The ultra-high performance, fully integrated and calibrated Dual Channel Airborne Mapping System RIEGL VQ-1560i makes use of RIEGL's sophisticated Waveform-LiDAR technology enabling an excellent multiple-target detection capability and Multiple-Time-Around (MTA) processing. The system is capable of online waveform processing as well as full or smart waveform recording, resulting in unsurpassed information content on each single target.

The VQ-1560i provides a laser pulse repetition rate of up to 2 MHz resulting in more than 1.3 million measurements per second on the ground and operates at an altitude of up to 18,300 ft. That allows operation at varying flight altitudes resulting in a wide range of point densities. Thus, the system is ideally suited for aerial survey of ultra-wide areas as well as of complex urban environments. By the way, faster and more efficient flight planning and safer flights are enabled.

The RIEGL VQ-1560i comes with a unique forward/backward scan angle. This enables capturing data from multiple angles more effectively and more accurately at a high point density. With its large field of view of 56 degrees and its widely variable scan parameters the system enables highly efficient scan data acquisition.

The system is equipped with a seamlessly integrated high performance IMU/GNSS unit and an optional 100 megapixel RGB camera as well as another camera, e.g. a thermal camera or a 100 megapixels near-infrared camera. All individual components are integrated into a compact housing, featuring a mounting flange for interfacing typical hatches or gyro-stabilized leveling mounts.

**Applications:**
- Ultra 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
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.

<table>
<thead>
<tr>
<th>Tilt Angle of Scan Lines</th>
<th>± 14°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward/Backward Scan Angle in Non-Nadir Direction</td>
<td>± 8° at the edge</td>
</tr>
</tbody>
</table>
A minimum number of system components and external cabling is required for an easy and quick installation in aircrafts.

**RIEGL VQ-1560i Installation Examples**

- **RIEGL VQ-1560i** installed in the nose pod of fixed-wing aircraft DA42 MPP
- **RIEGL VQ-1560i** installed on GSM-4000 gyro-stabilized platform to be used in a helicopter or fixed-wing aircraft
The following conditions are assumed for the Operating Flight Altitude AGL:

- Ambiguity resolved by multiple-time-around (MTA) processing
- Target size ≥ laser footprint
- Effective FOV 58°
- Average ambient brightness
- Roll angle ±5°

Typical ENOHD

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

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%.

Example: VQ-1560i at 150,000 pulses/sec, laser power level 100%
- Altitude = 14,900 ft AGL, Speed 150 kn

Results:
- Point Density ~ 0.51 pts/m²
- Area Acquisition Rate ~ 1130 km²/h

Example: VQ-1560i at 250,000 pulses/sec, laser power level 100%
- Altitude = 12,100 ft AGL, Speed 140 kn

Results:
- Point Density ~ 1.12 pts/m²
- Area Acquisition Rate ~ 857 km²/h

Example: VQ-1560i at 350,000 pulses/sec, laser power level 100%
- Altitude = 8,400 ft AGL, Speed 130 kn

Results:
- Point Density ~ 2.43 pts/m²
- Area Acquisition Rate ~ 552 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
- average ambient brightness
- roll angle ±5°

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

**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%.

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**Example:**
- RIEGL VQ-1560i at 500,000 pulses/sec, laser power level 100%
  - Altitude = 5,600 ft AGL, Speed 170 kn
  - Results: Point Density ~ 3.97 pts/m², Area Acquisition Rate ~ 481 km²/h

**Example:**
- RIEGL VQ-1560i at 700,000 pulses/sec, laser power level 100%
  - Altitude = 3,700 ft AGL, Speed 115 kn
  - Results: Point Density ~ 12.49 pts/m², Area Acquisition Rate ~ 215 km²/h

**Example:**
- RIEGL VQ-1560i at 1,000,000 pulses/sec, laser power level 100%
  - Altitude = 6,800 ft AGL, Speed 170 kn
  - Results: Point Density ~ 6.57 pts/m², Area Acquisition Rate ~ 584 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
- Average ambient brightness
- Roll angle ±5°
- Effective FOV 58°
- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10 kn.

