A Performance Comparison Between 3D Detection Systems

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Outlines

- Background
- Scope
- Limitations of the study
- Some results
- Conclusions

Sponsors

This study is mainly sponsored by the Swedish and Finnish Transport Administration.

VTI and Ramböll are running the project and have also sponsored the study by in kind contributions.

Background

Sweden and Finland have much in common regarding roads, vehicles with studded tires and high allowed total loads.

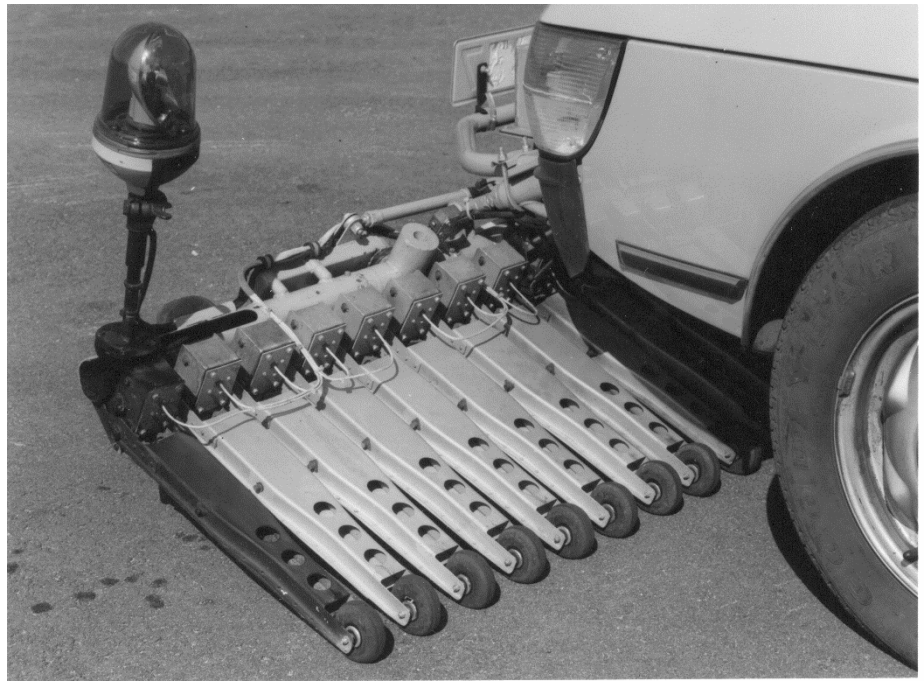
Geographically the two countries are close and both countries buy the monitoring services in a procurement process where quality tests helps to choose the supplier.

Both countries are using rut depth as an important factor in maintenance planning.

The suppliers of measurements have mainly used point laser systems from Ramböll or Greenwood.

Background

The development has gone from mechanical devices in the early seventies with a lot of wear and maintenance.



To the first laser based systems that was introduced in the late seventies in Sweden.

Background

The development of the systems has been rather limited and the increase of data usage has been rather low from the 80ies up till today.

It´s still mainly evenness in the longitudinal and transversal direction that is used for maintenance planning in the Transport Administrations.

There is a need from the administrations to get a more complete description of the condition on the road network, especially about surface defects and cracks.

The administrations have therefore begun to pay interest in the scanning laser technology.

Scope of the Study

Can we maintain the same high quality in the transversal unevenness if we introduce new techniques?

Can the Administrations use the same criteria in procurement tests if new technique is used?

What extra benefits can we get from the new technique?

Limitations of the Study

The study is limited to look at transversal evenness

The parameters we will study is,

- Transversal profile
- Rut depth

We will look at,

- Repeatability and validity (procurement test)
- Comparability with point laser systems

The analysis method will be,

- Standard procurement test criteria, test sections, project level, route
- “Standard” quality control procedures at network measurements

Tested Equipment's – Fraunhofers PPS-System Operated by Lehman+Partner

D
Pavement Cameras

E
Panorama Cameras

F
Distance
Measurement Unit

A
Position and
Orientation System

B
Pavement Profile
Scanner (PPS)

C
Corridor Profile
Scanner (CPS)

