Lightweight UAV Laser Scanner with Online Waveform Processing

RIEGL VUX®-1UAV22

- *10 mm survey-grade accuracy*
- *scan speed up to 200 scans / second*
- *PRR values freely selectable*
- *measurement rate up to 1,200,000 meas./sec (@ 1200 kHz PRR & 360° FOV)*
- *operating flight altitude more than 2,640 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 professional UAS / UAV / RPAS*
- *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*

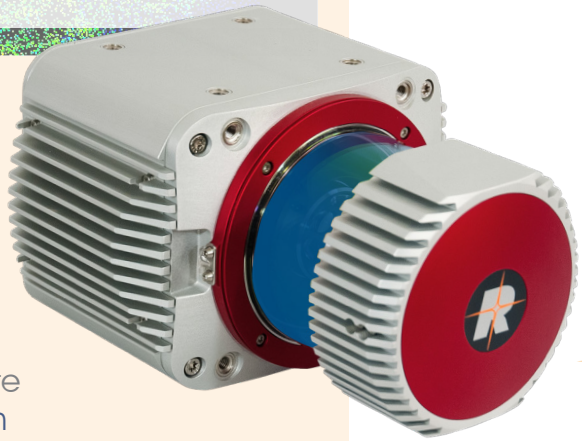
The *RIEGL* VUX-1UAV22 is a very lightweight and compact laser scanner, meeting the challenges of emerging survey solutions by UAS/UAV/RPAS both in measurement performance as well as in system integration.

With regard to the specific constraints and flight characteristics of the UAS, the *RIEGL* VUX-1UAV22 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-1UAV22 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

- *Agriculture & Forestry*
- *Archaeology and Cultural Heritage Documentation*
- *Corridor Mapping: Power Line, Railway Track, and Pipeline Inspection*
- *Topography in Open-Cast Mining*
- *Construction-Site Monitoring*
- *Surveying of Urban Environments*
- *Resources Management*



visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS

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

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*	*100 kHz*	*200 kHz*	*400 kHz*	*600 kHz*	*800 kHz*	*1200 kHz*
Max. Measuring Range [3) 4)]							
natural targets ρ ≥ 20 %	755 m	545 m	390 m	280 m	230 m	200 m	160 m
natural targets ρ ≥ 60 %	1250 m	910 m	660 m	480 m	390 m	340 m	280 m
natural targets ρ ≥ 80 %	1415 m	1040 m	755 m	550 m	450 m	390 m	320 m
Max. Operating Flight Altitude AGL [1) 5)]							
@ ρ ≥ 20 %	490 m (1590 ft)	350 m (1150 ft)	250 m (820 ft)	180 m (590 ft)	150 m (490 ft)	130 m (420 ft)	100 m (340 ft)
@ ρ ≥ 60 %	800 m (2640 ft)	580 m (1920 ft)	420 m (1390 ft)	310 m (1010 ft)	250 m (820 ft)	220 m (720 ft)	180 m (590 ft)
Max. Number of Targets per Pulse up to [6)]	15	15	15	15	15	11	7

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)]	10 mm
Precision [8) 9)]	5 mm
Laser Pulse Repetition Rate [1) 10)]	up to 1200 kHz
Max. Effective Measurement Rate [1)]	up to 1200 000 meas./sec. (@ 1200 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° (full range measurement performance) [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	0.003° ≤ 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

