FLYBOTIX

ASIO

(edited 2024-02-26)

FLYBOTIX

USER MANUAL

Contents

FCC Statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions :

(1) This device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

1 Table of safety symbols

	General warning symbol, pay extra care to the given information.
	Surfaces may get very hot under normal operation. Be cautious when touching hot surfaces.
	Wrong manipulations may lead to damage to the drone.
	Optical radiation, RG2 class light. Avoid exposure. Do not stare into light. Brightness of light may cause eye injury.
	Class 1 invisible laser radiation present.
	Do not touch any parts of the drone while in operation (armed, propellers spinning).
	Wrong manipulations may lead to a crash.
	Wear gloves to protect hands from injury.

2 Disclaimer

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3 Safety precautions

- Always stay clear of people with the drone. Maintain a minimum safe distance of at least 2 meters (6 feet) from anyone, including the pilot, when the drone is armed. Observers should always be properly briefed and stand in a safe location.
- Wear safety glasses whenever ASIO is armed. Debris that is lifted from the ground or a propeller breaking mid-air can cause extensive damage to the eyes.
- When flying in dusty environments, it is recommended to wear a mask and glasses to prevent fine particles from entering the lungs and eyes. When applicable, prefer flying in from outside the environment, using the range extender to place the antenna in the environment.
- Although the noise level of the drone is relatively low in normal operation (noise level < 80 dB), prolonged exposure to the noise emission may lead to ear fatigue. It is recommended to wear ear protection when exposed for long durations.
- Never look straight into the lighting LEDs (especially above 20% lighting power) as this may lead to damage to the eyes.
- If catching ASIO by hand for landing, wear high quality protective gloves.
- Do not insert anything inside ASIO's protective cage while it's armed.
- It is not permitted to carry out any modifications to the drone. This includes self-made reparations, which may induce vibrations. No accessories such as external cameras, other sensors or mechanical parts can be added to the drone. Each drone is tested individually and goes through a precise calibration procedure. Changing the weight distribution on the drone will degrade flight quality and may even lead to a crash.
- Do not fly if the ambient temperature is below 0°C (32°F) or above 40°C (104°F).
- When flying at above 35°C (95°F), allow a minimum of 10 minutes of cooling time between flights to avoid overheating.

- When flying under 15°C (59°F) or above 30°C (86°F), keep the batteries at room temperature (20°C / 68°F) before using them.
- Do not fly close to water or in rain. If ASIO was flown in a humid environment, make sure it is completely dry before powering on for the next flight.
- Battery must be removed from the drone when not flying.
- Charge the batteries only with the provided charger with the correct settings.
- The batteries and the charger must never be opened and worked on as there is a risk of electrocution and shock.
- Before inserting the battery in the drone, do not press on the power button within 10 seconds of the connection, as this may cause a spark.
- Take off and land at low speed.
- Do not initiate take-off if the battery level is lower than 40%.
- Always make sure to have enough battery left to fly back.
- Features that rely on IR sensors for function should not be activated in very dusty environments. Doing so may result in a crash.
- The Wall Lock feature should never be activated more than 3 m (10 ft) away from a sufficiently large wall.
- The operator must be ready at all times to take control of the drone in a fully manual mode in case Vel Lock is no longer effective.
- Only the cage, propellers and blade-linker can be replaced by the user. Any other maintenance/replacement operations will be carried out by a certified Flybotix reseller.
- Damaged carbon (from the cage) should be handled with extreme care. Wear protective gloves and glasses.
- The drone is not ATEX certified (explosion proof). Always check with asset experts whether the environment is safe for flight.
- Do not leave the drone turned on without flying for more than 20 minutes as the video module will get very hot and may shut down to protect its components.

CAUTION

The motors and the video bay heatsink can be very hot after flying. Allow a cooling time of a minimum of 10 minutes before touching the motors or the video bay heatsink. Take extra care when removing the SD card from its slot due to proximity with these hot components.

Make sure to follow a training dispensed by a certified trainer before attempting to fly your ASIO drone. Failure to do so may lead to damage to the drone and will void warranty.

4 Authorized accessories and tools

WARNING

The authorized accessories and tools for the ASIO drone must be respected. Using other accessories and tools may lead to damage and void warranty.

- Replace broken propellers only with original Flybotix propellers, using the screwdriver provided in the toolkit.
- Only the original herelink antennas provided with the solution should be used. If an antenna is damaged, replace it with an original herelink antenna.
- Only the official range extender provided by Flybotix (available in 10 m or 20 m versions) can be used.
- Use only official Flybotix batteries to power the drone.
- Use the brush provided in the toolkit and micro-fiber cloth to clean the sensor glasses.

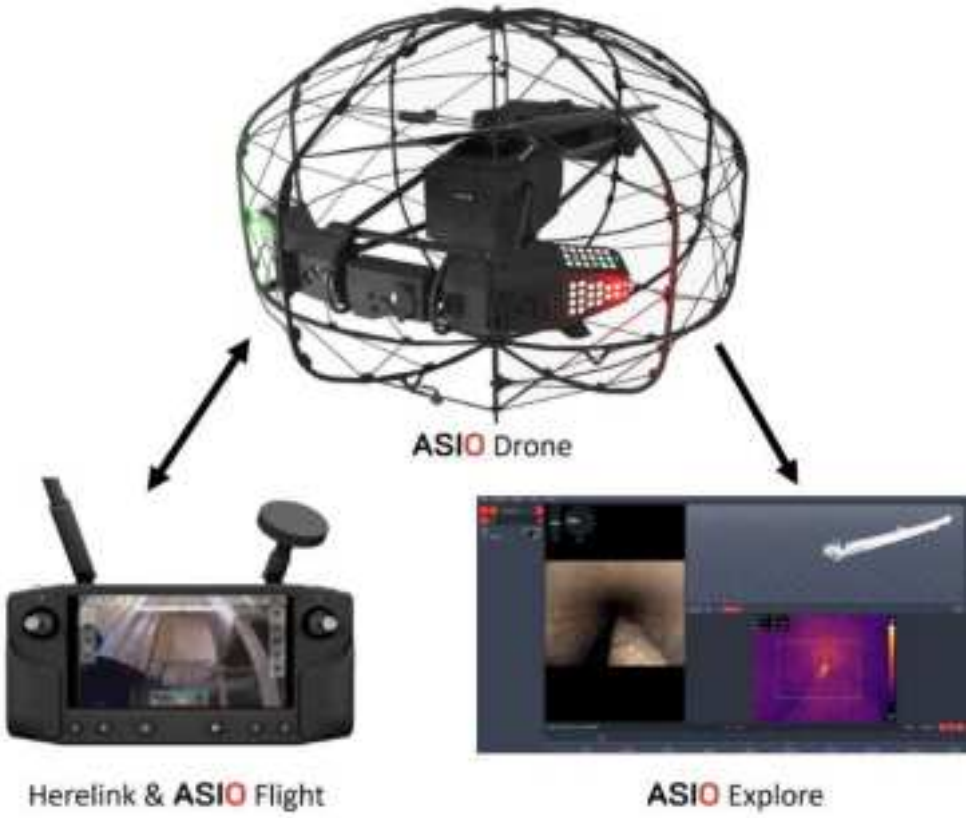
5 ASIO Solution content

The ASIO solution provides everything required to carry out an inspection, including the screen-equipped ground station (herelink controller), the drone, and the post-processing software for post-mission analysis.

Note: Battery packs must be removed from the drone and stored in their safety bags when not flying.

*The toolkit contains a T6 screwdriver (for propeller screws), 4 spare propeller screws, a spare 64 GB microSD card with adapter, a charging cable for the herelink transmitter, spare zip-ties and a brush for sensor cleaning.

6 ASIO Solution description



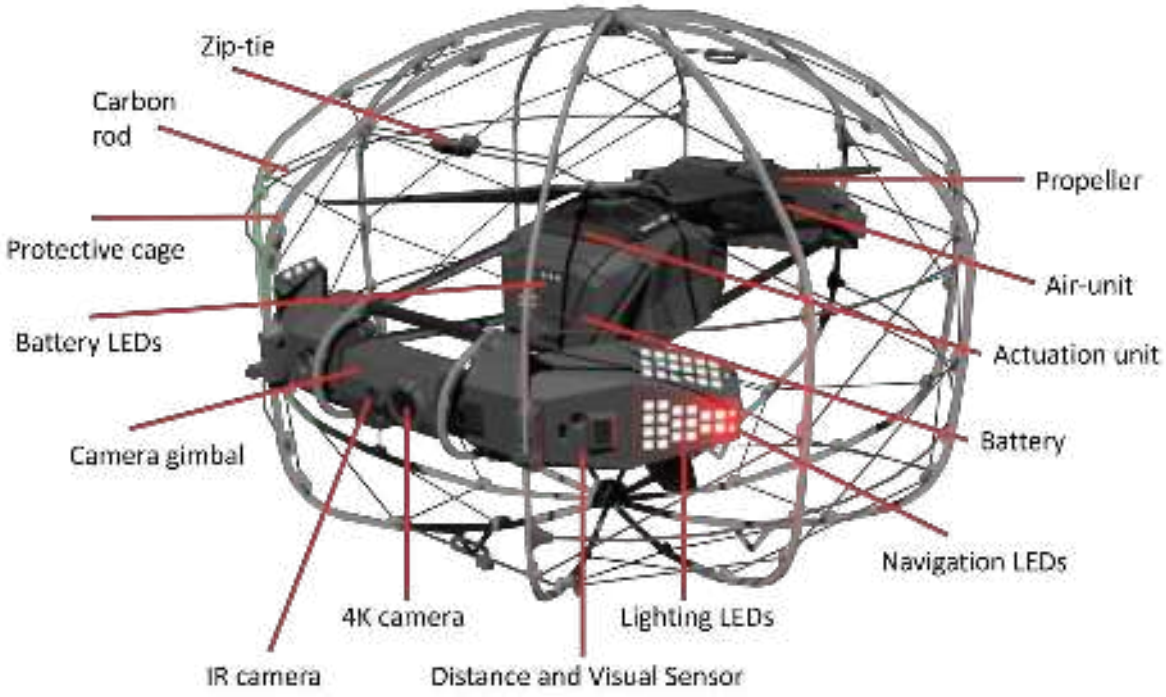
With its protective cage and visual-based stabilization, the ASIO drone is optimized for confined spaces and is intended to be used as a visual inspection tool, providing live video in difficult and dangerous to reach environments. Usage of the drone in outdoor conditions will not take full advantage of the assistances and **will require compliance with local regulations.**

The herelink ground station is equipped with the ASIO flight application, providing the operator with a real-time image (both in RGB (Full-HD) and in Infrared (thermal camera)) and telemetry sent by the herelink air-unit mounted on the drone.

Flight controls are sent from the ground station to the drone over the same communication link.

Post-mission analysis is carried out in the ASIO explore software, enabling visualization of recorded RGB video in 4K, high definition (12 MP) images of selected points of interest (POI) and synchronized radiometric IR video. A 3D point-cloud model can be generated based on the captured video (see more in the ASIO explore section).

7 ASIO Drone presentation



4K Camera

The ASIO drone is equipped with a RGB (Red-green-blue) 4K camera able to record video footage at 30 fps and to take still pictures (referred to as points of interest (POI)) at 12 MP that can then be viewed in ASIO Explore. It is mounted on a gimbal for stabilization and for tilt control.

The RGB video is streamed in real-time on the herelink ground station at a lower resolution of 1080p (Full-HD). ISO and exposure settings are automatically adapted by default, but can be set manually in the **Image** menu in the ASIO flight app.

Recording starts automatically as soon as the drone is armed and is stopped and saved as soon as the drone is disarmed. However, recording can be manually started (before arming) and stopped (before the end of the mission, for saving space for ex.).

IR (thermal) Camera

An infrared (IR) FLIR Lepton camera records at 160 px *x* 120 px at 9 fps. It is mounted on the same camera gimbal unit as the 4K camera, at the same angle. The Recorded IR video is radiometric (temperature can be read in the Explore software post-mission).

Camera gimbal

The 4K and IR cameras are mounted on a gimbal for stabilization and for tilt control, allowing both cameras to point fully downwards (–90°) and fully upwards (+90°).

Smart Battery

The drone is powered by a 5-cell LiHV battery of 3900 mAh equipped with a smart battery management system that automatically balances cells and monitors voltage, current draw and temperature. The battery power is 74.1 Wh (accepted by most airlines).

Three LEDs (Battery LEDs) on the top of the battery pack show battery status (refer to section Battery LEDs).

Lighting LEDs

Oblique lighting is provided by three LED panels on each side (facing upwards, downwards and forward). LEDs can be toggled ON or OFF with a single button press and the intensity is adjustable in the **LED** menu in the ASIO flight app. Both sides can be turned on separately for depth perception (see Using Left and Right lighting).

For lighting optimization, the LED intensity follows the movement of the camera gimbal (adjusted with the roller on the top left side of the remote). If the camera is tilted upwards, the LED intensity will increase in the top portion of the panel to better illuminate the field of view of the camera.

CAUTION

ASIO's LEDs are very powerful (RG2 class light). Danger of optical radiation. Users should never look straight into the LEDs as this may damage the eyes especially for prolonged exposure.

Navigation (Status) LEDs

Red and green navigation lights assist the pilot in visual line of sight (VLOS) flight. On the left side of the drone, the navigation light is red, on the right side, it is green. These lights also serve as drone status indicators, based on the flashing frequency (refer to section Navigation LEDs).

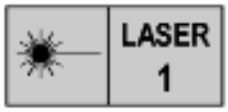
Distance and vision sensors

The drone is equipped with 7 sets of sensors looking all around the drone (3 in the front, 4 in the back). Each sensor set consists in a time-of-flight sensor for distance measurement, a camera for optical-flow measurement and IR LEDs that enable the optical flow cameras to work even in pitch black environments.

The distance sensors are used for Height Lock, Wall Lock and Repulsion. See the Flight assistances section for descriptions of these functionalities.

The optical-flow cameras enable measurement of the drone's velocity in GPS-denied environments and are essential for the drone's stability in assisted mode (Vel Lock mode).

NOTICE



Time-of-flight sensors emit class 1 invisible laser radiation.

Air-unit

The herelink air-unit, located in the back module of the drone, communicates with the herelink ground station over the 2.4 Ghz frequency band. It sends the video stream and telemetry to the ground station and receives controls from it.

Protective cage

The main core of the drone is protected by a protective cage consisting in carbon fiber hoops and sailing-grade wire to prevent contact of the propellers with obstacles. This allows the drone to collide with obstacles and assets without damaging the drone or the asset. The cage is secured around the main core using zip-ties. This allows quick and simple cage replacement (changing a full cage takes less than 5 minutes).

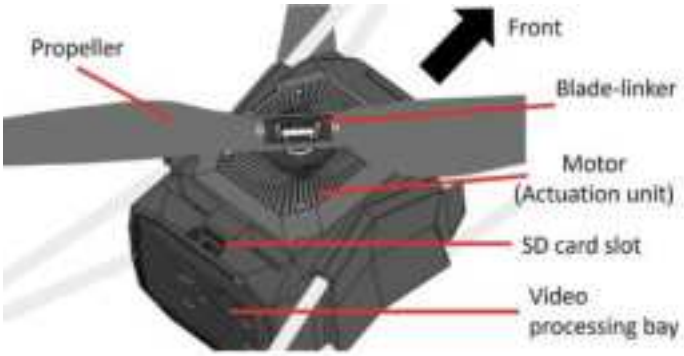
Carbon fiber rods running around the circumference of the cage are mounted at propeller height to increase protection of the propellers from external obstacles.

DANGER

Although the drone is protected by a cage, small objects can still enter the cage. Operators must never insert their hands in the cage when propellers are spinning. Before touching the drone, always wait for propellers to be at a complete stop.

Main core

The main core of the drone contains the autopilot, the actuation (propulsion) units and the video processing bay.



Propeller

Two counter-rotating propellers allow the drone to fly. The large size of the propellers, compared to standard quadcopter drones puts less load on the motors and propellers, thus prolonging lifetime. Markings on the propellers indicate which way to mount them (TOP Motor and BOTTOM Motor, with an indication of which side goes up).

Actuation unit

The actuation unit refers to the motor and tilt-mechanism assembly. Two Maxon custom-built motors spin the propellers via a fuse-mechanism (blade-linker) that protects the motors in case of a propeller-strike. The motors are burried inside the drone core for extra dust and particles protection.

Blade-linker

The blade-linker serves as a propeller mount and is designed such that in the case of a collision between the propeller and an obstacle, the blade-linker does not bend or break, instead releasing the energy by breaking the propeller.