Photo: Lehman+Partner

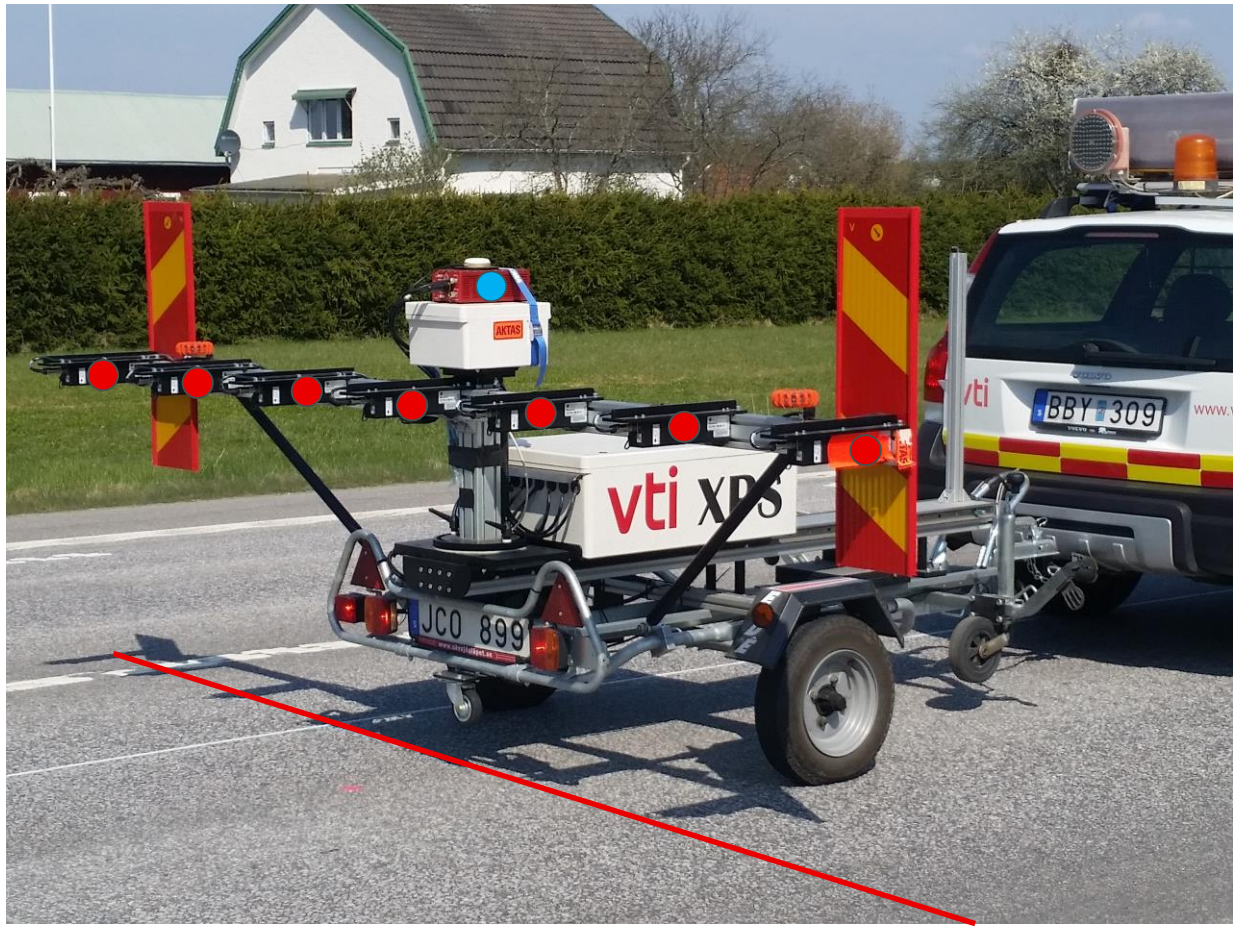
Tested Equipment's – Pavemetrics LCMS-system Operated by Vars Brno (Integrated with a RST-System from Ramböll)

LCMS
(Laser Crack Measurement System)

Point Laser Systems in the Study, RST-33 and VTIRST
17 Measurement Points and 3,2 m Measurement Width

Reference Equipment - VTIXPS

Transverse profile, Rut Depth, Crossfall (Cross Profile Scanner)



Trailer

- 7 LMI Gocators 2375
- OXTS Survey+

Longitudinal spacing
= 0.1 m

Transverse spacing
< 1 mm

Measurements in the Study

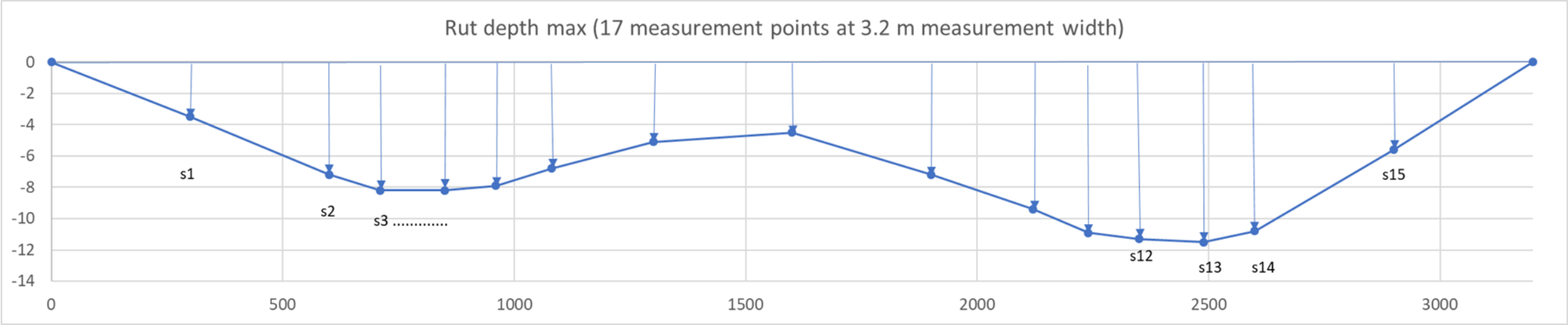
	PPS	LCMS	RST33	VTIRST	VTIXPS
Three Test Sections Each 1 200 m	5 rep. 30 km/h 5 rep. 50 km/h 5 rep. 70 km/h	5 rep. 30 km/h 5 rep. 50 km/h 5 rep. 70 km/h	5 rep. 30 km/h 5 rep. 50 km/h 5 rep. 70 km/h	5 rep. 30 km/h 5 rep. 50 km/h 5 rep. 70 km/h	5 rep.
Two Project Level Sections Each 4 000 m	4 rep. speed selected by driver	4 rep. speed selected by driver	4 rep. speed selected by driver	4 rep. speed selected by driver	
One Route 93 km	5 rep. speed selected by driver	5 rep. speed selected by driver	5 rep. speed selected by driver	5 rep. speed selected by driver	

All measurements are done according the same instructions.
The measurements are done by the system owners (Vars, Lehman+Partner, Ramböll, VTI)

Data Processing

- All systems have delivered a transversal profile per 0.1 m to VTI
- VTI has calculated transversal profiles and rut depth from the profiles.
- This ensures that we have the same calculation method for all systems in the study.