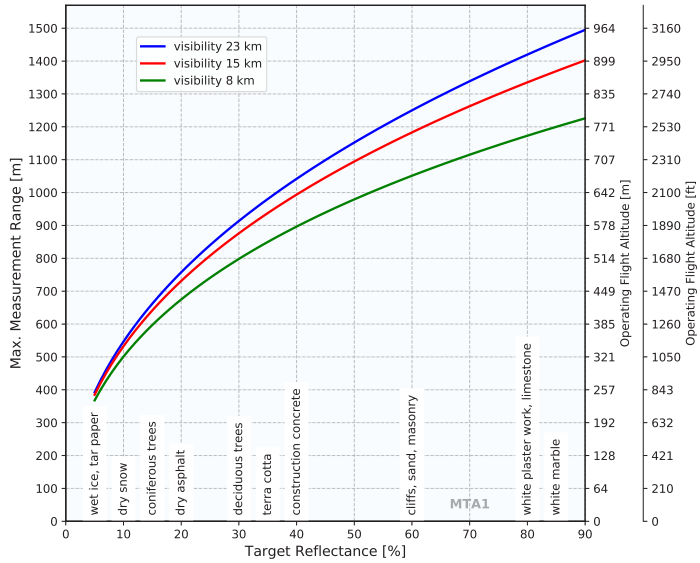
Power Supply Input Voltage / Consumption [17)]	11 - 34 V DC / typ. 60 W
Main Dimensions [18)]	
VUX-1UAV without / with Cooling Fan	227 x 180 x 125 mm / 227 x 209 x 129 mm
Weight [18)]	
VUX-1UAV without / with Cooling Fan	approx. 3.5 kg / approx. 3.75 kg
Humidity	max. 80 % non condensing @ 31°C
Protection 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)

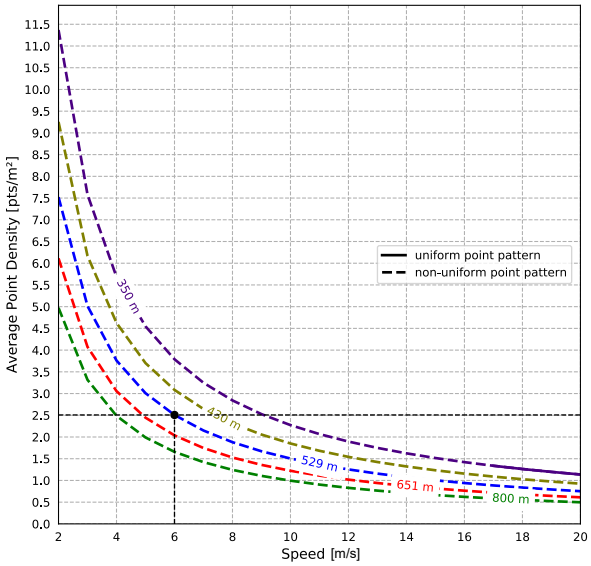
Embedded GNSS-Inertial System	high performance multi-channel GNSS receiver, low-grade, solid-state MEMS IMU

15) applies to IMU APX-20 UAV only
16) CFast is a registered trademark of CompactFlash Association
17) without external IMU/GNSS, cooling fan 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 (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.

