission requires utilizing the maximum possible flight time, please consider the following:

- Energy may be saved during takeoff and landing by conducting these manually and reducing the time spent in COPTER mode. This is only recommended to experienced pilots. Please keep a safe distance (at least 25 m above ground or obstacle) for the transition, nevertheless.
- The landing approach may be initiated slightly later than at the 20% remaining battery charge, recommended in section 9.4. This is only recommended to pilots who are very familiar with the aircraft's behavior under the current conditions (temperature, altitude, payload, wind, battery type, etc.)
- Decreasing the airspeed (slightly) below the value recommended in section 9.3 can reduce the power consumption but also decreases the margin of safety. It should only be done in calm conditions and under the pilot's responsibility!

Note that a lower airspeed can increase flight time while reducing range.

9.3 Airspeed

As the flight controller cannot know the loading of the UAV, the user must set an adequate airspeed manually. Please use at least the value from the table. It does not need to be adjusted when flying lighter, i.e. a faster airspeed than specified in the table is okay but will be less economic.

To preset the airspeed, go to the Settings menu and Flight Settings. The default airspeed can be set in the bottom right corner of the pop-up window.

You can also use the “Set Airspeed”-button that appears in the bottom right corner of the map. Note that this will only influence the airspeed temporarily – it will be reset when the flight mode is changed. This option may be useful to adapt the airspeed to changed conditions quickly, e.g. when rain or strong wind arises.

<i>TOTAL MASS (KG)</i>	<i>LOAD (KG) SONGBIRD 100</i>	<i>LOAD (KG) SONGBIRD 150</i>	<i>SPEED-TO-FLY (M/S)</i>
9.4	2.6	x	16.8
9.6	2.8	2.0	17.0
9.8	3.0	2.2	17.1
10.0	3.2	2.4	17.3
10.2	3.4	2.6	17.5
10.4	3.6	2.8	17.7
10.6	3.8	3.0	17.8
10.8	4	3.2	18.0
11.0	x	3.4	18.2
11.2	x	3.6	18.3
11.4	x	3.8	18.5
11.6	x	4.0	18.7
11.8	x	4.2	18.8
12.0	x	4.4	19.0
12.2	x	4.6	19.1
12.4	x	4.8	19.3
12.6	x	5.0	19.4

12.8	x	5.2	19.6
13.0	x	5.4	19.7
13.2	x	5.6	19.9
13.4	x	5.8	20.0
13.6	x	6.0	20.2
13.8	x	6.2	20.3
14.0	x	6.4	20.5

Note: The load values in the above table refer to typical SONGBIRDS with empty masses of 6.8 kg (model 100) or 7.6 kg (model 150), respectively. If your aircraft is heavier due to extra equipment or modifications, please refer to the total-mass-column only.

9.4 Return & Landing Calculation

Batteries do not degrade linearly which can be critical for landings: Shortly before they are fully depleted, their power drops to a point at which hovering and holding altitude is not possible anymore. Thus, it is important to note that the weights specified in the table in section 9.1 refer to a minimum charge status of 10 %. When flights are conducted beyond this point the batteries may be damaged and safe flight characteristics cannot be guaranteed anymore.

It is best practice to initiate the landing approach when the battery status reaches 20% at the latest. In some conditions you should add an additional margin as shown in the table below.

Minimum Battery Status (%):

<i>CONDITIONS</i>	<i>BEGIN LANDING APPROACH</i>	<i>LANDED</i>
Normal	20 %	10 %
Wind gusts 6 m/s (21 km/h) or more	add 5	add 5 %
Heavy load (within 300g of the max. according to the tables in 9.1)	add 5 %*	add 5 %
Extended landing phase (e. g. returning after BVLOS flight, transitioning at altitudes higher than normal, etc.)	add accordingly*	-

Example: The landing approach with a fully loaded SONGBIRD in windy conditions should be initiated when the battery reaches $20\% + 5\% + 5\% = 30\%$.

*A typical SONGBIRD consumes 1-2 % battery per minute and per kilometer in cruise flight which can be used as a reference. You may also refer to the “Battery Remaining” indication, which can be found in the Telemetry widget. It displays the remaining flight time based on the previous power consumption. An indication of 00:00 means that the remaining charge only lasts for a transition to COPTER and a landing (from an altitude of 50 m max.). Note that head winds can significantly decrease the actual remaining range (see section 9.5).

Caution: The battery % indication may be misleading when a wrong battery type has been selected or the battery wasn't fully charged. Always monitor the discharged mAh and the voltage as well. The latter is subject to various influences but as a rule of thumb you can suppose that:

100% ~ 33.5V

30% ~ 29.7 V

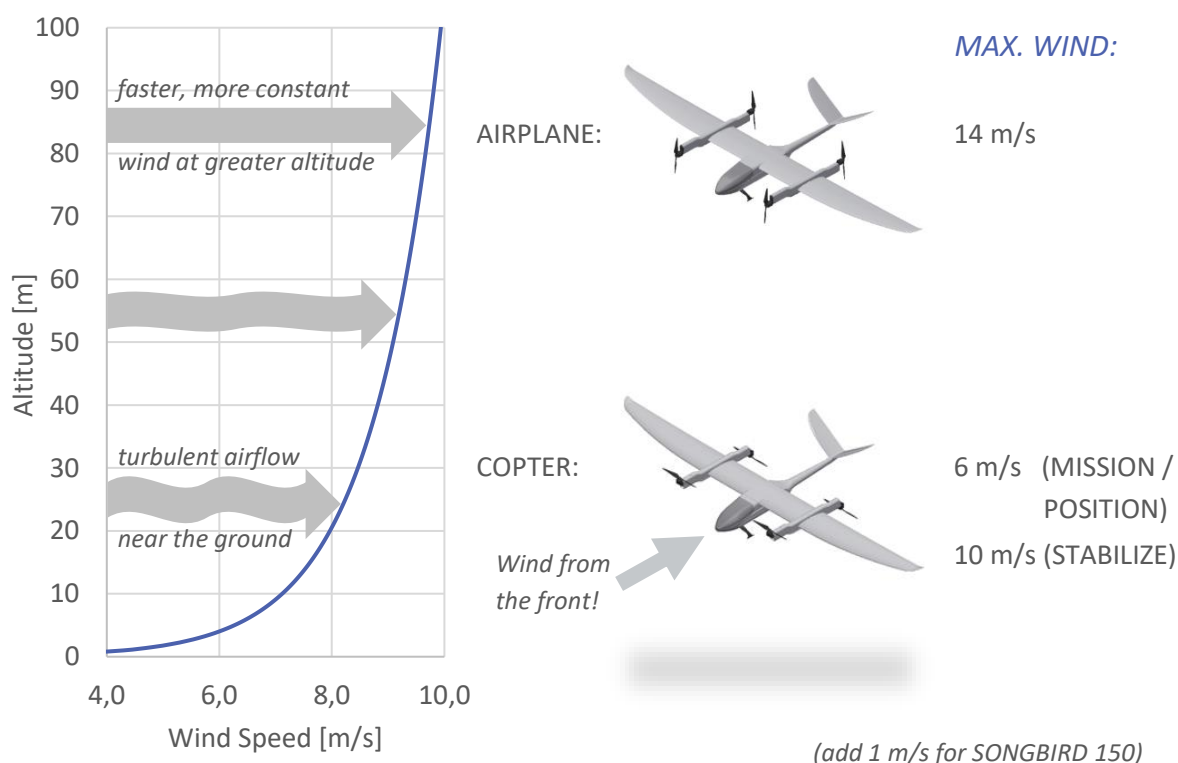
50% ~ 30.1 V

20% ~ 29.4 V

9.5 Wind & Rain

Strong Wind and Flight Modes:

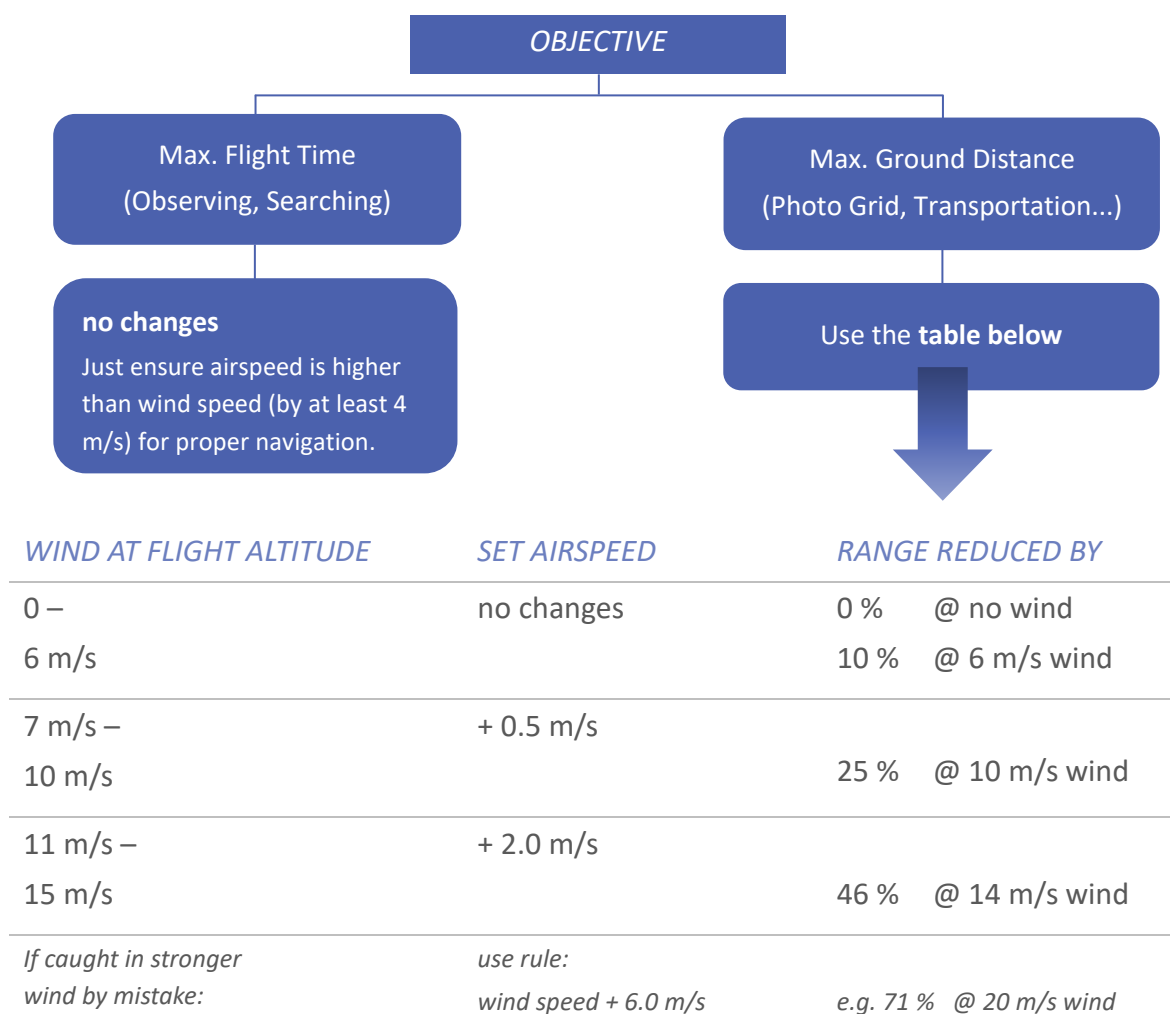
The airspeed in COPTER and POSITION or MISSION mode is limited for safety reasons. If wind gusts exceed 6 m/s (21 km/h, please measure approx. 2 m over ground in an open area) this can lead to drifting downwind or a jerking attitude as the flight controller is unable to compensate for the wind steadily. In such conditions you may be required to take manual control: Using the COPTER mode is possible in wind speeds of up to 10 m/s (36 km/h) in STABILIZE. In such conditions it is especially important to keep the Nose pointed towards the wind. While the wind at higher altitudes is stronger (see the graph of a typical wind distribution below) the SONGBIRD flies faster in AIRPLANE mode, so that wind speeds up to 14 m/s are acceptable at cruising altitude.



Strong Wind and Flight Planning:

- Safe airspeed: When turbulences or strong gusts are expected, raise the airspeed by at least 1 m/s.
- Mission planning: When planning a mission in windy conditions, please consider that the speed over ground can become very small. The time and energy needed to cover a certain ground distance may be greatly increased. The head- and tailwind sections on a round trip do not compensate for each other!

→ You may be required to increase the airspeed from section 10.3 and expect a reduced range.



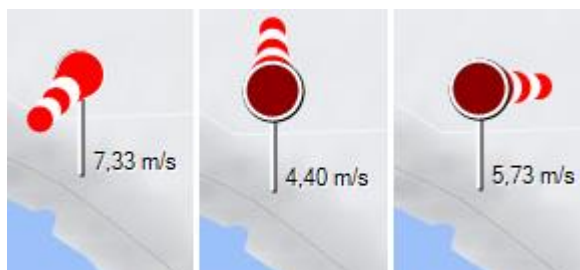
Note: The above table is valid for typical round-trip missions. Failing to set the optimal airspeed will amplify the reduction of range. If the wind at flight altitude is unknown, using “wind at ground level · 2” works as an approximation in the typical use cases. Please seek advice from local experts when flying in areas with irregular wind such as mountains.

Wind Indicators in the GCS:

- When connected to the internet, the weather at the current map location will be displayed at the upper right-hand corner of the map.



- The flight controller calculates the wind direction and speed based on the differences between air- and ground-speed (note that the data can therefore be unprecise until the SONGBIRD has spent some time in cruise flight). The result is displayed by the windsock



Examples: 7.3 m/s wind from the northeast, 4.4 m/s from the south, 5.7 m/s from the west.

symbol in the upper right-hand corner of the map. Examples: 7.3 m/s from the northeast, 4.4 m/s wind from the south, 5.7 m/s from the west. The data can also be viewed in the Telemetry widget. The automatic orientation of the nose into the wind during automatic landings uses these data.

Rain:

The SONGBIRD is splash water protected and can withstand moderate rain. Wetness may, however, reduce the overall product lifetime. It is recommended to interrupt the mission and conduct a normal landing if there is more than just a temporary drizzle.

Rain can reduce lift and efficiency. If possible, raise the airspeed by at least 0.5 m/s in rainy conditions.

