



Airborne Laser Scanning

Karel Sukup
PONYSTAR s.r.o.



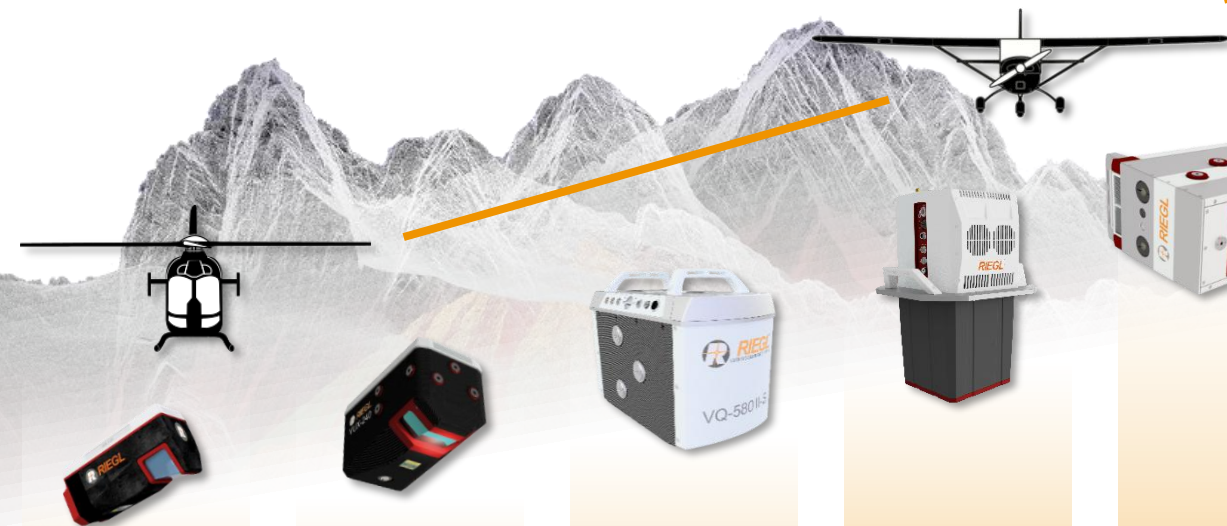
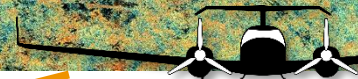
RIEGL®

- *Product Overview RIEGL ALS*
- *Product Overview RIEGL UAV*
- *Product Overview RIEGL Terrestrial scanners*



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Innovation in 3D

RIEGL ALS product portfolio – 2023/2024



2.4 MHz
75° FoV
980m AGL
800lps
VUX-180²⁴



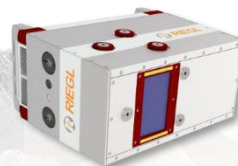
2.4 MHz
75° FoV
1430m AGL
600lps
VUX-240²⁴



2 MHz
75° FoV
2200m AGL
VQ-580 II-S



2.4 MHz
60° FoV N/F/B
2300m AGL
500lps
VQ-680



2 MHz
60° FoV
3900m AGL
VQ-780 II-S



2.2 / 4.4 MHz
60° FoV
4400m AGL
600lps
VQ-1260/1460



2 x 2.2 MHz
58° FoV
3900m AGL
600lps
VQ-1560 III-S

*The new **VQ-1260** and **VQ-1460** wide area mapping system series*

- new exterior design



The new VQ-1260 and VQ-1460 wide area mapping system series

- new exterior design
- new electronics platform design



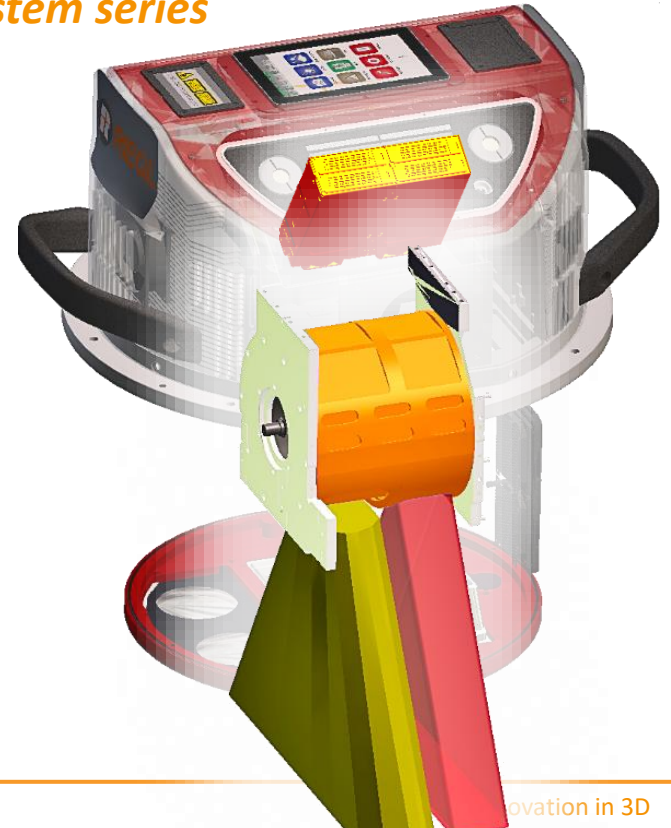
*The new **VQ-1260** and **VQ-1460** wide area mapping system series*

- new exterior design
- new electronics platform design
- new innovative optical front end design



The new VQ-1260 and VQ-1460 wide area mapping system series

- new exterior design
- new electronics platform design
- new innovative optical front end design
- integrated data recorder



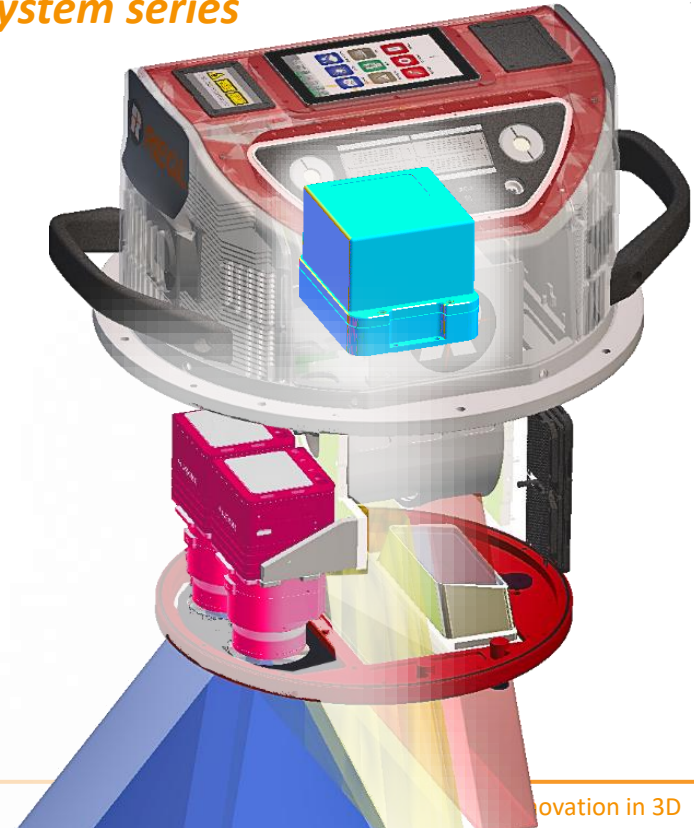
The new VQ-1260 and VQ-1460 wide area mapping system series

- new exterior design
- new electronics platform design
- new innovative optical front end design
- integrated data recorder
- high-end IMU / GNSS system



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- integrated data recorder
- high-end IMU / GNSS system
- RGB & IR camera



The new VQ-1260 and VQ-1460 wide area mapping system

- new exterior design
- new electronics platform design
- new innovative optical front end design
- integrated data recorder
- high-end IMU / GNSS system
- RGB & IR camera
- modular structure for future upgrade



The new VQ-1260 and VQ-1460 wide area mapping system series

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- high-end IMU / GNSS system
- RGB & IR camera
- modular structure for future upgrade
- graphical user interface



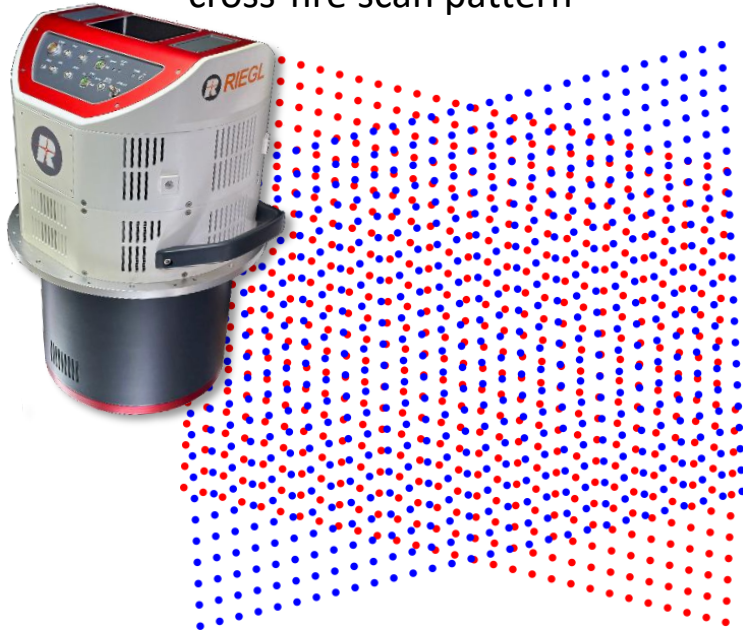
The new VQ-1260 and VQ-1460 wide area mapping system series

- new exterior design
- new electronics platform design
- new innovative optical front end design
- integrated data recorder
- high-end IMU / GNSS system
- RGB & IR camera
- modular structure for future upgrade
- graphical user interface
- fits gyro-stabilized mounts

