

# 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 acquisition**
- **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 new 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**

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## Camera Option

A high-precision mount enables the **integration of an optional DSLR camera**. The camera can be easily integrated into the mount by means of two screws. Precise position and orientation of the camera is enabled by three supporting points. Power supply and a USB interface are provided via the scanner directly. The combination of scanner, software, and camera results in photorealistic 3D data, exact identification of details, positions, and distance measurements, as well as a re-creation of any virtual point of view. A new feature enables the acquisition of images simultaneously during scanning and thus, 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 with Bluetooth

## Lightweight Carbon Tripod

RIEGL offers a lightweight carbon tripod to support a quick and smooth workflow in 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)
- >> RIEGL Add-On Rechargeable NiMH Battery RBNE 2210 (205 Wh)
- >> NiMH Battery (235 Wh)

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

## 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

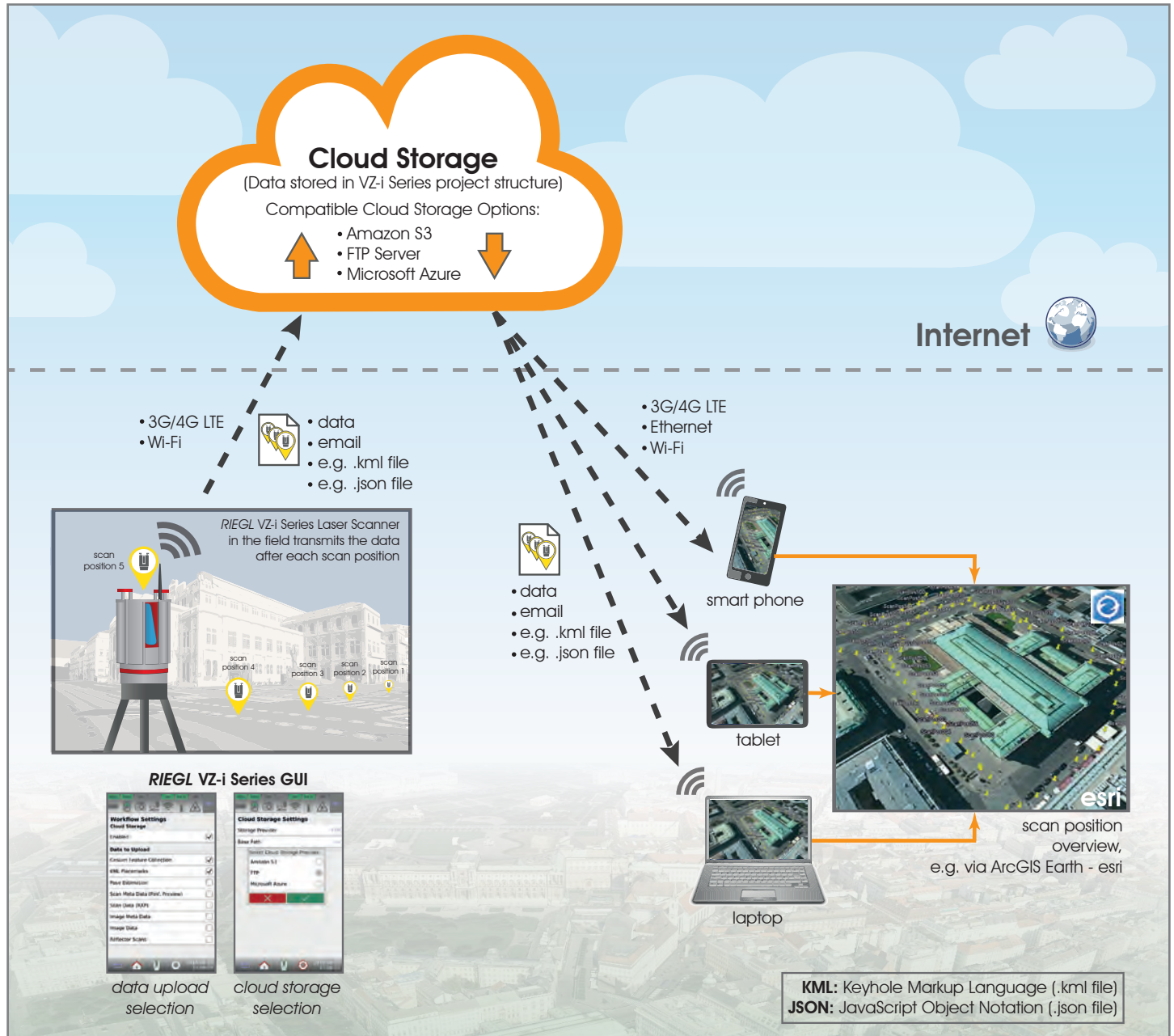




The RIEGL VZ-i Series provides cloud connectivity via either the 3G/4G LTE, Wi-Fi network, or LAN.

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:

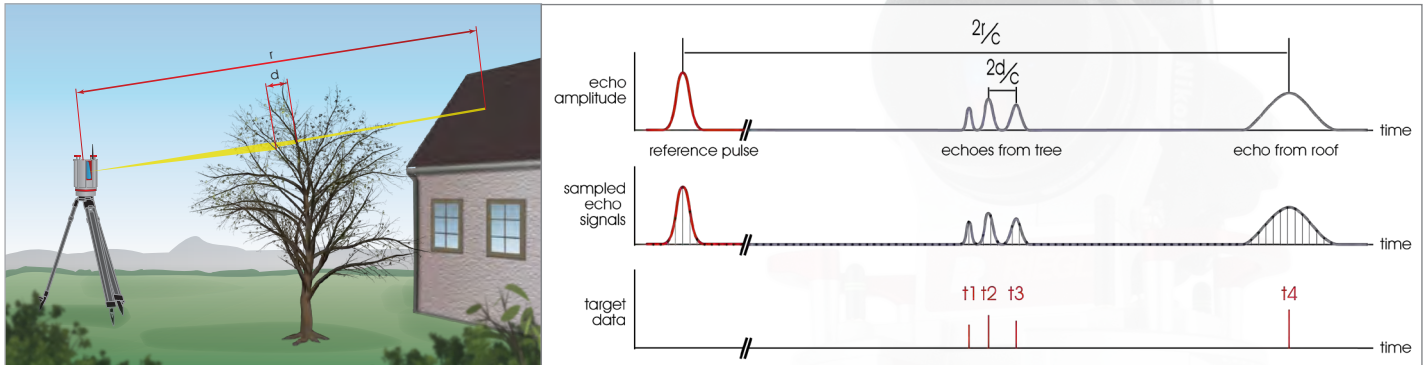
- >> the scanner's position in WGS84 geographic coordinates as \*.kml and \*.json
- >> scan data preview as \*.png image
- >> thumb-nails of the images as \*.jpg
- >> scan data as \*.rxp
- >> image data as \*.jpg
- >> error messages

Please note: Adequate data transmission bandwidth is required.

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



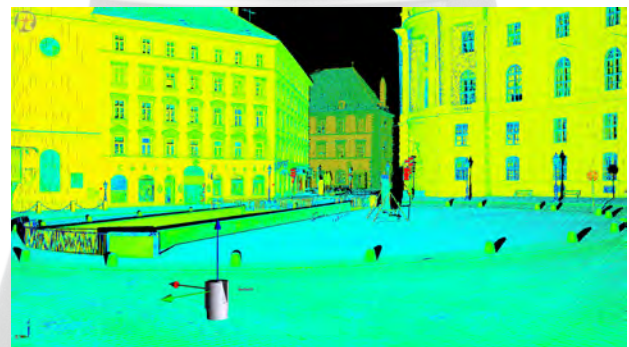
data after elimination of the „invalid“ points

