LiHawk

Fixed-wing LIDAR System User Guide

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About This Guide

This document is a general introduction and operation guide for GVI's LiHawk lightweight FIXED-WING LIDAR mapping/survey systems.

> As we continue to update and improve the product, you may find some differences between the contents of this document and your LiHawk system. We will diligently update this guide as the product changes.

Please check with GVI for the latest release of this guide and contact GVI support at suppprt@greenvalleyintl.com if you have any questions.

Content

1. Read This First

Important Notices

<table>
<tr><td>STOP! PLEASE READ THIS SECTION CAREFULLY BEFORE USING THE PRODUCT!</td></tr>
</table>

✦ LiHawk systems use Class 1 (IEC60825-1:2014) eye-safe laser sensors. If you have any concerns, please contact GVI for details.

✦ System operator must be at least 18 years old.

✦ Tampering with the product is strictly prohibited and will void the Product Warranty. Any repair, modification, or upgrade must be performed by GVI technician or authorized service provider.

✦ Do NOT use any power supply outside the specified voltage range (18~30 V, 4.2 A@24VDC). Incorrect voltage supply may cause permanent damages to the integrated instruments and other hazards. Damage caused by the use of unauthorized power supply are not covered by your warranty.

✦ System safe operating temperature: -10℃ to + 40℃.

✦ STOP using the product and contact GVI support immediately if there is any visible damage or if persistent system warnings or alarms are observed. Failure to do so may result in permanent damage to the LiHawk system.

✦ This product is NOT water-proof. Do NOT operate in rain or snow. Water damage is NOT covered by the Product Warranty.

✦ This product is a high-precision mapping and surveying instrument that must be handled with care. Damages caused by improper handling of the product are not covered by your warranty.

✦ Properly disconnect all batteries, antennas, and cables after use.

✦ This product should by stored and transported in the protective case provided by or authorized for use by GVI.

✦ Clean the product thoroughly after each use. Use only proper cleaning agents for scientific instrument. Do NOT use water.

✦ When not in use, store the product in a cool and dry environment.

<table>
<tr><td>There may be additional notices and warning in other parts of this document. Please read them carefully and follow the instructions.</td></tr>
</table>

2.Brief Introduction of LiHawk System

2.1 About

LiHawk is an aerial LiDAR surveying system designed for large area and long-range 3D data collection projects. GVI provides customers with different LiDAR sensors (Riegl VUX-1LR or Riegl VUX-1UAV) to choose from. The system is designed to be mounted to a fixed-wing airplane platform or multi-rotor UAV and features a best-in class inertial measurement unit (IMU) for increased point cloud accuracy and precision. LiHawk is well-suited for projects aiming to map terrain features beneath forest canopies and extract structural parameters from forest LiDAR data. The centimeter-level accuracy of this measurement device will meet the rigorous accuracy demands of civil engineering and critical infrastructure maintenance professionals. And the high-definition digital camera module can be used to generate photogrammetry products as well as true color 3D point clouds during each LiDAR survey.

2.2 System Basics

LiHawk is comprised of multiple systems. Its main components include:

- Laser Scanner (LIDAR sensor)
- GNSS (Global Navigation Satellite System)
- IMU (Inertial Measurement Unit)
- System Control and Storage Unit
- Power Supply and Management Unit

> The GNSS unit and IMU unit together form what is often referred to as the POS Module.

2.3 System Principles

- In operation, the System Controller receives and executes operational commands while controlling the measurement instrumentation required for FIXED-WING-LIDAR data collection.

- The POS Module (GNSS and IMU) determines LiHawk's position and attitude.

- The precise coordinates of each data point measured by the Laser Scanner is calculated based on the laser's distance and angular measurements, together with its registered POS data.

- The laser data is stored in an external solid-state hard drive or inside the laser.

