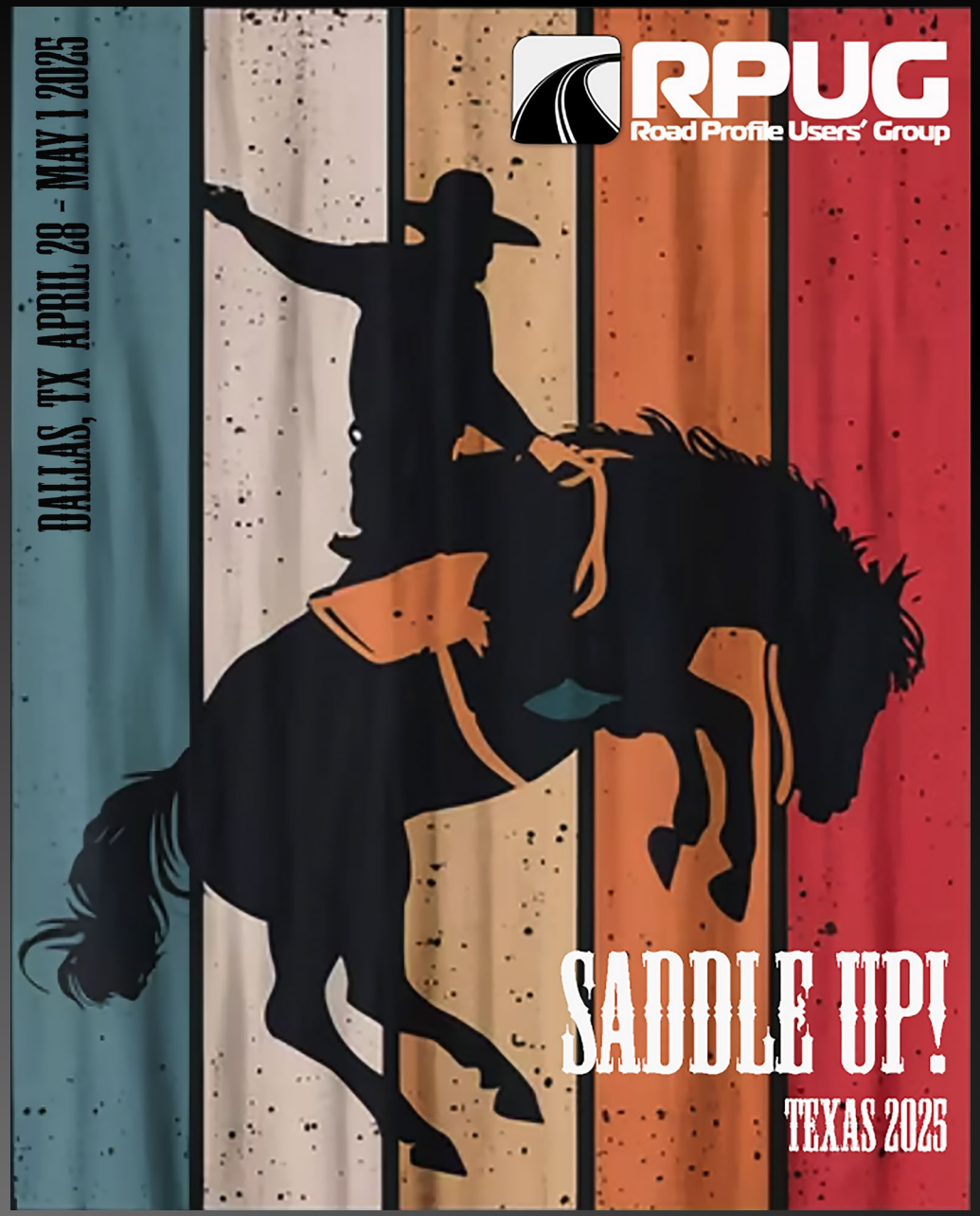

REAL TIME SMOOTHNESS FOR CONCRETE PAVEMENTS: STATE-OF-THE-PRACTICE AND VALUE PROPOSITION

DAVID K. MERRITT, PROJECT DIRECTOR

THE TRANSTEC GROUP
A Terracon Company

RPUG
Road Profile Users' Group

Real Time Smoothness (RTS)

- Overview of RTS technology and implementation
- What we can learn from RTS technology
- Value Proposition for RTS

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Overview of RTS Technology

Real Time Smoothness (RTS) is a Quality Control tool for assessing pavement smoothness during construction (paving operations).

