

# Evaluation of connected road surface monitoring

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## Experiences from two activities

- Activity 2: Comparative measurements, reference and supplier, focus on roughness data
- Activity 3: Comparison of randomly selected sections from supplier fleet measurements vs. reference.
  
- Participating suppliers, Nira Dynamics (Nira), Mercedes Benz (MB) and Universes (Univ)



# Transport administration innovation procurement

Ongoing development during the project

Three main objects to detect

- Winter damage
- Potholes
- Frost heave

Focus of the evaluation has been on evenness measurement and to detect defects/object (potholes, cracks etc.).

Focus has also been on high values/poor condition, sections in need for operation and maintenance.



## Variables - reference

- IRI, International Roughness Index – a standardized longitudinal roughness index, wl. 0.5 m to 30 m
- LO, Local Roughness – a national longitudinal roughness index to detect unevenness with a short longitudinal representation (potholes, bridge joints, etc.).
- RMS2, - a national longitudinal roughness index for wavelengths between 1 m and 3 m (used to detect a snowy road surface)
- RMS3, - a national longitudinal roughness index for wavelengths between 3 m and 10 m (minor influence of snow on the road)

All variables can be measured by an ordinary profilometer like the reference, VTIRST we used in the project



# Nira Dynamics

Measurement principle – connected vehicle

Evaluated variables

- Estimated IRI – presentation length 25 m – reference IRI – evaluated at 25 m
- Obstacles, Anomalies, extremes – reference local roughness



# Mercedes Benz

Measurement principle – connected vehicle

Evaluated variables

- Estimated IRI – presentation length 10 m – reference IRI, evaluated at 20 m
- RMS2 – presentation length 10 m – reference RMS2, evaluated at 20 m
- RMS3 – presentation length 10 m – reference RMS3, evaluated at 20 m
- Surface event – extremes - reference local roughness



# Univrses

Measurement principle – smartphone

Evaluated variables

- Potholes – geometry/area – Reference Local roughness evaluated at 20 m and visual inspection
- Damage level – overall damage level – Reference visual inspection
- Cracks – geometry - Reference visual inspection
- RMS3 - presentation length 20 m – reference RMS3, evaluated at 20 m



## Activity 2

- Data from supplier compared with reference
- Dedicated supplier and reference measurements in Dalarna
- Not necessary the same variable compared between supplier and reference.
- VTIRST used as reference – standard measurement vehicle as used for network road monitoring for the Transport Adm.
- Reference data and position calculated at 1 m level – to enable exact matching with supplier data



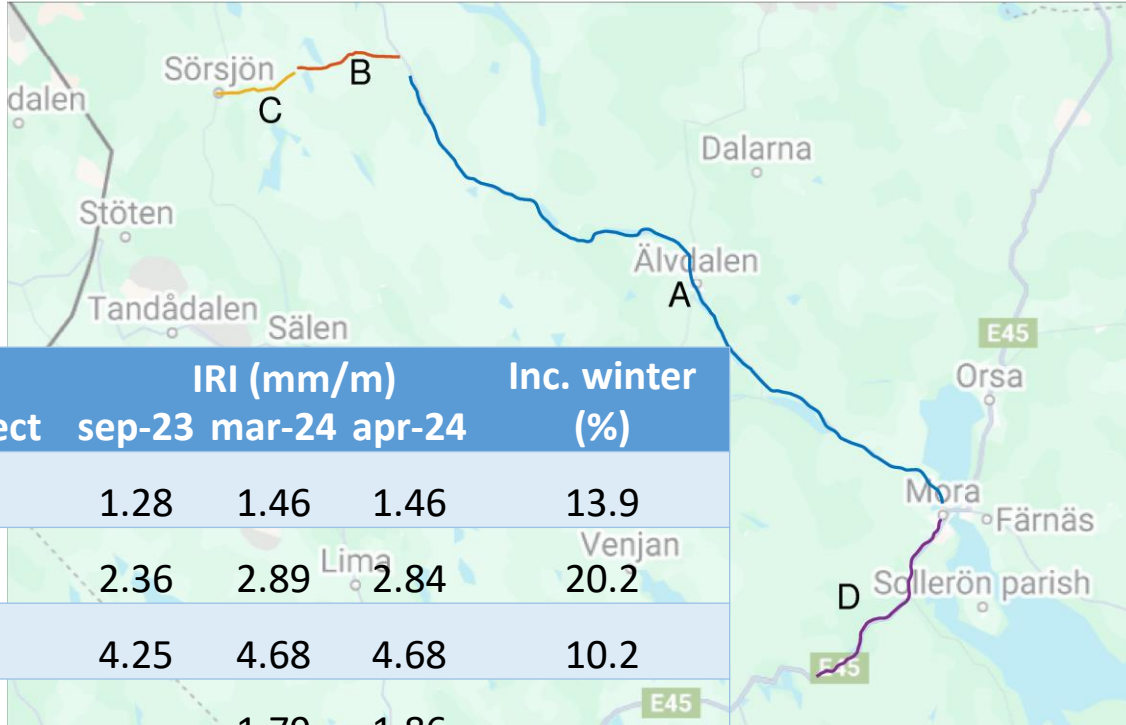
## Activity 2 – Test sections in Dalarna

