Waveform Processing Airborne Laser Scanner for Wide Area Mapping and High Productivity

The Waveform Processing Airborne Laser Scanner RIEGL VQ-780 II provides further increased performance and highest productivity based on a laser pulse repetition rate of up to 2 MHz, resulting in more than 1.33 million measurements/sec on the ground.

The versatile scanner is designed for high efficient data acquisition at low, mid, and high altitudes, covering a variety of different airborne laser scanning applications from high density to wide area mapping. Its high speed rotating mirror design ensures reliability, and uniform point distribution across its entire wide field of view and at all flying altitudes. Based on RIEGL’s proven Waveform-LiDAR technology, the system provides point clouds with highest accuracy, excellent vertical target resolution, calibrated reflectance readings, and pulse shape deviation for unsurpassed information content on each single measurement. Excellent atmospheric clutter suppression yields clean point clouds with minimum efforts in filtering isolated noise points.

The RIEGL VQ-780 II is designed to work with the latest Inertial Navigation (IMU) Systems, flight management systems, and camera options. The system is complimented with RIEGL’s advanced acquisition and data processing software suite that utilizes parallel computing (GPU) for fast data processing.

Applications:
• 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
The RIEGL VQ-780 II Airborne Laser Scanner offers highest productivity.

**Examples**

<table>
<thead>
<tr>
<th>Average Point Density</th>
<th>1 pts/m²</th>
<th>2 pts/m²</th>
<th>4 pts/m²</th>
<th>8 pts/m²</th>
<th>20 pts/m²</th>
<th>30 pts/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Altitude AGL</td>
<td>6960 ft</td>
<td>4920 ft</td>
<td>3580 ft</td>
<td>3580 ft</td>
<td>2820 ft</td>
<td>2310 ft</td>
</tr>
<tr>
<td></td>
<td>2120 m</td>
<td>1500 m</td>
<td>1090 m</td>
<td>1090 m</td>
<td>860 m</td>
<td>700 m</td>
</tr>
<tr>
<td>Ground Speed</td>
<td>300 kn</td>
<td>300 kn</td>
<td>292 kn</td>
<td>206 kn</td>
<td>130 kn</td>
<td>106 kn</td>
</tr>
<tr>
<td>Swath Width</td>
<td>2450 m</td>
<td>1730 m</td>
<td>1260 m</td>
<td>1260 m</td>
<td>990 m</td>
<td>810 m</td>
</tr>
<tr>
<td>Productivity</td>
<td>1090 km²/h</td>
<td>770 km²/h</td>
<td>545 km²/h</td>
<td>386 km²/h</td>
<td>192 km²/h</td>
<td>128 km²/h</td>
</tr>
<tr>
<td>Measurement Rate</td>
<td>378 000 meas./sec</td>
<td>535 000 meas./sec</td>
<td>757 000 meas./sec</td>
<td>1.07 mill. meas./sec</td>
<td>1.33 mill. meas./sec</td>
<td>1.33 mill. meas./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.

**RIEGL VQ®-780 II Dense Scan Pattern and Wide Effective Swath Width**

The **RIEGL VQ-780 II** scanning mechanism – based on a continuously rotating polygon mirror wheel – delivers straight parallel scan lines resulting in a regular point pattern on the ground. With equal spatial sampling frequency along and across track, object extents are well defined and even small objects may be detected. The instrument is perfectly suited for applications where a superior point pattern on target surfaces is required.

The wide field of view and the multiple-time-around measurement capability of the **RIEGL VQ-780 II** make the instrument perfectly suited for wide area mapping applications. The instrument has been designed for utmost efficiency in collecting data by enabling scanning operations from high altitudes at high laser pulse repetition rates simultaneously, reducing the necessary flight time to a minimum.
Example: VQ-780 II at 150,000 pulses/sec, laser power level 100%
Altitude = 9,900 ft AGL, Speed 160 kn

Results: Point Density ~ 0.35 pts/m²
Area Acquisition Rate ~ 826 km²/h

Example: VQ-780 II at 250,000 pulses/sec, laser power level 100%
Altitude = 9,700 ft AGL, Speed 140 kn

Results: Point Density ~ 0.68 pts/m²
Area Acquisition Rate ~ 708 km²/h

Example: VQ-780 II at 500,000 pulses/sec, laser power level 100%
Altitude = 4,400 ft AGL, Speed 110 kn

Results: Point Density ~ 3.8 pts/m²
Area Acquisition Rate ~ 252 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
- full FOV of 60°
- average ambient brightness
- roll angle ±5°

Typical ENHHD
- 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%.

