Lightweight UAV Laser Scanner with Online Waveform Processing

RIEGL VUX®-240

- *laser pulse repetition rate up to 1.8 MHz*
- *measurement rate up to 1,500,000 meas./sec*
- *scan speed up to 400 lines/second*
- *operating flight altitude up to 1,400m / 4,600 ft*
- *Field of View up to 75°*
- *perfectly linear and parallel scan lines*
- *cutting edge RIEGL technology providing:*
  - *echo signal digitization*
  - *multiple target capability*
  - *online waveform processing*
  - *multiple-time-around processing*
- *compact & lightweight*
- *easily mountable to unmanned platforms (UAVs) and to helicopters, gyrocopters, and other small manned aircrafts*
- *mechanical and electrical interface for INS/GNSS integration (optional)*
- *interfaces for up to 4 optional cameras*
- *scan data storage on internal 1 TByte SSD Memory*

The *RIEGL* VUX-240 is a lightweight airborne laser scanner, especially designed for use on UAS/UAV/RPAS and small manned aeroplanes or helicopters.
With its wide field of view of 75 degrees and an extremely fast data acquisition rate of up to 1.8 MHz, the instrument is perfectly suited for high point density corridor mapping applications.

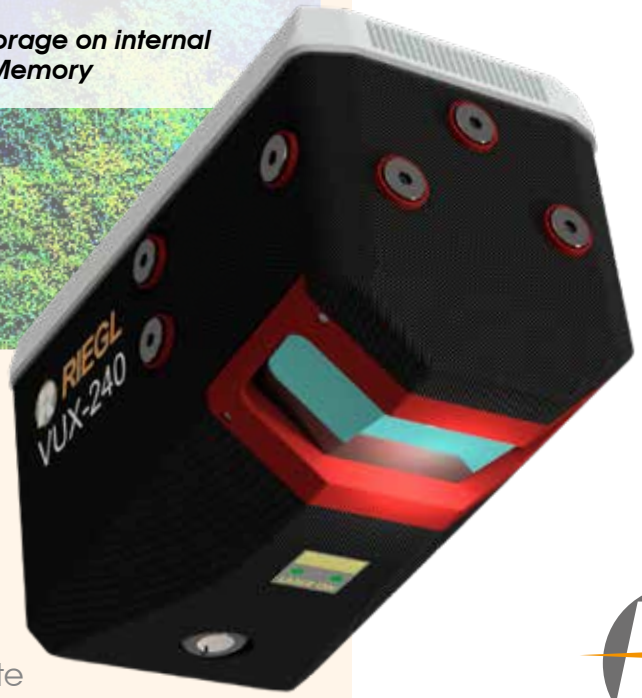
The VUX-240 makes use of *RIEGL*'s unique Waveform-LiDAR technology, allowing echo digitization and online waveform processing. Multi-target resolution is the basis for penetrating even dense foliage.

A continuously rotating polygon mirror wheel enables scan speeds of up to 400 lines per second, for efficiently covering large areas when operated from fast UAVs or aircrafts.

The scanner provides an internal data storage capacity of 1 TByte and is equipped with interfaces for an external IMU/GNSS system as well as to control up to four external cameras. WLAN enables direct access to the laser scanner for changing configuration settings and checking the system status.

Typical applications include

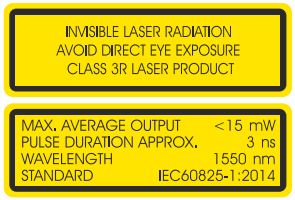
- *Corridor Mapping: Power Line, Railway Track and Pipeline Inspection*
- *Topography in Open-Cast Mining*
- *Surveying of Urban Environments*
- *Archeology and Cultural Heritage Documentation*
- *Agriculture & Forestry*



visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS

Laser Product Classification	Class 3R 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 conformance with IEC 60825-1 Ed.3., as described in Laser Notice No. 56, dated May 8, 2019.
NOHD (Nominal Ocular Hazard Distance)	0.3 m
ENOHD (Extended Nominal Ocular Hazard Distance)	2.5 m



