High Performance Topo-Bathymetric Airborne Laser Scanner
with Online Waveform Processing and Full Waveform Recording

NEW

RIEGL VQ®-860-G

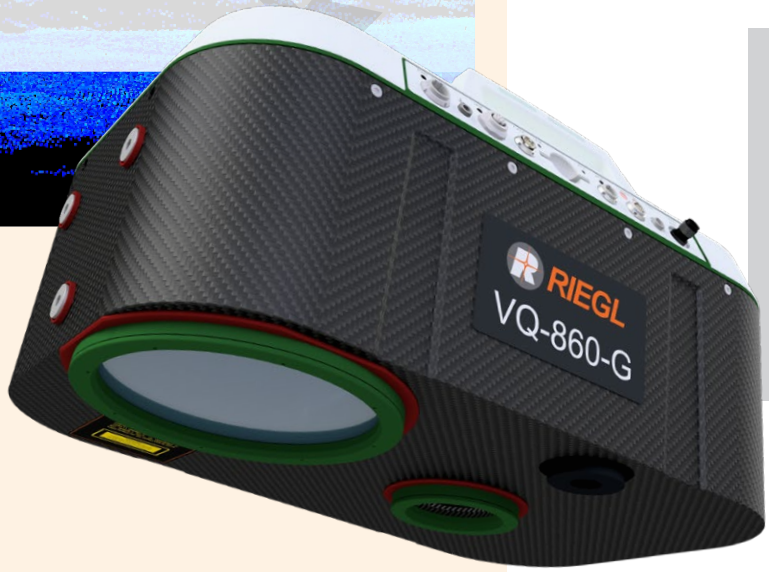
excellent depth performance

- *wide operational envelope: flight altitudes from 75 m to 300 m*
- *high accuracy ranging based on echo digitization and online waveform processing with multiple-target capability*
- *concurrent comprehensive full waveform storage of all measurements for subsequent full waveform analysis*
- *high spatial resolution due to measurement rates of up to 100 kHz and high scanning speed of up to 100 scans/sec*
- *IMU/GNSS system and digital camera (optionally integrated)*
- *compact and robust design*
- *high autonomy provided by large internal storage capacity*
- *provides operational mode with reduced laser power to adapt to eye-safety requirements in sensitive areas*

The *RIEGL*® VQ-860-G airborne laser scanner with increased performance enhances depth penetration in surveying inland waters and near shore waters for even more efficiency in bathymetric applications. The complete system is offered with an optionally integrated and factory-calibrated IMU/GNSS system and a digital camera.

The *RIEGL* VQ-860-G is a compact and versatile system designed for straight forward integration on crewed aircraft. Weighing only 15 kg (33 lbs), integration into drones is also possible. Parametrization of the instrument allows high operational flexibility in order to adapt performance ideally to the survey project, with regards to the carrier aircraft's altitude and speed as well as the mission objective. The rugged internal mechanical structure together with the dust- and splash water proof housing enable long-term operation on airborne platforms.

The scanner carries out laser range measurements for high resolution surveying of underwater topography with a narrow, visible green laser beam, emitted from a pulsed laser source. Subject to clarity, at this particular wavelength the laser beam penetrates water enabling measurement of submerged targets on the seafloor and in the water column.



Typical applications include

- *coastline cartography*
- *detection of submerged and floating targets*
- *surveying for hydraulic engineering*
- *hydro-archeological surveying*
- *river mapping*