Video processing bay

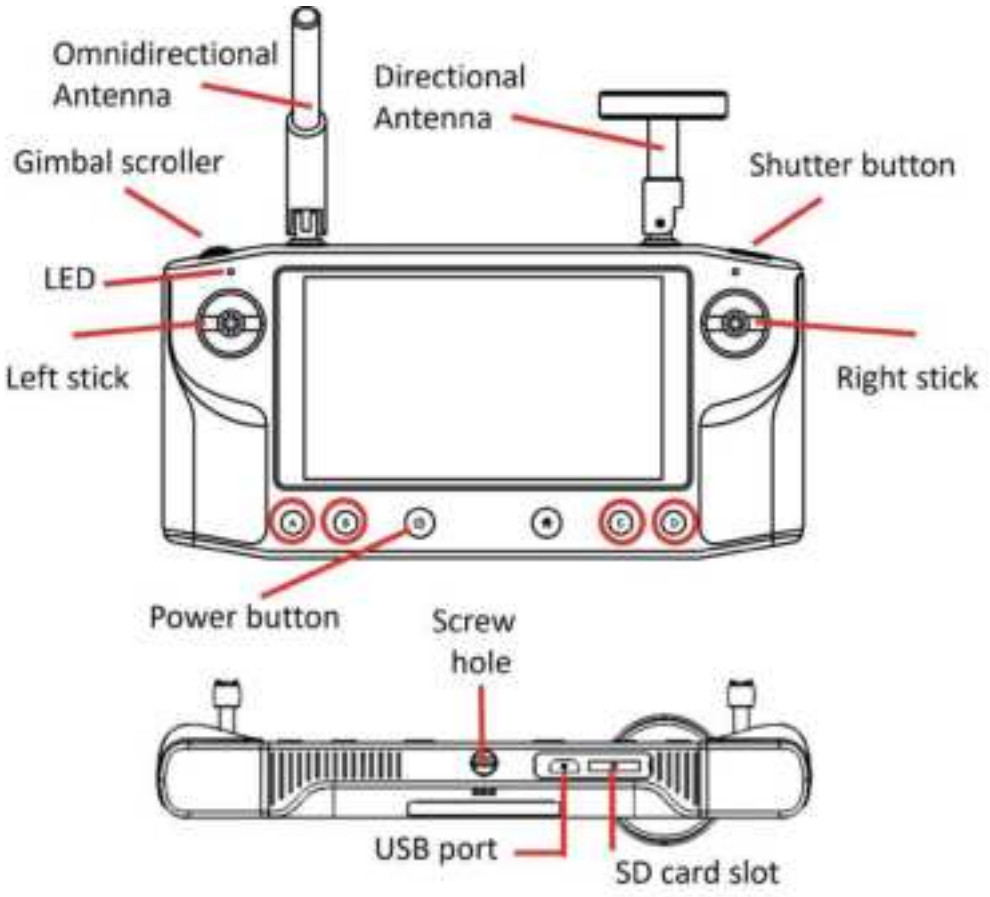
The video processing bay contains the onboard computer (Nvidia) that generates the video stream that is then sent out to the ground station via the air-unit. The SD card is mounted in this unit.

SD card slot

The SD card slot is located in the back of the drone (in the video processing bay). All of the flight data is recorded directly onboard the drone. A properly formatted SD card (FAT32) is required for the drone to start-up and record data. Without a FAT32 formatted SD card, an error message will appear on-screen and **no data will be recorded**.
Video footage of a 20 minute flight with photogrammetry can take up to about 12 GB. Make sure sufficient space is available before carrying out a mission, otherwise recording will stop mid-flight.

8 Herelink ground station

The herelink ground station consists in a controller with an integrated screen. It allows the pilot to control the drone and to visualize real-time video streaming for navigation and inspection.



The standard configuration of the controller is mode 2. The controller mode can be easily changed by following the procedure described in the Controller stick modes section.

Power button

Press and hold the power button for 3 seconds to turn the controller ON. Once ON, short-pressing the power button will put the controller in sleep mode. Pressing the power button for 3 seconds will shut down the controller after on-screen confirmation.

LED

The LED on the left hand side of the remote indicates the battery level.

- Steady green light: Sufficient battery power
- Steady yellow light: Medium battery power
- Steady red light: Low battery power (recommended to land)
- Flashing red light: Critical battery power (The remote can turn off without warning)

WARNING

Always be aware of battery level to avoid loss of communication due to completely depleted battery.

Antennas

The herelink controller is equipped with two antennas working in a diversity configuration. The controller will automatically select the antenna where signal reception is the best in order to receive and transmit data from and to the drone. One of the antennas (straight antenna) is omnidirectional (signal reception is average in all directions) and the other (mushroom shape) is directional (signal reception is very good in a specific direction).

NOTICE

The main antenna port is on the left side. The range-extender should always be connected to the left side.

Left stick

Controls the aircraft's altitude (or throttle) and yaw in standard configuration (mode 2).

Right stick

Controls the aircraft's pitch and roll in standard configuration (mode 2).

Gimbal scroller

Controls the gimbal angle (within +-90°). In standard configuration pulling on the scroller outwards will tilt the camera upwards and pushing on the scroller inwards will tilt the camera downwards. The gimbal can be quickly centered by short-pressing the quick-access button **A**.

Shutter button

Pressing this button will capture a 12 MP image of a point of interest (POI) and store it in the SD card's HQ folder.

Quick-access buttons A-D

By short-pressing the buttons **A**-**D**, the following functionalities can be quickly accessed :

- Button **A** : Center gimbal to 0° angle
- Button **B** : Toggle LEDs ON or OFF
- Button **C** : Activate or Deactivate Vel Lock (see Flight assistances section)
- Button **D** : Activate or Deactivate Wall Lock (see Flight assistances section)

Micro-USB port

Located on the bottom of the herelink controller, under a rubber cover, the micro-USB port is used both for charging the controller and for sharing the screen by cable to an external monitor (see the Screen sharing section).

SD card slot

An SD card can be inserted in the slot at the bottom of the herelink controller, under the rubber cover. Using a screen-recording application (not provided by Flybotix), the herelink screen can be recorded and serve as a back-up in case of an incident with the drone where it cannot be recovered.

Screw hole

This screw hole is used for securing the range extender or can be used to attach a neckstrap to the controller.

8.1 Herelink settings

The transmitter mode (modes 1 to 4 available) and the gimbal roller direction can both be changed directly and simply from the herelink settings menu. To access the menu :

- Turn on the herelink (press power button for 3 seconds)
- Access the applications menu (click on the applications menu at the bottom right)
- Select **Herelink settings** (circled in red)

8.1.1 Controller stick modes

The user can modify the standard mode 2 configuration in the herelink settings menu. Modes 1-4 can be selected (see the Controls section). To change the stick function assignement (controller mode) :

- Open **Herelink settings** (as described above)
- Click on the **Joystick** tab (second tab)
- Select the desired mode (bottom of the screen)
- Click on **SAVE**

Restart the ASIO flight application and the drone every time the mode is changed.

8.1.2 Gimbal roller direction

To change the gimbal roller direction :

- Click on the **Joystick** tab (second tab)
- Activate the slider in AXIS "**W**" (see figure, highlighted in blue)
- Click on **SAVE**

8.2 Screen sharing

For inspection purposes, the herelink controller's screen can be shared to an external monitor. There are two options :

HDMI monitor

Using a Micro-USB to HDMI adapter, the screen can be shared to a monitor with HMDI input. This will require an active adapter cable that is powered by a 5V source.

- Install a screen sharing app such as Drongscreen on the controller (see Android application installation)
- Connect the HDMI adapter to the controller, the 5V source and the monitor
- Run the screen sharing app and allow to capture screen

NOTICE

Micro-USB to HDMI adapters without external power will not work. The adapter must be active. Contact Flybotix to purchase or for recommended products.

Computer screen

Using a micro-USB to USB connector and the ASIO share application, compatible on Windows, the screen can be shared directly to a computer screen.

- Download the ASIO share folder from the Flybotix website
- Turn on the herelink controller and connect by USB to the computer
- Allow USB-debugging when prompted
- Run Screen share by double-clicking the Screen Share application

NOTICE

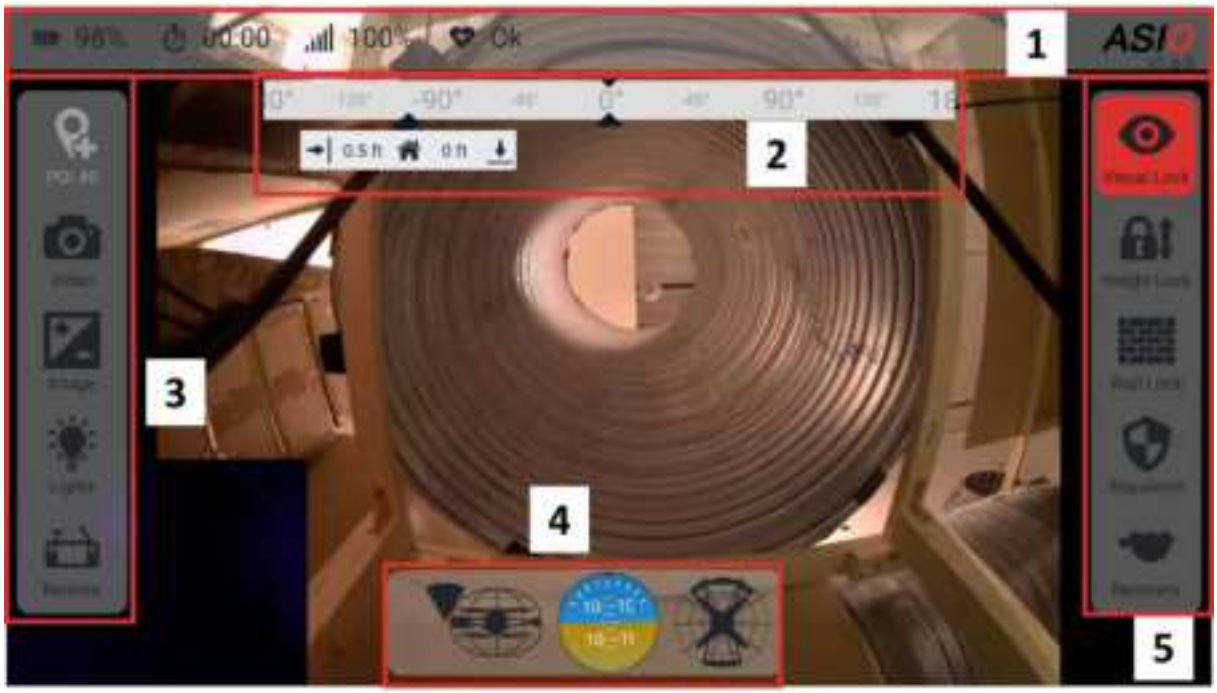
The computer mouse can be used to control the herelink screen functionalities such as activating features or changing parameters.

NOTICE

Setup on Mac OS requires homebrew for installation. Please contact Flybotix support for information on the procedure.

9 ASIO Flight application

The remote controller runs ASIO Flight for an intuitive control of ASIO. The features are described in 5 blocks, numbered in the figure. In flight, all active features show up in red.



NOTICE

In flight, or while running the application, the herelink controller battery level can be obtained by sliding the finger from the top of the screen downwards. The herelink battery level is then shown in percentage on the top left side.

CAUTION

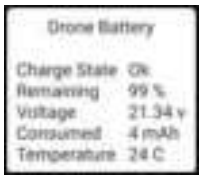
Every time the drone is restarted, the ASIO Flight application must be restarted. Failure to do so may result in erronous on-screen telemetry.

9.1 System status indicator (1)

The top part of the screen shows battery level, flight-time, signal strength and system health.

Battery level

Clicking on the battery level expands the battery menu, showing battery voltage, consumed mAh and temperature.



Flight time

Clicking on the flight time will display total flight time of the drone.

Signal strength

Clicking on the signal strength will display signal values.

System health

Clicking on the system health will show the inertial unit state, the vibration level indicator, as well as Accelerometer clipping.

Drone firmware version

On the right hand side of the top bar, under the ASIO logo, the drone's firmware version is indicated. This version number may be asked when troubleshooting.

9.2 Compass and distance to home (2)

The compass indicates the relative heading of the drone, with respect to the starting position. The 0° heading corresponds to the heading in which the drone was turned ON. The distance to home indicators give the horizontal and vertical distances from the starting point. This localisation feature is dependant on the quality of the optical flow and will not work in poorly contrasted environments. It is not to be used as a precise navigation tool, but an assistance.

9.3 Image, lighting and remote settings (3)

Points Of Interest

Pressing the on-screen POI widget will capture a full resolution 12 MP image. POI number is automatically incremented, confirming an image was captured. Images can also be captured by short pressing the shutter button on the top right part of the controller once.

Video

Pressing the Video widget brings up the video settings. Video stream can be selected (choose between fullscreen RGB or IR video and include an IR or RGB picture-in-picture (PiP) stream). Default is **RGB with PiP IR** stream.

It is recommended to use the RGB 4K camera's image in large for navigation. The videos of both the RGB and the IR cameras are automatically saved on the SD card whenever the drone is armed. Recording can be stopped in the same menu. A photogrammetry mode can be activated. When activated, the RGB camera will acquire 12 MP images at the selected frequency (which should be set depending on flight speed).

Image

Pressing the **image** widget opens the image settings. In this menu, ISO and Exposure settings are available to users who wish to fine-tune their camera to the environment in which the drone is used. The default setting is **Auto** for the ISO and 1/125 for the exposure.

The white balance can also be set in this menu and should be adjusted for best results depending on the environments in which the drone is flying.

Lights

Pressing the lights widget opens lighting LED settings. Lighting intensity ranges between 1% and 100% and an automatic mode automatically adapts the lighting to the amount of light in the surrounding environment.

LEDs can be turned on for both sides of the drone either simultaneously or separately (Left or Right), which may be used to study cracks and rust profiles (see Using Left and Right lighting).

LEDs can be toggled ON and OFF quickly by pressing the quick access button **B**, or by long pressing the lights widget.

Remote

Pressing the remote widget opens controller settings. To better adapt the reactivity of the drone to the environment and to pilot skills, the controller sensitivity can be set to either slow mode, standard mode or sport mode, corresponding to 30%, 60% and 100% of maximum stick inputs respectively.

WARNING

Flying in sport mode is recommended only for advanced pilots.

Trimming, can be carried out with the trim arrows (see the trimming procedure in section Manual mode trimming).

WARNING

In manual flight mode, always set the reactivity to standard or sport. If the drone is poorly trimmed and the reactivity is set to slow, the pilot may be unable to compensate for drift, which may lead to a crash.

9.4 Flight instruments (4)

Gimbal indicator

The gimbal indicator shows the gimbal position so the pilot knows at which angle the camera is looking.

Artificial horizon

The artificial horizon shows the attitude of the drone. It is especially useful when stuck against an obstacle to understand how the drone is stuck (see the section on Getting out of a stuck position).

Propeller activity indicator

When armed, the propellers will be spinning on the indicator.

9.5 Flight assistances (5)

ASIO can either be flown in a fully manual mode, where no assistances are active to help the pilot, or, in favorable environments, assisted modes may be used to facilitate the pilot's experience. See the REF section for more detailed explanations of the assisted modes.

Vel Lock

Vel Lock is a stabilization algorithm based on optical flow information obtained by the sensors around the drone. It is used to compensate drift due to the lack of GPS.

Vel Lock is activated by either clicking on the **Vel Lock** icon and selecting "On", by long pressing the **Vel Lock** icon, or by pressing the quick access button **C**.

This feature however cannot be used in environments without texture, such as an environment with featureless white walls. Although the stabilization may work in a specific environment, it can stop working temporarily and will switch to manual mode. The pilot must be ready

at all times to recover in the fully manual mode. Ideal environments include, amongst others, brick walls, walls with cracks or rusty environments.

Turning the **Above water mode** ON deactivates the optical flow input from the bottom facing sensor. This should be used when flying over water, or over a conveyer belt.

CAUTION

Vel Lock is disabled by default. Before activating, the pilot must understand the limitations of Vel Lock and be aware that manual control might be necessary in some cases.

Height lock

There are three options for Height lock:

Altitude Lock, that uses the barometer to stabilize the altitude of the drone, is the first option. Alternately, the drone can use either the bottom-facing or the top-facing IR sensors to maintain a fixed distance to the ground or to the roof respectively, with no additional input on the throttle stick.

By default, Altitude Lock is active upon startup. Activate Ground Lock or Roof Lock by pressing the **Height Lock** menu and selecting “On”.

To change the height setpoint, simply increase or decrease throttle and the drone will adopt the new height.

Functionality of Ground Lock or Roof Lock is limited to 5m from the ground or the roof.

It is not recommended to use the ground lock feature above water. Instead, for uneven grounds, select roof lock and vice-versa. In some environments, such as dry sewers, both can be used simultaneously. This assistance is not compatible with dusty environments.

NOTICE

Since the drone follows the topography of the underlying or overlying environment, sudden changes in topography may lead to the drone abruptly changing its height. Always be aware of this once height lock is activated.

Wall Lock

Activate Wall Lock in the **Wall Lock** menu or by pressing the quick access button **D**.

