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Heavy and Autonomous Vehicles on Rural Roads, Threats and Opportunities

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Future Challenge but also an Opportunity

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INTRODUCTION – RECENT HISTORY IN FINLAND

- **October 2013: maximum allowed total weight 60 to 76 tonnes**
- **In practice: 76 tonnes requires 9 axles. With 8 axles 68 tonnes allowed.**
- Some maximum allowed axle weights increased as well; e.g. **triple bogie on a truck 24 tonnes → 27** tonnes
- Triple bogie on a trailer still remains at 24 tonnes
- At least **65% of the trailer weight on dual tyre axles** to minimize pavement damage (but there are exceptions)
- Without dual tyres it is allowed to have 74 t /10 axles and 76 t / 11 axles
- There will be many different semitrailers >52 t and > 6 axles

Benefits for the Industries (TUT):
80 – 160 M€ /year

INTRODUCTION – WHAT HAS HAPPENED

- The amount of 76 tonnes has increased all the time and after transition period **64 tonne trucks have disappeared**
- Practically **all the longer heavy haulage will be made using 68 or 76 tonne trucks**
- Many approved for 76 tonnes, but not connected to trailer adequate for that weight (Due to dual tyre rule?) → **In road freight 68 t (9-axle) quite popular:** truck with two driving axles and dual tyre trailer increase costs, but 76 tonnes not reached
- **In timber transport higher total weights have increased faster**
- **Currently 21 HCT trucks** > 76 tonnes are allowed to drive in Finland. They can drive only on predefined routes, Driver have to be named and they need to have special training

Latest News from Finland, 34.5 m Long Trucks Allowed from 21/01/2019 – Max Allowed Weights Do Not Increase

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Instead of length control , dirigibility will be emphasized on regulations

Figure: Trafi

This will have a big impact in “lighter cargo” transports in 2019

FACTORS AFFECTING PAVEMENT PERFORMANCE UNDER HEAVY TRUCKS

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Trucks:

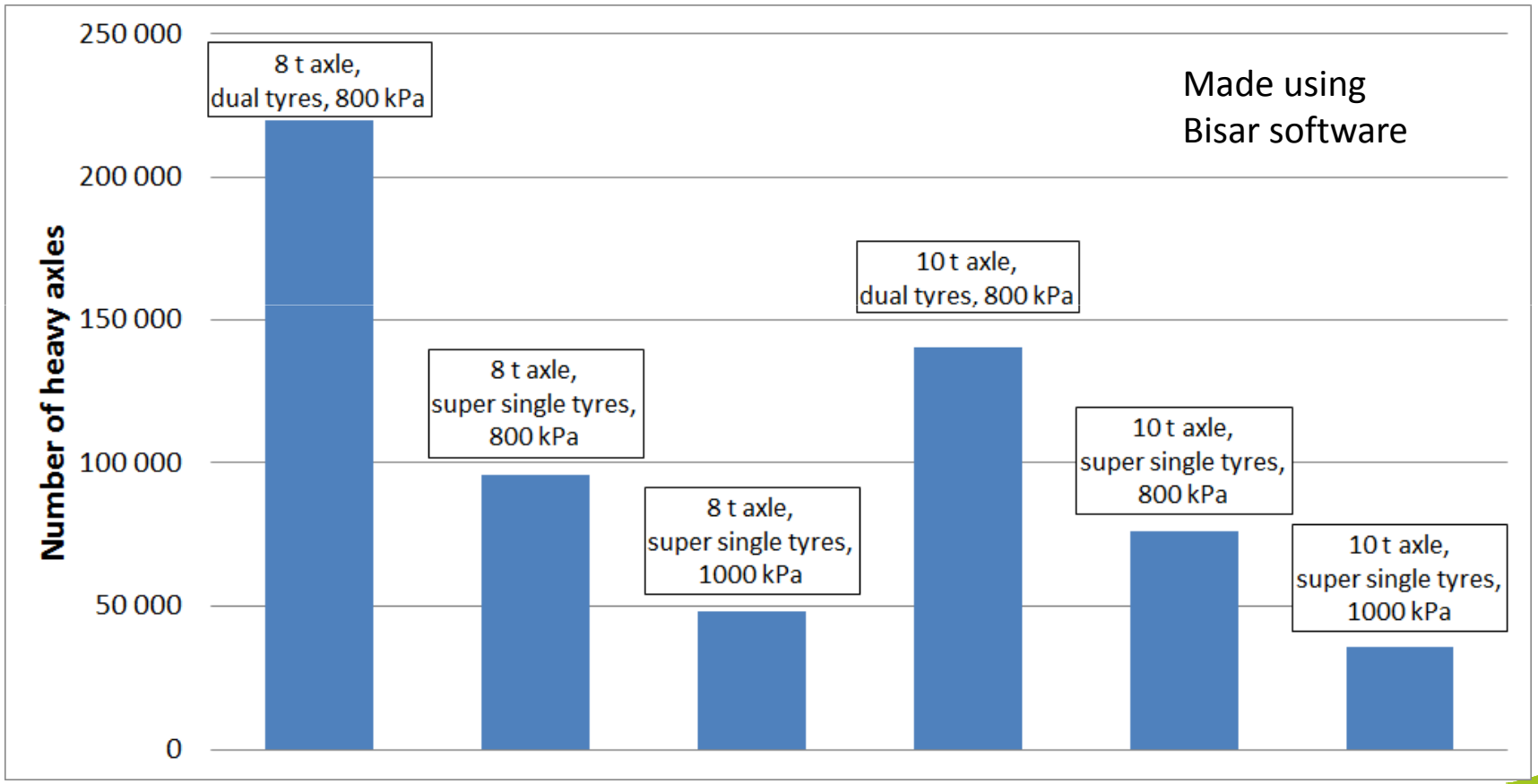
- Tyre type, tyre pressure, tyre size
- Axle load, axle configurations
- Total weight, number of axles
- Tyre wander

Roads:

- Pavement thickness
- Subgrade quality (weak subgrades)
- Material quality (moisture susceptibility)
- Geometry and road width
- Drainage, winter maintenance

Theorethical Calculations:

Effect of Tyre Type and Tyre Pressure on Pavement Life Time for Typical Finnish Paved Roads



… but they match with TUT instrumented road test results

SOFT SUBGRADE RELATED MODE 2 RUTTING PROBLEMS

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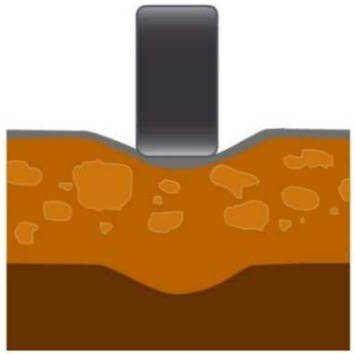

