Lightweight Airborne Laser Scanner with Online Waveform Processing

RIEGL VUX®-1LR22

- *15 mm survey-grade accuracy*
- *scan speed up to 200 scans / second*
- *PRR values freely selectable*
- *measurement rate up to 1,500,000 meas./sec (@ 1500 kHz PRR & 360° FOV)*
- *operating flight altitude more than 3,440 ft*
- *field of view up to 360° 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 - up to 15 target echoes*
- *compact (227x180x125 mm), lightweight (3.5 kg), and rugged*
- *easily mountable to helicopters, gyrocopters, 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*
- *internal data storage on Solid State Disc SSD, 1 TByte*

The *RIEGL* VUX-1LR22 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 well as in system integration.

With regard to the specific constraints and flight characteristics, the *RIEGL* VUX-1LR22 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 1 TByte SSD and/or provided as real-time line scan data via the integrated LAN-TCP/IP interface.

The *RIEGL* VUX-1LR22 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

RIEGL®
LASER MEASUREMENT SYSTEMS

Laser Product Classification according to IEC 60825-1:2014	Class 1 Laser Product

The following clause applies for instruments delivered into the United States: Complies 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.



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) 2)]	*50 kHz*	*200 kHz*	*400 kHz*	*600 kHz*	*800 kHz*	*1200 kHz*	*1500 kHz*
Max. Measuring Range [3) 4)]							
natural targets ρ ≥ 20 %	1000 m	600 m	435 m	355 m	310 m	255 m	230 m
natural targets ρ ≥ 60 %	1630 m	1000 m	730 m	600 m	525 m	435 m	390 m
natural targets ρ ≥ 80 %	1845 m	1140 m	830 m	690 m	600 m	500 m	445 m
Max. Operating Flight Altitude AGL [1) 5)]							
@ ρ ≥ 20 %	640 m (2110 ft)	390 m (1270 ft)	280 m (920 ft)	230 m (750 ft)	200 m (650 ft)	160 m (540 ft)	150 m (490 ft)
@ ρ ≥ 60 %	1050 m (3440 ft)	640 m (2110 ft)	470 m (1540 ft)	390 m (1270 ft)	340 m (1110 ft)	280 m (920 ft)	250 m (820 ft)
Max. Number of Targets per Pulse [6)]	15	15	15	15	11	7	5

1) Rounded values.
2) Setting of intermediate PRR values possible.
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 RiUNITE software.
5) Flat terrain assumed, scan angle ±45° FOV.
6) If more than one target is hit, the total laser transmitter power is split and, accordingly, the achieveable range is reduced.

Minimum Range	3m @ PRR ≤ 500 kHz, 2m @ 500 kHz < PRR < 1 MHz, 1.5m @ PRR ≥ 1 MHz
Accuracy [7) 9)]	15 mm
Precision [8) 9)]	5 mm
Laser Pulse Repetition Rate [1) 10)]	up to 1500 kHz
Max. Effective Measurement Rate [1)]	up to 1 500 000 meas./sec. (@ 1500 kHz PRR & 360° FOV)
Echo Signal Intensity	for each echo signal, high-resolution 16 bit intensity information is provided
Laser Wavelength	near infrared
Laser Beam Divergence	typ. 0.35 mrad @ 1/e [11)], typ. 0.5 mrad @ 1/e² [12)]
Laser Beam Footprint (Gaussian Beam Definition)	50 mm @ 100 m, 250 mm @ 500 m, 500 mm @ 1000 m

7) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
8) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
9) One sigma @ 150 m range under *RIEGL* test conditions.
10) User selectable, setting of intermediate PRR values possible.
11) Measured at the 1/e points. 0.35 mrad corresponds to an increase of 35 mm of beam diameter per 100 m distance.
12) 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 [14)]	rotating mirror
Field of View (selectable)	up to 360° [13)]
Scan Speed (selectable) [14)]	10 - 200 revolutions per second, equivalent to 10 - 200 scans/sec
Angular Step Width Δ ϑ (selectable) between consecutive laser shots	0.002° ≤ Δ ϑ ≤ 1.5°
Angle Measurement Resolution	0.001°
Internal Sync Timer	for real-time synchronized time stamping of scan data
Scan Sync (optional)	scanner rotation synchronization

13) slightly degraded ranging performance around 0°/360°
14) The rotation noise may vary from device to device and depends strongly on the rotation speed. A louder rotation noise in a device compared to other devices is usually no indication of a malfunction, does not qualify for a rectification, nor does it constitute a warranty case. The max. noise is less than 70 dB(A) at 1 m distance.

