Advances in Mobile Laser Scanning Data Acquisition

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Airborne Scanning
Mobile Scanning
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VQ-250 on the boat
VZ-400 & VQ250 on the train
VZ-400 & VQ-250 on the car
RIEGL VMX-250
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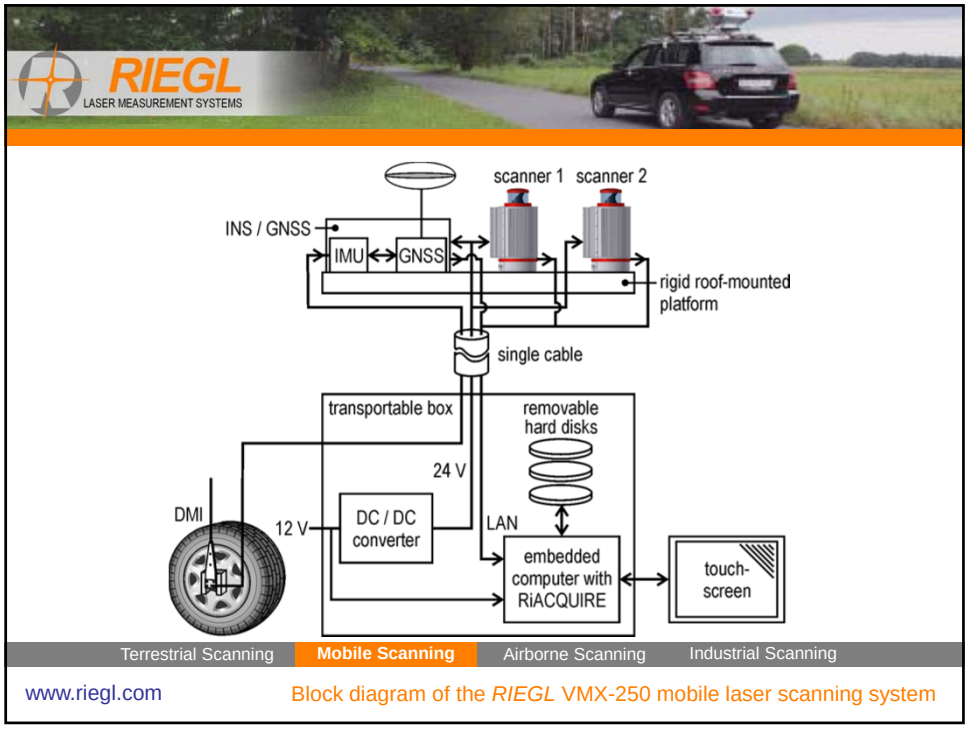
RIEGL Mobile Laser Scanning Systems



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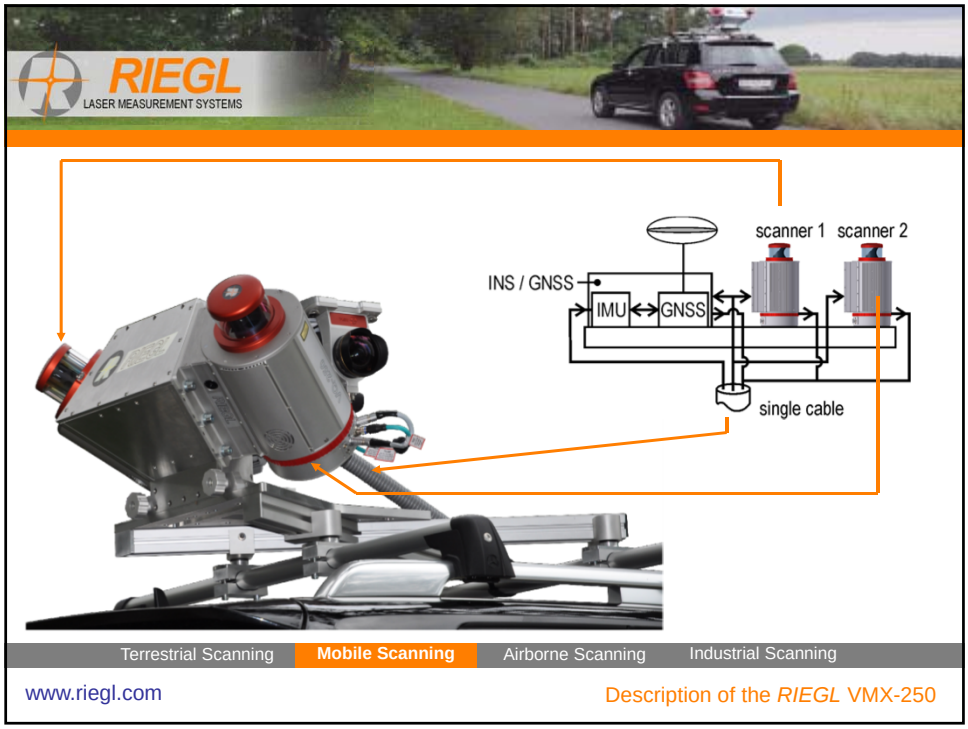
Block diagram of the *RIEGL* VMX-250 mobile laser scanning system



