Full Waveform Digitizing, Dual Channel
Airborne LiDAR Scanning System for Ultra Wide Area Mapping

RIEGL LMS-Q1560

- *high laser pulse repetition rate up to 800 kHz*
- *digitization electronics for full waveform data*
- *innovative forward/backward looking capability*
- *single multifacet polygon mirror for beam deflection*
- *integrated multi-megapixel aerial medium format camera*
- *integrated secondary camera (e.g. IR-camera)*
- *integrated inertial navigation system and GNSS receiver*
- *fiber coupled high speed data interface to single RIEGL Data Recorder*
- *single power supply*
- *various interfaces to external cameras, GNSS etc.*
- *mounting flange for interfacing with typical hatches and stabilized platforms*
- *compact and robust housing*

The new high performance, fully integrated long-range airborne laser scanner system *RIEGL* LMS-Q1560 is a cutting-edge tool for a variety of airborne surveying missions. The two channel scanner makes use of powerful laser sources, Multiple-Time-Around (MTA) processing, echo digitization and waveform analysis. That allows operation at varying flight altitudes and is therefore ideally suited for aerial survey of ultra wide areas as well as of complex urban environments.

The *RIEGL* LMS-Q1560 can be operated at a maximum pulse repetition rate of 800 kHz providing an effective measurement rate of 532,000 measurements on the ground, and operates at an altitude of up to 15,500 ft. Usually occurring range ambiguities at this measurement rate are automatically resolved by *RIEGL*'s multiple time around processing software RiMTA, handling more than 10 pulses in the air simultaneously. This enables much faster and more efficient flight planning and safer flights.

The *RIEGL* LMS-Q1560 comes with a unique and innovative forward/backward looking capability. This enables capturing data from multiple angles more effectively and more accurately at high point density. With its large field of view of 58 degrees and its widely variable scan parameters the system accounts for highest efficiency of scan data acquisition in its class.

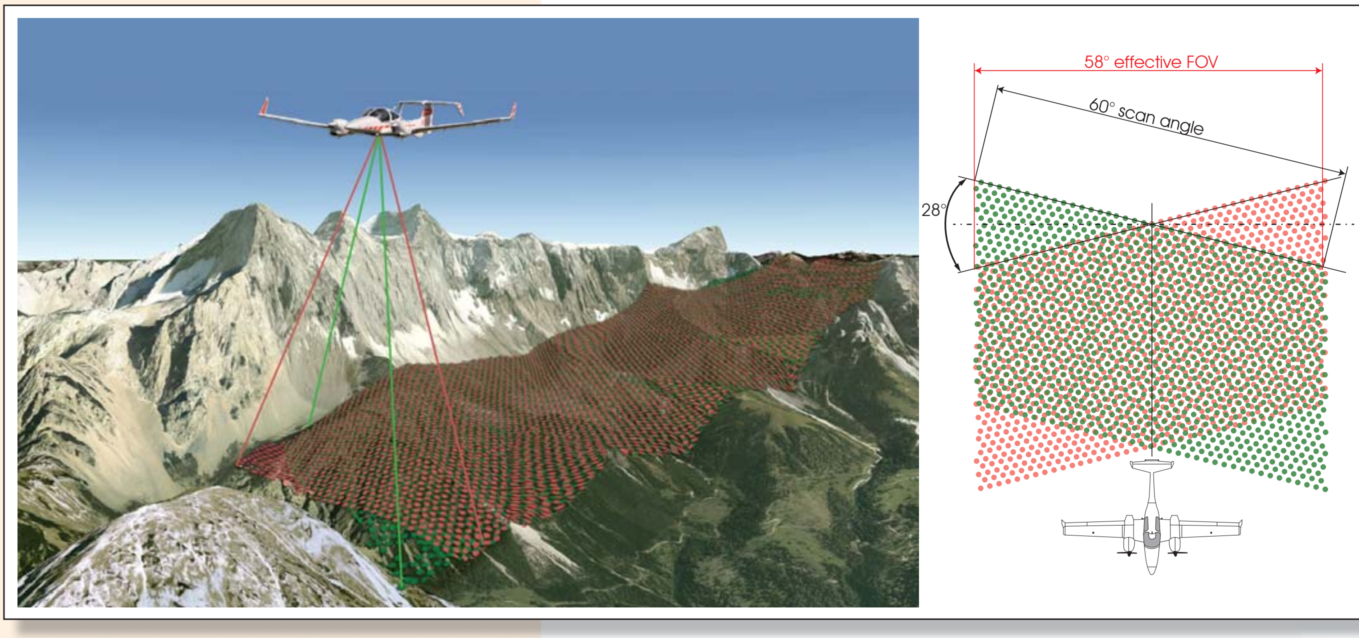
The system is equipped with a seamlessly integrated IMU/GNSS system. Optionally, an already available IMU sensor may be easily integrated; making the *RIEGL* LMS-Q1560 a cost-effective solution for system upgrades. An 80 megapixel RBG camera and the capability to in tegrate a secondary IR camera complete the system. With all individual components integrated into one single instrument of compact design, suited for gyro-stabilized leveling mounts, the system installation is outstandingly easy and straight-forward.

