Pavement Surface Properties Consortium

Profiler Certification Process at the Virginia Smart Road

Center for Sustainable Transportation Infrastructure

Outline

- Introduction
- Objectives
- Profiler Certification Procedures
- Data Collection
- Data Analysis
- Repeatability & Reproducibility
- Conclusions and recommendations

Introduction

- **Profilers are used for Pavement Condition (Ride Quality) Assessments**
  - **Functional Performance Indicator**
  - **Major determinant of Road User Costs**
- **Major obstacles: testing their accuracy**
  - **Needs stable, consistent scale**
  - **Certification programs are set up following federal and state highway guidelines and specifications to test compliance**

Objectives

- Develop a certification site to carry out profiler verification per AASHTO PP-49 (Repeatability and Reproducibility)
- Certification site: Virginia Smart Road
- Study how different factors affect accuracy comparisons
  - Grade (6%) (stable scale)
  - Reference device (accuracy)
  - Reference sections (consistent scale)

AASHTO Provisional Profiler Certification Procedures

- Selection of Test Sections:

2 Asphalt Sections	One smooth / one relatively rough
2 Concrete Sections	One smooth / one relatively rough
1 Rehabilitated Section	Overlaid section

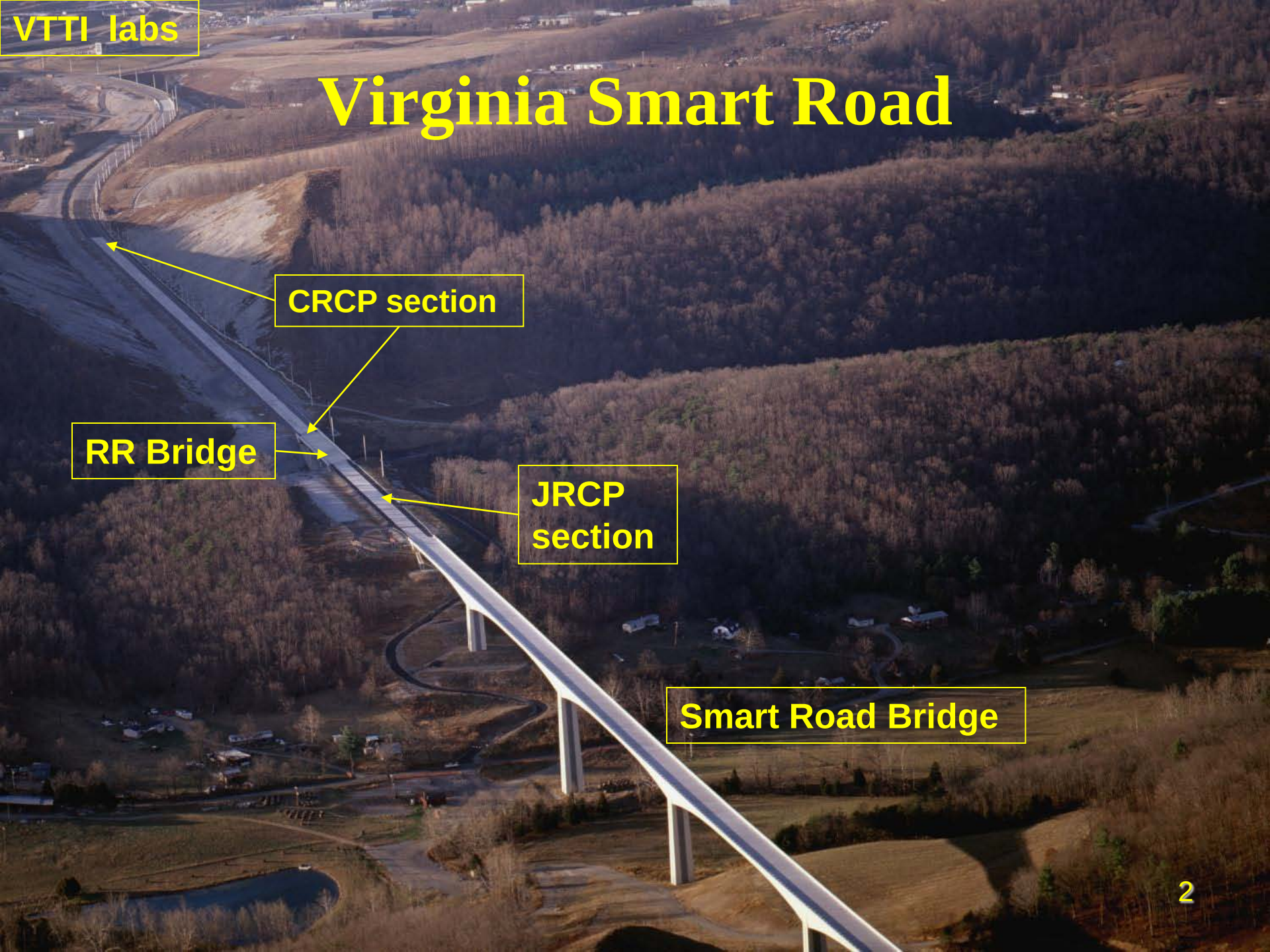
- Data Collection Procedures:

  Reference Profiler

  Participant Profilers

  Weather conditions

Virginia Smart Road


VTTI labs
Virginia Smart Road
CRCP section
RR Bridge
JRCP section
Smart Road Bridge