Data Interfaces

Configuration / Scan Data Output	LAN 10/100/1000 Mbit/sec / LAN 10/100/1000 Mbit/sec or USB 2.0
GNSS Interface	Serial RS-232 interface for data string with GNSS-time information,
TTL input for 1PPS synchronization pulse	
Internal Data Storage	1 TByte SSD
Memory Card Slot [15)]	for CFAST® [16)] industrial memory card 240 GByte (can be upgraded to 480 GByte)
External Camera	TTL input/output
External GNSS Antenna	SMA connector (optional)

General Technical Data

Power Supply Input Voltage / Consumption [17)]	11 - 34 V DC / typ. 65 W
Main Dimensions [18)]	
VUX-1LR without / with Cooling Fan	227 x 180 x 125 mm / 227 x 209 x 129 mm
Weight [18)]	
VUX-1LR without / with Cooling Fan	approx. 3.5 kg / approx. 3.75 kg
Humidity	max. 80 % non condensing @ 31°C
Protection Class	IP64, dust and splash-proof
Max. Flight Altitude (operating / not operating)	16 500 ft (5 000 m) above MSL / 18 000 ft (5 500 m) above MSL
Temperature Range [19)]	-20°C[20)] up to +40°C (operation) / -20°C up to +50°C (storage)

Optional Components (integrated)

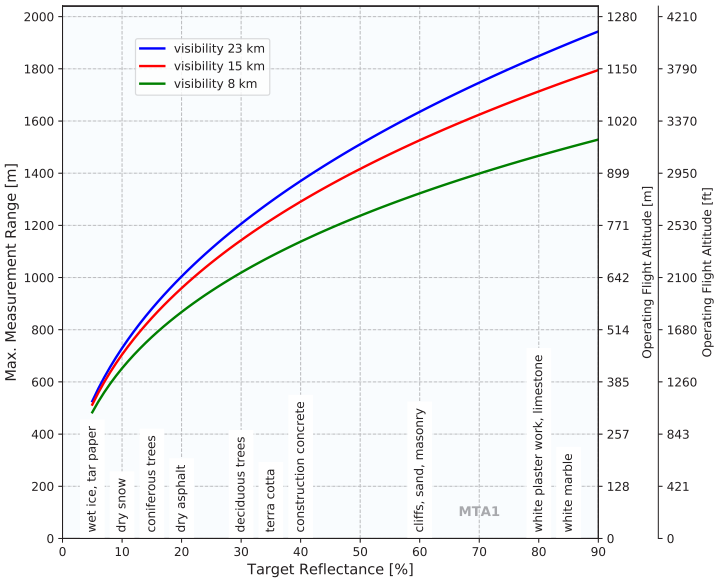
Embedded GNSS-Inertial System	high performance multi-channel GNSS receiver, low-grade, solid-state MEMS IMU

15) applies to IMU APX-20 UAV only
16) CFast is a registered trademark of CompactFlash Association
17) without external IMU/GNSS, cooling fan device not in operation
18 without external IMU/GNSS
19) 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.
20) Contininous scanning operation if instrument is powered on while internal temperature is at or above 0°C and still air. Insulating the scanner with appropriate material will enable operation at even lower temperatures.

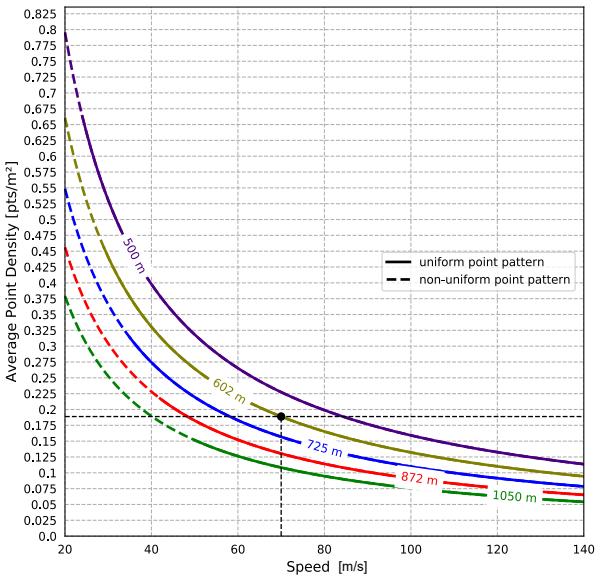
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Maximum Measurement Range & Point Density *RIEGL* VUX®-1LR[22]

