

Lightweight Airborne Laser Scanner with Online Waveform Processing

RIEGL VUX-1LR

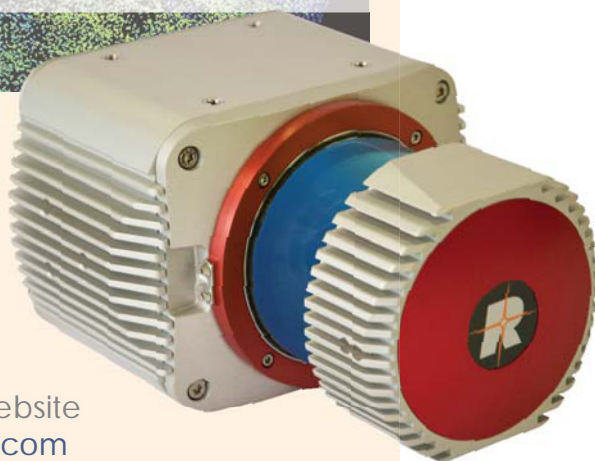
- 15 mm survey-grade accuracy
- scan speed up to 200 scans / second
- measurement rate up to 750,000 meas./sec
- operating flight altitude up to more than 1,700 ft
- field of view up to 330° for practically unrestricted data acquisition
- regular point pattern, perfectly parallel scan lines
- cutting edge RIEGL technology providing:
 - echo signal digitization
 - online waveform processing
 - multiple-time-around processing
- multiple target capability - practically unlimited number of target echoes
- compact (227x180x125 mm), lightweight (3.5 kg), and rugged
- easily mountable to helicopters, gyrocopter, and other small manned aircrafts
- mechanical and electrical interface for IMU mounting
- electrical interfaces for GPS data string and Sync Pulse (1PPS)
- LAN-TCP/IP interface
- scan data storage on internal 240 GByte SSD Memory

The *RIEGL VUX-1LR* is a very lightweight and compact laser scanner, meeting the challenges of airborne laser scanning by helicopter, gyrocopter, and other small aircraft both in measurement performance as in system integration. With regard to the specific constraints and flight characteristics, the *RIEGL VUX-1LR* is designed to be mounted in any orientation and even under limited weight and space conditions. Modest in power consumption, the instrument requires only a single power supply. The entire data set of an acquisition campaign is stored onto an internal 240 GByte SSD and/or provided as real-time line scan data via the integrated LAN-TCP/IP interface.

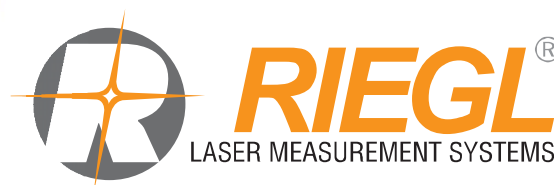
The *RIEGL VUX-1LR* provides highspeed data acquisition using a narrow infrared laser beam and a fast line scanning mechanism. High-accuracy laser ranging is based on *RIEGL*'s unique echo digitization and online waveform processing, which enables achieving superior measurement results even under adverse atmospheric conditions, and the evaluation of multiple target echoes. The scanning mechanism is based on an extremely fast rotating mirror, which provides fully linear, unidirectional and parallel scan lines, resulting in excellent regular point pattern.

Typical applications include

- **Corridor Mapping:**
Power Line, Railway Track and Pipeline Inspection
- **Topography in Open-Cast Mining**
- **Terrain and Canyon Mapping**
- **Surveying of Urban Environments**
- **Archeology and Cultural Heritage Documentation**
- **Agriculture & Forestry**
- **Resources Management**
- **Rapid Response in Small Scale Surveying (Collision Investigation, Risk Prevention)**



visit our website
www.riegl.com



Technical Data *RIEGL VUX®-1LR*

Laser Product Classification

Class 1 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.