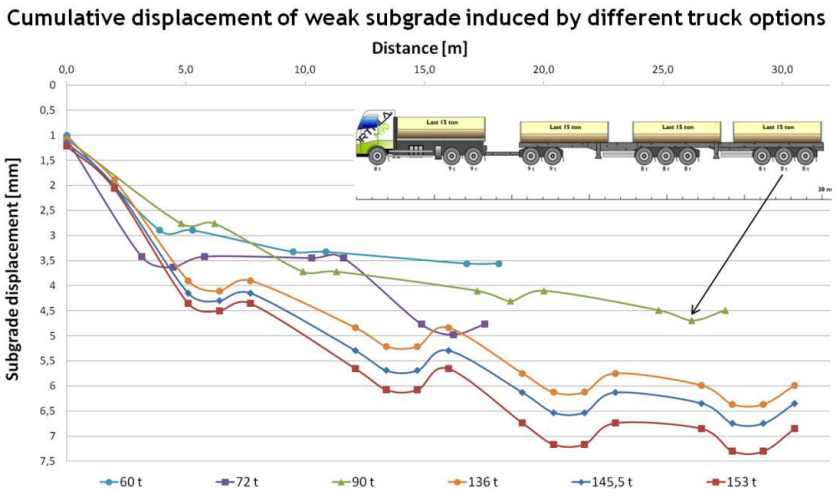

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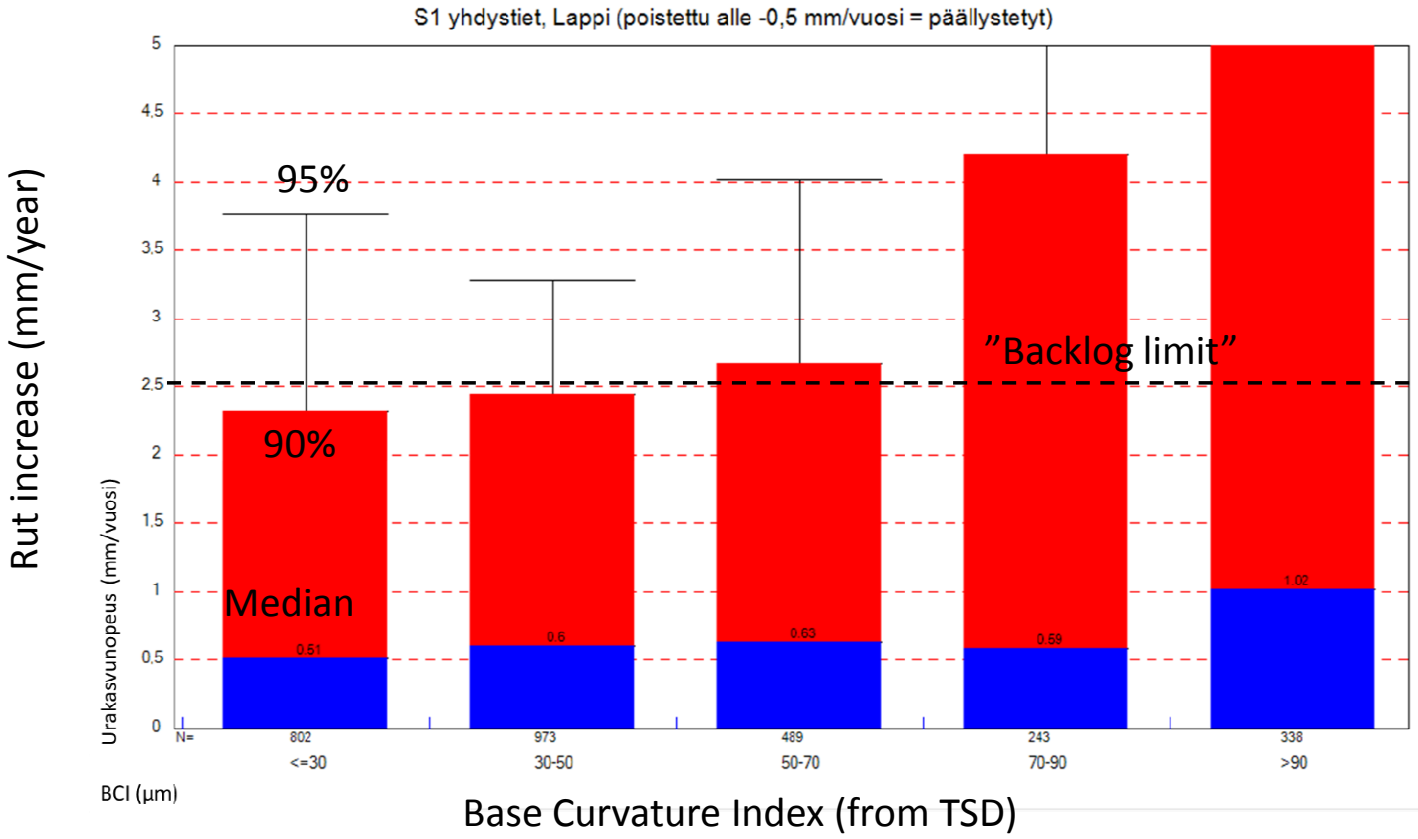
BCI AND RUT INCREASE IN CONNECTING ROADS IN LAPLAND



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Heavy Truck Tests in 2015 in Angeli Finland

by Roadscanners and TUT

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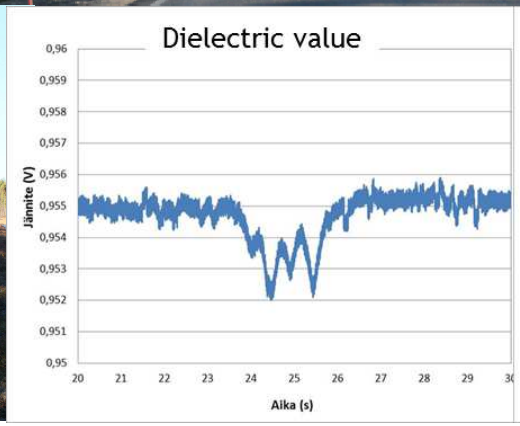
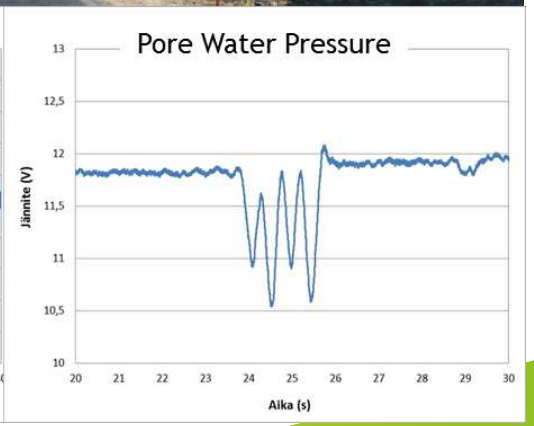
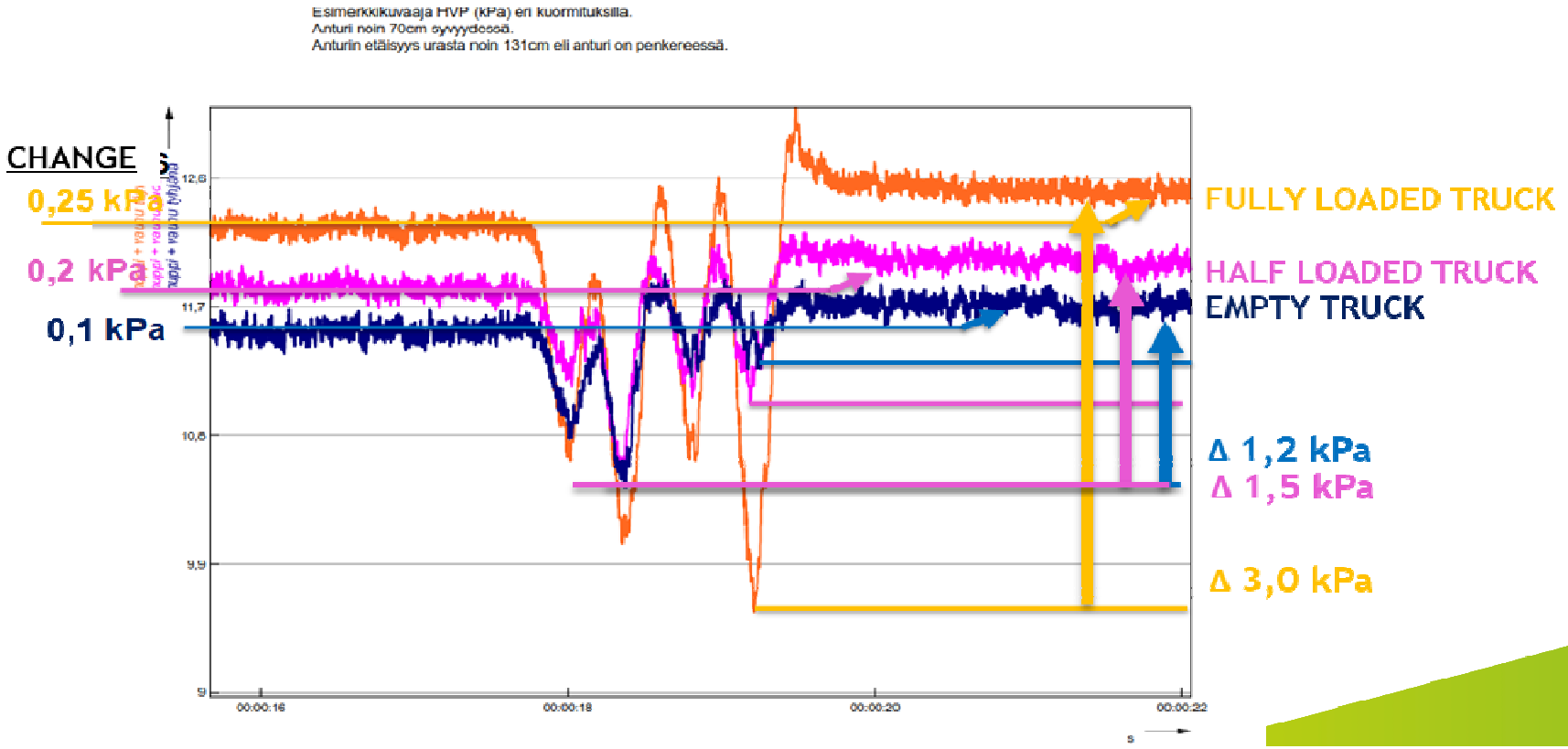