PRR = 50 kHz

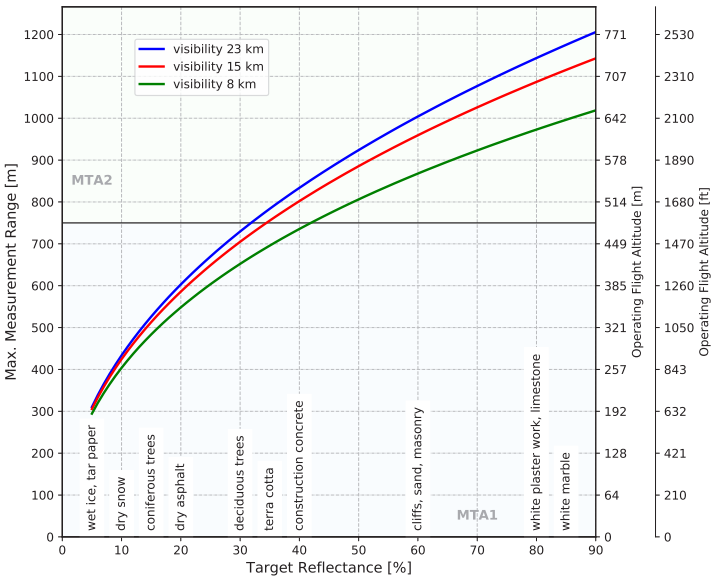


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

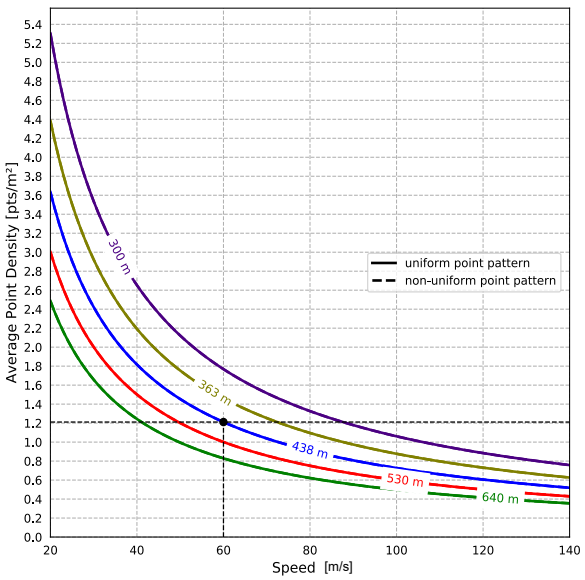


Example: VUX-1LR[22] at 50,000 pulses/second, speed = 70 m/s,
range to target = 602 m, resulting point density ~ 0.19 pts/m²