Surface wire method – Rut depth, measurement width = 3.2 m
Rut depth = s13; (max of s1, s2 …. S15)



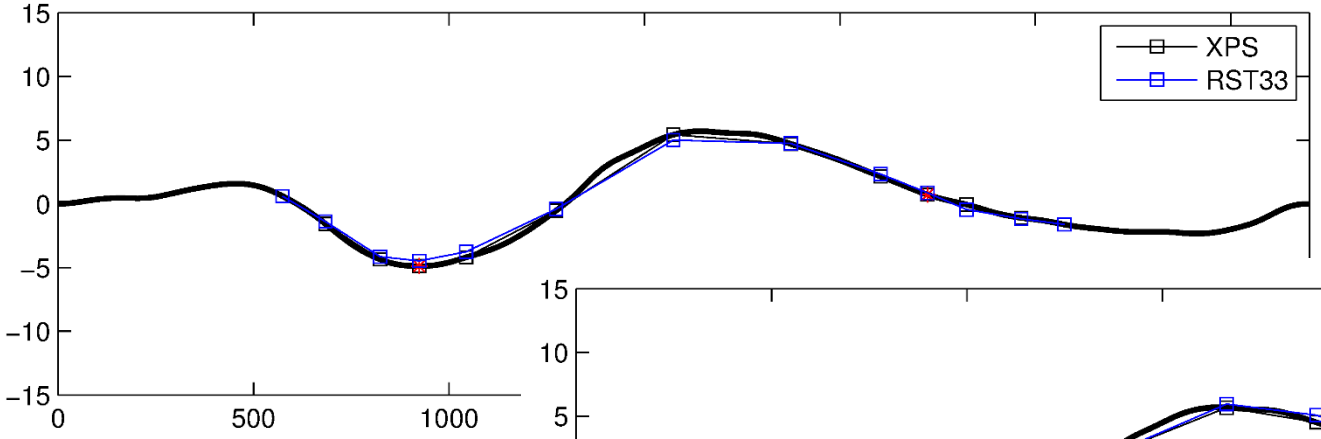
Some Results – Test Sections – Transversal Profile

Control method –

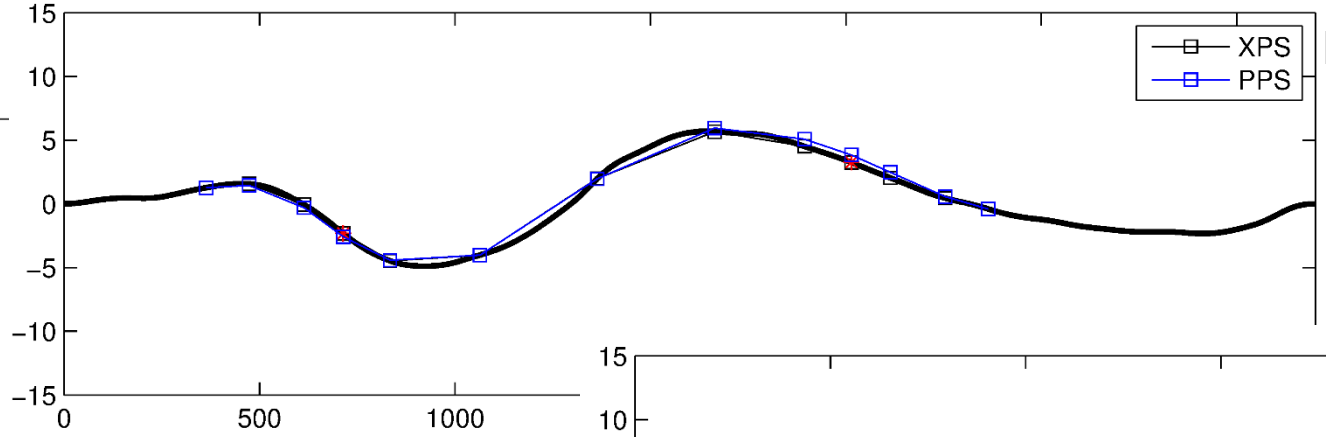
- The tested and reference profile is matched transversally for a mean of 20 m, correlation, translation, rotation
- A difference, point by point, between tested system and the reference transversal profile is calculated (20 m level).
- 80 % of the differences must be within ±0.5 mm.

Adobe
Acrobat-dokumen

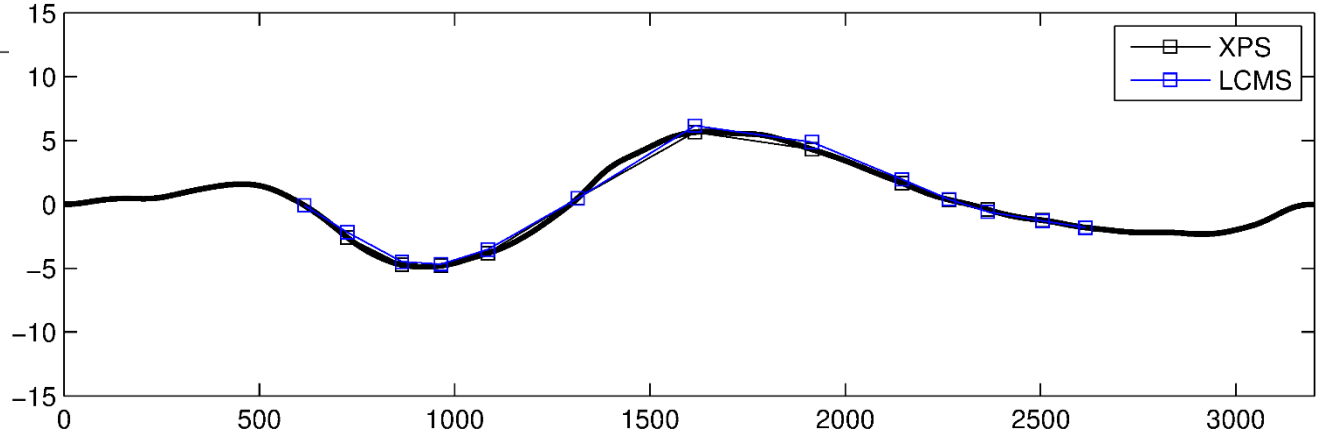
Validity – Transversal Profile



RST33, 99.9 % within limits



PPS, 98.3 % within limits



LCMS, 97.6 % within limits

Validity and Repeatability – Rut Depth – Test Sections

Validity control method, 20 m sections

Rut depth difference between tested and reference system is calculated

80 % of the differences must be within;

