



STORMBEE User Manual



Think 3D BVBA

30/09/2018

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Version Control

Author	Date	Version	Comments/Adaptations
Jon Verbeke	26/04/2018	1.0	First draft
Jon Verbeke	30/09/2018	1.1	Updated to S20 model

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Symbols and abbreviations

ASAP	As Soon As Possible	
ATC	Air Traffic Control	
CG	Centre of Gravity	
DJI	Dà-Jiāng Innovations	
DSLR	Digital Single Lens Reflex (camera)	
ESC	Electronic Speed Controller	
FC	Flight Controller (autopilot)	
FPV	First-Person-View	
GNSS	Global Navigation Satellite System	
GPS	Global Positioning System	
H	Height	[m]
HDMI	High-Definition Multimedia Interface	
IMU	Inertial Measurement Unit	
L	Length	[m]
LB2	Lightbridge 2	
LED	Light Emitting Diode	
LiPo	Lithium Polymer	
MTOM	Maximum Take-Off Mass	[kg]
NOTAM	Notice To Airmen	
PMU	Power Module Unit	
RGB	Red-Green-Blue (camera)	
RPA	Remotely Piloted Aircraft	
RPAS	Remotely Piloted Aircraft System	
RTH	Return-To-Home	
SDI	Serial Digital Interface	
UAS	Unmanned Aerial System	
UAV	Unmanned Aerial Vehicle	
USB	Universal Serial Bus	
UTC	Universal Coordinated Time	[hh:mm]
VLOS	Visual Line Of Sight	
VNE	Velocity Never Exceed	[m/s]
W	Width	[m]
WiFi	Wireless Fidelity	

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1 Introduction

This user manual applies to the STORMBEE S20 drone developed by Think 3D BVBA (Figure 1.1).



Figure 1.1 STORMBEE S20

Please read, understand and adhere to the procedures and guidelines described in the following documents before flying with the STORMBEE S20 drone:

- STORMBEE User Manual (this document)
- STORMBEE Quick Reference Handbook (separate PDF)
- STORMBEE Software User Manual (separate PDF)
- DJI Lightbridge 2 User Manual (download here: <https://www.dji.com/lightbridge-2>)
- DJI A3 User Manual (download here: <https://www.dji.com/a3>)
- DJI A3 Disclaimer and Safety Guidelines (download here: <https://www.dji.com/a3>)

You can search these PDF documents in Windows using Ctrl+F or on Mac using Command+F. If you have further questions, please contact your authorised reseller.

The following definitions apply to warnings, cautions, and notes used in this User Manual:

- | | |
|------------------|--|
| WARNING!! | Disregarding the following instructions leads to an immediate or severe deterioration of flight safety and hazardous situations, including such resulting in personal injury and damage to property. |
| CAUTION! | Disregarding the following instructions leads to a serious or long-term deterioration of flight safety. |
| NOTE | Draws the attention to any special item not directly related to safety, but which is important or unusual. |

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2 STORMBEE specifications

STORMBEE is a multirotor drone (Unmanned Aerial Vehicle, UAV, or Remotely Piloted Aircraft, RPA) with 8 motors mounted in X8 configuration, meaning 2 contrarotating motors per arm (Figure 1.1). Both the motor arms and landing gear are foldable for transport. The standard payload consists of a Faro Focus (X- or S- series) scanner used for airborne laser scanning.

The main specifications of STORMBEE S20 are given in Table 2.1.

Table 2.1 STORMBEE specifications and performance

Specifications	Value	Unit
Maximum Take-Off Mass (MTOM)	25	Kg
Empty mass	12	Kg
Batteries mass	4.5	Kg
Payload mass	< 5	kg
Size (L x W x H)	145x150x60	Cm
Battery capacity	2x16	Ah
Remote controller	Lightbridge 2 + iPad (mini)	
Tablet app	DJI GS Pro (or DJI GO)	

2.1 Three-View-Drawing of the STORMBEE S20



Figure 2.1 STORMBEE S20 three-view drawing

2.2 Flight controller schematics

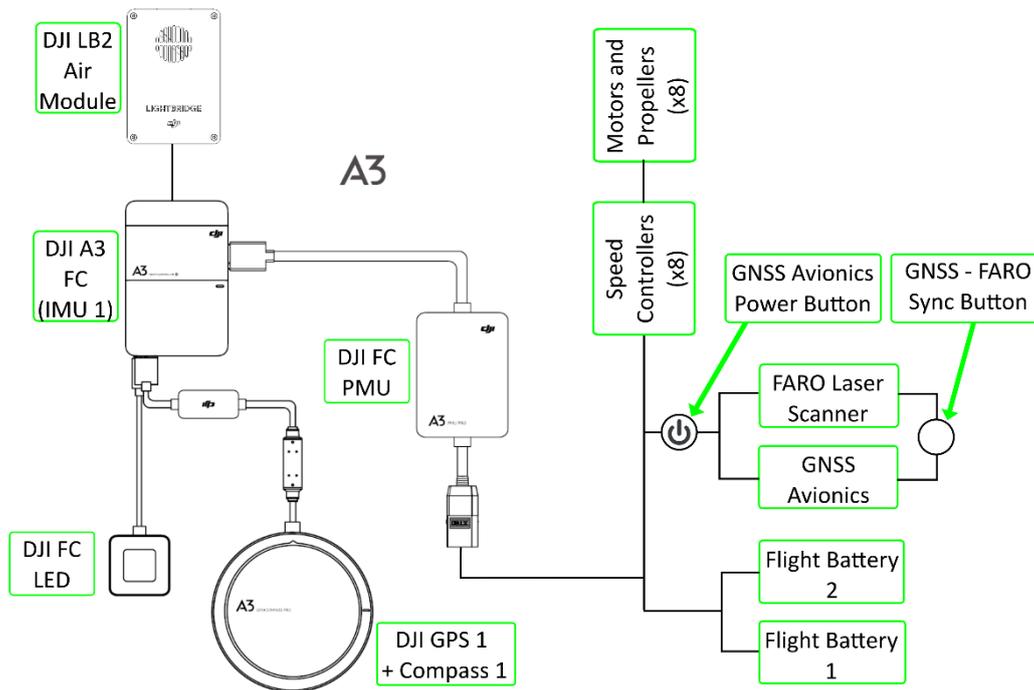


Figure 2.2 STORMBEE with DJI A3 flight controller schematics [DJI]

2.3 Component placement

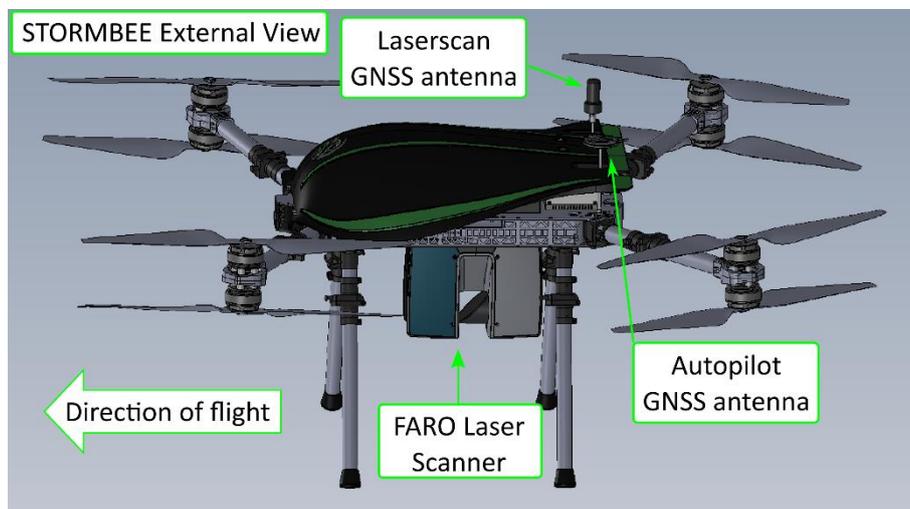


Figure 2.3 STORMBEE S20 component placement (external view)

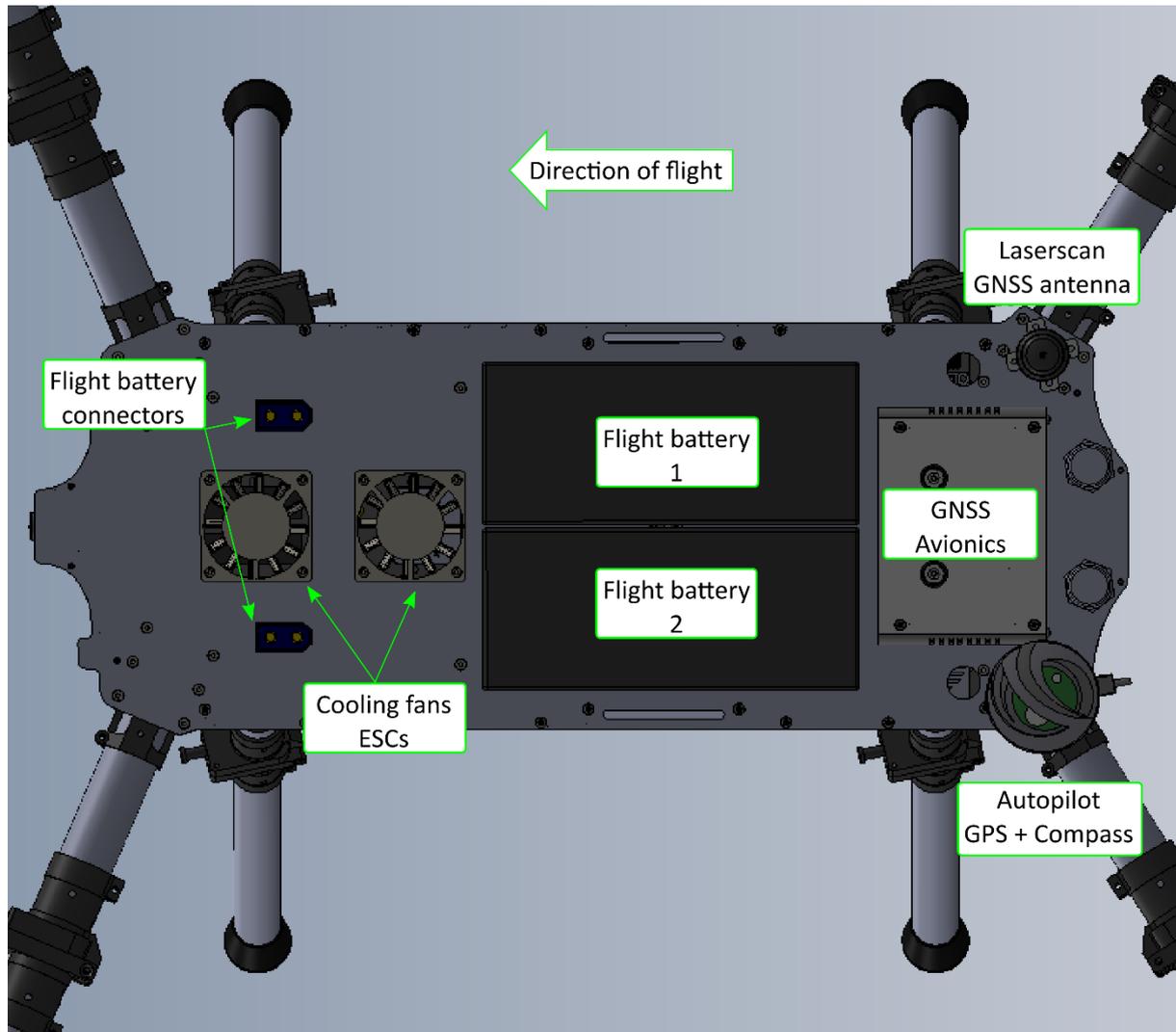


Figure 2.4 STORMBEE component placement (top level, with canopy removed)

2.4 Dimensions

Size extremities (including propeller diameter):

- Length: 1,45m (≈ 4,8ft)
- Width: 1,50m (≈ 4,8ft)
- Height: 0,60m (≈ 2,0ft)

Size (folded for transport):

- Length: 0,70m (≈ 2,3ft)
- Width: 0,60m (≈ 2,0ft)
- Height: 0,40m (≈ 1,3ft)

2.5 Weights

Maximum allowed Take-Off Mass (MTOM):

25kg (≈ 55lbs)

Empty mass — without batteries or payload:

12 kg (≈ 26.5 lbs)

Flight batteries (2):

4 – 5kg (≈ 9 – 11 lbs)

- 16Ah each: 2.1 kg (≈ 4.6 lbs)
- 18Ah each: 2.3kg (≈ 5.1 lbs)
- Batteries with larger capacity are allowed as long as MTOM is not exceeded and after approval of Think 3D.

Payload:

- Faro Focus Scanner, X-series (without battery): 4.4kg (≈ 9.7 lbs)
- Faro Focus Scanner, S-series (without battery): 3.4kg (≈ 7.5 lbs)
- DSLR camera and mounting bracket: 1kg (≈ 2.2 lbs)
- Other payloads are allowed if MTOM and Centre of Gravity (CG) limitations are respected and after approval of Think 3D.

WARNING!! Exceeding weight limitations may lead to overloading of STORMBEE's structure and cause loss of control of STORMBEE and/or structural damage.

2.6 Limitations

Given the longitudinal and lateral symmetry of STORMBEE, the reference line for the longitudinal and lateral Centre of Gravity (CG) is located on the symmetry axes. This corresponds also with the horizontal centre of the FARO Focus scanner mount.

WARNING!! Exceeding the centre of gravity limitations reduces the manoeuvrability and stability of STORMBEE.

Longitudinal Centre of Gravity Limits:

Forward | Aft: +/- 10cm from centre of scanner mount

Lateral Centre of Gravity Limits:

Left | Right: +/- 5cm from centre of scanner mount

Flight and Manoeuvre:

Do not fly indoors, or below structures (obscured sky) in P-GPS mode.

Flight Battery:

Always limit your flight to leave at least 20% (or 21.6V during flight) of battery charge level to have a good battery life and safe flight. Land ASAP when voltage drops below 21.4V. Discharging the battery below this minimum capacity may result in permanent battery damage. Do not take-off with a (motors-off) battery voltage lower than 22.5V.

Maximum flight time depends on many factors such as battery health state, environment (atmospheric) temperature, payload mass and flight speed. Expected endurance varies between 8 and 15 minutes, depending on these factors.

Weather:

Fly only during dry (no precipitation) weather conditions. Max wind speed: 30 km/h (≈ 20 mph, 5Bft).

3 Remote Pilot Station

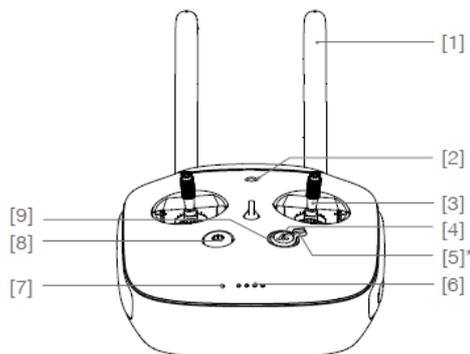
3.1 General layout

STORMBEE is controlled by a DJI A3 flight controller through a DJI Lightbridge 2 (LB2) remote controller together with a tablet mounted on top of the LB2 running the DJI Go app or GS Pro app. The apps are used for streaming the video feed of the onboard First-Person-View (FPV) camera. The GS Pro app additionally allows programming waypoints into the DJI A3 flight controller for automated flights. The GS Pro app is preferred for scanning missions as flying in AUTO mode (using GPS waypoints and long straight-line segments) ensures more stable flight trajectories and attitudes resulting in more accurate laser point cloud measurements. Note that the GS Pro app is currently only compatible with an Apple device such as an iPad. An iPad mini fits very well on the Lightbridge 2 and is still quite light.



Figure 3.1 DJI Lightbridge 2 remote controller with iPad (mini) running DJI Go app [DJI]

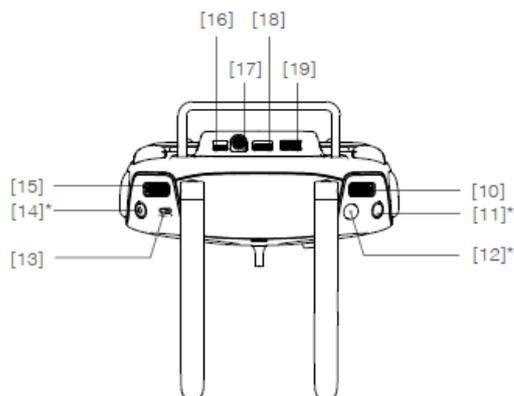
3.2 Lightbridge 2 controls layout



- [1] Antennas
Transmits the aircraft's control and video signals.
- [2] Mobile Device Holder Screw Hole
Used to mount the Mobile Device Holder.

- [3] Control Sticks
Controls the aircraft movement.
Customizable in the DJI GO app and DJI Flight Controller Assistant.
- [4] Return-to-Home (RTH) Button
Press and hold to initiate the RTH procedure.
- [5] Transformation Switch*
Customizable switch in the DJI Flight Controller Assistant.
- [6] Battery Level Indicator
Displays the current battery level.
- [7] Status Indicator
Indicates the connection status between the Air System and Ground System.

Figure 3.2 DJI Lightbridge 2 controls layout (front) [DJI]



- [10] Camera Settings Dial
Reserved Port.
- [11] Playback Button*
Customizable button in the DJI Flight Controller Assistant.
- [12] Shutter Button*
Customizable button in the DJI Flight Controller Assistant.
- [13] Flight Mode Switch
Switches between P-mode (Positioning), Atti mode (Attitude) and F-mode(Function).
F-mode can be customized in the DJI Flight Controller Assistant.

- [14] Record Button*
Customizable button in the DJI Flight Controller Assistant.
- [15] Gimbal Dial
Used to control the pitch of the gimbal.
- [16] Reserved Port
Do not connect any cables to this Micro USB port.
- [17] SDI OUT
Outputs video data to an SDI monitor.
- [18] HDMI OUT
Outputs video data to an HDMI monitor.
- [19] USB Port
Connects to your mobile device.
Live HD video and flight telemetry can be viewed in the DJI GO app.

Figure 3.3 DJI Lightbridge 2 controls layout (top) [DJI]

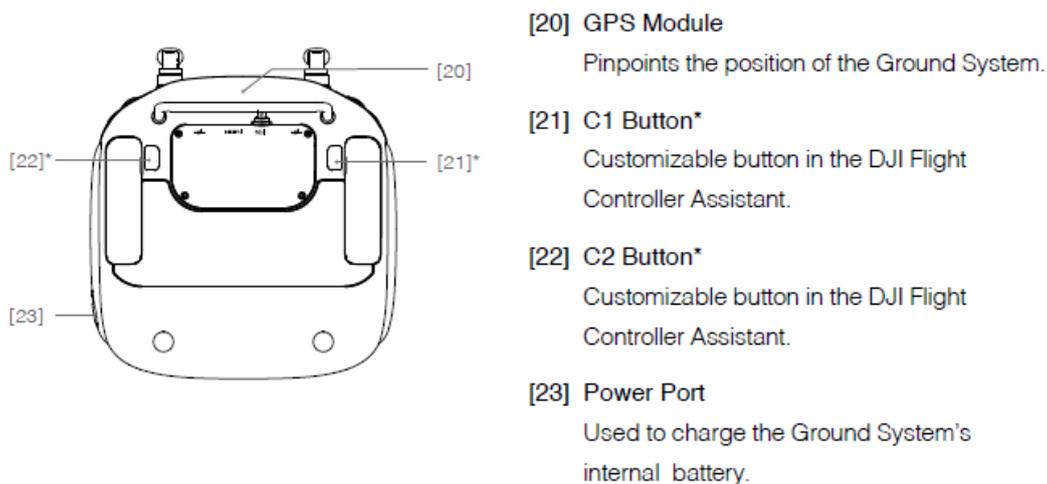


Figure 3.4 DJI Lightbridge 2 controls layout (back) [DJI]

Please refer to the DJI Lightbridge 2 manual for more details on the remote controller (download here: <https://www.dji.com/lightbridge-2>).

Frequencies Lightbridge 2:

5,8Ghz (25mW) and 2,4Ghz (100mW) CE approved.

3.3 DJI Go App

Please refer to the DJI Go App website (<https://www.dji.com/goapp>) for more details on the DJI Go App.

3.4 DJI GS Pro app

Please refer to the DJI GS Pro User Manual (download here: <https://www.dji.com/ground-station-pro>) for more details on the DJI GS Pro App and how to program "Waypoint Flight Missions" (Figure 3.5 and Figure 3.6).



Figure 3.5 DJI GS Pro "Waypoint Flight Mission" logo [DJI]

3.5 Firmware | Software

WARNING!! All firmware and software updates must be done by Think 3D or a Think 3D approved maintenance centre. **DO NOT UPDATE ANY COMPONENT:** neither the DJI GO app, the DJI GS Pro app, the DJI Lightbridge 2 nor the DJI A3 controller! Performing updates of any component without proper guidance or approval from Think 3D or its maintenance centres risks changing critical settings or introducing incompatibilities which may threaten the flight safety of future missions.

