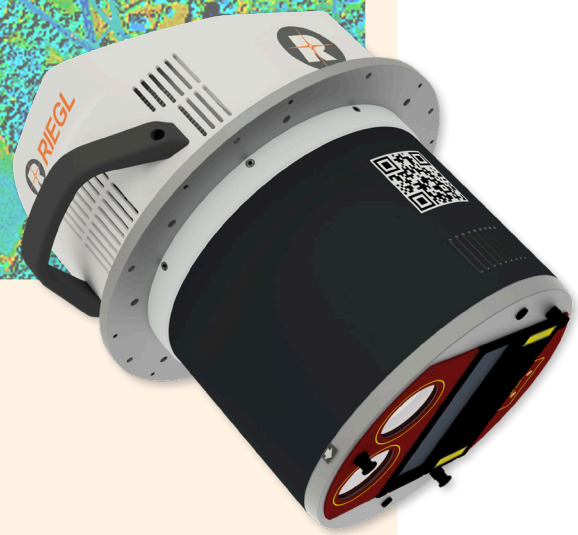
Waveform Processing Airborne LiDAR Scanning System for High Point Density Mapping and Ultra-Wide Area Mapping

RIEGL VQ®-1260

- *high pulse repetition rates of up to 2.2 MHz*
- *up to 1.47 million measurements per second on the ground*
- *best point distribution for optimum target resolution*
- *excellent atmospheric clutter suppression*
- *multiple target capability*
- *online waveform processing and full waveform data recording*
- *on-board graphical user interface for easy access to primary scanner parameters*
- *integrated inertial measurement unit and GNSS receiver*
- *prepared for the integration of up to two high resolution RGB/NIR cameras*
- *optimized for interfacing with typical hatches and stabilized platforms*
- *deteachable handgrips for facilitated handling*



The VQ-1260 is one of *RIEGL's* latest high-end airborne laser scanning systems, suitable for a wide field of applications – from high-point density wide area mapping to ultra-high resolution city mapping or corridor mapping.

The unique design features pulse repetition rates from 2.2 MHz, resulting in a regular point spacing and an almost constant point density distribution on the ground. For a target reflectance of 20 %, the system features large measurement distances of up to 5400 m at a minium PRR of 270 kHz and up to 2300 m at a maximum PRR of 2.2 MHz, resulting in an unsurpassed high efficiency in area acquisition of e.g., up to 500 km²/h at 150 knots flying speed for an average of 8 points per square meter.

A newly designed optical frontend significantly minimizes for near-range echoes due to atmospheric clutter, resulting in clean point clouds. Online-Waveform processing and full-waveform processing capabilities are a matter of course for this class of equipment.
Scan data and camera images are stored on removable hard disks that can be accessed directly on the device, eliminating the need for an external data recorder.

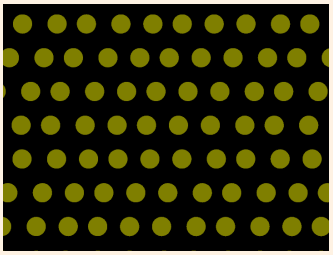
A high-performance IMU/GNSS unit and one or two optional high-resolution RGB/NIR cameras are seamlessly integrated in the compact and user-friendly designed housing. The standardized mounting flange fits typical hatches or gyro-stabilized leveling mounts for maintaining optimum point distribution.

Applications:
- *Ultra Wide Area / High Altitude Mapping*
- *Ultra-High Point Density Mapping*
- *Mapping of Complex Urban Environments*
- *Glacier & Snowfield Mapping*
- *City Modeling*
- *Mapping of Lakesides & River Banks*
- *Agriculture & Forestry*
- *Corridor Mapping*

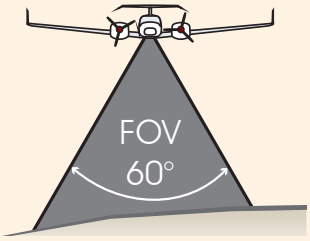
visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS

RIEGL VQ®-1260 Dense Scan Pattern and Wide Effective Swath Width



RIEGL VQ-1260 point distribution

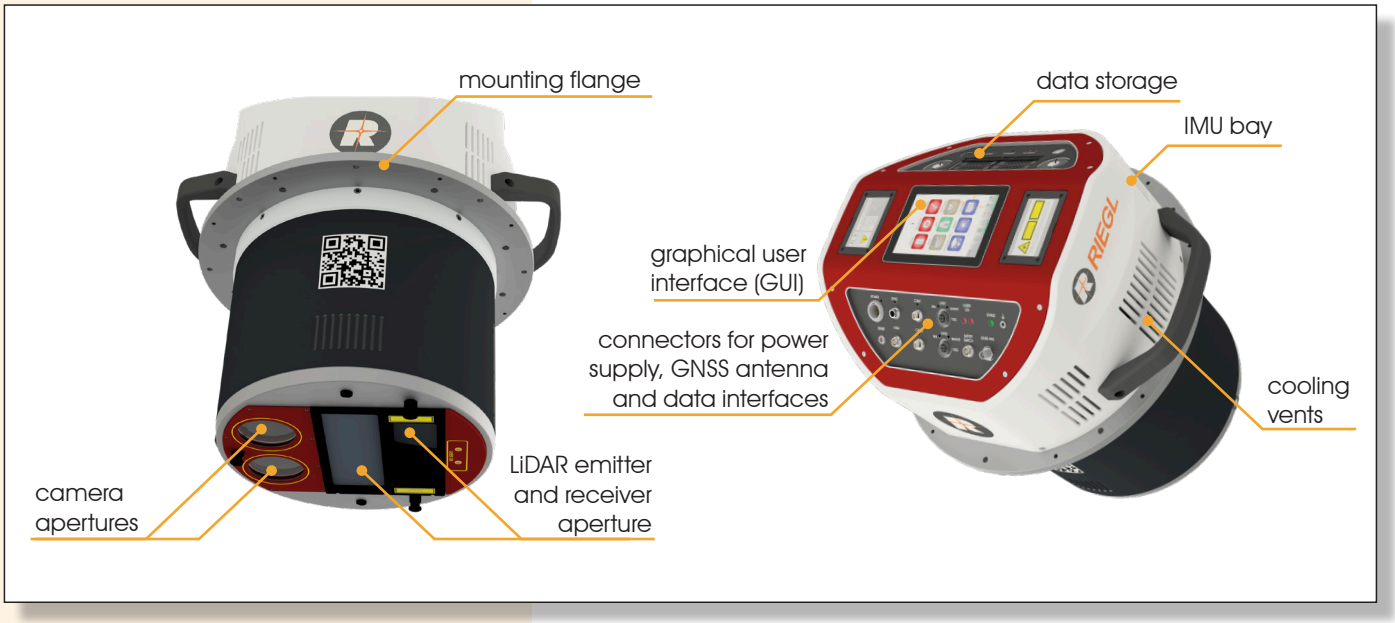


broad effective swath width

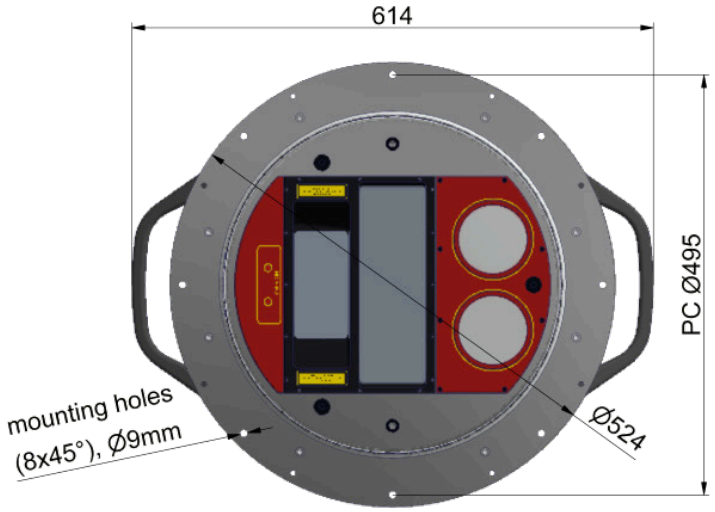
The *RIEGL* VQ-1260 scanning mechanism – based on a continuously rotating polygon mirror wheel – delivers straight parallel scan lines resulting in a regular point pattern on the ground. With equal spatial sampling frequency along and across track, object extents are well defined and even small objects may be detected. The instrument is perfectly suited for applications where a superior point pattern on target surfaces is required.

The wide field of view and the multiple-time-around measurement capability of the *RIEGL* VQ-1260 make the instrument perfectly suited for wide area mapping applications. The instrument has been designed for utmost efficiency in collecting data by enabling scanning operations from high altitudes at high laser pulse repetition rates simultaneously, reducing the necessary flight time to a minimum.

