SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

Lessons Learned from Real-Time Smoothness Technology Demonstrations

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U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
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Real-Time Smoothness for Concrete Paving

- Overview of Real-Time Smoothness Technology
- SHRP2 RTS Implementation Program
- Lessons Learned from Equipment Loan Program

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What is Real-Time Smoothness?

Real-time Smoothness (RTS) refers to measuring and evaluating the concrete pavement surface profile during construction, somewhere along the paving train while the concrete surface is still wet (plastic).

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RTS Profilers

GOMACO Smoothness Indicator (GSI)

Ames Engineering Real Time Profiler (RTP)

SSI Dynamic Profiler (*not shown*)

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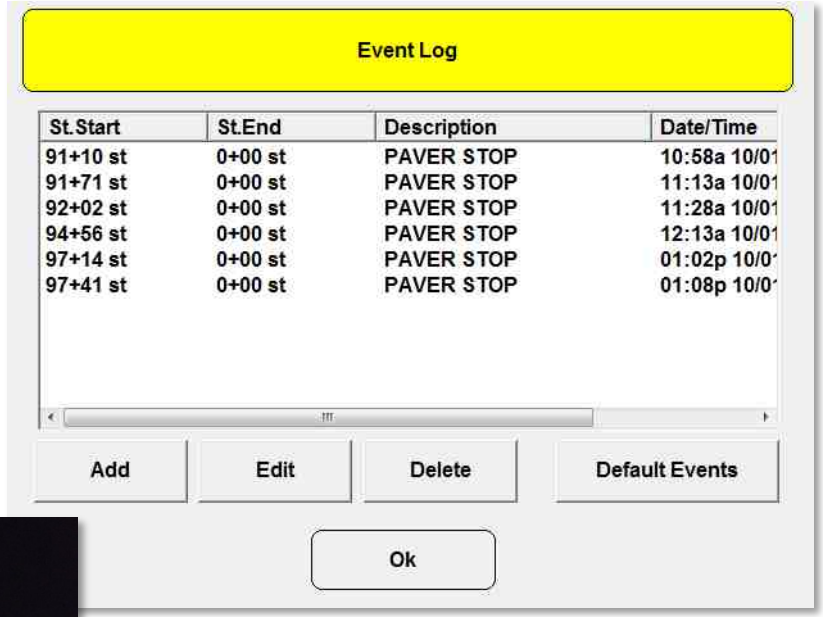
RTS Profilers

Stand-Alone GOMACO GSI Machine

Real-Time Feedback and Tracking of Events



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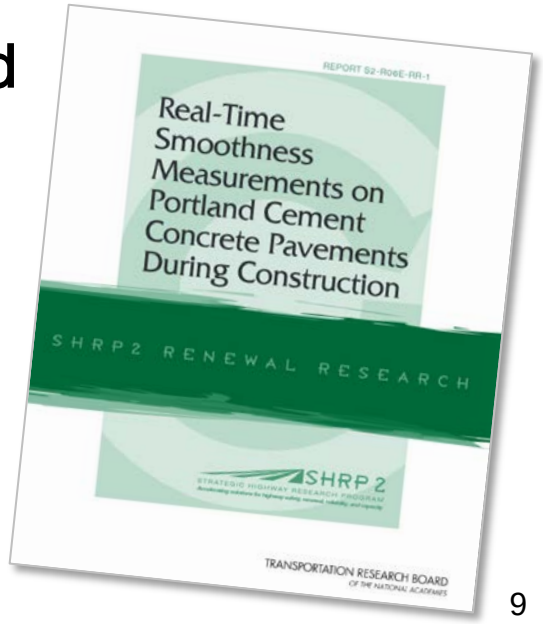
SHRP2 RTS Implementation Program

- SHRP2 Project R06(E): Effort to demonstrate and evaluate existing RTS measuring technologies (2009–2011).
  - Georgia, Arkansas, Texas, Michigan & New York
- Developed draft model specifications and guidelines.
- Final report online:

http://www.trb.org/Main/Blurbs/167282.aspx



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SHRP2 RTS Implementation Program

SHRP2 Solutions Implementation effort (2014-2017):

- Equipment Loan Program
- Showcase
- Workshops
- Documentation of results/case studies
- Specification Refinement

National Concrete Pavement Technology Center

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SHRP2 RTS Implementation Program

Equipment Loan Program

- Idaho, I-84
- Nebraska, I-80
- Michigan, I-69
- Texas, SH99
- Pennsylvania, I-81
- Iowa, Lyon Co. L-26
- Illinois, I-90 Tollway
- Utah, I-15
- Utah, I-215
- California, SR46
- Iowa, US 20

- 8 JPCP, 2 CRCP, 1 Thin Overlay
- Varying slab thickness and base/subbase types
- Daytime and nighttime paving
- Varying paver types and setup (paver width, concrete delivery, finishing operations)
- Varying mix designs
- Dowel baskets and DBI
- 9 stringless, 2 stringline

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Lessons Learned from RTS Equipment Loan Program

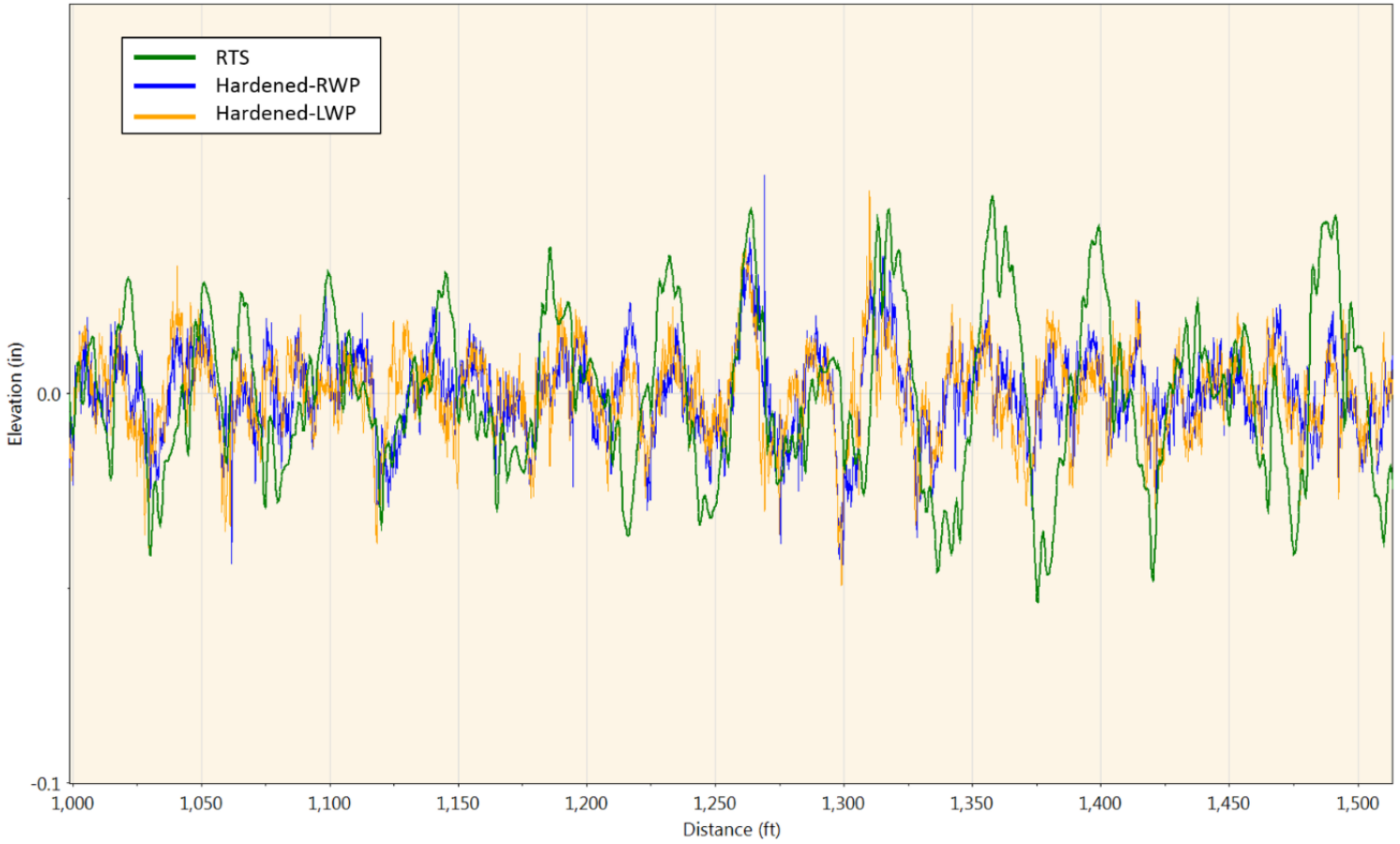
1. RTS vs. Hardened Profiles
2. Features Picked Up by RTS
3. Benefits for Contractors and Agencies

