High-Performance Corridor Mapping System for Infrastructure Applications

NEW

RIEGL VQ-1060

- *high pulse repetition rates of up to 2.4 MHz*
- *up to 2 million measurements per second on the ground*
- *forward / nadir / backward scan directions at +20 / +10 / 0 / -10 / -20 degrees*
- *wide field of view of 60 degrees*
- *multiple target capability*
- *online waveform processing*
- *supporting up to four integrated cameras*
- *integrated IMU/GNSS system*
- *compatible with typical gyro stabilizing mounts*

The *RIEGL* VQ-1060 is a fully integrated corridor mapping system, specifically designed for surveying powerlines, pipelines, railways, highways, and more. Its compact design meets the demand for a tailored solution in infrastructure mapping, offering precision and versatility.

The system integrates the core module of the *RIEGL* VQ-680 LiDAR scanner with two oblique RGB cameras, oriented at 45° forward and backward, as well as two nadir cameras – one RGB camera and one near-infrared (NIR) camera. Additionally, the VQ-1060 features a high-end IMU/GNSS system and an integrated data recorder for both, scan data and image data storage, ensuring seamless data collection.

It features an advanced beam deflection mechanism, providing oblique scanning angles of ±20° and ±10° for forward and backward views, as well as a nadir angle at 0°, each with a 60° field of view. This configuration delivers exceptional coverage of vertical structures such as powerline poles, overhead lines, facades, and vegetation, while also capturing horizontal surfaces in narrow street canyons. With an operational range from altitudes of approximately 120 m AGL (at a pulse repetition rate PRR of 2.4 MHz) to 2300 m (at a PRR 300 kHz for targets with reflectivity over 20 %), the system ensures accurate data collection over diverse environments.

Integrated cameras offer a high resolution of up to 150 MPix for nadir views in both RGB and NIR, featuring 50 mm focal length lenses. The cameras are optimally aligned with the laser scanner's field of view. For the oblique forward (+45°) and backward (-45°) cameras, lenses with 110 mm or 150 mm focal length are offered.

Designed for seamless integration into aircraft, the system fits into standard hatches with or without GSM leveling mounts, requiring minimal cabling efforts.

Applications:
- *Corridor Mapping*
- *Mapping of Complex Urban Environments*
- *City Modeling*
- *Ultra-High Resolution Mapping*
- *Oblique Mapping of Vertical Structures*
- *Forestry*

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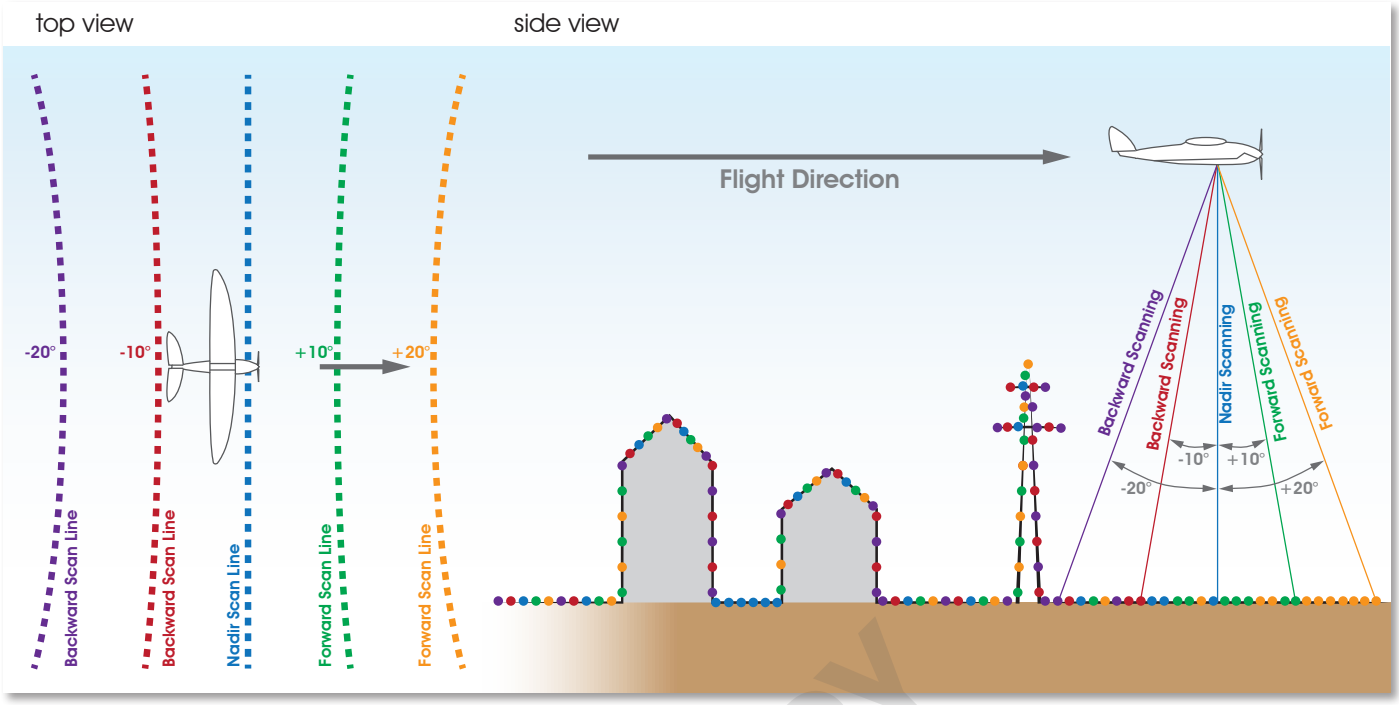
RIEGL®
LASER MEASUREMENT SYSTEMS

