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, accuracy 5 mm*
- *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*
- *NEW simultaneous image and scan data acquisition*
- *user-developed apps via python software*
- *cloud connectivity via Wi-Fi and 3G/4G LTE*
- *fully compatible with the RIEGL VMZ Hybrid Mobile Laser Mapping System*
- *multiple target capability*
- *optional waveform data output*
- *orientation sensor for pose estimation*
- *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 Infrastructure Management (BIM)*
- *Forensics & Crash Scene Investigation*
- *City Modeling*
- *Tunnel Surveying*
- *Civil Engineering*
- *Forestry*
- *Research*
- *Monitoring*

visit our website
www.riegl.com

RIEGL®
LASER MEASUREMENT SYSTEMS
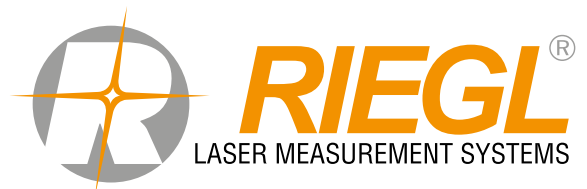
Camera Option

A 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.

External GNSS Receiver
with Bluetooth Connection

To support precise global scan data registration, the *RIEGL* VZ-400i offers an interface for a high-end external third party GNSS receiver that is to be mounted on top of the instrument. For smooth operation in the field, GNSS data is transferred to the scanner via Bluetooth transmission or cable.

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:

>> **NEW** *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.

RIEGL Add-On Rechargeable Li-Ion Battery RBLI 2900

NiMH Battery

RIEGL Add-On NiMH Rechargeable Battery RBNE 2210

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

 Data Sheet

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.
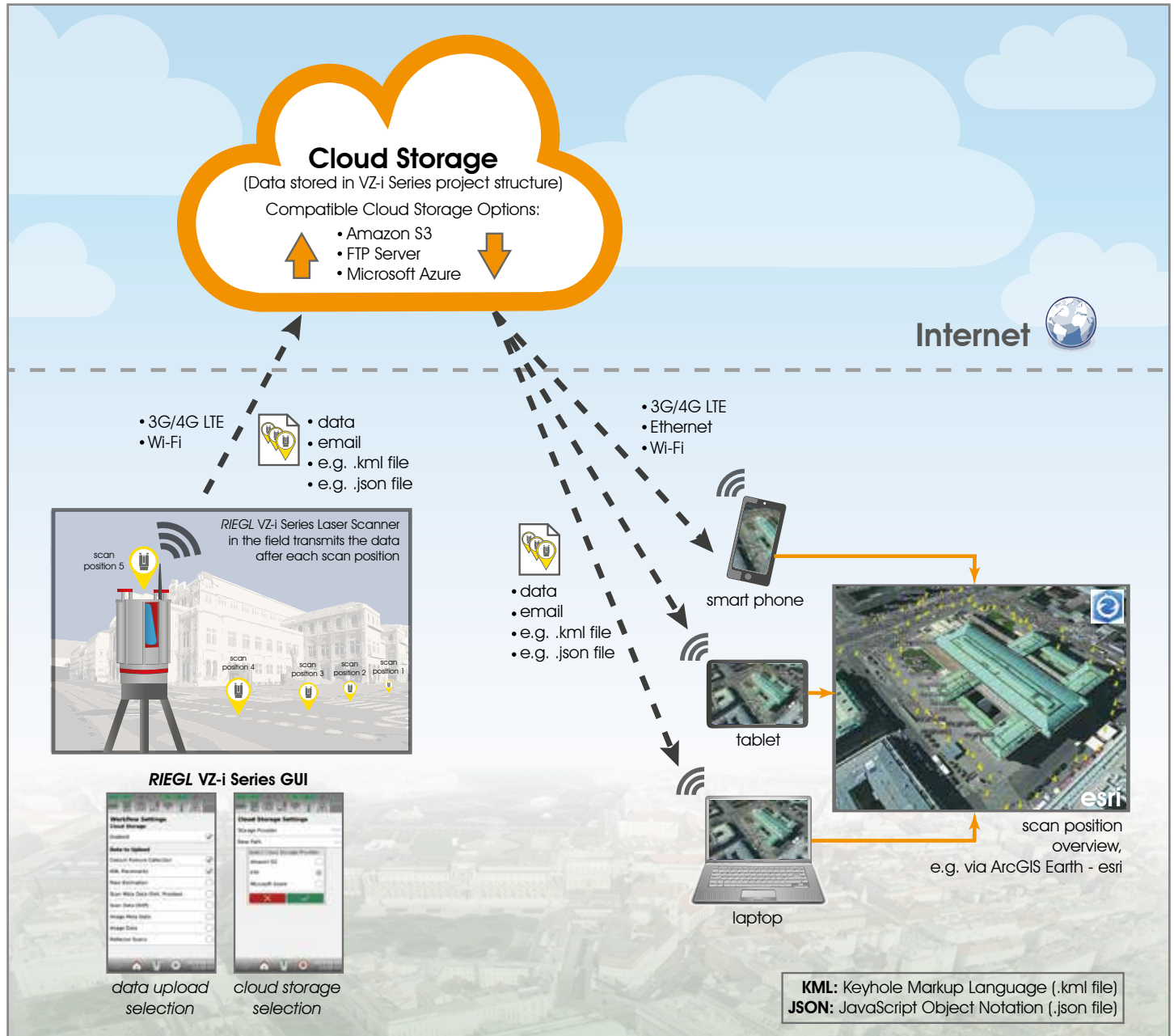