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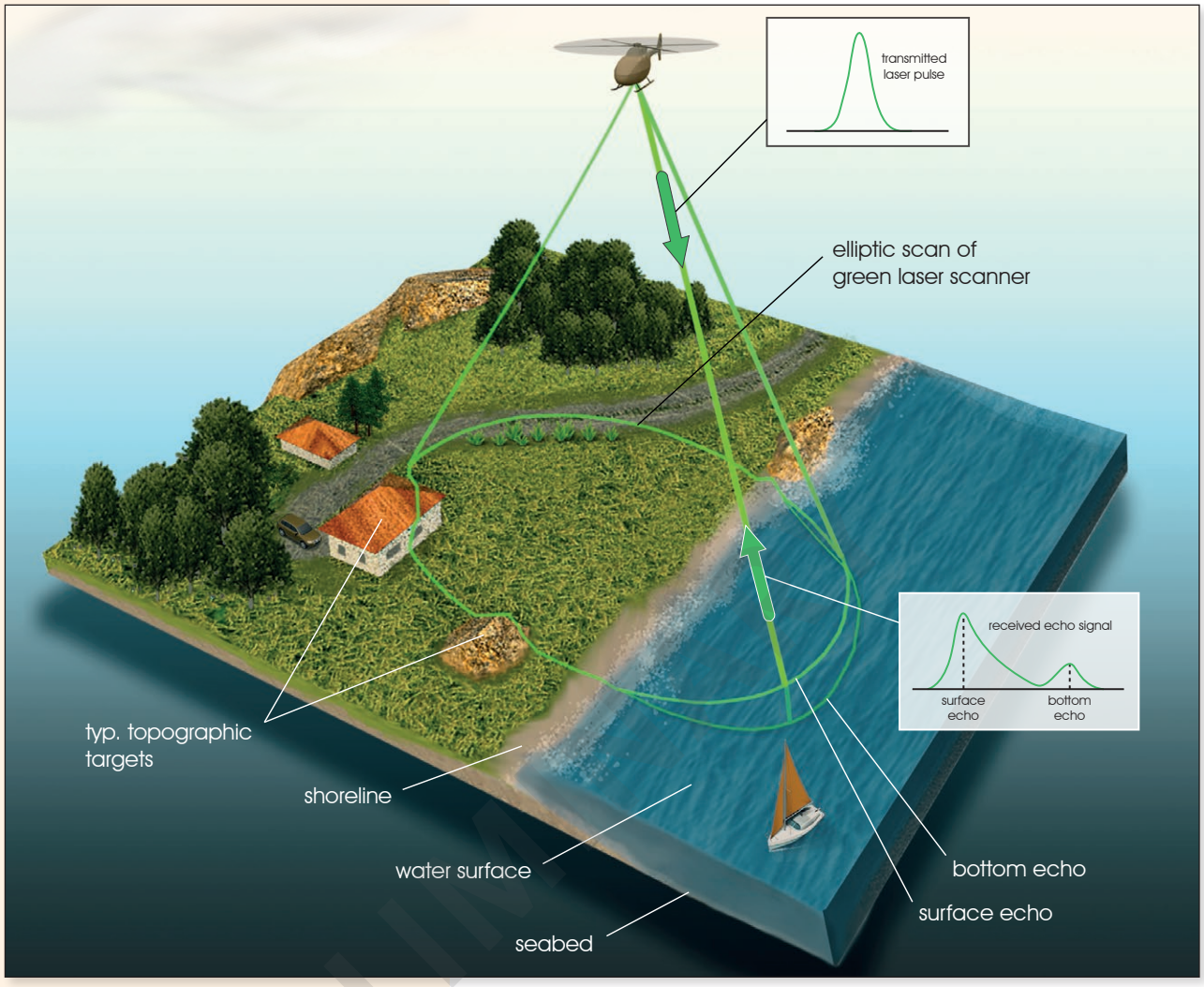
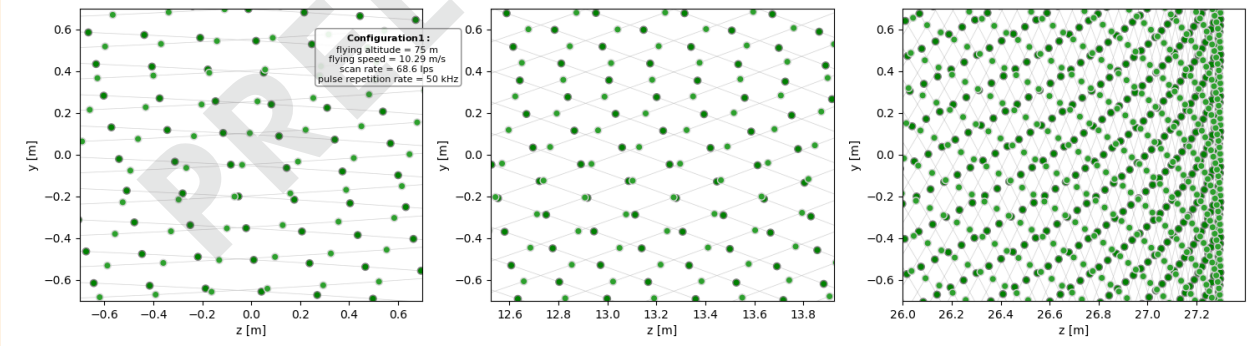
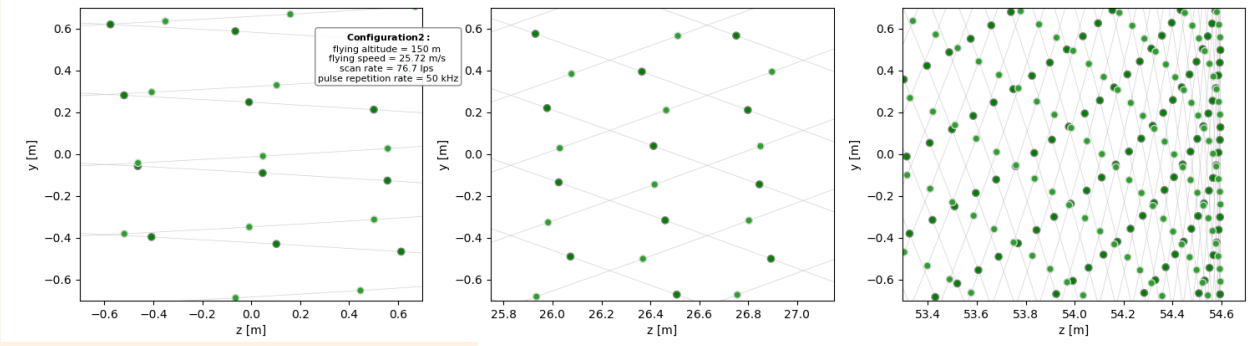
www.riegl.com

