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Experience of GPR from Norway

used for measuring air void content in asphalt

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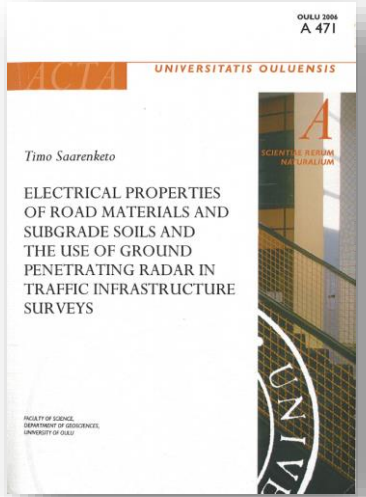
Collaboration with Roadscanners OY in Finland

- NPRA, Northern Region – Collaboration with Saarenketo thru the ROADEX project
- Method presented in Timo Saarenketos PhD-thesis



- Roadscanners OY did the first void measurement using GPR in 2016 in Troms County. Two tunnels in Tromsø was measured. Approximately length 7 km.

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GPR – 2016–2018

- In Northern Region the measurements are manly done by Roadscanners.
- One consultancy from southern Norway did some measurement, but was unable to produce any results.
- NPRA, Central Region has performed some measurement in the southern part of Northern Region.

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GPR – Roadscanners OY

- Air-coupled antenna
  - GSSI SIR-30 system with GSSI 2 GHz model 42000S and GSSI 1 GHz model 41000S
- Ground-coupled antennas
  - GSSI 400 MHz model

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Measurements in Northern Region

- 2016 – approx. 7 km
- 2017 – approx. 14 km
- 2018 – approx. 50 km

- 2019 – will measure approx. 230 km

In 2018 only 13 km were analyzed because the laboratory staff did not have the capacity to take drill core samples for calibration.

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GPR-measurements in Northern Region

- 2017 – The tender documents for 2017 assumed that the asphalt contractors themselves should ensure that the GPR-measurements were carried out.
  - one consultancy used by the contractors, failed to deliver results

- For 2016 and 2018, NPRA engaged a consultancy firm to conduct the measurements and this will also be done In 2019. Based on the tender document and received offers, it will be decided which consultancy that shall perform the measurements.

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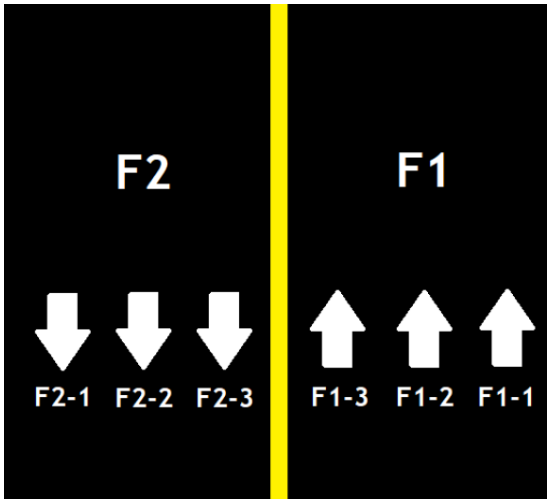
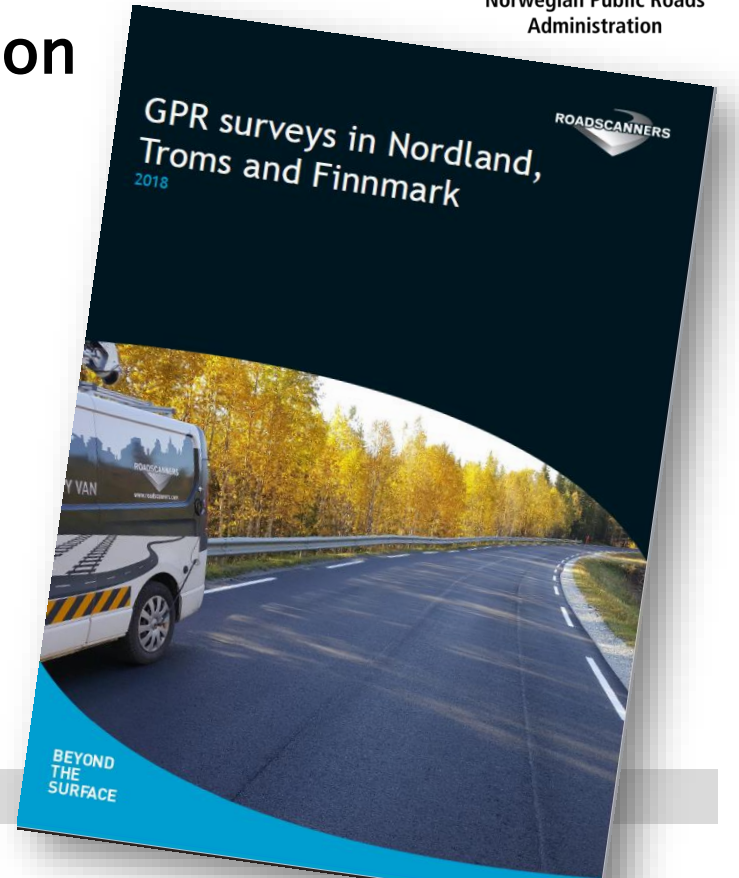
Examples form Northern Region



