Where Does Safety Fit In Pavement Evaluation?

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“Forest for the Trees”

Three Objectives:

1. Review challenges/pitfalls of traditional assessments
2. Share changes in technology
   (making more comprehensive assessments now possible)
3. Review potential implications

History

- 1st International Skid Prevention Conference held in the USA, 1959
- American Society for Testing and Materials,

  ASTM committee E-17 on Skid Resistance, formed in 1960

Traditional Safety Measurements

Standard Safety Analysis Methods

Safety Performance Functions (SPF), relate crashes to several factors:

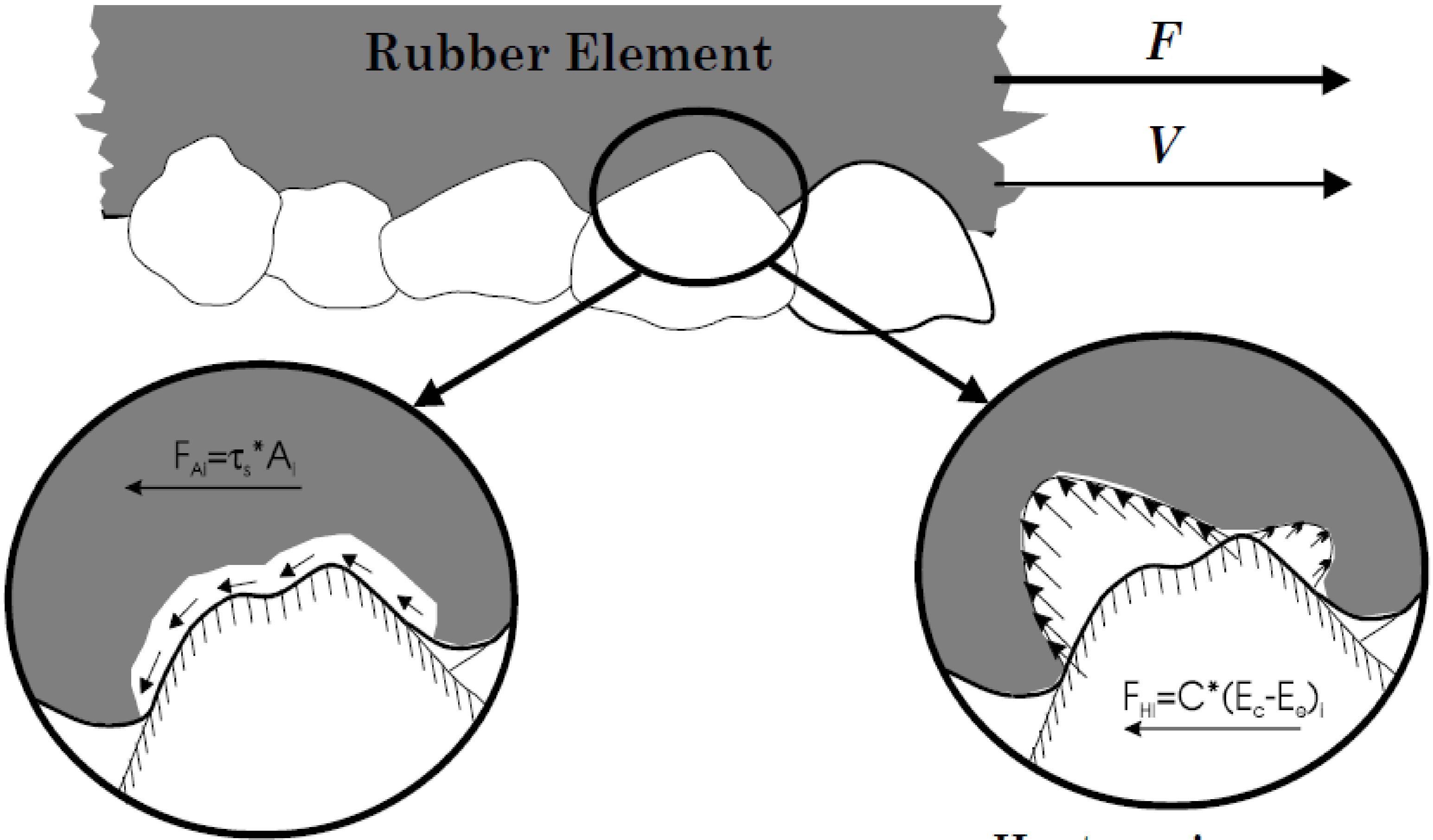
$X_1, X_2, \ldots, X_n$

Explanatory variables

- ✓ *P*: Number of crashes on segment L
- ✓ *AADT*: Traffic count
- ✓ X_i: Friction, Texture, Curvature, cross-slope, grade, etc.

