Calibration, Certification, and Verification of Transverse Pavement Profile Measurements

By

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Today's Discussion

- Project Objectives and Background
- Work to Date
- Overview of Standards
- Explanation of Ground Reference Data and Analysis

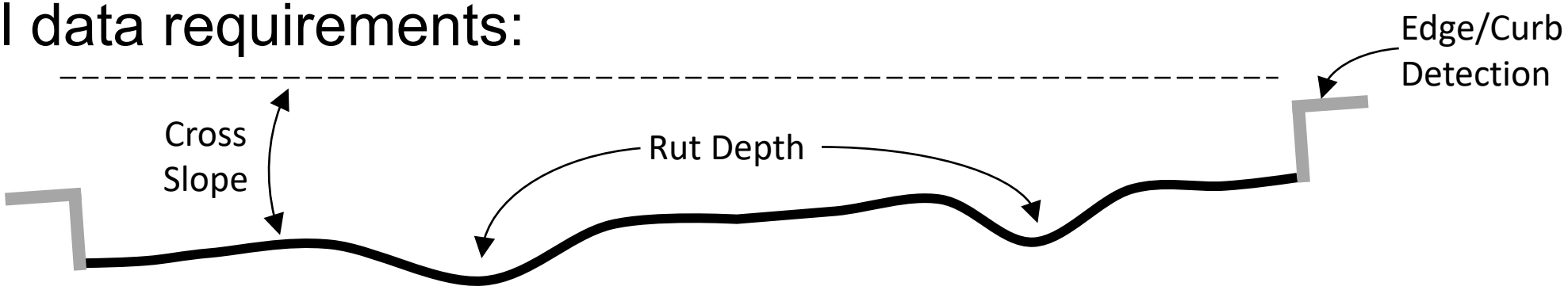
Objectives for Transverse Pavement Profile

- Determine precision and accuracy of highway speed transverse profile measurements
- Evaluate if the transverse pavement profiler measurements satisfy the accuracy and precision requirements

- Project Oversight Panel:
  - Weigel, ND
  - Andrews, former MD
  - Coplantz, OR
  - Miller, KS
  - Luhr, former WS
  - Li, TX
  - Mergenmeier, FHWA

Project Background

- Final data requirements:



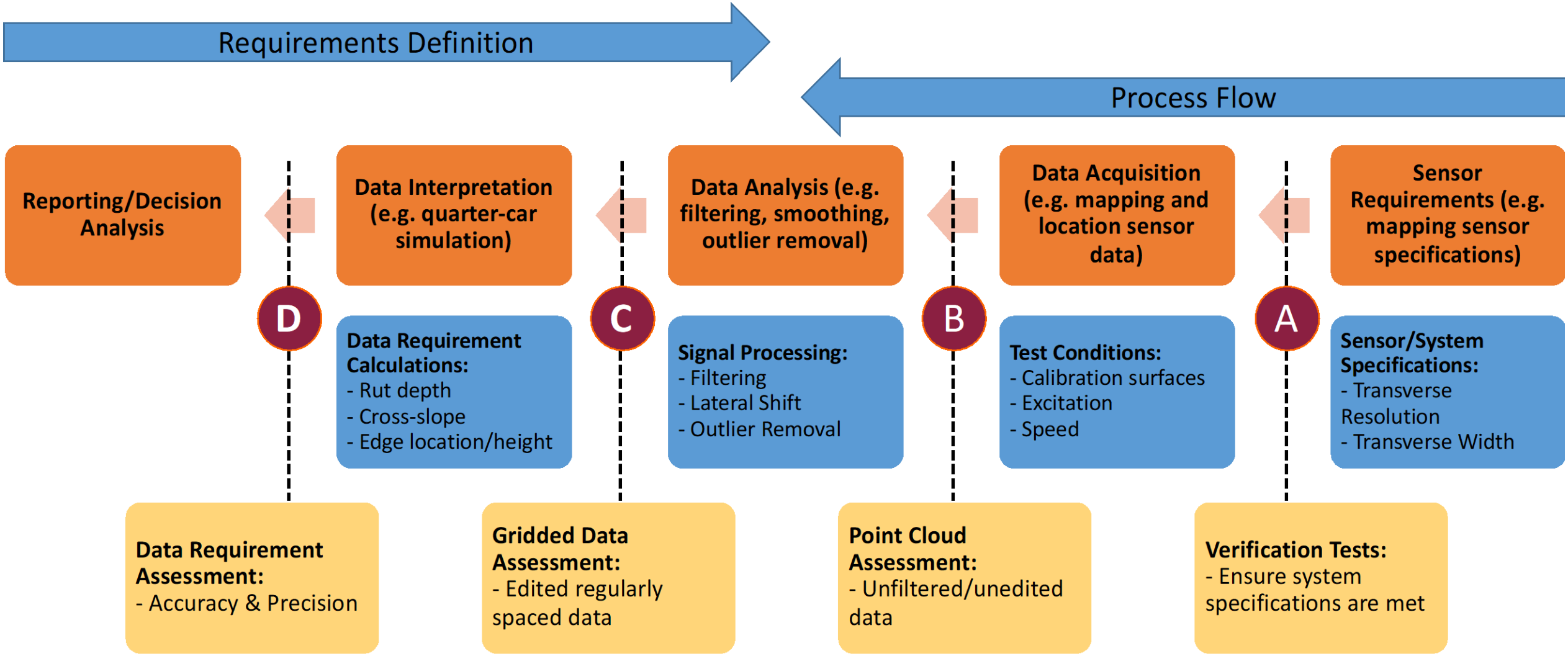
- Final Requirement Statement

Accuracy and Precision (mm)					
	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	-1.0	NA	1.0	2.5

Work to Date

- Two Equipment Rodeos
  - April 2018
  - May 2019
- Five Proposed AASHTO Standards
  - Static Performance
  - Body Motion Cancelation
  - Navigation Drift
  - Highway Performance
  - Acceptance of Ground Reference Equipment

Layers of Assessment



Developed Certification Tests

Static performance

Evaluate the accuracy and precision of the measurement sensors using traceable surfaces (straight edge and gauge blocks)

Body motion cancelation

Evaluate the capability of the transverse pavement profiler to remove movement of the vehicle body due to primary ride and roll excitations