- Three Primary Purposes
  1) Provides a general idea of smoothness (IRI) values during paving.
  2) Assess the impact of changes to paving operations on smoothness during paving.
  3) Identify (and mitigate) systematic paving factors that may be impacting smoothness.

Overview of RTS Technology

- Equipment: Profiling Sensors
  - Ames RTP (laser based)
  - Gomaco GSI (sonic sensor plus slope meter)
  - SSI On-Paver Profiler (laser based)

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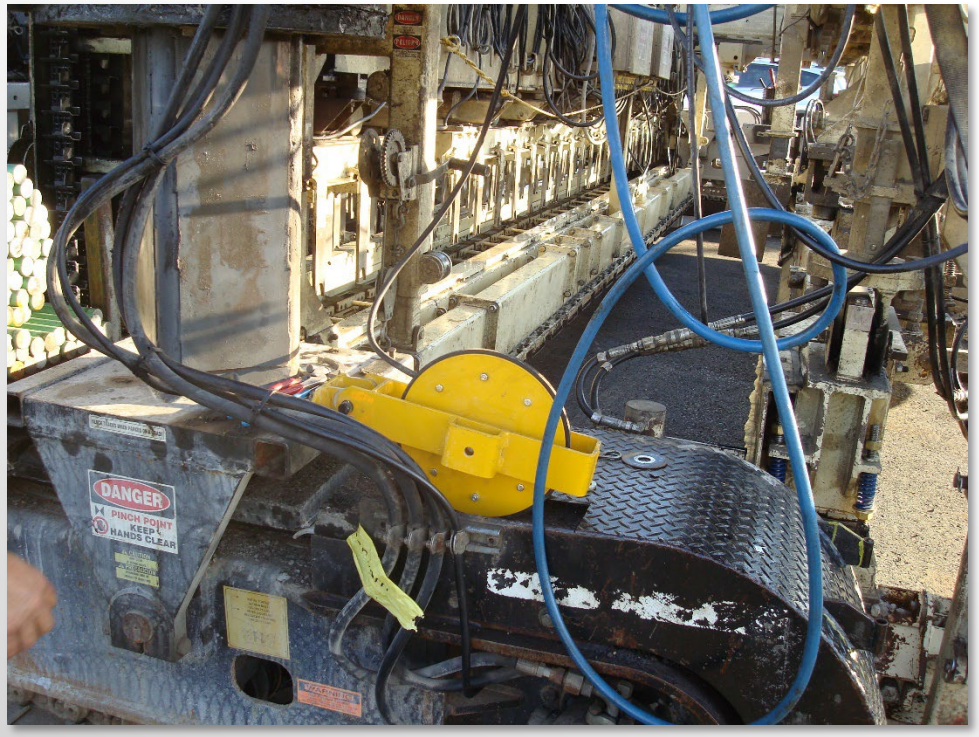
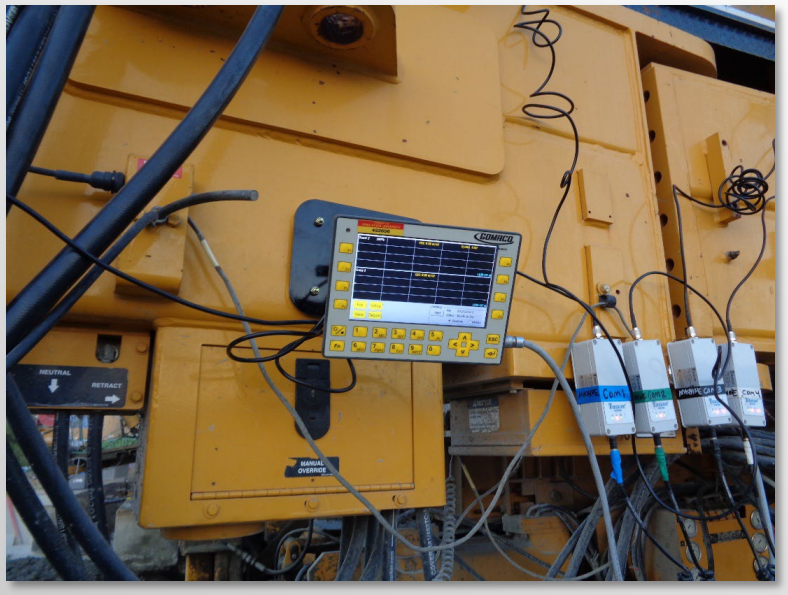
Overview of RTS Technology