± 1 mm, for reference values up to 7.5 mm

± 1+(ref.-7.5)×5% mm, for reference values over 7.5 mm

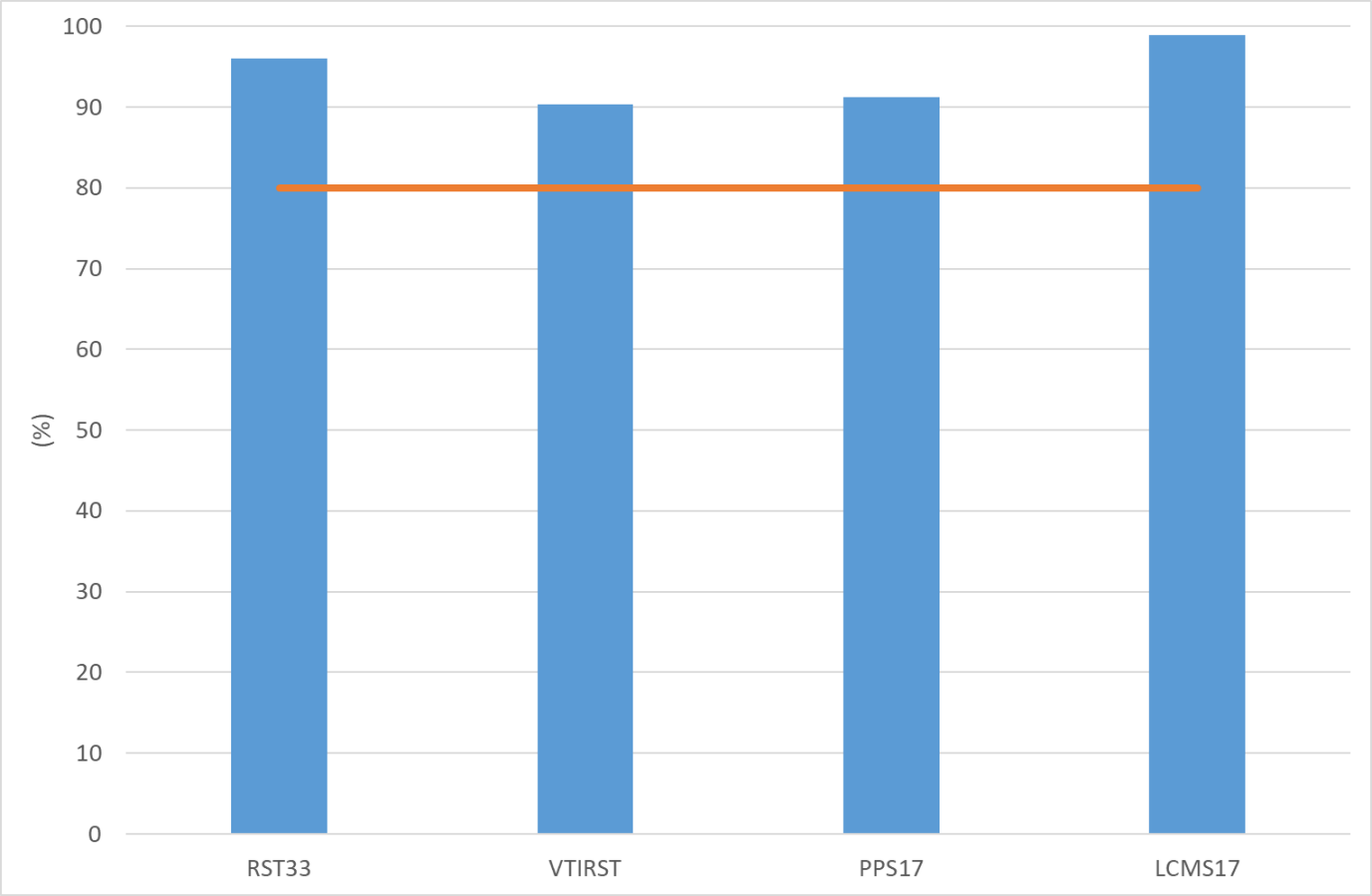
Repeatability control method, 20 m sections

For each 20 m section, a standard deviation is calculated of the 15 individual runs

The 75th percentile of all 20 m standard deviations must be below;