$$P = L \times e^{\beta_o + \ln(AADT)\beta_1 + X_{1+i}\beta_{1+j}}$$

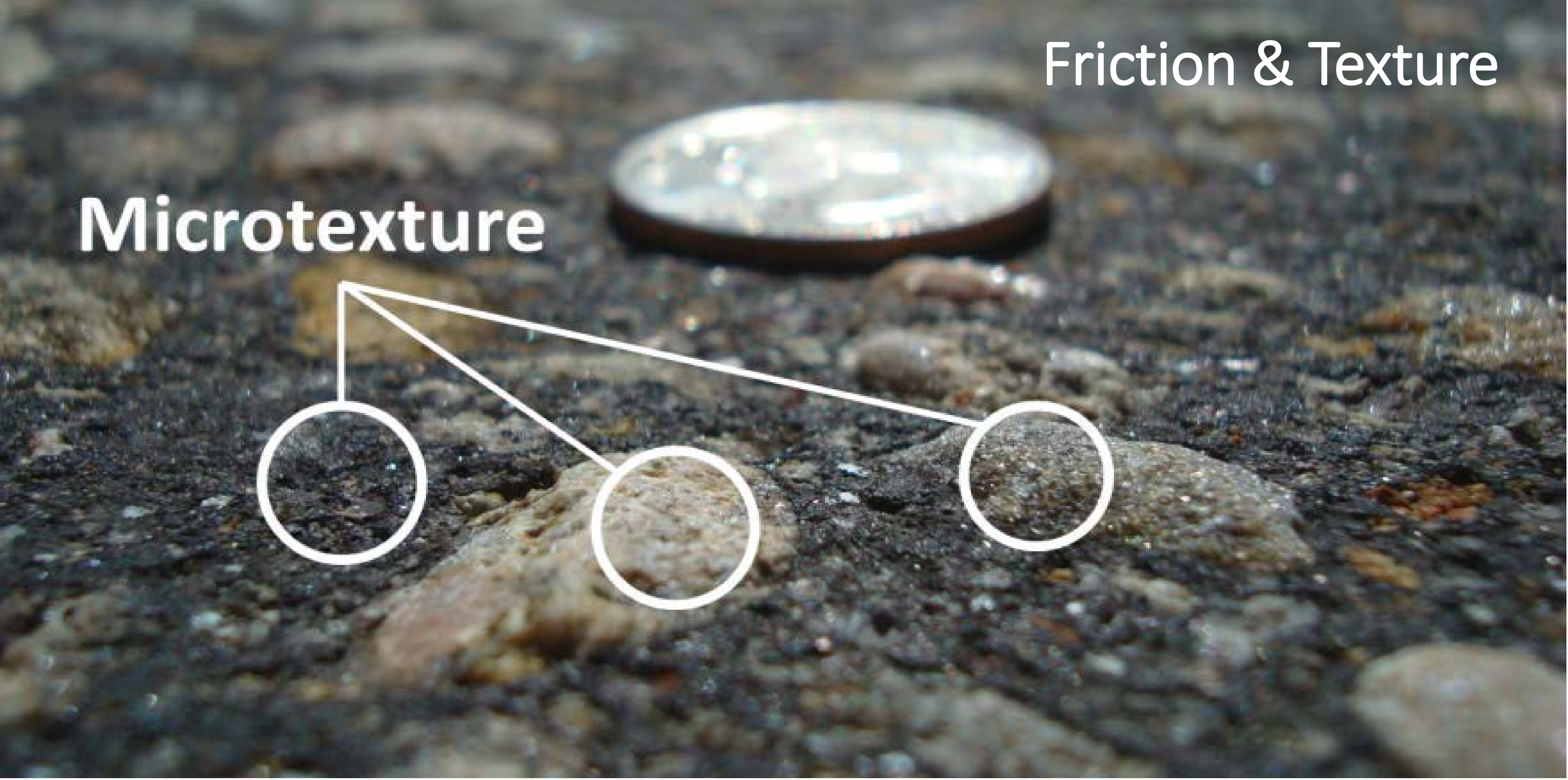
Friction Assessment



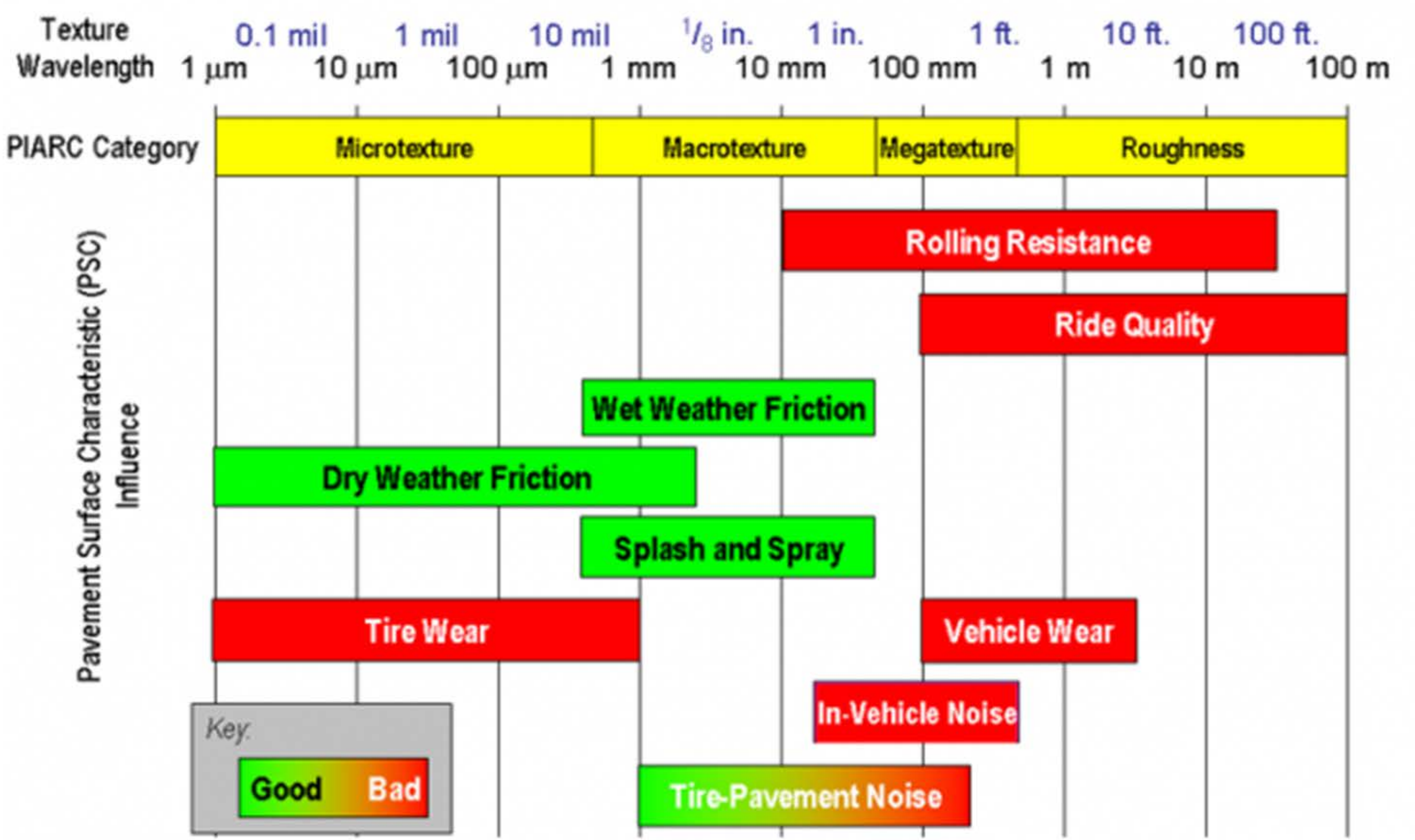
Adhesion
Depends mostly on micro-level surface roughness