PRR = 50 kHz

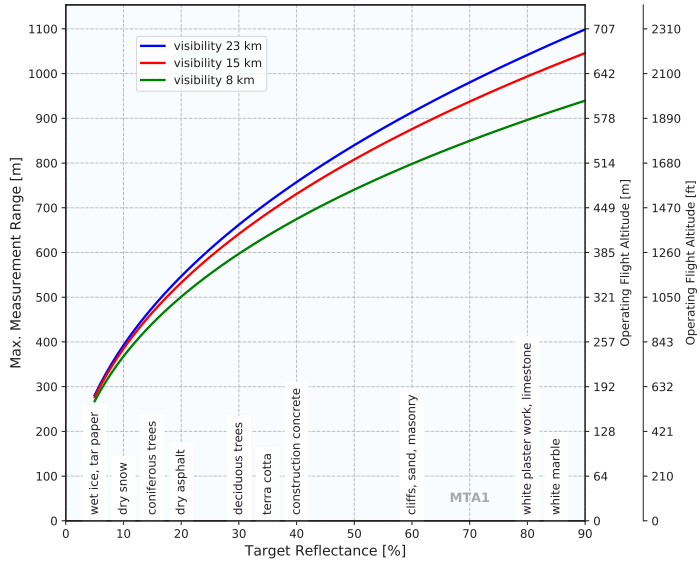


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

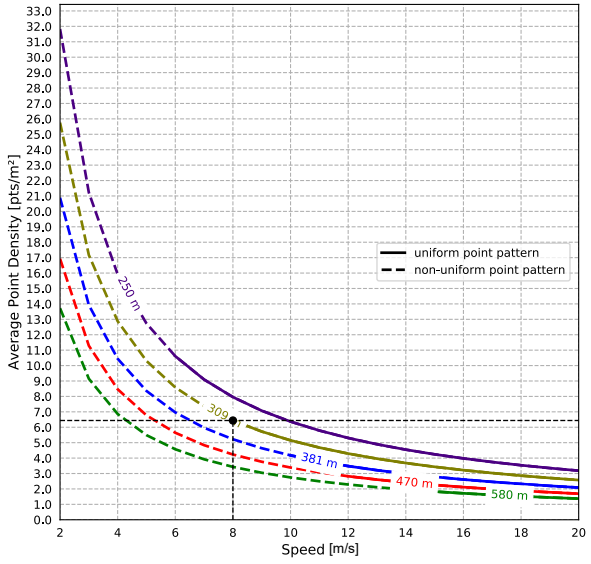


Example: VUX-1UAV[22] at 50,000 pulses/second, speed = 6 m/s,
range to target = 529 m, resulting point density ~ 2.5 pts/m²

PRR = 100 kHz

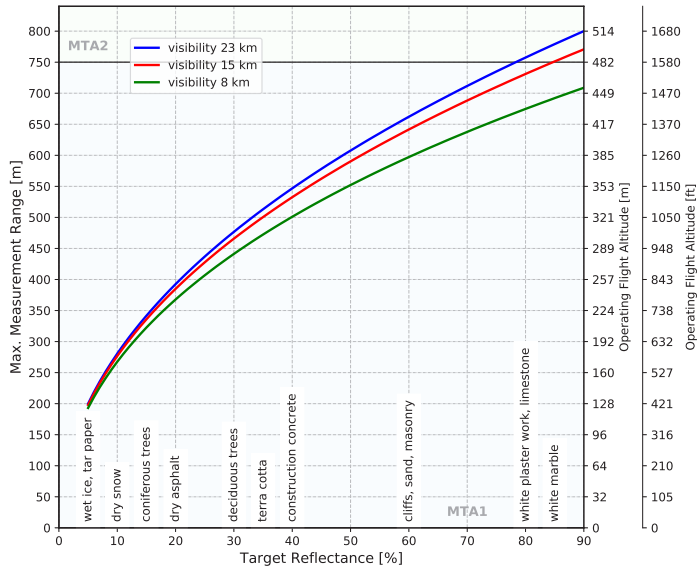


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

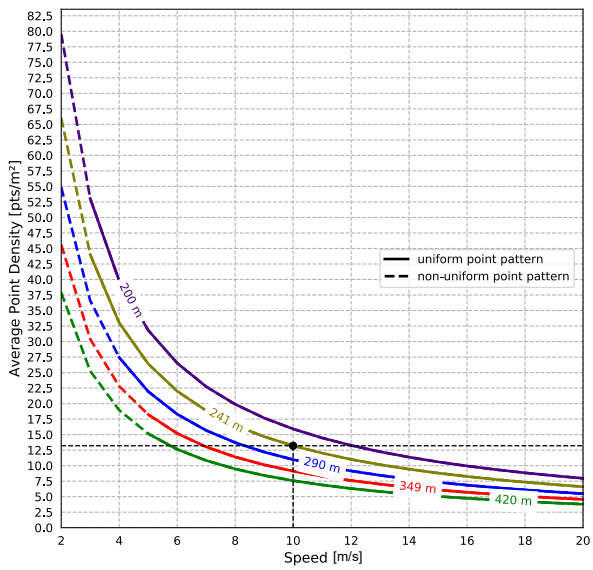


Example: VUX-1UAV[22] at 100,000 pulses/second, speed = 8 m/s,
range to target = 309 m, resulting point density ~ 6.5 pts/m²