Range Measurement Performance

Measuring Principle

time of flight measurement, echo signal digitization,
online waveform processing, multiple-time-around-processing

| Laser Pulse Repetition Rate PRR ¹⁾ | 50 kHz | 100 kHz | 200 kHz | 400 kHz | 600 kHz | 820 kHz | |
|---|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-----------------------------|
| | | | | | | full power | reduced power ²⁾ |
| Max. Measuring Range ^{3) 4)} | | | | | | | |
| natural targets $\rho \geq 20\%$ | 820 m | 600 m | 430 m | 300 m | 250 m | 215 m | 110 m |
| natural targets $\rho \geq 60\%$ | 1350 m | 1000 m | 720 m | 520 m | 430 m | 370 m | 180 m |
| Max. Operating Flight Altitude AGL ^{1) 5)} | 530 m (1740 ft) | 380 m (1250 ft) | 270 m (880 ft) | 190 m (620 ft) | 160 m (520 ft) | 140 m (460 ft) | 70 m (230 ft) |

Max. Number of Targets per Pulse practically unlimited (details on request)

- 1) Rounded values.
- 2) Laser power optimized (reduced) for measurements of short ranges with high pulse repetition rate.
- 3) Typical values for average conditions. 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 23 km. In bright sunlight, the max. range is shorter than under overcast sky.
- 4) Ambiguity to be resolved by post-processing with RIMTA ALS software.
- 5) Reflectivity $\rho \geq 20\%$, flat terrain assumed, scan angle $\pm 45^\circ$ FOV

Minimum Range

Accuracy ^{6) 8)}

Precision ^{7) 8)}

Laser Pulse Repetition Rate ^{1) 9)}

Max. Effective Measurement Rate ¹⁾

Echo Signal Intensity

Laser Wavelength

Laser Beam Divergence

Laser Beam Footprint (Gaussian Beam Definition)

5 m
15 mm
10 mm
up to 820 kHz
up to 750 000 meas./sec. (@ 820 kHz PRR & 330° FOV)
for each echo signal, high-resolution 16 bit intensity information is provided near infrared
0.5 mrad ¹⁰⁾
50 mm @ 100 m, 250 mm @ 500 m, 500 mm @ 1000 m

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

- 8) One sigma @ 150 m range under *RIEGL* test conditions.
- 9) User selectable.
- 10) Measured at the 1/e² points. 0.50 mrad corresponds to an increase of 50 mm of beam diameter per 100 m distance.

Scanner Performance

Scanning Mechanism

Field of View (selectable)

Scan Speed (selectable)

Angular Step Width $\Delta \theta$ (selectable)

between consecutive laser shots

Angle Measurement Resolution

Internal Sync Timer

Scan Sync (optional)

rotating mirror
up to 330° (full range measurement performance)
10 - 200 revolutions per second, equivalent to 10 - 200 scans/sec
 $0.004^\circ \leq \Delta \theta \leq 1.5^\circ$
0.001°
for real-time synchronized time stamping of scan data
scanner rotation synchronization

Data Interfaces

Configuration

Scan Data Output

GNSS Interface

Internal Memory

External Camera

External GNSS Antenna

LAN 10/100/1000 Mbit/sec
LAN 10/100/1000 Mbit/sec or USB 2.0
Serial RS232 interface for data string with GNSS-time information,
TTL input for 1PPS synchronization pulse
240 GByte SSD
TTL input/output
SMA connector

General Technical Data

Power Supply Input Voltage / Consumption ¹¹⁾

Main Dimensions ¹¹⁾

VUX-1UAV without / with Cooling Fan Device

Weight ¹¹⁾

VUX-1UAV without / with Cooling Fan Device

Humidity

Protection Class

Max. Flight Altitude (operating / not operating)

Temperature Range ¹²⁾

11 - 32 V DC / typ. 65 W
227 x 180 x 125 mm / 227 x 209 x 129 mm
approx. 3.5 kg / approx. 3.75 kg
max. 80 % non condensing @ 31°C
IP64, dust and splash-proof
16 500 ft (5 000 m) above MSL / 18 000 ft (5 500 m) above MSL
0°C up to +40°C (operation) / -20°C up to +50°C (storage)