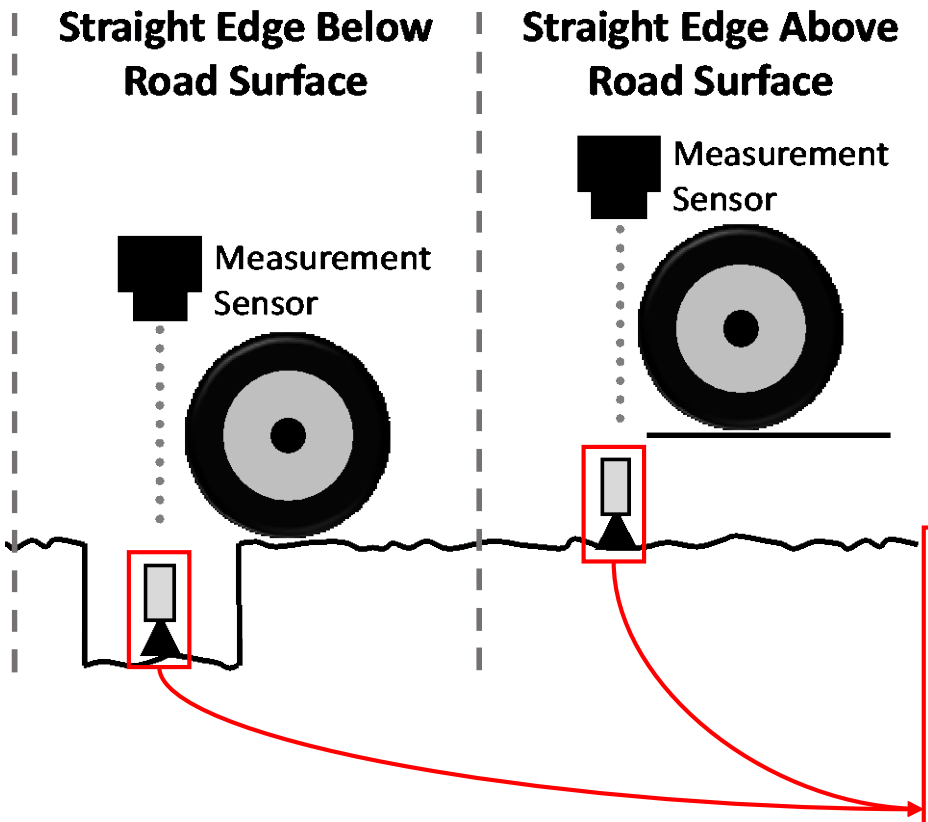
Navigation drift mitigation

Evaluate the magnitude of drift present in the reported global position of a stationary object when repeat passes are made over the object

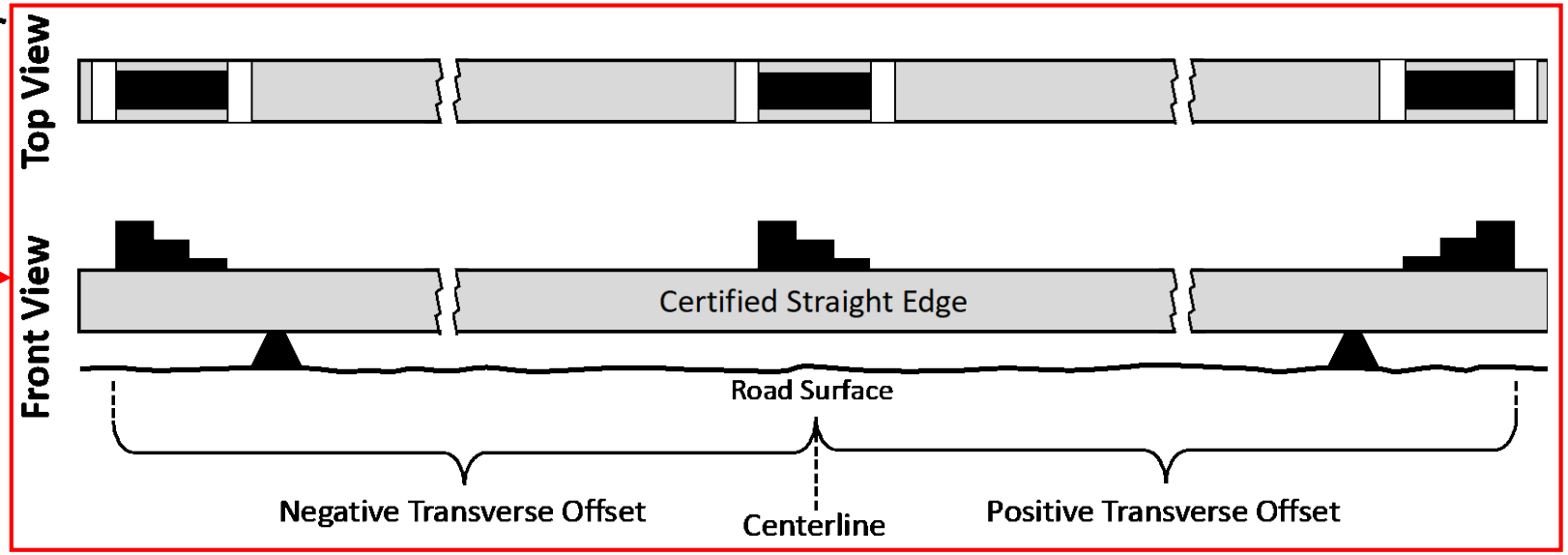
Typical highway performance

Evaluate the accuracy and precision of the complete transverse pavement profiler during typical highway operations

Static Performance



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



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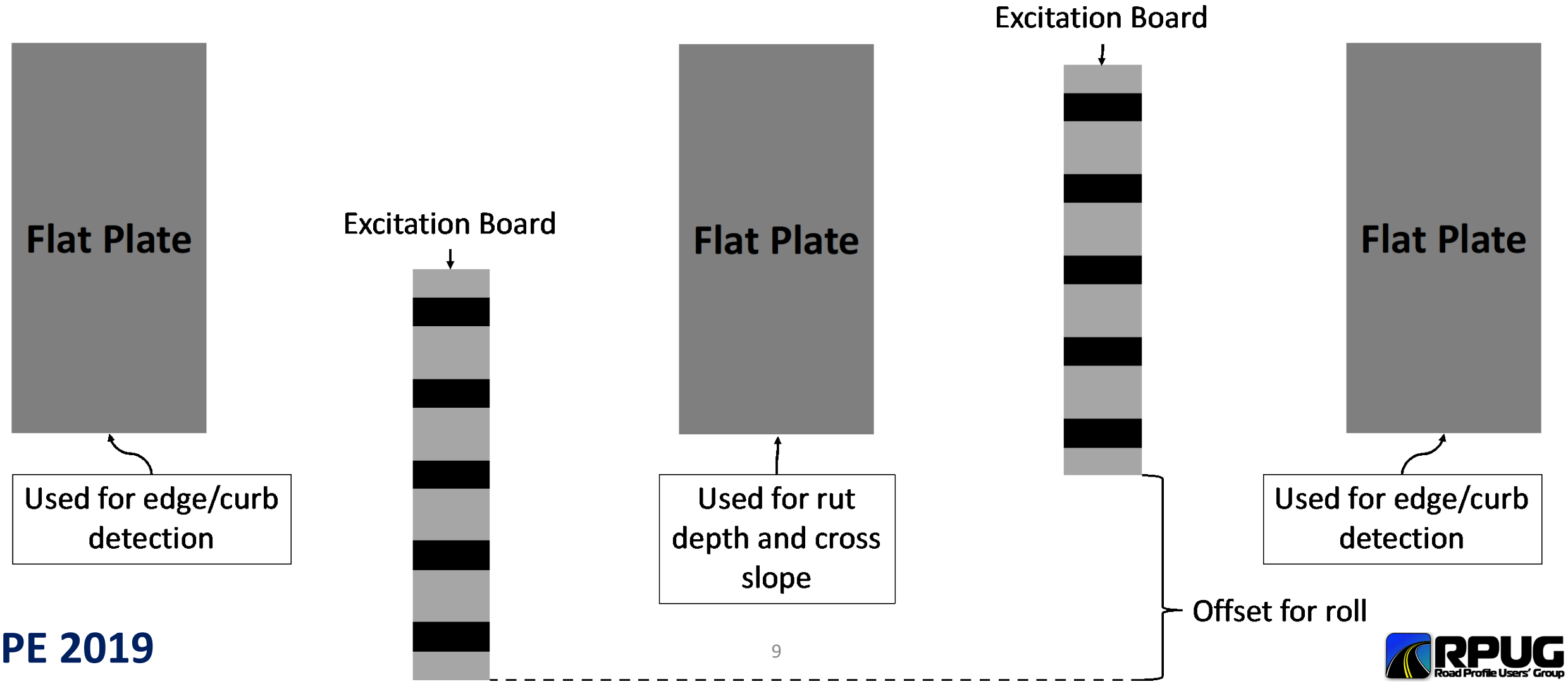
Body Motion Cancelation