- Equipment: Distance Measurement Instrument (DMI) and GPS
  - Stand-alone DMI
  - Tap into paver DMI (GSI on newer G+ pavers)



Overview of RTS Technology

- Equipment: Data Collection and Feedback



RTS Implementation Efforts

- 2010 – 2013: SHRP2 Project R06(E) RTS technology evaluation
- 2014 – 2017: SHRP2 Solutions RTS technology implementation
  - 11 equipment loans
  - 8 workshops
- 2017 – 2019: FHWA RTS technology implementation
  - 6 equipment loans
  - On-call technical support
  - 2 webinars
  - Guide Specification
  - Guidelines for Best Practices
- 2020 – 2024: FHWA-CP Tech Center Cooperative Agreement
  - 5 equipment loans
  - On-call technical support

SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

National Concrete Pavement Technology Center
CP Tech Center

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RTS Implementation Efforts

- 22 Equipment Loans (22 Paving Contractors) in 17 States
  - Pavement types: JPCP, CRCP, Thin Overlay
  - Urban paving, rural paving
  - Varying slab thickness and base/subbase (granular, stabilized, etc.) types
  - Daytime and nighttime paving
  - Varying paver types and setup (G&Z, GOMACO, Wirtgen)
  - Varying paving train setup (concrete delivery, finishing and texturing operations)
  - Varying mix designs and materials
  - Dowel Baskets and Dowel Bar Inserters
  - Stringless and Stringline

RTS Implementation Efforts

- Resources:
  - FHWA and CP Tech Center Implementation

    https://cptechcenter.org/real-time-smoothness/
    - Project Reports and Equipment Loan Reports
    - Presentations and Webinars
    - Implementation and Best Practices for Concrete Pavement Smoothness
    - Guide Specification (AASHTO R54 Commentary)
  - FHWA Concrete Clips (YouTube)

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Real Time Smoothness (RTS)

- Overview of RTS technology and implementation
- What we can learn from RTS technology
- Value Proposition for RTS