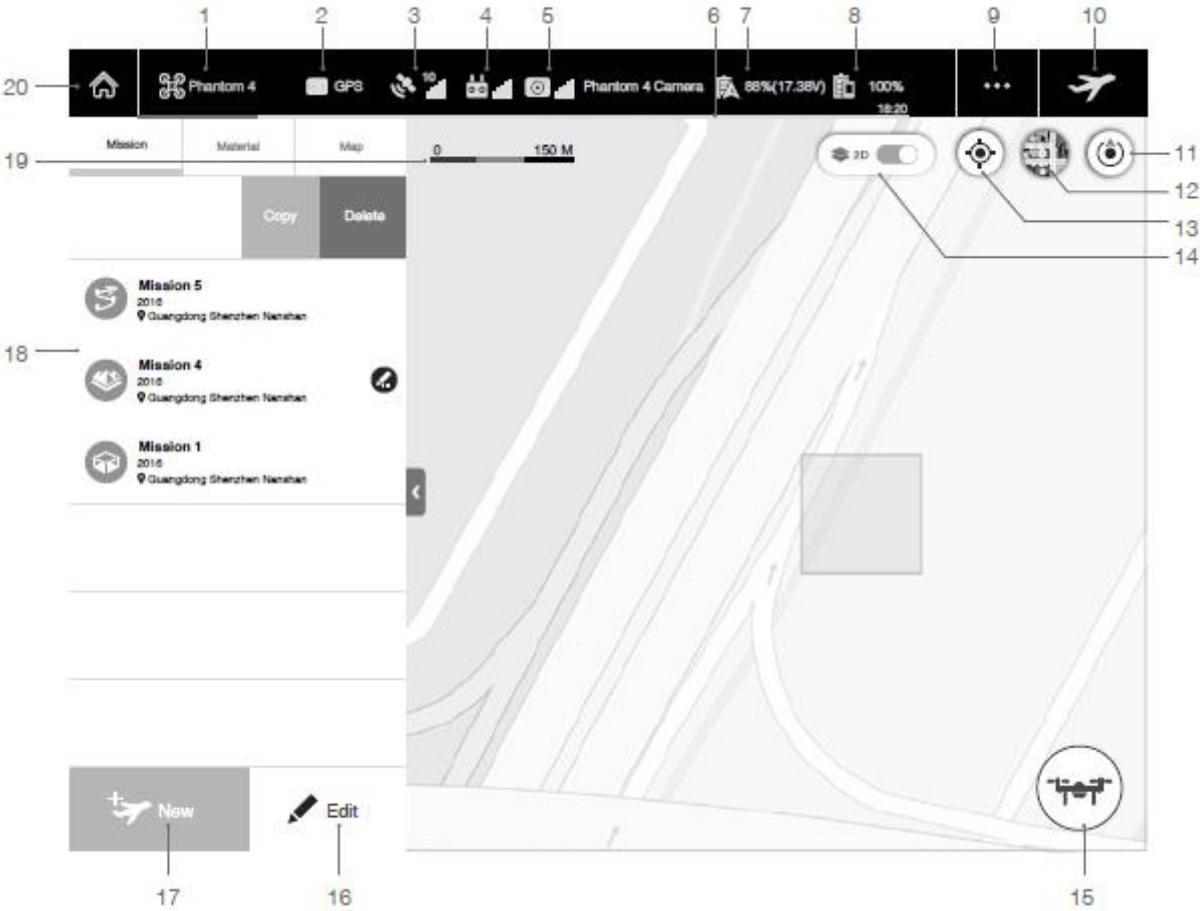


Figure 3.6 DJI GS Pro interface [DJI]

4 Pre-flight actions

4.1 Mission preparation at home

4.1.1 Checking documents, permits and weather

1. Verify that all documents are in order and (copies) are available to take with you to your mission location. These may include but are not limited to the following documents and depend on your country's national and regional regulations:
 - Valid passport/identification card(s) pilot (and crew)
 - Valid RPAS/UAS/Drone pilot license
 - Valid medical certificate pilot
 - Pilot logbook
 - STORMBEE flight logbook
 - STORMBEE maintenance logbook
 - STORMBEE registration document
 - STORMBEE certification document
 - STORMBEE insurance document
 - Mission permit document
 - Mission risk analysis document
 - STORMBEE User Manual
 - STORMBEE Quick Reference Handbook (checklists)
 - STORMBEE/company operational manual
 - Permission of owner of terrain where STORMBEE will take-off, (fly over) and land

2. Check your mission operational aspects:
 - Check the airspace in which you will perform your mission. Ensure you are allowed by your national and regional authorities to fly there and have the necessary permits if applicable. The airspace classification can be checked on a (manned aviation) VFR low air chart or on dedicated websites or apps.
 - Check the active Notice to Airmen (NOTAM) reports. Keep a (digital) copy of these reports for legal and administrative purposes.
 - Check the weather expected during the mission, especially temperature, precipitation and wind conditions, and verify they are within the limits of STORMBEE. Weather reports (Operational meteorological information, OPMET) can be found on (manned aviation) dedicated websites usually operated by your national authorities. Keep a (digital) copy of these reports for legal and administrative purposes.
 - Check the Kp-index. The Kp-index classifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0–9 with 1 being calm and 5 or more indicating a geomagnetic storm. This type of storm can affect the GPS and compass quality. Therefore, flights should be postponed if the Kp-index is higher than 5. The Kp-index (current value and prediction for the next two days) can be found on dedicated websites such as <https://www.spaceweatherlive.com/en/auroral-activity/aurora-forecast>. Keep a (digital) copy of the predicted Kp-index for legal and administrative purposes.

- If the mission requires ATC communication, the pilot should have a communication device (radio, mobile phone) on his/her person which can directly contact the appropriate ATC service or other authorities.
- Think 3D advises STORMBEE operators to use Citizen Bands (CB) radios for communication between pilot and observers when they are far away from each other and/or establish the use of hand signals performed by the observer to guide the pilot. Hand signals are also useful when the drone is close to either one of them and there is too much noise to talk over the radio.
- Check applicable privacy laws and take appropriate measures to adhere to them.

3. Prepare mission:

- Think 3D strongly advises STORMBEE operators to visit the inspection site a few days before the actual inspection flight to acquaint yourself with the surroundings (obstacles, roads, waterways, people, crowds, trees, antennas, high-rise buildings, power lines...) and mission (infrastructure/area to scan) which will enable you to improve your flight planning and increase safety. DO NOT solely rely on Google Maps, or any other equivalent software package, to prepare your mission as they do not show all (temporary) obstacles such as high voltage power lines or tower cranes! It is best to let the pilot flying that specific mission perform the visit of the inspection site and or someone with equivalent knowledge and experience.
- As part of the mission preparation, draw flight trajectories, take-off and landing zones on a Google Maps' printout (or on laptop) so you lose less time in programming it into the DJI GS Pro app while on-site. The DJI GS Pro app allows you to fully plan missions before departing to the flight area. However, Think 3D prefers users to perform the actual mission programming in the DJI app on-site. The reason for this is that there may be new (temporary) obstacles or operational aspects, not foreseen in the visit a few days before the flight, which require altering the flight path.
- Verify that there are public (online and operational) base stations within 50km of your mission site for post-processing the data afterwards. Otherwise you will have to consider using either the (paid) SmartBase processing method or your own base station on-site to ensure the final point cloud accuracy is good enough.
- STORMBEE's maximum flight time is between 8 and 15 minutes depending on conditions, so plan your mission well and divide it into multiple flights and even different landing and take-off locations if necessary.
- Depending on your inspection mission, you should choose an appropriate helical mode setting of the FARO Focus scanner and pre-program it into the scanner. Please refer to your FARO Focus scanner's user manual and section 7.2 "Settings" on how to do this.
- The pilot and crew should be briefed on the mission, what to expect, how the mission will proceed and what to do in case of emergency. Fill in mission preparation documents if required.
- Pilot and crew should be in good physical and mental health and not intoxicated. They should be well rested and not have drunk any alcohol in the last 12 hours before the flight.

- Although STORMBEE can easily be flown by a single person, Think 3D advises its operators to operate STORMBEE with a two person crew as it facilitates easier handling of STORMBEE and its accessories during pre-and post-flight actions on the ground.

4.1.2 Charging flight batteries STORMBEE

Charge the flight batteries 1 to 2 days before the mission as one set of flight batteries may take up to 1 hour to charge. Do not charge them more than a few days before the mission. LiPo batteries should be stored at their half-charged level as this prolongs the battery's life and quality. Use the provided battery voltage checker to verify the charge level state. The full manuals of both the battery charge and its hubs can be found in "Appendix E: PC1080 Battery charger and G630 hub manuals".

1. Plug the charger into a wall socket and switch it on using the red switch on the back



Figure 4.1 Battery charging process step 1

2. You should now see the home screens of both charge outputs. Using the "Start" button and "Status" arrows up and down to select the correct mode ("Fast Charge" or "Balanced Charge") and maximum current (20A). The "Fast Charge" mode will not balance the battery cells individually, but charges the battery the fastest (1 hour per battery). The "Balanced Charge" mode will both charge the battery and ensure that the voltage difference between individual cells is minimised, however this takes a little more time (1-1.5hours per battery). Think 3D recommends to use "Balanced charge" every five times you use the "Fast Charge" mode to prevent individual cell voltage differences to become too large and to prolong the battery life.



Figure 4.2 Battery charging process step 2

4.1.2.1 Without battery charging hubs (2 batteries max)

If you only want to charge two batteries simultaneously (instead of three or more, see section), then you don't need the charging hubs and can connect the batteries directly to the two ports of the main charger. Please be aware that the battery charger and its charging hubs have (yellow) male XT90 connectors and STORMBEE's batteries have 200A (black) female connectors. Therefore custom conversion connector were made and provided to be able to connect the STORMBEE batteries to the battery charger and its hubs.

3. Connect both the power cables and the balancer cable of each battery to the charger. Otherwise the battery charger will refuse to charge the battery.

WARNING!! You should shove the battery connectors and the conversion connectors smoothly and completely into each other and in the socket of the charger in one fluent motion. Do not leave it halfway or fumble about too much when shoving it in the socket. The battery connectors have a capacitor build-in to prevent sparks from occurring while connecting the batteries to the charger (and STORMBEE). However, this capacitor can burn through if the connector is not fully and smoothly shoved into the socket. If this happens, the battery will be permanently damaged.



Figure 4.3 Battery charging process step 3a

4. After connecting the batteries and ensuring the battery charger's both ports are in the correct mode, simply press "Start" for a few seconds on each port and the charger will verify the balancer connector is connected, the voltage level is consistent with a 6S LiPo battery (as STORMBEE's are) and start charging the battery.



Figure 4.4 Battery charging process step 3b (after pressing "Start")

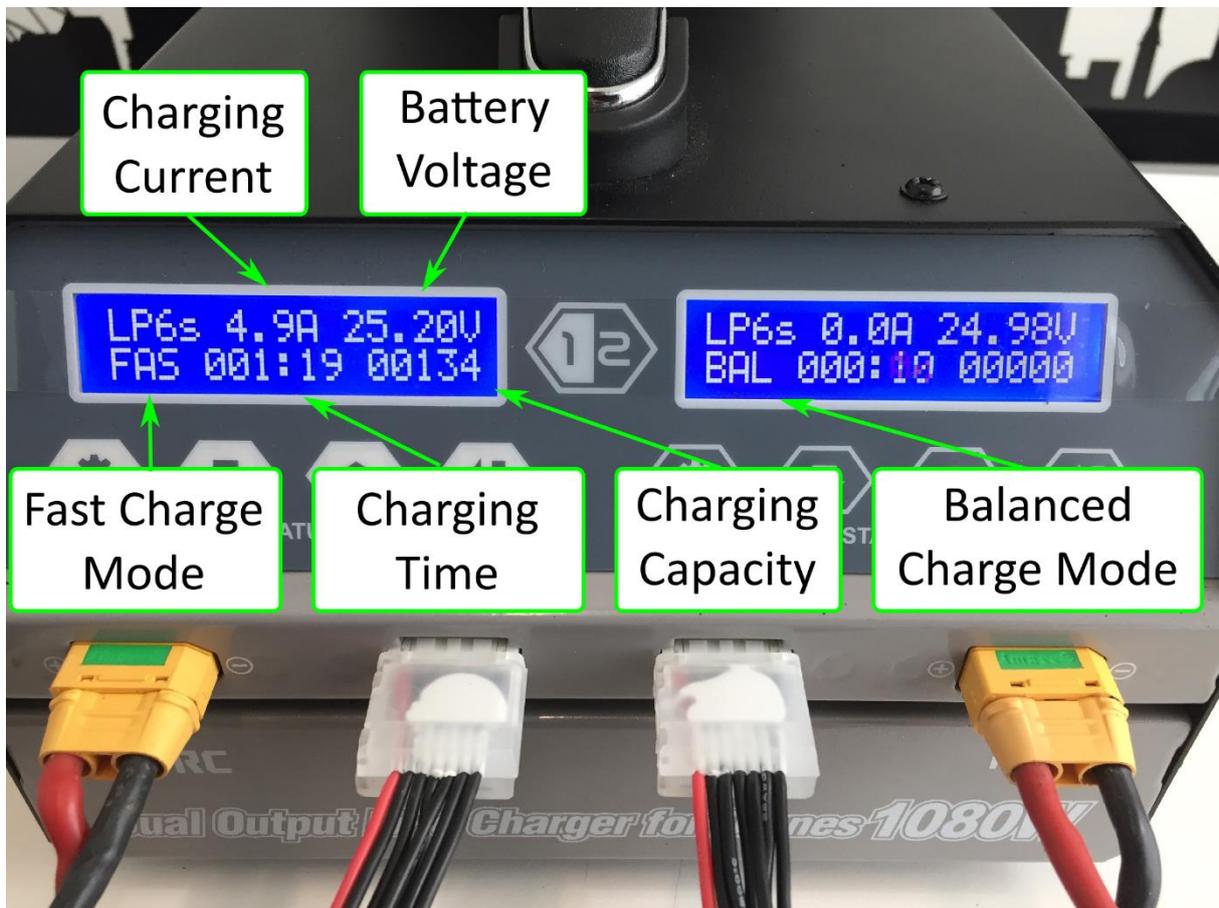


Figure 4.5 Battery charging process step 3c (left screen: "Fast Charge", right screen: "Balanced Charge")

5. When the charging process is complete or you want to abort the charging, simply press the "Stop" button. Then disconnect each battery, turn off the power supply and unplug the charger from the wall socket.

4.1.2.2 With battery charging hubs (12 batteries max)

When you want to charge three or more batteries simultaneously, you need to connect the charging hubs to the battery charger.

3. First ensure the battery charger is powered on and has the following settings "LiPo", "Fast-Charge", "20.0A", "Off-line".
4. Then connect one or both charging hubs to the battery charger. Finally connect all batteries, both their power connector and balancer connector to the respective ports of the charging hubs.

NOTE One battery charging hub can connect up to 6 STORMBEE batteries, but it only charges one at a time. The first connected battery will be charged first, while the others (connected to the same charging hub) will be charged according to their voltage level. The battery with the highest voltage level will be charged first, then the one with the second highest and so on.

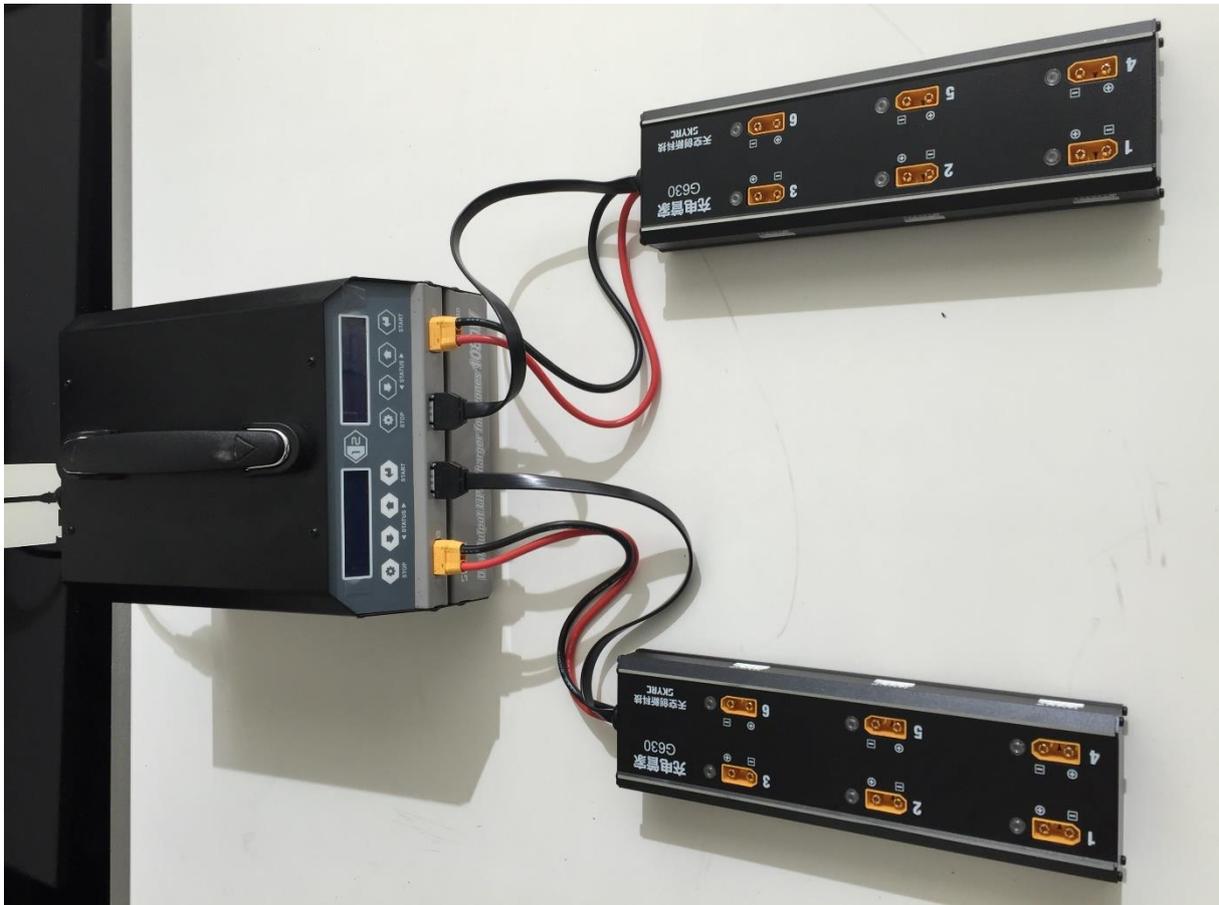


Figure 4.6 Battery charging process step 4

5. Press the  key to enter the G630 interface.

6. Press the "Start" key to start the charging process. During the charging, the current and capacity percentage will be displayed.

7. When a battery is fully charged, the corresponding LED on the charging hub will turn solid green and the buzzer will beep 5 times.

8. When the charging process is complete or you want to abort the charging, simply press the "Stop" button. Then disconnect each battery, turn off the power supply and unplug the charger from the wall socket.

4.1.3 Checking health and preparing STORMBEE and accessories

**If any abnormality is detected, contact Think 3D or its authorised maintenance centres for advice.
DO NOT FLY.**

1. Check STORMBEE's general state:
 - Check for the presence of dents, cracks, dirt.
 - Clean STORMBEE, (spare) propellers and carbon tubes using a little mild window-cleaner product and a soft cloth. DO NOT apply too much liquid on the cloth as STORMBEE's avionics are not waterproof!
 - Ensure all components are attached firmly and nothing is loose.
2. Check the motors and propellers:
 - Verify the condition of each propeller. Check (and feel with fingers) for cracks. Replace propeller if cracked or you suspect damage.
 - Verify that the propellers are firmly attached to the motors.
 - Verify that the motor's (rotating) casing is firmly attached to the motor's (non-rotating) base and can move less than 0.5mm up or down.
 - Verify that the motor's (non-rotating) base is firmly attached to the aluminium motor mount
 - Verify that the (aluminium) motor mount is firmly attached to the carbon tube and cannot be rotated along the tube. Verify that the fixation screw of the (aluminium) motor mount is firmly inserted into the carbon tube.
 - Verify that the carbon tube is firmly attached to the central structure and cannot be twisted or displaced.
3. Check the central structure:
 - Verify that DJI GPS antenna, next to the GNSS avionics box, is rigidly attached and that its arrow direction is aligned with and towards the front of STORMBEE.
 - Verify that the GNSS GPS antenna, next to the GNSS avionics box, is rigidly attached.
 - Verify that the LB2 air module antennas, mounted on the landing gear underneath STORMBEE, are ok. They should be within the same plane and pointing roughly 90° with respect to each other within that plane.
 - Verify that the canopy is not cracked or damaged and is (or can be) firmly attached to the central structure.
 - Verify that the velcro battery strap is in good condition: remove it and give it a good pull to verify its strength before attaching it back to the central structure. Verify the Velcro is still of good quality.
 - Verify that the battery connectors mounted on the top plate of the central structure are in good condition: not deformed nor charred black.
 - Verify the cooling fans can rotate freely and are clean of dust
 - Verify all screws are inserted firmly and none are missing.
4. Check the landing gear:
 - Verify that the carbon tubes and hinges are in good condition (attached firmly) and don't have any cracks
 - Verify that the landing gear mounts on the bottom of the central structure are in good condition (attached firmly) and don't have any cracks.

- Verify that the landing gear tubes have a plastic cover at the bottom end to protect them during landing. Verify that they are in good condition.
- 5. Electronics and batteries
 - Check all visible wires
 - Check for discolouration which could indicate electrical failure.
 - Smell all components of STORMBEE. If a burned smell is present, this indicates an electronic failure of that component.
 - Ensure all wires are firmly attached, their connectors are in good condition and no metal parts of the wires are exposed.
 - Check all flight batteries are ok and fully charged:
 - Verify the batteries are not swollen, and connectors and wires are in good condition (not deformed nor charred black).
 - Check battery (charge) level using battery voltage checker.
 - Check DJI LED and GNSS LED are in good condition
 - (Temporarily) mount the batteries and check STORMBEE's mass and that its Centre of Gravity position is within allowed limits.
- 6. Check the condition of the Lightbridge 2 remote controller and tablet:
 - Check it's general state: no parts are loose, antennas Lightbridge ok.
 - Set flight mode switch to P-GPS
 - Check battery voltage level of both Lightbridge 2 and tablet. For Lightbridge 2 press the power button once (short) and look at its series of four LEDs showing its battery level. Four led up LEDs means the battery is full, no illuminated LEDs means the battery is completely drained. Two out of four LEDs means the battery is half charged.
 - Check the condition of the USB cable.
- 7. Check condition of accessories such as battery charger and power generator if batteries need to be charged on-site to enable more flights during one mission.
- 8. Check the condition of the FARO Focus3D scanner. Ensure there is no damage and it is in good working condition. Verify the mirror is clean and has no scratches on it.
- 9. Check the condition of the laser range finder binocular.
- 10. Put the STORMBEE, FARO Focus scanner and their accessories in the appropriate transport cases. To dismount the FARO Focus scanner from underneath STORMBEE after flight, loosen the four bolts through the top plate of STORMBEE with the correct hex key tool while holding the FARO Focus scanner.
- 11. Ensure that the pilot has appropriate clothing and emergency supplies:
 - Food and (non-alcoholic) drinks
 - Sunglasses
 - Appropriate clothing (warm versus cold weather)
 - Sunscreen
 - Anti-mosquito spray
 - Mobile phone with emergency contact details pre-programmed
 - High visibility markers to cordon off take-off and landing zone
 - High visibility safety jackets for pilot and crew
 - Gloves during cold weather. Most gloves don't work well for operating the tablet, so cut out the top of one or two fingers of the glove if required.
 - First aid kit suitable for dressing cuts, wounds and bruises

- Fire extinguisher (the one belonging with the vehicle used to go to the mission site is fine)
 - Small set of tools, including a hex key set to tighten or loosen the four screws of the FARO Focus scanner mount.
 - Laptop for on-site data processing (optional)
12. Load vehicle with STORMBEE, FARO Focus scanner, accessories and pilot supplies. Do not forget the flight batteries nor remote controller, USB cable and tablet! These are forgotten most. Label the transport cases and other items to help verify they are all present in the vehicle. See “Appendix A: Transportation checklist” for a full list of items to take with you to a mission.

4.2 Mission preparation on-site

CAUTION! **SAFETY FIRST!!** Do not rush your preparation nor flight mission itself as this will lead to errors which can endanger flight safety and safety of pilot, crew and bystanders. Be aware that the propellers of STORMBEE are large (60cm, 22”) and rotate at very high speeds which makes them capable of inflicting serious injuries. Take all necessary precautions to ensure everyone’s safety, try to reduce the number of bystanders as much as possible and keep bystanders away as far as possible from STORMBEE at any point during the mission.