Hysteresis
Depends mostly on macro-level surface roughness

Friction & Texture



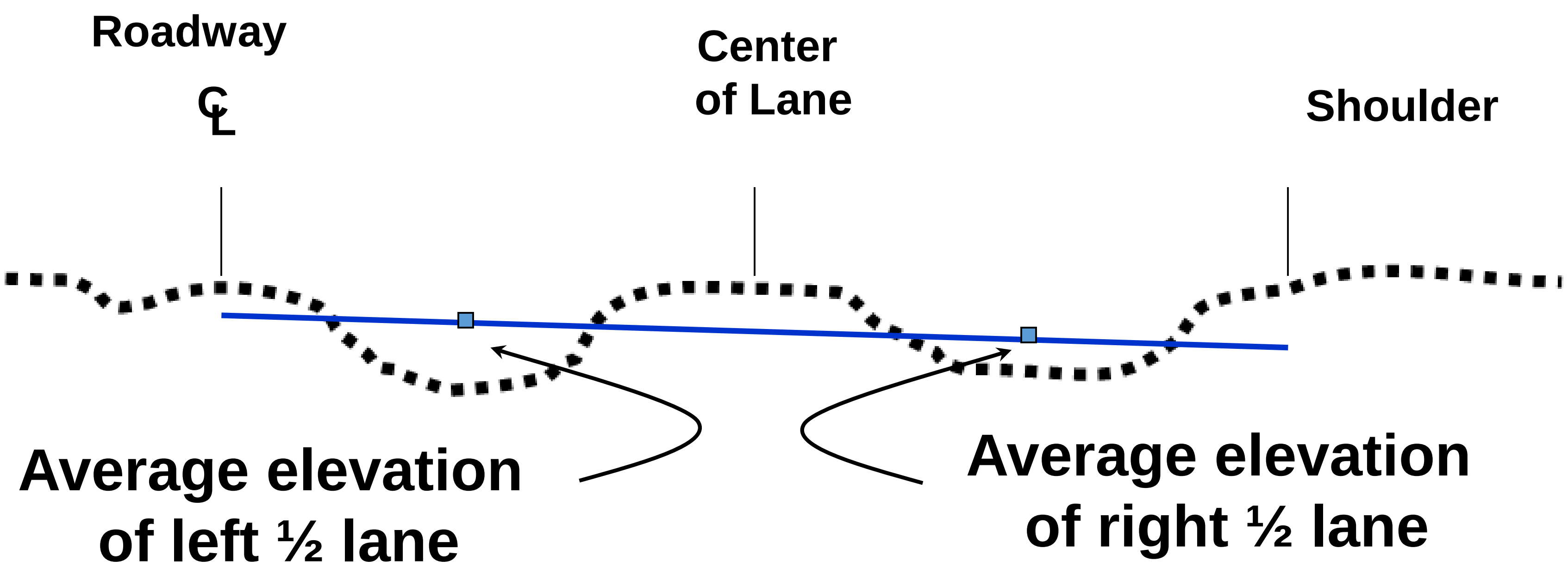
Friction & Texture



Source: PIARC

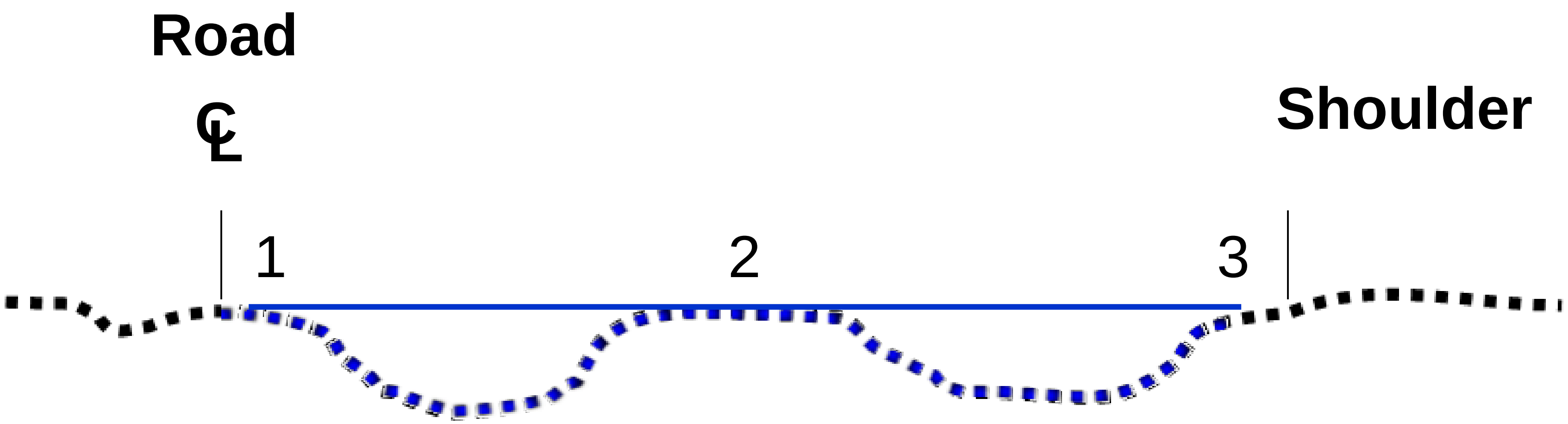
Transverse Profile Analysis

1. Calculate Cross-slope



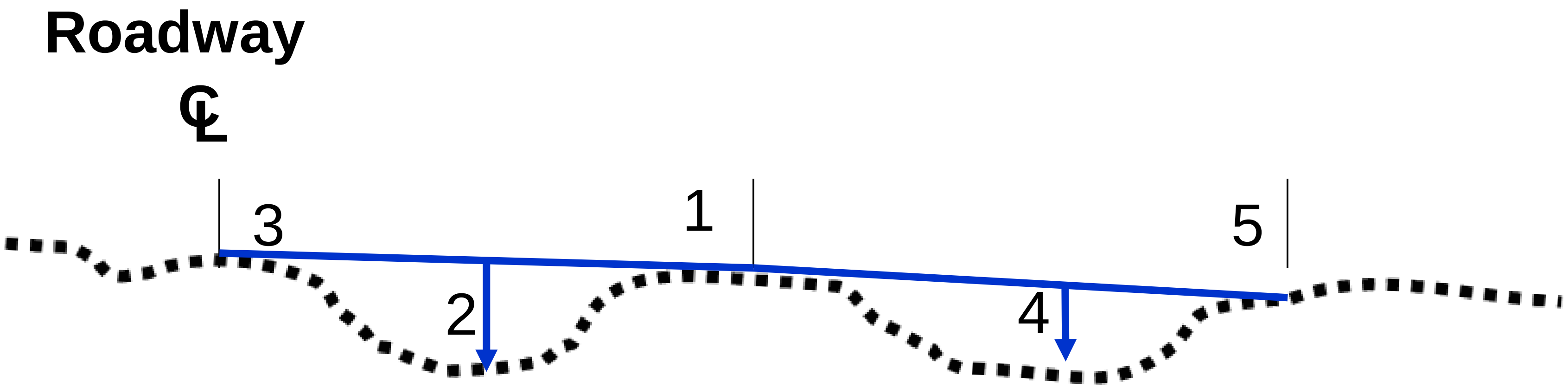
Transverse Profile Analysis

2. Calculate Percent Deformation:



Transverse Profile Analysis

3. Calculate Rut Depths



"Because the intensity of the polishing process increases markedly with tread element slip, all other factors being equal, the lowest friction levels are found on high-speed roads, curves, and approaches to intersections; in short, in locations at which high friction values are needed most."

NCHRP Report 37, 1967

Friction Demand – Investigatory Levels (UK)

Site category and definition		Investigatory level (50 or 80 km/h)							
		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
A	Motorway								
B	Dual carriageway non-event								
C	Single carriageway non-event								
Q	Approaches to and across minor and major junctions, approaches to roundabouts								
K	Approaches to pedestrian crossings and other high risk situations								
R	Roundabout								
G1	Gradient 5-10% longer than 50m								
G2	Gradient >10% longer than 50m								
S1	Bend radius < 500m - dual carriageway								
S2	Bend radius < 500m - single carriageway								