ε_r recorded in three longitudinal lines for each lane



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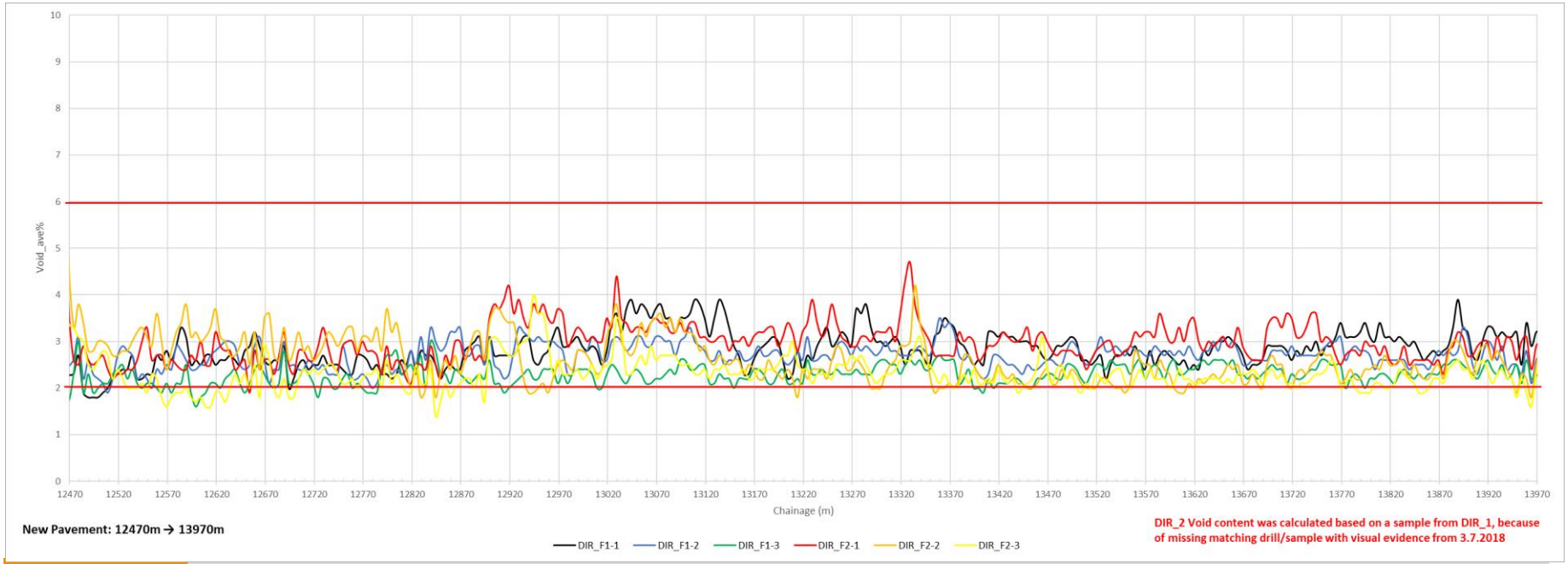
Example 1 – Ev8, hp 6. Air void content.



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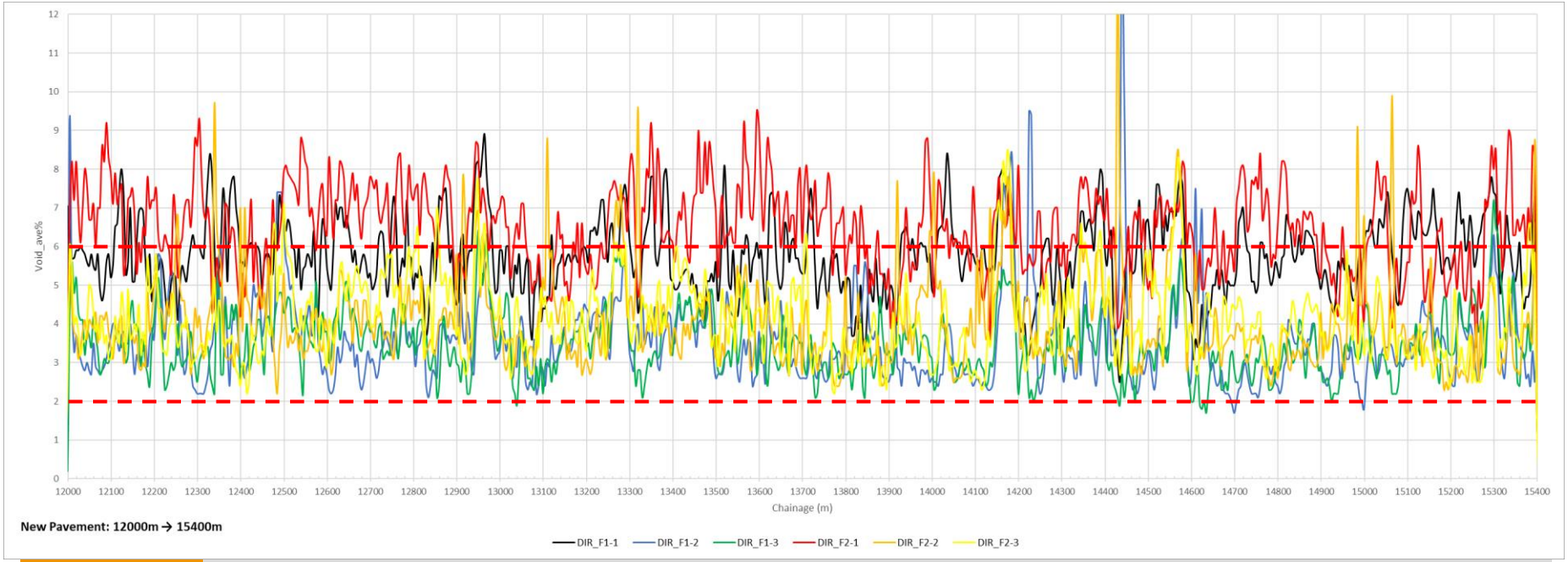
County road in Troms. Air void content.



Air void content F1-2 vs F1-3
Moving averages

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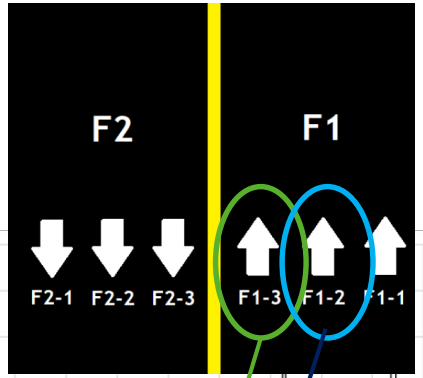