PRR = 200 kHz

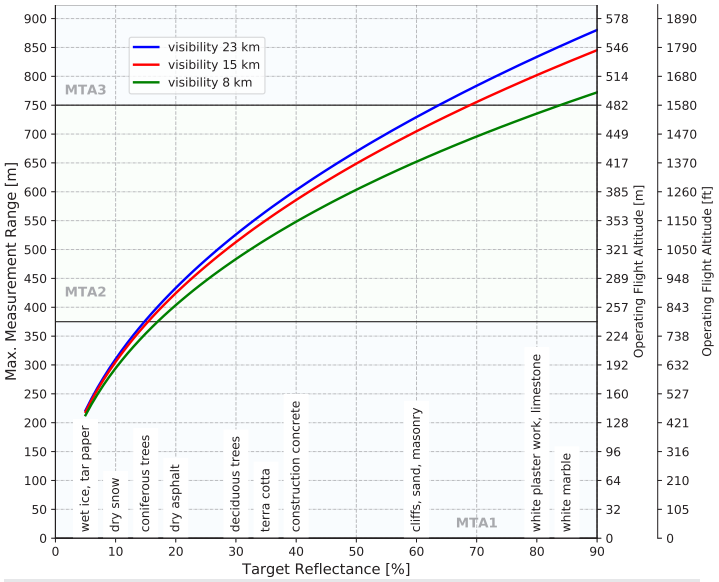


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

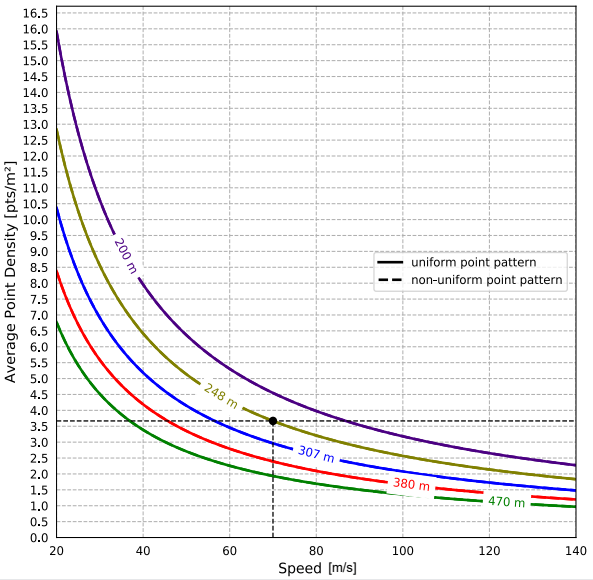


Example: VUX-1LR[22] at 200,000 pulses/second, speed = 60 m/s,
range to target = 438 m, resulting point density ~ 1.2 pts/m²

PRR = 400 kHz



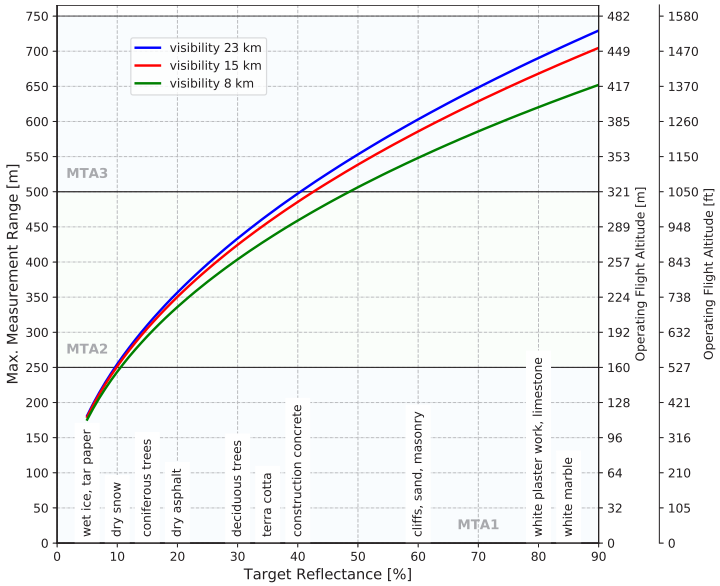
Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint



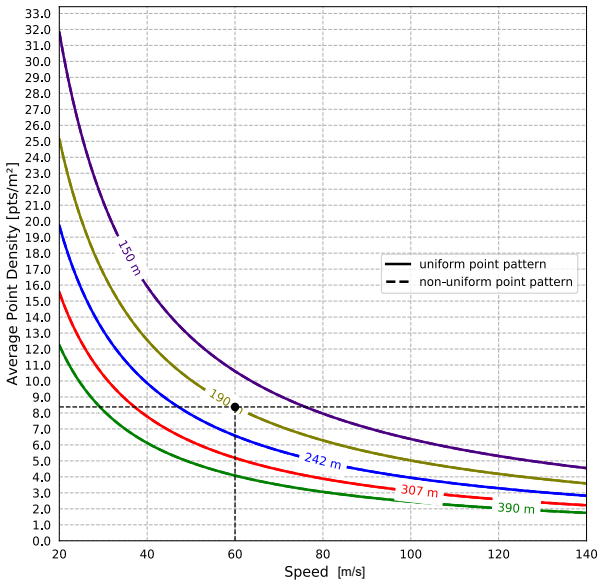
Example: VUX-1LR[22] at 400,000 pulses/second, speed = 70 m/s,
range to target = 248 m, resulting point density ~ 3.6 pts/m²

