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Practical experiences in the creation of road parameters with RIEGL Mobile Laser Scanning Systems



Innovation in 3D

About RIEGL

RIEGL is producing LiDAR systems commercially for **more than 40 years** and focuses on **pulsed time-of-flight laser radar technology** in multiple wavelengths.

The *RIEGL* headquarters Wordwide is based in Horn and Vienna, Austria and the Headquarter North America is based in Winter Garden, Florida. To ensure a close customer relation *RIEGL* provides a worldwide distribution partner network for sales, training and support.

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Innovation in 3D

RIEGL laser scanning covers a wide field of applications

let's dive into details

VMX-2HA

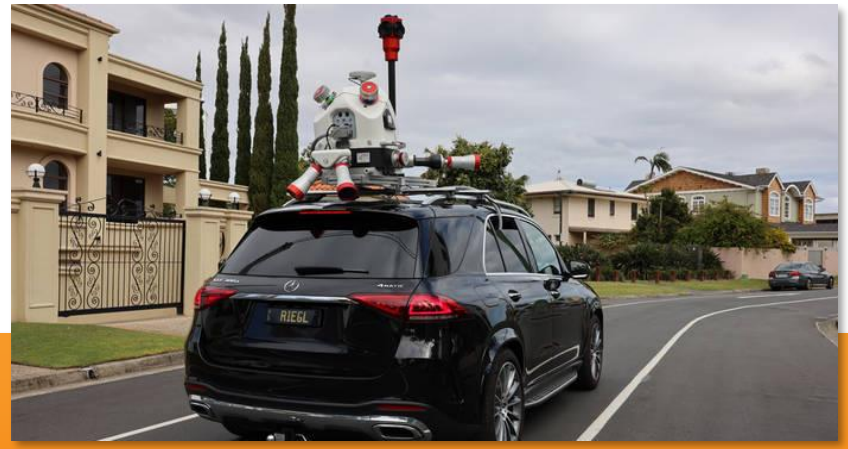
RIEGL VMX – 2HA

high-performance dual scanner mobile mapping system

- equipped with two *RIEGL* VUX-1HA laser scanners with up to
  2x 1.8 million laser measurements per second
  2x 250 profiles per second with 360 deg FOV
- 3 mm precision / 5 mm accuracy
- high-grade FOG INS/GNSS subsystem for
  high relative and high absolute georeferencing accuracy

VMX-2HA | utmost performance and flexibility

RIEGL Mobile Laser Scanning



RIEGL Mobile Mapping Systems mounted on various different platforms

VMX-2HA

RIEGL VMX – 2HA

high-performance dual scanner mobile mapping system

get the full 360 deg clearance profile in a single run

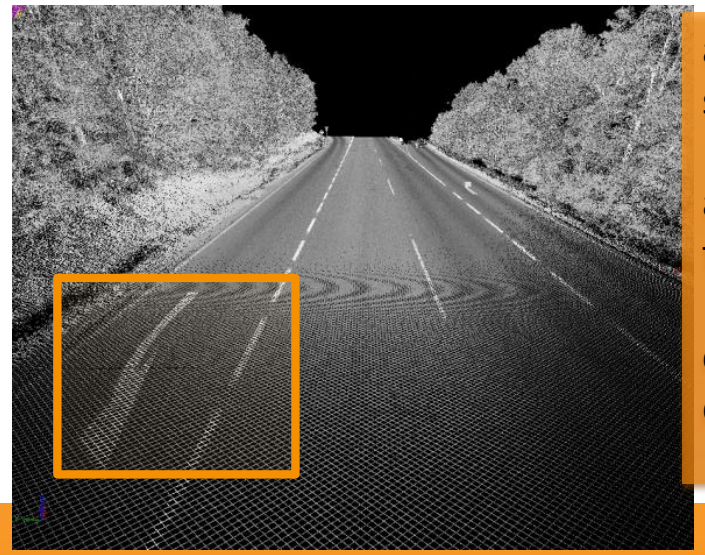
VMX-2HA

RIEGL VMX – 2HA

capture details from multiple lanes in a single run

get a high level of detail in the point cloud even for objects captured from the neighboring lane

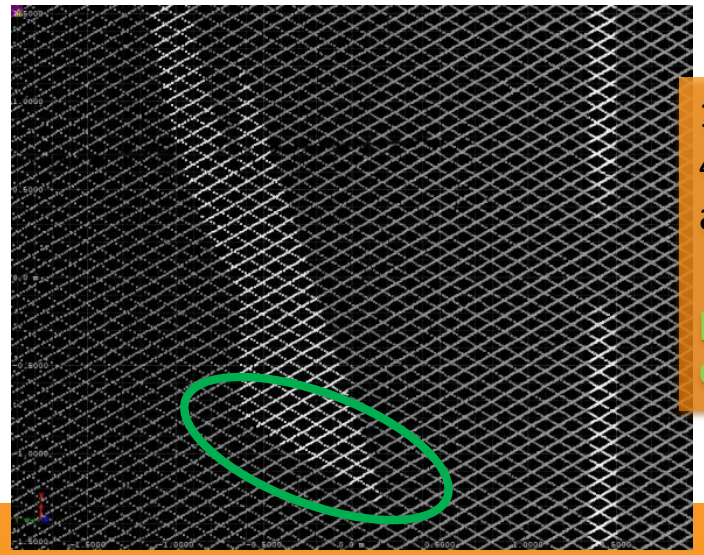
dense point cloud enables accurate and reliable feature extraction



achieve a dense, crossed scan line pattern

acquisition is not limited to single lane

capture the complete digital twin in a single run



11 cm line spacing
4.5 mm point spacing
acc, prec: 5/3mm

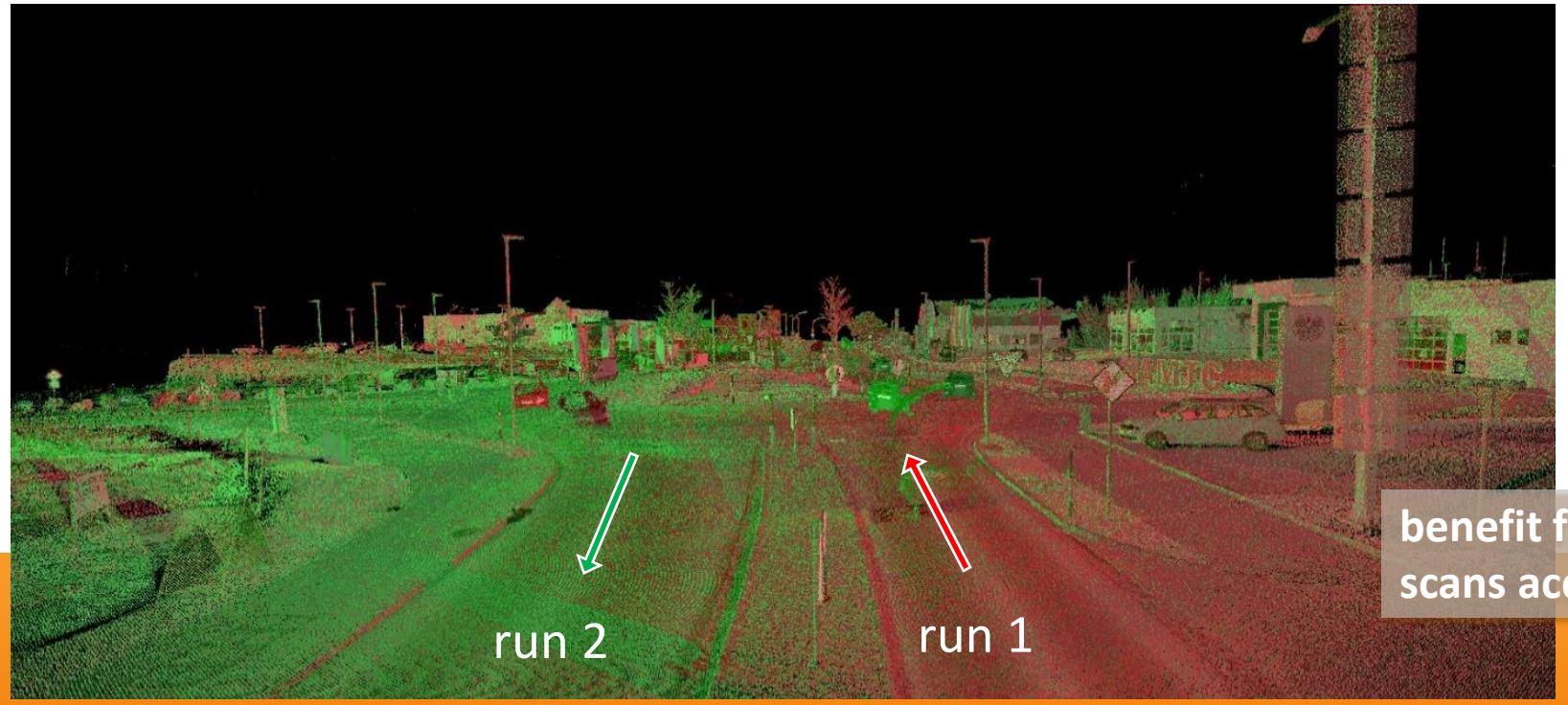
precise object and edge detection in a single run

