ALBATROSS UAV

USER MANUAL

Applied Aeronautics. Revision 1.4

PRE-FLIGHT CHECKLIST:

- **Assemble Albatross:**
  - Tail pieces x 2
  - Wings x 3
  - Battery
  - Landing gear (rear and nose)
  - Fuselage and canopy

- **Airframe Check:**
  - Check all control surfaces and make sure there are no loose parts.
  - Check that the motor is firmly mounted and that the propeller is not slipping and the spinner firmly attached.
  - Check the wheels and mount points, in particular the nose gear and wheel collars on the main landing gear axles are tight.
  - Check that all items are secure including internal batteries, applicable cameras and the airspeed adapter.
  - Physically check the LIDAR unit on the underside of the fuselage

- **Balance Check:**
  - The center of gravity is located 90mm from the leading wing edge. This should be the balance point of the Albatross. A slight nose down attitude is ok but there should be no tendency for it to be tail heavy (so horizontal or slightly nose down is best).

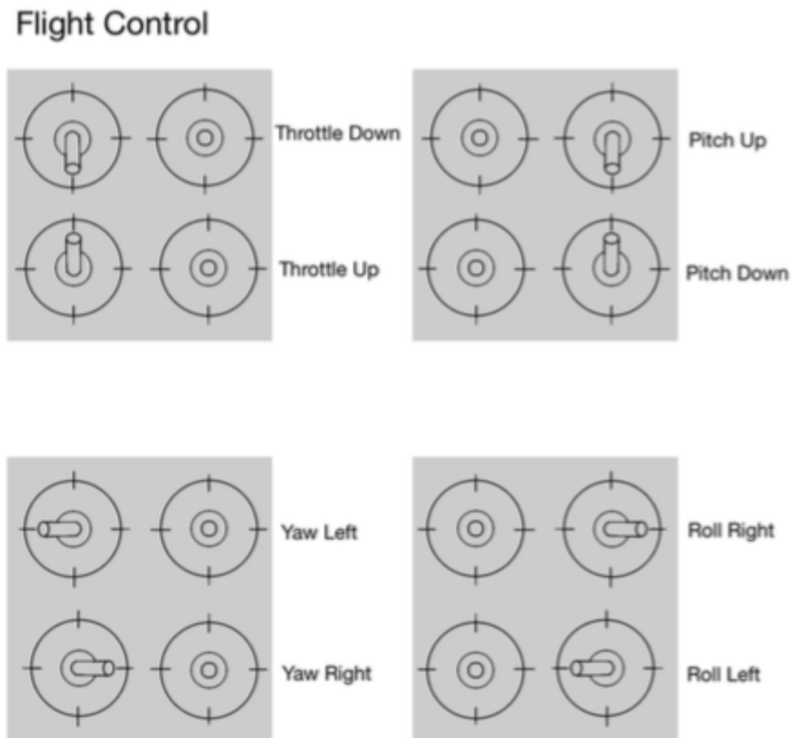
- **Systems Check:**
  - Power on the RC Transmitter

- Plug in Albatross Flight Battery
- Let sit for a few minutes
    - **Airspeed Check**
        - With no wind the airspeed should not be more than about 5m/s.
        - Blow into the PITOT tube. Airspeed should go above 20m/s
            - <u>This must be checked on the QGroundControl software in the analyze widget.</u>
    - **LIDAR Check**
        - Check the distance with the plane on the ground and lift it up and down to check the accuracy.
            - <u>This must be checked on the QGroundControl software in the analyze widget under distance.</u>
    - **GPS Check**
        - Let sit for several minutes for the GPS to acquire a 3D signal fix
            - <u>This must be checked on the QGroundControl software</u>
    - **Compass Check**
        - Switch to the HUD view (flying paper airplane button) and slowly rotate the plane 360 degrees. Check that the compass/heading follows smoothly without any sudden jumps or significant lag.
        - If something is wrong here you ***must*** recalibrate the sensors (start with the magnetometer) and do not fly the plane until the issue is resolved.
    - **Battery Check**
        - Check reported battery level is accurate.
    - **Error Reporting**
        - Look for errors reported in the status window

- **Control Surface Check**

Ensure proper response from ailerons, tail and nose wheel

- Move right stick right
  - Left aileron tilts down, right aileron tilts up
- Move right stick left
  - Left aileron tilts up, right aileron tilts down
- Move right stick up
  - Both elevators tilt down
- Move right stick down
  - Both elevators tilt up
- Move left stick right
  - Left elevator goes down, right elevator goes up
- Move left stick left
  - Left elevator goes up, right elevator goes down
- Move left stick upwards (careful – Throttle!)