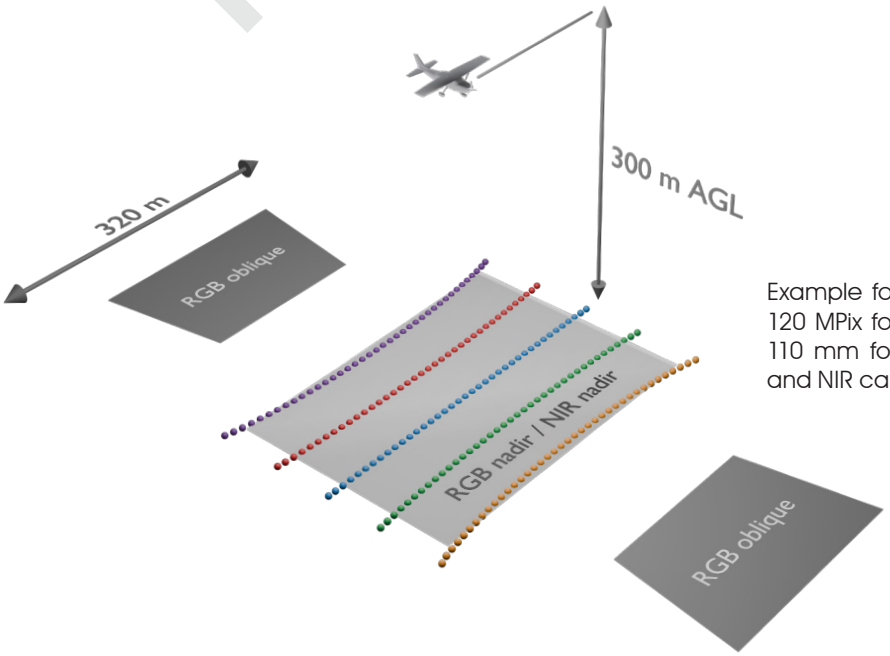
RIEGL VQ-1060 Scan Pattern „NFB“ (Nadir/Forward/Backward)



The *RIEGL* VQ-1060 offers a sophisticated, multi-axis scan geometry consisting of five parallel scan lines per scanner rotation, but with each scan line having its own unique scan direction. The scan directions change consecutively from nadir, to +10 and +20 degrees forward, and to -10 and -20 degrees backward. This scan geometry provides superior coverage of vertical features ahead of and behind the sensor, creating best-of-class 3D LiDAR data sets.
This is of value in urban, forestry, and asset mapping applications where wholly complete coverages of vertical and planimetric features are now possible. By also maintaining a nadir scan direction, the new VQ-1060 excels at city mapping applications and digital twins whereby inner courtyards and deep urban canyons are effectively mapped with little to no occlusions within the data sets.

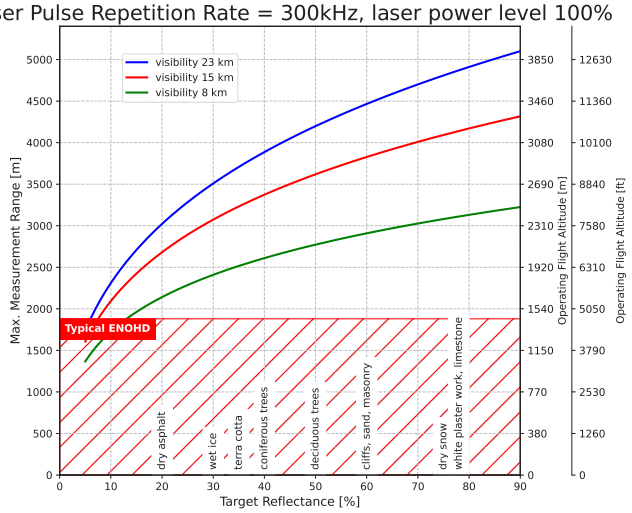
	Field of View		
Cross Flight Direction	± **30 deg**		
In-Flight Direction (at swath center)	**nadir**	± **10 deg**	± **20 deg**
In-Flight Direction (at swath edge)	**nadir**	± **11.5 deg**	± **22.8 deg**