### 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



## Rain and Haze Penetration

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



point cloud before filter application



automatically cleaned-up point cloud

## VZ-400i – a NEW Standard in User-Friendliness

### 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

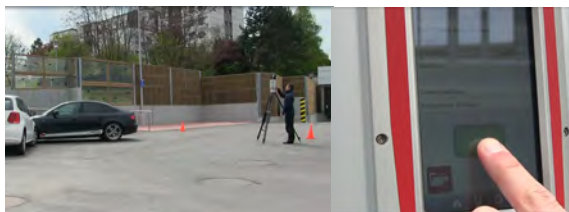
Several pre-defined data acquisition workflows (e.g. Default, Forensics, OneTouch) are available. These **pre-defined workflows** allow the operation of the scanner by pushing just one icon on the screen per scan position. Once the tripod is re-arranged, a new scan position will automatically be generated.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

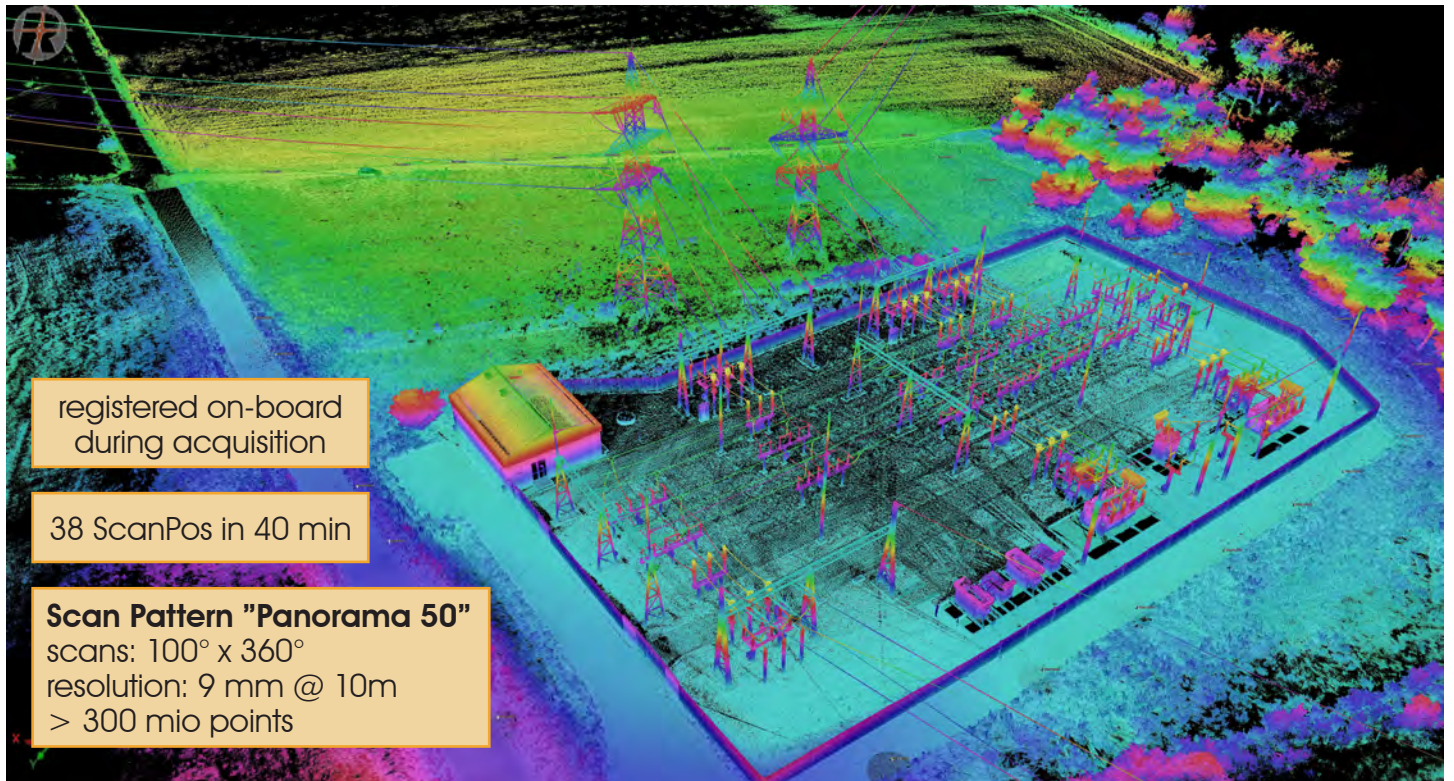
The integrated IMU in connection with the *RIEGL VZ-i* GNSS RTK receiver allows the acquisition of kinematic scan data and trajectory data, resulting in a highly accurate 3D point cloud.