- **Throttle**. This controls the propeller. If the Albatross is armed the propeller can spin so caution must be taken

- **Stabilization Testing**
  - Disable the safety switch by pressing and holding the red flashing button on the fuselage (do not arm the motor)
  - Raise the tail up – elevators should deflect up
  - Raise the nose up – elevator should deflect down
  - Raise the left wing up – left aileron should raise and right aileron lower
  - Raise the right wing up – right aileron should raise and left aileron lower

- Open QGroundControl
- Create Mission
- Upload Mission to the Albatross

Pre-Flight Checklist Summary:

- **Systems Check**
    - Make sure QGroundControl is in at least audible range for the takeoff
    - Check reported battery level is accurate.
        - Look for errors reported in the status window
    - GPS icon should be indicating a 3D satellite lock
        - Check the location of the Albatross is correct on the map in Plan tab.
    - Load the mission and ensure it has been received and is active.

    - Switch to the analyze tab and verify:
        - Airspeed:
            - Airspeed at rest should be either 0 or around 3-5 m/s with zero wind.
            - Blow into the pitot tube and check registered speed (should be over 20m/s when blowing hard).
        - LIDAR:
            - Check the measured distance with plane on the ground.
            - Raise the plane to shoulder height and check for new distance and approximate accuracy.
            - <u>Note that the speed of updates for the lidar via wireless telemetry will be slow.</u>
        - Compass/Magnetometer
            - Switch to the Fly tab and slowly rotate the plane 360 degrees and check that the compass/heading follows smoothly without any sudden jumps or significant lag.

- **<u>If something is wrong here you *must* recalibrate magnetometer and fix the issue prior to flight. This is crucial.</u>**

- Arming
  - Make sure RC is on and mode switch is in manual and the stabilised switch is on.

- Disable the safety switch by holding it down (the red flashing button on the fuselage).

- Check that all control surface and travel amounts are the expected distance and direction.

- Lift the tail, nose and each wingtip and make sure the control surface move as expected (see Stabilised Mode above).

- Arm the motor (hold the left stick [yaw] to the right).

- Check motor operation prior to flight.

Launch Notes

- The motor should ramp up to full throttle in approximately 2 second. **<u>NOT</u>** instantly when enabling an auto mission.

- QGC should report "Takeoff on runway" within 2-3 seconds of switching to auto/mission

- You will need to flip the switch to the Auto Mission position quickly.

Launch

- Make sure that the plane is facing the takeoff waypoint (This can be altered in the parameter settings but it is good practice to have it point the correct direction).

- Make sure the RC throttle stick (left stick) is all the way down (zero throttle).

- Flip the three-way flight mode switch to the mission position ***quickly*** (see the mode selection section below).

- Check for motor ramp-up within 2 seconds and QGC reporting “Takeoff on runway” ***otherwise abort by flipping the mode switch back to manual***!

- The plane should take off within 100m (330 feet) otherwise you may want to abort the takeoff (steering will then be manual).

- Optional: On landing after coming to a stop switch the mode switch to manual

- Enable the safety switch.

RC TARANIS Mode Selection Switch Guide:

Crow/Spoileron Switch:

Switch	Resulting Mode
SF	Crow/Spoilerons
Down	Disabled
Up	Enabled

Mode Switch:

Switch	Switch	Switch	Resulting Mode
SB	**SC**	**SD**	
Up	Up/Mid	Up/Mid/Down	Manual
Mid/Down	Up/Mid	Up/Mid/Down	Stabilized
Up/Mid/Down	Down	Up/Mid	Auto Mission
Up/Mid/Down	Down	Down	Loiter

INTRODUCTION

The Albatross is capable of flying a fully autonomous flight including runway takeoffs and landings. The following discusses these topics in depth and also explains some of the settings we use during our own missions.