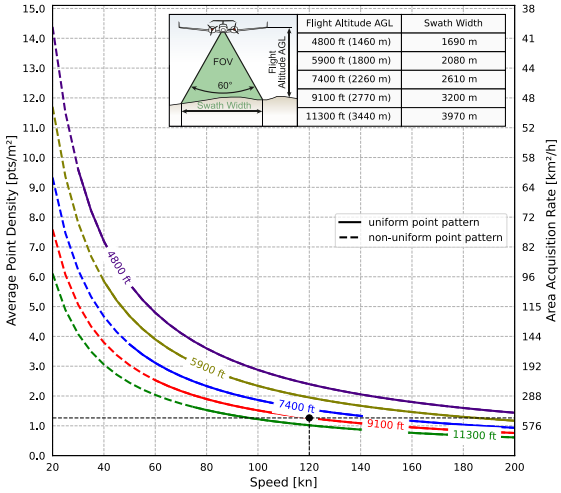
RIEGL VQ-1060 Camera Footprint



Example footprint from 300 m AGL flying altitude, 120 MPix forward/backward oblique cameras with 110 mm focal length lenses. 150 MPix nadir RGB and NIR cameras with 50 mm focal length lenses.

Laser Pulse Repetition Rate = 300kHz, laser power level 100%

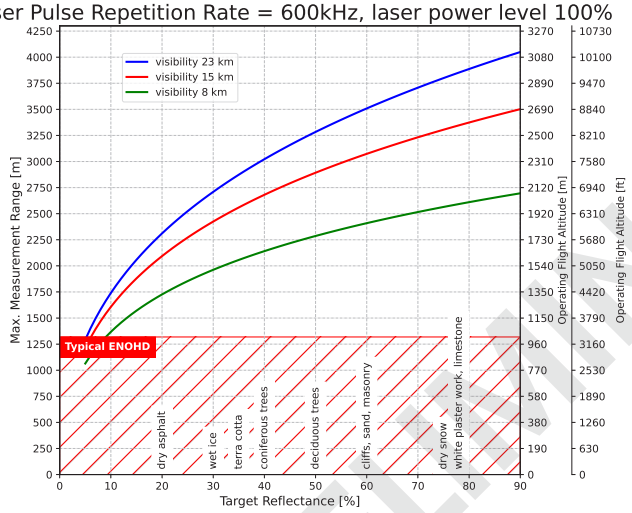


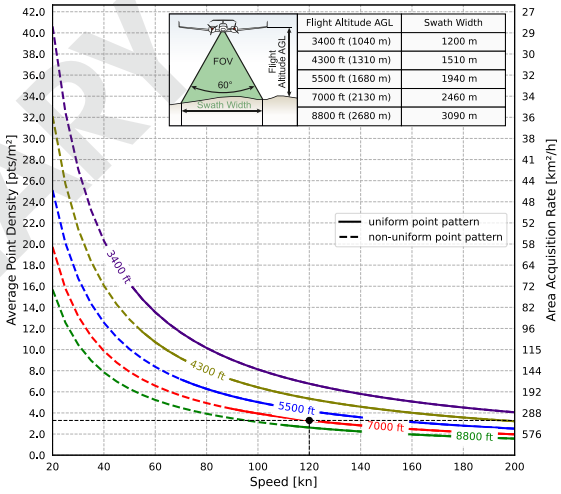


Example: VQ-1060 at 300,000 pulses/sec, laser power level 100%
Altitude = 9,100 ft AGL, Speed 120 kn

Results: Point Density ~ 1.3 pts/m²
Area Acquisition Rate ~ 456 km²/h

Laser Pulse Repetition Rate = 600kHz, laser power level 100%

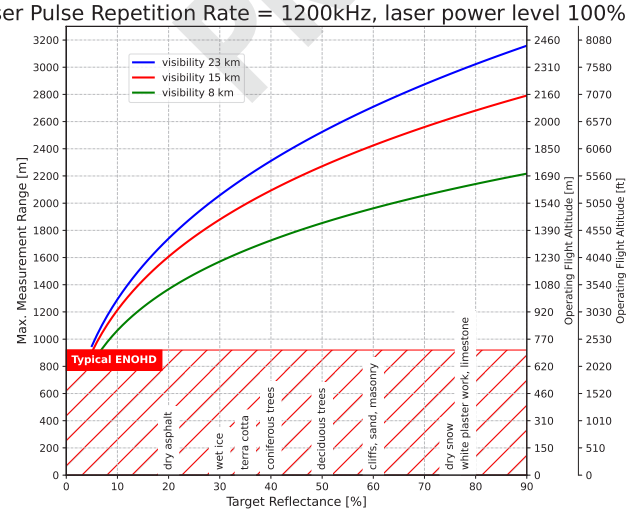


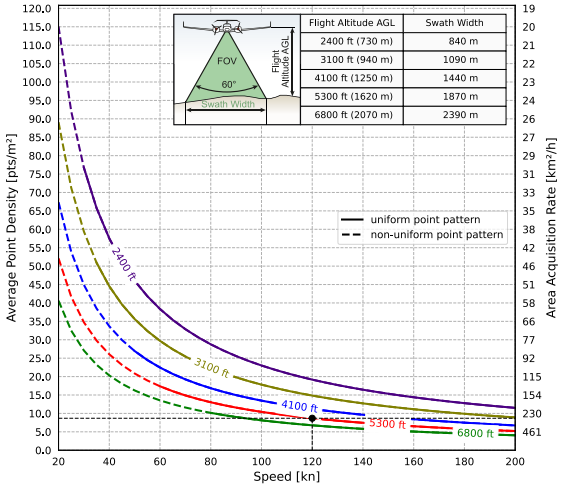


Example: VQ-1060 at 600,000 pulses/sec, laser power level 100%
Altitude = 7,000 ft AGL, Speed 120 kn