Fog or Clouds:

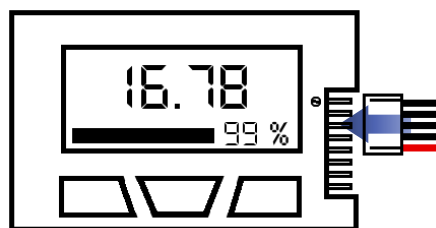
Water will collect on the airplanes surfaces in foggy conditions so it should be treated like light rain.

Moreover, it is recommended to avoid flying in fog longer than necessary. Moisture can enter the airspeed sensor making for lower readings and thus causing the flight controller to fly faster than needed. This effect will build up over time and can be monitored through the Air- Groundspeed plot (as explained in section 0 – Airspeed). After letting the UAV dry, the sensor will function normal. A calibration is not needed in this case.

10 USING THE BATTERIES

Important remarks

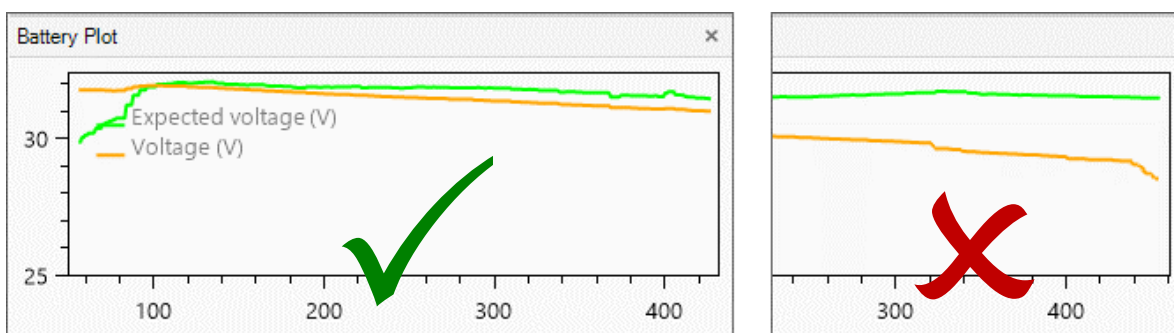
- It is recommended to start flights only with fully charged and faultless batteries. Otherwise, a potentially dangerous misjudgment of the remaining capacity and flight time can occur (for details, see “Battery status” in section 8.5)
- Signs of a faulty battery can include
 - swollen cells or physical damage
 - unusual smell
 - cell drift (voltage difference between individual cells) of more than 0.1 V. This should be checked regularly with a LiPo checker.
 - discrepancies in the battery plot (see below)
- Lithium polymer batteries (LiPo) should always be protected from severe mechanical action.
- A LiPo battery should never be discharged below 3.3 V (without load) per cell
- If a LiPo battery is not in use for more than two weeks, it should be brought to storage voltage (approx. 3.8 V per cell – you can use the storage mode of the charger) and its status should be checked once a month.
- When you connect or disconnect a battery, grab the connector and not the cable.
- Store LiPo batteries in a safe place away from flammable material.



Note: Other than for checking cell drift, LiPo checkers are useful to determine the approximate charging status of batteries. As they only measure the voltage, their estimation of the capacity can be inaccurate – therefore do not worry if they display less remaining capacity after a flight than the GCS. Rather check if the “Battery Used mAh” information in the Telemetry widget matches the capacity that your charger displays after recharging.

Battery Plot

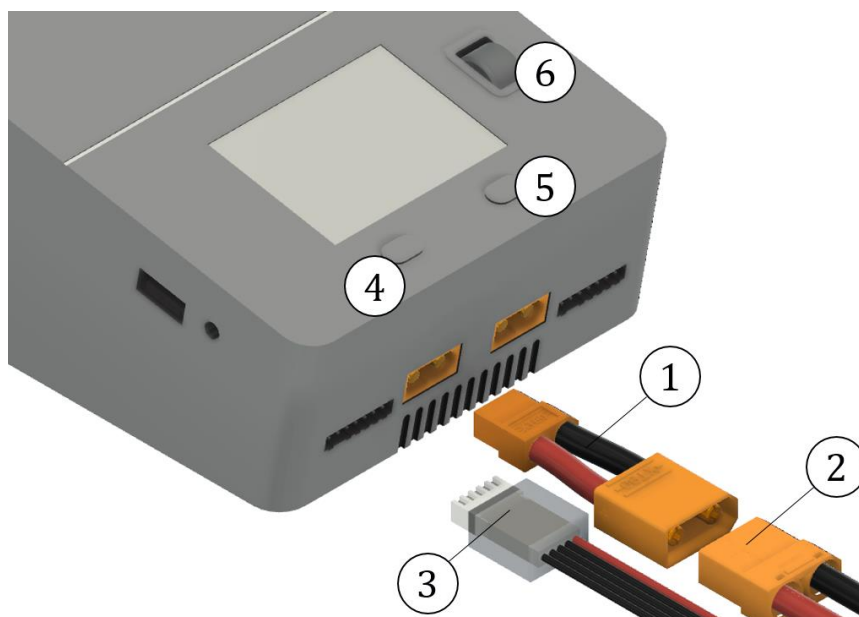
The Battery Plot can be selected in the View menu. It compares the flight battery's expected voltage to its actual value. Be cautious when the orange plot is clearly lower than the green plot. Reduced battery performance can be associated with low temperature (which improves as the battery warms up) or poor battery health. A strong and permanent deviation can indicate a loss of usable capacity. Allow for an extra buffer in this case and exchange the battery soon.



Note: For the battery plot to work properly, the correct battery type must be set (right-click on the battery-percentage indicator to check your selection).

Charging

With the delivery of the SONGBIRD you have received an ISDT D2 dual charger (Part No. 9 in chapter 3). This charger can charge a pack consisting of two batteries simultaneously with a max. output of 200 W.



You can power the charger from an outlet with 100 – 240 V AC and it switches on immediately. Plug the short XT60-XT90 adapter cable (1) into the first port of the charger and connect the power cable of one LiPo battery (2). Then plug the balancer cable (3) of the same battery into the balancer port next to it. Pay attention that it must be connected in the leftmost position. Repeat for the second battery using the ports on the other side.

Now press the channel 1 select button (4) and press the shuttle key (6) to make the task setting menu for channel 1 pop up on the screen. The items in the menu should be set as follows:

CH1 Task settings	
Select task	Charge
Battery type	LiPo
Cell Voltage	4.20 V
Cell Count	4S
Current setting	6.0A
Start task	

If everything is set correctly, the task can be started by choosing the corresponding item in the menu. To start charging a battery connected at the other side just follow the same procedure after pressing the channel 2 button (5).

