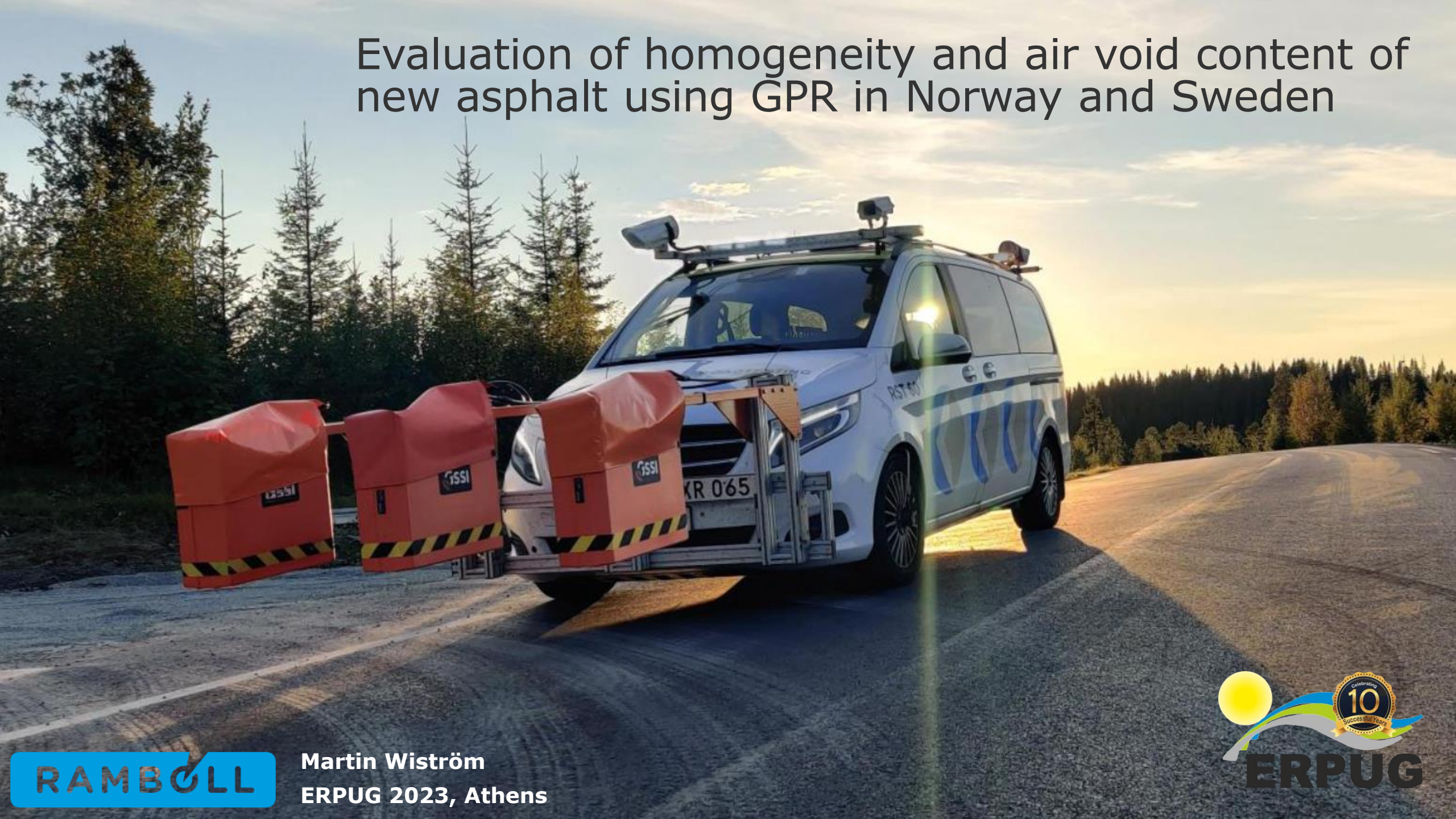
Evaluation of homogeneity and air void content of new asphalt using GPR in Norway and Sweden



Martin Wiström

ERPUG 2023, Athens

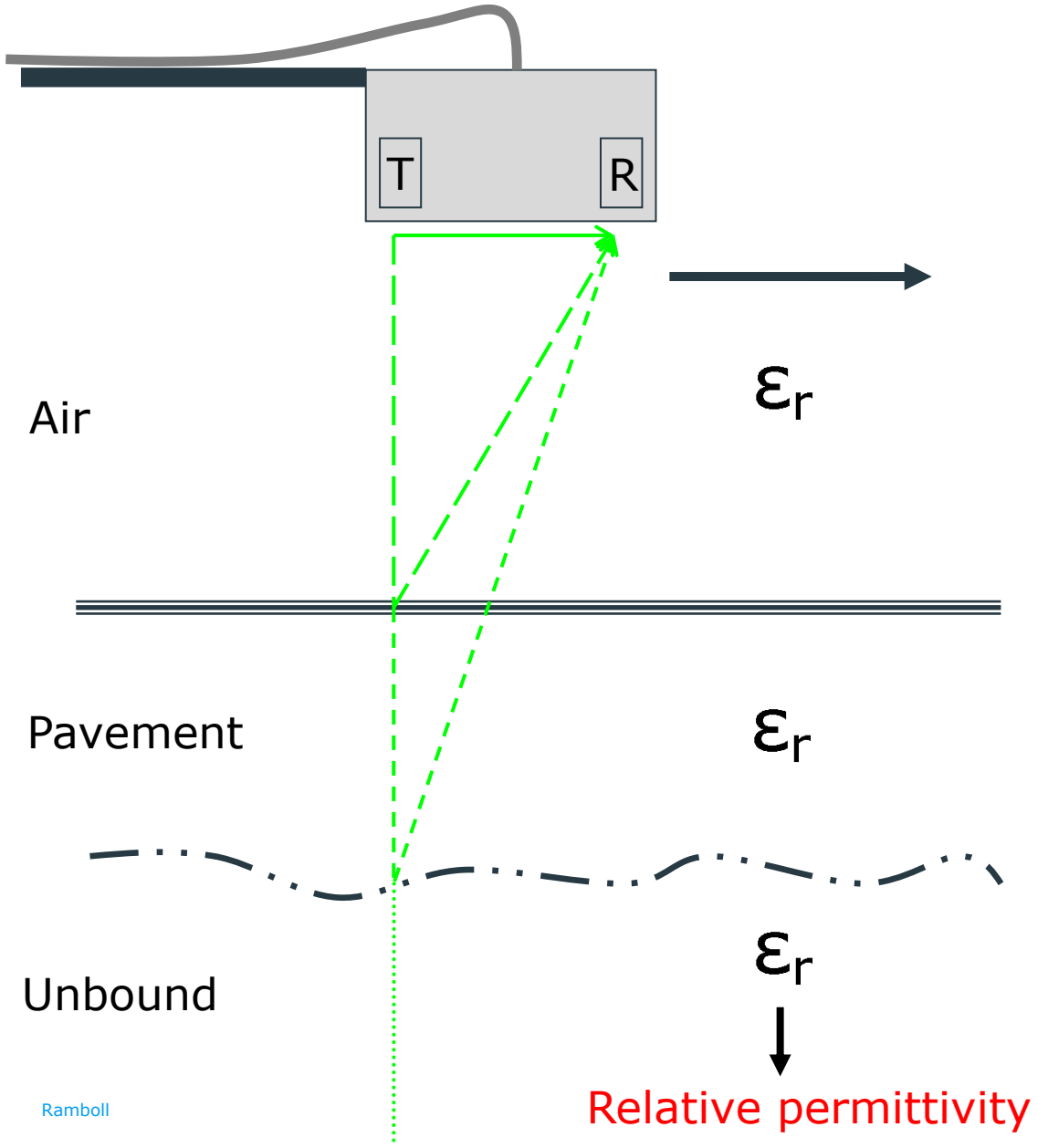
The Why do it?

