Ghost Aerial Photography System

Thank you for purchasing the Snelflight Ghost, a complete, ready-to-operate aerial photography system. It is capable of producing beautiful, professional quality video under a wide range of conditions. The aircraft is exceptionally easy to fly, and features fully automated GPS stabilization and hovering, plus return-to-home failsafe mode which activates automatically if the radio control signal is lost. All functions are operated from the dedicated multi-channel 2.4GHz transmitter handset.

The Ghost is fitted with a state-of-the-art brushless camera stabilization gimbal, which keeps the video image extremely steady during flight. The camera itself is capable of recording full HD 1080p video at 60 frames per second, for super smooth motion even during panning movements. The camera's image is transmitted live to a hand-held monitor during flight, so that the view can be adjusted in real time using the gimbal tilt control. The live image includes an overlay showing the voltage of the aircraft's flight battery, so that the pilot always knows whether it is safe to continue flying.

Please read through this manual fully, to acquaint yourself with all the features and functions of your Ghost.

IMPORTANT SAFETY NOTICE

- The Ghost is not a toy. It is a powerful machine which is capable of causing serious injury if it is not operated safely. This manual should be read carefully before first operation.

- Always handle the Ghost carefully, and be mindful that it might start suddenly in the case of an error or malfunction. It is safest to switch the transmitter off during pre-flight preparations.

- Always disconnect the battery before leaving the Ghost unattended, and after use.

- Take precautions against propellers flying off the motors. Check them for tightness frequently, and never point the Ghost towards anybody or lean over it whilst testing it.

- Never fly over people's heads, or near to children or pets. Make sure that others nearby know that you are flying the Ghost. The Ghost is heavy enough to cause serious injury if it falls on somebody, and sudden stoppages can occur in the event of malfunction.

- Remember that the working parts of the Ghost can get hot during use, particularly the motors. Other parts can also get hot in the event of a malfunction.

- Do not allow the Ghost to get wet and if it does, disconnect the battery immediately and thoroughly dry everything before testing carefully.

- If a malfunction is suspected, disconnect the battery and remove the propellers before investigating.

- Always treat lithium polymer batteries with great respect, and follow the manufacturer's instructions for safe use. Never leave a lithium battery unattended whilst charging.

- If charging a lithium polymer battery indoors, a flameproof container is recommended.

- Always disconnect the battery from the Ghost when not in use. If the battery remains connected it will be seriously damaged by over-discharge, and may overheat or catch fire when next charged.

- Examine the lithium polymer battery extremely carefully after a crash, and do not use it if crushed or if a cell envelope has been ruptured.

- Remember that lithium polymer batteries contain large amounts of energy. They can overheat, catch fire or explode if damaged, mistreated or if they fail internally. Always treat them with the greatest care.

- ALWAYS REMEMBER THAT YOU ARE RESPONSIBLE FOR THE SAFE OPERATION OF YOUR GHOST.

Packing List

Your kit should contain the following parts. If any of these items is missing then please contact us at support@snelflight.co.uk. *Please note: Product contains nuts.*

1) 1 x fully assembled Ghost aircraft.
2) 1 x 2.4GHz RC transmitter.
3) 1 x lithium polymer rechargeable flight battery.
4) 8 x AA batteries for the transmitter (these may be pre-fitted).
5) 1 x instruction manual.

Complete Package Only

6) 1 x solid aluminium brushless camera gimbal, pre-mounted on aircraft.
7) 1 x SJ5000+ sports camera - pre-mounted onto the gimbal.
8) 1 x TS832 multi-channel video sender, pre-installed on aircraft.
9) 1 x Video On-Screen-Display (OSD) module, pre-installed on aircraft.
10) 1 x RX-LCD5802 video receiver monitor.
11) 1 x EV-Peak ecube lithium polymer battery charger.
12) 1 x charger for monitor.
13) 1 x manufacturer-supplied accessories and packaging for camera.

Overview of the Ghost

The Snelflight Ghost is a type of aircraft known as a quadcopter, which is widely used as an aerial photography platform due to several distinct advantages over conventional helicopters:

1) The only moving parts are the propellers. Flight control is achieved entirely by varying the speeds of the propellers in different combinations to change the aircraft's orientation in the desired manner. Quadcopters are therefore very reliable, and in-flight mechanical failures are extremely rare.

2) The four lift propellers spin much faster than a single large rotor, so that their vibration has a correspondingly higher frequency. This is easier to isolate from the camera than conventional helicopter vibration.

3) Because of the aircraft's mechanical simplicity, the electronic control systems for quadcopters are very well developed, due to a number of open-source projects, academic interests and so on. Although similar control systems are available for helicopters, they tend to be more expensive and less effective.

Along with these advantages, quadcopters do have some downsides which should be borne in mind when operating them:

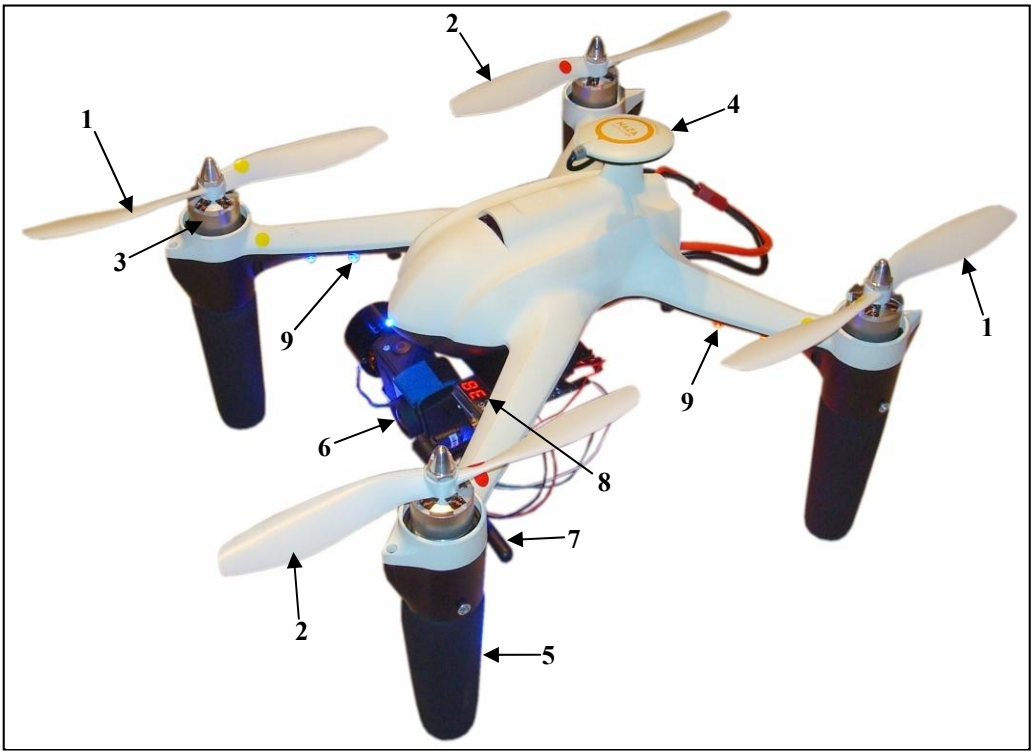
4) Compared with helicopters, quadcopters have virtually no mechanical stability at all, and rely entirely upon their sophisticated electronics to keep them flying the right way up. They generally respond to wind more erratically than helicopters, and have zero ability to glide or auto-rotate in the event of power failure. In such a situation a quadcopter will simply fall from the air, perhaps with one or more propellers still spinning. It is very important to take care when flying, and never to fly over people.

5) Small propellers are generally less efficient than a large rotor, so flight times of quadcopters tend to be shorter than those of helicopters.

Identification and Description of Parts

Figures 1 - 5 show the major parts of the Ghost. Please read through the explanations to familiarise yourself with the various systems.

Fig. 1: General Aircraft Features



1) **Anticlockwise propellers:** These are identified by yellow spot stickers. The correct locations for these propellers are indicated on the aircraft by corresponding yellow spots.

2) **Clockwise propellers:** These are identified by red spot stickers. The correct locations for these propellers are indicated on the aircraft by corresponding red spots.

3) **One of four brushless motors**.

4) **GPS receiver and compass module**: This measures the aircraft's position using the GPS satellite system, and also the direction of heading so that the system knows in what direction to fly in order to maintain the required location.

5) **One of four foam take-off and landing legs.**

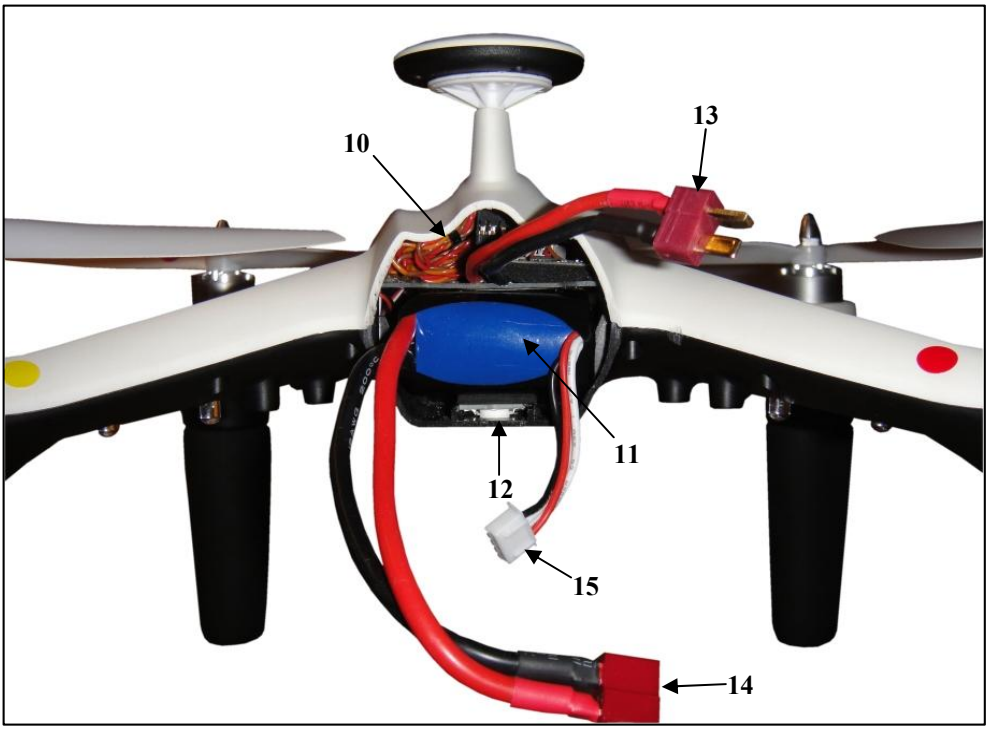
6) **Gimballed video camera.**

7) **Video transmission antenna.** This screws onto the video sender module (page 6); take care not to over-tighten it. Note its position under the front left motor arm.
Important: Do not operate the transmitter without the antenna, or it will be damaged.

8) **Video transmission channel indicator:** Factory preset to channel 38.

9) **Under-body LED lights:** Blue on the front, red on the rear. For decoration, and an aid to orientation. They could be used for night flying, with practice!

Fig. 2: Rear Body



10) **Rear access port:** The flight battery is inserted here.

11) **Flight battery:** It slides out rearwards.

