Topo-Bathymetric Airborne Laser Scanning System
with Online Waveform Processing and Full Waveform Recording

RIEGL VQ®-880-GH

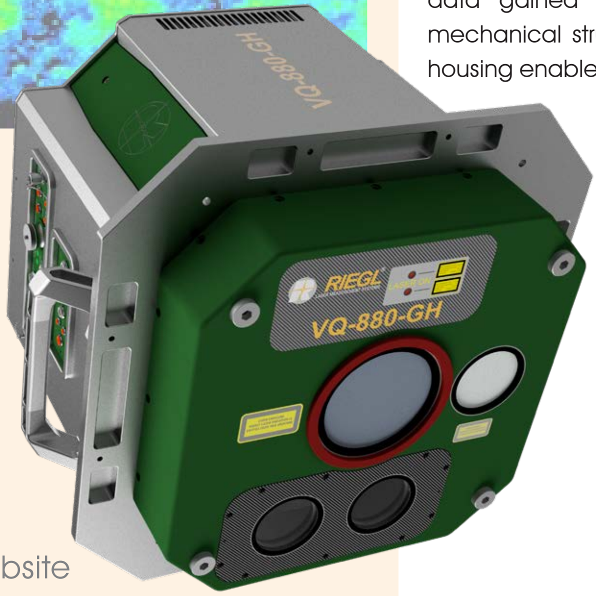
- *designed for combined topographic and bathymetric airborne survey*
- *green laser scanner with up to 700kHz measurement rate*
- *IR laser scanner with up to 279kHz measurement rate and improved ranging performance*
- *high accuracy ranging based on echo digitization and online wave-form processing with multiple-target capability*
- *multiple-time-around processing for straightforward mission planning and operation*
- *concurrent full waveform output for all measurements for subsequent full waveform analysis for the green channel*
- *integrated inertial navigation system*
- *up to two integrated digital cameras*
- *form factor with reduced height optimized for helicopter integrations*

The *RIEGL*® VQ-880-GH is a fully integrated airborne laser scanning system for combined topographic and bathymetric surveying. The system is offered with integrated and factory-calibrated high-end IMU/GNSS system and up to two cameras. The design allows flexible application of these components to meet specific requirements. Complemented by a *RIEGL* data recorder, the *RIEGL* VQ-880-GH LiDAR system is ready for straightforward installation on various platforms. Its compact form factor makes it specifically suitable for helicopter integration or use in small aircraft with limited space for sensor integration.

The *RIEGL* VQ-880-GH carries out laser range measurements for high resolution surveying of underwater topography with a narrow, visible green laser beam, emitted from a powerful pulsed laser source. Subject to clarity, at this particular wavelength the laser beam penetrates water enabling measurement of submerged targets.

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 on the *RIEGL* solid state data recorder for subsequent off-line waveform analysis. The laser beam is deflected in a circular scan pattern and hits the water surface at a nominally constant incidence angle.

The VQ-880-GH comprises a high precision inertial measurement sensor for subsequent precise estimation of the instrument's exact location and orientation. Two high-resolution digital cameras and an additional infrared laser scanner are integrated to supplement the data gained by the green laser scanner. The rugged internal mechanical structure together with the dust- und splash water proof housing enables long-term operation on airborne platforms.



Typical applications include
- *coastline and shallow water mapping*
- *acquiring base data for flood prevention*
- *measurement for aggradation zones*
- *habitat mapping*
- *surveying for hydraulic engineering*
- *hydro-archeological-surveying*