Range Measurement Performance

Measuring Principle	time of flight measurement, echo signal digitization, multiple target capability, online waveform processing, multiple-time-around-processing

Laser Pulse Repetition Rate PRR [1]	*150 kHz*	*300 kHz*	*600 kHz*	*1200 kHz*	*1800 kHz*
Max. Measuring Range [2] [3]					
natural targets ρ ≥ 20 %	1200 m	850 m	650 m	450 m	350 m
natural targets ρ ≥ 60 %	1900 m	1400 m	1050 m	750 m	650 m
Max. Operating Flight Altitude AGL [2] [4]					
@ ρ ≥ 20 %	900 m (2950 ft)	600 m (1950 ft)	500 m (1650 ft)	350 m (1150 ft)	250 m (800 ft)
@ ρ ≥ 60 %	1400 m (4600 ft)	1050 m (3450 ft)	900 m (2950 ft)	550 m (1800 ft)	500 m (1650 ft)
Max. Number of Targets per Pulse [5]	15	15	15	8	5

1) Rounded average PRR.
2) Typical values for average conditions and average ambient brightness. In bright sunlight, the max. range is shorter 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 23 km. Range ambiguities have to be resolved by multiple-time-around processing.
4) Effective FOV 75°, additional roll angle ± 5°.
5) 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.

Minimum Range	5 m
Accuracy [7] [9]	20 mm
Precision [8] [9]	15 mm
Laser Pulse Repetition Rate [1] [10]	up to 1800 kHz
Max. Effective Measurement Rate [1]	up to 1,500,000 meas./sec. (@ 1800 kHz PRR & 75° FOV)
Echo Signal Intensity	for each echo signal, high-resolution 16 bit intensity information is provided
Laser Wavelength	near infrared
Laser Beam Divergence	0.35 mrad [11]
Laser Beam Footprint (Gaussian Beam Definition)	35 mm @ 100 m, 175 mm @ 500 m, 350 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.
11) Measured at the $1/e^2$ points. 0.35 mrad corresponds to an increase of 35 mm of beam diameter per 100 m distance.

Scanner Performance

Scanning Mechanism	rotating polygon mirror
Scan Pattern	parallel scan lines
Field of View (selectable)	± 37.5° = 75°
Scan Speed (selectable)	40 - 400 lines/sec
Angular Step Width Δ ϑ (selectable) between consecutive laser shots	0.002° ≤ Δ ϑ ≤ 0.24° [12] [13]
Angle Measurement Resolution	0.001°
Scan Sync (optional)	scanner rotation synchronization

Data Interfaces

Configuration	LAN 10/100/1000 Mbit/sec, WLAN
Scan Data Output	LAN 10/100/1000 Mbit/sec
GNSS Interface	Serial RS232 interface for data string with GNSS-time information, TTL input for 1PPS synchronization pulse
External Camera	4x power, RS232, 1pps, trigger, exposure, TTL input/output
External IMU & GNSS	combined connector with power supply and signal interface to external IMU & GNSS