Lessons Learned from RTS Equipment Loan Program

1. RTS vs. Hardened Profiles
2. Features Picked Up by RTS
3. Benefits for Contractors and Agencies

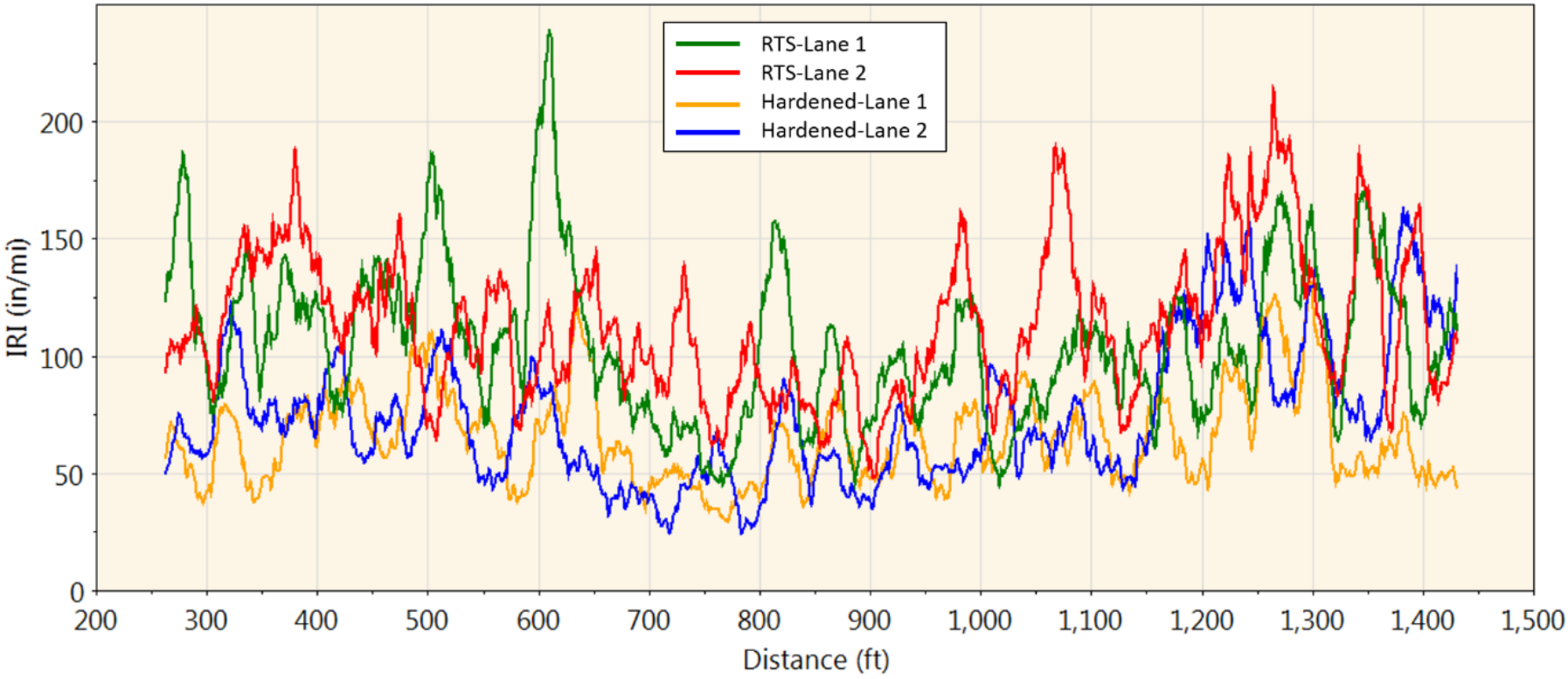
Lessons Learned:
1. RTS vs. Hardened Profiles

- Raw profiles are different but *trends* are similar



Lessons Learned:
1. RTS vs. Hardened Profiles

- Roughness results are different (RTS generally higher) but *trends* are similar.



Lessons Learned:
1. RTS vs. Hardened Profiles

- There is no fixed correlation between RTS and hardened numbers.
- In general, RTS numbers will always be higher, but the degree is project/crew/equipment specific.
- Any correlation will need to be established during the first few days of paving.

Lessons Learned:
1. RTS vs. Hardened Profiles

- *Rule of thumb:* the higher the RTS numbers, the greater the difference between RTS and hardened, the lower the RTS numbers, the smaller the difference.

