

New Technology=Ultra efficient wide area mapping

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- Today's Mapping Challenges in Mountainous terrain
- Case Study
- New technology



Experience

RIEGL has over 35 years of experience in the research, development and production of laser radar measurement devices and systems, and is the global leader in the innovation of LIDAR technology for land, marine, and airborne survey.

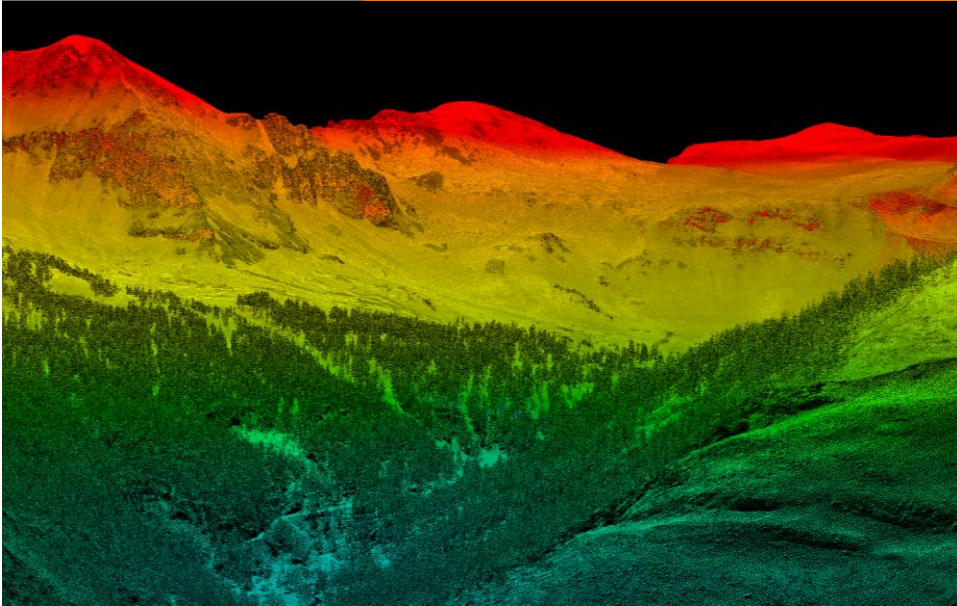


Challenges in the mountains

- Requirements
 - High point density
 - High Accuracy
 - High Efficiency
- Challenges
 - Extreme Terrain variations
 - Eye safety
 - Uniform point spacing
 - Complete coverage

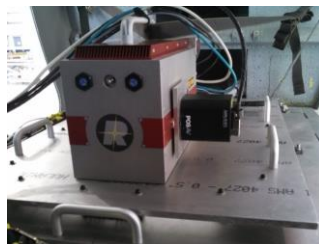


Case Study – Rocky Mountains



System Setup

- Hardware configuration
 - System: Riegl LMS-Q780
 - Aircraft: DeHavilland Twin Otter (DHC-6)



Hardware overview - LMS-Q780



LMS-Q780 - Specifications



LMS-Q780 - Specifications

MAX. AVERAGE OUTPUT <400 mW
PULSE DURATION APPROX. 100 ns
WAVELENGTH 1064 nm
STANDARD IEC60825-1:2007

Full Waveform Digitizing Airborne Laser Scanner

Applications:

- Full Laser Power
- Reduced Laser Power

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Ranging Performance

Full Laser Power

Laser Power Level	100%			
Laser Pulse Repetition Rate (PRR)	100 kHz	200 kHz	300 kHz	400 kHz
Max. Measuring Range ^{1) 2)}				
natural targets $\rho \geq 20\%$	4100 m	3500 m	3000 m	2700 m
natural targets $\rho \geq 60\%$	5800 m	5100 m	4500 m	4100 m
Max. Operating Flight Altitude Above Ground Level (AGL) ^{2) 3)}	3350 m	2850 m	2450 m	2200 m
	11000 ft	9400 ft	8000 ft	7200 ft
NOHD ⁴⁾	200 m	160 m	125 m	105 m
ENOH ⁵⁾	1500 m	1200 m	960 m	820 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) 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) Nominal Ocular Hazard Distance, based on MPE according to IEC60825-1:2007, for single pulse condition
 4) Extended Nominal Ocular Hazard Distance, based on 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)	400 kHz	400 kHz	400 kHz	400 kHz
Max. Measuring Range ^{4) 5)}				
natural targets $\rho \geq 20\%$	2100 m	1500 m	1120 m	820 m
natural targets $\rho \geq 60\%$	3200 m	2400 m	1800 m	1350 m
Max. Operating Flight Altitude Above Ground Level (AGL) ^{7) 8)}	1700 m	1200 m	920 m	670 m
	5600 ft	4000 ft	3000 ft	2200 ft
NOHD ⁹⁾	70 m	68 m	44 m	25 m
ENOH ¹⁰⁾	560 m	550 m	360 m	250 m