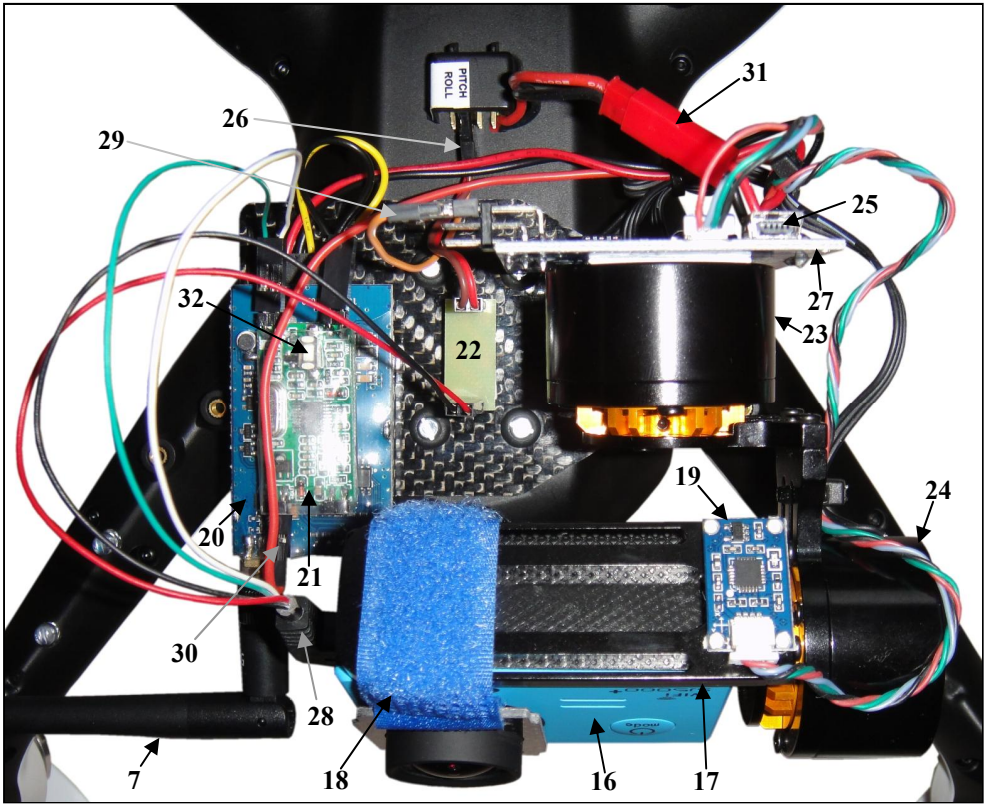
12) **Status LED:** This shows on the underside of the aircraft so that it can be seen during flight.

13) **Aircraft power connector:** This is a standard "Deans" plug.

14) **Battery power connector:** This is a Deans socket, which fits the aircraft connector.

15) **Battery balance connector:** This is used during charging.

Fig. 3: Underside, Video System



16) **Camera:** Capable of recording and playing back 1080p video at up to 60 frames per second.

17) **Camera mounting plate:** This is the part of the gimbal mechanism onto which the camera is attached.

18) **Camera securing strap:** This uses Velcro for fastening, and has a sturdy carbon-fibre bracket which fits around the camera lens.

19) **Camera motion sensing circuit:** This tiny circuit includes three separate gyroscope sensors, plus three accelerometers for monitoring the motion of the camera during flight. These measurements are sent to the main control board, which drives the two gimbal motors to keep the camera steady as the aircraft pitches and rolls in the air.

20) **5.8GHz video sending transmitter (blue board):** This transmits the camera's live video image to the viewing monitor, and is completely separate from the on board high-definition recording.

21) **On-screen display (OSD) module (green board):** This monitors the voltage of the flight battery, and overlays a numerical readout on the transmitted video image (not the recording).

22) **Camera power filter:** This small module removes electrical noise from the power supply to the camera, for a cleaner video image.

23) **Camera roll motor:** This motor tilts the camera from side to side, to compensate for aircraft roll movements.

24) **Camera pitch motor:** This motor tilts the camera up and down, to compensate for aircraft pitch movements.

25) **Gimbal configuration USB socket:** This allows the gimbal system to be connected to a PC for adjustment using special software.

26) **3-wire connector:** This carries 5V power for the camera, plus the command signal for manual tilt control. Note that it plugs into the second-from-left column of pins within the array under the aircraft, with the orange wire at the top (nearest the aircraft's belly).

27) **Gimbal control circuit board:** This receives information from the camera motion sensors and the manual controls, and coordinates the movements of the two gimbal motors to keep the camera steady.

28) **Camera connection plug:** This carries 5V power to the camera (red and black wires) and the output video signal for transmission (green and white wires).

29) **Camera tilt command plug with single orange wire:** This connects to the gimbal control circuit board - the other end originates from connector **26**.

30) **12V power plug with single red wire:** This connects to the single pin on the front end of the OSD module, for flight battery voltage monitoring. DO NOT CONNECT IT ANYWHERE ELSE.

31) **12V power connector:** This carries power from the aircraft's flight battery, to operate the gimbal and the video sender module.

32) **OSD adjust button:** Pressing this button shifts the position of the battery voltage display on the monitor screen.

Fig. 4: RC Transmitter

33) **Power switch:** Slide up to turn on, down to turn off. Shown in the off position.

34) **Set-up switches:** Note the positions shown, needed for flying the Ghost.

35) **Pitch/Roll joystick:** The aircraft will tilt and fly in the direction that this joystick is moved.

36) **Altitude/Yaw joystick:** Moving this joystick up or down will cause the aircraft to climb or descend. Left or right movements will steer the aircraft in the horizontal plane (like the rudder on a boat).