Applications:
- *Ultra Wide Area / High Altitude 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

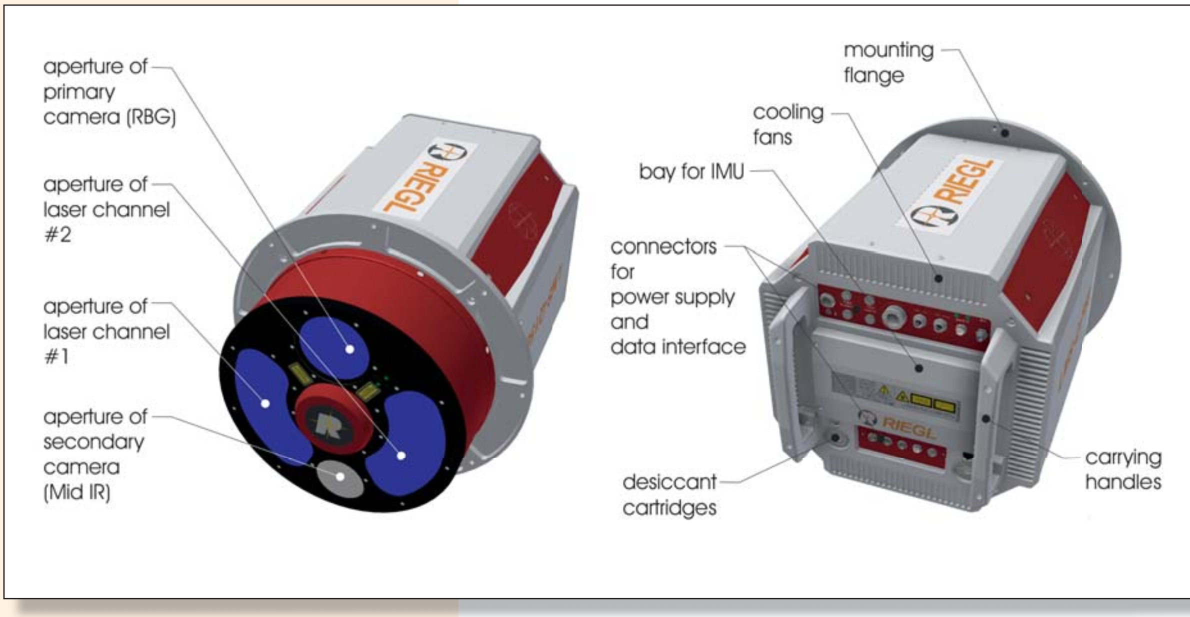
RIEGL LMS-Q1560 Scan Pattern



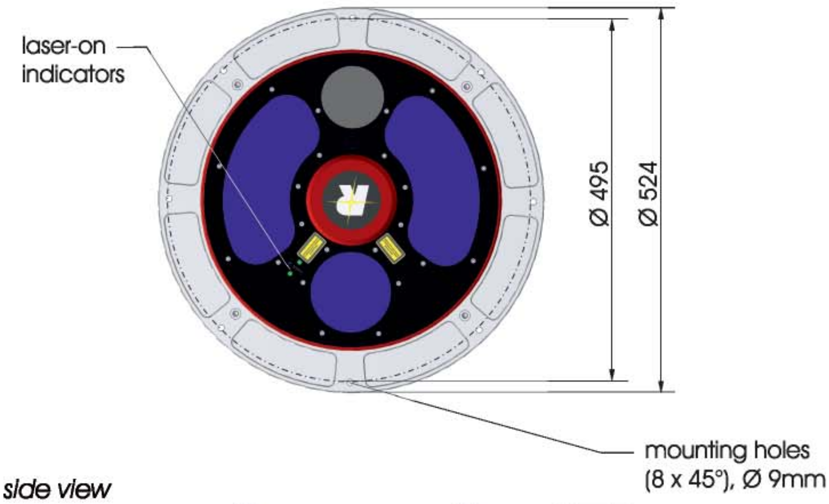
Each channel delivers straight parallel scan lines. The scan lines of the two channels are tilted against each other by 28 degrees providing an optimum distribution of the measurements on the ground invariant to changes in terrain height.

Tilt Angle of Scan Lines	**+/- 14°**
Forward/Backward Look in Non-Nadir Direction	**+/-8° at the edges**