Measurement Accuracy

assumed: • target is larger than
• incidence
• max. scan angle 60°, additional roll angle $\pm 5^\circ$
operational range may be considerably shorter and
Distance, based upon MPE according to IEC60825
Ocular Hazard Distance, based upon MPE according to IEC60825

Minimum Range ¹¹⁾ 30 m
Accuracy ^{12) 13)} 20 mm
Precision ^{12) 14)} 20 mm
Laser Pulse Repetition Rate ¹⁵⁾ up to 266 kHz
Effective Measurement Rate up to 266 kHz
Laser Wavelength near infrared
Laser Beam Divergence ¹⁵⁾ ≤ 0.25 mrad
Number of Targets per Pulse digitized waveform monitoring

Applications:
Full Laser Power:
• Topographic mapping
• Construction & surveying
• City planning
• Mapping of coastal & river
• Agriculture & forestry
• Climate mapping

Reduced Laser Power:
• Topographic mapping
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LASER MEASUREMENT SYSTEMS

Preliminary Data Sheet

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Multiple-Time-Around Capability

MS-Q780

NO DEAD ZONES – NO GAPS IN THE DATA
EASY FLIGHT PLANNING
HIGH POINT DENSITY

Applications:
Full Laser Power:
• Topographic mapping
• Construction & surveying
• City planning
• Mapping of coastal & river
• Agriculture & forestry
• Climate mapping

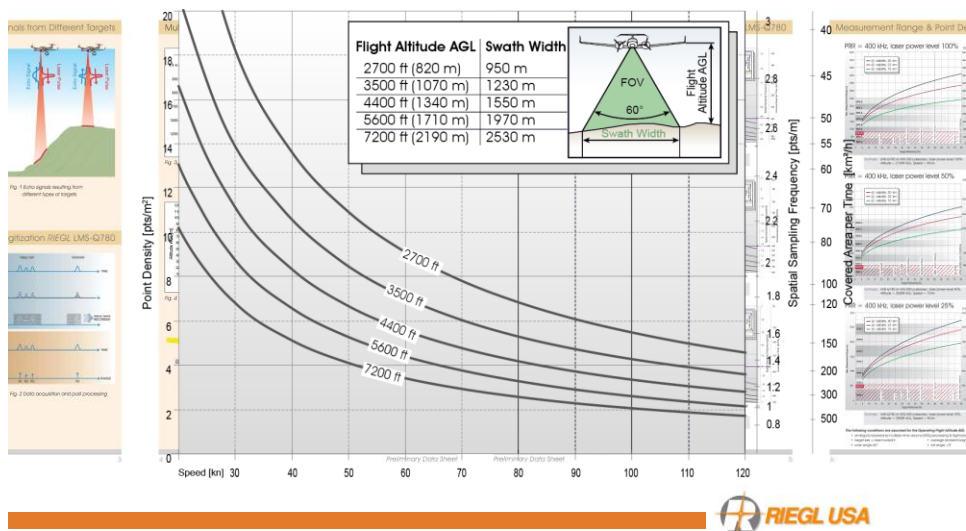
Reduced Laser Power:
• Topographic mapping
• Construction & surveying
• City planning
• Mapping of coastal & river
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• Climate mapping