Results: Point Density ~ 3.3 pts/m²
Area Acquisition Rate ~ 350 km²/h

Laser Pulse Repetition Rate = 1200kHz, laser power level 100%





Example: VQ-1060 at 1,200,000 pulses/sec, laser power level 100%
Altitude = 5,100 ft AGL, Speed 120 kn

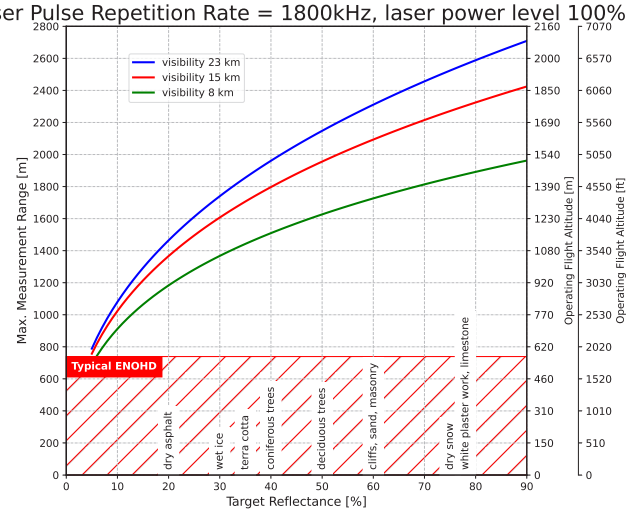
Results: Point Density ~ 9 pts/m²
Area Acquisition Rate ~ 255 km²/h

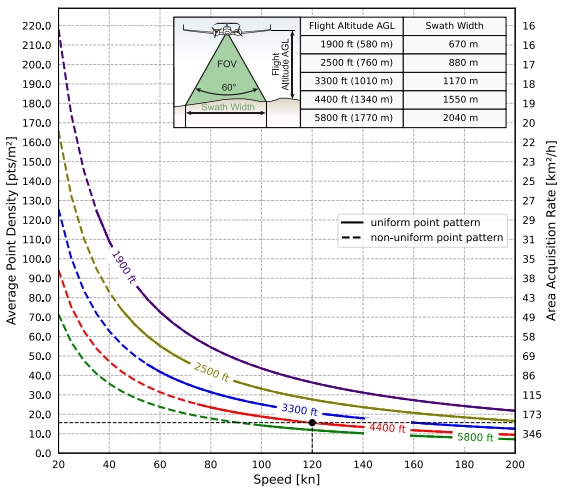
The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- roll angle ±5°
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of +/- 37.5°

Maximum Measurement Range & Point Density *RIEGL* VQ-1060

Laser Pulse Repetition Rate = 1800kHz, laser power level 100%

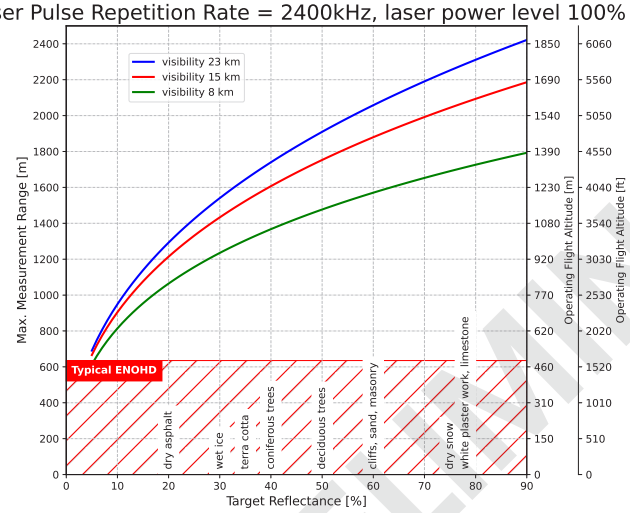


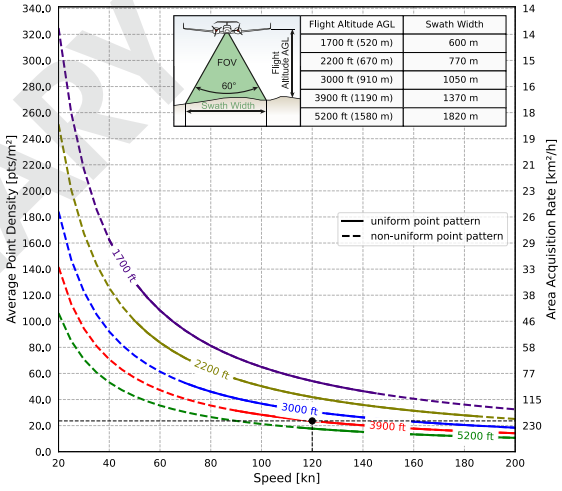


Example: VQ-1060 at 1,800,000 pulses/sec, laser power level 100%
Altitude = 4,400 ft AGL, Speed 120 kn