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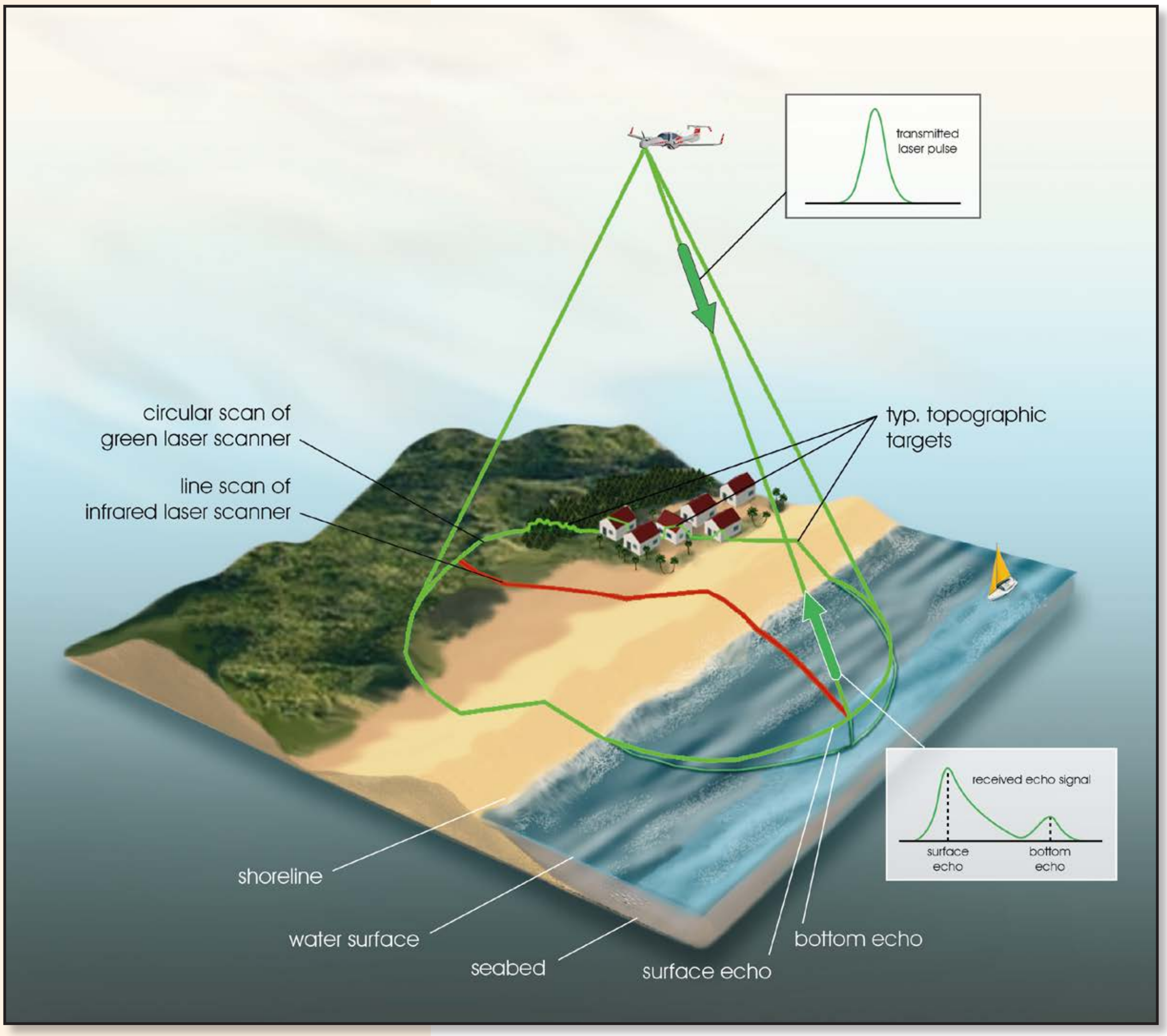