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LASER MEASUREMENT SYSTEMS

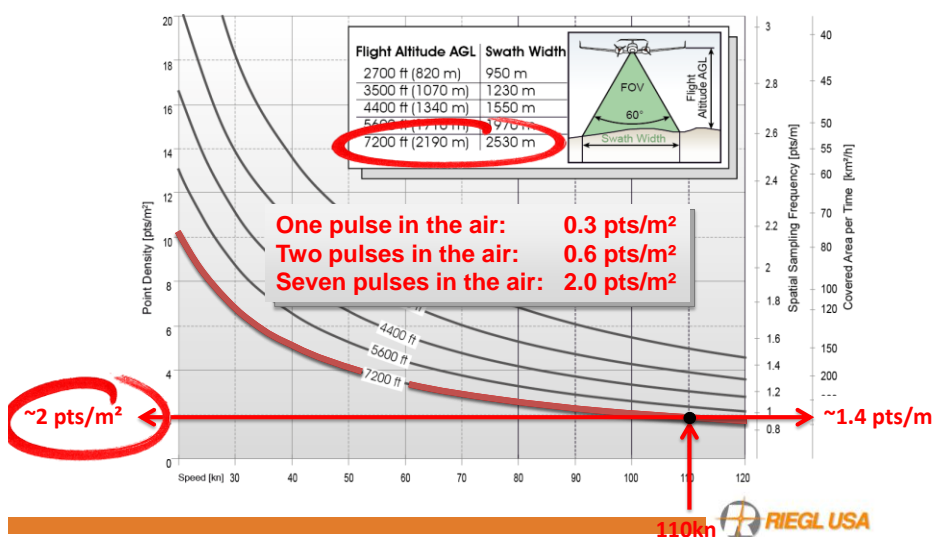
Preliminary Data Sheet

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High point density... ...from high altitudes



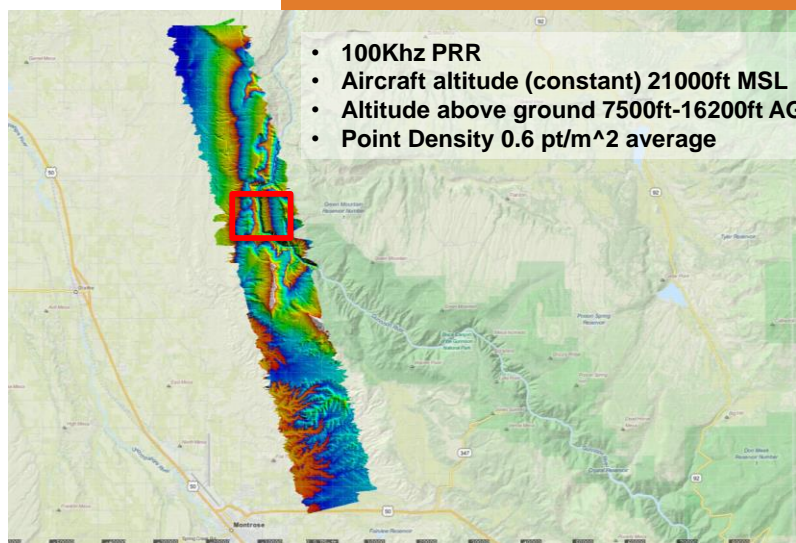
High point density... ...from high altitudes



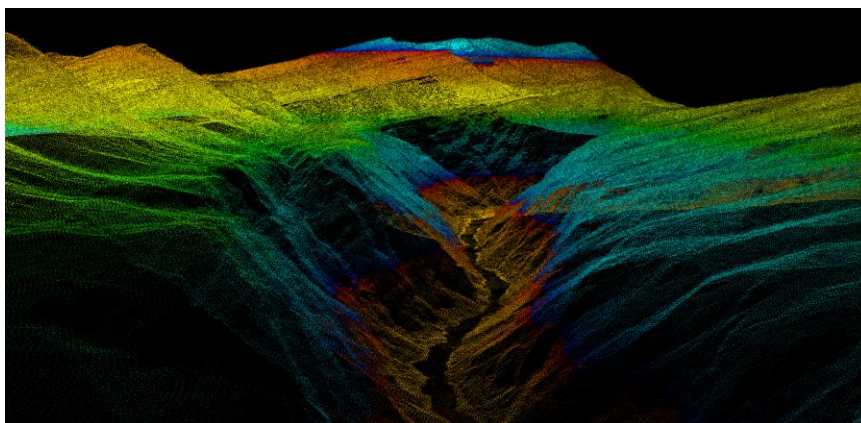
Project Area

Data Acquisition	
Recorded data coverage	In total about 400 km ² (155mile ²) of topographic area with height variations between 2400m to 4000m (8000ft to 13,000 ft.)
Raw data volume	Scan data 67 GB
Software used	Riegl Acquisition software – RiAcquire
Aircraft speed during acquisition	120 kn - 160 kn
Altitude	Max Altitude 21000 ft MSL, >16000 ft AGL
Project Acquisition time	1 operator for RiAcquire, 2 pilots ~ 3 hours net acquisition time
Data Post Processing	
Post Processed data volume	76GB
Ground point density	Approx 0.6-4pt/m ²
Software used	Riegl Software Suite –RiProcess, RiAnalyze, RiWorld
Number of points	>500 million points
Data Processing time	1 person – 2 hours