2.4 Technical Specification

Table 2-1. LiHawk Specifications

| LiHawk SPECIFICATIONS			
Key Parameters	**Weight**	5.3 kg (excl. camera) 5.6 kg (incl. camera)	
	System Accuracy	Flight Height: 200m Horizontal Accuracy: < 10 cm Vertical Accuracy: < 10 cm	
	Voltage	18~30 V	
	Consumption	100 W	
	Working Temperature	-10~40℃	
	Storage Temperature	-20~50℃	
	Dimension	297 mm×180 mm×147 mm (excl. camera) 368.5 mm×180 mm×166 mm (incl. camera)	
LIDAR Unit	**LiDAR Sensor**	RIEGL VUX-1LR	RIEGL VUX-1UAV
	Scan Range	5-1350 m	3-1050 m
	Field of View (FOV)	330°	330°
	Max. Effective Measurement Rate	750,000 pts/s	500,000 pts/s
Integrated Navigation System	**GNSS**	GPS, GLONASS, BeiDou	
	POS System Performance (after post-processing)	Attitude: 0.006° Azimuth: 0.019°	
Camera (optional)	**Camera Model**	Sony A7R II	
	Lens	24 mm fixed focal length lens	
	Effective pixels	42.4 MP (megapixel)	

3.LiDAR System
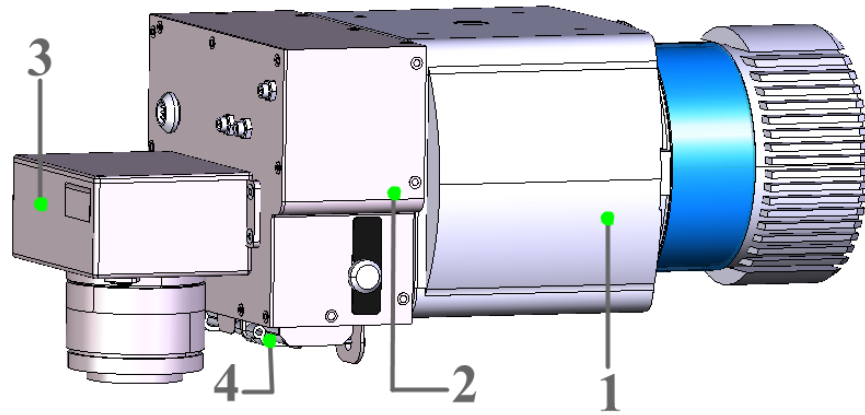
Figure 3-1 Components of LiHawk

1. **Laser scanner**

2. **Control and Storage Unit**

3. **SONY A7R II RGB Camera Module (selectable)**

4. **External SSD for data storage**

3.1 Laser Scanner (Optional)

The laser scanner is the core component of the LIDAR system. The transmitter of the laser scanner transmits an ultrashort pulse. It hits the target object and be reflected diffusely. Then the receiver receives the echo. With the time difference between the pulse transmitting and receiving, the distance from the laser scanner to the scanned object can be calculated.
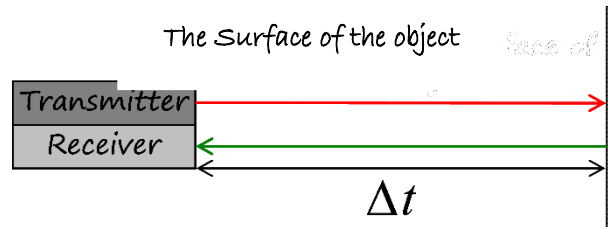

Figure 3-2. The Principle of Laser Scanner

The formula of the distance calculating: $S = \frac{1}{2} \times c \times \Delta t$

In the formula, S is the distance from the laser scanner to the scanned object, c is the light speed, and the Δt is the time difference between the signal transmitting and receiving.

Figure 3-3. VUX-1LR Laser Scanner (left) & VUX-1UAV Laser Scanner (Right)

GVI provides customers with different LiDAR sensors (Riegl VUX-1LR or Riegl VUX-1UAV) to choose from. The system is designed to be mounted to a fixed-wing airplane platform or multi-rotor UAV and features a best-in class inertial measurement unit (IMU) for increased point cloud accuracy and precision. For detailed parameters, see the table below.