Output Test Statistics
Vehicle Body Motion Error
Vertical Measurement Spacing



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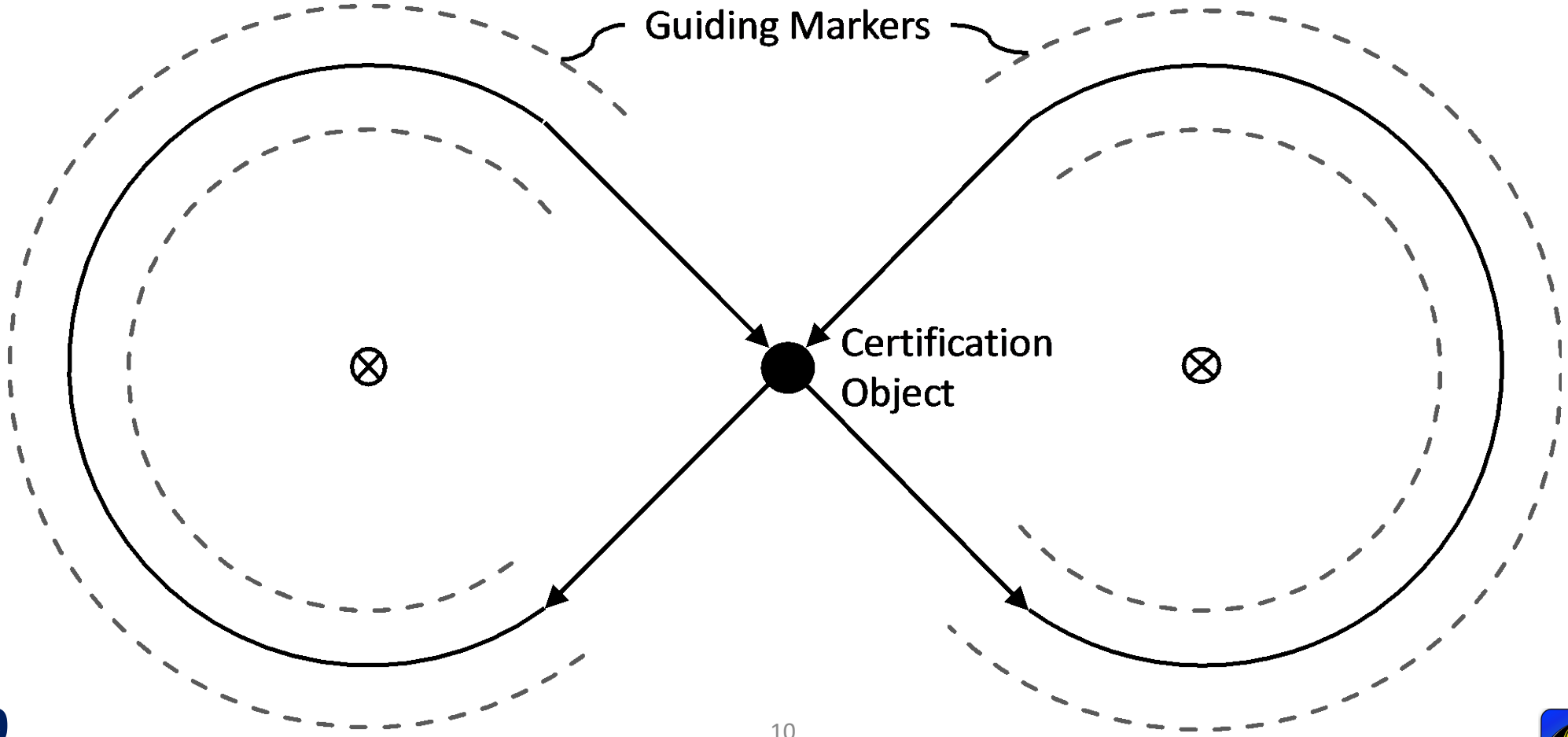
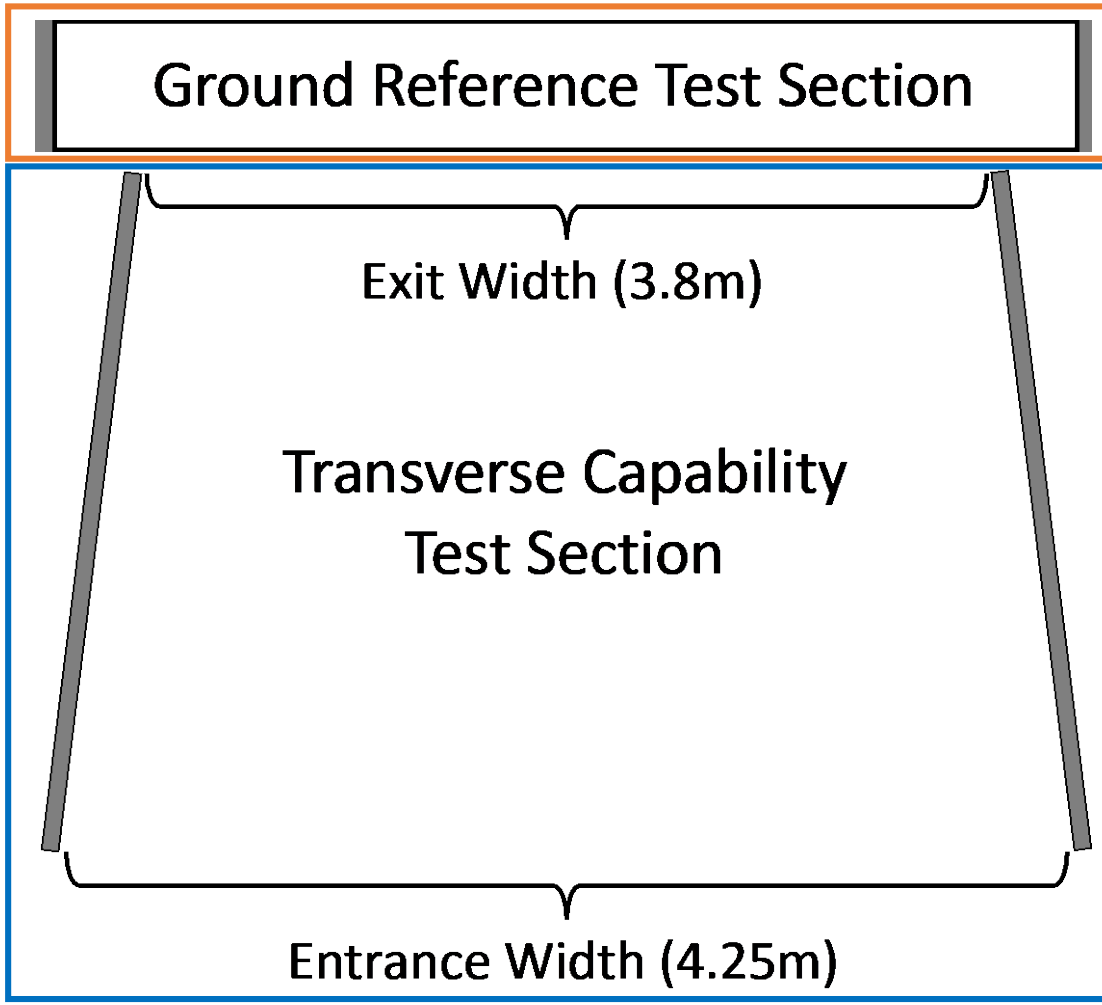
Navigation Drift