4.2.1 Unboxing UAV, GCS and assembly

To prepare STORMBEE after transport for flight, please perform the following steps:

1. Take STORMBEE, the FARO Focus scanner and their accessories out of their transport cases. Ensure that the FARO Focus scanner (X-series only) is equipped with the STORMBEE (provided) helical operation brackets (section 7.1.1 “Replacing brackets”).
2. Unfold (downwards) the four landing gear legs and ensure each locking pin in the hinge is fully extended.
3. Unfold (sideward) the four propulsion arms and ensure each locking pin in the hinge is fully extended.
4. Check STORMBEE, the FARO Focus scanner and their accessories for damage similar as before transport (section 4.1.3 “Checking health and preparing STORMBEE and accessories”)
5. Remove the foam mirror protection piece before powering on the scanner.
6. Turn on the FARO scanner and select the STORMBEE helical profile on the FARO Focus scanner’s user interface. In addition, set a new project name and number (Home – Manage – Projects/Clusters – Project Name or Initial Scan No.). Afterwards, shut down the scanner.
7. Remove the battery of the FARO scanner as it gets its power from STORMBEE directly and this reduces the weight and improves flight endurance. Mount the FARO Focus scanner underneath the STORMBEE. The FARO Focus scanner is positioned correctly into its mount if the 12-pin automation interface fits nicely in the corresponding interface of STORMBEE’s scanner mount. The pin on the front side of that mount should be pointing downwards, not

forwards. Secure the FARO Focus scanner by tightening the four bolts through the holes in the top plate of the STORMBEE while holding the scanner against its mount. Tighten the bolt opposite the last one you tightened in a crisscross pattern. This insures that the stress is distributed evenly across the FARO Focus mount. When you've tightened all the bolts, go back through the pattern again to ensure that each bolt is evenly tight.

NOTE If the flight will occur without the FARO Focus scanner or any other payload, for instance for training purposes, then the pilot is advised to hang a 4 kg dummy weight underneath the STORMBEE. The reason for this is that a multicopter varies the thrust of each propulsion unit individually to control its attitude. However, if the thrust it must deliver is lower than normal, for instance when STORMBEE has no payload attached, then the amount of thrust it can vary will also be smaller. This will result in less agility and thus less stability in the presence of (strong) winds and turbulence (gusts).

NOTE Verify that the mirror of the FARO Focus scanner is clean. If not, follow the cleaning instructions from your FARO Focus scanner manual. Be very careful to not scratch the mirror when cleaning it as this may irreversibly damage it.



Figure 4.7 Remove battery FARO scanner (Left: X-series, Right: S-series [FARO])

8. Mount the two flight batteries on top of the STORMBEE top plate and secure them using the Velcro strap. Ensure they are positioned in the (lateral) centre of the STORMBEE to ensure the Centre of Gravity of the STORMBEE is in its correct horizontal centre. Verify their individual charge level with the provided battery voltage checker.

WARNING!! STORMBEE should never be flown with only 1 battery under any circumstance! Operators and pilots should keep batteries paired up and labelled to ensure the same set of batteries is used each time. For instance, label one set of batteries A1 and A2, and other set B1 and B2. Never use A1 and B2 together as they might have different voltage levels. Connecting two batteries with different voltage levels (different charge levels) to STORMBEE will cause one battery to drain the other and increase the risk of

damage and fire/explosion. Always use fully charged batteries to ensure both batteries have the same voltage level.

WARNING!! The Velcro strap should always be used to keep the batteries in place during flight. DO NOT FLY if Velcro strap is damaged or missing.

9. Mount the tablet on top of the Lightbridge 2 and connect the USB cable between the Lightbridge 2 and the tablet. Unfold the LB2 antennas.

10. Place canopy on STORMBEE.

4.2.2 Flight operational preparations

1. Carefully select and prepare your take-off area.
 - a. Ensure the area is relatively flat, at least 7m by 7m wide and free from obstacles, dirt and small rocks.
 - b. Do not take-off near buildings as they might interfere with the GPS signal quality. The sky should be unobstructed within a radius of at least 10m. It is recommended to take-off in P-GPS mode rather than automatically through the app or as part of an automated Waypoint Mission. Start the Waypoint mission after all take-off procedures/checks are completed.
 - c. Mark the take-off zone with high visibility pylons/markers to ensure bystanders do not accidentally walk into this area. Optionally, also mark the pilot zone.
 - d. Pilots should always maintain at least 5 meters distance between STORMBEE and themselves, bystanders and (mission-unrelated) obstacles.

NOTE If possible, choose a take-off location downwind of the pilot, crew and bystanders for increased safety. In case of a failure during take-off, or when the pilot accidentally takes off in ATTI-mode but doesn't realise this, STORMBEE will have the tendency, due to the wind, to move away from the pilot, crew and bystanders.

2. Inform crew and bystanders of the upcoming mission and what to expect with respect to flight manoeuvres.

3. If the pilot will have to walk around during the flight to keep STORMBEE within Visual Line of Sight (VLOS), discuss the route of travelling and ensure it is obstacle free so the pilot can keep his/her eyes focused on the STORMBEE at each phase of the flight without the risk of tripping over something.

4. Verify the weather is as expected and within limitations of STORMBEE and its mission. Ensure the visibility is always at least 1,5 times the greatest distance that will occur between STORMBEE and the pilot, in all directions including upwards.

CAUTION! Keep in mind that the wind can change significantly and suddenly when flying behind and/or above buildings, infrastructure or any other obstacle. This can affect the drift of STORMBEE. In general, the higher you fly, the stronger the wind you should expect.

4.2.3 Pre-flight actions with DJI GO app (only manual flight)

You should now decide whether to fly a manual or an automated mission. For the first, follow the instructions in this section. For the latter, follow the instructions in section 4.2.4 “Pre-flight actions with DJI GS Pro app (automated flight)”. The GS Pro app is preferred for scanning missions as flying in AUTO mode (using GPS waypoints and long straight-line segments) ensures more stable flight trajectories and attitudes resulting in more accurate laser point cloud measurements.

WARNING!! **NEVER** use both apps (Go and GS Pro) simultaneously as they will interfere with each other and could result in unpredictable behaviour of the STORMBEE. Ensure that they are not running in the background on your tablet.

1. If you have not done so yet, move STORMBEE to its take-off location.
2. Launch the DJI Go app. When the app is booted up, it is normal that there is no mention of the DJI A3 controller as the Lightbridge 2 (LB2) remote controller and STORMBEE are not powered up yet. It is important to not enter any menu or press “Enter device”. Just leave it on the main start-up screen.

CAUTION! Ignore all updates suggestions as only Think 3D or its authorised maintenance centres may perform updates to ensure compatibility and correct settings are maintained.

3. Power on the Lightbridge 2 by pressing the power button first short, then long. When the LB2 is powered on, the DJI Go app) should now show a picture of the LB2 and its name. If not, the USB cable between the LB2 and the tablet may be wrongly connected or even disconnected. If this is the case, simply unplug the USB cable from the LB2 and plug it back in again. As for the previous step, it is important to not enter any menu or press “Enter device”. Just leave it on the main start-up screen.

NOTE If the LB2 is powered on and no pilot input is given for some time, the LB2 may start beeping as a reminder to the pilot to turn it off if the LB2 is no longer required (to preserve battery level). Just touch the control sticks slightly to stop the beeping.

4. Go to STORMBEE and connect the batteries to their respective power port.

NOTE When standing close to STORMBEE, be careful not to scrape against its propellers with your clothing or boots as this could damage them.

WARNING!! You should shove the battery connector smoothly and completely into the socket on the top plate of STORMBEE in one fluent motion. Do not leave it halfway or fumble about too much when shoving it in the socket. The battery connectors have a capacitor build-in to prevent sparks from occurring while connecting the battery to STORMBEE. However, this capacitor can burn through if the connector is not fully and smoothly shoved into the socket. If this happens, the battery will be permanently damaged.

5. Go back to the LB2 controller and its tablet. You should now see the DJI A3 controller figure and name appear in the app on the tablet. If not, the USB cable between the LB2 and the tablet may be wrongly connected or even disconnected. If this is the case, simply unplug the USB cable from the LB2 and plug it back in again. Press the “camera” button which should be illuminated in blue.

6. Verify that the status LED of the LB2 is continuously green. If not, the LB2 might be powered off, the RC connection signal of poor quality or the DJI A3 and LB2 not paired yet. For the latter case, refer to the manual of the A3 flight controller for pairing it with a DJI LB2.

7. After pressing the blue camera button in the app, you should now see the main mission screen of the app and the camera view of the FPV camera onboard the STORMBEE which is pointed forward. A window will immediately open with the “Aircraft Status”. If you get a message that the firmware is out of date, ignore it as only Think 3D or its authorised maintenance centres may perform updates to ensure compatibility and correct settings are maintained. Verify status elements (flight battery voltage STORMBEE, remote controller battery charge level, GPS, compass...) are all green and OK.

NOTE It might take some time for the DJI A3 GPS to acquire a good signal and find its location on the small window in the corner of the app. In the meantime, the supposed location of the STORMBEE will be the last location where the DJI A3 GPS had a position lock.

NOTE If you have a good connection with the LB2 but can't see the FPV view. The DJI GO app default settings is showing the feed from a digital camera connected to the HDMI port of the LB2 air module. However, STORMBEE uses an analogue FPV camera connected to the AV port of the LB2 air module which reduces latency at the cost of lower image pixel resolution. Go to the settings menu and move the slider from HDMI to AV. In addition, slide the bottom slider fully left to turn off HDMI completely (100%). If done correctly, you should now see the camera view of the FPV camera.

NOTE If the compass status is not good, there might be metal in the ground or some other electromagnetic emitting source nearby which disturbs the compass. Move the STORMBEE to another location and verify that the error goes away. If the error persists or if requested by the DJI app, perform the compass calibration procedure described in the DJI A3 User Manual. The calibration procedure may also be required when the pilot observes STORMBEE to be performing small circles during flight when it should remain in hover (control sticks centred and P-GSP mode active).

CAUTION! If the RC remote control connection is not good, try to move the STORMBEE to another location. Most interference comes from Wi-Fi routers in the vicinity. Be very cautious when the signal is poor. The pilot should decide at his/her own discretion whether to take-off/continue or not/land. If the signal becomes poor during flight, the DJI Go app will show a pop-up window to inform the pilot of this.

8. Press on the small map in the bottom corner to switch between the “Google Maps” window and the camera feed window. The Google Maps (satellite view) window will maximize, and you should visually verify that STORMBEE’s location is correct.

9. Verify the DJI A3 LED module is blinking green.

10. Use the laser range finder binocular to measure the height of the relevant obstacles within or close by your mission area.

11. Check the altitude set for the Return-To-Home (RTH) failsafe mode. Ensure that altitude set is always at least 10m (30ft) higher than the highest structure in your vicinity.

12. Ensure that the Lightbridge 2 remote controller is in the correct flight control mode! Pilots can choose between different flight control modes for which the pitch, roll, yaw and throttle stick functions are switched around across the two control sticks. The default flight controls mode is “Mode 2”.

WARNING!! Accidentally trying to take-off with the wrong flight control mode will very likely result in a crash!

13. Remove the foam mirror protection piece.

14. Go to STORMBEE and power on the GNSS avionics by pressing the large button with the power symbol  on it. The button will light up green and the GNSS avionics will boot up. This will take several minutes. In addition, the FARO Focus scanner will now also receive power from the flight batteries. After a few minutes, the GNSS avionics will start to find the current GPS-location of the GPS modules attached at each end of the long carbon arms at the front and back of the STORMBEE. The searching is indicated by the GNSS LED module blinking first red/yellow and then green. When the GNSS LED module is blinking green for some time, the GNSS GPS location is of sufficient quality for take-off (but not for the mission itself, see note below).

NOTE Keep at least 2 meters (6 feet) away from STORMBEE while the GNSS acquires its current GPS position. Also keep mobile devices away that emit wireless signals such as mobile phones or Wi-Fi routers.

NOTE STORMBEE S20 is equipped with the Applanix APX-20 GNSS-inertial module and a single GNSS receiver. Compared to systems that have two GNSS receivers (mounted on long arms), the heading of STORMBEE cannot be directly measured by comparing the positions of the GNSS receiver. Therefore, it requires STORMBEE to first fly a little (10 seconds or so) to be able to determine the initial heading from the flight's trajectory. Ideally, this required time window will be at the same moment when you verify the response of STORMBEE immediately after take-off before you start the (automated) mission.

NOTE It is possible that the GNSS LED module during flight starts blinking green again after it was continuously green. This indicates that the GNSS GPS signal acquisition is (temporarily) of lower quality. As long as this only occurs for a few seconds at a time, the final point cloud data should still be of sufficient quality.

NOTE The GNSS avionics box has two synchronised LED modules that indicate its status. One, small LED, is mounted on the side of the GNSS avionics box. A second, large and powerful LED, is mounted underneath the STORMBEE to visually check its status during flight.

15. Boot up the FARO Focus scanner. The scanner's boot-up sequence takes several minutes. The FARO Focus scanner will blink blue when ready.

16. Wait until the scanner and GNSS are both booted up, and the latter has acquired a good quality GPS lock. On the FARO scanner screen, press "Start scan". The mirror will spool up and start performing the scan. Once scanning, the scanner will start blinking red.

NOTE As the scanner is mounted upside down underneath STORMBEE, the text on the FARO Focus scanner screen is also upside down! Be careful when pressing (virtual) buttons on the screen of the laser scanner.

17. After the scanner has started scanning, the mirror has spooled up and the scanner has blinked red 5 times, press the large GNSS-scanner synchronisation button (next to the GNSS power button) to start recording the FARO Focus scanner mirror rotations and its time stamp with respect to the GNSS position estimation. This synchronisation time stamp data is required for post-processing the point cloud.

You are now ready for take-off!!

4.2.4 Pre-flight actions with DJI GS Pro app (automated flight)

You should now decide whether to fly a manual or an automated mission. For the first, follow the instructions in section 4.2.3 “Pre-flight actions with DJI GO app (only manual flight)”. For the latter, follow the instructions in this section. The GS Pro app is preferred for scanning missions as flying in AUTO mode (using GPS waypoints and long straight-line segments) ensures more stable flight trajectories and attitudes resulting in more accurate laser point cloud measurements.

WARNING!! **NEVER** use both apps (Go and GS Pro) simultaneously as they will interfere with each other and could result in unpredictable behaviour of the STORMBEE. Ensure that they are not running in the background on your tablet.

1. If you have not done so yet, move the STORMBEE to its take-off location.
2. Launch the DJI GS Pro app. When the app is booted up, it is normal that there is no mention of the DJI A3 controller as the Lightbridge 2 (LB2) remote controller and STORMBEE are not powered up yet.

CAUTION! Ignore all updates suggestions as only Think 3D or its authorised maintenance centres may perform updates to ensure compatibility and correct settings are maintained.

3. Use the laser range finder binocular to measure the height of the relevant obstacles within or close by your mission area.
4. Program your waypoint mission. Please refer to the GS Pro manual for instructions on how to do this.

WARNING!! When the mission is programmed and uploaded to STORMBEE, you will see a “Prepare for flight” pop-up window where the status of the different elements is checked. If all are green, then the DJI A3 is ready for automated flight. **DO NOT PRESS “Start to fly”** as this will immediately initiate STORMBEE to start its programmed mission and perform an automated take-off. Think 3D requires the pilot to take-off with STORMBEE in P-GPS mode controlled by the pilot. This allows the pilot to perform some checks after take-off to ensure STORMBEE is working properly before starting any mission, manual or otherwise. Only after these take-off checks (described in section 5.2 “Take-off procedure”) are successful, should the pilot press the “Start to fly” button to let STORMBEE perform its automated mission.

5. Power on the Lightbridge 2 by pressing the power button first short, then long.

NOTE If the LB2 is powered on and no pilot input is given for some time, the LB2 may start beeping as a reminder to the pilot to turn it off if the LB2 is no longer required (to preserve battery level). Just touch the control sticks slightly to stop the beeping.

6. Go to STORMBEE and connect the batteries to their respective power port.

WARNING!! You should shove the battery connector smoothly and completely into the socket on the top plate of the STORMBEE in one fluent motion. Do not leave it halfway or fumble about too much when shoving it in the socket. The battery connectors have a capacitor build-in to prevent sparks from occurring while connecting the battery to STORMBEE. However, this capacitor can burn through if the connector is not fully and smoothly shoved into the socket. If this happens the battery will be permanently damaged.

7. Go back to the Lightbridge 2 controller and its tablet. You should now see the DJI A3 controller name appear in the app on the tablet (left-hand top corner). If not, the USB cable between the LB2 and the tablet may be wrongly connected or even disconnected. If this is the case, simply unplug the USB cable from the LB2 and plug it back in again.

8. Verify that the status LED of the LB2 is continuously green. If not, the LB2 might be powered off, the RC connection signal of poor quality or the DJI A3 and LB2 not paired yet. For the latter case, refer to the manual of the A3 flight controller for pairing it with a DJI LB2.

9. You should now see the main mission screen of the app and in the right bottom corner a small window with the camera view of the FPV camera onboard the STORMBEE. The FPV camera is mounted underneath the front GNSS receiver and is pointing forward.

NOTE It is possible that you do not see the camera live feed yet. The GS Pro app default settings is showing the feed from a digital camera connected to the HDMI port of the LB2 air module. However, STORMBEE uses an analogue FPV camera connected to the AV port of the LB2 air module which reduces latency at the cost of lower image pixel resolution. Tap on the window and move the top slider from HDMI to AV. In addition, slide the bottom slider fully left to turn off HDMI completely (100%). If done correctly, you should now see the camera view of the FPV camera.

10. Visually verify that STORMBEE's location is correct on the Google Maps (satellite view) background.

11. Tap on the FPV video feed window to maximize it. The mission window will now minimize. Zoom in or out and move the waypoint trajectory so that it is fully visible within the minimized mission window. That way you can easily keep track of where STORMBEE is on its flight path at each moment of the flight, and have the enlarged FPV camera view to monitor STORMBEE's surroundings during flight.

12. Verify status elements (flight battery voltage STORMBEE 25V fully charged, tablet battery charge level...) are all OK. Verify on the GS Pro display that there are a 10 or more GPS satellites available. Also verify that the RC signal and video signal is of good quality.

NOTE It might take some time for the DJI A3 GPS to acquire a good signal and find its location on the small window in the corner of the app. In the meantime, the supposed location of the STORMBEE will be the last location where the DJI A3 GPS had a position lock.

NOTE If the compass status is not good, there might be metal in the ground or some other electromagnetic emitting source nearby which disturbs the compass. Move the STORMBEE to another location and verify that the error goes away. If the error persists or if requested by the DJI app, perform the compass calibration procedure described in the DJI A3 User Manual. The calibration procedure may also be required when the pilot observes STORMBEE to be performing small circles during flight when it should remain in hover (control sticks centred and P-GSP mode active).

CAUTION! If the RC remote control connection is not good, try to move the STORMBEE to another location. Most interference comes from Wi-Fi routers in the vicinity. Be very cautious when the signal is poor. The pilot should decide at his/her own discretion whether to take-off/continue or not/land. If the signal becomes poor during flight, the DJI app will show a pop-up window to inform the pilot of this.

13. Verify the DJI A3 LED module is blinking green.

14. Ensure that the Lightbridge 2 remote controller is in the correct flight control mode! Pilots can choose between different flight control modes for which the pitch, roll, yaw and throttle stick functions are switched around across the two control sticks. The default flight controls mode is "Mode 2". You can change the flight control (stick) mode in the general settings (●● icon).

WARNING!! Accidentally trying to take-off with the wrong flight control mode will very likely result in a crash!

15. Remove the foam mirror protection piece.

16. Go to STORMBEE and power on the GNSS avionics by pressing the large button with the power symbol  on it. The button will light up green and the GNSS avionics will boot up. This will take several minutes. In addition, the FARO Focus scanner will now also receive power from the flight batteries. After a few minutes, the GNSS avionics will start to find the current GPS-location of the GPS modules attached at each end of the long carbon arms at the front and back of the STORMBEE. The searching is indicated by the GNSS LED module blinking first red/yellow and then green. When the GNSS LED module is blinking green for some time, the GNSS GPS location is of sufficient quality for take-off (but not for the mission itself, see note below).

NOTE Keep at least 2 meters (6 feet) away from STORMBEE while the GNSS acquires its current GPS position. Also keep mobile devices away that emit wireless signals such as mobile phones or Wi-Fi routers.

NOTE STORMBEE S20 is equipped with the Applanix APX-20 GNSS-inertial module and a single GNSS receiver. Compared to systems that have two GNSS receivers (mounted on long arms), the heading of STORMBEE cannot be directly measured by comparing the positions of the GNSS receiver. Therefore, it requires STORMBEE to first fly a little (10 seconds or so) to be able to determine the initial heading from the flight's trajectory. Ideally, this required time window will be at the same moment when you verify the response of STORMBEE immediately after take-off before you start the (automated) mission.

NOTE The GNSS avionics box has two synchronised LED modules that indicate its status. One, small LED, is mounted on the side of the GNSS avionics box. A second, large and powerful LED, is mounted underneath the STORMBEE to visually check its status during flight.

17. Boot up the FARO Focus scanner. The scanner's boot-up sequence takes several minutes. The FARO Focus scanner will blink blue when ready.

18. Wait until the scanner and GNSS are both booted up, and the latter has acquired a good quality GPS lock. On the FARO scanner screen, press "Start scan". The mirror will spool up and start performing the scan. Once scanning, the scanner will start blinking red.

NOTE As the scanner is mounted upside down underneath STORMBEE, the text on the FARO Focus scanner screen is also upside down! Be careful when pressing (virtual) buttons on the screen of the laser scanner.

19. After the scanner has started scanning, the mirror has spooled up and the scanner has blinked red 5 times, press the large GNSS-scanner synchronisation button (next to the GNSS power button) to start recording the FARO Focus scanner mirror rotations and its time stamp with respect to the GNSS position estimation. This synchronisation time stamp data is required for post-processing the point cloud.

You are now ready for take-off!!

5 Flight actions

5.1 Flight modes

5.1.1 Manual (A-/ATTI-/P-ATTI mode)

NOTE This is the emergency flight mode to which the pilot should switch immediately if STORMBEE exhibits strange behaviour.

In ATTI-mode, GPS positioning is not used. STORMBEE does not have a Vision Positioning system. The DJI A3 flight controller is using only its barometer for altitude control and IMU for stabilising the STORMBEE in attitude (pitch, roll and yaw), but not the horizontal position (drift).

In ATTI-mode, only height limits work and flights cannot go higher than 120 meters (can be set higher in the DJI GS Pro or DJI GO app). The height limit is automatically lowered to 50 meters if the GPS signal is of poor quality during flight.

If the Lightbridge 2 remote controller signal is lost and the Home Point (location) has been recorded successfully while the DJI A3 is still receiving a GPS signal, then the aircraft can automatically return home.

CAUTION! Even if no wind is present, the STORMBEE will slowly drift away. If wind is present, it will drift downwind and drift faster.

5.1.2 P-GPS mode (Positioning)

NOTE This is the default flight mode when flying manually or automatically using waypoints.

In P-GPS mode the DJI A3 flight controller uses its GPS, IMU and barometer for position control, both horizontally and vertically.

P-GPS mode works best when GPS signal is strong. There are three different states of P mode, which will be automatically selected by the A3 depending on GPS signal strength and Vision Positioning sensors. However, as STORMBEE does not have a Vision Positioning system, only P-GPS mode is available in which the aircraft is using GPS for positioning.

5.1.3 Waypoint flight mode (DJI GS Pro)

The “Waypoint Flight Mission” mode is an intelligent flight mode of DJI running on top of the P-GPS mode. It allows you to execute a pre-programmed GPS-trajectory for the STORMBEE and set the desired velocities, heights and headings during each segment of the trajectory. This can only be done with the DJI GS Pro app on the tablet as described in section 4.2.4 “Pre-flight actions with DJI GS Pro app (automated flight)”.