Once activated, the drone will lock onto a pre-set distance and angle with respect to a wall. These parameters are selected directly in the **Wall Lock** menu.

This allows the pilot to effectively scan a wall without worrying about yaw and pitch controls, thus reducing the necessary stick inputs.

WARNING

This feature requires a sufficiently large wall for proper function and should never be activated far away from a wall, which may lead to a crash. Wall Lock will be deactivated by default when the drone is turned on. Never arm the drone with Wall Lock activated.

Repulsion

Activate Repulsion in the **Repulsion** menu after setting the distance. When Repulsion is active, the drone uses all the IR sensors around the drone to detect and move in the direction opposite of obstacles.

This allows the pilot to avoid colliding into walls in confined spaces. The minimum distance to maintain from the obstacles can be set in the **Repulsion** menu on the right hand side of the screen. This mode only works when Vel Lock is activated.

CAUTION

Repulsion mode does not guarantee no collision will occur since the width of the IR beams used for sensing obstacles is small and thus, sensors may not detect thin obstacles. Pilot must be cautious at all times. Repulsion is not suited for dusty environments.

Failsafe

Clicking on the **Failsafe** icon will open up the failsafe and recovery options. The Recovery feature allows the drone to return to an upright position from an upside-down position. It can either be left constantly ON, or activated only when necessary.

In the case where Recovery is ON and the drone crash-lands and finds itself upside-down, it will automatically disarm. If there is no visible damage to the drone, the pilot can then arm the drone and the recovery procedure will start. At this point, the drone will start rocking back and forth in an area of roughly 50 cm x 50 cm (1.6 ft x 1.6 ft) until it rocks back into an upright position. Once upright, the drone will again disarm and wait for the pilot to rearm before spinning the propellers in idle mode and resuming flight.

In the case where Recovery mode is not active, if the drone crashes and flips upside-down, the propellers will not stop spinning. The pilot is required to manually disarm the drone. From this position, recovery mode can be activated and the drone armed. The rest is as described above.

WARNING

When activating the Recovery mode, make sure the environment allows sufficient space to carry out the recovery maneuver.

The **Rewind** feature, if enabled, will allow the drone to backtrack on its path if the signal is lost. This may allow the signal to be recovered if the loss of signal was caused by flying slightly out of range (see the section on Lost radio communication).

If **Auto land** is activated, the failsafe for a lost signal and for an emergency battery level will be an automatic safety landing. The failsafe procedures are described in the Failsafe section.

9.6 Warning messages

All warning messages should be observed by the pilot to prevent damaging the drone or the battery. Low battery warnings, ESC error and SD card error messages will show up as a pop-up message on-screen. The inertial unit failure and vibration alerts will be shown by the system health icon (see ASIO Flight application) turning red.

9.6.1 Pre-arm errors

Sensor error

If a sensor is faulty or is no longer sending data to the autopilot, the navigation LEDs will not stop flashing at boot-up. If for example the front facing sensor is not working, an error message distof 0 off will appear if the pilot attempts to arm the drone. In this scenario, the drone will not arm.

If the sensor fails mid-flight, no error message will appear but the navigation LEDs will be flashing, indicating a fault. In this case, the pilot should be cautious.

Motor error

Similarly to the sensor errors, if the motors are not sending data to the autopilot, the navigation LEDs will not stop flashing at boot-up. If arming is attempted, an error message will indicate if the top motor or the bottom motor is faulty.

SD card error If the SD card format is invalid (not FAT32) the SD Error message pops up. Check the format and the available space on the SD card (make sure min. 12 Gb are available)

9.6.2 Arming errors (motors)

If there is an issue with one/both of/both the motors, the following error messages may pop-up when arming the drone :

ESC arming safety: - Offline - Disarmed - FOC over-cur - FOC track-error - Tilt over-cur - Tilt track-err

The motor facing the issue will be indicated as top or bot. These errors can be due to damage in the rotor assembly, a tracking error in the tilting system or a communication error with the motor (the communication error will have been indicated before arming, as shown above).

- Check for any resistance in the tilting mechanism by changing the propeller pitch by hand.

Resistance may indicate an issue with the magnetic system.

- If free of resistance, try rotating the propeller by hand 1-2 turns and reattempt arming. Do not attempt this more than twice.

- If this does not solve the issue, disassemble the rotor head and check integrity of the propeller, blade-linker and fork as shown in the Maintenance and repair section.
- If the issue persists, contact Flybotix support.

9.6.3 Low battery level

There are 3 levels of battery warnings.

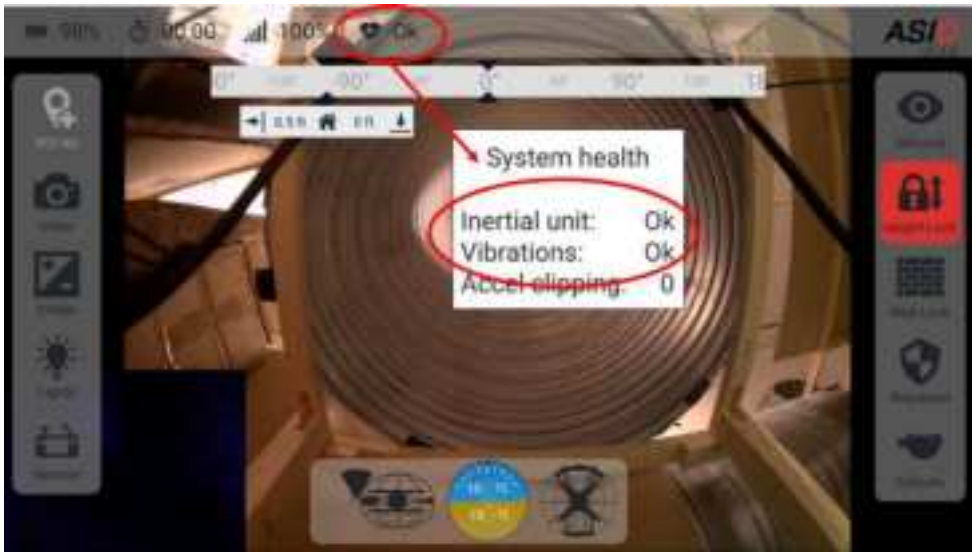
- Low-battery level at 30%
- Critical battery level at 10%
- Emergency battery level at 1% and automatic landing

These messages appear on screen and must be closed manually. At critical battery level, the top "Status" bar will turn red.

To prevent an automatic emergency landing, observe the warnings and anticipate mission end.

9.6.4 Inertial unit failure

In the System health menu, the inertial unit may show **Failure** in the case where flight conditions are really bad. Vibrations may induce this as well. This may occur when stuck against a wall for prolonged times. The image shows the system health menu.



9.6.5 High vibration levels

If the drone vibrates in flight, the system health indicator will indicate that vibrations are too high.

The origin of such vibrations can either be loose parts, unbalanced propellers or an inappropriate attachement between drone core and cage.

If vibrations are observed after changing propellers, check that both of the propellers are not damaged, that there are no chips or dents and that they are securely fastened. Even very small dents can change the balance in a propeller and lead to vibrations. Change propellers immediately at the slightest sign of damage.

If vibrations are observed after changing a cage, verify that the tension in the wires is properly adjusted and that the cage is securely attached with four zip-ties to the four bumpers (two in the front of the drone, two in the back).

9.7 Controller battery level

To see the battery level of the controller, in percentage, slide down with one finger from the top of the screen as shown. The battery percentage is on the left side (circled in red).

9.8 Changing icon size

The icon size on the herelink can be changed to better suit the operator's preferences. To access the icon size settings :

- Open the applications menu (bottom right of the herelink start-up screen)
- Open **Settings** menu
- Scroll down to **Accessibility** and open
- Scroll down to **Display size** and adjust with the slider

As an example, the default setting and the largest available setting are shown.

10 Drone operation

It is important to check all systems prior to any missions to minimize operational risks and potential damage.

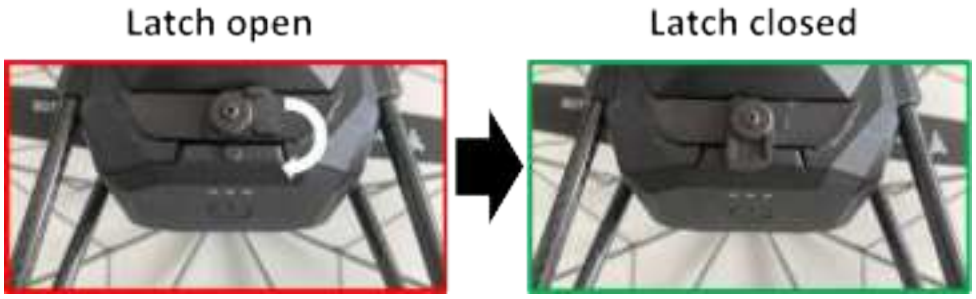
10.1 Inserting the drone battery

When inserting the battery, make sure to insert the battery in the right direction. The 3 status LEDs should be on top of the power button.

The battery must be inserted completely until the bottom locking mechanism clicks. Refer to the following images to check for a properly locked battery (upside-down view from the bottom of the drone).

If the battery fails to properly secure, push on the sides of the battery until secure as shown on the images. If impossible to do so, take the battery back out and restart the procedure until it is successfully locked.

After securing the bottom clip, secure the top locking latch as shown in the following image (clockwise turn).

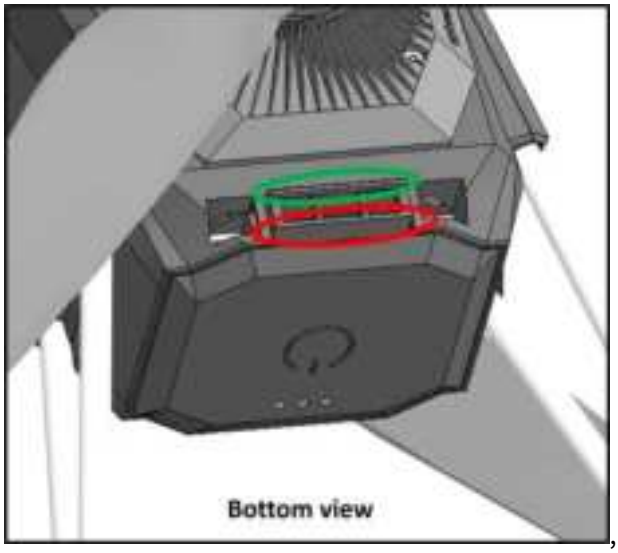


WARNING

Failure to properly secure the battery may result in battery disconnection, especially in combination with shocks against obstacles. ALWAYS check that the bottom clip and the top latch are properly engaged before flying.

10.2 Extracting the battery

To extract the battery it must first be released. To release the battery, start with the top latch. Open the latch by rotating counter-clockwise. To release the bottom clip, press on the locking clip on the inner-most part. Pressing on the outer-side of the locking clip will not release the battery. If done improperly the battery will not be released, and pulling on it will damage the battery case. See the following figure (view from underneath the drone). The green area shows where the clip should be pressed.



WARNING

Before removing the battery, make sure that the drone is no longer powered (wait at least 10 seconds after the navigation LEDs stop blinking). Before pulling on the battery for extraction, always make sure the clip has been released. Failure to do so will lead to damage to the drone or battery.

10.3 Mission preparation

Before an inspection and to ensure the longest flight time, all batteries and the remote should be fully charged. Check charge level of the batteries according to the LED code described in section 5.1.

- Inspect the drone for damage from previous flights.
- Check that the cage hoops are not cracked and ensure that all sensor glasses are clean.
- If a range-extender is used, connect it to the herelink controller before turning it ON.
- Never turn on the remote without both antennas. Doing so will damage the remote.
- Before starting up, select a suitable area for take-off and landing, which should be a flat, horizontal surface, free of obstacles and easy to access.

10.3.1 Pre-flight briefing

The pre-flight briefing can be printed out from the support section of the Flybotix website. We give some more detail in what follows.

ASIO Mission Briefing

Task:

- What is the pilot inspecting/looking for? - The pilot needs to be aware of what kind of defects or features he is looking for to fly accordingly
- Should photogrammetry be active? Frequency? - If the client wants images for photogrammetry, the pilot should turn this mode ON and set the frequency depending on the planned flight speed

Environment:

- What are potential obstacles? - This will allow the pilot to anticipate the presence of these obstacles and fly accordingly
- Which assistances can be used? - The pilot must evaluate the environment to determine if Vel Lock, Height lock etc can be used to assist
- How to enter and exit the inspection area? - Planning the entrance and exit are crucial to ensuring a safe flight
- Are there emergency exits available? - The pilot needs to have a plan for if there is an issue during the mission

Logistics:

- Is the range extender necessary? Where and how should the antenna be placed? - If the mission takes place in a sewer, tank etc… the pilot should setup the range extender within the environment

- Is screen sharing necessary? - Do the inspectors want to see the video in real-time or is data collection sufficient
- Can the drone be retrieved in case of a problem? - The pilot needs to have a plan for if there is an issue during the mission
- How much time is needed/when to turn back? - Setting up these parameters is crucial to making sure the drone returns before battery is depleted

ASIO pre-flight checklist

Before powering on:

- No damage to drone core or cage, zip-ties healthy - This should especially be done after a crash to check for non-obvious damage
- Propellers tight and not damaged (in depth check) - Check that there are no dents in the propellers and that the propellers are not cracked at the mounting point
- Both motors turn freely: Rotate by hand and check for hard points - If there is a hard point the motor may be damaged or something might be stuck in the motor
- Rotor head/blade-linker healthy: Move propeller tips up and down & Move propeller pitch - This is to check that the head is properly secured and that the tilting mechanism is not stuck
- SD card in position - FAT32 format - Enough free space
- Battery fully charged and no error (press button) - Always start a flight with a full battery to ensure longest possible flight time
- Herelink battery min. 60% - This value is not exact but will ensure that a full flight can be carried out without doubt
- Sensors and camera clean (use brush and cloth) - Sensor cleanliness maximizes performance of stabilization

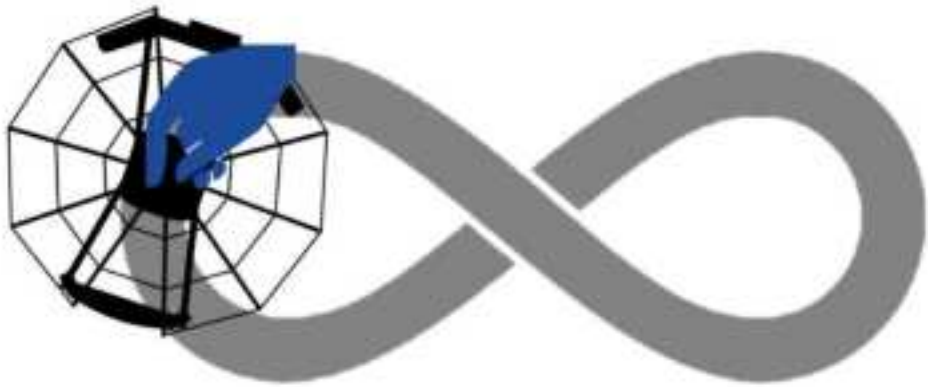
After powering on:

- Drone powered on and bound to controller
- Video live on screen (HD and infrared cameras)
- Gimbal and LEDs work properly
- Assistances and LED/camera settings set for mission
- Artificial horizon is level - showing 0°
- Drone trimmed (throttle hover point set)

10.4 Pre-flight calibration procedure

Although not compulsory, it is recommended to carry out the following procedure to help the position estimator to converge. This will lead to better quality stabilization as soon as the drone takes off, provided Vel Lock is being used.

After the drone has fully booted (untouched during the booting phase), pick it up by hand and move the drone in an 8 motion, while simultaneously moving yaw slowly.



Set the drone down for arming.

10.5 Setting failsafe options

For functionalities, please refer to the Failsafe section. Prior to each flight, it is important to set the failsafes in a way that is adapted to the environment.

Rewind should not be activated for missions where the flight environment is very small, due to increased risk of collision during backtrack flight.

The auto-land feature should not be used above water as chances of recovery will be reduced. Indeed, if the drone is hovering, it may be reached in time before crash-landing in water. When this failsafe is due to loss of signal, moving the antenna closer to the drone's location may lead to signal recovery.

10.6 Arming the drone

DANGER

Once armed and propellers are spinning, never insert any objects or body parts in the cage. Touching the propellers will result in serious injury.

The drone is armed holding the throttle at minimum and by performing a quick right-left-right motion on the yaw.

Left stick (Throttle and Yaw)

NOTICE

The throttle must be held at minimum during the right-left-right motion and the motion must be carried out rapidly or the drone will not arm.