Project A

	Segment	RTS IRI (in/mi)	QC MRI (in/mi)	Difference (in/mi)
Day 1	1	113.2	67.0	46.2
	2	77.3	57.0	20.2
	3	79.9	64.6	15.3
Day 2	1	90.0	53.2	36.7
	2	108.9	77.5	31.4
	3	114.4	57.2	57.1
Day 3	1	111.7	65.3	46.4
	2	118.2	71.0	47.2
	3	116.4	68.0	48.4
	4	94.9	61.9	33.1
Day 4	1	122.6	64.5	58.1
	2	122.5	61.9	60.7
	Avg.	**105.8**	**64.1**	**41.7**

Project B

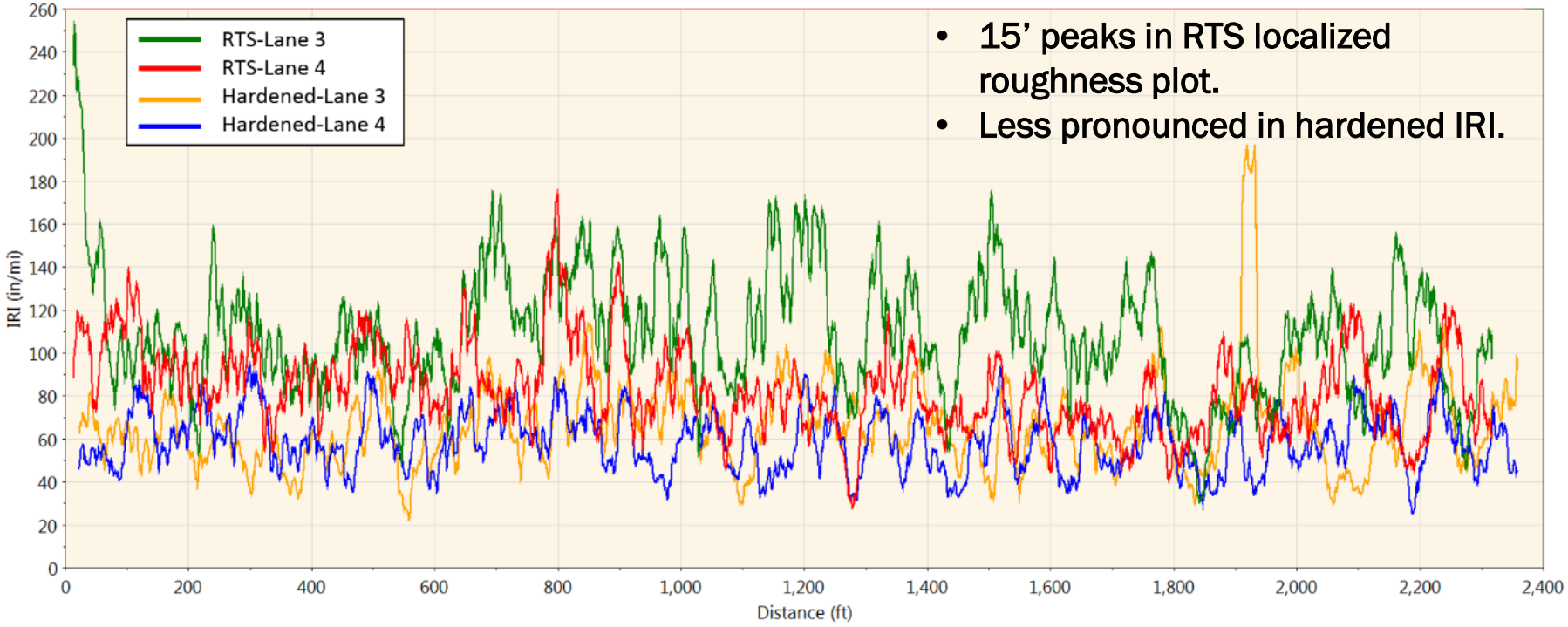
	Segment	RTS IRI (in/mi)	QC MRI (in/mi)	Difference (in/mi)
Day 1	1	66.2	61.1	5.1
	2	65.7	62.2	3.5
	3	58.0	48.8	9.2
Day 2	1	59.3	51.6	7.7
	2	59.4	47.7	11.7
	3	62.5	45.1	17.4
	4	54.3	48.2	6.2
Day 3	1	54.7	44.1	10.6
	2	65.6	57.8	7.8
	3	69.6	57.6	12.0
	4	70.9	61.1	9.8
Day 4	1	58.1	53.0	5.1
	2	91.8	66.3	25.4
	3	71.2	54.3	17.0
	4	86.5	66.5	20.1
	Avg.	**66.3**	**55.0**	**11.2**

Lessons Learned from RTS Equipment Loan Program

1. RTS vs. Hardened Profiles
2. Features Picked Up by RTS
3. Benefits for Contractors and Agencies

Lessons Learned:
2. Features Picked Up by RTS

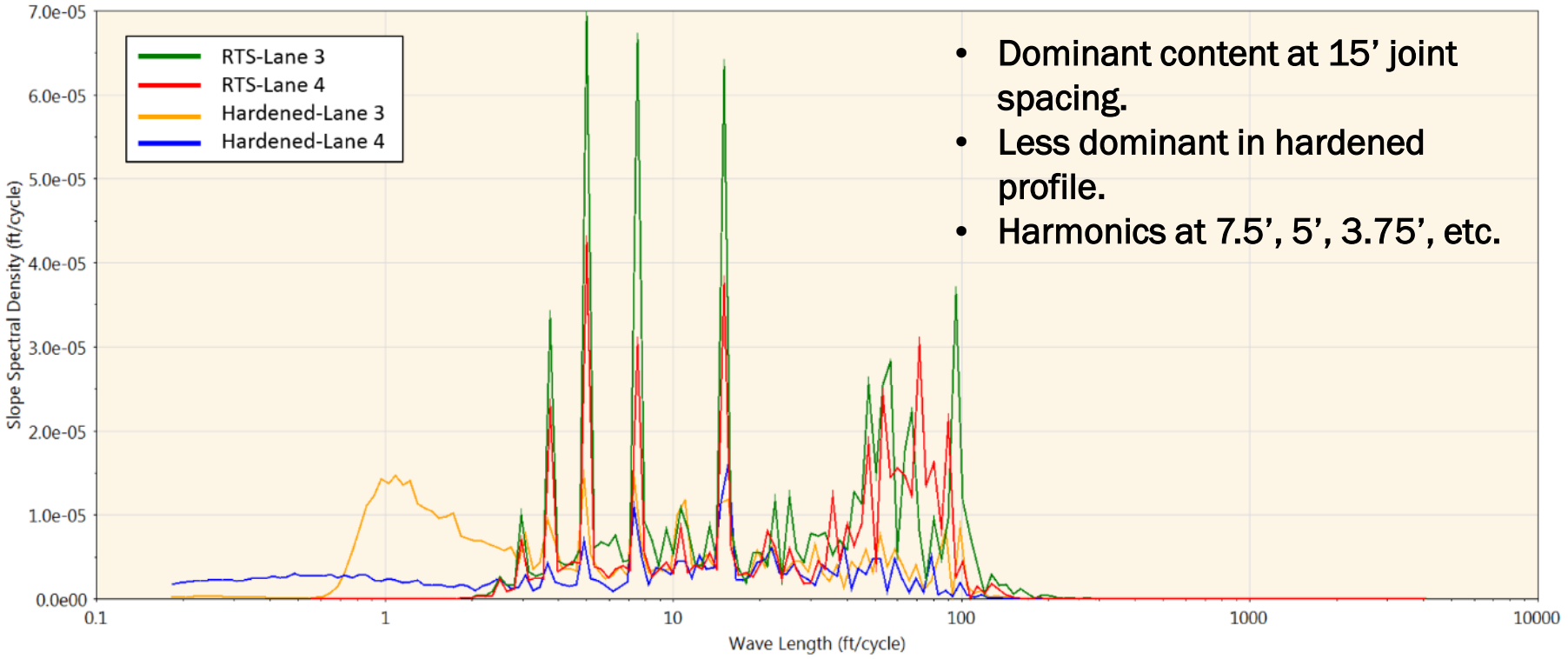
- Joint spacing/dowel basket effects



- 15’ peaks in RTS localized roughness plot.
- Less pronounced in hardened IRI.