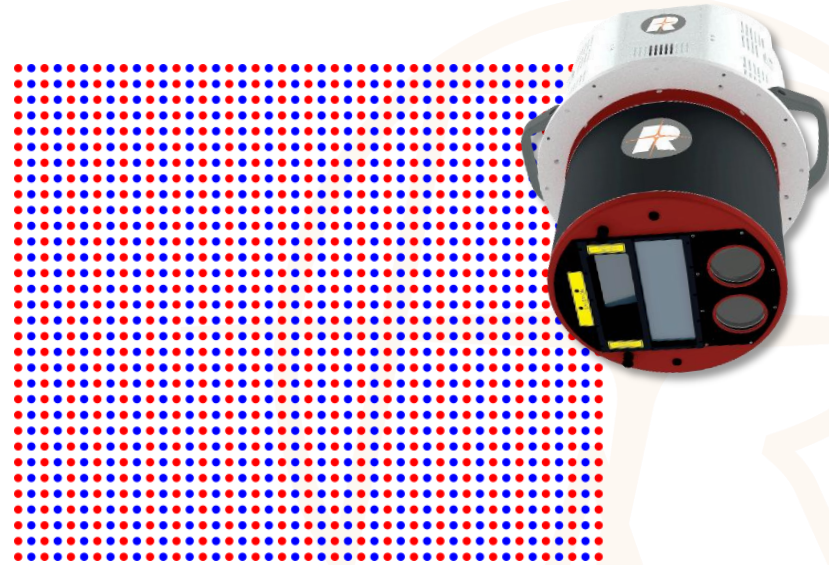


Comparison of VQ-1560III-S and VQ-1460

- atmospheric clutter suppression
- cross-fire scan pattern



- excellent atmospheric clutter suppression
- regular scan pattern





Installation of the VQ 480 II system - cables



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RiACQUIRE: scan data gap detection



The **VQ-680** city mapping system

Product launch: the **new VQ-680** ...for city and corridor mapping

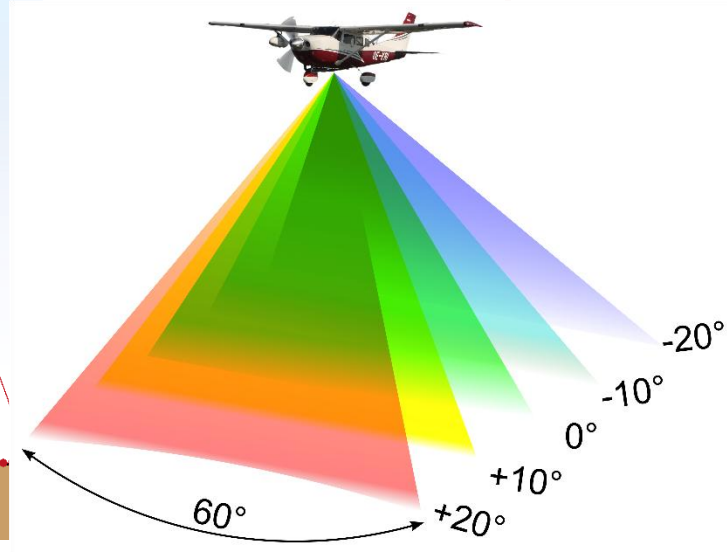
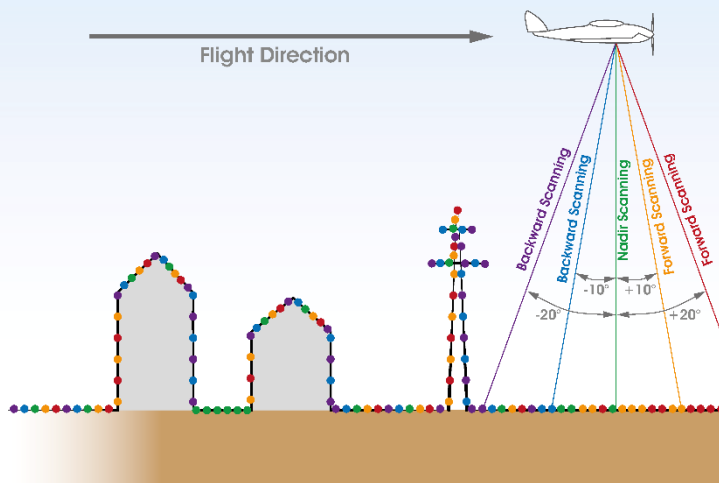
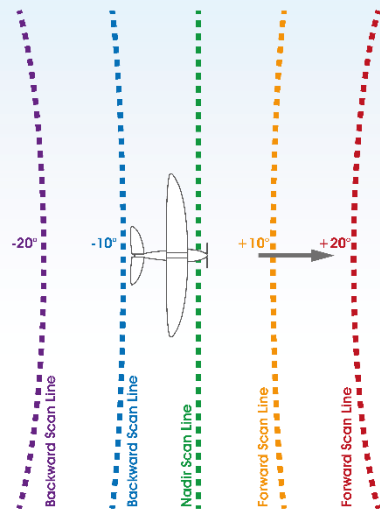
- nadir/forward/backward scanning (NFB)
at +20 / +10 / 0 / -10 / -20 degrees
- wide total field of view 60° across track,
40° along track
- high PRR up to 2.4MHz, 500 lps
- measurement ranges ($\rho \geq 20\%$)
3000m @ 300kHz
1300m @ 2400kHz
- interfaces for up to 6 cameras
- optionally integrated Applanix stack
- fits into SOMAG DSM400



