

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
- 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 visibility 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



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 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 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-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



recommended base station
EMLID REACH RS2



RIEGL Add-On Rechargeable
Li-Ion Battery RBLI 2900



RIEGL Add-On NiMH
Rechargeable Battery RBNE 2210



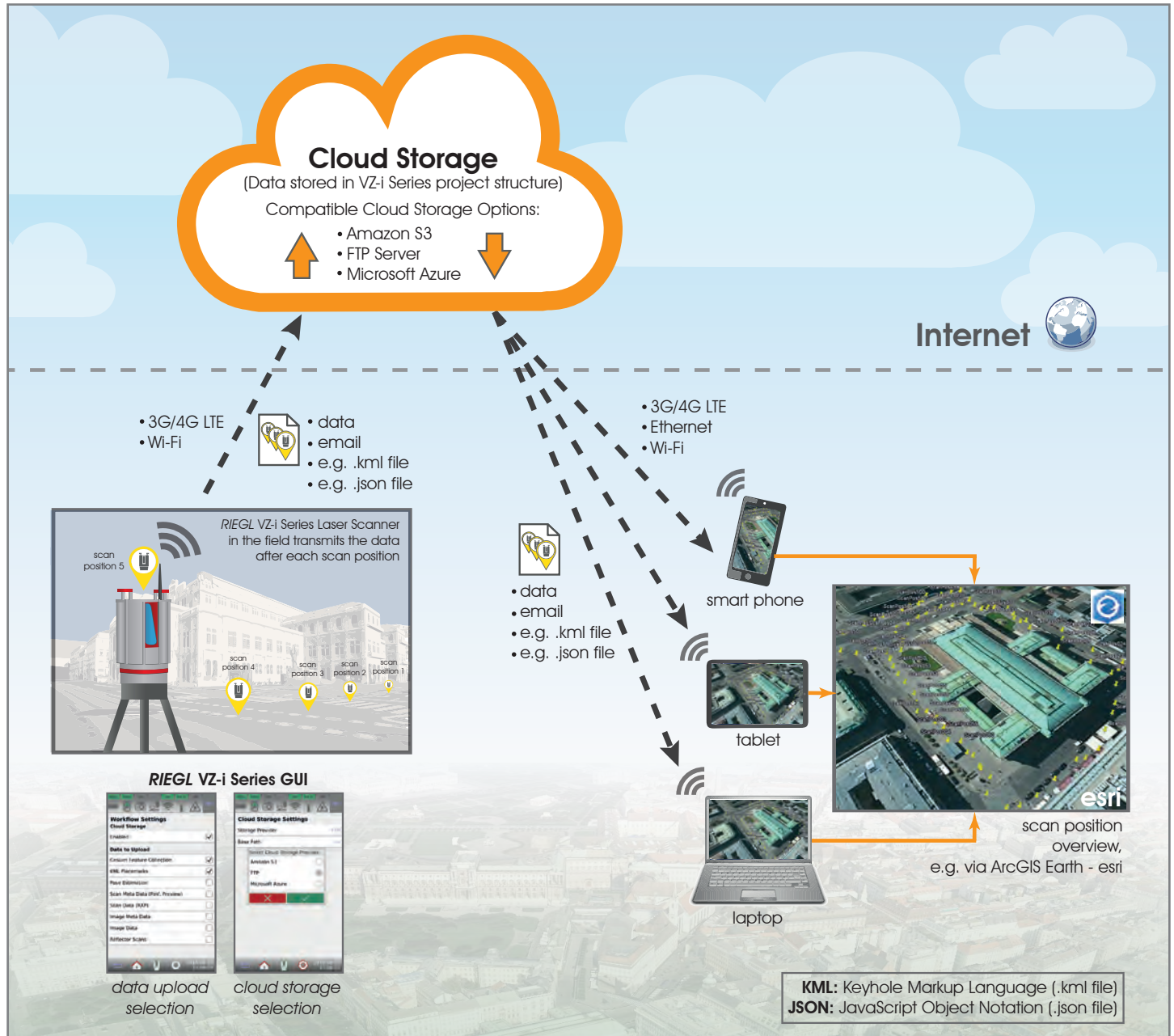
NiMH Battery



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:

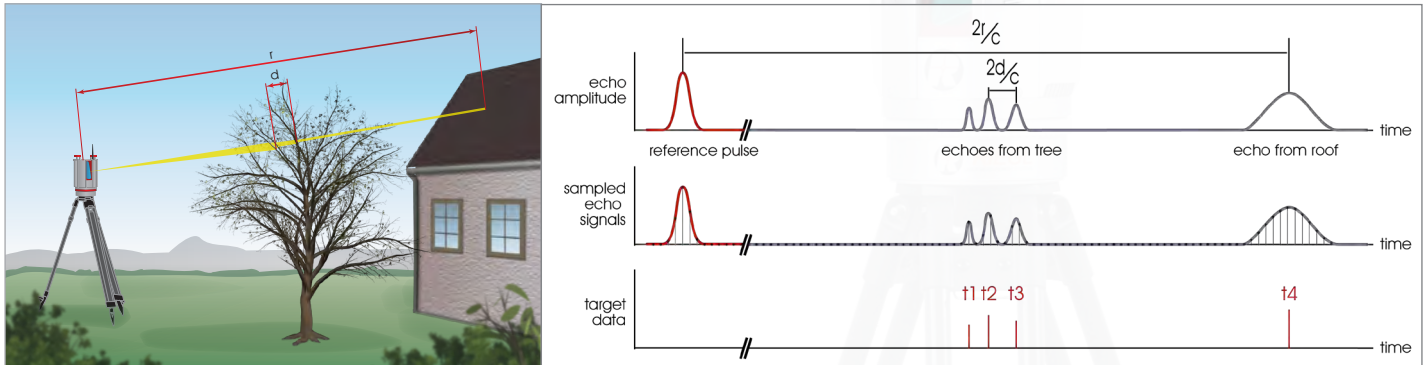
- >> the scanner's position in WGS84 geographic coordinates as *.kml and *.json
- >> scan data preview as *.png image
- >> thumb-nails of the images as *.jpg
- >> scan data as *.rxp
- >> image data as *.jpg
- >> error messages

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.

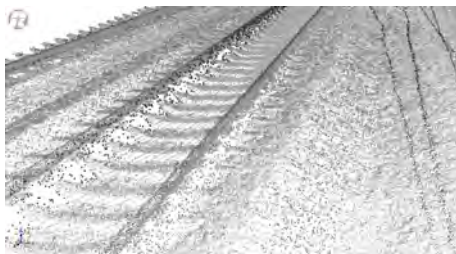
Multi Target Capability - the Basis for High Penetration Capability

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

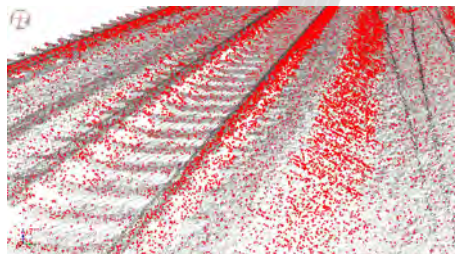


Pulse Shape Deviation Output

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



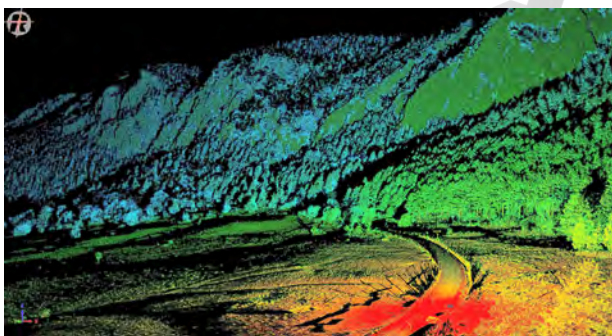
automatic selection of „invalid“ points
using the pulse shape deviation
attribute information



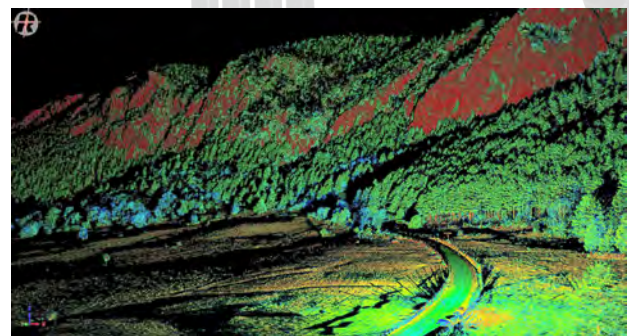
data after elimination of the „invalid“ points

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

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

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.