Optional Components (integrated) ¹³⁾

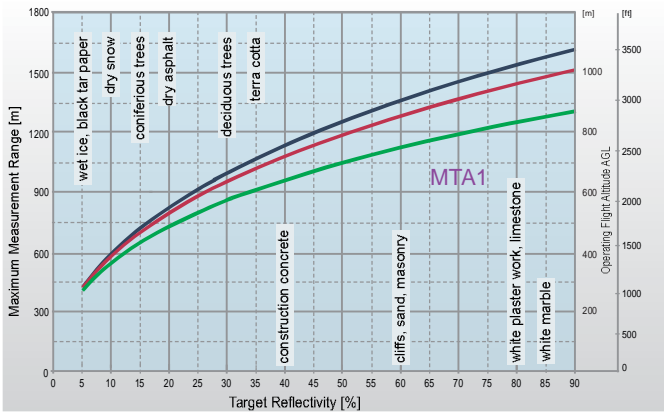
Embedded GNSS-Inertial System

high performance multi-channel, multi-band GNSS receiver,
solid-state MEMS IMU

- 11) without external IMU/GNSS, cooling fan device not in operation
- 12) The instrument requires air convection with a minimum flow rate of 5 m/s for continuous operation at +15 °C and above. If the necessary flow rate cannot be provided by the moving platform, the cooling fan device (included in the scope of delivery) has to be used.
- 13) available last quarter 2015

Maximum Measurement Range & Point Density RIEGL VUX®-1LR

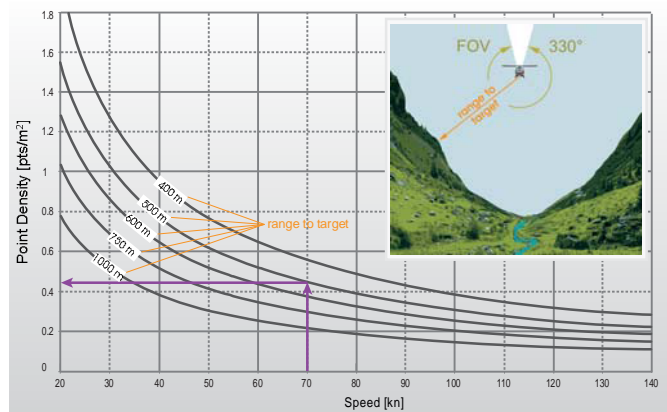
PRR = 50 kHz



MTA1: no ambiguity / one transmitted pulse „in the air“

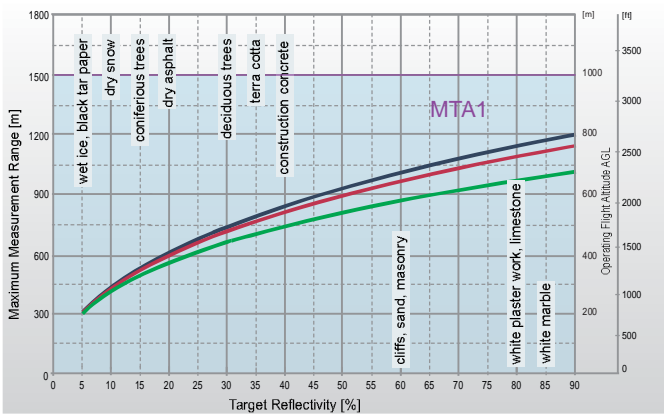
— @ visibility 23 km
— @ visibility 15 km
— @ visibility 8 km

PRR = 50 kHz



Example: VUX-1LR at 50,000 pulses/second
range to target = 500 m, speed = 70 kn
Resulting Point Density = 0.44 pts/m²