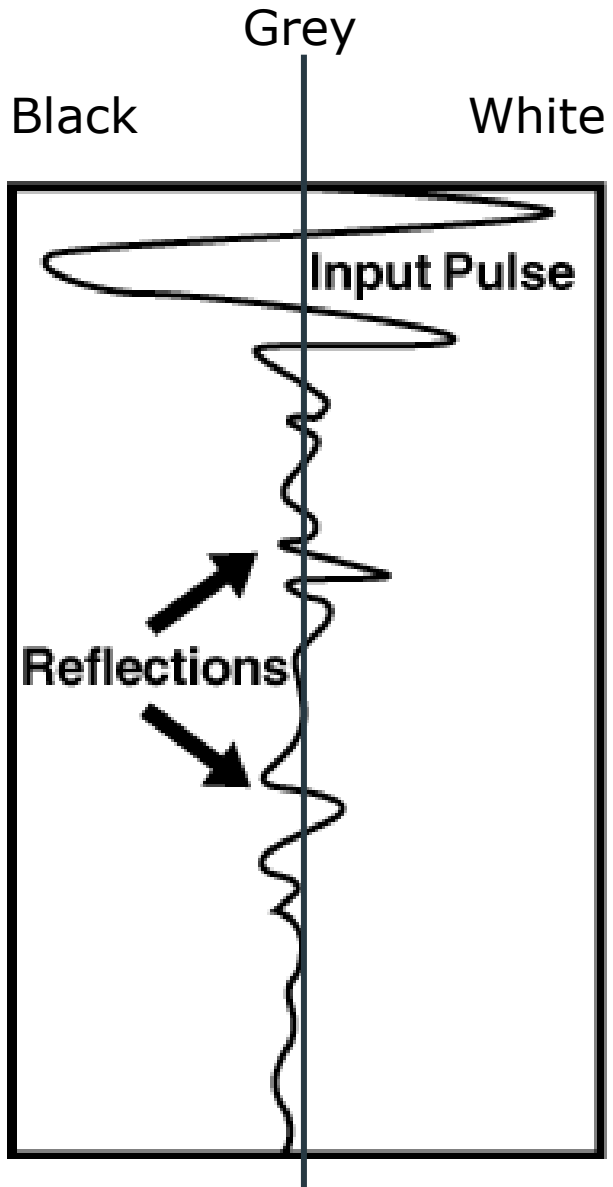
Why does the homogeneity matter?

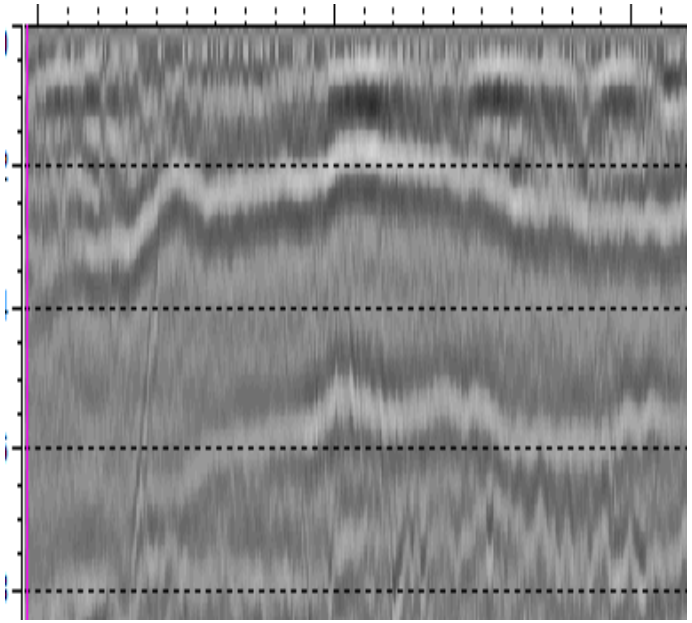
Traditional method

Air void content from cores

GPR Theory (the short short version)

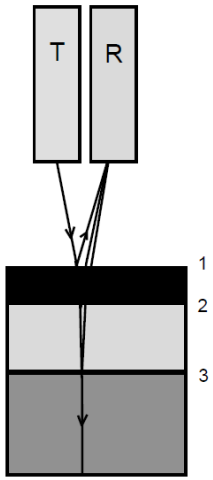


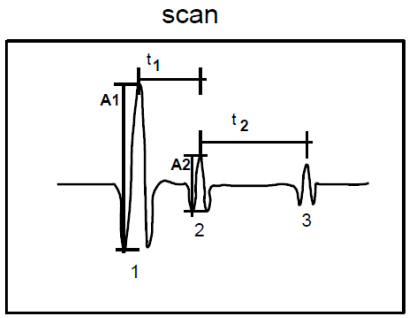




GPR Theory (the short short version)