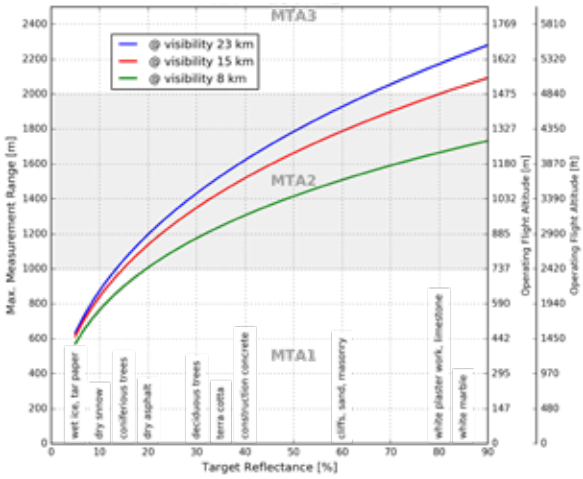
General Technical Data

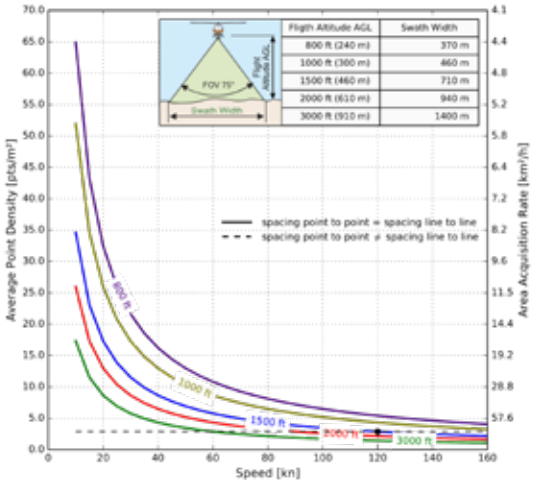
Power Supply Input Voltage / Consumption [14]	11 - 34 V DC / typ. 60 W
Main Dimensions (L x W x H)	292 mm x 164 mm x 185 mm (without IMU/GNSS) 380 mm x 164 mm x 185 mm (with IMU/GNSS)
Weight	≤ 4.1 kg (without IMU/GNSS), ≤ 4.9 kg (with IMU/GNSS)
Humidity	max. 80 % non condensing @ 31°C
Protection Class	IP64, dust and splash-proof
Max. Flight Altitude (operating & not operating)	18 500 ft (5 600 m) above MSL (Mean Sea Level)
Temperature Range	-10°C up to +40°C (operation) / -20°C up to +50°C (storage)

12) The angular step width depends on the selected laser PRR.
13) The maximum angular step width is limited by the maximum scan rate.
14) without external IMU/GNSS

to be continued at page 6

PRR = 150 kHz



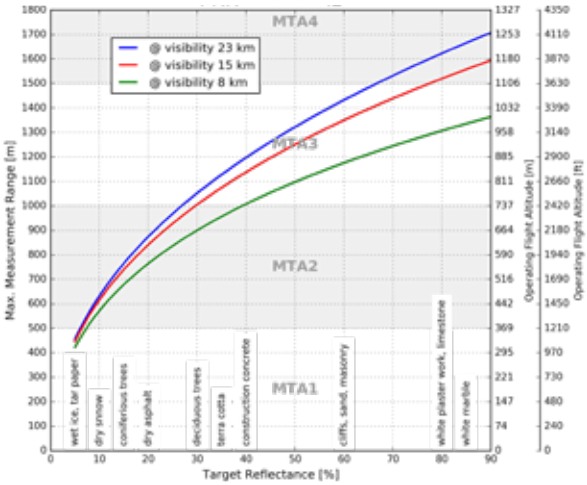


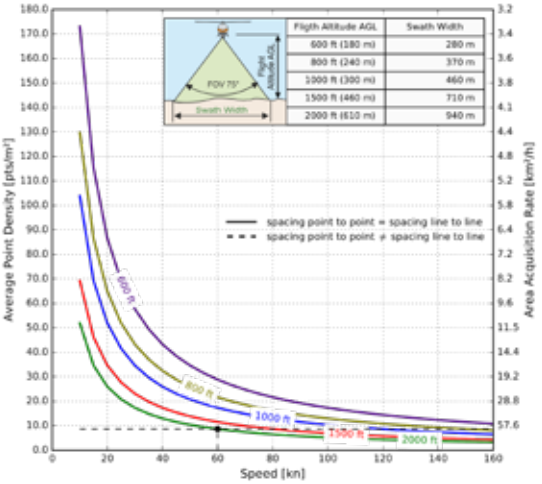
Flight Altitude AGL	Swath Width
800 ft (240 m)	370 m
1000 ft (300 m)	460 m
1500 ft (460 m)	710 m
2000 ft (610 m)	940 m
3000 ft (910 m)	1400 m

Example: VUX-240 at 150,000 pulses/sec, laser power level 100%
Altitude = 1,500 ft AGL, Speed 120 kn