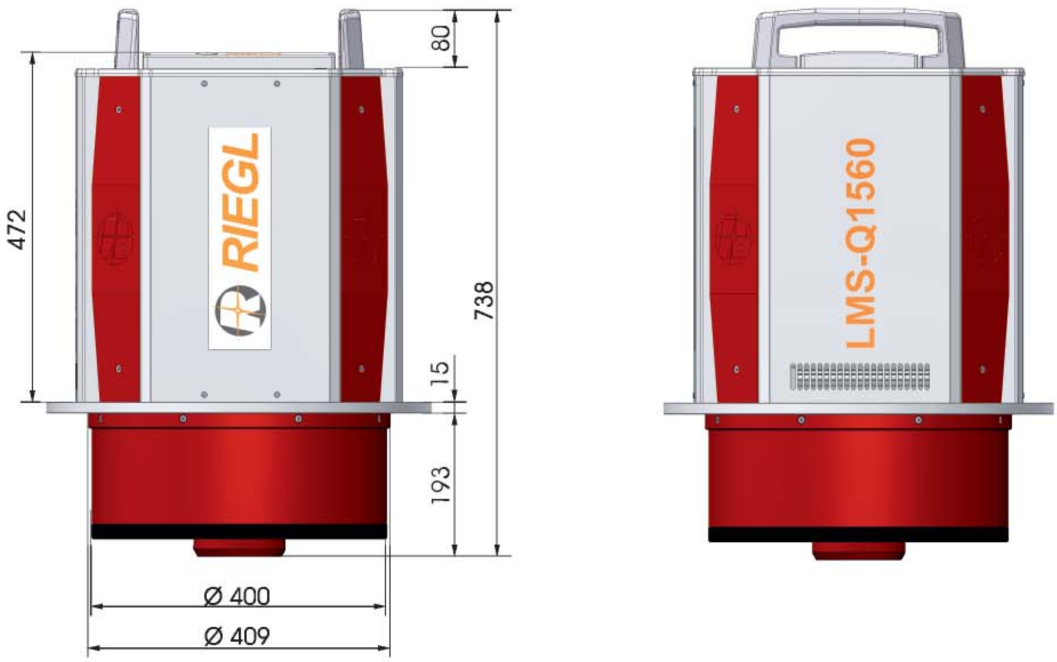
RIEGL LMS-Q1560 Housing



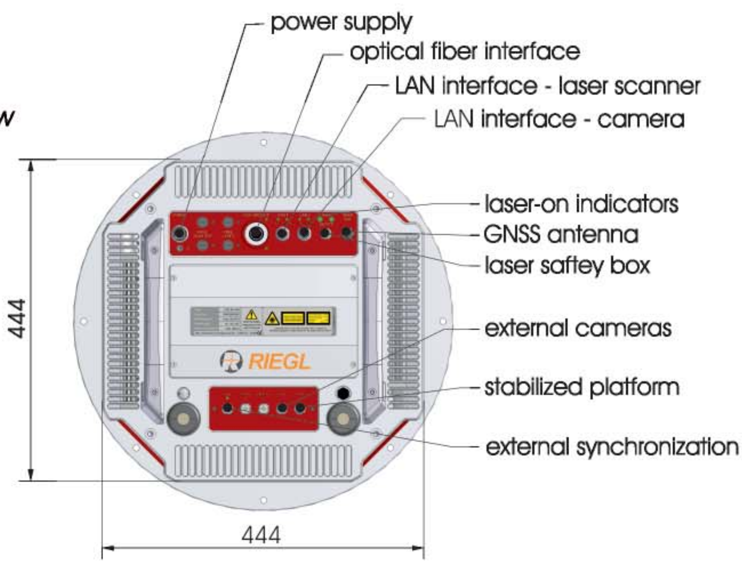
bottom view



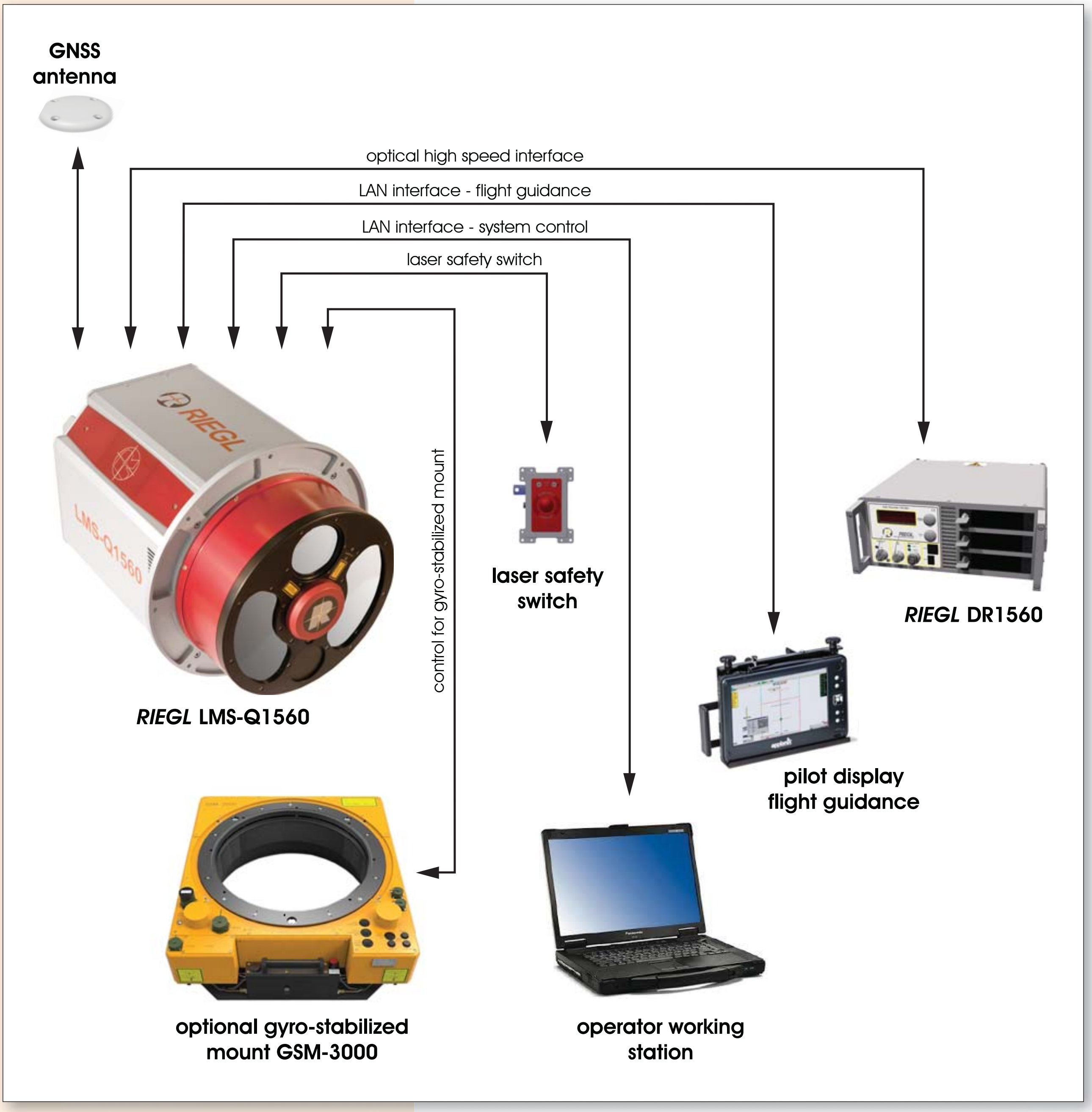
side view



top view



all dimensions in mm

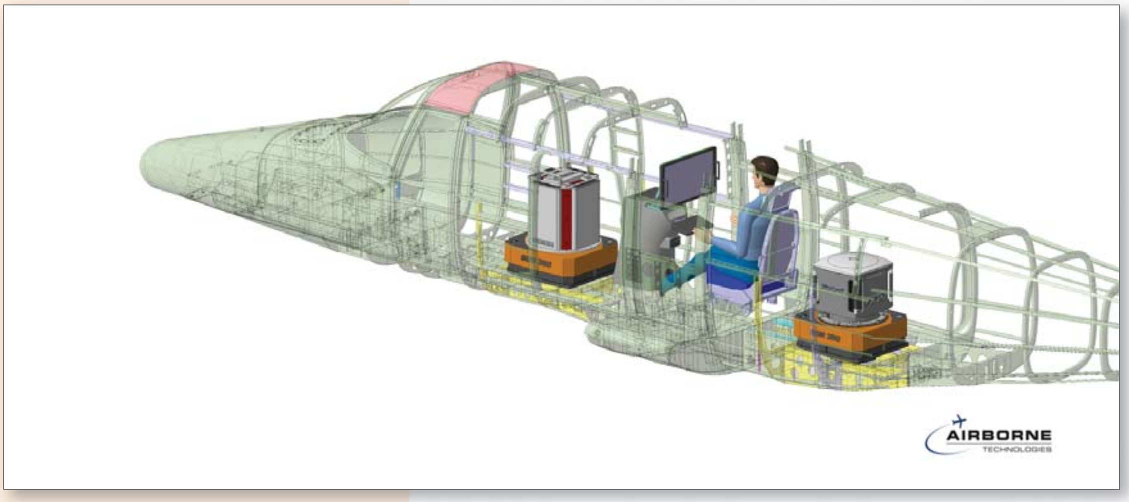


A minimum number of system components and external cabling is required for easy and quick installation in aircrafts.

RIEGL LMS-Q1560 installed
in the nose pod of fixed-wing
aircraft **DA42 MPP**

RIEGL LMS-1560 installed on GSM-3000
gyro-stabilized platform to be used in
a helicopter or fixed-wing aircraft