Horn Antenna Pair



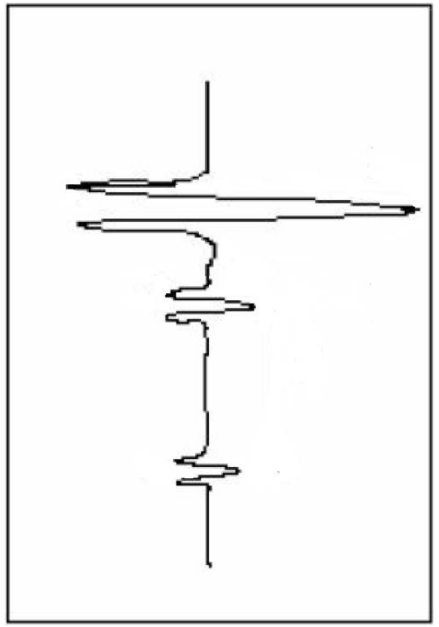


t_1 = travel time in pavement

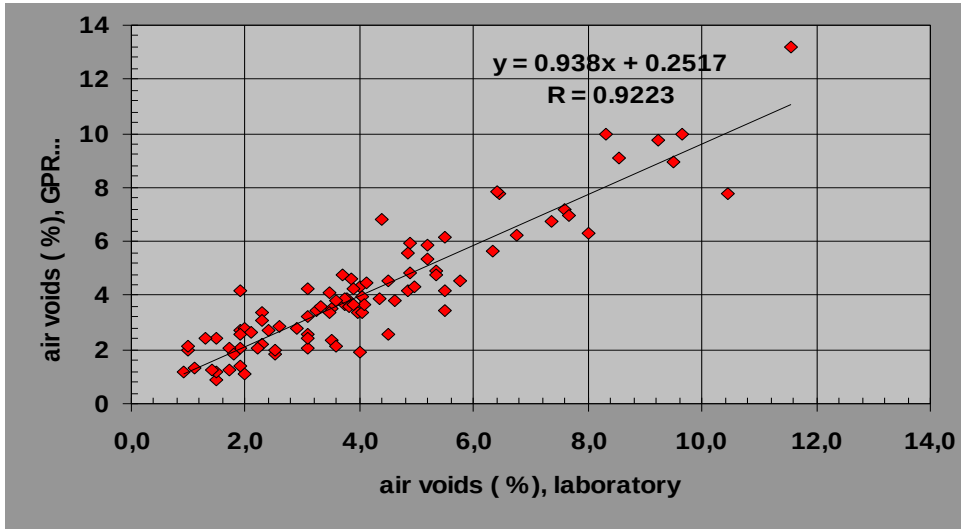
t_2 = travel time in base

A1 = amplitude of reflection from asphalt

A2 = amplitude of reflection from base



$$\sqrt{\varepsilon} = \frac{1 + \frac{A_0}{A_m}}{1 - \frac{A_0}{A_m}}$$



Sources: MaraNord Guidelines, TDOK 2014:0150, T Saarenketo

Relative permittivity, air voids and frequencies

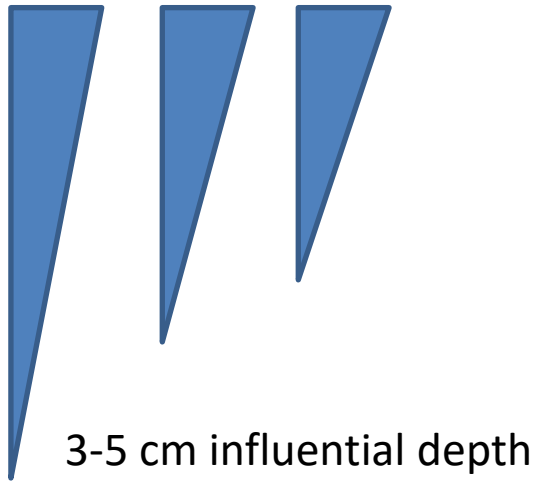
"The vertical resolution can be estimated to half the wavelength of the GPR signal, which in turn is dependent on the relative permittivity of the material and the central frequency of the system"

$$h = \frac{\tau \cdot c}{2 \cdot \sqrt{\varepsilon_r}}$$

c = the speed of light in vacuum (0.3 m/ns)
τ = the pulse length (ns)
ε_r = medium's relative dielectricity