The DJI Go app is not capable of pre-programming a GPS-trajectory, but it can record a (manual) flight path, after which the aircraft will fly along the same path repeatedly. This flight path can be saved and re-applied in the future.

NOTE Think3d advises STORMBEE operators to use the DJI GS Pro app and fly the missions in automated flight mode, using GPS waypoints, instead of piloted P-GPS. This will result

in the most accurate flight path and stabilisation for STORMBEE. Steady accurate flight trajectories result in accurate GNSS positioning and high quality point cloud data after post-processing. For both automated and piloted manual flight, try to program/fly as much straight lines as possible. Refrain from adjusting STORMBEE's heading during those straight lines, as then the GNSS positioning is most precise and the resulting laser scan point cloud will be most accurate.

WARNING!! SAFETY FIRST!! DO NOT solely rely on the FPV screen to estimate distances between STORMBEE and obstacles as the camera has only a limited field of view and judging distances from a 2D screen is very difficult and inaccurate. Watch STORMBEE at all times during the flight! The pilot or one of his/her observers should always be within Visual Line of Sight (VLOS). The pilot should always keep his/her left-hand index finger on the flight mode switch on top of the DJI Lightbridge 2 to be able to instantly switch to ATTI-mode if something goes wrong (without having to first search/feel for the button).

WARNING!! The pilot (and/or crew) should continuously re-position him-/herself during the flight to keep STORMBEE within VLOS with free air between STORMBEE and its nearest obstacles. It is almost impossible to perceive depth at distances of 50m or more. If STORMBEE is flying on a straight line between you and a tree/obstacle further on, you cannot accurately estimate how close STORMBEE is to that tree/obstacle. Re-position yourself at a(n) (right) angle of the path between STORMBEE and that obstacle. That way you will see free room (air) between them and can judge the distance between them more accurately. Discuss the pilot's movements before the flight and assure the path on the ground is free from obstacles over which the pilot can stumble/trip.

5.1.4 Return-to-Home (RTH)

The DJI A3 flight controller is quite aggressive when RTH is active and STORMBEE will abruptly and aggressively execute its RTH manoeuvres. This behaviour is normal. The reason for this is that this is a failsafe (emergency) mode and as such it is assumed you want STORMBEE on the ground as fast as possible.

Failsafe RTH:

The failsafe action of the DJI A3 controller, when the communication between transmitter and RPA (including video relay signal if DJI Lightbridge 2 used) is lost (for more than 3 seconds), differs between manual flight and automated flight. If the RPA is flying automatically by means of GPS waypoints, depending on the GS pro app settings, the RPA will either perform a RTH manoeuvre immediately or continue its mission. In the latter case, when the communication is not restored by the end of that automated mission, the RPA will then still switch to RTH and land. If the RPA is controlled manually at the time of communication loss, the RPA will switch to RTH failsafe immediately. RTH entails that STORMBEE will climb to a pilot pre-programmed height, set higher than any obstacle in the vicinity, and then fly home in a direct line, after which it will land at a pre-programmed location. This location is usually the location at which STORMBEE has powered up its motors (take-off location) but can also be re-programmed by the pilot during flight.

The aircraft cannot execute RTH failsafe if the DJI A3 LED is slowly blinking yellow or the GPS does not work.

The RTH process may be interrupted and the operator can regain control over the aircraft if the remote controller signal is resumed. The aircraft cannot avoid obstacles during Failsafe RTH. Therefore, it is important to set a reasonable failsafe altitude before each flight.

If the aircraft flies within a 20m (65ft) radius of the Home Point (take-off location) when RTH is triggered, the aircraft will automatically descend and land at its current location and not at its Home Point.

If the aircraft flies outside of the 20m (65ft) radius of the Home Point (take-off location) the aircraft will stop ascending and immediately return to the Home Point if you move the throttle stick when the aircraft reaches an altitude of 20m or above during Failsafe RTH.

Smart RTH:

Use the RTH button on the remote controller when GPS is available to enable Smart RTH. During the Smart RTH procedure, the aircraft returns to the last recorded Home Point, but you may control the aircraft's orientation to avoid collisions. Press the Smart RTH button once to start the process. Press the Smart RTH button again to exit Smart RTH and regain the control.

5.2 Take-off procedure

1. Set the DJI Lightbridge 2 remote controller to P-GPS mode using the flight mode switch on top. Look at the current time and remember it to note it down in your pilot and STORMBEE logbook after your flight.
2. If the mission requires ATC communication, now is the time to contact the appropriate ATC service or other authorities to let them know (or ask for permission) to take-off with STORMBEE.
3. Perform a final check of the communication and GSP status on tablet and verify DJI A3 LED on-board STORMBEE is slowly blinking green. Position yourself approximately 5m from the drone during take-off (and landing).
4. Start-up the STORMBEE motors and propellers by moving both control sticks inwards and downwards. DO NOT TAKE-OFF just yet. Verify all propellers are rotating.
5. Before take-off, while the motors are spinning, press on the small map in the bottom corner of the DJI app to switch between the “Google Maps” window and the camera feed window. The Google maps window will maximize, and you should visually verify that STORMBEE’s location is still correct, but also that the Home Point is also set to that same location. This Home Point location is the location to which STORMBEE will return in case of emergency or when the pilot has activated the Return-to-Home function. If Home Point is ok, minimize the Google Maps window by tapping on the minimized video feed window.

6. In addition, before take-off, listen to the sound of the motors and propellers. You should hear a uniform sound from all motors and propellers and you should visually verify that STORMBEE exhibits little to no vibrations, in other words, STORMBEE is not shaking.
7. Take-off by moving the throttle stick slowly upwards. Keep the direction and force of the prevailing winds in mind and correct where necessary. Climb to around 2m (6ft) height above the terrain.

NOTE Keep in mind that STORMBEE is a 2m long, 26kg heavy, multirotor and as such is less nimble than a small drone. Although its response is quite crisp, its inertia will make it feel like flying a jumbo jet instead of a small aircraft. The DJI A3 flight controller settings are also set to respond less aggressive on purpose for this reason. Keep your pilot inputs small and gentle.

CAUTION! Keep in mind that when the STORMBEE is moving forward and you set the control sticks to neutral, thus requesting it to hover in P-GPS mode, it will have quite a long braking distance before it comes to a hover. Both acceleration and deceleration are set to be gentle!

WARNING!! Watch STORMBEE at all times during the flight! Keep your left-hand index finger on the flight mode switch on top of the DJI Lightbridge 2 at all times so you can switch to ATTI mode if something goes wrong without having to first search/feel for the button.

8. Verify on the GS Pro display that there are 10 or more GPS satellites available.
9. Keep hovering at 2m height above the terrain and check the response of STORMBEE to (small and gentle) roll, pitch, yaw and throttle inputs to verify its responses are correct and no position drift is present.

WARNING!! This is the point in flight at which you should and want to find out if you have accidentally set the wrong pilot flight control mode (mode 1, 2, 3 or other) or if something is wrong with the DJI A3 flight controller or its sensors. Therefore, keep your pilot inputs small and gentle and be very careful during take-off and while checking the response.

10. When using the GS Pro app, you should now see the RTH (virtual) button on the GS Pro app on the left-hand side with the RTH altitude underneath. Tap on the altitude (text) to adjust the RTH altitude if necessary. Be careful to not accidentally tap on the RTH button itself at it would land the STORMBEE. You should have used the laser range finder binocular to measure the

height of the relevant obstacles within or close by your mission area before programming the mission.

11. Verify that the GNSS LED module is solid green. If not, please fly a varying trajectory until it is.

NOTE STORMBEE S20 is equipped with the Applanix APX-20 GNSS-inertial module and a single GNSS receiver. Compared to systems that have two GNSS receivers (mounted on long arms), the heading of STORMBEE cannot be directly measured by comparing the positions of the GNSS receiver. Therefore, it requires STORMBEE to first fly a little (10 seconds or so) to be able to determine the initial heading from the flight's trajectory. Ideally, this required time window will be at the same moment when you verify the response of STORMBEE immediately after take-off before you start the (automated) mission.

NOTE It is possible that the GNSS LED module during flight starts blinking green again after it was continuously green. This indicates that the GNSS GPS signal acquisition is (temporarily) of lower quality. As long as this only occurs for a few seconds at a time, the final point cloud data should still be of sufficient quality.

12. If all take-off checks are fine, you can start flying your scanning mission, either manually or automatically. In the latter case, you may now press the plane icon in the top-right corner of the GS Pro app. Verify that all mission elements are green and OK and press the “Start to fly” button in the DJI GS Pro app to let STORMBEE perform its automated mission.

NOTE When the automated mission is started, STORMBEE will first climb straight up to the altitude of its first waypoint. Then it will turn towards the first waypoint after which it will fly towards it. After reaching the first waypoint, it will hover, turn towards the second waypoint and follow the consecutive waypoints with the velocities, altitudes and headings according to the programmed flight path. The DJI A3 flight controller is quite aggressive when flying towards the first mission waypoints as the velocity restrictions only apply from the first waypoint onwards. This behaviour is normal.

NOTE It is best to program the STORMBEE to hover when reaching the last waypoint after which the pilot should then manually (in P-GPS mode) fly STORMBEE back to its landing area and land.

5.3 Flight

WARNING!! Regularly (every minute) check the mission health status and the FPV camera view on the DJI GS Pro app regardless of what flight mode the STORMBEE is in. **Check the voltage level of the STORMBEE flight batteries every 30 seconds! Abort the mission and return to landing site to land when the voltage level drops below 21.6V. Land ASAP at current location if voltage drops below 21.4V.** Continuously switch your attention between STORMBEE, battery level, FPV camera view and small mission window.

Flying your missions in automated flight mode, using GPS waypoints, instead of piloted P-GPS will result in the most accurate flight path and stabilisation for STORMBEE. Steady accurate flight trajectories result in accurate GNSS positioning and high quality point cloud data after post-processing. For both automated and piloted manual flight, try to program/fly as much straight lines as possible. Refrain from adjusting STORMBEE's heading during those straight lines, as then the GNSS positioning is most precise and the resulting laser scan point cloud will be most accurate.

The GS Pro app shows the progress of the automated mission (active waypoint, velocity, altitude,...) at the bottom of the screen.

NOTE If any other aircraft, drone or bird comes near your mission flight area, take appropriate actions. Drones should always give way to any other type of aircraft, balloon, glider, airship and helicopter. Descend immediately or execute an evasive manoeuvre. If necessary, land immediately.

NOTE It is possible that the GNSS LED module during flight starts blinking green again after it was continuously green. This indicates that the GNSS GPS signal acquisition is (temporarily) of lower quality. As long as this only occurs for a few seconds at a time, the final point cloud data should still be of sufficient quality.

NOTE Keep in mind that STORMBEE is a large and heavy multirotor and as such is less nimble than a small drone. Although its response is quite crisp, its inertia will make it feel like flying a jumbo jet instead of a small general aviation aircraft. The DJI A3 flight controller settings are also set to respond less aggressive on purpose for this reason. Keep your pilot inputs small and gentle.

CAUTION! Keep in mind that when STORMBEE is moving forward and you set the control stick to neutral, thus requesting it to hover in P-GPS mode, it will have quite a long braking distance before it comes to a hover. Both acceleration and deceleration are set to be gentle!

WARNING!! Watch STORMBEE at all times during the flight! Thus, the pilot or one of his/her observers should always be within Visual Line of Sight (VLOS). The pilot should always keep his/her left-hand index finger on the flight mode switch on top of the DJI Lightbridge 2 to be able to instantly switch to ATTI-mode if something goes wrong (without having to first search/feel for the button). DO NOT solely rely on the FPV screen to estimate distances between STORMBEE and obstacles as the camera has only a limited field of view and judging distances from a 2D screen is very difficult and inaccurate.

WARNING!! The pilot (and/or crew) should continuously re-position him-/herself during the flight to keep STORMBEE within VLOS with free air between STORMBEE and its nearest obstacles. It is almost impossible to perceive depth at distances of 50m or more. If STORMBEE is flying on a straight line between you and a tree/obstacle further on, you cannot accurately estimate how close STORMBEE is to that tree/obstacle. Re-position yourself at a(n) (right) angle of the path between STORMBEE and that obstacle. That way you will see free room (air) between them and can judge the distance between

them more accurately. Discuss the pilot's movements before the flight and assure the path on the ground is free from obstacles over which the pilot can stumble/trip.

WARNING!! If all control of the STORMBEE is lost and neither the Return-To-Home function nor STORMBEE's response in ATTI-mode are sufficient to bring STORMBEE home and land, then as a last resort you can move both control sticks inwards and downwards as you did to start up the motors. When this control input is performed during flight it will immediately stop all motors and result in STORMBEE to crash instantly. If performed, STORMBEE and payload will be irrevocably damaged and very likely beyond all repair. **This is the absolute last resort emergency procedure with the sole purpose to not endanger surrounding people and infrastructure in case of fly-away!! Please refer to section 8.5.7 "Fly-away" for further instructions.**

5.4 Landing

1. When flying back to your landing zone, do this at a low speed and keep STORMBEE high enough (at least 3-4m above the terrain or obstacles). Inform your crew and bystanders of your intentions to land and that they should remain well clear of the landing zone. Position yourself at approximately 5m from the landing location to have good visibility and depth perception on the drone.
2. When in hover above the landing zone, slowly lower your throttle to make it descend gently. At 1m above the ground visually check that the landing area is clear of small rocks. If necessary, stop the descend and hover again at 1m above the ground to let STORMBEE blow any remaining dust away. Otherwise, during touchdown, that dust could recirculate into the motors and reduce their lifetime. Normally, you should have cleared the landing zone from dust and debris before the flight if procedures were followed correctly.
3. If the landing area is fully clear, descend gently and land STORMBEE either manually in P-GPS mode or automatically through the GS Pro App. Usually, in P-GPS mode, the pilot will have to do little to no corrections for pitch and roll as the DJI A3 controller is quite good in keeping its horizontal position fixed even when close to the ground where ground effect is present. When STORMBEE is fully on the ground, push the throttle stick fully downwards to shut down the motors (during manual landing).

CAUTION! Only approach the STORMBEE after all propellers have stopped. Especially small children, dogs and bystanders are keen to come too close too soon, so keep everyone away until STORMBEE is fully shut down and the flight batteries are disconnected according to the procedure described in Section 6.1 "Shut-down procedure".

WARNING!! **DO NOT** move both control sticks inwards and downwards as you did to start up the motors during take-off. When this control input is performed during flight it will immediately stop all motors and result in STORMBEE to crash instantly as this control stick action is intended as a last resort emergency procedure in case of fly-away

(section 5.3 “Flight”). If performed during landing or just after touchdown STORMBEE might still respond to your inputs and start wobbling around and possibly tilt over resulting in a crash as well.

4. If the mission requires ATC communication, now is the time to contact the appropriate ATC service or other authorities to let them know STORMBEE has landed.

5. Shut down the STORMBEE and FARO Focus scanner according to the procedure described in Section 6.1 “Shut-down procedure”.

6 Post-flight actions

6.1 Shut-down procedure

CAUTION! It is very important that you shut down the scanner and STORMBEE in the correct sequence as otherwise the scanner and GNSS data might not be stored!

1. With your bare hands, feel the warmth of each motor. They should all feel lukewarm. If one motor feels significantly warmer than the others, this indicates that its bearings are worn out and maintenance is required to replace them. This maintenance may only be done by Think 3D or one of its authorised maintenance centres.
2. Verify that the FARO Focus scanner is still blinking red when landing.
3. Press the large GNSS-scanner synchronisation button to stop recording the FARO Focus scanner mirror rotations and its time stamp with respect to the GNSS position estimation.
4. On the FARO Focus scanner, press on “Stop scan”. The scanner mirror should slow down and stop. This can take up to half a minute.

NOTE As the scanner is mounted upside down underneath STORMBEE, the text on the FARO Focus scanner screen is also upside down! Be careful when pressing (virtual) buttons on the screen of the laser scanner.

NOTE If you accidentally have pressed the “Stop scan” button twice, the FARO scanner may skip the next step (“Save scan data”).

5. When the scanner has fully stopped, a (virtual) button will appear with the text “Save scan data”. Press this button.

NOTE Be very careful as the save and delete (virtual) buttons on the laser scanner’s touchscreen are small, narrow and very close to each other. In addition, the FARO scanner control touchscreen window is upside down while mounted underneath the STORMBEE. Having cold fingers after a flight in cold weather makes it more difficult to aim precisely and press the right button!

6. Verify that the data is saved on the screen of the FARO scanner by pressing on the “View Scans” virtual button (centre bottom screen). If the data was successfully saved, you should see that

the latest scan (with a time stamp equal to the scan start time) has more than 100MB of data per minute of flight (roughly 700MB or more for standard flight).

7. Turn of the FARO scanner.
8. On the STORMBEE, power off the GNSS avionics (and FARO Focus scanner) by pressing the large button with the power symbol  on it.
9. Remove the canopy from STORMBEE.
10. Shut down the STORMBEE itself by disconnecting both flight batteries.
11. Shut down the DJI Lightbridge 2 by pressing its power button first short, then long.
12. Close the DJI GS Pro app (or DJI Go app).
13. Check the time of landing and GPS location and fill them in all logbooks (pilot and STORMBEE). Use UTC time notation for both take-off and landing time.
14. After retrieving the laser scan data and GNSS data, as described in section 6.2 “Data retrieval”, prepare STORMBEE and accessories for transport according to procedure described in section 4.1.3 “Checking health and preparing STORMBEE and accessories”. Don't forget to re-insert the FARO scanner's battery and SD-card.

6.2 Data retrieval

6.2.1 Extracting data from FARO scanner

6.2.1.1 Extraction

1. Ensure that the FARO scanner is powered off.

2. Remove the SD card of the FARO scanner. Please refer to the manual of your specific FARO scanner on how to do this.



Figure 6.1 Remove SD-card from FARO scanner (Left: X-series, Right: S-series [FARO])

3. Plug the SD-card into an SD-card reader connected with your laptop. Copy the data to your laptop in a folder of your choice.



Figure 6.2 Insert SD-card into computer

6.2.1.2 Format

The FARO scanner data is stored within a folder named “***.fls”. It should contain several files and subfolders. Each “*.fls” folder represents a single STORMBEE flight (Figure 6.3).

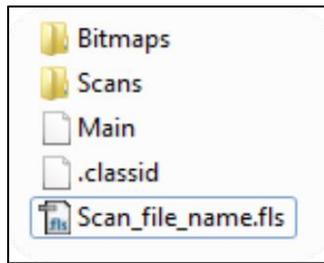


Figure 6.3 FARO scanner data *.fls folder structure

6.2.2 Extracting data from GNSS module

Data retrieval requires FileZilla Client Basic (or equivalent) software. Please download and install program from <https://filezilla-project.org/>.

1. Connect battery (1 is sufficient)

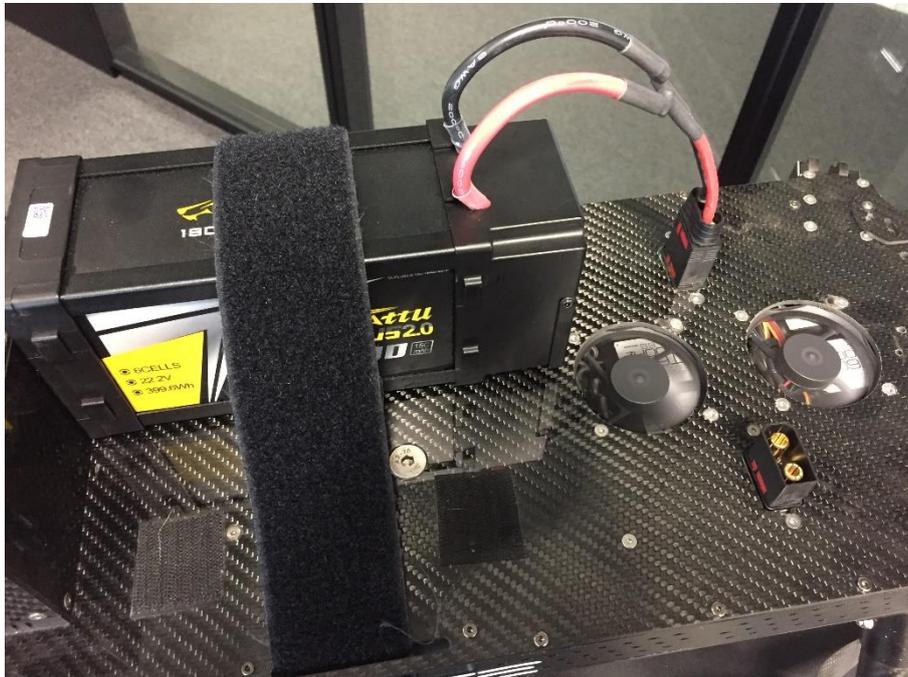


Figure 6.4 Data extraction: connect battery

2. On the STORMBEE, power on the GNSS avionics (and FARO Focus scanner) by pressing the large button with the power symbol  on it.

3. Wait until the large LED is blinking and then connect the ethernet cable from the GNSS avionics box to your PC.



Figure 6.5 Data extraction: turn on GNSS avionics and connect ethernet cable

4. You should verify that the adapter settings of your ethernet port are set to the correct fixed IP address. Otherwise FileZilla cannot connect to it. Open your Windows settings page and left-click on "network and internet settings". Go to page "Ethernet". Click on "Change adapter options". You should now see the adapters (usually "Bluetooth", "Ethernet" and "Wi-Fi"). Right-click on "Properties". Select "Internet Protocol version 4 (TCP/IPv4)" and click below on "Properties". You should now see the IP and DNS properties window. Here is where you need to set the manual IP address to be able to connect with STORMBEE. Usually this will be set to "apply automatic IP and DNS addresses". If it is filled in with other values or you use an ethernet cable for internet then you should remember to revert the following changes afterwards. Otherwise your (wired) internet connection might not work anymore. The settings don't affect your Wi-Fi connections. Set IP-address to "192.168.53.101" and subnet mask to "255.255.255.0". Leave the rest empty. Press OK until all windows are closed.