HEAVY TRUCKS AND PORE WATER PRESSURE - Inari Angeli Road results 16.10.2015

At depth of 0,7 m truck + trailer causes some rise in pore water pressure level, which did not take place with truck only (without trailer). The effect of truck weight is also seen clearly on the pressures.



RECOVERY TIMES, PUMPING AND DEFORMATIONS ON WEAK SUBGRADE SOILS

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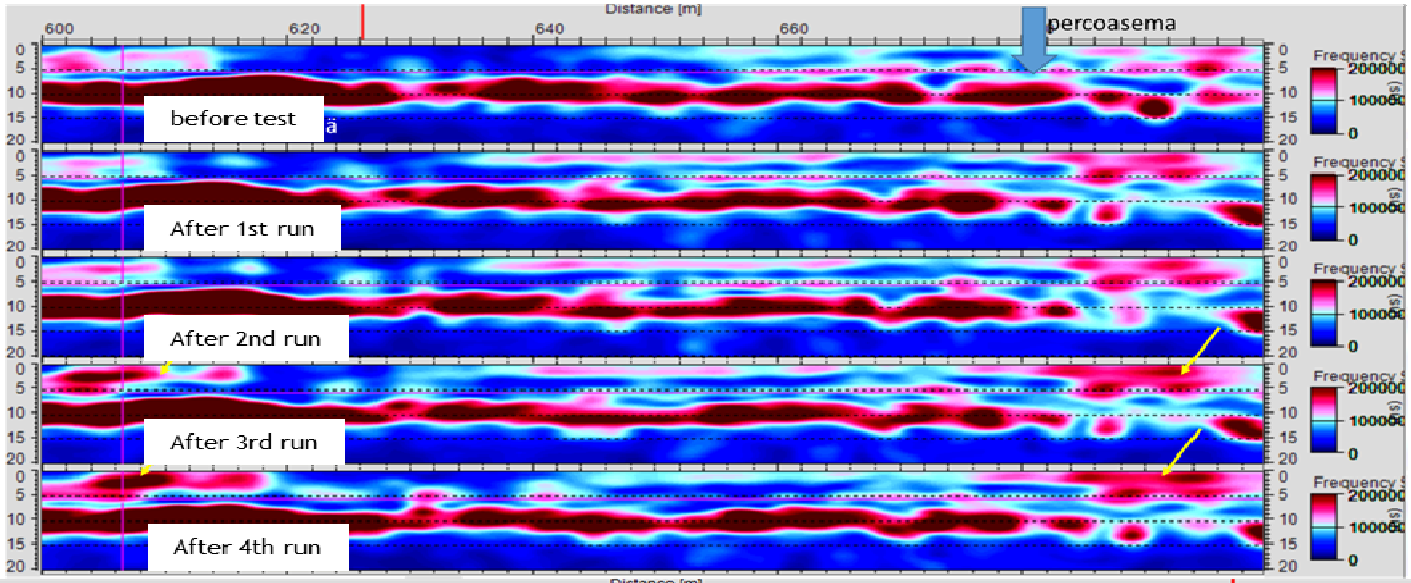
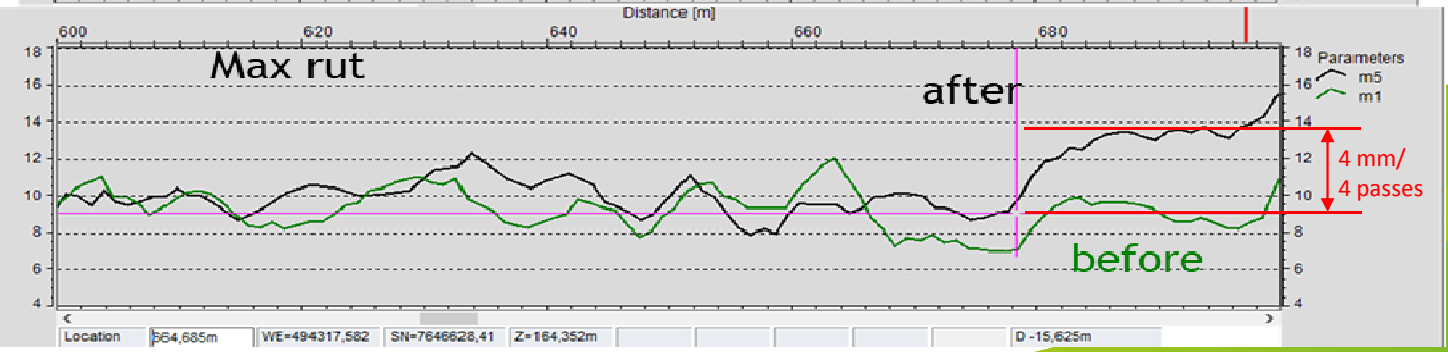
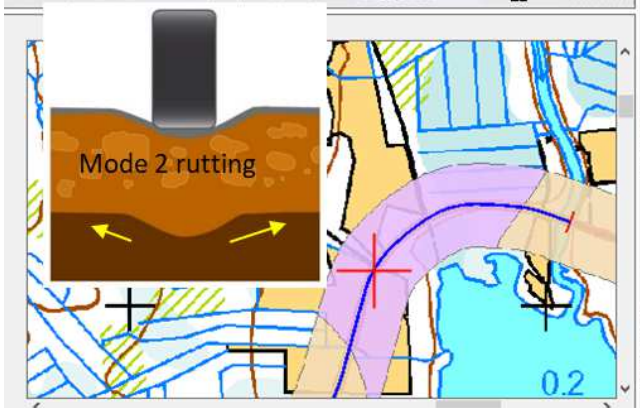
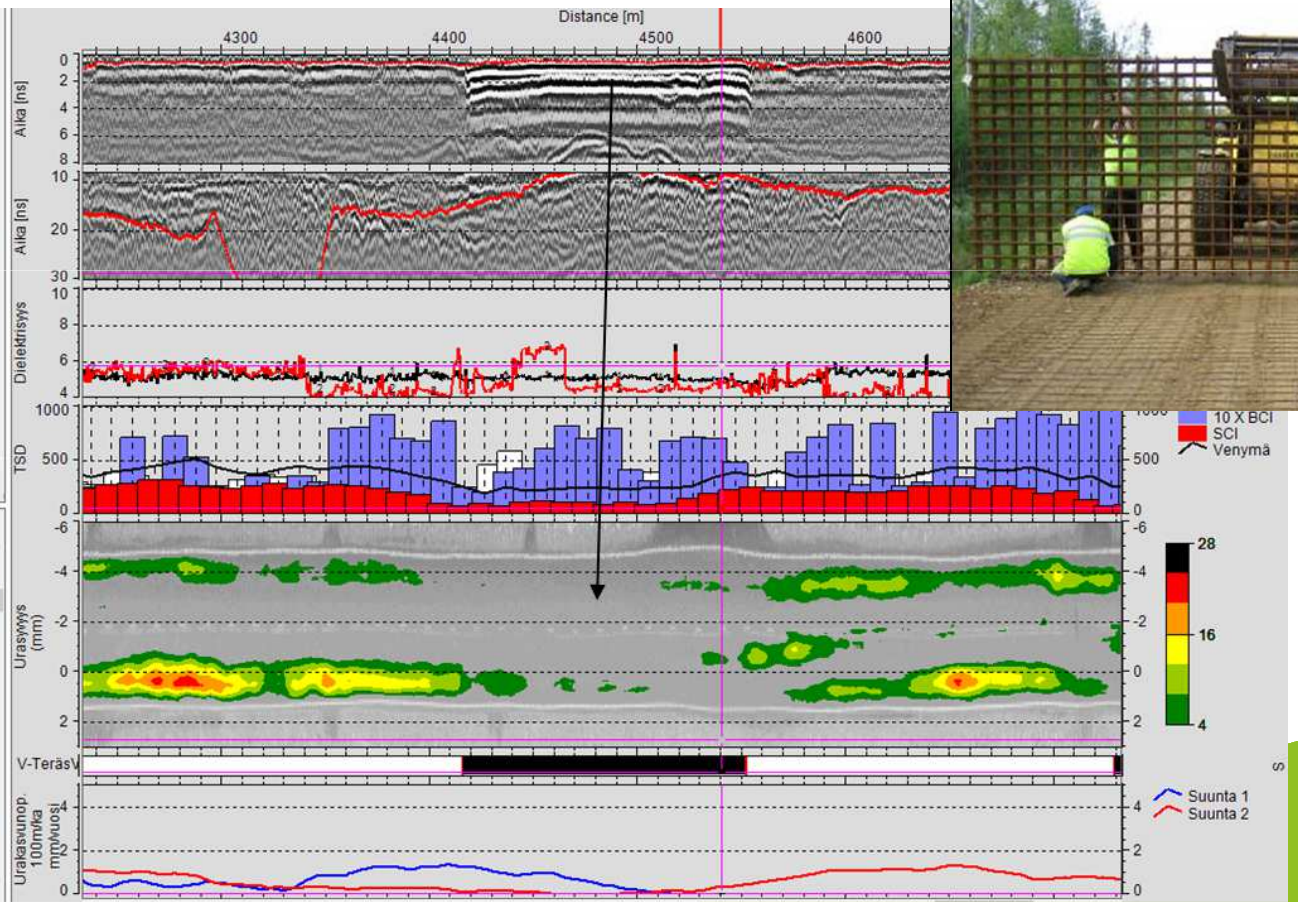