RIEGL VMX-2HA Point Pattern @ 100 km/h; 5m range

VMX-2HA

RIEGL VMX – 2HA

high-performance dual scanner mobile mapping system

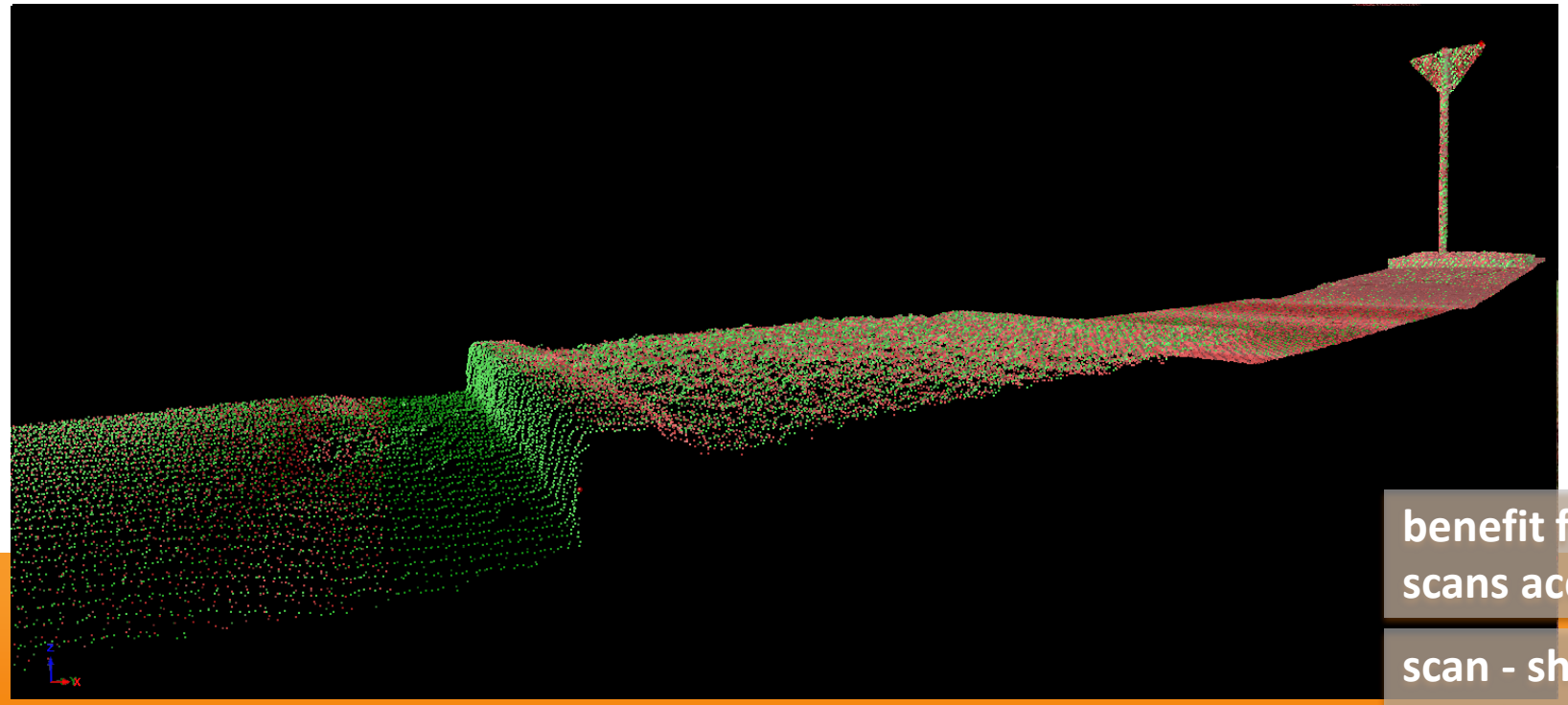


benefit from accurately fitting overlaying scans acquired in multiple runs

VMX-2HA

RIEGL VMX – 2HA

high-performance dual scanner mobile mapping system



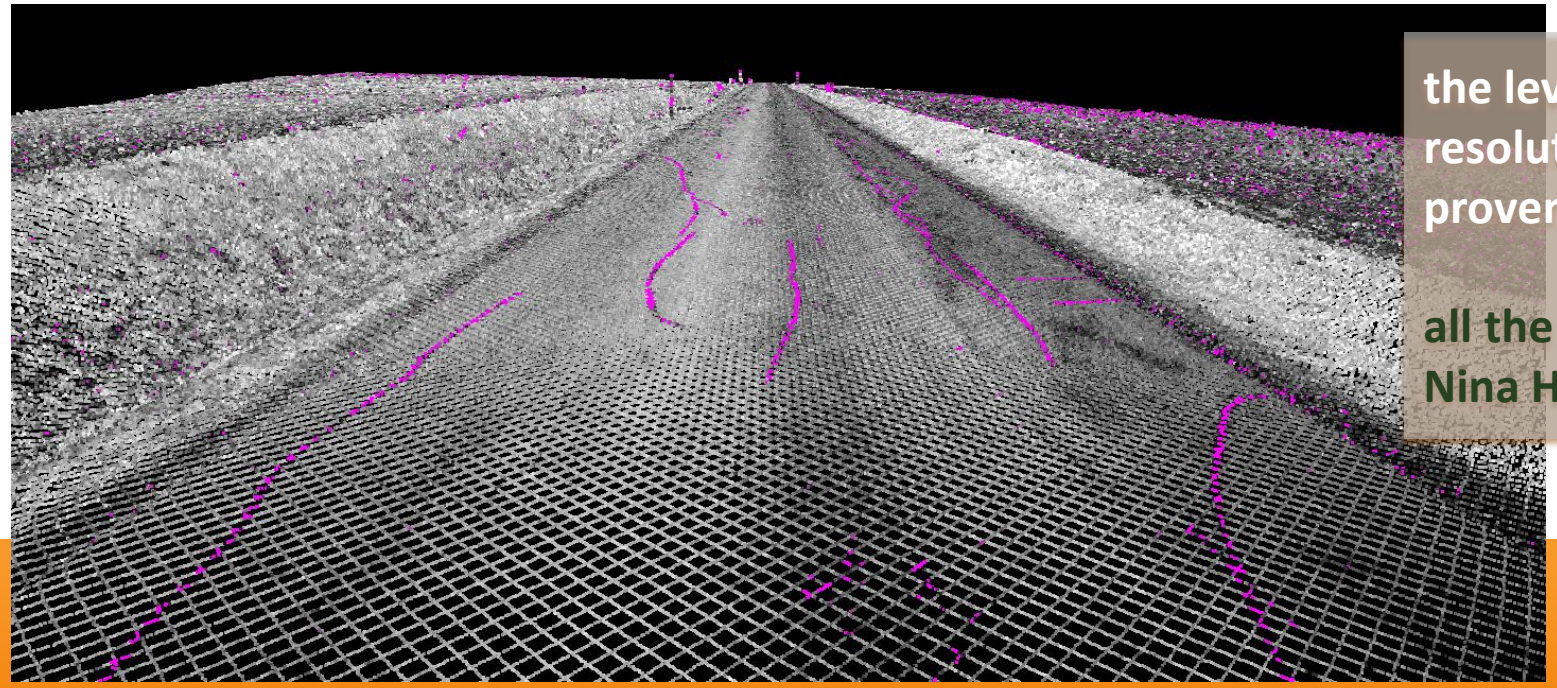
benefit from accurately fitting overlaying scans acquired in multiple runs