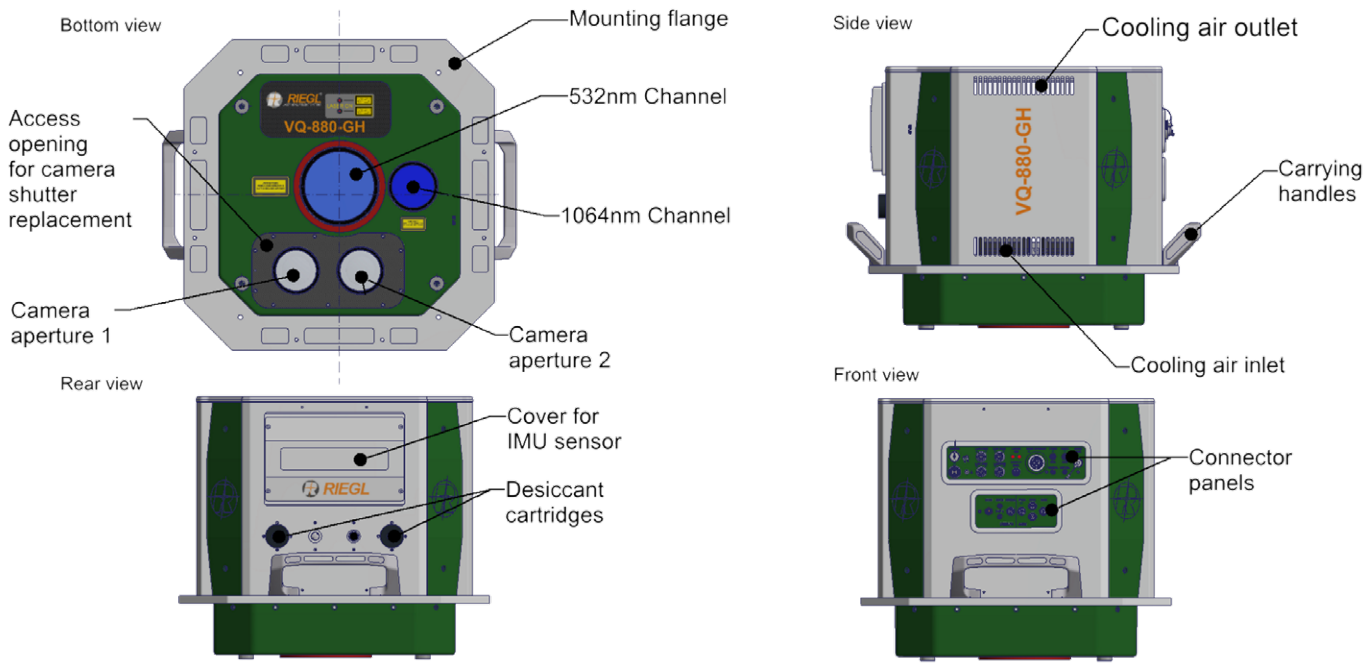
www.riegl.com

