Airborne Laser Scanner with Online Waveform Processing

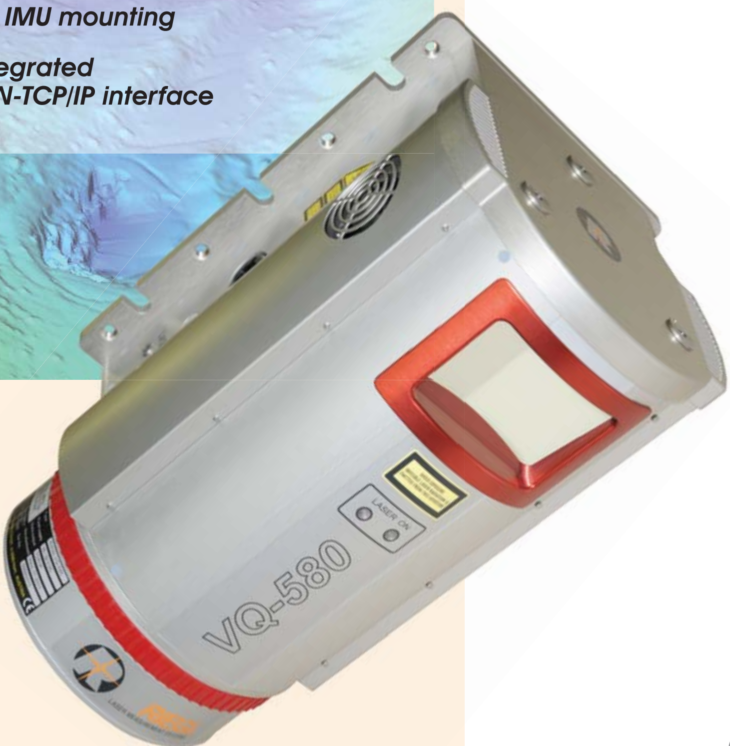
RIEGL VQ®-580

- *especially designed to measure on snow & ice*
- *high-accuracy ranging based on echo digitization and online waveform processing*
- *high laser repetition rate - fast data acquisition*
- *multiple target capability - unlimited number of targets*
- *perfectly linear scan lines*
- *compact, rugged and lightweight design*
- *electrical interfaces for GPS data string and Sync Pulse (1PPS)*
- *mechanical interface for IMU mounting*
- *integrated LAN-TCP/IP interface*

The V-Line® Airborne Laser Scanner *RIEGL* VQ-580 provides high speed, non-contact data acquisition using a narrow near-infrared laser beam and a fast line scanning mechanism. High-accuracy laser ranging is based on *RIEGL*´s unique echo digitization and online waveform processing, which allows achieving superior measurement results even under adverse atmospheric conditions, and the evaluation of multiple target echoes.

The scanning mechanism is based on a fast rotating multi-facet polygonal mirror, which provides fully linear, unidirectional and parallel scan lines.

The *RIEGL* VQ-580 is a very compact and lightweight scanner, mountable in any orientation and even under limited space conditions on helicopters or UAVs. The instrument needs only one power supply and provides line scan data via the integrated LAN-TCP/IP interface. The binary data stream can easily be decoded by user-designed software making use of the available software library RiVLib.



Typical applications include

- ***Glacier Mapping***
- ***Snowfield Mapping***
- ***Moist Grassland Mapping***
- ***Corridor Mapping***

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RIEGL®
LASER MEASUREMENT SYSTEMS