Uniform Point Pattern
- The line to line spacing is equal to the average point to point spacing.
### Typical ENOHD
- Calculated under assumption of an angular step width of 0.012° and an aircraft speed higher than 10kn.

### Uniform Point Pattern
- The line to line spacing is equal to the average point to point spacing.

---

### Measurement Range & Point Density RIEGL VQ®-780 II

**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%.
- Target size ≥ laser footprint
- Full FOV of 60°
- Average ambient brightness
- Roll angle ±5°

**Example:**
- **VQ-780 II at 1.0 mill. pulses/sec, laser power level 100%**
  - Altitude = 5,200 ft AGL, Speed 170 kn
  - **Results:**
    - Point Density ~ 4.17 pts/m²
    - Area Acquisition Rate ~ 461 km²/h

**Example:**
- **VQ-780 II at 2.0 mill. pulses/sec, laser power level 100%**
  - Altitude = 5,000 ft AGL, Speed 150 kn
  - **Results:**
    - Point Density ~ 9.82 pts/m²
    - Area Acquisition Rate ~ 391 km²/h

**Example:**
- **VQ-780 II at 2.0 mill. pulses/sec, laser power level 50%**
  - Altitude = 2,700 ft AGL, Speed 120 kn
  - **Results:**
    - Point Density ~ 22.73 pts/m²
    - Area Acquisition Rate ~ 169 km²/h

---

**Data Sheet**

4

Copyright RIEGL Laser Measurement Systems GmbH © 2020– All rights reserved.
The following conditions are assumed for the Operating Flight Altitude AGL:

- Ambiguity resolved by multiple-time-around (MTA) processing
- Target size = laser footprint
- Full FOV of 60°
- 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 100 km/h.

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%.

Uniform Point Pattern

The line to line spacing is equal to the average point to point spacing.

Example: VQ-780 II at 2.0 mill. pulses/sec, laser power level 25%
Altitude = 2,400 ft AGL, Speed 115 kn

Results:
Point Density ~ 26.68 pts/m²
Area Acquisition Rate ~ 144 km²/h

Example: VQ-780 II at 2.0 mill. pulses/sec, laser power level 12%
Altitude = 2,500 ft AGL, Speed 100 kn

Results:
Point Density ~ 29.46 pts/m²
Area Acquisition Rate ~ 130 km²/h

Example: VQ-780 II at 2.0 mill. pulses/sec, laser power level 6%
Altitude = 1,800 ft AGL, Speed 80 kn

Results:
Point Density ~ 51.14 pts/m²
Area Acquisition Rate ~ 75 km²/h
RIEGL VQ®-780 II Main Dimensions

Bottom View
3x M8x1.25 - 6H threads, depth 9 mm

Rear View
connector panels

Side View
beam exit aperture

Top View
cooling air inlet

Front View
cooling air outlet
desiccant cartridge
carrying handle

Front View
nitrogen valve

all dimensions in mm
Laser Product Classification
Class 3B Laser Product according to IEC60825-1:2014

The following clause applies for instruments delivered into the United States: Compiles 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**

<table>
<thead>
<tr>
<th>Laser Power Level</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Pulse Repetition Rate (PRR)</td>
<td>1) 150 kHz</td>
</tr>
<tr>
<td>Max. Measuring Range (1) (2) (3) (4)</td>
<td>natural targets (\rho \geq 20%)</td>
</tr>
<tr>
<td></td>
<td>natural targets (\rho \geq 60%)</td>
</tr>
<tr>
<td>Max. Operating Flight Altitude (1) (2) (3) (4)</td>
<td>natural targets (\rho \geq 20%)</td>
</tr>
<tr>
<td></td>
<td>natural targets (\rho \geq 60%)</td>
</tr>
<tr>
<td>NOHD (5) (6)</td>
<td>370 m</td>
</tr>
<tr>
<td>ENOHD (7) (8)</td>
<td>2450 m</td>
</tr>
<tr>
<td>Number of Targets per Laser Pulse up to (10)</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laser Power Level</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>2000 kHz</td>
<td>2000 kHz</td>
<td>2000 kHz</td>
<td>2000 kHz</td>
</tr>
<tr>
<td>Max. Measuring Range (1) (2) (3) (4)</td>
<td>natural targets (\rho \geq 20%)</td>
<td>1100 m</td>
<td>780 m</td>
<td>560 m</td>
</tr>
<tr>
<td></td>
<td>natural targets (\rho \geq 60%)</td>
<td>1800 m</td>
<td>1300 m</td>
<td>940 m</td>
</tr>
<tr>
<td>Max. Operating Flight Altitude (1) (2) (3) (4)</td>
<td>natural targets (\rho \geq 20%)</td>
<td>900 m</td>
<td>640 m</td>
<td>460 m</td>
</tr>
<tr>
<td></td>
<td>natural targets (\rho \geq 60%)</td>
<td>3000 ft</td>
<td>2100 ft</td>
<td>1500 ft</td>
</tr>
<tr>
<td>NOHD (5) (6)</td>
<td>61 m</td>
<td>37 m</td>
<td>21 m</td>
<td>12 m</td>
</tr>
<tr>
<td>ENOHD (7) (8)</td>
<td>430 m</td>
<td>270 m</td>
<td>145 m</td>
<td>82 m</td>
</tr>
<tr>
<td>Number of Targets per Laser Pulse up to (10)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