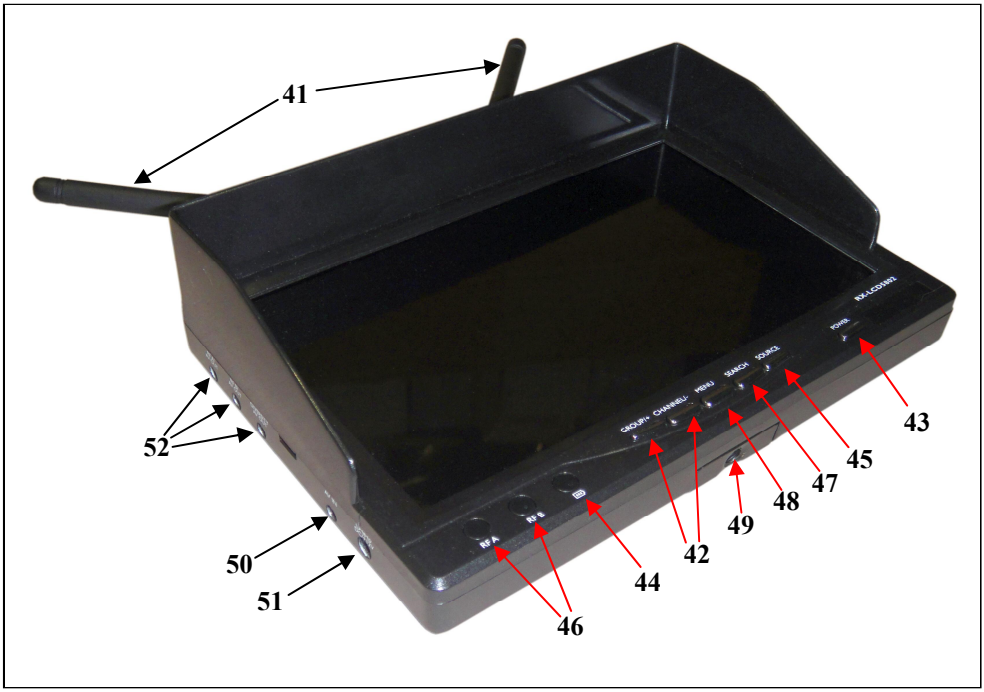
37) **One of four trim controls:** These adjust the joystick centre neutral points. If the aircraft constantly drifts in one direction then the related trim should be adjusted the opposite way. The trims are of the electronic type, which work with repeated clicks in the desired direction. At each click the trim advances slightly, and a short bleep is heard. The bleep is longer when the centre position is reached. At each endpoint, the bleep sounds continuously until the button is released.

38) **Camera tilt control:** Turning this control adjusts the angle of the camera.

39) **Flight mode switch:** Selects between GPS mode, attitude-only "ATTI" mode and Go Home.

40) **Power status light**: Shows green when the power is on. Flashes red with audible bleeping to indicate low battery.

Fig. 5: Video Monitor (included in the Ghost Complete Package)



41) Dual receiving antennas: The monitor features diversity reception, which employs two receivers to improve quality. The system automatically recognises which signal is better, and switches between receivers accordingly.

42) Channel select buttons: The 5.8GHz video band is divided into 32 channels, any one of which can be selected for reception. The 32 channels are split into four groups of eight, and each is designated by a group letter A - D, plus a number 1 - 8. The two selector buttons allow group and number to be chosen. The Ghost is shipped with its transmitter factory set to channel C8, so the monitor should also be set to this channel. The selected channel is displayed in the top left corner of the screen. Please note that in order to add unnecessary confusion, the groups are designated 1 - 4 instead of A - D on the transmitter module. So the channel number displayed in the transmitter is 38, not C8.

43) Power button: This needs a 1-second press to turn the power on or off.

44) Charge indicator: This illuminates red during charging, changing to blue when fully charged. A full charge cycle takes about 3 hours, and provides around 90 minutes of use. The battery state during use is displayed in the top right corner of the screen.

45) Source Select button: With its dual receivers, the monitor can display its picture from Receiver A, Receiver B, Diversity (real time auto-selection), and from the external AV input socket **50**. The current selection is displayed in the top left corner of the screen. A different channel number can be selected for each input source.

46) Receiver Lights: These illuminate blue to show which receiver is currently active.

47) Channel Search Button: Pressing this button causes the monitor to cycle through all channels, looking for a signal. It is not really very useful!

48) **Menu button:** Pressing this opens up the monitor's control menu, and further presses cycle through various items such as brightness, contrast etc. Each setting is adjusted up or down using the Group and Channel buttons **42**.

49) **Tripod socket:** Allows the monitor to be mounted on a camera tripod with the standard 1/4-20 UNC screw attachment.

50) **AV input socket:** This accepts an external video source in either PAL or NTSC format, plus a stereo audio signal. The latter is played in mono through the monitor's single loudspeaker. Two cables are included which fit this socket.

51) **Power/charge socket:** The supplied 12V adapter connects here, to provide external power and to charge the monitor's internal battery.

52) **AV output sockets:** There are three AV output sockets, providing separate access to the signal from each of the monitor's two receivers, plus the diversity reception system.

Preparing for your First Flight

Readying the Transmitter

a) Slide open the battery bay on the back of the transmitter, and lift out the black battery holder. It is on a short lead at the left-hand end, so please take care not to strain this.
b) Insert 8 x alkaline AA batteries (supplied), according to the polarities embossed onto the plastic.
c) Replace the battery holder with the batteries (not the plastic sidewall) facing outwards, and close the battery bay.
d) Switch on the transmitter.
e) Check that the trims are all centred. To do so, press each one by a single click in either direction, and note the short bleep. Then press back in the opposite direction. If the trim is at the centre position then a longer bleep will sound, which will finish before the button is released. Then let go the button.
f) Otherwise, hold the button until hearing a long bleep. If the trim is now at the centre then the bleep will finish before the button is released; let go and you're done. If the bleep continues to sound whilst the button is held, then this indicates that an endpoint has been reached. If this happens then press the trim in the other direction until hearing the centre bleep.
g) When all four trims have been checked, switch off the transmitter.

Charging the Flight Battery

If you are using your own battery charger, please follow the manufacturer's directions for charging a 5000mA 3S lithium polymer battery. If using the **EV-Peak ecube** charger, please follow the steps below:

a) Plug the charger into a wall outlet using the power cord provided, and wait for the blue status lights to start blinking.
b) Connect the battery's white balance connector into the charger's middle socket.
c) Charging will commence immediately, with progress indicated by the blue status lights.
d) A full charge cycle will take about 75 minutes, after which all status lights will be illuminated solidly.

The charger may become quite hot during use - this is normal. Do not cover it with anything, or leave it unattended whilst charging. For safety indoors the battery should be placed in a flameproof container, or at least on a non-combustible surface such as a dinner plate. Always remember that a lithium battery can contain a very large amount of energy, and a faulty one can catch fire during charging, burning very fiercely. Although it rarely happens, we have seen this type of behaviour for real: please take care!