Results: Point Density ~ 15.7 pts/m²
Area Acquisition Rate ~ 220 km²/h

Laser Pulse Repetition Rate = 2400kHz, laser power level 100%





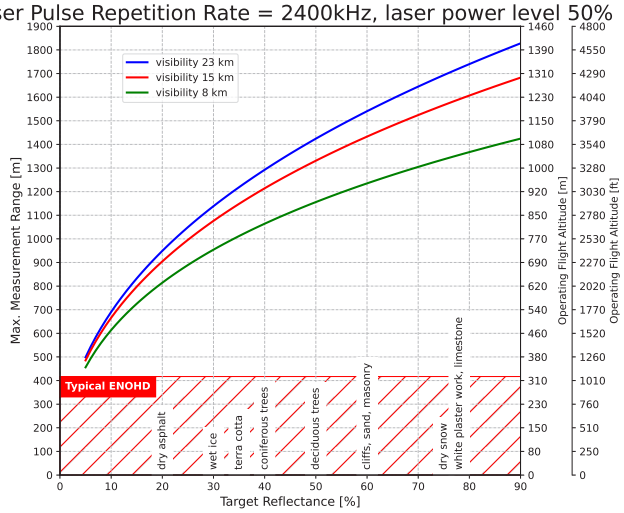
Example: VQ-1060 at 2,400,000 pulses/sec, laser power level 100%
Altitude = 3,900 ft AGL, Speed 120 kn

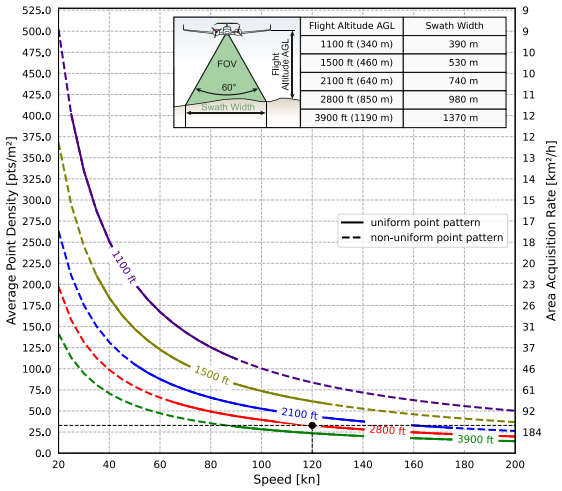
Results: Point Density ~ 23 pts/m²
Area Acquisition Rate ~ 195 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- roll angle ±5°
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of +/- 37.5°

Laser Pulse Repetition Rate = 2400kHz, laser power level 50%

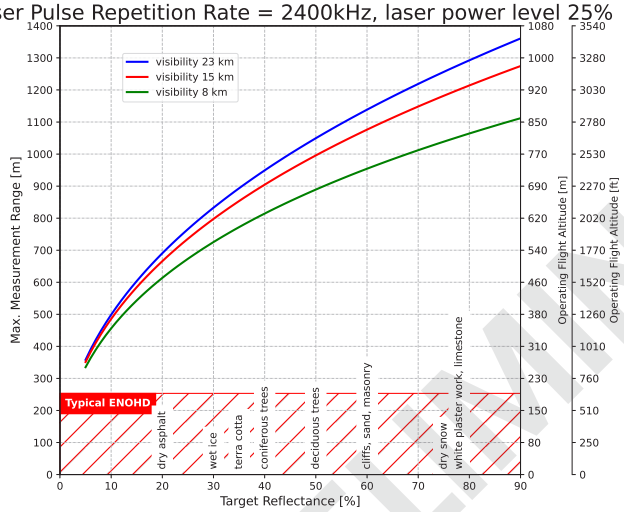


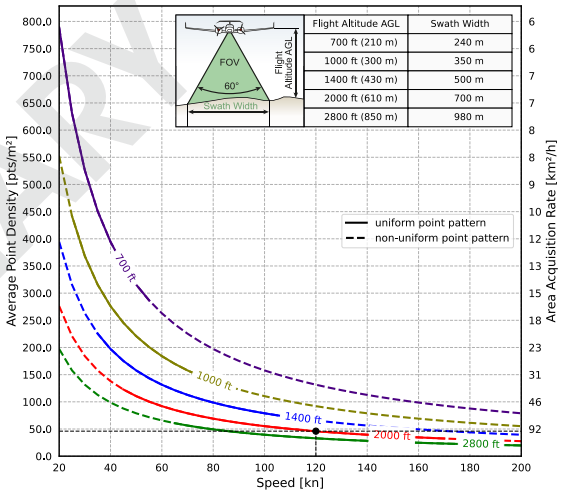


Example: VQ-1060 at 2,400,000 pulses/sec, laser power level 50%
Altitude = 2,800 ft AGL, Speed 120 kn