Output Test Statistics
Easting Position Error
Northing Position Error
Elevation Repeatability



Highway Performance



Output Test Statistics (Ground Reference Test Section)
Point Cloud Vertical Error
Gridded Data Vertical Error
Cross Slope Error
Rut Depth Error
Edge/Curb Transverse Location Error
Edge/Curb Vertical Magnitude Error

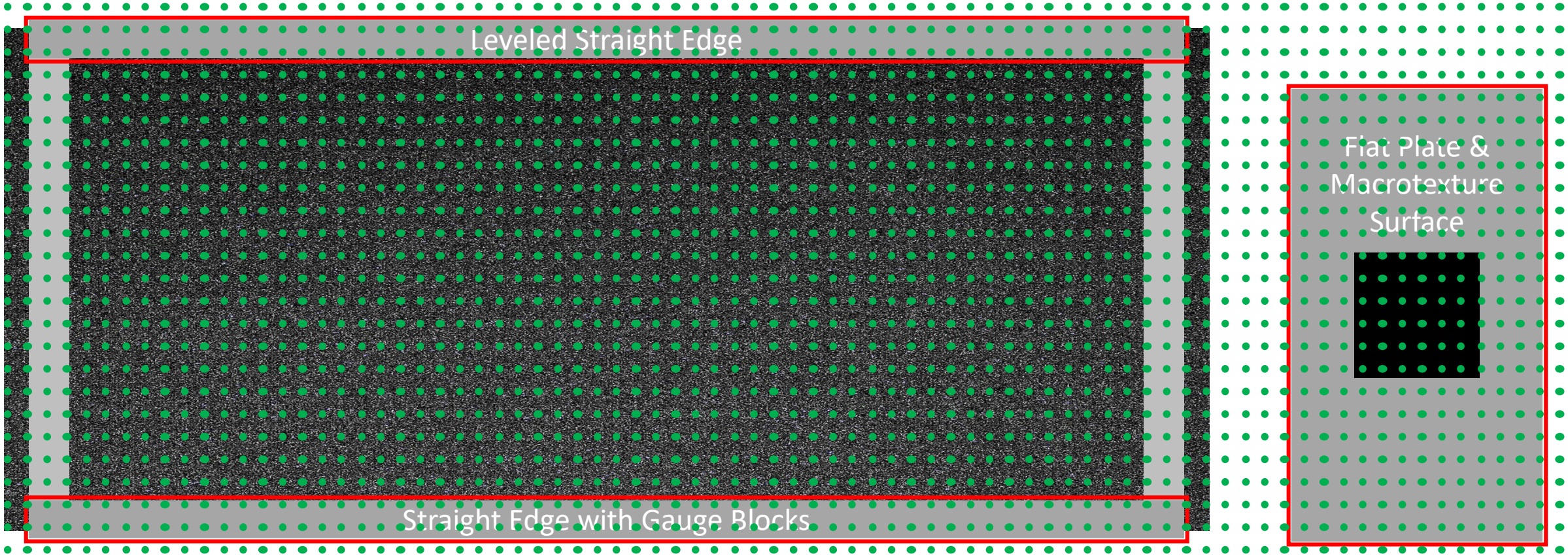
Output Test Statistics (Transverse Capability Test Section)
Transverse Measurement Spacing
Longitudinal Measurement Spacing
Effective Transverse Width

Ground Reference

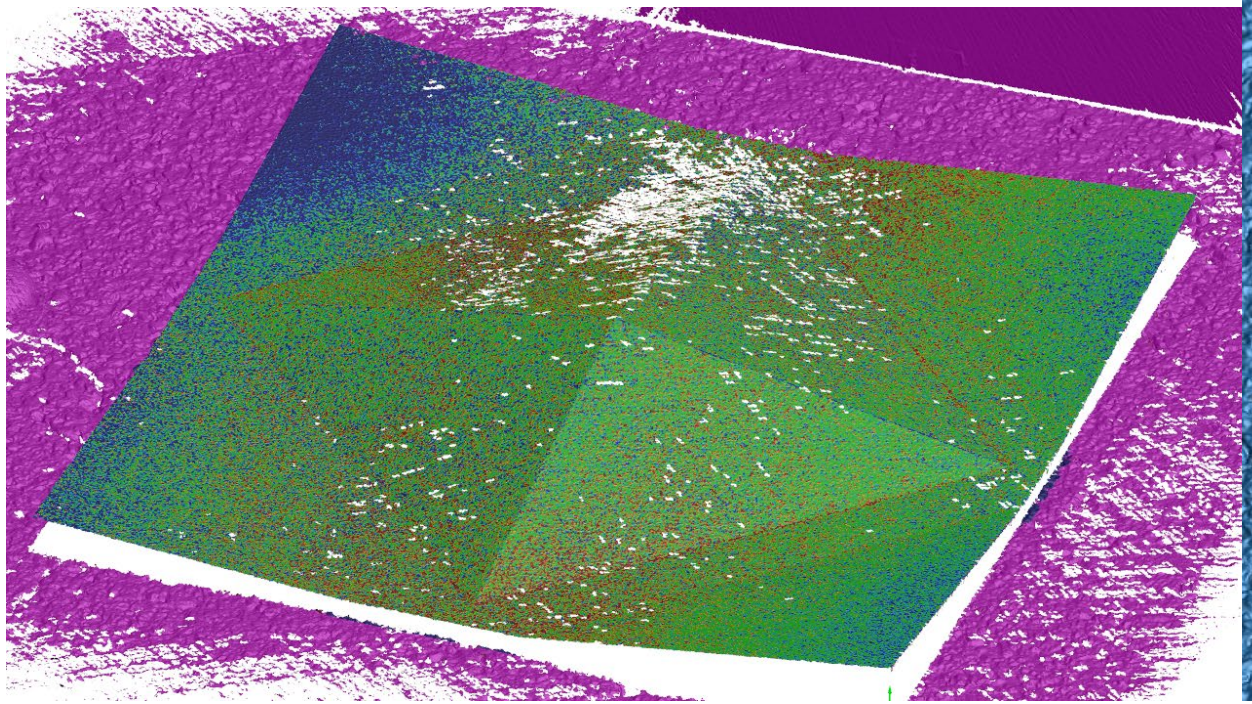
- Only test section where measurements of interest are of a pavement surface
- We need reference measures which are more accurate than the transverse pavement profiler
- We need an an analysis which captures the uncertainty of all measurements

