2020 WEBINAR SERIES
RPUG Road Profile Users' Group

Implementing Transverse Profile Certification Standards

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VIRGINIA TECH

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AASHTO Standards

Developed under TPF-5(299)/(399) 24 State DOTs (FHWA Admin.):

Improve the Quality of Pavement Surface Distress and Transverse Profile Data Collection and Analysis

Thanks to

- Andy Mergenmeier, FHWA
- Project Panel: John Andrews, John Coplantz, David Luhr, Jenny Li, Rick Miller, Stephanie Weigel

AASHTO Standards

Created as Research Program at Virginia Tech

PI: John Ferris

Thanks to

- My former students
  - Savio Pereira, Ph.D. now at RobotWits LLC
  - Craig Altmann, Ph.D. now at Virginia Military Institute
- VTTI: Gerardo Flintsch, Edgar de Leon Izeppi, Samer Katicha

AASHTO Standards

Implementing through FHWA TOPR with **Quality Engineering Solutions**

Thanks to

- Sherry Morian, Dennis Morian, Doug Firth

Including a subcontract to **Road Scholar Solutions**

- John Ferris, Managing Member

Outline

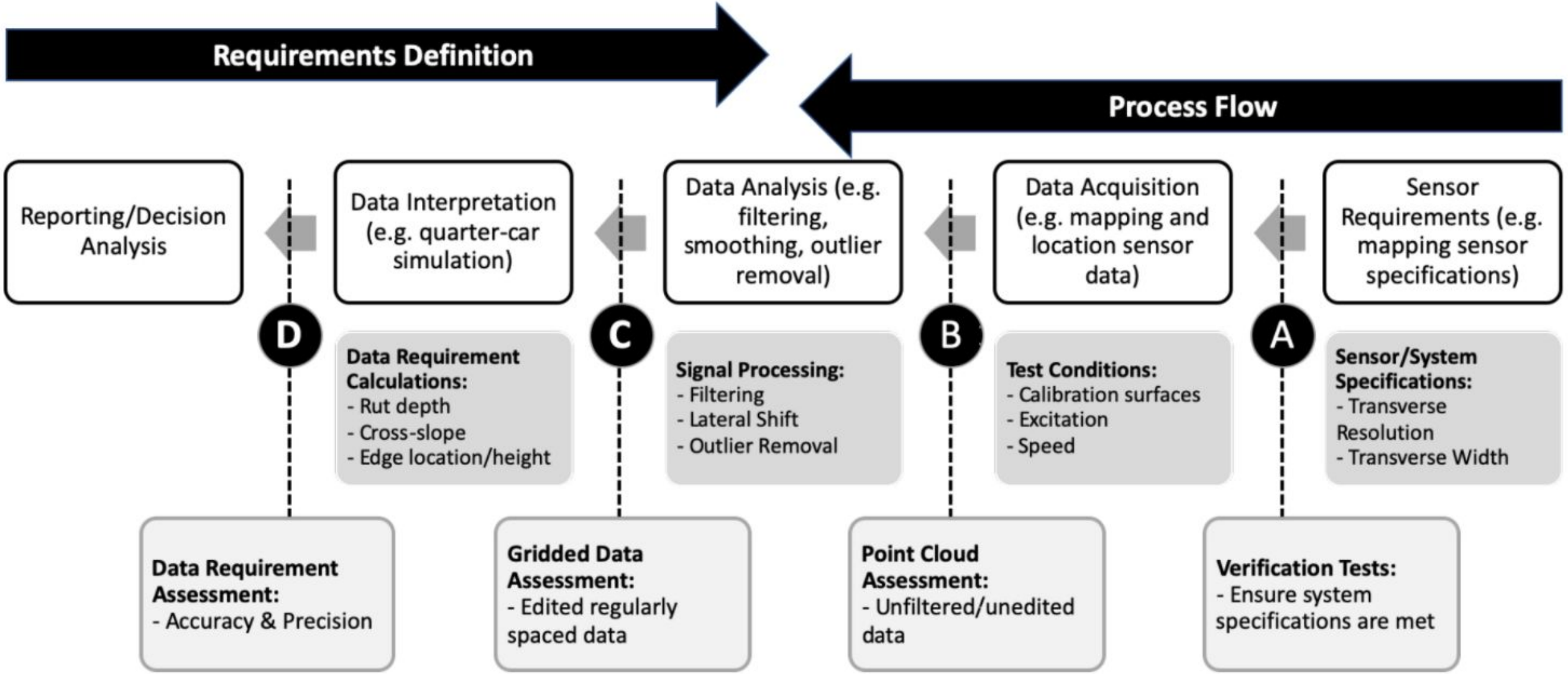
Overview, Definitions and Approach

Transverse Pavement Profiler (TPP) Assessment Tests

Ground Reference Equipment (GRE) Measurements

Assessment of GRE and TPP

Overview



RPUG Road Profile Users' Group

Definitions

Mapping Sensor

measure road surface relative to TPP coordinates

Examples:

- Laser/Lidar
- Camera
- Radar

Localization Sensor

georeference TPP system in global coordinates

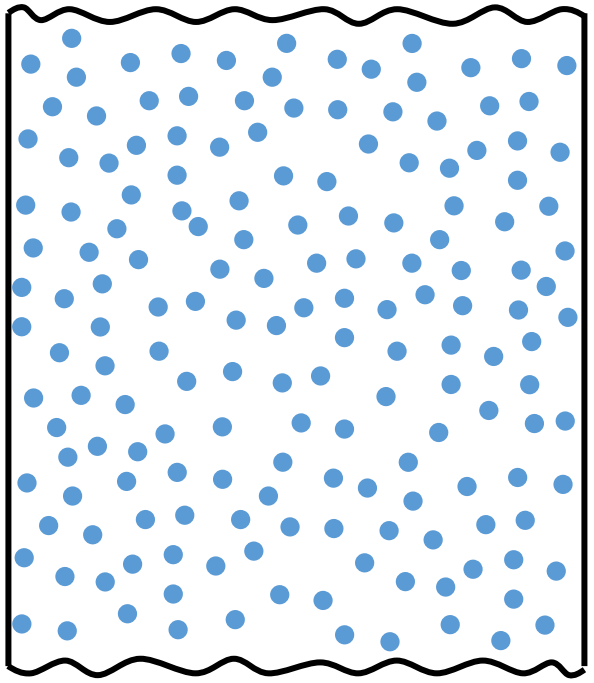
Examples:

- Inertial Nav. (GPS, IMU)
- Accelerometers

Fused to form georeferenced road surface data (point cloud)

