RIEGL VZ-400i®

- *high laser pulse repetition rate of up to 1.2 MHz*
- *high speed data acquisition with up to 500,000 measurements/sec*
- *eye safe operation at Laser Class 1*
- *wide field of view 100°x360°*
- *range up to 800 m*
- *high accuracy, high precision ranging based on echo digitization, online waveform processing, and multiple-time-around processing*
- *innovative processing architecture for data acquisition and simultaneous geo-referencing in real-time*
- *automatic on-board registration*
- *simultaneous image and scan data acquisition*
- *user-developed apps via python software*
- *cloud connectivity via Wi-Fi and 3G/4G LTE*
- *integrated IMU for pose estimation and kinematic data acquistion*
- *multiple target capability*
- *optional waveform data output*
- *integrated GNSS receiver*

The *RIEGL* VZ-400i is a cutting-edge 3D Laser Scanning System which combines a future-oriented, innovative processing architecture and internet connectivity with *RIEGL*'s latest waveform processing LiDAR technology.

This real-time data flow is enabled through dual processing platforms: a dedicated processing system for simultaneous acquisition of scan data and image data, waveform processing and system operations, and a second processing platform which enables automatic on-board registration, geo-referencing, and analysis to be executed in parallel. The VZ-400i provides an integrated 3G/4G LTE modem, Wi-Fi, and Ethernet communications hardware.
With its integrated orientation sensor (MEMS IMU, compass, and barometer), the VZ-400i's up to 1200 kHz pulse repetition rate can be fully utilized in many environments and orientations. The system provides a high range of flexibility by supporting numerous external peripherals and accessories via its integrated USB ports and stable mounting points.



Typical applications include

- *As-Built Surveying*
- *Architecture & Facade Measurement*
- *Archeology & Cultural Heritage Documentation*
- *Building Information Modeling (BIM)*
- *Forensics & Crash Scene Investigation*
- *City Modeling*
- *Tunnel Surveying*
- *Civil Engineering*
- *Forestry*
- *Research*
- *Monitoring*

visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS

Camera Option

A DSLR camera or the *RIEGL* VZ-i-20M heavy duty camera can be integrated using a high-precision camera mount. Power supply and USB interface are provided via the scanner directly. Acquisition of images simultaneously during scanning reduces the time for handling a scan position drastically.

GNSS Receiver Options

>> RTK capability by using of:

- *RIEGL* VZ-i GNSS RTK Receiver, recommended base station via LoRa radio (up to 10 km), network, or NTRIP/TCP
- GNSS correction service via internet

>> external GNSS Receiver via data-cable or Bluetooth



recommended base station
EMLID REACH RS2



Lightweight Carbon Tripod

RIEGL offers a lightweight carbon tripod to support a quick and smooth workflow for data acquisition.

Power Supply via Rechargeable Batteries

The *RIEGL* VZ-400i can be connected to the following optionally available rechargeable batteries:

>> *RIEGL* Add-On Rechargeable Li-Ion Battery RBLI 2900 (3 X 99 Wh)

>> NiMH Battery (235 Wh)

Use of other battery types to be discussed with *RIEGL* support.



RIEGL Add-On Rechargeable Li-Ion Battery RBLI 2900



NiMH Battery

NEW Protective Housing

The *RIEGL* Protective Housing PH-VZ Light-S provides reliable protection of the scanner against dust, rain, wind, and changing weather conditions during long-term and unattended missions.

>> dust and weather protection

>> designed for 24/7 scanner operation

>> quick installation via existing screws



Protective Housing
PH-VZ Light-S

Waveform Data Output Option

The digitized echo signals, also known as full waveform data, acquired by the *RIEGL* VZ-400i are the basis for waveform analysis. This data is provided via the optionally available waveform data output and accessible with the associated *RIEGL* software library RiWAVELib for advanced research and analysis of digital waveform data samples acquired in multiple-target situations.

RIEGL Software Packages

>> **RiSCAN PRO** standard processing software for efficient data acquisition and registration in terrestrial laser scanning