- Four road sections selected
- Three "sessions": 2023/09, 2024/03 and 2024/04.
- Sections A-C measured in all sessions. Section D only in the 2024 sessions.
- Measured twice per session
- A total of 500 km per session for each supplier





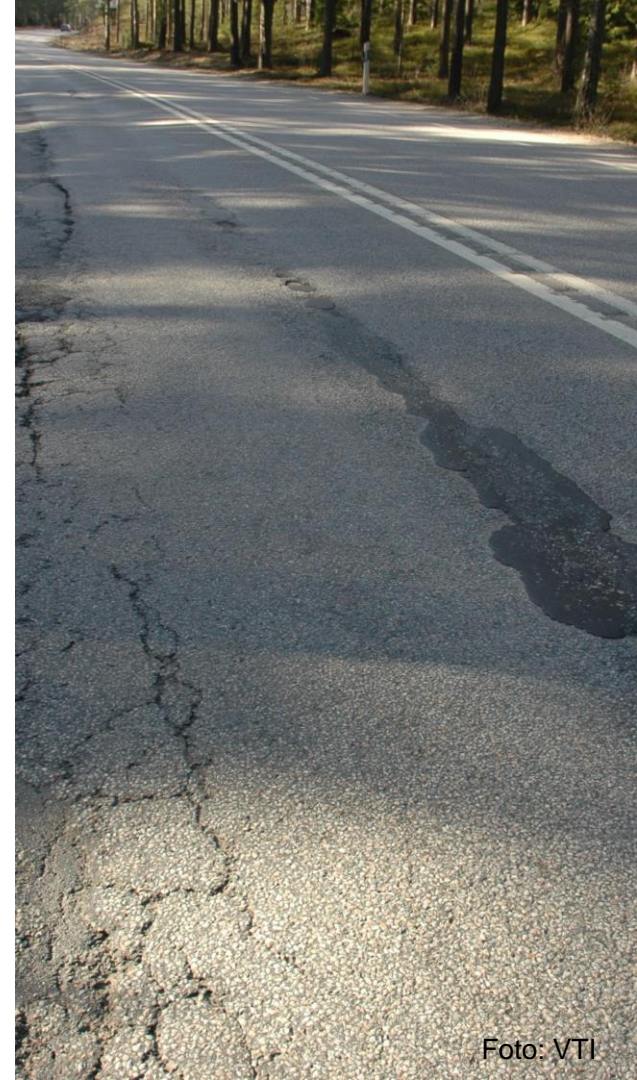
## Activity 2 – Sections A-D



- A: Road W70, 82 km, normal road – rather good standard
- B: Road W1037, 12 km – uneven
- C: Road W1037, 9 km – very uneven
- D: Road E45, 24 km – partly good, partly bad (winter damages)

# Three evaluation methods

- **Rank method:** Percentage of supplier data where the rank is within +/- 15% from reference data.
- **Norm(alized) method:** Percentage of normalized supplier data with a minimum absolute difference lower than:
  - 0.5mm/m for IRI, 0.2mm for RMS2, 0.4mm for RMS3, 1.0mm for RMS4.
- **Orig(inal) method:** Percentage of delivered supplier data with a minimum absolute difference lower than:
  - 0.5mm/m for IRI, 0.2mm for RMS2, 0.4mm for RMS3, 1.0mm for RMS4.
- **Use only data where supplier rank is larger than 50% (per section).**



## Evaluation method – Ranking, limit $\pm 15\%$

- Rank data from 0% to 100%.