RIEGL VQ-1260 Elements of Function and Operation



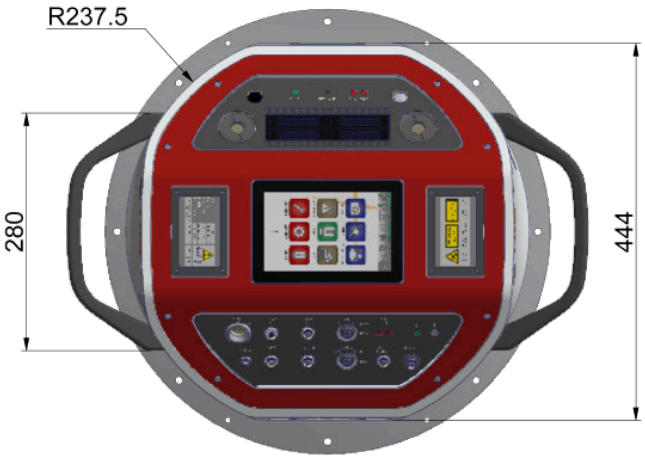
bottom view



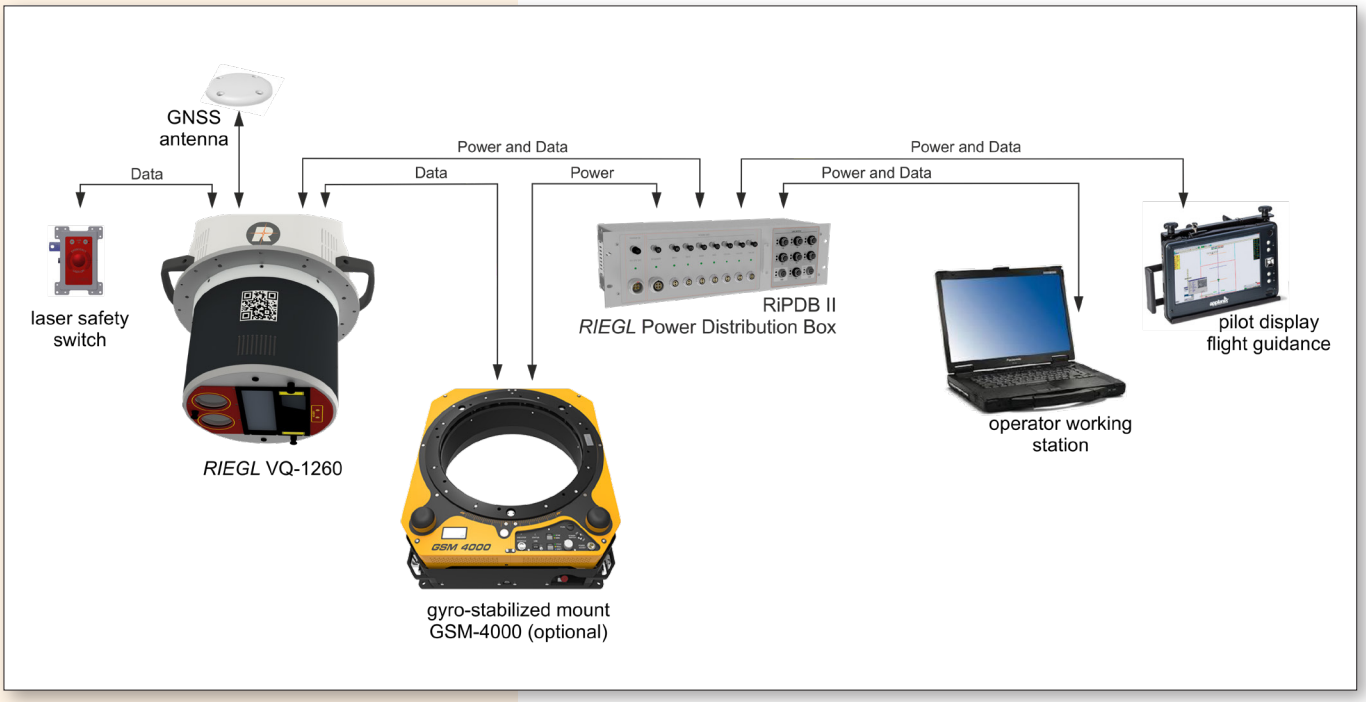
side view

side view

top view



dimensions in mm

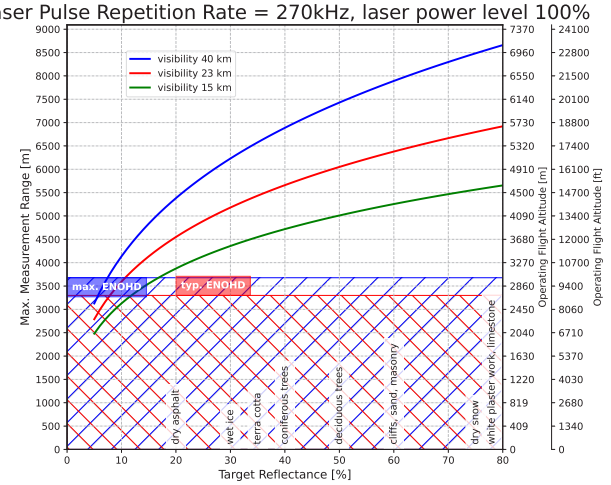


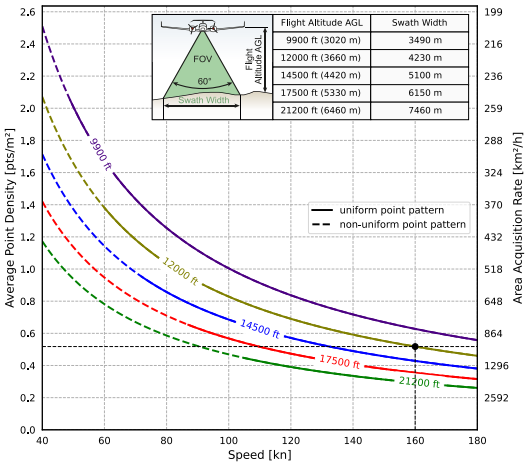
A minimum number of system components and external cabling is required for an easy and quick installation in aircrafts.