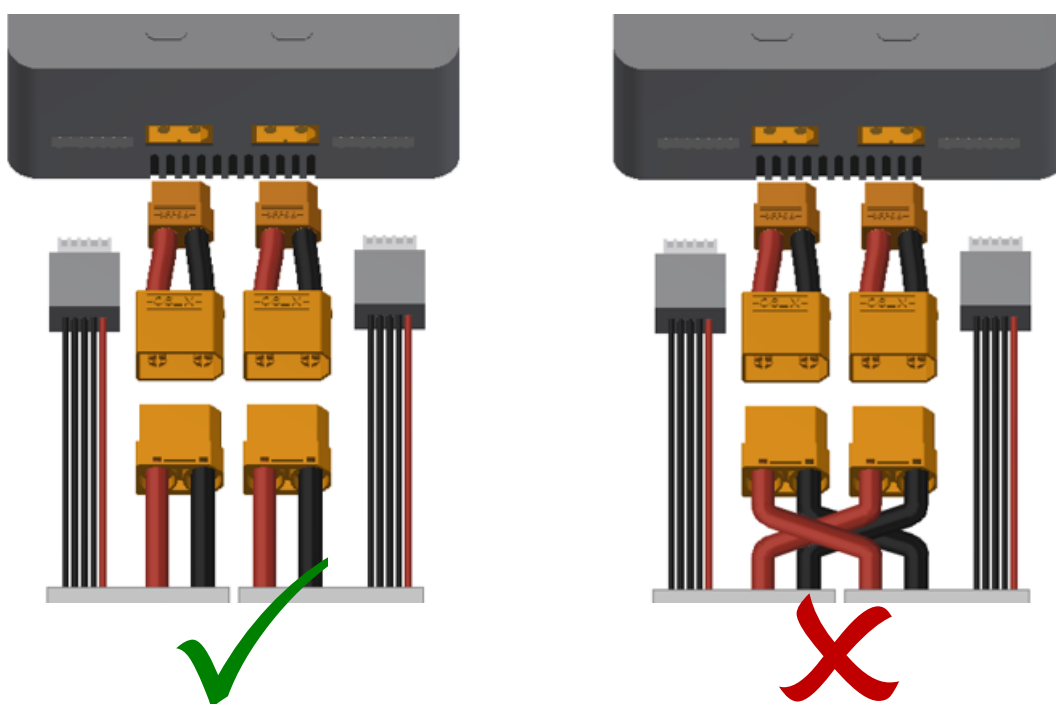
The display is divided in the middle and each half will show status information about the charging process at the corresponding channel. The following illustration provides an example.

00:51:00 CH1	01:16:30 CH2
6.0 A	0.3 A
LiPo - 4S	LiPo - 4S
5.88 Ah	7.50 Ah
16.2 V	16.8 V
4.03 ~ 4.08 V	4.20 ~ 4.21 V

The colors indicate whether the charging is still in progress (Red), nearly finished (green) or finished (blue). Waiting until it is finished is always recommended.

Unplug the battery after charging. For flying you always need a pack of two fully charged 4 Cell LiPo batteries.

Note: When charging two batteries, double-check that the power- and balancer cables of each battery are connected to the same channel.



The procedure described here refers to the charging of the delivered batteries for the Songbird. The Songbird works with 8-cell LiPo batteries consisting of two single 4-cell batteries. If you want to charge other batteries or use other functions of the charger, please refer to the enclosed instructions of the ISDT D2 dual charger.

Never leave charging LiPo batteries unattended. Also pay attention to the surface beneath the charger – it must be heat-proof, fire-proof and non-conductive.

It is recommended to use only batteries provided by Germandrones.

11 MAINTENANCE

A universal life span of UAV components cannot be defined because environmental operating conditions are the driving factor. Therefore, the approach to ensure safety and enhance the operational lifetime of the SONGBIRD is to perform frequent checkups which can be done by the customers. In addition, inspections and the periodic replacement of wearing parts is done by Germandrones its representative.

You will notice some overlap between the tasks listed in this chapter and the preflight- and “Changed Conditions” checklist. While those are optimized for field operation, performing the tasks below is recommended between deployments.

The flight time and total flights counter will help you to determine if a check-up is due. It is displayed in the Message widget of the GCS every time a connection with a SONGBIRD is established as well as after every landing. The flight hours can also be seen in the logs (see section 8.7 for instructions on retrieving log files). In case of any questions or detected failures, please contact Germandrones.

11.1 Regular Check-Ups

Check frequently (e.g. before every new deployment):

- Verify that all propellers are securely tightened.
- Check propellers for damage. Propellers are prone to impacts of small particles during takeoff and landing and may show signs of wear. They may need to be rebalanced and eventually replaced. Pay close attention to the correct orientation when replacing a propeller.
- Check all linkages for possible mechanical clearance.
- Verify flawless movability of all control surfaces.
- Check for any loose parts inside the fuselage.
- Check that the joints of all four motor-tilt-mechanisms are still tight.

Additionally, check every 25 flight hours or 50 flights

or after flying under unusual circumstances (dust, moisture, heat etc.) and after rough landings, long distance transportation or long-term storage:

- Check the fuselage, wings and landing gear for cracks or any other signs of structural damage.
- Check for any loose plugs. They should fit tightly and require some force to remove. This applies especially to the battery connectors.
- Check visibly for broken or loose contacts in wires and connectors.
- Check the inside of the fuselage, the motor-tilt-mechanics and the motors for dirt, dust, or moisture.
- The lid at the bottom side of the motor arms is held by tiny screws. Check them for tight fit.

- Ensure that the screws holding the center wing and the v-tail have no play and that the outer wings are held tightly by the locking mechanism. It should snap back into place, after being pulled outwards slightly.
- Check the battery for signs of deterioration. Dispose of inflated LiPo batteries and replace them. Check voltage and cell drift as explained in chapter 10.

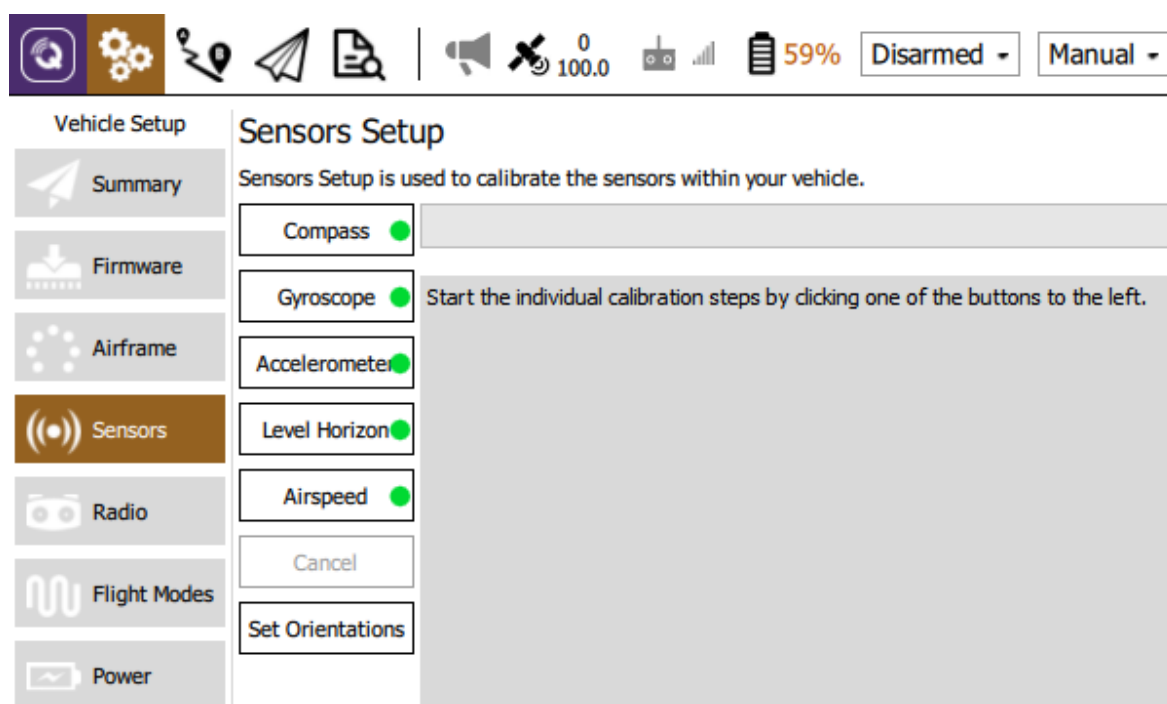
Please contact Germandrones for a general check-up every 100 flight hours.