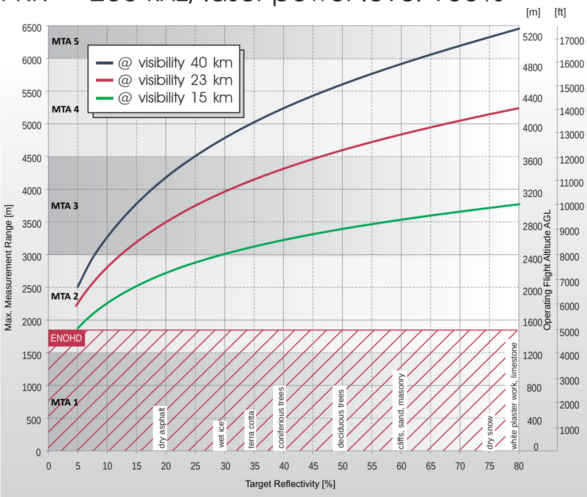
RIEGL LMS-Q1560 installed on GSM-3000 stabilized
platform in the fixed-wing aircraft **TECNAM MMA**

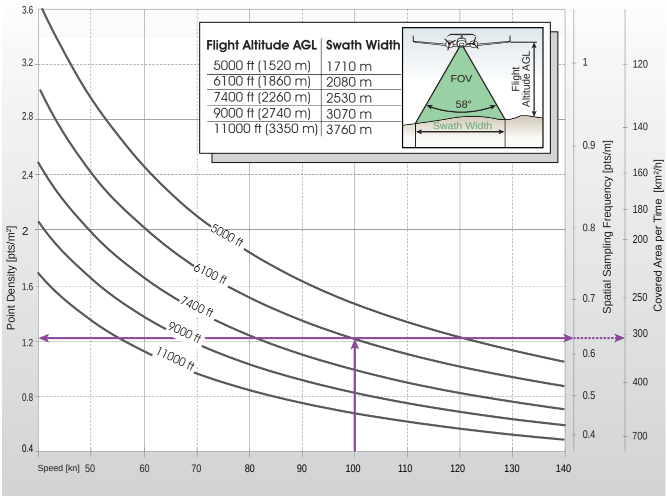


RIEGL LMS-Q1560 installed on GSM-3000 stabilized
platform in the fixed-wing aircraft **A-VIATOR AP68PT-600**

Measurement Range & Point Density *RIEGL* LMS-Q1560

PRR = 200 kHz, laser power level 100%

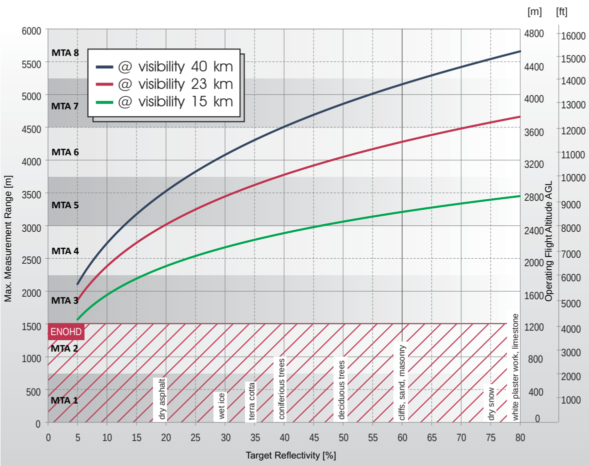


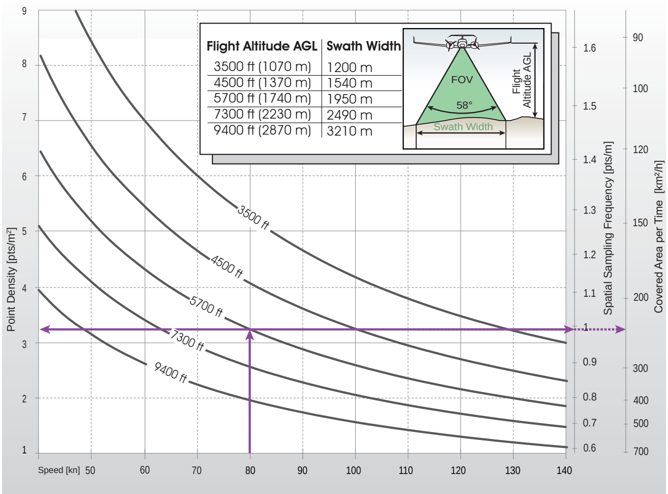


Example: LMS-Q1560 at 200,000 pulses/sec, laser power level 100%
Altitude = 6100ft AGL, Speed = 100 kn