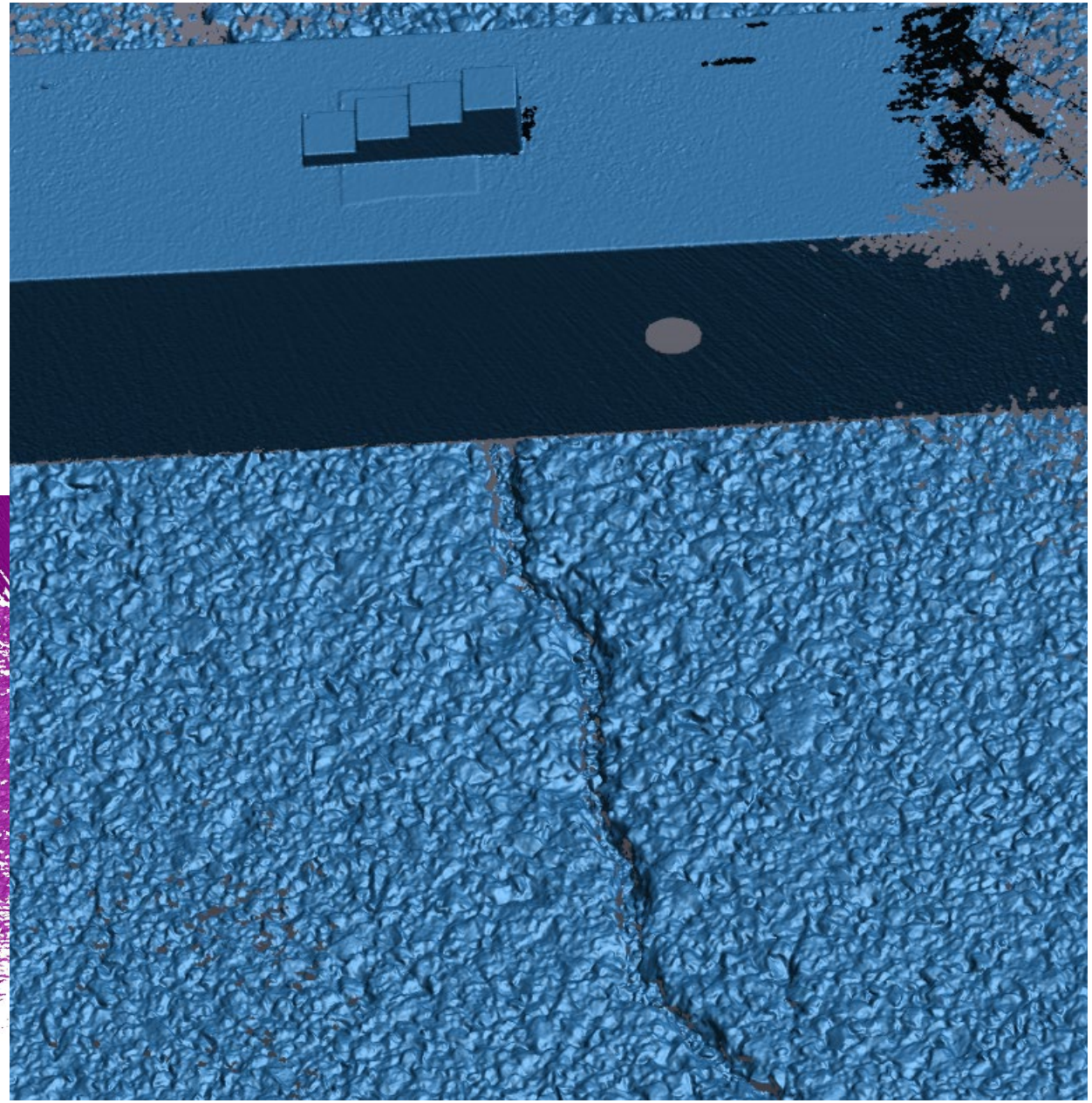
Ensuring accurate reference data

Include traceable objects at the time of ground reference data collection



Ground Reference Example Scans



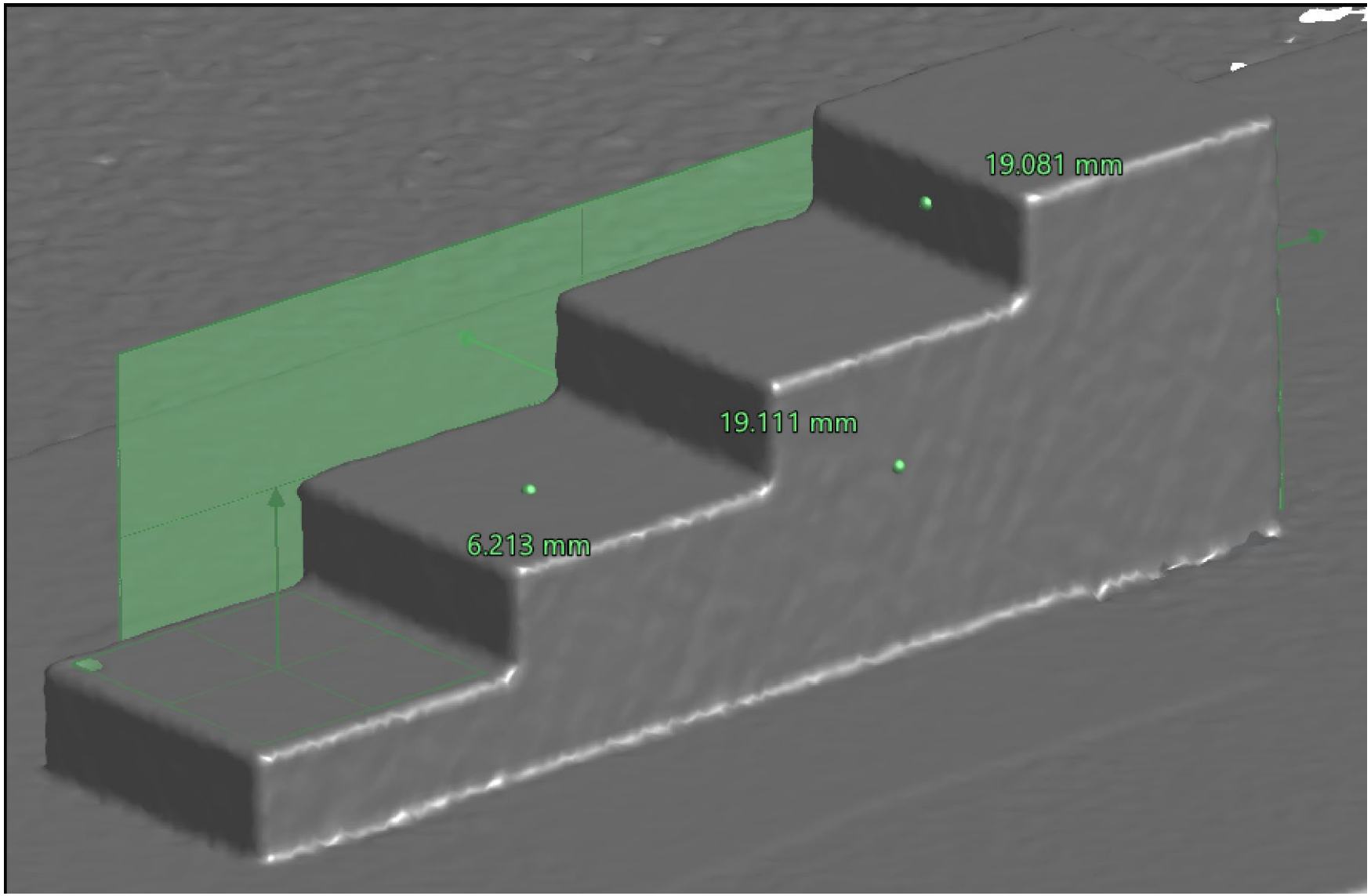


Ground Reference: Measurement Spacing

Accuracy and Precision Defined as Bias and Confidence Intervals (mm)						
		Lower Bounds (percentile)			Upper Bounds (percentile)	
		90% (5%)	50% (25%)	Bias	50% (75%)	90% (95%)
Transverse Measurement Spacing	**Required** Vendor					**2.0** 0.14*
Longitudinal Measurement Spacing	**Required** Vendor					**2.0** 0.15*
Vertical Measurement Spacing	**Required** Vendor					**0.03** 0.003