- All parts will be checked for wear and potentially changed.
- Servos will be replaced routinely.
- Motor shafts and bearings will be replaced routinely.
- In addition, after 400 hours the complete propulsion chain, joints and all regularly used connectors are replaced.

11.2 Calibrating

The SONGBIRD is equipped with various sensors, some of which need to be calibrated occasionally. In this section you will find a list of the sensors with information when to calibrate them and how to do it.

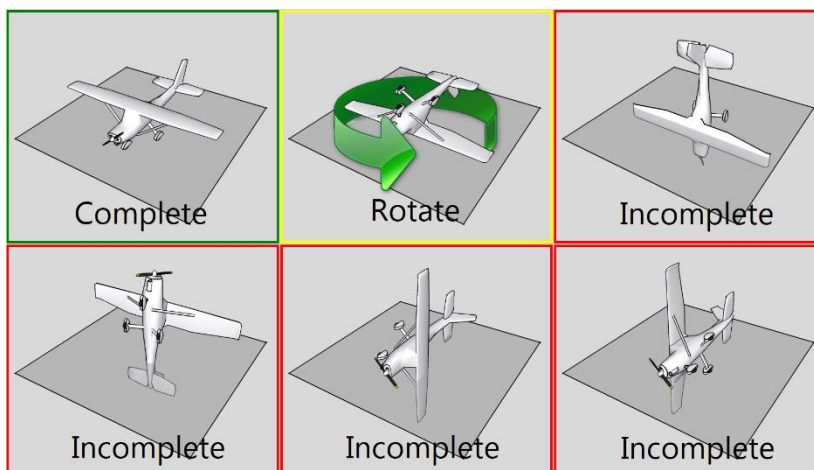
To calibrate any sensor, you need the software “QGroundControl” which can be downloaded from qgroundcontrol.com free of charge. Ideally, you install it on your ground station computer. Setup the SONGBIRD and your telemetry module as usual, start QGroundControl and it will connect automatically (if not, go to “Comm Links” in the main menu, click “Add”, choose “serial” and the COM port of your device). Navigate to the Vehicle Setup menu and select Sensors. Here you can start the calibration process for each of the sensors.



COMPASS

When to calibrate: The magnetometer usually needs no calibration. It can become necessary when changes have been made to the airframe that change its magnetic properties. Calibrate the compass if you see corresponding error messages in the GCS Message widget or if the heading of the SONGBIRD symbol in the live map clearly does not match its actual orientation.

How to calibrate: Click on the Compass button and “Ok” (the setting in the drop-down menu should be ROTATION_YAW_90). Place the SONGBIRD in any of the six basic orientations shown on the screen. Hold it still and begin to rotate around the specified axis in either direction when prompted to do so. When the calibration is complete for the current orientation the corresponding image turns green. Repeat the process for the other orientations. No USB cable should be plugged into the flight controller during calibration.



GYROSCOPE

When to calibrate: Calibrate the gyroscope in case the flight controller repeatedly refuses to arm the vehicle and a message is displayed in the Message widget “Gyro sensors inconsistent”. You can also try this in case of an “EKF internal checks” error after calibrating the accelerometer.

How to calibrate: Place the SONGBIRD on a level surface, start the calibration and wait until the progress bar shows that the process is finished.

ACCELEROMETER

When to calibrate:	Calibrate the accelerometer in case the flight controller repeatedly refuses to arm the vehicle and a message “EKF internal checks” or “Accels inconsistent” appears in the Message widget. The latter is accompanied by a number indicating the residuals.
--------------------	---

Note: IMU drift can occur during the warmup-phase. Often, restarting the aircraft or waiting for a few minutes can help – if you try arming several times, the residuals should approach 0.900 at which point the UAV can be armed.

How to calibrate:	The process is very similar to that of the compass calibration, except that you will not rotate the aircraft but simply hold it still in each position.
-------------------	---

LEVEL HORIZON

When to calibrate:	Use this function if you notice a false pitch or bank angle being displayed in the GCS (of more than 1 or 2 degrees), for example, when the aircraft sits on a level surface before takeoff. You may also notice an asymmetrical deflection of control surfaces in such case. Note that a uniform “up”-deflection of the elevators by a few mm is normal on the ground.
--------------------	---

Leveling the horizon may become necessary after calibrating the accelerometer or gyroscope.

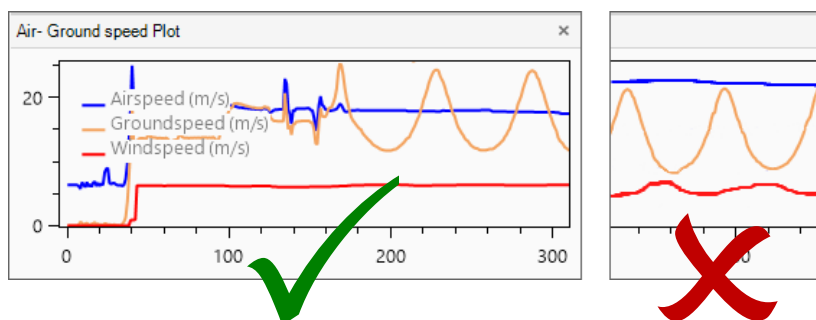
How to calibrate:	Place the SONGBIRD on a level surface, click on the Level Horizon button and “Ok” (the setting in the drop-down menu should be ROTATION_YAW_90). The current orientation will be saved.
-------------------	---

AIRSPEED

When to calibrate:

The airspeed sensor should be calibrated if it reads 2 m/s or more in completely calm air (e.g. indoors) or if its reading seems otherwise implausible. Note that flight preparation in windy conditions can cause the system to assume a miscalibration due to the high airspeed measured on the ground when actually there is no problem. You can follow through with the flight in this case or restart the aircraft while sheltering the airspeed sensor to ensure a correct reading at startup.

Please also check the Air- Ground speed plot occasionally. When the SONGBIRD flies in changing directions (e.g. in circles) the wind's influence on the ground speed will constantly change, causing the graph to oscillate. The max. and min. values should roughly be equidistant from the measured airspeed. If the airspeed graph is clearly above the median of the ground speed, it must be calibrated. If you notice this during flight, increase the airspeed, as such offset could lead to the flight controller over-estimating its airspeed and causing a stall!



If the airspeed reading is clearly too low, the flight controller will tend to fly faster than necessary. It should also be calibrated.