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PRR = 600 kHz

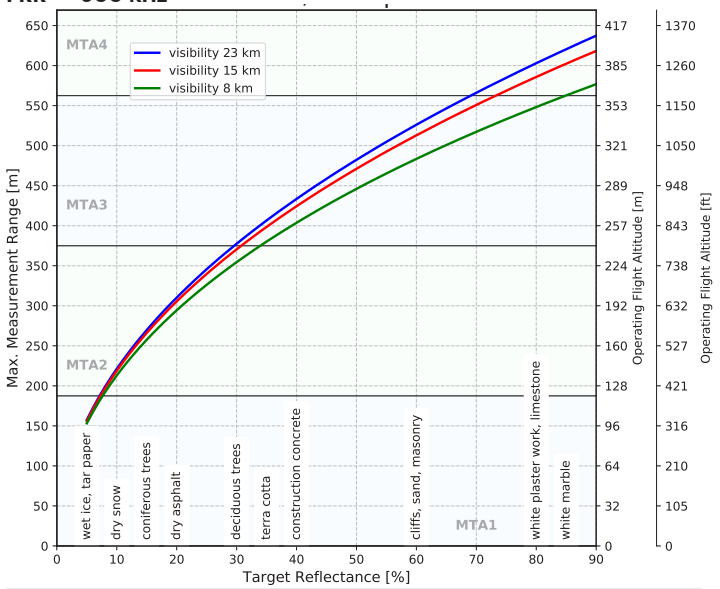


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

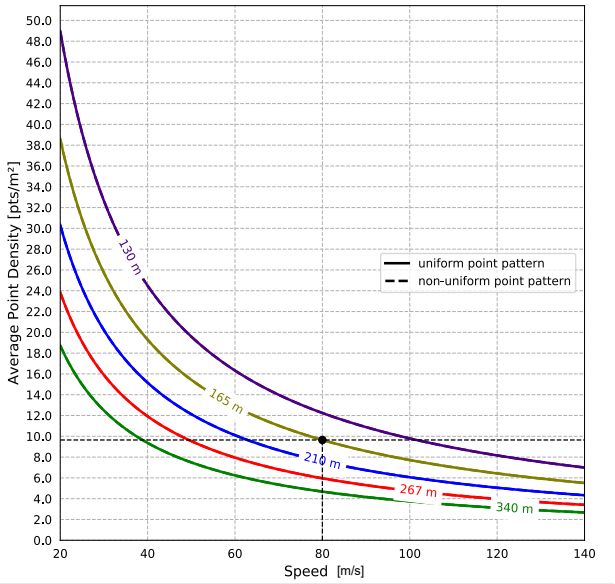


Example: VUX-1LR[22] at 600,000 pulses/second, speed = 60 m/s, range to target = 190 m, resulting point density ~ 8.4 pts/m²