PEHKO FINDINGS: MODE 2 RUTTING

1. MODE 2 RUTTING ON WEAK SUBGRADES IS A MUCH BIGGER PROBLEM THAN EXPECTED (REASON: NEW HEAVY TRUCKS)
2. STEEL GRIDS IN BASE COURSE PERFORM VERY WELL AGAINST MODE 2 RUTTING





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EVALUATION OF THE REPAIR COSTS OF MODE 2 RUTTING PROBLEMS /USING STEEL GRIDS IN FINLAND

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- The amount of risk sections (7 %) 4.000 km

- Sections increase paving backlog 28 milj €/year

Repair costs 300-450 milj€ (main roads ~100 milj)

Mode 2 Rutting Risk, N59 Ireland

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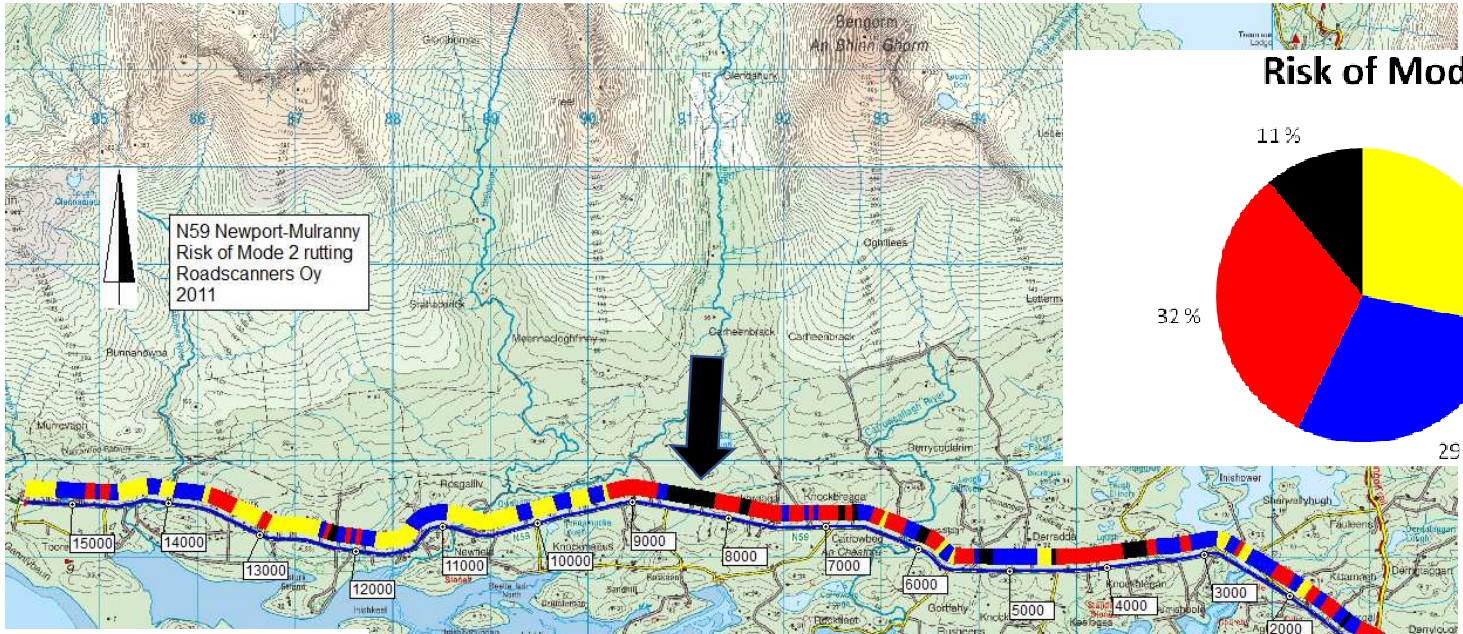