scan - shadow minimized point cloud with a high level of detail

VMX-2HA

RIEGL VMX – 2HA

high-performance dual scanner mobile mapping system



the level of detail and the precision of the high resolution point cloud has been successfully proven for pavement condition analysis

all the details will be given in a moment by Nina Heiska

VMX-2HA

RIEGL VMX – 2HA

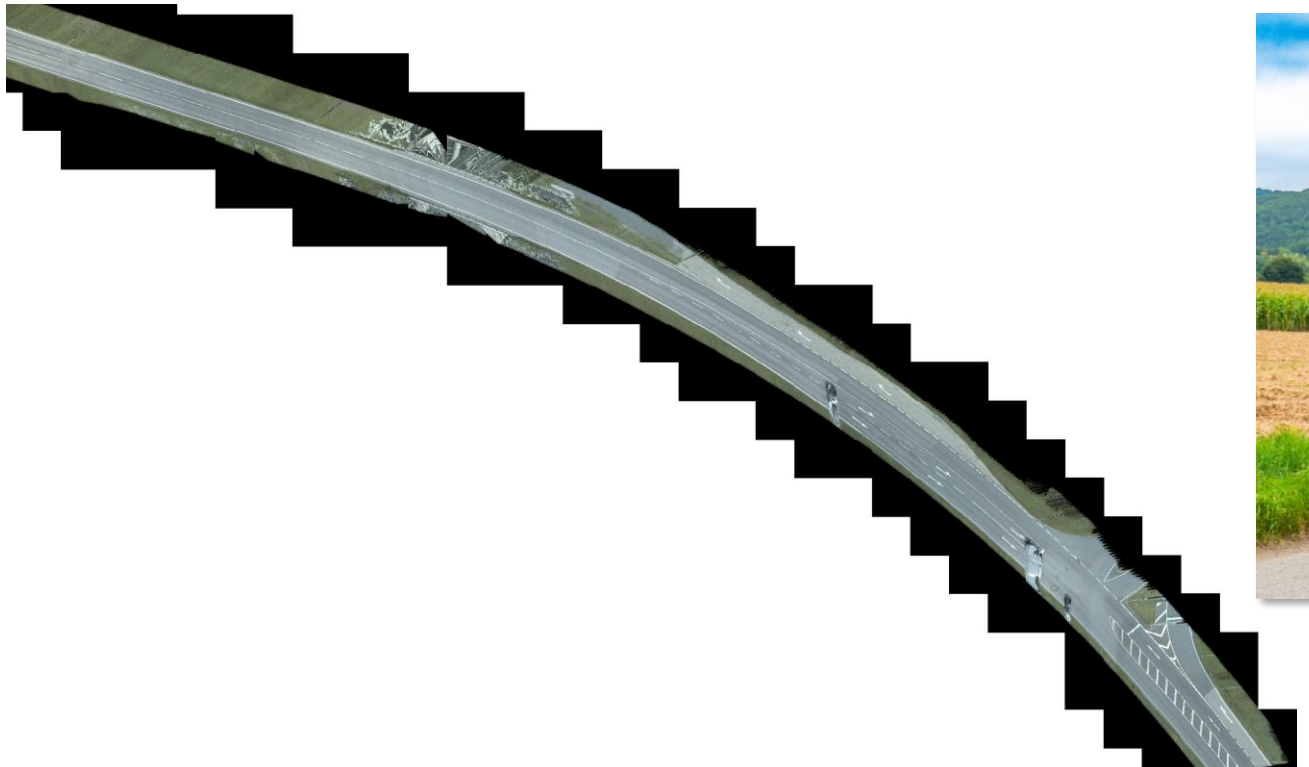
high-performance dual scanner mobile mapping system

get additional information of pavement surface conditions and texture from high resolution imagery

Pavement Camera System

True-Orthophotos

- the desired target resolution for the true-orthophoto is defined in the RiPROCESS orthophoto wizard
- in this example the source images have been captured with 2 x 5 MP cameras, 1 m distance trigger @ 70 km/h
- the orthophoto of the shown road segment has a resolution of 2 x 2 mm => 1 x 1 mm is in prototyping



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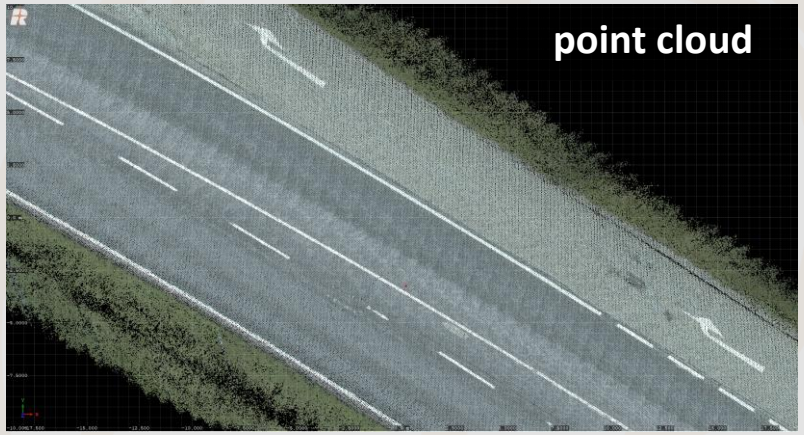
Pavement Camera System

True-Orthophotos

- the desired target resolution for the true-orthophoto is defined in the RiPROCESS orthophoto wizard
- in this example the source images have been captured with 2 x 5 MP cameras, 1 m distance trigger @ 70 km/h

the ortho-photo is comparable to the bird eye view of the colored point cloud but with much higher resolution and LoD



comparison with same spot in the point cloud

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Pavement Camera System

True-Orthophotos

- the desired target resolution for the true-orthophoto is defined in the RiPROCESS orthophoto wizard
- in this example the source images have been captured with 2 x 5 MP cameras, 1 m distance trigger @ 70 km/h

the ortho-photo is comparable to the bird eye view of the colored point cloud but with much higher resolution and LoD

comparison with same spot in the point cloud

cracks are not visible in the point cloud
but well represented in the ortho-photo