>> **RiSOLVE** for automatic registration, colorization, and 2D-map generation

>> **RiMINING** optimized workflow for open-pit mining

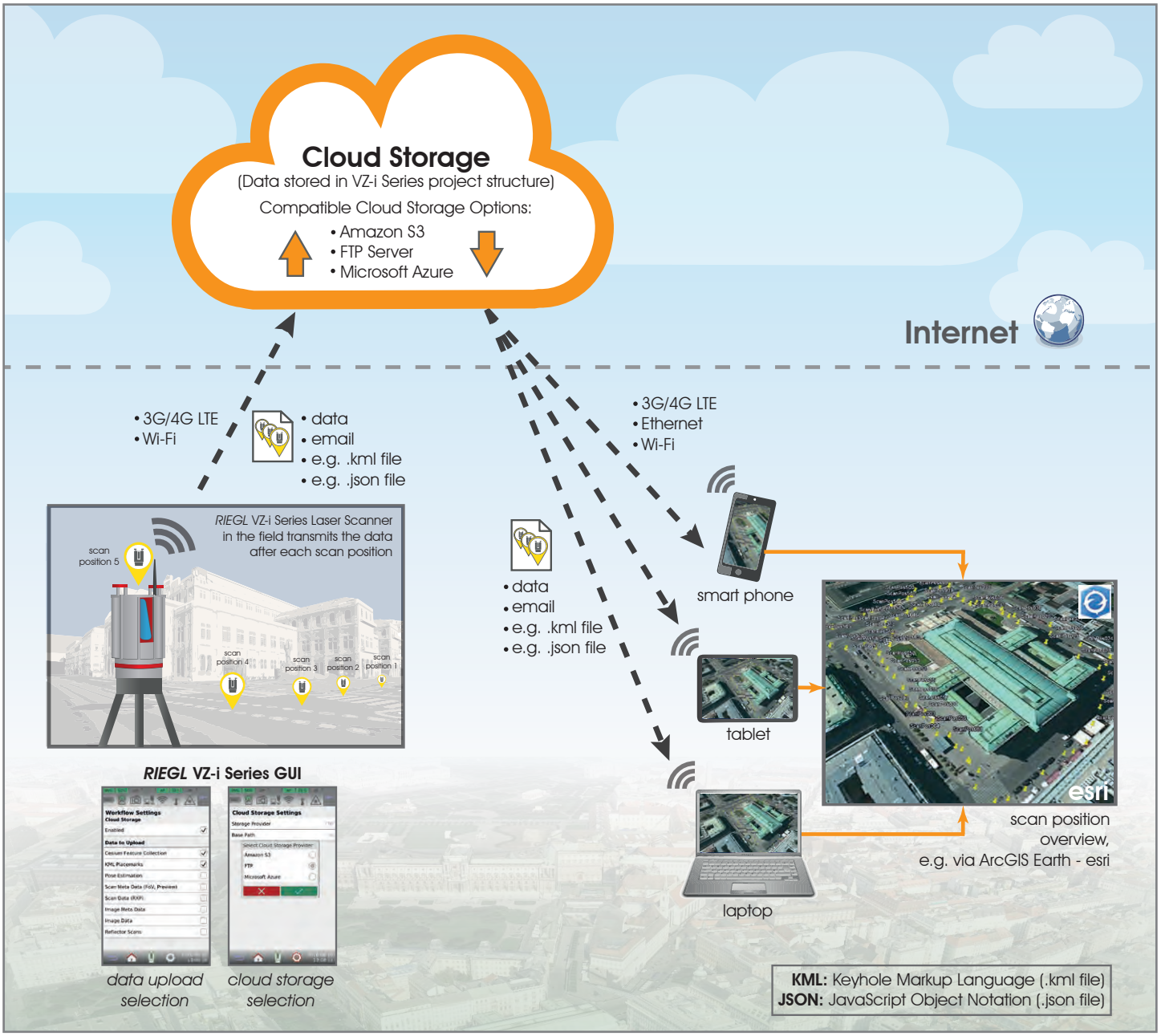


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The *RIEGL* VZ-i Series provides cloud connectivity via either the 3G/4G LTE, Wi-Fi network, or LAN.

The content uploaded to, stored in, and downloaded from the cloud, as well as the appropriate cloud storage provider or FTP server are user definable. The defined data then is transferred to the cloud after finishing each scan.

Supported cloud storage currently includes Amazon S3 and Microsoft Azure.



Transferable data includes:

- >> the scanner's position in WGS84 geographic coordinates as *.kml and *.json
- >> scan data preview as *.png image
- >> thumb-nails of the images as *.jpg
- >> scan data as *.rxp
- >> image data as *.jpg
- >> error messages