Results: Point Density ~ 3 pts/m²

PRR = 300 kHz



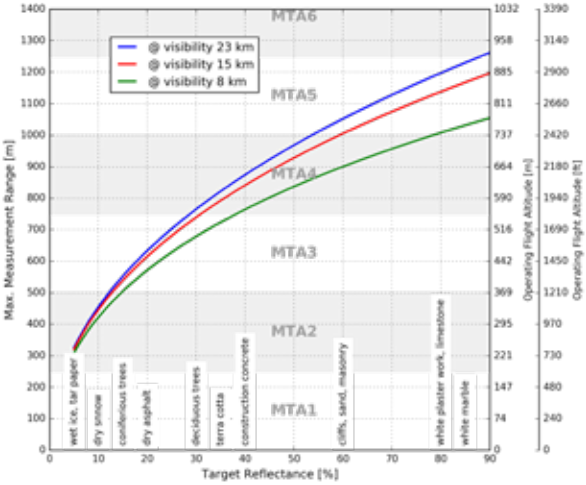


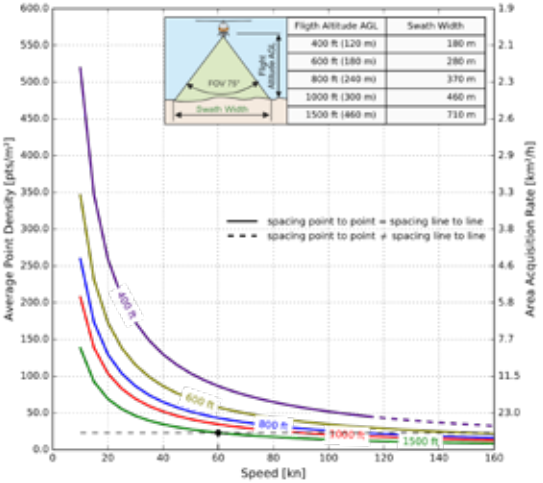
Flight Altitude AGL	Swath Width
600 ft (180 m)	280 m
800 ft (240 m)	370 m
1000 ft (300 m)	460 m
1500 ft (460 m)	710 m
2000 ft (610 m)	940 m

Example: VUX-240 at 300,000 pulses/sec, laser power level 100%
Altitude = 2,000 ft AGL, Speed 60 kn

Results: Point Density ~ 9 pts/m²

PRR = 600 kHz





Flight Altitude AGL	Swath Width
400 ft (120 m)	180 m
600 ft (180 m)	280 m
800 ft (240 m)	370 m
1000 ft (300 m)	460 m
1500 ft (460 m)	710 m

Example: VUX-240 at 600,000 pulses/sec, laser power level 100%
Altitude = 1,500 ft AGL, Speed 60 kn

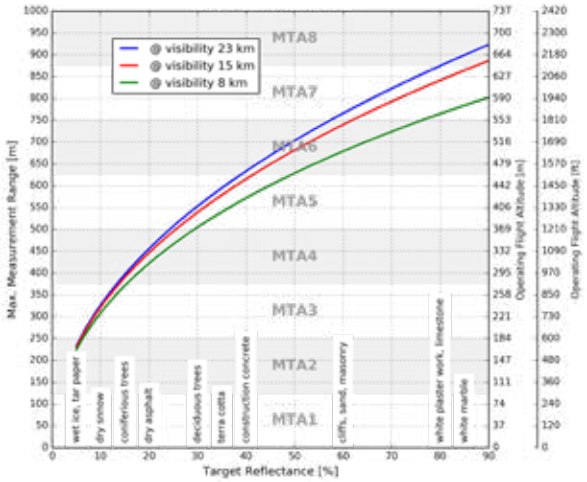
Results: Point Density ~ 22 pts/m²

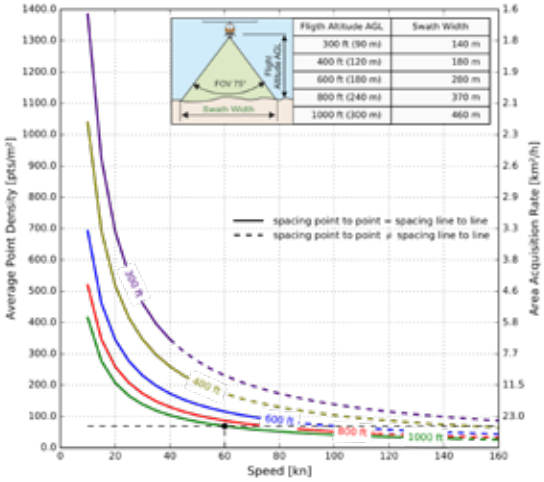
The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- target size ≥ laser footprint
- average ambient brightness
- roll angle ±5°
- operating flight altitude given at a FOV 75°