Automatic On-board Registration

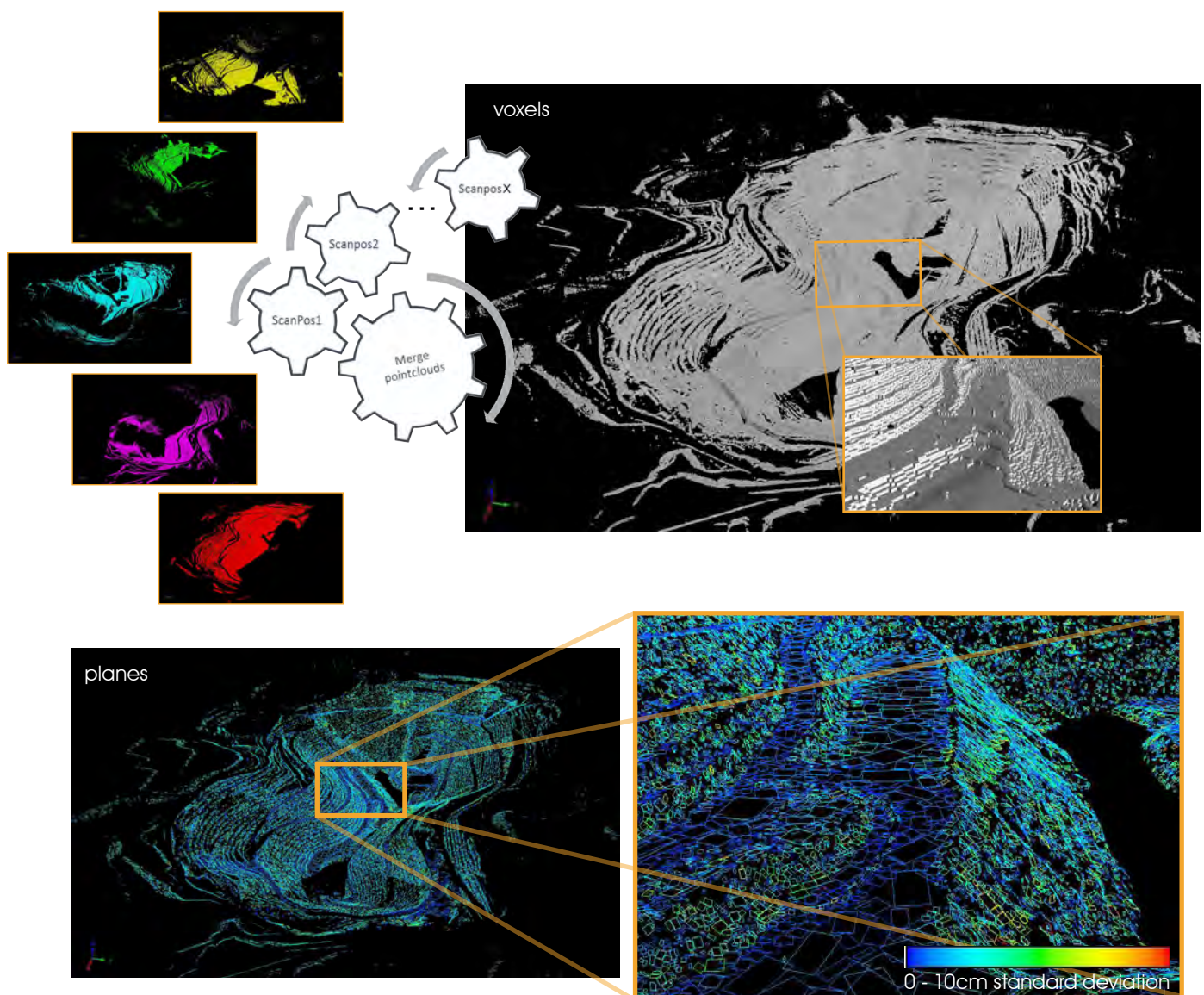
Matching point clouds of different scan positions (registration) has always been one of the most time-consuming tasks during the post-processing of 3D scanning projects.