Test Sections

No.	Section name	Mix type or Finish	Asphalt Binder	Length (feet)	MPD uphill (mm)	Section IRI (past) (in/mi)	Test Section No.	Length (feet)
1	Loop	SMA 19.0	PG 70-22	N/A	0.80	N/A		
2	A	SM-12.5D	PG 70-22	347	0.89	**123**	5	528
3	B	SM-9.5D	PG 70-22	289	1.01	**164**		
4	C	SM-9.5E	PG 76-22	292	0.79	77		
5	D	SM-9.5A	PG 64-22	407	0.70	195		
6	E	SM-9.5D	PG 70-22	268	N/A	90		
7	F	SM-9.5D	PG 70-22	302	N/A	**99**	4	528
8	G	SM-9.5D	PG 70-22	304	N/A	**108**		
9	H	SM-9.5D	PG 70-22	292	N/A	112		
10	I	SM-9.5A(h)	PG 64-22	338	0.73	93		
11	J	SM-9.5D	PG 70-22	280	0.85	105		
12	K	OGFC	PG 76-22	302	1.80	**134**	3	528
13	L	SMA-12.5D	PG 70-22	326	1.08	**113**		
14	CRCP	Tined		2,290	0.80	**69**	2	528
15	JRCP	Grooved		591	N/A	N/A	1	528

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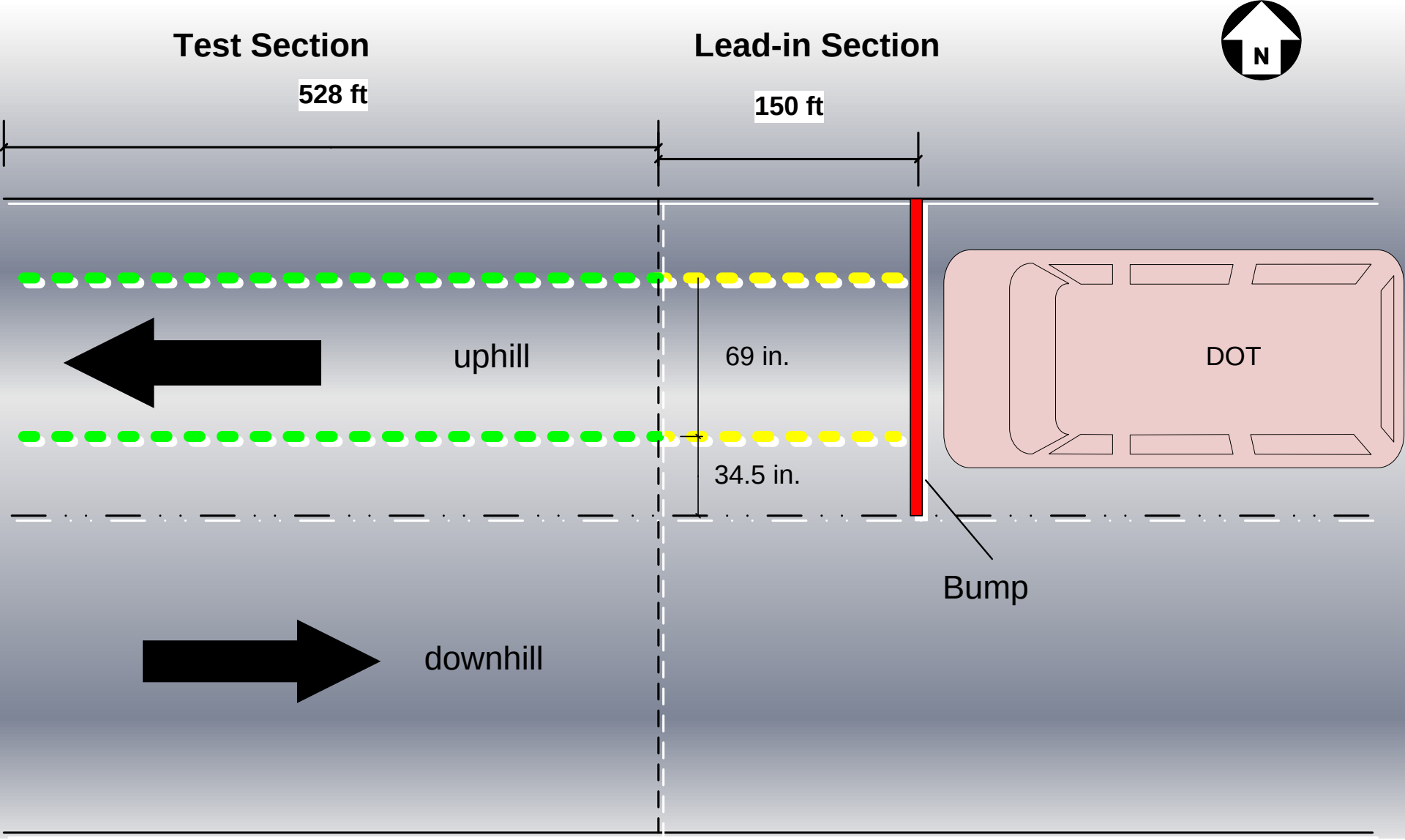

Test Section
528 ft
Lead-in Section
150 ft
N
uphill
69 in.
34.5 in.
DOT
Bump
downhill

Data Collection: Participant Profilers

Profiler Unit	Manufacturer	Sensor Type	Data Recording Interval
Unit 1	Dynatest	Single Spot Laser	1.00”
Unit 2	Dynatest		1.00”
Unit 3	ICC		0.98”
Unit 4	ICC		1.21”
Unit 5	ICC		3.06”
Unit 6	ICC		3.07”
Unit 7	ICC		0.77”
Unit 8	Fugro Roadware		0.93”
SURPRO	ICC	Inclinometer	1.00”