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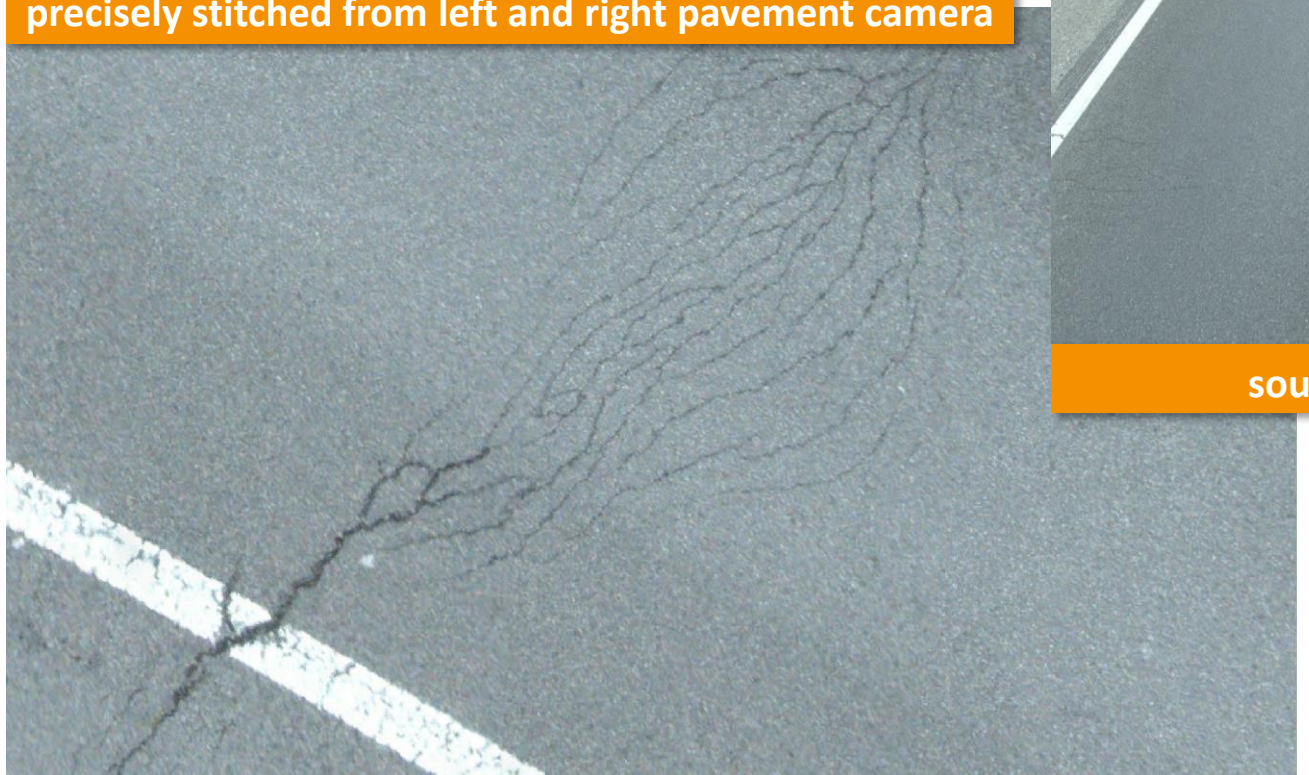
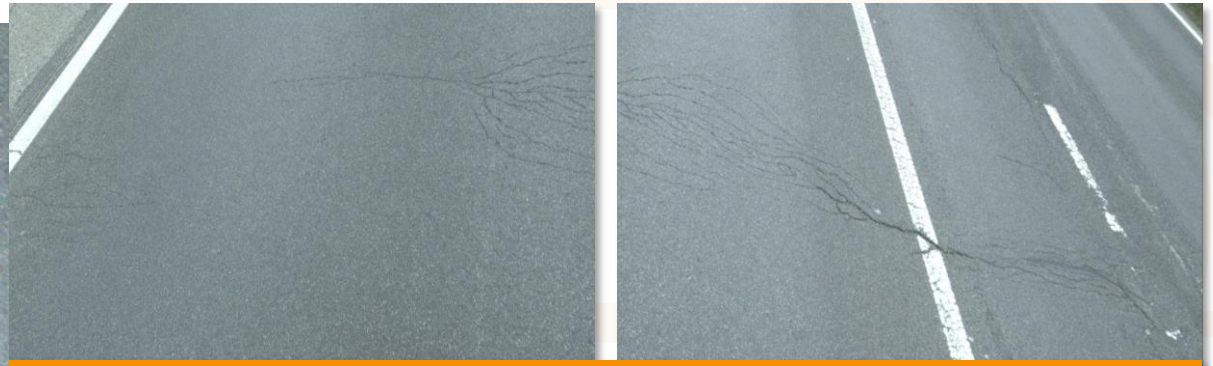
Pavement Camera System

True-Orthophotos

- the desired target resolution for the true-orthophoto is defined in the RiPROCESS orthophoto wizard
- in this example the source images have been captured with 2 x 5 MP cameras, 1 m distance trigger @ 70 km/h

true-ortho-photo with 2 x 2 mm resolution
precisely stitched from left and right pavement camera





source image left and right pavement camera

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Practical experiences in the creation of road parameters with RIEGL Mobile Laser Scanning System

ERPUG, Athens
25.10.2023

Nina Heiska

RIEGL
LASER MEASUREMENT SYSTEMS

Nordic Geo Center

Content

- Who we are & motivation to this project
- Road condition parameters produced with RIEGL VMX mobile laser scanning systems
- Results
- Discussion

Nordic Geo Center Ltd as a Company

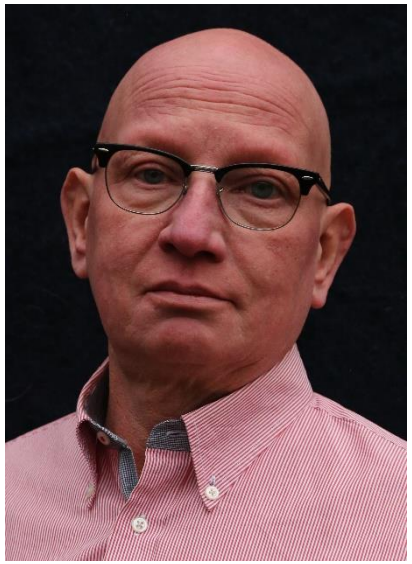
Our team & motivation
– 10 years of mobile road surveys with VMX
– 40…50 years of geodetic road surveys

Veli-Pekka
Puheloinen

Tauno
Suominen

Hannu
Heinonen

Mika
Salolahti



Nina
Heiska

Nordic Geo Center

Our Aims

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Hardware: RIEGL VMX development

2009: VMX-250

2012: VMX-450

2017: VMX-1HA

2018: VMX-2HA

2019: VMX-2HA^{Pavement}

2022 and 2023: VMX-2HA^{22}

Our development 2014 -2023

2015
- *New production methods* with *RIEGL* VMX-450
- The Finnish Transport Agency

2017
- *Pavement analysis test* in Finland with *RIEGL* VMX-1HA
- The Finnish Transport Agency

2017 - 2018
- *Test for automated road data analysis* with *RIEGL* VMX-1HA
- The Finnish Transport Agency

2019
- *Road Condition Measurements* with *RIEGL* VMX-2HA
- VTI quality tests in Sweden and in Finland

2022
- *Road Condition Measurements* with *RIEGL* VMX-2HA[22]
- VTI quality tests in Sweden and in Finland