Results: Point Density ~ 1.2 pts/m²
Spatial Sampling Frequency ~ 0.62 pts/m
Covered Area per Time ~ 310 km²/h

PRR = 400 kHz, laser power level 100%

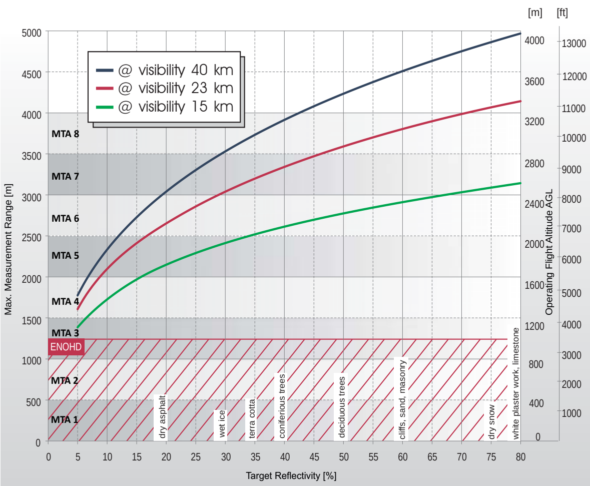


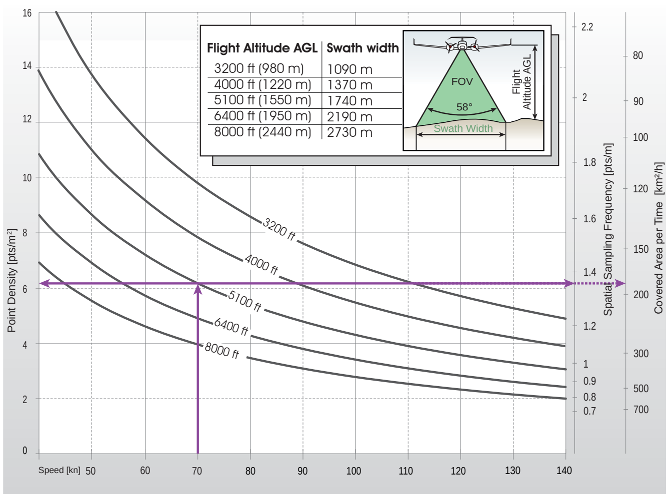


Example: LMS-Q1560 at 400,000 pulses/sec, laser power level 100%
Altitude = 5700ft AGL, Speed = 80 kn

Results: Point Density ~ 3.2 pts/m²
Spatial Sampling Frequency ~ 1 pts/m
Covered Area per Time ~ 250 km²/h

PRR = 600 kHz, laser power level 100%





Example: LMS-Q1560 at 600,000 pulses/sec, laser power level 100%
Altitude = 5100ft AGL, Speed = 70 kn

Results: Point Density ~ 6.2 pts/m²
Spatial Sampling Frequency ~ 1.38 pts/m
Covered Area per Time ~ 180 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

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

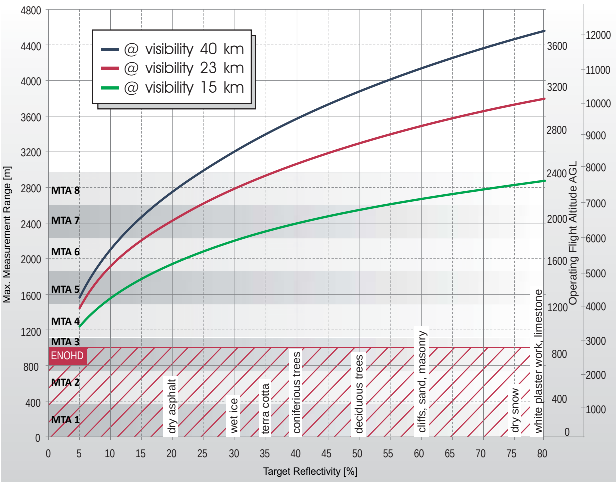
Assumptions for calculation of the Covered Area per Time

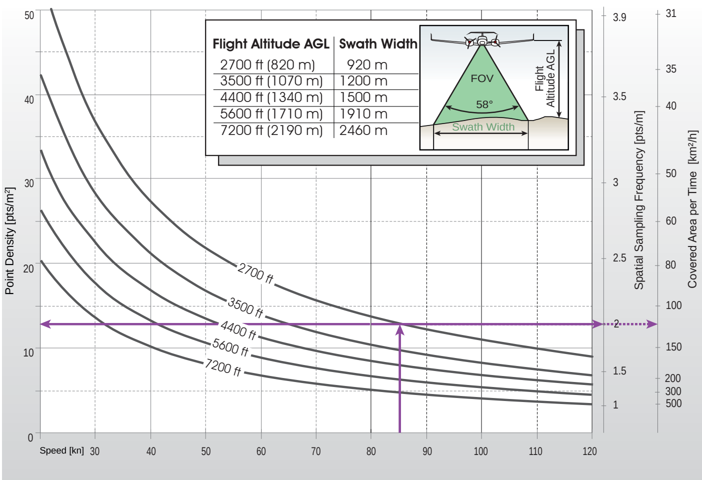
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

Definition of the Spatial Sampling Frequency

- The Spatial Sampling Frequency is the reciprocal of the 95th percentile of the distribution function of the maximum distances between neighboring scan points. When considering any individual scan point, the probability to find its most distant neighbor within the reciprocal of the Spatial Sampling Frequency is 95%.