Data Collection: High-speed Profilers

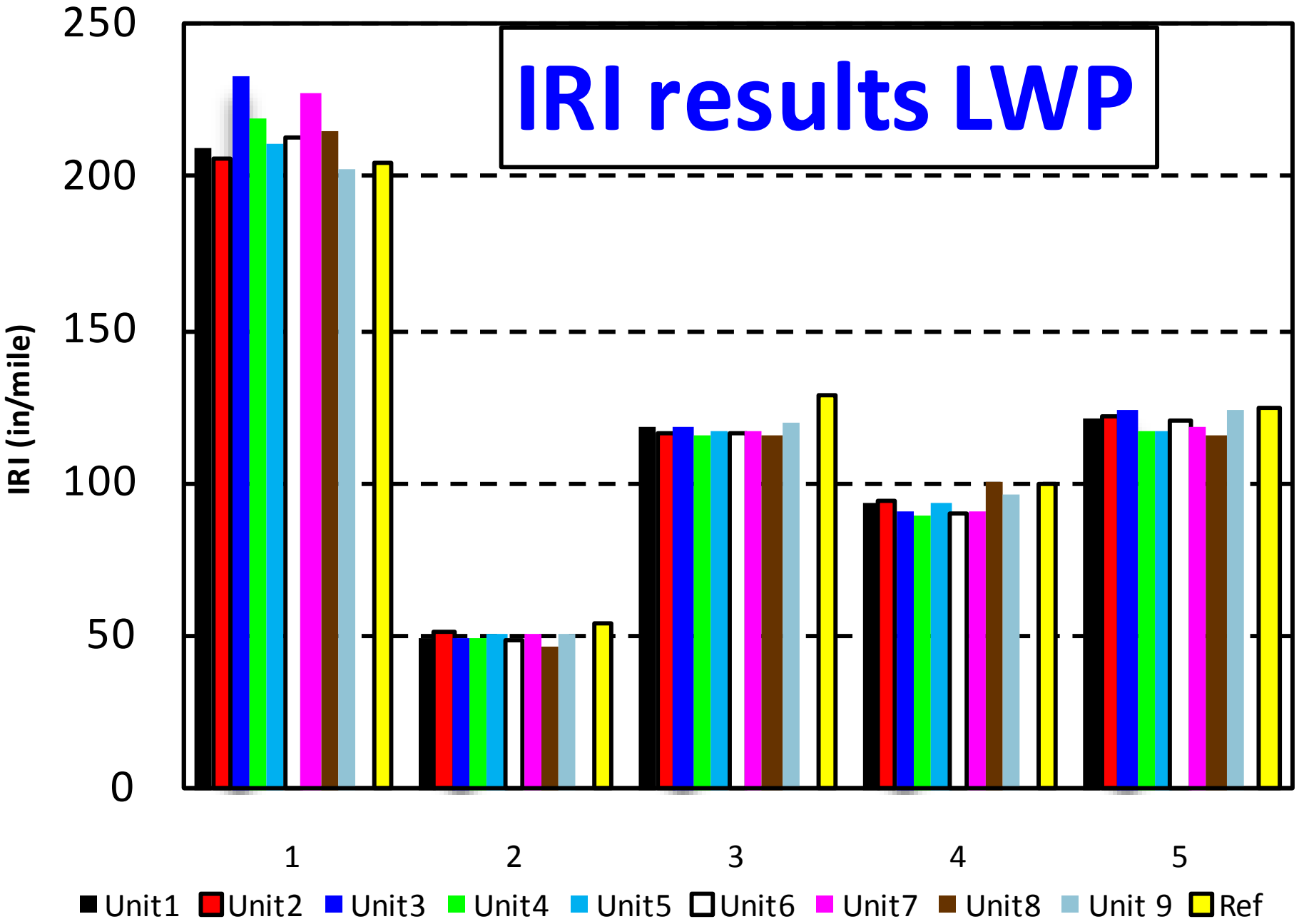
- Pre-Testing Calibration:
  - Static ‘Block’ Test: Height Sensor Calibration
  - Dynamic ‘Bounce’ Test: Accelerometer Calibration
  - DMI Calibration: 5-repeat runs made on 1000 feet section located **downhill** next to Section 2
- Data Collection: 10-repeat runs on each section at a constant speed of 50 mph w/o much lateral movement
- All raw profiles collected were filtered with 300-ft Butterworth high-pass filter to eliminate long wavelengths before converting to ‘ERD’ format