RIEGL VQ-1260 installed on the GSM-4000 gyro-stabilized platform

RIEGL VQ-1260 installed in the fuselage hatch of the Diamond Aircraft DA62 Survey Star

Laser Pulse Repetition Rate = 270kHz, laser power level 100%

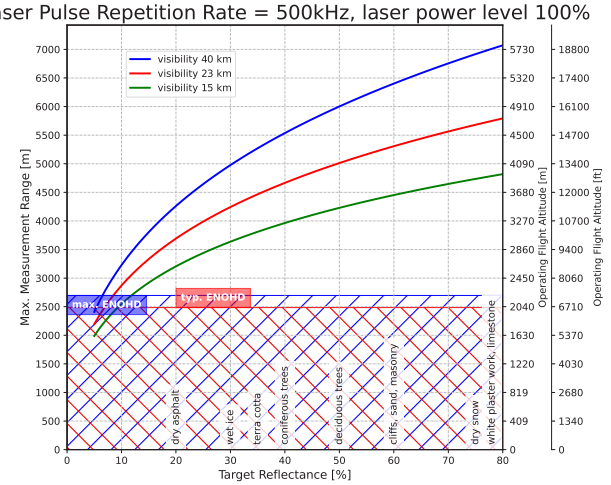


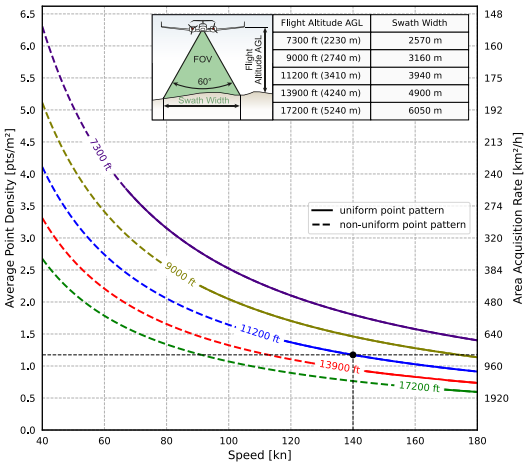


Example: VQ-1260 at 270,000 pulses/sec, laser power level 100%
altitude 12,000 ft AGL, speed 160 kn

Results: point density ~ 0.5 pts/m²
area acquisition rate ~ 1001 km²/h

Laser Pulse Repetition Rate = 500kHz, laser power level 100%

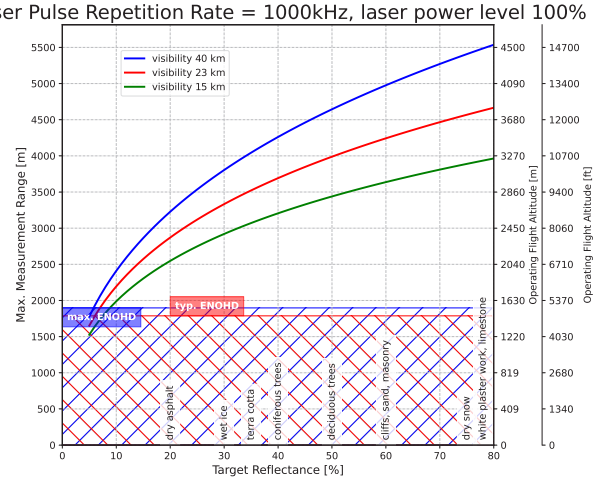


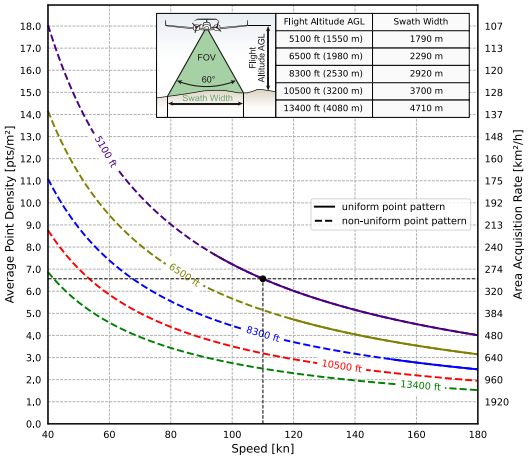


Example: VQ-1260 at 500,000 pulses/sec, laser power level 100%
altitude 11,200 ft AGL, speed 140 kn

Results: point density ~ 1.2 pts/m²
area acquisition rate ~ 818 km²/h

Laser Pulse Repetition Rate = 1000kHz, laser power level 100%





Example: VQ-1260 at 1,000,000 pulses/sec, laser power level 100%
altitude 5,100 ft AGL, speed 110 kn

Results: point density ~ 6.7 pts/m²
area acquisition rate ~ 293 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- effective FOV 58°
- average ambient brightness
- roll angle up to ±5°

Assumptions for calculation of the Area Acquisition Rate

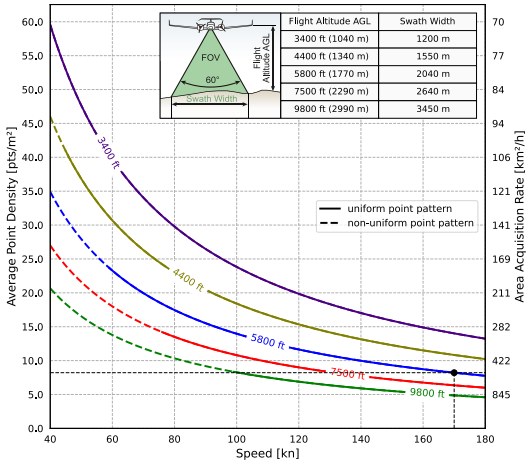
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

Typical ENOHD

- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10kn.