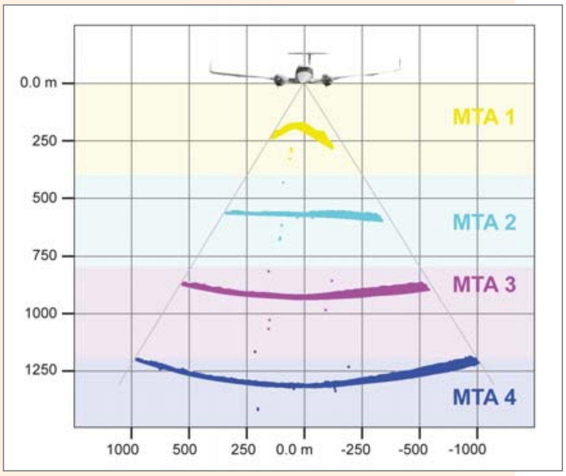


Fig. 1 Profile of scan data processed in MTA zones 1 to 4

In time-of-flight laser ranging a maximum unambiguous measurement range exists which is defined by the measurement repetition rate and the speed of light. When scanning at a pulse repetition rate of, e.g., 380 kHz, measurement ranges above approx. 395 m are ambiguous caused by an effect known as "Multiple-time-around" (MTA). In such case target echoes received may not be associated with their preceding laser pulses emitted any longer (MTA-zone 1), but have to be associated with their last but one (MTA-zone 2), or even last but two laser pulses emitted (MTA-zone 3), in order to determine the true measurement range.

Figure 1 gives an impression of ALS data where each single echo of a scan line is associated with each of its last four preceding laser shots emitted. Each single echo is represented by a measurement range calculated in MTA zone 1, 2, 3 and 4 respectively, but only one of the four realizations represents the true point cloud model of the scanned earth surface. The chosen example shows scan data correctly allocated in MTA zone 2, where the earth surface appears more or less flat in contrast to the typical spatial characteristics of incorrectly calculated ambiguous ranges in MTA zones 1, 3 and 4.

The *RIEGL* VQ-580 is capable of acquiring echo signals which arrive after a delay of more than one pulse repetition interval, thus allowing range measurements beyond the maximum unambiguous measurement range. Unique techniques in high-speed signal processing and a novel modulation scheme applied to the train of emitted laser pulses permit range measurements without any gaps at any distance within the instrument's maximum measurement range. The specific modulation scheme applied to the train of emitted laser pulses avoids a total loss of data at the transitions between MTA-zones and retains range measurement at approximately half the point density.

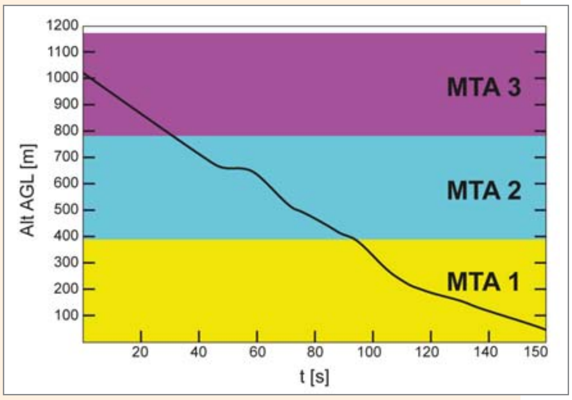
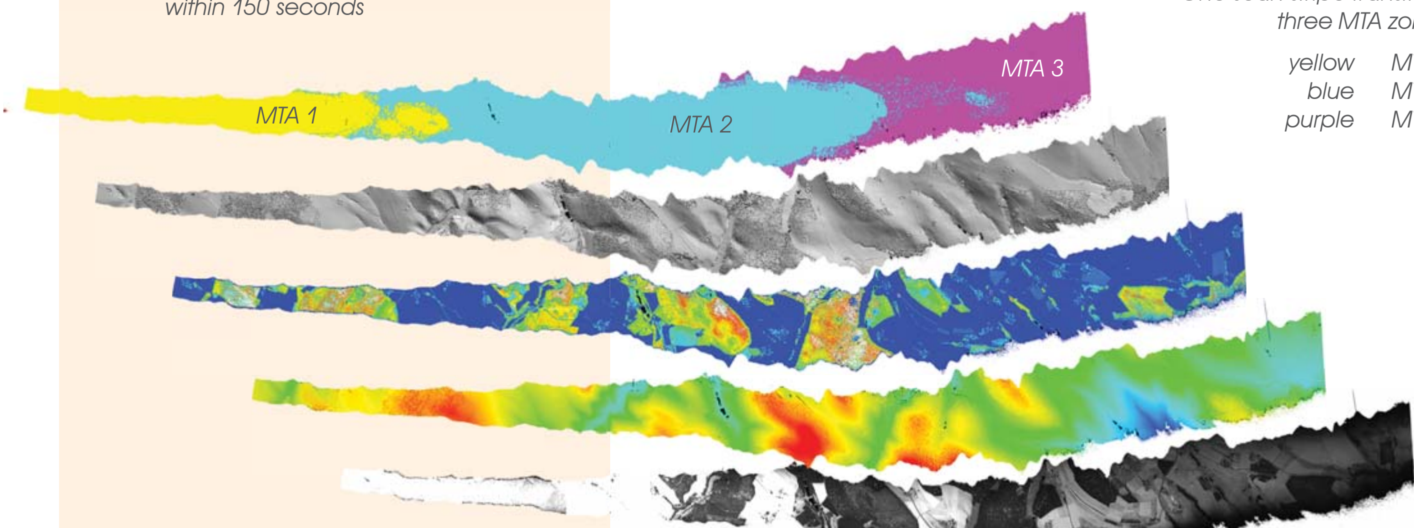