## 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
- simultaneous 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 enables 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 enabled.



## 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**

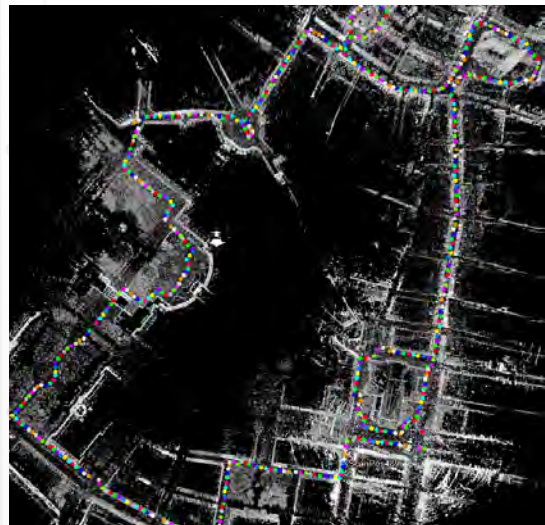
**8 hours**

**500+ scans**

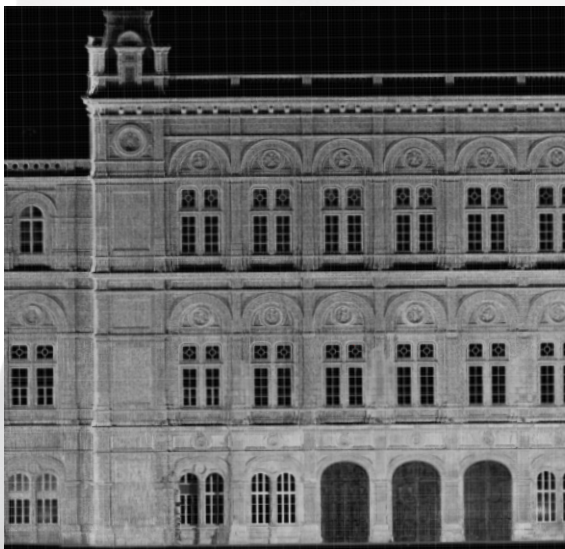
More than 500 scans (50mdeg) of approx. 5 km of downtown streets with adjoining buildings have been taken by just one operator within 8 hours of full acquisition time in the field. The mission was executed during night, the data of the whole scene was acquired by taking individual scan positions with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



RIEGL VZ-400i night scan



overview of scan positions (colored dots)