Measurement Range & Point Density *RIEGL* VQ-1260

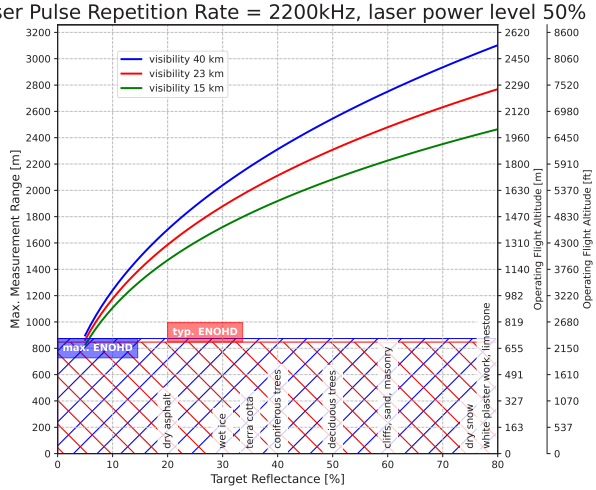
Laser Pulse Repetition Rate = 2200kHz, laser power level 100%

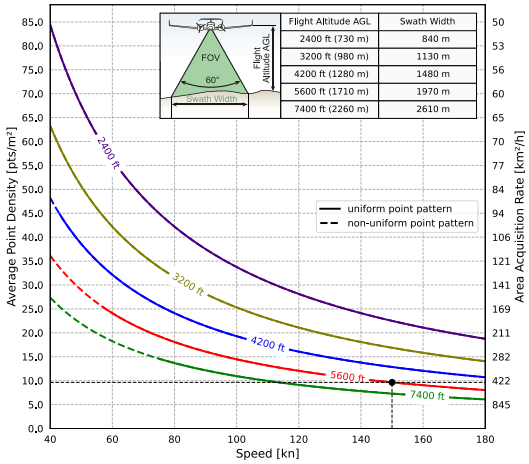


Example: VQ-1260 at 2,200,000 pulses/sec, laser power level 100%
altitude 5,800 ft AGL, speed 170 kn

Results: point density ~ 8.2 pts/m²
area acquisition rate ~ 514 km²/h

Laser Pulse Repetition Rate = 2200kHz, laser power level 50%

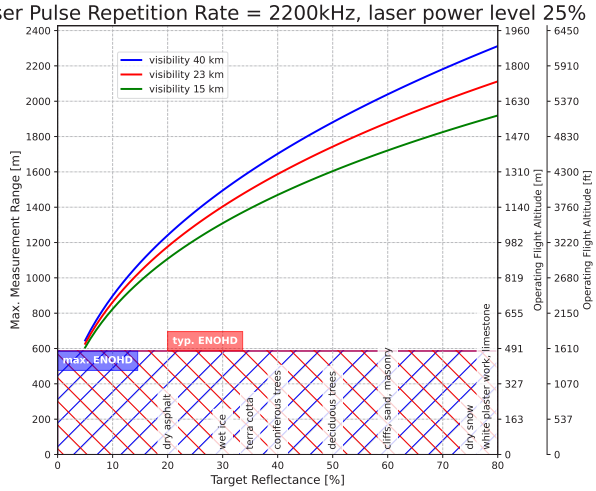


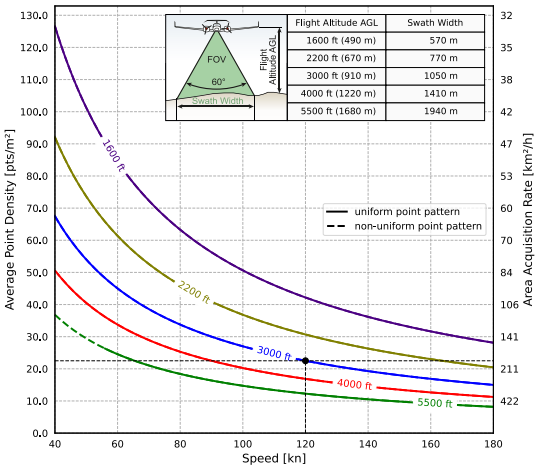


Example: VQ-1260 at 2,200,000 pulses/sec, laser power level 50%
altitude 5,600 ft AGL, speed 150 kn

Results: point density ~ 9.6 pts/m²
area acquisition rate ~ 438 km²/h

Laser Pulse Repetition Rate = 2200kHz, laser power level 25%





Example: VQ-1260 at 2,200,000 pulses/sec, laser power level 25%
altitude 3,000 ft AGL, speed 120 kn

Results: point density ~ 23 pts/m²
area acquisition rate ~ 188 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- effective FOV 58°
- average ambient brightness
- roll angle up to ±5°