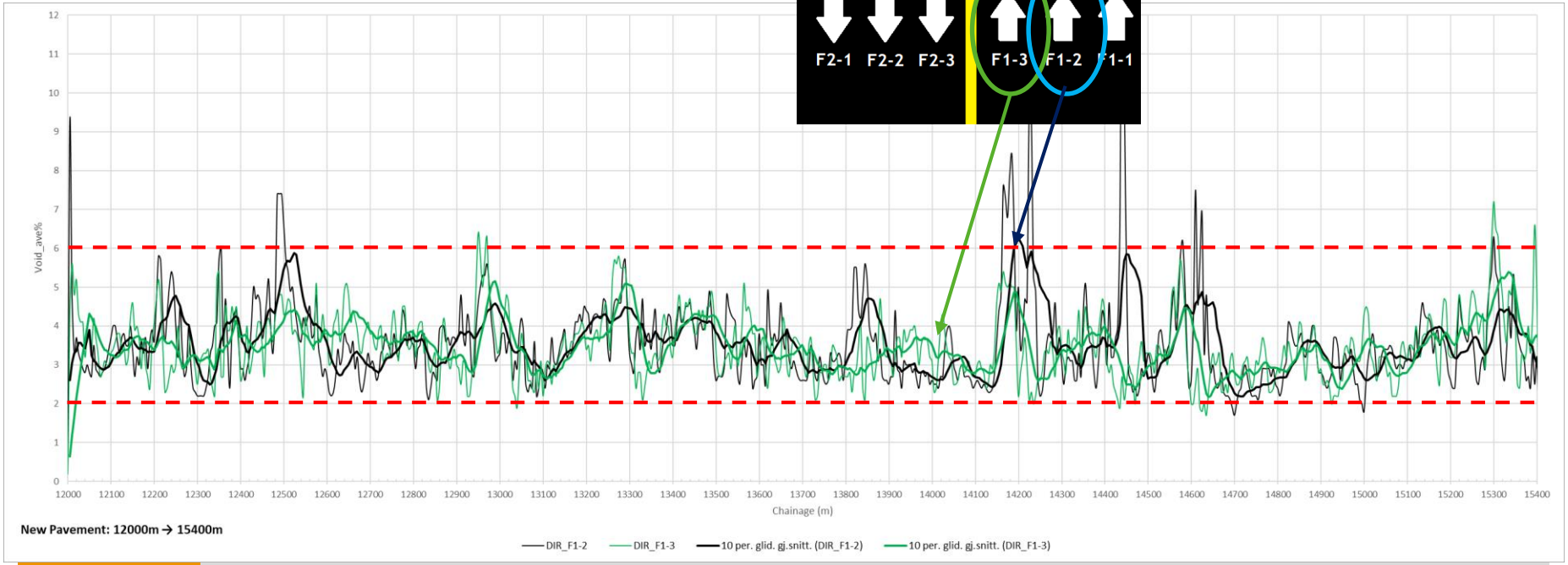

Air void content F1-2 vs F1-1
Moving averages

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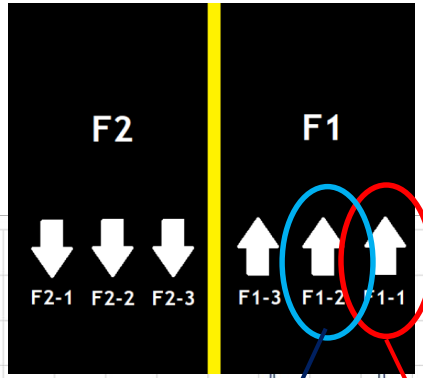

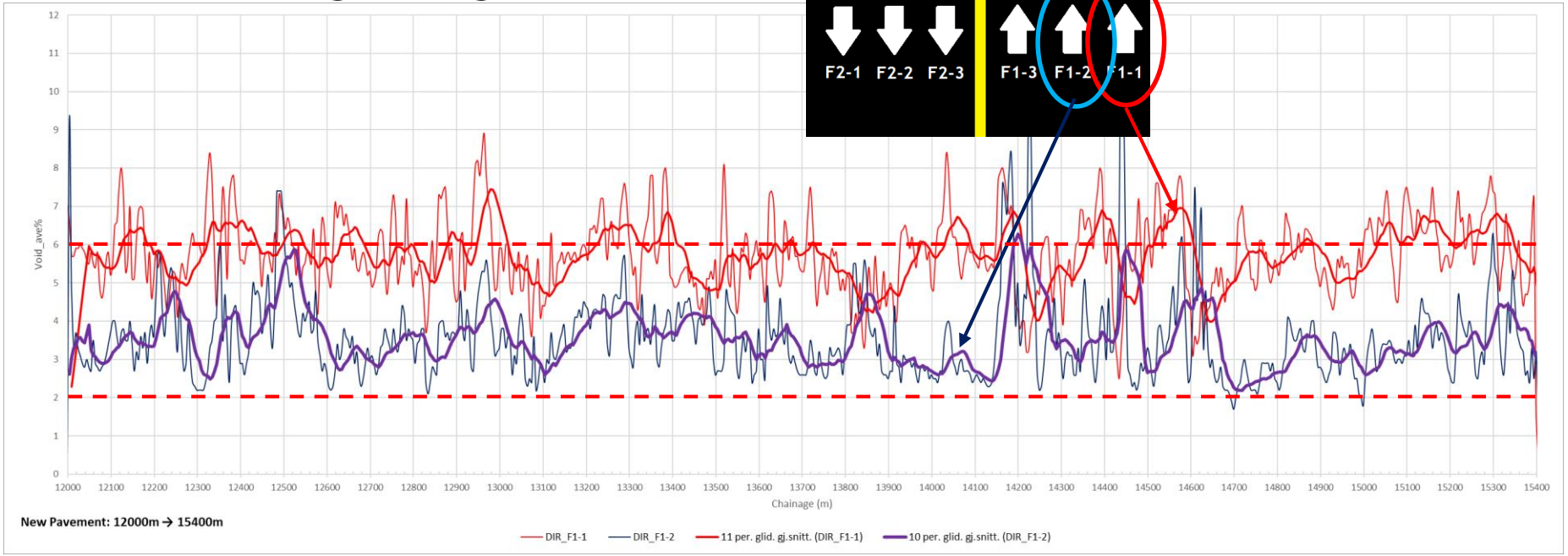

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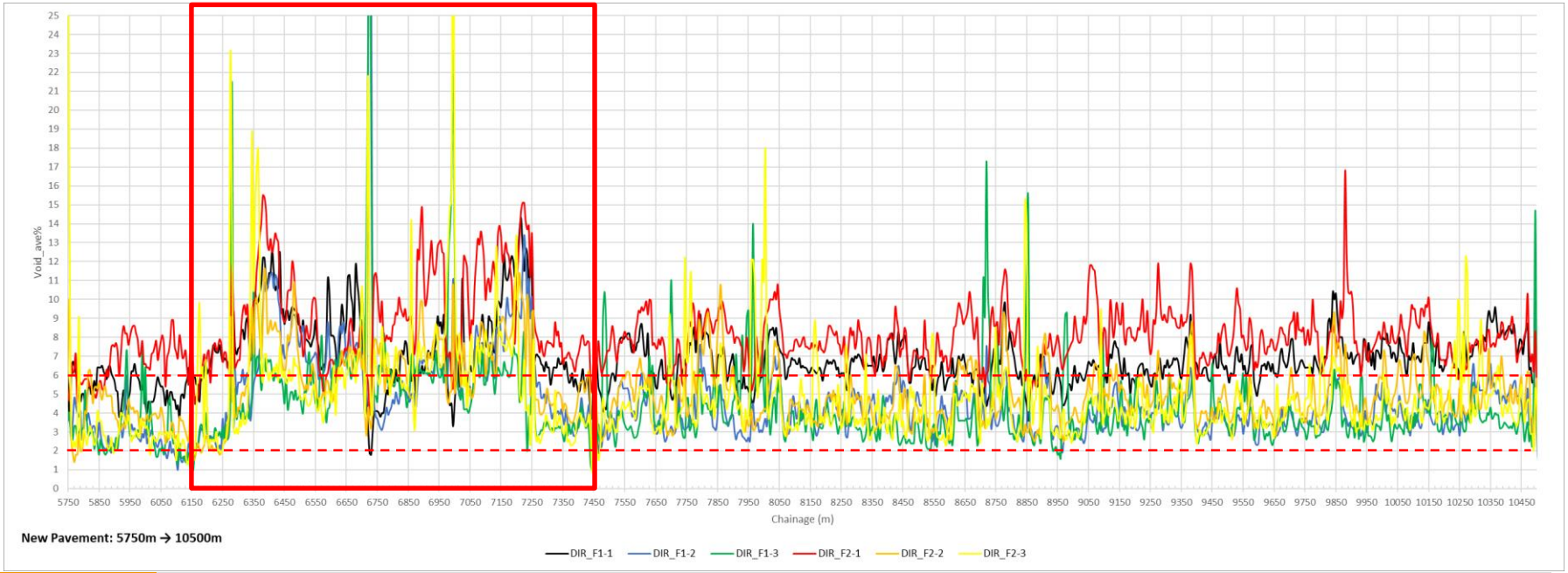
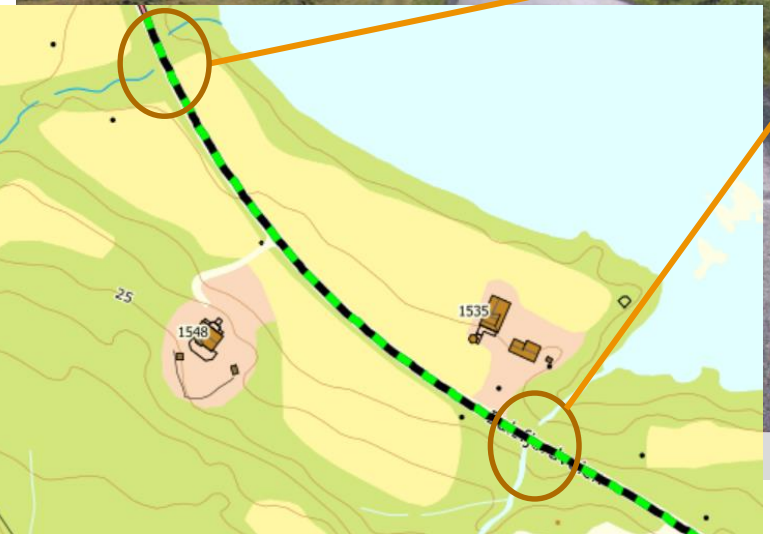
Another county road in Troms County