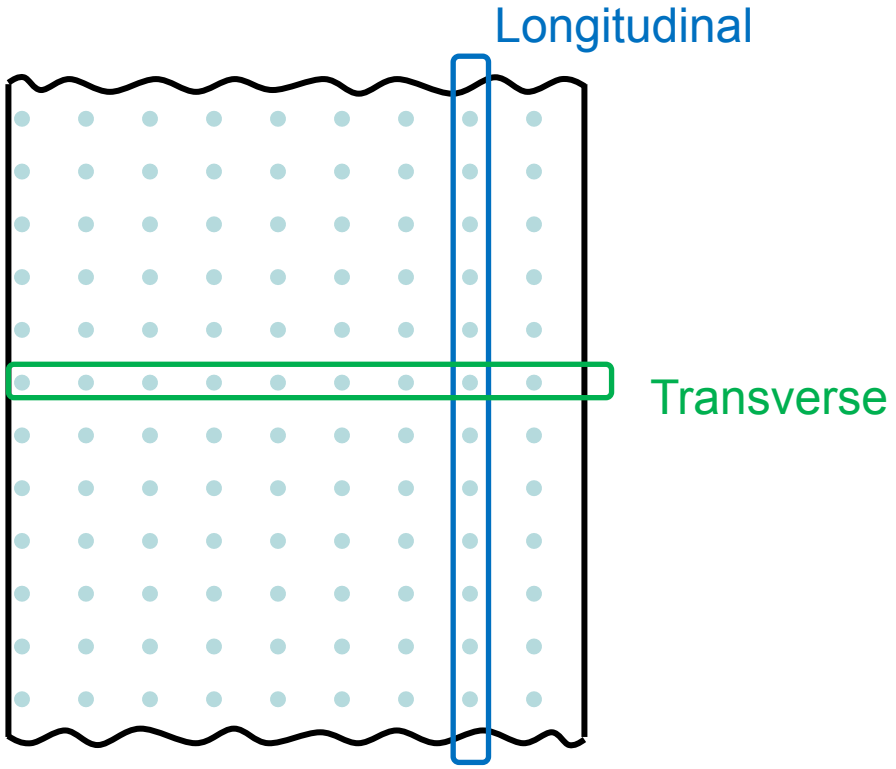
Definitions

Point Cloud



Georeferenced, but not filtered/edited

Gridded Data



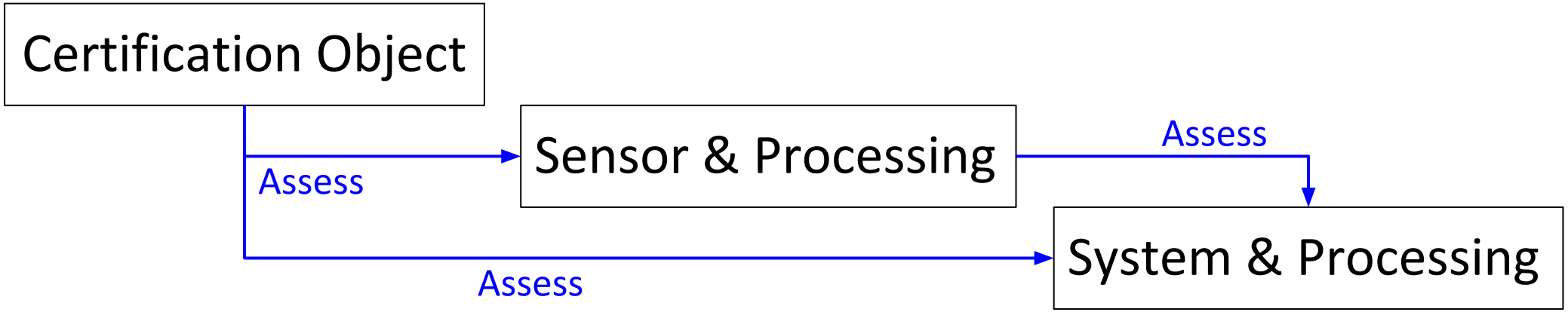
Filtered/edited & interpolated to regular grid

Top View

Approach

Chain of Traceability to Certification Objects

- Certification Objects
  - Dimensions measured by a certified laboratory (NIST, ISO…)
  - Dimensions known to some accuracy and precision traceable to Cert. Lab

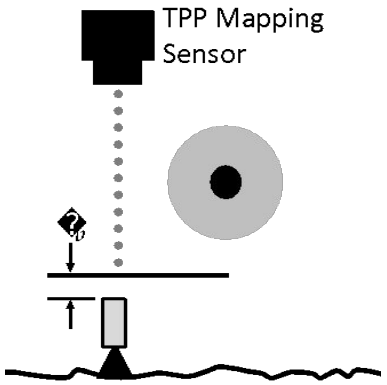


- Subsequent assessments limited by the accuracy of previous step

TPP Assessment Tests

Static performance	Evaluate static road surface measurement ability Assess mapping sensors
Body motion cancelation	Evaluate ability to remove body movement Assess localization sensors, fuse mapping and localization
Navigation drift mitigation	Evaluate drift in global position Assess localization sensors, fuse localization sensors
Typical highway	Evaluate complete TPP during typical highway operations - Transverse Capability - Ground Reference*