Fig. 2 Flight altitude above ground level descending from 1,000 m to 240 m within 150 seconds

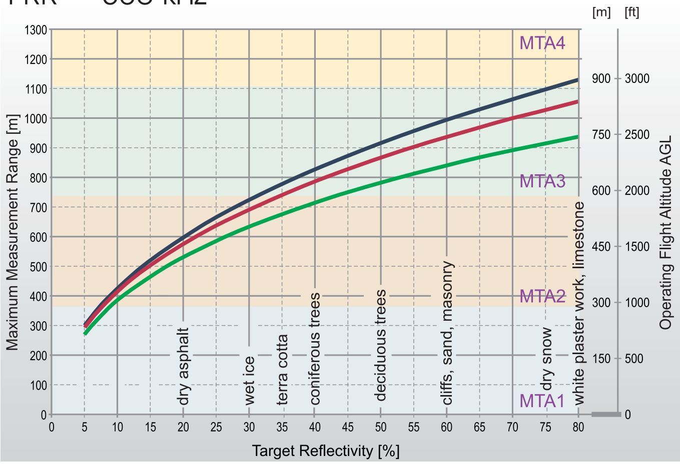
The correct resolution of ambiguous echo ranges is accomplished using SDCImport in combination with the associated algorithm library RiMTA ALS, which does not require any further user interaction, and maintains fast processing speed for mass data production.

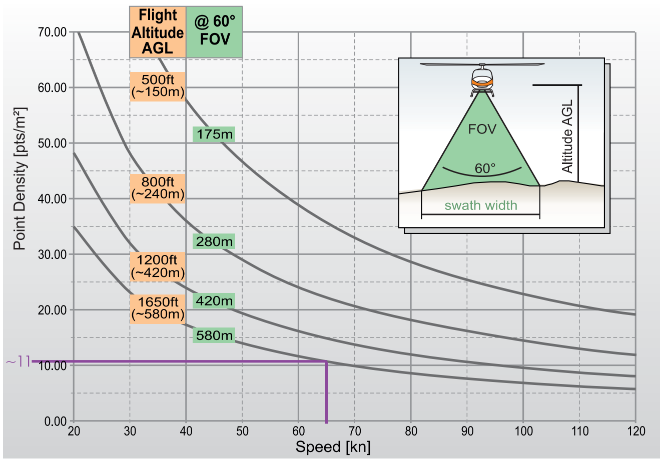
One scan stripe transitting three MTA zones:

yellow	*MTA 1*
blue	*MTA 2*
purple	*MTA 3*



PRR = 380 kHz



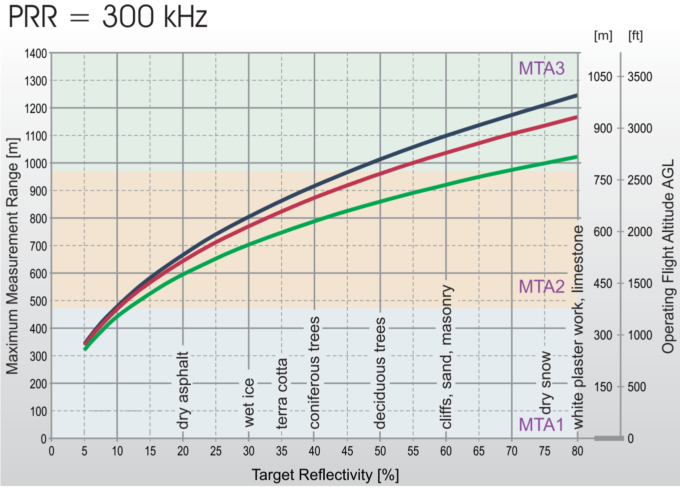


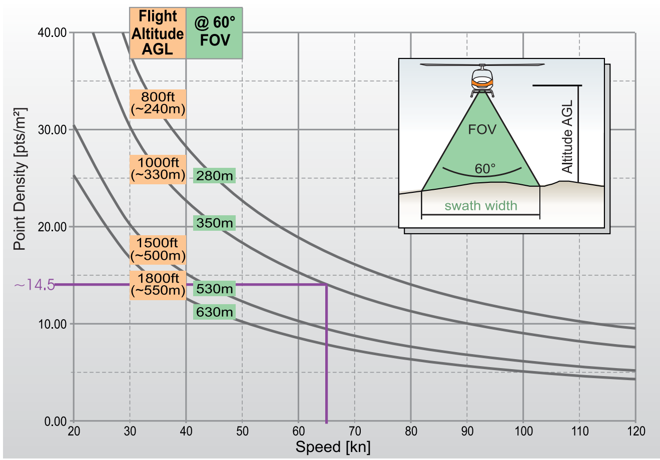
MTA1: no ambiguity / 1 transmitted pulse „in the air"
MTA2: 2 transmitted pulses „in the air"
MTA3: 3 transmitted pulses „in the air"
MTA4: 4 transmitted pulses „in the air"

@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 380,000 pulses/second
Altitude = 1650ft AGL, Speed = 65 kn
Resulting Point Density ~ 11 pts/m²

PRR = 300 kHz





MTA1: no ambiguity / 1 transmitted pulse „in the air"
MTA2: 2 transmitted pulses „in the air"
MTA3: 3 transmitted pulses „in the air"

@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 300,000 pulses/second
Altitude = 1000ft AGL, Speed = 65 kn
Resulting Point Density ~ 14.5 pts/m²

The following conditions are assumed:

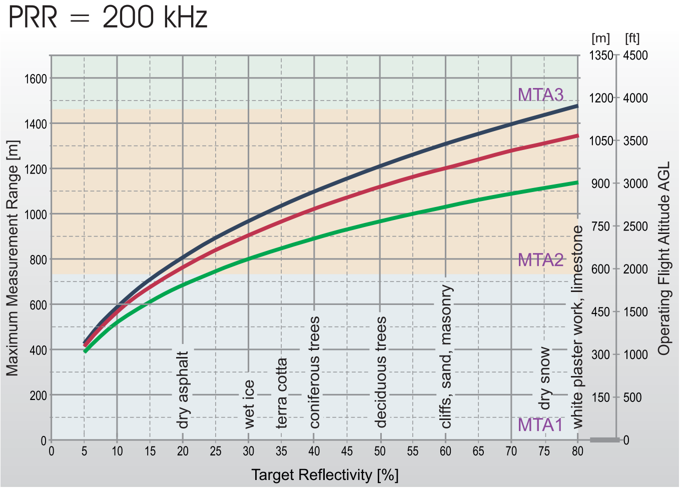
for the Operating Flight Altitude AGL

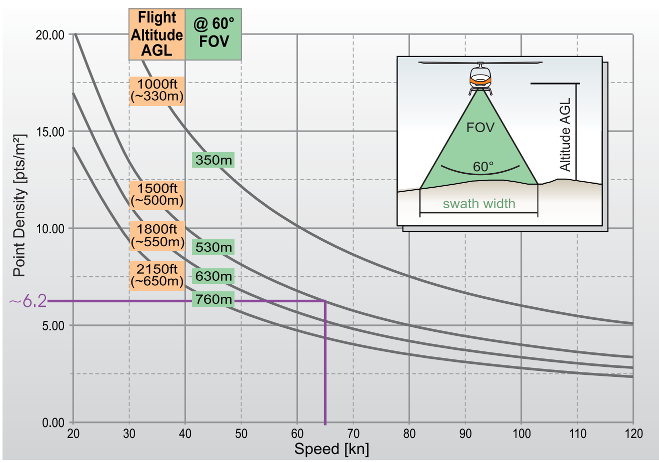
- ambiguity resolved by multiple-time-around (MTA) processing & flight planning
- target size ³ laser footprint
- scan angle 60°
- average ambient brightness
- roll angle +/-5°

for MTA zones

- half the point density in MTA-transition zones
- width of transition between MTA-zone 1 and 2 approx. 45 m
- width of transition between MTA-zone 2 and 3 approx. 75 m

