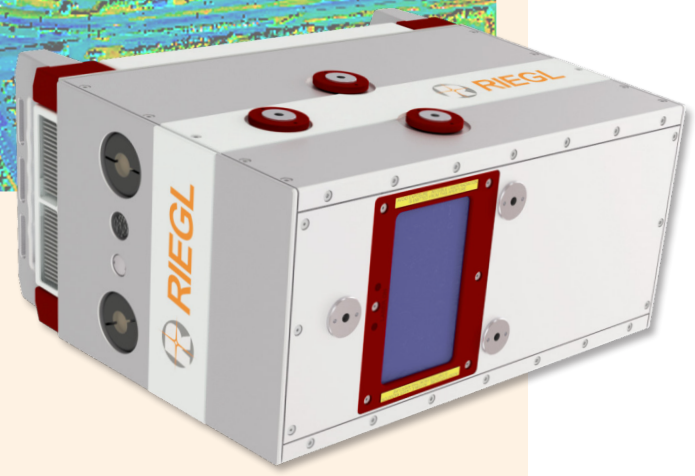
Waveform Processing Airborne Laser Scanner for Wide Area Mapping and High Productivity

RIEGL VQ®-780 II-S

- *high laser pulse repetition rate up to 2 MHz*
- *up to 1.33 million measurements/sec on the ground*
- *excellent multiple target detection capability*
- *excellent suppression of atmospheric clutter*
- *Multiple-Time-Around (MTA) processing of up to 45 pulses simultaneously in the air*
- *online waveform processing as well as smart and full waveform recording*
- *parallel scan lines and uniform point distribution*
- *interface for GNSS time synchronization*
- *seamless integration and compatibility with other RIEGL ALS systems and software packages*



The *RIEGL* VQ-780II-S is a high performance, rugged, lightweight, and compact airborne mapping sensor. This versatile system is designed for high efficient data acquisition at low, mid, and high altitudes, covering a variety of different airborne laser scanning applications from high density to wide area mapping.

The high speed rotating mirror design ensures reliability, and uniform point distribution across its entire wide field of view and at all flight altitudes. Based on *RIEGL*'s proven Waveform-LiDAR technology, the system provides point clouds with highest accuracy, excellent vertical target resolution, calibrated reflectance readings, and pulse shape deviation for unsurpassed information content on each single measurement. Excellent atmospheric clutter suppression yields clean point clouds with minimum efforts in filtering isolated noise points.

The system is complimented with *RIEGL*'s advanced acquisition and data processing software suite that utilizes parallel computing (GPU) for fast data processing.

The *RIEGL* VQ-780II-S is designed to work with the latest Inertial Navigation (IMU) Systems, flight management systems, and camera options.

Applications:

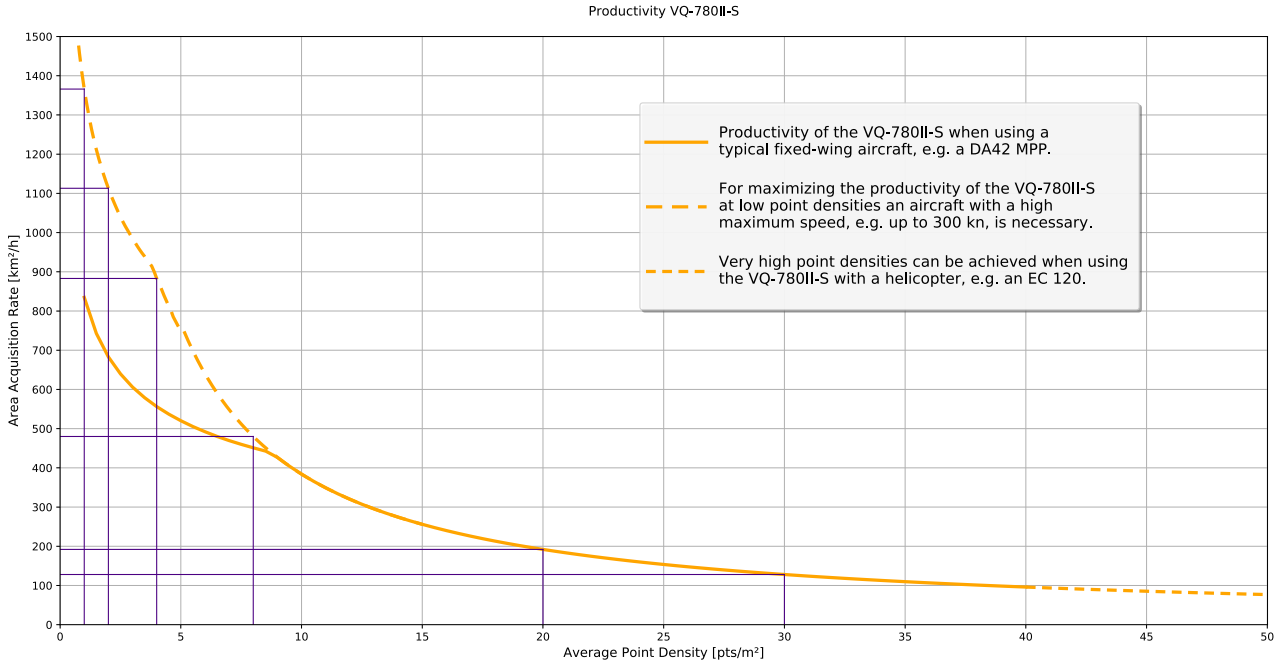
- *Wide Area / High Altitude Mapping*
- *High Point Density Mapping*
- *Mapping of Complex Urban Environments*
- *Glacier & Snowfield Mapping*
- *City Modeling*
- *Mapping of Lakesides & River Banks*
- *Agriculture & Forestry*
- *Corridor Mapping*

visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS

RIEGL VQ®-780II-S Productivity

The *RIEGL* VQ-780II-S Airborne Laser Scanner offers highest productivity.

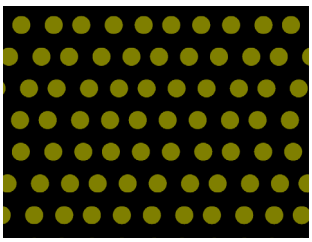


Examples [1]

Average Point Density	1 pts/m²	2 pts/m²	4 pts/m²	8 pts/m²	20 pts/m²	30 pts/m²
Flight Altitude AGL	8730 ft 2660 m	7110 ft 2170 m	5810 ft 1770 m	4460 ft 1360 m	3720 ft 1130 m	2460 ft 750 m
Ground Speed	300 kn	300 kn	291 kn	206 kn	99 kn	100 kn
Swath Width	3070 m	2500 m	2050 m	1570 m	1310 m	870 m
Productivity	1366 km²/h	1113 km²/h	883 km²/h	480 km²/h	192 km²/h	128 km²/h
Measurement Rate [2]	474 000 meas./sec	773 000 meas./sec	1.23 mill. meas./sec	1.33 mill. meas./sec	1.33 mill. meas./sec	1.33 mill. meas./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.

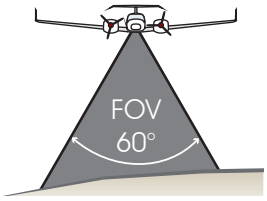
RIEGL VQ®-780II-S Dense Scan Pattern and Wide Effective Swath Width



RIEGL VQ-780II-S point distribution

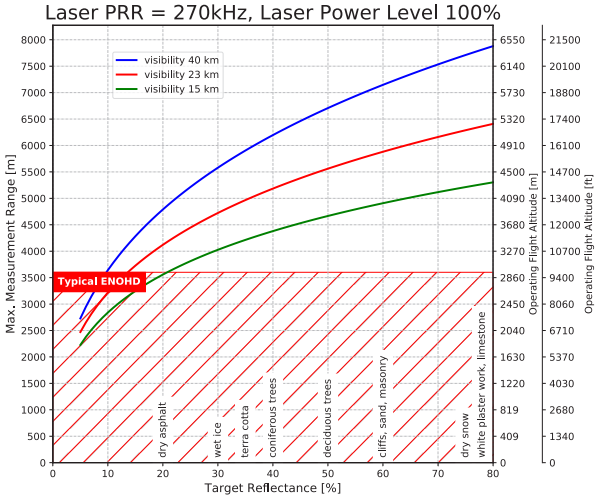
The *RIEGL* VQ-780II-S scanning mechanism – based on a continuously rotating polygon mirror wheel – delivers straight parallel scan lines resulting in a regular point pattern on the ground. With equal spatial sampling frequency along and across track, object extents are well defined and even small objects may be detected. The instrument is perfectly suited for applications where a superior point pattern on target surfaces is required.