If there are no issues with sensors or motors, which would be indicated by flashing navigation LEDs, ASIO will start spinning the propellers (armed). A sanity check is performed by the drone upon arming:

- Conditions OK : Idle mode (propellers spinning slowly).
- Conditions not OK: Disarm automatically. This is accompanied with one of the error messages described previously :

ESC arming safety: - Offline - Disarmed - FOC over-cur - FOC track-error - Tilt over-cur - Tilt track-err

If this happens, check for any resistance in the tilting mechanism by changing the propeller pitch by hand. If free, try rotating the propeller by hand 1-2 turns and reattempt arming. Do not attempt this more than twice. If this does not solve the issue, disassemble the rotor head and check integrity of the propeller, blade-linker and fork. If the issue persists, contact Flybotix support.

10.7 Disarming the drone

The disarming procedure is identical to the arming procedure. It should only be carried out once the drone is securely on the ground or is held firmly and safely.

Left stick (Throttle and Yaw)

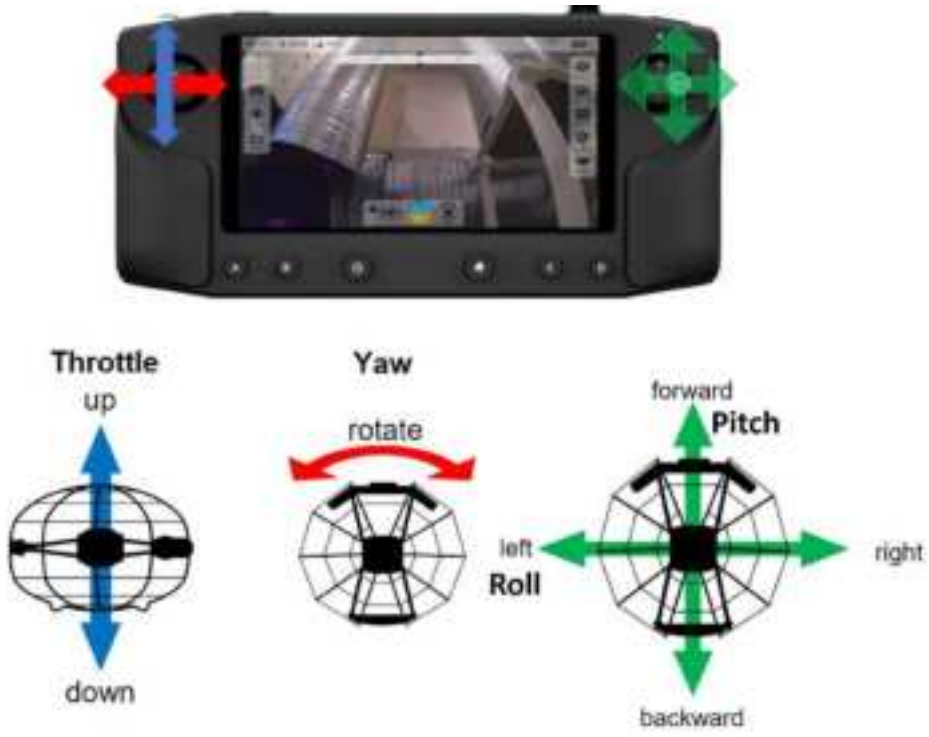
WARNING

Carrying out the disarm command in flight will lead to motors shutting down mid-air and will result in a crash.

NOTICE

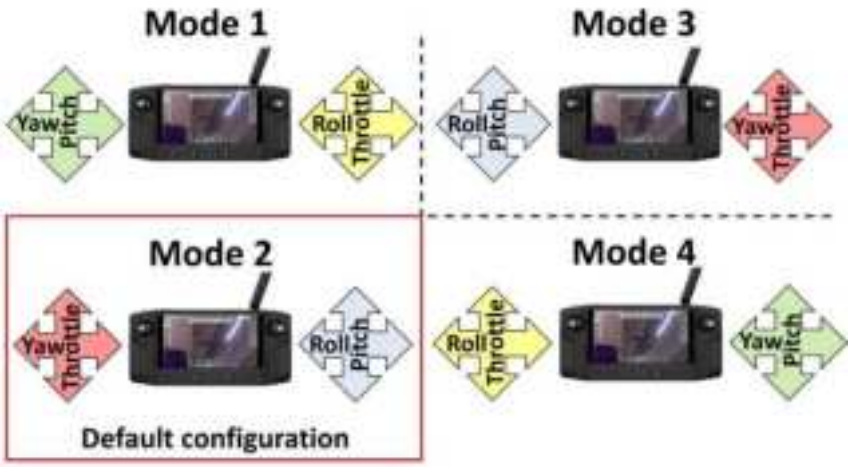
In the case of a crash, always disarm the drone immediately if motors are still spinning.

10.8 Controls



Controls in mode 2 are described in the figure above. The left stick controls heading (Yaw) and height (Throttle). The right stick controls the in-plane translations. Roll corresponds to a left-right movement and Pitch corresponds to a forward-backwards movement.

Other control modes can be set as described in section Controller stick modes. They correspond to the following mappings:



10.9 Flight modes

There are 3 main flight modes that can be used depending on the environment in which the drone is flying.

Flight mode	Functionality	Compatible environment
Manual mode	No assistances are active, full manual control	Works in any environment
Altitude hold (Height Lock mode)	Use barometer or IR sensors to keep fixed height	Low-dust environments, max. 6m away from ground or roof
Vel Lock	GPS-like stabilization	Contrasted/Textured, not too large environments

Altitude hold can be used when environments are poorly contrasted and thus not suited for Vel Lock. This stabilizes throttle and leaves only the in-plane motions to control manually, reducing the load on the pilot.

10.10 Starting up the drone

- Insert the battery as shown (LEDs above button) until it clicks. It is very important to make sure that the battery is securely clipped in the main body (refer to the section on Inserting the drone battery). **Failure to do so may lead to a crash.**
- Place the drone on the ground or on a flat surface.
- Short press the battery button **once** to turn on the drone.
- Do not touch the drone as it boots up and wait until the navigation LEDs stop flashing.
- Move 2 meters (6 feet) away from the drone for safety precautions.
- Arm the drone. If all internal checks are successful, the drone will enter IDLE mode (low motor RPM).
- Push the throttle stick up to accelerate the motors and proceed with the flight.

10.11 Manual mode trimming

In the case where the drone is drifting in manual mode, the drift can be compensated by selecting the **Remote** menu on the bottom left side of the screen and adjusting. It is recommended to trim the drone by first activating **Height Lock** only and adjusting drift on the front-back (Pitch) and left-right (Roll) axis. Once the drone no longer drifts in-plane deactivate **Height Lock** and adjust Throttle trim.

WARNING

Prior to starting trimming procedure, set reactivity to standard or sport. Failure to do so may lead to a drone run-away and eventually a crash.

NOTICE

When deactivating Height Lock, be ready to react on the throttle stick to a possible change in height (drone may fly up or down), which may arise from variations in pressure of the surrounding air.

10.11.1 Importance of Throttle trim

Due to the physics of flight, in order for the drone to fly, the drone's weight in air must be pushed down. The amount of air that needs to be pushed down will depend on the pressure of the air. Lower pressure environments will require more thrust than higher pressure environments. As such, throttle trim should be increased when flying at a higher altitude than usual and vice-versa. The effect of temperature is also non negligible and should be taken into account. High temperatures will require throttle trim to be increased slightly more with respect to standard temperatures. As a reference, we show typical throttle trim values for different altitudes.

Altitude	Sea level	400m (1300 ft)	1300m (4300 ft)
Trim value	48-49	50-52	56-58

WARNING

Throttle trim is extremely important and should always be tuned properly when flying in a new environment. Failure to do so may lead to a crash.

10.12 Using Vel Lock

In most environments, using Vel Lock will facilitate the experience for the pilot. However, in some cases, such as when environments are very uniform, with very little contrast or texture, Vel Lock may become unstable and require the pilot to fly completely manually. The pilot should always be ready to compensate for a drift.

- Prior to a mission, the throttle trim should **always be set properly**, in case the drone must be flown manually due to poor optical flow conditions (and thus poor Vel Lock stabilization).
- If starting from outdoors, be cautious with Vel Lock as stabilization may be affected by outdoor conditions. It is recommended to fly the drone in manual mode prior to entering the confined space.
- In very large environments, Vel Lock may perform worse than in more confined spaces. Stay close to the asset structures to guarantee optimal use of Vel Lock.

CAUTION

Vel Lock is disabled by default. Before activating, the pilot must understand the limitations of Vel Lock and be aware that manual control might be necessary in some cases.

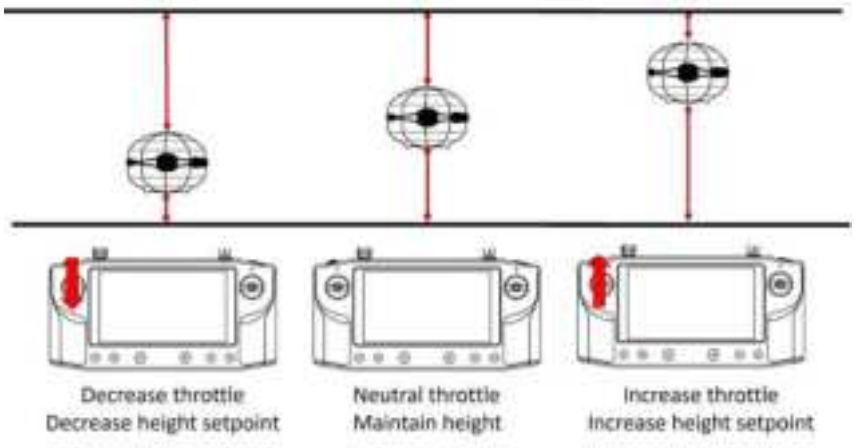
NOTICE

In general, Vel Lock can be used if the environment is not too large (or the drone stays close to the walls and structures) and if visibility allows for flight. If the drone senses that the quality of the environment for optical flow is too low, it will automatically switch to manual mode (and may drift). The drift can be minimized by properly trimming the throttle trim prior to flying.

10.13 Using Height Lock

Height Lock can be used in combination with Vel Lock. By default, Vel Lock already uses the barometer, similarly to Altitude Lock. If flying manually, it is recommended to use Altitude Lock.

Ground Lock or Roof Lock use the top and bottom IR sensors to lock the distance to either the ground or the roof when no additional input is given. It should only be used in situations where the amount of dust is low. The following figure shows the behavior of the drone in Height Lock.



- Without input in the throttle stick, the height will not change. If the throttle is lowered and then released as shown on the left side, the new flying height will be lower. Similarly, if the throttle is increased and then released, the new height position will be higher than previously (right side). Without further input to throttle, the drone will maintain the new height setting.
- Flying in a tube for example, using Roof Lock can allow the pilot to maintain constant height, as long as the position in the tube stays centered.

CAUTION

Altitude Lock is sensitive to variations in pressure. Some tight areas that are affected by the drone's airflow may lead to the drone's altitude controle becoming less stable.

CAUTION

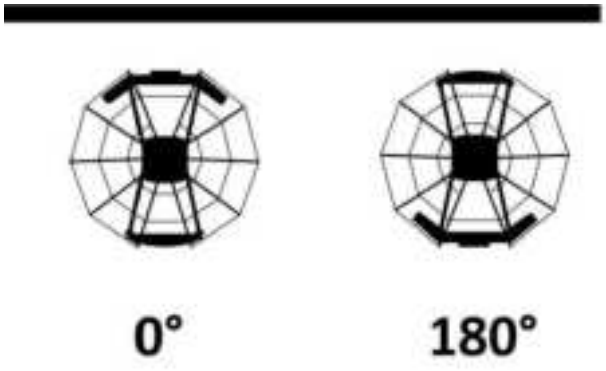
Once Height Lock is active, remember that changes in the locked surface topography (roof or ground) will lead to height variations.

10.14 Using Wall Lock

Because Wall Lock works with IR distance sensors, it should not be used in very dusty environments.

There are two possible angular configurations for Wall Lock; 0°, where the drone is facing the wall and 180°, where the drone is looking away from the wall. For each configuration the distance can also be selected, either set to auto or to a preset value.

The two configurations are illustrated hereafter.



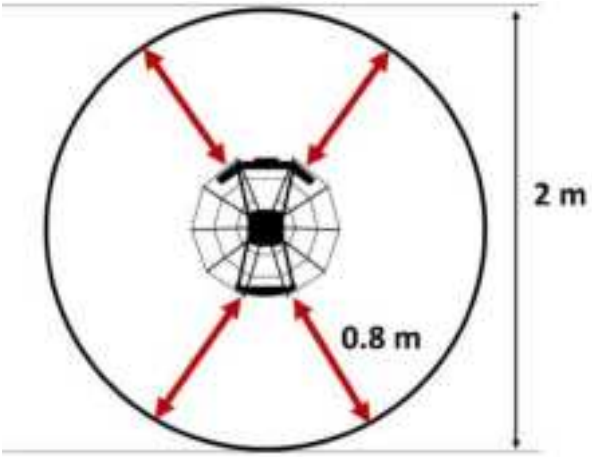
- In general, the pilot should always fly as close as possible to the desired configuration before activating Wall Lock. For example, if the intention is to use Wall Lock at 180° and 50 cm (1.5 ft), make sure the drone is already looking away from the drone at roughly the desired distance. This will ensure smooth reaction of the drone.
- If Wall Lock is activated and no wall is in proximity, the behavior of the drone will be unstable and may lead to a crash.
- Relying on multiple sensors, the Wall Lock functionality requires a **large wall**. Do not use Wall Lock on small walls. The minimum wall size will depend on the distance to the wall. As an example, if Wall Lock is set to 50 cm (1.5 ft), the wall should be minimum 3 m (10 ft) wide. At 1m (3 ft), the wall should be minimum 6m wide.
- When arriving at the edges of the wall, take care for unexpected behavior due to loss of Wall Lock. It is best to deactivate Wall Lock when reaching the edges.
- Wall Lock can be used on curved surfaces such as the inside of a large enough tank.

10.15 Using Repulsion

Repulsion should only be used in dust-free environments. Since the IR sensors used for repulsion are sensitive to dust, using repulsion in dusty environments will lead to unstable behavior of the drone that will constantly detect dust in the midst of the sensors.

When using repulsion, the repulsion distance should always be set to a value that allows movement of the drone in the environment without having repulsion constantly pushing the drone away in every direction. Since the drone measures roughly 40 cm in diameter, to calculate the maximum repulsion distance to set, apply the following formula :

Maximum repulsion distance (in meters) = Asset radius (in meters) - 0.2



As an example, if the drone is flying down a tube of 1 m radius, the maximum repulsion distance should be set to 0.8 meters. Any value lower than 0.8 meters will be acceptable.

CAUTION

In this example, if a distance larger than 0.8 meters is set, all sensors will constantly be detecting distances above the threshold and try to move away from the specific direction, and so on, leading to unstable behavior of the drone.

10.16 Using Left and Right lighting

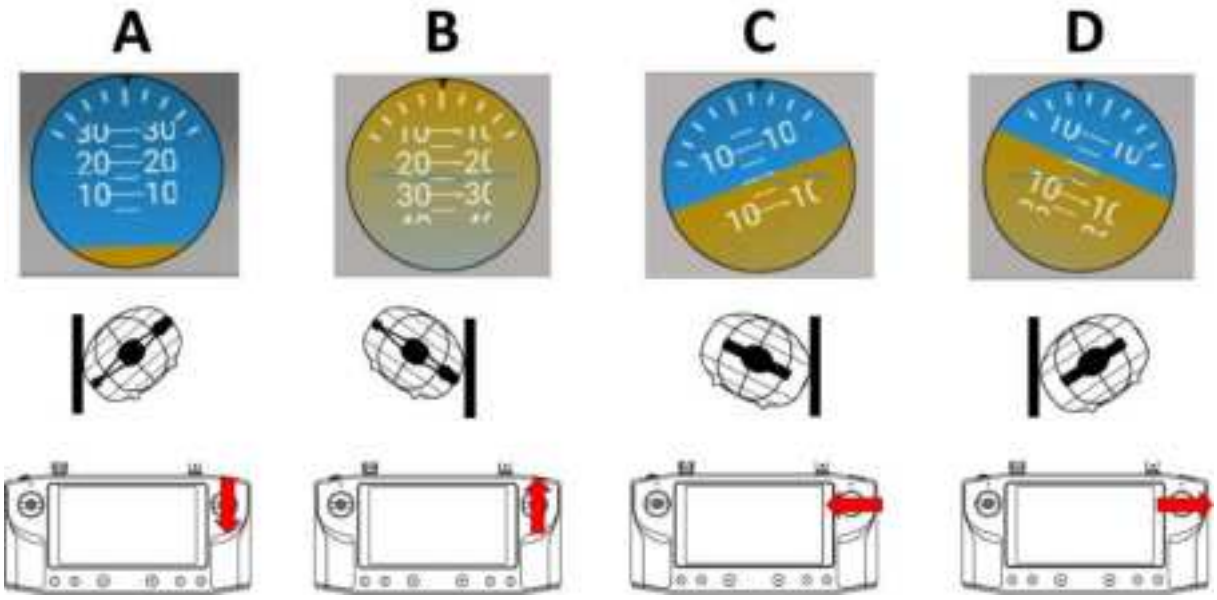
ASIO can be used to inspect rust on metallic structures such as ships. Using only one side of the lighting greatly increases the depth perception.