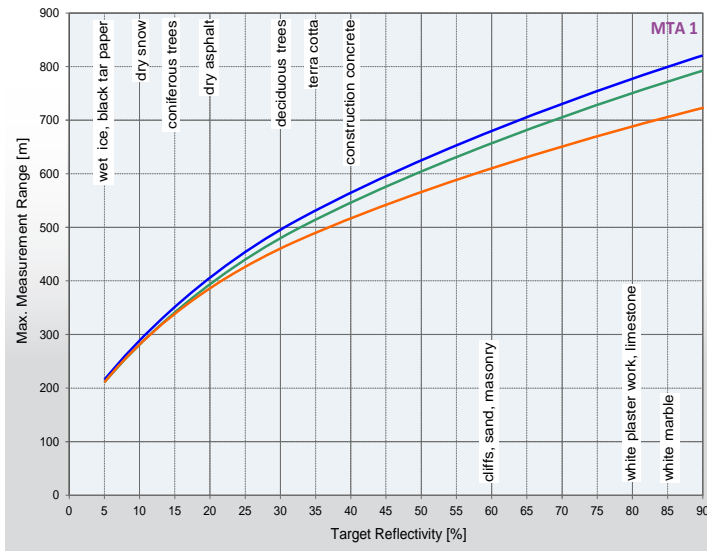


scan data detail, reflectance-scaled

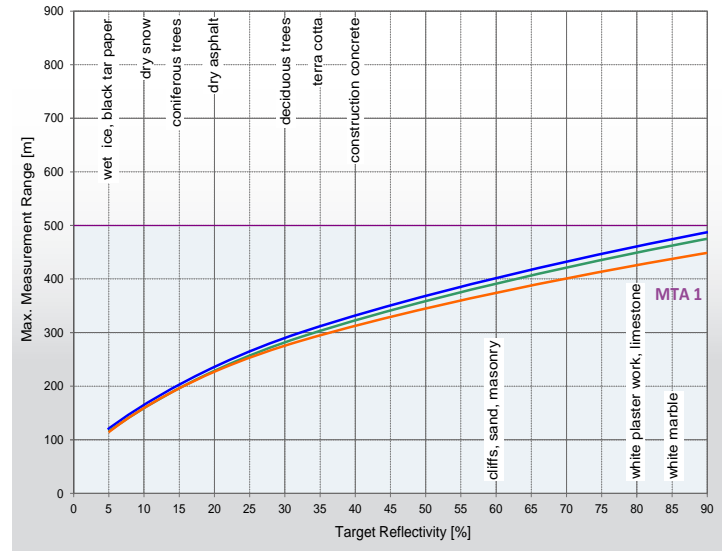


■ standard clear atmosphere; visibility 23 km  
■ clear atmosphere; visibility 15 km  
■ light haze; visibility 8 km