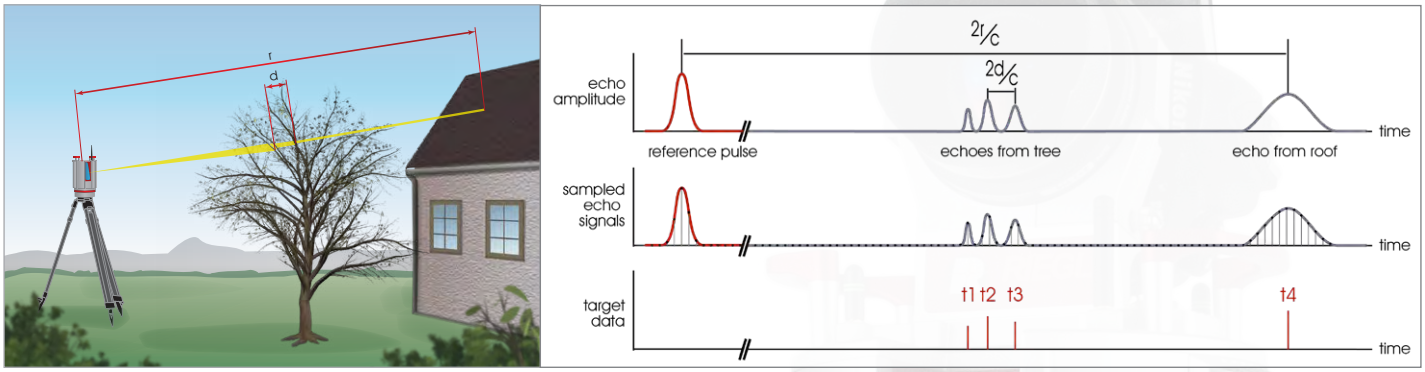
Please note: Adequate data transmission bandwidth is required.

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RIEGL's sophisticated LiDAR technology is the basis for highly informative scan data. Every laser pulse received provides several attributes in addition to the range measurement information. By using different features and filters provided with the scanner's software, this information can be used to significantly improve the informative content of point clouds.

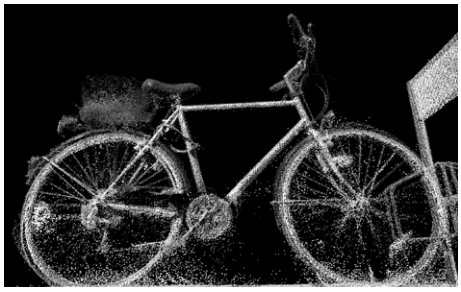
Multi Target Capability - the Basis for High Penetration Capability

Utilizing the pulsed time-of-flight method for laser range measurements, the VZ-400i enables determination of the range to all targets a single laser pulse is interacting with. Depending on the measurement program used, the maximum number of targets, which can be detected, is varying (4-15).



Pulse Shape Deviation Output

Even if the distance between two targets is too short to discriminate between the two echoes, valuable information about the pulse shape of the return pulse is given. That allows to discriminate whether the return echo originates from a single target or from two nearby targets. A simple thresholding with respect to the pulse shape information can remove most of the „invalid" points and keep only the reliable „real" targets.



original data



automatic selection of „invalid" points using the pulse shape deviation attribute information



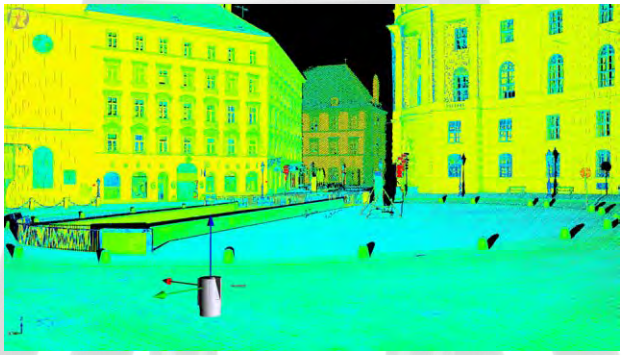
data after elimination of the „invalid" points

Calibrated Reflectance Output

This feature allows displaying the scan data colored by range-independent reflectance of the scanned object for better data classification.



point cloud colored by the range-depending amplitude



point cloud colored by the range-independent reflectance

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Rain, Haze, and Dust Penetration

Using deviation and reflectance filters, range measurements caused by rain drops, dust or haze can be identified, selected, and deleted, resulting in a clear and clean point cloud of the relevant scene.



point cloud before filter application



automatically cleaned-up point cloud

Operation & Remote Control

>> Easy operation of the *RIEGL* VZ-400i with the integrated Graphical User Interface (GUI) via touchscreen.

>> Remote control via *RIEGL* VZ-i Series App on your device. The GUI of the laser scanner will be displayed on the screen of your smart device. Connect locally or from anywhere in the world.

The App is available for iOS (iPhone, iPad, iPad Touch), Android and Windows PC (32 and 64 Bit).

Download now!



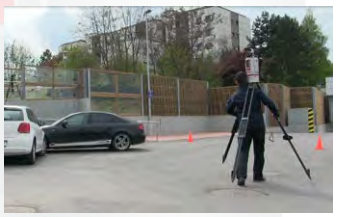
RIEGL VZ-i Series App

Scanner Motion Detection

Several pre-defined data acquisition workflows (e.g. Default, Forensics, OneTouch) are available. These **pre-defined workflows** allow the operation of the scanner by pushing just one icon on the screen per scan position. Once the tripod is re-arranged, a new scan position will automatically be generated. Modifications or creations of individual workflows to meet user specific requirements are also possible.



select the appropriate scanning parameters and start the first scan



move the scanner to the next scan position



to start the next scan, just press the START-button

User Applications

User developed applications (written in python software language) for further improvement of processing of surveying missions can be uploaded into the scanner.