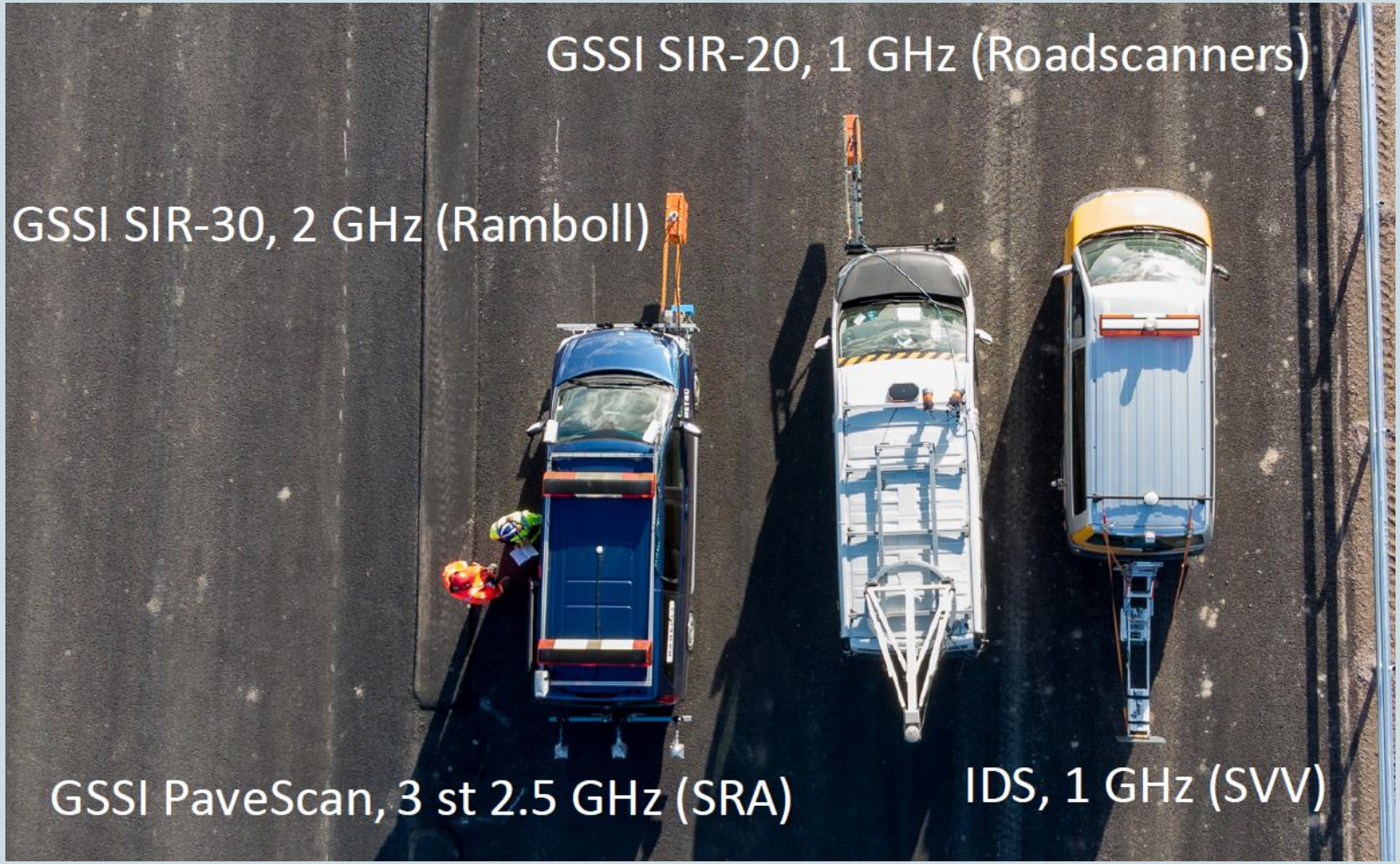
Relative permittivity

Air	$\varepsilon_r = 1$
Bitumen	$\varepsilon_r = 2.6$
Aggregate	$\varepsilon_r = 5\text{-}9$
Asphalt	$\varepsilon_r = 4\text{-}8$
Water	$\varepsilon_r = 81$



$$Air\ void\ content = 272{,}93\ e^{-1{,}3012 \cdot k \cdot \varepsilon_r}$$

Recent development and testing in Nordics



Identified topics

Variation between sensors and systems

When to do the measurement?
Weather conditions

What should be evaluated?

Recent development and testing in Nordics

Identified topics

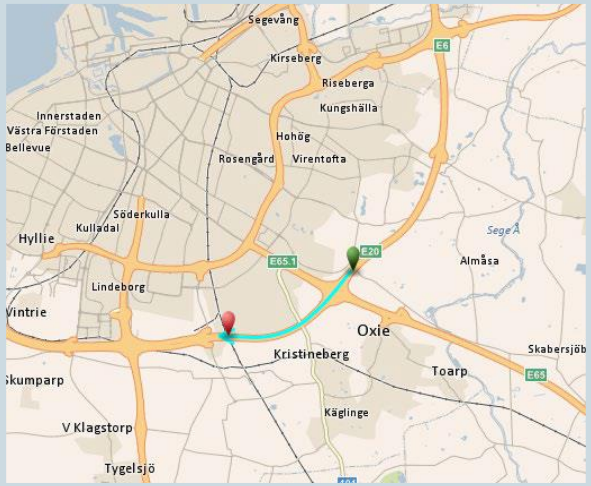
Variation between sensors and systems

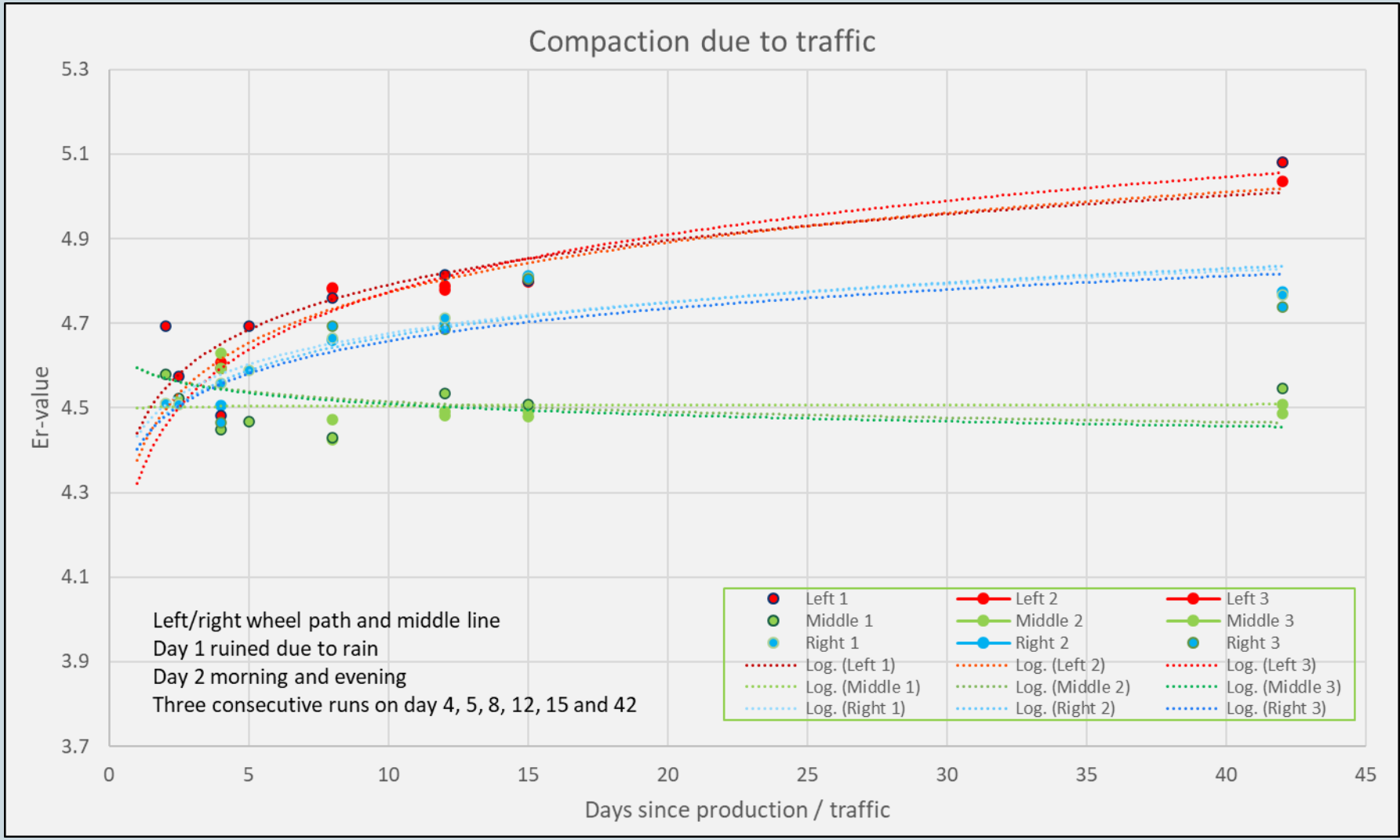
Effect on air void content / E_r due to traffic