PRR = 200 kHz

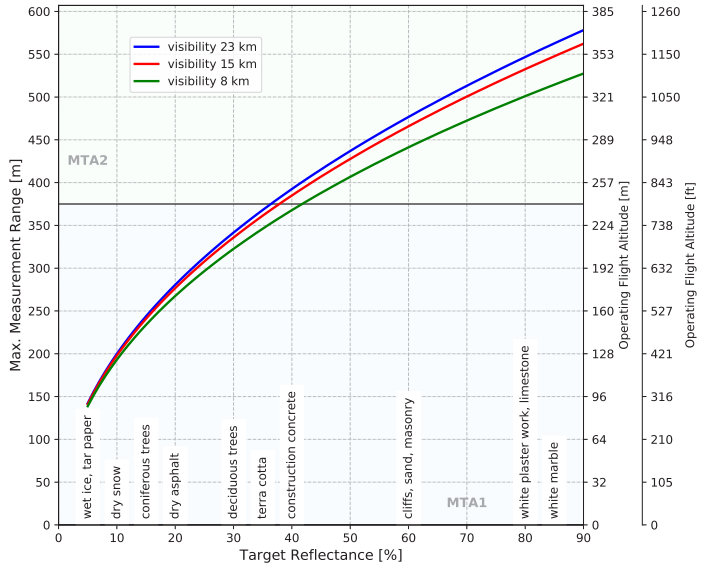


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

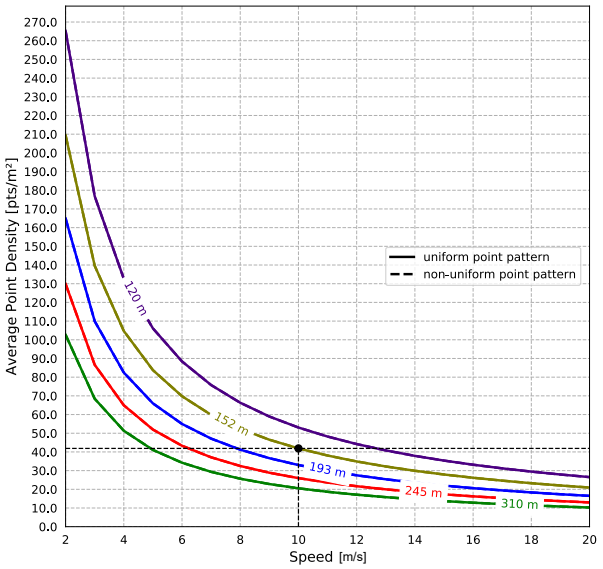


Example: VUX-1UAV[22] at 200,000 pulses/second, speed = 10 m/s,
range to target = 241 m, resulting point density ~ 13 pts/m²