To do this, the pilot places the drone on one side of the rust line and then switches on only the light on the side on which the drone is. As an example, we show the difference between lighting with left side LEDs on the left side of the rust line in comparison to the right side LEDs.

The Left side LEDs give rise to a far better depth perception thanks to the shadows. In contrast the right side LEDs show no depth information.

10.17 Getting out of a stuck position

When the drone is stuck against a wall, looking at the artifical horizon can indicate in which direction to move to free the drone.



- In A, the drone is stuck with the back against the wall:
  - Pitch forward and reduce throttle slightly if necessary.
- In B, the drone is stuck facing the wall:
  - Pitch backward and reduce throttle slightly if necessary.
- In C, the drone is stuck with the right part against the wall:
  - Roll left and reduce throttle slightly if necessary.
- In D, the drone is stuck with the left part against the wall:
  - Roll right and reduce throttle slightly if necessary.

All stick movements should be carried out slowly, gradually increasing the stick input until free.

10.18 Landing

- Select an appropriate landing spot. A flat and sufficiently large surface should be chosen.
- When the drone is in a safe position, disarm (same motion as arming).
- **Once the propellers have stopped**, short press the battery button twice (within 1 second) and wait until the drone turns off (nav. LEDs blink until shutdown is complete). Take care not to touch any hot components (motor heatsink and video module bay).
- Push the locking clip upwards and remove the battery by pulling it out of the main body. The clip must be pushed in the innermost part not the outside part, as shown in the Extracting the battery section, otherwise it may not release properly.

NOTICE

To prevent damaging the battery, shut the drone down immediately after landing. If landing on a safe spot is impossible, the drone can be caught by a pilot assistant. Doing so will require wearing protection glasses and gloves and should be coordinated with the pilot.

WARNING

If the battery is difficult to remove, do not pull. The clip is not properly disengaged. Pulling on the battery will damage it. Once properly released it will be easily removable.

10.19 Post-flight procedures

After each flight, if any contact was made or if flying in dirty environments, always carry out a visual inspection of the general state of the drone.

- Clean eventual contamination from environment (spider webs, water drops, dust etc…)
- Use compressed air to remove dust from sensors and overall body.
- Clean sensor glasses with the provided brush or a microfiber cloth

WARNING

If the drone is humid, dry completely before storing in the box, or the drone may suffer damage

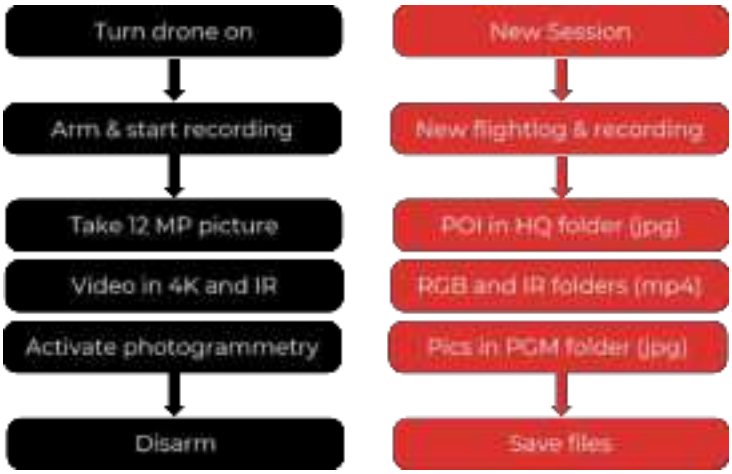
It is recommended to save all flight data after each flight.

- Download the data from the SD card to the computer
- Check that all necessary data is properly recorded

At the end of a mission, if not flying for 3-4 days, connect the batteries to the charger and discharge full batteries and charge empty batteries batteries to storage mode (see the section on Drone battery charging).

10.20 Flight data recording

All flight data is recorded on the SD card onboard the drone. Refer to the following diagram to understand data organization.



Video recording

Video recording is automatically started as soon as the aircraft is armed. This includes both the RGB and IR videos (saved respectively in RGB and IR folders). Recording can also be initiated prior to arming the aircraft by sliding the “recording ON/OFF” slider in the **Image** menu of the ASIO Flight app.

Recording stops automatically whenever the drone is disarmed. Alternately, recording can also be stopped mid-flight to save SD card space if not necessary.

NOTICE

Always properly shut down the drone to guarantee that all recordings are properly saved. Doing a force shutdown by long-pressing the power button may result in corrupted video.

The SD card should have sufficient free space (a full flight of 22 minutes with RGB, IR and photogrammetry mode at 1 Hz (1320 images) takes up 12 Gb of space). Incomplete data may be recorded otherwise.

Photogrammetry mode

12 MP pictures are automatically saved in the HQ folder at the frequency specified by the pilot in the Image menu.

POI recording

Pressing the POI widget on the ASIO flight app will capture a 12 MP image, that will be saved in the HQ folder with the photogrammetry pictures. The POI capture button on the herelink remote also captures an image.

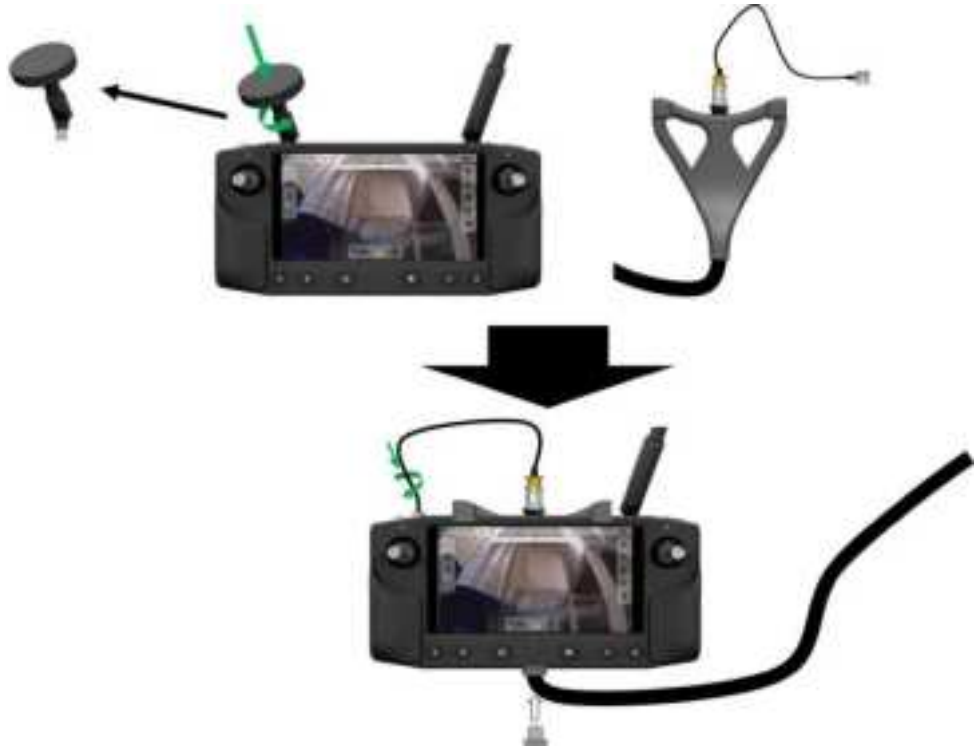
Photogrammetry pictures and POIs can be differentiated in the ASIO Explore software.

Flight logs

Flight logs capture all the sensorial data and controls of the aircraft, which can be used for troubleshooting. Flight logs automatically start recording as soon as the drone is armed and stop when the drone is disarmed.

10.21 Range extender

The ASIO passive range extender serves as a tool to place the antenna in visual-line-of-sight (VLOS) with the drone. This strongly increases range and is a necessity when flying in sewers and tanks from the outside for example.



To use the range extender:

- Remove the left side antenna
  - Press downwards against the remote
  - Rotate counter-clockwise (1/3 of a turn)
  - Remove the antenna
- Clip the range extender on the back of the remote:
  - Screw the bottom part in the remote using the provided screw
- Connect the range extender:
  - Press downwards against the remote
  - Rotate clockwise until secure (1/3 of a turn)

11 System status LEDs and indicators

11.1 Herelink LED

The LED on the left hand side of the remote indicates the battery level.

- Steady green light: Sufficient battery power
- Steady yellow light: Medium battery power
- Steady red light: Low battery power (recommended to land)
- Flashing red light: Critical battery power (The remote can turn off without warning)

11.2 Navigation LEDs

The navigation LEDs indicate the state of the aircraft. There are four statuses.

- LEDs off: Either the aircraft is turned off, or an internal issue will need to be analyzed
- LEDs blinking at 2 Hz (slowly): After pressing the power button, the aircraft is booting up or shutting down. At shut-down, wait until the LEDs are off before removing the battery
- LEDs blinking slowly in-flight: At least one sensor is failing
- LEDs solid: Aircraft is booted and ready for flight
- LEDs blinking at 5 Hz (fast): Aircraft firmware updating

11.3 Battery LEDs

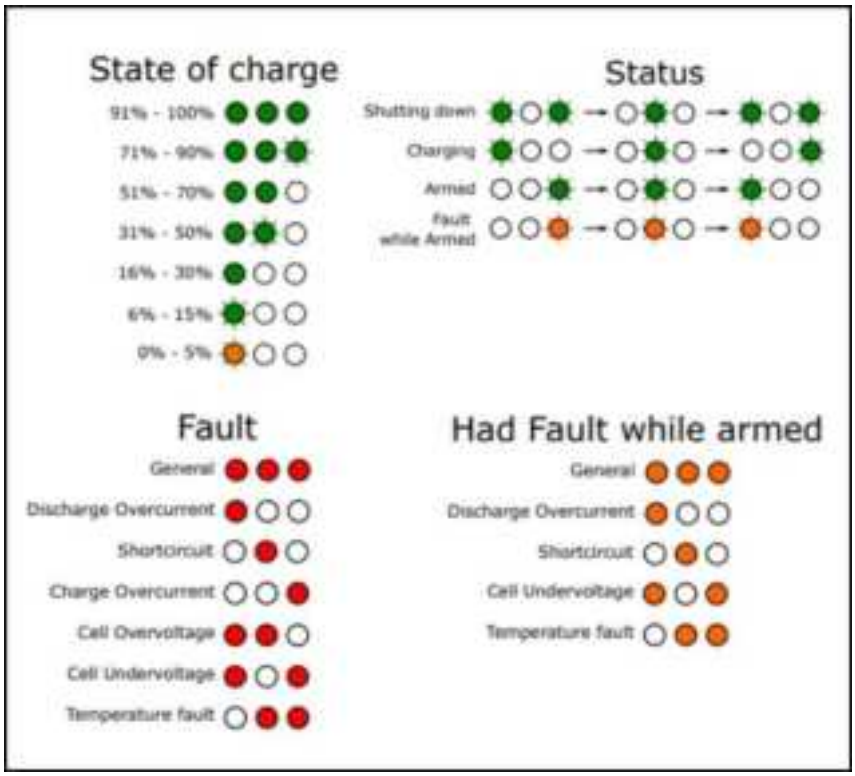
The battery is equipped with a smart battery management system (BMS), which balances cells and monitors the battery's status, health and temperature in flight. The power button at the front of the battery has multiple functionalities.

Button functionalities

- Short press while battery is disconnected to check the state of charge
- Short press while battery is connected to turn the drone ON
- Short press twice within 1 second to turn the drone OFF
- Long press (> 7 sec) while battery is connected to force shutdown of the drone (Not recommended as it may corrupt video. Use only if unable to turn OFF using short press)

The LEDs also give information on the battery status and on faults. These can be used to understand why issues arise and should be noted if they appear, for customer support.

All standard operations are indicated by green LEDs. If an error (fault) arrises while the drone is armed, the LEDs will be orange. A general failure of the battery pack will be indicated by red LEDs. If red LEDs appear, please report the status to your reseller.



Trusted/Untrusted state

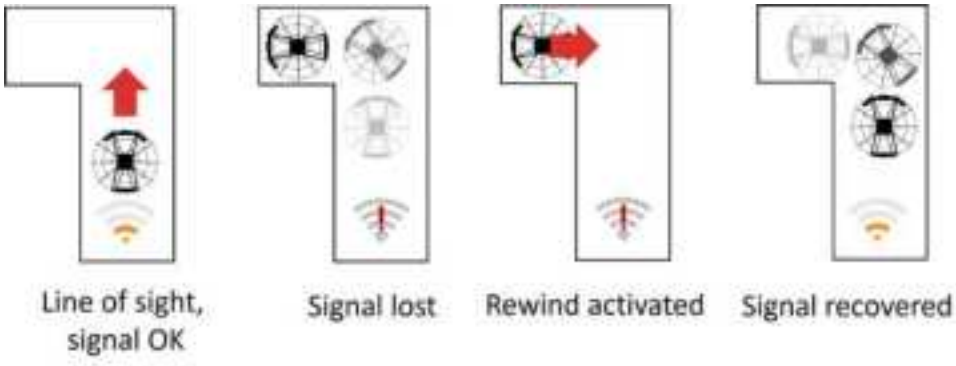
- When the drone was forced to shutdown by performing a 7 second press on the battery button, the battery enters an untrusted state.
- A battery in an untrusted state must be charged back to 100% before changing to a trusted state (see Charging procedures).
- If the same battery is used again without charging to 100%, the LEDs will flash when the power button is pressed and the drone will not turn on. This can however be bypassed **at the pilot's own risk**, by pressing the power button for 2 seconds while the LEDs are flashing. Flybotix does not recommend using a battery pack in an untrusted state and declines all responsibility.

12 Failsafe

Failsafe situations can in most cases be avoided by proper planning and preparation for a mission. The operator is responsible for avoiding these situations.

12.1 Lost radio communication

If communication between the ground station and the drone is lost, the Rewind functionality, if active, is the first failsafe.



Using the optical flow sensors, the drone attempts to backtrack on its path over the last 10 seconds of flight. This implies that this functionality is most effective in contrasted environments.

If the signal was lost turning a corner, the drone will try to come back around the corner and signal may be recovered.

- If the communication link is recovered within 30 seconds, the mission can be resumed.
- If the communication link cannot be recovered, with auto–land active, the drone will perform a safety landing, decreasing throttle until touching the ground. Otherwise, the drone will hover in position until the battery is depleted.

NOTICE

Always monitor signal strength to avoid such situations. A safe margin should always be observed (min. 30% signal). When signal is lower, fly slower to better anticipate loss of signal.

12.2 Emergency battery level

To prevent the drone from reaching a level of battery that would no longer allow it to fly, if auto land is active, a safety landing is performed, otherwise the drone will continue flying until battery is depleted.

NOTICE

Always monitor battery level to avoid such situations. A safe margin should always be observed (land with min. 20% battery).

13 Charging procedures

NOTICE

All charging procedures should always be respected to ensure prolonged lifetime of batteries and prevent incidents.

13.1 Drone battery charging

Each ASIO drone solution is equipped with a charger, that is preprogrammed for ASIO battery packs charging, and a charging cable, specifically designed for the ASIO drone.

WARNING

The cable provided by Flybotix is the only suitable charger for battery pack charging. Never attempt to use any other charging cables as this may damage the batteries.

Before charging a drone battery, make sure it is not damaged:

- Press the status button of the battery, check for any errors (see section Battery LEDs).

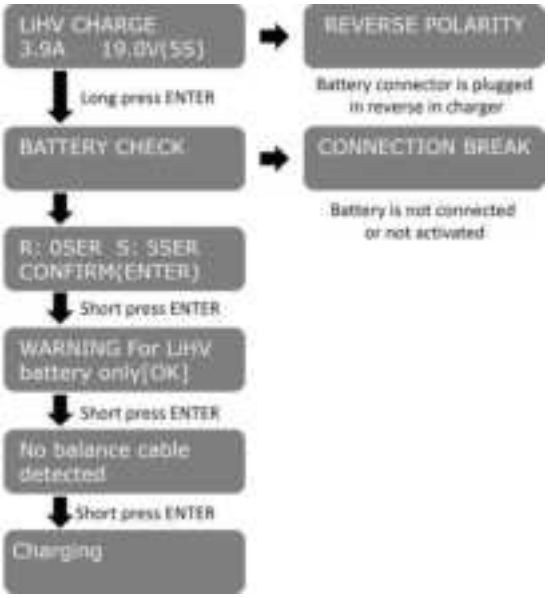
To start charging

- Turn on the charger by plugging it in. At startup the charger should show the appropriate settings (see figure).
- Connect the battery to the charger by sliding the connector into the battery as shown in the figure.