Static Performance

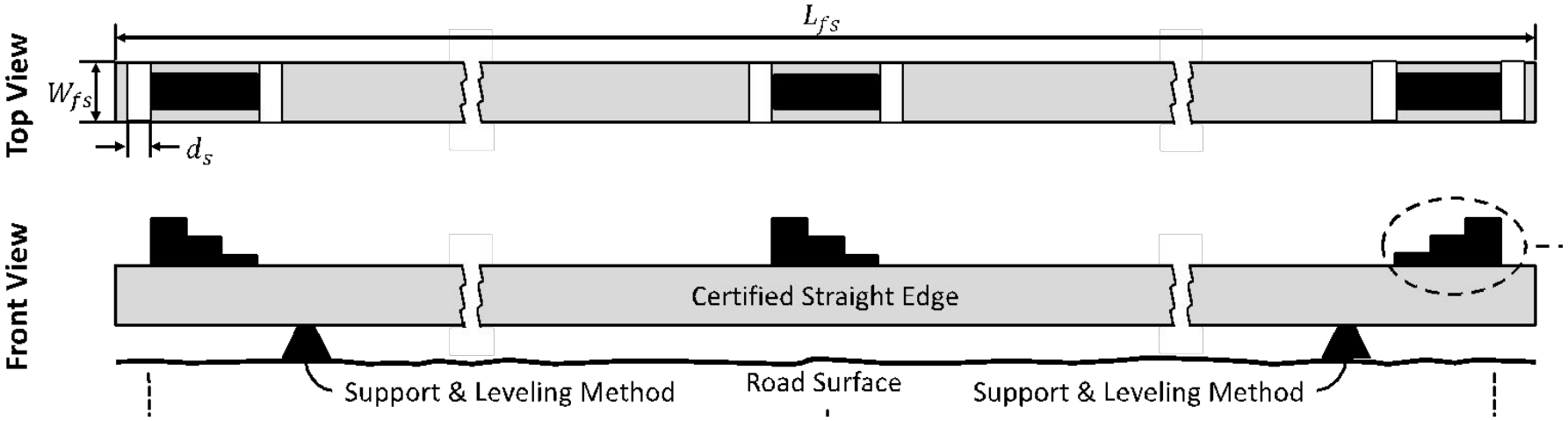


Side View

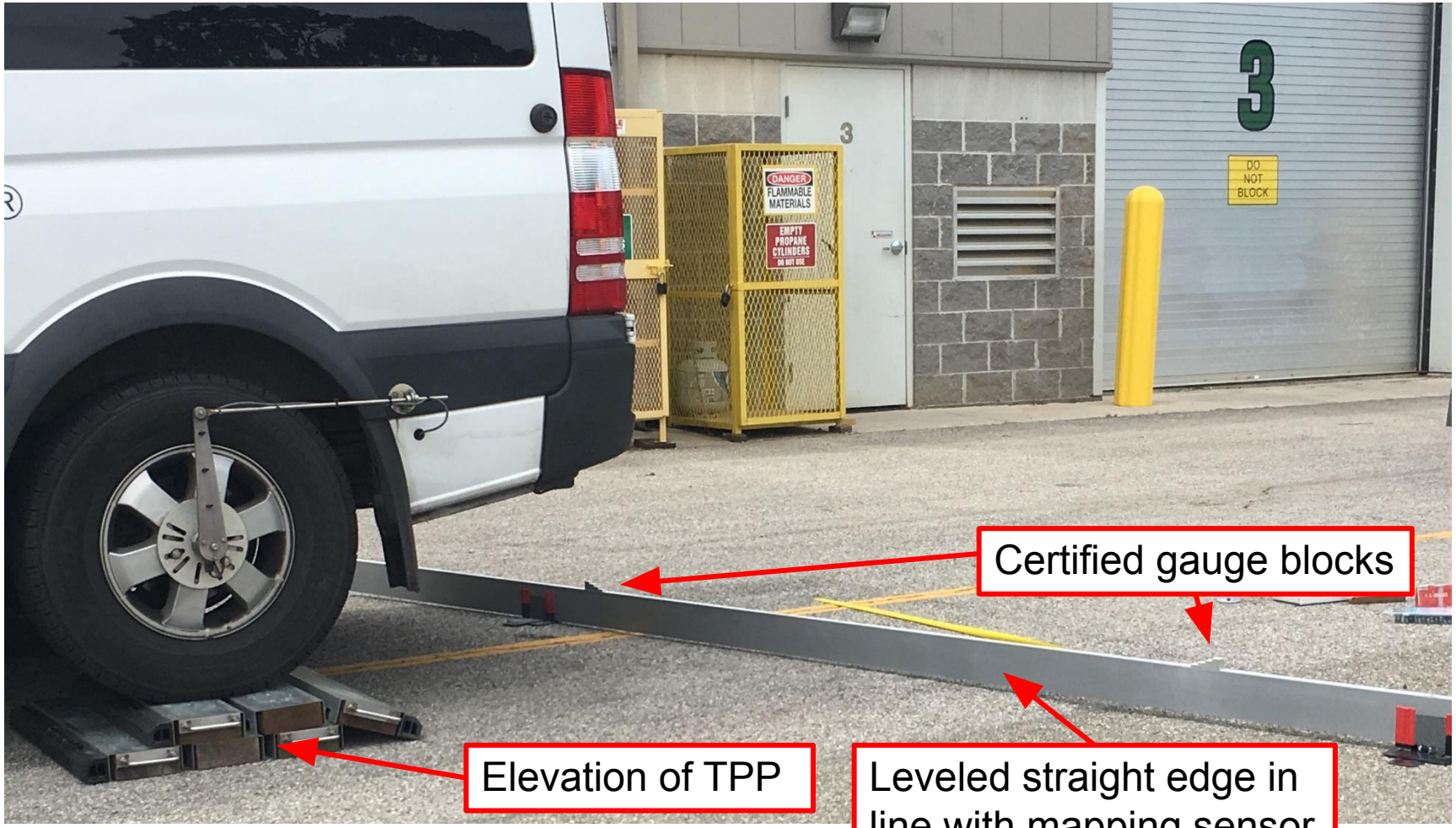
Assess:

- Mapping sensors (lasers)

Output Test Statistics
Transverse Measurement Resolution
Transverse Measurement Error
Vertical Measurement Resolution
Vertical Measurement Error
Total Transverse Width
Straightness Error