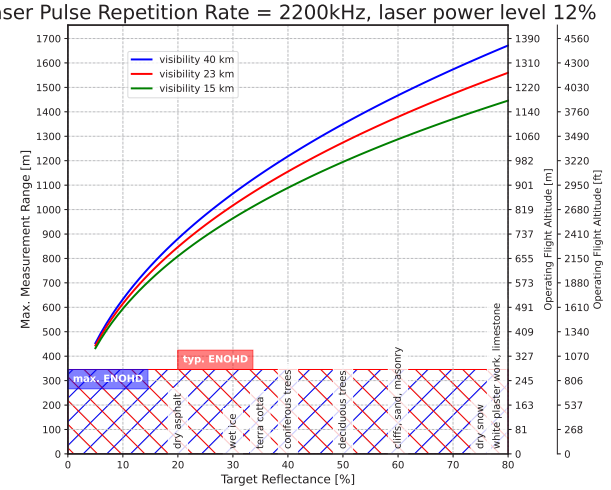
Assumptions for calculation of the Area Acquisition Rate

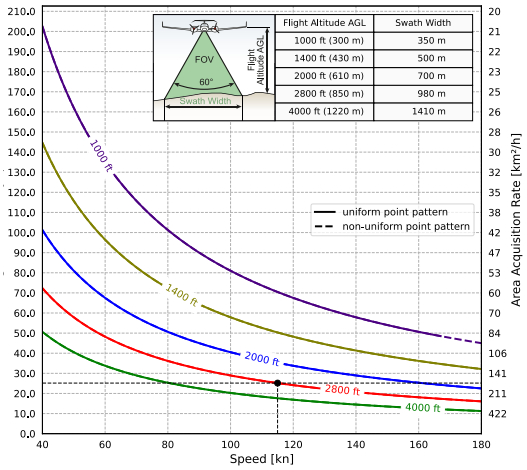
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

Typical ENOHD

- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10kn.

Laser Pulse Repetition Rate = 2200kHz, laser power level 12%

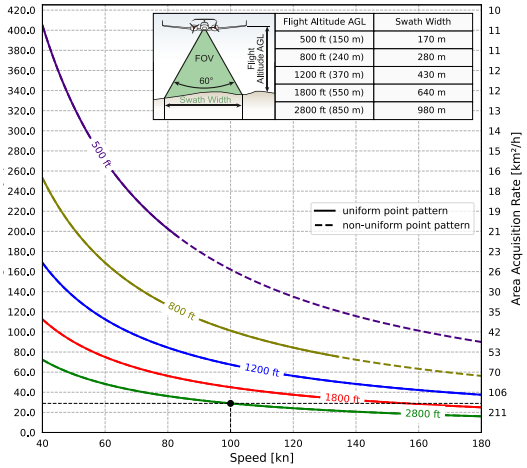




Example: VQ-1260 at 2,200,000 pulses/sec, laser power level 12%
altitude 2,800 ft AGL, speed 115 kn

Results: point density ~ 25 pts/m²
area acquisition rate ~ 168 km²/h

Laser Pulse Repetition Rate = 2200kHz, laser power level 6%



Example: VQ-1260 at 2,200,000 pulses/sec, laser power level 6%
altitude 2,800 ft AGL, speed 100 kn

Results: point density ~ 29 pts/m²
area acquisition rate ~ 146 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- effective FOV 58°
- average ambient brightness
- roll angle up to ±5°

Assumptions for calculation of the Area Acquisition Rate

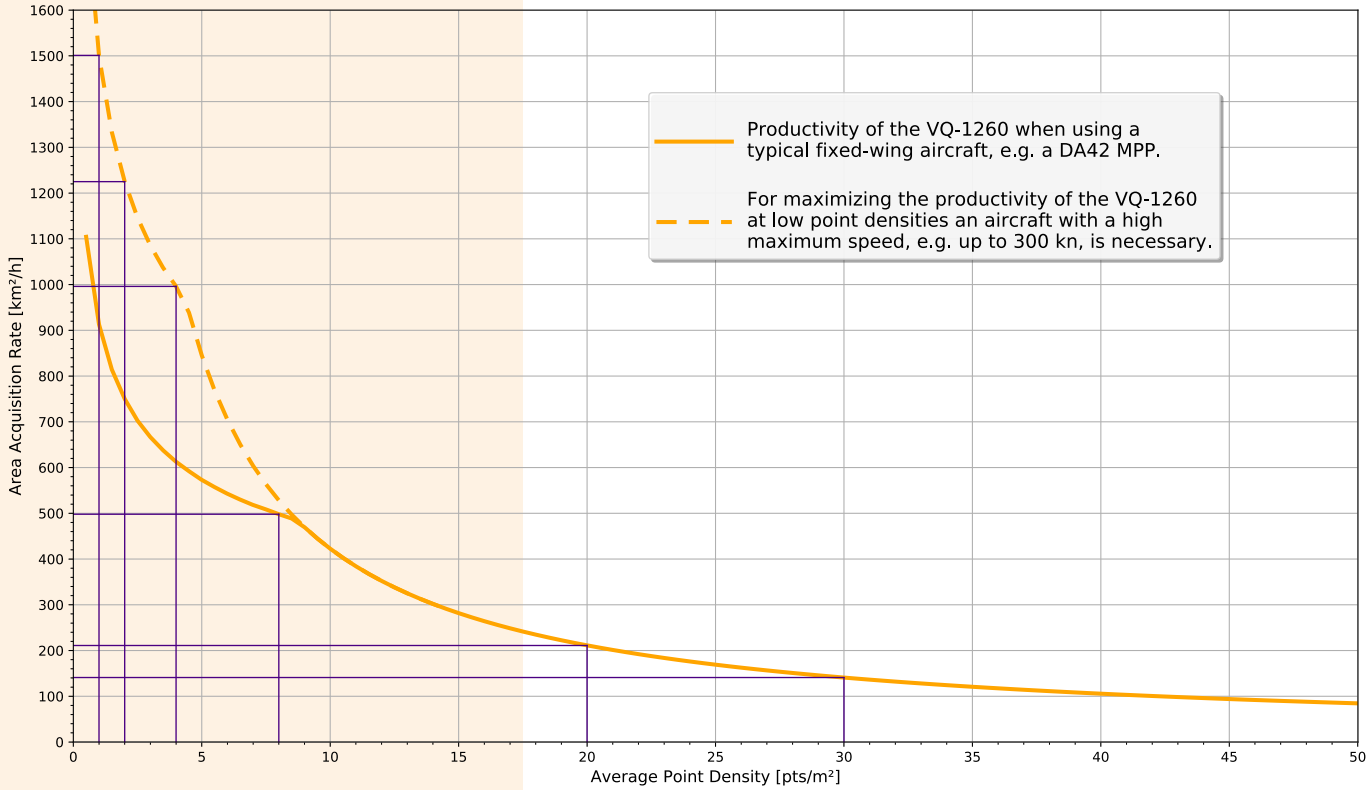
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