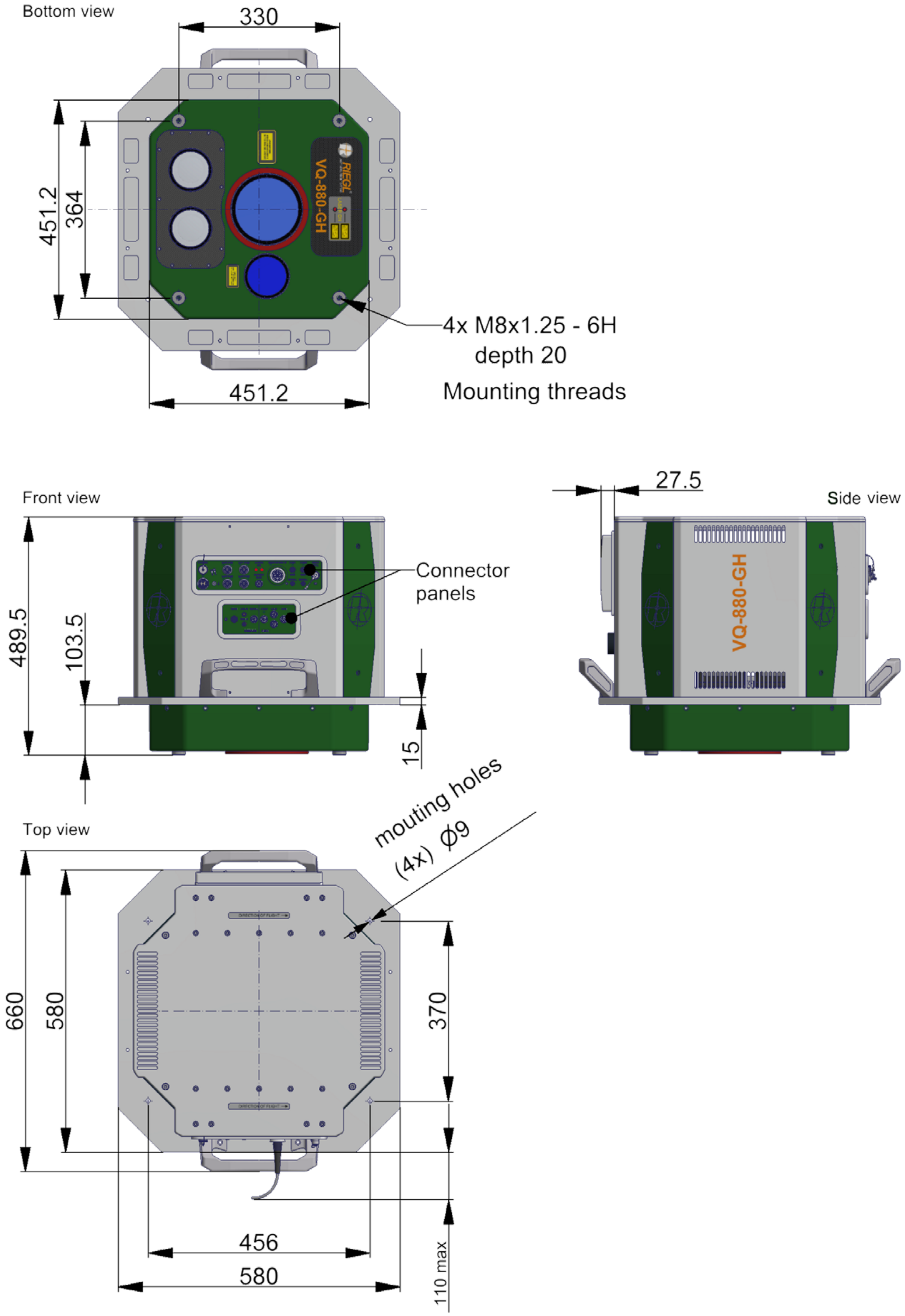
RIEGL
LASER MEASUREMENT SYSTEMS

RIEGL VQ-880-GH Scan Pattern



RIEGL VQ-880-GH Elements of Function and Operation





all dimensions in mm

Export Classification

The Topo-Bathymetric Airborne Laser Scanner VQ-880-GH has been designed and developed for commercial topographic, hydrographic and bathymetric surveying applications.

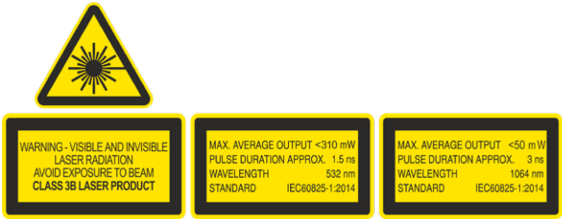
The VQ-880-GH is subject to export restrictions as set up by the Wassenaar Arrangement. It is classified as dual-use good according to position number 6A8j3 of the official Dual-Use-List to be found on site http://www.wassenaar.org.
Within the European Union, Regulation (EU) No. 2021/821 implements the 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.

The instrument must be used only in combination with the appropriate laser safety box.