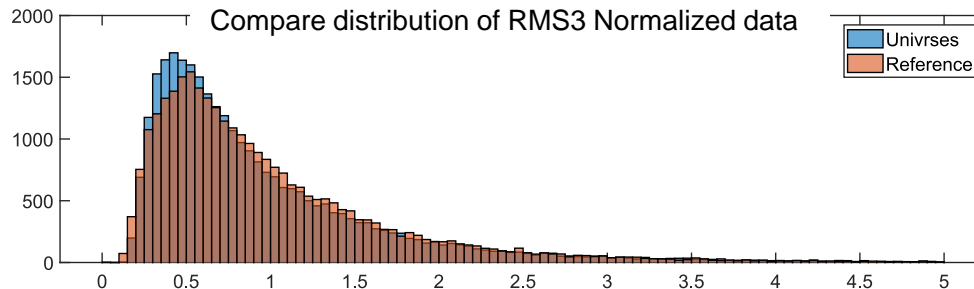
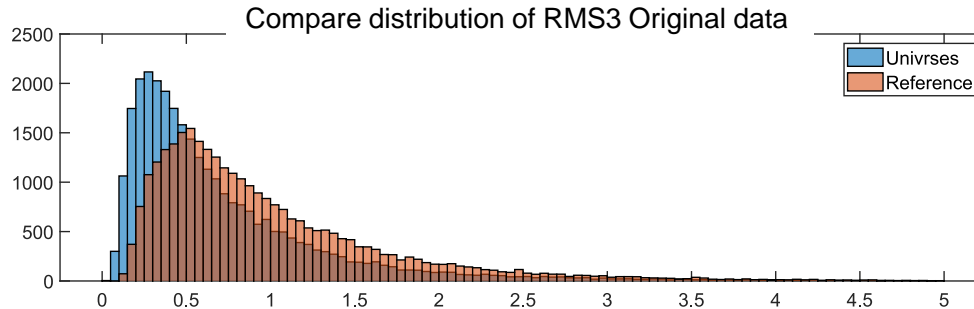
Data	Rank (%)
0.52	40.00
4.23	70.00
21.50	100.00
0.47	30.00
0.33	20.00
0.69	50.00
0.03	10.00
14.02	90.00
6.68	80.00
3.29	60.00

Example: Reference ranked 80% - supplier data  
"approved" with rank between 65% and 95%



# Evaluation method - Normalization

- Make the 10 and 90 percentiles for the supplier data the same as for the reference data.
- Use all available data (not per section).



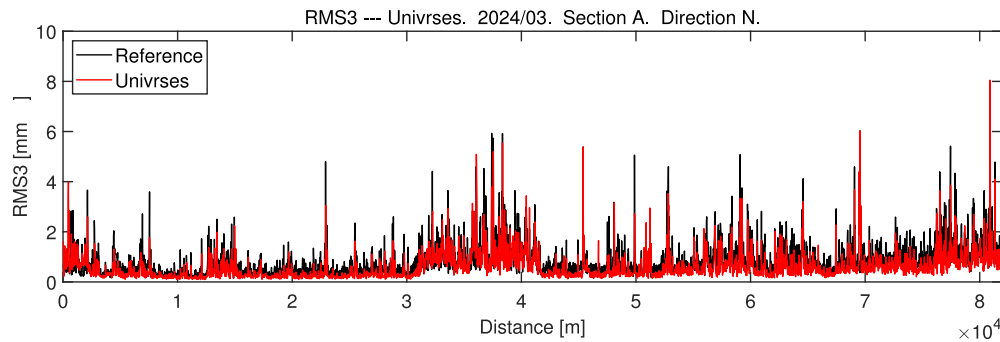
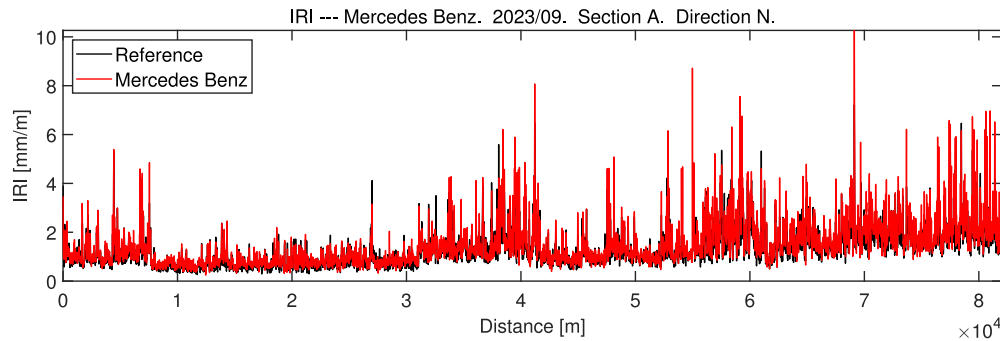
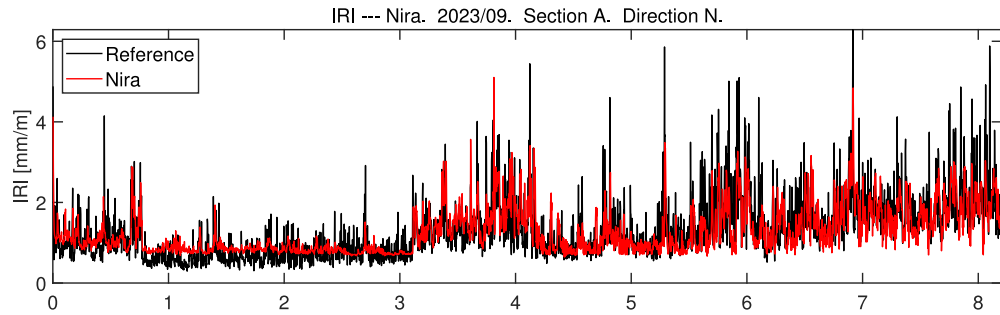