Figure 6.6 Ethernet settings 1

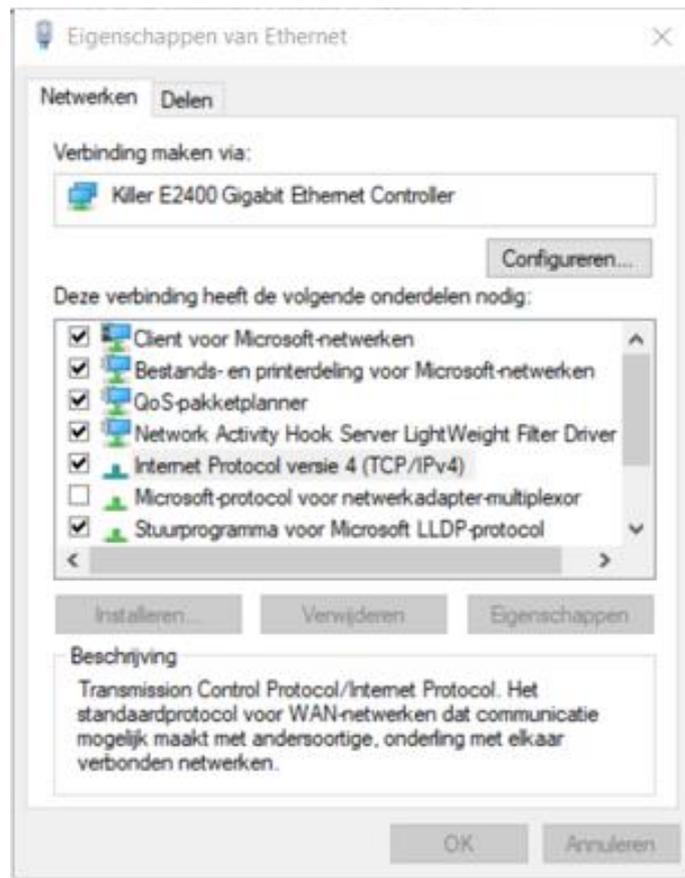


Figure 6.7 Ethernet settings 2

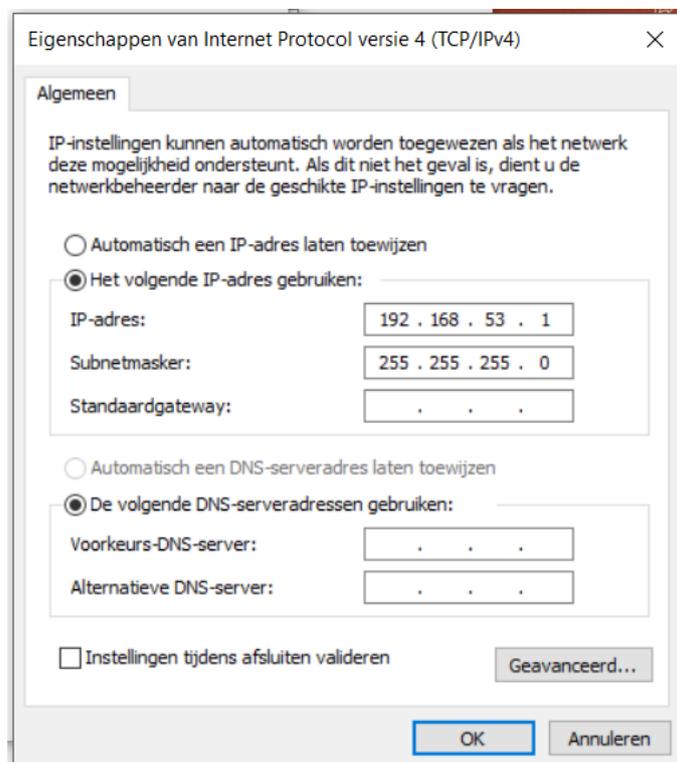


Figure 6.8 Ethernet settings 3

5. Open FileZilla

6. File -> Site Manager

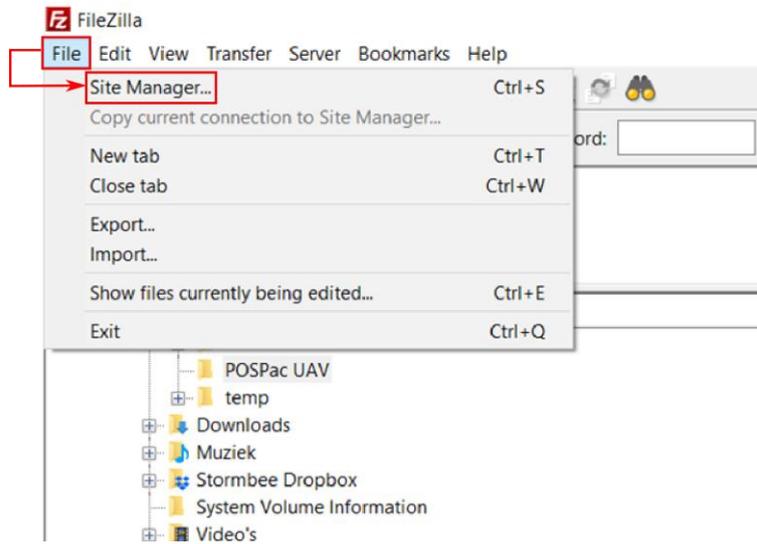


Figure 6.9 FileZilla open site manager

7. If you have already performed this step once, you can skip this step.

For first use, you need to add the STORMBEE as a new “site”. If you have set this before, skip to step 7. Press “New Site”, change its name to STORMBEE by simply clicking on the text and fill in the following settings:

- Host: 192.168.53.100
- Protocol: FTP- File Transfer Protocol
- Encryption: Only use plain FTP (insecure)
- Logon Type: Normal
- User: guest
- Password: Applanix

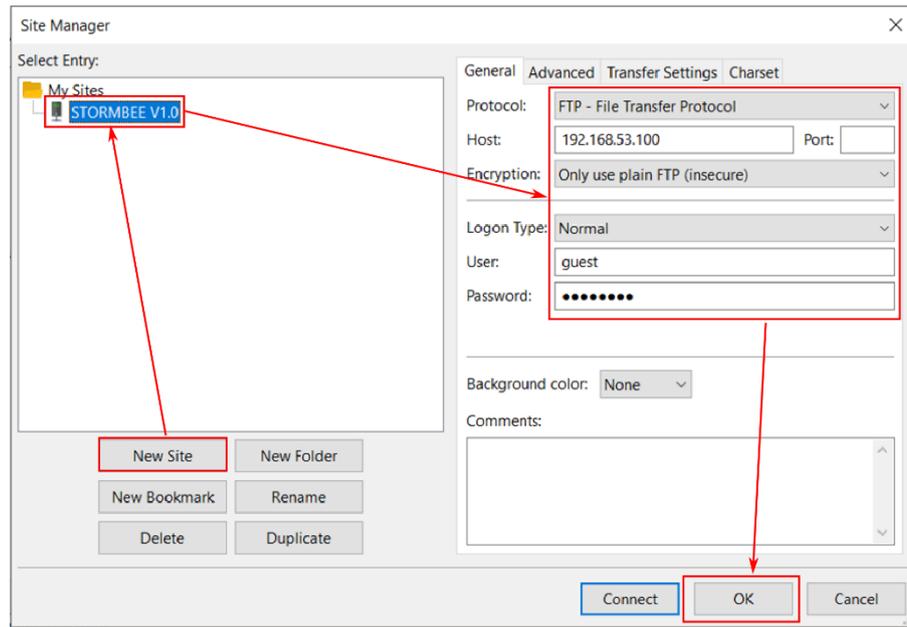


Figure 6.10 FileZilla site manager settings

8. Connect to STORMBEE using the dropdown menu of the upper left icon and choose “STORMBEE”. FileZilla will connect to STORMBEE and show the file structure in the right-hand window.

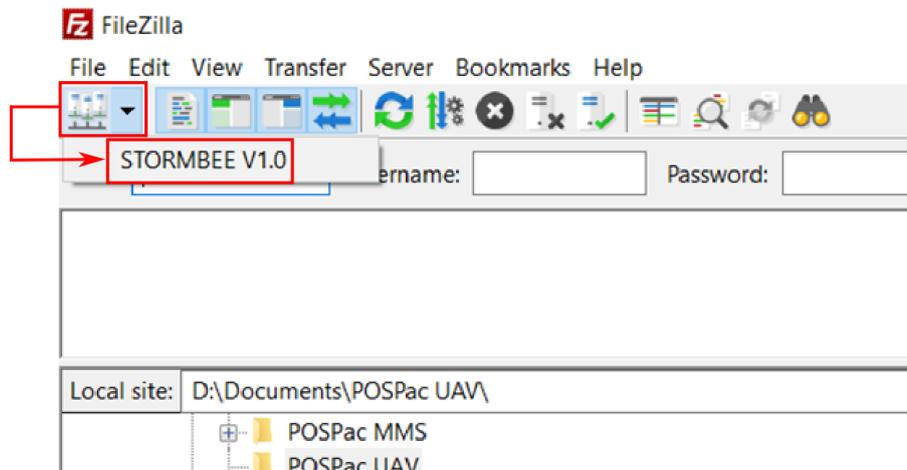


Figure 6.11 FileZilla connect to STORMBEE

- Find the data file with the newest date of creation (Last modified) corresponding to your flight. Select all relevant files. In the left-hand window go to your preferred folder in which the GNSS data files may be stored. Simply click-and-drag from the right-hand window (STORMBEE onboard data folder) to the left-hand window (your PC folder)

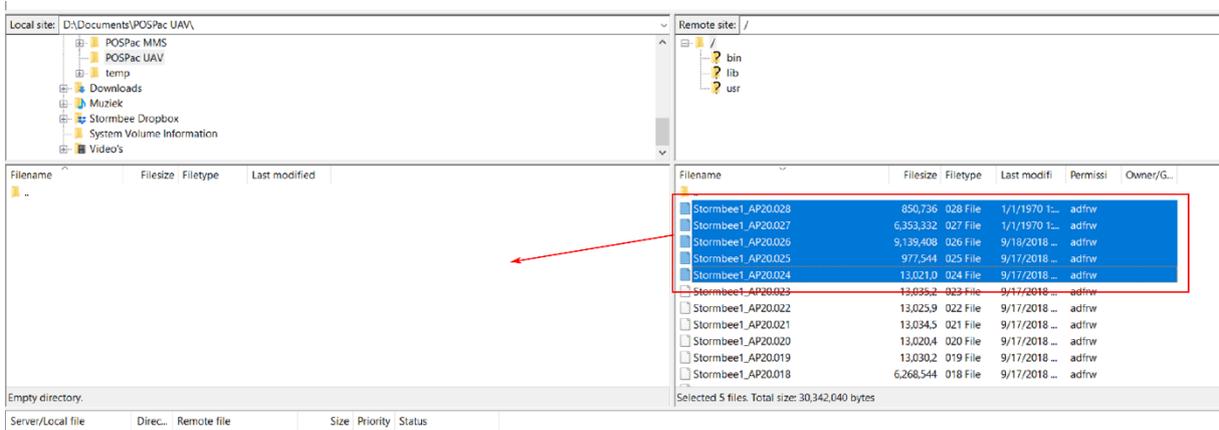


Figure 6.12 FileZilla select files and drag to left screen

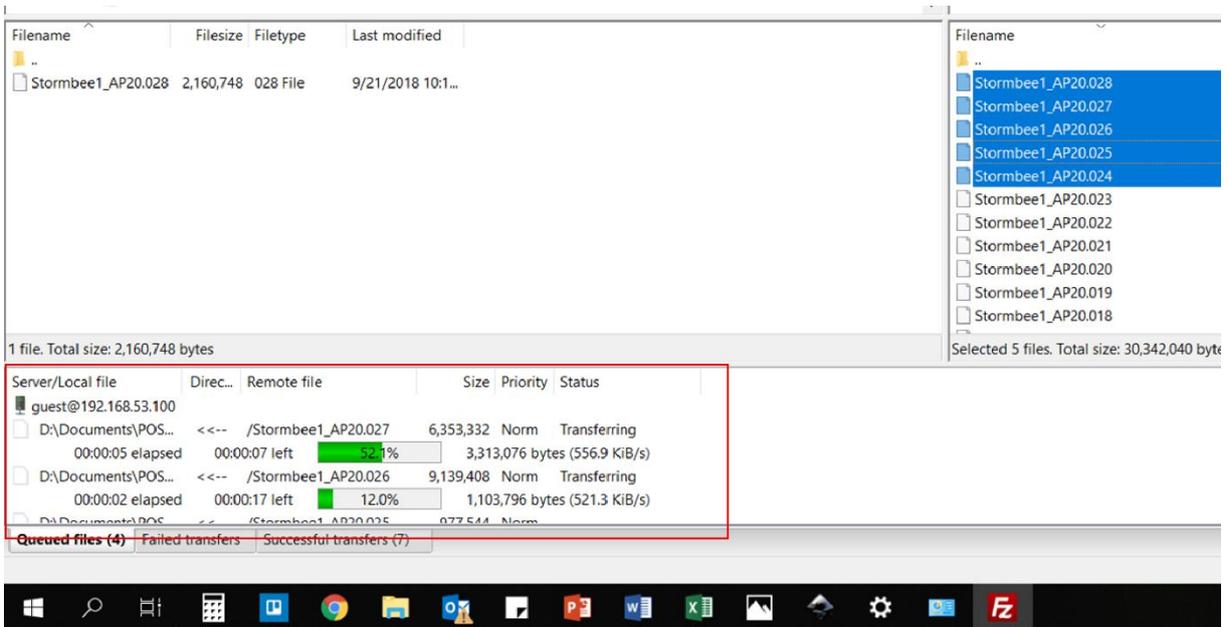


Figure 6.13 FileZilla file transfer progress

- If all went well, the text window at the top will display: "File transfer successful".

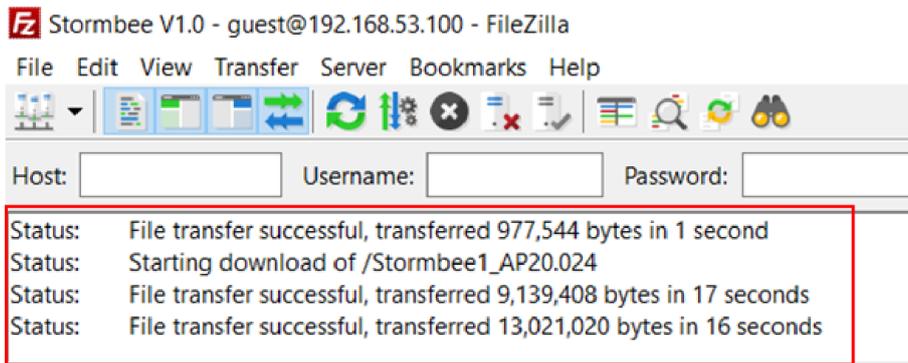


Figure 6.14 FileZilla file transfer succesful

11. Close FileZilla, disconnect the ethernet cable and power off the GNSS avionics (and FARO Focus scanner) by pressing the large button with the power symbol  on it. Afterwards, disconnect the flight battery/batteries.

12. Don't forget to revert the changes to the IP-address window if you use wired internet (through ethernet cable). See step 4.

7 FARO Focus scanner settings and usage inflight

7.1 Hardware preparation and mounting before flight

7.1.1 Replacing brackets (X-series only!)

To mount the FARO Focus scanner (X-series only, S-series not required) underneath STORMBEE, the standard scanner brackets should be replaced with the STORMBEE (provided) helical operation brackets. Please refer to “Appendix B: FARO Focus scanner helical operation brackets” for instructions on how to replace the brackets. The STORMBEE helical operation brackets have a recess which ensures the scanner remains aligned with STORMBEE’s mount during flight. These special brackets are also suitable for static (non-helical) laser scanning inspections, so one should not have to switch brackets before and after every flight.



Figure 7.1 FARO Focus helical operation brackets [FARO]

7.1.2 Mounting scanner

To prepare STORMBEE after transport for flight, please perform the following steps:

1. Take STORMBEE, the FARO Focus scanner and their accessories out of their transport cases. Ensure that the FARO Focus scanner (X-series only!) is equipped with the STORMBEE (provided) helical operation brackets (section 7.1.1 “Replacing brackets”).
2. Mount the FARO Focus scanner underneath the STORMBEE. The FARO Focus scanner is positioned correctly into its mount if the 12-pin automation interface fits nicely in the corresponding interface of STORMBEE’s scanner mount. The pin on the front side of that mount should be pointing downwards, not forwards. Secure the FARO Focus scanner by tightening the four bolts through the holes in the top plate of the STORMBEE while holding the scanner against its mount. Tighten the bolt opposite the last one you tightened in a crisscross pattern. This insures that the stress is distributed evenly across the FARO Focus mount. When

you've tightened all the bolts, go back through the pattern again to ensure that each bolt is evenly tight.

NOTE If the flight will occur without the FARO Focus scanner or any other payload, for instance for training purposes, then the pilot is advised to hang a dummy weight underneath the STORMBEE to keep the Take-Off Mass near the MTOM. The reason of this is that a multicopter varies the thrust of each propulsion unit individually to control its attitude. However, if the thrust it must deliver is lower than normal, for instance when STORMBEE has no payload attached, then the amount of thrust it can vary will also be smaller. This will result in less agility and thus less stability in the presence of (strong) winds and turbulence (gusts).

NOTE Check that the mirror of the FARO Focus scanner is clean. If not, follow the cleaning instructions from your FARO Focus scanner manual. Be very careful to not scratch the mirror when cleaning it as this may irreversibly damage it.

3. Remove the foam mirror protection piece before powering on the scanner.

7.2 Settings

The FARO Focus scanner supports two basic laser scanner operation modes, the spherical scan mode (used for static operations) and the helical scan mode (used by STORMBEE). The helical mode has two sub modes, the helical TTL and the helical CAN mode. These two sub modes differ from one another in the control and communication signals. **STORMBEE operations require the user to use the TTL helical mode, not the CAN mode!** STORMBEE needs the FARO Focus scanner to be in TTL mode to enable mirror and time stamp synchronization with the positioning data of the GNSS module for post-processing the laser scan data.

When a helical mode is enabled, the horizontal rotation axis stays locked and the scanner will not turn horizontally. When switching the scanner off in helical mode, it will keep knowledge about this mode and the horizontal rotation axis is still locked when the scanner is switched on again.

Depending on your scanner, please refer to either "Appendix C: FARO Focus scanner STORMBEE helical profile settings (X-series only)" or "Appendix D: FARO Focus scanner STORMBEE helical profile settings (S-series only)" on how to create and select an appropriate helical profile suitable for STORMBEE operations.

NOTE In helical mode, capturing of coloured scans is not supported as well as setting the horizontal scan angles.

Table 7.1 FARO Focus scanner STORMBEE helical profile settings

Specifications	Unit	Value
Resolution	-	1/5
Quality	-	2x
Scan duration	mm:ss	55:55
Scan size	Pt x Pt	200,000 x 3414
MPts	MPts	682.8
Point distance	mm/10m	7.670
Helical scan position	°	A (90.00)
Number of scan lines	-	200,000
Split scan files after	-	200,000
Eye safety distance	m	Stationary 3.80 Moving (>3.00km/h) 1.30
Scan file size	MB	2539.06

7.3 Calibration

The STORMBEE with the FARO Focus scanner mounted on it should be calibrated at regular intervals or after maintenance or repair to ensure the relative location and attitude of the GNSS module components with respect to the FARO Focus scanner are still accurate. Otherwise the margin of error after post-processing will be larger than normal.

Currently, this calibration can only be done by Think 3D. However, to do this calibration, Think 3D only requires the user to send (over internet) the point cloud data files of one of the last flights in which a Hashtag (#) manoeuvre is performed (Figure 7.2). Afterwards, you will receive the new correction factors which you should implement in the config.ini file used by BEEFLEX (see separate PDF “STORMBEE Software User Manual” on how to do this).

STORMBEE operators should send through a (calibration suitable) set of scan and GNSS data to Think 3D every 6 months or 20 hours of flight time (roughly every 150 flights), whichever comes first.

The Hashtag (#) manoeuvre consists of flying automatically horizontally along the lines of the shape of a hashtag in the vicinity of some form of infrastructure while the scanner is active. There needs to be some form of infrastructure (road, building) nearby as the calibration will be done with respect to this infrastructure. You do not need to fly this manoeuvre in “crab” (heading 20° offset with respect to flight direction), simply fly it with nose forward. As this manoeuvre takes little flight time (roughly 2 minutes), one can simply perform it at the end of an inspection flight when sufficient battery is left. There is no need to perform a separate flight.

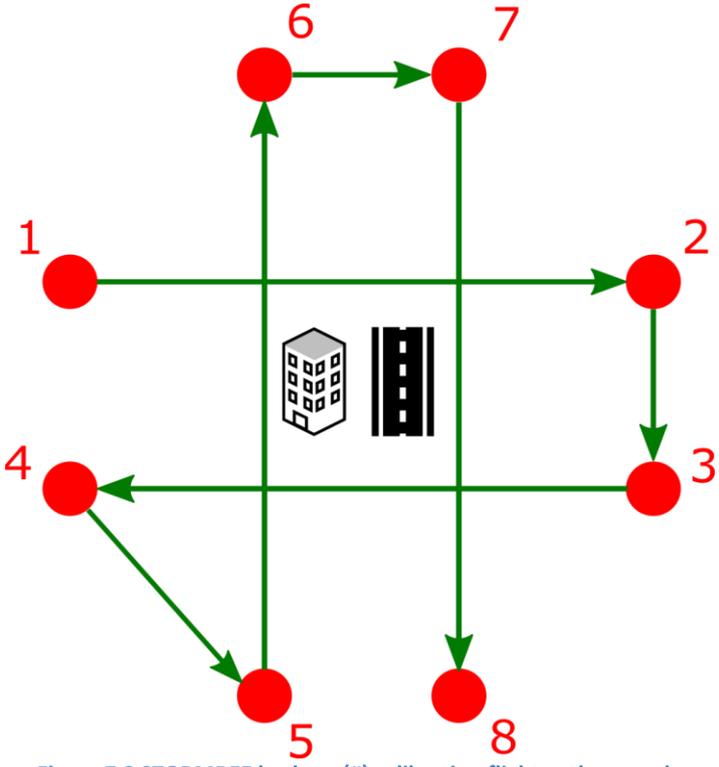


Figure 7.2 STORMBEE hashtag (#) calibration flight path example

7.4 Data retrieval

See section 6.2 "Data retrieval".

8.2 Operational safety guidelines

First and foremost: SAFETY FIRST! Follow all procedures described in this manual!

All safety guidelines issued by DJI for the A3, DJI Lightbridge 2, DJI Go app and DJI GS PRO app apply to the STORMBEE and its operations as well, except if they conflict with the STORMBEE guidelines in which case the STORMBEE guidelines have priority. In case of conflict, the STORMBEE manual should explicitly mention this conflict and instruct you to ignore that specific DJI guideline. If this is not the case, or in case of doubt, contact Think 3D or one of its resellers or authorised maintenance centres.

An example of conflict between DJI guidelines and STORMBEE guidelines is with regards to the firmware update. DJI requires its users to update all firmware as soon as it is released. A firmware update of any STORMBEE (DJI) component or accessory is only allowed to be performed by Think 3D or one of its authorised maintenance centres. The manual, at various locations, explicitly mentions this conflict and instructs STORMBEE user to ignore this specific DJI guideline.

All safety guidelines issued by GensAce Tattu, with respect to the LiPo batteries used by STORMBEE, and FARO, with respect to its Focus (series) laser scanner, should be read and adhered to.

Some safety guidelines are listed in this chapter, but the absence of one here, which is still mentioned in the DJI, Tattu or FARO Focus safety guidelines doesn't mean that they should not be followed.

STORMBEE general safety guidelines:

1. Do not leave the STORMBEE in direct sunlight on warm summer days. The carbon plates and arms heat up fast and the temperature within STORMBEE may reach dangerous levels with respect to the electronics.
2. Ensure the remote controller, aircraft battery and your mobile device (for the app) are sufficiently charged.
3. Ensure the propellers are securely mounted onto the motors, and the motors can start and function normally.
4. Ensure you observe all local regulations, obtain appropriate authorization and understand the potential risks. REMEMBER: It is solely your responsibility to comply with all flight regulations.
5. Ensure your flight area is not near a No-Fly Zone and that conditions are suitable for flying the aircraft.
6. DO NOT attempt to fly under the influence of alcohol, drugs or any substance that may impair your cognitive abilities.
7. Ensure you are familiar with the selected flight mode and understand all safety functions and warnings.
8. Ensure the compass is calibrated if the app requires you to. Failure to do so may lead to unexpected flight behaviour or serious accidents.
9. After successful calibration, the compass may become abnormal when you place the aircraft on the ground. This may be because of underground magnetic interference. Move the aircraft to another location and try again.
10. When to calibrate:
 - a. When compass data is abnormal, and the LED module is blinking red and yellow.
 - b. When severe drifting occurs in flight, i.e. the aircraft DOES NOT fly in straight lines.
11. Land immediately when severe drifting occurs in flight, i.e., the aircraft DOES NOT fly in straight lines.