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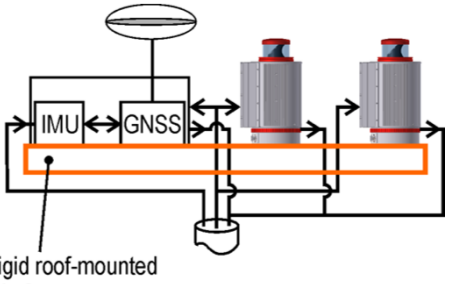
Description of the *RIEGL* VMX-250



rigid roof-mounted platform

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Description of the *RIEGL* VMX-250

DMI – distance measuring indicator

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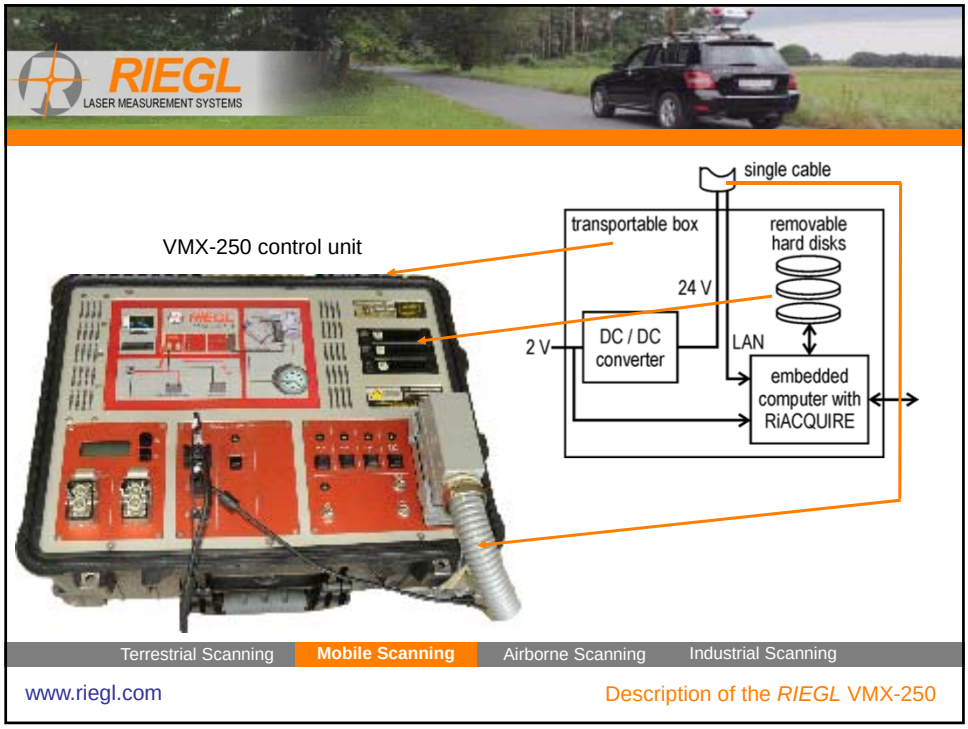
Description of the *RIEGL* VMX-250