PRR = 200 kHz





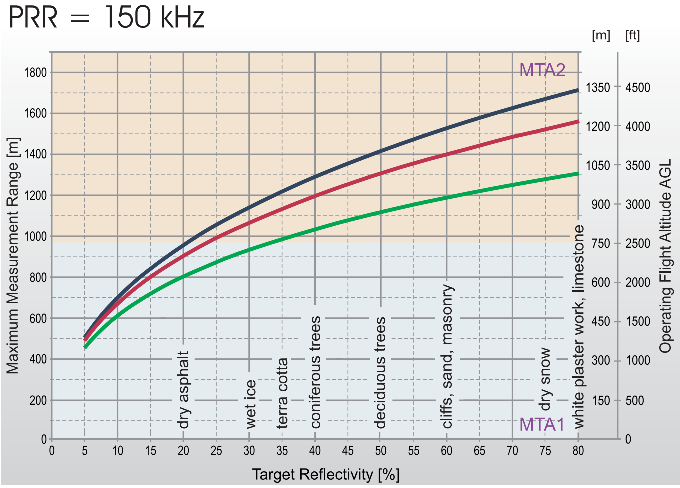
MTA1: no ambiguity / 1transmitted pulse „in the air"
MTA2: 2 transmitted pulses „in the air"
MTA3: 3 transmitted pulses „in the air"

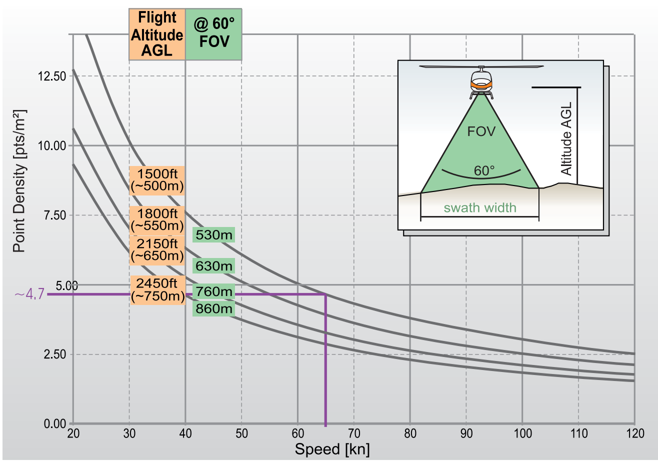
@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 200,000 pulses/second
Altitude = 1500ft AGL, Speed = 65 kn
Resulting Point Density ~ 6.2 pts/m²