25
1548
1535

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Experiences form NPRA, Eastern Region

- Measurement was done by NPRA, Central Region
- Started in 2017 and measured about 156 km
- In 2018 we measured approx. 124 km
- Only one logitudinal line between the wheel paths is measured!

- Terratec AS measured 4 section (8,6 km) using 3D-radar in 2018
- The aim was to evaluate the equipment for determine the void content in asphalt

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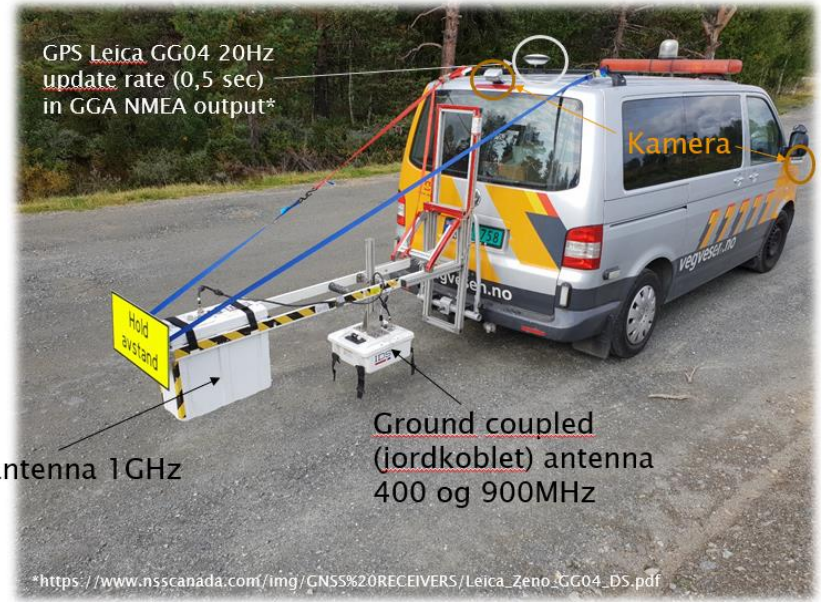
GPR – NPRA, Central Region, Trondheim

- **NPRA, Central Region:**
  - IDS Hi-pave system (Ingegneria Dei Sistemi S.p.A)
  - Horn antenna 1,0 GHz (10 scann/m)
  - Ground coupled antenna 400 and 900 MHz



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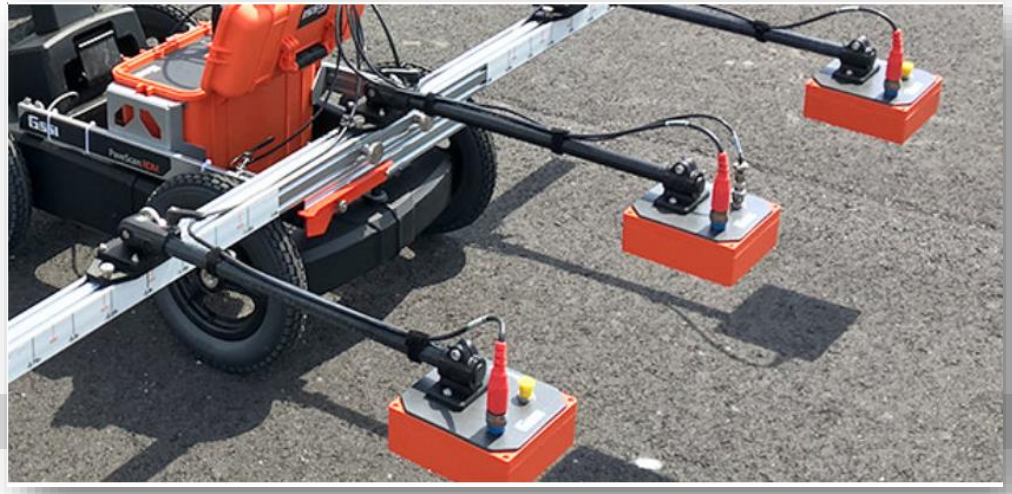
NEW EQUIPMENT!

- Central Region has ordered a PaveScan RDM with three sensors!
- Will be mounted on a car.