RIEGL Kinematic App for Mobile Data Acquisition

The integrated IMU in connection with the *RIEGL* VZ-i GNSS RTK receiver allows the acquisition of kinematic scan data and trajectory data, resulting in a highly accurate 3D point cloud.

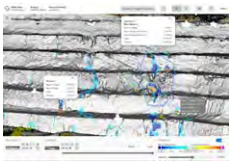
RIEGL Kinematic App Infosheet



RIEGL Monitoring Apps

- configuration of complex monitoring scenarios
- on-board data processing
- visualization of results via web viewer

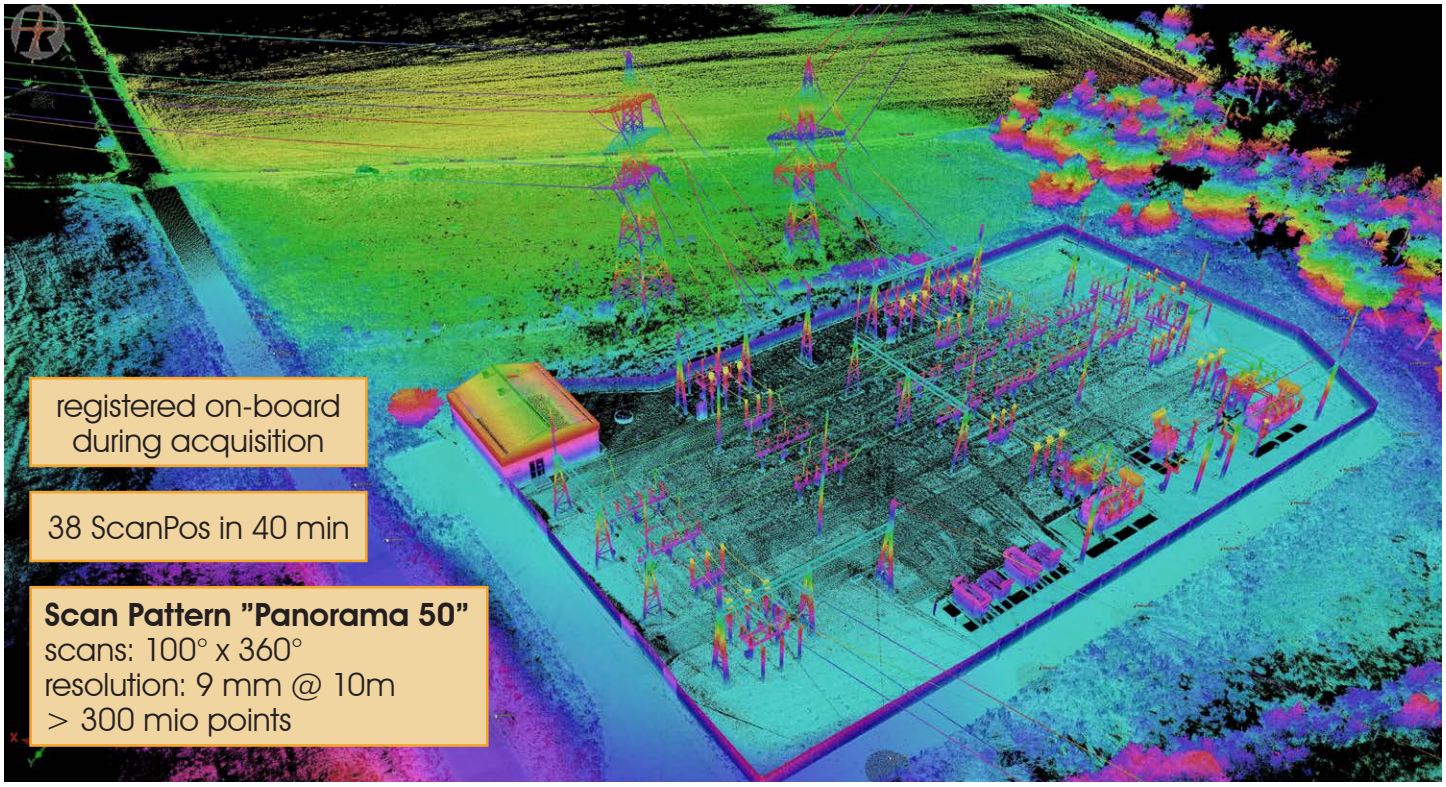
RIEGL Monitoring App Infosheet



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Automatic On-board Registration

Matching point clouds of different scan positions (registration) has always been one of the most time-consuming tasks during the post processing of 3D scanning projects.