PRR = 400 kHz

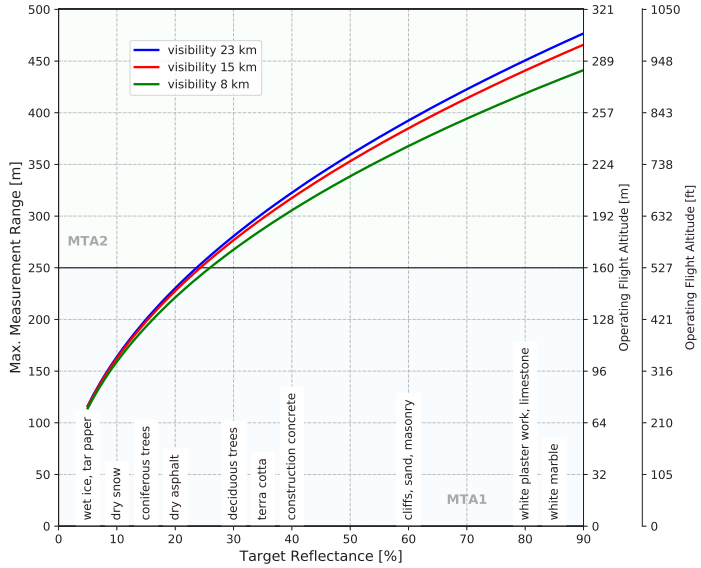


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

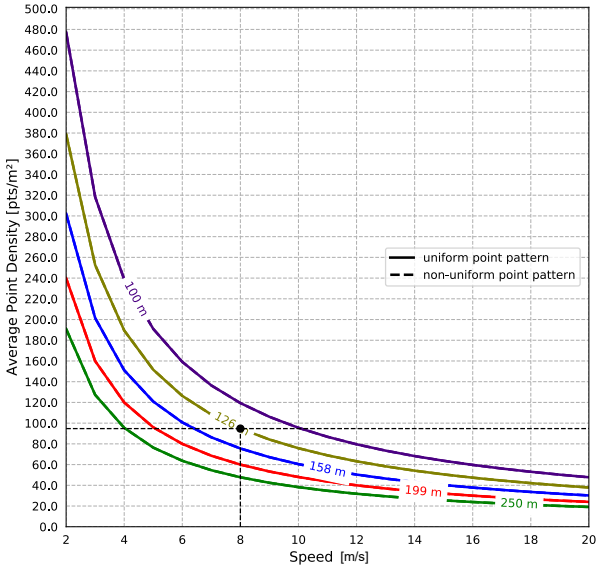


Example: VUX-1UAV[22] at 400,000 pulses/second, speed = 10 m/s,
range to target = 152 m, resulting point density ~ 42 pts/m²

PRR = 600 kHz

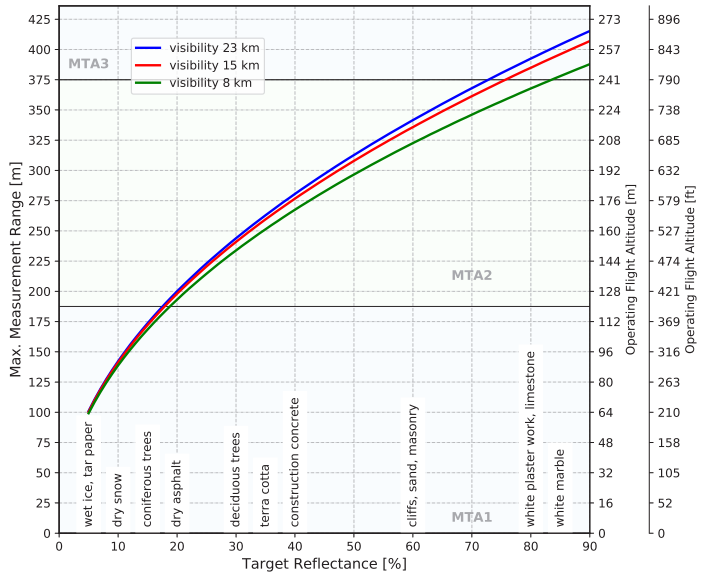


Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint

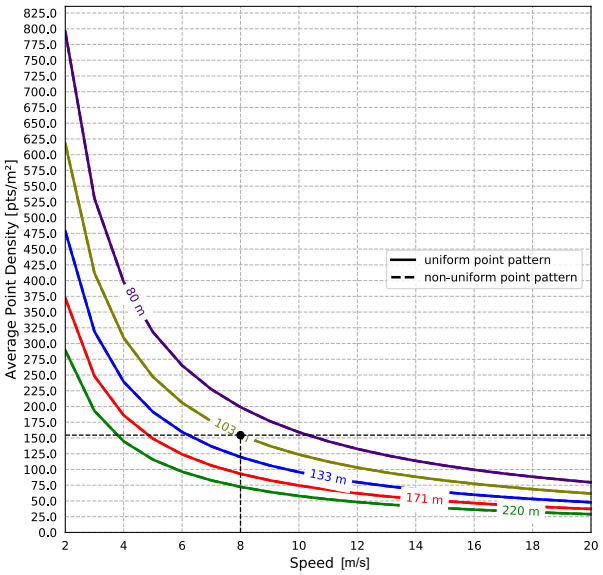


Example: VUX-1UAV[22] at 600,000 pulses/second, speed = 8 m/s,
range to target = 126 m, resulting point density ~ 95 pts/m²