Maximum Measurement Range & Point Density *RIEGL* VUX®-240

PRR = 1200 kHz

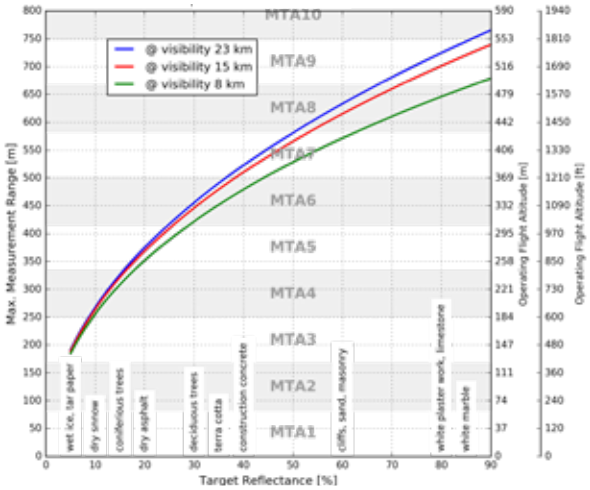


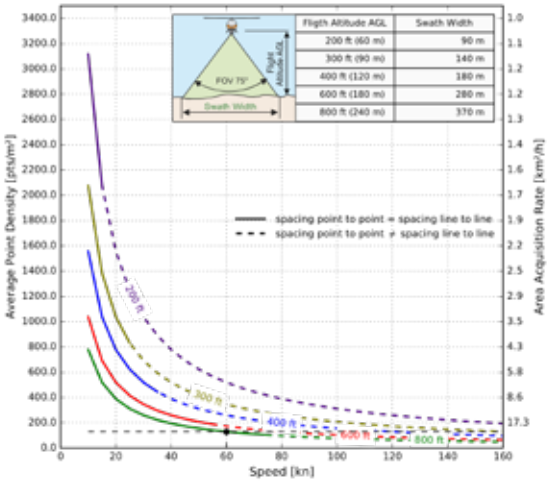


Example: VUX-240 at 1,200,000 pulses/sec, laser power level 100%
Altitude = 1,000 ft AGL, Speed 60 kn

Results: Point Density ~ 60 pts/m²

PRR = 1800 kHz





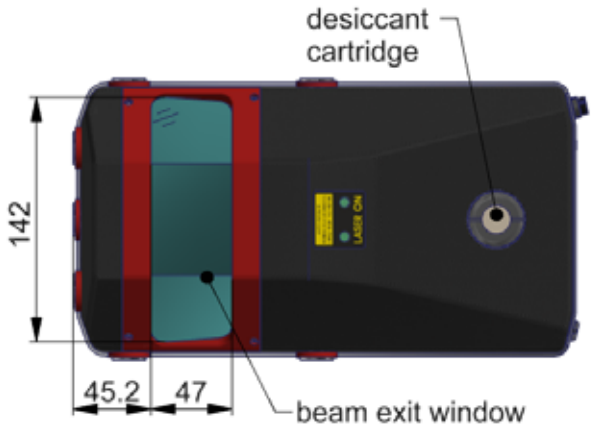
Example: VUX-240 at 1,800,000 pulses/sec, laser power level 100%
Altitude = 800 ft AGL, Speed 60 kn

