RIEGL VZ®-2000i

- *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 2500 m, accuracy 5 mm*
- *high accuracy, high precision ranging based on echo digitization, online waveform processing, and multiple-time-around processing*
- *new, innovative processing architecture for data acquisition and simultaneous geo-referencing, in real-time*
- *automatic on-board registration*
- *NEW simultaneous image and scan data acquisition*
- *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*
- *remote control*
- *integrated GNSS receiver*

Based on a future-oriented, innovative new processing architecture, internet connectivity, and *RIEGL*'s latest waveform processing LiDAR technology, the *RIEGL* VZ-2000i Long Range 3D Laser Scanning System combines proven user friendliness in the field with fast and highly accurate data acquisition.

Its new processing architecture enables execution of different background tasks (such as point cloud registration, geo-referencing, orientation via integrated Inertial Measurement Unit, etc.) on-board in parallel to the simultaneous acquisition of scan data and image data. A full documentation of the scanner's software components – directly accessible on the *RIEGL* VZ-2000i – provides a sound basis for creation of your own python apps to enhance the scanner functionality. The system provides highest flexibility by supporting numerous peripherals and accessories such as the integrated GNSS unit for high accurate RTK solution, a SIM Card slot for 3G/4G LTE, WLAN, LAN, USB, and different other ports of external units.

RIEGL's unique Waveform-LiDAR technology – based on echo digitization, online waveform processing, and multiple-time-around processing – is the key to enabling such high speed, long range, high accuracy measurements even in poor visibitlity and demanding multi-target situations caused by dust, haze, rain, vegetation, etc.

Typical applications include

- *Topography and Mining*
- *Natural Hazard Surveying*
- *Construction Site Monitoring*
- *Archeology & Cultural Heritage Documentation*
- *City Modeling*
- *Tunnel Surveying*
- *Civil Engineering*
- *Research*

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.

GNSS Receiver Options

>> Integrated L1 GNSS receiver, RTK capability by using of:
- GNSS correction service via internet
- recommended base station via LoRa radio (up to 10 km), network, or NTRIP/TCP

>> external GNSS Receiver with Bluetooth

recommended base station EMLID REACH RS, model RRS-1

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-2000i can be connected to the following optionally available rechargeable batteries:

>> *RIEGL* Add-On NiMH Rechargeable Battery RBNE 2210 (205 Wh)

>> NiMH Battery (235 Wh)

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

RIEGL Add-On NiMH Rechargeable Battery RBNE 2210

NiMH Battery

Waveform Data Output Option

The digitized echo signals, also known as full waveform data, acquired by the *RIEGL* VZ-2000i 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
breakline detection and volume calculation fully supported
various mining exchange formats for full compatibility with mine planning software