Typical ENOHD

- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10kn.

RIEGL VQ-1260 Productivity

The *RIEGL* VQ-1260 Waveform Processing Airborne LiDAR Mapping System offers highest productivity.



Examples [1]

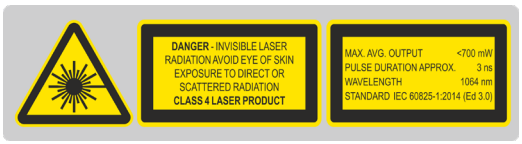
Average Point Density	1 pts/m²	2 pts/m²	4 pts/m²	8 pts/m²	20 pts/m²	30 pts/m²
Flight Altitude	9590 ft 2920 m	7830 ft 2390 m	6370 ft 1940 m	6370 ft 1940 m	2720 ft 830 m	2420 ft 740 m
Ground Speed	300 kn	300 kn	300 kn	150 kn	150 kn	110 kn
Swath Width	3380 m	2760 m	2240 m	2240 m	960 m	850 m
Productivity	1501 km²/h	1225 km²/h	996 km²/h	498 km²/h	211 km²/h	141 km²/h
eff. Measurement Rate [2]	521,000 meas./sec	851,000 meas./sec	1,383,000 meas./sec	1,381,000 meas./sec	1,468,000 meas./sec	1,468,000 meas./sec
Camera GSD [3] [4]	220 mm	180 mm	146 mm	90 mm	63 mm	56 mm
Camera Trigger Intervall [4]	5.7 sec	4.6 sec	3.8 sec	4.6 sec	3.2 sec	2.9 sec

1) calculated for 20% target reflectivity and 20% stripe overlap
2) The target detection rate is equal to the measurement rate for terrains offering only one target per laser pulse but may be much higher for vegetated areas.
3) Ground Sampling Distance
4) Calculated for a 150 MPixel CMOS camera with a FOV of 56.2° x 43.7° and 60% image overlap in flight direction (endlap).

Laser Product Classification

Class 4 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.



Range Measurement Performance

as a function of laser power setting, PRR, and target reflectivity

Laser Power Level	100%			
Laser Pulse Repetition Rate (PRR) [1]	270 kHz	500 kHz	1000 kHz	2200 kHz
Max. Measuring Range [2] [3] [4]				
natural targets ρ ≥ 20 %	5380 m	4260 m	3230 m	2310 m
natural targets ρ ≥ 60 %	7890 m	6400 m	4980 m	3660 m
Max. Operating Flight Altitude [2] [5] (AGL) [6]				
natural targets ρ ≥ 20 %	4410 m 14450 ft	3490 m 11450 ft	2640 m 8650 ft	1890 m 6200 ft
natural targets ρ ≥ 60 %	6460 m 21200 ft	5240 m 17200 ft	4080 m 13400 ft	3000 m 9850 ft
NOHD [7] [9]	421 m (414 m [10])	309 m (305 m [10])	217 m (215 m [10])	143 m (142 m [10])
ENOHD [8] [9]	3012 m (2702 m [10])	2209 m (2035 m [10])	1554 m (1464 m [10])	1035 m (993m [10])
Number of Targets per Laser Pulse up to [11]	31	31	15	7