| Minimum Range \(11\) | 100 m |
| Accuracy \(12\) \(13\) | 20 mm |
| Precision \(13\) \(14\) | 20 mm |
| Laser Pulse Repetition Rate \(15\) | 150 kHz up to 2 MHz, selectable in steps of less than 1% |
| Effective Measurement Rate | up to 1333 kHz \(\times 60^\circ\) scan angle |
| Echo Signal Intensity | provided for each echo signal |
| Laser Wavelength | near infrared |
| Laser Beam Divergence | \(\leq 0.18\) mrad \(\times 1/e\) \(16\), typ. 0.25 mrad \(\times 1/e^2\) \(17\) |

**Scanner Performance**

- **Scanning Mechanism**: rotating polygon mirror
- **parallel scan lines**
- **Scan Angle Range**: \(\pm 30^\circ\) \(= 60^\circ\)
- **Total Scan Rate**: 20 \(18\) - 300 lines/sec
- **Angular Step Width \(\Delta \theta\)**
- **Angle Measurement Resolution**: 0.006\(^\circ\) \(\leq \Delta \theta \leq 0.108\(^\circ\) \(19\) \(20\)

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) If the laser beam hits, in part, more than one target, the laser’s pulse power is split accordingly. Thus, the achievable range is reduced.
5) Typical values for max. effective FOV 56\(^\circ\), additional roll angle \(\leq 5^\circ\)
6) Above Ground Level
7) Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition
8) Extended Nominal Ocular Hazard Distance, based upon MPE according to IEC 60825-1:2014, for single line condition
9) NOHD and ENOHD have been calculated for a typical angular step width of 0.012\(^\circ\) (which means non-overlapping laser footprints), and an aircraft speed higher than 10 km. NOHD and ENOHD increase when using overlapping laser footprints which may be intended e.g. for power line mapping.
10) when using online waveform processing

---

1) Limitation for range measurement capability, does not consider laser safety issues. The minimum range for valid reflectivity values is 250 m.
2) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
3) Standard deviation one sigma @ 250 m range under RIEGL test conditions.
4) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
5) For smart and full waveform recording the max. laser PRR is limited to 1600kHz.
6) Measured at the 1/e points. 0.18 mrad correspond to an increase of 18 cm of beam diameter per 1000 m distance.
7) Measured at the 1/e\(^2\) points. 0.25 mrad correspond to an increase of 25 cm of beam diameter per 1000 m distance.
8) The minimum scan rate depends on the selected laser PRR.
9) The minimum angular step width is limited by the maximum scan rate.

Technical Data to be continued at page 8
Technical Data  

**RIEGL VQ®-780 II** (continued)

**Data Interfaces**
- Configuration
- Monitoring Data Output
- Digitized Data Output
- Synchronization
- Camera interface

**Data Interfaces**
- TCP/IP Ethernet (10/100/1000 MBit/s)
- TCP/IP Ethernet (10/100/1000 MBit/s)
- High-speed data link to RIEGL Data Recorder DR1560i
- Serial RS-232 interface, TTL input for 1 pps synchronization pulse, accepts different data formats for GNSS-time information
- 2 x power, RS-232, 1 pps, trigger, exposure

**General Technical Data**

**Power Supply / Power Consumption**
- 18 - 32 V DC / typ. 160 W

**Main Dimensions (length x width x height)**
- 425 mm x 212 mm x 331 mm

**Weight**
- approx. 20 kg

**Protection Class**
- IP54

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

**Temperature Range**
- operation: -5°C up to +40°C
- storage: -10°C up to +50°C

---

1) Mean Sea Level