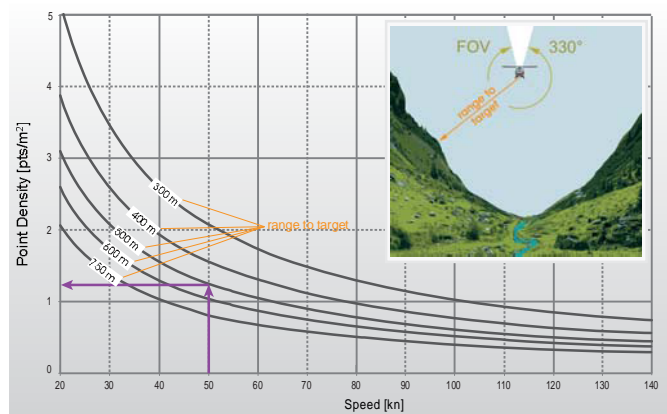
PRR = 100 kHz



MTA1: no ambiguity / one transmitted pulse „in the air“

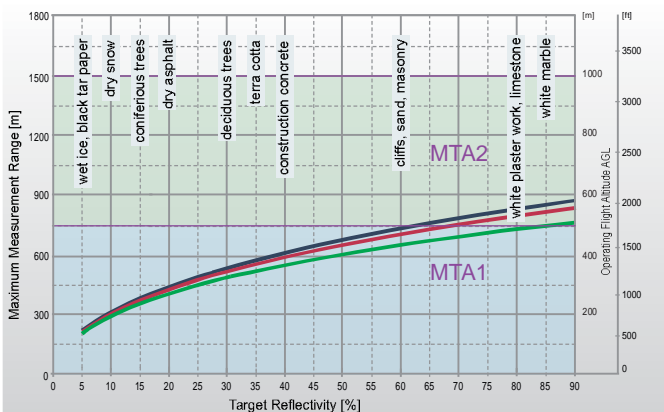
— @ visibility 23 km
— @ visibility 15 km
— @ visibility 8 km

PRR = 100 kHz



Example: VUX-1LR at 100,000 pulses/second
range to target = 500 m, speed = 50 kn
Resulting Point Density = 1.2 pts/m²

PRR = 200 kHz

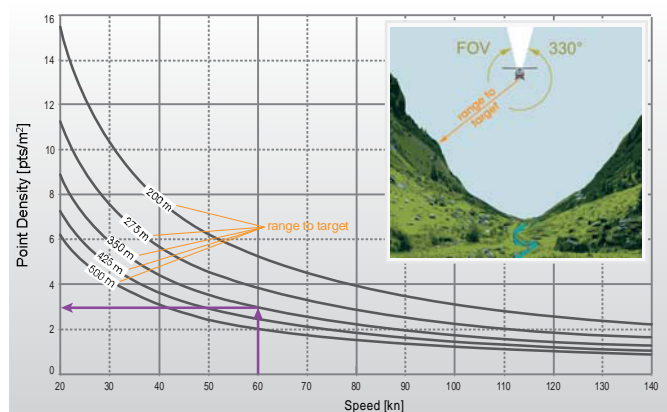


MTA1: no ambiguity / one transmitted pulse „in the air“

MTA2: two transmitted pulses „in the air“

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

PRR = 200 kHz



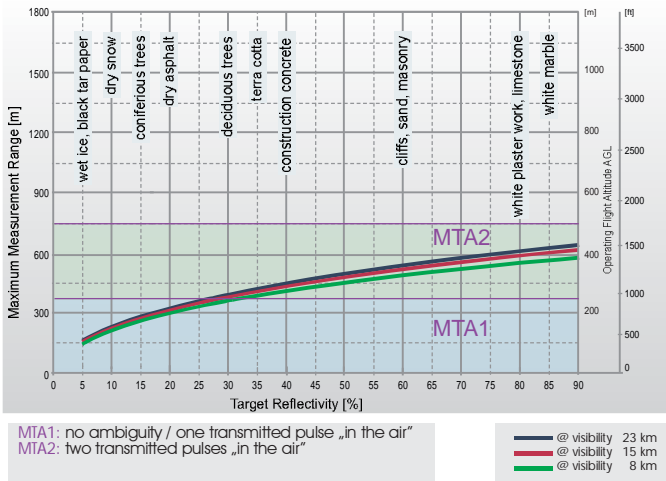
Example: VUX-1LR at 200,000 pulses/second
range to target = 350 m, speed = 60 kn
Resulting Point Density = 3.0 pts/m²