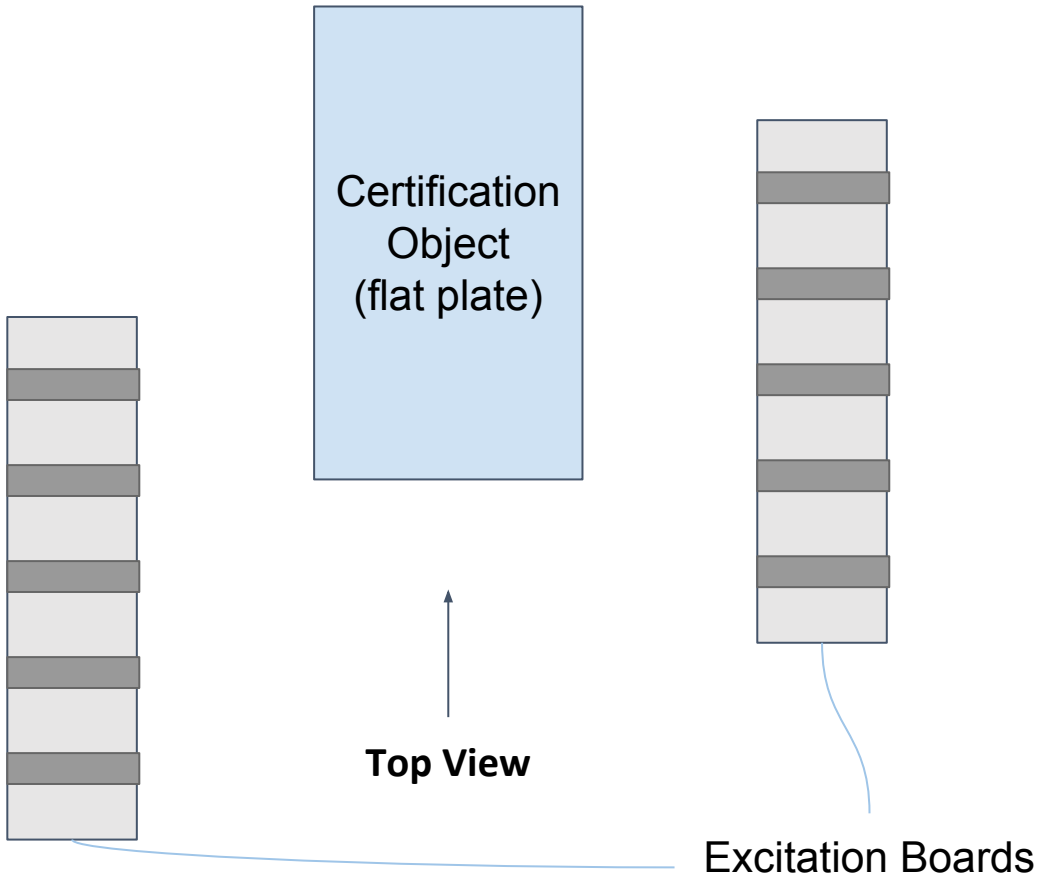
Static Performance



Body Motion Cancelation

Output Test Statistics

Vehicle Body Motion Error



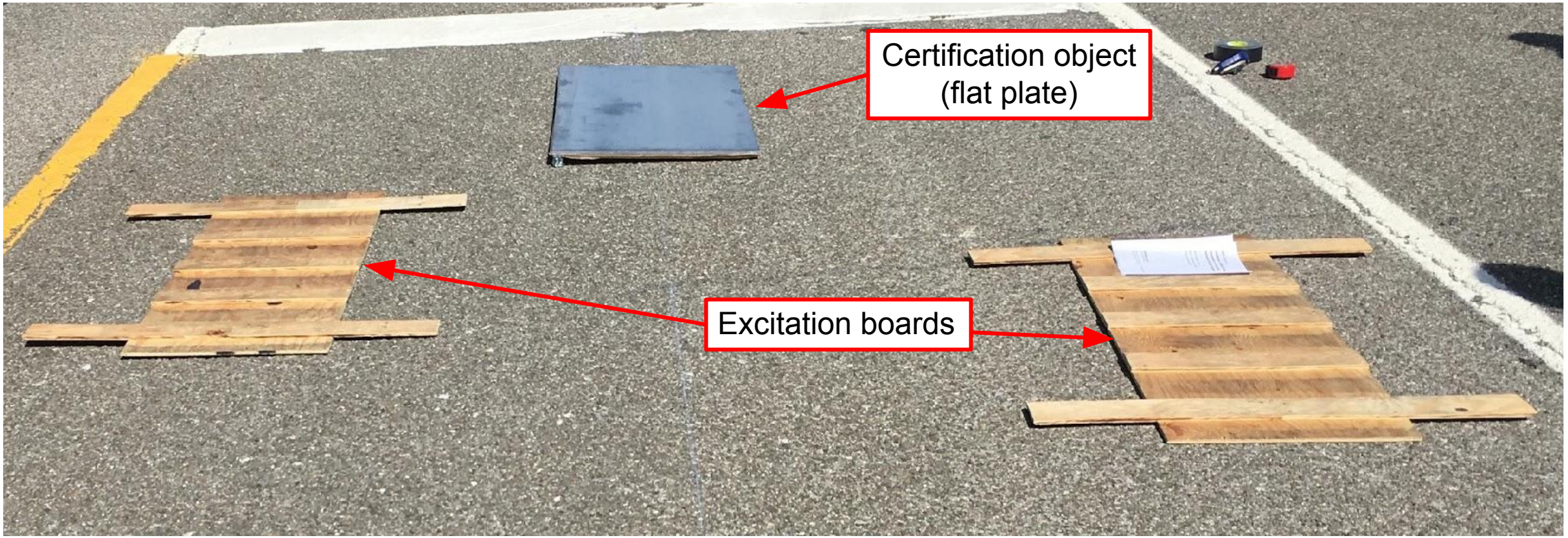
Assess:

- Localization sensors (IMU/gyro, accels)
- Processing: Fuse mapping and localization sensors

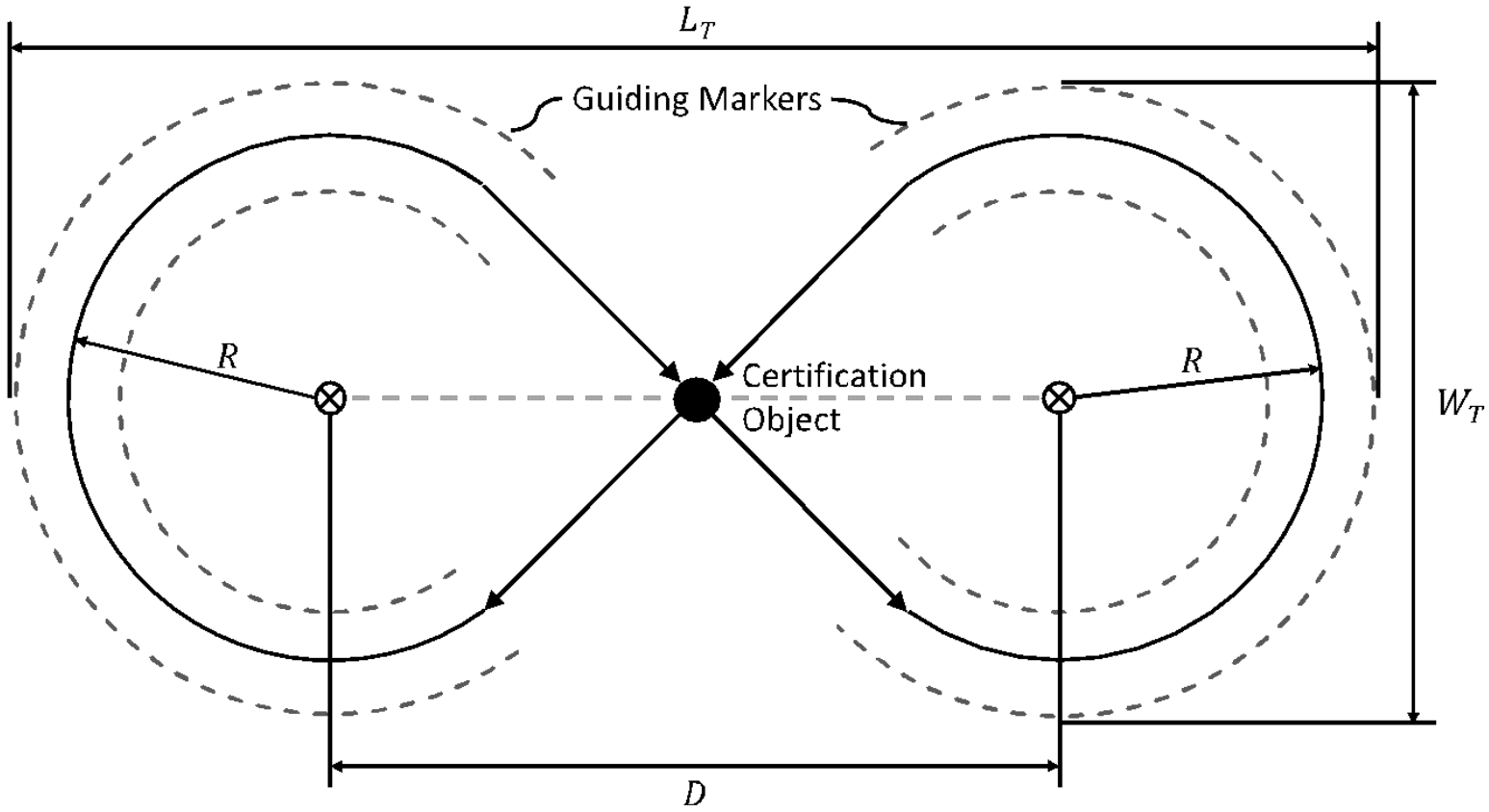
Induce:

- Roll
- Pitch
- Primary Bounce (~1.5 Hz)
- Secondary Bounce (~15 Hz)