Lessons Learned:
2. Features Picked Up by RTS

- Joint spacing/dowel basket effects

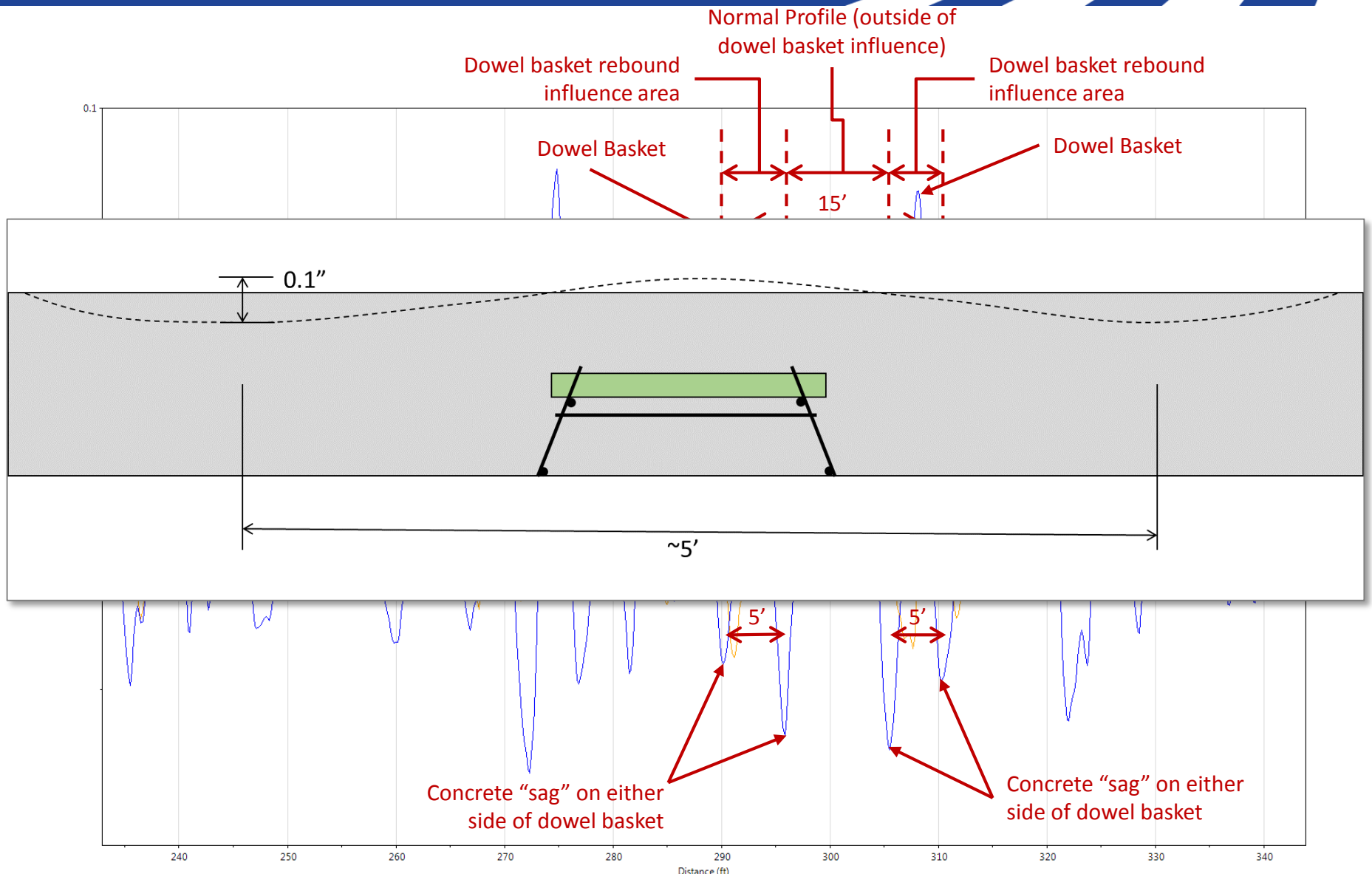


- Dominant content at 15’ joint spacing.
- Less dominant in hardened profile.
- Harmonics at 7.5’, 5’, 3.75’, etc.

Lessons Learned:
2. Features Picked Up by RTS

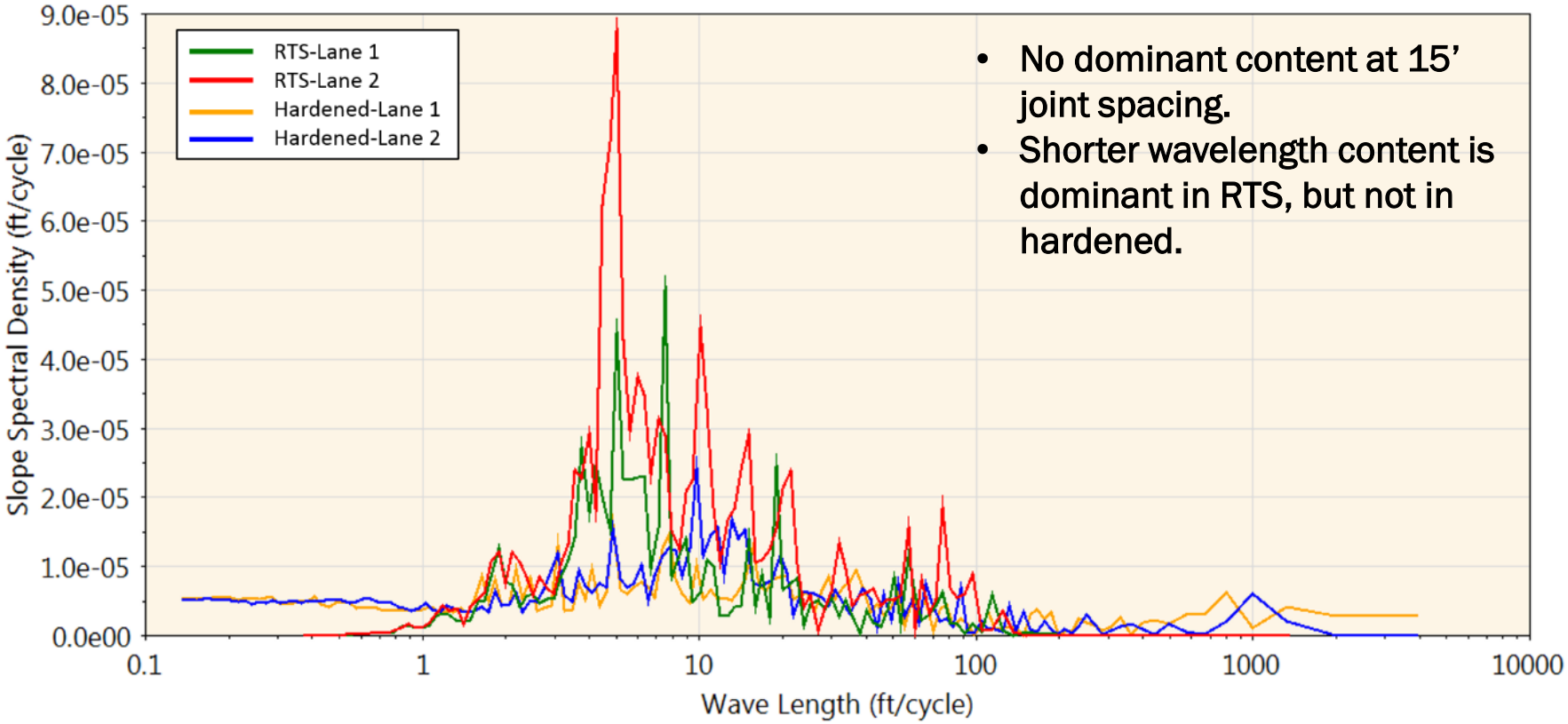
- Dowel basket effect is reduced in hardened profile as finishers remove much of this shorter wavelength content.
- Are harmonics “real” content?