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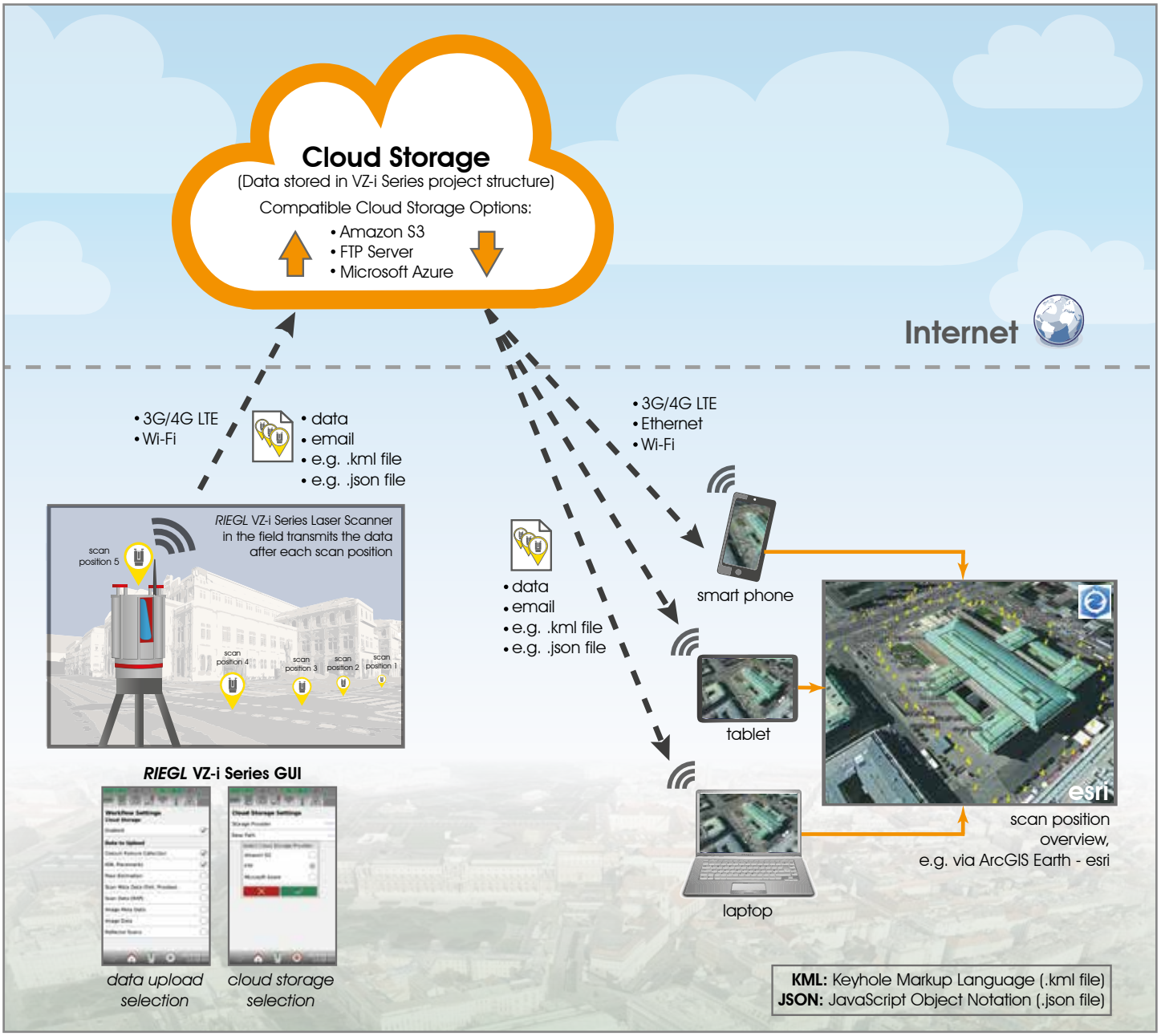
The *RIEGL* VZ-i Series provides cloud connectivity via either the 3G/4G LTE, Wi-Fi network, or LAN.

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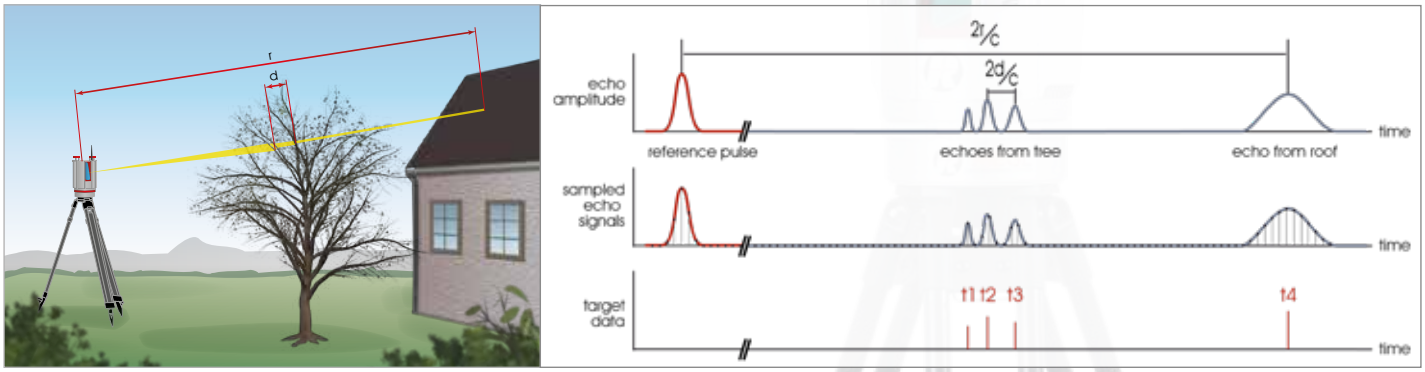
RIEGL's sophisticated LiDAR technology is the basis for highly informative scan data. Every laser pulse received provides several attributes in addition to the range measurement information. By using different features and filters provided with the scanner's software, this information can be used to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

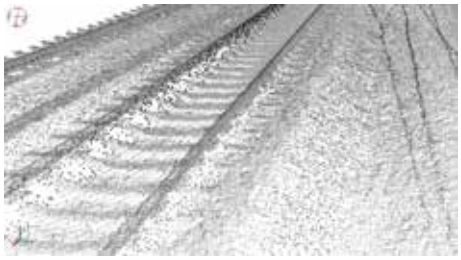
Multi Target Capability - the Basis for High Penetration Capability

Utilizing the pulsed time-of-flight method for laser range measurements, the VZ-2000i 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).