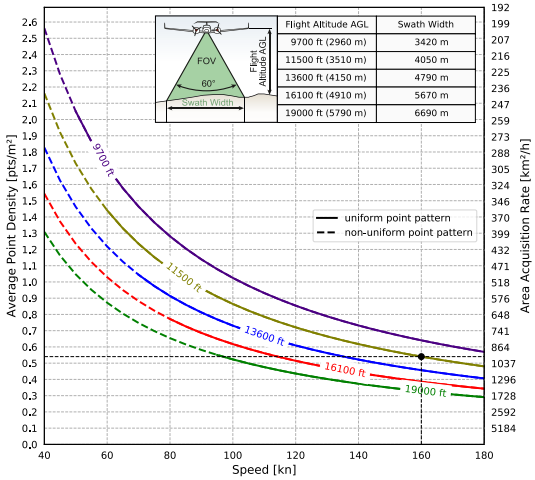
The wide field of view and the multiple-time-around (MTA) measurement capability of the *RIEGL* VQ-780II-S make the instrument perfectly suited for wide area mapping applications. The instrument has been designed for utmost efficiency in collecting data by enabling scanning operations from high altitudes at high laser pulse repetition rates simultaneously, reducing the necessary flight time to a minimum.



broad effective swath width

Laser PRR = 270kHz, Laser Power Level 100%



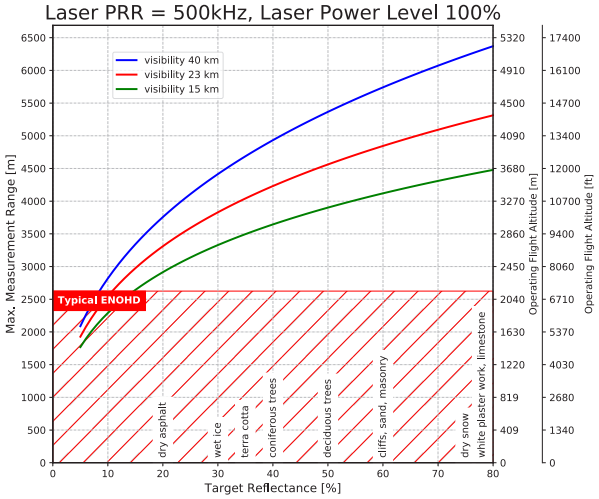


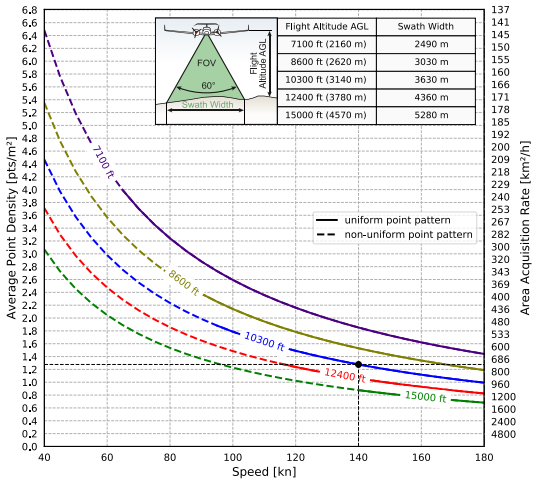
Flight Altitude AGL	Swath Width
9700 ft (2960 m)	3420 m
11500 ft (3510 m)	4050 m
13600 ft (4150 m)	4790 m
16100 ft (4910 m)	5670 m
19000 ft (5790 m)	6690 m

Example: VQ-780II-S at 270,000 pulses/sec, laser power level 100%
Altitude = 11,500 ft AGL, Speed 160 kn