Maximum Measurement Range & Point Density for *RIEGL* VQ®-580

PRR = 150 kHz



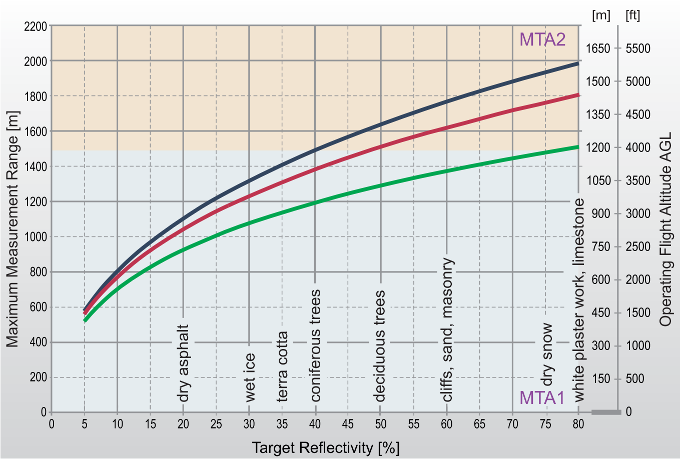


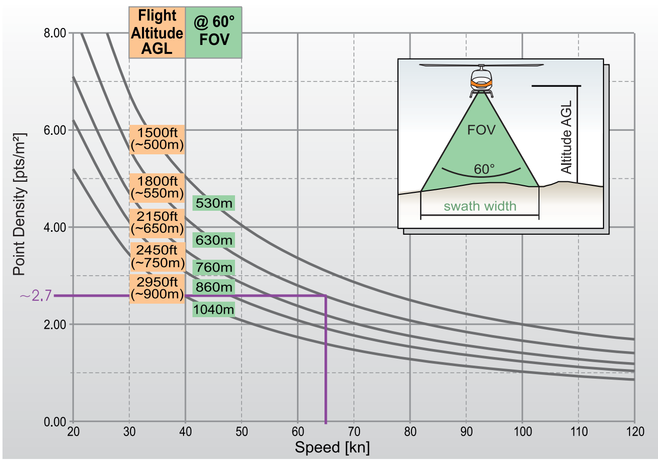
MTA1: no ambiguity / 1 transmitted pulse „in the air"
MTA2: 2 transmitted pulses „in the air"

@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 150,000 pulses/second
Altitude = 1500ft AGL, Speed = 65 kn
Resulting Point Density ~ 4.7 pts/m²

PRR = 100 kHz





MTA1: no ambiguity / 1 transmitted pulse „in the air"
MTA2: 2 transmitted pulses „in the air"

@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 100,000 pulses/second
Altitude = 1800ft AGL, Speed = 65 kn
Resulting Point Density ~ 14.5 pts/m²

The following conditions are assumed:

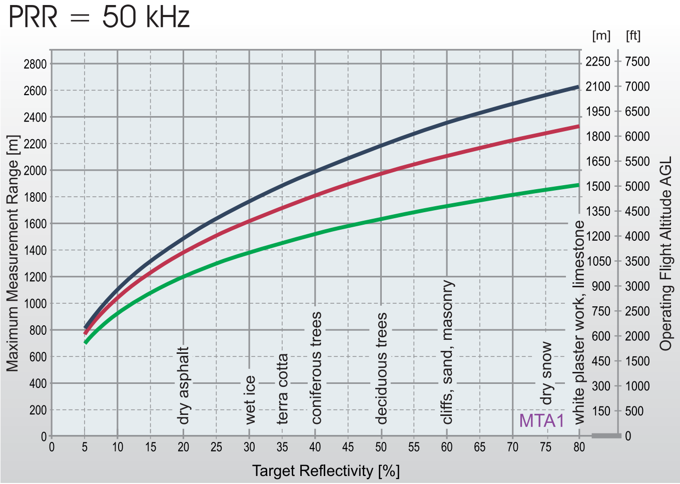
for the Operating Flight Altitude AGL

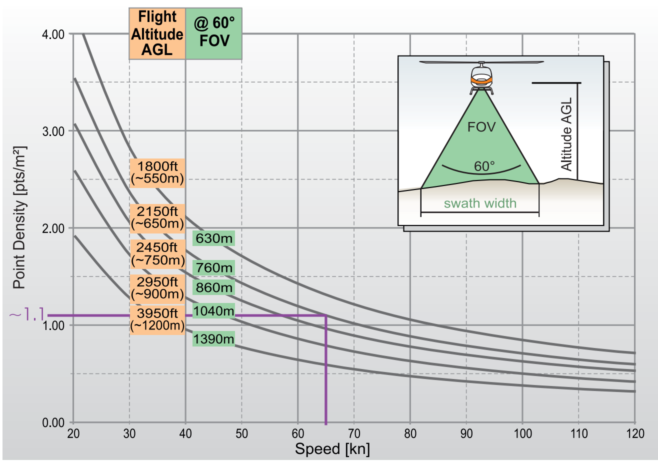
- ambiguity resolved by multiple-time-around (MTA) processing & flight planning
- target size ³ laser footprint
- scan angle 60°
- average ambient brightness
- roll angle +/-5°

for MTA zones

- half the point density in MTA-transition zones
- width of transition between MTA-zone 1 and 2 approx. 45 m
- width of transition between MTA-zone 2 and 3 approx. 75 m