Continuous vs. Sampled

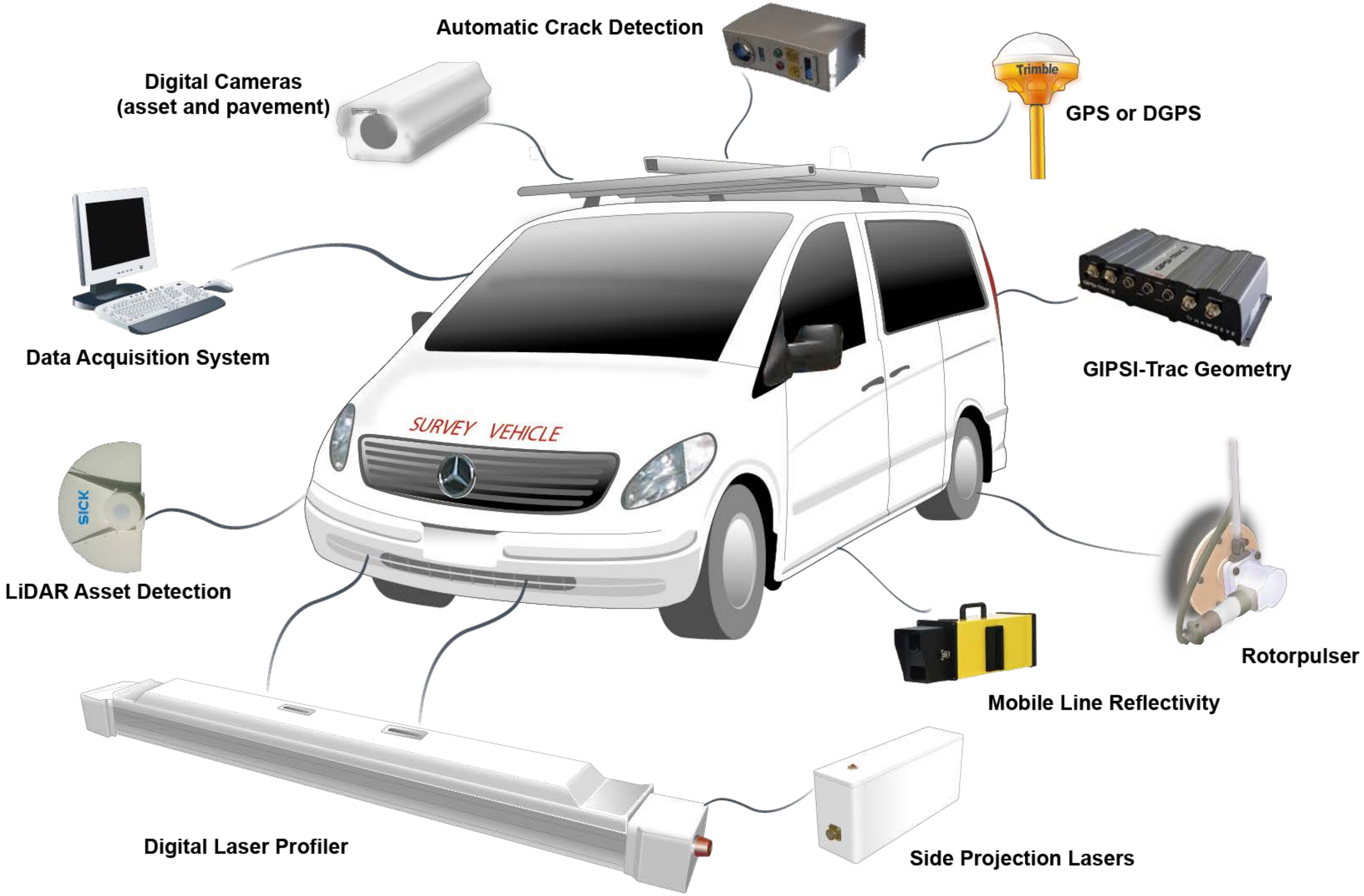
Standard friction testing in the USA is:

- “Sample" based
- Locked Wheel Skid Testing (LWST)

Pavement conditions however, vary along roadways

- Density (Intelligent Compaction, Infrared Technology, GPR)
- Structural Integrity (TSD, GPR)
- Segregation (Texture)
- Ride

Road inspection technology



Hawkeye 2000 system integration

- high resolution and calibrated images
- geo-referenced
- Gipsitrac (IMU)
    - For objective measure of horizontal curvature
- fully integrated outputs
- customised safety rating software
- collection of roughness, rutting and texture data

Calibrated images

Continuous Friction Measurement

- Continuous friction measurement
- 15 to 55 mph
- Typically 150 lane miles per day

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Continuous Friction Measurement

- Skewed tire (20°- 34% slip)
- Dynamic vertical load system
- Continuous tire pressure monitoring
- Dynamic speed controlled water system
- Ambient air temperature monitoring
- Tire temperature monitoring

Full compliance with BS 7941-1:2006.