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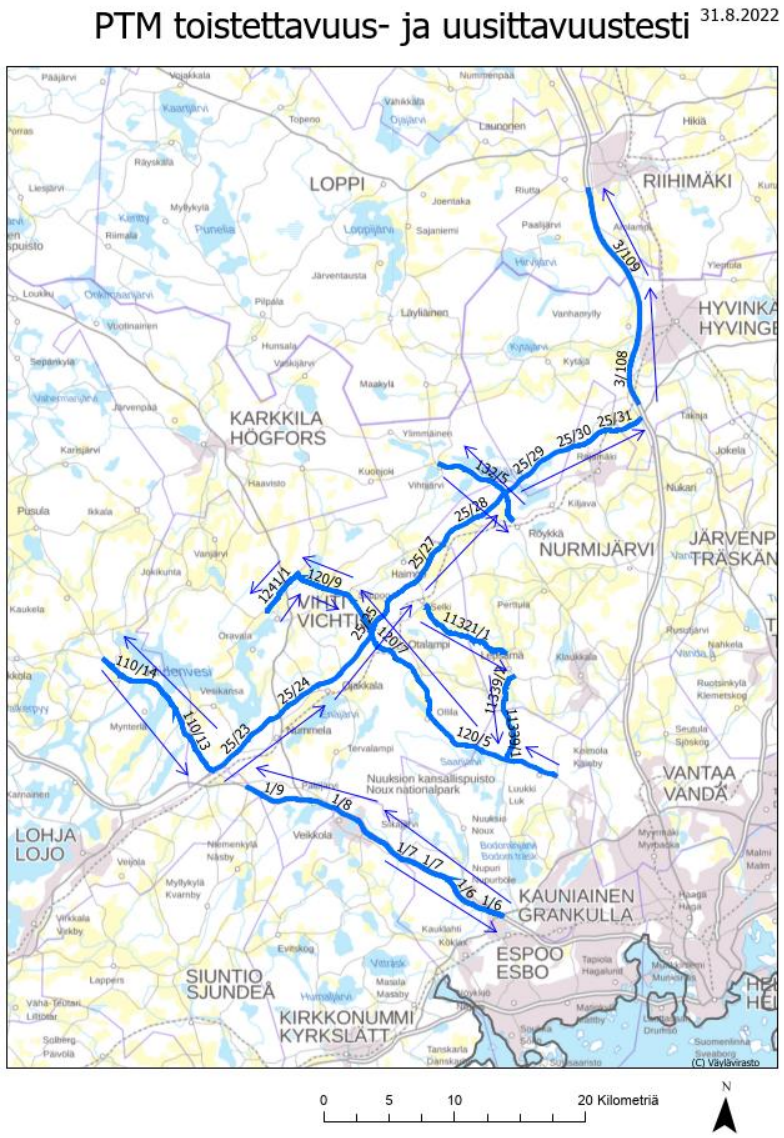
The 2022 test sections in Finland and Sweden (VTI)



Test sections 2022

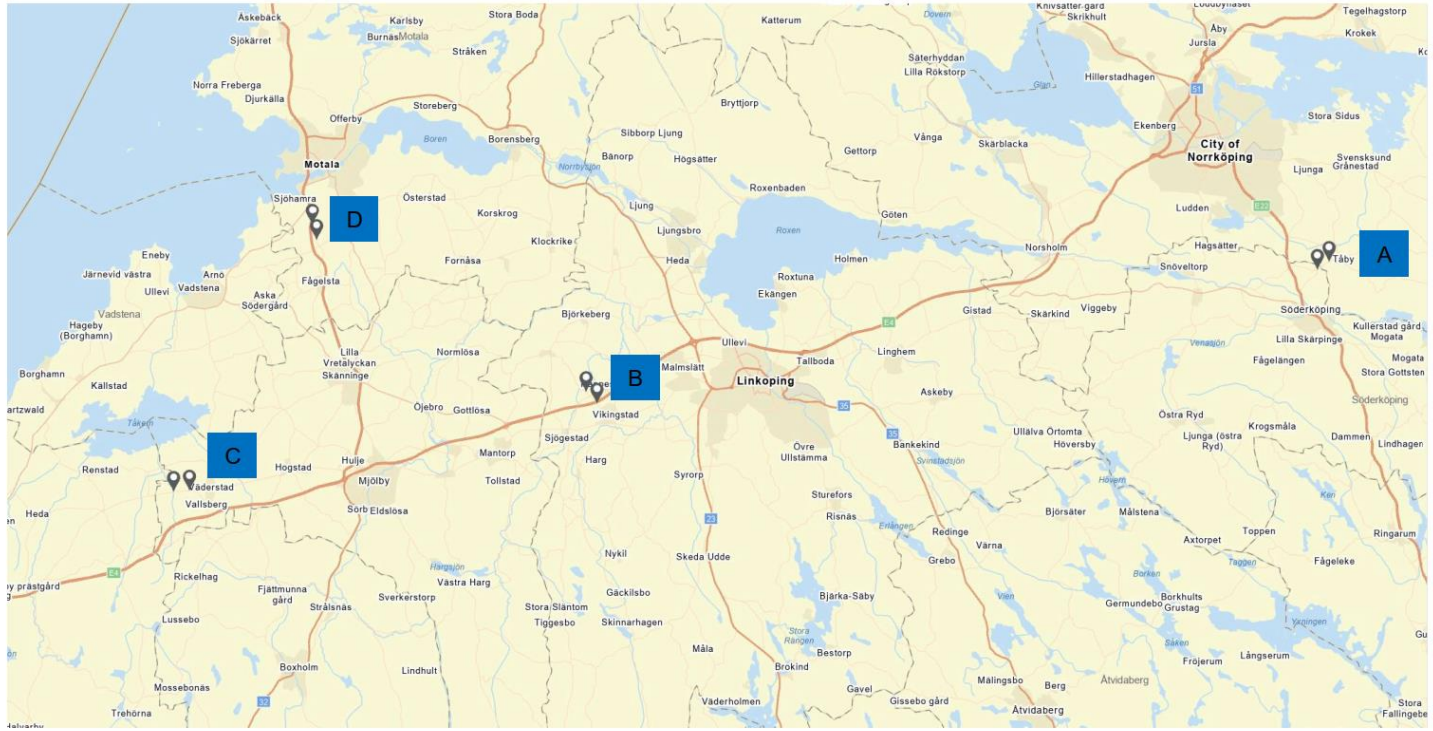


Image : VTI, The Swedish National Road and Transport Research Institute

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Road Surface Condition Parameters – 2022 VTI reference

Transverse profile, crossfall and rut depth

The reference method for transverse profile is the VTI-XPS (Figure 3). Seven LMI Gocator 2375 is used to collect the transverse profile. The measurement width is 3,6 m. The measurement is combined with a GPS receiver with an inertial navigation unit (OXTS Survey+) used to orientate the transverse profile to the horizon to be able to calculate crossfall.

Figure 3 VTI-XPS

Parameter	Class	Category	Acceptance interval	Limit
IRI Right	M	Reference ≤2.00 mm/m	Ref-0.35 mm/m≤TV≤Ref+0.35 mm/m	72%
IRI Right	M	Reference >2.00 mm/m	Ref-(0.35+(Ref-2.00)×10%) mm/m≤TV≤Ref+(0.35+(Ref-2.00)×10%) mm/m	68%
Rut depth max	M	Reference ≤7.5 mm	Ref-1.0 mm≤TV≤Ref+1.0 mm	77%
Rut depth max	M	Reference >7.5 mm	Ref-(1.0+(Ref-7.5)×5%) mm≤TV≤Ref+(1.0+(Ref-7.5)×5%) mm	77%
Rut depth left	A	Reference ≤7.5 mm	Ref-1.0 mm≤TV≤Ref+1.0 mm	77%
Rut depth left	A	Reference >7.5 mm	Ref-(1.0+(Ref-7.5)×5%) mm≤TV≤Ref+(1.0+(Ref-7.5)×5%) mm	77%
Rut depth right	A	Reference ≤7.5 mm	Ref-1.0 mm≤TV≤Ref+1.0 mm	72%
Rut depth right	A	Reference >7.5 mm	Ref-(1.0+(Ref-7.5)×5%) mm≤TV≤Ref+(1.0+(Ref-7.5)×5%) mm	72%
Height of ridge	M	Reference ≤7.5 mm	Ref-1.0 mm≤TV≤Ref+1.0 mm	77%
Height of ridge	M	Reference >7.5 mm	Ref-(1.0+(Ref-7.5)×5%) mm≤TV≤Ref+(1.0+(Ref-7.5)×5%) mm	77%
Position X, Y SWEREF99 TM	A		|TV-Ref| ≤ 0.75 m	95%
Position Z RH 2000	A		|TV-Ref| ≤ 4 m	95%
Crossfall regression	A	|Reference| < 3.00%	|TV-Ref| ≤ 0.50 %	85%
Crossfall regression	A	|Reference| ≥ 3.00%	|TV-Ref| ≤ (0.50+(|Ref|-3.0)×5%) %	85%
Hilliness	A	|Reference| < 3.00%	|TV-Ref| ≤ 0.75 %	85%
Hilliness	A	|Reference| ≥ 3.00%	|TV-Ref| ≤ (0.75+(|Ref|-3.0)×5%) %	85%
Transverse profile	A		Point by point |TV-Ref| ≤ 0.5 mm	80%