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Nuclear Gauge

- Normally used in Eastern Region for quality control
- Only for identifying areas where the demands for void content are not fulfilled
- Only void content from drill core specimens are accepted as proper void content – currently

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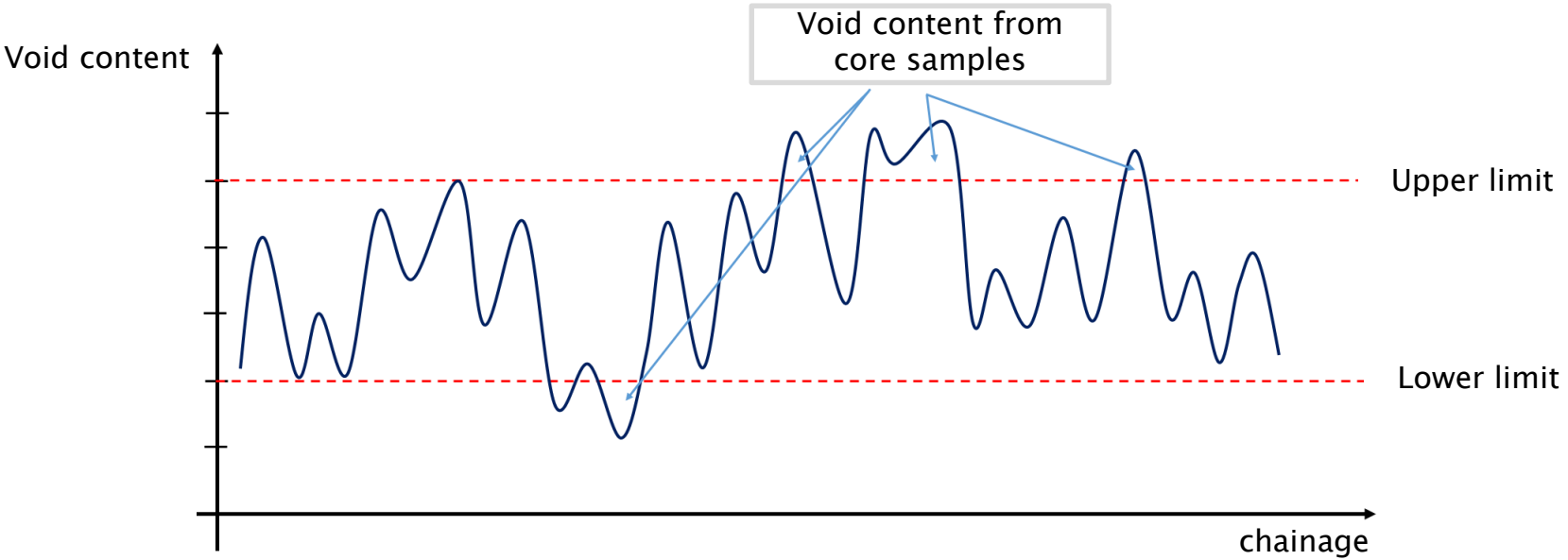
Void content – first calibration using nuclear gauges



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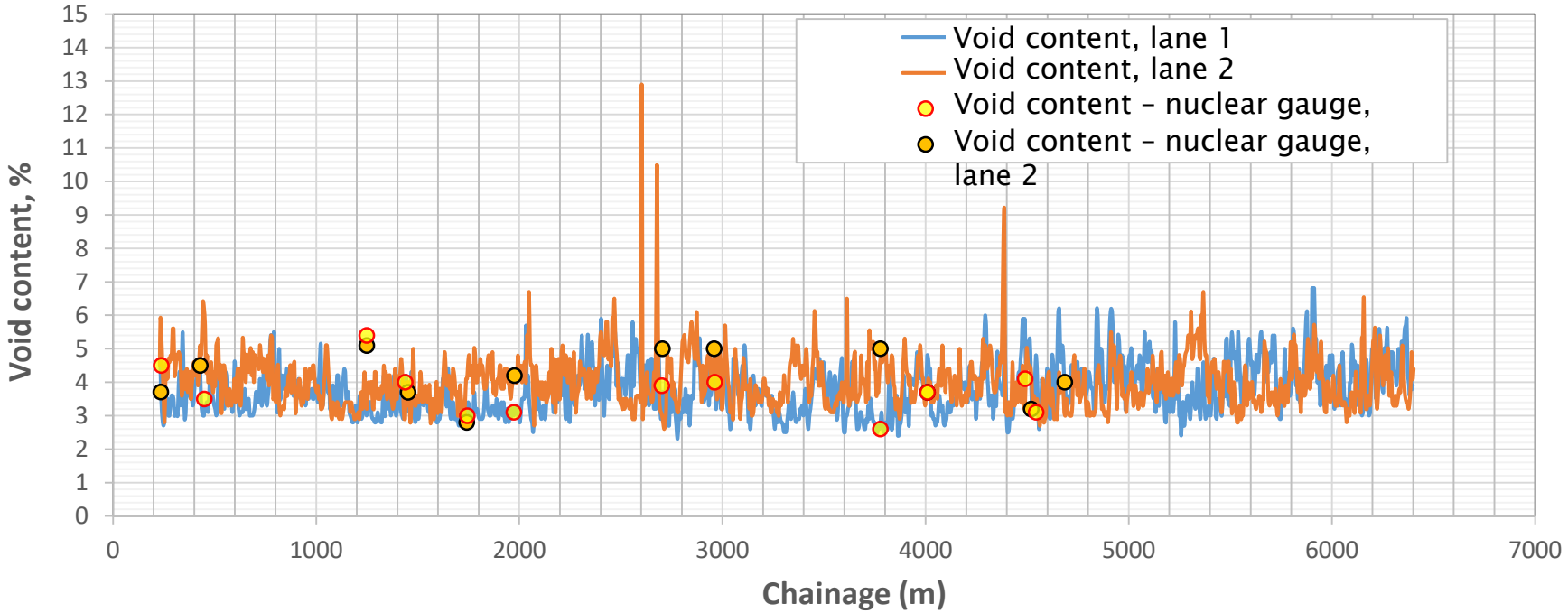
Example: Fv123, hp 3, lane 1 og 2