Black Canyon



Black Canyon



Black Canyon

PRCS:
 X [US-ft]: 53550.329
 Y [US-ft]: 59210.045
 Z [US-ft]: 5104.571

SOCs:
 X [US-ft]: 16251.469
 Y [US-ft]: 11.100
 Z [US-ft]: 755.101
 Range [US-ft]: 16269.005
 Theta [deg]: 87.310
 Phi [deg]: 0.039

System speed: 55.85 m/s

13-05-17 21:34:27+016

Scanner 1)

13-05-17 21:47:45+953

13-05-17 21:47:45+953

13-05-17 21:47:45+951

13-05-17 21:47:45+953

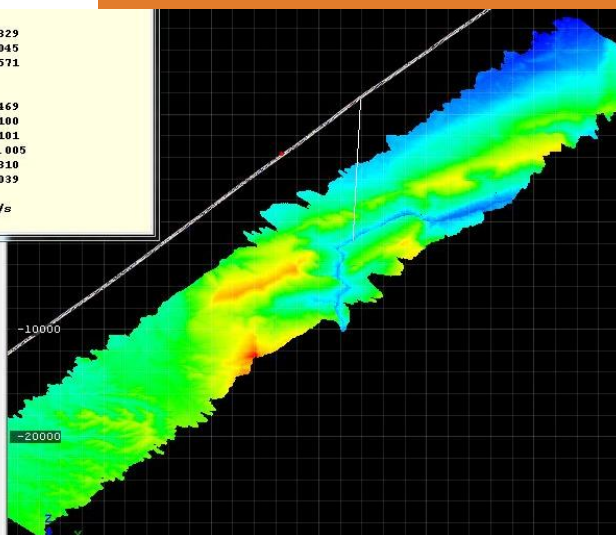
Scanner 1)

13-05-17 21:52:52+355

13-05-17 21:52:52+355

13-05-17 21:52:52+489

13-05-17 21:52:52+492



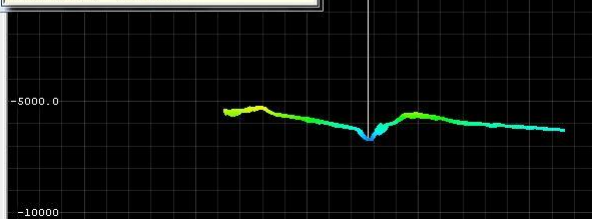
Black Canyon

Point index: 1
 Classification: 004 - Medium
 vegetation
 Attributes:
 RCI: 33515
 Channel: 17
 Facet: 1
 Target: 1 of 1
 Scan angle [deg]: -1.000

PRCS:
 X [US-ft]: 53433.222
 Y [US-ft]: 61206.432
 Z [US-ft]: 5124.199

SOCS:
 X [US-ft]: 16225.701
 Y [US-ft]: 11.175
 Z [US-ft]: 497.181
 Range [US-ft]: 16233.320
 Theta [deg]: 88.216
 Phi [deg]: 0.039