The following conditions are assumed for the Operating Flight Altitude AGL

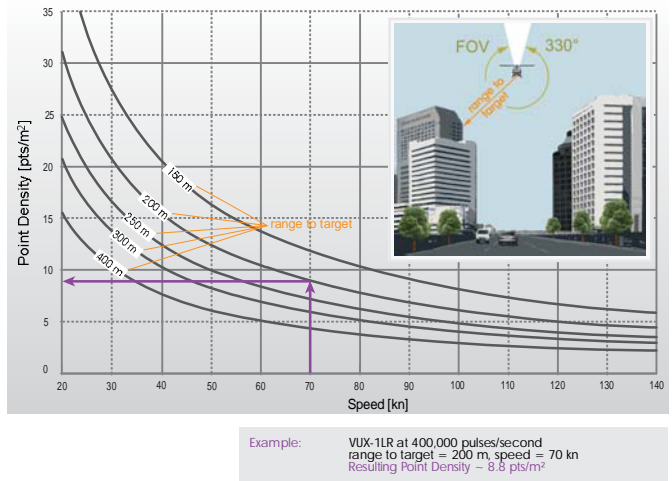
- ambiguity resolved by multiple-time-around (MTA) processing & flight planning
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of +/-45°

Maximum Measurement Range & Point Density *RIEGL VUX®-1LR*

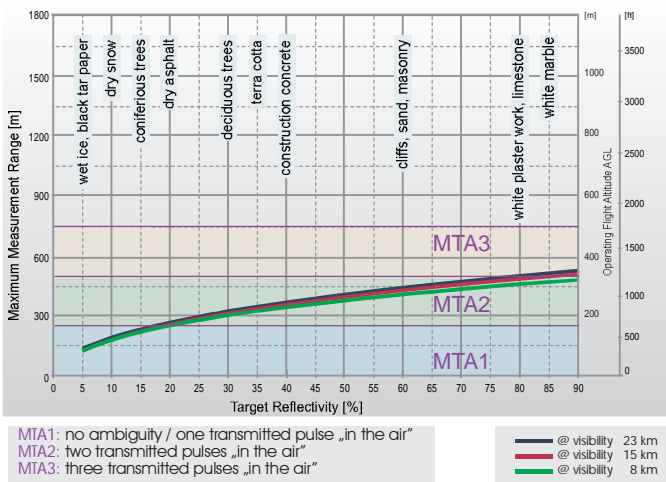
PRR = 400 kHz



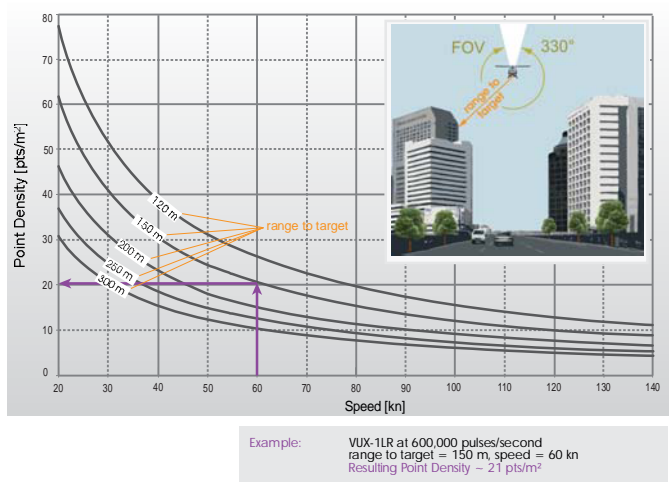
PRR = 400 kHz



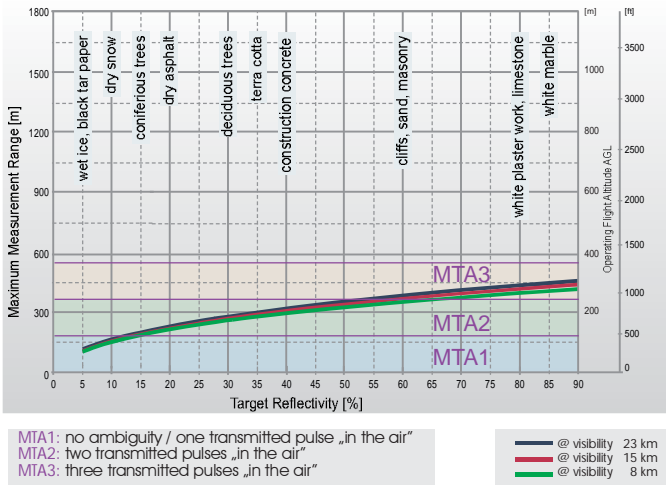
PRR = 600 kHz