Results: Point Density ~ 0.54 pts/m²
Area Acquisition Rate ~ 959 km²/h

Laser PRR = 500kHz, Laser Power Level 100%



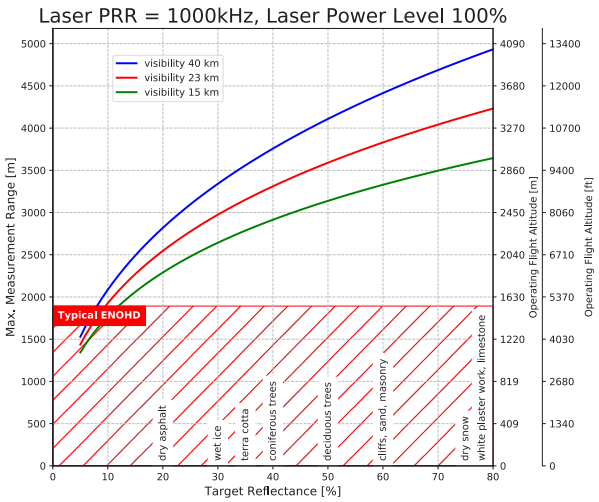


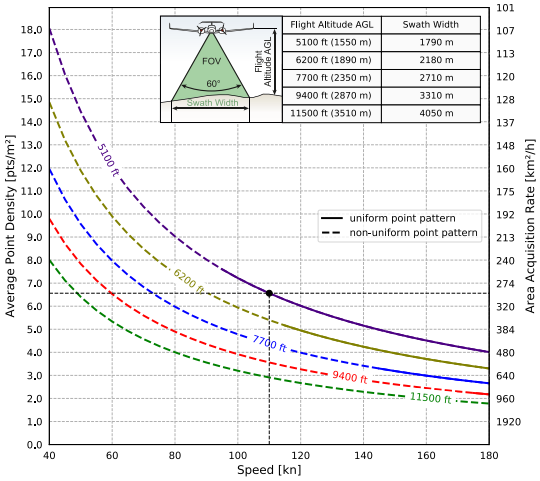
Flight Altitude AGL	Swath Width
7100 ft (2160 m)	2490 m
8600 ft (2620 m)	3030 m
10300 ft (3140 m)	3630 m
12400 ft (3780 m)	4360 m
15000 ft (4570 m)	5280 m

Example: VQ-780II-S at 500,000 pulses/sec, laser power level 100%
Altitude = 10,300 ft AGL, Speed 140 kn

Results: Point Density ~ 1.28 pts/m²
Area Acquisition Rate ~ 752 km²/h

Laser PRR = 1000kHz, Laser Power Level 100%





Flight Altitude AGL	Swath Width
5100 ft (1550 m)	1790 m
6200 ft (1890 m)	2180 m
7700 ft (2350 m)	2710 m
9400 ft (2870 m)	3310 m
11500 ft (3510 m)	4050 m

Example: VQ-780II-S at 1,000,000 pulses/sec, laser power level 100%
Altitude = 5,100 ft AGL, Speed 110 kn

Results: Point Density ~ 6.56 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
- full FOV of 60°
- average ambient brightness
- roll angle ±5°

Assumptions for calculation of the Area Acquisition Rate

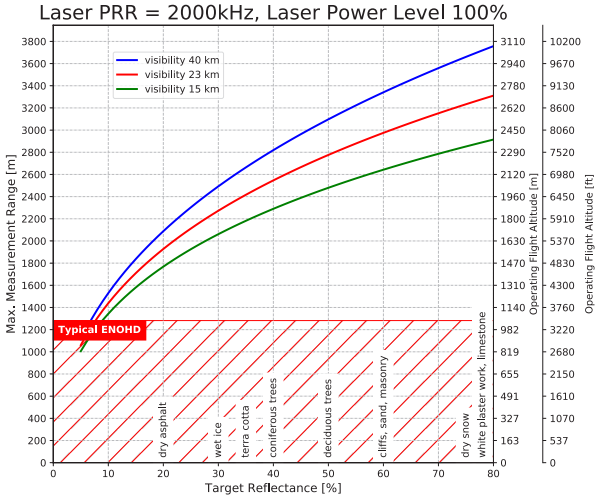
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