3500 meter section, SMA16

AADT 20 000, 10% heavy

Measured on day (1, rain), 2x2, 4, 5, 8, 12, 15, 42





Current Norwegian method

Three lines, R/M/L

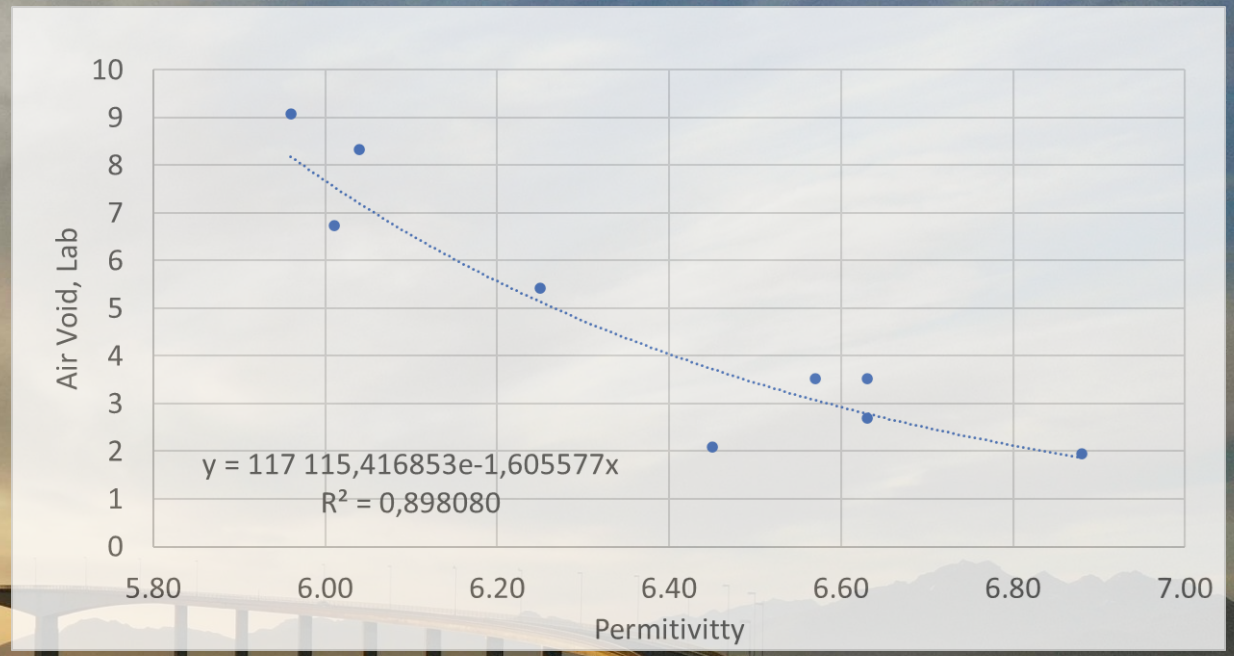
2 meters average values

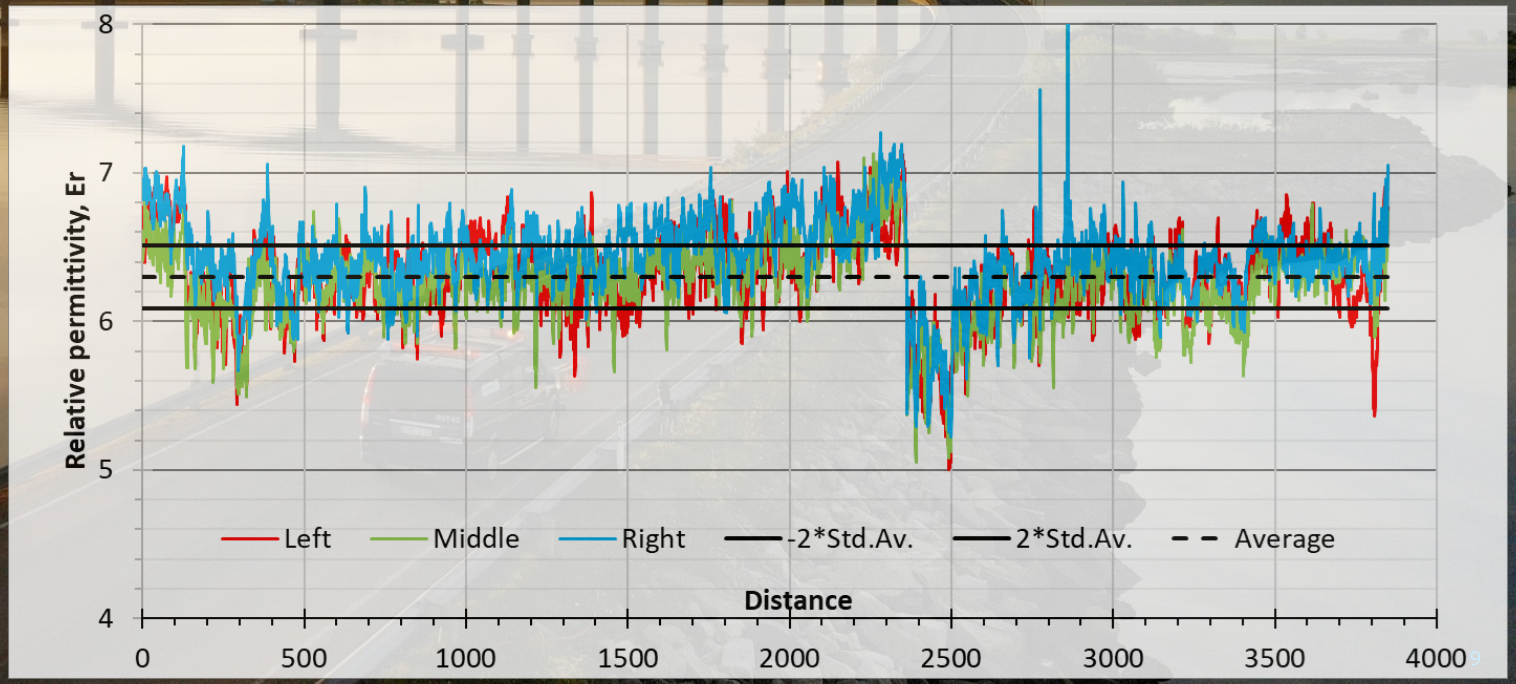
Analyse data in field and identify areas with average, low (ave-2σ) and high (ave+2σ) dielectric values