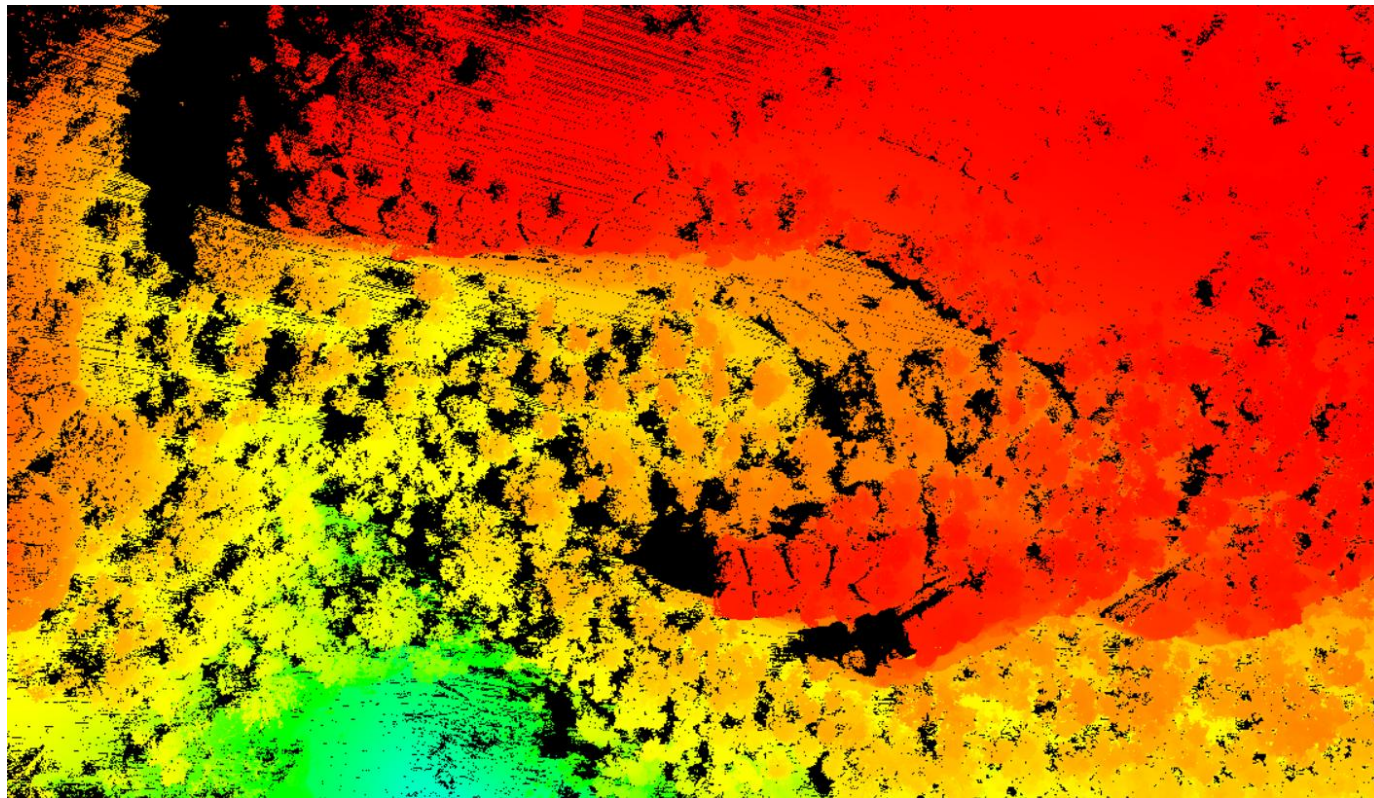
The new VQ-680: measurement principle

tr top view

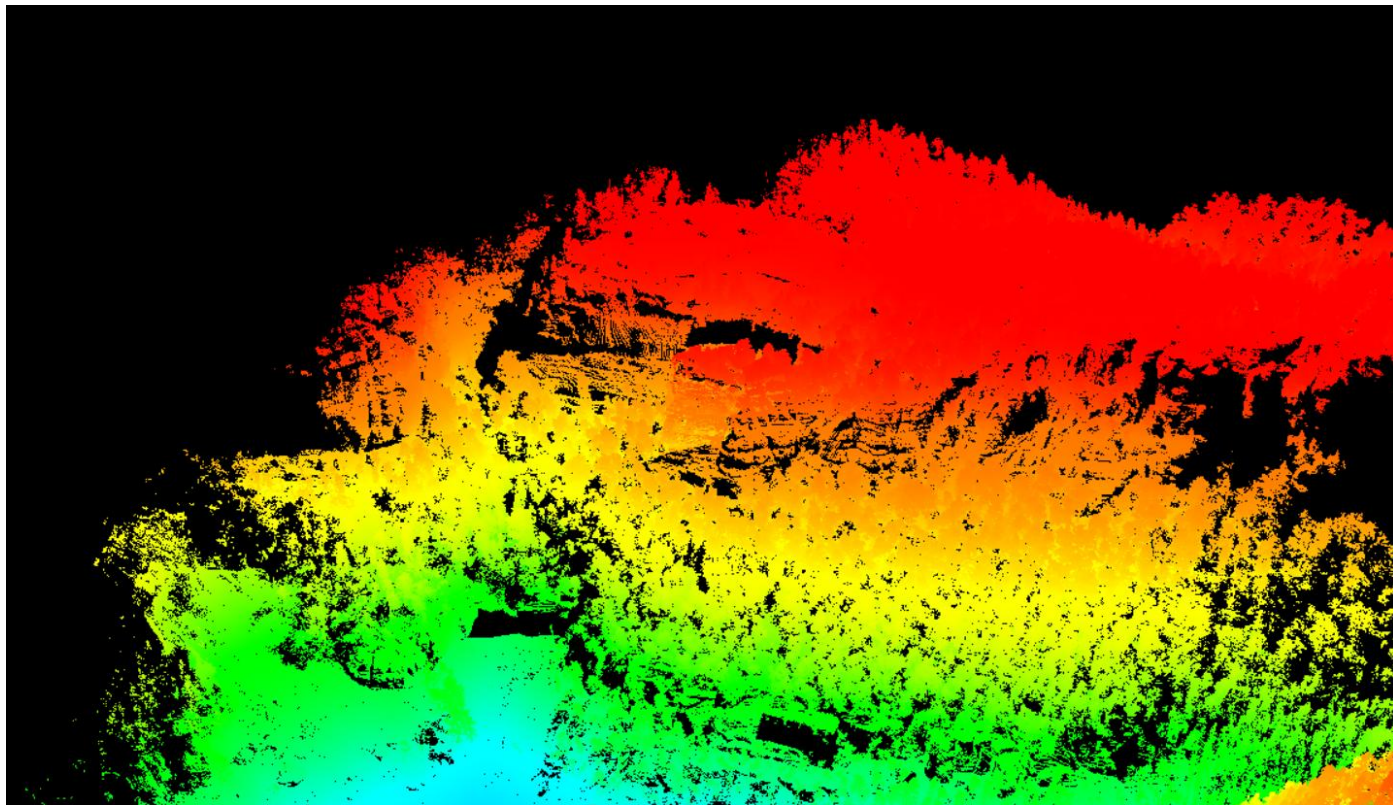
side view



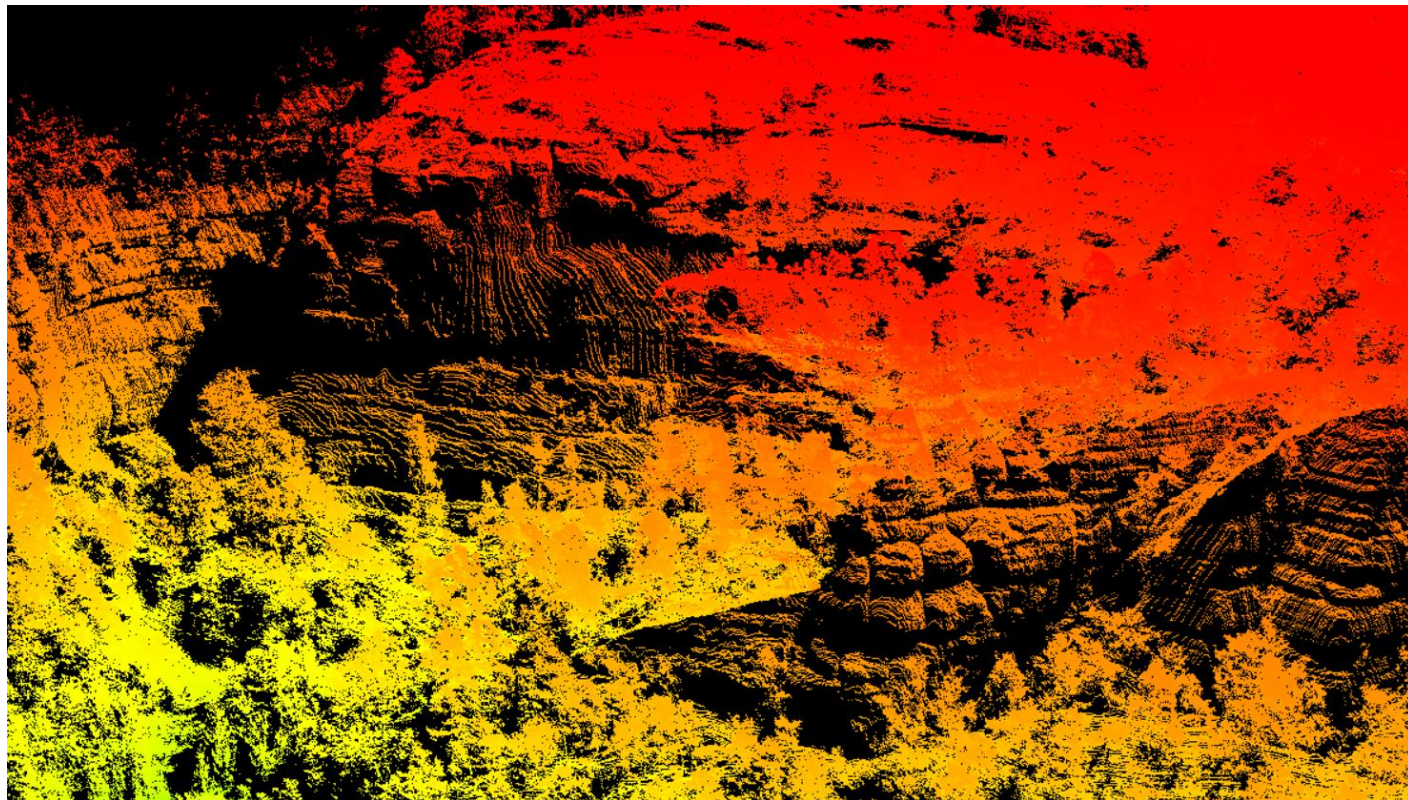
Data sample



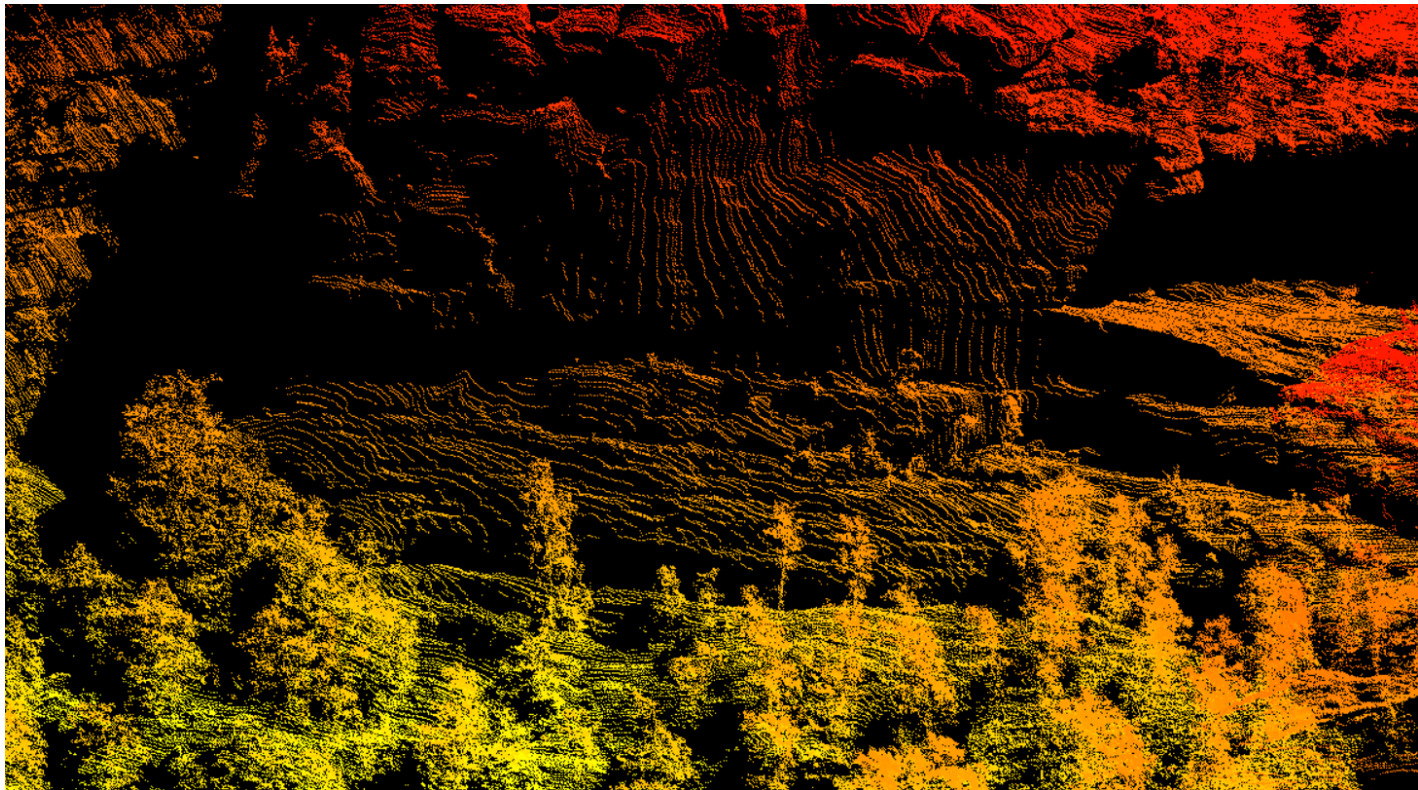
Data sample



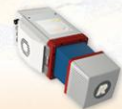
Data sample



Data sample



RIEGL UAV-based Laser Scanning – Product Overview



1.6 kg
360° FOV
100 / 200 kHz
eff. pulse rate

*extremely
lightweight*



3.5 kg
360° FOV
1.2 / 1.5 MHz
eff. pulse rate

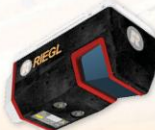
*powerful sensor
for various
applications
in wide area
UAV surveying*

NEW



2.3 kg
160° FOV
1.33 MHz
eff. pulse rate
scan speed
up to 200 lines/sec

*large FOV
and lightweight;
suited for
complex areas
and flexible
use*



2.3 kg
100° FOV
2 MHz
eff. pulse rate

*NFB
(Nadir/Forward/
Backward)
Scanning
for an optimal
coverage of
complex and
vertical targets*