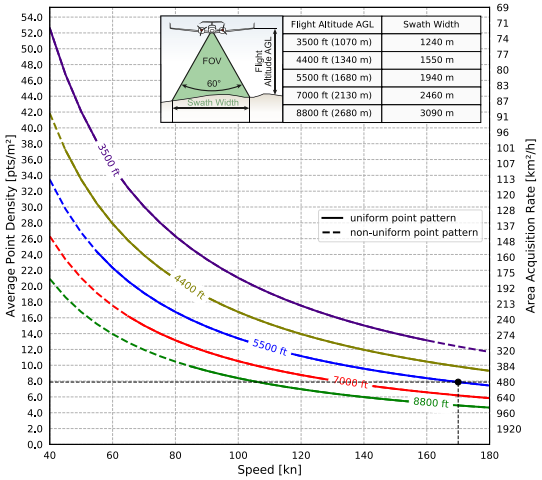
Typical ENOHD

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

Measurement Range & Point Density *RIEGL* VQ®-780II-S

Laser PRR = 2000kHz, Laser Power Level 100%

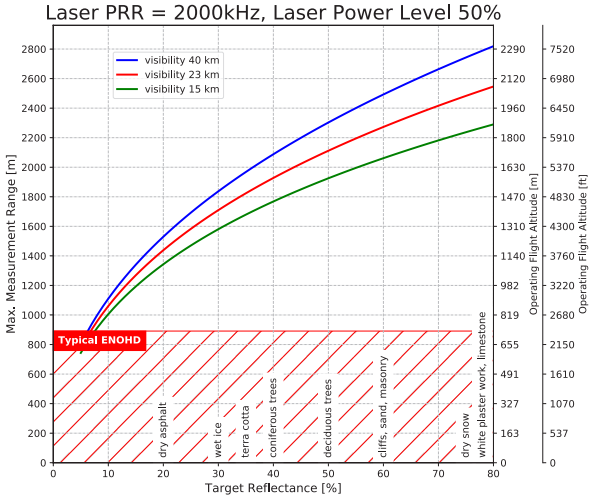


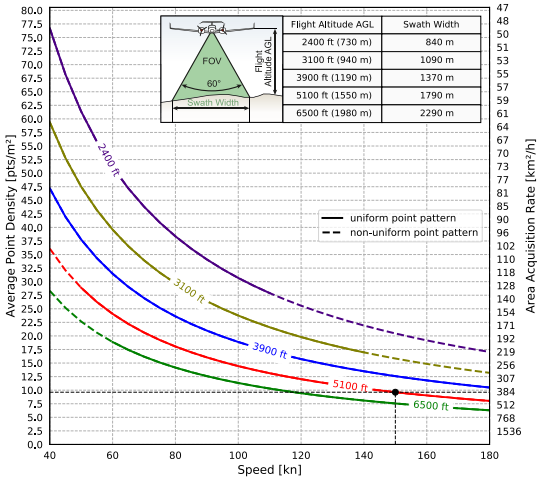


Example: VQ-780II-S at 2,000,000 pulses/sec, laser power level 100%
Altitude = 5,500 ft AGL, Speed 170 kn

Results: Point Density ~ 7.88 pts/m²
Area Acquisition Rate ~ 488 km²/h

Laser PRR = 2000kHz, Laser Power Level 50%

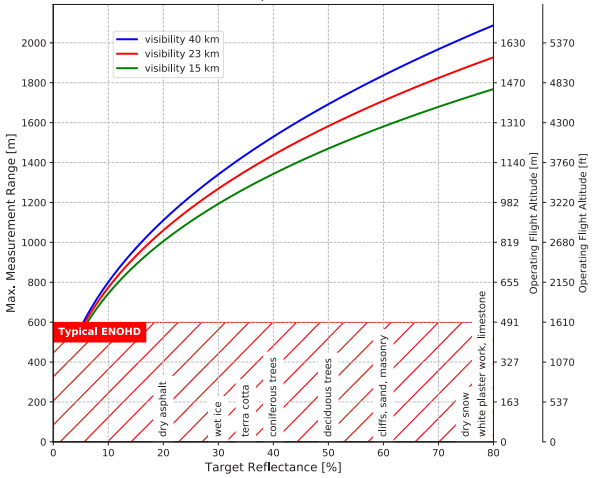


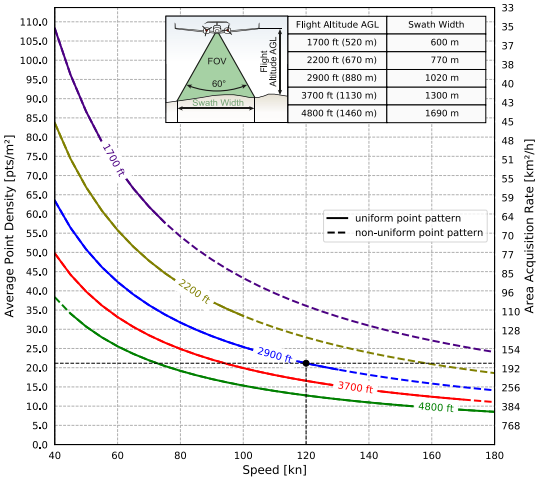


Example: VQ-780II-S at 2,000,000 pulses/sec, laser power level 50%
Altitude = 5,100 ft AGL, Speed 150 kn