*Adjustable down to 0.05 mm

Ground Reference: Measurement Error



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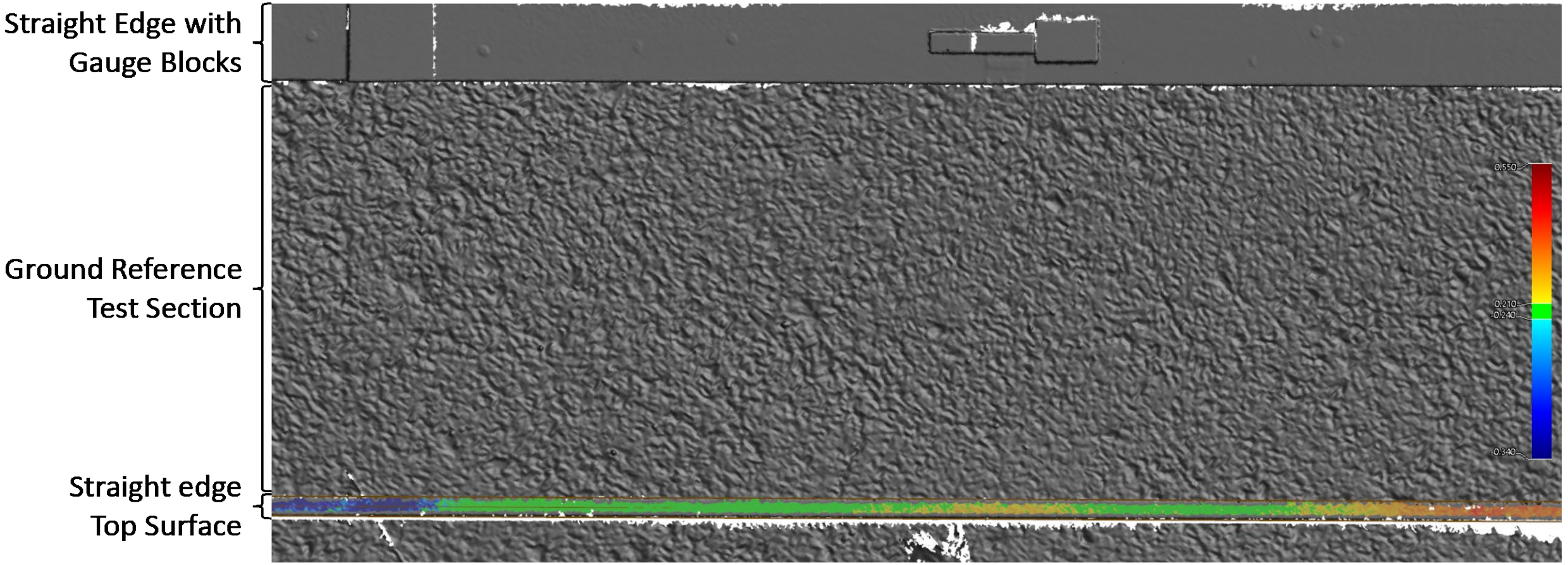
Ground Reference: Measurement Error

Accuracy and Precision Defined as Bias and Confidence Intervals (mm)						
		Lower Bounds (percentile)		Bias	Upper Bounds (percentile)	
		90% (5%)	50% (25%)		50% (75%)	90% (95%)
Transverse Measurement Error	**Required**	**-0.30**	**-0.15**		**0.15**	**0.30**
	Vendor	-0.04	0.01		0.07	0.13
Longitudinal Measurement Error	**Required**	**-0.30**	**-0.15**		**0.15**	**0.30**
	Vendor	-0.08	0.05		0.09	0.21
Vertical Measurement Error	**Required**	**-0.30**	**-0.15**		**0.15**	**0.30**
	Vendor	-0.16	-0.08		0.001	0.08