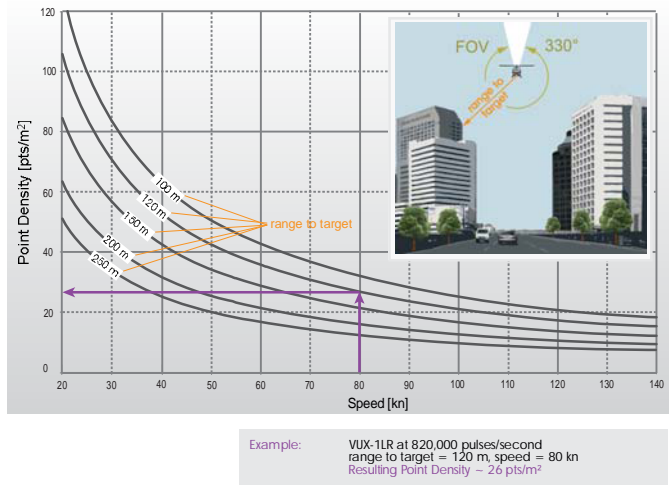
PRR = 600 kHz



PRR = 820 kHz



PRR = 820 kHz



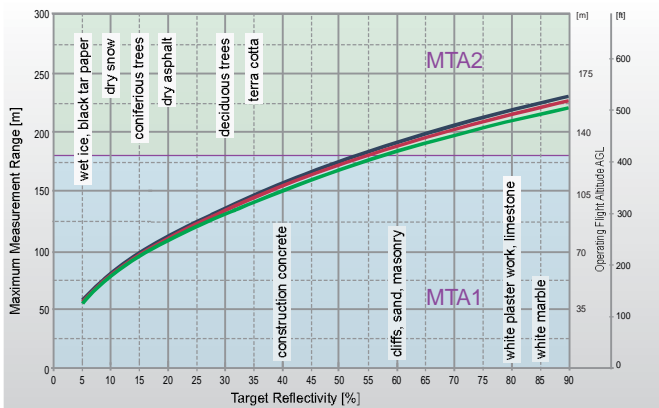
The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing & flight planning
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of +/-45°

Maximum Measurement Range & Point Density *RIEGL VUX®-1LR*

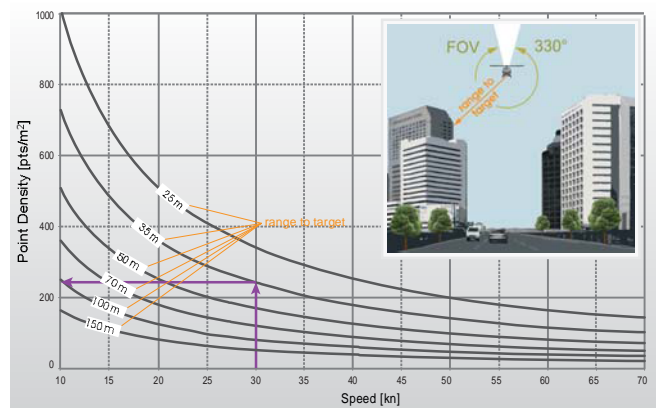
PRR = 820 kHz reduced power

PRR = 820 kHz reduced power



MTA1: no ambiguity / one transmitted pulse „in the air“
 MTA2: two transmitted pulses „in the air“