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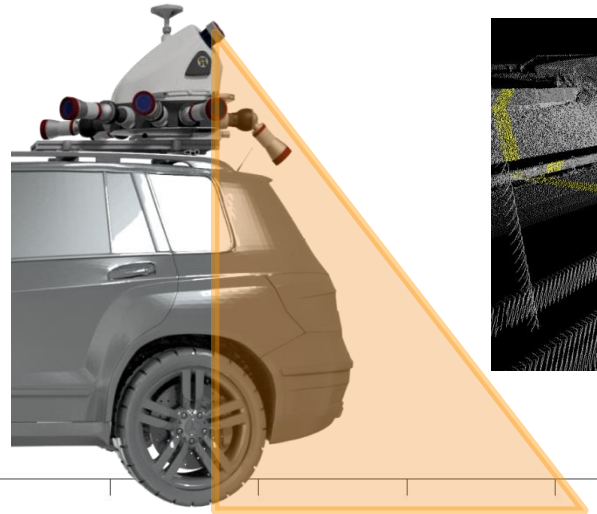
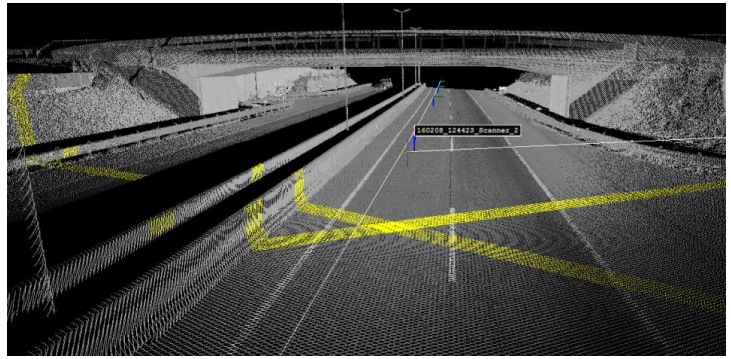
Images and text: VTI

Results in 2022

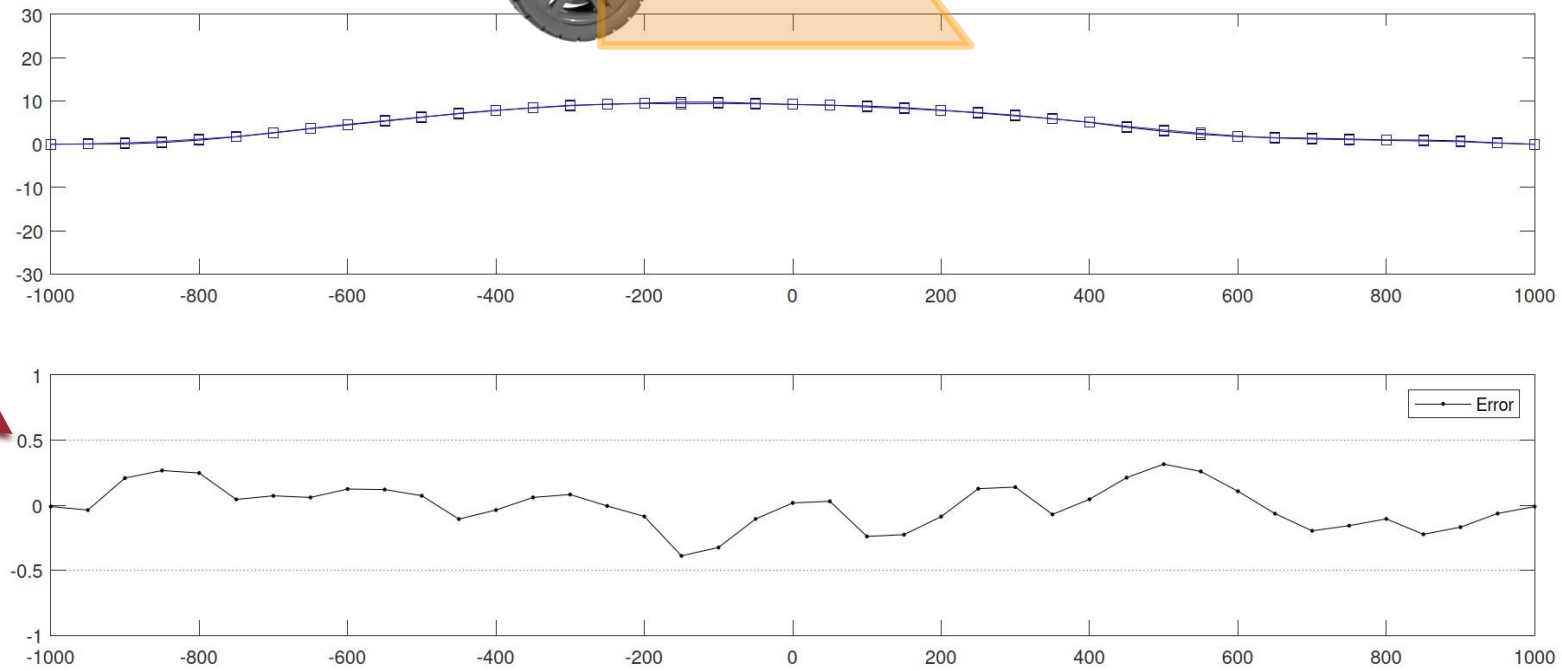




"Tests in 2022: You are approved for the most important variables that are normally used for the project level measurements in Finland, see the attached file.

I believe you have done great and important improvements with your data to adapt to the Finnish regulations."

mm!



RIEGL VMX-2HA – VTI reference Transverse Profile

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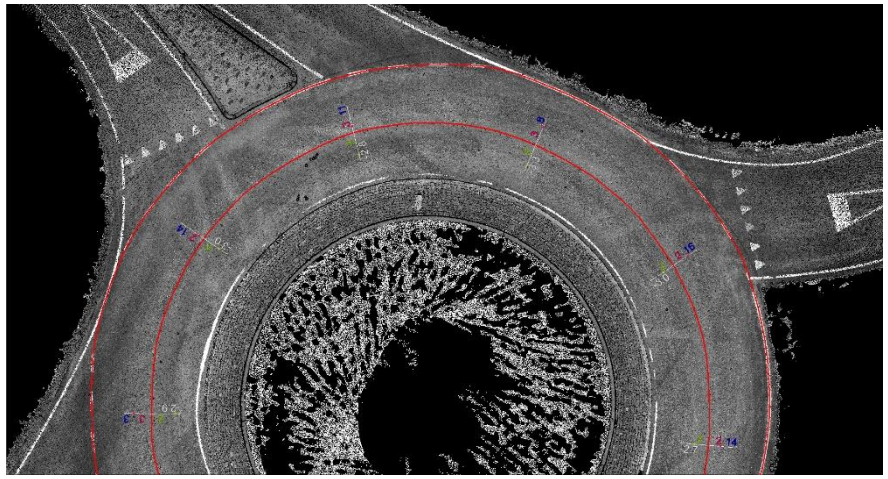
Results 2014 - 2023

- VMX data is comparable to traditional road condition survey values
- *RIEGL* VMX technology can be used in network level road surface condition surveys
- VMX acquisition speed is faster
- Calibrating the system during acquisition campaign is not necessary
- Geometry and position are several orders of magnitude better than with traditional methods



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Can we extract more results of the road surface?