RIEGL
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VMX-250 control unit
single cable
transportable box
removable hard disks
24 V
2 V
DC / DC converter
LAN
embedded computer with RiACQUIRE
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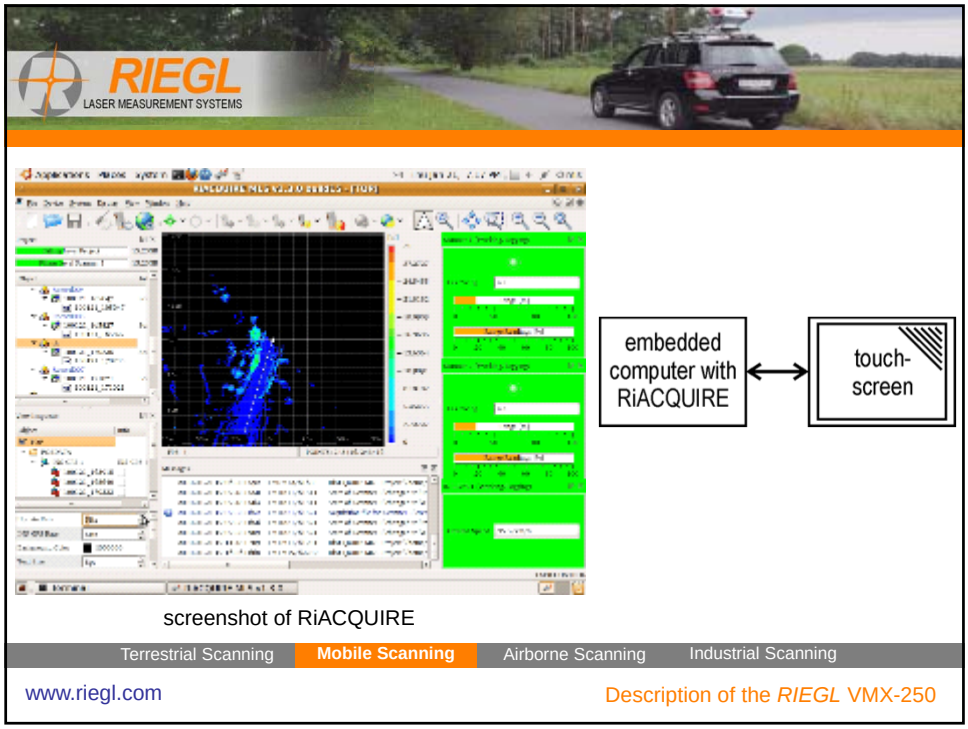
Description of the RIEGL VMX-250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embedded computer with RiACQUIRE
touch-screen
screenshot of RiACQUIRE
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Description of the RIEGL VMX-250

RIEGL VMX-250 in operation

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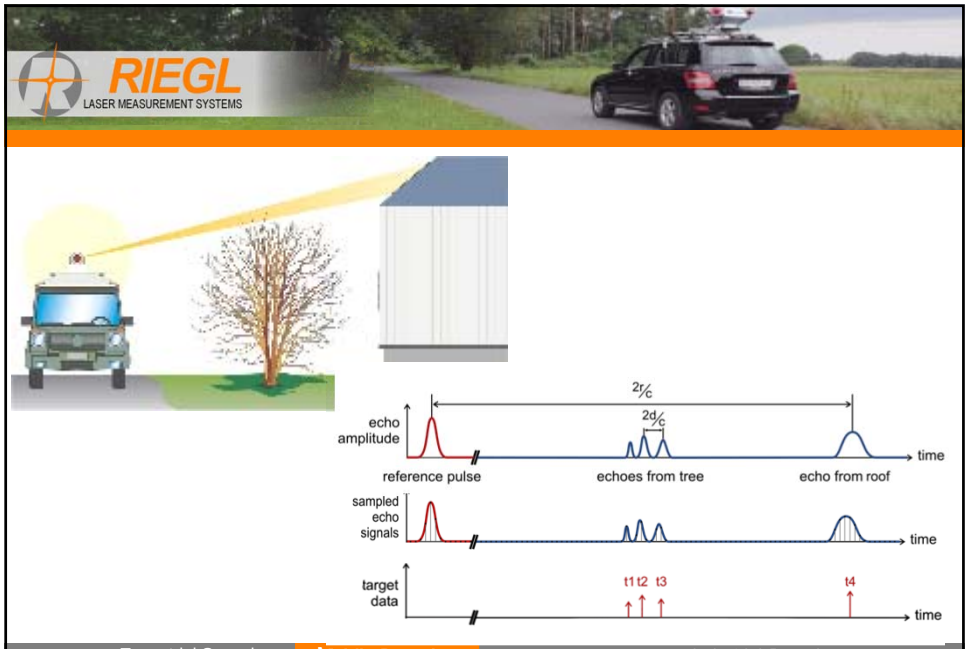
RIEGL VMX-250 mobile laser scanning system



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Echo digitization

2D laser scanner *RIEGL* VQ-250

pulsed “time-of-flight” range measurement
+
echo digitization
+
online waveform analysis

- high maximum range / even to poorly reflecting targets
- multi-target point cloud
- high measurement rate
- high accuracy
- calibrated amplitude / reflectance reading
- pulse shape analysis