Continuous Friction Measurement

Rubber Tire Slip

- measuring **micro**-texture continuously

Laser based texture measurement system

- measuring **macro**-texture continuously

Both Wheel Paths Simultaneously

Additional Assessment Capabilities

+ Digital imaging system

+ GNNS DGPS geospatial location

Geometry – Cross fall, Grade, Horizontal and Vertical curvature

Continuous Friction Response

+ Rutting over full late width

+ Texture in Center and Both wheel paths

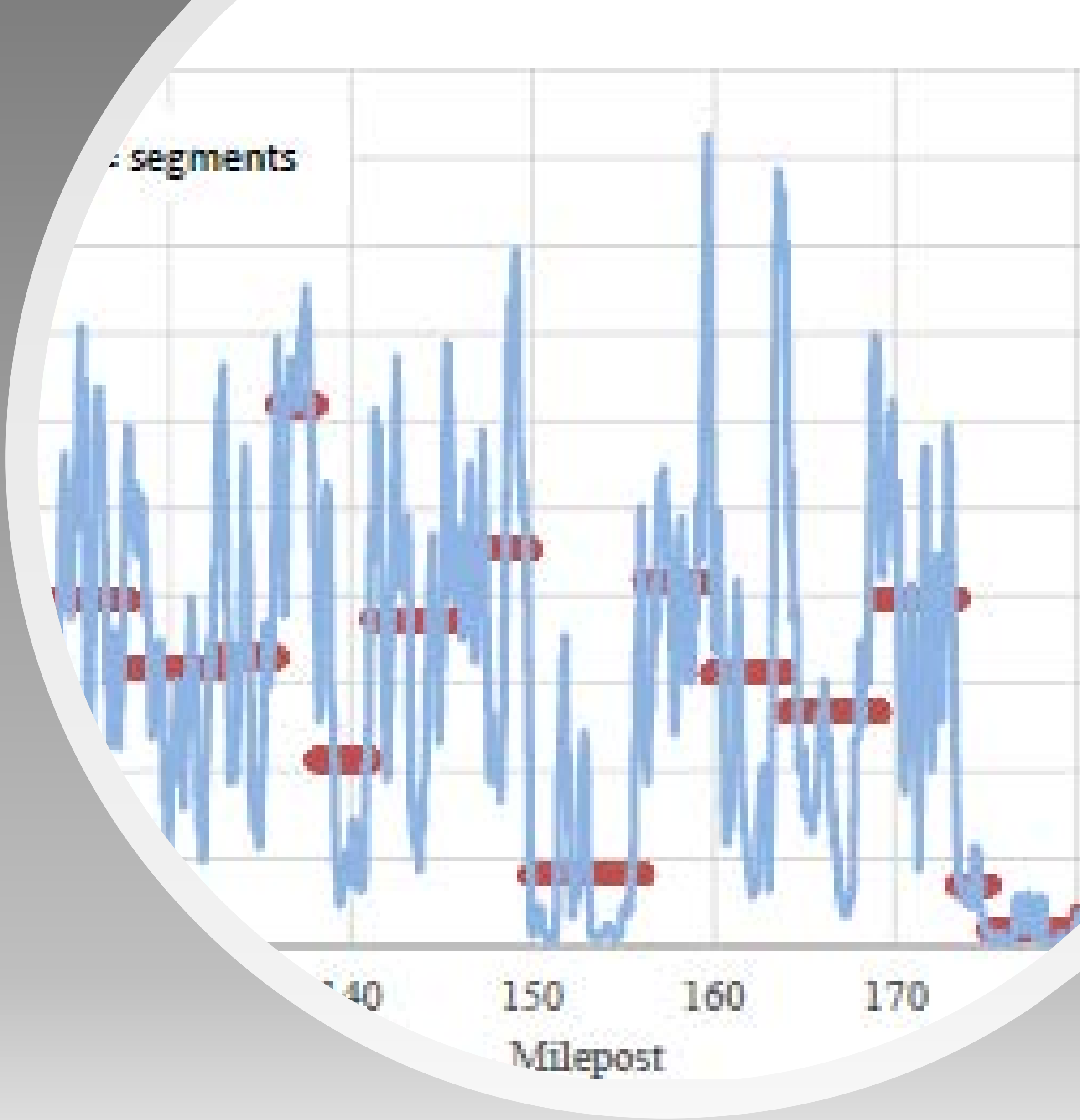
Network level data, project level detail