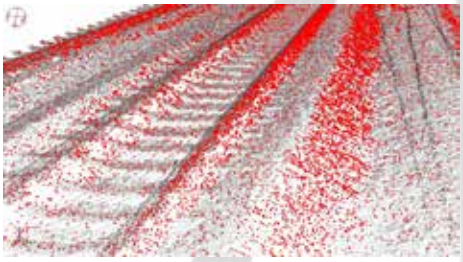


Pulse Shape Deviation Output

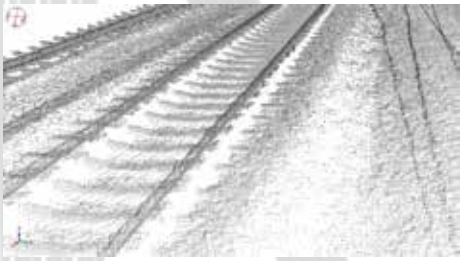
Even if the distance between two targets is too short to discriminate between the two echoes, valuable information about the pulse shape of the return pulse is given. That allows it to discriminate whether the return echo originates from a single target or from two nearby targets. A simple thresholding,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



original scan data
range approx. 90 m
15 mdeg angular resolution



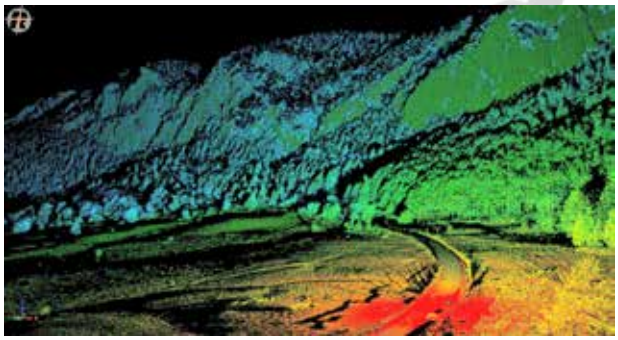
automatic selection of „invalid" points using the pulse shape deviation attribute information



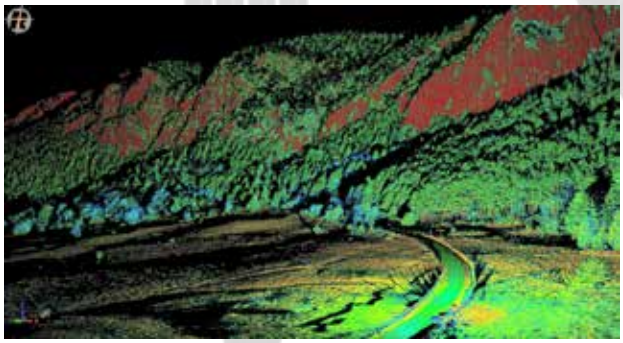
data after elimination of the „invalid" points

Calibrated Reflectance Output

This feature allows the scan data to be displayed and 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.

scanning in the rain

point cloud before filter application

automatically cleaned-up point cloud

A NEW Standard in User-Friendliness

Operation & Remote Control

>> Easy operation of the *RIEGL* VZ-2000i 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 VMZ Hybrid Mobile Laser Mapping System

Mobilization of the *RIEGL* VZ-2000i

The *RIEGL* VMZ Hybrid Mobile Laser Mapping System with fully integrated IMU/GNSS unit supports the VZ-2000i 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.