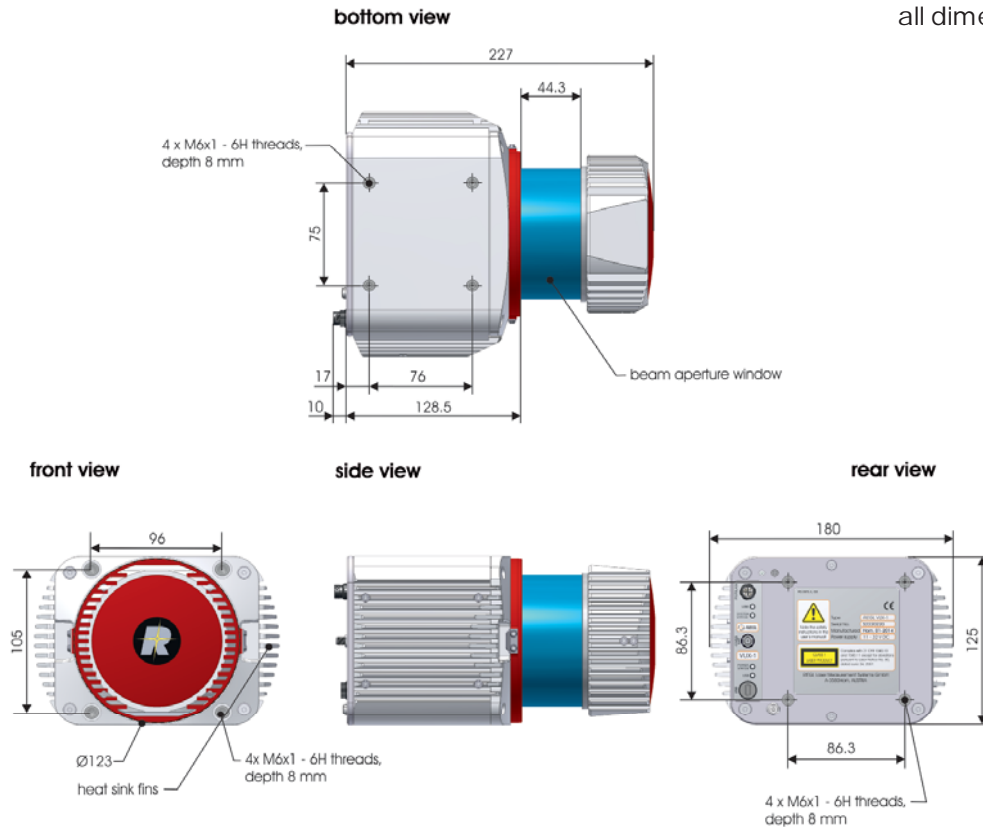
— @ visibility 23 km
 — @ visibility 15 km
 — @ visibility 8 km



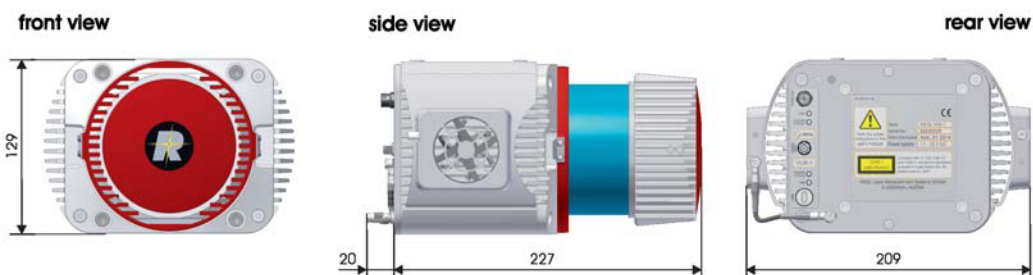
Example: VUX-1LR at 820 000 pulses/second reduced range to target = 35 m, speed = 30 kn
 Resulting Point Density = 240 pts/m²