Laser Power Level	50%	25%	12%	6%
Laser Pulse Repetition Rate (PRR) [1]	2200 kHz	2200 kHz	2200 kHz	2200 kHz
Max. Measuring Range [2] [3] [4]				
natural targets ρ ≥ 20 %	1700 m	1240 m	880 m	630 m
natural targets ρ ≥ 60 %	2750 m	2040 m	1470 m	1070 m
Max. Operating Flight Altitude [2] [5] (AGL) [6]				
natural targets ρ ≥ 20 %	1390 m 4450 ft	1020 m 3350 ft	700 m 2350 ft	520 m 1700 ft
natural targets ρ ≥ 60 %	2250 m 7400 ft	1670 m 5500 ft	1200 m 3950 ft	870 m 2850 ft
NOHD [7] [9]	97 m (97 m [10])	63 m (63 m [10])	34 m (34 m [10])	19 m (19 m [10])
ENOHD [8] [9]	716 m (694 m [10])	480 m (469 m [10])	283 m (277 m [10])	134 m (132 m [10])
Number of Targets per Laser Pulse up to [11]	7	7	7	7

1) rounded average PRR
2) Typical values for average conditions and average ambient brightness; in bright sunlight the operational range may be considerably shorter and the operational flight altitude may be considerably lower than under an overcast sky.
3) The 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 40 km. Range ambiguities have to be resolved by multiple-time-around processing.
4) 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.
5) Typical values for max. effective FOV 58°, additional roll angle up to ± 5°
6) Above Ground Level
7) Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition
8) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition
9) NOHD and ENOHD have been calculated for a typical angular step width of 0.013° (which means non-overlapping laser footprints), and an aircraft speed higher than 10 kn. NOHD and ENOHD increase when using overlapping laser footprints which may be intended e.g. for power line mapping.
10) The atmospheric attenuation of the laser beam is taken into account assuming standard clear conditions with a visibility of 23.5 km. Absorption by water vapor and carbon dioxide is neglected.
11) when using online waveform processing

Minimum Range [12]	100 m
Accuracy [13] [14] / Precision [14] [15]	20 mm / 20 mm
Laser Pulse Repetition Rate	270 kHz up to 2.2 MHz, selectable in steps of less than 1%
Effective Measurement Rate	up to 1.47 MHz @ 60° scan angle
Echo Signal Intensity	provided for each echo signal
Laser Wavelength	near infrared
Laser Beam Divergence	typ. 0.17 mrad @ 1/e [16], typ. 0.23 mrad @ 1/e² [17]

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines
Scan Angle Range	60°
Total Scan Rate	36 [18] - 600 lines/sec
Angular Step Width $\Delta\vartheta$	$0.006° \leq \Delta\vartheta \leq 0.100°$ [19] [20]
Angle Measurement Resolution	0.001°

12) Limitation for range measurement capability, does not consider laser safety issues! The minimum range for valid reflectivity values is 250 m.
13) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
14) Standard deviation one sigma @ 250 m range under *RIEGL* test conditions.
15) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
16) Measured at the 1/e points. 0.17 mrad correspond to an increase of 17 cm of beam diameter per 1000 m distance.
17) Measured at the 1/e² points. 0.23 mrad correspond to an increase of 23 cm of beam diameter per 1000 m distance.
18) The minimum scan rate depends on the selected laser PRR.
19) The minimum angular step width depends on the selected laser PRR.
20) The maximum angular step width is limited by the maximum scan rate.

Technical Data to be continued at page 10

Technical Data *RIEGL* VQ-1260 *(continued)*

Data Interfaces

Configuration	LAN 10/100/1000/2500/5000/10000 MBit/s)
Scan Data Output	LAN 10/100/1000/2500/5000/10000 MBit/s)
Synchronization	Serial RS-232 interface, TTL input for 1 pps synchronization pulse, accepts different data formats for GNSS-time information
Camera Interface	2 connectors with power, RS-232, pps, trigger, exposure
Removable Storage Device	1x U.2 SSD, up to 15.36 TByte

General Technical Data

Power Supply / Power Consumption	20 - 32 V DC / typ. 350 W max. 600 W, depending on integrated optional components
Main Dimensions (flange diameter x height)	Ø 524 mm x 603 mm (without flange mounted carrying handles)
Weight	approx. 60 kg without any camera but including a typical IMU/GNSS unit approx. 65 kg with optional components
Protection Class	IP54
Max. Flight Altitude operating / not operating	18500 ft (5600 m) above MSL[1] / 18500 ft (5600 m) above MSL
Temperature Range operation / storage	-5°C up to +35°C / -10°C up to +50°C

Recommended IMU/GNSS System [2] [3]

IMU Accuracy [4]	
Roll, Pitch	0.0025°
Heading	0.005°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	0.05 m - 0.1 m

Optional Components VQ-1260

Primary Camera	RGB
Sensor Resolution	e.g. 150 MPixel CMOS
Sensor Dimensions (diagonal)	66.7 mm (medium format)
Focal Length of Camera Lens	50 mm
Field of View (FOV)	approx. 54.6° x 42.3°
Data Storage	1x U.2 SSD, up to 15.36 TByte
Secondary Camera	Different camera types including thermal or NIR cameras can be integrated, details on request.

1) Mean Sea Level
2) The recommended 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) The *RIEGL* VQ-1260 Laser Scanning system supports different IMU/GNSS Systems, details on request.
4) One sigma values, no GNSS outages, post-processed with base station data

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.
RIEGL South America SpA
RIEGL Deutschland Vertriebsgesellschaft mbH

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