0.5 mm

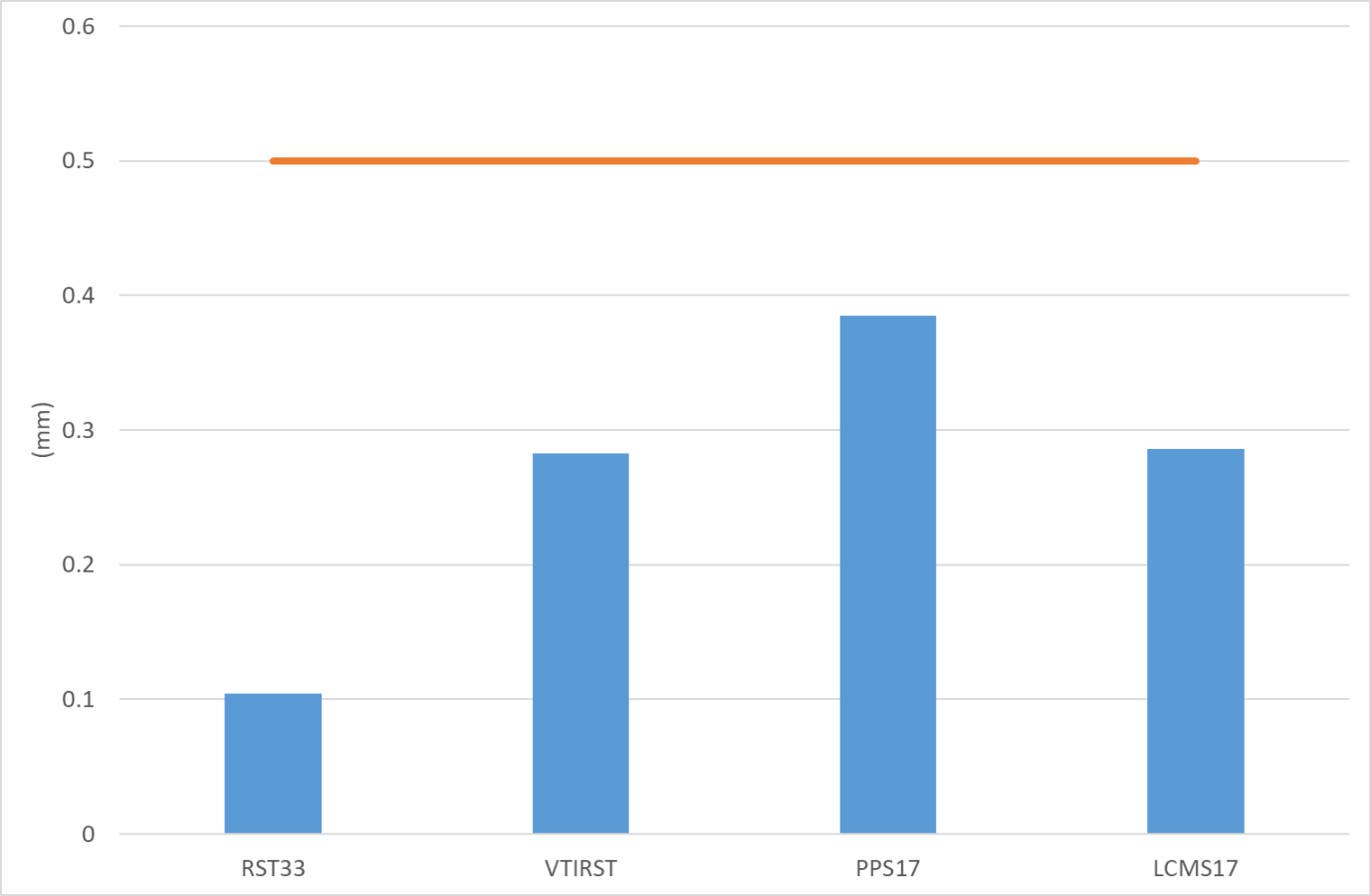
Some results – Validity, Rut Depth Calculated with 17 Measurement Points for All Systems



All systems pass the validity limit (80 %).

The systems are also approved if we use all available measurement points from PPS and LCMS.

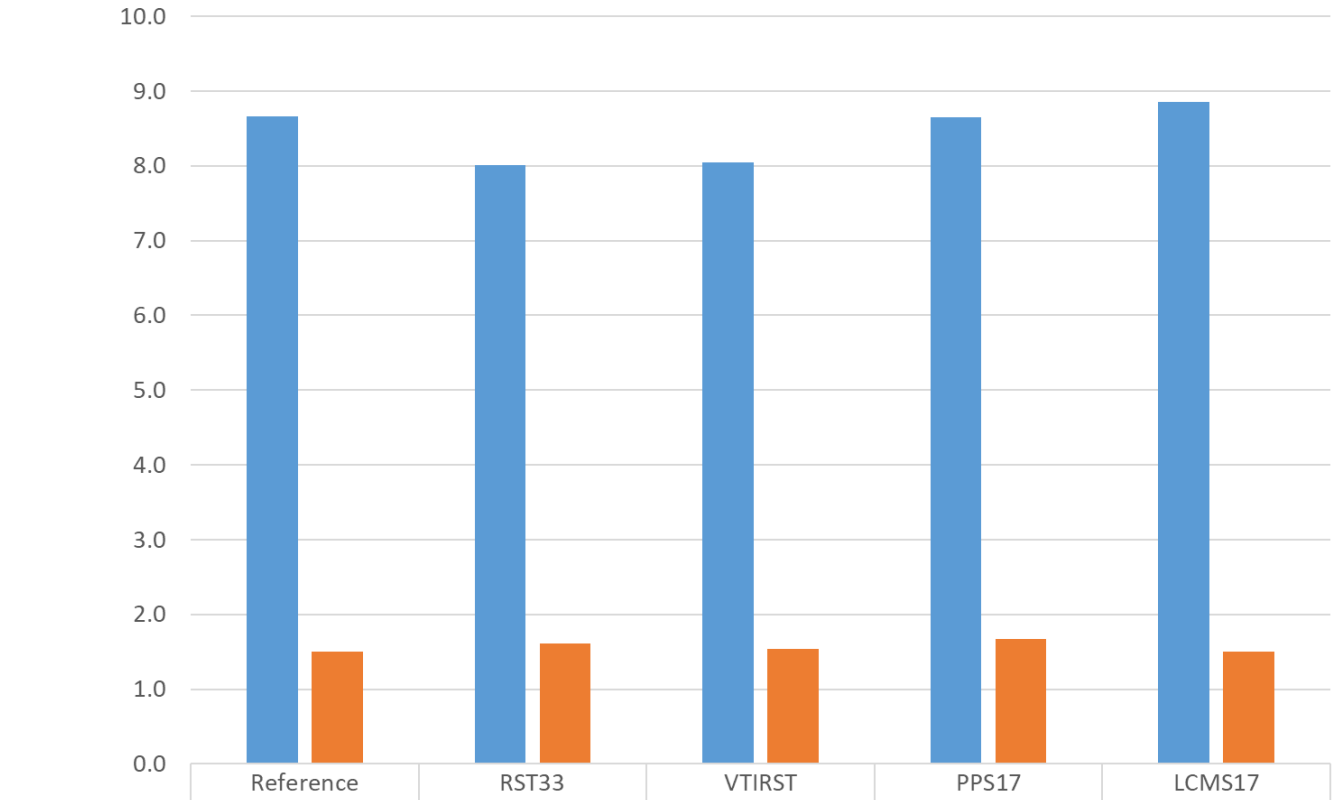
Some Results – Repeatability, Rut Depth Calculated with 17 Measurement Points for All Systems