2.6 kg
100° FOV
2 MHz
eff. pulse rate

*fully integrated
IMU/GNSS
system*

*NFB
(Nadir/Forward/
Backward)
Scanning
for an optimal
coverage of
complex and
vertical targets*

2.7 kg
75° FOV
2 MHz
eff. pulse rate

*fully integrated
IMU/GNSS
system*

*scan speed up
to 800 lines/sec,
resulting in an
optimal line and
point distribution;
perfectly suited
for use on high-
speed UAVs*



4.3 kg
75° FOV
2 MHz
eff. pulse rate

*operating
flight altitude
up to 1,430 m
(4,700 ft)
@ 60%
target reflectivity*

*versatile scanner
for use on
high-speed UAVs,
helicopters or
small manned
aeroplanes*

minMUX-1 UAV, /-3UAV

VUX-1 UAV²² /-LR²²

NEW VUX-100²⁵

VUX-120²³

VUX-160²³ / VUX-180²⁴

VUX-240²⁴

for applications using low-flying small or mid-sized multi-rotor UAVs
e.g. mining, topography, forestry, landslide and avalanche monitoring

for applications using fixed-wing UAVs
e.g. corridor mapping, city modeling

for applications using higher-flying large UAVs or helicopters
e.g. mapping with the need of detailed high-resolution data



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Performance Comparison

	NEW VUX-100 ²⁵ 	VUX-120 ²³ 	VUX-160 ²³	VUX-180 ²⁴
PRR (max). / eff. meas. rate	1.5 MHz / 1,333,000 pts/sec.	2.4 MHz / 2,000,000 pts/sec.	2.4 MHz / 2,000,000 pts/sec.	2.4 MHz / 2,000,000 pts/sec.
accuracy / precision	10 mm / 5 mm	10 mm / 5 mm	10 mm / 5 mm	10 mm / 5 mm
FoV (scan pattern)	160°	100° (NFB)	100° (NFB)	75°
lines per sec.	200 lps	400 lps	400 lps	800 lps
max. measuring range (20%)	510 m @ 500 kHz	760 m @ 150 kHz	980 m @ 300 kHz	810 m @ 300 kHz
max. measuring range (80%)	980 m @ 500 kHz	1430 m @ 150 kHz	1800 m @ 300 kHz	1520 m @ 300 kHz
laser class	class 1	class 1	class 1	class 3R (practically eye-safe)
weight	2.30 kg	2.65 kg	2.65 kg	2.7 kg



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RIEGL RiLOC-F

Location and Orientation Component

- Specifications
 - high-precision MEMS-based IMU
 - multi-constellations (GPS, GLONASS, Galileo, BeiDou) & up to triple-frequency
 - IMU sampling rate: > 700 Hz
 - IMU angular rate range: $\pm 300^\circ/\text{s}$
 - performance, position: **0.02 – 0.03 m**
 - RiLOC-F weight: **0.36 kg / 0.8 lbs**
- Highlights
 - ✓ fully integrated IMU/GNSS system
 - ✓ full RIEGL hardware integration
 - ✓ fully supported by the RIEGL software workflow

*RIEGL's IMU/GNSS solution for
VUX-series laser scanners*





RIEGL VUX-120 with RiLOC-F



Substation, power lines

- few buildings, transformers
- meandering flight pattern and
- “stitch flight” along power line





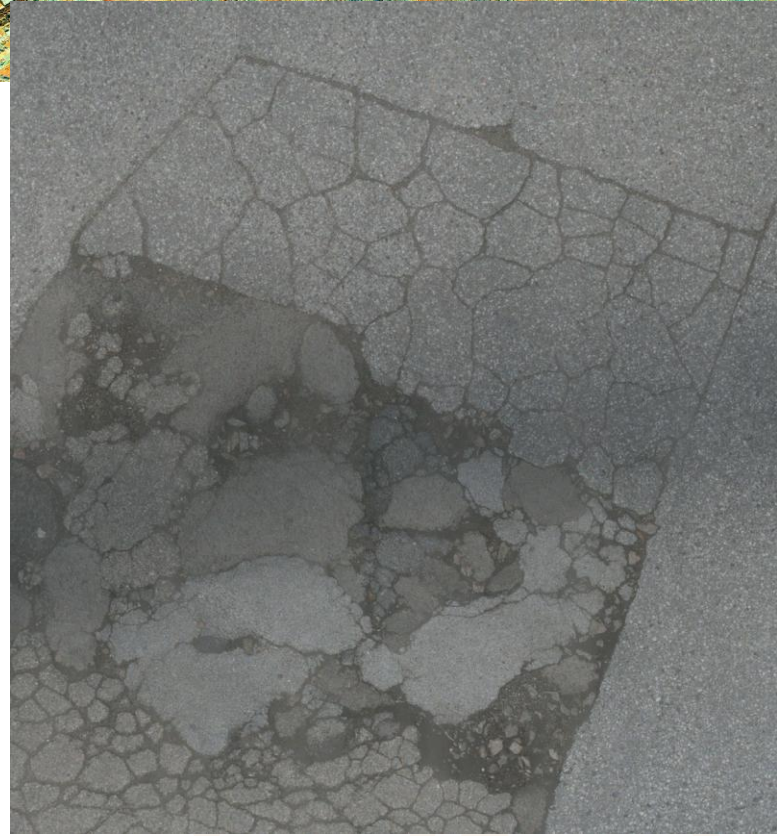
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VMY-1	VMY-2	VMQ-1HA	VMX-2HA
 150 scan lines/sec 300 kHz eff. meas. rate up to 4 cameras including spherical camera <i>typ. point density 550 points/m² on pavement surface @ 80 km/h</i>	 300 scan lines/sec 600 kHz eff. meas. rate up to 4 cameras including spherical camera <i>typ. point density 1,100 points/m² on pavement surface @ 80 km/h</i>	 250 scan lines/sec 1.8 MHz eff. meas. rate up to 4 cameras including spherical camera multiple swivel positions for improved scan pattern in multi- pass applications <i>typ. point density 3,200 points/m² on pavement surface @ 80 km/h</i>	 500 scan lines/sec 3.6 MHz eff. meas. rate up to 9 cameras including spherical camera and up to 2 high- speed pavement cameras simultaneous capturing of spherical and directional imagery with a total resolution of up to 1370 MP/sec <i>typ. point density 6,400 points/m² on pavement surface @ 80 km/h</i>

New RIEGL Photo Features

- **RIEGL 12 MP JPEG camera** is available now
- enables high enough framerates for pavement imagery



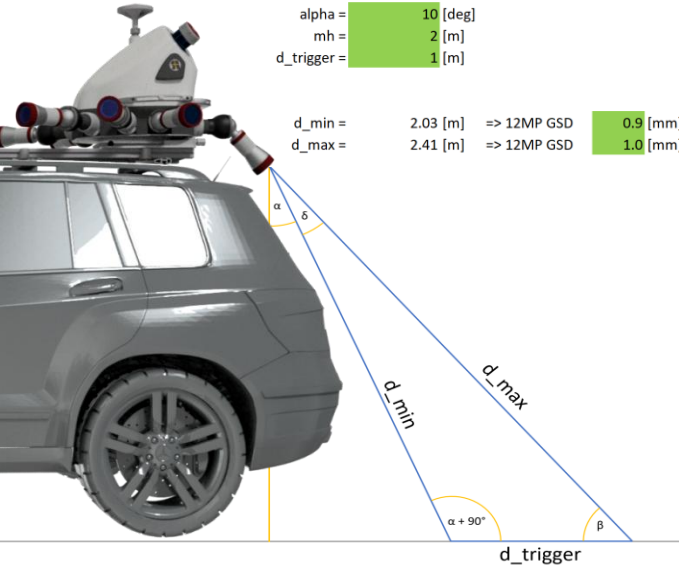
New RIEGL Photo Features

- a **RIEGL 12 MP JPEG camera** is available now
- enables high enough framerates for pavement imagery
- achieve a ground sampling distance up to 1 mm

Pixel Size $d_{x,y}$ = 3.45 [μm]
Focal Length = 8 [mm]

α = 10 [deg]
 m_h = 2 [m]
 d_{trigger} = 1 [m]

d_{min} = 2.03 [m] => 12MP GSD 0.9 [mm]
 d_{max} = 2.41 [m] => 12MP GSD 1.0 [mm]



1 mm rastered true-orthophoto captured with 2 x 12 MP dual pavement camera



the control measurement shows 2 mm crack width that is clearly captured in the orthophoto