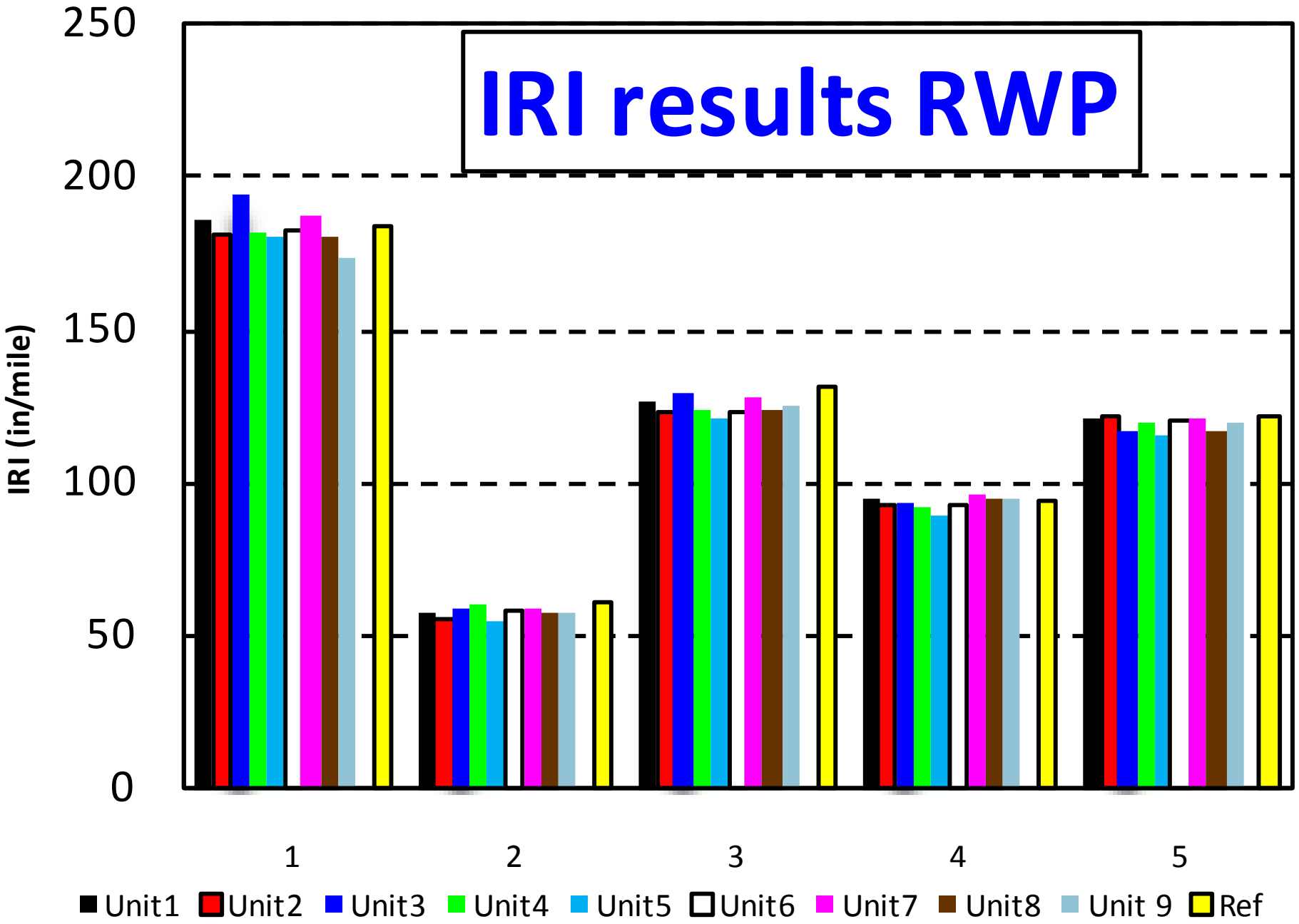
Data Collection: Weather conditions

DAY	MAX	MIN	AVG	DEP H	DD	CDD	WATER	SNOW
===	====	====	====	=====	===	===	=======	=====
1	74	58	66	12	0	1	T	0
11	56	43	50	-7	15	0	0.42	0
12	69	43	56	-2	9	0	0	0
13	68	42	55	-3	10	0	0	0
14	73	58	66	8	0	1	0.95	0
15	77	59	68	9	0	3	0.12	0
16	78	57	68	9	0	3	0.32	0
17	61	48	55	-4	10	0	0.09	0
18	63	37	50	-10	15	0	0	0
19	67	33	50	-10	15	0	0	0
20	74	36	55	-5	10	0	0	0
21	78	44	61	1	4	0	0	0
30	74	51	63	0	2	0	0	0
31	77	54	66	3	0	1	0.23	0

Data Analysis

- Repeatability, reproducibility assessment, and IRI computation done in PROVAL
- Use of Cross-Correlation method to output obtained after IRI filter (w/ 250 mm Moving Average) applied
- The 250 mm Moving Average was **not** used on the profiles obtained from Reference Device


IRI results LWP
IRI (in/mile)
250
200
150
100
50
0
1
2
3
4
5
Unit1
Unit2
Unit3
Unit4
Unit5
Unit6
Unit7
Unit8
Unit 9
Ref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0
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Unit3
Unit4
Unit5
Unit6
Unit7
Unit8
Unit 9
Ref

Repeatability Results

	Average Repeatability Cross Correlation									
	Section 1		Section 2		Section 3		Section 4		Section 5	
Profiler	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Unit 1	88	86	88	92	94	93	95	94	92	88
Unit 2	97	96	94	94	94	96	97	96	93	90
Unit 3	96	92	89	92	93	93	95	95	89	90
Unit 4	95	92	93	94	95	95	95	95	93	91
Unit 5	96	92	90	92	95	96	96	95	89	87
Unit 6	95	92	94	95	94	95	95	95	93	90
Unit 7	96	92	93	91	95	94	95	93	94	87
Unit 8	95	88	93	96	96	96	95	95	93	88

Repeatability Results (cont.)

- AASHTO PP-49 requires an **average CC of at least 92%** when each profile is compared with remaining nine (Total of 90 comparisons)
- All of the profilers scored more than 92% on sections 3 and 4 on both wheel paths
- None of the profilers passed the repeatability test with values more than 92% for **ALL** sections (some failed sections 1 and 2 and all failed section 5)