All systems pass the repeatability limit (0.5 mm).

The PPS- and LCMS-system are also approved if we use all available measurement points.

Some Results – Rut Depth Calculated with 17 Measurement Points for all Systems, Average and Standard dev.

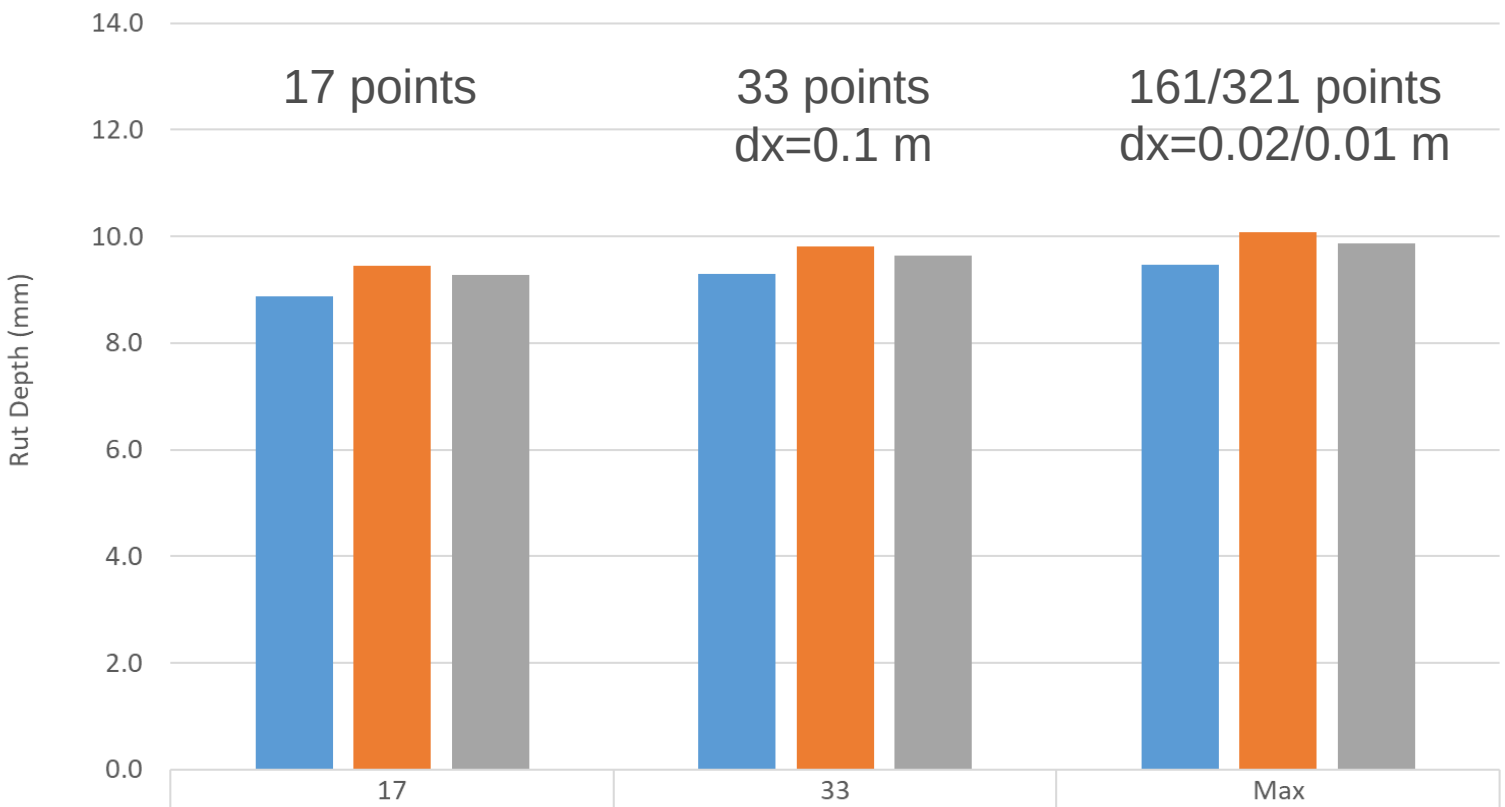


	Reference	RST33	VTIRST	PPS17	LCMS17
Mean	8.7	8.0	8.0	8.6	8.9
Standard dev.	1.50	1.60	1.54	1.67	1.50

One observation we have seen is that the scanning systems have a little bit higher rut depth values than the point laser systems, even if number of measurement points are the same, but the rut depth level is the same as the reference.

Possible explanation, how the filtering of the transverse profile is done before calculating rut depth.