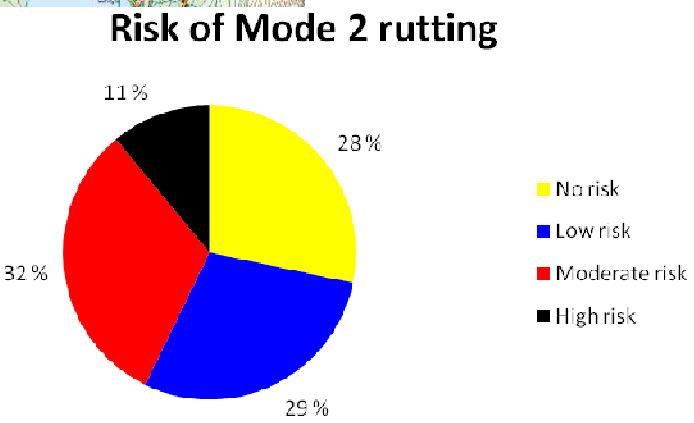

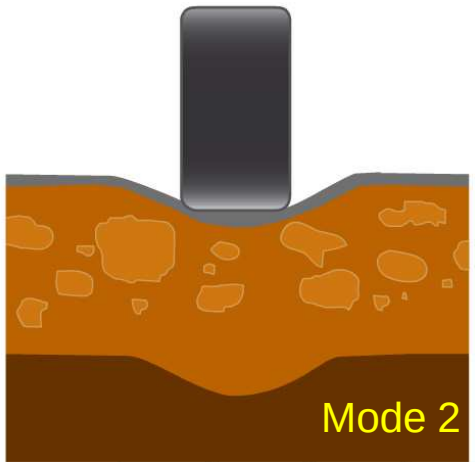

Heavy Trucks and Risk for Mode 1 Rutting

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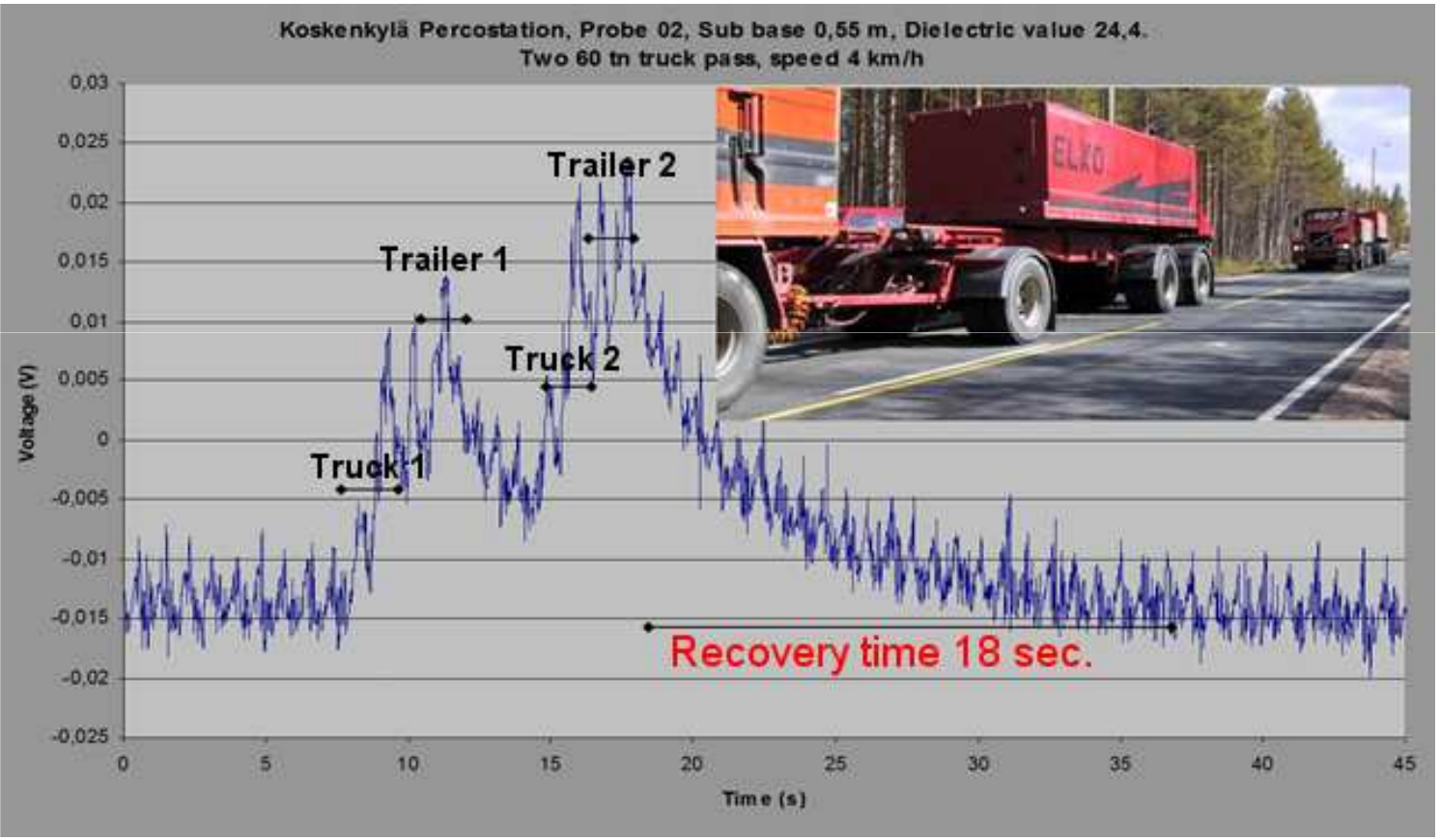
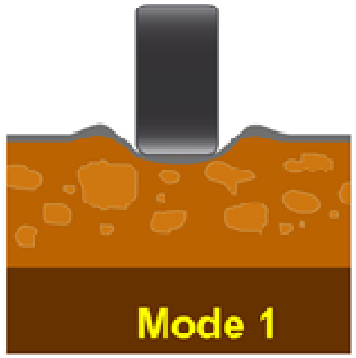




HCT tests in Central and Northern Finland in 2017-2018

Porewater pressure sensor

Displacement sensors

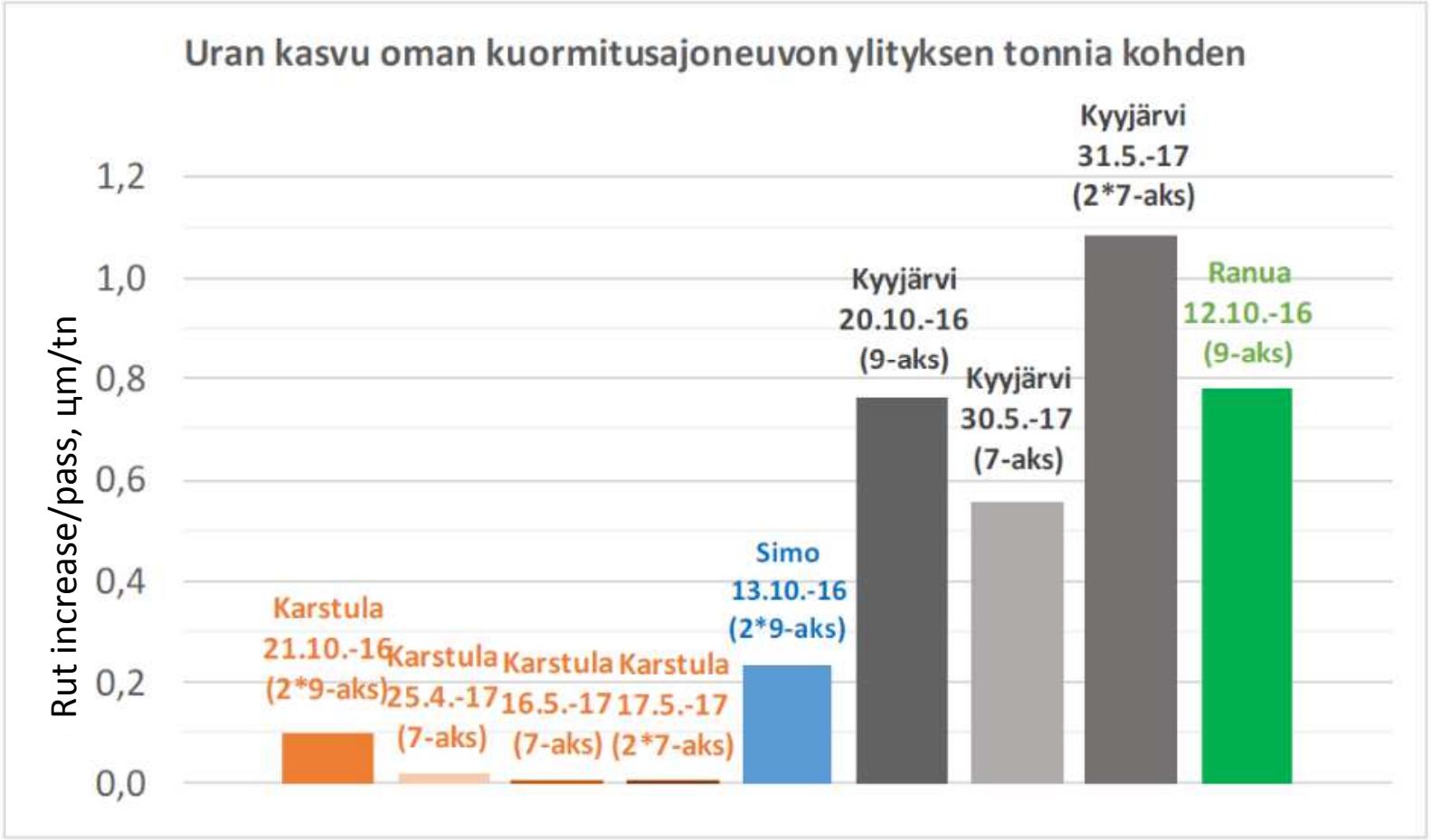
RUT INCREASE AFTER TEST TRUCK PASSES / TON