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

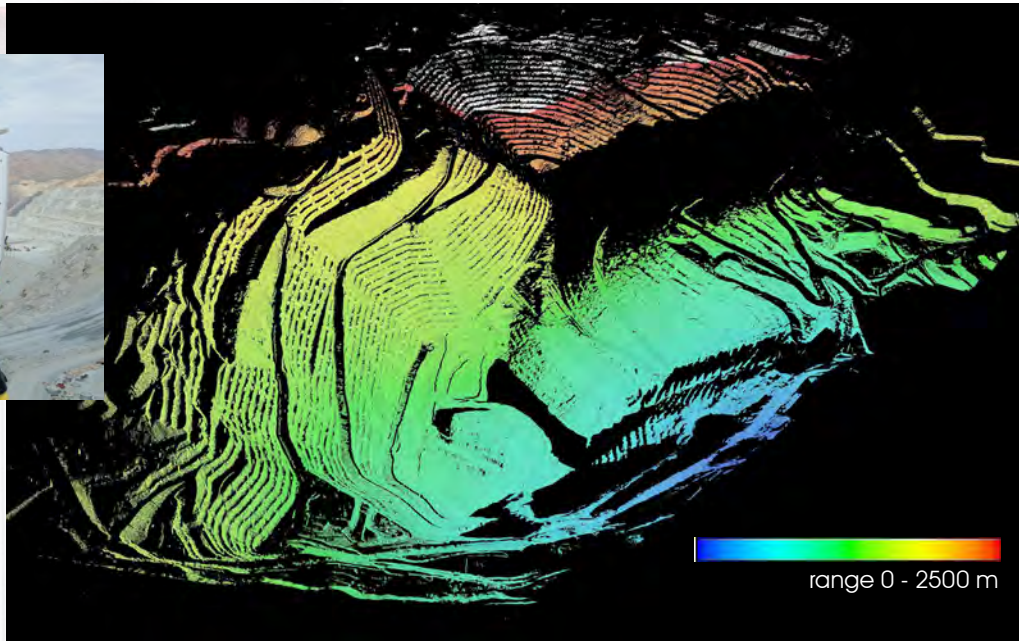
Open-Pit Mining

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.



Scanning parameters:

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



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

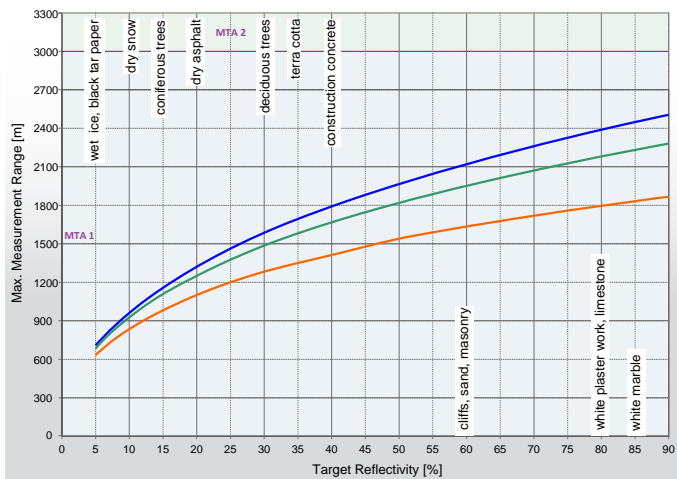
Railroad Surveying

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.

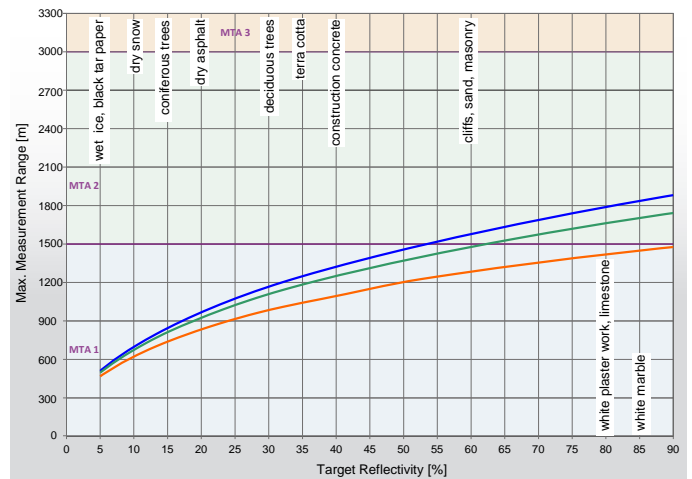


- Scanning parameters:
- 300 kHz pulse repetition rate
 - more than 1,100 m
 - 25 million points / scan
 - 15 mdeg resolution