Body Motion Cancelation



Navigation Drift Mitigation



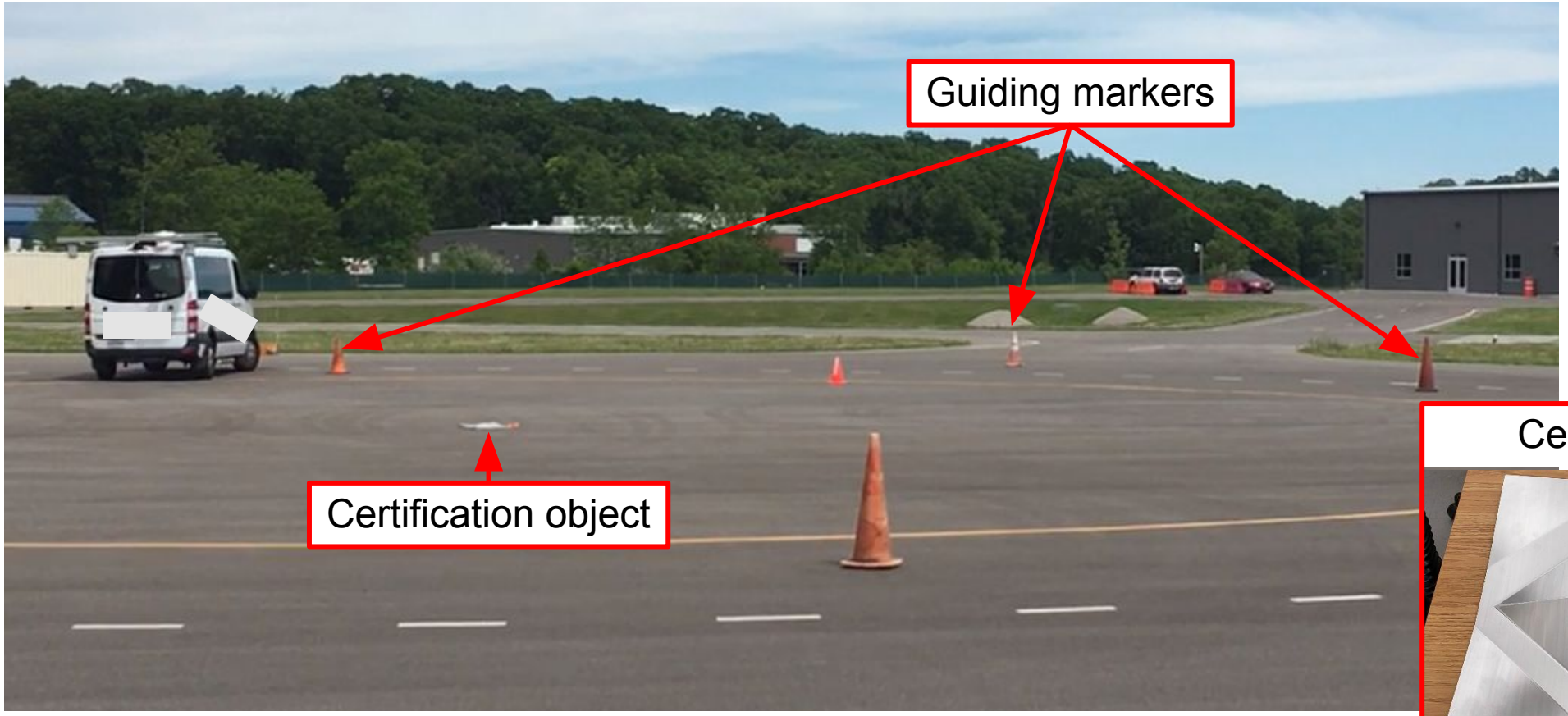
Top View

Output Test Statistics
Easting Position Error
Northing Position Error
Elevation Position Error

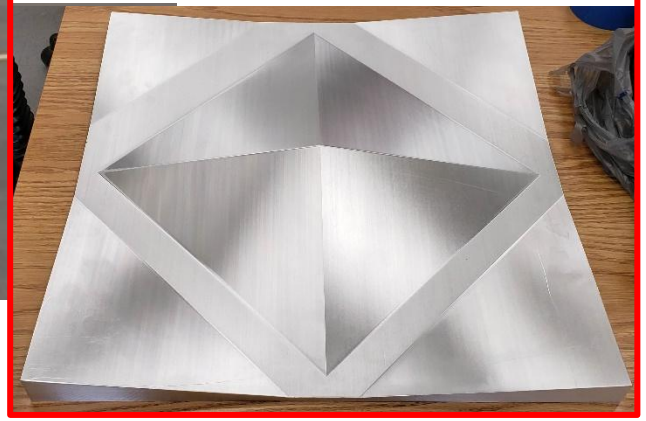
Assess:

- Localization sensors (GPS, IMU/gyro, accels)
- Processing: Fuse various localization sensors