Different Number of Measurement Points Used for Rut Depth Calculations



	17	33	Max
PPS	8.9	9.3	9.5
LCMS	9.4	9.8	10.1
Reference	9.3	9.6	9.9

When you increase number of measurement points you must be aware of the affect it will have on trends in your PM-system.

If you increase the number of measurement points from 17 to one every cm, the rut depth will increase by ≈ 0.6 mm, provided a maintained measurement width.

Lateral Correction of Measurement

The new systems can detect the lateral position of the road markings in relation to the transverse profile. You will have a possibility to use a part of the profile that isn´t affected of the markings.

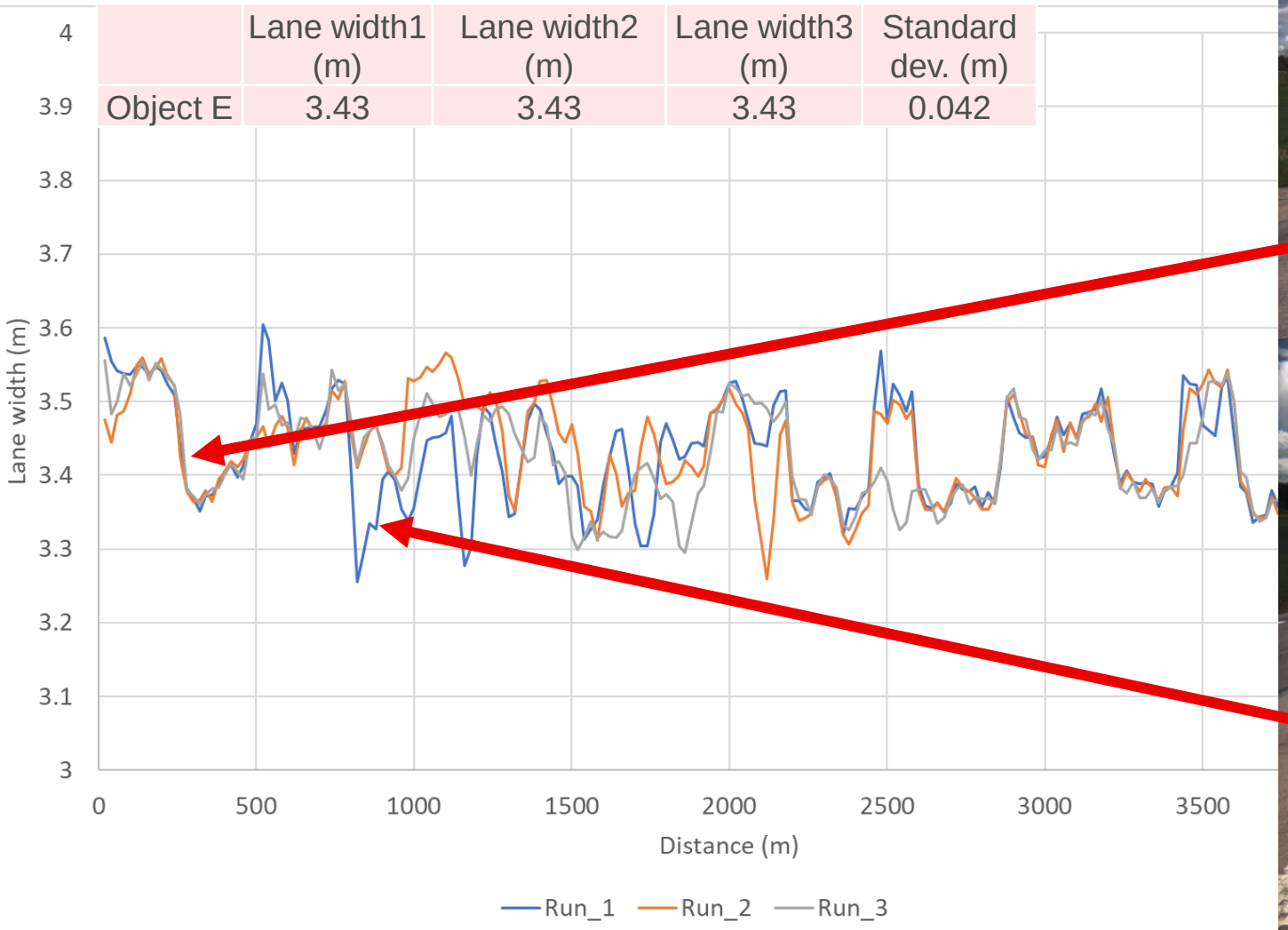
This could be used to exclude laser readings on road markings that affects rut depth.

This could also be used to improve the repeatability of measurements.