Using RTS Systems

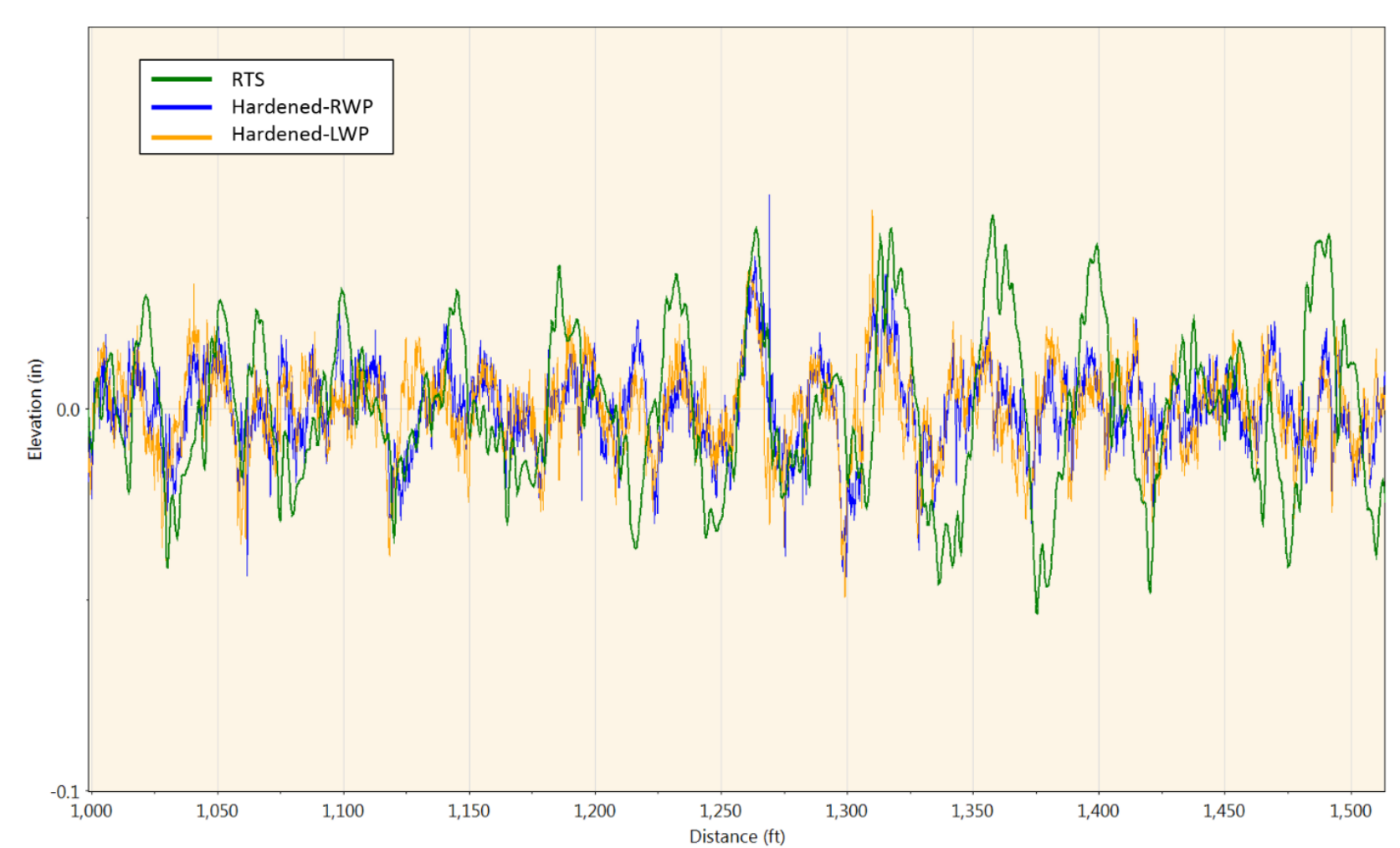
1. Provides a general idea of smoothness (IRI) values during paving.
2. Assess the impact of changes to paving operations on smoothness during paving.
3. Identify (and mitigate) systematic paving factors that may be impacting smoothness.

Using RTS Systems

1. Provides a general idea of smoothness (IRI) values during paving.
   - General trends for smoothness during paving.
   - No “surprises” when QC profile data is collected.
   - RTS vs. QC IRI