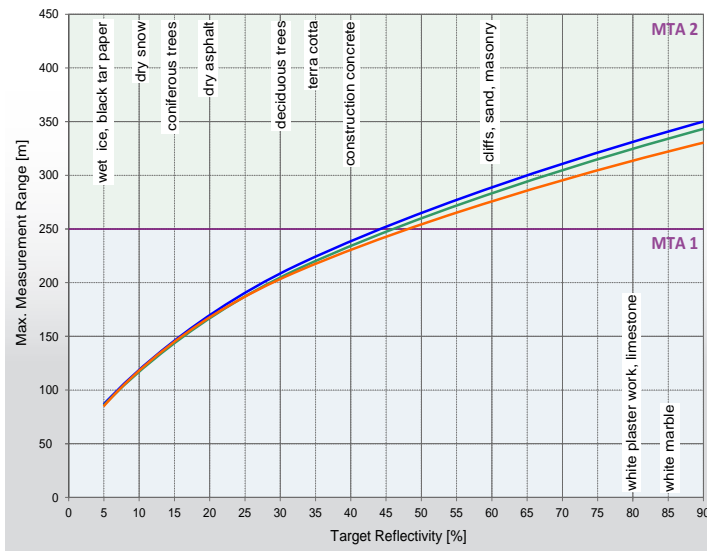
## 100 kHz Laser Pulse Repetition Rate



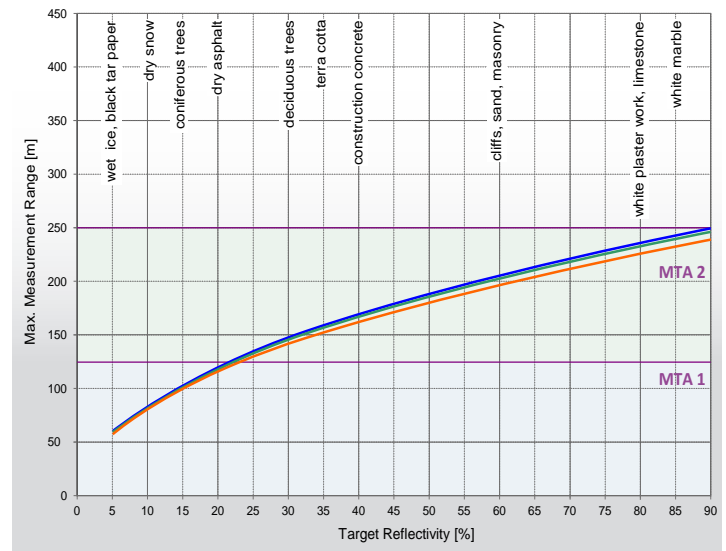
## 300 kHz Laser Pulse Repetition Rate



## 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:

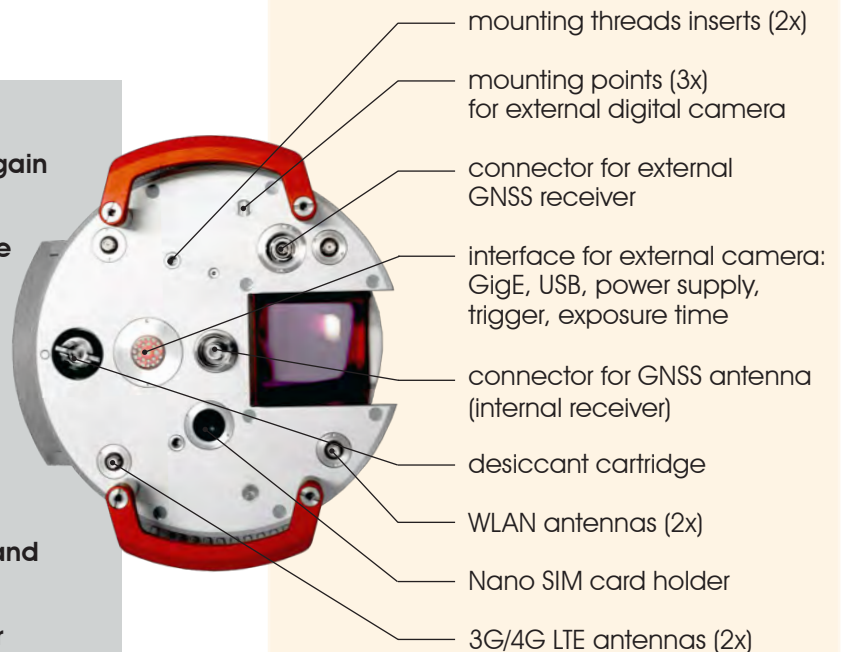
MTA 1: no ambiguity / 1 pulse „in the air“  
 MTA 2: 2 pulses „in the air“





## Communication and Interfaces

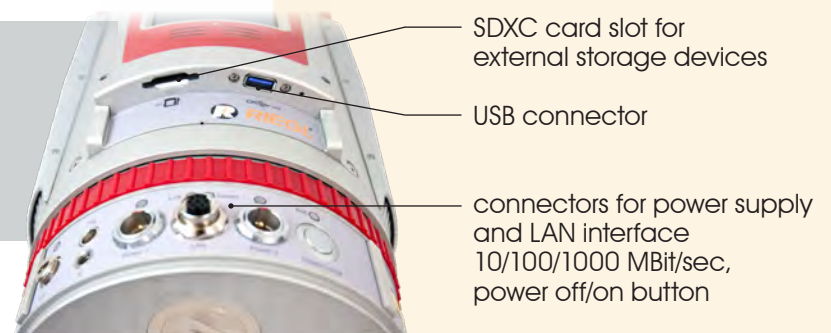
- LAN port 10/100/1000 MBit/sec
- integrated WLAN interface<sup>1)</sup> with high-gain MIMO antennas
- integrated multi-mode cellular module available for different regions<sup>2)</sup> with MIMO 3G/4G LTE antennas
- GigE and USB for connecting an external digital camera
- connector for GNSS antenna
- 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)