Reproducibility Results

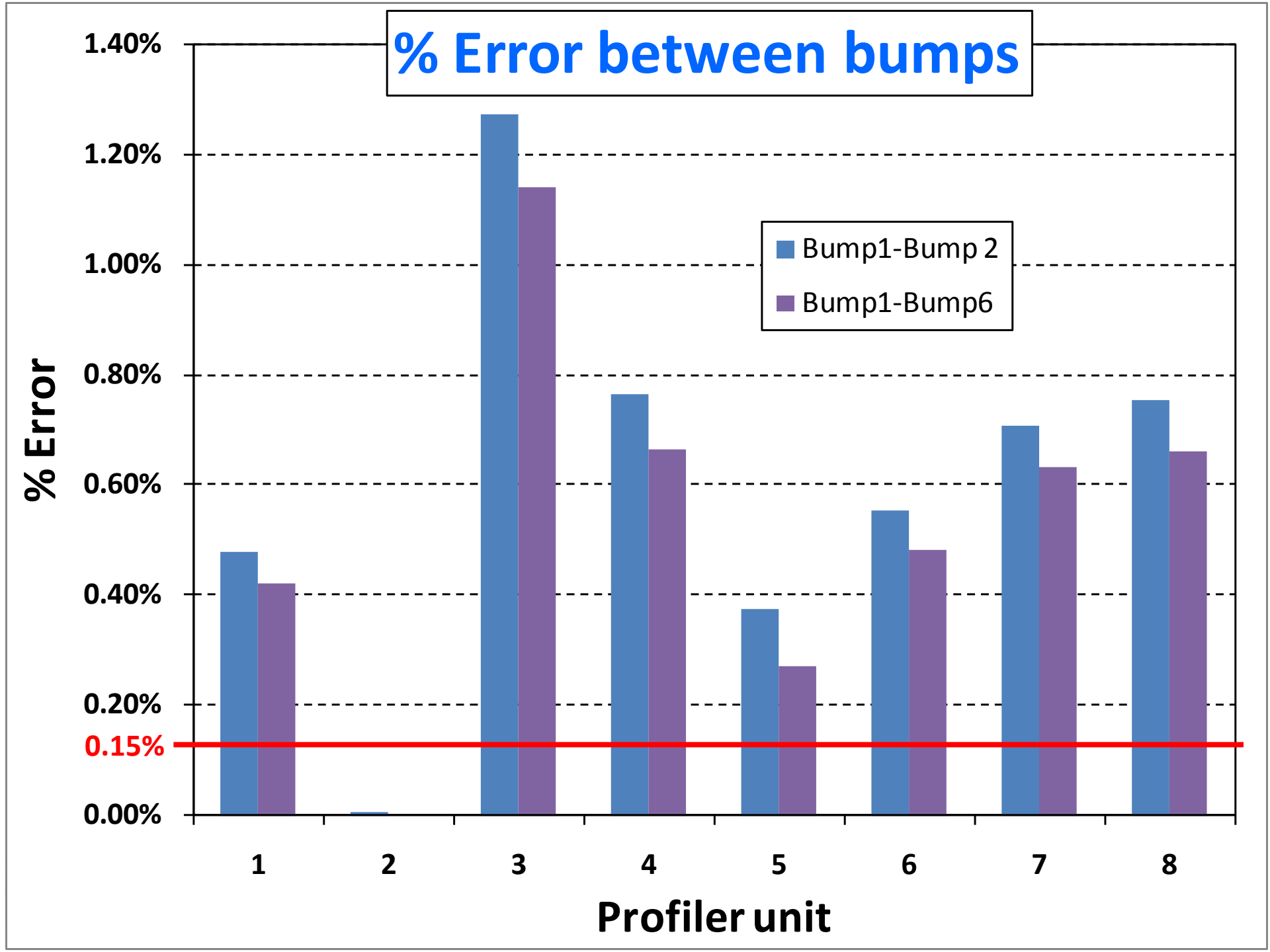
	Average Reproducibility Cross Correlation									
	Section 1		Section 2		Section 3		Section 4		Section 5	
Profiler	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Unit 1	73	66	67	70	74	76	71	72	75	76
Unit 2	93	90	86	82	75	76	77	76	84	79
Unit 3	49	52	33	35	64	63	61	51	43	54
Unit 4	62	51	49	53	69	68	66	62	67	73
Unit 5	86	77	75	72	75	75	74	74	76	75
Unit 6	73	63	53	65	72	73	68	68	74	77
Unit 7	62	52	43	50	71	72	65	63	63	67
Unit 8	62	48	49	53	78	79	86	80	69	74

Reproducibility Results (cont.)

- AASHTO PP-49 requires a **minimum CC-value of 90%** for a profiler unit to pass the reproducibility test when compared with Reference device.
- All reproducibility CC-values were originally very low, with only **one** profiler scoring satisfactorily in only one section.