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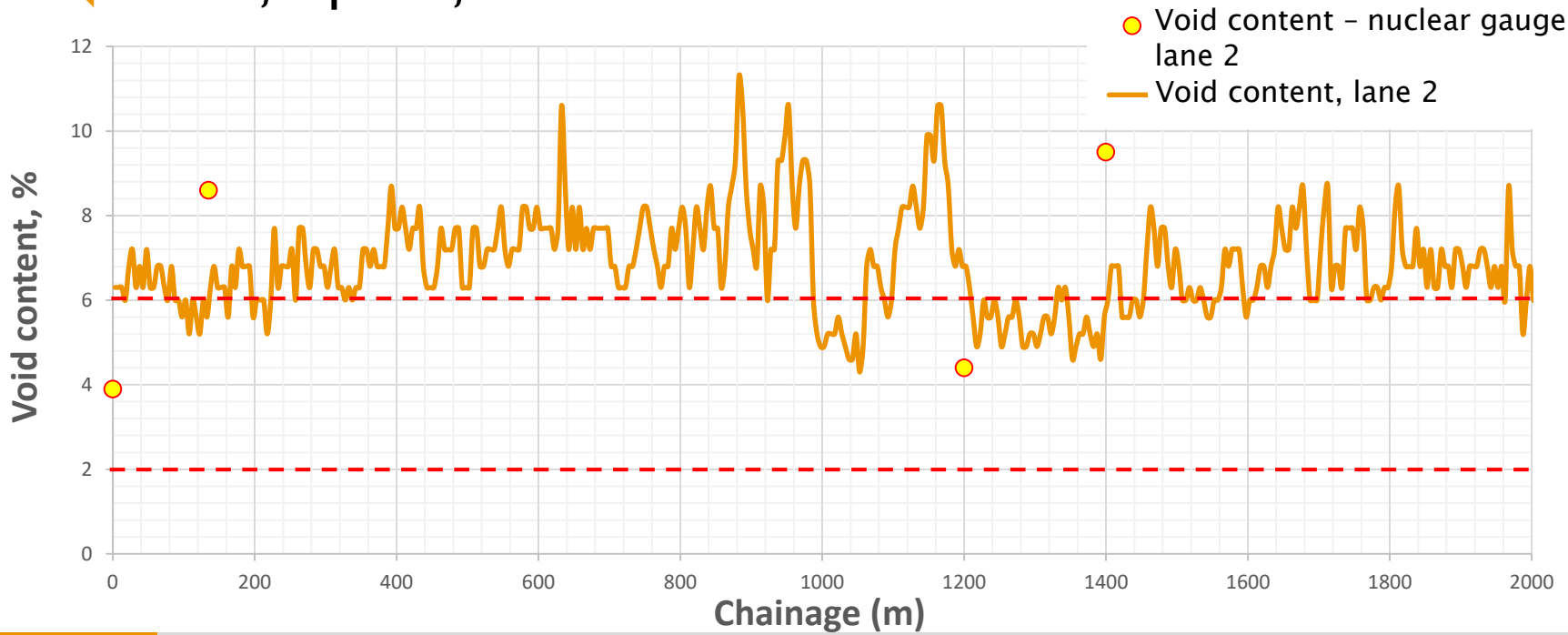
Example
E18, hp 10, lane 2 – SMA 16



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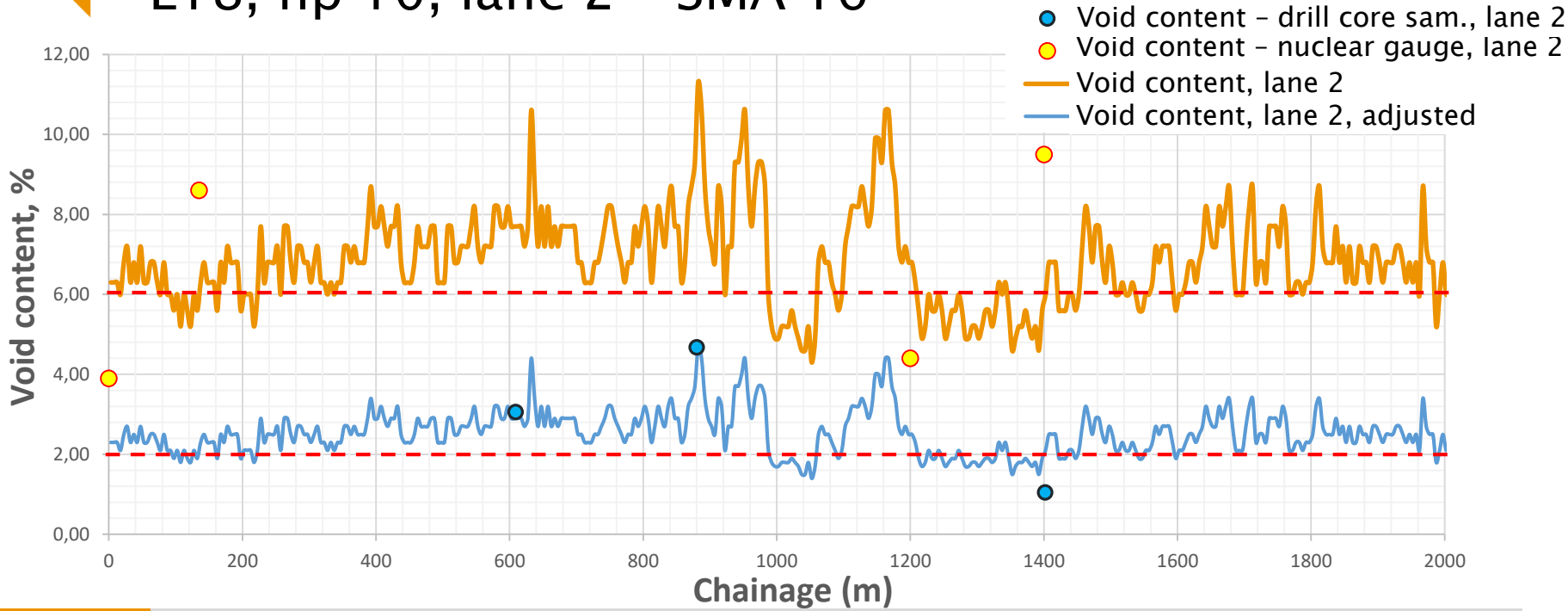
Example
E18, hp 10, lane 2 – SMA 16



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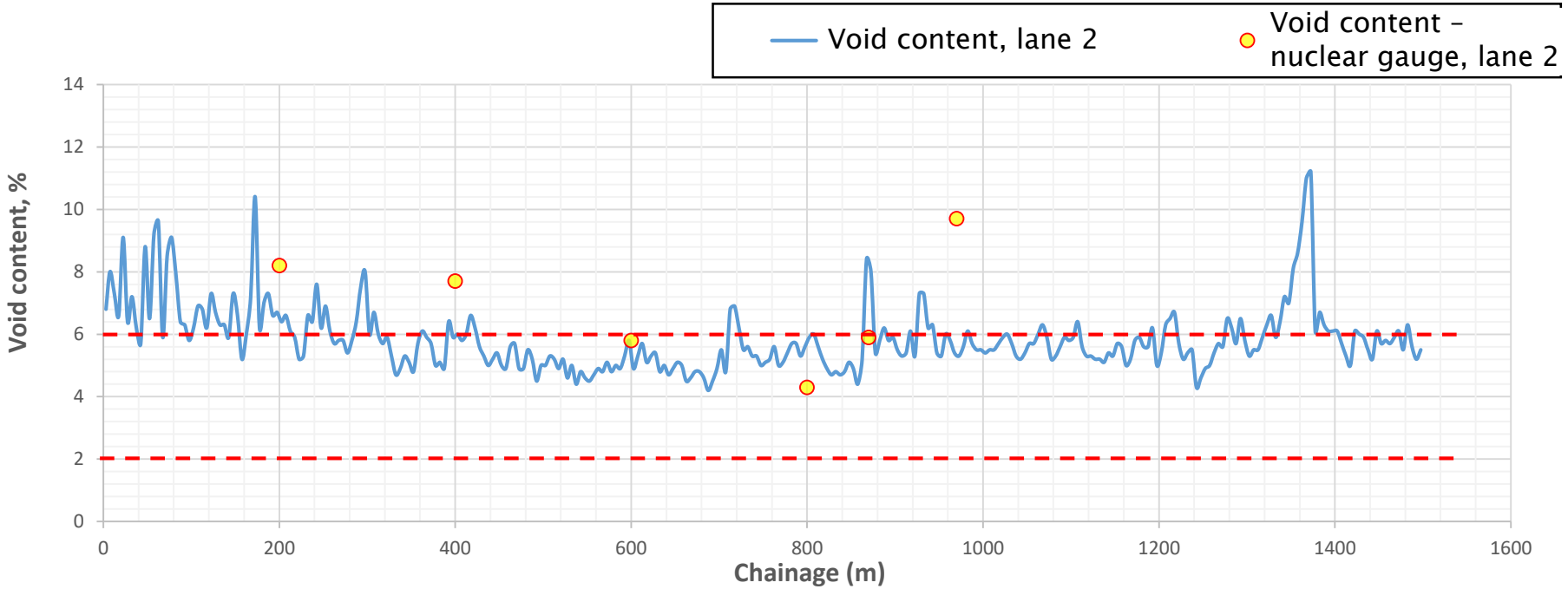
E18, hp 09, lane 2