Foto: VTI

# Aggregated results

Supplier	Index	Type	Rank(%)	Norm(%)	Orig(%)
Nira	IRI	Fleet	59.21	45.89	47.78
Nira	IRI	Testv	60.22	40.86	44.14
Mercedes-Benz	IRI	Testv	84.91	67.86	58.84
Mercedes-Benz	RMS2	Testv	79.88	87.93	87.04
Mercedes-Benz	RMS3	Testv	85.44	81.06	77.52
Mercedes-Benz	RMS4	Testv	56.90	39.60	41.07
Univrses	RMS3	Testv	59.76	56.34	52.45



# Aggregated results per section

- Mercedes IRI (test vehicle)

Section	Rank	Norm	Orig	Ref. IRI
A	83.48	72.88	62.58	2.16
B	90.84	64.60	49.24	2.84
C	99.67	44.82	19.14	4.62
D	81.41	60.89	65.57	2.34
W. Mean	84.91	67.86	58.84	2.43

- Nira IRI (fleet data)

Section	Rank	Norm	Orig	Ref. IRI
A	54.04	47.96	49.37	1.99
B	70.14	40.42	43.20	2.73
C	97.69	26.18	31.84	4.48
D	57.24	48.83	50.51	2.05
W. Mean	59.21	45.89	47.78	2.25

## Univrses RMS3 (test vehicle)

Section	Rank	Norm	Orig	RMS3
A	56.24	57.57	54.67	1.22
B	71.55	56.03	40.71	1.61
C	83.58	43.56	34.61	2.04
D	57.20	57.05	57.20	1.23
W. Mean	59.76	56.34	52.45	1.32

## Nira IRI (test vehicle)

Section	Rank	Norm	Orig	IRI
A	53.10	41.00	44.36	2.10
B	76.61	44.19	44.85	2.94
C	97.98	34.13	31.55	4.60
D	56.56	43.08	47.03	2.13
W. Mean	59.09	41.19	44.00	2.36

# Local roughness

Supplier	REF>99%	REF>85%
Nira	79%	97%
Mercedes-Benz	96%	100%
Univrse	30%	66%

- Nira: Obstacles, all data used
- Mercedes-Benz: Surface Events/Jerks over 25.
- Univrse: Damages/potholes with area over 0.5m<sup>2</sup>. \*

Reference is local roughness, +/- 20m from the reported damage.

\*Note, univrse are detecting potholes, it does not automatically correlate to a rough road.





## Summary Activity 2

- Overall good results at aggregated level
- More to analyze/explain/investigate at object level
- A more thorough analysis of data coverage must be done