Scan data of a power plant, height scaled with grayscale overlay based on reflection

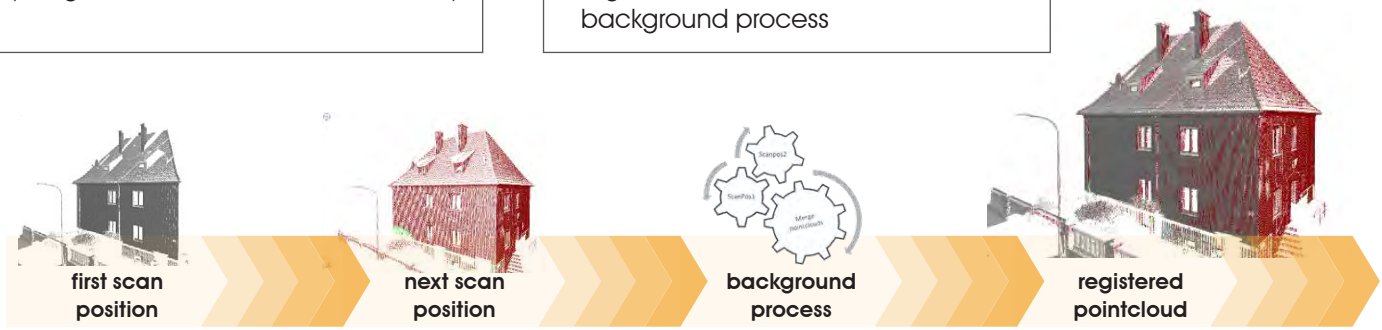
With two processors on-board, the *RIEGL* VZ-400i is able to perform different processes in real-time such as automatic on-board registration in parallel to the scan data acquisition.

Processor 1

- scan data acquisition
- simultanous acquisition of photographs during scanning
- pose estimation (using GNSS/IMU/environment sensors)

Processor 2

- conversion of scan data into *RIEGL* data base
- on-board multiple time around resolution
- registration of scan data as a background process



RIEGL RiSCAN PRO / RiSOLVE Software

RiSCAN PRO / RiSOLVE allows a fully automatic registration and colorization of scan data. This stream-lined process enables an efficient and fast workflow to acquire, register and colorize 3D scan data. With additional tools for filtering, scene animation and measurements, a rapid turnaround of critical information is realized.

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Field Experience

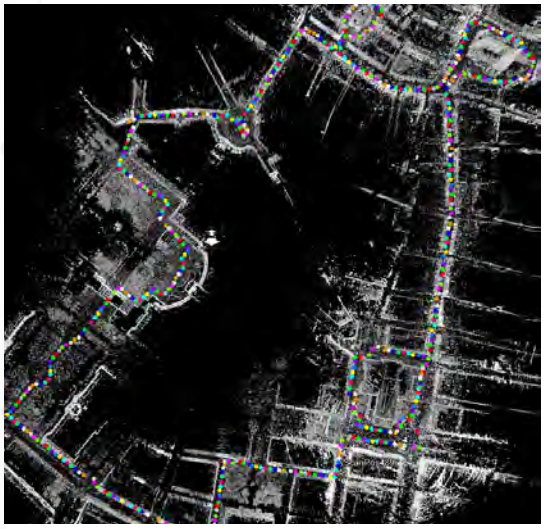
The VZ-400i's high performance scanning technology provides high pulse repetition rates and high line scan speeds as well as user-friendliness, enabling a significant reduction of the scanning time in the field.

1 operator → **8 hours** → **500+ scans**

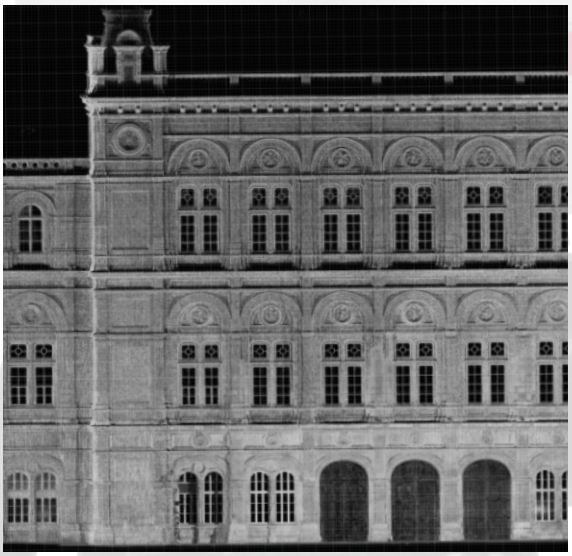
More than 500 scans (50 mdeg) of approx. 5 km of downtown streets with adjoining buildings have been taken by just one operator within 8 hours of full acquisiton time in the field. The mission was executed during night, the data of the whole scene was acquired by taking individual scan positions with approx. 10 m distance in between.