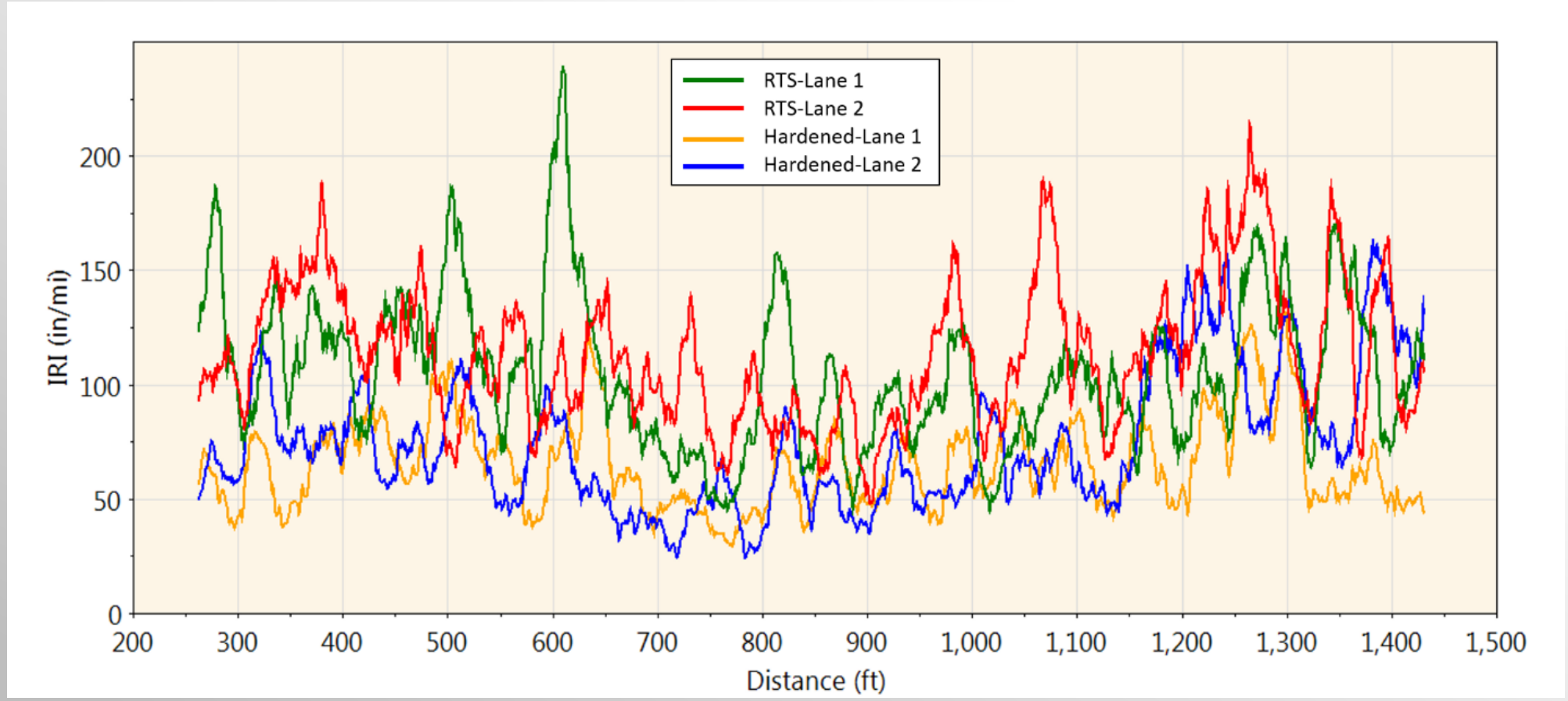
RTS vs. QC Profiles

- Raw profiles are different, but trends are similar



RTS vs. QC Profiles

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



RTS vs. QC Profiles

- There is no fixed correlation between RTS and QC profile numbers.
- In general, RTS numbers will be higher (not always), but the degree is project/crew/equipment specific.
- Any correlation will need to be established during the first few days of paving.

RTS vs. QC Profiles

- Rule of thumb: the higher the RTS numbers, the greater the difference between RTS and QC, 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**