Results: Point Density ~ 33 pts/m²
Area Acquisition Rate ~ 140 km²/h

Laser Pulse Repetition Rate = 2400kHz, laser power level 25%

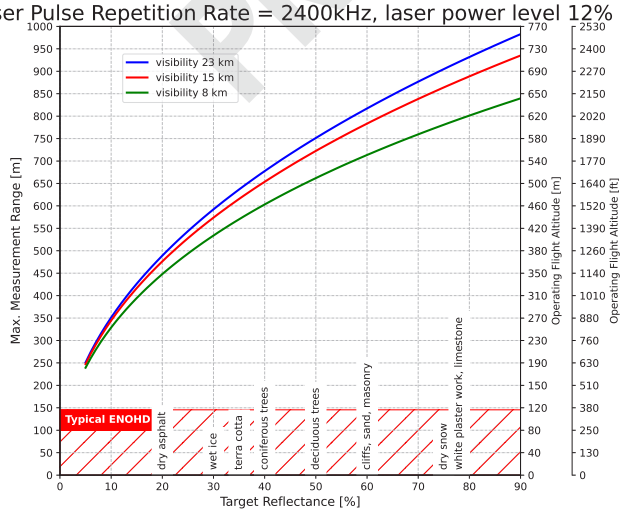


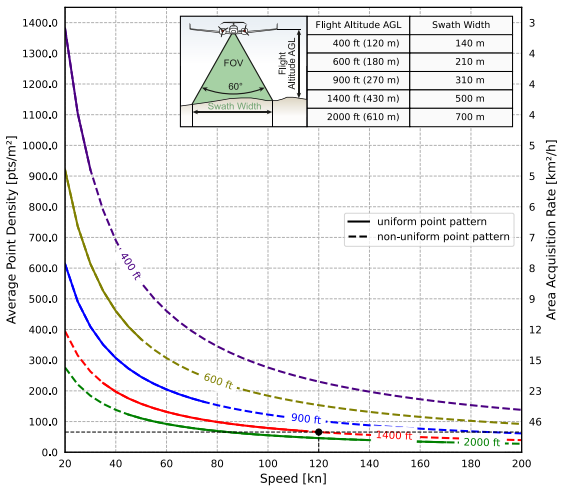


Example: VQ-1060 at 2,400,000 pulses/sec, laser power level 25%
Altitude = 2,000 ft AGL, Speed 120 kn

Results: Point Density ~ 46 pts/m²
Area Acquisition Rate ~ 100 km²/h

Laser Pulse Repetition Rate = 2400kHz, laser power level 12%





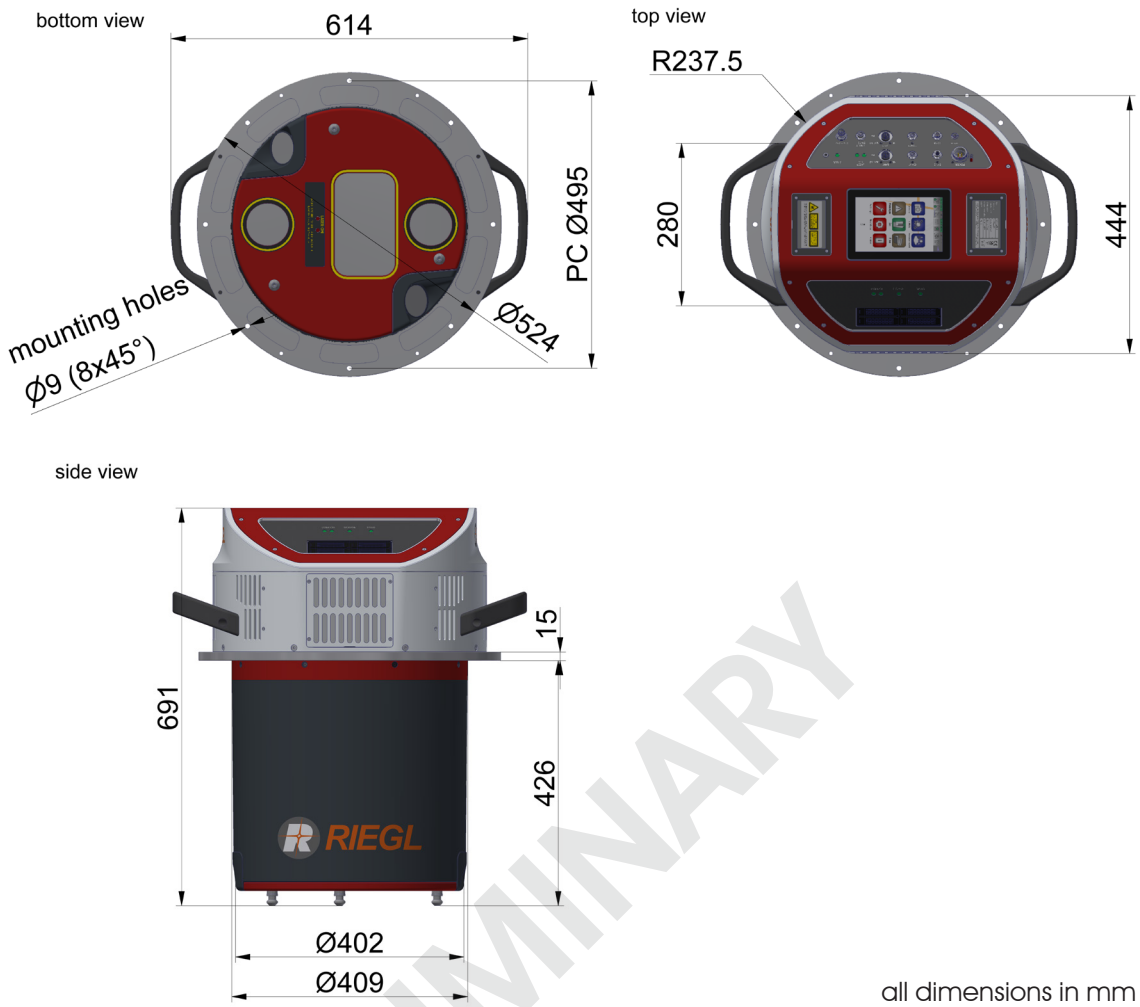
Example: VQ-1060 at 2,400,000 pulses/sec, laser power level 12%
Altitude = 1,400 ft AGL, Speed 120 kn