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2D laser scanner *RIEGL* VQ-250

2D laser scanner *RIEGL* VQ-250

eff. measurement rate	50 to 300 kHz
max. measuring range	500 m @ $\rho \geq 80\%$ and 50 kHz 75 m @ $\rho \geq 10\%$ and 300 kHz
max. number of targets per pulse	practically unlimited
accuracy	10 mm
precision	5 mm
laser product classification	Class 1 laser product
field of view (selectable)	up to 360° „full circle“, without any gap
scan speed (selectable)	up to 100 scans/sec
weight	approx. 11 kg

Specifications of the *RIEGL* VQ-250

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Specifications of the 2D laser scanner *RIEGL* VQ-250

Mobile Laser Scanner
System *RIEGL* VMX-250

eff. measurement rate	100 to 600 kHz
max. measuring range	500 m @ ρ ≥ 80% and 100 kHz 75 m @ ρ ≥ 10% and 600 kHz
accuracy	10 mm
precision	5 mm
position (absolute)	typ. 20-50 mm
position (relative)	typ. 10 mm
roll & pitch	0.005°
heading	0.015°
weight "measuring head"	approx. 38 kg
weight "control unit"	approx. 18 kg

Specifications of the *RIEGL* VMX-250

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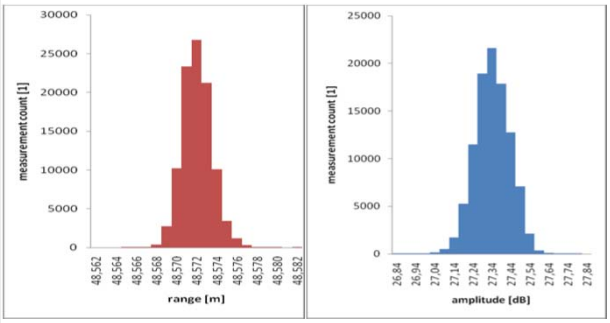
Specifications of the 2D laser scanner *RIEGL* VQ-250



absolute frequency of range and amplitude results of
100,000 consecutive measurements
on a white diffusely reflecting target at a range of about 50 m.

target	diffusely reflective
range	about 50 m
number of measurements	100,000 consecutive single measurements
σ of the range measurements	**1.5 mm**
σ of the amplitude measurements	**<0.1 dB**

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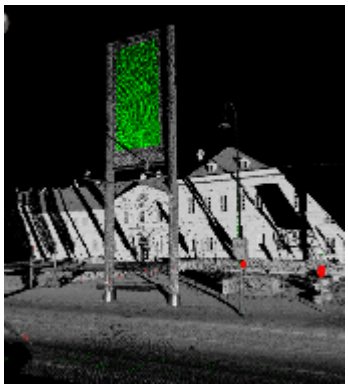
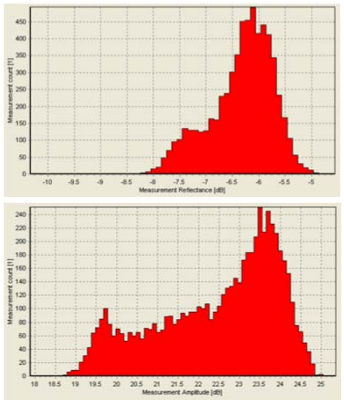
Stationary ranging performance of *RIEGL* VQ-250



point cloud from one VQ-250
with brightness according to reflectance,
green colored points are the selected ones,
red points indicate reflectance in access of +5 dB



absolute frequency of selected points
versus reflectance (upper diagram) and
amplitude of echo signal (lower diagram)

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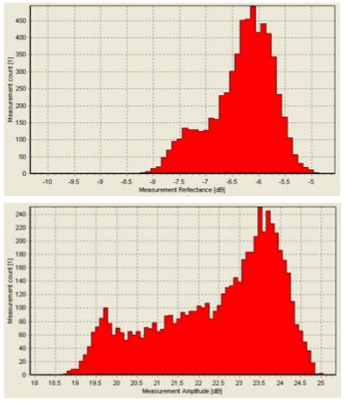
Performance of single *RIEGL* VQ-250 as part of VMX-250

target	diffusely reflective
range	about 20 m
number of measurements	6,000 single measurements
covered area	32 m²
σ of the range measurements	**1.6 mm**
σ of the reflectance	**<3 dB**



absolute frequency of selected points
versus reflectance (upper diagram) and
amplitude of echo signal (lower diagram).