Pavement Conditions Vary

- Continuous properties needed

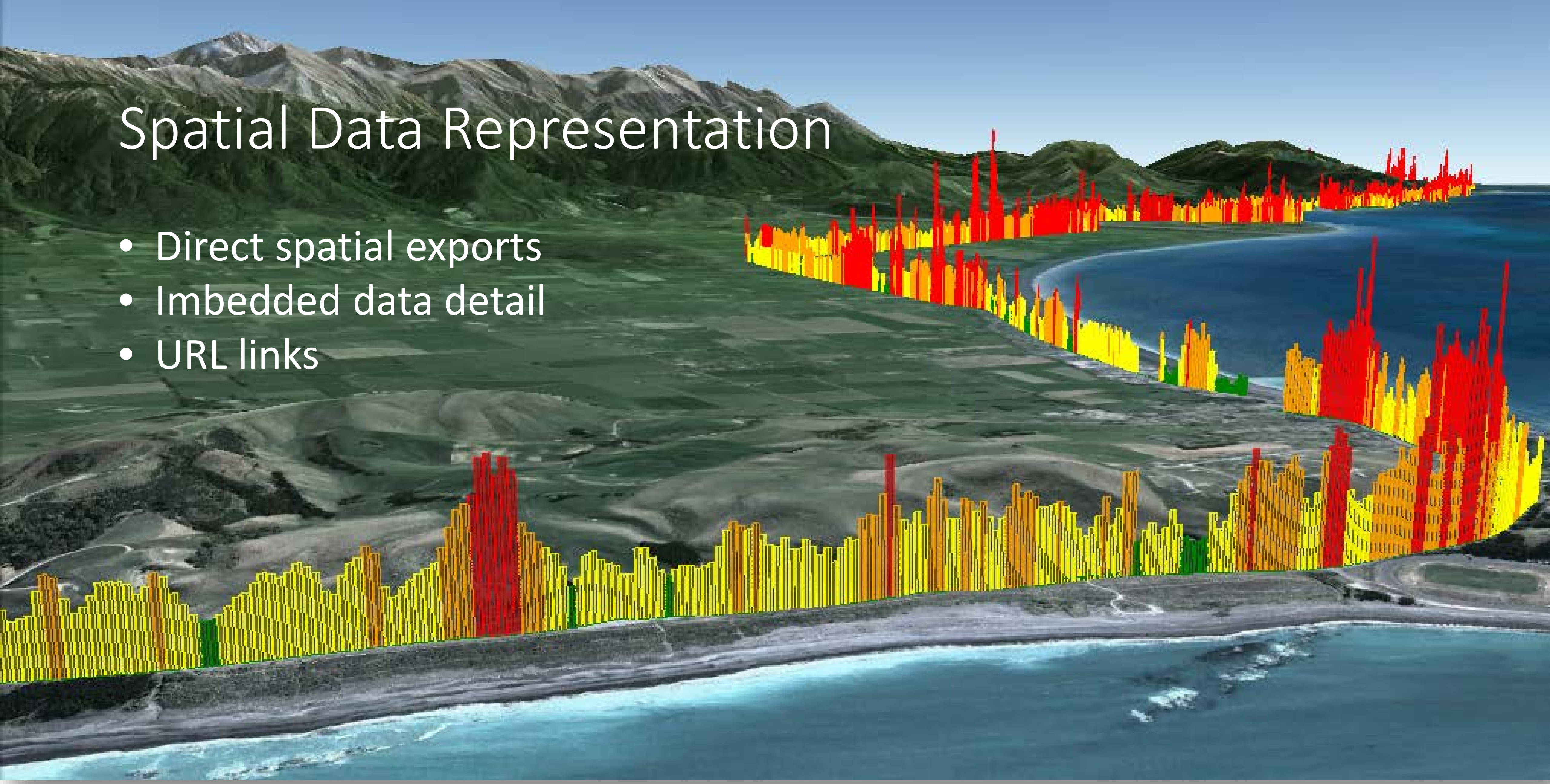
Averages over network level segments

- Lose something in the summation.