PRR = 800 kHz, laser power level 100%

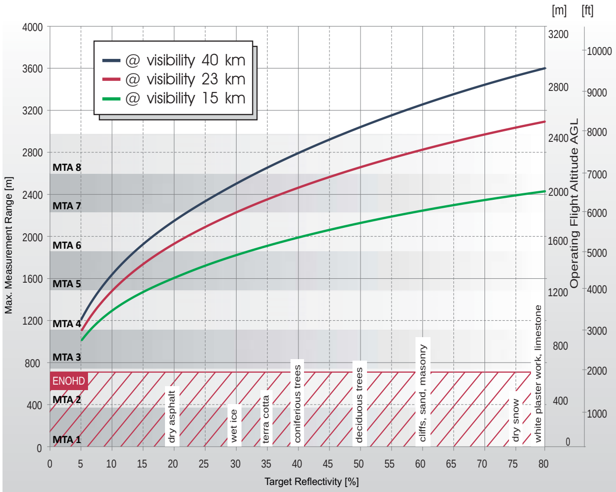


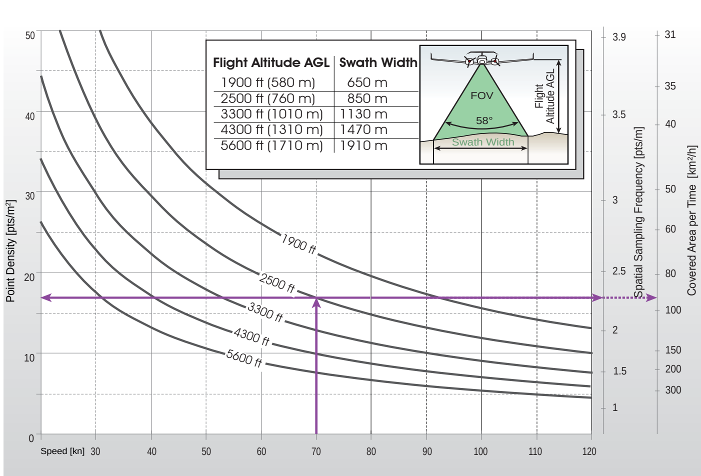


Example: LMS-Q1560 at 800,000 pulses/sec, laser power level 100%
Altitude = 2700ft AGL, Speed = 85 kn

Results: Point Density ~ 12.8 pts/m²
Spatial Sampling Frequency ~ 2 pts/m
Covered Area per Time ~ 120 km²/h

PRR = 800 kHz, laser power level 50%

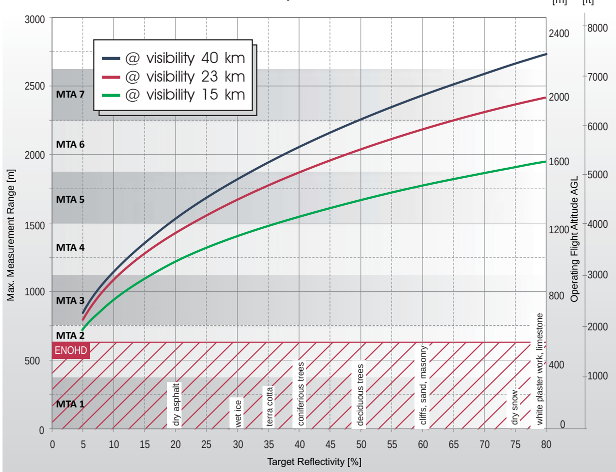


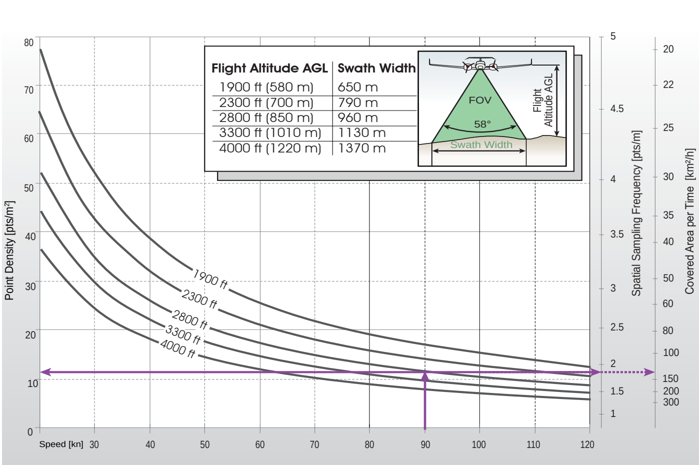


Example: LMS-Q1560 at 800,000 pulses/sec, laser power level 50%
Altitude = 2500ft AGL, Speed = 70 kn

Results: Point Density ~ 16.8 pts/m²
Spatial Sampling Frequency ~ 2.2 pts/m
Covered Area per Time ~ 95 km²/h

PRR = 800 kHz, laser power level 25%





Example: LMS-Q1560 at 800,000 pulses/sec, laser power level 25%
Altitude = 2800ft AGL, Speed = 90 kn

Results: Point Density ~ 11.6 pts/m²
Spatial Sampling Frequency ~ 1.8 pts/m
Covered Area per Time ~ 140 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

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

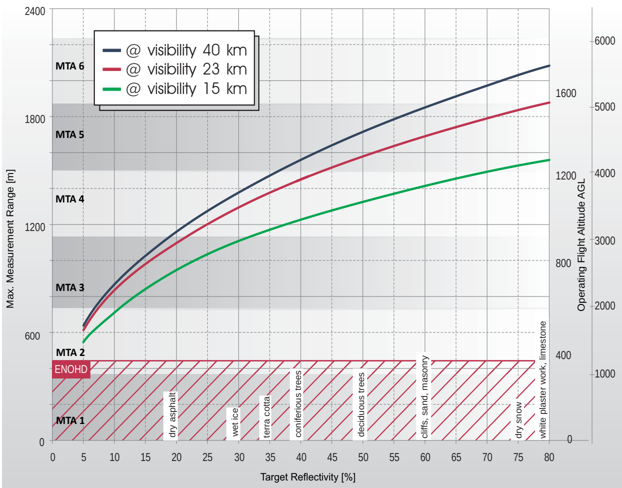
Assumptions for calculation of the Covered Area per Time