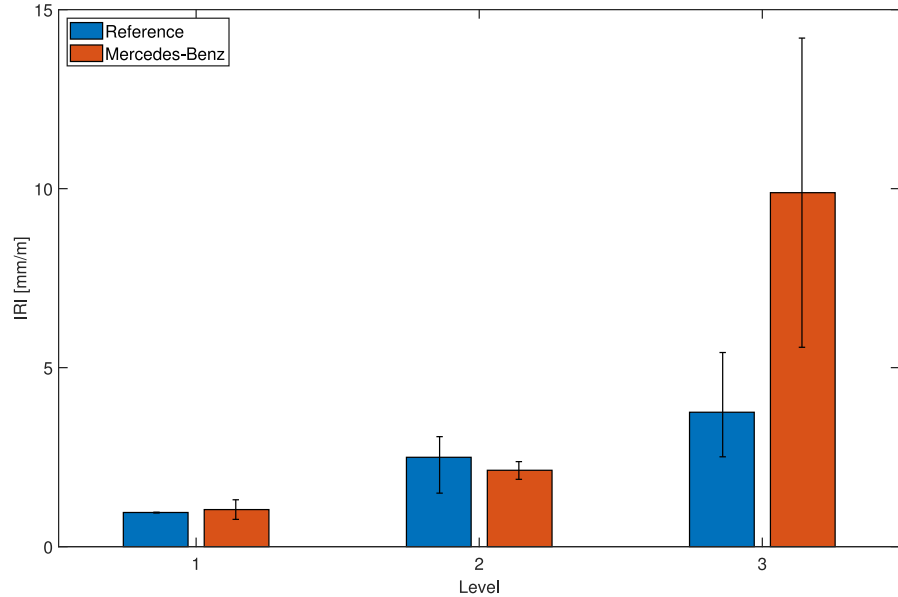


## Activity 3

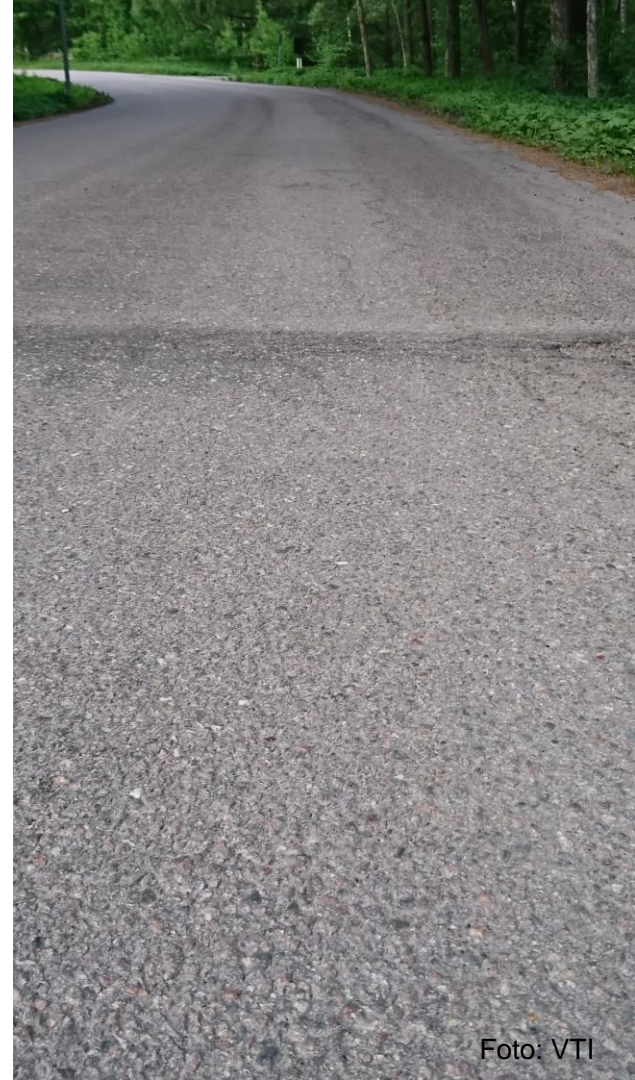
- Comparison between VTIRST (ref) and supplier fleet data
- Access to fleet data from supplier (Dalarna and Gävleborg)
- Randomly selected 10 sections in three categories of supplier fleet data
  - Level 1, 0-50 percentile – some/minor defects, 2 sections
  - Level 2, 75-90 percentile – defects, 4 sections
  - Level 3, 90-100 percentile – severe defects, 4 sections
- The section was measured twice with the reference (VTIRST)



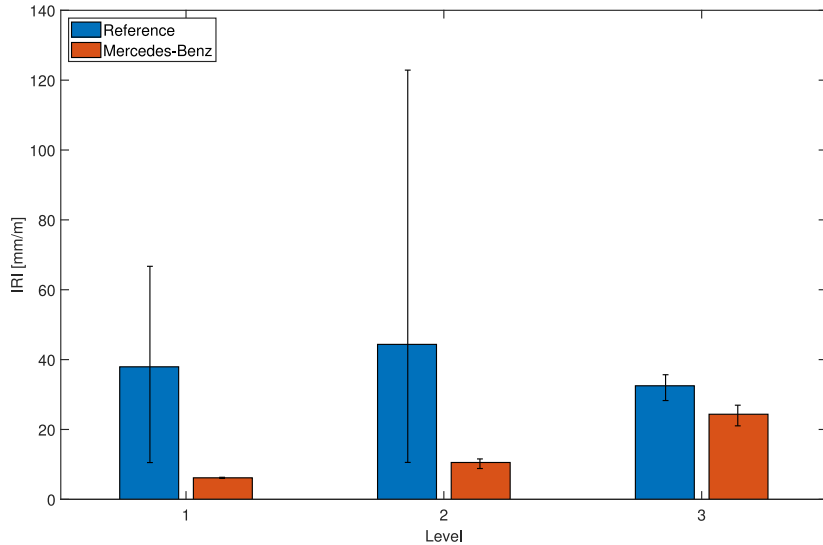
# Mercedes Activity 3 (Waviness/IRI)