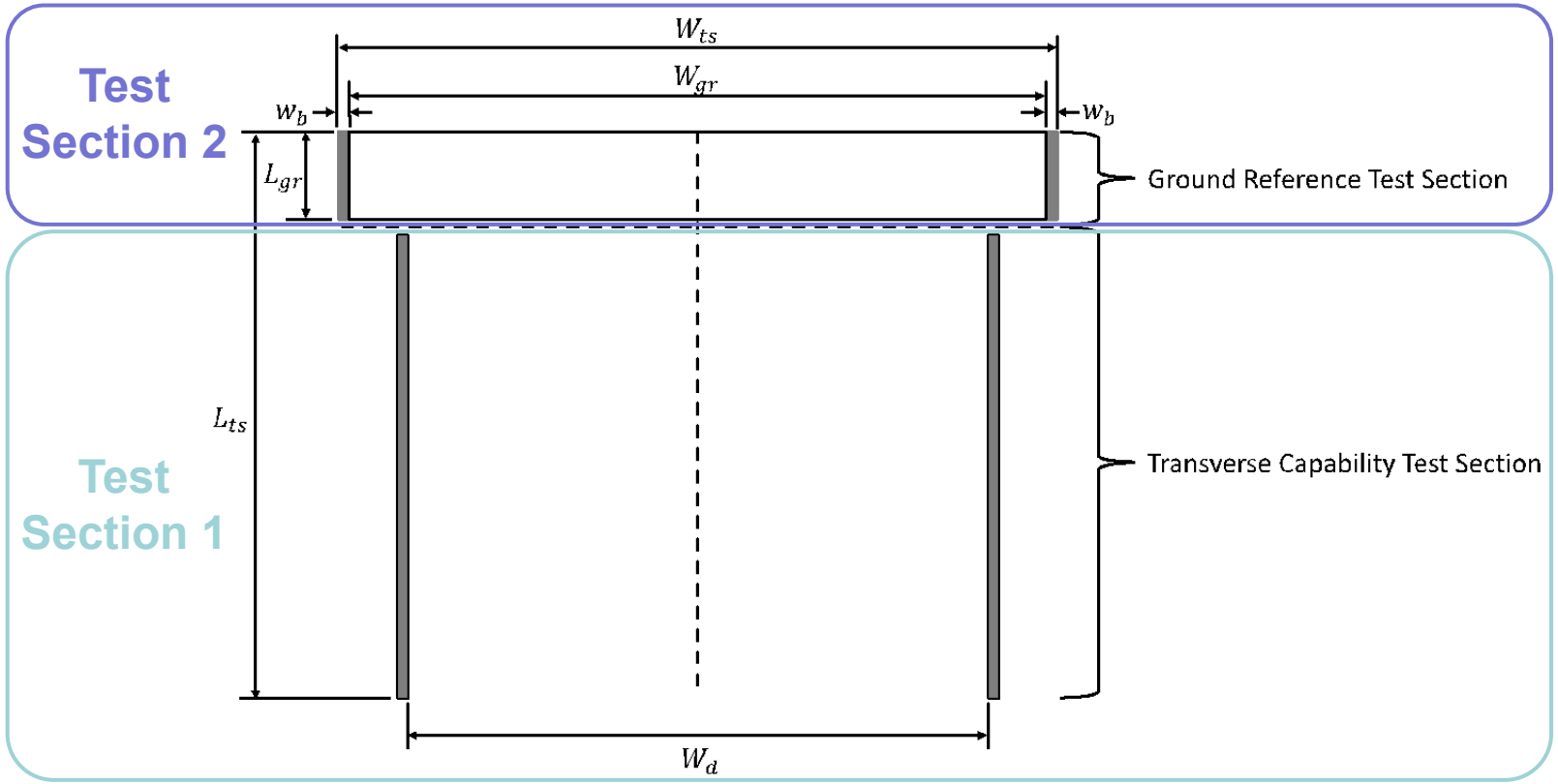
Navigation Drift Mitigation



Certification object



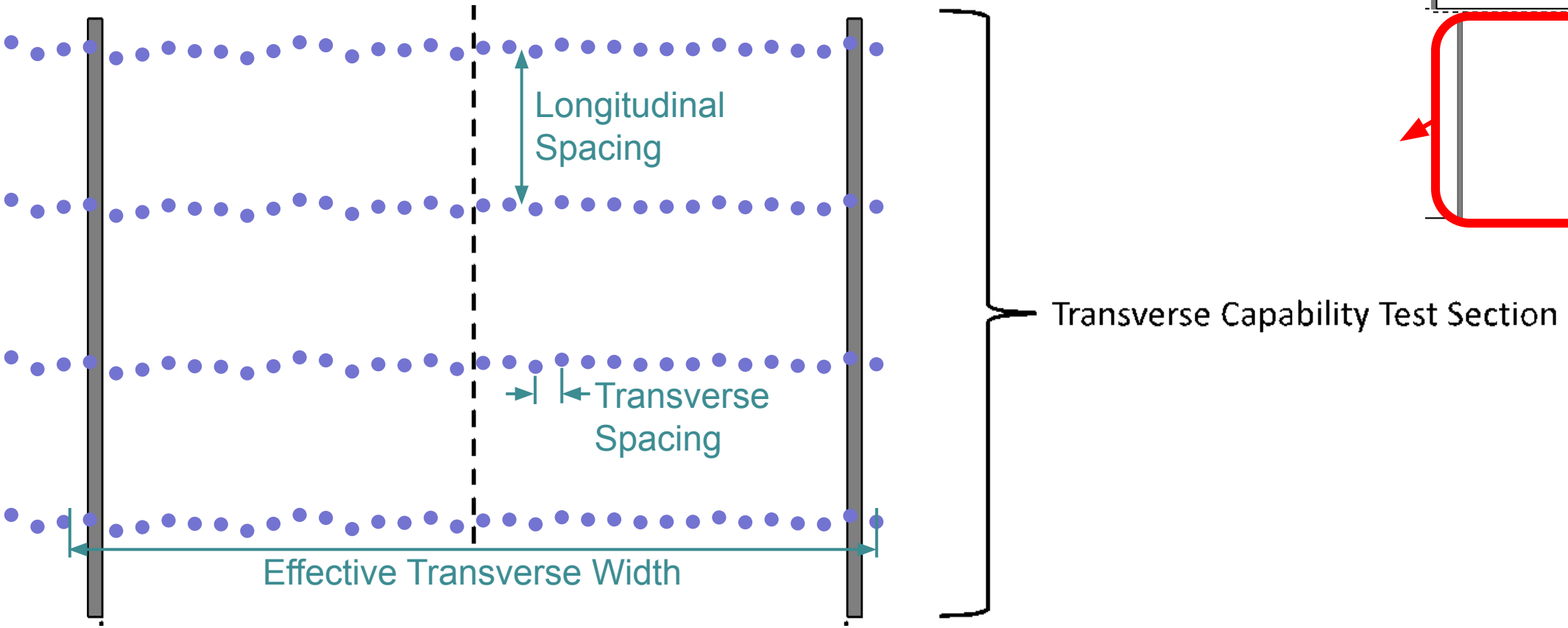
Typical highway performance

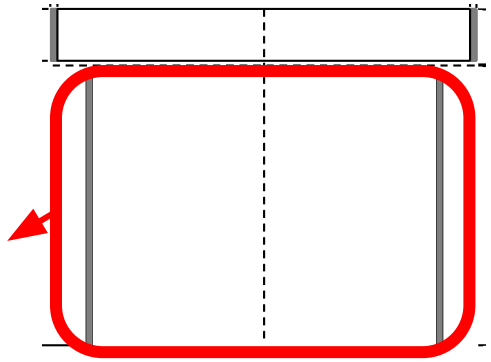


Top View

Output Test Statistics
Transverse Measurement Spacing [1]
Effective Transverse Width [1]
Vertical Measurement Spacing [1]
Longitudinal Measurement Spacing [1]
Point Cloud Vertical Error [2]
Gridded Data Vertical Error [2]
Cross Slope Error [2]
Rut Depth Error [2]
Edge/Curb Transverse Location Error [2]
Edge/Curb Vertical Magnitude Error [2]