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%.
- Area Acquisition Rate = 21.81 pts/m²
- Area Acquisition Rate = 28.11 pts/m²
- Area Acquisition Rate = 61.45 pts/m²

Example:
- VQ-1560i at 1,000,000 pulses/sec, laser power level 50%
  - Altitude = 2,900 ft AGL, Speed 120 kn
  - Point Density ~ 21.81 pts/m²
  - Area Acquisition Rate ~ 176 km²/h

Example:
- VQ-1560i at 1,000,000 pulses/sec, laser power level 25%
  - Altitude = 2,700 ft AGL, Speed 100 kn
  - Point Density ~ 28.11 pts/m²
  - Area Acquisition Rate ~ 136 km²/h

Example:
- VQ-1560i at 1,000,000 pulses/sec, laser power level 12%
  - Altitude = 1,300 ft AGL, Speed 95 kn
  - Point Density ~ 61.45 pts/m²
  - Area Acquisition Rate ~ 62 km²/h
Measurement Range & Point Density RIEGL VQ-1560i

The following conditions are assumed for the Operating Flight Altitude AGL:
- ambiguity resolved by multiple-time-around (MTA) processing
- target size = laser footprint
- effective FOV 58°

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

Example: VQ-1560i at 1,000,000 pulses/sec, laser power level 6%
Altitude = 800 ft AGL, Speed 75 kn

Results:
- Point Density ~ 126.49 pts/m²
- Area Acquisition Rate ~ 30 km²/h

Assumptions for calculation of the Area Acquisition Rate
• 30% overlap of neighboring flight strips. This overlap covers a roll angle of ±5° or a reduction of flight altitude AGL of 20%.

The following conditions are assumed for the Operating Flight Altitude AGL:
- flight altitude AGL
- effective FOV 58°
- average ambient brightness
- roll angle ±5°

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

Example:
VQ-1560i at 1,000,000 pulses/sec, laser power level 6%
Altitude = 800 ft AGL, Speed 75 kn

Results:
- Point Density ~ 126.49 pts/m²
- Area Acquisition Rate ~ 30 km²/h

The RIEGL VQ-1560i Dual Channel Airborne Mapping System offers highest productivity.

Examples:

<table>
<thead>
<tr>
<th>Average Point Density</th>
<th>2 pts/m²</th>
<th>8 pts/m²</th>
<th>20 pts/m²</th>
<th>60 pts/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Altitude</td>
<td>6560 ft</td>
<td>4500 ft</td>
<td>3300 ft</td>
<td>1150 ft</td>
</tr>
<tr>
<td>Ground Speed</td>
<td>300 kn</td>
<td>210 kn</td>
<td>115 kn</td>
<td>110 kn</td>
</tr>
<tr>
<td>Swath Width</td>
<td>2240 m</td>
<td>1540 m</td>
<td>1130 m</td>
<td>400 m</td>
</tr>
<tr>
<td>Productivity</td>
<td>996 km²/h</td>
<td>480 km²/h</td>
<td>192 km²/h</td>
<td>64 km²/h</td>
</tr>
<tr>
<td>Measurement Rate</td>
<td>933 000 meas./sec</td>
<td>1.33 mill meas./sec</td>
<td>1.33 mill meas./sec</td>
<td>1.33 mill meas./sec</td>
</tr>
<tr>
<td>Camera GSD</td>
<td>184 mm</td>
<td>126 mm</td>
<td>92 mm</td>
<td>32 mm</td>
</tr>
<tr>
<td>Camera Trigger Interval</td>
<td>4.15 sec</td>
<td>4.1 sec</td>
<td>5.4 sec</td>
<td>2.0 sec</td>
</tr>
</tbody>
</table>

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.
3) Ground Sampling Distance
4) Calculated for a 100 MPixel CMOS camera with a FOV of 56.2° x 43.7° and 60% image overlap in flight direction (endlap).
Technical Data RIEGL VQ-1560i

Laser Product Classification
Class 3B 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 deviations pursuant to Laser Notice No. 50, dated June 24, 2007.