RiPROCESS – AI point classifier

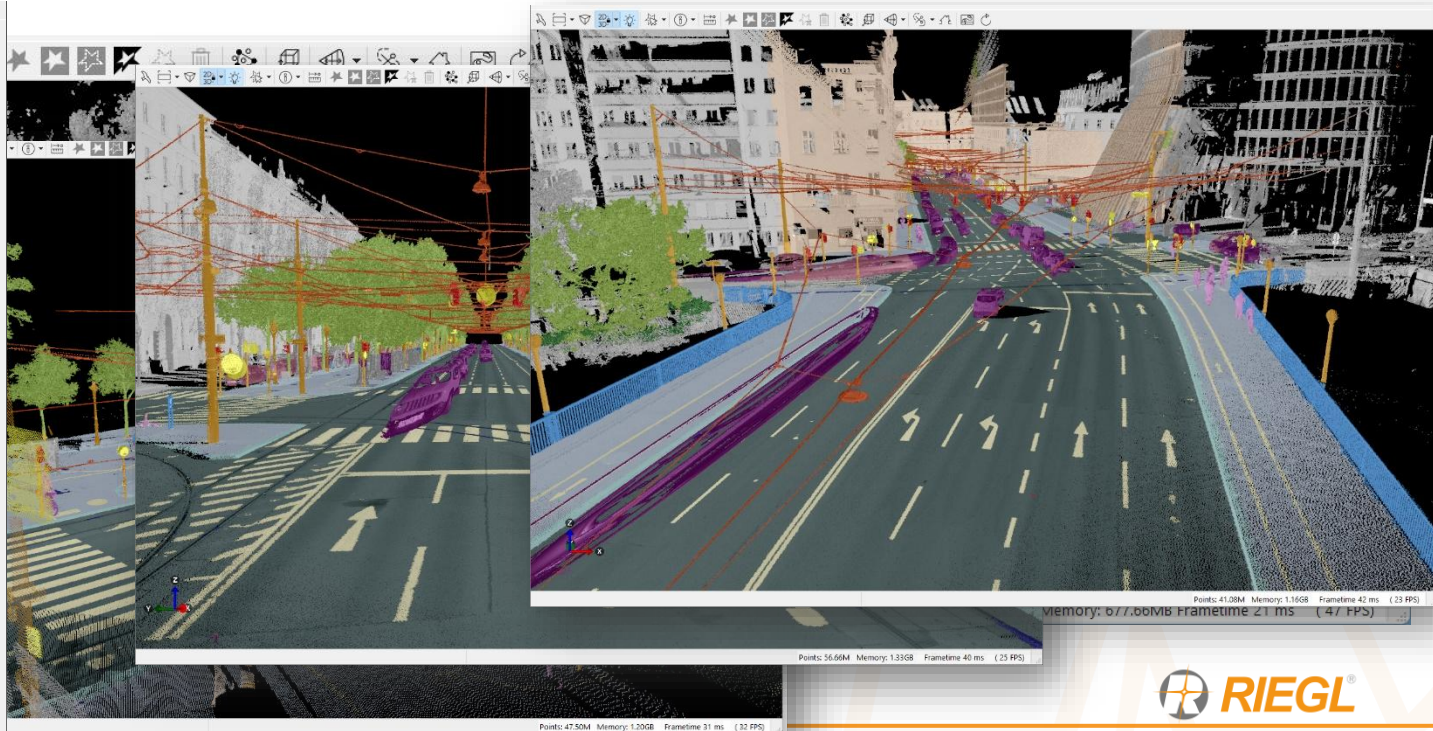
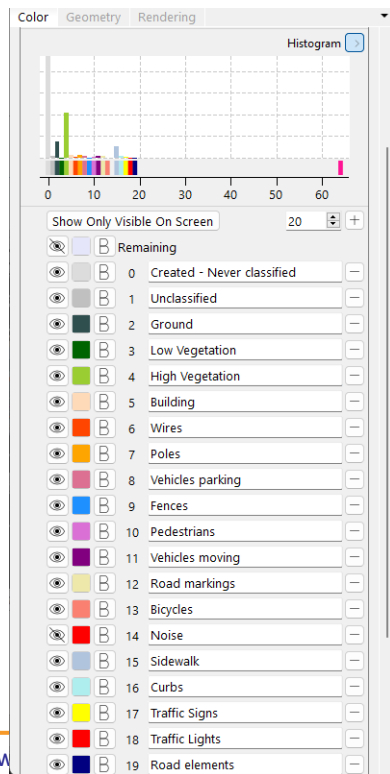
- deep learning based **mobile mapping point cloud classification**
- the classified objects are handled as a **point cloud attribute**
- the training was focused on “**road applications**” in **urban environment**
- not yet specifically trained for “rail applications”
- the semantic point cloud segmentation will provide **enhanced filter capabilities**, e.g. to
 - clean car noise
 - clean pedestrians

0	B	1	Others (unclassified)
1	B	2	Ground
2	B	3	Low Vegetation
3	B	5	High Vegetation
4	B	6	Building
5	B	68	Parking car
6	B	69	Moving car
7	B	70	Fence
8	B	71	Pedestrian & Bike
9	B	72	Wire
10	B	73	Pole
11	B	74	Traffic sign
12	B	75	Traffic light
13	B	76	Drive way
14	B	77	Side walk
15	B	78	Curbstone
16	B	79	Road mark
17	B	80	Road element



Two step Deep Learning classification tool

1. Classification into base classes: ground, vegetation, buildings, wire, poles, traffic signs & lights, vehicles, fences and pedestrians
2. Ground points subsequently subdivided into additional classes: driving & non-driving way, curbstone, road markings and road elements (eg. sewers, manholes,...)









Terrestrial laser scanners

Hardware

RIEGL VZ-i Series

*ultra high-performance 3D terrestrial laser scanning systems
with innovative new processing architecture & connectivity*

- RIEGL Waveform-LiDAR technology
- automatic registration during data acquisition
- simultaneous image and scan data acquisition
- cloud connectivity via LAN, Wi-Fi and LTE 4G/3G
- remote control via app
- customizable workflows
- rugged design, fast set-up, user-friendly touch screen
- optional camera, various built-in sensors
- fully compatible with the RIEGL VMZ hybrid mobile mapping system

RIEGL VZ-400i / VZ-2000i

- range up to 800 m / 2,500 m
- accuracy 5 mm / precision 3 mm

RIEGL VZ-Series

3D terrestrial laser scanners for very long ranges

RIEGL VZ-4000

- range up to 4,000 m, accuracy 15 mm
- up to 222,000 meas./sec
- 300 kHz laser pulse repetition rate

RIEGL VZ-6000

- range up to 6,000 m, accuracy 15 mm
- up to 222,000 meas./sec
- 300 kHz laser pulse repetition rate



RIEGL VZ-600i

“The *RIEGL VZ-600i* is **one of the fastest TLS scanners** in the market”

- > fast data collection
- > fast data transfer (CFexpress card)
- > fast data processing (One Touch Processing Wizard)

- projects -> large **surveying companies** (Railway, BIM,...)
- fast data collection -> top **construction companies**
- wide range of features -> **universities**
- etc.



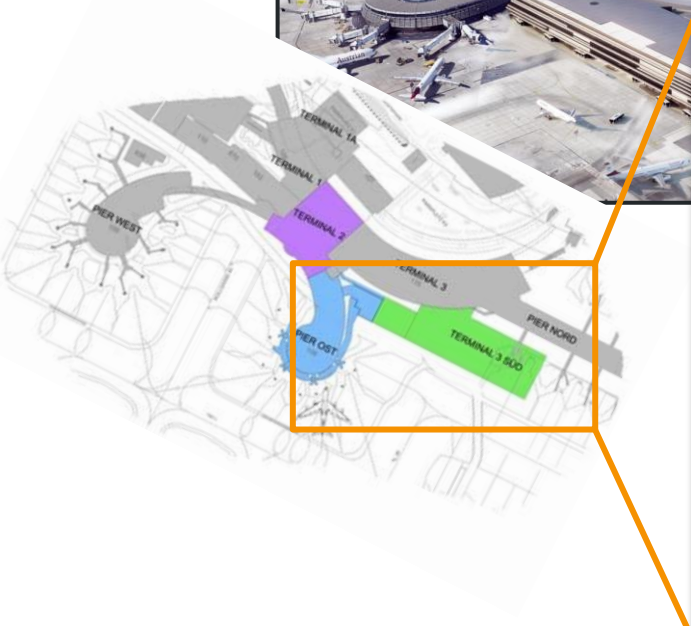
RIEGL VZ-600i



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Construction site – Vienna Airport



Construction site – Vienna Airport

automatic registration



data acquisition	RIEGL VZ-600i laser scanner
date	August 2024
time	9:24 – 15:41 (6:17) 9:34 – 16:13 (6:39)
scan positions	277 + 265 = 542



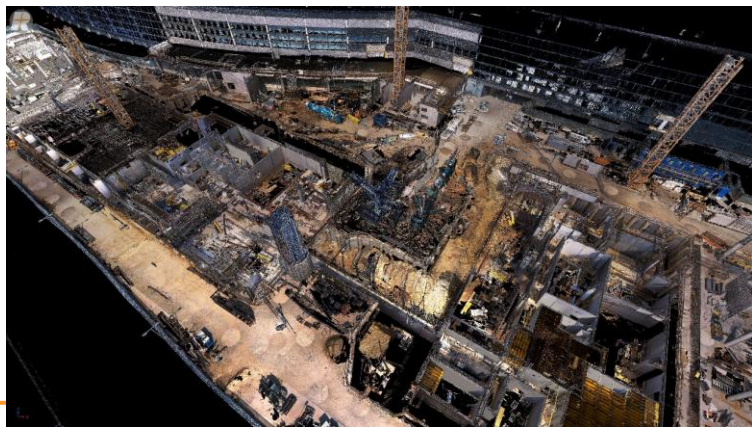
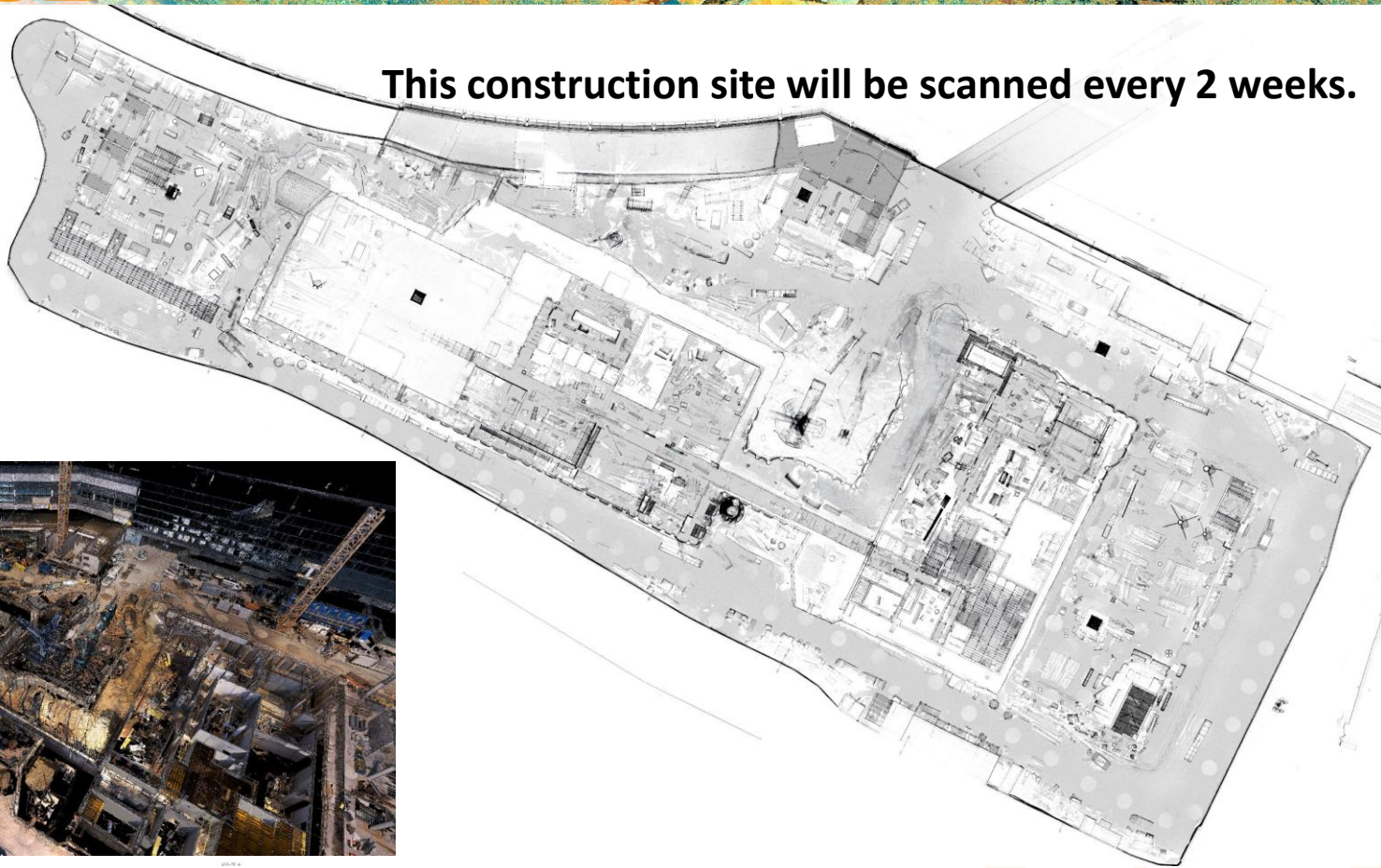
Internal cameras / panorama image