Distance Measured for each unit

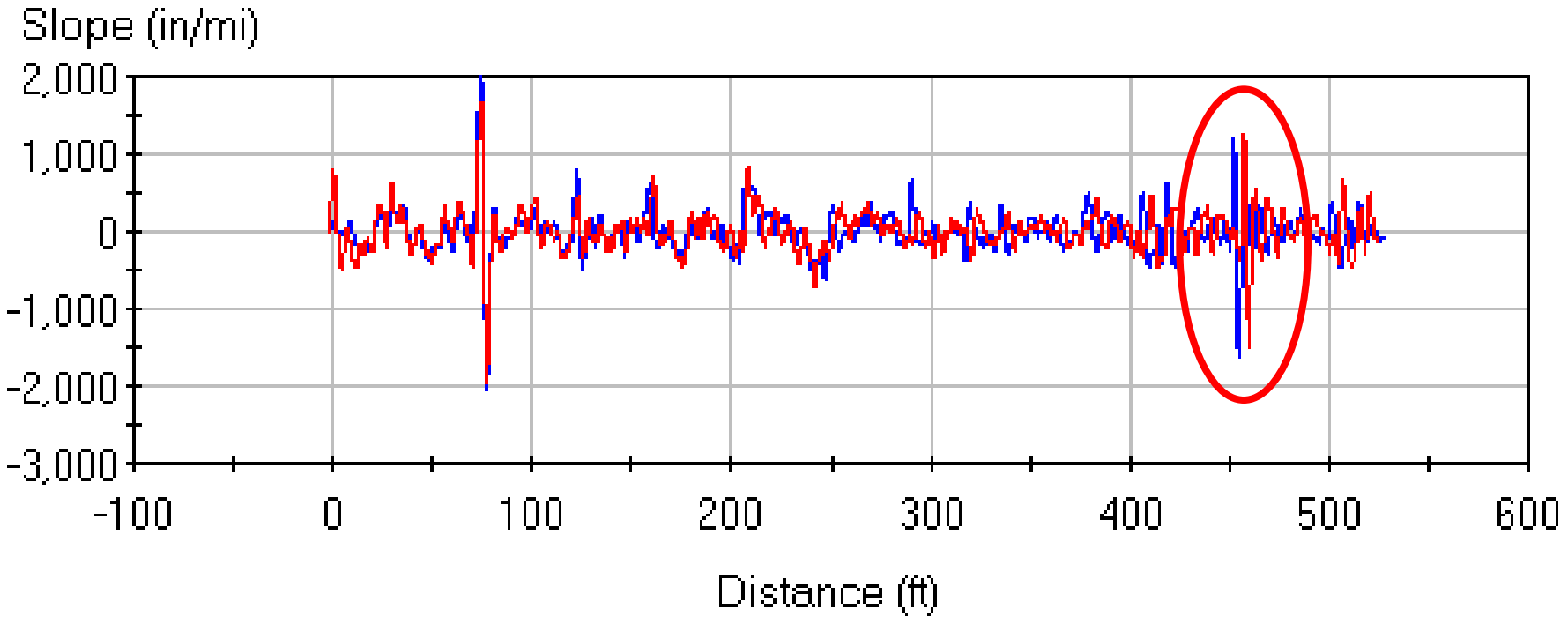
Difference in Distances between bump markers for all units				
Bump1-Bump 2	= 1716.58 feet	% Error	Bump1-Bump6	% Error
Profiler	Distance		Distance	
Unit 1	1724.8	0.48%	7230	0.42%
Unit 2	1716.7	0.01%	7200	N/A
Unit 3	1738.4	1.27%	7282	1.14%
Unit 4	1729.7	0.76%	7248	0.66%
Unit 5	1723.0	0.37%	7219	0.27%
Unit 6	1726.1	0.55%	7235	0.48%
Unit 7	1728.7	0.71%	7246	0.63%
Unit 8	1729.5	0.75%	7248	0.66%


% Error between bumps
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.15%
0.00%
% Error
Bump1-Bump 2
Bump1-Bump6
1
2
3
4
5
6
7
8
Profiler unit

DMI Calibration Error

- All DMI measurement errors were found to be greater than **0.15%** limit as specified by AASHTO PP-49
- Downhill direction for DMI Calibration
- Change in Rolling Radius of the tire affects DMI calibration and could induce incorrect recording of distances measured