Transferable data includes:

>> 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).
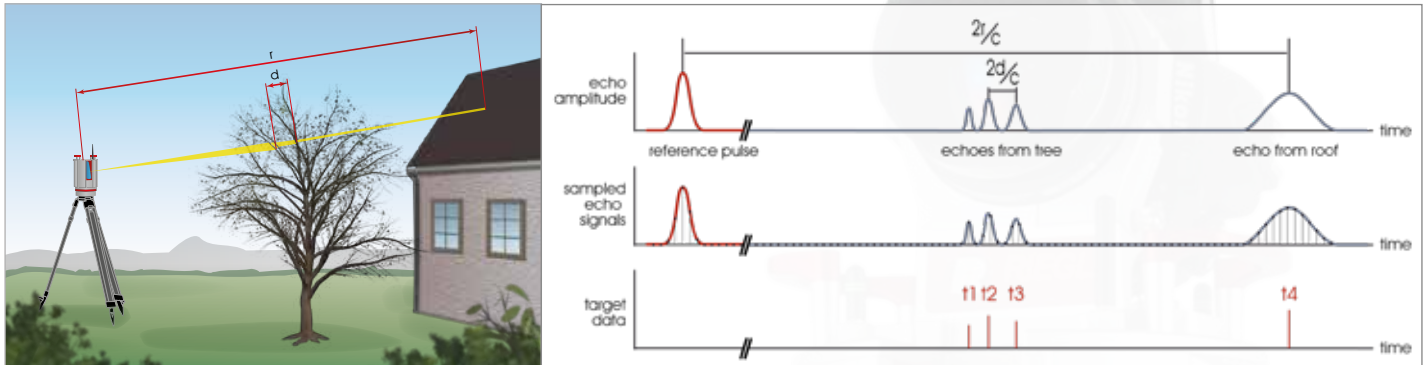
▶ Pulse Shape Deviation Output

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
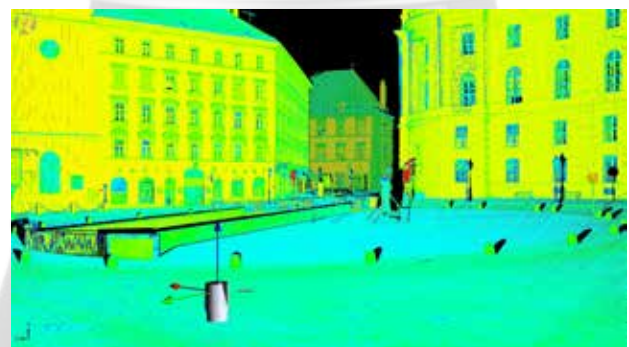
data after elimination of the „invalid" points

▶ 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

Data Sheet

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 szene.