Please note: Lithium batteries should not be stored for long periods in a fully charged or discharged state. If they will be unused for more than a couple of days, they should be charged about half way.

Powering up the Ghost for the First Time

This procedure should be carried out indoors, prior to attempting a first flight:

a) Insert the flight battery into the Ghost by sliding it in at the rear (Fig. 2). It is held in place by the foam pad in the bottom of the battery compartment, which should offer some resistance as the battery is pushed into place.

b) Switch on the transmitter. Select GPS flight mode (switch **39** in the bottom position), and adjust the camera tilt control **38** roughly to the centre of its range.

c) Connect the battery to the Ghost by plugging together the two red connectors **13** and **14**. The Ghost's lights will illuminate, and it will emit a series of musical tones. The status LED **12** will cycle through a sequence of colours, and during this time the Ghost should not be moved. This allows the aircraft's flight sensors to auto-zero.

d) The status LED should then blink with this repeating pattern:

The green blink indicates that GPS mode is selected, whilst the three red blinks mean that satellite reception is at its worst. GPS doesn't work indoors!

e) If one of the transmitter joysticks is moved, then the blink pattern will change to this:

The double green blink indicates that one of the joysticks is off-centre.

f) If the Flight Mode Switch **39** is set to Atti (centre position), then the green blink will change to yellow:

For a full explanation of all status LED blink patterns and their meanings, please see pages 13 -14.

g) When the flight battery is connected, the camera gimbal should energise and move to a stable position. It may be tilted slightly forwards or backwards - this can be adjusted with control **38** on the transmitter.

h) If the camera is not level from side-to-side, then the gimbal should be zeroed by briefly pressing the reset button on the control board (Fig. 6). The gimbal will appear to power down, then re-start in the horizontal position.

i)

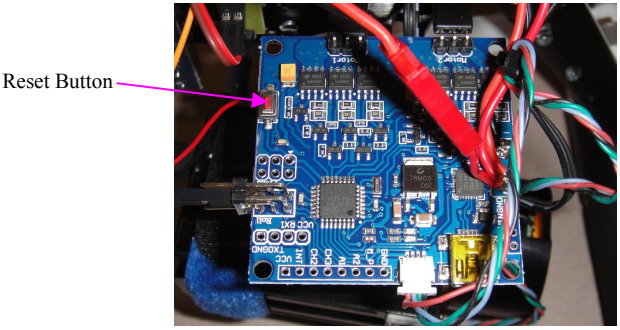


Fig. 6: Location of Gimbal Reset Button

j) The camera itself should also power up with the Ghost. Its blue lights will blink several times, then turn off for a few seconds before illuminating solidly.

k) Occasionally the camera might fail to power up, especially if its battery is low on charge or if it is turned off and on again too quickly. If this happens, switch it on manually by briefly pressing the button on the front.

l) Please switch on the video monitor now. Provided that it is set to the correct channel (C8), it should display the image seen by the camera.

m) The flight battery voltage will be displayed in the top left hand corner of the monitor. A fully charged battery will show a voltage of about 12V, and it is safe to fly until the voltage has dropped to around 10V. By this time the Ghost will have signalled its low battery warning (rapid red blinking of the status LED), and will soon run out of power. The Ghost should be landed as soon as possible.

n) When flying, it is very important that the battery cables do not foul the propellers. To prevent this, the main loop of wired should be tucked into the back of the aircraft (Fig. 7). The white battery balance plug should also be kept out of the way.

Fig. 7: Stowing of Battery Cables

Compass Calibration

The onboard electronic compass is crucial to the Ghost's auto-hover function. Although GPS provides a location, it cannot measure what direction the aircraft is facing. This information is vital to allow the aircraft to maintain its designated hover spot, and it is provided by the compass.

Unfortunately the earth's magnetic field is not perfectly consistent or uniform. In particular, the direction of magnetic north differs from true geographic north by an angle called its declination, which varies from one place to another. To allow effective flight control the Ghost's system includes a database of declinations around the globe, which can be as great as 20° at moderate latitudes. However local variations also occur, due to large metal objects in the area as well as various mineral deposits in the ground. To allow for these, the compass needs to be calibrated prior to flying at a new site.

The procedure is very quick and easy, and is carried out as follows:

a) Switch on the transmitter, and then power up the Ghost. Select GPS mode and wait until the status LED begins its repeating blink pattern.

b) Move the flight mode switch fully between GPS and Go Home and back again, six times in rapid succession. You should finish in GPS mode. The status LED should change to solid yellow, indicating that the system is ready for compass calibration.

c) Next, pick up the Ghost and hold it horizontally. Rotate it clockwise fully through 360° - it is easiest just to turn yourself on the spot. When the circle is complete, the status light will turn green.

d) Now hold the Ghost nose downwards, and repeat the clockwise 360° rotation. When the circle is complete the status LED should revert to its normal repeating blink pattern. All done!

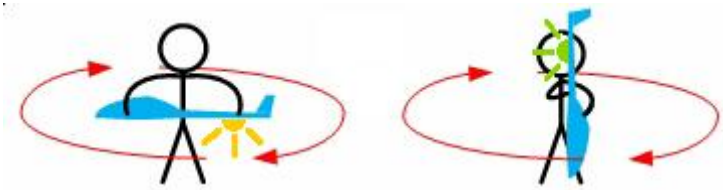


Fig. 8: Compass Calibration Procedure

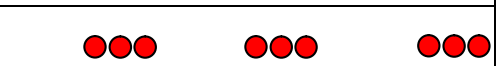
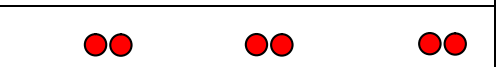
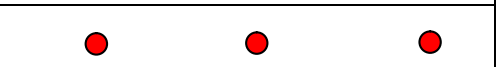
If the compass is out of calibration when hovering under GPS control, the Ghost will move in the wrong direction when trying to maintain/correct its position. This will lead to a new position error and a new misguided movement, and so on. The result will be a circular flight pattern colourfully referred to as a "toilet bowl". It can be halted by switching off GPS; the cure is to land and calibrate the compass.