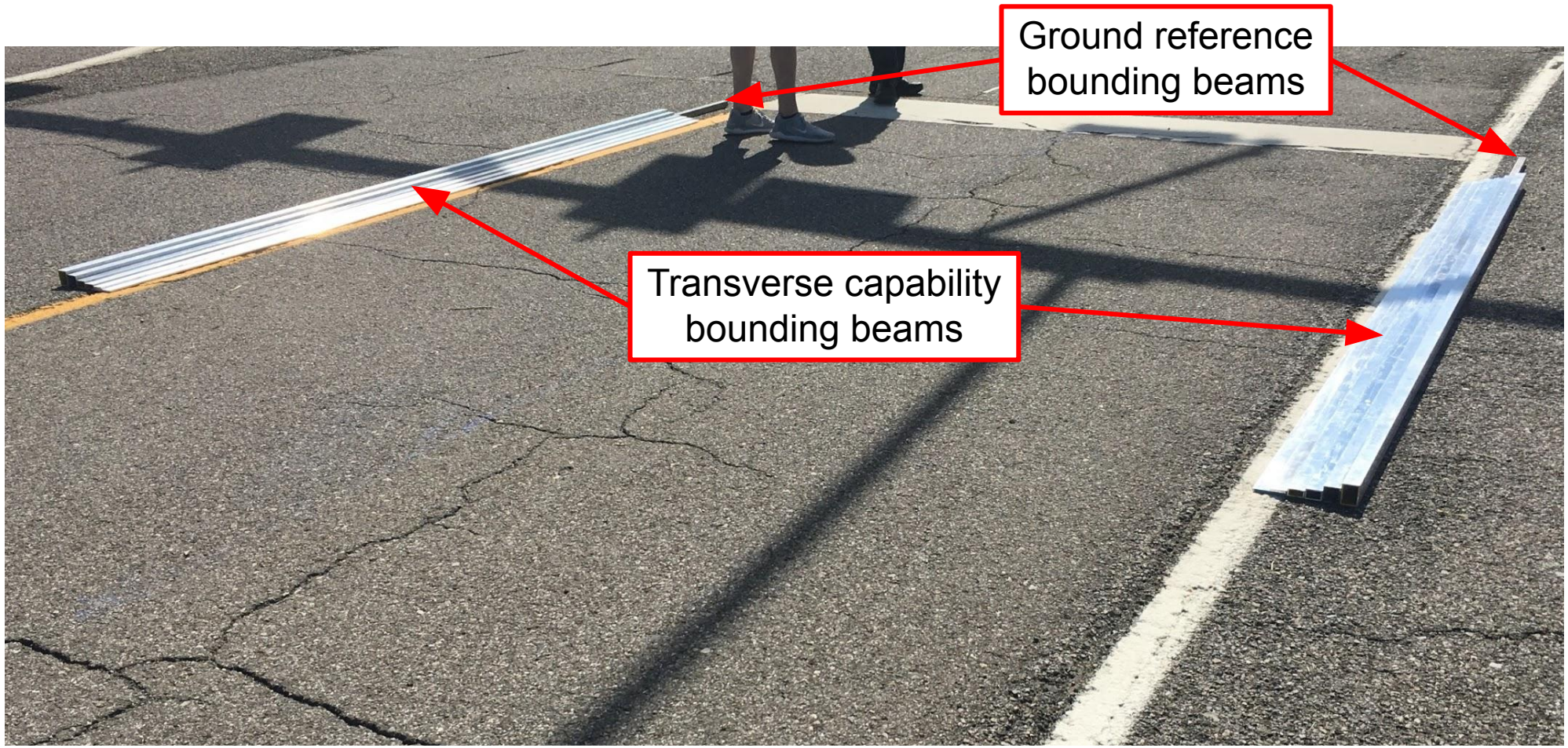
Transverse Capability Test – Section 1





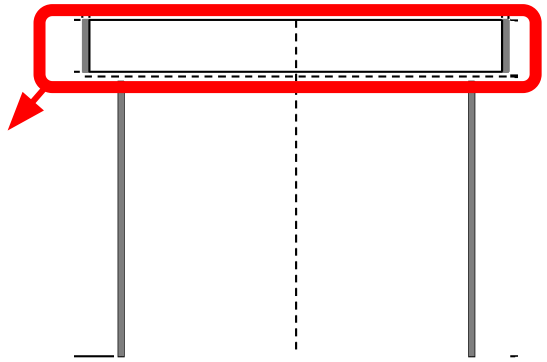
Top View

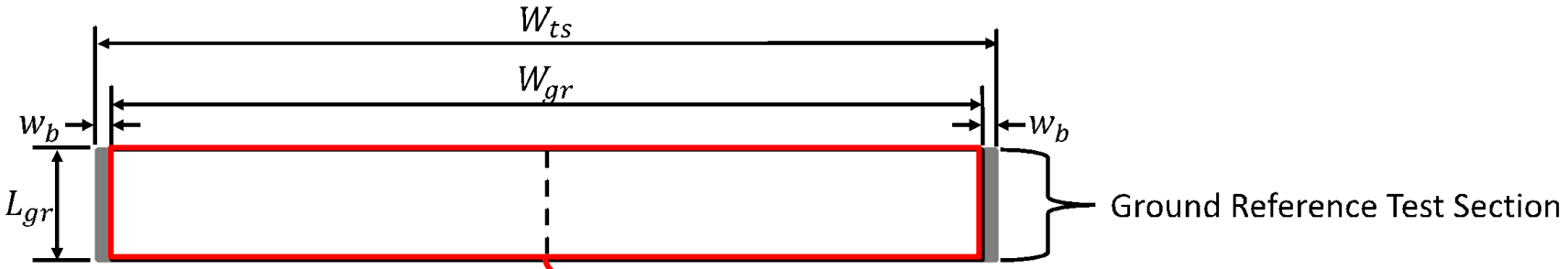
Typical highway performance



Ground Reference Test – Section 2

*Section with **reference** measurements is required*

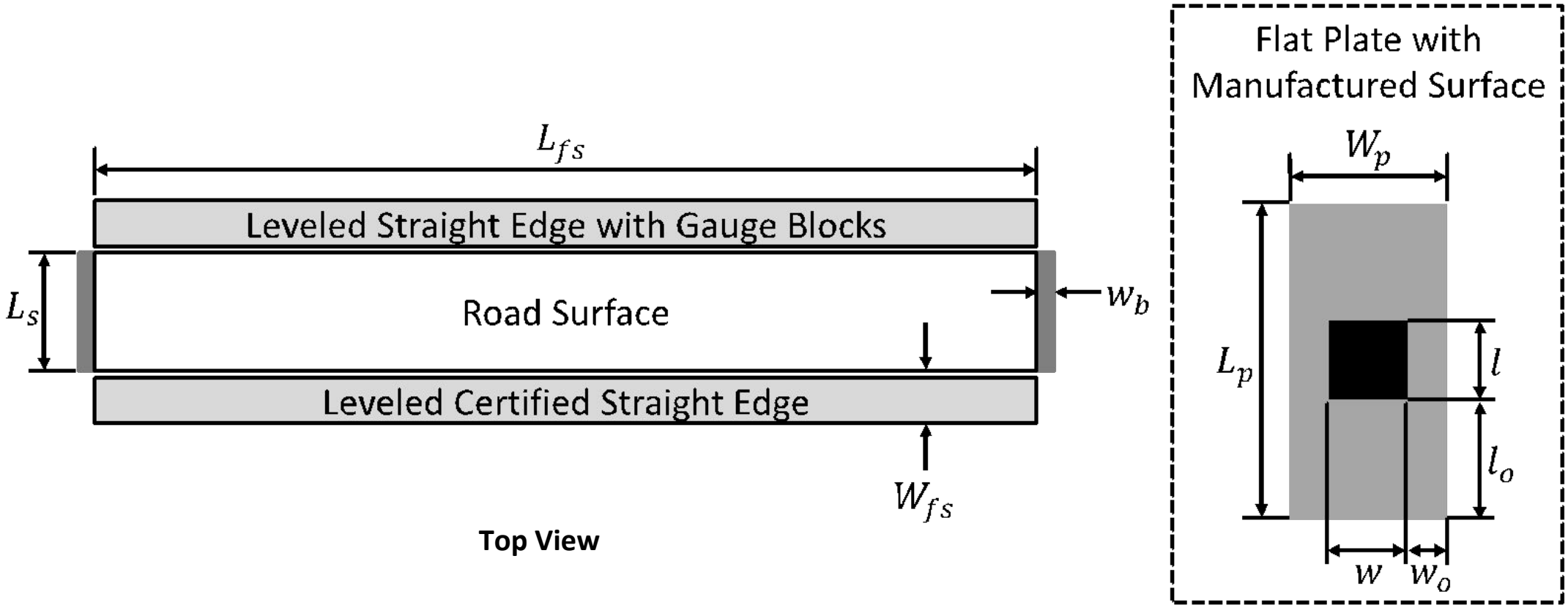




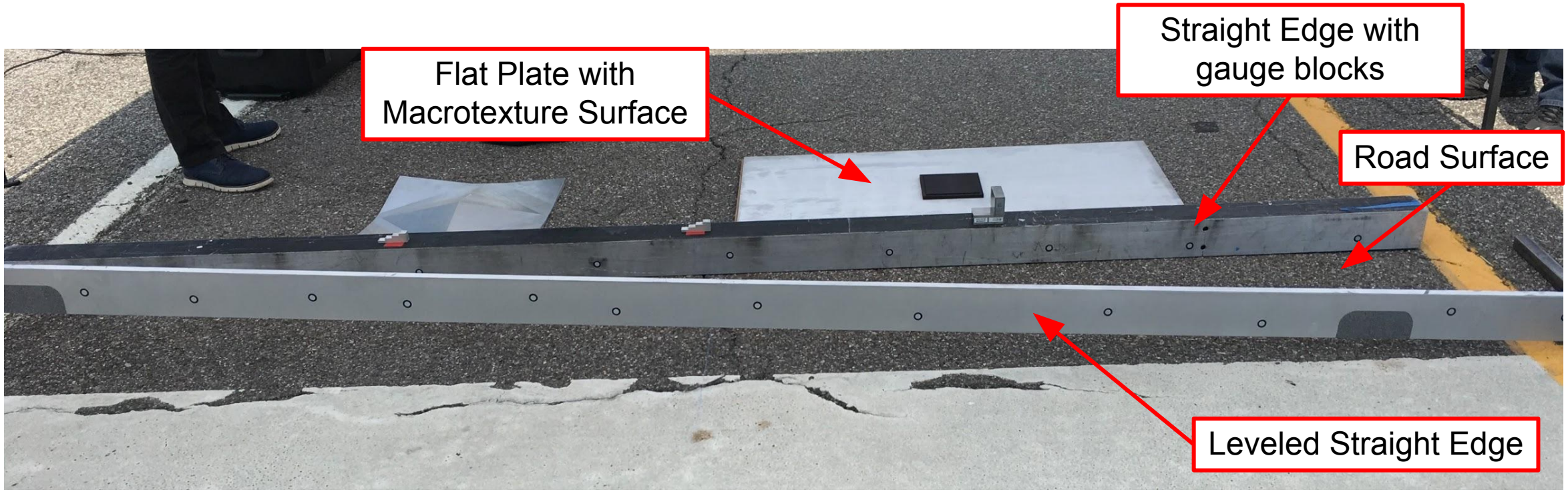
Top View

Acceptance of GRE Measurements

Use the proposed TPP certifications as a guide for developing GRE certifications

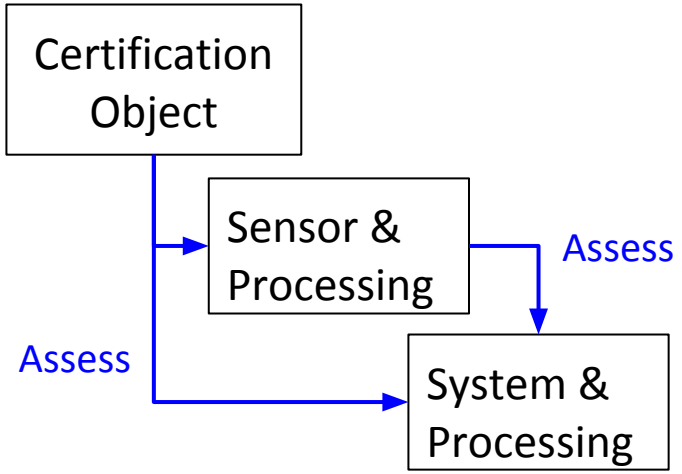


Acceptance of GRE Measurements

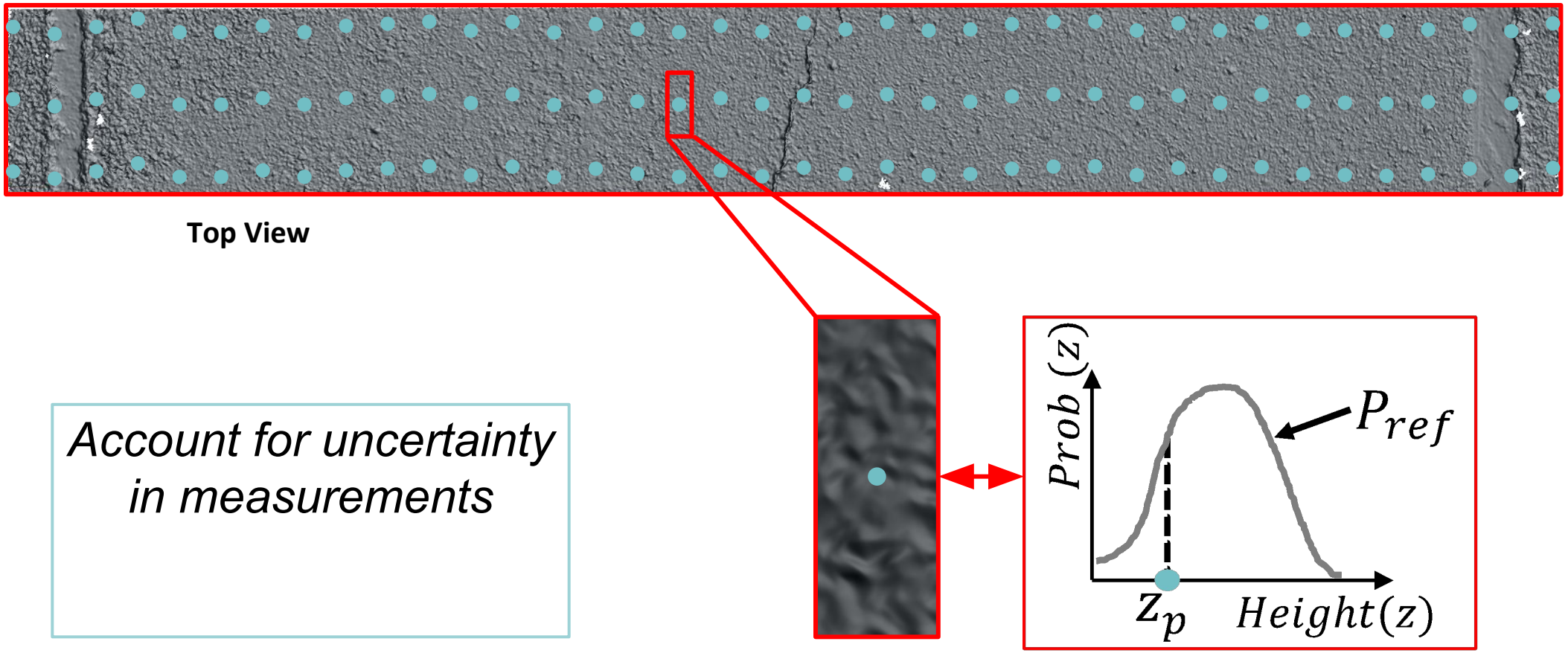


Acceptance of GRE Measurements

Recall Chain of Traceability:



Ground Reference Test: TPP Measurements



Account for uncertainty in measurements

Precision and accuracy of TPP vs Requirements

Data Requirements
Requirements Statement (RS)

Accuracy and Precision					
	Lower Bounds (mm)		Bias	Upper Bounds (mm)	
	90% (5%)	50% (25%)		50% (75%)	90% (95%)
Rut Depth Error	-2.5	-1.0	NA	1.0	2.5
Cross Slope Error (%)	-0.4	-0.15	NA	0.15	0.40
Edge/Curb Transverse Location Error	-50	-25	NA	25	50
Edge/Curb Vertical Magnitude Error	-2.5	-1.5	NA	1.5	2.5

TPP Capabilities
Capability Statement (CS)

Accuracy and Precision					
	Lower Bounds (mm)		Bias	Upper Bounds (mm)	
	90% (5%)	50% (25%)		50% (75%)	90% (95%)
Transverse Measurement Error					
Vertical Measurement Error					
Transverse Measurement Resolution					
Vertical Measurement Resolution					
Transverse Width					
⋮					

Summary

- Tests for Transverse Pavement Profiler (TPP)
- Overview of Ground Reference Equipment
- Assessment of TPP Capabilities with respect to Requirements

Thank you