Static measurement in 12 points, 30 seconds each

Drill cores from 9 of these

Fit a curve and analyse air void content





Current Swedish method

Verification of equipment with short- and long-term stability

Three lines, R/M/L

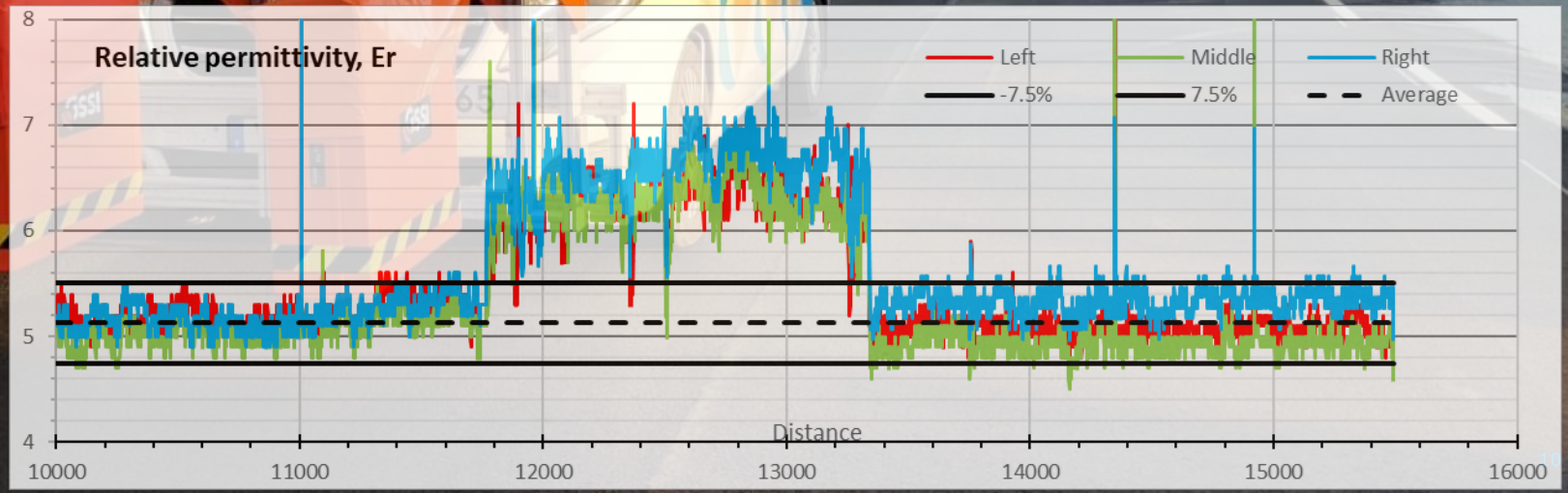
Calibration on HDPE-plate to control variations

1 meter average values

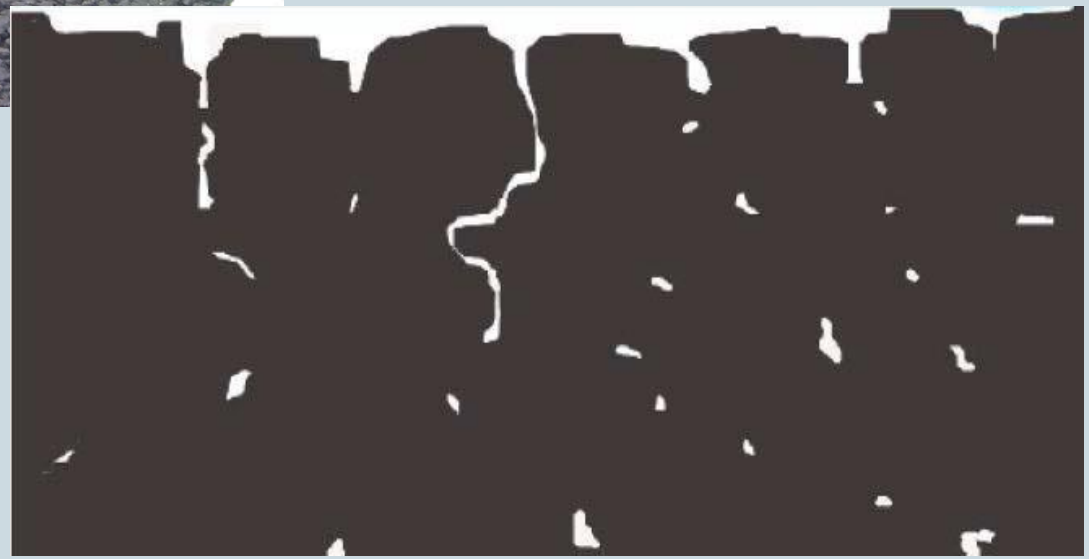
No static measurements and only evaluation on homogeneity by ε_r-values