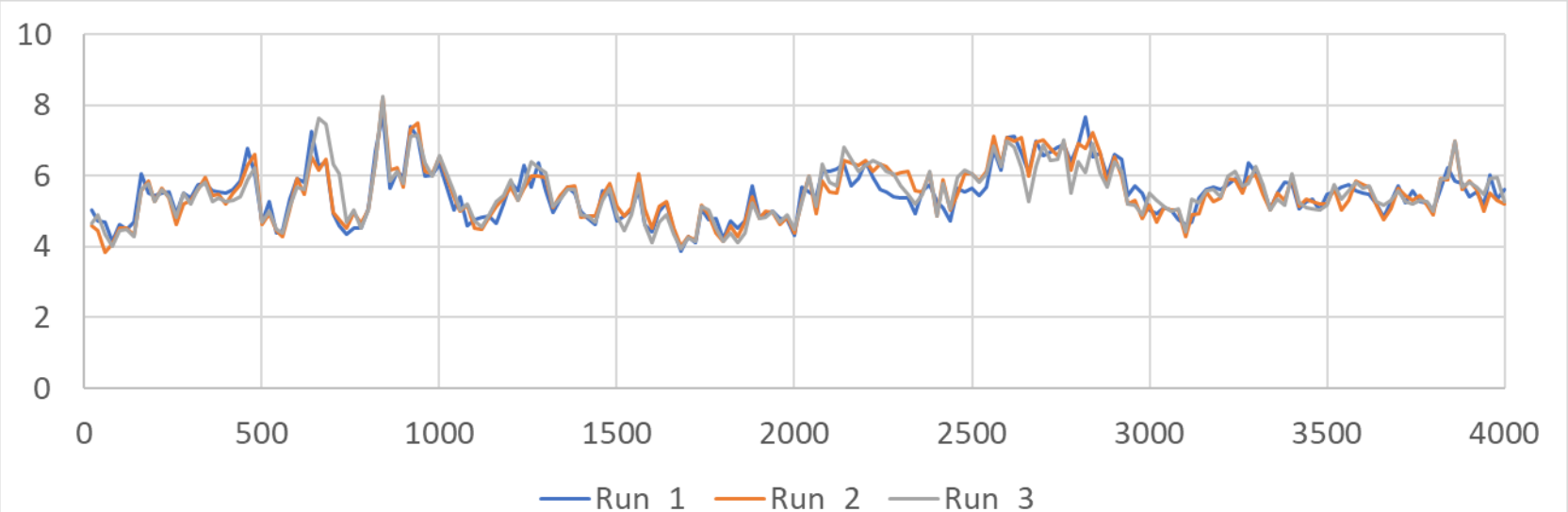
Finally, this could be used in network measurements to minimize uncertainty in long term trends.

Detection of Road Markings
Lane Width - Distance Between Center and Right Road Marking

	Lane width1 (m)	Lane width2 (m)	Lane width3 (m)	Standard dev. (m)
Object E	3.43	3.43	3.43	0.042

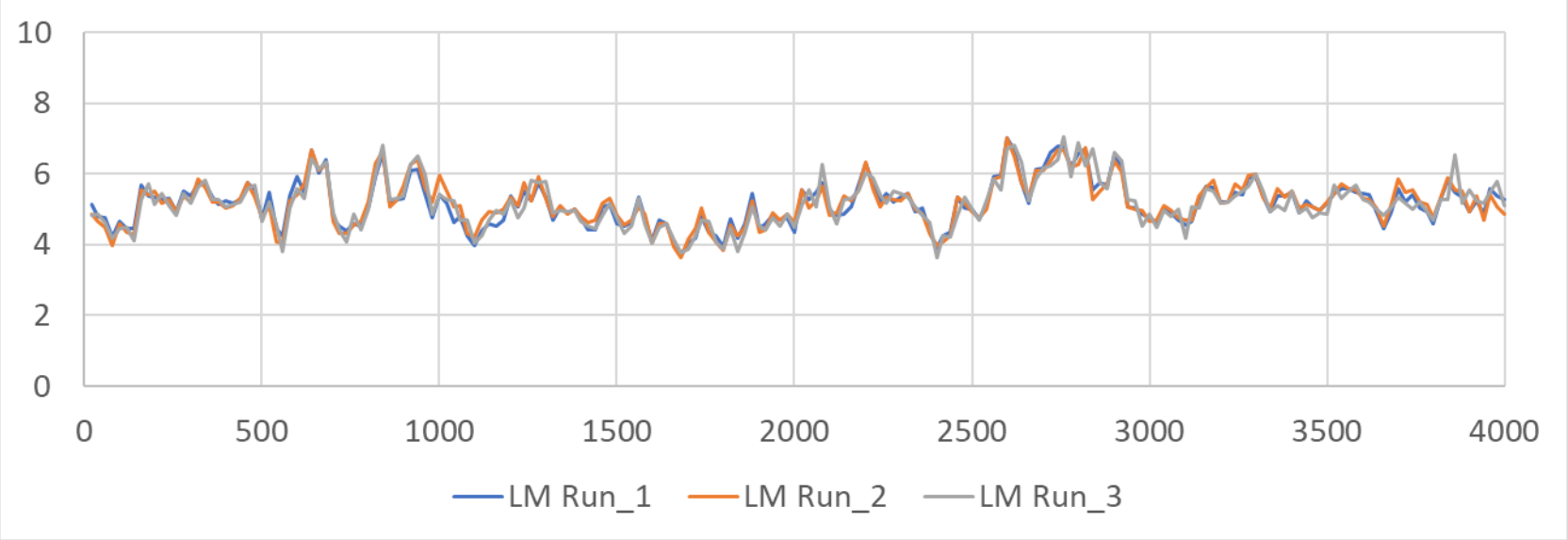


Rut depth calculated with and without lateral correction



No lateral correction,

Rut depth (20m)
Standard dev.=0.25 mm



Lateral correction

Rut depth (20m)
Standard dev.=0.18 mm

Lateral correction – Summary

At project level measurements and at major roads lateral correction is recommended.
These sections have normally good line marking quality.

At network level, especially at the secondary roads, the road markings are of varying quality.
Wear, maintenance and operations affects the line quality and the ability to detect them.

Conclusions

- The quality of the “scanning” laser systems are good and comparable with the quality of point laser systems.
- You need more benefits than just a more detailed profile to invest in new technique, like the ability to detect surface defects, cracks and innovative analyzing methods of the shape of the transverse profile. This is possible today!
- You can use the same procurement criteria (as used in Sweden and Finland) for the scanning systems (regarding rut depth and transversal profile).
- The driver and operator of the systems still is an important factor for a successful measurement. You cannot replace a good driver with only new technique.
- Automatic lateral correction is recommended at project level and major roads but must be more evaluated how to use at network level, especially at secondary roads.

Thanks for your attention

The report will be published in Swedish and English at the end of 2017.
It will be possible to download at www.vti.se/en/publications/

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