Karstula:
Strong structure
Subgrade peat

Simo
“Medium” structure
Subgrade silt

Kyyjärvi
Weak structure
Subgrade peat

Ranua
“Medium” gravel road
Subgrade silt / peat



Urasyvyyden ja pysyvän siirtymän kasvu

- Urasyvyyden ja pysyvän siirtymän kasvu koekohteen yli kulkenutta massaa kohden
- Sama massa kulki koekohteen yli samassa ajassa
- Urasyvyyden kasvun suuruusjärjestys on eri pituiselta mittausmatkalta erilainen

Gravel road

Paved road

structure improves ⬇

Kuormitus	Urakasvu tai pysyvä siirtymäero, µm/tn					
	Kaikki ylitykset			Ensimmäiset ylitykset pois		
	Pitkä väli	lyhyt väli	siirtymäero*	Pitkä väli	lyhyt väli	siirtymäero*
Ranua 2.10.2018 ap 14-aks						
Ranua 2.10.2018 ip 7-aks						
Ranua 3.10.2018 ap 7-aks						
Ranua 3.10.2018 ip 14-aks						
Kyyjärvi 30.5.2017 7-aks						
Kyyjärvi 31.5.2017 14-aks						
Kyyjärvi 23.10.2018 ap 14-aks						
Kyyjärvi 23.10.2018 ip 7-aks						
Kyyjärvi 24.10.2018 ap 7-aks						
Kyyjärvi 24.10.2018 ip 14-aks						
Simo 5.6.2018 7-aks						
Simo 6.6.2018 14-aks						
Karstula 16.5.2017 7-aks						
Karstula 17.5.2017 14-aks						
Keskiarvo **Ranua 14-aks**	**1,45**	2,17	--	**0,49**	**1,17**	--
Keskiarvo **Ranua 7-aks**	0,87	1,52	--	-0,39	-0,79	--
Keskiarvo **Kyyjärvi 2018 14-aks**	**0,60**	**1,63**	0,77	**0,14**	**1,12**	0,51
Keskiarvo **Kyyjärvi 2018 7-aks**	-0,04	-0,78	0,48	-0,51	-0,68	0,23

14-axle trucks have HIGHER RUT INCREASE Values compared to 7-axle trucks

NO DIFFERENCE between 7-axle and 14-axle trucks

Kohteen suurin mittausarvo Kohteen pienin mittausarvo

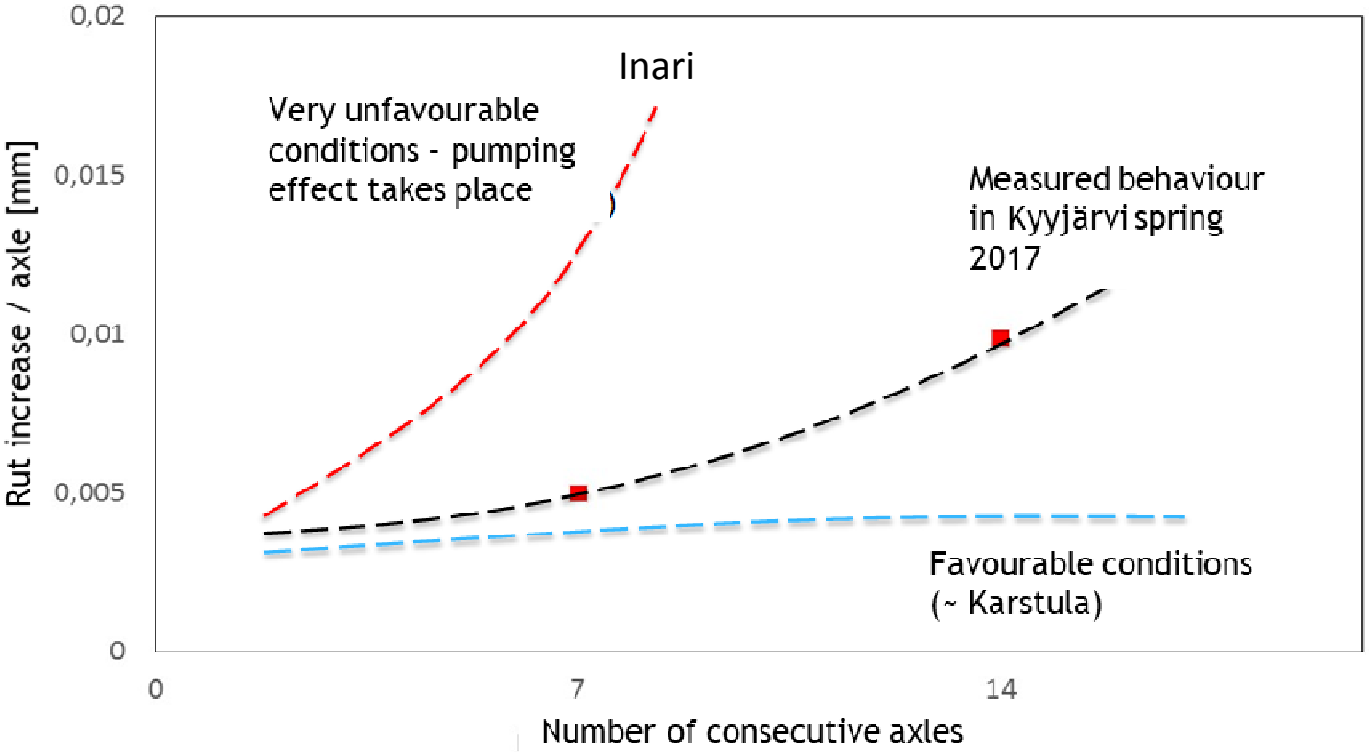
* Pystysiirtymäanturien välinen siirtymäero eli tien pinnan painumaero 0,5 m matkalla

** Pystysiirtymäanturin siirtymä

Mittausajanjakson mittausarvo lihavoitu, jos se on selkeästi suurempi tai pienempi kuin vertailtavan ajoneuvoyhdistelmän

Tampereen yliopisto ROADSCANNERS OULUN YLIOPISTO VÄYLÄ

Rut Increase / Axle vs. Number of Consecutive Axles



Unfavourable conditions (soft subgrade, high ground water table): Rutting speed accelerates

Favourable conditions (strong structure, good drainage): Rutting speed remains the same or may even decelerate over time

EFEFCT OF TYRE WANDER TO PAVEMENT FATIQUE

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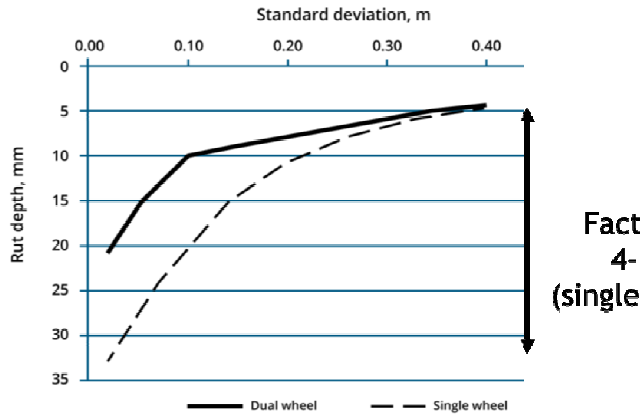
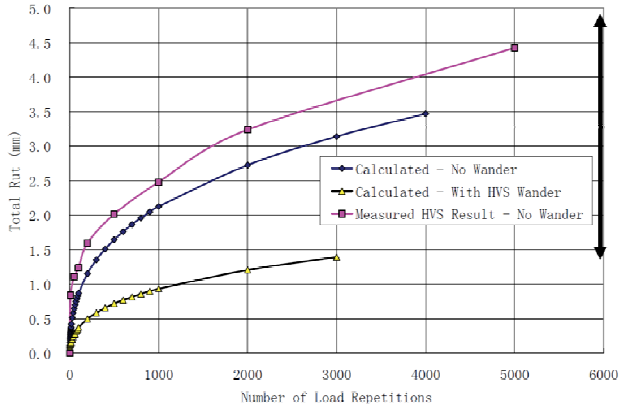
TYRE WANDER