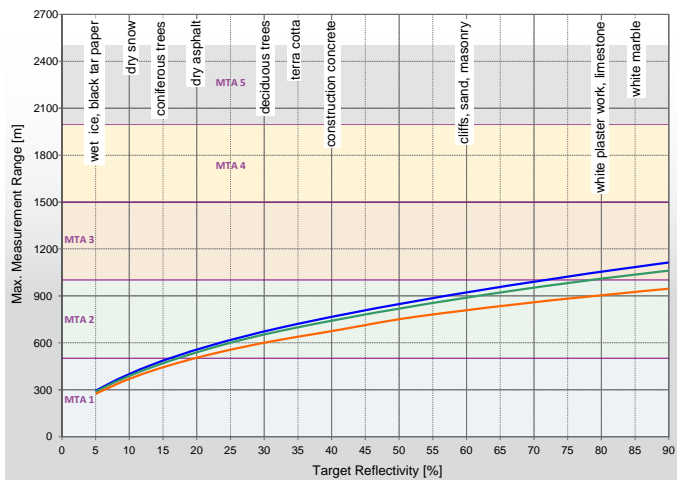
50 kHz Laser Pulse Repetition Rate



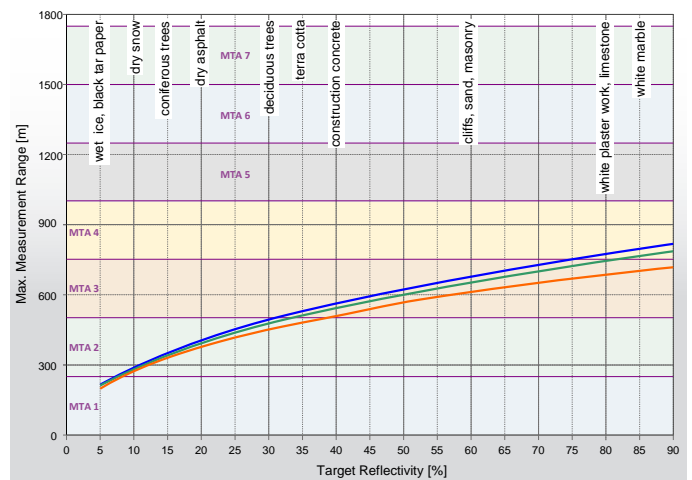
100 kHz Laser Pulse Repetition Rate



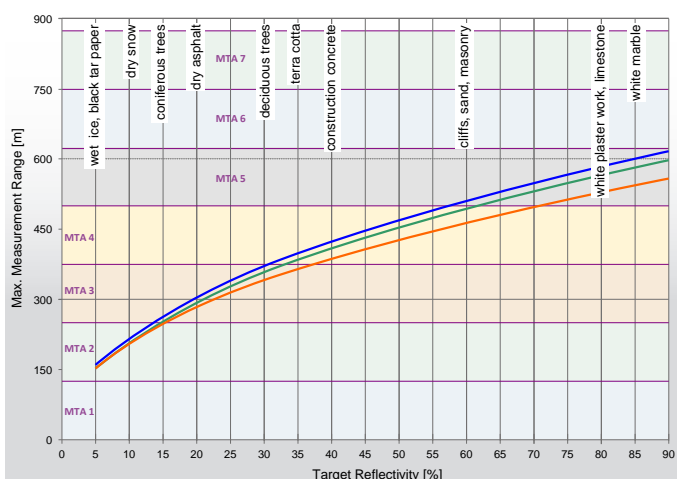
300 kHz Laser Pulse Repetition Rate



600 kHz Laser Pulse Repetition Rate



1200 kHz Laser Pulse Repetition Rate



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

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“

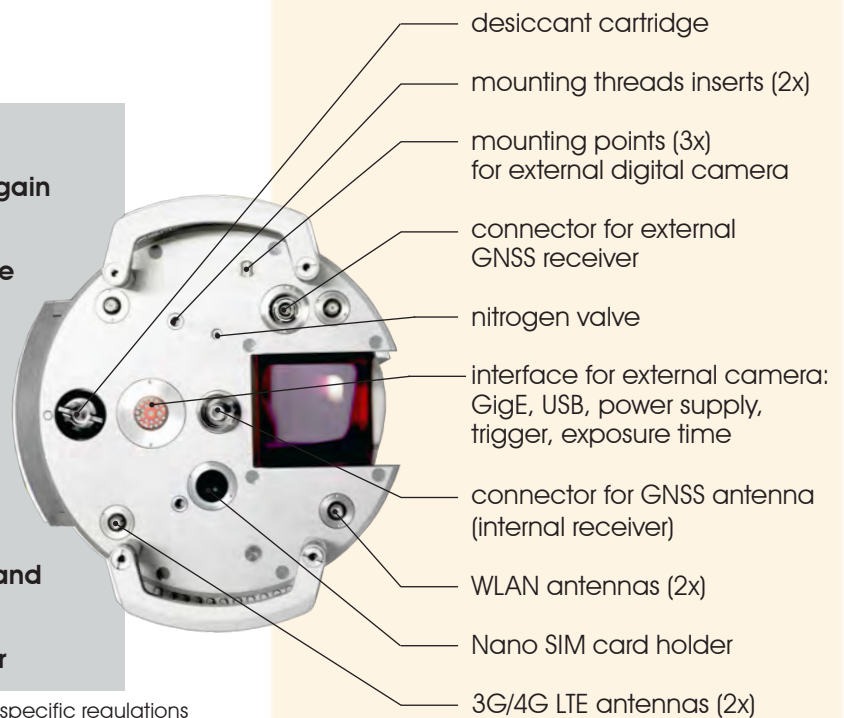
MTA X: X pulses „in the air“



Communication and Interfaces

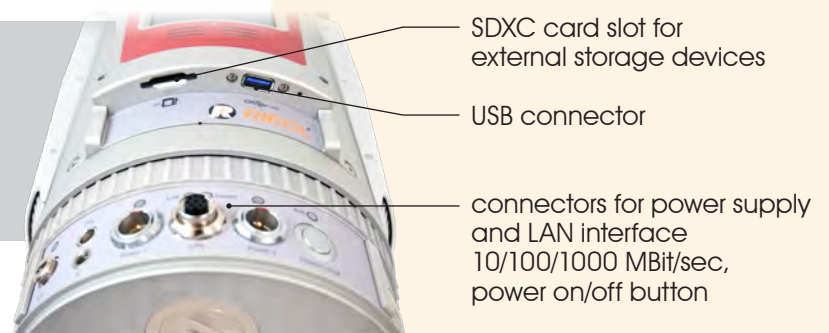
- LAN port 10/100/1000 MBit/sec
- integrated WLAN interface¹⁾ with high-gain MIMO antennas
- integrated multi-mode cellular module available for different regions²⁾ with MIMO 3G/4G LTE antennas
- GigE and USB for connecting an external digital camera
- connector for GNSS antenna
- two external power 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®-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 $\rho \geq 90\%$	2,500 m	1,850 m	1,100 m	800 m	600 m
natural targets $\rho \geq 20\%$	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

Ranging Accuracy ^{6) 8)}

5 mm

Ranging Precision ^{7) 8)}

3 mm

3D Position Accuracy ⁹⁾

3 mm @ 50 m, 5 mm @ 100 m

Laser Wavelength

near infrared

Laser Beam Divergence

0.19 mrad @ $1/e^{10}$, 0.27 mrad @ $1/e^2$ ¹¹⁾

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 achievable 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) 1-sigma @ 100 m range under *RIEGL* test conditions.