Activate the battery pack by clicking once on the status button. **If the battery is in an untrusted state (LEDs flashing), press the power button for 2 seconds while the LEDs are flashing to activate for charge.** If the battery pack is not activated before starting the charge, a “Connection Break” message appears.

Once connected and activated :

- Long press the ENTER/Start button (circled in red in the previous figure)
- Short press ENTER to confirm the settings
- Short press ENTER to confirm LiHV battery
- Short press ENTER to confirm no balance cable



Wait until full charge is complete before unplugging the battery.

To start a second charge, press on the STOP button once and restart the procedure.

A full charge from a completely empty battery requires 70 minutes. A battery at 20% will charge in less than an hour.

NOTICE

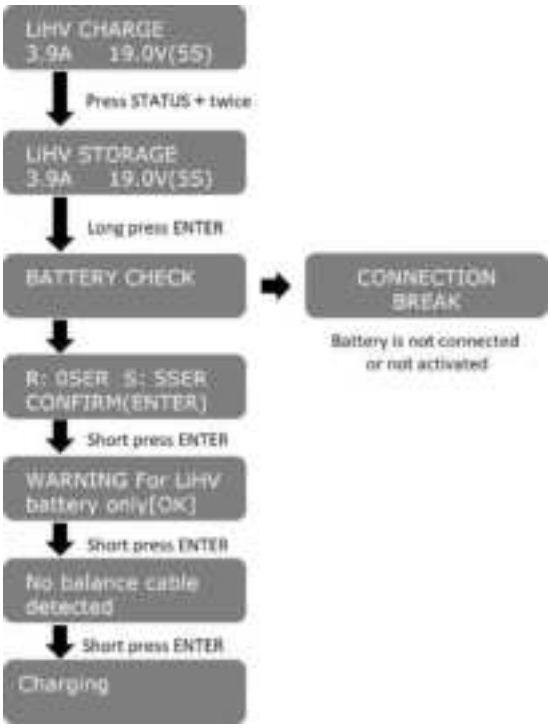
To maximize longevity of batteries, when hot after a flight, allow some cooling time before charging.

Storage mode

To charge/discharge the battery to storage voltage (if batteries won't be used within the next 3-4 days), turn on the charger, it will turn on to LiHV Charge, by default.

Press on the Status (+) button twice to reach the storage menu. Start the storage similarly to the charging procedure.

After storage is complete, click on STOP and click the Status (-) button twice to return to the LiHV Charge menu.



13.2 Herelink controller charging

The herelink controller is meant to be charged via the micro-USB port located at the bottom of the controller (the rubber dust protector must be lifted).

- A USB to micro-USB charging cable is included in the toolkit with every ASIO solution.
- Any standard 5 V output will charge the controller (computer or 5 V, 2 A wall charger).
- It is recommended to always start a mission with full herelink battery level. During missions, the controller can be charged using a powerbank.

NOTICE

When carrying out multiple successive missions, make sure to keep the herelink charged and monitor battery level regularly.

14 Post-Processing software ASIO Explore

14.1 Getting started

Once installed, open ASIO Explore and enter the Username and Password as defined. The main window upon startup gives the possibility to create a new project or to open an existing project and shows recent projects.

14.1.1 Creating a new project

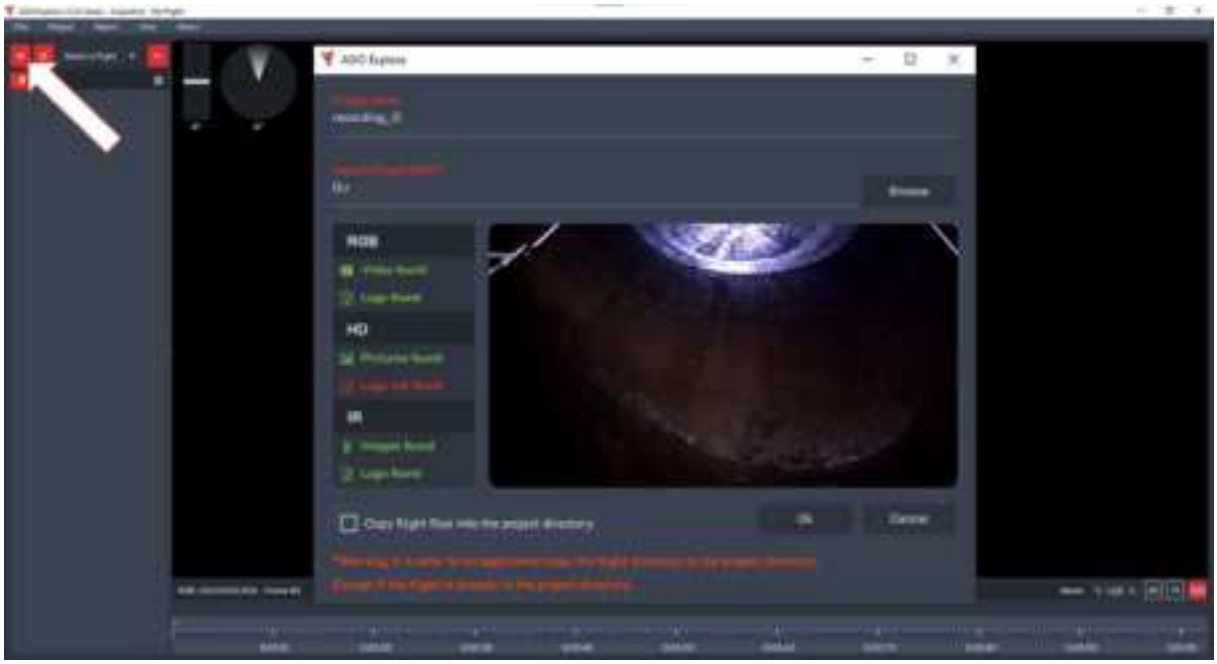
Upon clicking on the *New Project* button, the *Create Project* box opens. The user can then enter the name of the project, the file path to where the project will be saved, the inspection company, the location and customer as well as the reporter name.

The project is created when *Ok* is clicked.

14.1.2 Importing a new flight

Once the project has been created, a flight can be imported.

- Click on the + symbol on the top left corner to import a new flight.
- Specify the path to the flight data folder and add.
- Verify that RGB video, HD pictures (if any) and IR images have all been found successfully (note that if no POIs were acquired, the HD logs will show up in red, as shown).
- Flight files can be saved in the same directory by ticking in the optional box (this is recommended).
- Confirm by clicking *Ok*.



Once the flight has been imported, the RGB video shows up on the screen. The POI pictures taken during the mission are showed on the left hand side with their respective timestamps.

14.1.3 Full layout

Clicking on the 3D and IR buttons on the bottom right of the screen splits the full screen to show IR video and the 3D point-cloud along with the RGB video. Each sub-window can then be adjusted in size to suit the needs of the user.

In what follows each of the RGB, IR and 3D point-cloud model sections are detailed.

14.2 RGB Video

For the RGB video display, the following tools are available:

POI list (1) On the left hand side, all POIs are listed, in order of acquisition, with a timestamp attributed to each.

New POI

By clicking the New POI button, a still frame is captured at the current location in the video and is stored in the POI lsit (1).

Gimbal angle and heading indicators (2)

The rectangular display shows the gimbal angle and the circular display shows the heading with respect to boot-up heading.

Layout selection (3)

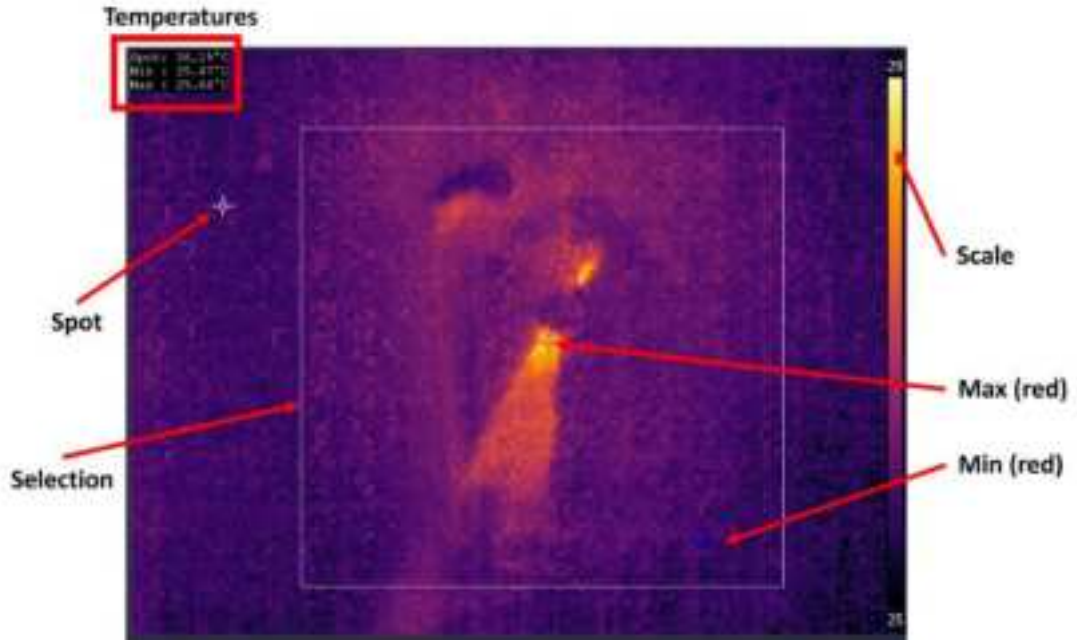
The IR and 3D datasets can be accessed by activating the respective buttons by clicking once.

Video tools (4)

The video tools allow visualizing the position in the video, pausing/playing the video, rewinding and forwarding as well as setting playback speed.

14.3 Radiometric IR Video

The IR window enables measurement of temperature with sub-degree accuracy. Specific spots can be selected by clicking in the desired location. The temperature value shows up in the top left corner.

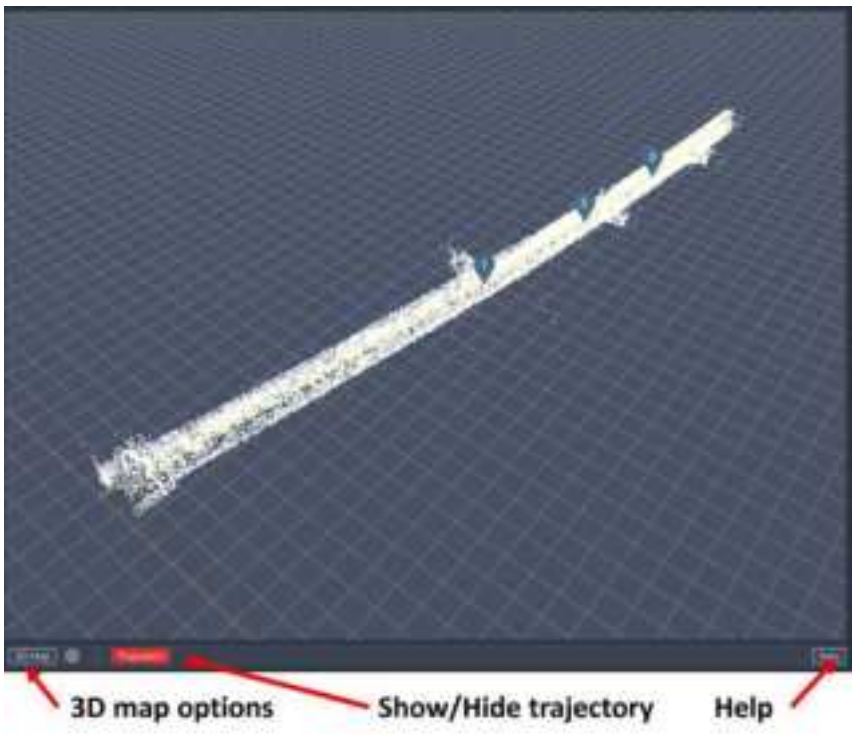


A selection square can be defined in the image. The spots of maximum and minimum temperatures within the selected area are marked with a red and a blue cross respectively. The temperatures are marked in the top left corner under the spot value.

The scale is shown on the right hand side.

14.4 3D point-cloud generation (SLAM)

The 3D point-cloud section contains all necessary tools for model generation and analysis.



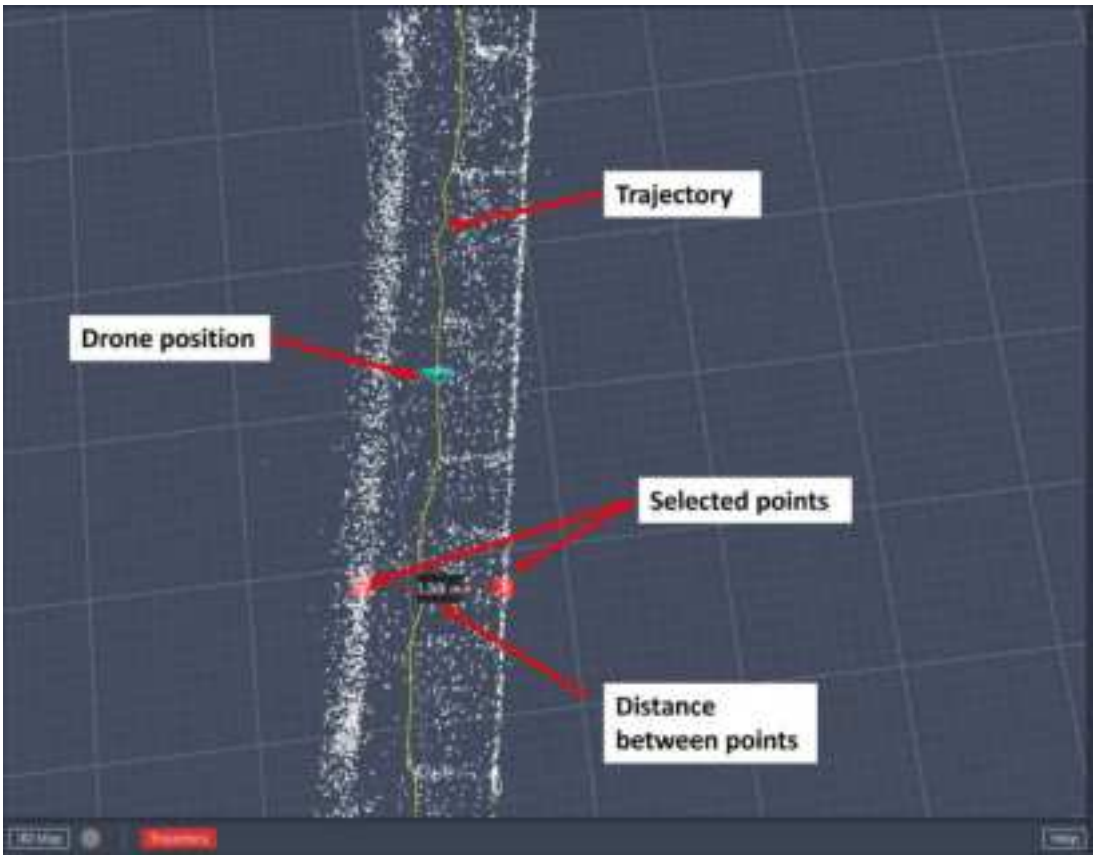
Clicking on the bottom left **3D Map** button will open the 3D map options.

To start generating a map, a new session must first be started by clicking the **+** button.

Trim the video to the desired length. To trim, place the cursor of the video at the desired starting position and press on the white arrow next to **Start position**. Then, place the video cursor at the

desired end position and press on the white arrow next to **End position**.

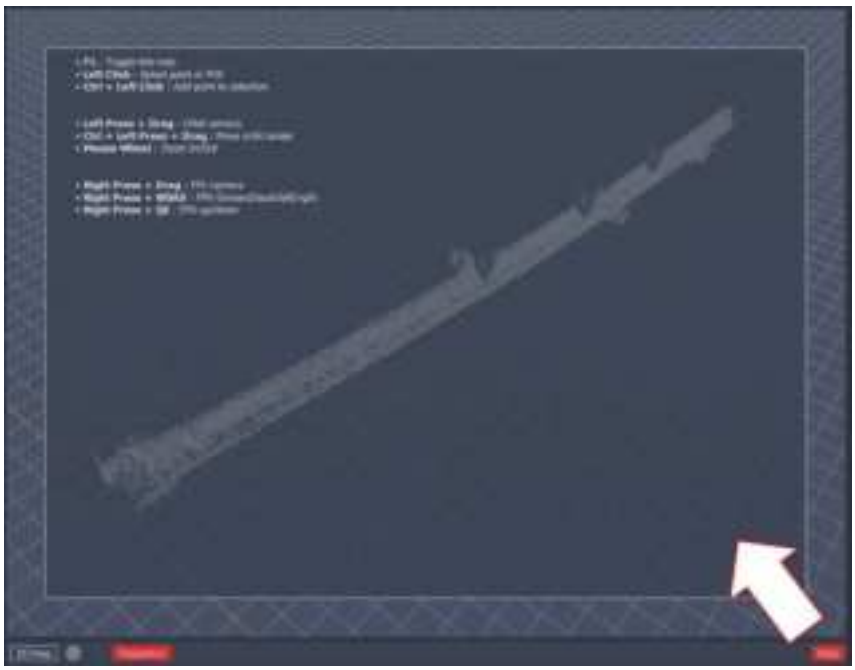
Launch the map generation by clicking on **Start**. Once processing is done, the resulting maps are shown in the dropdown **Selected map** menu. Generally, the map with **(best)** written next to it will be the most complete. It is however possible that the algorithm got lost due to lack of features at some point and may have generated another map for another part of the flight. Changing starting positions may enhance results depending on flights.