Table 3-1. Specifications

LSAER SCANNER SPECIFICATIONS (RIEGL VUX-1LR)		(RIEGL VUX-1UAV)
Scanning Mechanism	Rotating Mirror	Rotating Mirror
Max. Measuring Range	820 m @ Reflectance ≥ 20% 1350 m @ Reflectance ≥ 60%	550 m @ Reflectance ≥ 20% 920 m @ Reflectance ≥ 60% 1050 m @ Reflectance ≥ 80%
Scan Speed	10-200 revolutions per second	10-200 revolutions per second
Field of View (FOV)	Up to 330°	Up to 330°
Laser Pulse Repetition Rate	Up to 820 kHz	Up to 550 kHz
Angular Measurement Resolution	0.001°	0.001°
Scan Data Output	LAN 10/100/1000 Mbit/sec or USB 2.0	LAN 10/100/1000 Mbit/sec or USB 2.0
Internal Memory	240 GByte SSD	240 GByte SSD
Eye Safety Class	Laser Class 1 (IEC60825-1:2014)	Laser Class 1 (IEC60825-1:2014)
Power Supply Input Voltage/Consumption	11-32 V DC / typ. 65W	11-34 V DC / typ. 60W
Humidity	Max. 80% non considering @ 31℃	Max. 80% non considering @ 31℃
Protection Class	IP64, dust and splash-proof	IP64, dust and splash-proof
Max. Flight Altitude	16 500 ft (5000 m) above MSL / 18 000 ft (5500 m) above MSL	16 500 ft (5000 m) above MSL / 18 000 ft (5500 m) above MSL
Temperature Range	0℃ up to +40℃ (operation) / -20℃ up to +50℃ (storage)	-10℃ up to +40℃ (operation) / -20℃ up to +50℃ (storage)

Lidar's ranging capability is related to ground reflectivity and pulse frequency. The greater the ground reflectivity, the greater the measurement distance. The greater the pulse frequency, the smaller the measurement distance.

Table 3-2. Riegl VUX-1LR Performance:

Laser Pulse Repetition Rate PRR[1]	50KHz	100KHz	200KHz	400KHz	600KHz	820KHz	
						Full Power	Reduced Power[2]
Max. Measuring Range[3] [4] Natural targets ≥ 20%	820m	600m	430m	300m	250m	215m	110m
Natural targets ≥ 60%	1350m	1000m	720m	520m	430m	370m	180m
Max.Operating Flight Altitude[5]	530m	380m	270m	190m	160m	140m	70m

1) Rounded values

2) Laser power optimized (reduced) for measurements of short ranges with high pulse repetition rate.

3) Typical values for average conditions. Maximum range is specified for flat targets with size in excess of the laser beam diameter, perpendicular angle of incidence, and for atmospheric visibility of 23 km. In bright sunlight, the max. range is shorter than under overcast sky.

4) Ambiguity to be resolved by post-processing with RiMTA ALS software.

5) Reflectivity p≥ 20%, flat terrain assumed, scan angle ±45°.

Table 3-2. Riegl VUX-1UAV Performance:

Laser Pulse Repetition Rate PRR [1]	50KHz	100KHz	200KHz	300KHz	380KHz	550KHz	
						Full Power	Reduced Power [2]
Max. Measuring Range [3] [4]							
Natural targets ≥ 20%	550m	400m	280m	230m	200m	170m	85m
Natural targets ≥ 60%	920m	660m	480m	400m	350m	300m	150m
Natural targets ≥ 80%	1050m	760m	550m	450m	400m	340m	170m
Max.Operating Flight Altitude [5]							
Natural targets ≥ 20%	350m	250m	180m	150m	130m	110m	55m
Natural targets ≥ 60%	590m	420m	310m	260m	230m	190m	100m

1) Rounded values

2) Laser power optimized (reduced) for measurements of short ranges with high pulse repetition rate.

3) Typical values for average conditions. Maximum range is specified for flat targets with size in excess of the laser beam diameter, perpendicular angle of incidence, and for atmospheric visibility of 23 km. In bright sunlight, the max. range is shorter than under overcast sky.

4) Ambiguity to be resolved by post-processing with RiMTA ALS software.

5) Reflectivity p≥ 20%, flat terrain assumed, scan angle ±45°.