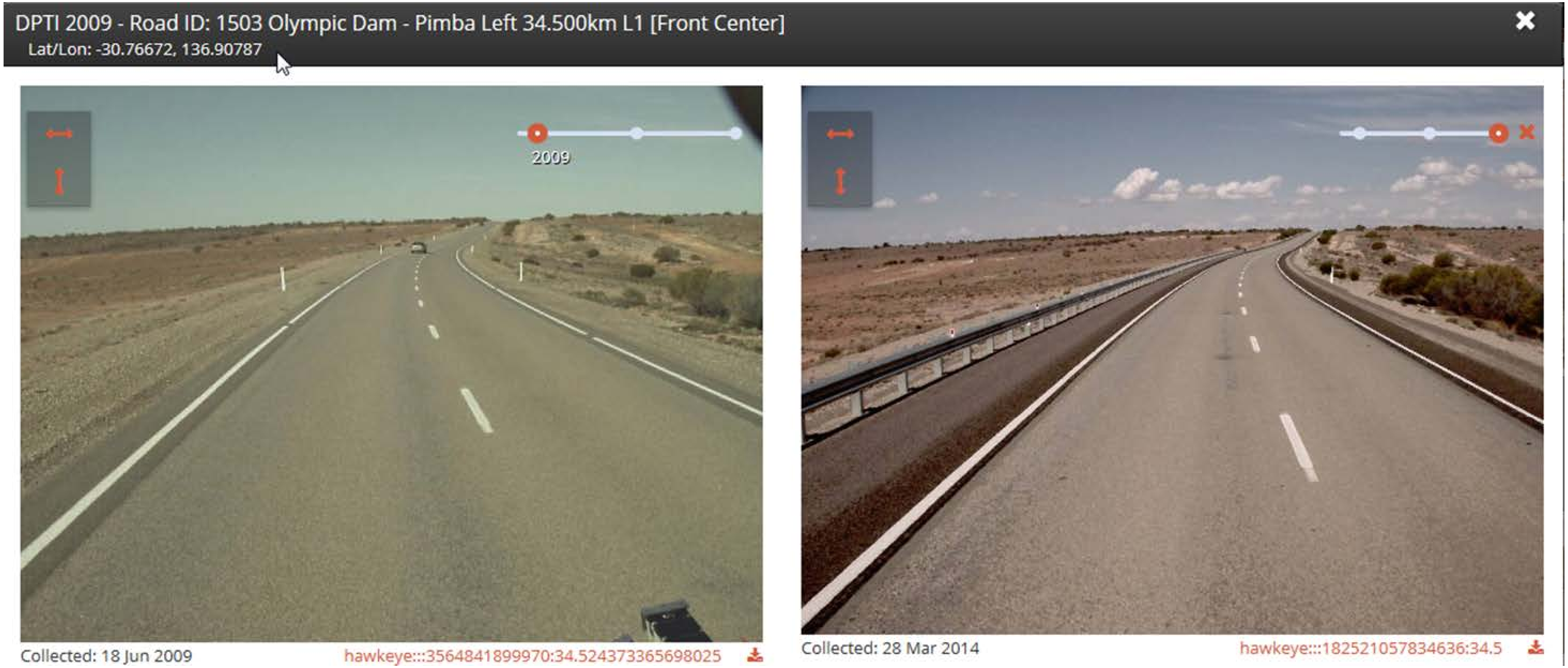


Spatial Data Representation

- Direct spatial exports
- Imbedded data detail
- URL links



All data in one place...for all time



9 years ago in 2009

4 years ago in 2014

Preliminary Conclusions

Measuring friction continuously, especially when complemented by:

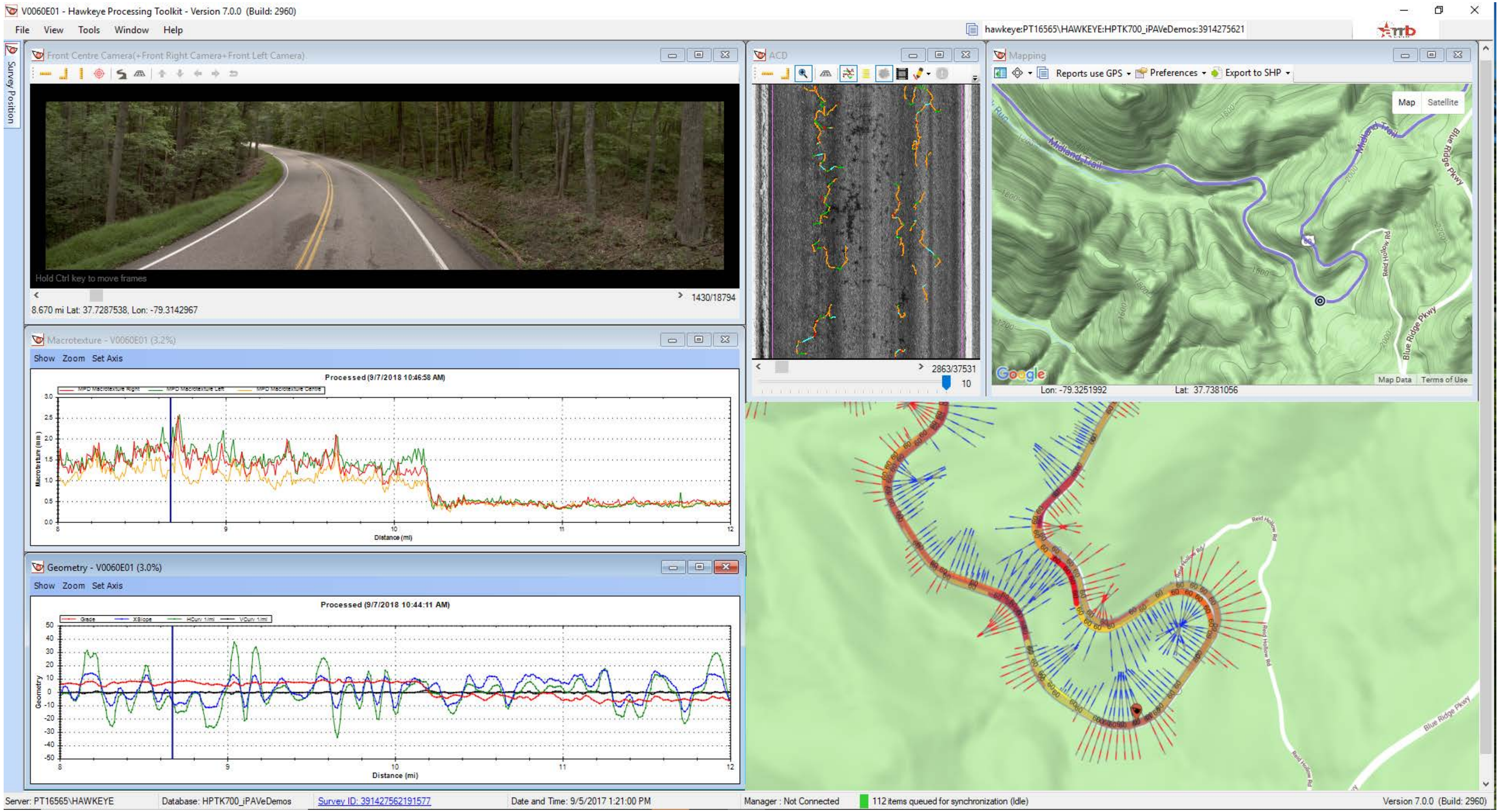
+ road geometry	+ imagery
+ texture	+ rutting
+ traffic	+ crash data

✓ Provides a more effective method for identifying the most critical sections

✓ Allow for focused safety improvement efforts on higher risk locations, such as:

- intersections and
- curves.

Comprehensive Assessment



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Questions

- How can network level pavement evaluation better support safety assessments decisions?
- What are the perceived limitations and/or potential approaches for mitigation?
- What additional applications for these new tools merit consideration?

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