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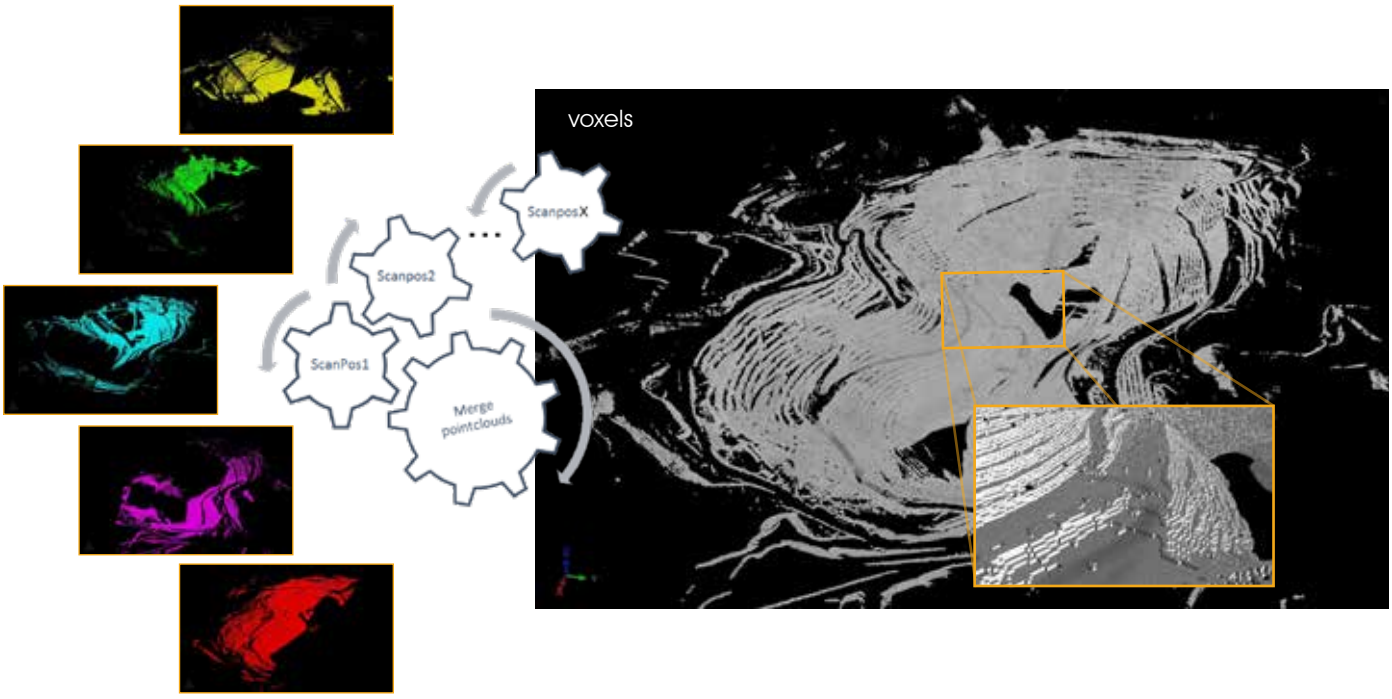
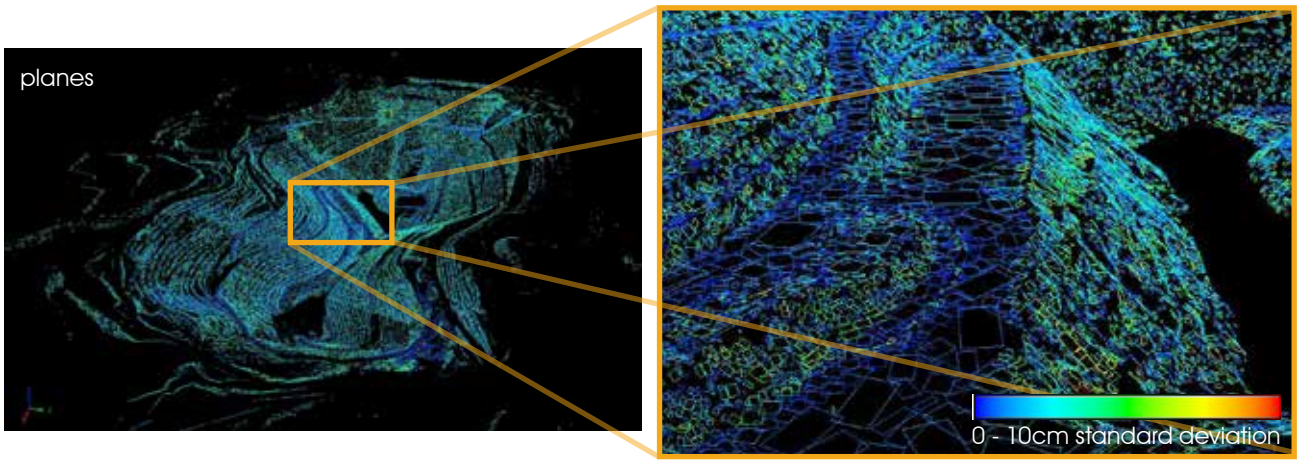
Automatic On-board Registration

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.
With two processors on-board, the *RIEGL* VZ-2000i carries out some post-processing tasks in real-time such as automatic on-board registration in parallel to the scan data acquisition. Find here some examples on how this feature may be utilized to fasten the registration process in open-pit mine surveying.