Common surface reflectance table:

Features	Reflectivity
Wet snow, black asphalt paper	5%
Dry snow	10%
Conifer	15%
Dry asphalt	20%
Deciduous tree	30%
Terracotta	35%
Building concrete	40%
Cliff, sand, masonry	60%
White gypsum, limestone	80%
White marble	85%

Please note: When performing a flight mission, choose the appropriate laser frequency according to the flight altitude to avoid missing ground objects due to insufficient range

3.2 Control and Storage Unit

Main functions of the control and storage unit includes:

1. Receiving the commands from the computer and executes the commands

2. Controlling and coordinating each sensor to work properly

3. Storing the data. The 64 GB SD card inside is used to store the data of IMU, camera, and device log.
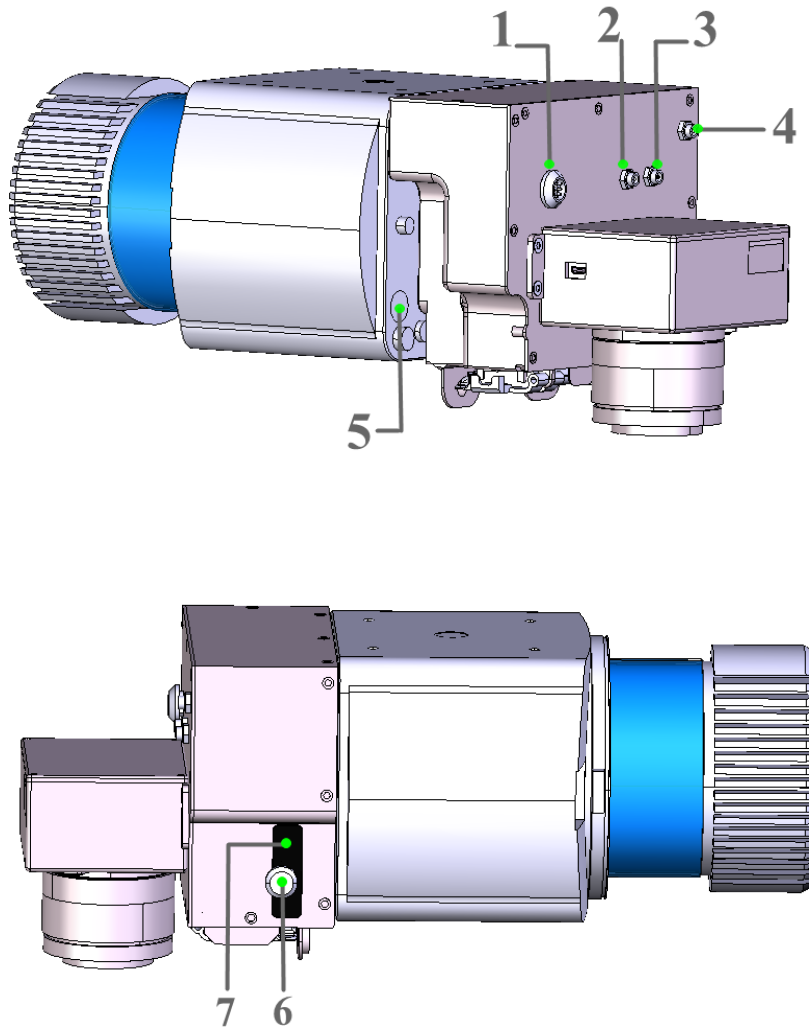

Figure 3-4 Control Panel Graph

The ports and indicator LEDs on the control panel are listed as follow:

1 – Power Port: This port is used to power our multi-integrated sensors product (18~30 V, 4.2 A@24VDC).

2 – GNSS1 Antenna Port: This port is used to connect with the GNSS antenna with feeder cable as the first choice.

3 – GNSS$_2$ Antenna Port: This port is used to connect with the GNSS antenna with feeder cable as the second choice

4 – Radio Antenna Port: Connect 900MHZ rod antenna for communication between equipment and ground.

5 – USB Port: Connect an external solid-state hard drive via Micro USB to Type C cable to transmit laser data.