Results: Point Density ~ 120 pts/m²

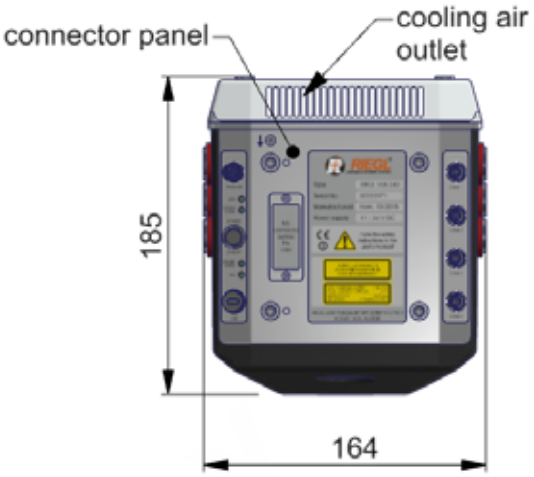
The following conditions are assumed for the Operating Flight Altitude AGL

- ambiguity resolved by multiple-time-around (MTA) processing
- roll angle ±5°
- target size ≥ laser footprint
- average ambient brightness
- operating flight altitude given at a FOV of 75°

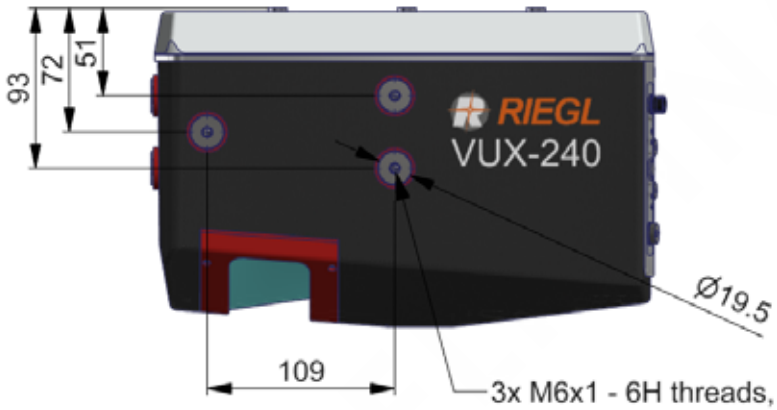
bottom view



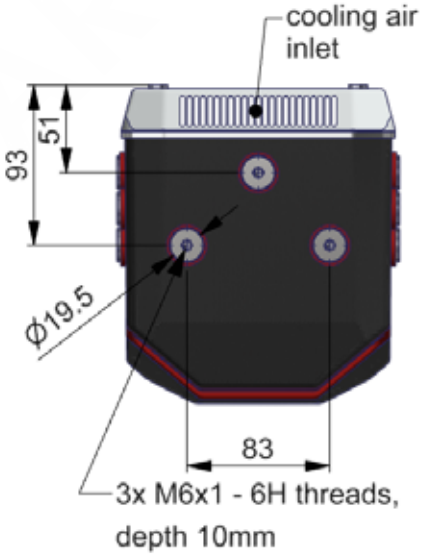
rear view



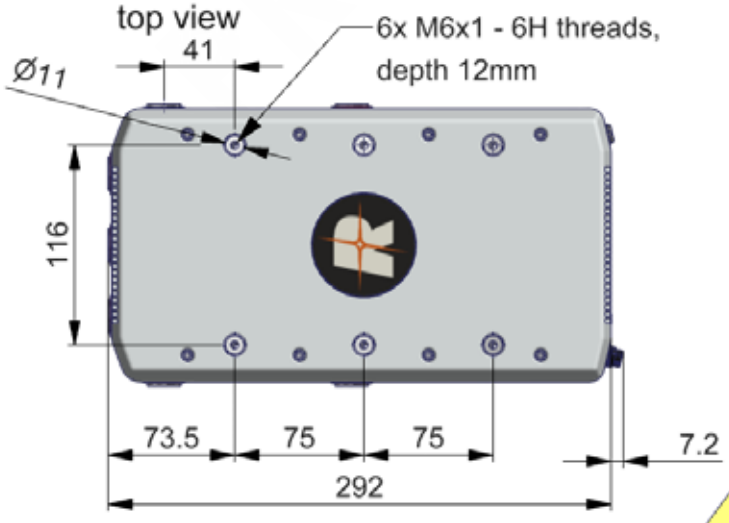
side view



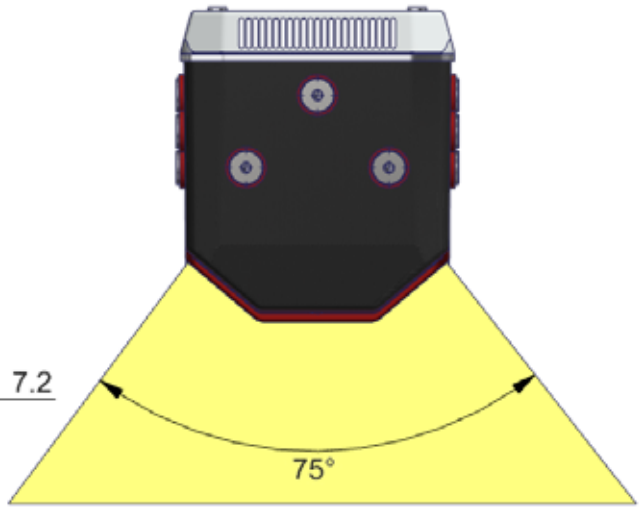
front view



top view



front view with FOV



all dimensions in mm

Technical Data *RIEGL* VUX®-240 (continued)

Data Storage

Internal Data Storage	Solid State Disc SSD, 1TByte
Memory Card Slot[1)]	for CFAST® [2)] memory card 120 GByte (can be upgraded to 256 GByte)