RIEGL
LASER MEASUREMENT SYSTEMS





Point pattern and density for UAV applications
flying altitude 75 m, flying speed 10 m/sec, scan rate 69 lps, pulse repetion rate 50 kHz, average point density: 92 points/sqm
grey lines: scan trace on ground, green dots: points on the ground (dark green: forward look, light green: backward look)



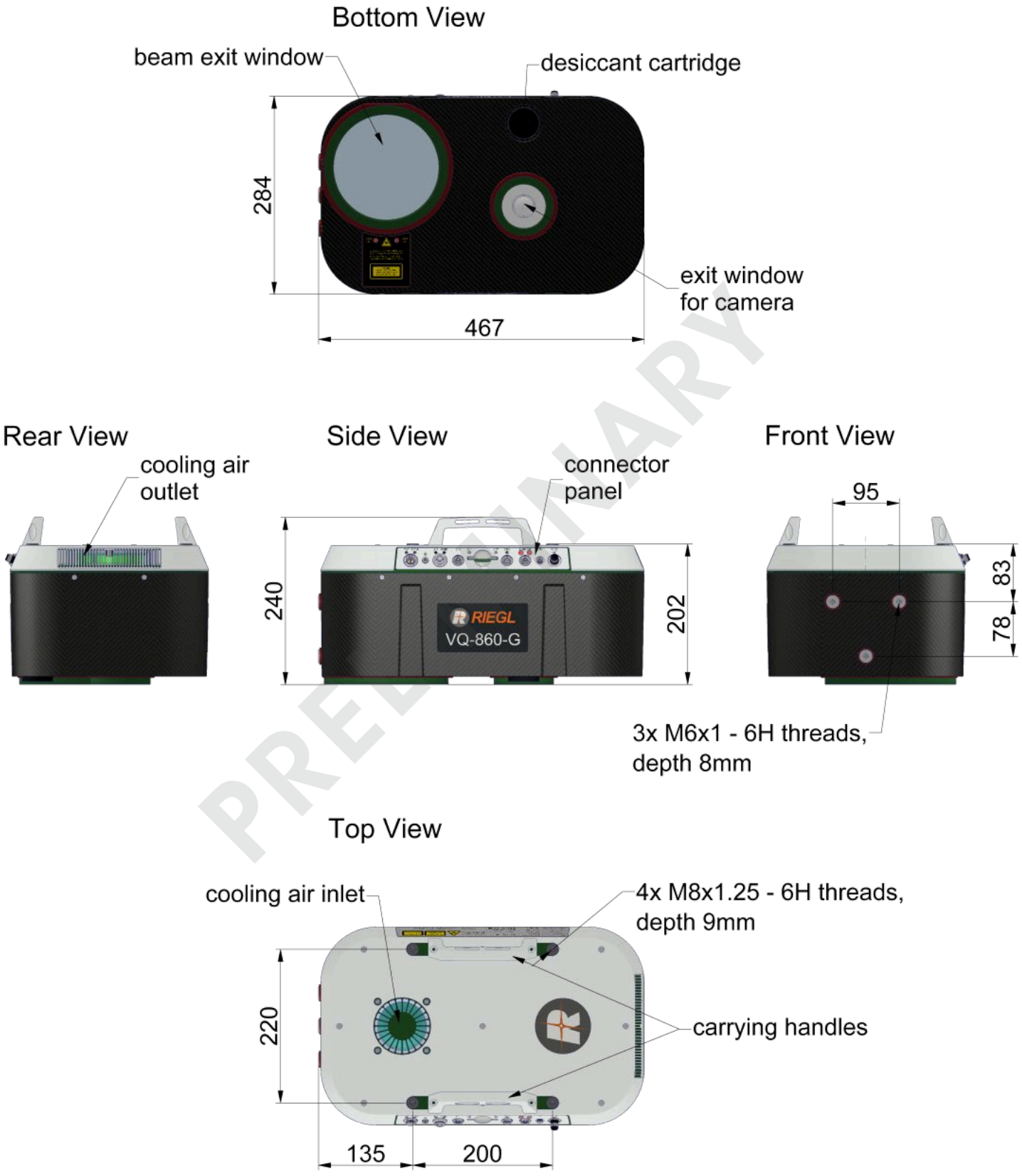
Point pattern and density for helicopter applications
flying altitude 150 m, flying speed 26 m/sec, scan rate 77 lps, pulse repetition rate 50 kHz, average point density: 18 points/sqm
grey lines: scan trace on ground, green dots: points on the ground (dark green: forward look, light green: backward look)