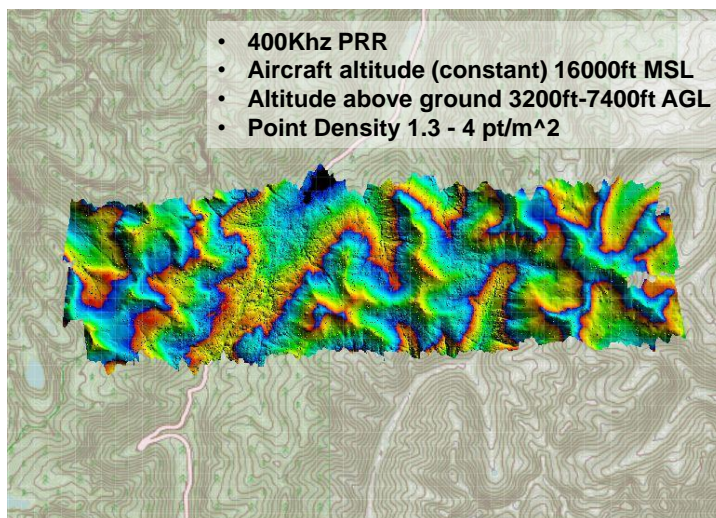
System speed: 55.03 m/s



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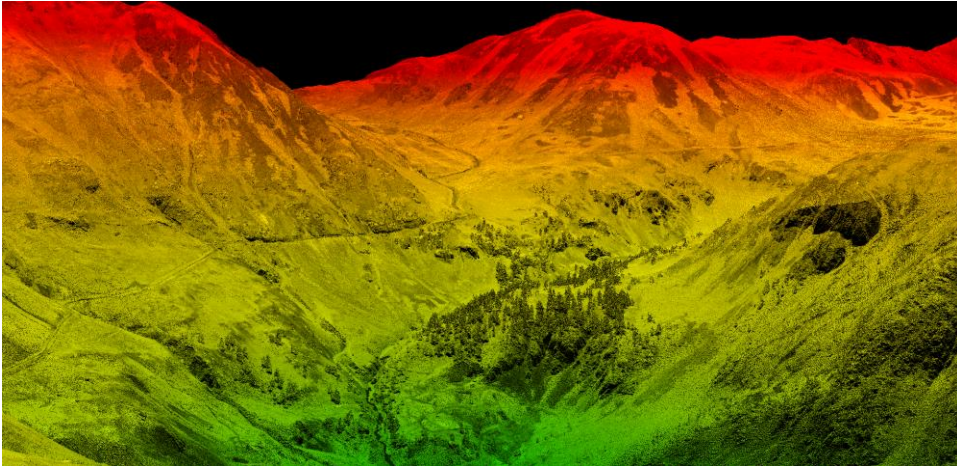
Red Mountains

- 400Khz PRR
- Aircraft altitude (constant) 16000ft MSL
- Altitude above ground 3200ft-7400ft AGL
- Point Density 1.3 - 4 pt/m²

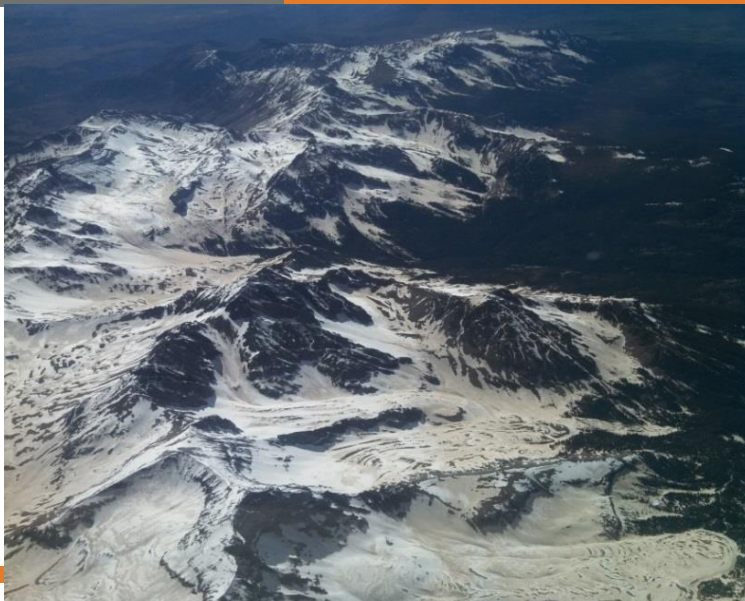


RIEGL USA

Red Mountains



Project Area



Conclusion

- Riegl LMS-Q780 proved to be very effective tool for mapping mountainous terrain. Due to high PRR, wide 60deg FOV, MTA, and long range capabilities of this instrument Riegl LMS-Q780 requires less flying time while achieving high point density, uniform point distribution, and high efficiency.