internal cameras (max. 26.471 x 7893 pixel =199 Mega-pixels)



This construction site will be scanned every 2 weeks.





RIEGL VZ-600i 3D laser scanner



point cloud

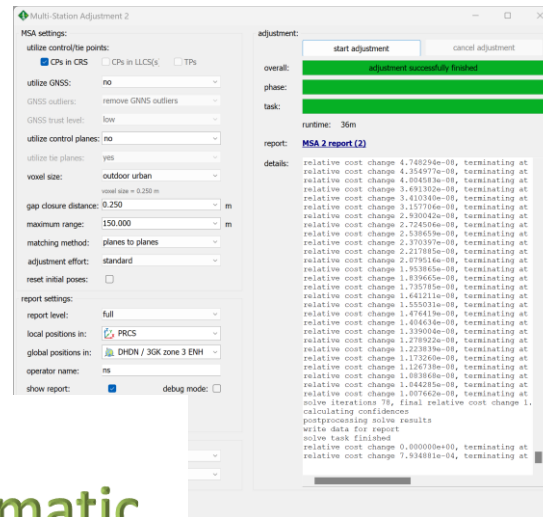


Highway bridge

Control points in CRS#2 .. **WGS84 / UTM zone 32N (EPSG::32632)**

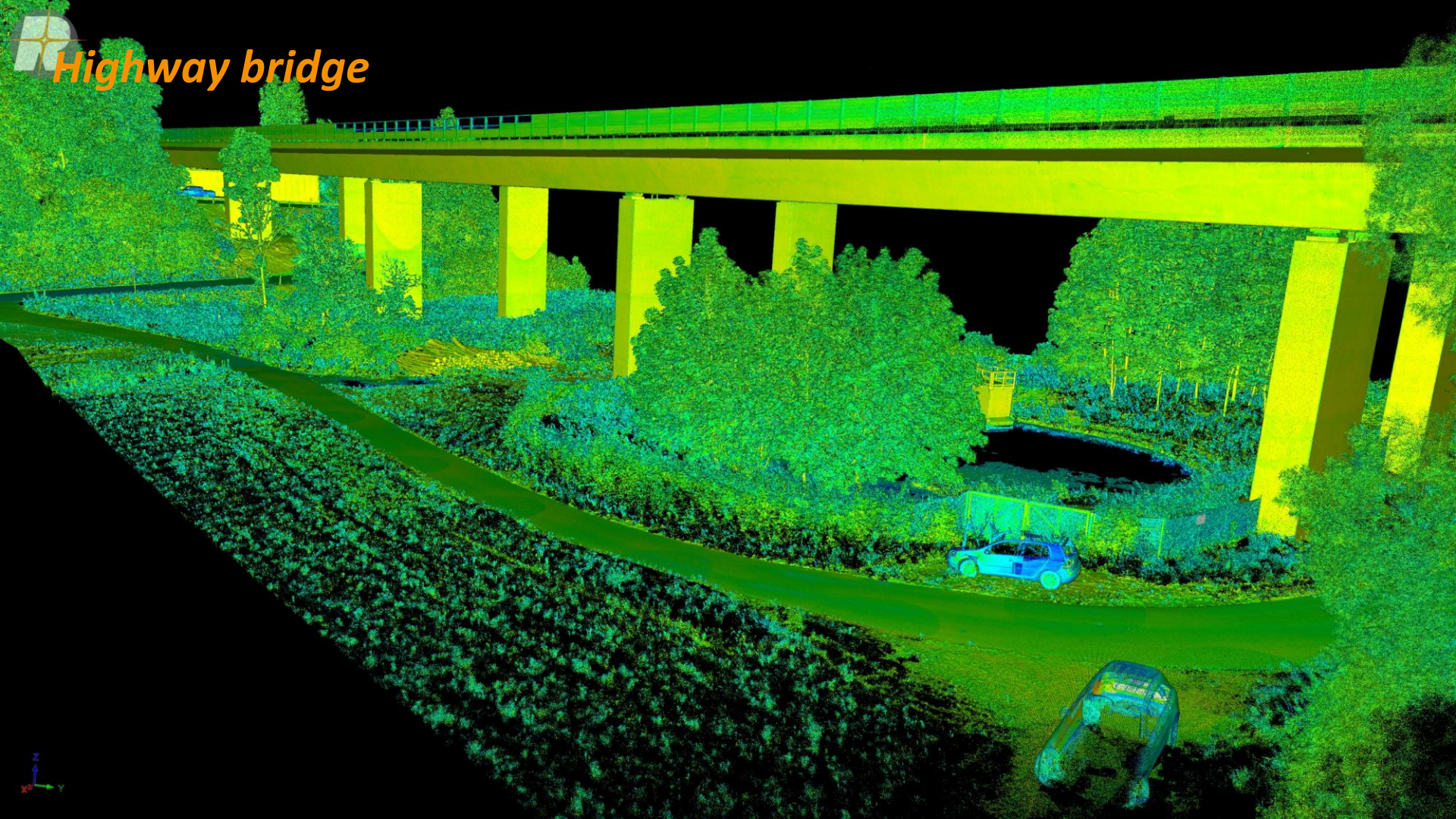
13 observations have been utilized on 13 control points in CRS. MSA results in the following statistics on the residuals:

	dX [m]	dY [m]	dZ [m]	dist. [m]
Minimum deviation	-0.0050	-0.0048	-0.0099	0.0022
Maximum deviation	0.0063	0.0080	0.0072	0.0109
Mean deviation	0.0001	0.0004	0.0007	0.0057
Standard deviation	0.0031	0.0036	0.0043	---



$\sigma < 10\text{mm}$ -> good for surveying a bridge

- Static scanning is here more suitable than kinematic



Highway bridge



Highway bridge



RIEGL kinematic acquisition Lidar Technology

- **kinematic data acquisitions for TLS**
utilizing add-on RTK GNSS receiver and internal IMU
- **tight coupling of GNSS, IMU and lidar data**
novel approach for rigorous adjustment



VZi instruments

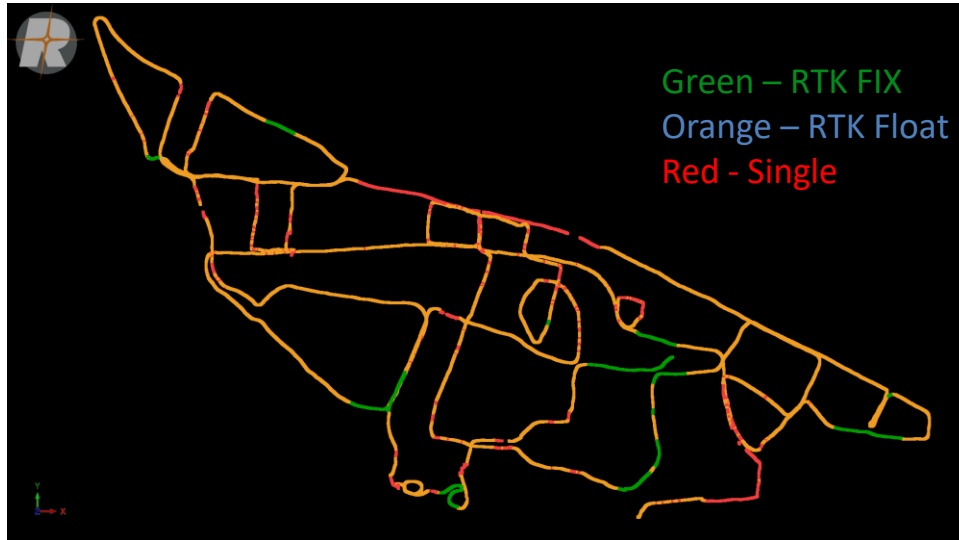




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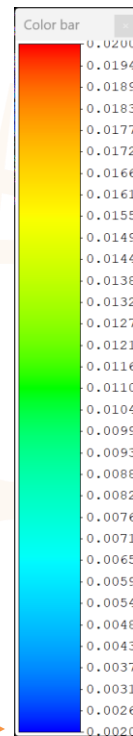
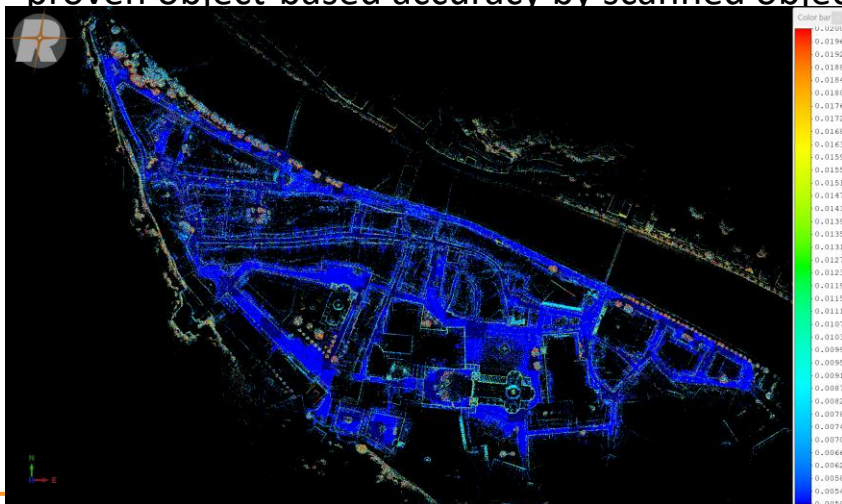
Further Improvements on VZ-i Series Kinematic App