Ground Reference: Transverse Straightness & Width

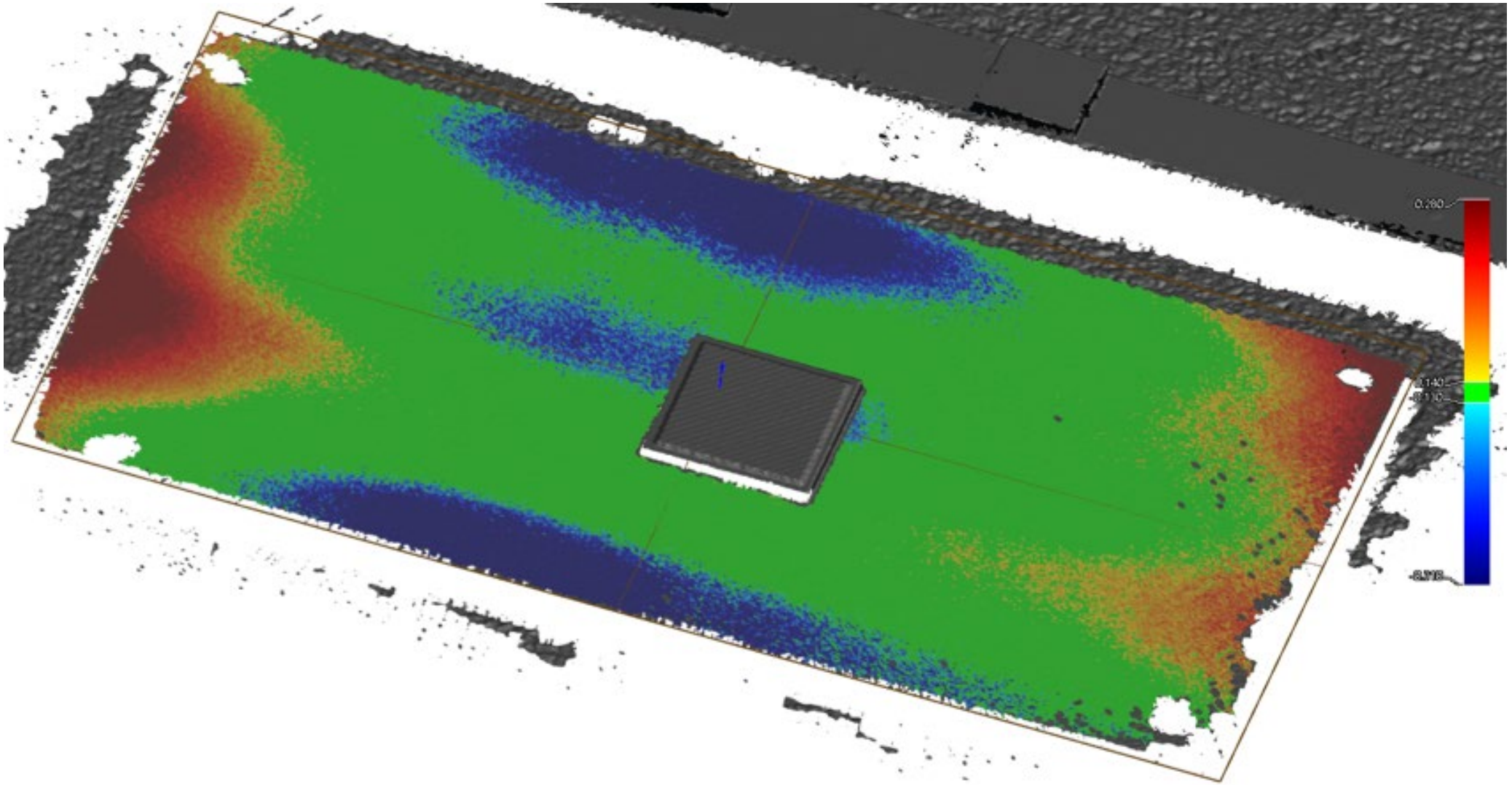


Ground Reference: Transverse Straightness & Width

Accuracy and Precision Defined as Bias and Confidence Intervals (mm)						
		Lower Bounds (percentile)			Upper Bounds (percentile)	
		90% (5%)	50% (25%)	Bias	50% (75%)	90% (95%)
Transverse Straightness	**Required**	**-1.0**	**-0.5**		**0.5**	**1.0**
	Vendor	-0.34	-0.24		0.21	0.55
Transverse Width	**Required**					**4000**
	Vendor					4876.8*