PRR = 50 kHz



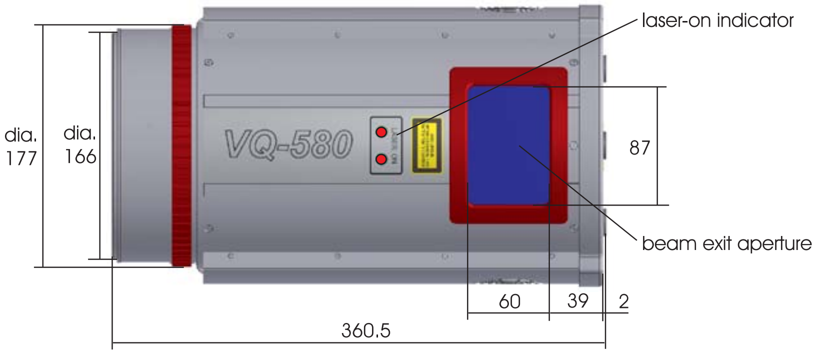


MTA1: no ambiguity / 1 transmitted pulse „in the air"

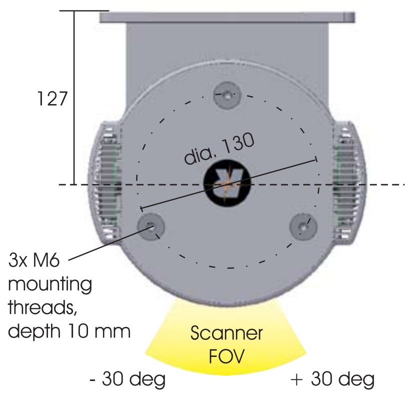
@ visibility 23 km
@ visibility 15 km
@ visibility 8 km

Example: VQ-580 at 50,000 pulses/second
Altitude = 2150ft AGL, Speed = 65 kn
Resulting Point Density ~ 1.1 pts/m²

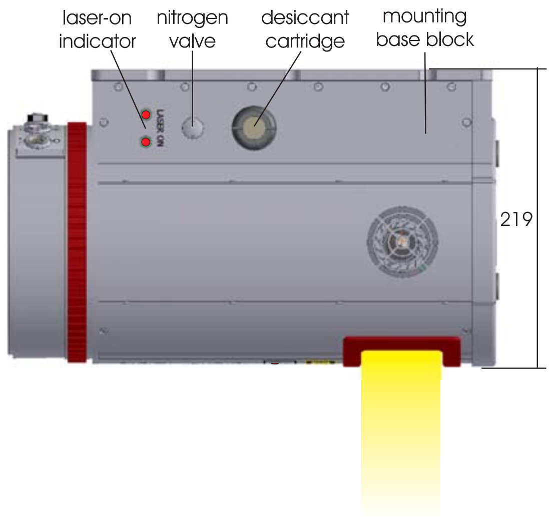
bottom view



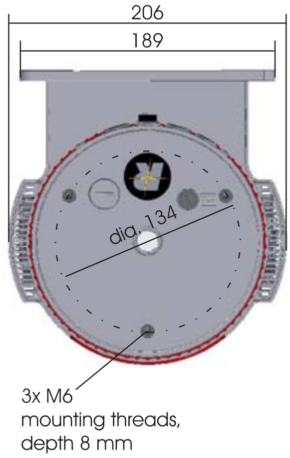
front view



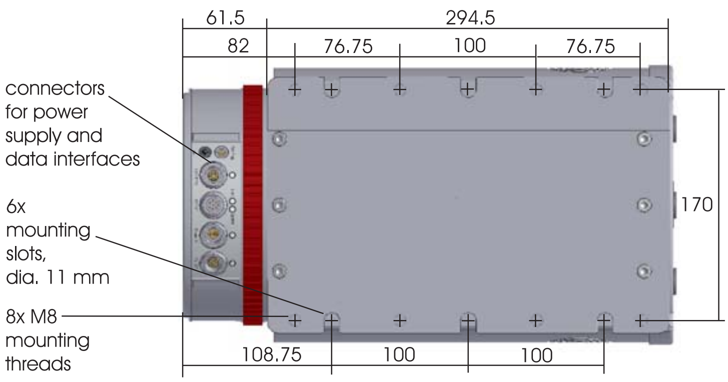
side view



rear view



top view



all dimensions in mm

Technical Data *RIEGL* VQ®-580

Laser Product Classification

Class 3B Laser Product according to IEC60825-1:2007

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

The following clause applies for instruments delivered into the United States: Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