Results: Point Density ~ 66 pts/m²
Area Acquisition Rate ~ 70 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

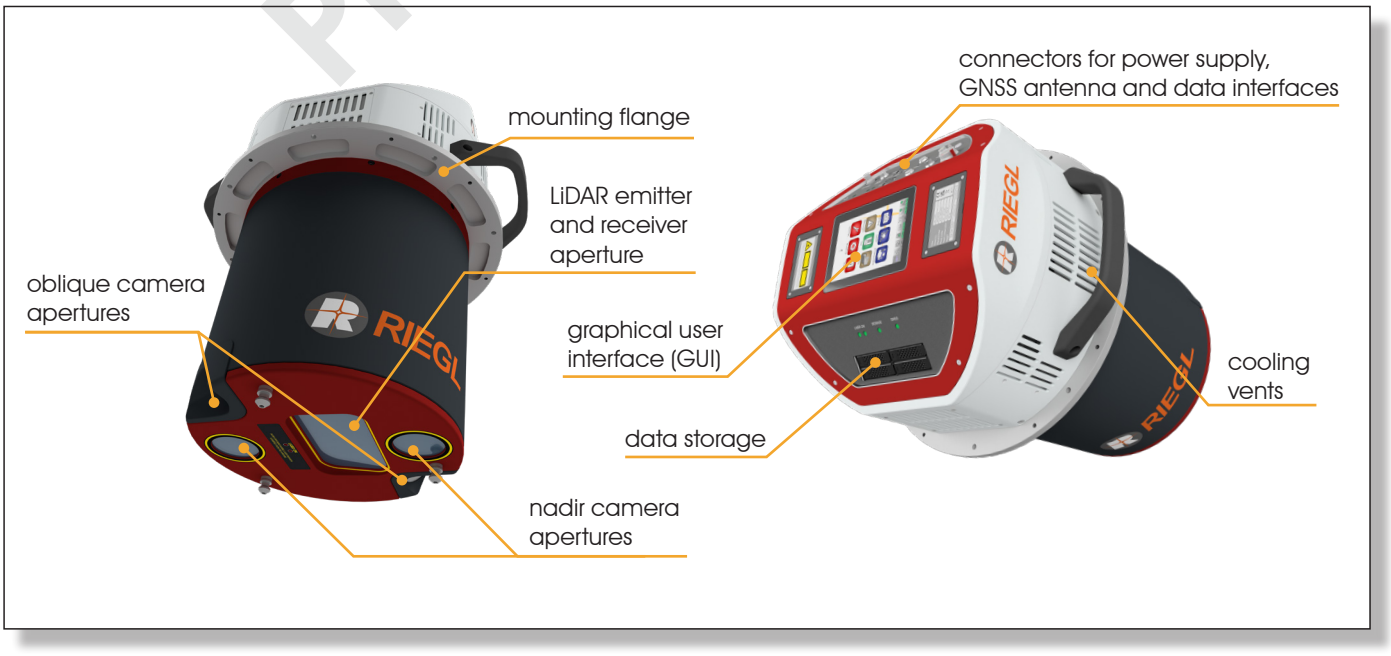
- ambiguity resolved by multiple-time-around (MTA) processing
- roll angle ±5°
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of +/- 37.5°