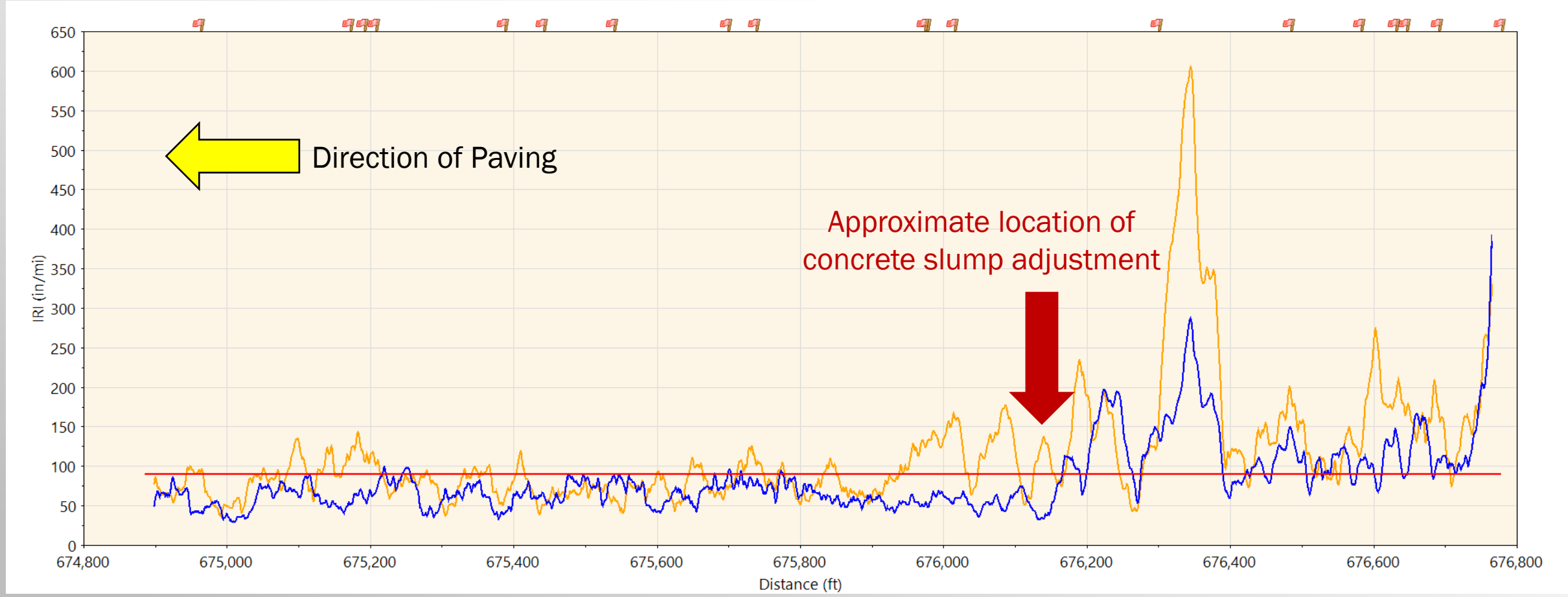
Using RTS Systems

2. **Assess the impact of changes to paving operations on smoothness during paving.**
   - Changes to concrete mix
   - Changes to paver settings
     - Grade control sensitivity
     - Vibrator settings
     - Concrete head
   - What shows up in the hardened profile?