PRR = 800 kHz



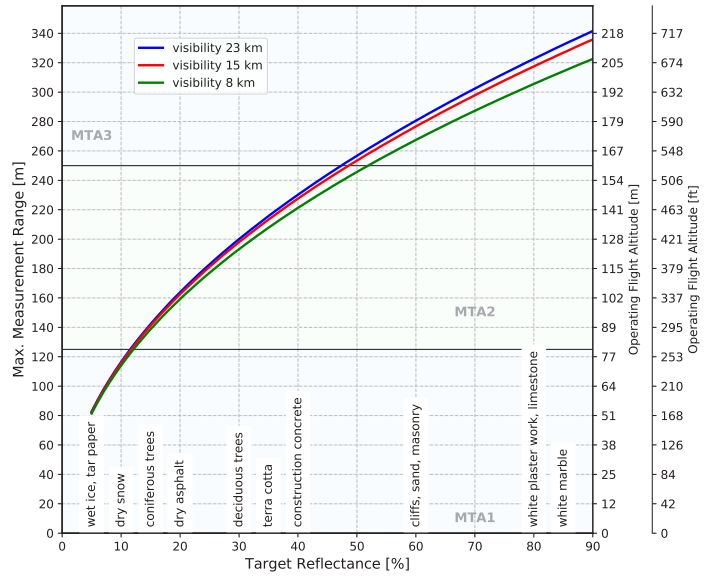
Operating flight altitude AGL given for the following conditions:
FOV +/- 45°, target size ≥ laser footprint



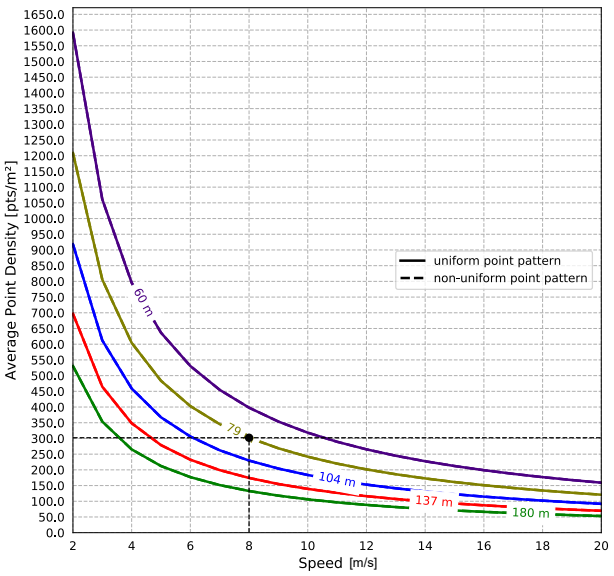
Example: VUX-1UAV[22] at 800,000 pulses/second, speed = 8 m/s,
range to target = 103 m, resulting point density ~ 155 pts/m²

Maximum Measurement Range & Point Density *RIEGL* VUX®-1UAV22

PRR = 1200 kHz



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

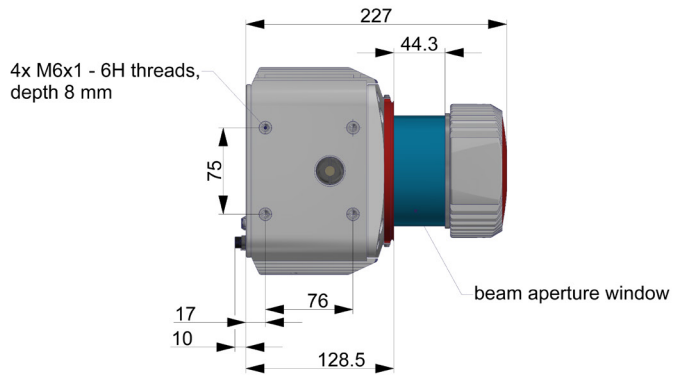


Example: VUX-1UAV22 at 1,200,000 pulses/second, speed = 8 m/s,
range to target = 79 m, resulting point density ~ 302 pts/m²