Source: Said 2012

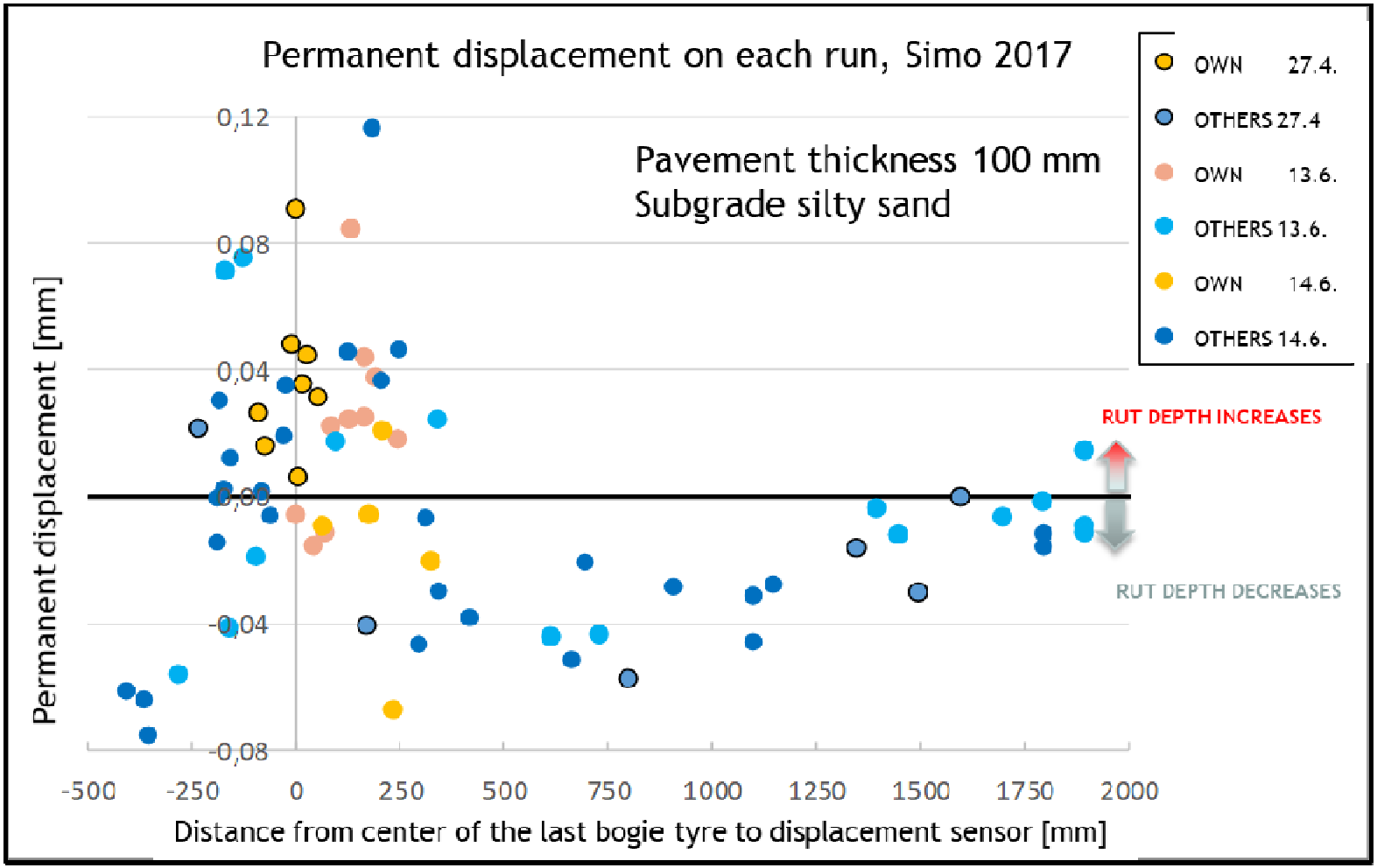
Factor:
4-5
(single tyre)



