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**
- **new, innovative processing architecture for data acquisition and simultaneous geo-referencing, in real-time**
- **easy to use – easy to train (user friendly touchscreen interface, single touch operation, etc.)**
- **automatic scan data registration with RiSOLVE**
- **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 data acquisition, waveform processing and system operations, and a second processing platform which enables on-board data registration, geo-referencing, and analysis to be executed simultaneously. Future improvements by continuous development will be available via online firmware updates. 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

Preliminary Data Sheet

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 3.0 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.

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:

>> *RIEGL* Add-On NiMH Rechargeable Battery (97.2 Wh)

>> NiMH Battery (235 Wh)

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

RIEGL Add-On NiMH
Rechargeable Battery

NiMH Battery

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 for Users

>> **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

RIEGL Software Packages for Software Developers

>> **RiVLib**
library for developing customized software to acquire and process .rxp data streams

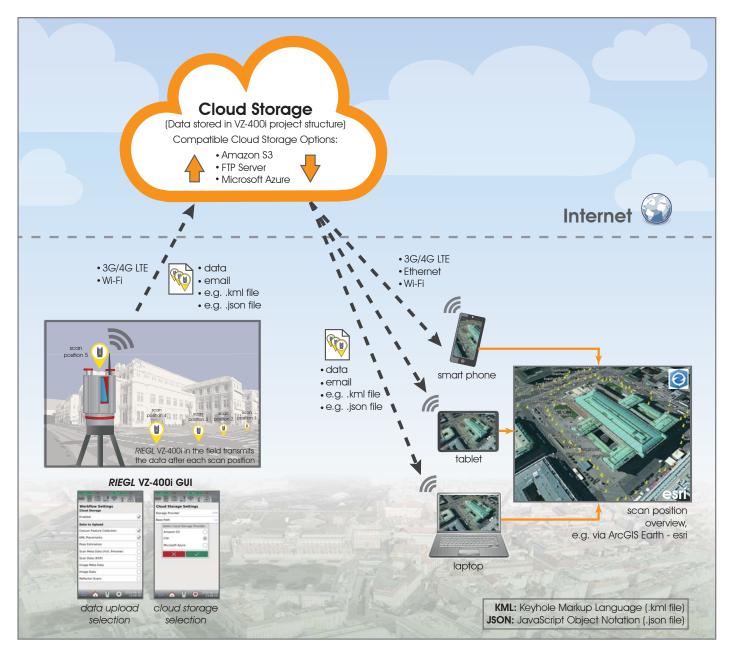>> **RiMTA TLS**
for automated resolution of range ambiguities

The *RIEG*L VZ-400i provides cloud connectivity by internet connection via either the 3G/4G LTE or Wi-Fi network.

The content to be 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 position.

Supported cloud storage currently includes Amazons S3 and Microsoft Azure.

Cloud Storage
(Data stored in VZ-400i project structure)
Compatible Cloud Storage Options:
• Amazon S3
• FTP Server
• Microsoft Azure

Internet

• 3G/4G LTE
• Wi-Fi

• data
• email
• e.g. .kml file
• e.g. .json file

• 3G/4G LTE
• Ethernet
• Wi-Fi

• data
• email
• e.g. .kml file
• e.g. .json file

scan position 5

scan position 4
scan position 3
scan position 2
scan position 1

RIEGL VZ-400i in the field transmits the data after each scan position

RIEGL **VZ-400i GUI**

smart phone

tablet

laptop

scan position overview, e.g. via ArcGIS Earth - esri

data upload selection

cloud storage selection

KML: Keyhole Markup Language (.kml file)
JSON: JavaScript Object Notation (.json file)

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 itself as *.rxp
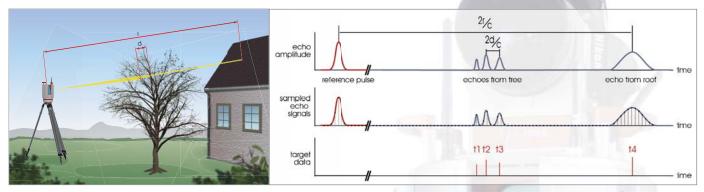
>> image data itself as *.jpg

>> 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.