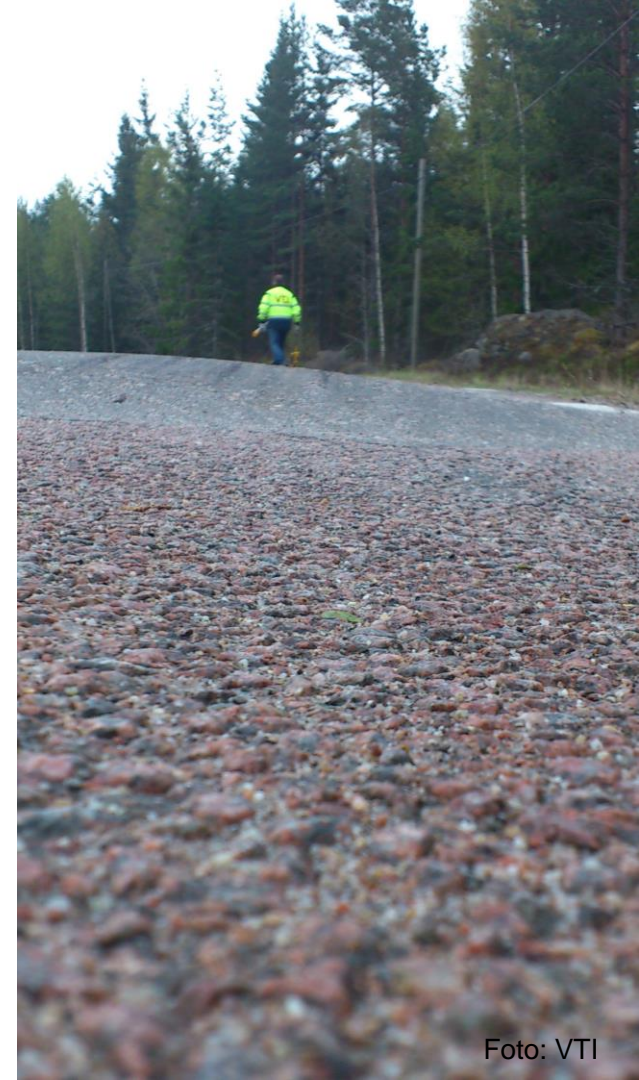
Level	MB	Ref
1	0.76	0.96
1	0.76	0.94
1	1.31	0.95
1	1.31	0.96
2	1.88	1.49
2	1.88	1.57
2	2.37	2.88
2	2.37	2.91
2	2.11	3.07
2	2.11	3.01
2	2.20	2.54
3	5.57	2.58
3	5.57	2.51
3	14.21	4.50
3	14.21	5.42



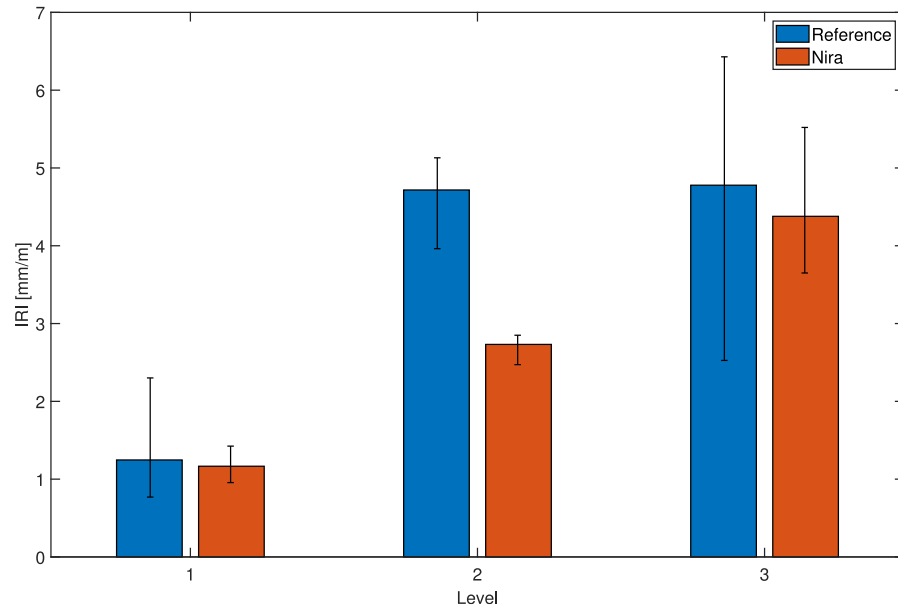
# Mercedes Activity 3 (Surface Events/Local Roughness)