RIEGL VZ-400i night scan



overview of scan positions (colored dots)



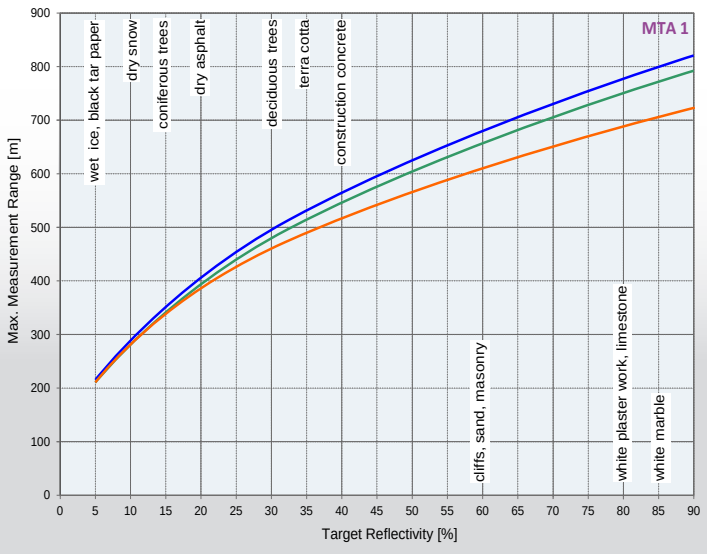


scan data detail, reflectance-scaled

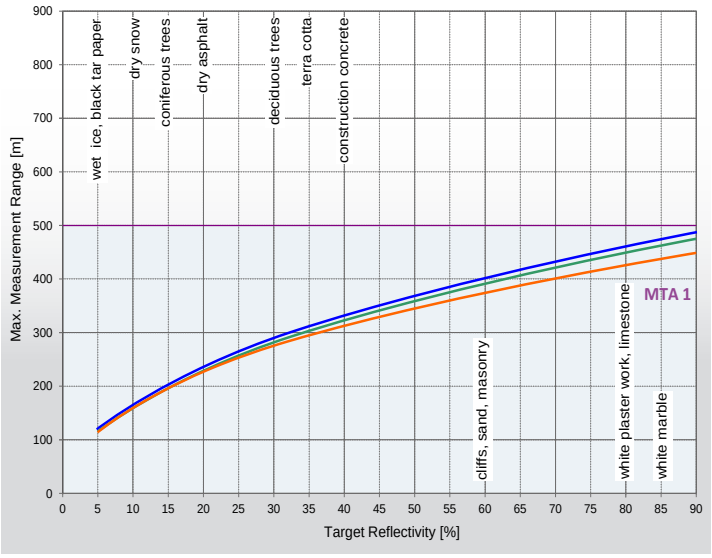
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standard clear atmosphere: visibility 23 km
clear atmosphere: visibility 15 km
light haze: visibility 8 km