Results: Point Density ~ 9.63 pts/m²
Area Acquisition Rate ~ 399 km²/h

Laser PRR = 2000kHz, Laser Power Level 25%





Example: VQ-780II-S at 2,000,000 pulses/sec, laser power level 25%
Altitude = 2,900 ft AGL, Speed 120 kn

Results: Point Density ~ 21.16 pts/m²
Area Acquisition Rate ~ 181 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

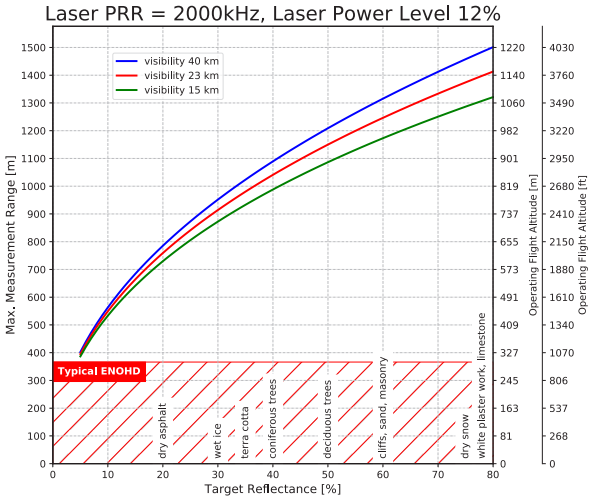
- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- full FOV of 60°
- average ambient brightness
- roll angle ±5°

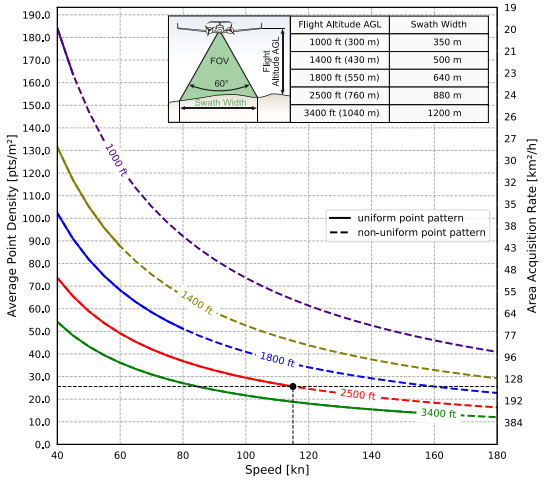
Assumptions for calculation of the Area Acquisition Rate

- 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

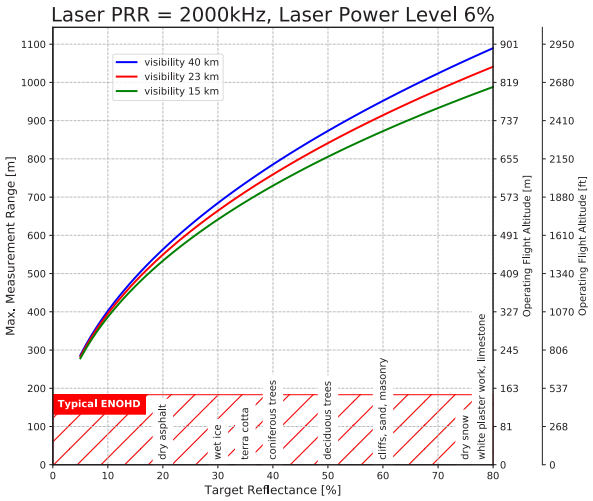
- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10kn.

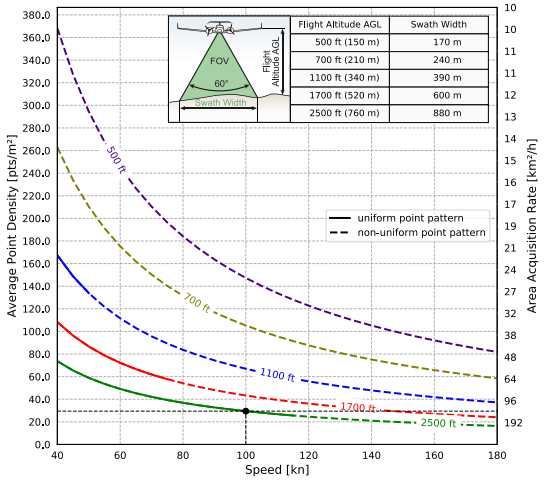




Example: VQ-780II-S at 2,000,000 pulses/sec, laser power level 12%
Altitude = 2,500 ft AGL, Speed 115 kn