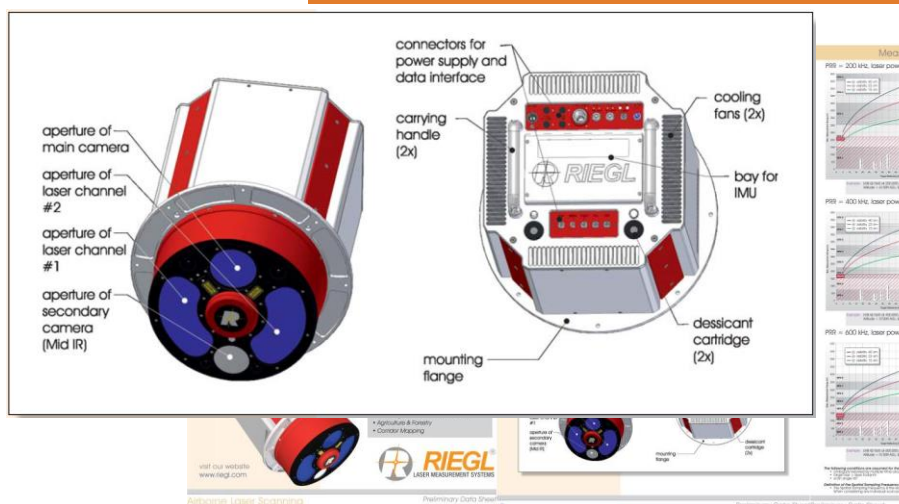
- Whats next for LiDAR technology???



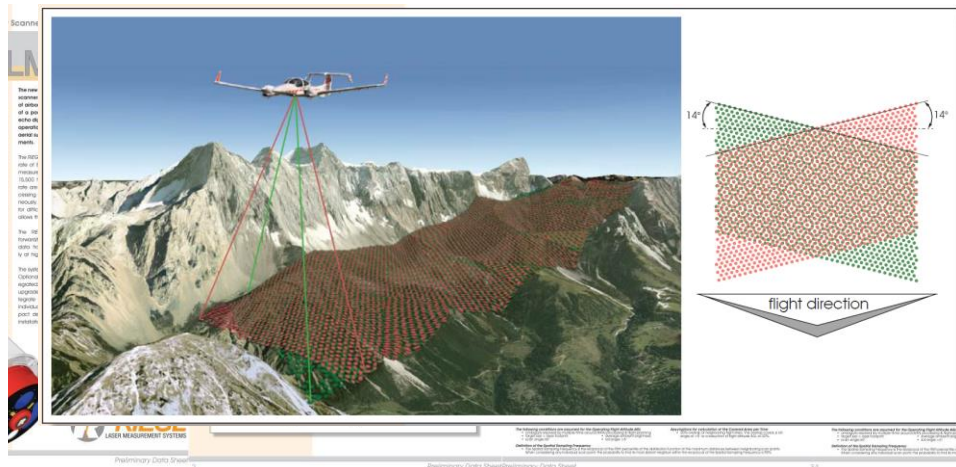
LMS-Q1560 - Specifications



System Layout



Scan Pattern



Ranging Performance

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 $p \geq 20\%$	4100 m	3500 m	3000 m	2700 m	
natural targets $p \geq 60\%$	5800 m	5100 m	4500 m	4100 m	
Max. Operating Flight Altitude Above Ground Level (AGL) ²⁾³⁾	4700 m	4200 m	3700 m	3300 m	
	15500 ft	13700 ft	12000 ft	11000 ft	
NOHD ⁴⁾	290 m	240 m	190 m	160 m	
ENOHD ⁵⁾	2200 m	1770 m	1440 m	1240 m	
1) The following conditions are assumed: <ul style="list-style-type: none"> 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 $p \geq 60\%$, max. scan angle 60° , additional roll angle $\pm 5^\circ$					
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 ⁹⁾⁹⁾					
natural targets $p \geq 20\%$	2100 m	1500 m	1120 m	820 m	
natural targets $p \geq 60\%$	3200 m	2400 m	1800 m	1350 m	
Max. Operating Flight Altitude Above Ground Level (AGL) ⁷⁾⁸⁾	2600 m	1950 m	1450 m	1100 m	
	8600 ft	6400 ft	4800 ft	3600 ft	
NOHD ⁹⁾	110 m	105 m	70 m	45 m	
ENOHD ¹⁰⁾	860 m	840 m	570 m	370 m	