STORMBEE flight safety guidelines:

1. The ESCs are programmed to stop if the propellers are obstructed both in flight and on the ground. If the obstruction is removed, the propellers are spooled up again. This way there is a higher chance of keeping the aircraft airborne and less risk of overloading the motor (burn-out).
2. STORMBEE's DJI A3 flight controller is geofenced by DJI and can't go close to major airfields or other restricted areas when GPS flight is used. These areas were restricted by your national government. The DJI flight controller also prevents take-offs within these restricted zones. In addition, the geofencing limits STORMBEE to fly higher than a pre-configured height above the home location (default 91 meters or 300 ft) and distance from the pilot (500 meters). DJI has a website where you can request permission (requires up to one day) to be able to take-off in a restricted zone: <https://www.dji.com/flysafe>.
3. The failsafe action of the DJI A3 controller, when the communication between transmitter and RPA is lost (for more than 3 seconds), differs between manual flight and automated flight. If the RPA is flying automatically by means of GPS waypoints, depending on the GS pro app settings, the RPA will either perform a RTH manoeuvre immediately or continue its mission. In the latter case, when the communication is not restored by the end of that automated mission, the RPA will then still switch to RTH and land. If the RPA is controlled manually at the time of communication loss, the RPA will switch to RTH failsafe immediately. RTH entails that STORMBEE will climb to a pilot pre-programmed height, set higher than any obstacle in the vicinity, and then fly home in a direct line, after which it will land at a pre-programmed location. This location is usually the location at which STORMBEE has powered up its motors (take-off location) but can also be re-programmed by the pilot during flight.

8.3 Battery safety guidelines

All instructions and warnings must be followed exactly to prevent property damage and/or severe injury as the mishandling of LiPo batteries can result in fire. By handling, charging or using the included LiPo battery you assume all risks associated with LiPo batteries.

1. Always start your flight with fully charged batteries.
2. Never fly with only one of the two flight batteries connected.
3. Always land as soon as possible when the flight battery voltage drops below 21.6V. Never take-off with less than 22.5V. Discharging the battery too low (below 21.4V) can cause damage to the battery resulting in reduced power, reduced capacity or failure of the battery entirely.
4. Always remove batteries after use and store/transport them per the corresponding guidelines.
5. If the batteries are warm after flight, let them cool down before charging them again.
6. If the batteries are warm after charging, let them cool down before using them in-flight.
7. Always operate your aircraft when the voltage of the battery in the Lightbridge 2 and tablet is in a safe range (as indicated by the Lightbridge 2 LED lights and in the DJI apps).
8. You must always charge the LiPo battery in a safe, well-ventilated area away from flammable material.
9. Never charge the LiPo battery unattended at any time. When charging the battery, you must always remain in constant observation to monitor the charging process and react immediately to any potential problems that may occur. Never leave batteries, chargers and power supplies unattended during use.
10. To charge the LiPo battery you must use only Think 3D approved chargers. Failure to do so may result in a fire causing property damage and/or severe injury.

11. If at any time the LiPo battery begins to balloon or swell, discontinue charging or discharging immediately. Quickly and safely disconnect the battery, then place it in a safe, open area away from flammable materials to observe it for at least 15 minutes. Continuing to charge or discharge a battery that has begun to balloon or swell, can result in a fire.
12. Never attempt to charge low voltage, ballooned/swollen, damaged or wet batteries. These batteries must be removed from service completely.
13. Store the LiPo battery at room temperature and in a dry area for best results. Cold batteries lose a significant amount of their energy capacity and will severely reduce the flight time of the STORMBEE. During cold weather, try to keep them as long as possible in a warm environment (in the car or a heated building) before mounting them on the STORMBEE.
14. When charging, transporting or temporarily storing the LiPo battery the temperature range may be between approximately 5 and 49° C. However, it is advised to keep the battery stored within a temperature range of 15 to 40°C as this will ensure it retains its maximum charge level. Below 15°C, the batteries may lose up to 20% of their charge level.
15. Do not store the battery or aircraft in a hot garage, car or direct sunlight. If stored in a hot garage or car the battery can be damaged or even catch fire.
16. Store batteries in dedicated cases or LiPo safety bags to prevent battery malfunctions resulting in a fire to spread further.
17. Never allow untrained persons to charge batteries.
18. Never charge a battery if any of the wire leads have been damaged or shorted.
19. Never attempt to disassemble the battery, charger or power supply.
20. Never drop batteries, chargers or power supplies.
21. Always inspect the battery, charger and power supply before charging.
22. Always ensure correct polarity before connecting batteries, chargers and power supplies.
23. Always disconnect the battery after charging.
24. Always terminate all processes if the battery, charger or power supply malfunctions.

8.4 Flight controller safety settings

Both the DJI A3 flight controller and DJI Lightbridge 2 remote controller have a unique identification number to avoid pairing with the wrong devices. The datalink uses DJI encrypted protocols for data security.

The failsafe action of the DJI A3 controller, when the communication between transmitter and RPA is lost (for more than 3 seconds), differs between manual flight and automated flight. If the RPA is flying automatically by means of GPS waypoints, depending on the GS pro app settings, the RPA will either perform a RTH manoeuvre immediately or continue its mission. In the latter case, when the communication is not restored by the end of that automated mission, the RPA will then still switch to RTH and land. If the RPA is controlled manually at the time of communication loss, the RPA will switch to RTH failsafe immediately. This entails that STORMBEE will climb to a pilot pre-programmed height, set higher than any obstacle in the vicinity, and then fly home in a direct line, after which it will land at a pre-programmed location. This location is usually the location at which STORMBEE has powered up its motors (take-off location) but can also be re-programmed by the pilot during flight.

DJI Lightbridge 2:

The DJI Lightbridge 2 is used in combination with an iPad or Android tablet, mounted on top of the Lightbridge 2, and the DJI GS Pro app (or DJI Go app) running on that tablet.

The DJI Lightbridge 2 has a dedicated hardware button to activate the (Smart) Return to Home (Smart RTH) mode in case of problems in which STORMBEE must come home immediately. This entails that

STORMBEE will climb to a pre-programmed height, which the pilot should set (5 to 10m) higher than any obstacle in the vicinity before take-off, and then fly home in a direct line, after which it will land at a pre-programmed location. This location is usually the location at which STORMBEE has powered up its motors (take-off location, Home Point) but can also be re-programmed by the pilot during flight.

If the GPS fails, the pilot can still fly STORMBEE in Attitude-mode (ATTI) and should land ASAP.

The DJI Lightbridge 2 has been designed so as to assure that the operator will correctly perform the operational sequences and that the possibility of human errors is reduced as much as possible. Switches and buttons have been placed in such a way that unintentional activation is avoided.

The Lightbridge 2 will send out audible and visual alerts in case of problems with STORMBEE or the communication with it.

DJI GS Pro:

GS Pro is an iPad (series) app designed to control or plan automatic flights for DJI aircraft. Through its clear, concise interface, complex flight missions can be planned with a few taps. GS Pro will then automatically take pictures at pre-set waypoints, providing the accuracy required for precision mapping. GS Pro also allows to modify your flight trajectory/mission in-flight, control your camera, and receive a live HD view of what that camera sees. Flight information including current status, full telemetry, location, heading, and more is displayed and updated live, making every flight safe and convenient.

GS Pro also allows to set a Virtual Fence which increases safety and ease of use by locking the aircraft's height and speed within a designated area. Virtual fence defines a specific area of flight and is useful in scenarios where some areas of a site are no-fly zones or if flight should only happen within one area, such as during manual pesticide spraying or flight. It is also useful in pilot training situations. As the aircraft approaches the virtual fence, it will brake and hover to ensure it stays within the flight area. The app also contains a map of restricted or forbidden flight areas which will prevent the pilot from taking off within these areas or enter these areas during flight.

8.5 Emergency procedures

8.5.1 Datalink & Radio Control link failure

The failsafe action of the DJI A3 controller, when the communication between transmitter and RPA is lost (for more than 3 seconds), differs between manual flight and automated flight. If the RPA is flying automatically by means of GPS waypoints, depending on the GS pro app settings, the RPA will either perform a RTH manoeuvre immediately or continue its mission. In the latter case, when the communication is not restored by the end of that automated mission, the RPA will then still switch to RTH and land. If the RPA is controlled manually at the time of communication loss, the RPA will switch to RTH failsafe immediately. This entails that STORMBEE will climb to a pilot pre-programmed height, set higher than any obstacle in the vicinity, and then fly home in a direct line, after which it will land at a pre-programmed location. This location is usually the location at which STORMBEE has powered up its motors (take-off location) but can also be re-programmed by the pilot during flight.

1. Verify that the landing area is clear.
2. Try to regain control.

3. If the mission requires ATC communication, the pilot should have a communication device (radio, Mobile phone) on his/her person which can directly contact the appropriate ATC service or other authorities.

8.5.2 Electrical failure

Land ASAP (at STORMBEE's current location)

8.5.3 Low battery

Temperature too hot:

Land ASAP (at STORMBEE's current location)

Temperature too cold:

Land ASAP (at STORMBEE's current location)

Low battery voltage (<21.6V):

Return to landing zone and land

Critical battery voltage (<21.4V):

Land ASAP (at STORMBEE's current location)

8.5.4 Motor failure

The A3 flight control system will automatically and instantly detect a motor failure and can still control the aircraft's attitude with one motor inoperable. STORMBEE is attitude controllable when one motor output fails but will have reduced manoeuvrability and maximum airspeed. The DJI GS Pro app will warn the pilot if a motor fails.

Land ASAP (at STORMBEE's current location).

8.5.5 Remote Pilot Station failure

Low battery:

The Lightbridge 2 transmitter will emit a very loud beeping sound for a long time which is almost impossible to miss. Press the RTH button on the transmitter or app, or pilot STORMBEE to landing zone and land ASAP.

Sticks calibration error:

Calibrate remote controller in the DJI GS Pro app. If problem persists, contact Think 3D or one of its authorised maintenance centres.

Control stick error:

Control sticks may experience severe electromagnetic interference and may not function properly. Use RTH button on LB2 to make STORMBEE return home and land ASAP. STORMBEE will not take-off with this warning.

8.5.6 Fire

Fire during start/take-off:

1. Throttle down and shut down the motors.
2. Try to extinguish fire, but do not come too close.
3. Turn off the Lightbridge 2.

Fire during flight:

Land ASAP.

1. Inform bystanders of your intentions and verify the landing area is clear.
2. Land.
3. Throttle down and shut down motors after landing.
4. Try to extinguish fire, but do not come too close.
5. Turn off the Lightbridge 2.

8.5.7 Fly-away

This may occur in case of GPS-signal interference, strong winds or turbulence.

1. Switch to ATTI-mode (A-mode) and try to fly to the landing zone.
If not possible, land ASAP at the current location of STORMBEE.
2. Inform bystanders, verify landing area is clear.
3. If the aircraft, for some unknown reason, does not return home or land at the location where the failure occurred:
 - a. Try to fly STORMBEE as low as possible.
 - b. Verify or wait until the area underneath the STORMBEE, with a radius as wide as STORMBEE's height above the terrain, is clear of persons and infrastructure.
 - c. Apply the emergency procedure to shut down motors in-flight (sticks inwards and downwards) and crash STORMBEE.
4. Inform appropriate authorities, search for and recover STORMBEE.

8.5.8 Procedure after incident, accident or crash

Follow the national and regional UAS/RPAS/drone guidelines regarding how to inform the authorities of incidents, accidents or crashes.

Immediately inform Think 3D or its authorised maintenance centres or resellers when incidents, accidents and/or crashes occur. They will help set-up an appropriate action plan on how to prevent these in the future, verify STORMBEE's integrity and take the necessary repair/maintenance actions to get your STORMBEE back to operational status.

8.6 Maintenance program

Periodical inspections and maintenance:

STORMBEE should be inspected and serviced each 100 hours of operation with at least one inspection per year.

All pre-flight inspections specified in chapter 4 "Pre-flight actions" should be performed before each flight and at least once every 6 months to maintain/verify STORMBEE's operational status.

Maintenance may only be performed by Think 3D approved servicers. Maintenance events should be marked in the maintenance logbook of STORMBEE.

Batteries:

All STORMBEE batteries should be individually checked and charged to their recommended voltage storage level every 6 months.

Motors and propellers:

Propellers must be checked before each flight for nicks or cracks. When necessary, clean props, motors and other surfaces with window-cleaner products and a soft cloth.

8.7 FARO Focus scanner safety guidelines

Please refer to the safety guidelines in the user manual of your specific FARO Focus scanner.

Appendix A: Transportation checklist

Here you will find a complete list of all items that you (may) need to take with you to perform an inspection flight in the form of a checklist. The items themselves have already been mentioned in earlier chapters. The purpose of this list is to help you prevent forgetting to take something with you which may require you to cancel/postpone the mission or diminish its safety.

DOCUMENTS	
WEATHER INFO, FORECAST & KP-INDEX	
NOTAMS	
VFR MAP	
PASSPORT(S) PILOT AND CREW	
DRONE PILOT LICENSE	
DRONE PILOT MEDICAL CERTIFICATE	
DRONE PILOT LOGBOOK	
STORMBEE FLIGHT LOGBOOK	
STORMBEE MAINTENANCE LOGBOOK	
STORMBEE REGISTRATION DOCUMENT (COPY)	
STORMBEE CERTIFICATION DOCUMENT (COPY)	
STORMBEE INSURANCE DOCUMENT (COPY)	
MISSION PERMIT DOCUMENT	
MISSION RISK ANALYSIS DOCUMENT	
STORMBEE USER MANUAL & QRH	
COMPANY OPERATIONAL MANUAL	
PERMISSION OWNER TERRAIN	
MISSION PREPARATION	

EQUIPMENT	
STORMBEE	
STORMBEE CANOPY	
BATTERIES STORMBEE	
LIGHTBRIDGE 2	
TABLET	
TABLET USB CABLE	
FARO FOCUS SCANNER	
LASER RANGE FINDER BINOCULARS	
LIPO BATTERY CHARGER AND ACCESSORIES	
LIPO BATTERY CHARGER POWER SUPPLY	
HIGH VISIBILITY MARKERS T/O AREA	
SMALL SET OF TOOLS	
HEX KEY FARO FOCUS MOUNT BOLTS	
RADIO (CB AND/OR ATC)	
LAPTOP	
CHARGER TABLET	
CHARGER MOBILE PHONE	
CHARGER RADIOS	
CHARGER LAPTOP	
POWER STATION	
EXTRA PROPELLERS STORMBEE	
CLEANING CLOTH MIRROR SCANNER	
CLEANING PRODUCT MIRROR SCANNER	
FIRST AID KIT	
FIRE EXTINGUISHER	

CREW	
APPROPRIATE CLOTHING	
FOOD AND DRINKS	
SUNGLASSES	
SUNSCREEN	
ANTI-MOSQUITO SPRAY	
MOBILE PHONE WITH EMERGENCY CONTACT DETAILS PRE-PROGRAMMED	
HIGH VISIBILITY JACKETS	
GLOVES	

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Appendix B: FARO Focus scanner helical operation brackets (X-series only)

1. Remove the small covers on top of each clamp with the help of a small screw driver or tweezers.

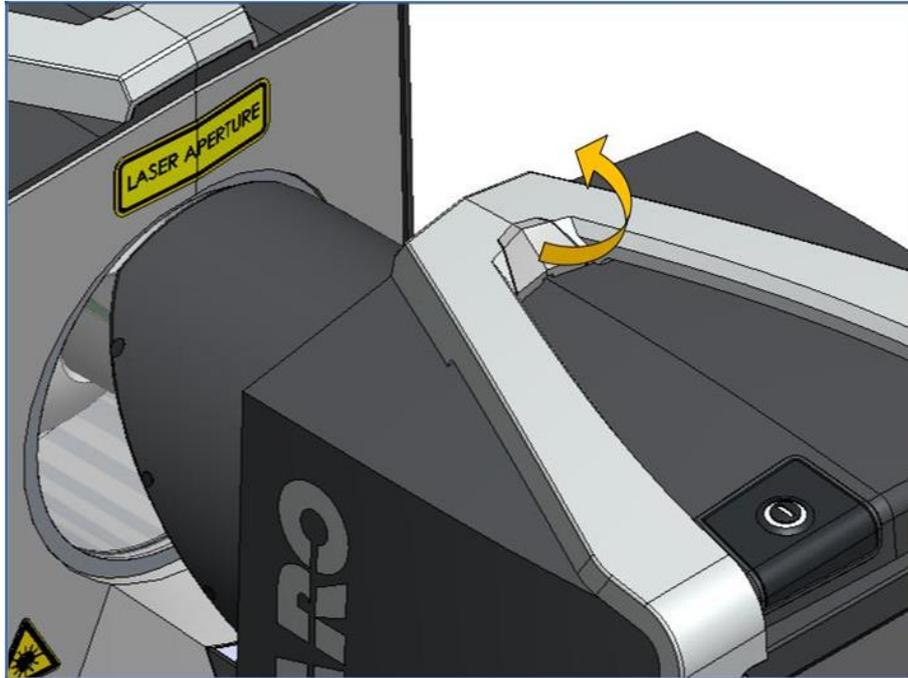


Figure B. 1 Brackets replacement step 1 [FARO]

2. Loosen the two M2 screws (one per clamp) that are located under the re-moved cover by using a Torx T6 screw driver.

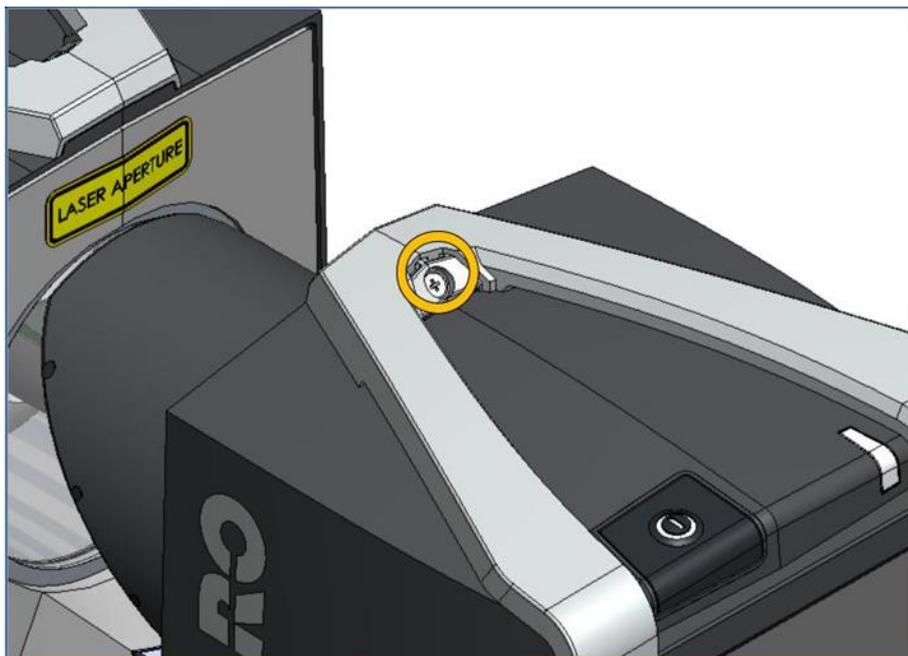


Figure B. 2 Brackets replacement step 2 [FARO]

3. Loosen the four M3 screws (two per clamp) on the bottom of the scanner housings by using a Torx T10 screw driver. You might have to remove the security labels covering the screws first.

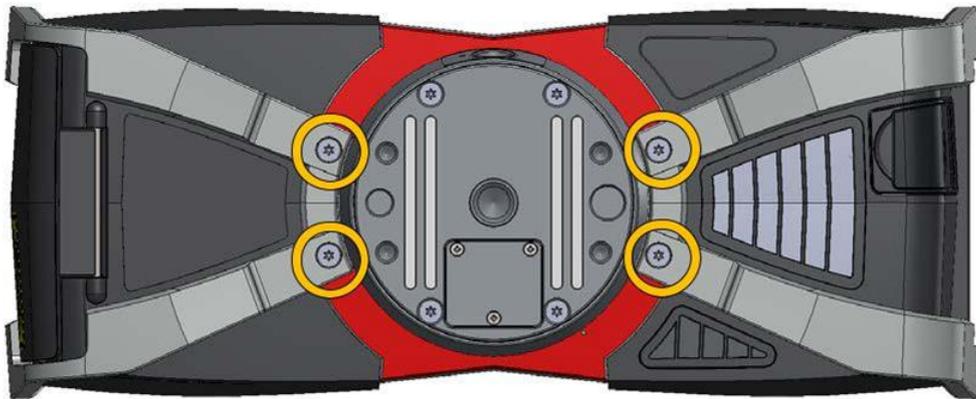


Figure B. 3 Brackets replacement step 3 [FARO]

4. Carefully dismount both clamps.

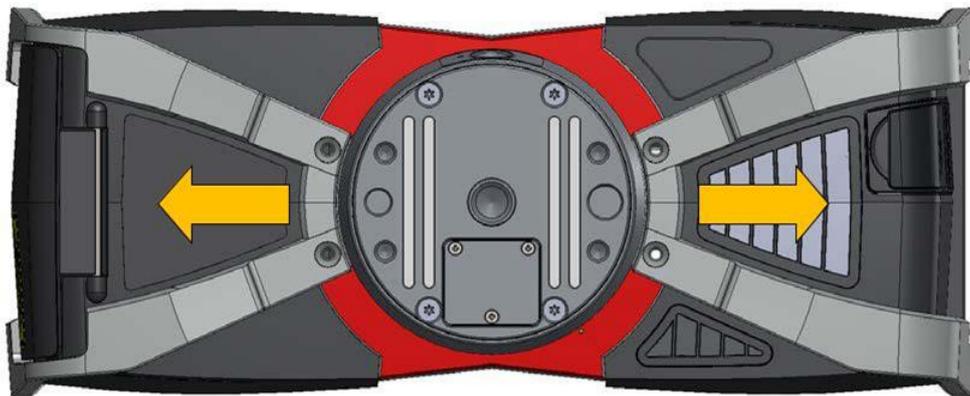


Figure B. 4 Brackets replacement step 4 [FARO]

5. Carefully mount both helical clamps.

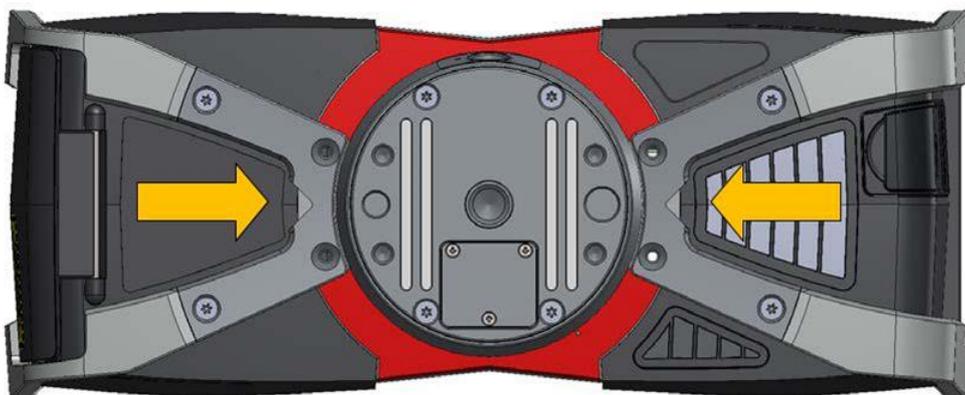


Figure B. 5 Brackets replacement step 5 [FARO]

6. Tighten the four M3 screws (two per clamp) on the bottom of the scanner housings by using a Torx T10 screw driver (with a torque of 1 Nm).