- maximum trajectory length not any longer limited to 30min
- data acquisition under poor GNSS quality
- on start trajectory RTK fix is mandatory
- during data acquisition GNSS quality can drop temporary to RTK float or even single solution

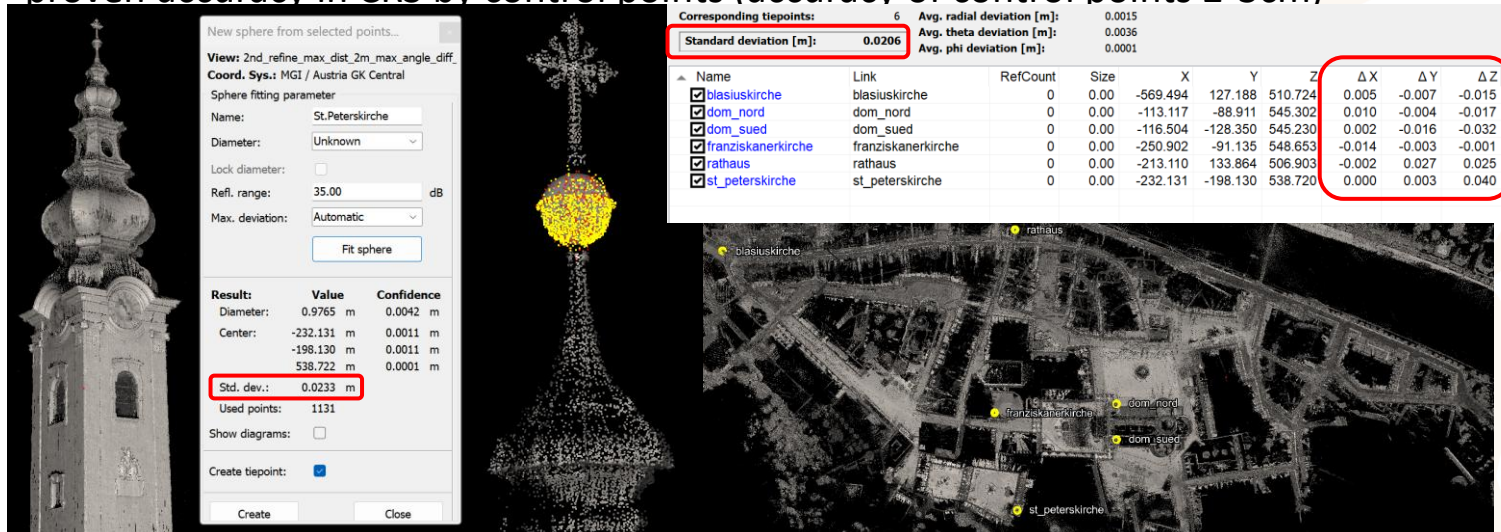


Further Improvements on VZ-i Series Kinematic App

- maximum trajectory length not any longer limited to 30min
- data acquisition under poor GNSS quality
- new refine trajectory calculation scenarios + defining of a custom scenario
- proven object-based accuracy by scanned objects via voxel dataset



- maximum trajectory length not any longer limited to 30min
- data acquisition under poor GNSS quality
- new refine trajectory calculation scenarios + defining of a custom scenario
- proven accuracy in CRS by control points (accuracy of control points 2-3cm)



new functions:

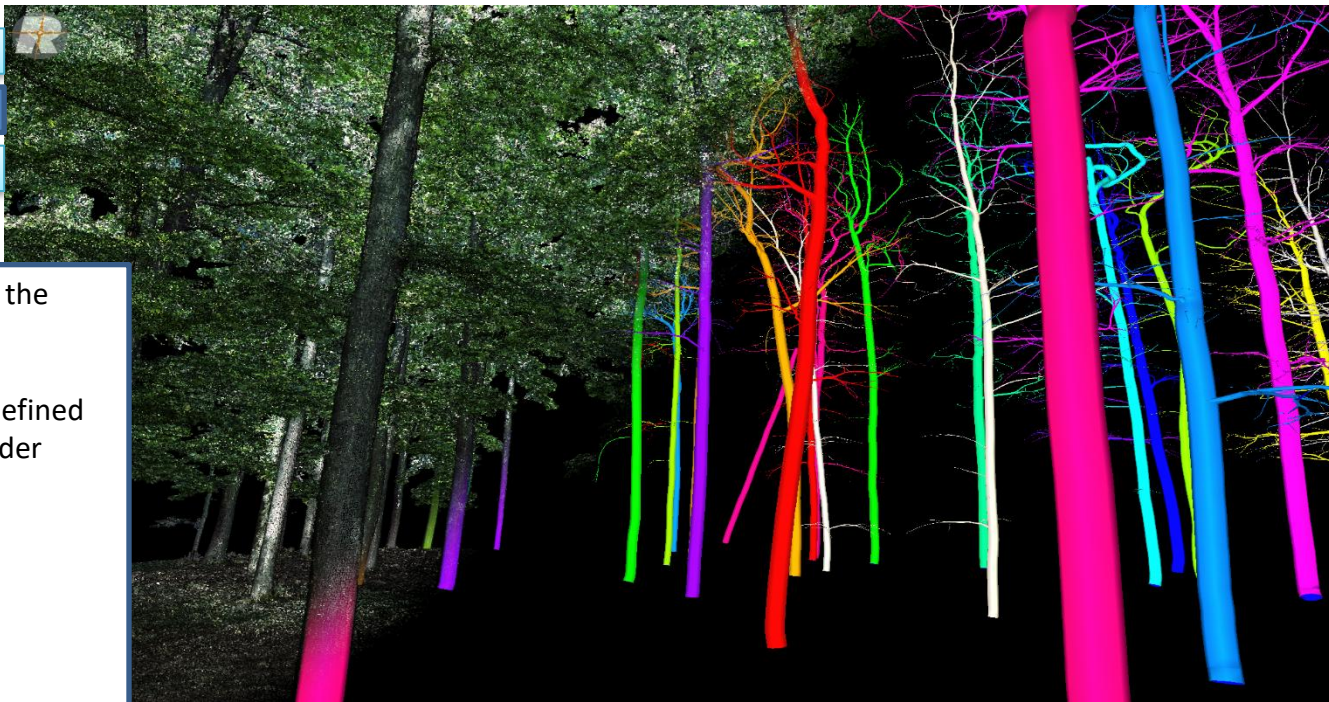
Edit tree segmentation

Volume calculation

Crown plot

Fitting cylinder segments to the segmented point cloud.

Stem volume in three user defined categories according to cylinder diameters.



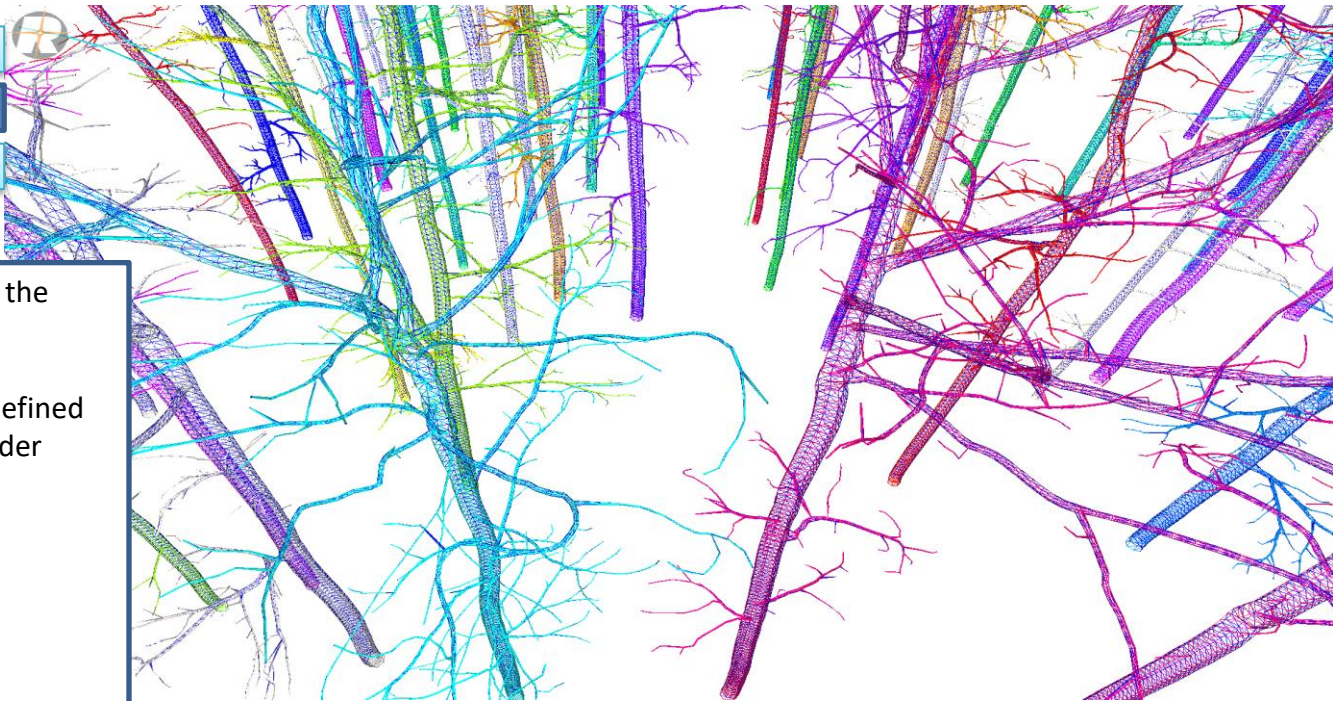
Edit tree segmentation

Volume calculation

Crown plot

Fitting cylinder segments to the segmented point cloud.