scanning in the rain

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 localy 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.
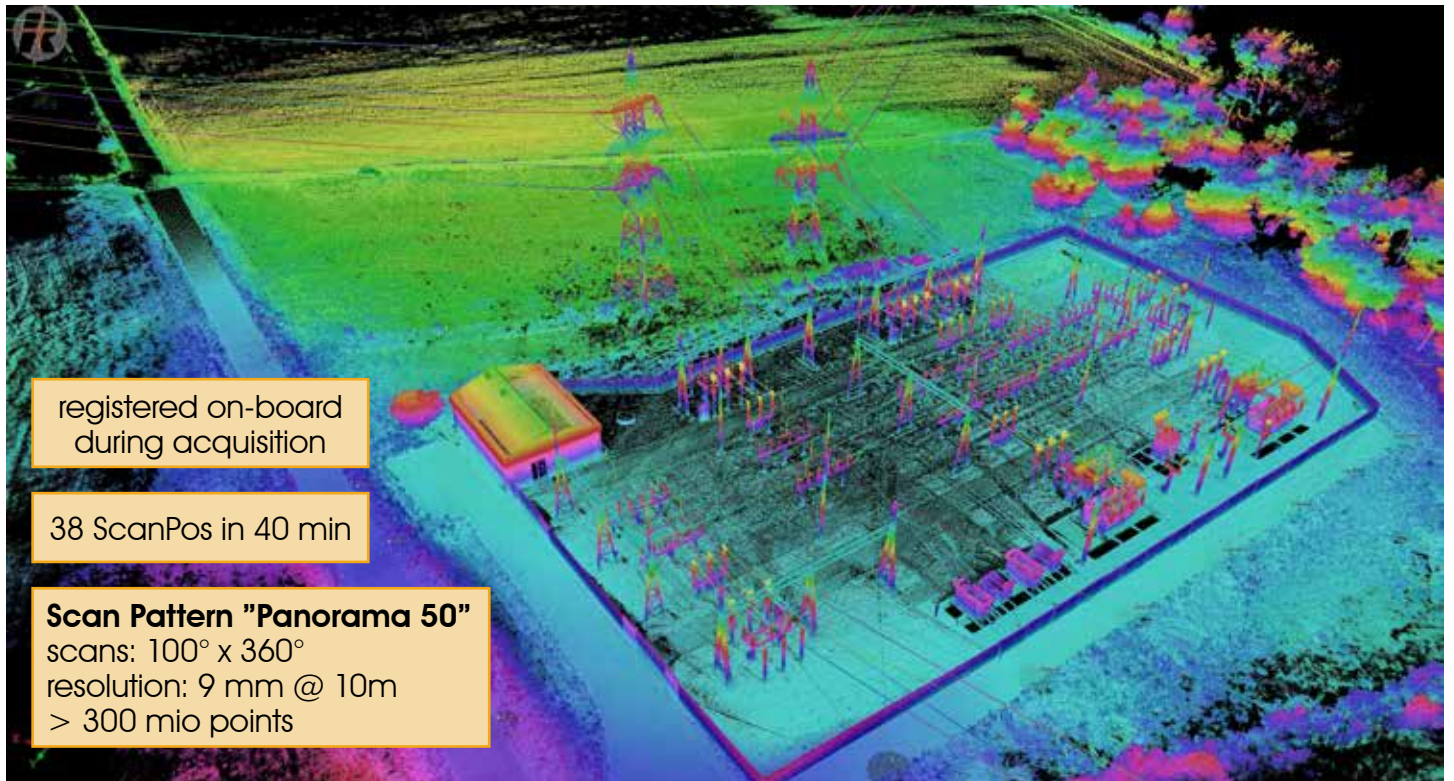

RIEGL VMZ Hybrid Mobile Laser Mapping System

Mobilization of the *RIEGL* VZ-400i

The *RIEGL* VMZ Hybrid Mobile Laser Mapping System with fully integrated IMU/GNSS unit supports the VZ-400i scanner for kinematic data acquisition. A well proven platform design enables quick transition from mobile to terrestrial applications, and vice versa, without losing system calibration. Flexible installation options and fully integrated optional cameras complement this user-friendly solution.