Range Measurement Performance

<table>
<thead>
<tr>
<th>Laser Power Level</th>
<th>100%</th>
<th>50%</th>
<th>25%</th>
<th>12%</th>
<th>6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Pulse Repetition Rate (PRR)</td>
<td>2 x 1000 kHz</td>
<td>2 x 1000 kHz</td>
<td>2 x 1000 kHz</td>
<td>2 x 1000 kHz</td>
<td>2 x 1000 kHz</td>
</tr>
<tr>
<td>Max. Measuring Range</td>
<td>2050 m</td>
<td>1500 m</td>
<td>1100 m</td>
<td>780 m</td>
<td>560 m</td>
</tr>
<tr>
<td>natural targets ( p \geq 20 % )</td>
<td>3300 m</td>
<td>2450 m</td>
<td>1800 m</td>
<td>1300 m</td>
<td>940 m</td>
</tr>
<tr>
<td>natural targets ( p \geq 60 % )</td>
<td>2700 m</td>
<td>2000 m</td>
<td>1450 m</td>
<td>1050 m</td>
<td>770 m</td>
</tr>
<tr>
<td>Above Ground Level (AGL)</td>
<td>140 m</td>
<td>95 m</td>
<td>61 m</td>
<td>36 m</td>
<td>21 m</td>
</tr>
<tr>
<td>NOHD (( \Delta \geq 60 % ))</td>
<td>940 m</td>
<td>650 m</td>
<td>430 m</td>
<td>260 m</td>
<td>145 m</td>
</tr>
<tr>
<td>ENOHD (( \Delta \geq 60 % ))</td>
<td>140 m</td>
<td>95 m</td>
<td>61 m</td>
<td>36 m</td>
<td>21 m</td>
</tr>
</tbody>
</table>

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) typical values for reflectivity \( \Delta \geq 60 \% \), max. effective FOV 58°, additional roll angle \( \pm 5 \° \)
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 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.

Minimum Range 8)
Accuracy 9)\( ^{10} \)
Precision 10)\( ^{11} \)
Laser Pulse Repetition Rate
Effective Measurement Rate
Echo Signal Intensity
Laser Wavelength
Laser Beam Divergence
Number of Targets per Pulse

Scanner Performance

<table>
<thead>
<tr>
<th>Scanning Mechanism</th>
<th>100 m</th>
<th>20 m</th>
<th>20 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>rotating polygon mirror</td>
<td>up to 2 MHz</td>
<td>up to 1.33 MHz @ 60° scan angle</td>
<td>provided for each echo signal</td>
</tr>
</tbody>
</table>

 Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
 Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.

Technical Data to be continued at page 10
### Technical Data RIEGL VQ-1560i (continued)

#### Data Interfaces
- **Configuration**
- **Monitoring Data Output**
- **Digitized Data Output**
- **Synchronization**

TCP/IP Ethernet (10/100/1000 MBit/s)
TCP/IP Ethernet (10/100/1000 MBit/s)
Dual glass fiber data link to RIEGL Data Recorder DR1560(i)
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**
20 - 32 V DC / typ. 250 W
max. 550 W, depending on integrated optional components

**Main Dimensions (flange diameter x height)**
Ø 524 mm x 780 mm (without flange mounted carrying handles)
approx. 55 kg without any camera but including a typical IMU/GNSS unit
approx. 60 kg with optional components

**Weight**
approx. 55 kg without any camera but including a typical IMU/GNSS unit
approx. 60 kg with optional components

**Protection Class**
IP54

**Max. Flight Altitude operating / not operating**
18500 ft (5600 m) above MSL / 18500 ft (5600 m) above MSL

**Temperature Range operation / storage**
0°C up to +40°C / -10°C up to +50°C

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#### Recommended IMU/GNSS System

- **IMU Accuracy**
  - Roll, Pitch
  - Heading
- **IMU Sampling Rate**
- **Position Accuracy (typ.)**

0.0025°
0.005°
200 Hz
0.05 m - 0.1 m

#### Optional Components VQ-1560i

**Primary Camera**
- **Sensor Resolution**
e.g. 100 MPixel CMOS
- **Sensor Dimensions (diagonal)**
67.2 mm (medium format)
- **Focal Length of Camera Lens**
50 mm
- **Field of View (FOV)**
approx. 56.2° x 43.7°
- **Interface**
USB 3.0
- **Data Storage**
iX-Controller

**Secondary Camera**
Different camera types including thermal or NIR cameras can be integrated, details on request.

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2) The recommended 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.

3) The RIEGL VQ-1560i Laser Scanning system supports different IMU/GNSS Systems, details on request.

4) One sigma values, no GNSS outages, post-processed with base station data

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1) Mean Sea Level

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This data sheet is compiled with care. However, errors cannot be fully excluded and alterations might be necessary.