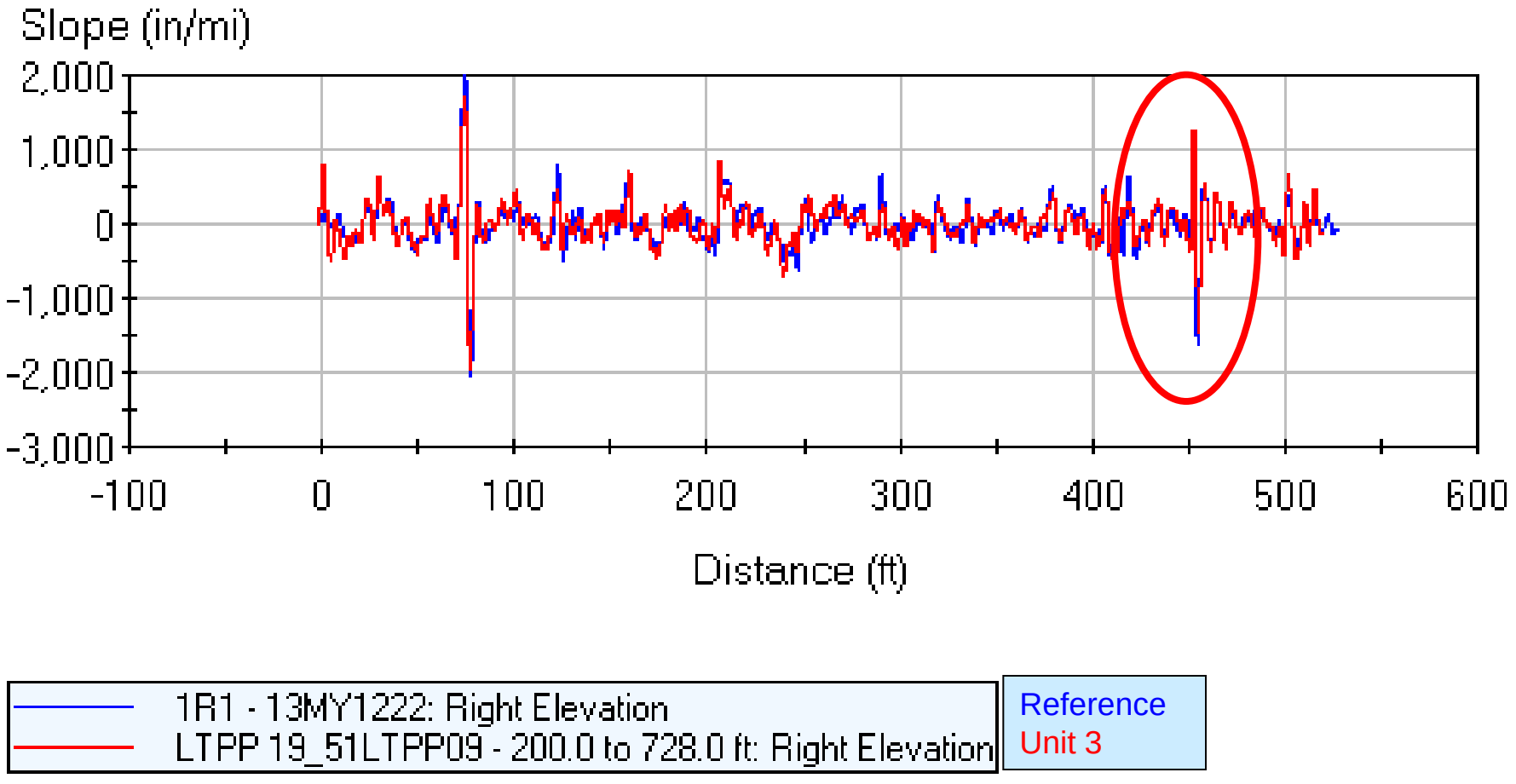
Repositioning and 'Squeezing' Profiles

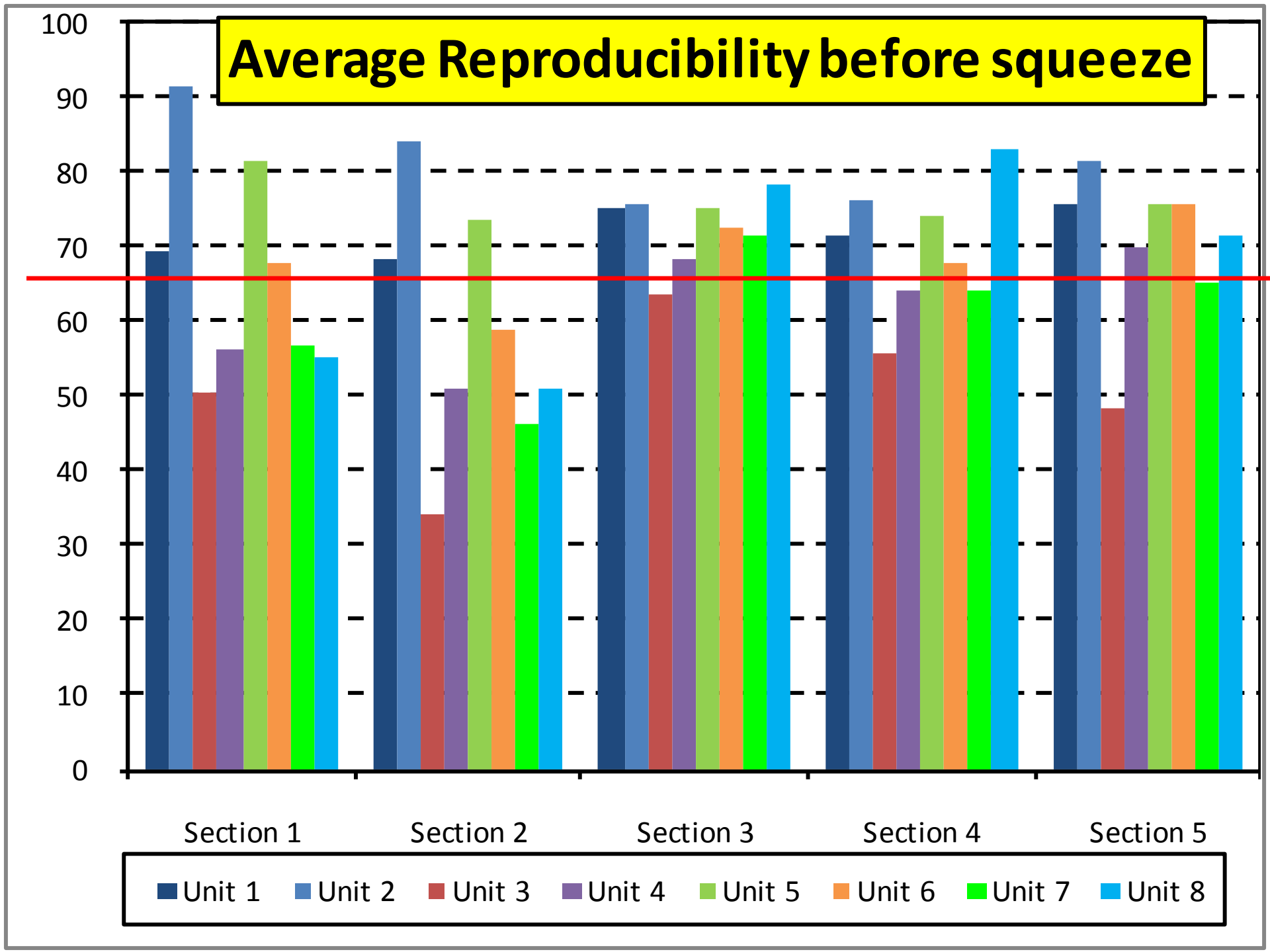


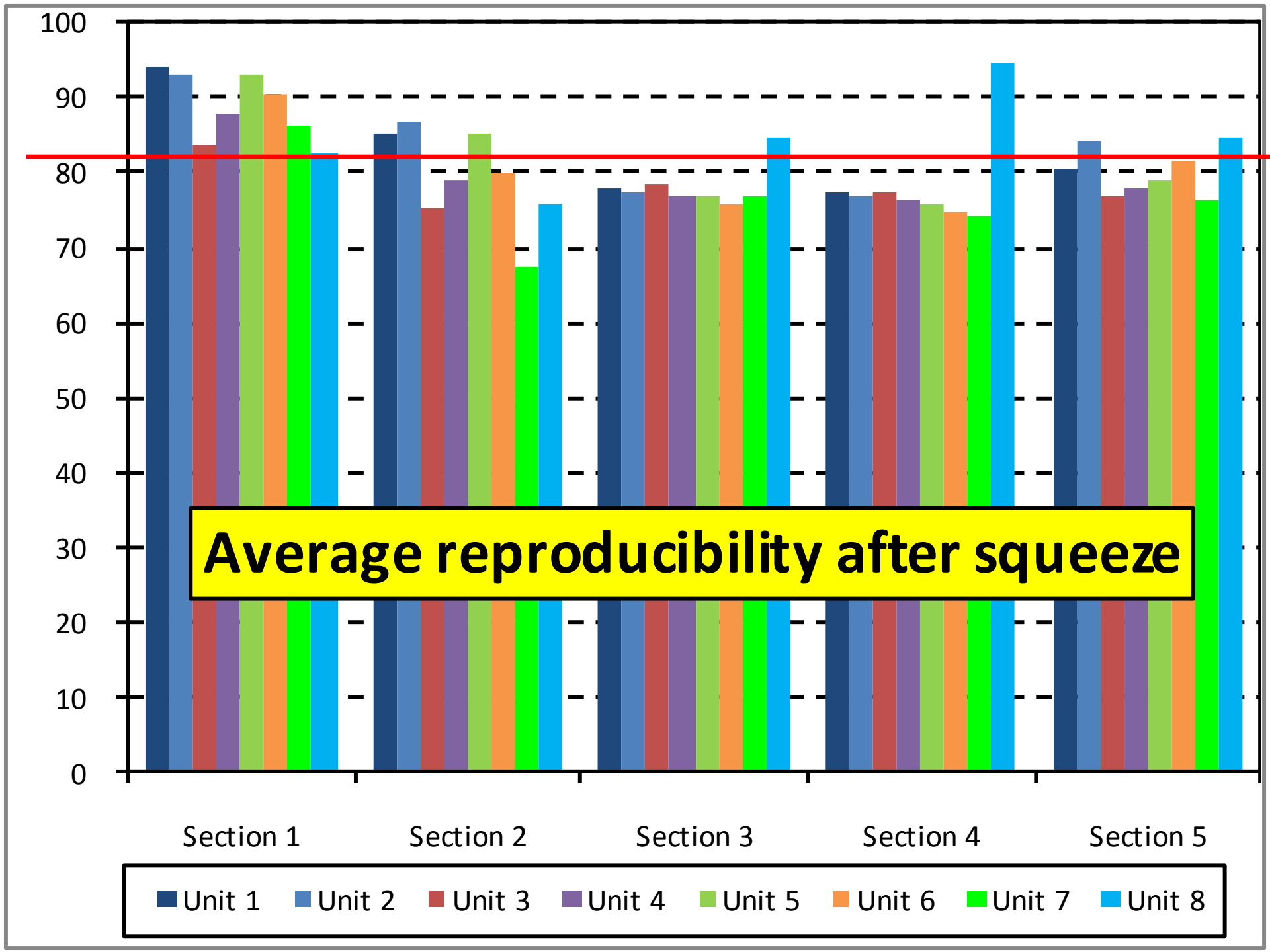
Squeezing of Profiles

- The amount of ‘shift’ was calculated for each unit profile when compared with SURPRO and readjustment was done by changing the ‘sample interval’ by an amount equivalent to the ‘shift’ observed
- This resulted in ‘squeezing’ of the profiles resulting in a better match when compared with SURPRO profiles
- Note: squeezed results are not valid for profiler certification

‘Squeezed’ Profile




Average Reproducibility before squeeze
100
90
80
70
60
50
40
30
20
10
0
Section 1
Section 2
Section 3
Section 4
Section 5
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Unit 8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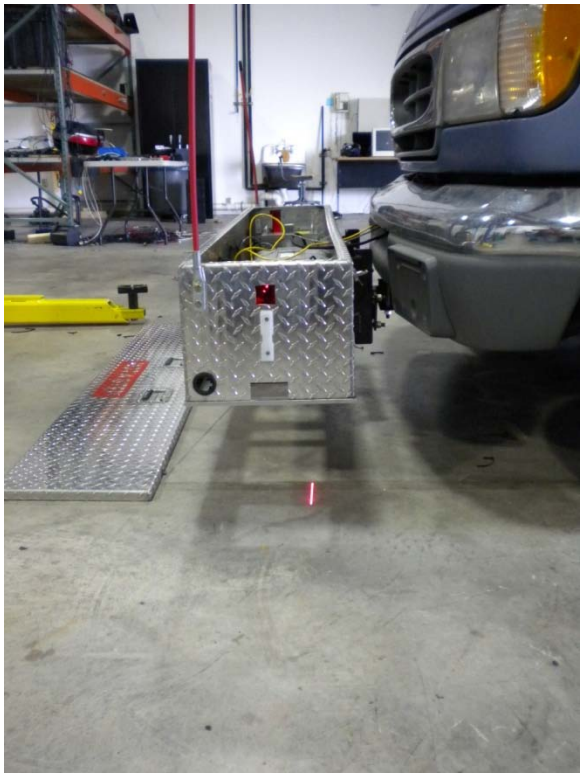
Section 1
Section 2
Section 3
Section 4
Section 5
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Unit 8

Findings and Conclusions

- Good agreement of IRI values were found between the reference device (SURPRO) and each of the participant profilers IRI for all test sections
- Error in the distances recorded by the profilers DMIs were related to the procedures followed for their calibration, which in turn affected the repeatability and reproducibility correlations.

Recommendations/Further Research

- Care should be taken when calibrating on a grade as it will likely affect DMI calibration: grade should be avoided for this type of calibration



- Further research will continue in 2010, with the effect of new wide footprint sensors for high-speed profilers on ground PCC

Acknowledgements

- **FHWA FALCON team: Mark Swanlund, Bob Orthmeyer & Larry Wiser**
- **Rohan Perera and Joshua Parker from SME**
- ***Pavement Surface Properties Consortium* members, CT, GA, SC, MS, PA, VA, LTPP**
- **VA-SPRC team**

Questions?