   - *NOTE: Changes don't always show up immediately!*

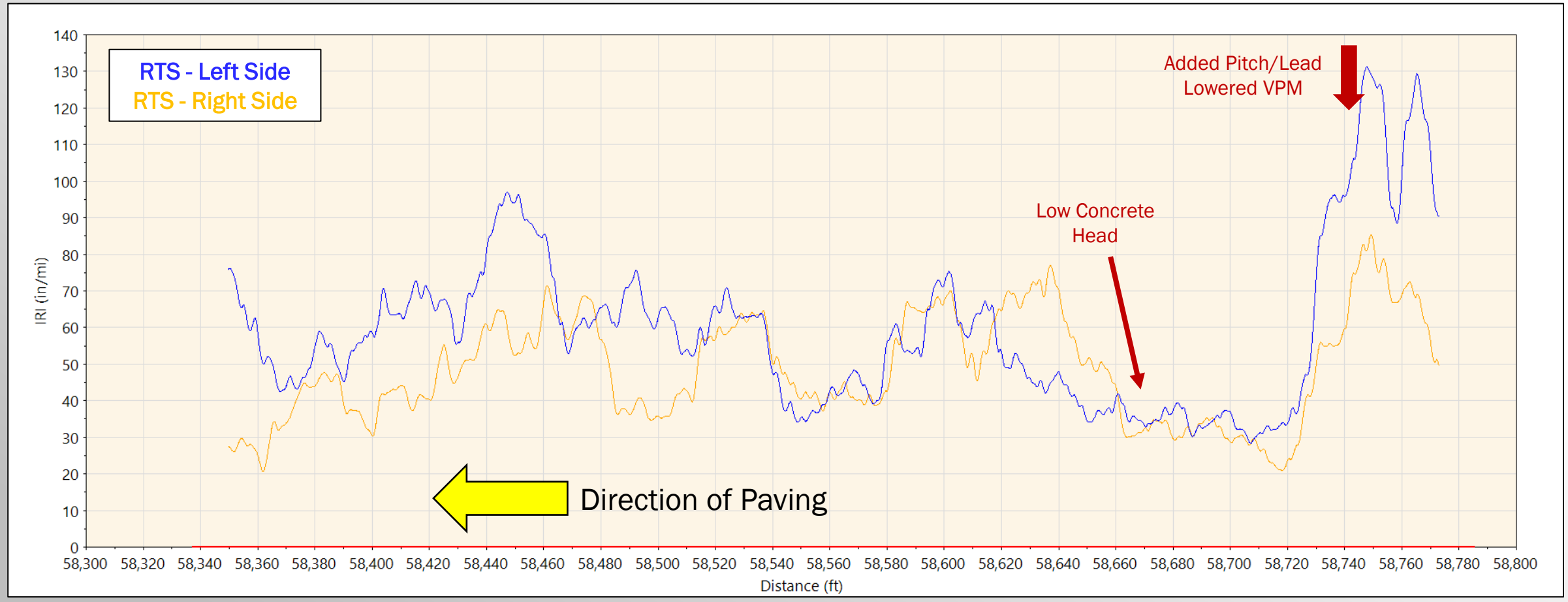
Impact of Paving Operation Changes

- Concrete Mixture Adjustments



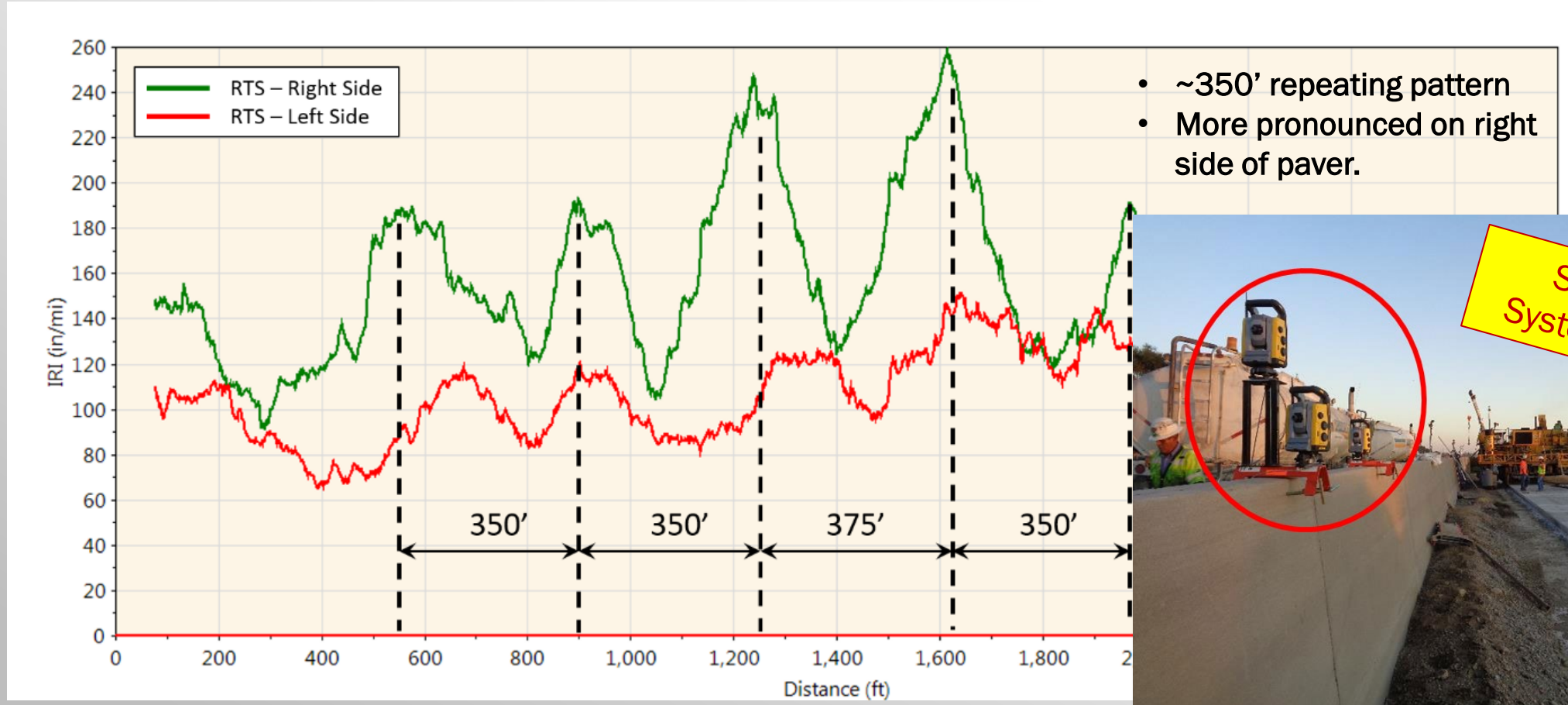
Impact of Paving Operation Changes