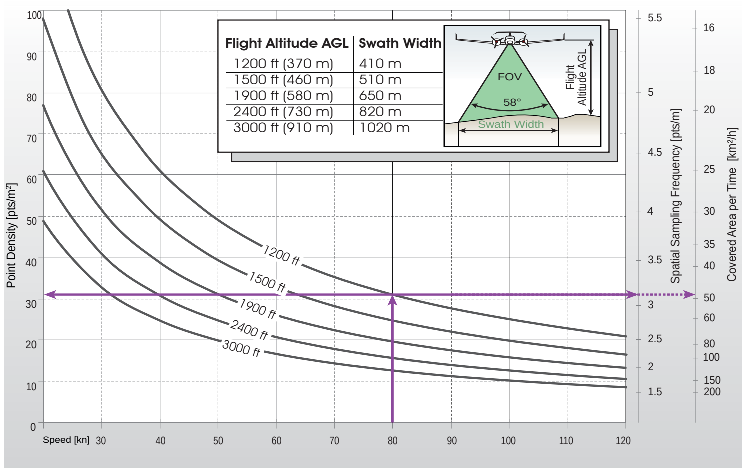
- 20% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

Definition of the Spatial Sampling Frequency

- The Spatial Sampling Frequency is the reciprocal of the 95th percentile of the distribution function of the maximum distances between neighboring scan points. When considering any individual scan point, the probability to find its most distant neighbor within the reciprocal of the Spatial Sampling Frequency is 95%.

PRR = 800 kHz, laser power level 12%

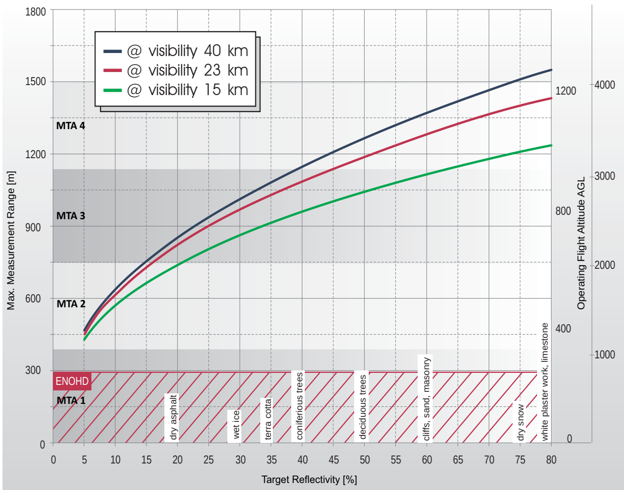


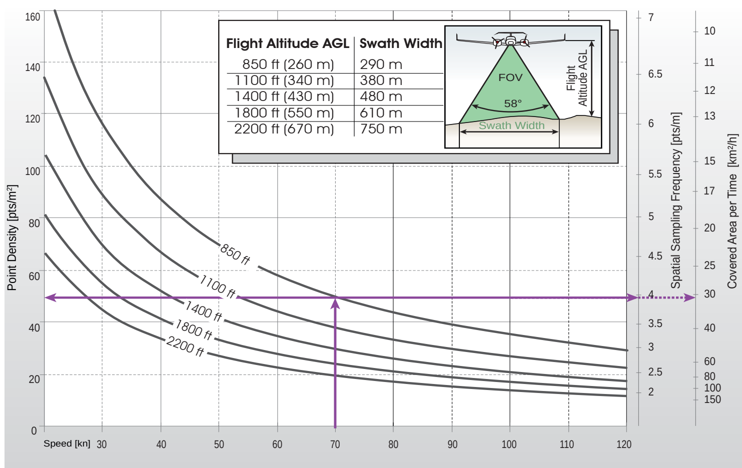


Example: LMS-Q1560 at 800,000 pulses/sec, laser power level 12%
Altitude = 1200ft AGL, Speed = 80 kn

Results: Point Density ~ 31 pts/m²
Spatial Sampling Frequency ~ 3.1 pts/m
Covered Area per Time ~ 49 km²/h

PRR = 800 kHz, laser power level 6%





Example: LMS-Q1560 at 800,000 pulses/sec, laser power level 6%
Altitude = 850ft AGL, Speed = 70 kn

Results: Point Density ~ 49.4 pts/m²
Spatial Sampling Frequency ~ 4 pts/m
Covered Area per Time ~ 31 km²/h

The following conditions are assumed for the Operating Flight Altitude AGL

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

Assumptions for calculation of the Covered Area per Time

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

Definition of the Spatial Sampling Frequency

- The Spatial Sampling Frequency is the reciprocal of the 95th percentile of the distribution function of the maximum distances between neighboring scan points. When considering any individual scan point, the probability to find its most distant neighbor within the reciprocal of the Spatial Sampling Frequency is 95%.

Technical Data *RIEGL* LMS-Q1560

Laser Product Classification

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

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.