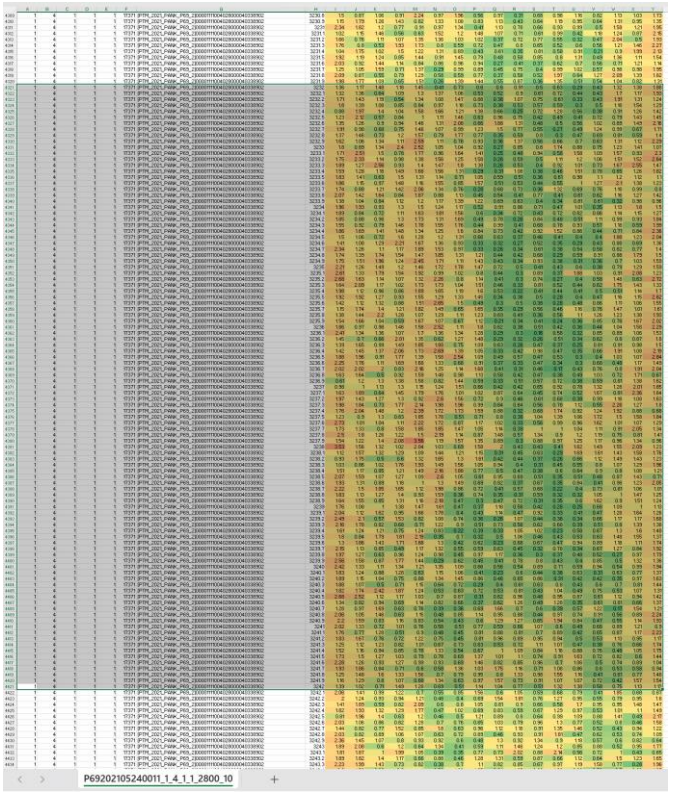
- The shape, area and volume of the ruts and the form of the edges

- Mean Profile Depth (MPD)

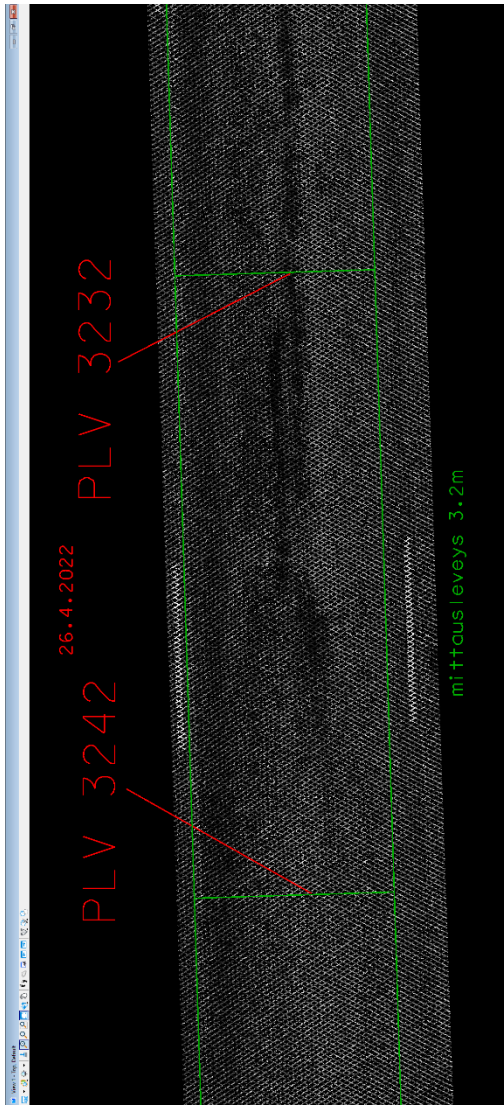
- Reflectivity value of the painted lines

- …

Reference MPD values



VMX- data



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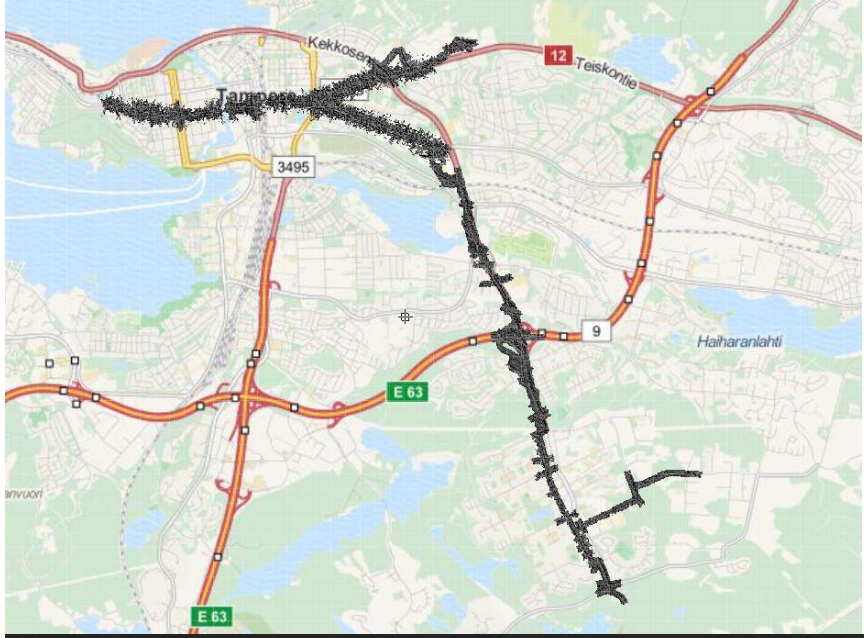
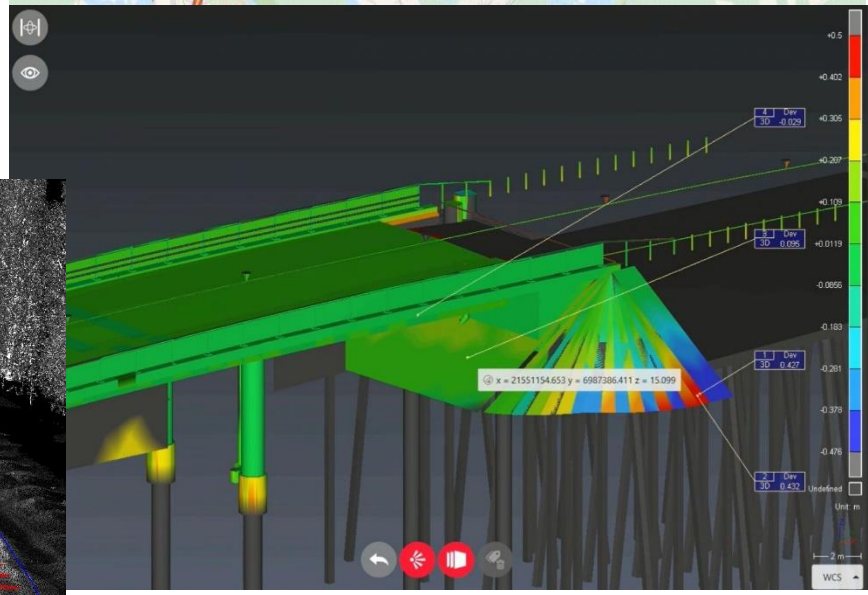
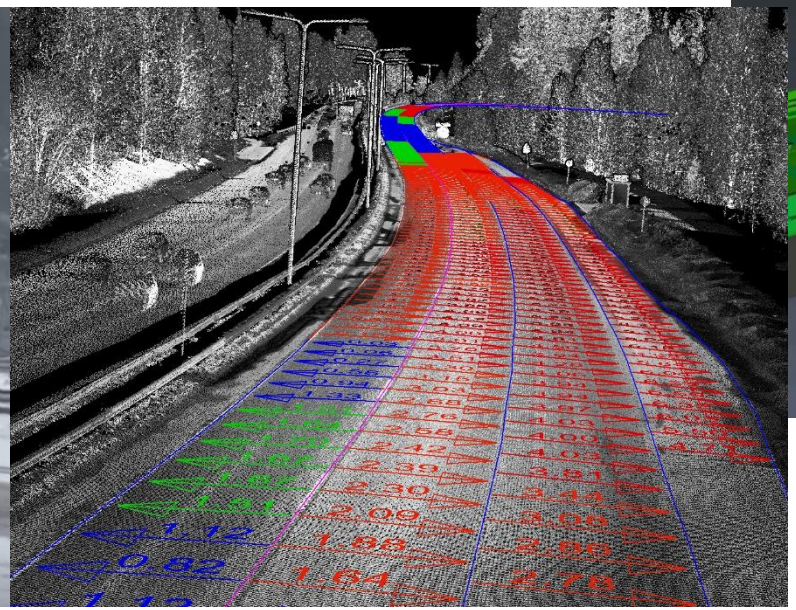
Can we get more information from the data?