Please note: The compass module must be aligned forwards on the aircraft, with its cable exiting at the front. It can sometimes get twisted out of line, and this will cause erratic flight just like poor calibration. It is important to check this before flying.

Status LED Indications

The status LED will illuminate and blink in various patterns to indicate different system conditions. These are detailed in the table below.

At Power Up	
System start and self-check.	
Warm-up after power on - this happens rarely.	 . . . etc
Error - Aircraft moved during start-up.	 . . . etc
Compass error - can be caused by proximity to metal, or a need to re-calibrate.	 . . . etc
One or more transmitter joystick mid-points are incorrect at start-up. Usually caused by excessive trim offset on one or more joysticks, A re-start is needed to try again after correcting the problem.	 . . . etc

Before Take-off and During Flight	
GPS Flight Mode	
Atti Flight Mode	
If one or more transmitter joysticks is moved off-centre, then the single blinks become double.	
The green or yellow blinks are interleaved with red ones according to the number of satellites which the system has locked onto. Fewer red blinks is better, so as more satellites are acquired, the number of red blinks reduces. The system needs to be in GPS mode to acquire more satellites, but will remain in contact with current ones if switched to Atti mode.	
4 or less satellites - not enough to work.	
5 satellites - enough to auto-hover but the system will not register the home position before take-off.	
6 satellites - minimum needed to register the home position before take-off.	
7 or more satellites - ideal reception.	No red blinks
Manual go-home activated, or failsafe auto go-home triggered by loss of transmitter signal.	
Once enough satellites are locked on, the system will record its home position for manual and emergency go-home operation. This is signalled by a burst of rapid green blinks.	
Low flight battery voltage warning. Land as soon as possible. When the voltage drops a little further, the aircraft will start to descend automatically in an attempt to land before control is lost.	
Compass Calibration	
Begin horizontal calibration.	
Begin nose-down calibration.	
Calibration failure - try again. This happens rarely.	

The Ghost's transmitter uses the standard "mode 2" joystick layout familiar to most model aircraft pilots. The controls are summarized in Fig. 9 below. Please take time to familiarize yourself with these functions.

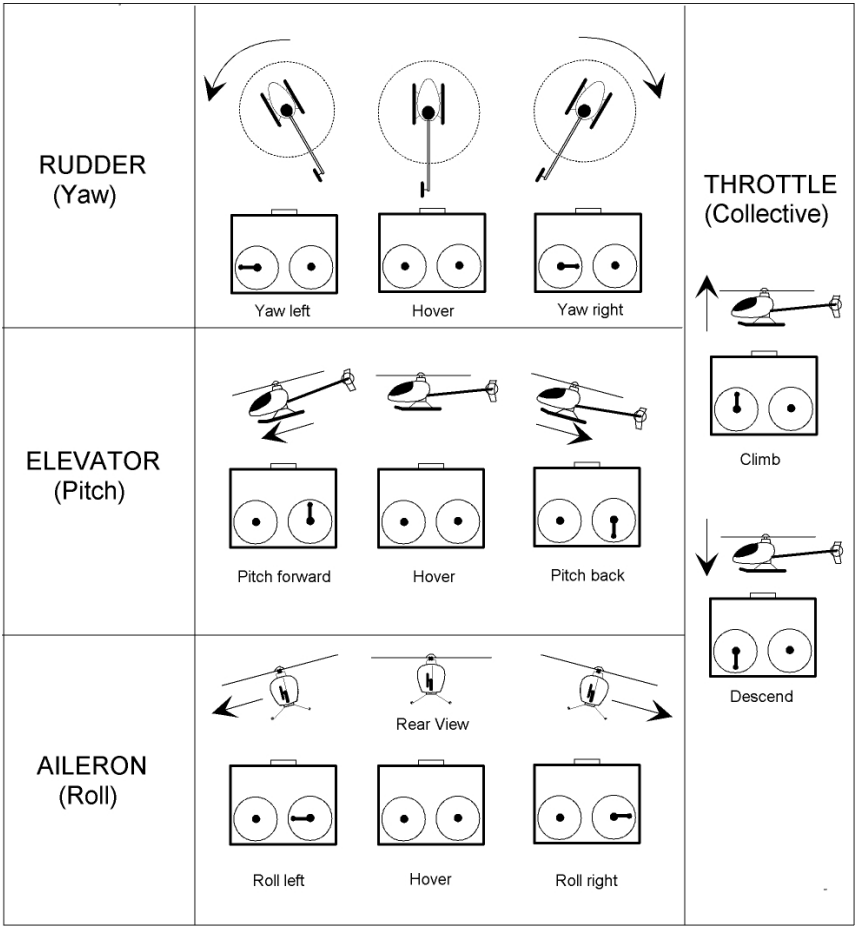


Fig. 9: Transmitter Joystick Functions

Flight Modes

The Ghost has three Flight Modes, selected by switch **39** on the transmitter. They function as follows:

GPS Mode: In this flight mode, the Ghost is capable of fully automatic stationary hovering. This is very useful when shooting video, because the pilot can watch the monitor image and steer the camera while the aircraft takes care of itself. GPS mode begins before take-off, when the system will record its "home position" once sufficient GPS satellites have been acquired. This is the location to which the aircraft will return if the go-home function is activated.

After take-off, the GPS guidance system will hold the aircraft in its current location while the transmitter joysticks are at their centre (neutral) positions, compensating for drift and wind. Altitude is also actively maintained, using an on-board barometric altitude sensor.

Please note the following:

- GPS is not perfect! It is only accurate to about 3 metres, so the aircraft can drift within this radius, and may be blown beyond it by a sudden strong gust, though it should return as the system recognizes the problem. It is particularly important to understand that the "home position" will not be spot-on, so there is a danger that the aircraft will bump into something if auto-landing in a confined space. It is therefore safer to fly from an open area.
- GPS can sometimes fail altogether, due to signal interference or adverse atmospheric conditions. It also works poorly among tall trees and buildings, which can sometimes generate rogue signals which send the aircraft chasing off after a phantom satellite.
- Barometric height control can be affected by a gust of wind, which has a lower pressure than still air. This fools the system into thinking that the altitude has increased suddenly, so it responds by making the aircraft descend.
- The number of satellites visible in the sky varies during the day, due to their continuous orbits around the Earth. When fewer satellites are visible it will be more difficult to acquire enough for reliable control. This is most often experienced as a difficulty in locking onto enough satellites to get a home position fix before take-off, but satellites can also be "lost" during flight.