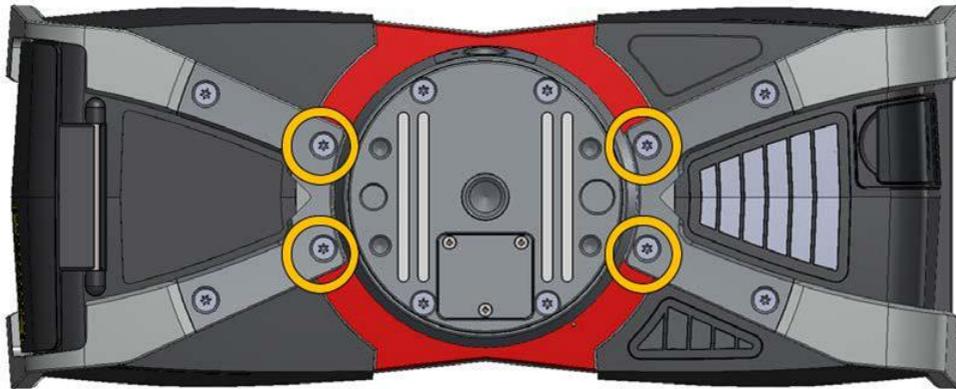


Figure B. 6 Brackets replacement step 6 [FARO]

7. Tighten the two M2 screws (one per clamp) that are located under the re-moved cover by using a Torx T6 screw driver (with a torque of 0.24 Nm).

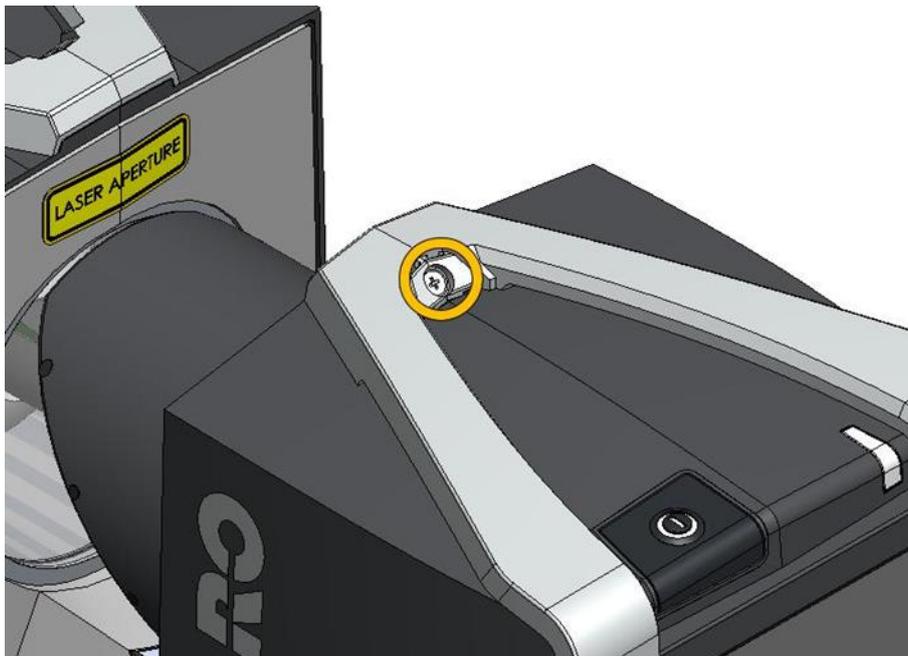


Figure B. 7 Brackets replacement step 7 [FARO]

8. Mount the small covers on top of each clamp.

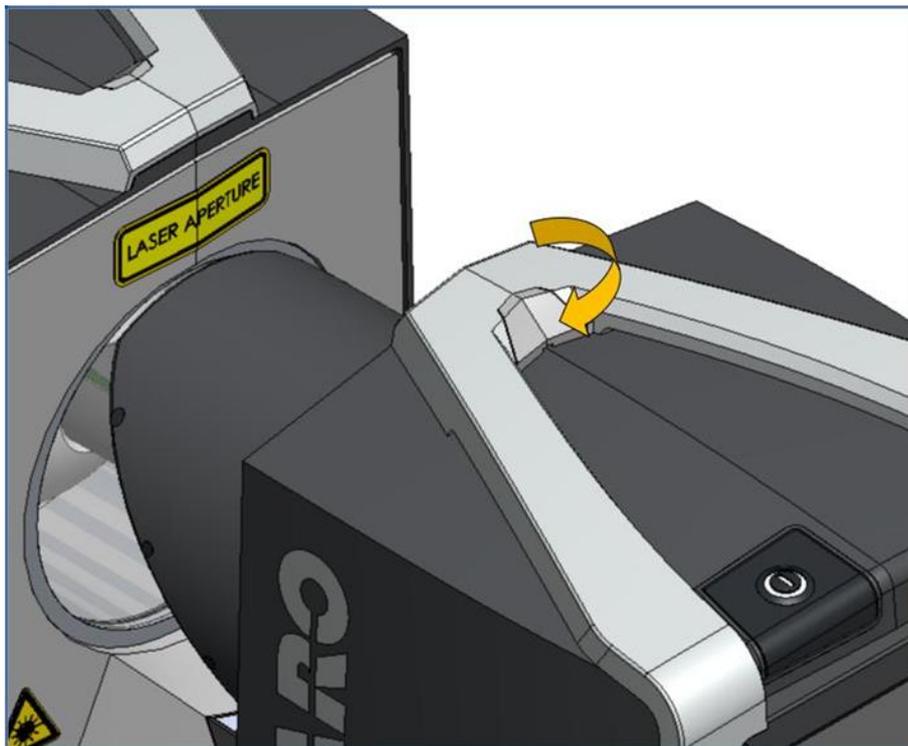


Figure B. 8 Brackets replacement step 8 [FARO]

9. Remove the Interface Cover: Loosen the three M1.6 screws on the bottom of the scanner base (use the Phillips Ph00 screw driver) and remove the interface cover.

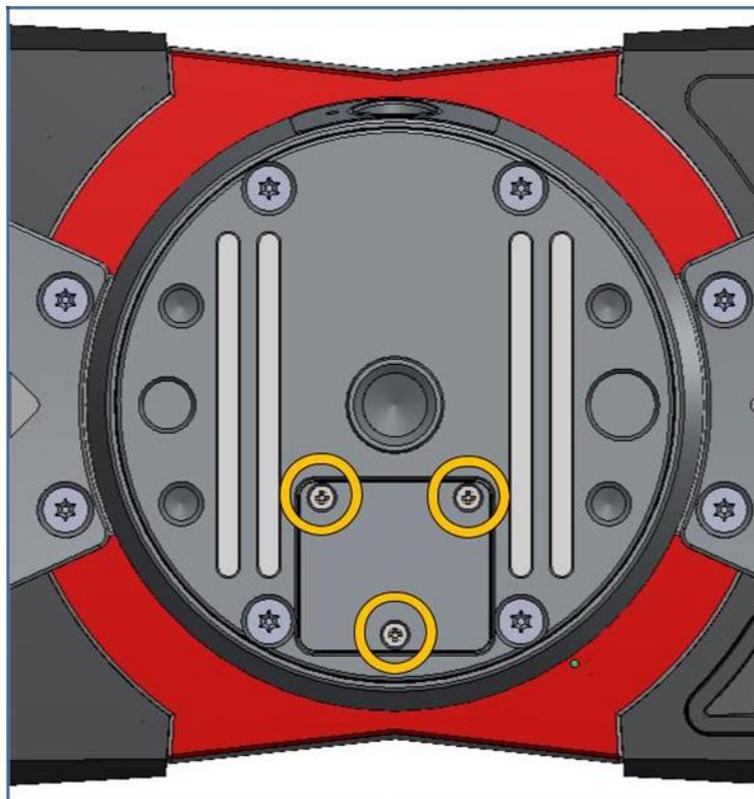


Figure B. 9 Brackets replacement step 9 [FARO]

Appendix C: FARO Focus scanner STORMBEE helical profile settings (X-series only)

Please also refer to section 7.2 “Settings” for the description of the helical mode and overview of settings of the FARO Focus scanner STORMBEE helical profile. The full documentation about all helical settings can be found in the "FARO Focus 3D Automation Interface Manual".

C.1 Enabling the helical scan mode via the scanner’s user interface

The correct TTL helical sub mode for STORMBEE operations has to be created and enabled. Creating and enabling this TTL helical sub mode as well as setting the scanning parameters can be done via the scanner’s user interface.

First of all, a new scan profile with the helical mode enabled has to be created. The way of creating a so called helical scan profile differs from the way of creating normal scan profiles. To create a helical scan profile, go to “Manage” → “Service” and click on the “Command Prompt” button, then type in the command “HelicalGrey” (Figure C. 1). “HelicalGrey” adds a helical scan profile with the TTL mode enabled.

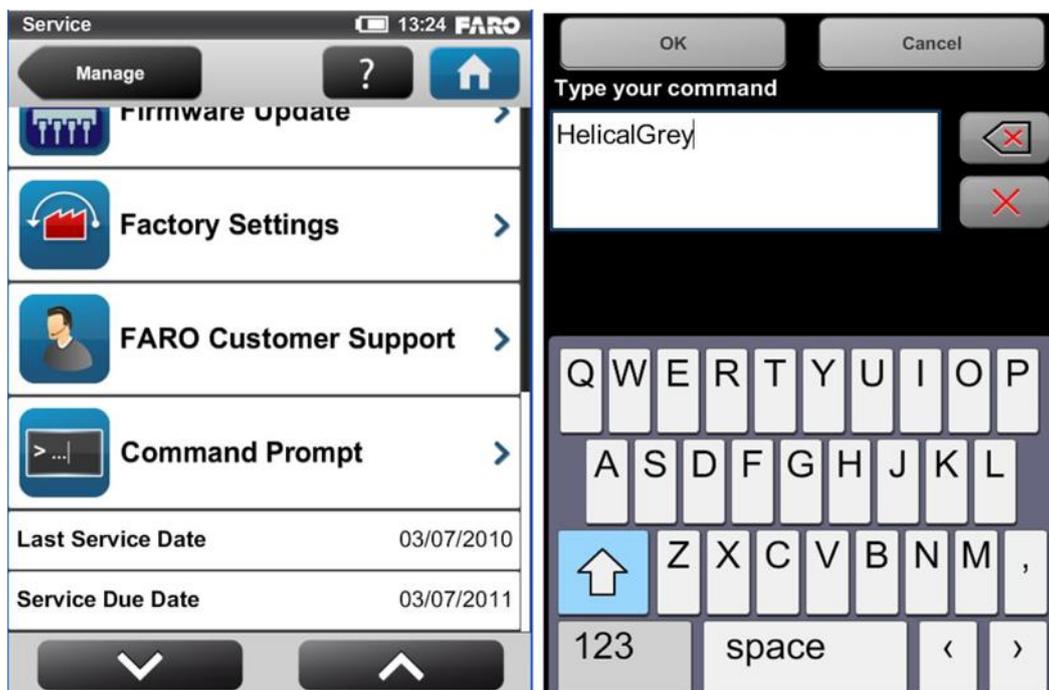


Figure C. 1 Creating helical scan profile via command prompt [FARO]

The new helical scan profile will be added to your profiles list and will automatically be selected as the currently used profile: helical mode is enabled and the scanning parameters are changed accordingly. Helical profiles can easily be recognized by their special icon. Furthermore, if the helical mode is enabled, the helical icon  is displayed in the status bar of the screen.

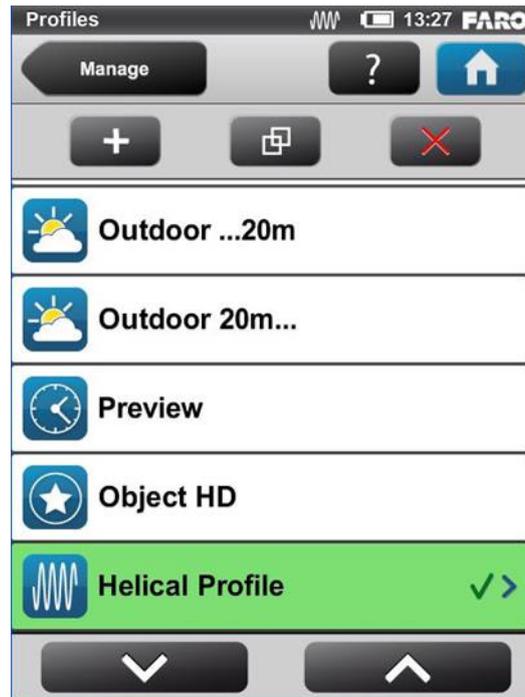


Figure C. 2 Overview current profiles [FARO]

The newly added helical profile is generated with the following default settings:

- Resolution 1/8
- Quality 4x
- Helical TTL mode or CAN mode
- Number of scan lines to be recorded 10000
- Spilt scan files after 1000 scan lines
- Helical Scan Position: Home Position (0°)



Figure C. 3 Helical mode default settings [FARO]

You can add additional helical scan profiles by duplicating the existing helical profile under “Manage” → “Profiles” or by re-entering the “HelicalGrey” command in the command prompt as described above.

You can change the parameters of the helical scan profile any time, but editing them differs a little bit from non-helical (spherical) profiles. Figure C. 4 and Table 7.1 show the settings of the STORMBEE helical scan mode.

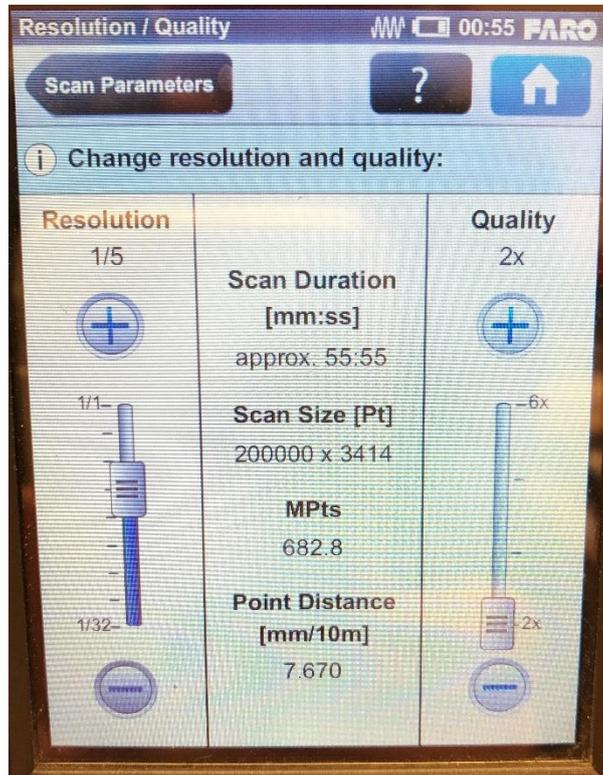


Figure C. 4 STORMBEE helical scan mode resolution and quality

You can change the profile name, the resolution and the quality as usual, but the button to change the horizontal and vertical angles as well as the button to enable or disable colour recording are not displayed. Instead, there is the Helical Scan Mode Settings button. It opens a screen (Figure C. 5) where you can adapt the following settings:

Helical Scan Mode:

Select the Helical TTL mode.

Helical Scan Position

Before starting a helical scan you should set the helical scan position in degrees and let the scanner rotate to this position. You should select Helical Adapter Scan position A (90°)

Number of Scan Lines

Enter an expected number of scan lines. Set this to 200,000.

Split Scan Files

The scan data stream can automatically be split into several files when a certain amount of scan lines has been reached. The minimum number is 100. Smaller scan files are not supported. Set this equal to

the number of scan lines (200,000) so there is only one large scan data file (per flight), which is required for post-processing.

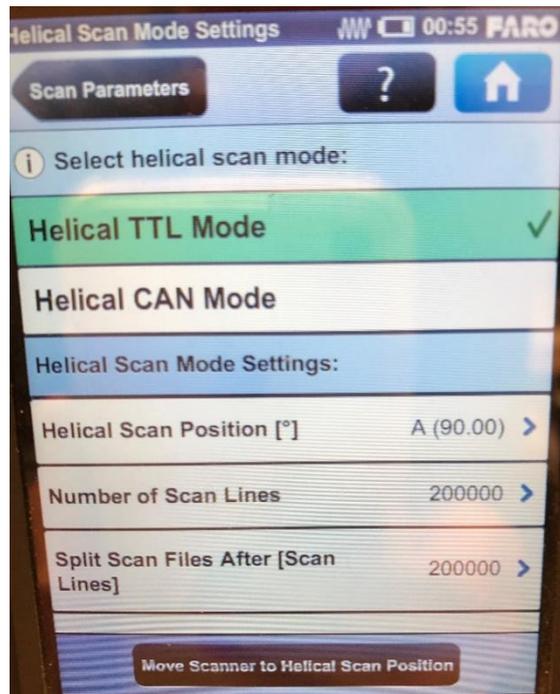


Figure C. 5 STORMBEE helical scan mode settings

C.2 Switching between profiles via the scanner’s user interface

Once a helical profile has been added to your profiles list, you can switch between your standard (static inspection) mode and the STORMBEE helical mode by simply selecting them from the profiles list (Figure C. 2) and verify the settings of that profile (Figure C. 6 and Table 7.1). Don't forget to set a new project name for every mission to ensure all scan files have a suitable name.



Figure C. 6 STORMBEE helical scan mode settings quick overview

Appendix D: FARO Focus scanner STORMBEE helical profile settings (S-series only)

Please also refer to section 7.2 “Settings” for the description of the helical mode and overview of settings of the FARO Focus scanner STORMBEE helical profile.

D.1 Enabling the helical scan mode via the scanner’s user interface

The correct TTL helical sub mode for STORMBEE operations has to be created and enabled. Creating and enabling this TTL helical sub mode as well as setting the scanning parameters can be done via the scanner’s user interface.

First of all, a new scan profile with the helical mode enabled has to be created. The way of creating a so called helical scan profile differs from the way of creating normal scan profiles. To create a helical scan profile, go to “Manage” → “Service” and click on the “Command Prompt” button, then type in the command “HelicalGrey” (Figure D. 1). “HelicalGrey” adds a helical scan profile with the TTL mode enabled.

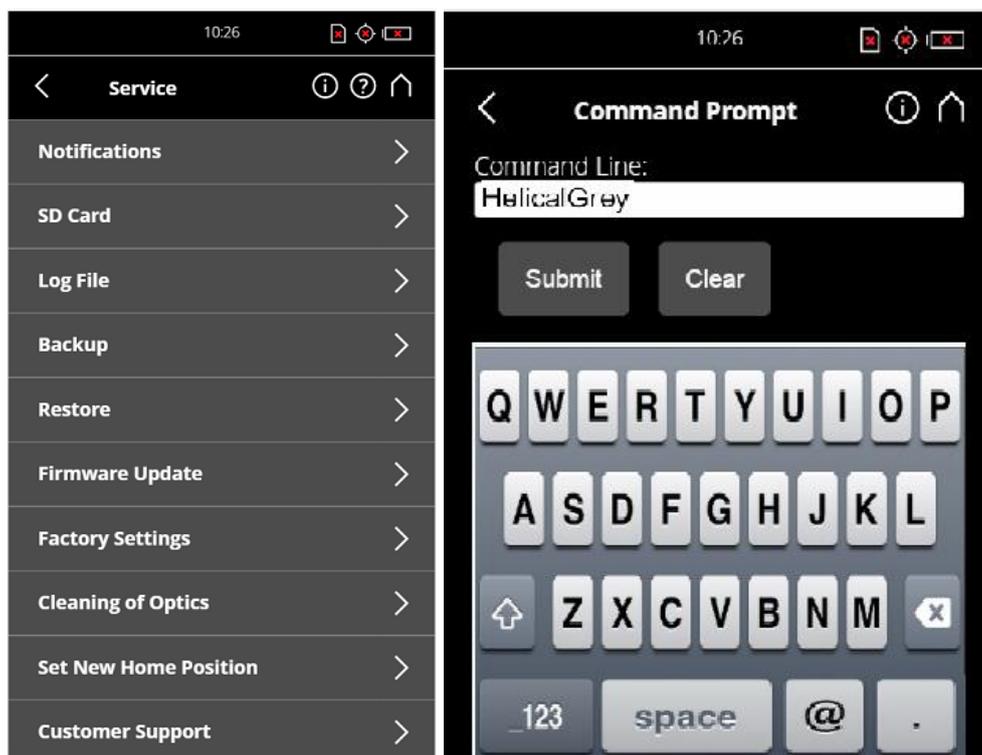


Figure D. 1 Creating helical scan profile via command prompt [FARO]

The new helical scan profile will be added to your profiles list and will automatically be selected as the currently used profile: helical mode is enabled and the scanning parameters are changed accordingly. Helical profiles can easily be recognized by their special icon. Furthermore, if the helical mode is enabled, the helical icon  is displayed in the status bar of the screen.