Note: The indicated airspeed also depends on the air density. In case of the SONGBIRD you can assume the ground speed to be increased by approx. 1 m/s per 1000 m above sea level. E.g. choosing a value of 19 m/s according to section 9.3 will result in a "true airspeed" of $19 \text{ m/s} + 2 \text{ m/s} = 21 \text{ m/s}$ at 2000 m MSL, which is intended.

How to calibrate:

Shelter the sensor from wind but do not touch it. Start the calibration process. After some time, you will be prompted to blow into the sensor for verification. Keep it sheltered for three more seconds afterwards. Then the calibration is done.

12 SAFE OPERATION

Please observe the following rules to ensure safe operation of the SONGBIRD:

- The SONGBIRD must never be operated within the immediate **proximity of people**. Also, do **not fly above people**.
- Moreover, people should not stay near a ready-to-fly-UAV. Spinning or unexpectedly armed propellers are especially dangerous!
- **Always prepare flights thoroughly** and conduct all preflight checks. The checklists provided in the annex can help you with this.
- Never fly with damaged parts.
- Only take off with **fully charged batteries**.
- Never fly until the battery is completely drained. **Always keep a reserve** for approach, landing and possibly a second attempt, as explained in chapter 9.4.
- **The SONGBIRD must always be operated within its inherent flight envelope.** In normal operation, the flight controller will take care of this – however, do not initiate risky maneuvers deliberately and **avoid abrasive control inputs**. Fly calmly and foresighted. The SONGBIRD is designed as working equipment and not as an aerobatic aircraft.
- Respect the aircraft's **operational limits** regarding temperature, takeoff mass, wind speed etc. You can find the relevant data in the chapters 2 and 9 of this manual.
- Keep in mind that you are taking part in air traffic.
- **Never fly in controlled or restricted airspace without permission!**
- Please inform yourself about the legal requirements in your area. This may include obtaining a flight permission and/or air traffic control clearance. Always hold a valid insurance.

- Inform yourself about the frequencies you are using (usually 433 MHz, 868/900 MHz, 2.4 GHz). Check if you can use them in your area and avoid interference. If you are unsure about your setup or environment, do a range test – on the ground it should be possible to move the transmitter and ground station at least 150 m away from the UAV without issues.
- **Take on responsibility for maintenance of the SONGBIRD** (see chapter 11).
- **The SONGBIRD is intended for professional use.** It should only be operated by responsible individuals who have fully understood the instructions. It is strongly recommended to take part in a training course before piloting the UAV.
- Please make sure to have a clear allocation of tasks for all persons involved.

Emergency Checklist



General Malfunction (unstable flight, wrong path, loose parts...)

- Switch to **COPTER** and **Pos. Hold**
- The SONGBIRD will stop moving. You can now decide how to proceed.

Lost Connection with UAV

- If in MISSION mode, just wait until the UAV comes closer.
- If RC transmitter malfunctioning, use the GCS instead. Right click on map and "go to location" to make the UAV come back. You can use the GCS to issue an automatic landing later.

Motor(s): Power Loss / Malfunction

- Stay in **AIRPLANE mode**. The UAV cannot be controlled in COPTER mode with three or less active motors.
- Do an **emergency landing** in AIRPLANE mode (in gliding flight if necessary). Choose a location free of people even though the UAV may take damage when landed in rough terrain.
- Tell assistant to **warn people** in the designated landing area.

After a Crash:

- **Disarm**
- **Do not** turn off the transmitter.
- **Disconnect** the battery
- If serious **injuries** or **damage to property** occurred:
Emergency call: **112** in Europe
911 in North America
_____ your local emergency call number.

(You may want to note down the number of local operation controllers.

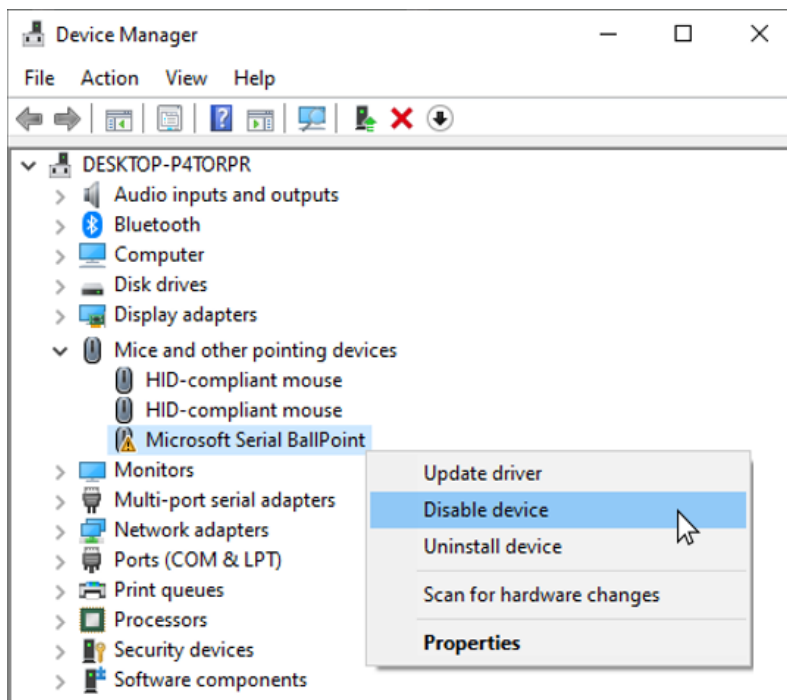
Often, they can act quicker than general emergency number operators.)

- (later) Inform Germandrones of the crash to discuss how to proceed.

13 TROUBLESHOOTING

The following instructions may help solving common problems. You should not start a flight while they persist.

<i>PROBLEM</i>	<i>POSSIBLE SOLUTION</i>
Motors do not arm:	<ul style="list-style-type: none">▪ When this happens check the error message in the GCS for further information. It probably indicates a missing step in the mission preparation or a sensor that needs to be calibrated.▪ Disarming (turn arming knob back) and waiting for a few seconds before trying to arm again can solve the problem, as the system needs time to find GNSS satellites etc.▪ Check if all parts are connected properly.▪ If the autopilot refuses to start a mission, check if the vehicle is placed in a zone that is forbidden by a geofence. It may not be obvious in case a geofence is still existing from an earlier mission. To resolve this problem, you can create a new geofence (that allows the current location to be flown at) which will overwrite the old one.
Ground Station cannot connect / send / receive	<ul style="list-style-type: none">▪ Check if the MAVLink module has been recognized as being connected to a COM-port in Windows Device Manager and select the corresponding COM-port manually in the mission planner. Also check the Baud rate (57600) and make sure that the flight controllers are powered.▪ Ensure that no other device interferes with the signal. When using a Dragon Link
Mouse cursor makes erratic movements	<ul style="list-style-type: none">▪ This can be caused by an error in MS Windows causing the computer to mistake the telemetry module for a mouse. Turn off the UAV but leave the telemetry module plugged in. Then go to the Windows device manager and find “Windows ball-point mouse” in the list. Right-click and disable it (do not uninstall!). Then you can turn the SONGBIRD back on.



GCS connected but data exchange is slow, or UAV does not react

- If it happens in flight: The weak signal due to long distance transmission can cause some packets to get lost. Repeat trying to send the command a couple times.
- Ensure that no other device interferes with the signal. This can happen, for example, when using a Dragon Link in conjunction with a 868 MHz telemetry module and trying to exchange data during the mission setup. Move the interfering transmitters/receivers away from each other. Usually the problem will be gone in flight.