Results: Point Density ~ 25.61 pts/m²
Area Acquisition Rate ~ 150 km²/h





Example: VQ-780II-S at 2,000,000 pulses/sec, laser power level 6%
Altitude = 2,500 ft AGL, Speed 100 kn

Results: Point Density ~ 29.46 pts/m²
Area Acquisition Rate ~ 130 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

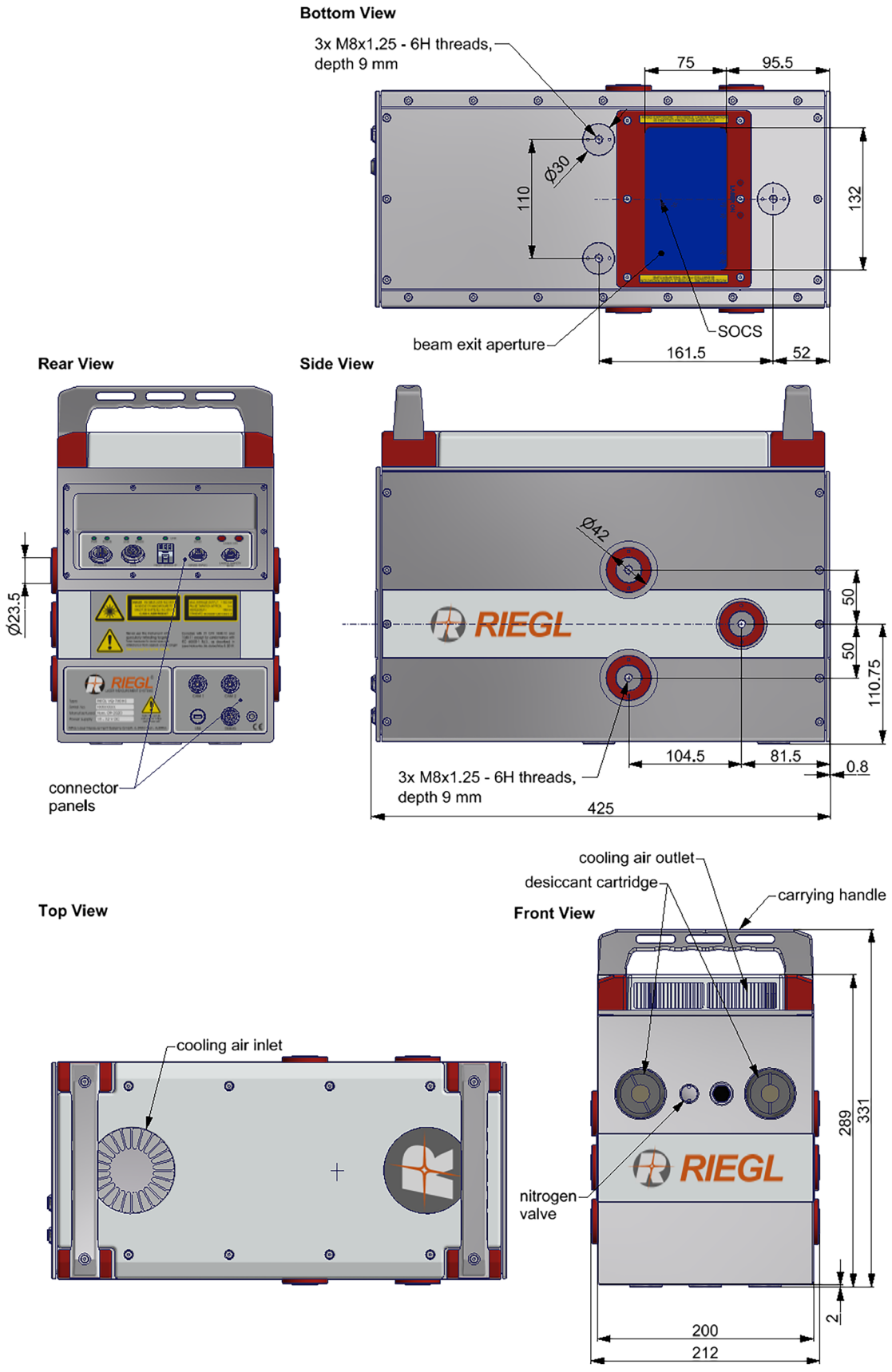
- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- full FOV of 60°
- average ambient brightness
- roll angle ±5°