Measurement Principle

The laser beam is deflected in order to generate a nearly elliptic scan pattern and hits the water surface at an incidence angle with low variation. The distance measurement is based on the time-of-flight measurement with very short laser pulses and subsequent echo digitization and online waveform processing. To handle target situations with most complex multiple echo signals, beside the online waveform processing the digitized echo waveforms can be stored internally or on the removable data storage card for subsequent off-line full waveform analysis.

Optional Equipment

The VQ-860-G can be complemented with an inertial navigation sensor for subsequent estimation of the instrument's location and orientation. As another option a high-resolution digital camera can be integrated to supplement the data gained by the laser scanner.



dimensions in mm

Export Classification

The Topo-Bathymetric Airborne Laser Scanner VQ-860-G has been designed and developed for commercial topographic, hydrographic and bathymetric surveying applications.

The VQ-860-G is subject to export restrictions as set up by the Wassenaar Arrangement. It is classified as dual-use good according to position number 6A8j3 of the official Dual-Use-List to be found on site http://www.wassenaar.org.
Within the European Union, (Regulation (EU) No. 2021/821) implements the export restrictions of the Wassenaar Arrangement. The corresponding position number is **6A008j3**.

Laser Product Classification

Class 3B Laser Product according to IEC60825-1:2014
The following clause applies for instruments delivered into the United States: Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed.3., as described in Laser Notice No. 56, dated May 8, 2019.

NOHD [1) 2) 3)]	50 m / 20 m (reduced mode)

1) NOHD ... Nominal Ocular Hazard Distance
2) beam divergence 6 mrad, laser PRR 50kHz
3) provided that the instrument is mounted on a moving platform

Range Measurement Performance

Measuring Principle: echo signal digitization, online waveform processing, full waveform recording, time-of-flight measurement, multiple target capability

Measurement Rate [4)]	50 kHz (reduced)	100 kHz	50 kHz	5 kHz [7)]	0.5 kHz [7)]
Max. Water Depth Penetration in Secchi Depths [5) 6)] (Flight altitude 75m above water level)	2.0	2.3	2.5	2.7 (enhanced by averaging)	3.0

Minimum Range	20 m
Accuracy [8) 10)]	20 mm
Precision [9) 10)]	15 mm
Laser Pulse Repetition Rate	50 kHz to 100 kHz
Echo Signal Intensity	for each echo signal, high-resolution 16 bit intensity information is provided
Number of Targets per Pulse	online waveform processing: up to 15 [11)]
Laser Wavelength	532 nm, green
Laser Beam Divergence	selectable, 1 up to 6 mrad [12)]
Receiver Field of View	selectable, 3 up to 18 mrad
Laser Beam Footprint (Gaussian Beam Definition)	50 mm @ 50 m, 100 mm @ 100 m, 150 mm @ 150 m [13)]