▶ Pulse Shape Deviation Output

Even if the distance between two targets is too short to discriminate between 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 „invalid" points and keep only the reliable „real" targets.

original data

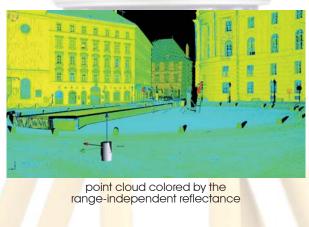automatic selection of „invalid" points using the pulse shape deviation attribute information

data after elimination of „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, re-classified, 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 of the *RIEGL* VZ-400i is easy with the integrated **Graphical User Interface (GUI)** via touch-screen, or by remote control of the scanner via VNC Viewer with any tablet PC or mobile device using Wi-Fi connection.

Scan data registration is supported by on-board **orientation sensors**, integrated **L1 GPS receiver**, an interface for a **high-end external GNSS receiver** on top of the scanner (now also via Bluetooth connection), a **digital compass,** and a built-in **SSD data storage media**.

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 own workflows to meet individual user requirements are possible.

select the appropriate scanning parameters and start the first scan

move scanner to 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 Registration with *RIEGL* RiSOLVE

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 outdoor 3D scan data. With additional tools for filtering, scene animation and measurements, RiSOLVE enables a rapid turnaround of critical information.

Workflow: 5 easy steps

Scan
- 20+ million measurements
- 5 high-resolution images
- precise inclination data
- GNSS position
- compass bearing

With the new VZ-400i*:
75 seconds
per position

Import
- download project
- import from USB flash drive
- create project structure

1 minute
per position

Register
Automatic Registration:
1) position estimation via: inclination, GPS & compass
2) coarse registration
3) fine adjustment

less than 1 minute
per position

Color
One-Click Color:
- utilizes calibrated images
- automatically adjusts frame
- colorizes point cloud

less than 1 minute
per position

Plot
- automatically selects region
- exportable to PDF
- plot to image

* @ scan resolution= 0.05 deg

RiSOLVE Key Features:

>> fully automatic registration and colorization of scan data

>> fast and easy solution to acquire, register, and colorize outdoor 3D scan data

>> rapid turnaround of critical information with additional tools for filtering, scene animation and measurements

>> takes the complexity out of the registration process by utilizing positioning information provided by sensors integrated into VZ-Line scanners

>> enables a final, fine adjustment of all scans to produce a seamless, fully registered point cloud
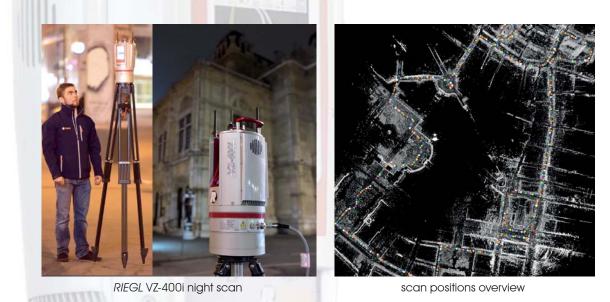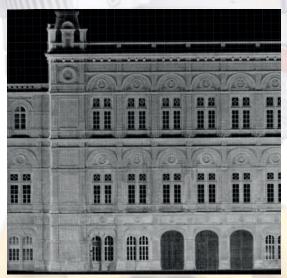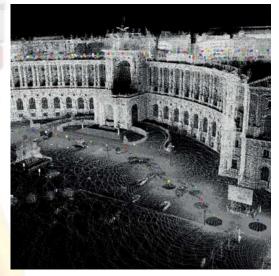
Preliminary Data Sheet

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 scanning time in the field.

1 operator	8 hours	500+ scans

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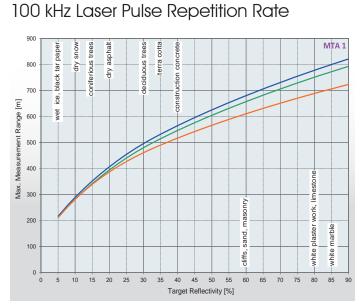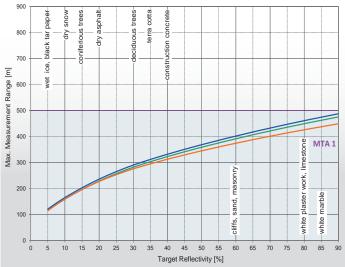