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.



all dimensions in mm

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	2000 kHz
Max. Measuring Range [2] [3] [4]				
natural targets ρ ≥ 20 %	4800 m	3700 m	2800 m	2050 m
natural targets ρ ≥ 60 %	7100 m	5600 m	4300 m	3300 m
Max. Operating Flight Altitude Above Ground Level [2] [5]				
natural targets ρ ≥ 20 %	3900 m 12800 ft	3000 m 10000 ft	2200 m 7500 ft	1700 m 5500 ft
natural targets ρ ≥ 60 %	5800 m 19000 ft	4600 m 15000 ft	3500 m 11500 ft	2700 m 8800 ft
NOHD [6] [8]	430 m	310 m	220 m	155 m
ENOHD [7] [8]	2950 m	2150 m	1550 m	1050 m
Max. Number of Targets per Pulse [9]	14	14	9	4

Laser Power Level	50%	25%	12%	6%
Laser Pulse Repetition Rate (PRR) [1]	2000 kHz	2000 kHz	2000 kHz	2000 kHz
Max. Measuring Range [2] [3] [4]				
natural targets ρ ≥ 20 %	1500 m	1100 m	780 m	560 m
natural targets ρ ≥ 60 %	2450 m	1800 m	1300 m	940 m
Max. Operating Flight Altitude Above Ground Level [2] [5]				
natural targets ρ ≥ 20 %	1200 m 4100 ft	900 m 2900 ft	630 m 2100 ft	450 m 1500 ft
natural targets ρ ≥ 60 %	2000 m 6500 ft	1450 m 4800 ft	1050 m 3400 ft	760 m 2500 ft
NOHD [6] [8]	105 m	67 m	38 m	22 m
ENOHD [7] [8]	730 m	490 m	300 m	150 m
Max. Number of Targets per Pulse [9]	4	4	4	4

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 60°, additional roll angle ± 5°
6) Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition.
7) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition.
8) NOHD and ENOHD have been calculated for a typical angular step width of 0.012° (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.
9) when using online waveform processing

Minimum Range [10]	100 m
Accuracy [11] [12]	20 mm
Precision [12] [13]	20 mm
Laser Pulse Repetition Rate [19]	270 kHz up to 2 MHz, selectable in steps of less than 1%
Effective Measurement Rate	up to 1333 kHz @ 60° scan angle
Echo Signal Intensity	provided for each echo signal
Laser Wavelength	near infrared
Laser Beam Divergence	typ. 0.17 mrad @ 1/e [14], typ. 0.23 mrad @ $1/e^2$ [15]

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines
Scan Angle Range	± 30° = 60°
Total Scan Rate	20 [16] - 300 lines/sec
Angular Step Width Δϑ	0.006° ≤ Δϑ ≤ 0.100° [17] [18]
Angle Measurement Resolution	0.001°

10) Limitation for range measurement capability, does not consider laser safety issues! The minimum range for valid reflectivity values is 250 m.
11) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
12) Standard deviation one sigma @ 250 m range under *RIEGL* test conditions.
13) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
14) Measured at the 1/e points. 0.17 mrad correspond to an increase of 17 cm of beam diameter per 1000 m distance.
15) Measured at the $1/e^2$ points. 0.23 mrad correspond to an increase of 23 cm of beam diameter per 1000 m distance.
16) The minimum scan rate depends on the selected laser PRR.
17) The minimum angular step width depends on the selected laser PRR.
18) The maximum angular step width is limited by the maximum scan rate.
19) For smart and full waveform recording the max. laser PRR is limited to 1600kHz.

Technical Data to be continued at page 8

Data Interfaces

Configuration	TCP/IP Ethernet (10/100/1000 MBit/s)
Monitoring Data Output	TCP/IP Ethernet (10/100/1000 MBit/s)
Digitized Data Output	High-speed data link to *RIEGL* Data Recorder DR1560i
Synchronization	Serial RS-232 interface, TTL input for 1 pps synchronization pulse, accepts different data formats for GNSS-time information
Camera interface	2 x power, RS-232, 1 pps, trigger, exposure

General Technical Data

Power Supply / Power Consumption	18 - 32 V DC / typ. 220 W
Main Dimensions (length x width x height)	425 mm x 212 mm x 331 mm
Weight	approx. 20 kg
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

1) Mean Sea Level

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