INVISIBLE LASER RADIATION AVOID EXPOSURE TO BEAM CLASS 3B LASER PRODUCT

MAX. AVERAGE OUTPUT <18 mW PULSE DURATION APPROX. 3.3 ns WAVELENGTH 1064 nm STANDARD IEC60825-1:2007

Range Measurement Performance

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

Laser Pulse Repetition Rate PRR [1]	*50 kHz*	*100 kHz*	*150 kHz*	*200 kHz*	*300 kHz*	*380 kHz*
Effective Measurement Rate (meas./sec.) [1] [2]	25 000	50 000	75 000	100 000	150 000	190 000
Max. Unambiguous Measuring Range [3] [4] [5]						
natural targets ρ ≥ 20 %	1500 m	1100 m	900 m	800 m	650 m	600 m
natural targets ρ ≥ 60 %	2350 m	1750 m	1500 m	1300 m	1100 m	1000 m
Max. Operating Flight Altitude AGL [2]	1200 m	900 m	750 m	650 m	550 m	500 m
	3950 ft	2950 ft	2450 ft	2150 ft	1800 ft	1650 ft
Max. Number of Targets per Pulse	practically unlimited (details on request)					
NOHD [6]	72 m	37 m	18 m	1 m	-	-
eNOHD [7]	555 m	337 m	249 m	1 m	1 m	1 m

1) Rounded values.
2) Reflectivity ρ ≥ 20%, ±30° FOV, additional roll angle ±5°.
3) The following conditions are assumed: target larger than the footprint of the laser beam, perpendicular angle of incidence, visibility 23 km, average ambient brightness.
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 RiMTA ALS software.
6) Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, for single pulse condition
7) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, for single pulse condition

Minimum Range [8]	10 m
Accuracy [9] [11]	25 mm
Precision [10] [11]	25 mm
Laser Pulse Repetition Rate [1] [12]	up to 380 kHz
Max. Effective Measurement Rate [1]	up to 190 000 meas./sec. (@ 380 kHz PRR & 60° FOV)
Echo Signal Intensity	for each echo signal, high-resolution 16 bit intensity information is provided
Laser Wavelength	near infrared
Laser Beam Divergence [13]	0.2 mrad
Laser Beam Footprint (Gaussian Beam Definition)	22 mm @ 100 m, 52 mm @ 250 m, 102 mm @ 500 m

8) Limitation for range measurement capability does not consider laser safety
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 the 1/e² points. 0.20 mrad correspond to an increase of 20 cm of beam diameter per 1000 m distance.

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Field of View (selectable)	60° (+30° / -30°)
Scan Speed (selectable)	10 - 150 scans/sec
Angular Step Width Δ ϑ (selectable) between consecutive laser shots	0.003° ≤ Δ ϑ ≤ 0.36°
Angle Measurement Resolution	0.001°
Internal Sync Timer	for real-time synchronized time stamping of scan data
Scan Sync (optional)	scanner rotation synchronization

Data Interfaces

Configuration	LAN 10/100/1000 Mbit/sec
Scan Data Output	LAN 10/100/1000 Mbit/sec
GPS-System	Serial RS232 interface for data string with GPS-time information, TTL input for 1PPS synchronization pulse

Mechanical Interfaces

Mounting of the Laser Scanner	mounting base block (with 8 x M8 thread inserts and 6x mounting slots)
Mounting of IMU sensor	3 x M6 thread inserts in the rear and the front plate (rigidly coupled with the internal mechanical structure)

General Technical Data

Power Supply Input Voltage	18 - 32 V DC
Current Consumption	typ. 65 W
Main Dimensions / Weight	360.5 x 206 x 219 mm (length x width x height), approx. 13 kg
Humidity	max. 80 % non condensing @ +31°C
Protection Class	IP64, dust and splash-proof
Max. Flight Altitude (operating)	16 500 ft (5 000 m) above MSL
Max. Flight Altitude (not operating)	18 000 ft (5 500 m) above MSL
Temperature Range	-10°C up to +40°C (operation) / -20°C up to +50°C (storage)

RIEGL® LASER MEASUREMENT SYSTEMS

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