9) 1-sigma value, based on target modelling, under *RIEGL* test conditions.

10) Measured at the $1/e$ points. 0.19 mrad corresponds to an increase of 19 mm of beam diameter per 100 m distance.

11) 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

Scan Angle Range

Vertical (Line) Scan

total 100° (+60° / -40°)

Scanning Mechanism

rotating multi-facet mirror

Scan Speed

3 lines/sec to 240 lines/sec

Angular Step Width ¹²⁾ $\Delta \theta$ (vertical), $\Delta \phi$ (horizontal)

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

between consecutive laser shots

0.0028° (10 arcsec)

better 0.0007° (2.5 arcsec)

Angular Accuracy ¹⁴⁾

Angle Measurement Resolution

Horizontal (Frame) Scan

max. 360°

rotating head

0°/sec to 150°/sec ¹³⁾

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

between consecutive scan lines

0.0028° (10 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

12) Selectable.

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

14) 1-sigma value, based on target modelling, under *RIEGL* test conditions.

General Technical Data

Power Supply Input Voltage

11 - 34 V DC

Power Consumption

typ. 70 W (max. 87 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 346 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

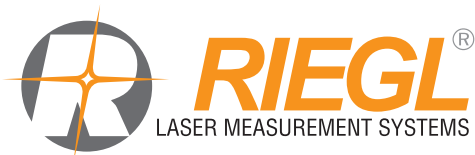
0°C up to +40°C: standard operation

Low Temperature Operation ¹⁵⁾

-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

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



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