6 – Data Port: Connect to the computer via a data cable to download data.

7 – System Status Indicator LEDs: This indicator LEDs show the working status of the sensors.

The status and the meanings of the indicator LEDs are shown in the table below:

Table 3-3 Specifications of Indicator LEDs

Indicator LEDs	Light Status	Status Description
PWR	Solid Green	Power on successfully
SYS	Solid Green	Work normally
	Flashing Green once per sec	System SD card space is less than 6G
	Flashing Green once per 0.2 sec	System SD card failed to mount
IMU	Solid Green	IMU's initial alignment (completed)
CAM	Solid Green	In calculating
LIDAR	Solid Green	LIDAR is synchronized

3.3 IMU

Inertia measurement unit, or IMU, consists of a high-accuracy three-axis gyroscope and a high-accuracy three-axis accelerometer. It is the benchmark center of the LiDAR system. Its role is to get the position and orientation information without external reference data.

The LiHawk integrates a 3-axis MEMS (Micro-Electro-Mechanical System) gyroscope, 3-axis MEMS accelerometer and dual GNSS/BD receivers into one system, the POS system. Together the POS system components gather multi-reference parameters that provide accurate, effective and reliable navigation data by optimization algorithm of integrated navigation system.

Specification of IMU:

Table 3-4. IMU Specifications

Horizontal Positioning Accuracy (RMS)	Single Point L1/L2	1.2 m
	SBAS	0.6 m
	DGPS	0.4 m
	RTK	1 cm +1 ppm
Measurement Frequency	IMU	125 Hz
	GNSS	20 Hz
Gyroscope Type	MEMS Gyroscope	
Temperature	Operating: -40 ℃ ~ +65 ℃ Storage: -50 ℃ ~ +80 ℃	
Humidity	95% NC	
Dimensions	152 × 142 × 51 mm	
Weight	540 g	
Input Voltage	+10~+30 V DC	

Power Consumption		6 W (Max)	
	Positioning Accuracy (m) RMS Horizontal/Vertical	Speed Accuracy（m） RMS Horizontal/Vertical	Orientation Accuracy (°) RMS Roll/Pitch/Heading
RTK	0.020 / 0.030	0.020 / 0.010	0.015 / 0.015 / 0.008
SP	1.000 / 0.600	0.020 / 0.010	0.015 / 0.015 / 0.008
PP	0.010 / 0.020	0.020 / 0.010	0.006 / 0.006 / 0.019

Note: Please DO NOT install antenna or coaxial cable while using the IMU in the storm environment.

3.4 Radio Station

LiHawk lidar system is equipped with a Microhard P900 serial radio, which is used for communication between the device and the ground. The control software sends commands to the device through the radio to control the device to collect data.

Brief Introduction of Radio Station

Figure 3-5 Radio Station

1. Antenna port: This port is used to connect with 900MHZ antenna.

2. External power source port: This port is used to connect with external battery

3. Working Status Indicator LEDs: It mainly includes RSSI, TX, PWR indicator lights. The three RSSI indicator lights represent the signal receiving strength; the TX red steady light indicates good data transmission; the PWR blue steady light indicates good power supply;

4. Serial port: The port is used to connect radio station and computer.

Specification of radio station:

Table 3-5 Specifications of Radio Station

Voltage	9 ~ 30 V
Current	3.3V+/-0.3V@1W
Fan Radiator Working Temperature	-55℃-+85℃
Dimension	46mm*66mm*25mm

Note: the radio station cannot be exposed to the high temperatures. Otherwise it may cause permanent damages to the radio station.

3.5 Camera

LiHawk is equipped with a modified Sony A7RII RGB camera. The specifications of the camera are shown in the table below:

Specifications of Camera:

Table 3-6 Specifications of Camera

Model	SONY A7RII
Image sensor format	Full-Frame (1x Crop Factor)
Lens	24 mm fixed focal length lens
Effective pixels	42.4 MP (megapixel)
Sensor type	COMS
Exposure mode	Fixed distance interval/Fixed time interval
Weight	407 g

3.6 GPS Base Station

The main function of the GPS base station is to position the same point in order to get high-accuracy location of single point. And all the information recorded will be used as a reference for difference. The GNSS base station consists of GPS antenna, GPS receiver, and a power source.