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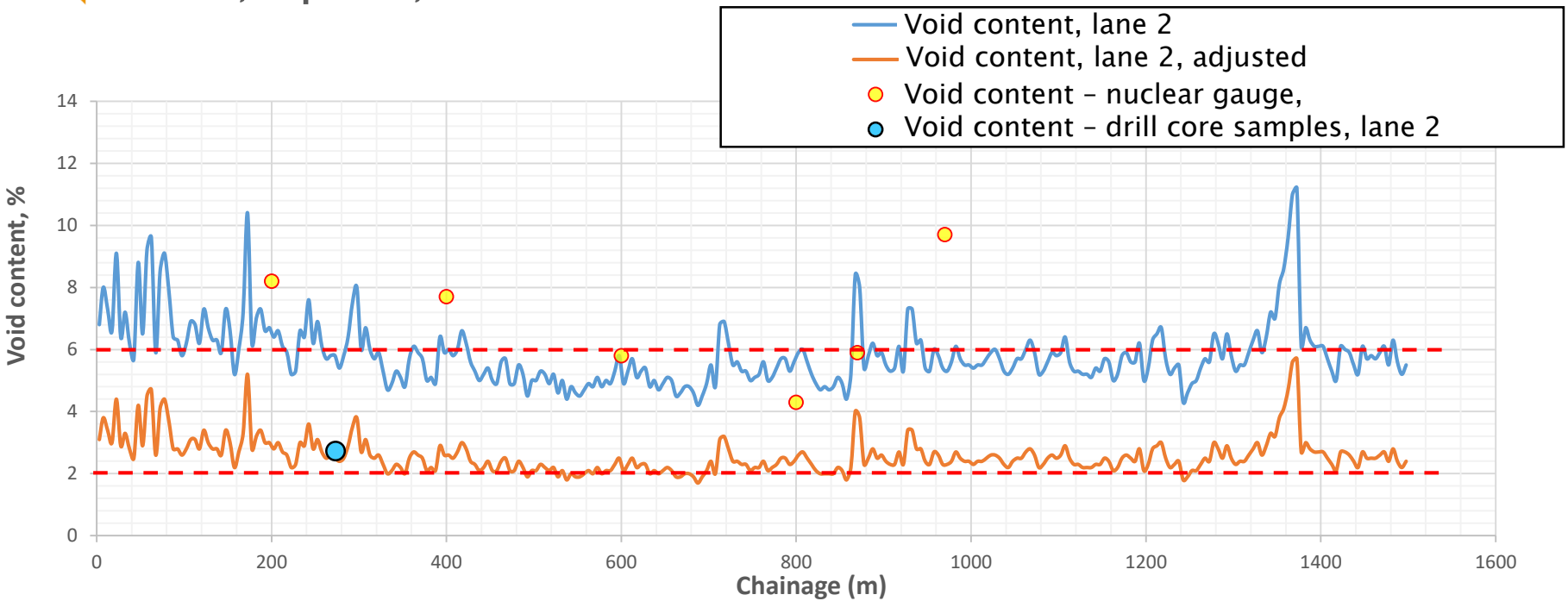
E18, hp 09, lane 2



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Calibration

- It is costly and time consuming to take and analyze drill core samples!
- For most asphalt materials it is possible to use nuclear gauge measurements for calibration
- Some problems on coarse SMA, but improving measurement procedures can provide better or more correct values
- We want to replace the nuclear gauges (because of the radioactive source)
  - nondestructive methods that cover the whole area
- Hopefully will this work on GPR give us the necessary tools that we needs!

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3D-Radar

- Terratec AS, Oslo
- Measured 4 road section
- Total length 8617 m

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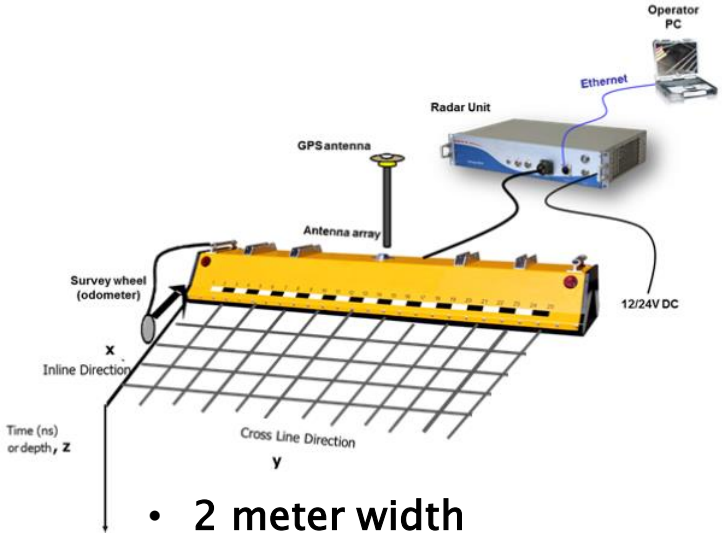
Prinsipp 3D-RADAR

- 3 dimensional radar. Measures X, Y, and Z (time/depth).
- Connected GPS Antenna and PC that manages the radar.
- Connects to vehicles for efficient collection over distances



- 2 meter width
- 25 channels
- Can measure with 9 channels at speed 80 km/h
- Raw data – 1 measurement per 10 cm