NOHD 1) — 180 m 2)

1) NOHD ... Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2014, for single pulse condition

2) NOHD is determined by green laser scanner, @ 80 lps, 1.1 mrad, 550 kHz; NOHD of the infrared laser scanner: 60 m @ 900 kHz

INFRARED LASER CHANNEL

Range Measurement Performance

Measuring Principle — time of flight measurement, echo signal digitization, online waveform processing

Max. Measurement Range 3) 4) 5)

@ Laser Pulse Repetition Rate	150 kHz	300 kHz	600 kHz	900 kHz
natural targets ρ≥20 %	1800 m	1300 m	950 m	800 m
natural targets ρ≥60 %	2800 m	2100 m	1600 m	1300 m
Max. Operating Flight Altitude 6) Above Ground Level (AGL)	1600 m (5250 ft.)	1100 m (3600 ft.)	850 m (2790 ft.)	700 m (2290 ft.)

Minimum Range 7)	10 m
Accuracy 8) 10)	25 mm
Precision 9) 10)	25 mm
Laser Pulse Repetition Rate 11) 12)	up to 900 kHz
Max. Effective Measurement Rate 6) 12)	47 000 meas./sec (@ 150 kHz PRR & 40° FOV) 93 000 meas./sec (@ 300 kHz PRR 40° FOV) 186 000 meas./sec (@ 600 kHz PRR & 40° FOV) 279 000 meas./sec (@ 900 kHz PRR & 40° FOV)
Echo Signal Intensity	for each echo signal, high-resolution 16 bit intensity information is provided
Number of Targets per Pulse	practically unlimited (details on request) 13)
Laser Wavelength	1.064 nm (near infrared)
Laser Beam Divergence	0.3 mrad 14)
Laser Beam Footprint (Gaussian Beam Definition)	30 mm @ 100 m, 150 mm @ 500 m, 300 mm @ 1000 m

Scanner Performance

Scanning Mechanism / Scan Pattern	rotating polygon mirror / curved parallel lines
Field of View (selectable)	± 20° = 40°
Scan Speed (selectable)	28 - 200 scans/sec
Angular Step Width Δ ϑ (selectable) between consecutive laser shots	0.006° ≤ Δ ϑ ≤ 0.042° (for PRR 600 kHz)
Angle Measurement Resolution	better than 0.001° (3.6 arcsec)

3) The following conditions are assumed: target larger than the footprint of the laser beam, average ambient brightness, visibility 23 km, perpendicular angle of incidence.
4) In bright sunlight, the operational range may be considerably shorter and the operational flight altitude may be considerably lower than under an overcast sky.
5) Ambiguity to be resolved by post-processing with RiUNITE software.
6) Reflectivity ρ ≥ 20%, 40° FOV, additional roll angle ±5°
7) Limitations for range measurement capability does not consider laser safety.
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) Rounded values.
12) User selectable.
13) If the laser beam hits, in part, more than one target, the laser's pulse power is split accordingly. Thus, the achievable range is reduced.
14) Measured at the 1/e² points. 0.30 mrad corresponds to an increase of 30 cm of beam diameter per 1000 m distance.

Technical Data to be continued on page 5 and 6

GREEN LASER CHANNEL

Range Measurement Performance

Measuring Principle	time of flight measurement, echo signal digitization, online waveform processing, full waveform recording for post processing
Hydrography	
Typ. Measurement Range	1.5 Secchi depths [1] for bright ground (ρ≥80 %) [2]
Enhanced Depth Performance [3]	up to 1.7 Secchi depths (averaging 10 waveforms) up to 2.0 Secchi depths (averaging 100 waveforms)
Topography (diffusely reflecting targets)	
Max. Measurement Range [4] [5] [6] [7]	
natural targets ρ≥20 %	2500 m
natural targets ρ≥60 %	3600 m
Minimum Range	10 m
Accuracy [8] [10]	25 mm
Precision [9] [10]	25 mm
Laser Pulse Repetition Rate	up to 700 kHz [4]
Max. Effective Measurement Rate [4]	200 000 meas./sec (@ 200 kHz PRR) 400 000 meas./sec (@ 400 kHz PRR) 550 000 meas./sec (@ 550 kHz PRR) 700 000 meas./sec (@ 700 kHz PRR)
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 9, depending on measurement program [11]
Laser Wavelength	532 nm, green
Laser Beam Divergence	selectable, 0.7 up to 2.0 mrad [12]
Laser Beam Footprint (Gaussian Beam Definition)	100 mm @ 100 m, 500 mm @ 500 m, 1000 mm @ 1000 m [13]