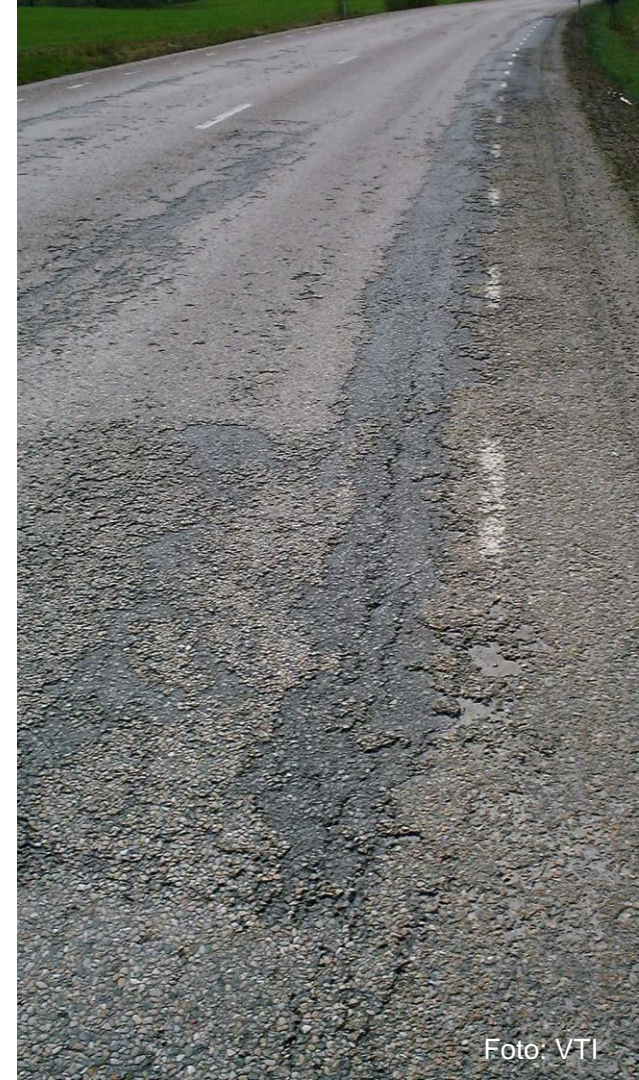
Level	MB	Ref
1	6.31	10.64
1	6.31	10.53
1	6.00	63.88
1	6.00	66.71
2	8.82	19.87
2	8.82	20.28
2	11.57	21.47
2	11.57	10.57
2	10.82	28.16
2	10.82	18.97
2	10.98	112.67
2	10.98	122.87
3	24.05	35.32
3	24.05	35.67
3	21.04	28.28
3	21.04	29.12
3	24.11	34.60
3	24.11	34.97
3	26.95	32.18
3	26.95	30.72
3	26.95	31.72