COMPONENTS

1) **Range Finder**

   In order to ensure precise landings, the Albatross uses a laser range finder that measures the distance from the plane to the ground. The altitude estimation from the autopilot is not sufficient alone for two reasons. First, during the flight the altitude estimate is subject to drift, which is caused by the atmospheric change in pressure. Second, you may wish to land in an area with uncertain terrain altitude which makes it impossible for the autopilot to know how far it's located away from the ground.The Albatross supports the usage of several variants of Lidar range finders.

2) **Landing Gear**

   The Albatross uses its steerable nose wheel to hold its heading during a takeoff which ensures good maneuverability even at low speeds.

3) **GPS**

   The Albatross has a GPS unit on board in order to estimate its global position, altitude and speed.

4) **Airspeed Sensor**

   Both takeoff and landing algorithms require airspeed measurements in order to ensure safe operation. It is absolutely necessary to have an airspeed sensor installed.

AUTOPILOT SETUP

The following parameters are set correctly as below:

Group: Fixed Wing Position Control FW_LND_USETER = 1

This parameter enables terrain estimation using the data from the range finder

Group: Sensor Enable SENS_EN_LL40LS = 1

This parameter will enable the Lidar Lite range finder

Group: Runway Takeoff RWTO_TKOFF = 1

This parameter will enable the runway takeoff handling

Group: Runway Takeoff RWTO_HDG = 1

This specifies if the Albatross should take off towards the takeoff waypoint (1) or into the direction it's pointing when engaging the mission (0)

The following parameters are play a crucial role in terms of speed:
FW_AIRSPD_TRIM - Cruise Airspeed - The autopilot tries to fly the Albatross at this airspeed. We aim for 18 m/s.

FW_AIRSPD_MIN - Minimum Airspeed Parameter - If the airspeed falls below this value, the autopilot will try to increase airspeed more aggressively.

FW_AIRSPD_MAX - Maximum Airspeed - If the airspeed is above this value, the autopilot will try to decrease airspeed more aggressively.

FW_LND_AIRSPD_SC - Minimum airspeed scaling factor for landing. This factor is multiplied by the minimum airspeed parameter set to give the target airspeed for the landing approach. (FW_AIRSPD_MIN * FW_LND_AIRSPD_SC)

RWTO_AIRSPD_SCL - Minimum airspeed scaling factor for takeoff. Pitch up will be commanded when the following airspeed is reached: FW_AIRSPD_MIN * RWTO_AIRSPD_SCL

TESTING THE SETUP

It is a good idea to check that the range sensor is outputting the correct data. For this the Albatross must be turned on via battery and connected via telemetry or USB to QGroundControl. Navigate to Widgets → Analyze and use the filter tool to look for the 'DISTANCE' message. Hold the plane over the ground and ensure that the distance displayed is reflecting the actual situation.

Before every flight make sure that your airspeed sensor is working properly. The measured airspeed should appear on the heads up display (HUD) displayed in QGroundControl. When there is no airflow you should see a value smaller than 6 m/s. Blow into the sensor and you should see the airspeed increasing (typically a value between 15 and 30 m/s). If you can't reproduce the upper described situation, then re-calibrate the airspeed sensor. Make sure that the small holes at the front and on the side of the pitot tube are not blocked.

In case you are using flaps / spoilerons make sure they are behaving correctly. See section "Use of Flaps and Ailerons as Spoileron speed brakes".

PLANNING THE MISSION

Takeoff Waypoint

The first waypoint of the mission is a takeoff waypoint (1). Set this item onto the virtual line created by the runway some distance after the end of the runway. Depending on the

RWTO_HDG parameter the plane will either be taking off into the direction of the waypoint or using its current heading to calculate the takeoff path. The takeoff waypoint is needed in any case. Set the altitude of the takeoff waypoint to a reasonable value, e.g. 25-50m (relative altitude).

Landing Waypoint

The landing waypoint should be set to the location on the map where you want the plane to touch down. The Albatross will try to hold the heading given by the waypoint which comes before landing and the landing waypoint itself. Therefore, make sure that these two waypoints create a virtual line which is parallel to the runway. Make sure that the plane is already aligned with the runway and at a low altitude when it has reached the waypoint before landing (it should be no higher than 70% of the range of the onboard distance sensor. This is 25m-70m depending on the installed sensor). The altitude of the landing waypoint should be equal to the altitude of the runway you are landing on. If you are using relative altitude and you are taking off and landing on. If you are using relative altitude and you are taking off and landing on the same runway, then set the landing altitude to zero. QGroundControl will additionally give you feedback if the landing is not feasible. You will get this feedback at the time you are trying to upload the mission to the autopilot.