Merging of Scan Positions

The on-board sensors (GNSS, mems-IMU, compass) deliver a rough orientation of the different scan positions.
The registration task running in the background extracts a voxel representation of the data and it merges automatically the scan positions based on these voxels. Thereafter a fine-alignment is done based on extracted plane-patches from all the scan positions. The resulting common dataset of plane-patches visualized by standard-deviation of these planes indicates the quality of the overall alignment.





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

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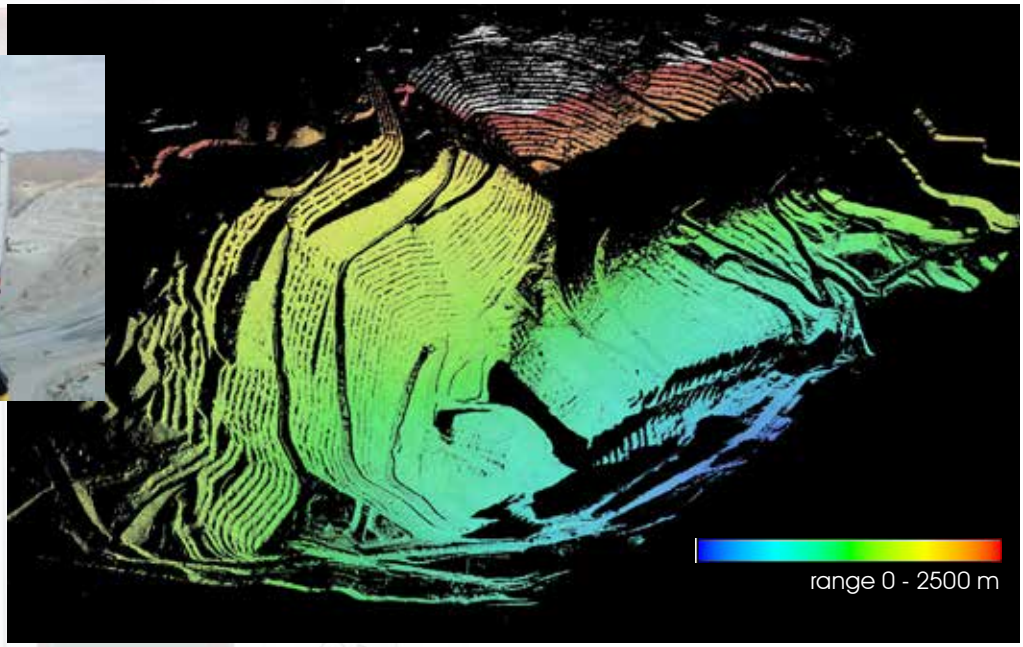
Open-Pit Mining

The real-time on-board registered pointclouds can be directly uploaded to a remote storage and to the cloud for applying further automated analysis steps common in monitoring, autonomous machine control, volume calculations, blast planning, and break line extraction.



scan data of an open-pit mining area, range-colored

Scanning parameters:

- mining area > 8 km²
- 5 scan positions
- 50 kHz measurement rate
- > 8 million points / scan

Railroad Surveying

In the example illustrated here, the *RIEGL* VZ-2000i acquired scan data of a railway line. The automatic on-board registration was used to register the scan data of 16 scan positions covering an area of more than 10 km².

Scanning parameters:

- 300 kHz pulse repetition rate
- more than 1,100 m
- 25 million points / scan
- 15 mdeg resolution