Example – air void content

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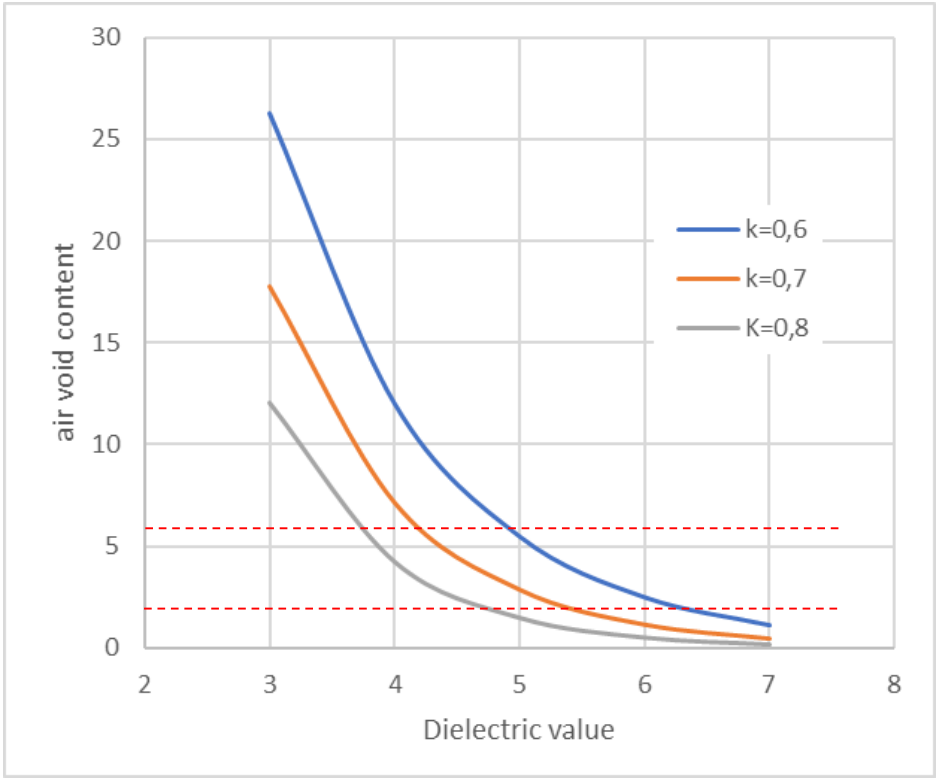
Strekning 01-03


30
25
20
15
10
5
0
air void content
2
3
4
5
6
7
8
Dielectric value
k=0,6
k=0,7
K=0,8

Road section 01-03

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02.04.2019

Example: Thickness of the asphalt layer

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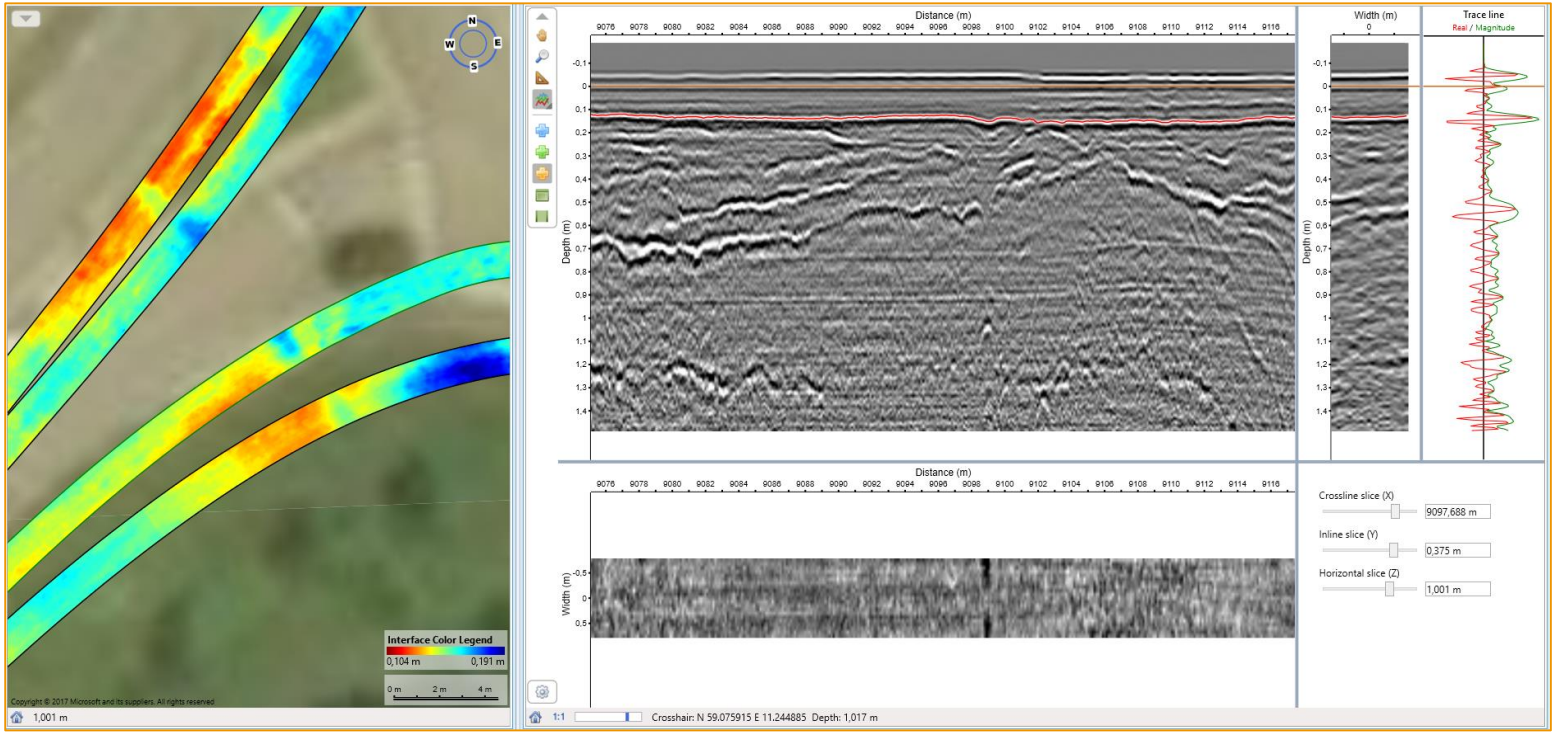

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Some conclusions

- All in all, the GPR measurements provide a representative image of the air void content for the road section.
- GPR is a good complement to drill core samples and nuclear gauge measurements and improves the overview of variations in air void content on the road section.
- The variation in air void content is well presented regardless of whether you make an exact calibration or not. An estimated calibration factor can provide a good estimate of variation in the air void content.
- Together with IR-scanning from the paver, it will be possible to give the control staff a more systematic procedure to clarify how thorough controls should be carried out.