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.

registered on-board during acquisition

38 ScanPos in 40 min

Scan Pattern "Panorama 50"
scans: 100° x 360°
resolution: 9 mm @ 10m
> 300 mio points

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

first scan position → **next scan position** → **background process** → **registered pointcloud**

▶ *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 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
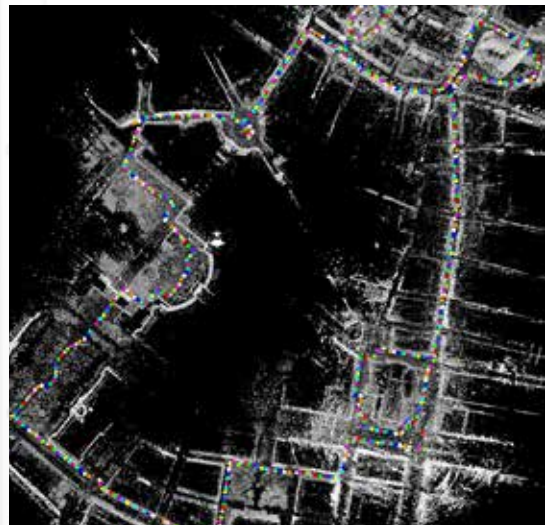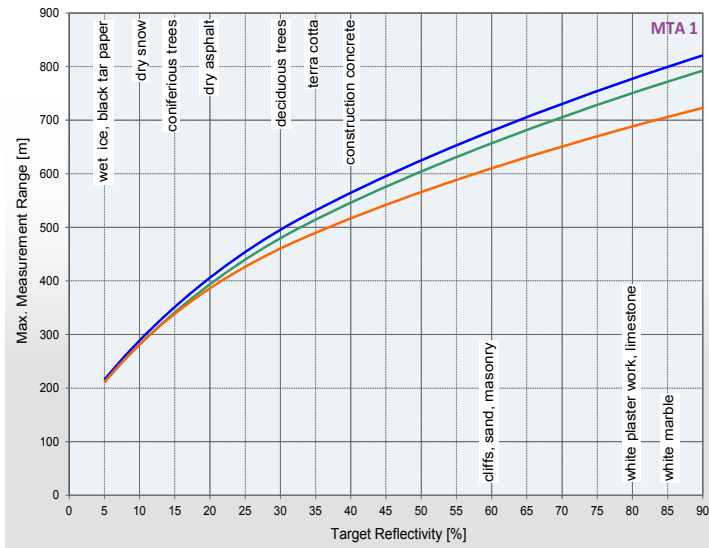

overview of scan positions (colored dots)
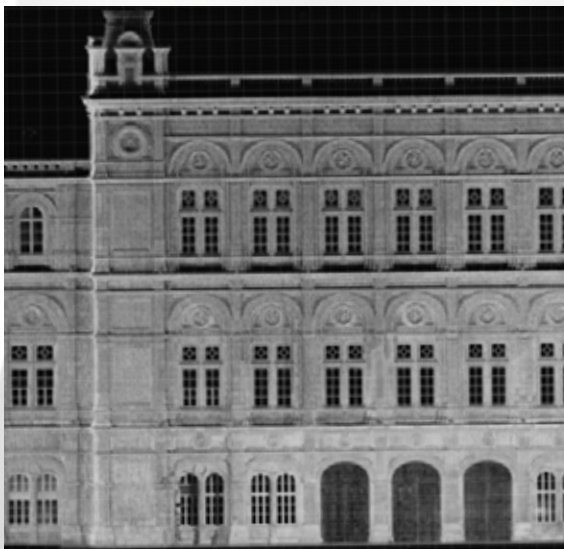
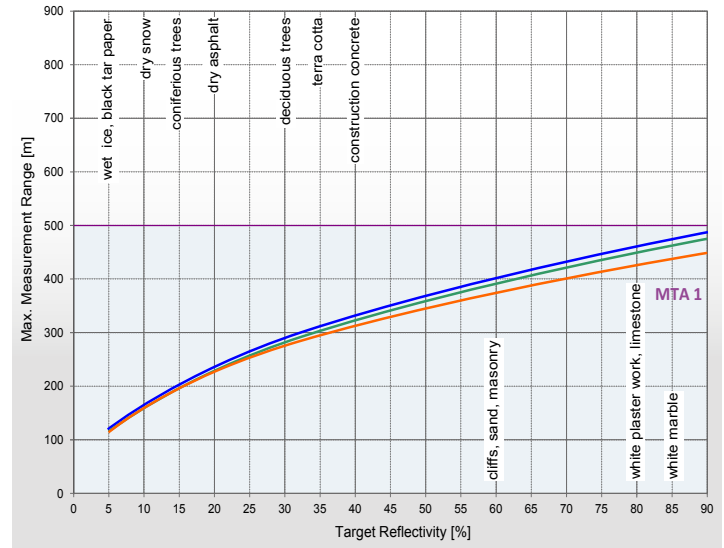
scan data detail, reflectance-scaled