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Performance of single *RIEGL* VQ-250 as part of VMX-250

RIEGL calibrates the systems amplitude reading such that the amplitude for each measurement A_{dB} is given in dB over the detection threshold for the entire dynamic range of the instrument:

$$A_{dB} = 10 \cdot \log\left(\frac{P_{echo}}{P_{DL}}\right)$$

where P_{echo} is the optical input power for the corresponding measurement
and P_{DL} is the minimum detectable input power.
Thus, signal strength ratios in dB between different targets can be obtained simply by calculating the difference between the corresponding amplitude values:

$$10 \cdot \log\left(\frac{P_{echo,1}}{P_{echo,2}}\right) = A_{dB,1} - A_{dB,2}$$

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Calibrated amplitude and reflectance reading

the "relative reflectance" is proportional to the logarithmic ratio of the target's reflectance over a perfectly white diffuse reflector

$$\rho_{rel} = A_{dB} - A_{dB,Ref}(R)$$

Reflectance is the ratio of the optical power reflected in any direction *Prefl* to the total impinging optical power P_{tot}, which may also interpreted as the relative portion of power not absorbed by the target:

$$\rho = \frac{P_{refl}}{P_{tot}} = 1 - \frac{P_{abs}}{P_{tot}}$$

The relative reflectance is the ratio of the absolute reflectance of a target to the reflectance of the target the instrument was calibrated with, i.e. a white reflectance standard with 98% reflectance.

Thus, white diffuse targets would have assigned about 0dB, black paper would give about -10dB – indifferent to the object's actual distance from the scanner.