No control over the camera

- The GCS must be connected to the UAV and the joystick symbol in the upper-right hand toolbar must be selected (green).
- Check if the joystick is configured correctly (see chapter 8.7).

Payload not working

- Doublecheck if the payload box is pushed all the way down so that the connector is plugged in properly.
- Check if the payload port is powered (Camera Control widget → Turn power on / off).

No control via the transmitter.

- Check that both the SONGBIRD and the transmitter are switched on, with sufficient battery voltage.
- If the problem occurs inflight: The signal may get lost due to obstacles or long distance. Depending on the safety settings in the GCS, the Autopilot may return and land automatically.
- Ensure that no other device jams the signal.
- In case parts were used otherwise, the transmitter and receiver may need to be linked again. In the transmitter's menu, scroll down to "System" - "Link" and press return. Then power on the SONGBIRD. The system will bind within a few seconds. If you use a Dragon Link range extender, please contact Germandrones for detailed instructions.

Servos / control surfaces dither on ground.

- Gentle movements can be issued by the flight controller which is always active. But strong jittering can indicate a damaged servo, please contact Germandrones for a replacement in this case.
-

14 ANNEX

Packing Checklist

Minimal / Necessary for Flight

Date: _____

Transport Box

1. Fuselage /w 2x Screws	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Midwing / Middle Section /w 2x screws	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Motor Arm left	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Motor Arm right	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. V Tail /w screw	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Wing / Outer Section left	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Wing / Outer Section right	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Nose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Battery	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Payloadbox	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Transmitter & belt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Spare propellers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Ground Station

1. Ground station	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Radio module + antenna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. LiPo Tester	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Additional Equipment (Optional)

Supporting Equipment

1. Roll of tape	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Velcro	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Zipties	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Flat screwdriver	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Philips screwdriver	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Cutter knife	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Superglue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Small sidecutter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Propeller Tool	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Charging of Batteries

1. Charger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Power cord for charger	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Balancer board if necessary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. 2x XT60→XT90 adapter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Generator (Check oil)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Extension cord	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Fuel for generator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Preflight Checklist

SETUP

Check wind ≤ 6 m/s at takeoff/landing site (≤ 7 m/s for SONGBIRD 150)

Check forecast: light rain max., no thunderstorms

Payload ready; weight within "allowable load" limits

All Plugs 1 - 10 connected & tight (*partially not used in all versions of the SONGBIRD*)

No damage to propellers or their mounting, propellers not loose

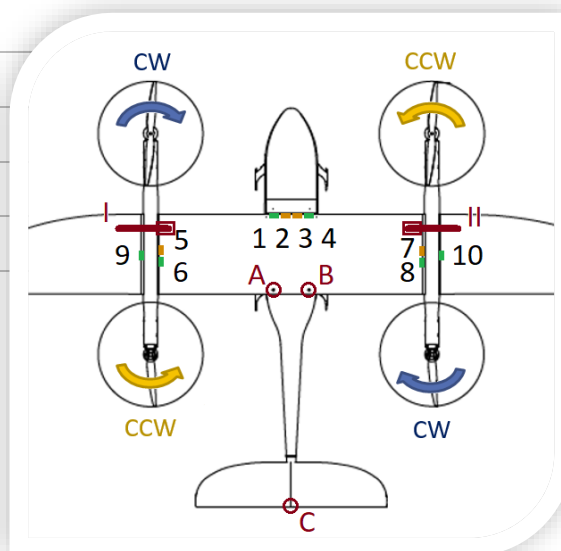
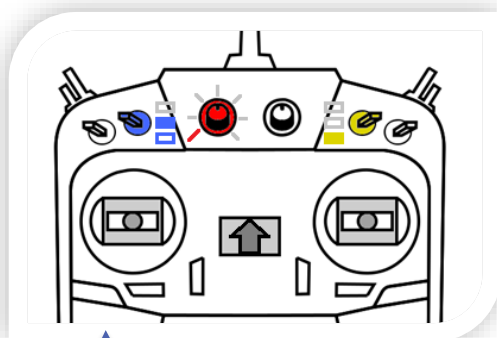
Middle wing screws fastened (A, B)

V-Tail-Screw fastened (C)

Outer Wings locked in (I, II)

Battery mounted securely (not connected yet)

Transmitter between 7.6 V and 8.4 V



BEFORE TAKEOFF

RC transmitter ON, DISARMED, COPTER, STABILIZE or POS. HOLD

Connect battery plugs & check tight fit

Mount nose cone

Prepare mission via GCS & Upload

Mission has safe altitude and airspeed, T/O and landing path preferably against the wind. Emergency settings adequate for the mission.

All servos and control surfaces working (may use STABILIZE to check it)

Battery voltage in GCS ok (normal: ≥ 33.5 V)

Nose in the wind

Launch site and departure path free

Set POS. HOLD

Arm

Check: All four propellers spinning

Switch to MISSION or increase throttle to take off manually

Changed Conditions Checklist

Complete this Checklist in addition to the preflight Checklist when aircraft parts have been altered, after long storage or travel or in new environmental conditions.

Unfamiliar site:

- Check local conditions (delimited takeoff/landing spot, flight area, obstacles, people, hazards...)
- Determine emergency landing spot/area; take measures to keep it free, if necessary


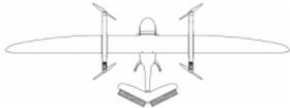
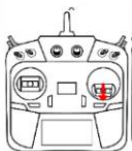
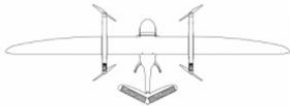

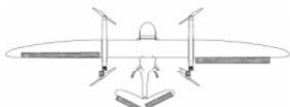

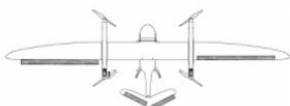
Before assembly:

- Check all pins (Spars, Anti-Torsion Pins)

After assembly:

- Check all control-surface-linkages for loose parts
- Check fixation of parts prone to mechanical stress, e. g. Motor mounts
- Check fastening of all removable parts:
 - Middle wing (screws)
 - outer wings (locking mechanism)
 - v-tail (screw tight, no play)
 - propellers (fastened with correct orientation, labels facing up),

Check control surfaces:

Pitch Down		Left Rudder DOWN		Right Rudder DOWN
Pitch UP		Left Rudder UP		Right Rudder UP
Roll Left		Left Aileron UP Left Rudder DOWN		Right Aileron DOWN Right Rudder UP
Roll Right		Left Aileron DOWN Left Rudder UP		Right Aileron UP Right Rudder down