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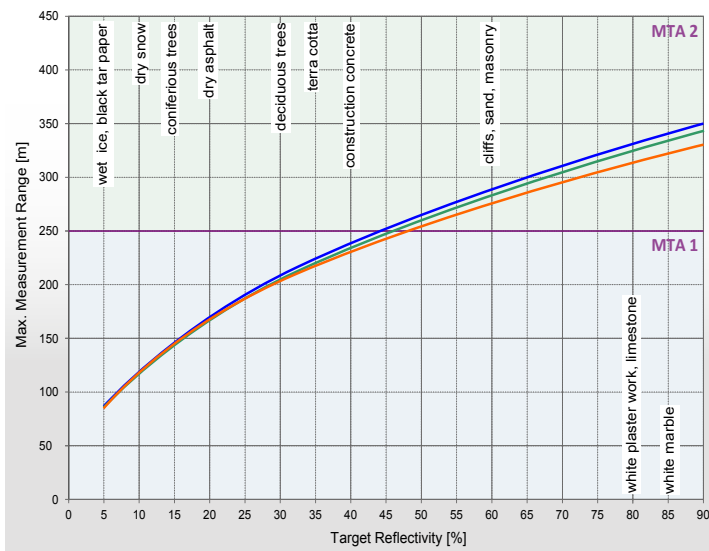**light haze: visibility 8 km**

100 kHz Laser Pulse Repetition Rate
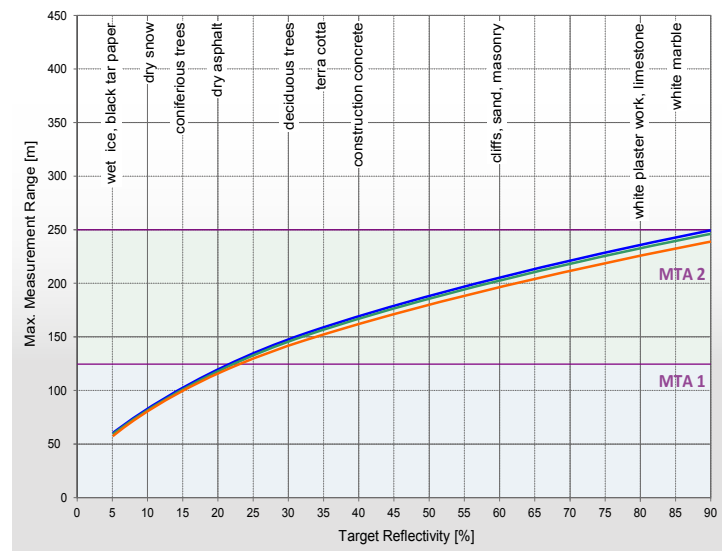

300 kHz Laser Pulse Repetition Rate

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
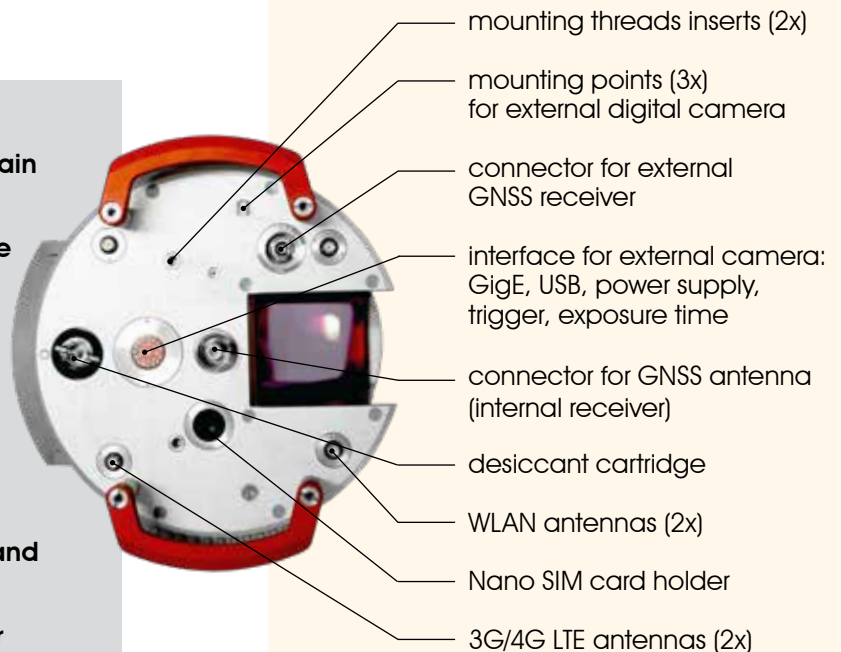- ambiguity resolved by post processing within RiSCAN PRO