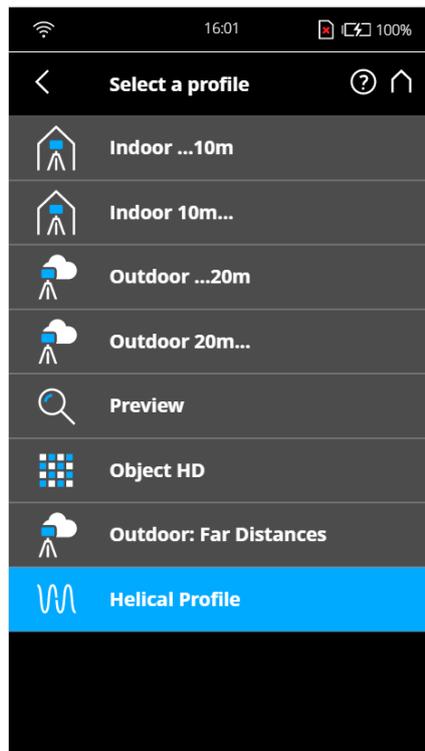


Figure D. 2 Overview current profiles [FARO]

The newly added helical profile is generated with the following default settings:

- Resolution 1/8
- Quality 4x
- Helical TTL mode or CAN mode
- Number of scan lines to be recorded 10000
- Spilt scan files after 1000 scan lines
- Helical Scan Position: Home Position (0°)

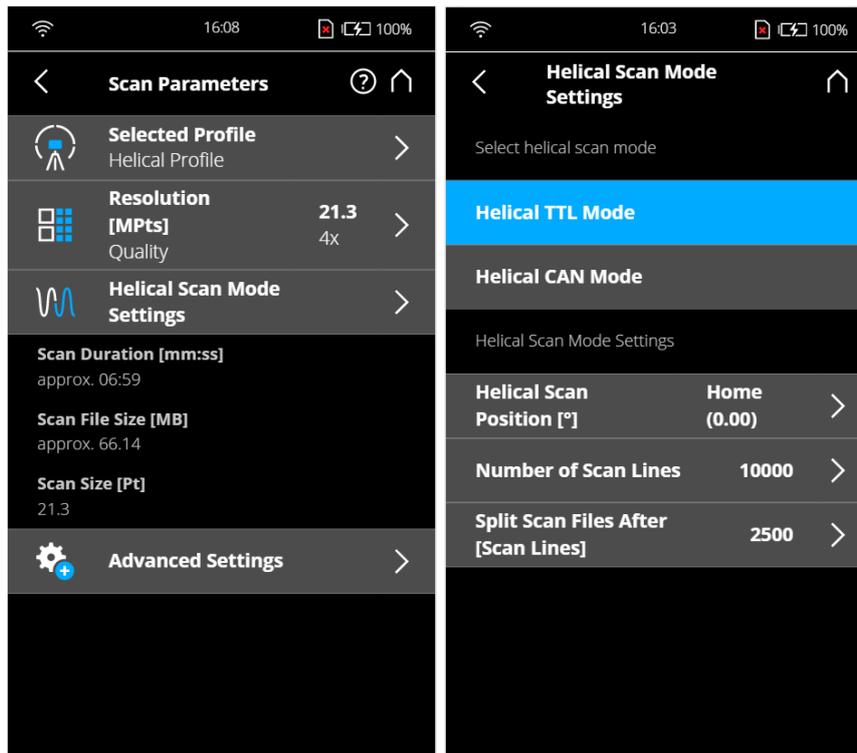


Figure D. 3 Helical mode default settings [FARO]

You can add additional helical scan profiles by duplicating the existing helical profile under “Manage” → “Profiles” or by re-entering the “HelicalGrey” command in the command prompt as described above.

You can change the parameters of the helical scan profile any time, but editing them differs a little bit from non-helical (spherical) profiles. Table 7.1 shows the settings of the STORMBEE helical scan mode.

You can change the profile name, the resolution and the quality as usual, but the button to change the horizontal and vertical angles as well as the button to enable or disable colour recording are not displayed. Instead, there is the Helical Scan Mode Settings button. It opens a screen (Figure D. 3) where you can adapt the following settings:

Helical Scan Mode:

Select the Helical TTL mode.

Helical Scan Position

Before starting a helical scan you should set the helical scan position in degrees and let the scanner rotate to this position. As STORMBEE uses the FARO Helical Adapter to prevent the scanner from turning within the limits of its pan axis’ backlash, you must let the scanner rotate to the selected position by clicking the "Move Scanner to Helical Scan Position button". Afterwards, lock the scanner’s position with the fixation pins of the Helical Adapter.

Number of Scan Lines

Enter an expected number of scan lines. Set this to 200,000.

Split Scan Files

The scan data stream can automatically be split into several files when a certain amount of scan lines has been reached. The minimum number is 100. Smaller scan files are not supported. Set this equal to

the number of scan lines (200,000) so there is only one large scan data file (per flight), which is required for post-processing.

D.2 Switching between profiles via the scanner's user interface

Once a helical profile has been added to your profiles list, you can switch between your standard (static inspection) mode and the STORMBEE helical mode by simply selecting them from the profiles list (Figure D. 2) and verify the settings of that profile (Figure D. 4 and Table 7.1). Don't forget to set a new project name for every mission to ensure all scan files have a suitable name.



Figure D. 4 STORMBEE helical scan mode settings quick overview

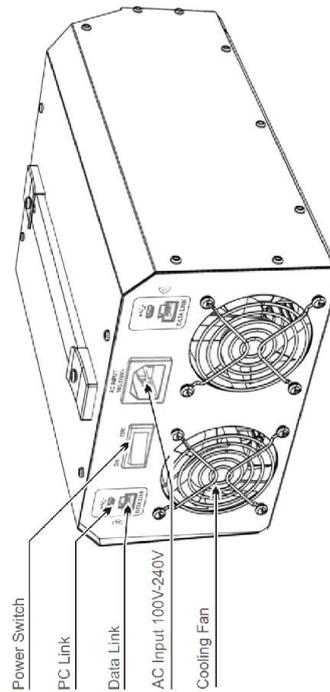
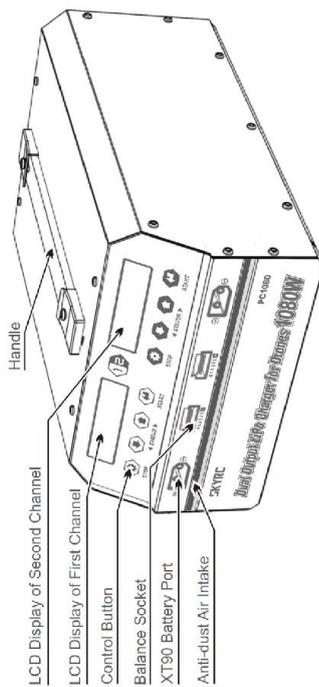
Appendix E: PC1080 Battery charger and G630 hub manuals

INSTRUCTION MANUAL PC1080 SK-100124



PRODUCT DESCRIPTION

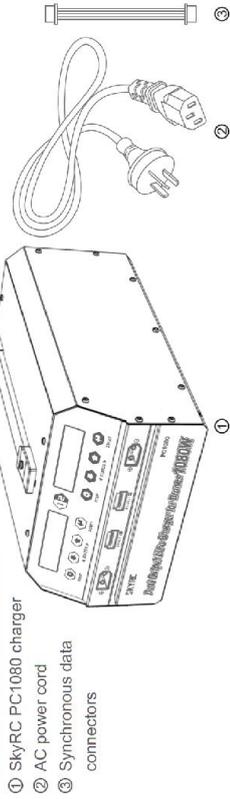
Thank you for choosing SkyRC PC1080 dual channel LiPo charger. This charger is capable of balance charging 2 packs of 6 cell batteries simultaneously. It is specifically designed for big battery pack. There are three working modes, fast charge, balance charge and storage. Master and Slave mode are available, enabling the user to perform synchronous settings for numerous (synchronize 2 or more) chargers via data cables. In addition, PC1080 has short-circuit, reverse polarity, and overheat protection to ensure maximum safety.



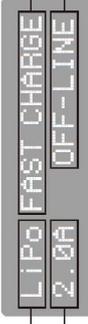
FEATURES

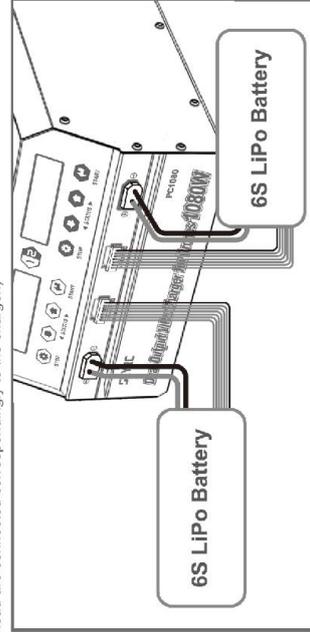
- Support charging 2 packs of 6s LiPo batteries simultaneously
- Support high voltage LiPo (LiHV) battery
- Memorizing last charging current
- Three working modes: fast charge, balance charge & storage
- Master & Slave mode available
- Synchronize 2 or more chargers via data cable.
- Maximum safety: short circuit protection, reverse polarity protection & over heat protection.
- Adjustable charging current
- 2x16 LCD screen.
- Real time charging/ discharging status display
- Battery voltage meter
- Battery internal resistance meter
- Firmware upgrade via USB port

PACKAGE CONTENTS



OPERATION PROCEDURE

- 1) Power on: connect to the power source and turn on the power switch. A beep sound will be heard, and the LCD screen will be displayed as below:

 - Battery Type (LiPo/LiHV)
 - Charging Current (1.0-20.0A)
 - Charging modes (fast charge balance charge & storage)
 - Synchronous status (Off, Master, Slave)
- 2) Battery connection: Please connect your batteries to PC1080 charger as below:
 (Note: Be aware that the Lithium battery to be charged should be 6 cells. Make sure the battery balance lead and charging lead are connected correspondingly to the charger.)



BATTERY VOLTAGE METER

Press a few times until the screen displays the battery meter. This function can detect the remaining capacity, battery voltage per cell, total voltage, highest voltage & lowest voltage.

BATTERY METER

FUEL GAUGE
78%

3.97 3.99 3.95U
3.99 3.99 3.97U

Battery Voltage Per Cell

MAIN: 23.88V
H: 3.993 L: 3.946U

Total Voltage
Highest Voltage & Lowest Voltage

BATTERY RESISTANCE METER

Press a few times until the screen displays the battery resistance meter. This function can detect internal resistance per cell and total resistance. The lower the battery resistance is, the higher the battery performance will be. Internal resistance will increase after the battery is commonly used.

BATT RESISTANCE

6 5 6 mΩ
6 6 7 mΩ

Battery Resistance Per Cell

TOTAL: 36mΩ

Total Resistance

SYSTEM SETUP

Press several times until the screen displays the system setup.

SYSTEM SETUP	Charging Time Protection (1-720 minutes)	Balance Charging (ON/OFF)
Safety Timer 120min	Charging Capacity Protection (1-50000mAh)	Press and hold for 3 seconds to restore factory setting
Capacity Out-Off Protection 30000mAh	Key Tone (ON/OFF)	Charger version checking
Key Beep Buzzer ON	Version HH: 1.2 SK: 1.01	

ERRORS

NO BATT DETECTED	Failure to detect the battery	OVER TIME LIMIT	Charging time exceeds the setting time
CELL ERROR	Incorrect cell count	INT. TEMP TOO HI	High internal temperature
CONNECT ERROR CHECK MAIN PORT	Connection error & Check Main Port	REVERSE POLARITY	Reverse Polarity
OVER CHARGE CAPACITY LIMIT	Over capacity protection	BATTERY HAS FULL	Battery fully charged
CONTROL FAIL	Control failure	CELLS VOLTAGE HI CHECK MAIN PORT	Cells Voltage Hi Check Main Port

SPECIFICATIONS

- Input Voltage: 100-240V
- Output Power: 1080W (540Wx2)
- Discharging Power: 50Wx2
- Charging Current Range: 1.0-20.0Ax2
- Balance Current: 1.2A Max.
- Battery Type: LIPo/LiHV
- Battery Cell Count: 6sx2
- Charging Modes: Fast Charge/Balance Charge/Storage
- Size: 272x202x118.6mm
- Weight: 4.88kg

WARNING AND SAFETY PRECAUTIONS

These warnings and safety notes are particularly important. Please follow the instructions for maximum safety. Otherwise the charger and the battery can be damaged or at worst it can catch fire.

- ❶ Never leave the charger unattended when it is connected to its power supply. If any malfunction is found, TERMINATE THE PROCESS AT ONCE and refer to the operation manual.
- ❷ Keep the charger well away from dust, moist, rain, heat, direct sunshine and vibration.
- ❸ Never drop it.
- ❹ The allowable AC input voltage is AC 100-240V.
- ❺ This charger and the battery should be put on a heat-resistant, non-flammable and non-conductive surface. Never place them on a car seat, carpet or the like. Keep all the inflammable and volatile materials away from the operating area.
- ❻ Make sure you know the specifications of the battery to be charged or discharged to ensure it meets the requirements of this charger. If the program is set up incorrectly, the battery and charger may be damaged. It can cause fire or explosion due to overcharging.

❶ Never attempt to charge or discharge the following types of batteries

A battery pack which consists of different types of cells (including different manufacturers)

A battery already fully charged or just slightly discharged

Non-rechargeable batteries (Explosion hazard)

A battery requires a different charge technique

A faulty or damaged battery

A battery fitted with an integral charge circuit or a protection circuit.

Batteries installed in other devices or connected to other parts.

Batteries that are not expressly stated by the manufacturer to be suitable for the currents the charger delivers during the charge process.

❷ Please bear in mind the following points before beginning charging:

Did you select the appropriate program suitable for the type of battery you are charging?

Did you set up adequate current for charging?

Have you checked that all connections are firm and secure?

Make sure there are no intermittent contacts at any point in the circuit.

❸ Charging

During the charge process, a specific quantity of electrical energy is fed into the battery. The charge capacity is calculated by multiplying charge current by charge time. The maximum permissible charge current varies depending on the battery type or its performance, and can be found in the information provided by the battery manufacturer. Only batteries that are expressly stated to be capable of quick-charge are allowed to be charged at rates higher than the standard charge current.

Connect the battery to the terminal of the charger. Red is positive and black is negative. Due to the difference between resistance of cable and connector, the charger cannot detect resistance of the battery pack. The essential requirement for the charger to work properly is that the charge lead should be of adequate conductor cross-section and that high quality connectors which are normally gold-plated should be fitted to both ends.

Always refer to the manual by the battery manufacturer about charging methods, recommended charging current and charging time. Especially, the lithium battery should be charged strictly according to the charging instruction provided by the manufacturer.

Special attention should be paid to the connection of lithium battery.

Do not attempt to disassemble the battery pack arbitrarily.

Be aware that lithium battery packs can be wired in parallel or in series. When the battery is connected in parallel, its capacity is calculated by multiplying the single battery capacity by the number of cells with the total voltage staying the same. Voltage imbalance may cause fire or explosion. Lithium battery is recommended for charging in series.

- ❶ The charger is not suitable for children under 14 years old. People with behavior disturbance, mental disorder or no experience should use it under the supervision and guidance. Children are forbidden to play with it. They are also NOT allowed to clean and maintain the device without the supervision.
- ❷ If the power cord is damaged, please return it back to the factory, supplier or technicians for replacement for fear of danger.

Liability exclusion

This charger is designed and approved exclusively for use with the types of battery stated in this Instruction Manual. SkyRC accepts no liability of any kind if the charger is used for any purpose other than that stated.

We are unable to ensure that you follow the instructions supplied with the charger, and we have no control over the methods you employ for using, operating and maintaining the device. For this reason we are obliged to deny all liability for loss, damage or costs which are incurred due to the incompetent or incorrect use and operation of our products, or which are connected with such operation in any way. Unless otherwise prescribed by law, our obligation to pay compensation, regardless of the legal argument employed, is limited to the invoice value of those SkyRC products which were immediately and directly involved in the event in which the damage occurred.

Warranty and service

We guarantee this product to be free of manufacturing and assembly defects for a period of one year from the time of purchase. The warranty only applies to material or operational defects, which are present at the time of purchase. During that period, we will repair or replace free of service charge for products deemed defective due to those causes.

This warranty is not valid for any damage or subsequent damage arising as a result of misuse, modification or as a result of failure to observe the procedures outlined in this manual.

Note:

1. The warranty service is valid in China only.
2. If you need warranty service overseas, please contact your dealer in the first instance, who is responsible for processing guarantee claims overseas. Due to high shipping cost, complicated custom clearance procedures to send back to China. Please understand SkyRC can't provide warranty service to overseas end user directly.
3. If you have any questions which are not mentioned in the manual, please feel free to send email to info@skyrc.cn



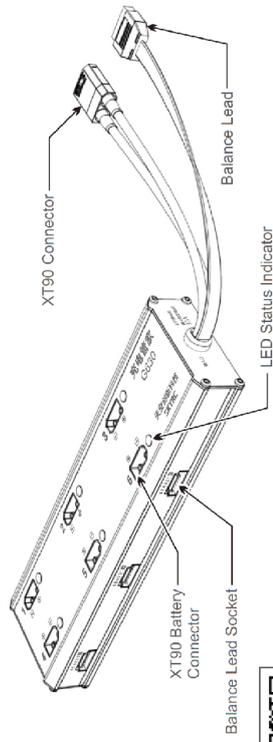
Manufactured by
SKYRC TECHNOLOGY CO., LTD.
www.skyrc.com
7504-0862-02

Instruction Manual V1.0 Charging Hub G630

SK-600124

Introduction

Charging hub G630 embeds an automatic charging management system. It only can work with SkyRC PC1080. 1 piece SkyRC PC1080 can work with 2 pieces G630, and 6 packs of LiPo batteries can be connected to 1 piece G630, i.e., 1 piece SkyRC PC1080 can charge 12 packs of LiPo batteries in sequence, automatically, according to their voltage, the highest one will be charged first. 6 LEDs indicate the status of each battery respectively.



扫码观看充电管家
操作介绍

Note: if you want to use G630, please make sure your SkyRC PC1080 has installed V1.05 firmware or above.

Optional Parts

AS150
(Female case w/ female terminals)



SK-600119-03

AS150
(Male case w/ female terminals)



SK-600119-04

AS150
(Male case w/ female terminal) +
XT150 Male connector



SK-600119-05

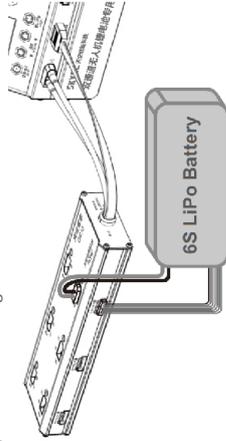
Operation Procedures

- Power on: connect the charger to AC source, switch on, charger will 'beep' once and fan will turn to self-check, screen display as below.

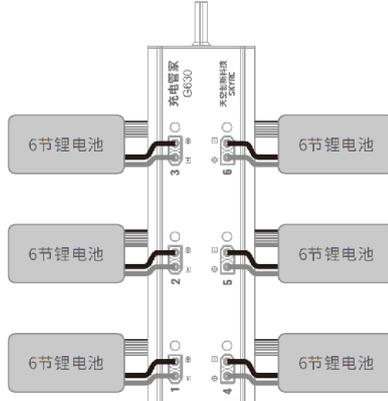
锂电池
20.0V

快速充
单机

- Connect G630 to SkyRC PC1080 charger.



- Connect batteries to G630. (as illustrated below)
(Note: only 6S LiPo batteries supported. Must connect both balance lead and main lead)



- Operate the charger:

One G630 can connect up to 6 pieces batteries and charge 1 piece battery at a time. The first connected battery will be charged first, and the rest will be charged according to their voltage, the highest one will be charged first.



- Charging finished.
The correspondent LED of the fully charged battery will turn solid green, buzzer will beep 5 times.

LED Indicator Explanation

LED Indicator	Explanation
All LEDs light orange 1 time in sequence	Connected the first battery
Correspondent LED flash green	Charging in process
Correspondent LED solid green	Charging finished
Correspondent LED solid yellow	Standby
Flash red	Battery balance lead has not connected to G630
Solid red, buzzer beeps 10 times	1.Connection abnormal between battery and G630 2.Connection abnormal between charger and G630

Specifications

- Battery Type: 6s LiPo
- Paired Charger: SkyRC PC1080 (firmware V1.05 or above)
- Maximum Current: 30A
- Size: 263x79x32mm
- Battery pack count: 6 packs
- Weight: 531g

Warning and Safety Notes

These warning and safety notes are particularly important. Please follow the instructions for maximum safety; otherwise the charger and the battery can be damaged or at worst it can cause a fire.

- 1 Never leave the charger unattended when it is connected to its power supply. If any malfunction is found, TERMINATE THE PROCESS AT ONCE and refer to the operation manual.
- 1 Keep the charger well away from dust, damp, rain, heat, direct sunshine and vibration. Never drop it.
- 1 The allowable AC input voltage for charger is 100-240V AC.
- 1 This charger and the battery should be put on a heat-resistant, non-inflammable and non-conductive surface. Never place them on a car seat, carpet or similar. Keep all the inflammable volatile materials away from operating area.
- 1 Make sure you know the specifications of the battery to be charged or discharged to ensure it meets the requirements of this charger. If the program is set up incorrectly, the battery and charger may be damaged. It can cause fire or explosion due to overcharging.
- 1 Never attempt to charge or storage charge the following types of batteries.
A battery pack which consists of different types of cells (including different manufacturers).
A battery that is already fully charged or just slightly discharged.
Non-rechargeable batteries (explosion hazard).
Batteries that require a different charge technique.
A faulty or damaged battery.
A battery fitted with an integral charge circuit or a protection circuit.
Batteries installed in a device or which are electrically linked to other components.
Battery that are not expressly stated by the manufacturer to be suitable for the currents the charger delivers during the charge process.

1 Please bear in mind the following points before commencing charging:

- Did you select the appropriate program?
- Have you set up adequate current for charging?
- Have you checked that all connections are firm and secure? Make sure there are no intermittent contacts at any point in the circuit.

2 Charging

During charge processing, a specific quantity of electrical energy is fed into the battery the charge quantity is calculated by multiplying charge current by charge time. The maximum permissible charge current varies depending on the battery type or its performance, and can be found in the information by the battery manufacturer. Only batteries that are expressly stated to be capable of quick-charge are allowed to be charged at rates higher than the standard charge current.

Connect the battery to the terminal of the charger: red is positive and black is negative. Due to the difference between resistance of cable and connector, the charger can not detect resistance of the battery pack, the essential requirement for the charger to work properly is that the charge lead should be of adequate conductor cross-section, and high quality connectors which are normally gold-plated should be fitted to both ends.

Always refer to the manual by battery manufacturer about charging methods, recommended charging current and charging time. Especially, the lithium battery should be charged according the charging instruction provided by the manufacturer strictly.

Attention should be paid to the connection of lithium battery especially.

Do not attempt to disassemble the battery pack arbitrarily.

Please get highlighted that lithium battery packs can be wired in parallel and in series. In the parallel connection, the battery's capacity is calculated by multiplying single battery capacity by the number of cells with total voltage stay the same. The voltages imbalance may cause fire or explosion. Lithium battery is recommended to charge in series.

This device can be used by people aged from 14 years old and above, persons with reduced physical, sensory or mental capabilities or lack of experience and knowledge if they have been given supervision or instruction concerning use of the appliance in a safe way and understand the hazards involved. Children shall not play with the appliance. Cleaning and user maintenance shall not be made by children without supervision.

If the supply cord is damaged, it must be replaced by the manufacturer, its service agent or similarly qualified person in order to avoid a hazard.

Liability Exclusion

This charger is designed and approved exclusively for use with the types of battery stated in this instruction manual. SkyRC accepts no liability of any kind if the charger is used for any purposes other than that stated.
We are unable to ensure that you follow the instructions supplied with the charger, and we have no control over the methods you employ for using, operating and maintaining the device. For this reason we are obliged to deny all liability for loss, damage or costs which are incurred due to the incompetent or incorrect use and operation of our products, or which are connected with such operation in any way. Unless otherwise prescribed by law, our obligation to pay compensation, regardless of the legal argument employed, is limited to the invoice value of those SkyRC products which were immediately and directly involved in the event in which the damage occurred.

Warranty and Service

We guarantee this product to be free of manufacturing and assembly defects for a period of one year from the time of purchase. The warranty only applies to material or operational defects, which are present at the time of purchase. During that period, we will repair or replace free of service charge for products deemed defective due to those causes.

This warranty is not valid for any damage or subsequent damage arising as a result of misuse, modification or as a result of failure to observe the procedures outlined in this manual.

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