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

Full Laser Power

Laser Power Level	100%			
Laser Pulse Repetition Rate (PRR)	200 kHz	400 kHz	600 kHz	800 kHz
Max. Measuring Range [1, 3]				
natural targets ρ ≥ 20 %	4100 m	3500 m	3000 m	2700 m
natural targets ρ ≥ 60 %	5800 m	5100 m	4500 m	4100 m
Max. Operating Flight Altitude Above Ground Level (AGL) [2, 3]	4700 m 15500 ft	4200 m 13700 ft	3700 m 12000 ft	3300 m 11000 ft
NOHD [4]	260 m	210 m	170 m	145 m
ENOHD [5]	1850 m	1500 m	1220 m	1050 m

1) The following conditions are assumed: • target is larger than the footprint of the laser beam • average ambient brightness • visibility 40 km • perpendicular angle of incidence • ambiguity resolved by multiple-time-around processing
2) Reflectivity ρ ≥ 60 %, max. scan angle 60°, additional roll angle ± 5°
3) In bright sunlight the operational range may be considerably shorter and the operational flight altitude may be considerably lower than under an overcast sky.
4) Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, for single pulse condition
5) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, for single pulse condition

Reduced Laser Power

Laser Power Level	50%	25%	12%	6%
Laser Pulse Repetition Rate (PRR)	800 kHz	800 kHz	800 kHz	800 kHz
Max. Measuring Range [6, 8]				
natural targets ρ ≥ 20 %	2100 m	1500 m	1120 m	820 m
natural targets ρ ≥ 60 %	3200 m	2400 m	1800 m	1350 m
Max. Operating Flight Altitude Above Ground Level (AGL) [7, 8]	2600 m 8600 ft	1950 m 6400 ft	1450 m 4800 ft	1100 m 3600 ft
NOHD [9]	100 m	87 m	59 m	38 m
ENOHD [10]	730 m	640 m	440 m	295 m

6) The following conditions are assumed: • target is larger than the footprint of the laser beam • average ambient brightness • visibility 40 km • perpendicular angle of incidence • ambiguity resolved by multiple-time-around processing
7) Reflectivity ρ ≥ 60 %, max. scan angle 60°, additional roll angle ± 5°
8) In bright sunlight the operational range may be considerably shorter and the operational flight altitude may be considerably lower than under an overcast sky.
9) Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, viewing a single scan line
10) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC60825-1:2007, viewing a single scan line

Minimum Range [11]	50 m
Accuracy [12, 13]	20 mm
Precision [12, 14]	20 mm
Laser Pulse Repetition Rate	up to 800 kHz
Effective Measurement Rate	up to 532 kHz @ 60° scan angle
Laser Wavelength	near infrared
Laser Beam Divergence [15]	≤ 0.25 mrad
Number of Targets per Pulse	digitized waveform processing: unlimited [16] monitoring data output: first pulse

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines per channel, crossed scan lines between channels
Tilt Angle of Scan Lines	± 14° = 28°
Forward/ Backward Look in Non-Nadir Direction	± 8° at the edges
Scan Angle Range	60° total per channel, resulting in an effective FOV of 58°
Scan Speed	28 - 400 lines/sec [17] @ laser power level ≥ 50% 20 - 400 lines/sec [18] @ laser power level < 50%
Angular Step Width Δϑ [19]	Δϑ ≥ 0.012° @ laser power level ≥ 50% Δϑ ≥ 0.006° @ laser power level < 50%
Angle Measurement Resolution	0.001°

11) Limitation for range measurement capability, does not consider laser safety!
12) Standard deviation one sigma @ 250 m range under *RIEGL* test conditions.
13) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
14) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
15) Measured at the 1/e² points. 0.25 mrad correspond to an increase of 25 cm of beam diameter per 1000 m distance.
16) Practically limited only by the maximum data rate allowed for the *RIEGL* Data Recorder.
17) Minimum scan speed increasing linearly to 106 lines/sec @ 800 000 Hz PRR @ laser power ≥ 50%
18) Minimum scan speed increasing linearly to 54 lines/sec @ 800 000 Hz PRR @ laser power < 50%
19) Angle between consecutive laser shots within a scan line, user adjustable

Technical Data to be continued at page 10

Intensity Measurement	For each echo signal, high-resolution 16-bit intensity information is provided which can be used for target discrimination and/or identification/classification.
Data Interfaces	
Configuration	TCP/IP Ethernet (10/100 MBit)
Monitoring Data Output	TCP/IP Ethernet (10/100 MBit)
Digitized Data Output	Dual glass fiber data link to *RIEGL* Data Recorder DR1560
Synchronization	Serial RS232 interface, TTL input for 1 pps synchronization pulse, accepts different data formats for GNSS-time information
General Technical Data	
Power Supply / Current Consumption	18 - 32 V DC / approx. 10 A @ 24 VDC
Main Dimensions (L x W x H)	444 x 444 x 738 mm, mounting flange diameter 524 mm
Weight	approx. 62 kg without optional components approx. 69 kg with optional components
Protection Class	IP54
Max. Flight Altitude operating / not operating	18500 ft (5600 m) above Mean Sea Level MSL / 18500 ft (5600 m) above MSL
Temperature Range	0°C up to +40°C (operation) / -10°C up to +50°C (storage)

Optional Components LMS-Q1560

Please note: The INS and the camera configuration of the *RIEGL* LMS-Q1560 Laser Scanning System can be modified to the customer's requirements.

Integrated Digital Cameras

RGB Camera	
Sensor Resolution	80 MPixel
Sensor Dimensions (diagonal)	67.2 mm (medium format)
Focal Length of Camera Lens	55 mm
Field of View (FOV)	approx. 52° x 40°
Interface	USB 3.0
Data Storage	via GigE to *RIEGL* Data Recorder DR1560
Infrared Camera (optional)	
Spectral Range	7.5 - 14 µm
Sensor Resolution	640 x 480 Pixel
Sensor Dimensions (diagonal)	13.6 mm
Focal Length of Camera Lens	13.1 mm
Field of View (FOV)	approx. 45° x 34°
Interface	GigE
Data Storage	via GigE to *RIEGL* Data Recorder DR1560

Integrated IMU/GNSS [1)]

IMU Accuracy [2)]	
Roll, Pitch	0.005°
Heading	0.008°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	0.05 m - 0.3 m

1) The installed IMU is listed neither in the European Export Control List (i.e. Annex 1 of Council Regulation 428/2009) nor in the Canadian Export Control List. Detailed information on certain cases will be provided on request.
2) One sigma values, no GNSS outages, post-processed with base station data

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