Lessons Learned:
2. Features Picked Up by RTS



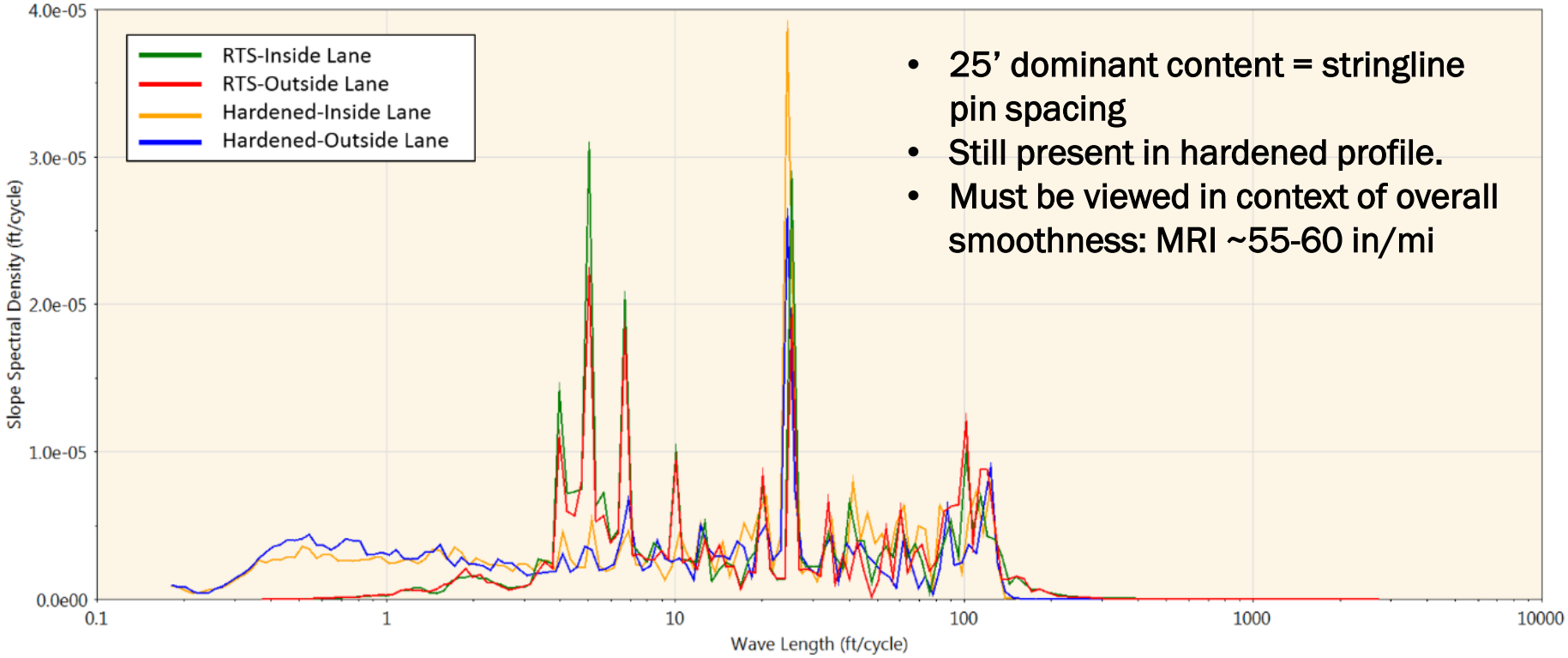
Lessons Learned:
2. Features Picked Up by RTS

- Project utilizing Dowel Bar Inserter



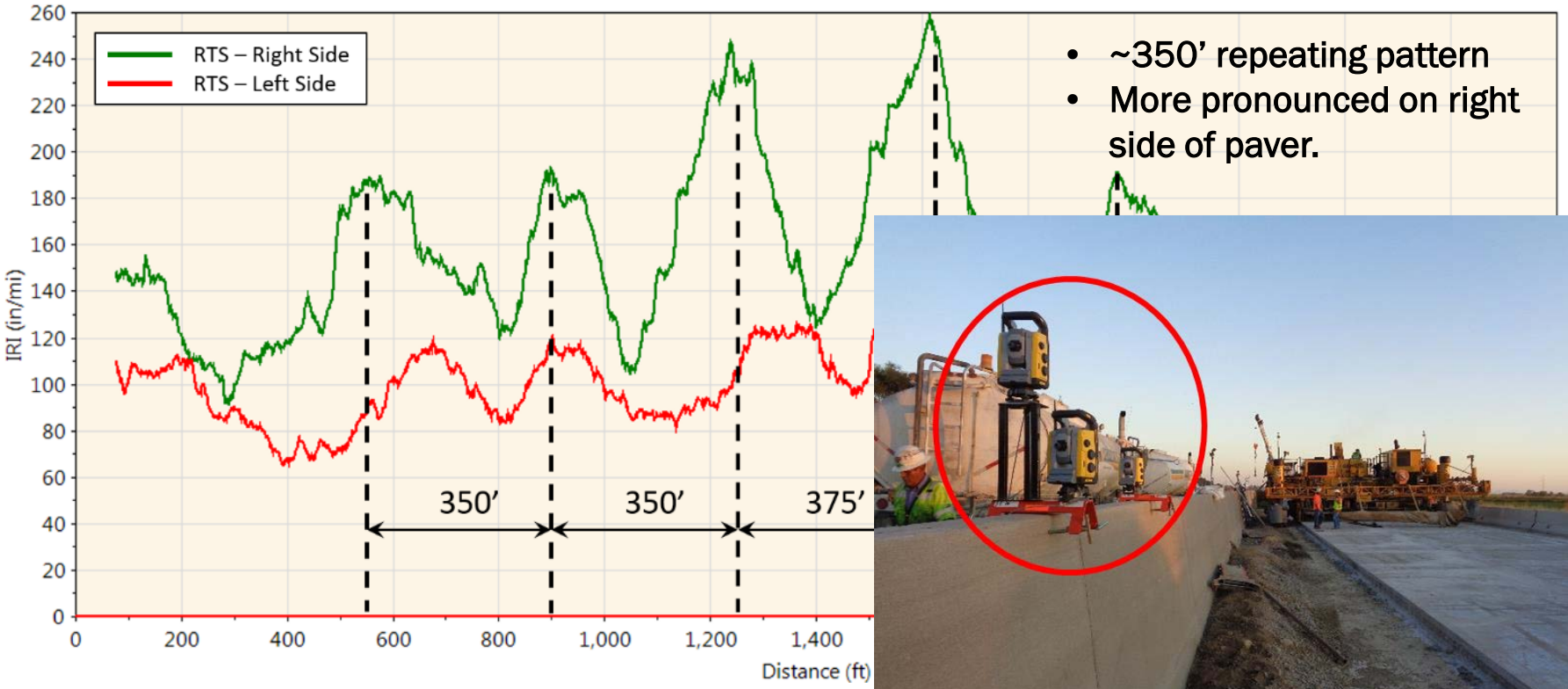
Lessons Learned:
2. Features Picked Up by RTS