1) applies to IMU APX-20 UAV only

2) CFast is a registered trademark of CompactFlash Association

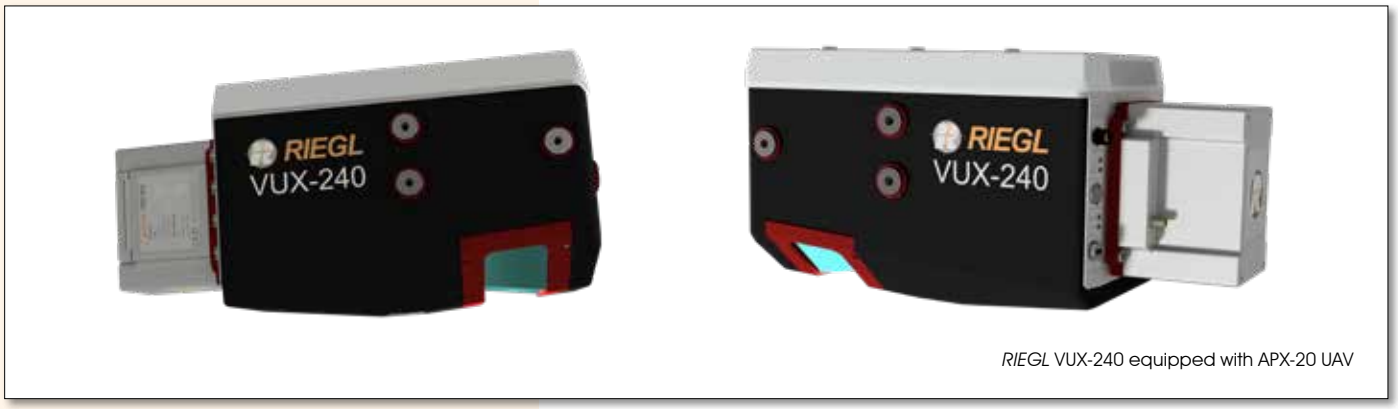
External IMU & GNSS (optional)

recommended: Applanix APX-20 UAV [3)]

IMU Accuracy [4)]	
Roll, Pitch	0.015°
Heading	0.035°
IMU Sampling Rate	200 Hz
Position Accuracy (typ.)	
horizontal	< 0.05m
vertical	< 0.1 m

3) See technical details at the according Applanix datasheet.

4) Accuracy specifications for post-processed data.



RIEGL VUX-240 equipped with APX-20 UAV

RIEGL VUX®-240 UAV Platform Integration (optional)

RiCOPTER with *RIEGL* VUX-240 LiDAR Sensor,
APX-20 UAV and nadir RGB camera fully integrated

RIEGL® LASER MEASUREMENT SYSTEMS

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