Stem volume in three user defined categories according to cylinder diameters.



Edit tree segmentation

Volume calculation

Crown plot

Crown coverage area by projecting tree point cloud onto the ground.

Crown coverage area is visualized in a **tree crown plot**.

RISCAN PRO 2.20 RIC4 - [Object view: 1cm new (1920 x 1200)]

Project Edit View Tool Registration Window Help ?

Project manager

1cm new_tree_9

1cm new_tree_30

1cm new_tree_31

1cm new_tree_92

1cm new_tree_93

1cm new_tree_94

1cm new_tree_95

1cm new_tree_96

1cm new_tree_97

1cm new_tree_98

1cm new_tree_99

PLANEFILES

VOXELFILES

rest 0.005 m

rest 0.005 m_stems

shes

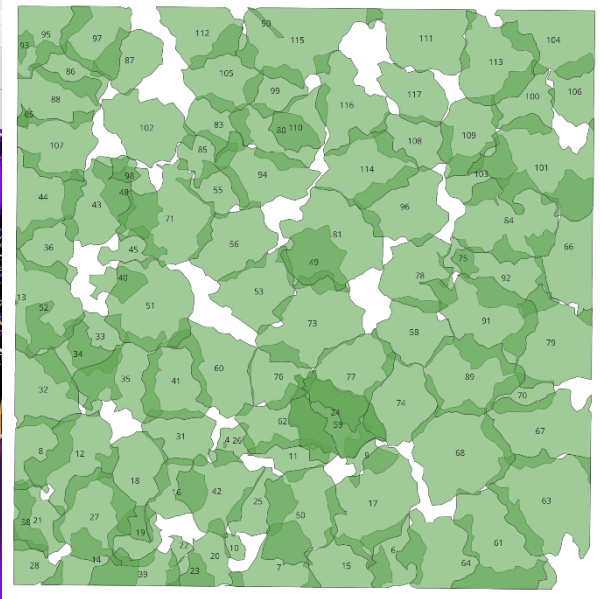
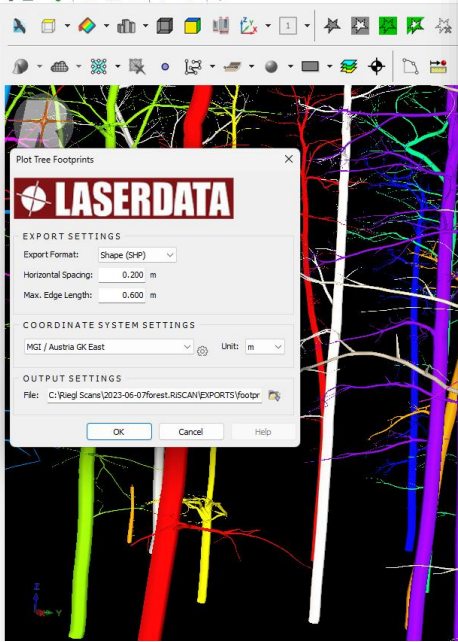
ms

inches

IMAGES

AGES

new available)



VMR 1- robot



RIEGL® Qbitec for Revit

Qbitec for Revit is a plugin for Autodesk Revit that makes loading and interacting with reality capture data more efficient and time-saving efficient

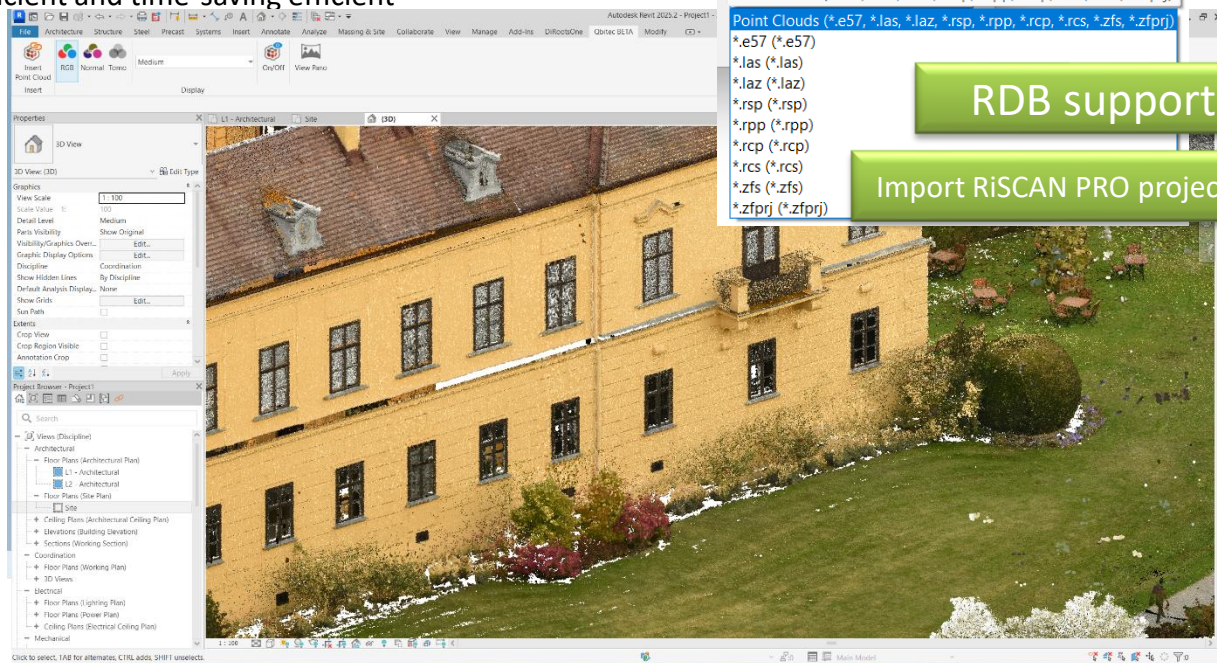
Local or cloud storage



Pointclouds &
panorama images



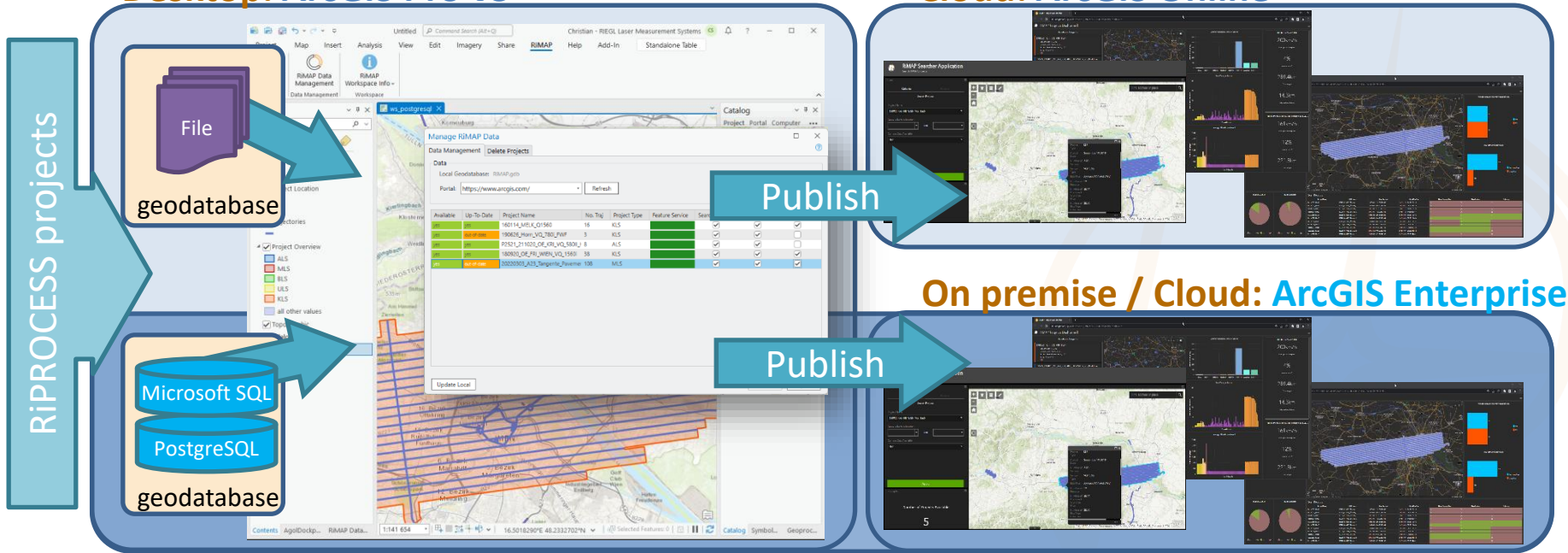
BIM Model



RiMAP is an Add-In to ESRI's ArcGIS Pro desktop GIS software.

Desktop: ArcGIS Pro v3

Cloud: ArcGIS Online



Cooperation and Distribution of Phase One cameras



CAMERAS
iXM-100



CAMERAS
iXM-GS120



CAMERAS
iXM-RS150F



CAMERAS
iXM-RS280F



CAMERAS
4-Band



LENSES
Lenses for iXM-RS

Cooperation and Distribution of Phase One cameras



PAS 150



PAS 280



PAS 880



PAS Pana

Cameras				
	Nadir 150MP RGB camera with a variety of lens options	Nadir 280MP RGB camera with a 90 mm lens	Nadir 280MP RGB camera with a 90 mm lens	Nadir 5x 150MP RGB camera with a 150 mm lens
	150MP NIR camera (optional)	150MP NIR camera with a 50 mm lens	150MP NIR camera with a 50 mm lens	2x 150MP NIR camera with a 70 mm lens
			Oblique 4x 150MP RGB cameras with 150 mm lenses	

Headwall hyperspectral

Nano HP[™]

Compact VNIR Hyperspectral Imaging
System for Remote-Sensing



Co-Aligned HP[™]

Compact VNIR-SWIR Hyperspectral
Imaging System for Remote Sensing





RIEGL®

Video

***RIEGL VQX-1 compact and
aerodynamically shaped wing pod***



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Innovation in 3D



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