- Stringline and Stringless System Effects

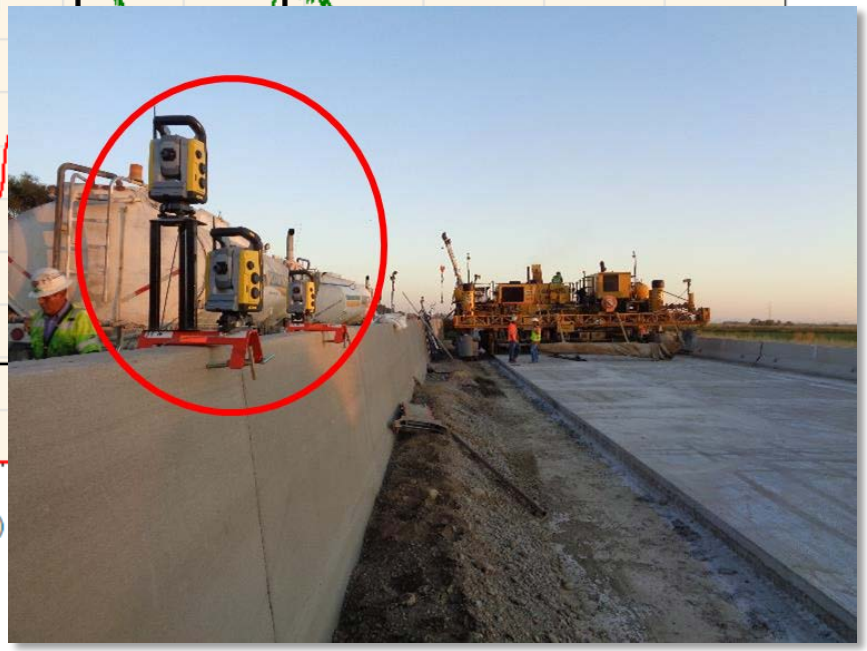


Lessons Learned:
2. Features Picked Up by RTS

- Stringline and Stringless System Effects

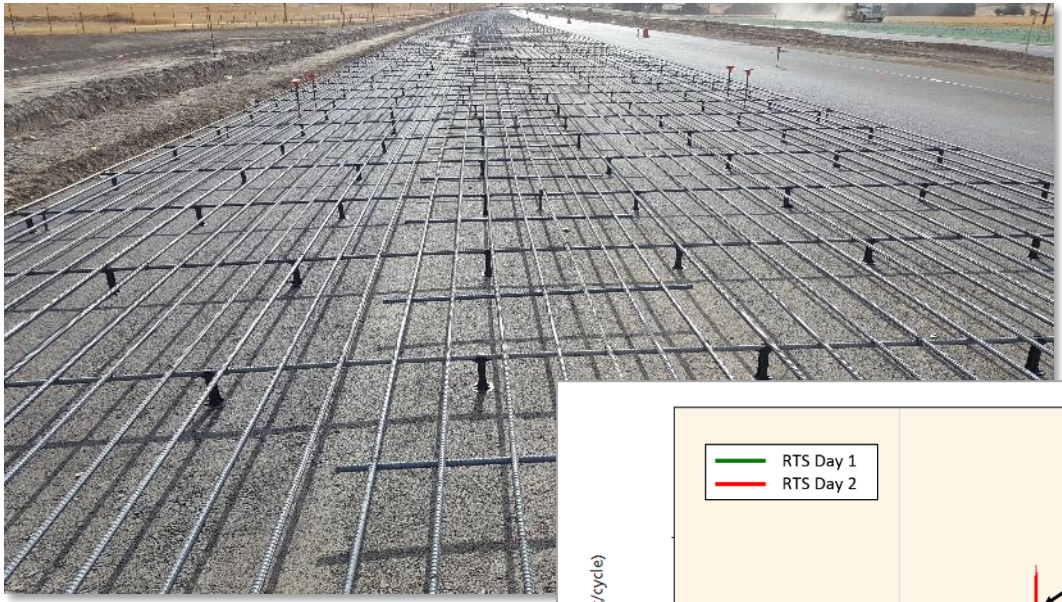


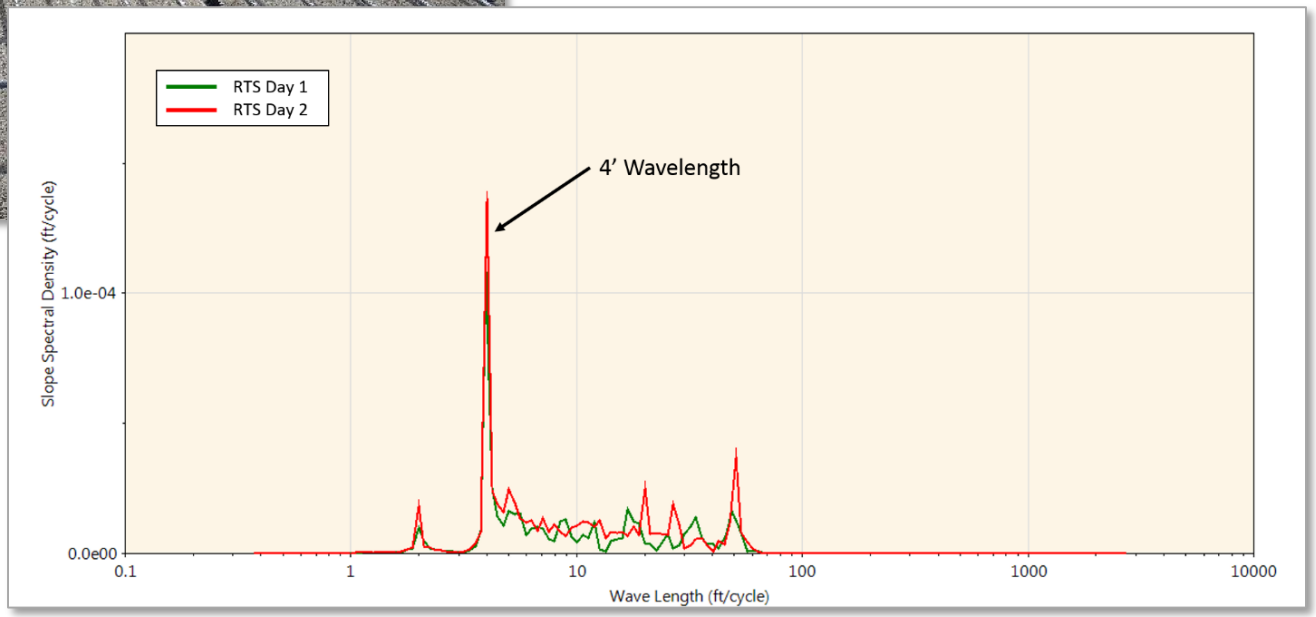
- ~350’ repeating pattern
- More pronounced on right side of paver.