RIEGL VZ-400i night scan

scan positions overview

scan data detail, reflectance-scaled

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

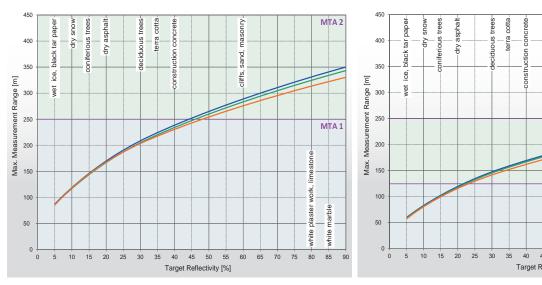## 100 kHz Laser Pulse Repetition Rate

300 kHz Laser Pulse Repetition Rate

600 kHz Laser Pulse Repetition Rate
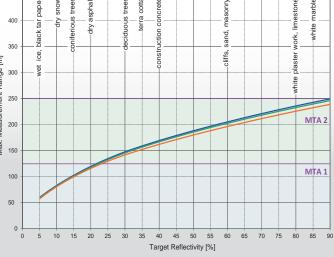

1200 kHz Laser Pulse Repetition Rate

The following conditions are assumed:

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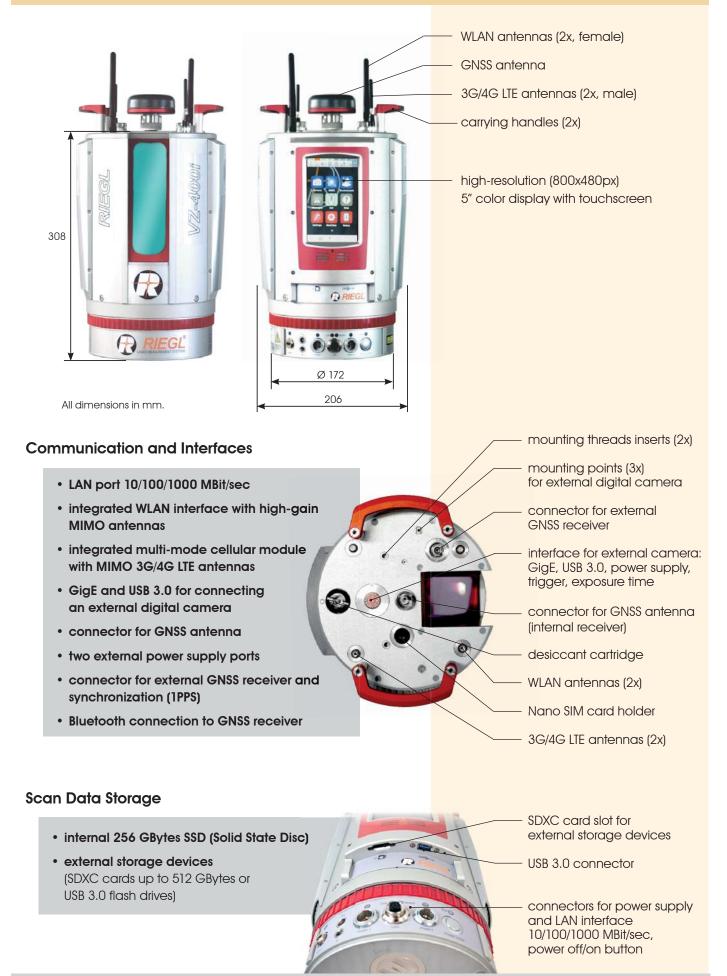- ambiguity resolved by post processing within RiSCAN PRO

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

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

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 with MIMO 3G/4G LTE antennas**

- **GigE and USB 3.0 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**

mounting threads inserts (2x)

mounting points (3x)
for external digital camera

connector for external
GNSS receiver

interface for external camera:
GigE, USB 3.0, 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 256 GBytes SSD (Solid State Disc)**

- **external storage devices**
  (SDXC cards up to 512 GBytes or
  USB 3.0 flash drives)

SDXC card slot for
external storage devices

USB 3.0 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 IEC60825-1:2007

The following clause applies for instruments delivered into the United States: Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.
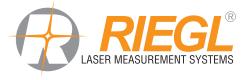
CLASS 1 LASER PRODUCT

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	15	15	8	4

Accuracy [6] [8]	5 mm
Precision [7] [8]	3 mm
Laser Wavelength	near infrared
Laser Beam Divergence	0.35 mrad [9]

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) 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. 0.35 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 [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
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
On-board registration	available approx. end of 2016

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. 58 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. 9.7 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 [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.