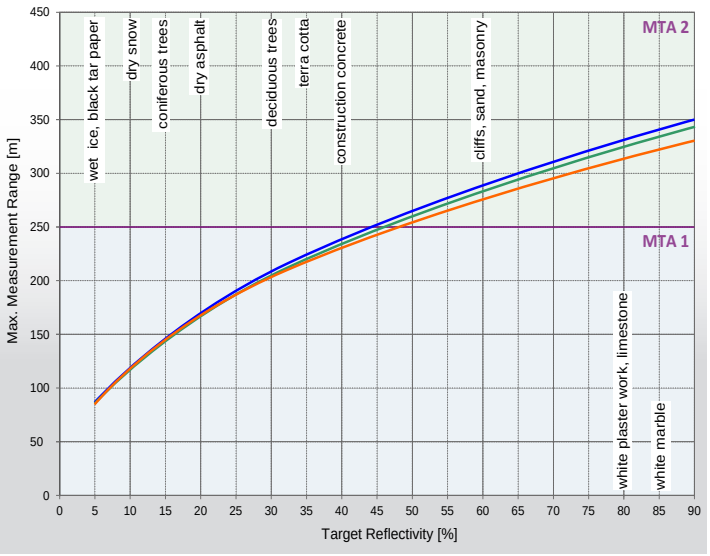
100 kHz Laser Pulse Repetition Rate



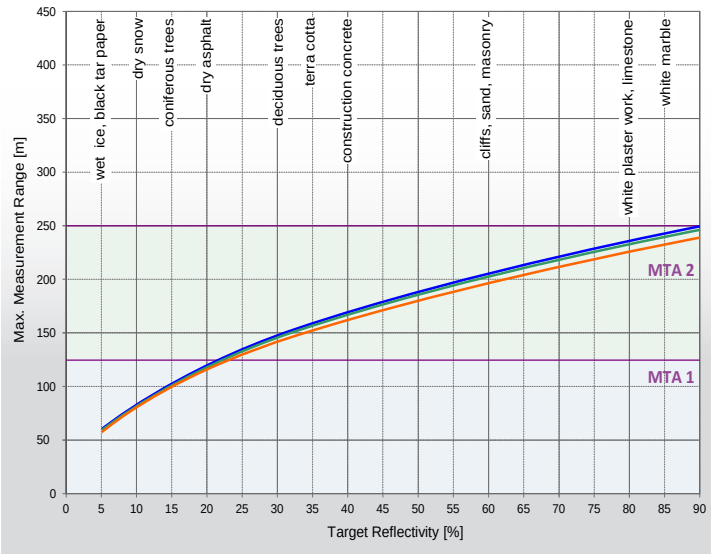
300 kHz Laser Pulse Repetition Rate



600 kHz Laser Pulse Repetition Rate



1200 kHz Laser Pulse Repetition Rate



The following conditions are assumed:

- flat target larger than the footprint of the laser beam
- perpendicular angle of incidence
- average brightness
- ambiguity resolved by post processing within RiSCAN PRO

MTA** (Multiple Time Around) **zones:

MTA 1: no ambiguity / 1 pulse „in the air"
MTA 2: 2 pulses „in the air"

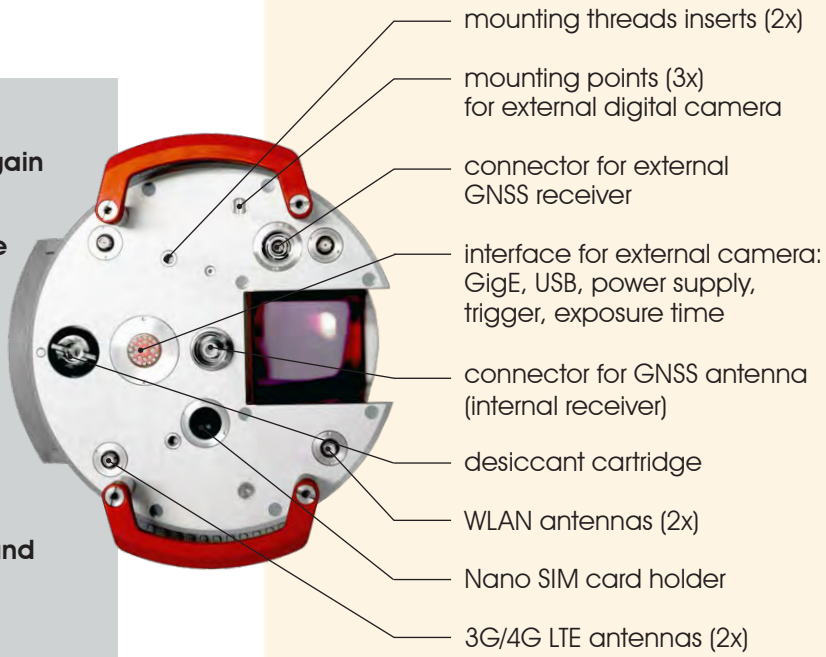
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All dimensions in mm.

Communication and Interfaces

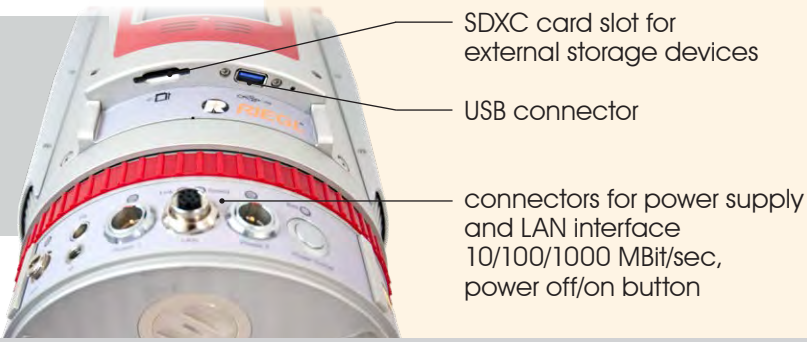
- **LAN port 10/100/1000 MBit/sec**
- **integrated WLAN interface[1] with high-gain MIMO antennas**
- **integrated multi-mode cellular module available for different regions[2] with MIMO 3G/4G LTE antennas**
- **GigE and USB for connecting an external digital camera**
- **connector for GNSS antenna**
- **two external power supply ports**
- **connector for external GNSS receiver and synchronization (1PPS)**
- **Bluetooth connection to GNSS receiver**



1) could be deactivated at the factory due to country-specific regulations
2) available for North America, Europe/APAC, Japan, or South America/APAC

Scan Data Storage

- **internal 1 TB SSD (Solid State Disc)**
  900 GB useable
- **external storage devices**
  (SDXC cards up to 512 GBytes or USB flash drives)



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Technical Data *RIEGL* VZ®-400i