To apply a new scale, select two points with known distance between them (click on one point, then hold **Ctrl** and select second point). Adjust the scale by changing the measured distance on the model to the known distance.

The trajectory can be plotted simultaneously and allows accurate localization of the drone within the 3D point cloud. The drone position is shown as a blue icon. Clicking the **Trajectory** button in the bottom will toggle the trajectory visualization ON or OFF.

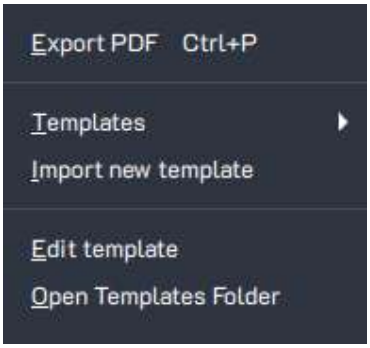
Clicking the Help button will open up the HELP window that shows how to navigate in the 3D point cloud.



Save the project before closing ASIO explore in order to reopen maps for future use.

14.5 Generating a report

After analyzing all Points of Interest, a report can be generated. This report can be generated in a PDF format by clicking the **Report** menu.



In the same menu, the user can select a template for the PDF report. The standard template provided with the software can easily be edited to include the inspector's logo and relevant information.

Alternately, the POIs can be exported in a raw format, which exports all images in a jpg format accompanied by a text file describing each POI. To export in raw format, click on **Project**, then **Export** and **POIs raw export**.

15 Maintenance and repairs

Throughout any maintenance or reparation procedures, always remove the drone battery to prevent any incidents due to battery power being applied. The following maintenance plan of the drone should be respected:

Component	Maintenance type	Unit	Time	Done by
Sensor cover glasses	Cleaning from outside	hours	1	Client
Fork	Tightening	hours	2	Client
Blade-linker	Inspection	hours	2	Client
Cage securing zip-ties	Replacement	hours	10	Client
Cage top and bottom zip-ties	Replacement	hours	10	Client
Blade-linker	Replacement	hours	25	Reseller
Fork	Replacement	hours	25	Reseller
Motor unit	Replacement	hours	100	Reseller
Battery	Replacement	cycles	100	Client

15.1 Storage and tansport recommendations

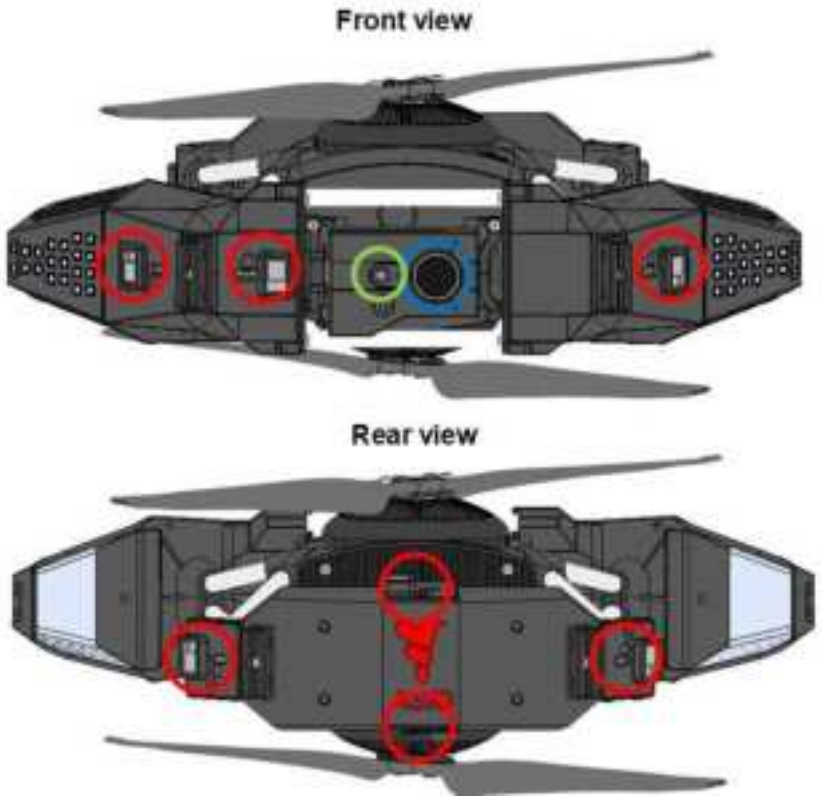
ASIO comes with a transport case which contains the drone and all its accessories. While storing or transporting the drone, it is recommended to leave the drone in its transport case to protect it as much as possible. ASIO should be stored in a dry environment where the ambient temperature is between 0°C and 35°C (32°F and 95°F). The battery packs must remain disconnected from the drone and stored inside the intended safety bags while transporting or storing, even for a short period of time. Failure to follow these instructions may lead to damage to the drone and the batteries.

In order to enhance the longevity and performance of the provided battery packs follow these rules as much as possible:

- Batteries should not be stored in a fully discharged state.
- Batteries can be stored in fully charged state for short periods of time (2-3 days).
- If unused for more than 10 days, the batteries should be put in storage mode. Connect the batteries to the charger and change the mode to “storage”.
- When travelling by airplane with ASIO, batteries must be kept with the passenger in a carry-on baggage and flight company regulations must be checked and applied.

15.2 Cleaning the drone

In order to maximize the flight performance and stability of the drone, it is recommended to regularly inspect and clean the sensor glasses. There are 7 sensors to check around the drone, circled in red below. If the sensors are dirty, the sensorial information will be of lower quality and may lead to instabilities in flight. To clean the sensors, use the brush contained in the tool-kit delivered with the solution. For dirt that is hard to remove, use a moist cloth first and then use a microfiber cloth to dry.



The main camera lens (in blue) and the IR camera glass (in green) can both be cleaned using a microfiber cloth. Take care not to press too hard on the IR camera glass as it may be pushed inwards.

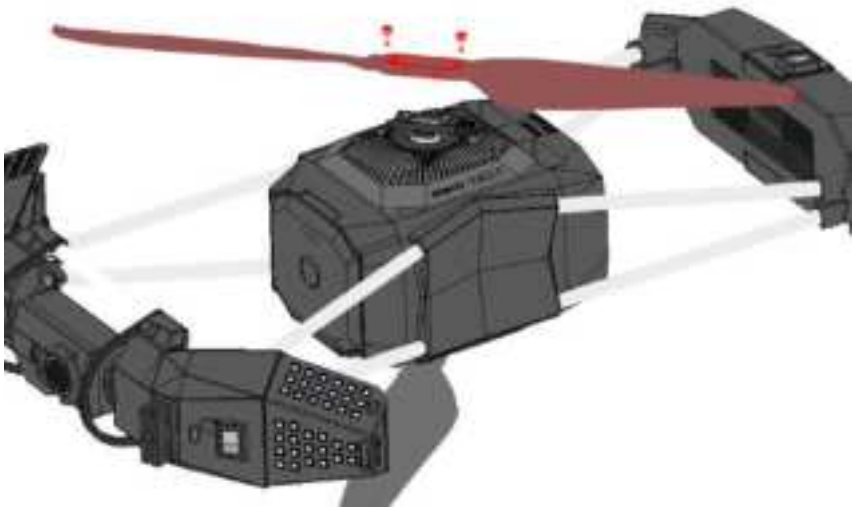
15.3 Changing a propeller

WARNING

If a broken propeller needs to be changed, there may be sharp edges that can cut the fingers. Manipulate carefully and with hand protection.

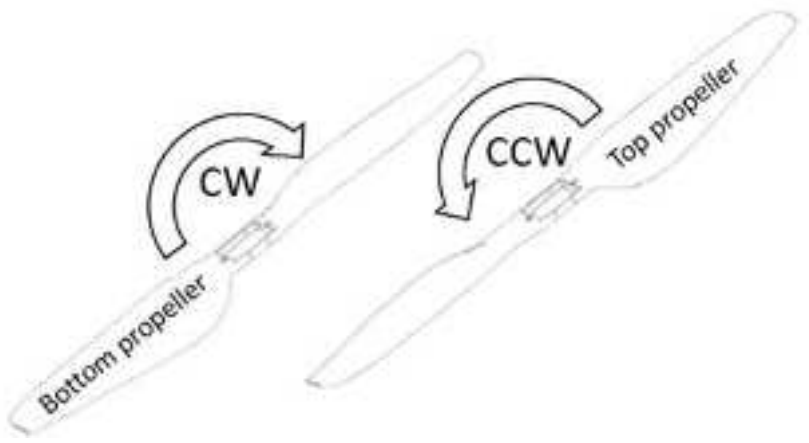
To change a propeller, the only required tool is the T6 screwdriver that is included in the toolkit.

Unscrew the two screws holding the propeller in position and lift the propeller gently, as described in the figure.



NOTICE

The top and bottom propellers are different and cannot be interchanged. Mount the propellers with the printed text facing up. The top propeller turns counter-clockwise and the bottom propeller turns clockwise.

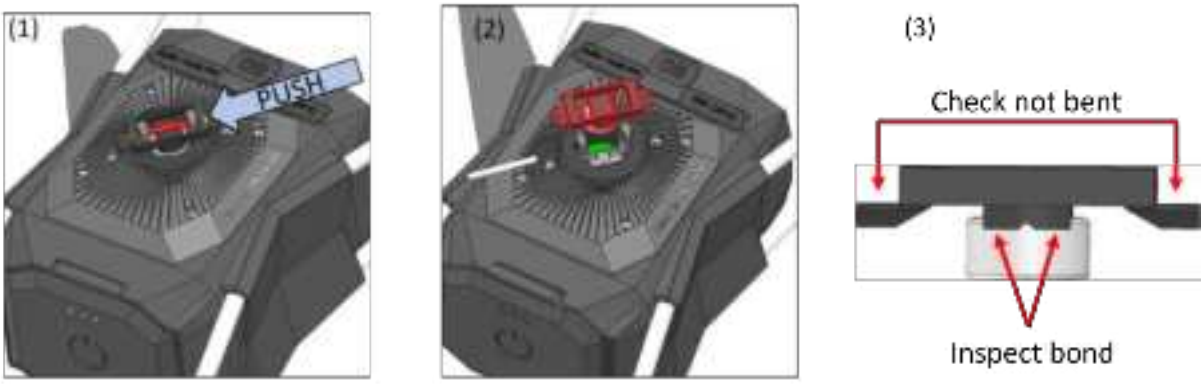


To reinstall, place the propeller on the blade-linker, take care not to force if there is resistance. This may be due to the pin in the blade-linker that may have moved. Make sure it is properly centered and attempt again. Secure with two screws (screw both screws progressively, to maintain equal pressure on both sides). Avoid overtightening, which may damage the propellers.

NOTICE

Change one propeller at a time and make sure that the replacement propeller is identical to the one being changed.

15.4 Blade-linker inspection



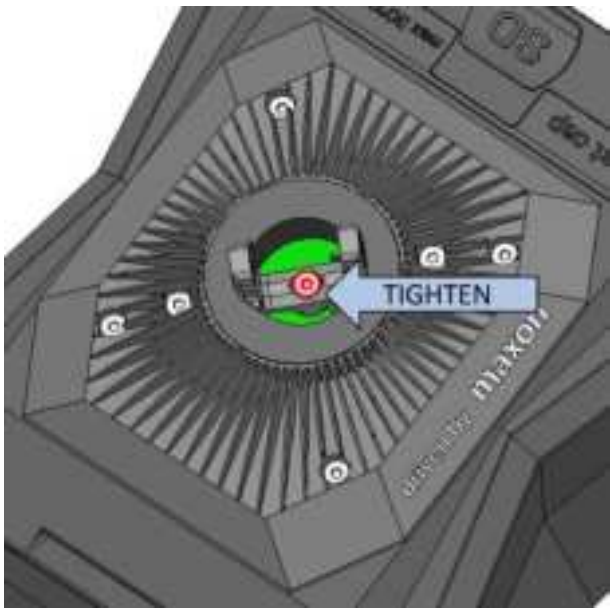
The blade-linker should be inspected for a proper magnet-blade-linker bonding as well as for bent components, especially after a crash. Follow the steps hereafter to carry out the checks.

- Start by removing the propeller
- With the propeller off, use a small tip to push the shaft out from the blade-linker as shown in the figures (1) and (2)
- With one hand, hold the blade-linker, with the other, grip the magnet and check that the bond is solid (see (3))
- Check that the blade-linker is not bent on the extremities (see (3))

15.5 Fork screw tightening

It is recommended to tighten the fork screw every 2 hours of flight.

- Start by removing the propeller and the blade-linker
- Use a T6 screwdriver to tighten the fork screw



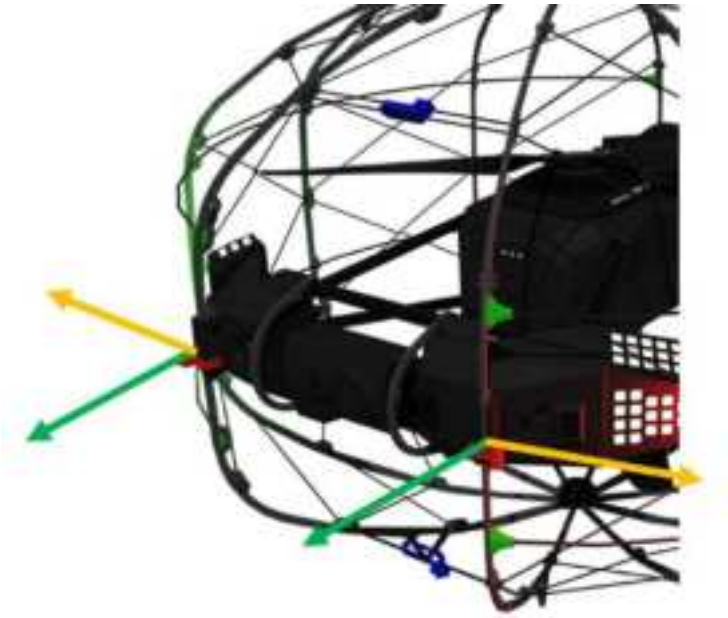
15.6 Changing the cage

To change a drone cage, the only required tools are zip-ties and cutting pliers.

WARNING

If the cage is broken, carbon shards can harm the hands. Wear protective gloves when manipulating broken carbon.

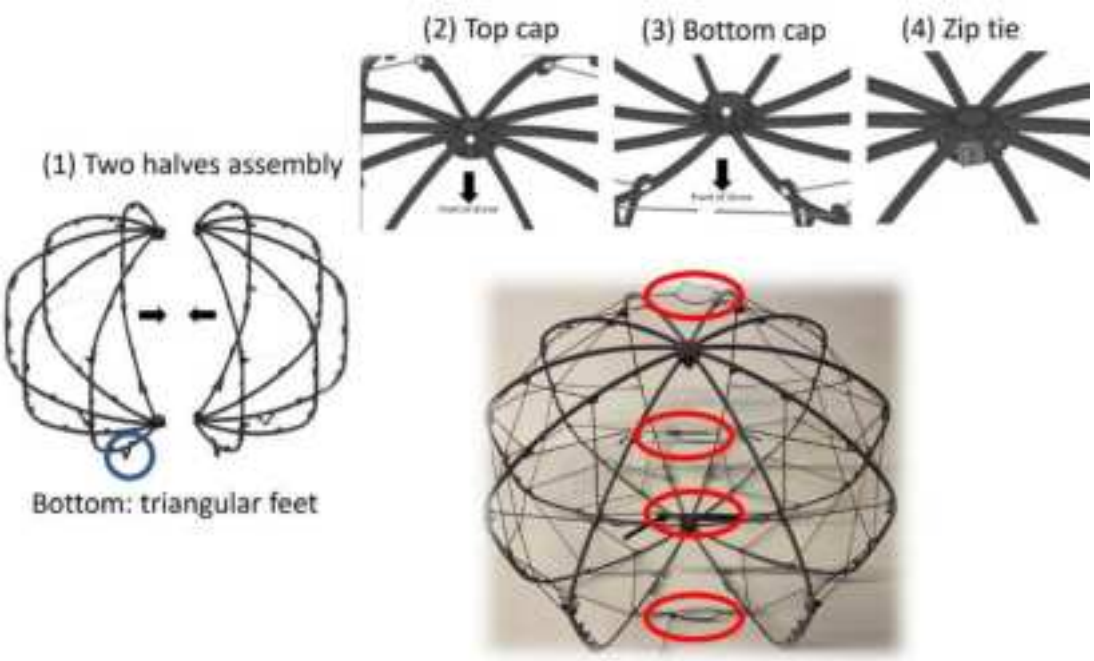
15.6.1 Extracting the drone core



To extract the drone from the cage, it is easiest to place the drone vertically, with the back module against the table, such that the core can then be simply lifted out of the cage. Follow these steps:

- Apply a (markless) protective tape on the sensor glasses (use masking tape).
- Cut the two front zipties (in blue)
- Release the 4 carbon rods from their plastic mounts (in green)
- Cut the 4 zipties around bumpers and cage (in red)
- Release the cage from the two front bumpers (Pull front hoops towards the front (along the green arrows) while holding the front module)
- Open the cage by pulling the front hoops sideways (along the yellow arows)
- Release the two rear bumpers from cage.
- Gently pull out the drone from the cage and set it on a main body support.