*Limited by 16ft straight edge

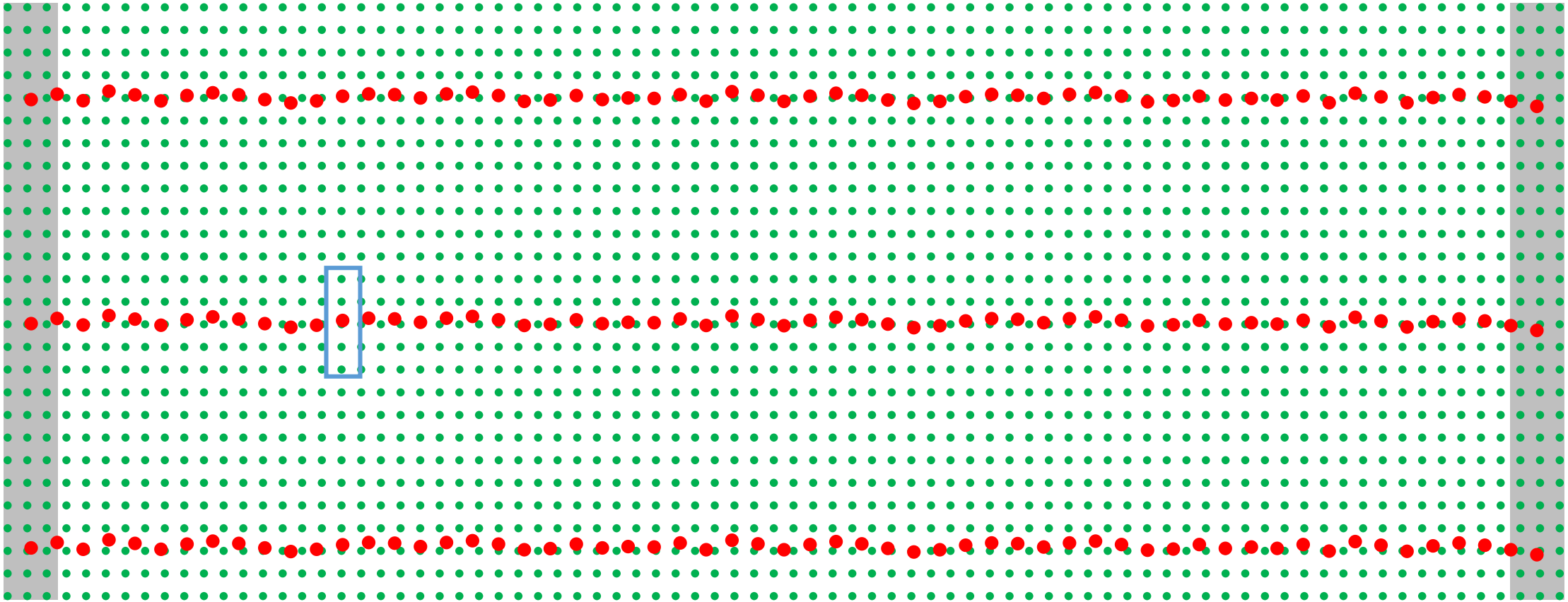
Ground Reference: Planar Flatness



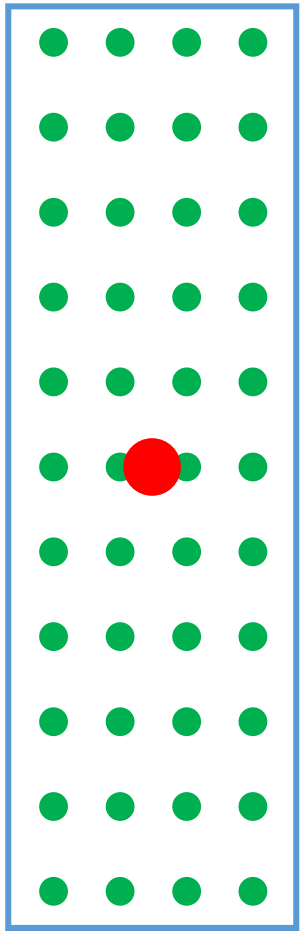
Ground Reference: Planar Flatness

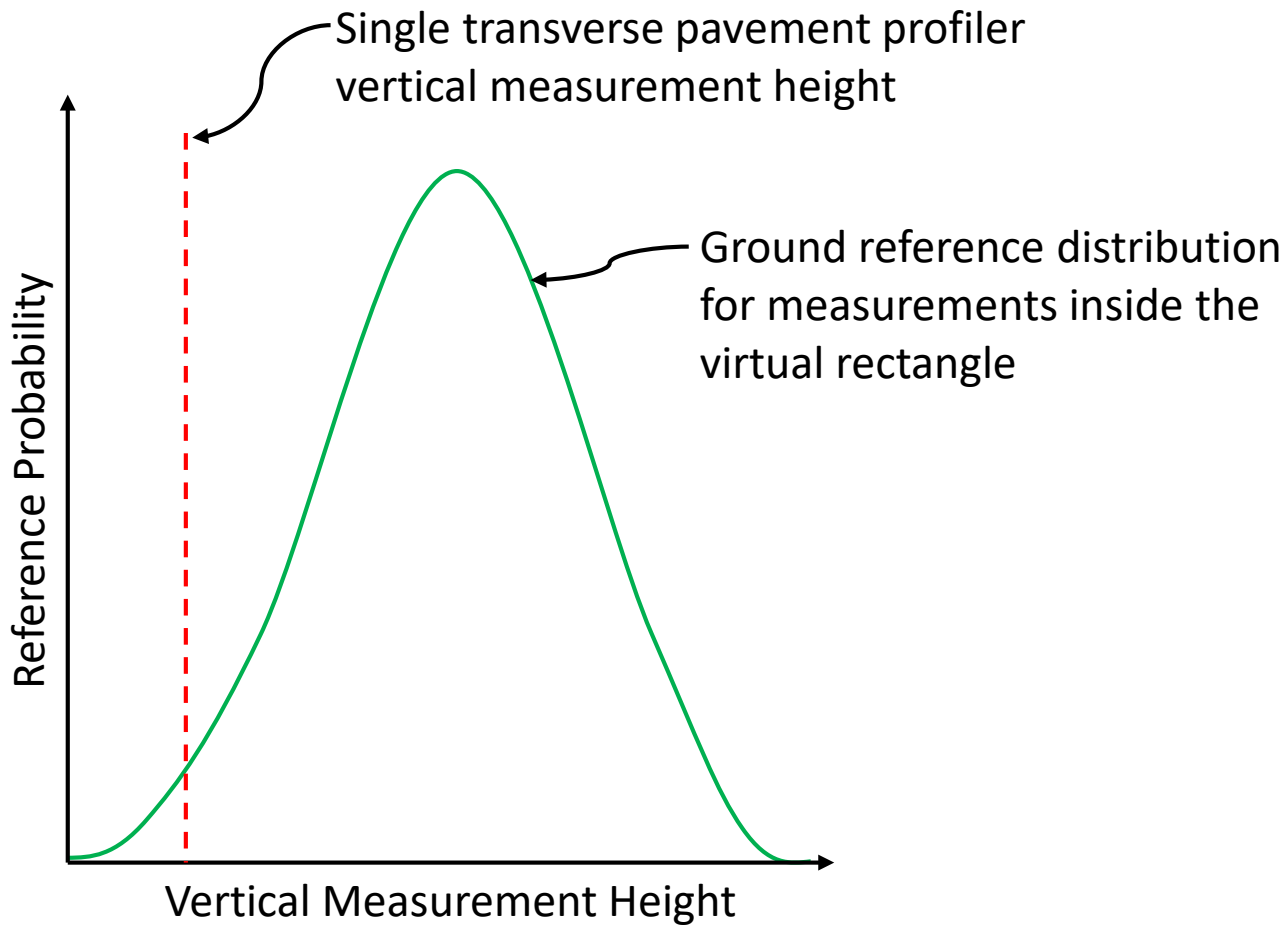
Accuracy and Precision Defined as Bias and Confidence Intervals (mm)						
		Lower Bounds (percentile)			Upper Bounds (percentile)	
		90% (5%)	50% (25%)	Bias	50% (75%)	90% (95%)
Planar Flatness Error	**Required**	**-1.0**	**-0.5**		**0.5**	**1.0**
	Vendor	-0.27	-0.11		0.12	0.24

Analysis Using Ground Reference Data

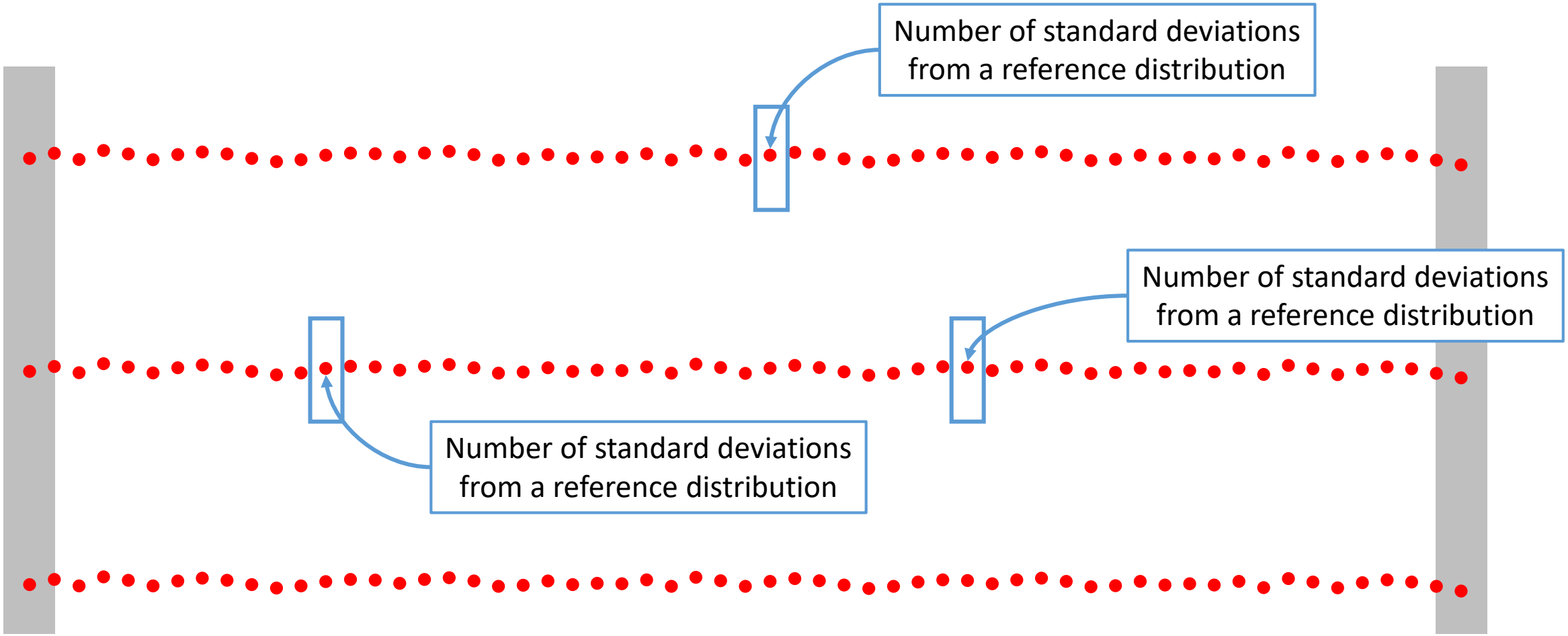


Analysis Using Ground Reference Data





Analysis Using Ground Reference Data

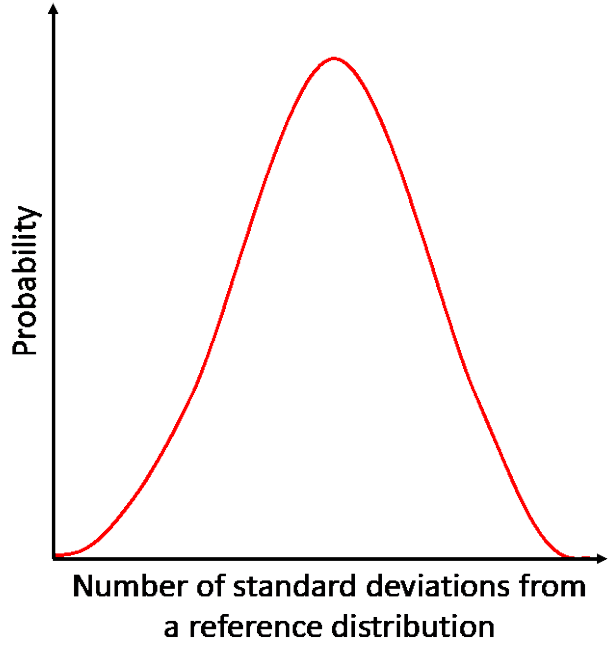


This process can be repeated for a set number of measurements inside the ground reference test section

Analysis Using Ground Reference Data

Analysis of each individual measurement can be summarized in a single distribution.

A set of confidence interval requirements can be made for this resulting distribution.



Accuracy and Precision (Standard Deviations from a Reference Distribution)					
	Lower Bounds (mm)		Bias	Upper Bounds (mm)	
	90% (5%)	50% (25%)		50% (75%)	90% (95%)
Point Cloud Vertical Error	-2.5	-1.0	NA	1.0	2.5
Gridded Data Vertical Error	-1.7	-0.7	NA	0.7	1.7

Thank you for your time

Questions?

Contact:
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