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

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

Data Sheet

WLAN antennas (2x, female)

GNSS antenna

3G/4G LTE antennas (2x, male)

carrying handles (2x)

high-resolution (800x480px)
5" color display with touchscreen

308

Ø 172

206

All dimensions in mm.

## Communication and Interfaces

- **LAN port 10/100/1000 MBit/sec**

- **integrated WLAN interface with high-gain MIMO antennas**

- **integrated multi-mode cellular module available for different regions[1] 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) available for North America, Europe/APAC, Japan, or South America/APAC

mounting threads inserts (2x)

mounting points (3x)
for external digital camera

connector for external
GNSS receiver

interface for external camera:
GigE, USB, power supply,
trigger, exposure time

connector for GNSS antenna
(internal receiver)

desiccant cartridge

WLAN antennas (2x)

Nano SIM card holder

3G/4G LTE antennas (2x)

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)

SDXC card slot for
external storage devices

USB connector

connectors for power supply
and LAN interface
10/100/1000 MBit/sec,
power off/on button
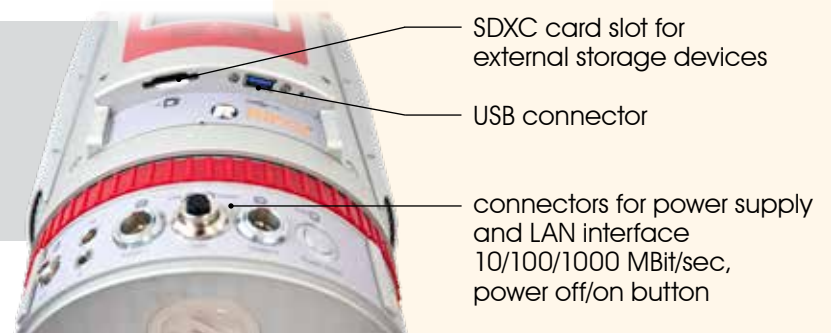
Technical Data *RIEGL* VZ®-400i

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 [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 $\rho \geq 90\ \%$	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 [5]	0.5 m [5]
Max. Number of Targets per Pulse [6]	15	15	8	4

Accuracy [7] [9]   5 mm
Precision [8] [9]   3 mm
Laser Wavelength   near infrared
Laser Beam Divergence   0.35 mrad [10]

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) One sigma @ 100 m range under *RIEGL* test conditions.
10) 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 [12]
Angular Step Width [11] $\Delta\ \vartheta$ (vertical), $\Delta\ \varphi$ (horizontal)	$0.0007° \leq \Delta\ \vartheta \leq 0.6°$ between consecutive laser shots	$0.0015° \leq \Delta\ \varphi \leq 0.62°$ between consecutive scan lines
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

11) Selectable.

12) Frame scan can be disabled, providing 2D scanner operation.

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
for uninterrupted operation, in addition to the *RIEGL* add-on NiMH battery

Main Dimensions   206 mm x 308 mm (width x height)
Weight   approx. 9.7 kg (with antennas)
Humidity   max. 80 % non condensing @ +31°C
Protection Class   IP64, dust- and splash-proof
Temperature Range

Storage   -10°C up to +50°C
Operation   0°C up to +40°C: standard operation
Low Temperature Operation [13]   -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

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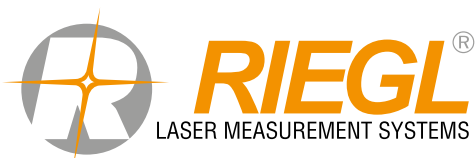
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