# 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.

CLASS 1  
LASER PRODUCT

## Range Measurement Performance <sup>1)</sup>

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) <sup>2) 3)</sup>	100 kHz	300 kHz	600 kHz	1200 kHz
Effective Measurement Rate (meas./sec) <sup>2)</sup>	42,000	125,000	250,000	500,000
Max. Measurement Range <sup>4)</sup>				
natural targets $\rho \geq 90\%$	800 m	480 m	350 m	250 m
natural targets $\rho \geq 20\%$	400 m	230 m	160 m	120 m
Minimum Range	1.5 m	1.2 m	0.5 m <sup>5)</sup>	0.5 m <sup>5)</sup>
Max. Number of Targets per Pulse <sup>6)</sup>	15	15	8	4

Ranging Accuracy <sup>7) 9)</sup>

Ranging Precision <sup>8) 9)</sup>

3D Position Accuracy <sup>10)</sup>

Laser Wavelength

Laser Beam Divergence

5 mm

3 mm

3 mm @ 50 m, 5 mm @ 100 m

near infrared

0.25 mrad @ 1/e <sup>11)</sup>, 0.35 mrad @ 1/e<sup>2</sup> <sup>12)</sup>

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 achievable 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/e<sup>2</sup> points. 0.35 mrad corresponds to an increase of 35 mm of beam diameter per 100 m distance.

## Scanner Performance

Scan Angle Range

Scanning Mechanism

Scan Speed

Angular Step Width <sup>14)</sup>  $\Delta \theta$  (vertical),  $\Delta \phi$  (horizontal)

Angular Accuracy <sup>15)</sup>

Angle Measurement Resolution

Orientation Sensors

GNSS Receiver

Laser Plummet

Internal Sync Timer

Scan Sync (optional)

Waveform Data Output (optional)

Cloud Storage

Automatic On-board Registration

*Vertical (Line) Scan*

total 100° (+60° / -40°)

rotating multi-facet mirror

3 lines/sec to 240 lines/sec

$0.0007^\circ \leq \Delta \theta \leq 0.6^\circ$

between consecutive laser shots

0.0028° (10 arcsec)

better 0.0007° (2.5 arcsec)

*Horizontal (Frame) Scan*

max. 360°

rotating head

0°/sec to 150°/sec <sup>13)</sup>

$0.0015^\circ \leq \Delta \phi \leq 0.62^\circ$

between consecutive scan lines

0.0028° (10 arcsec)

better 0.0005° (1.8 arcsec)

integrated 3-axis accelerometer, 3-axis gyroscope,

3-axis magnetometer (compass), barometer

integrated L1, concurrent reception of GPS, GLONASS, Beidou

integrated

integrated, for real-time synchronized time stamping of scan data

scanner rotation synchronization for operating several scanners

providing digitized echo signal information for specific target echoes

Amazon S3, FTP-Server, Microsoft Azure

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

External Power Supply

Main Dimensions (width x height)

Weight

Humidity

Protection Class

Temperature Range

Storage

Operation

Low Temperature Operation <sup>16)</sup>

11 - 34 V DC / typ. 65 W (max. 83 W)

up to two independent external power sources can be connected for uninterrupted operation, in addition to the *RIEGL* add-on NiMH battery

206 mm x 346 mm

approx. 9.7 kg (with antennas)

max. 80 % non condensing @ +31°C

IP64, dust- and splash-proof

-10°C up to +50°C

0°C up to +40°C: standard operation

-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 GmbH, Headquarters**  
**RIEGL USA Inc., Headquarters North America**

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

RIEGL UK Ltd.  
RIEGL South America Spa  
RIEGL Deutschland Vertriebsgesellschaft mbH

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