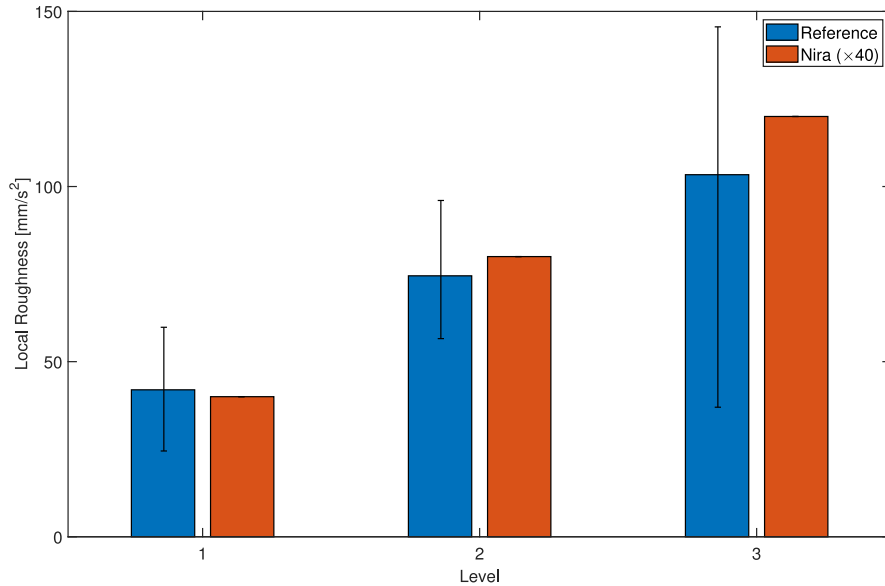
# Nira Activity 3: IRI



Level	Nira	Ref
1	1.42	2.30
1	1.42	1.95
1	1.12	0.82
1	1.12	0.83
1	0.96	0.80
1	0.96	0.77
2	2.85	4.93
2	2.85	5.02
2	2.85	4.96
2	2.47	3.97
2	2.47	3.96
2	2.81	5.05
2	2.81	5.13
3	3.65	2.53
3	3.65	2.57
3	5.52	5.87
3	5.52	5.85
3	4.44	6.43
3	4.44	6.06
3	3.91	4.30
3	3.91	4.62



## Nira Activity 3: Anomalies/Local Roughness



Level	Nira	Ref
1	1	24.50
1	1	24.50
1	1	59.82
1	1	59.03
2	2	83.15
2	2	82.87
2	2	78.63
2	2	76.35
2	2	60.09
2	2	96.02
2	2	56.58
2	2	62.39
3	3	138.22
3	3	145.58
3	3	102.04
3	3	122.06
3	3	36.99
3	3	57.69
3	3	108.38
3	3	116.06



## Univrses – Activity 3

- Data from Gävleborg County
- 1. **Damage level** – Overall road condition - three levels 1 to 3 (no data not damaged)
- 2. **Potholes** – area of pothole
- 3. **Cracks** – geometry of crack
- These features has been compared with visual inspection
- Randomly selected sections has been visually inspected and rated in three levels 1 to 3 – done by Trafikverket.
- Inspection rating, 1 some/minor defects, 2 defects and 3 severe defects

# Univrsees results – Damage level 3

- Result visual inspection, rating 2, 3, 1, 1
  - Frost cracks and load-bearing damage
  - Edge slump and cracks, generally uneven
  - Old brittle pavement, raveling, poor older repairs
  - Repaired cracks and potholes



Foton: Conny Olsson, Trafikverket





# Summary Univrses – Damage level

- Overall good results
- Univrses damage level three was visually classified as worst condition
- One section in damage level 2 without visual damage

## Univrses results – Pothole level 3

- Result visual inspection, rating 1, 2, 1, 1
  - Raveling, old paving
  - Potholes in the middle of the road
  - Potholes in the middle of the road
  - Potholes, poor elderly repair



Foton: Conny Olsson, Trafikverket

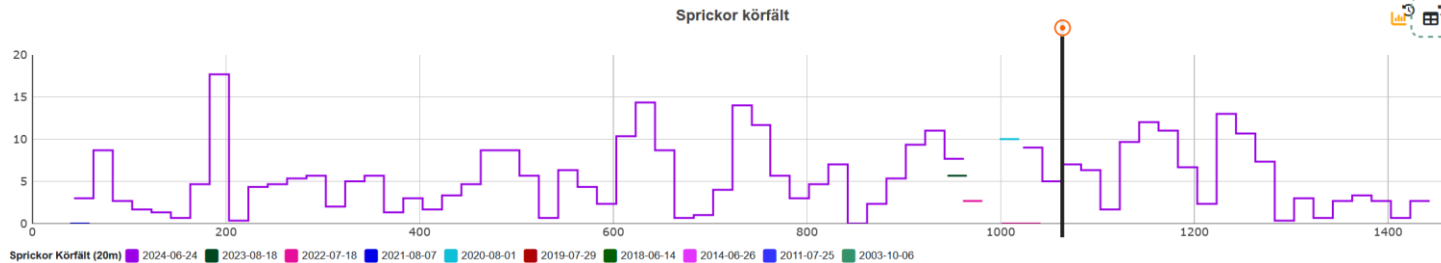
# Rating Univrses – Pothole

- Overall ok results
- Not always potholes detected at the sections
- Univrses pothole level 3 had potholes in three out of four sections
- Some sections were affected by road repair

# Activity 3 – Univrses – Example Cracks



Visual inspection



PMSv4



# Thank you for your attention

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