Scanner Performance

Scanning Mechanism / Scan Pattern	rotating prism / circular
Field of View (selectable)	± 20° = 40°
Scan Speed (selectable)	30 - 80 lines per second (lps) [14]
Angular Step Width Δ ϑ (selectable) between consecutive laser shots	0.02° ≤ Δ ϑ ≤ 0.052° (for PRR 550 kHz)
Angle Measurement Resolution	better than 0.001° (3.6 arcsec)

1) 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.
2) at 650 m flight altitude
3) Achievable by waveform averaging which is applied in post processing.
4) rounded values
5) The following conditions are assumed: target larger than the footprint of the laser beam, average ambient brightness, visibility 23 km, perpendicular angle of incidence, ambiguity to be resolved multiple-time-around processing.
6) In bright sunlight, the operational range may be considerably shorter than under an overcast sky.
7) additional roll angle ±5°
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) Topography, 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 is 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.

Technical Data to be continued on page 6

IMU/GNSS Performance [1) 2)]

IMU Accuracy [3)]	
Roll, Pitch	0.0025°
Heading	0.005°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	
horizontal / vertical	<0.05 m / <0.1 m

Integrated Digital Cameras [4)]

RGB and/or IR Camera	
Sensor Resolution	up to 100 MPixel CMOS without FMC[5)] or up to 80 MPixel CCD with FMC[5)]
Sensor Dimensions (diagonal)	67.2 mm (medium format)
Focal Length of Camera Lens	50 mm
Field of View (FOV)	approx. 56.2° x 43.7°
Interface	USB 3.0
Data Storage	separate dedicated data recorder

Data Interfaces

Configuration	LAN 10/100/1 000 Mbit/sec
Scan Data Output	LAN 10/100/1 000 Mbit/sec, High Speed Serial Dual Glass Fiber Link to *RIEGL* Data Recorder
GNSS Interface [6)]	Serial RS-232 interface for data string with GNSS-time information, TTL input for 1 PPS synchronization pulse

General Technical Data

Power Supply Input Voltage	18 - 32 V DC
Power Consumption	typ. 330 W (without IMU/GNSS/cameras) typ. 370 W (with IMU/GNSS/cameras) [7)] max. 400 W
Main Dimensions	489.5 mm x 660 mm x 580 mm, mounting flange 580 mm x 580 mm
Weight	approx. 70 kg (with IMU/GNSS/cameras and optional infrared laser scanner)
Humidity	non condensing
Protection Class Scan Head	IP54, dust and splash-proof
Max. Flight Altitude [8)]	
operating	16 500 ft (5 000 m) above Mean Sea Level (MSL)
not operating	18 000 ft (5 500 m) above MSL
Temperature Range	
operation / storage	0°C up to +40°C / -10°C up to +50°C

1) The INS configuration of the *RIEGL* VQ-880-GH Laser Scanning System can be modified to the customer's requirements.
2) The installed IMU is listed neither in the European Export Control List (i.e. Annex 1 of Regulation (EU) No. 2021/821 nor in the Canadian Export Control List. Detailed information on certain cases will be provided on request.
3) One sigma values, no GNSS outages, post-processed during base station data.
4) The camera configuration of the *RIEGL* VQ-880-GH Laser Scanning System can be modified to the customer's requirements.
5) Forward Motion Compensation
6) to be used for external GNSS receiver
7) @ 20°C ambient temperature, 100 kHz PRR, 100 scans/sec
8) For standard atmospheric conditions: 1013 mbar, +15°C at sea level