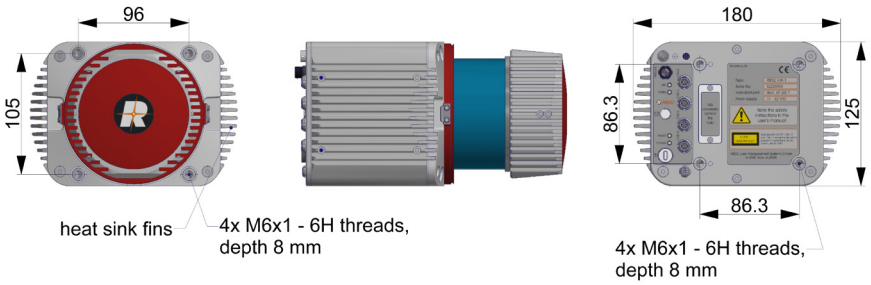
Dimensional Drawings *RIEGL* VUX®-1UAV22

all dimensions in mm

bottom view

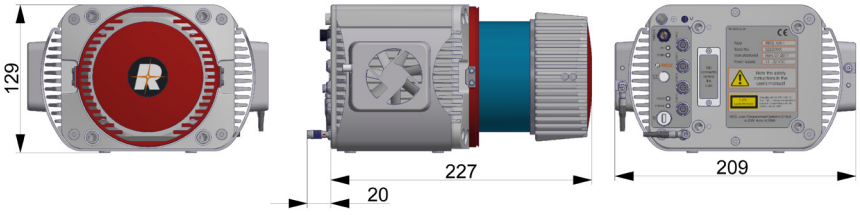


front view **side view** **rear view**



RIEGL VUX®-1UAV22 with Cooling Fan Device

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



RIEGL VUX®-1UAV[22] Additional Equipment and Integration

Cooling Fan

***RIEGL* VUX-1UAV[22] with Protective Cap**

***RIEGL* VUX-1UAV[22] with external IMU-Sensor**
(*RIEGL* VUX-SYS)

Additional Equipment for *RIEGL* VUX-1UAV[22]

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-1UAV[22]. The cooling fan can be mounted either on the top side or on the bottom side of the *RIEGL* VUX-1UAV[22] 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-1UAV[22] from mechanical damage and soiling, a protective cap is provided to cover the upper part of the instrument during transport and storage.

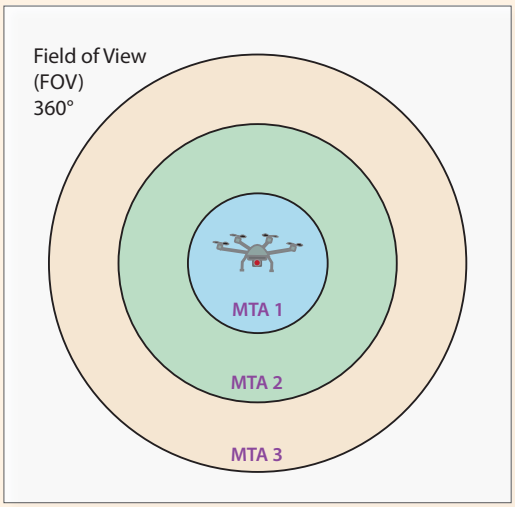
Options for *RIEGL* VUX-1UAV[22] Integration

RIEGL provides user-friendly, application- and installation-oriented solutions for integration of the VUX-1UAV[22] 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-1UAV[22], an IMU/GNSS unit and a dedicated control unit.
- **RiCOPTER**
  Ready to fly remotely piloted aircraft system with *RIEGL* VUX-SYS integrated
- ***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-1UAV[22] 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.

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