15.6.2 Cage assembly



- Bring together the two halves of the cage, taking care to place the triangular feet at the bottom (see (1)).
- Insert all hoops in the plastic cap for both the top and the bottom caps. The white dot marked on each cap should be facing the front of the drone and the inside of the cage (see (2) and (3)).
- Secure the hoops in position with a zip-tie. The locking mechanism of the zip-tie should be facing the front. Secure tightly and cut excess with cutting pliers (see (4)).
- Use four zip-ties to attach the halves of the cage (circled in red), these should not be tightened too much so they can be tightened once the drone is mounted and secured.

15.6.3 Inserting the drone core in a new cage

- Start with the cage assembled as described previously (cage assembly).
- Make sure all sensors are protected with masking tape.
- Place the cage vertically.
- Insert the drone inside the cage and align the rear
- Push the cage firmly in the two rear bumpers.
- Close the cage and insert the front hoops in the front bumpers.
- Fasten a new zip-tie around each bumper (in red). Use the bottom hole, there are 4 in total. Cut the excess zip-tie and check that the sensors are not obstructed by the zip-ties.
- Reinsert the carbon rods through the guide holes across the lateral hoops and secure in the front and back supports (in green).
- Finally, adjust the 4 zip-ties for cage tension and cut any excess zip-tie to not perturb sensors.

15.7 What to do after an incident with ASIO

In case of a crash or failure, do not attempt to rearm the drone before understanding the cause of the issue. Rearming the drone may cause even more damage. If Recovery mode is attempted, make sure the drone is not in water, as this will lead to electrical shorts. If the cage is damaged, handle the drone with protective gloves to prevent carbon shards from getting in the skin.

15.7.1 Incident report

To report an incident, please contact your local reseller as they will be able to assist you the quickest and most efficiently. If there are no local resellers, contact Flybotix directly via the website form for incident reporting. When reporting an incident, please include: * A detailed description of the events that lead to the incident * The flight logs in the SD card * Photos/videos of the state of the drone * The flight video * Any other useful information and data

WARNING

Do not attempt to repair anything other than the cage or propellers without consulting a reseller or Flybotix directly, as this may lead to catastrophic failure.

15.8 Drone firmware update

New firmware versions, when available, will be downloadable on the website www.flybotix.com. In order to update the drone's autopilot firmware, follow these steps :

- Turn on the herelink controller and activate the hotspot from the settings menu.
- Connect to the hotspot with a computer (Network name is BxDy for ex. B6D7 and password is 00000000).
- Turn on the drone.
- Open a web browser page and navigate to 192.168.144.21:3000.
- Drop the downloaded firmware file and click on *execute*.

NOTICE

It is important to upgrade firmware as soon as available to enhance performance, benefit from new features and address eventual issues.

15.9 ASIO Flight app update

The ASIO Flight application running on the herelink controller is updated using the ASIO Flight Updater application.

- Download ASIO Flight Updater (only necessary once, the first time).
- Open ASIO Flight Updater.
- Turn the herelink controller ON and connect to computer (wait until device is found).
- Download the new firmware.
- Browse to the downloaded firmware and select (or drop in the ASIO Flight Updater window).
- Click on *Update* and wait until completed.

NOTICE

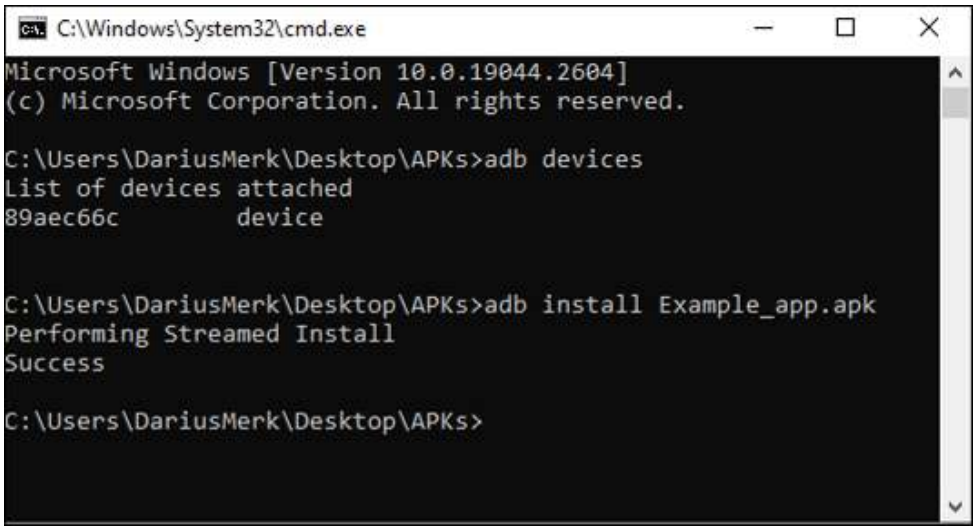
If the device is not found, make sure the USB cable is a data cable and not just a charging cable. Navigate to the settings menu of the herelink controller and check that debugging mode is enabled. Check that the USB configuration is set to "MTP Protocol" and not "Charging".

16 Miscellaneous

16.1 Android application installation

Applications for screen sharing or for screen recording can be downloaded directly online and installed on the herelink controller through any Windows or Mac computer equipped with the Android Debug Bridge (adb) package. Refer to the following procedure to install an application:

- Download the apk file of the application from a trusted source and place it in a folder
- Turn on the herelink controller and connect it to the computer via USB
- Allow USB debugging
- Open a terminal and navigate to the folder in which the apk file is stored
- type *abd install application_name.apk*
- Wait until completed



NOTICE

Typing "adb devices" allows one to check if the connected herelink is communicating with the computer. If not, check that the USB cable is a data cable and not just a charging cable. Navigate to the settings menu of the herelink controller and check that debugging mode is enabled. Check that the USB configuration is set to "MTP Protocol" and not "Charging".

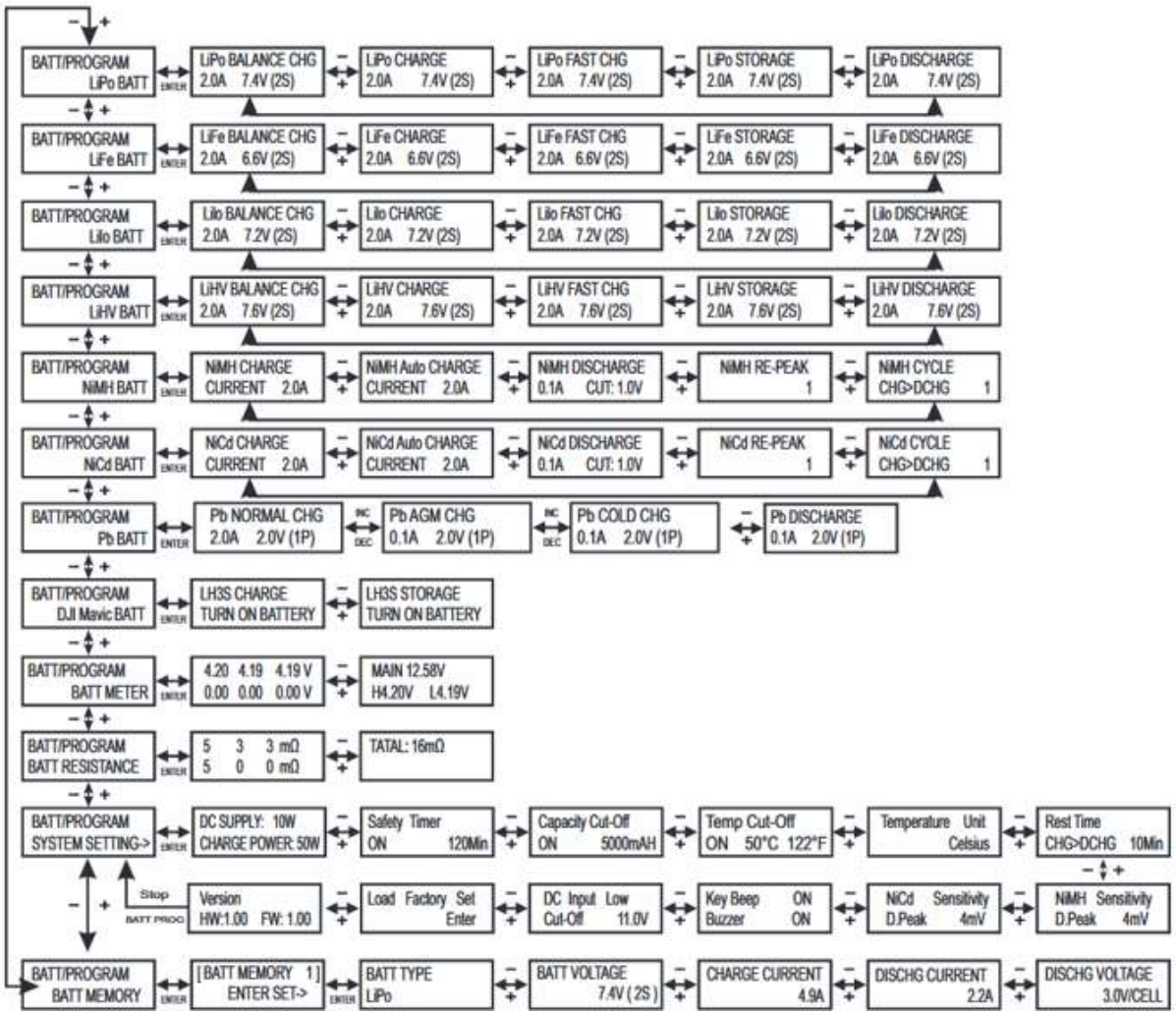
16.2 Troubleshooting guide

The issues listed here are the most common. In the case where the issue you are experiencing does not appear in this table, please contact your reseller.

Drone not booting (Navigation LEDs blinking)	SD card not formatted properly or not inserted or sensor error	Make sure SD card is in FAT32 format and properly inserted/try arming to see error message
Drone fails to arm (error message on screen ESC safety: - Offline - Disarmed - FOC over-cur track-error)	Tracking error between motor position and sensor	Check propeller and blade-linker integrity, move propellers around, perform 1-2 turns by hand and rearm ONCE, otherwise contact support
Lag in video	Incorrect boot-up of the video system	Reboot drone
Drone unstable in Vel Lock	Dirty sensors or environment not adapted for Vel Lock (poor optical flow)	Make sure sensor glasses are clean and if so, deactivate Vel Lock
Drone not climbing/climbing too fast when increasing throttle	Air pressure variations imply the need for more or less thrust to fly	Adjust throttle trim in remote settings
Drone drifting in manual mode	Perturbations in airflow or improperly trimmed drone	Adjust roll and pitch trims in remote settings (see trimming section)
Lighting LEDs not turning ON	If auto mode is selected and sufficient light is detected, LEDs remain off	Select power setting different from “Auto”
Video not recorded	SD card is full, wrong format or recording was stopped manually	Check SD card format and capacity

16.3 Battery charger program flow chart

If charging settings are lost, use this flowchart to set the appropriate settings (see Drone battery charging section). Never attempt charging with any different settings.



This figure is provided by SKYRC, producer of the charger.

17 Technical specifications

17.1 ASIO Solution Content

- 1x ASIO Aircraft
- 1x 2.4GHz Remote Controller
- 2x 64GB microSD Card (U3)
- 2x Spare pair of propellers
- 3x Battery and safety transport bag
- 1x Battery charger
- 1x Toolkit
- 1x Safety vest
- 1x Quick startup guide
- 1x Transport box

17.2 Aircraft

Operation

- Flight time: Up to 24 minutes
- Temperature operating range: 0-40°C / 32-104 °F
- Protection: Dust and water projections
- Max speed (Assisted): 1 m/s (3.2 ft/s)
- Max speed (Manual): 5 m/s (16.4 ft/s)
- Wind speed resistance: Up to 4 m/s (13 ft/s)
- Control algorithms: Vel Lock, Above water mode, Obstacle repulsion, Wall Lock, Altitude Lock, Roof Lock, Ground Lock, Rewind, Self-righting

Specifications

- Diameter: 395 mm / 15.6 in
- Height: 290 mm / 11.4 in
- Weight: 1 kg / 2.2 lbs
- Materials: Carbon fiber, Kevlar, aerospace grade composites, 3D printed thermoplastics
- Sensors: 3x IMUs, 1x magnetometer, 1x barometer, 7x distance sensors, 7x optical flow sensors
- Navigation LEDs: Red (port) and Green (starboard)
- Lighting LEDs: 6 panels

RGB Camera

- Sensor type: CMOS Rolling shutter
- Sensor size: 1/2.3”
- Sensor resolution: 12.3 MP

- Still pictures resolution: 4056 x 3040 px
- Video recording (4K): 3840x2160 px, 30 fps

- Video streaming (Full HD): 1920x1080 px, 30 fps
- Format (video): MP4
- Format (pictures): JPG

- Effective resolution: 0.2 mm at 30 cm (1 ft)
- Field of view: 153° diagonal, 121° horizontal
- Depth of field: 30 cm (1 ft) to infinity

IR Camera

- Sensor type: FLIR Lepton 3.5 (radiometric)

- Sensitivity: < 50 mK
- Sensor resolution: 160x120 px

- Wavelength: 8 µm to 14 µm
- Field of view: 71° diagonal, 57° horizontal
- Data recording: 9fps video, MP4
- Temperature range (Low gain mode): -10°C to 400°C (14°F to 750°F)
- Temperature range (High gain mode): -10°C to 140°C (14°F to 285°F)

Gimbal system

- Maximal upwards inclination: +90°
- Maximal downwards inclination: -90°
- Unobstructed vertical view: 200° (center of FOV)
- Unobstructed FOV (at ±90°): 50° (horizontal)
- Stabilization: Passive damping

Battery

- Battery type: Lithium Polymer (LiPo) High voltage (LiHV)

- Nominal voltage: 19 V
- Energy: 74.1 Wh

- Capacity: 3900 mAh
- Charging time: 75 min (100%), 45 min (80%)

- Storage temperature: -25°C to 35°C (-13°F to 95°F)

- Plane transportation: Approved for carry-on luggage
- Safety transport bag: Yes

LED lighting

- Lighting: 7000 Lumen oblique
- Light temperature: 5000 K
- Dimmable: 0-100%

- Orientation: Left / right / up / front / down (dimmed by software)
- Nominal power: 15W (eq. 2min flight time reduction)

17.3 Remote controller

- Screen size: 5.5”
- Resolution: Full HD (1920 x 1080 px)
- Screen mirroring: Yes
- Connectivity: microUSB, Wifi 2.4GHz
- Transmission distance: Up to 16km (line of sight)
- Operating frequency: 2.4GHz ISM
- Weight: 515 g (18 oz)
- Battery life: 4 h
- Operating temperature: 0°C to 45°C (32°F to 115°F)

- Certifications: CE / FCC / SRRC

17.4 Transport case

- Dimensions: 65 cm x 53 cm x 39 cm
- Empty weight: 11.5 kg
- Total weight: 15 kg

17.5 Emitted power and frequency range

All herelink systems are set to the region in which they are to be used. FCC can only be used in North America (including Canada), Central America, South America, Australia, New Zealand, India, Malaysia, the Philippines and Taiwan. All other regions must be operated accordig to the regulations in place. All users in europe must use the herelink controller in EU mode. Flybotix declines responsibility if inappropriate power settings are used.

- EU Mode: E.I.R.P < 19.5 dBm
- FCC Mode: conducted < 29 dBm
- Operating frequency: 2.4GHz ISM

17.6 Noise level

Noise level of 80 dB at 1 meter.

All instructions, safety precautions and any other document and files are subject to change at the sole discretion of Flybotix SA. For up-to-date product information, visit our website www.flybotix.com, check the product page or contact us at support@flybotix.com

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