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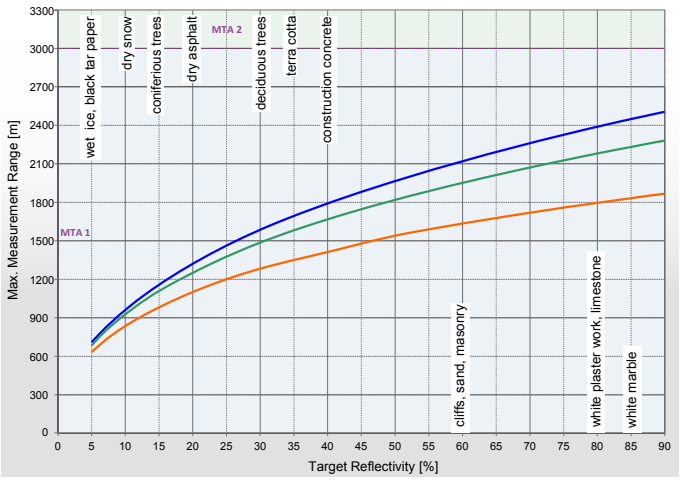
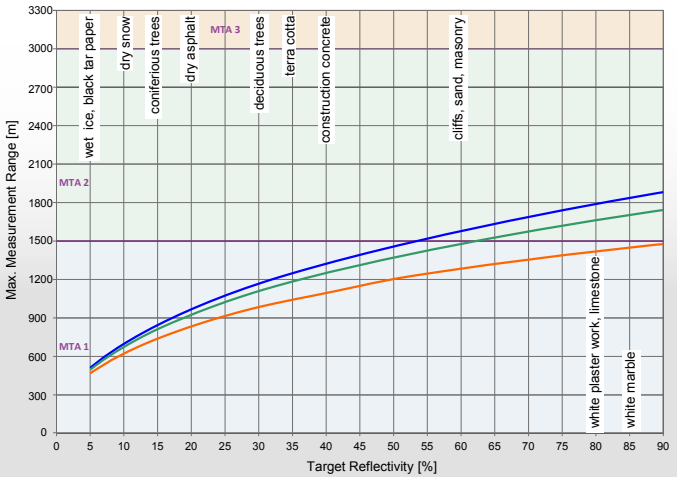
Max. Measurement Range *RIEGL* VZ®-2000i