These issues tend to be relatively unimportant if the aircraft is high in the air, but can get you into trouble at low altitudes. Do not rely too heavily on the automatic systems.

Atti Mode: Short for "attitude control mode", this mode maintains level flight using the onboard inertial sensors, but the aircraft cannot control its own position. Barometric height control is operational, but the aircraft must be guided around the sky manually by the pilot. It is a good idea to become practiced in this mode for occasions when GPS is unavailable or insufficient, such as when flying indoors or in a confined environment.

Please note that although the aircraft will return to level flight when the right-hand joystick is centred, it will not automatically stop moving. It will slow down gradually, but to stop it quickly an opposite joystick input must be applied. This needs plenty of practice!

Go Home: In Go Home mode, the Ghost will attempt to use GPS guidance to return to the recorded home position, where it will execute an automated landing. If GPS is unavailable then the aircraft will land at its present location.

When the Flight Mode switch is first set to Go Home, the Status LED will change to continuous rapid yellow blinking. The Ghost will then ascend to 60 feet altitude, if it is not this high already. It will turn to face home and fly back at medium speed, stopping over the home position. It will then descend, pausing several times to check its position, correcting if necessary. The final landing should be very gentle, after which the motors will stop.

Note that the final landing place may be as much as 3 metres from the true home position, which can cause collisions in a confined area. The joysticks have no effect in Go Home mode, but the pilot can re-take control at any time by switching back to Atti or GPS mode.

Failsafe: If the transmitter signal is lost for any reason, the Ghost will automatically enter Go Home mode. This might be because

- The transmitter has been turned off
- Its batteries have run out
- Interference or an obstruction is preventing reception.

If the signal is regained during the return flight then control will revert to the pilot, otherwise the Ghost will continue home and land.

Pre-Flight Checks

Before any flight, it is important to check that the aircraft is ready to operate. The following is a useful checklist:

1) Are the propeller nuts tight? Please refer to the Maintenance section on page 18.

2) Is the camera securely attached? Ensure that the non-slip rubber pad is in place under the camera, and that the Velcro strap is tight.
Important: If you wish to fly without the camera on board, then you must unplug the power supply to the gimbal assembly (Fig. 3, item **31**).

3) Does the camera have a memory card fitted?

4) Is the flight battery charged?

5) Are the transmitter batteries OK (green indicator light)?

6) Is the video monitor charged?

7) Is the aircraft compass module aligned straight forwards (cable at the front)? If it is twisted out-of-line by more than a few degrees then GPS flight will be affected - it must be straightened by hand before flying.

8) Is the camera switched on and providing a clear monitor picture?

9) Is the gimbal horizontal? If not then it should be reset - please see item **h** on page 11.

10) Is the video transmission antenna secure and correctly located? Please see item **7** on page 4.

11) Are the battery cables correctly stowed? Please see **Fig. 7** on page 12.

12) If flying at a new site, has the compass been calibrated (page 12)?

13) For GPS flight, have enough satellites been acquired and the home position recorded (pages 14 - 15)?

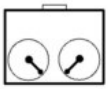
14) Finally, have you remembered to set the camera recording?

Your First Flight

1) Your first flight should be attempted on a calm day in an area with plenty of space. Place the aircraft on level ground and stand about 3 metres behind it, so that it is facing away from you. Any spectators should stand behind you.

2) Select GPS mode, and wait for the burst of rapid green blinks from the status LED, indicating that the home position has been recorded. This can take two or three minutes if GPS coverage is poor.
Tip: *The status LED can be hard to see on a bright day. It will be more visible if a white card is placed on the ground under it. Stay next to the aircraft until the home position has been set, then remove the card before flying.*

3) To start the Ghost's motors, pull both joysticks back into the "cross-eyed" position like this:



Alternatively the joysticks can be pulled back into the "toe out" position instead.

4) Once the motors start, the Ghost is ready to go. To take off, push the left hand joystick upwards about half-way. The motors will rev up, and the aircraft will lift into the air. Let it ascend to a height of about 6 feet, and then lower the joystick to the centre again. The Ghost should now hover in this position, guided by GPS. It may drift about slightly, and its height may also fluctuate. Watch the way it behaves, and try ascending or descending by small amounts.

5) Once you feel comfortable, you can try steering the Ghost by moving the left hand joystick from side-to-side. Use small inputs and watch the effect on the aircraft. ***Tip:*** *If you find that the Ghost slowly creeps around to the left or right, then this can be corrected by applying a few clicks to the rudder trim (under the left hand joystick) in the opposite direction.*

6) Next, steer the Ghost so that it is facing away from you, and then try applying small inputs to the right hand joystick. The aircraft will tilt in the direction of joystick input, and proceed to fly in that direction. It can fly forwards, backwards or sideways, so there is no need to turn it, unless you want to point the camera at something in another direction. Always remember however, that joystick movements relate to the direction that the aircraft is facing. So if it turns towards you then everything will seem reversed.

7) Landing: It is best to land well before the flight battery runs low, so that you are not rushed. Bring the aircraft to a height of about 6 feet, and guide it back to the landing area. To land, lower the left hand joystick just slightly, so that the aircraft descends very slowly. When it touches the ground, pull the left hand joystick fully down and hold it there until the motors stop (a few seconds).

Congratulations! You have just completed your first flight. We recommend that you practice for several full flights before attempting to shoot any video using the monitor, because it is very important to get used to the way the aircraft behaves in the air before taking your eyes off it to look at the camera image. We also recommend that you practice flying in Atti mode as well as GPS, so that you can recover the Ghost if GPS fails for some reason. Flight behaviour is similar in Atti mode, except that the aircraft will drift about more, and will blow downwind. So you must learn to fly against the wind to stay in position.