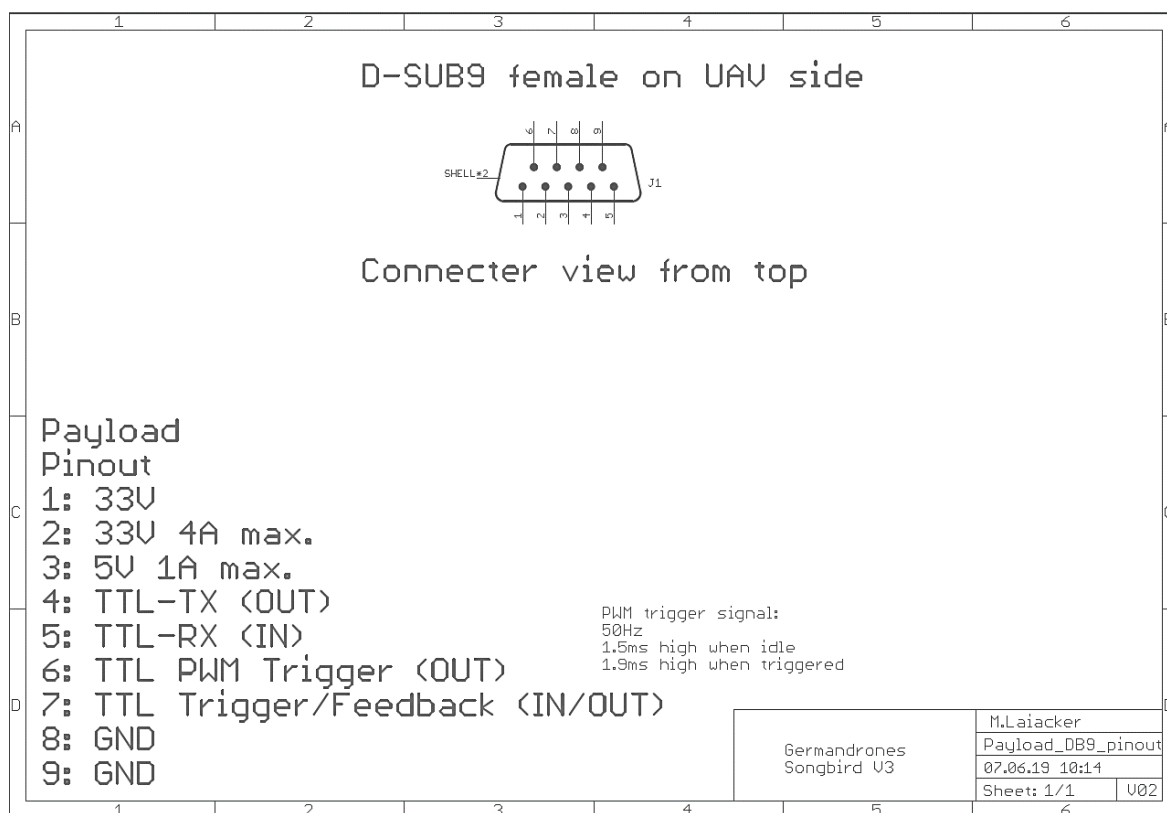
Check reaction of control surfaces to bank and pitch movements:

- Nose up → Pitch down reaction
- Nose down → Pitch up reaction
- Bank right → Roll left reaction
- Bank left → Roll right reaction

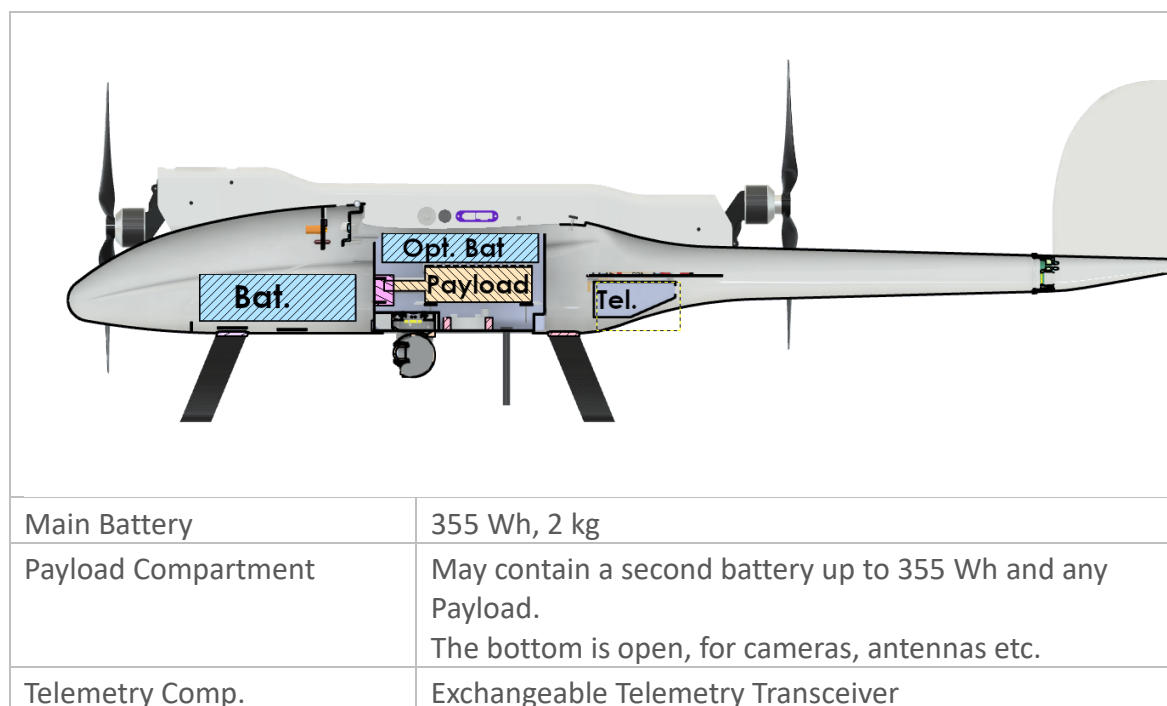
Test Hover: It is recommended to conclude this Checklist by hovering manually for a few seconds to verify the correct functioning of the vital systems.

Payload Integration Documentation

PAYLOAD CONNECTOR



PLACEMENT OF BATTERY AND PAYLOAD EQUIPMENT



Declaration of Conformity

Germandrones GmbH,
Alt-Moabit 55, DE-10555 Berlin,

hereby declares that the UAS **Songbird v3** complies with the requirements of the directives:

2014/30/EU (EMC) and 2014/53/EU (RED).

The product conforms to the relevant harmonized European standards:

ETSI EN 300 220-1 V2.4.1:2012	EN 50581:2012
ETSI EN 300 220-2 V2.4.1:2012	EN 55014-1:2006+A1:2009+A2:2011
ETSI EN 300 220-4 V1.1.1:2017	EN 55014-2:1997+A1:2001+A2:2008
ETSI EN 300 440 V2.1.1:2017	EN 55022:2010+AC:2011
ETSI EN 300 328 V2.1.1:2016	EN 55024:2010+A1:2015
ETSI EN 301 489-1 V1.9.2:2011	EN 55032:2015 CLASS B
ETSI EN 301 489-3 V1.6.1:2013	EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013
ETSI EN 301 489-17 V2.2.1:2012	EN 61000-3-2:2014
	EN 61000-3-3:2013
	EN 61000-4-3:2006+A1:2008+A2:2010
	EN 61000-4-2:2009
	EN 61000-6-1:2007
	EN 61000-6-3:2007+A1:2011+AC:2012
	EN 62311:2008
	EN 62479:2010

Warning: This is a Class A product. In a domestic environment, this product may cause radio interference, in which case the user may be required to take appropriate measures.

Disposal

Please note that some components of the SONGBIRD and ground equipment may not be disposed of via municipal waste. Contact GERMANDRONES for further information.

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