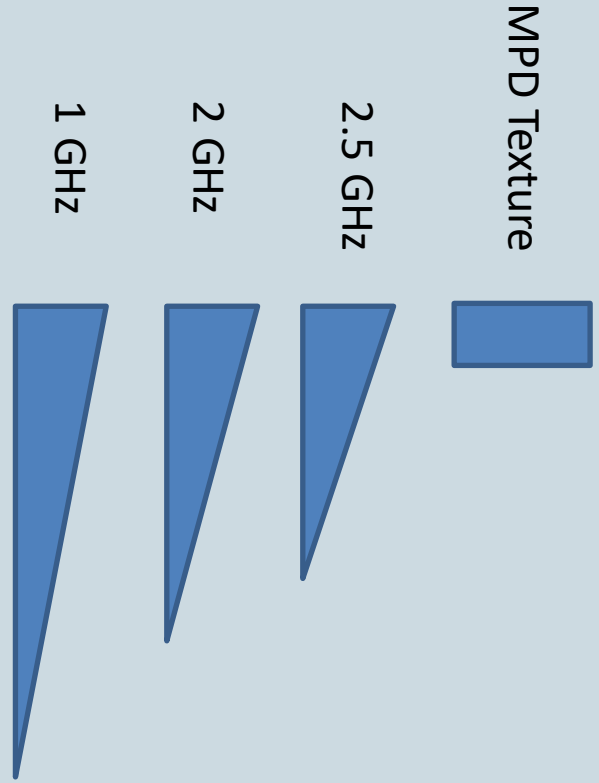
Limits set to average ±7.5%

If approved values <90% -> Traditional method



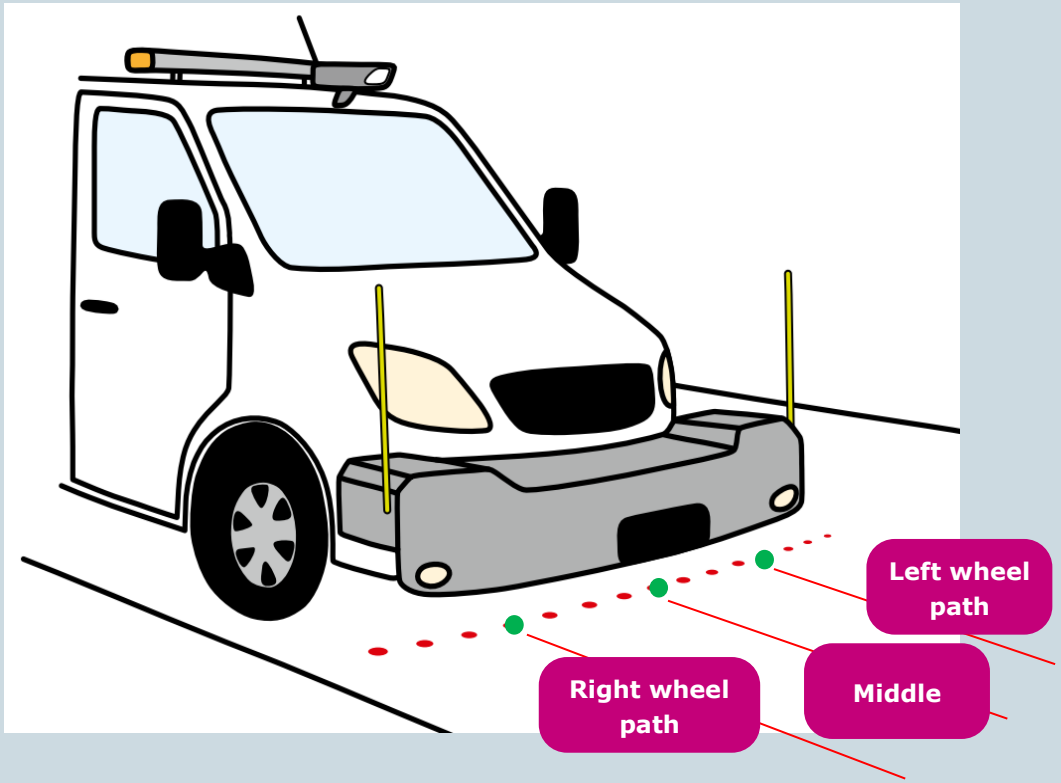
If only there were other methods…

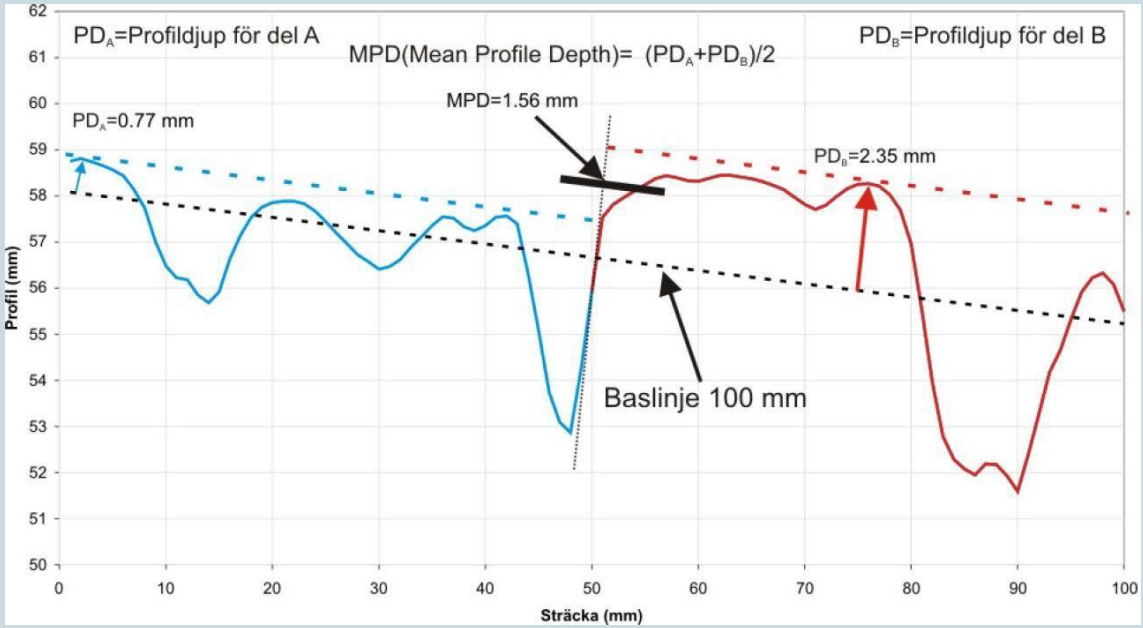




TEXTURE – MPD from longitudinal profiles

Makrotextur, filtered for 0.5-50 mm and treated according to ISO 13473-1





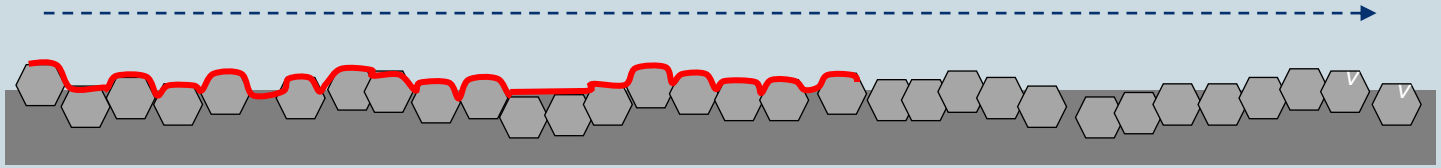