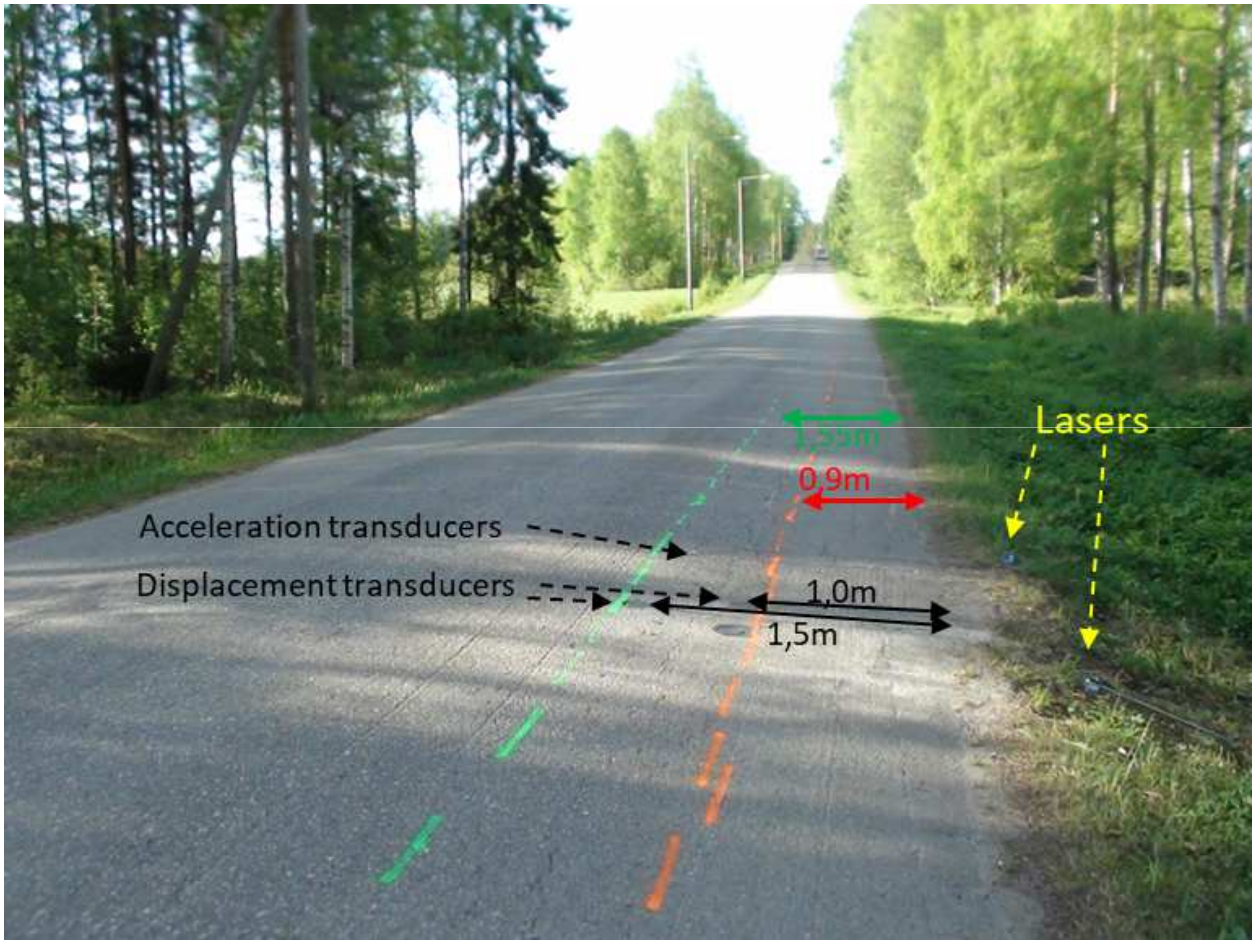
Factor:
3-4

Source: Wu and Harvey 2008

Simo Results 2017: Permanent Displacements- Pavement 100 mm



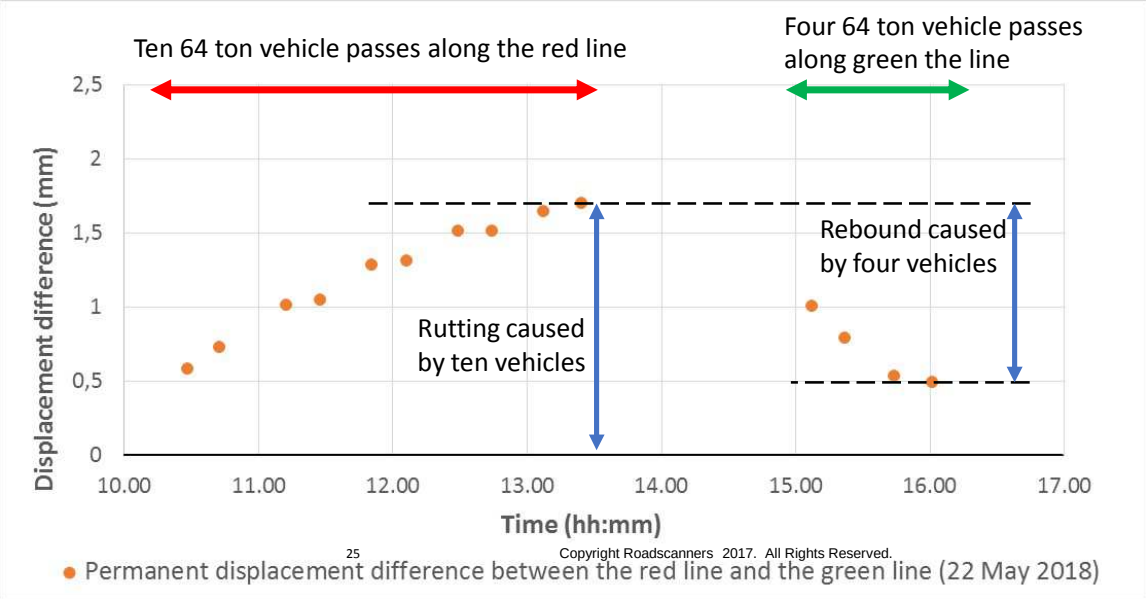
Plastic Rebound Test Site – Road 16863



- Measurements were carried out on a Low Volume Road site soon after the spring thaw in 2018
- Thickness of unbound layers about 0.5 m + a thin soft AC layer on top
- Subgrade soil peat

- → Fairly large permanent deformations were developing

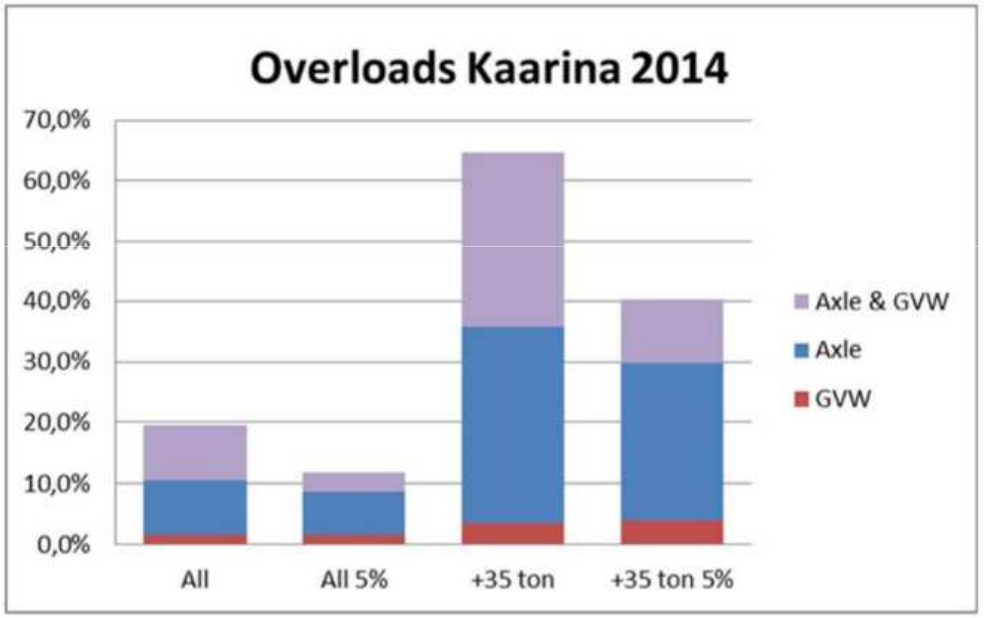
Permanent displacements – Road 16863

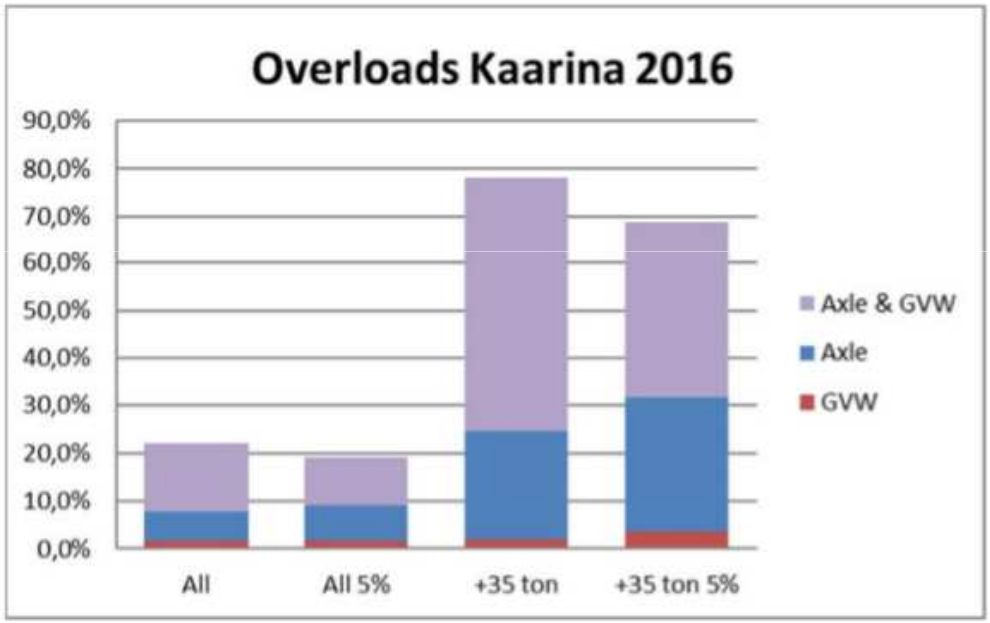


- **The largest change in rut depth is observed in connection with the first heavy vehicle driving along a certain wheel path**
- **As the number of vehicles on the same wheel path is increasing, rut depth keeps on growing but the rate is getting slower**

What we have also found in PEHKO project: increasing deformations / damages in inner curves this is due to last axles of long HCT truck drive very close to pavement edge?

OVERLOADING – WHAT HAS HAPPENED SINCE 76 TN TRUCKS STARTED TO DRIVE IN FINNISH ROADS





Source: Destia 2018

Summary: Threats and Opportunities

Threats

- Thin pavements and soft subgrade
- Tyre types and pressure
- Tyre wander
- Shoulder deformation in curves
- Overloading
- Seasonal change management
- Platoon driving

Opportunities

- CO2 emissions > 30% lower per tonne transported
- Transport costs / tonne
- Tyre wander in healing rutting
- Safety ???

THANK YOU

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Acknowledgements:

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Altti Kurki

ROADSCANNERS
Petri Varin

Thank You

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