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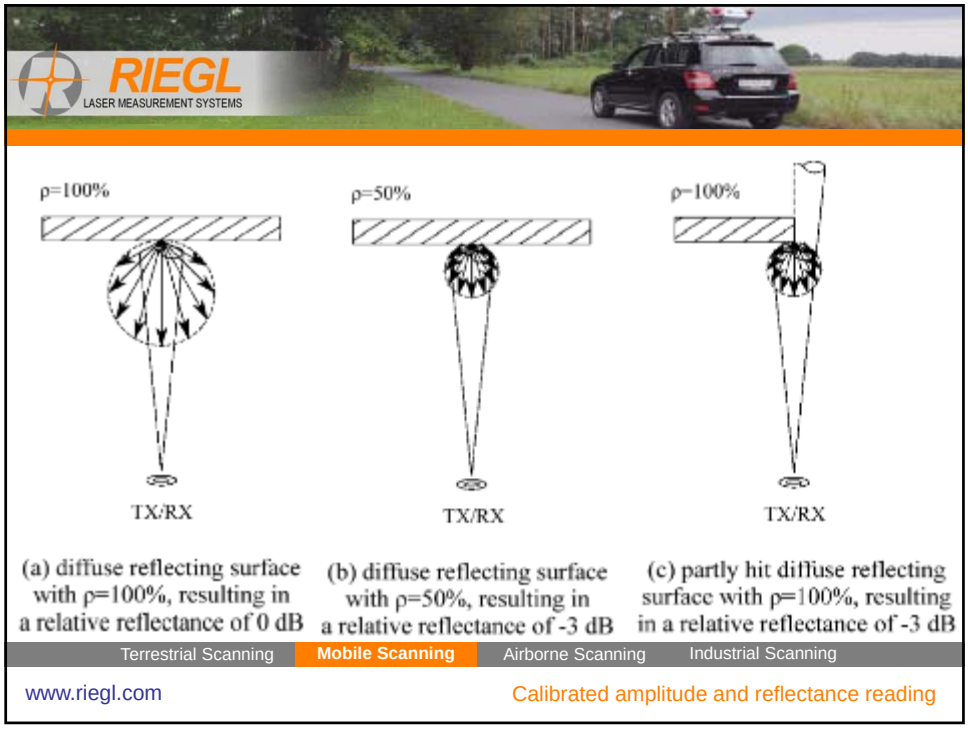
Calibrated amplitude and reflectance reading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ρ=100%
TX/RX
(a) diffuse reflecting surface with ρ=100%, resulting in a relative reflectance of 0 dB
ρ=50%
TX/RX
(b) diffuse reflecting surface with ρ=50%, resulting in a relative reflectance of -3 dB
ρ=100%
TX/RX
(c) partly hit diffuse reflecting surface with ρ=100%, resulting in a relative reflectance of -3 dB
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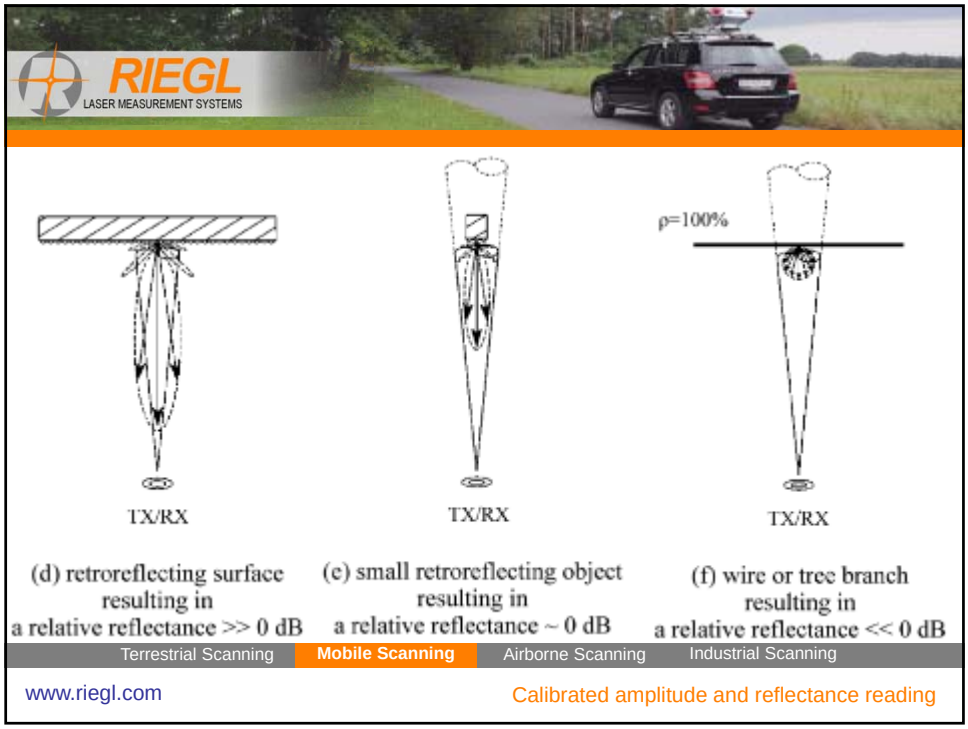
Calibrated amplitude and reflectance reading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TX/RX
(d) retroreflecting surface resulting in a relative reflectance >> 0 dB
TX/RX
(e) small retroreflecting object resulting in a relative reflectance ~ 0 dB
ρ=100%
TX/RX
(f) wire or tree branch resulting in a relative reflectance << 0 dB
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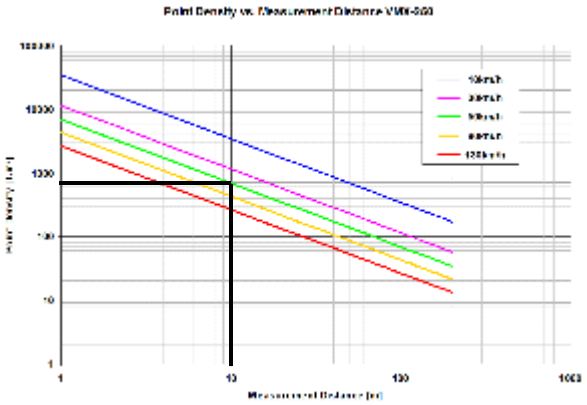
Calibrated amplitude and reflectance reading

$$D = \frac{PRR}{2\pi Rv}$$

D ..... point density [points per m²]
R..... range to target [m]
v..... speed of the vehicle [m/s]
PRR. pulse repetition rate [1/s]

Example:

PRR	600 000 1/s
R	10 m
v	50 km/h
D	690 points per m²



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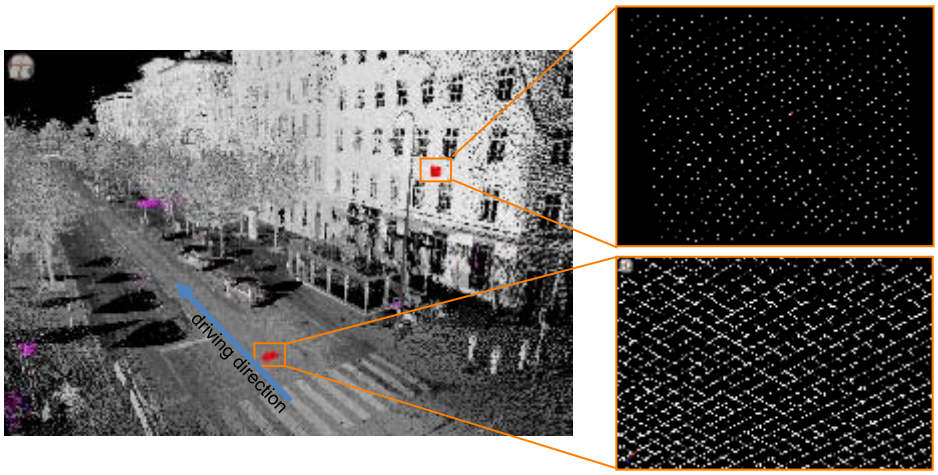
Point density



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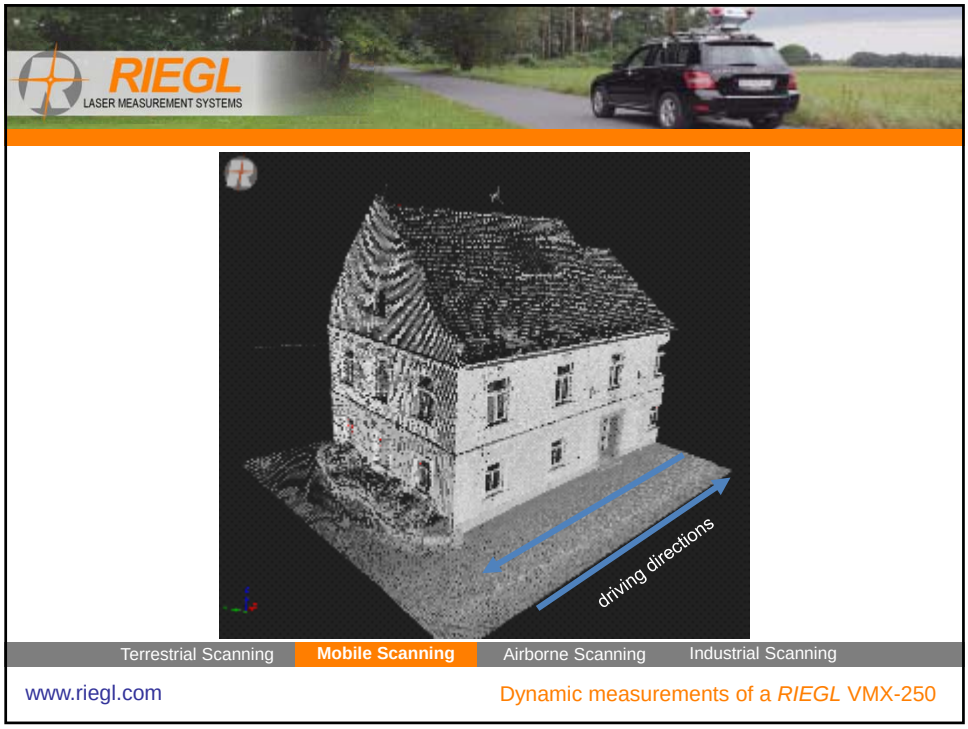
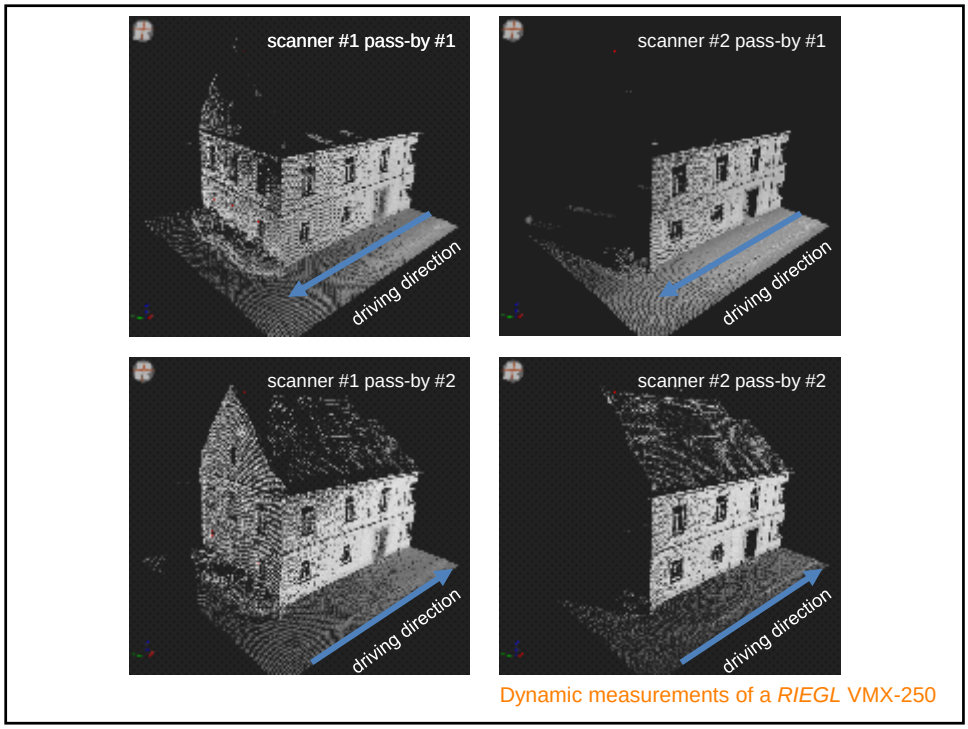
Scan pattern