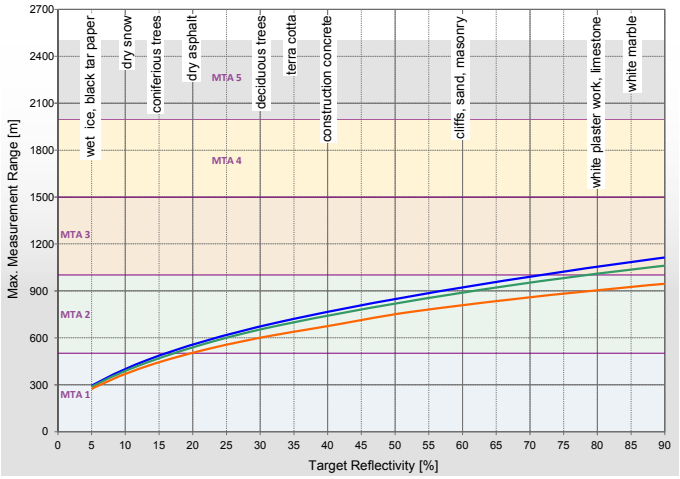
50 kHz Laser Pulse Repetition Rate



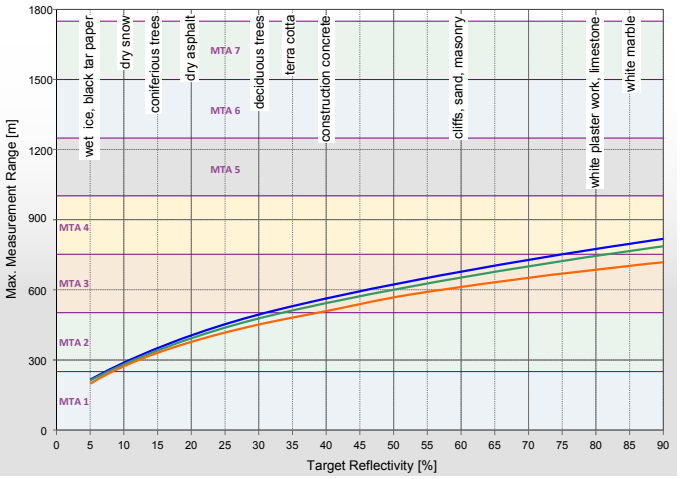
100 kHz Laser Pulse Repetition Rate



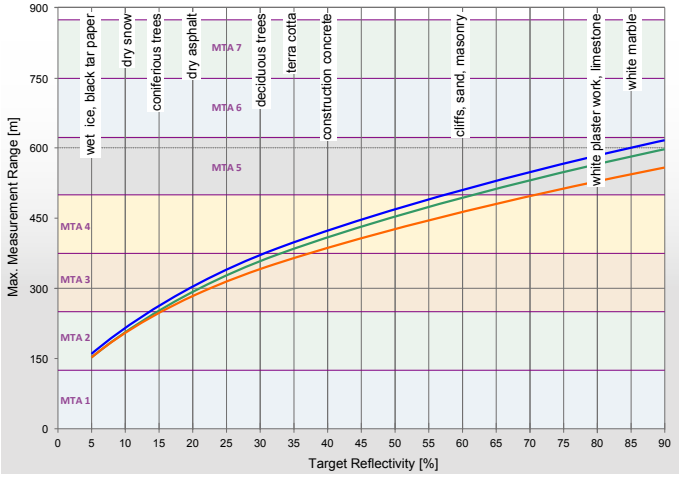
300 kHz Laser Pulse Repetition Rate

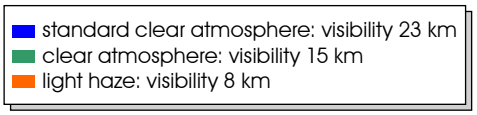


600 kHz Laser Pulse Repetition Rate



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"
MTA X: X pulses „in the air"

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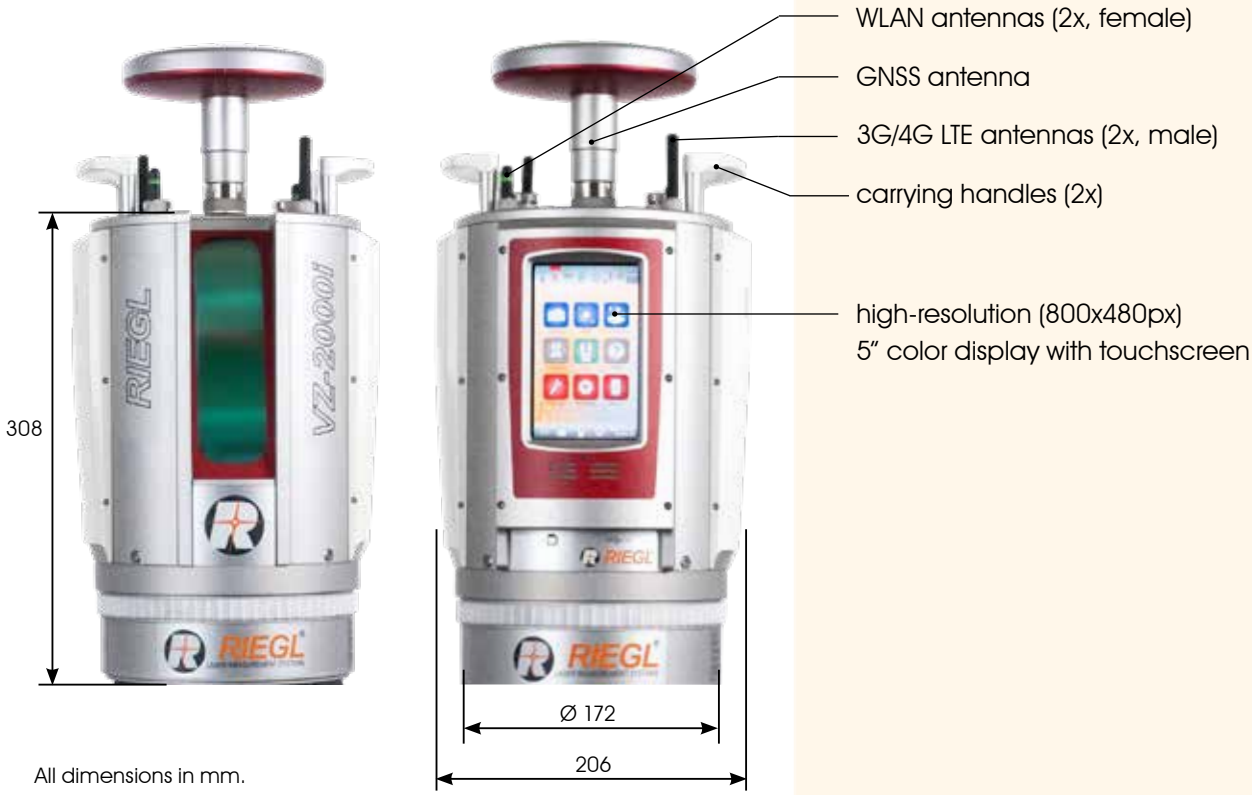
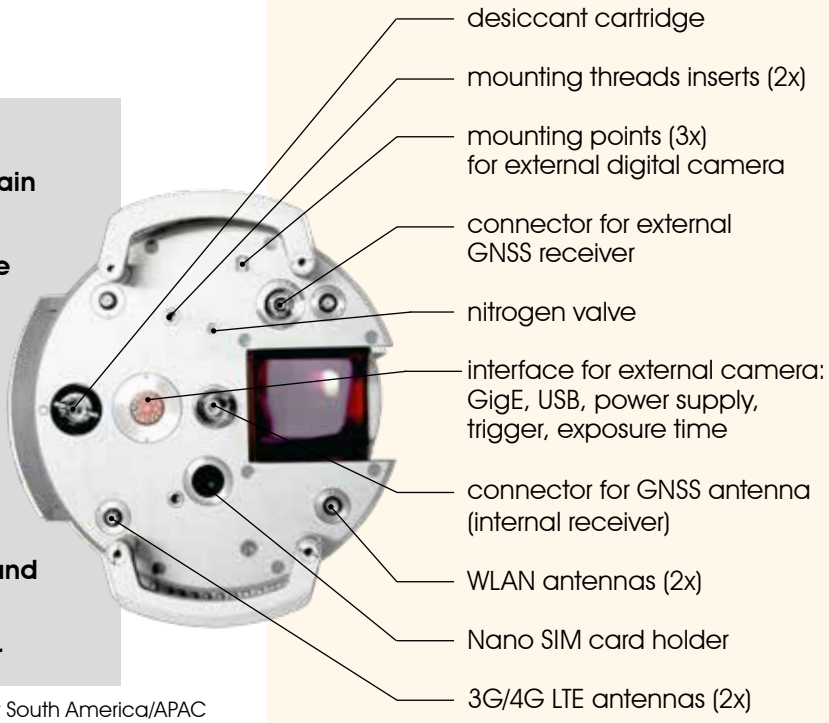