PRR = 800 kHz

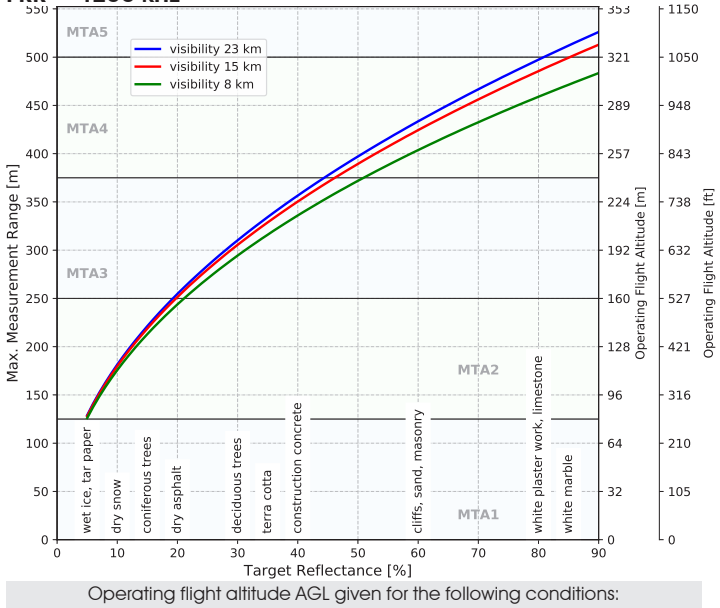


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

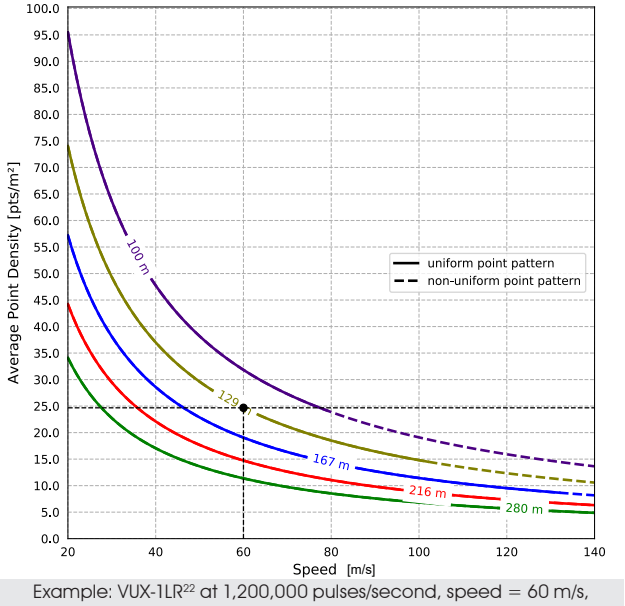


Example: VUX-1LR[22] at 800,000 pulses/second, speed = 80 m/s, range to target = 165 m, resulting point density ~ 9.7 pts/m²

PRR = 1200 kHz



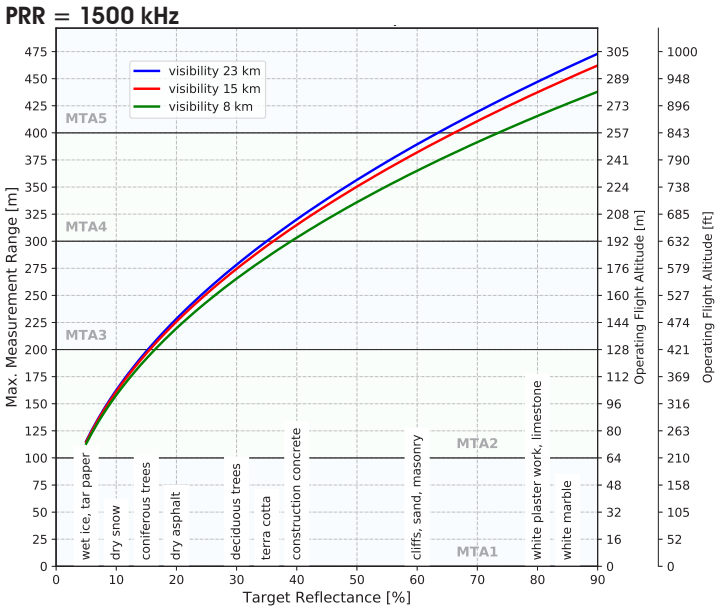
Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint



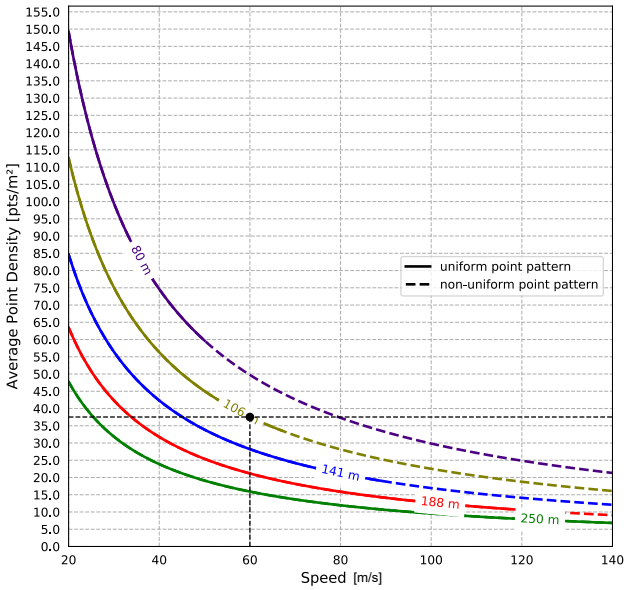
Example: VUX-1LR[22] at 1,200,000 pulses/second, speed = 60 m/s, range to target = 129 m, resulting point density ~ 25 pts/m²

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Maximum Measurement Range & Point Density *RIEGL* VUX®-1LR22



Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

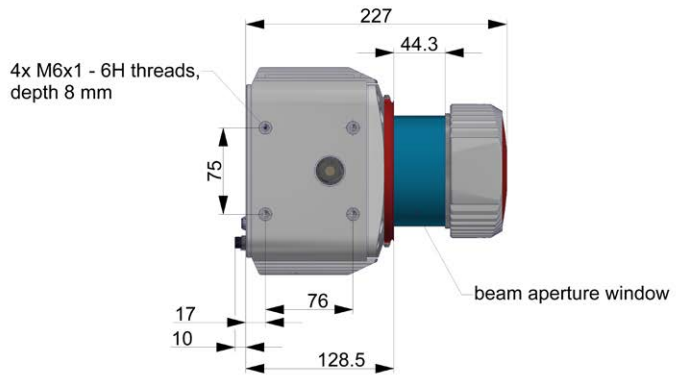


Example: VUX-1LR22 at 1,500,000 pulses/second, speed = 60 m/s,
range to target = 106 m, resulting point density ~ 38 pts/m²

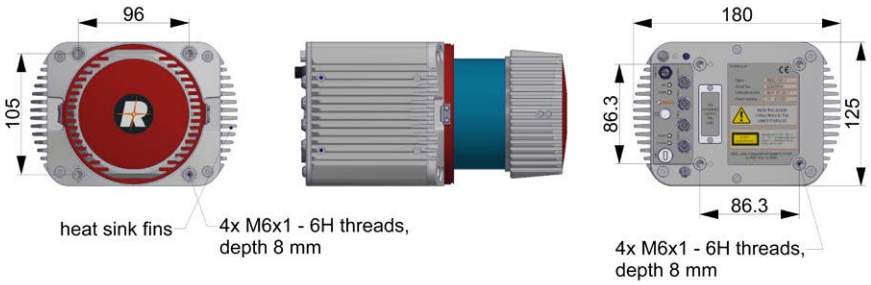
Dimensional Drawings *RIEGL* VUX®-1LR22

all dimensions in mm

bottom view

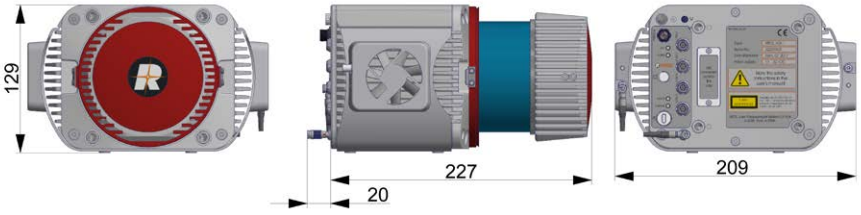


front view **side view** **rear view**



RIEGL VUX®-1LR22 with Cooling Fan Device

front view **side view** **rear view**



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RIEGL VUX®-1LR²² Additional Equipment and Integration



Cooling Fan



***RIEGL* VUX-1LR²² with Protective Cap**



***RIEGL* VUX-1LR²² with external IMU-Sensor**
(*RIEGL* VUX-SYS)

Additional Equipment for *RIEGL* VUX-1LR²²

Cooling Fan

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-1LR²². The cooling fan can be mounted either on the top side or on the bottom side of the *RIEGL* VUX-1LR²² and is included in the scanner's scope of delivery.

The cooling fan has to be mounted whenever the environmental conditions/ temperatures require (see "temperature range" on page 2 of this data sheet).

Protective Cap

To shield the glass tube of the *RIEGL* VUX-1LR²² 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-1LR²² Integration

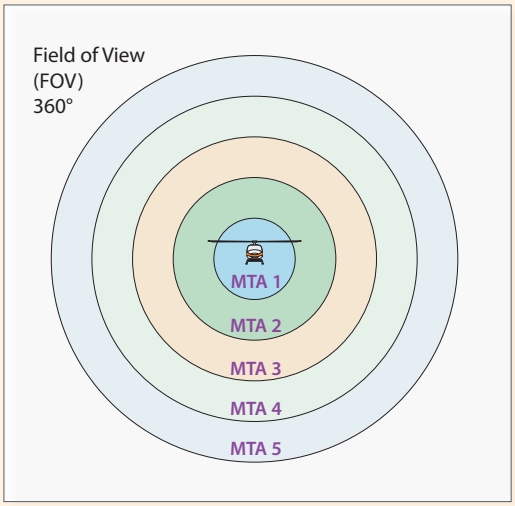
RIEGL provides user-friendly, application- and installation-oriented solutions for integration of the VUX-1LR²² LiDAR sensor:

- ***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-1LR²², an IMU/GNSS unit 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

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-1LR²² 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 module RiUNITE provides algorithms for multiple-time-around processing, which automatically assign definite range results to the correct MTA zones without any further user interaction required.

RIEGL® LASER MEASUREMENT SYSTEMS

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