- The whole road environment with homogenous accuracy (bridges, tunnels, etc.)
- Engineering survey quality data (needs calibration to local coordinate system)
- Best fit road geometry
- Comparison to design model







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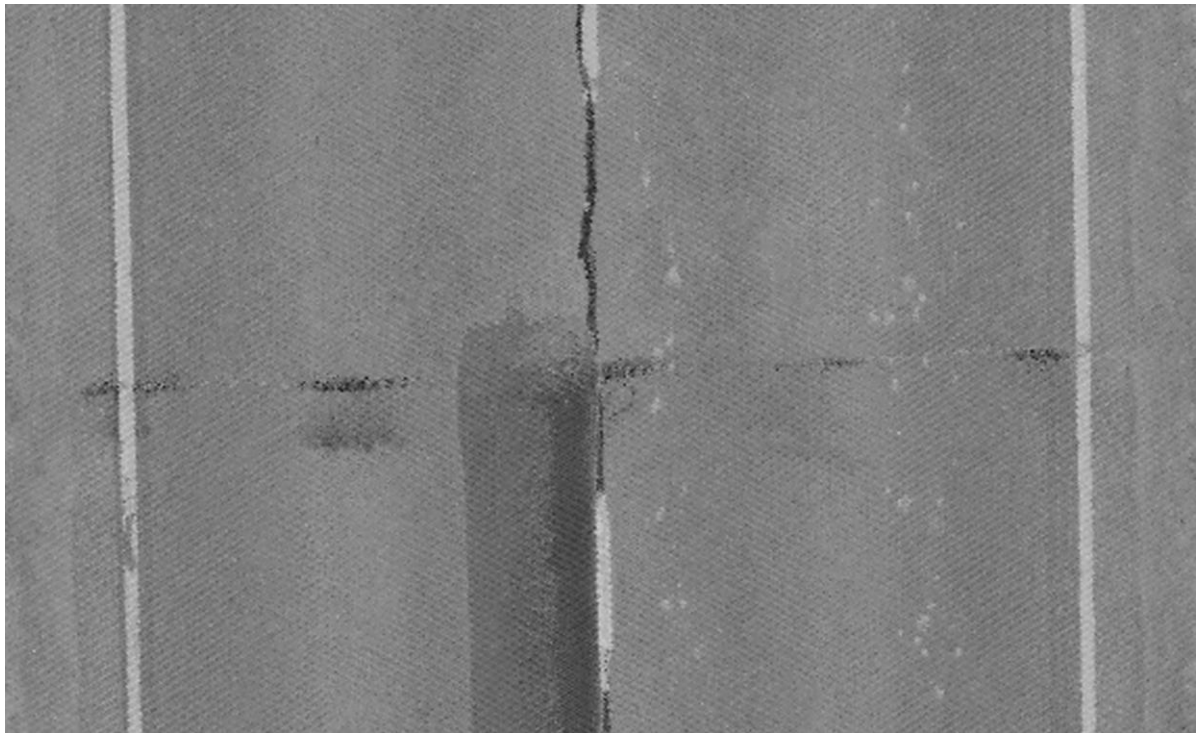
Images?

- RIEGL VMX-2HA system supports up to 240 Mpx of images



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Sub-millimeter values?

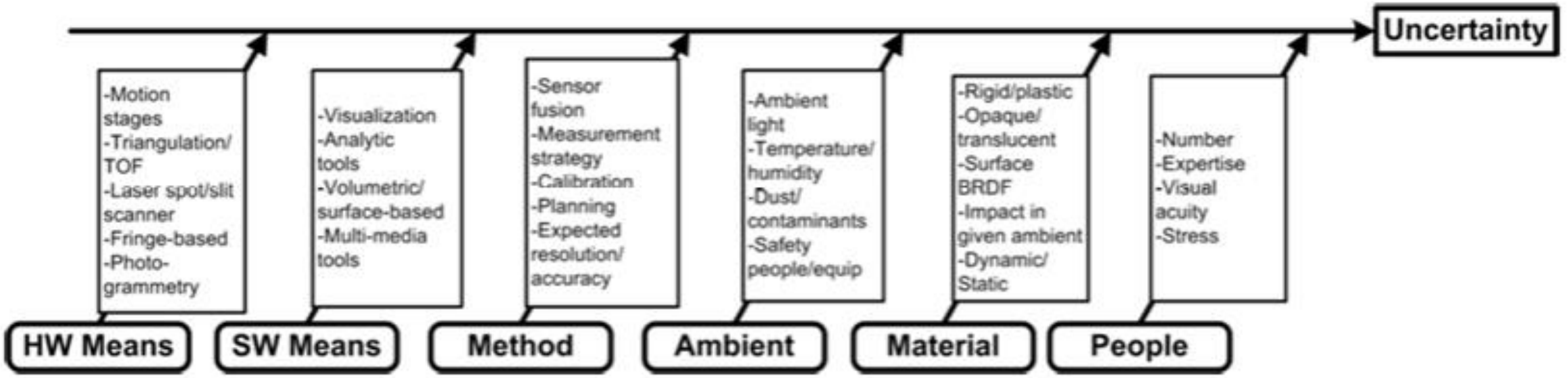

Figure 6. Origin of typical uncertainties in Optical 3D imaging systems.

Basic theory on surface measurement uncertainty of 3D imaging systems

From National Research Council Canada

Download	View accepted manuscript (PDF, 1.2 MiB)
DOI	https://doi.org/10.1117/12.804700
Author	Beraldin, J-Angelo[1]
Name affiliation	1. National Research Council of Canada. NRC Institute for Information Technology
Format	Text, Article
Conference	19-20 January 2009, San Jose, California, USA

Resolve DOI:https://doi.org/10.1117/12.804700

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Thank you for your kind attention!





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