Brief Introduction of GPS Base Station Receiver

Figure 3-6 GPS Base Station Receiver

1 – Power Port (9-30V, 0.3A@12V): This port is used to power the base station.

2 – USB Port: This port is used to connect with computer for the data transfer purposes.

3 – System Status Indicator LEDs: This indicator LEDs show the working status of the base station.

4 – RTK Button: Not effective for LiHawk.

5 – Save Button: This button is used to start/stop the base station data collection.

6 – RTK Antenna Port

7 – GNSS Antenna Port: This port is used to connect with the GNSS antenna with feeder cable.

8 –RTK Rod Antenna

Base Station Indicator LEDs

Table 3-7 Specifications of Indicator LEDs

LED Icon	Light Status	Status Description
	Solid red	Base station power supply is normal
	Flashing red	Base station power supply is low
	Solid blue	Recording base station data
	Flashing blue	Internal data storage failed to mount. Remaining storage space is low (less than 1 GB remaining)
	Off	Not recording base station data
	Solid green	RTK connection established
	Flashing orange	Locating satellites
	Solid orange	Satellite positions locked

Base Station Specifications

Table 3-8 Base Station Specifications

System Performance	Signals	GPS: L1, L2, L2C, LC GLONASS: L1, L2, L2C BDS: B1, B2 GALILEO: E1, E5a, E5b, ALtBOC, SBAS, QZSS, L-band	
	Horizontal positioning accuracy	Single point L1	1.5 m
		Single point L1/L2	1.2 m
		SBAS	0.6 m
		DGPS	0.4 m
		RT-2	1 cm + 1 ppm
		Initial time	< 10 s
		Initial reliability	> 99.9%
	Direction finding accuracy	0.2/m	
	Data update rate	Raw data	Up to 50 Hz

		Position data	Up to 50 Hz
	First position time	Cold start	< 50 s
		Warm start	< 35 s
Dimensions and electrical parameters	Dimensions (mm)	$130 \times 90 \times 32$	
	Weight	300 g	
	Input voltage	12 V	
	Consumption	4 W	
Communication Port	Download	USB	
Operating Environment	Temperature	Working temperature	-40℃ - +75℃
		Storage temperature	-40℃ - +85℃
	Relative humidity	95% no condensation	

4.Special Notes

Here are some special Note to pay attention while operating LiHawk. GVI has compiled these Note based on experiences and feedback from customers. The following points out details that seem small or insignificant but can, however, lead to issues that may be difficult or impossible to rectify post mission if left unchecked.

Operation Notice & Equipment Maintenance

- The LiHawk system integrates several high-precision instruments. Please handle with care.
- Avoid direct impact to the system. Always store all items properly in the protective case before transporting. Do not move or transport the system unprotected.

- This product should by stored and transported in the protective case provided by or authorized for use by GVI.

- Do NOT scratch the Laser Scanner Lens.

- Ensure the Laser Scanner Lens surface is clean before mission. Only clean the lens with special cleaning agents for high-precision measurement instruments and optics with soft cloth.

- Clean the product thoroughly after each use. Use only proper cleaning agents for scientific instrument.

- Pull the power off softly and properly disconnect all batteries, antennas, and cables after use.

- Please perform power-on test if the machine is not used for more than one month.

- Do NOT operate the system in raining or harsh environment outside its safe temperature range.

- System safe operating temperature: -10℃ to + 40℃.

- Storage temperature: -20℃ to + 50℃.
- This product is NOT water-proof. Do NOT operate in rain or snow. Water damage is NOT covered by the Product Warranty. When not in use, store the product in a cool and dry environment.

- Tampering with the product is strictly prohibited and will void the Product Warranty. Any repair, modification, or upgrade must be performed by GVI technician or authorized service provider.

- This product is a high-precision mapping and surveying instrument that must be handled with care. Damages caused by improper handling of the product are not covered by your warranty.