Lessons Learned:
2. Features Picked Up by RTS

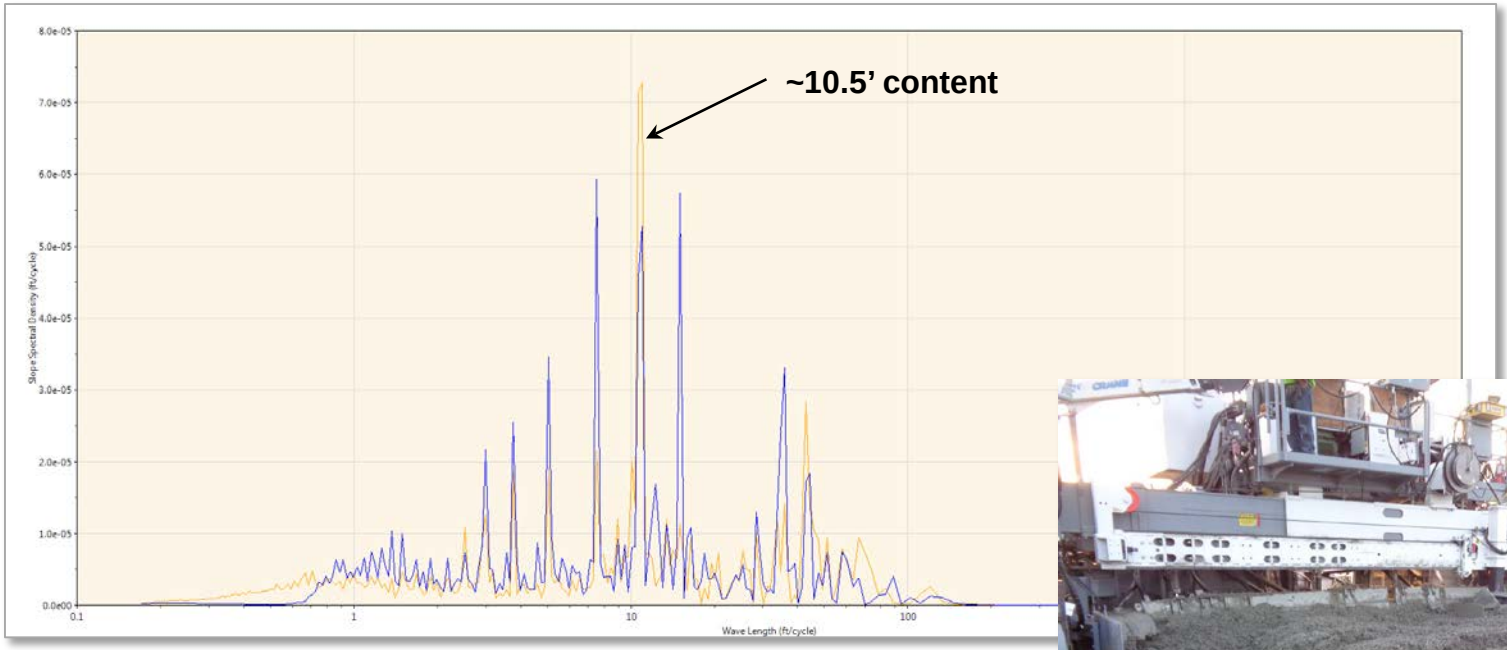
- CRCP Bar Supports





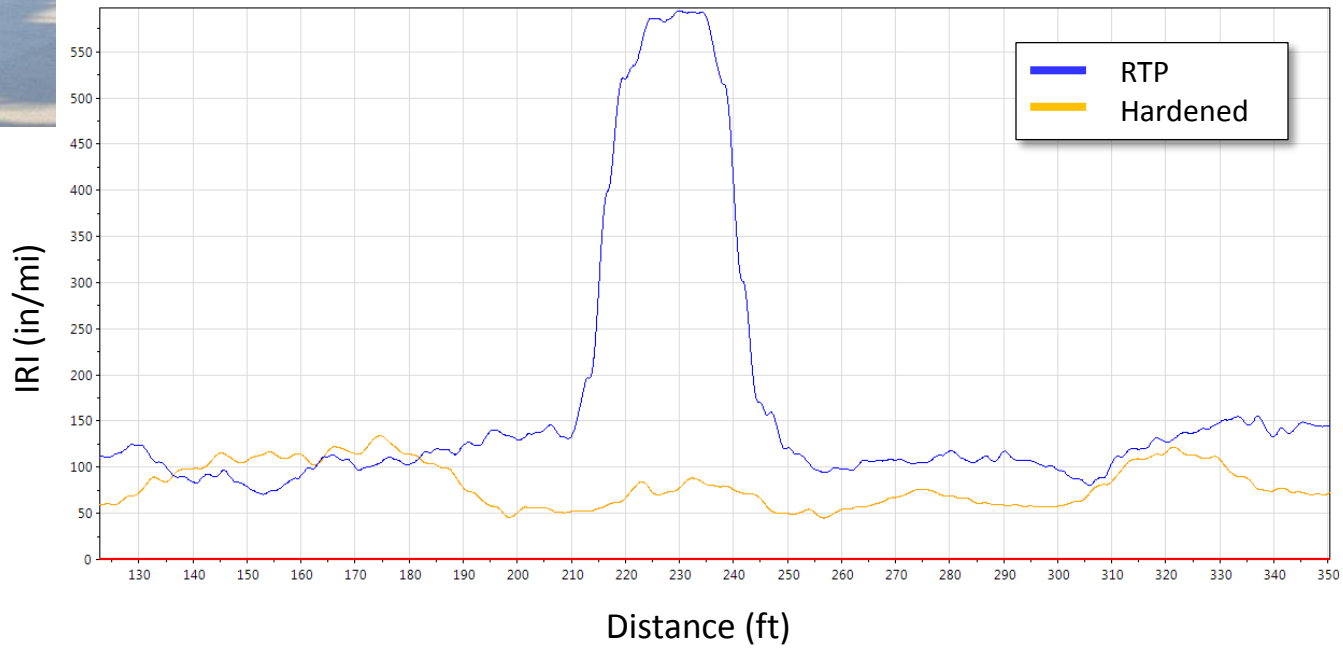
Lessons Learned:
2. Features Picked Up by RTS