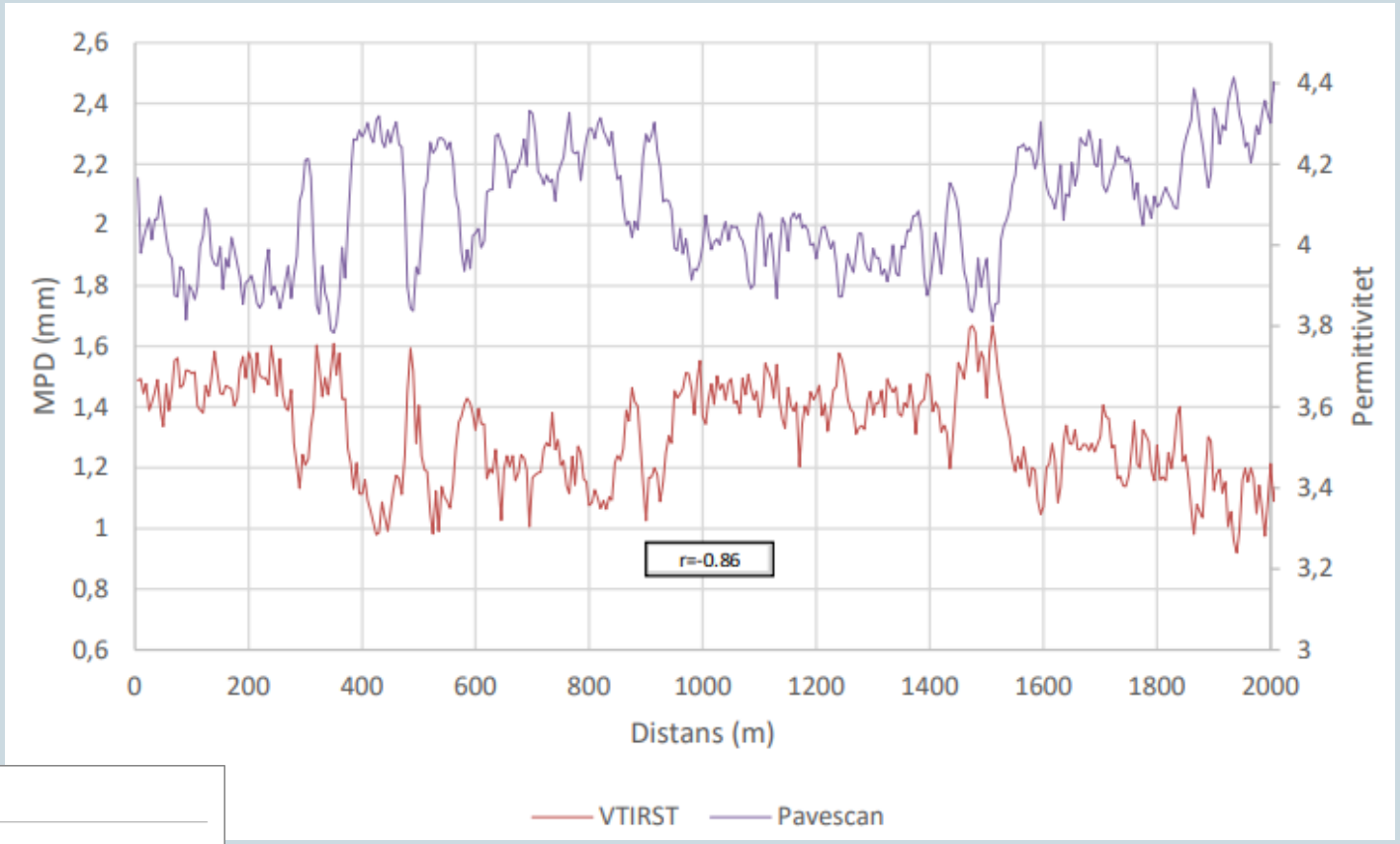
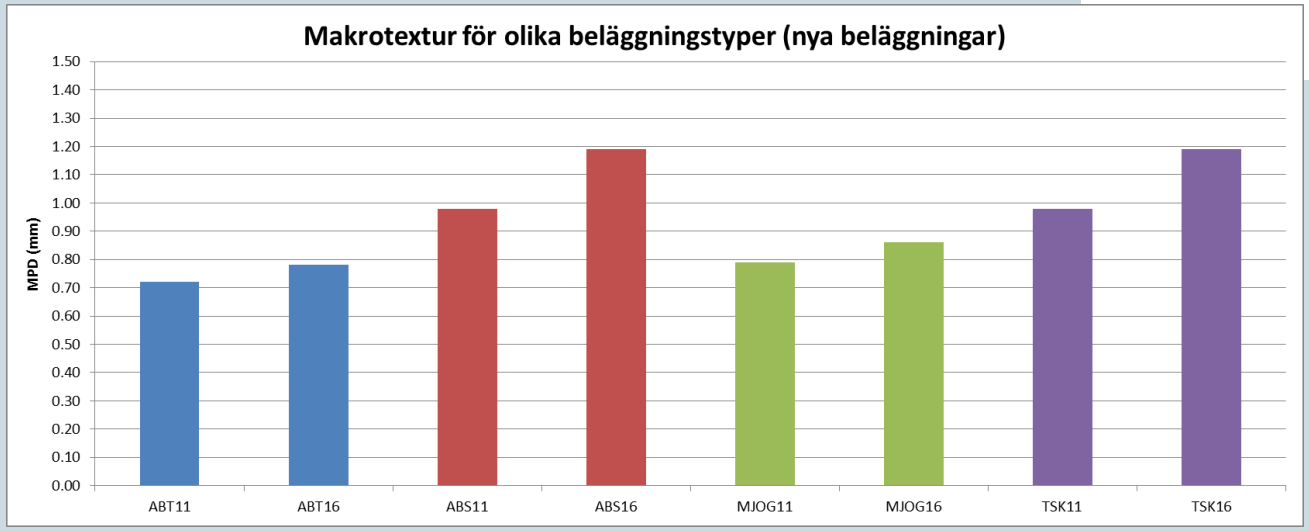


Bild: VTI


Jämförelse av makrotextur och permittivitet
vti


MPD (mm)
Permittivitet
Distans (m)
r=-0.86
VTIRST
Pavescan


Makrotextur för olika beläggningstyper (nya beläggningar)
MPD (mm)
ABT11
ABT16
ABS11
ABS16
MJOG11
MJOG16
TSK11
TSK16

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