Scanner Performance

Scanning Mechanism	rotating scan mirror
Scan Pattern	nearly elliptic
Off Nadir Scan Angle Range	± 20° = 40° perpendicular to flight direction, ± 14° = 28° in flight direction
Scan Speed (selectable)	10 - 100 lines/sec (lps) [14)]
Angular Step Width $\Delta\vartheta$ (selectable) between consecutive laser shots	$0.072° \leq \Delta\vartheta \leq 0.72°$ (for PRR 50 kHz) [15) 16)]
Angle Measurement Resolution	0.001° (3.6 arcsec)

4) rounded values
5) The Secchi depth is defined as the depth at which a standard black and white disc deployed into the water is no longer visible to the human eye.
6) The depth performance is specified for bright targets with size in excess of the laser beam diameter, for Secchi depths of 2 m to 5 m, and for clear atmospheric conditions.
7) waveform averaging applied in postprocessing, Laser PRR=50kHz
8) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
9) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
10) one sigma @ 150m range under *RIEGL* test conditions
11) If the laser beam hits, in part, more than one target, the laser's pulse power is split accordingly. Thus, the achievable range ist reduced.
12) measured at the $1/e^2$ points, 1.0 mrad corresponds to an increase of 100 mm of beam diameter per 100 m distance
13) The laser beam footprint values correspond to a beam divergence of 1mrad.
14) One line corresponds to a full revolution (360°) of the scan mechanism which can be split into two user defined segments.
15) The angular step width limits depend on the selected laser PRR.
16) The maximum angular step width is limited by the maximum scan rate.

General Technical Data

Power Supply Input Voltage	18 - 34 V DC
Power Consumption	typ. 180 W max. 260 W
Main Dimensions (L x W x H)	467 mm x 284 mm x 202 mm
Weight	approx. 15 kg <18.5 kg (with IMU/GNSS and camera)
Humidity	non condensing
Protection Class	IP64, dust and splash-proof
Max. Flight Altitude [17)] operating / not operating	18 500 ft (5 600 m) above Mean Sea Level (MSL)
Temperature Range operation / storage	-10°C up to +40°C / -20°C up to +50°C

17) for standard atmospheric conditions: 1013 mbar, +15°C at sea level

RIEGL VQ-860-G Technical Data (Optional Components)

IMU/GNSS (optional)

IMU Accuracy [1]	
Roll, Pitch	0.015°
Heading	0.035°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	
horizontal / vertical	<0.05 m / <0.1 m

Integrated Digital Camera (optional)

RGB Camera

Sensor Resolution	12 MPixel / 24 MPixel
Sensor Dimensions (diagonal)	17.5 mm (4112 x 3008 px)
Focal Length of Camera Lens	16 mm
Field of View (FOV)	approx. 47° x 36°
Interface	GigE

Data Interfaces

Configuration	LAN 10/100/1 000 Mbit/sec,
Scan Data Output	LAN 10/100/1 000 Mbit/sec, high speed data link to *RIEGL* DR1560ii (optional) [3]
GNSS Interface [2]	Serial RS-232 interface for data string with GNSS-time information, TTL input for 1 PPS synchronization pulse
General IO & Control	1x TTL input/output, 1x Serial RS-232 Interface, 1x Remote on/off
Camera Interface	1x GNSS RS-232 Tx & PPS, Power, Trigger, Exposure
Removable Storage Card	CFast®, up to 1 TByte (optional) [3]
Internal Data Storage	2 TB SSD

1) accuracy specifications for post-processed data
2) to be used for external GNSS receiver
3) only one single option (CFast or data recorder interface) can be implemented

RIEGL LASER MEASUREMENT SYSTEMS

RIEGL Laser Measurement Systems GmbH, *Headquarters*
RIEGL USA Inc., *Headquarters North America*

RIEGL Japan Ltd.
RIEGL China Ltd.
RIEGL Australia Pty Ltd.
RIEGL Canada Inc.
RIEGL UK Ltd.
RIEGL Asia Pacific Ltd.
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