All dimensions in mm.

Communication and Interfaces

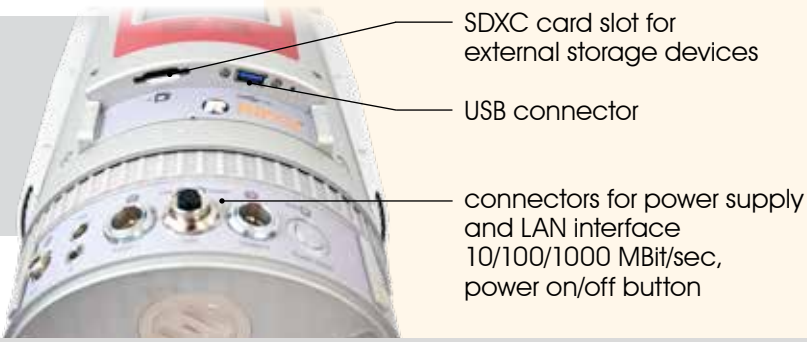
- **LAN port 10/100/1000 MBit/sec**
- **integrated WLAN interface with high-gain MIMO antennas**
- **integrated multi-mode cellular module available for different regions[1] with MIMO 3G/4G LTE antennas**
- **GigE and USB for connecting an external digital camera**
- **connector for GNSS antenna**
-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



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®-2000i

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]	50 kHz	100 kHz	300 kHz	600 kHz	1.2 MHz
Effective Measurement Rate (meas./sec) [2]	21,000	42,000	125,000	250,000	500,000
Max. Measurement Range [3]					
natural targets ρ ≥ 90 %	2,500 m	1,850 m	1,100 m	800 m	600 m
natural targets ρ ≥ 20 %	1,300 m	950 m	540 m	380 m	290 m
Minimum Range	2.0 m	1.5 m	1.5 m	1.0 m [4]	1.0 m [4]
Max. Number of Targets per Pulse [5]	15	15	15	8	4

Accuracy [6] [8]	5 mm
Precision [7] [8]	3 mm
Laser Wavelength	near infrared
Laser Beam Divergence	0.27 mrad [9]

1) With online waveform processing.
2) Rounded values.
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) Minimum range specified for vertical zenith angles from 30 deg to 120 deg, resp. 90° vertical field of view.
5) If more than one target is hit, the total laser transmitter power is split and, accordingly, the achieveable range is reduced.
6) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
7) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
8) One sigma @ 100 m range under *RIEGL* test conditions.
9) Measured at the $1/e^2$ points. 0.27 mrad corresponds to an increase of 27 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 [11]
Angular Step Width [10] $\Delta\ \vartheta$ (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 Real Time Kinematics RTK
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

10) Selectable.
11) Frame scan can be disabled, providing 2D scanner operation.

General Technical Data

Power Supply Input Voltage	11 - 34 V DC
Power Consumption	typ. 56 W (max. 80 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. 9.8 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 [12]	-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

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

RIEGL®
LASER MEASUREMENT SYSTEMS

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