Maintenance

The Ghost is generally reliable and does not need much routine maintenance. However it is a good idea to check regularly that the various attachments are secure, particularly the propellers and the gimbal assembly. It is also important to ensure that the GPS/compass module is properly aligned on the aircraft, with the cable exiting at the front.

The Ghost should not be flown in the rain; if it gets wet then the battery must be removed and the aircraft allowed to dry thoroughly and then tested both on the ground, and with a short hover at a height of two or three feet, before being flown normally again.

Propeller replacement: Propellers should not be flown if more than minimally chipped, as they will cause vibration which can seriously effect the onboard sensors. Damaged ones must therefore be replaced before flying again. The propellers come in clockwise and anticlockwise variants, which carry colour-coded stickers for easy identification. It is very important to fit the correct type of propeller to each motor - please see Fig. 10.

To remove a propeller, unscrew the silver dome nut using a small screwdriver inserted through the hole in the top - all four nuts unscrew anticlockwise. The propeller can then be pulled off.

To fit a propeller, place it over the motor, taking care to align it to the flattened surfaces on the sides of the spindle. The plastic around the propeller's hole can get burred, making installation difficult. If this happens then the burring should be removed with a sharp hobby knife or scalpel.

The dome nut should be tightened with a small screwdriver as above, taking care not to over-tighten. The correct torque is around 2 foot pounds.

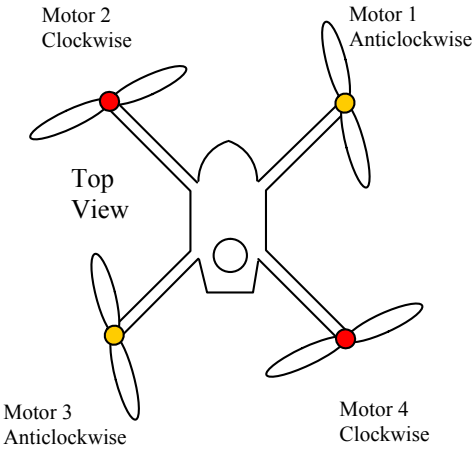


Fig 10. Motor Identifications and Directions

Gimbal assembly removal and re-fitting: The gimbal assembly comes off as a complete unit. Working with the aircraft upside down, begin by unplugging connectors **26** and **31** (Fig. 3). Then remove the four silver screws in the centre of the carbon base plate. The assembly will then lift off. Re-fitting is the reverse of the above steps.

The Ghost can be flown for practice with the gimbal assembly removed; this will extend the flight time.

Camera installation: The camera is held onto the gimbal mounting plate by a Velcro strap, and prevented from slipping by a rubber pad underneath it. The strap has a sturdy bracket at one end which fits around the camera's lens. After placing the camera on the mounting plate, fit the bracket over the lens with the strap downwards and the Velcro surface towards the front. The strap should be run under the mounting plate and up behind the camera, through the slot in the top of the bracket and back down again, where it attaches to itself at the rear. It should be pulled as tight as possible before fastening.

SJ5000+ Camera

The camera is supplied with its own instructions, which are worth reading. However we found that various points were unclear or simply left out, so the following notes might be useful:

1) The camera has an extensive menu of settings. We preset it at our factory for optimum performance with the Ghost, so it will not generally be necessary to make many adjustments.

2) All button operations should be brief presses, except when zooming, and switching the camera off manually. To do the latter, the front button must be held down until the blue lights start blinking.

3) The camera should turn on when the Ghost flight battery is connected. If it fails to do so, it can be turned on manually by pressing the front button.

4) The camera's three blue lights are all equivalent. They illuminate solidly to indicate power on, and blink slowly when the camera is recording.

5) The green light on the front means that WiFi is active. It is switched off by default.

6) The red light on the back means that the camera is charging.

7) After the camera powers up, it initially displays an image on its built-in screen. After a few seconds the internal screen shuts off, and the image is sent to the remote monitor instead. It occasionally

forgets to switch over to the external monitor; if this happens then the power should be manually cycled using the front button.

8) The first time a button is pressed after power-up, the internal screen will switch on again while leaving the remote one running as well. This button press won't do anything else, so you have to press again to get whatever you were hoping for.

9) When the camera is in standby, pressing the front button cycles through the following modes:

- Video recording
- Still photography
- Video playback
- Still photo viewing
- Setup menu

10) The top button starts and stops recording, takes photos, and selects menu items. The front button exits from menu items without changing anything.

11) The up/down buttons on the end of the camera scroll up and down the menu items.

12) The up button turns the microphone on and off when in standby or when recording.

13) The camera can sometimes catch the inner edges of the aircraft legs in its field of view. The cameras seem to vary slightly between units, but if this happens then the simple solution is to zoom in slightly. To do so, press and hold the up button in standby or recording, until zooming starts. As soon as it does, release the button; that will be enough to remove the legs from the picture. The button is a little awkward to get at when the camera is on the gimbal, but it can be twisted around slightly to gain access. The zoom will remain set until the power is turned off. A slight zoom does not affect video quality noticeably, because the camera's image sensor has very much greater resolution than 1080p. The output video is therefore generated via digital down-conversion (by a non-integer factor) even when un-zoomed. It works exceedingly well.

14) The camera firmware seems to have a bug which causes frequent crashing if the video output is set to PAL. When this happens it can only be reset by taking the battery out. The problem goes away in NTSC mode.

Specifications

Maximum take-off weight:	1450g
Maximum payload	400g
Maximum C of G off-centre:	10mm
Maximum wind speed:	20mph
Battery:	5000mAh 3S LiPo
Motors	4 x 2212, 980KV brushless
Flight time (fully loaded)	14 minutes
Power consumption at hover:	200W
Aircraft diameter	350mm
Propeller type	8" x 4.5"
Flight controller	DJI Naza M V2
Flight modes:	GPS autp-hover, Attitude only, Go-home
Camera gimbal:	2-axis brushless
Firmware:	AlexMos
Camera:	SJCam SJ5000+ Wifi
Video resolution:	1080p @ 60fps