Dimensional Drawings VQ-1060



all dimensions in mm

RIEGL VQ-1060 Elements of Function and Operation



Laser Product Classification

Class 3B Laser Product according to IEC 60825-1:2014

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

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

Laser Power Level Laser Pulse Repetition Rate PRR [1]	100 % 300 kHz	100 % 600 kHz	100 % 1200 kHz	100 % 1800 kHz	100 % 2400 kHz
Max. Measuring Range [2] [3]					
natural targets ρ ≥ 20 %	3020 m	2310 m	1740 m	1460 m	1290 m
natural targets ρ ≥ 60 %	4470 m	3510 m	2710 m	2310 m	2060 m
Max. Operating Flight Altitude [2] [4] Above Ground Level (AGL)					
natural targets ρ ≥ 20 %	2330 m 7650 ft	1780 m 5850 ft	1340 m 4400 ft	1130 m 3700 ft	1000 m 3250 ft
natural targets ρ ≥ 60 %	3440 m 11300 ft	2700 m 8850 ft	2080 m 6850 ft	1780 m 5850 ft	1580 m 5200 ft
NOHD [5] [7]	200 m	138 m	95 m	75 m	62 m
ENOHD [6] [7]	1447 m	1015 m	708 m	569 m	489 m
Max. Number of Targets per Pulse [8]	32	24	11	7	5

Laser Power Level Laser Pulse Repetition Rate PRR [1]	50 % 2400 kHz	25 % 2400 kHz	12 % 2400 kHz
Max. Measuring Range [2] [3]			
natural targets ρ ≥ 20 %	950 m	690 m	490 m
natural targets ρ ≥ 60 %	1540 m	1140 m	820 m
Max. Operating Flight Altitude [2] [4] Above Ground Level (AGL)			
natural targets ρ ≥ 20 %	730 m 2400 ft	530 m 1750 ft	380 m 1250 ft
natural targets ρ ≥ 60 %	1180 m 3900 ft	880 m 2850 ft	630 m 2050 ft
NOHD [5] [7]	39 m	23 m	12 m
ENOHD [6] [7]	321 m	195 m	112 m
Max. Number of Targets per Pulse [8]	5	5	5

1) Rounded average PRR
2) Typical values for average conditions and average ambient brightness. In bright sunlight, the max. range is shorter 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 23 km. Range ambiguities have to be resolved by multiple-time-around processing.
4) Typical values for max. effective FOV 60°, additional roll angle ±5°, forward/backward scan angle 20°
5) Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition.
6) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition.
7) NOHD and ENOHD have been calculated for a typical angular step width with 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.
8) If more than one target is hit, the total laser transmitter power is split and, accordingly, the achieveable range is reduced.

Minimum Range	20 m
Accuracy [9] [11]	20 mm
Precision [10] [11]	20 mm
Laser Pulse Repetition Rate [12]	up to 2400 kHz
Max. Effective Measurement Rate	up to 2,000,000 meas./sec. (@ 2400 kHz PRR & 60° scan angle)
Echo Signal Intensity	provided for each echo signal
Laser Wavelength	near infrared
Laser Beam Divergence	typ. 0.28 mrad @ 1/e² [13], typ. 0.22 mrad @ 1/e [14]

9) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
10) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
11) One sigma @ 150 m range under *RIEGL* test conditions.
12) User selectable.
13) Measured at 1/e² points, 0.28 mrad corresponds to an increase of 28 mm of beam diameter per 100 m distance.
14) Measured at 1/e points, 0.22 mrad corresponds to an increase of 22 mm of beam diameter per 100 m distance.

Technical Data VQ-1060

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines, angular directions -20°, -10°, 0°, +10°, +20° transvers to the scan
Scan angle range	±30° = 60°
Total Scan Rate	50 [1] - 500 lines/sec.
Angular Step Width [2] $\Delta\vartheta$	0.008° ≤ $\Delta\vartheta$ ≤ 0.12° [3]
Angle Measurement Resolution	0.001°

Camera Configuration [4]

Cameras Nadir	150 MPix, RGB, focal length 50 mm
	150 MPix, NIR, focal length 50 mm
Cameras Oblique	+45 degrees, 150 MPix, RGB, focal length 110 mm, or 120 MPix, RGB, focal length 150 mm
	-45 degrees, 150 MPix, RGB, focal length 110 mm, or 120 MPix, RGB, focal length 150 mm
Maximum Frame Rate	1.5 frames per second and per camera

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 for Additional External Camera	2 connectors for power, RS-232, pps, trigger, exposure
Removable Data Storage	4 x 2.5" NVMe U.2driver carrier with 4 TByte SSD, total 16 TByte for scan and image data

General Technical Data

Power Supply	20 - 32 V DC
Power Consumption	typ. 360 W / max. 750 W
Main Dimensions (flange diameter x height)	Ø 524 mm x 691 mm (without flange mounted carrying handles)
Weight	approx. 70 kg
Protection Class	IP54[5]
Max. Flight Altitude	
Operating / Not Operating	18500 ft (5600 m) above MSL[6] / 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 [7]

IMU Accuracy [8]	
Roll, Pitch	0.0025°
Heading	0.005°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	0.05 m - 0.1 m

1) The minimum scan rate depends on the selected laser PRR.
2) The angular step width depends on the selected laser PRR.
3) The maximum angular step width is limited by the maximum scan rate.
4) Recommended camera configuration, details on request.
5) Housing below the mounting flange
6) Mean Sea Level
7) 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.
8) 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*

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