Dimensional Drawings *RIEGL VUX®-1LR*

all dimensions in mm



RIEGL VUX®-1LR with Cooling Fan Device



RIEGL VUX®-1LR Additional Equipment and Integration



Cooling Fan Device



RIEGL VUX-1LR with Protective Cap



RIEGL VUX-1LR with external IMU-Sensor (RIEGL VUX-SYS)

Additional Equipment for RIEGL VUX-1LR

Cooling Fan Device

Lightweight structure with two axial fans providing forced air convection for applications where sufficient natural air flow cannot be guaranteed. Power supply is provided via a connector on the rear side of the RIEGL VUX-1LR. The cooling fan device can be mounted either on the top side or on the bottom side of the RIEGL VUX-1LR and is included in the scanner's scope of delivery. The cooling fan device is to be mounted whenever the environmental conditions/temperatures require (see "temperature range" on page 2 of this datasheet).

Protective Cap

To shield the glass tube of the RIEGL VUX-1LR from mechanical damage and soiling, a protective cap is provided to cover the upper part of the instrument during transport and storage.

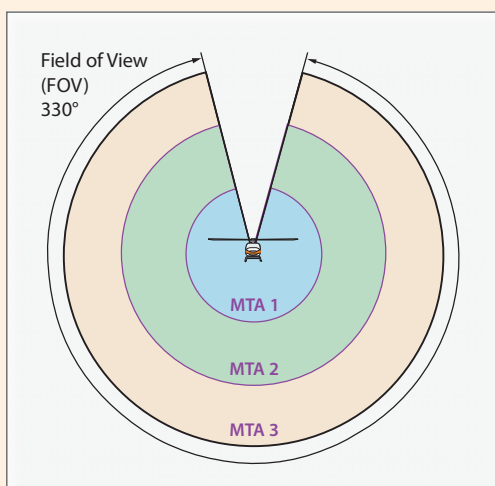
Options for RIEGL VUX-1LR Integration

RIEGL provides user-friendly, application- and installation-oriented solutions for integration of the VUX-1LR LiDAR sensor:

- **RIEGL VUX-SYS**
Complete airborne laser scanning system for flexible use in UAS/UAV/RPAS, helicopter, gyrocopter and ultra-light aircraft installations comprising the RIEGL VUX-1LR, an IMU/GNSS system and a dedicated control unit.
- **RIEGL VP-1**
Small and lightweight pod with integrated RIEGL VUX-SYS to be mounted on standard hard points and typical camera mounts of manned helicopters
- **RIEGL RiCOPTER**
Ready to fly remotely piloted airborne laser scanning system with RIEGL VUX-SYS integrated

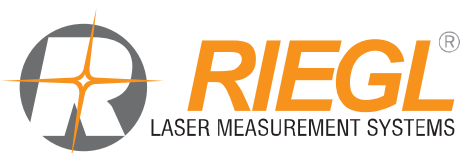
Details to be found on the relevant datasheets and infosheets.

Multiple-Time-Around Data Acquisition and Processing



In time-of-flight laser ranging a maximum unambiguous measurement range exists, which is defined by the laser pulse repetition rate and the speed of light. In case the echo signal of an emitted laser pulse arrives later than the emission of the subsequently emitted laser pulse, the range result becomes ambiguous - an effect known as „Multiple-Time-Around“ (MTA).

The RIEGL VUX-1LR allows ranging beyond the maximum unambiguous measurement range using a sophisticated modulation scheme applied to the train of emitted laser pulses. The dedicated post-processing software RiMTA provides algorithms for multiple-time-around processing, which automatically assign definite range results to the correct MTA zones without any further user interaction required.



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