Dynamic measurements of a *RIEGL* VMX-250



Dynamic measurements of a *RIEGL* VMX-250

presumably flat area on a façade
size about 2 x 2 m^2

scanner	pass-by	points	stddev
#1	#1	6490	3.4 mm
#2	#1	4114	3.2 mm
#1	#2	2983	3.1 mm
#2	#2	4288	3.3 mm
both	both	17875	3.8 mm

standard deviation
for different combinations of scanners and passes

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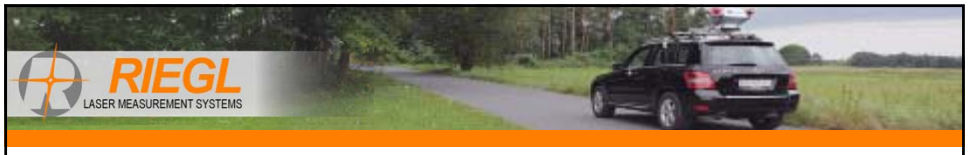
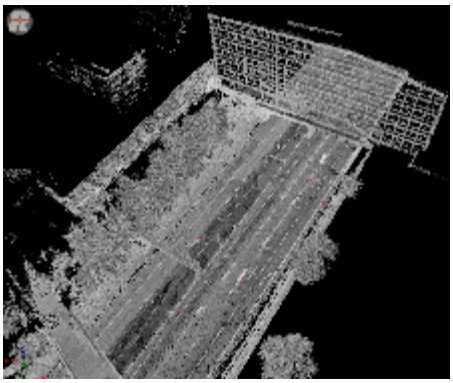
Dynamic measurements of a *RIEGL* VMX-250



data set acquired by an aerial camera
(Microsoft, 2010)



data set acquired by the *RIEGL* VMX-250
on an urban motorway

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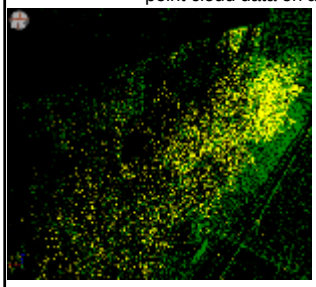
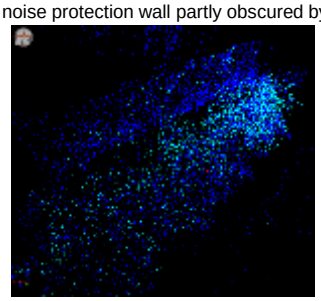
Multi-target capability

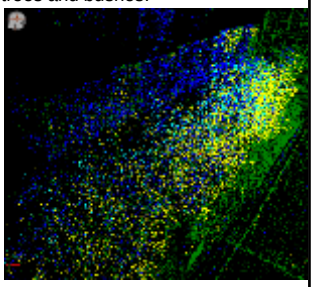
point cloud data on a noise protection wall partly obscured by trees and bushes.



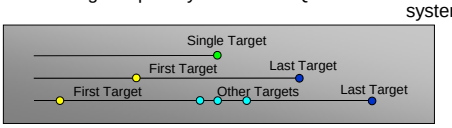
data as provided by "first target only" laser scanners



all additional data provided by multi-target capability of *RIEGL* VQ-250



all data acquired. Only the data of one passing-by of the VMX-250 system is shown.



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Multi-target capability

Thank you!

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