Examples

The two pictures below show examples of a mission visualized on the map in QGroundControl. The first picture represents a well-planned mission while the second one is not well planned for the reason mentioned below.

WELL-PLANNED MISSION

This is a well-planned mission because:

- Takeoff waypoint is on a virtual line created by the runway
- Takeoff waypoint is located some distance after the runway (plane takes off toward point 1)
- Waypoint 6 and Waypoint 7 create a line which aligns with the runway
- Enough time is given to level out before landing

POORLY-PLANNED MISSION

This is a poorly-planned mission because:

- Takeoff waypoint is on the side of the runway
- Waypoint 6 and Waypoint 7 are not aligned with the runway

TUNING THE LANDING

There are several parameters, which you can modify to change the behavior of the plane during takeoff or landing. These parameters are:

FW_LDN_ANG

This is the angle of the slope at which the plane will try to come in for landing. The larger the value, the faster the plane will try to descend in order to stay on the landing slope. Given the Albatross' high glide ratio, we have preset this angle to 8 °.

FW_LND_FLALT

This is the altitude relative to the ground at which the plane will start flaring. If this value is too small you will risk the plane touching down with too high vertical speed or the front tire touching the ground first. This is because the plane will not have enough time to rotate its nose up. We set this to 2.5m which has proven to work very well in our tests and regular flights.

FW_THR_LND_MAX

This is the throttle value to be applied once the flaring phase has started. The value is in the range (0-1). We set this to 0, but there are some instances where leaving the throttle enabled slightly is advantageous as it becomes easier for the flare to occur.

FW_THR_FLARE_PMIN

This is the minimum pitch value (in degrees) the plane will demand during the flaring phase before touchdown. This can be used to avoid the plane having the nose down too low on the landing. Increasing this value will make the plane lift the nose up higher. We set this to 2.5° but have had very good success with it also set to 0°.

FW_AIRSPD_SCALE

Multiplying this factor with the minimum airspeed of the plane (FW_AIRSPD_MIN) gives the target airspeed during takeoff and landing. We preset this at 1.

USE OF FLAPS AND AILERONS AS SPOILERON SPEED BRAKES

Flaps

Flaps are assigned to channel 9 within the Albatross settings. We have mixed this channel with the aileron channel so while using the corresponding switch on your radio (top left 2-way switch) check that the flaps are responding correctly. When the switch is off the flaps will be up in their stationary position and when the switch is on the flaps will deflect down. Also note that as the flaps are setup to be mixed with the aileron channel to create spoilerons, when the 2-way switch is on and the flaps deflect down at the same time the spoilerons will deflect up. You can use the parameter “FW_FLAPS_SCL” to fine-tune the range of the flap servos.

Spoilerons (Use of Ailerons as Spoilers)

Spoilerons are referring to the synchronous actuation of ailerons in order to increase the drag acting on the plane during landing. This is assigned to auxiliary channel 2. Using the same corresponding switch on your radio control as the flaps, make sure that the ailerons are responding correctly. When switched off both ailerons will be neutral and when switched on both ailerons will go up. The parameter “FW_FLAPERON_SCL” can be used to fine-tune the range of the aileron servos if desired.

During a mission, the flaps/spoilerons will be applied once the plane has reached the penultimate waypoint.

Failure Handling

During the landing approach, the plane relies heavily on the values reported by the range sensor.

If the data received from the range sensor does not seem to be feasible, the plane will abort landing and begin loitering. The plane will loiter around the landing waypoint at an altitude defined as follows:

loiter_altitude = landing_abort_altitude + 2 * param_climbout_diff

“landing_abort_altitude” is the altitude at which the plane was when the landing was aborted. “param_climbout_diff” is defined by the parameter “FW_CLMBOUT_DIFF”

In order to prevent the plane from aborting during landing, always be sure that the altitude of the waypoint prior to the landing waypoint does not exceed 70% of the maximum range of the range sensor.