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 [1]

Measuring Principle / Mode of Operation: time of flight measurement, echo signal digitization, online waveform processing, multiple-time-around processing, full waveform export capability (optional) / single pulse ranging

Laser Pulse Repetition Rate PRR (peak) [2] [3]	100 kHz	300 kHz	600 kHz	1200 kHz
Effective Measurement Rate (meas./sec) [2]	42,000	125,000	250,000	500,000
Max. Measurement Range [4]				
natural targets ρ ≥ 90 %	800 m	480 m	350 m	250 m
natural targets ρ ≥ 20 %	400 m	230 m	160 m	120 m
Minimum Range	1.5 m	1.2 m	0.5 m [5]	0.5 m [5]
Max. Number of Targets per Pulse [6]	15	15	8	4

Ranging Accuracy [7] [9]	5 mm
Ranging Precision [8] [9]	3 mm
3D Position Accuracy [10]	3 mm @ 50 m, 5 mm @ 100 m
Laser Wavelength	near infrared
Laser Beam Divergence	0.25 mrad @ 1/e [11], 0.35 mrad @ 1/e² [12]

1) With online waveform processing.
2) Rounded values.
3) In order to minimize multiple-time-around issues it is crucial to carefully select the laser pulse repetition rate according to the application in question.
4) 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.
5) Minimum range specified for vertical zenith angles from 30 deg to 120 deg, resp. 90° vertical field of view.
6) If more than one target is hit, the total laser transmitter power is split and, accordingly, the achieveable range is reduced.
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) 1 sigma @ 100 m range under *RIEGL* test conditions.
10) 1-sigma value, based on target modelling, under *RIEGL* test conditions.
11) Measured at the 1/e points. 0.25 mrad corresponds to an increase of 25 mm of beam diameter per 100 m distance.
12) Measured at the 1/e² points. 0.35 mrad corresponds to an increase of 35 mm of beam diameter per 100 m distance.

Scanner Performance

	Vertical (Line) Scan	*Horizontal (Frame) Scan*
Scan Angle Range	total 100° (+60° / -40°)	max. 360°
Scanning Mechanism	rotating multi-facet mirror	rotating head
Scan Speed	3 lines/sec to 240 lines/sec	0°/sec to 150°/sec [13]
Angular Step Width [14] Δ ϑ (vertical), Δ φ (horizontal)	0.0007° ≤ Δ ϑ ≤ 0.6° between consecutive laser shots	0.0015° ≤ Δ φ ≤ 0.62° between consecutive scan lines
Angular Accuracy [15]	0.0028° (10 arcsec)	0.0028° (10 arcsec)
Angle Measurement Resolution	better 0.0007° (2.5 arcsec)	better 0.0005° (1.8 arcsec)

Orientation Sensors	integrated 3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer (compass), barometer
GNSS Receiver	integrated L1, concurrent reception of GPS, GLONASS, Beidou
Laser Plummet	integrated
Internal Sync Timer	integrated, for real-time synchronized time stamping of scan data
Scan Sync (optional)	scanner rotation synchronization for operating several scanners
Waveform Data Output (optional)	providing digitized echo signal information for specific target echoes
Cloud Storage	Amazon S3, FTP-Server, Microsoft Azure
Automatic On-board Registration	automatic scan data registration as background process

13) Frame scan can be disabled, providing 2D scanner operation.
14) Selectable.
15) 1-sigma value, based on target modelling, under *RIEGL* test conditions.

General Technical Data

Power Supply Input Voltage / Consumption	11 - 34 V DC / typ. 65 W (max. 83 W)
External Power Supply	up to two independent external power sources can be connected simultaneously for uninterrupted operation, in addition to the *RIEGL* Add-On Li-Ion battery RBLI 2900
Main Dimensions (width x height)	206 mm x 346 mm
Weight	approx. 9.7 kg (with antennas)
Humidity	max. 80 % non condensing @ +31 °C
Protection Class	IP64, dust-tight and splash-proof
Temperature Range	
Storage	-10 °C up to +50 °C
Operation	0 °C up to +40 °C: standard operation
Low Temperature Operation [16]	-20 °C: continuous scanning operation if instrument is powered on while internal temperature is at or above 0 °C and still air -40 °C: scanning operation for about 20 minutes if instrument is powered on while internal temperature is at or above 15 °C and still air

16) Insulating the scanner with appropriate material will enable operation at even lower temperatures.

RIEGL® LASER MEASUREMENT SYSTEMS

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RIEGL USA Inc., *Headquarters North America*

RIEGL Japan Ltd.
RIEGL China Ltd.
RIEGL Australia Pty Ltd.
RIEGL Canada Inc.

RIEGL Asia Pacific Ltd.
RIEGL South America SpA
RIEGL Deutschland Vertriebsgesellschaft mbH
RIEGL France SAS

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