- Load Spacing



Lessons Learned:
2. Features Picked Up by RTS

- Localized roughness/improvement from finishers



Lessons Learned from RTS Equipment Loan Program

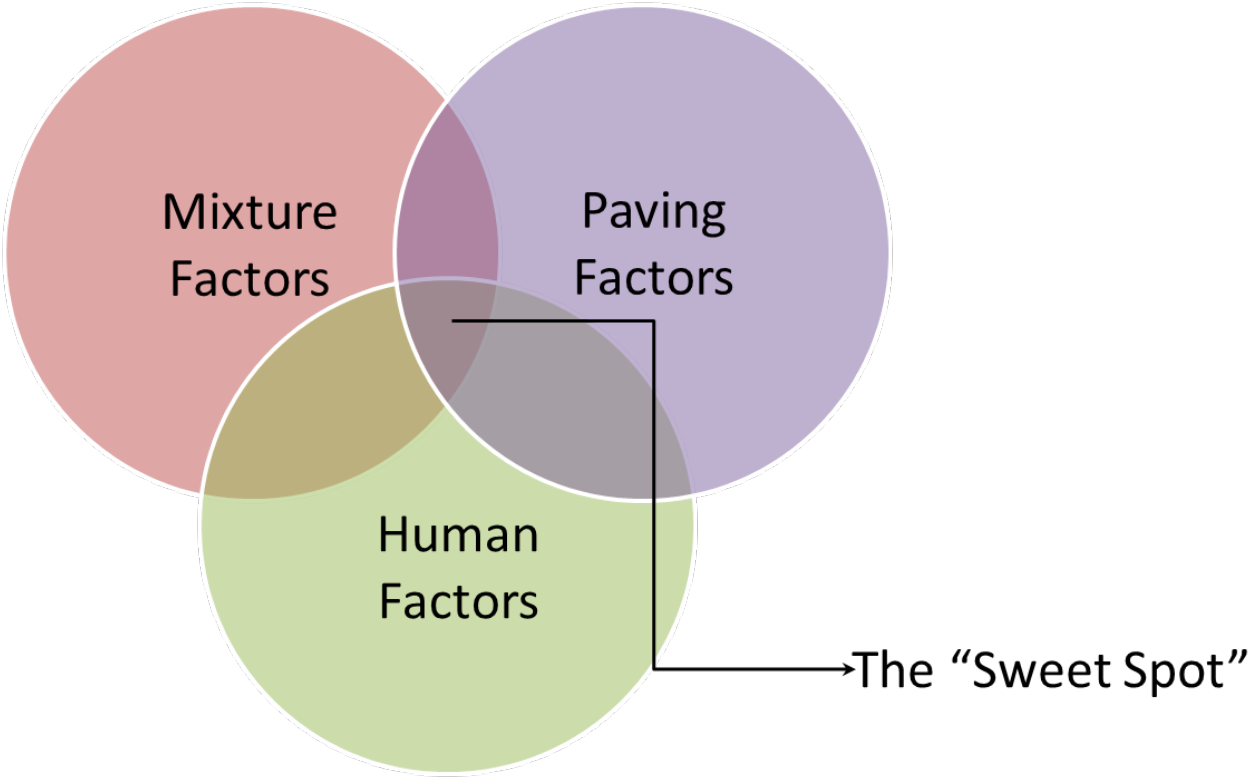
1. RTS vs. Hardened Profiles
2. Features Picked Up by RTS
3. Benefits for Contractors and Agencies

Lessons Learned:
3. Benefits for Contractors & Agencies

- **Primarily a QC tool for contractors**
  - Not so much for identifying localized roughness
  - Evaluating effects of changes during paving on smoothness
  - Identifying “systematic” issues in the paving operation
- **NOT a replacement for conventional (hardened) QC profiling.**
- **Transition from PrI to IRI specifications.**
- **Tool for agencies to understand effects of design factors on smoothness.**

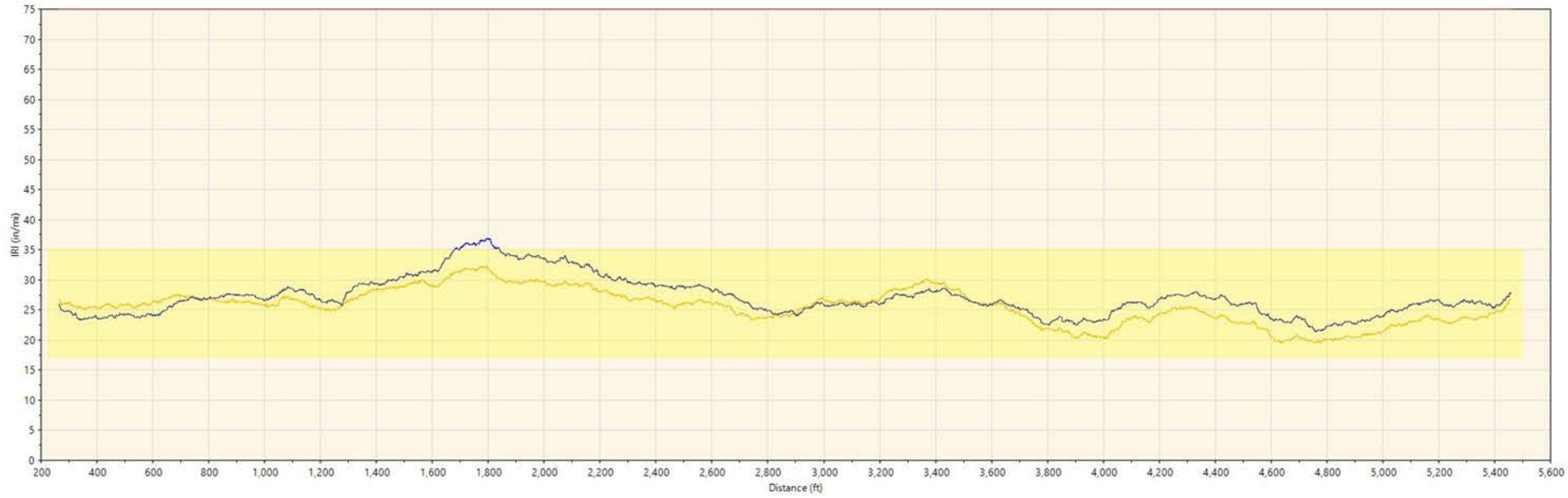
Lessons Learned:
3. Benefits for Contractors & Agencies

- Finding (and maximizing) the "sweet spot" for maximizing smoothness:



Lessons Learned:
3. Benefits for Contractors & Agencies

- **Example from North Dakota**
  - Specification: Full Pay = 50-54 in/mi, Correction > 68 in/mi, ALR (25’ baselength) = 80 in/mi.
  - Approx. 1.1 miles of paving: average IRI = 28 in/mi.



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Lessons Learned:
3. Benefits for Contractors & Agencies

- **Example from North Dakota**
  - Mixture Factors: optimized gradation mix, tailored for the project.
  - Human Factors:
    - Conscientious crew, everyone knew their job (no panicking)
    - Experience (paver operator in particular)
    - Good communication
  - Paving Factors:
    - Minimal design challenges (mostly tangent, little grade)
    - Well-maintained paver
    - Base trimmed to grade through padline
    - Two placer-spreaders = minimal “work” by paver
  - RTS used as a “smell check” QC tool.

Real-Time Smoothness for Concrete Paving

Questions and Discussion

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