- Paver Adjustments



Impact of Paving Operation Changes

- Grade Control



Impact of Paving Operation Changes

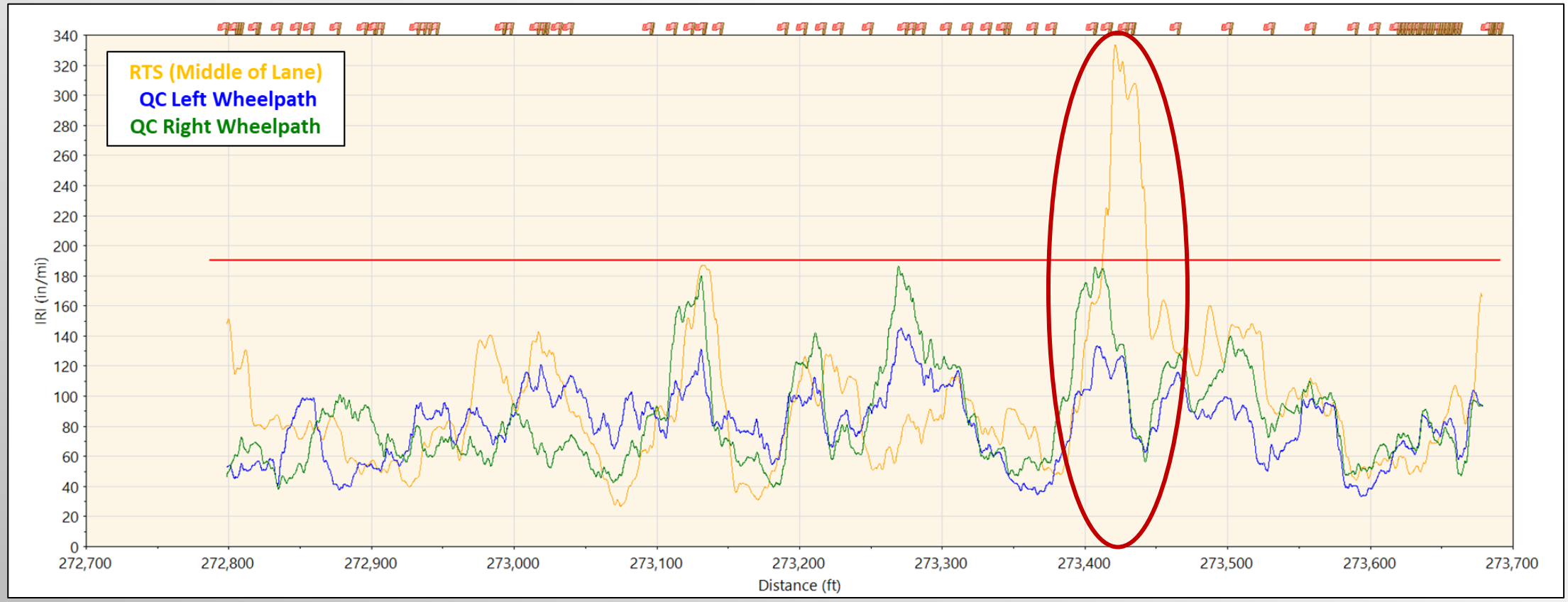
- Paver Padline Effects

Impact of Paving Operation Changes

- Paver Stops – Do They Matter?

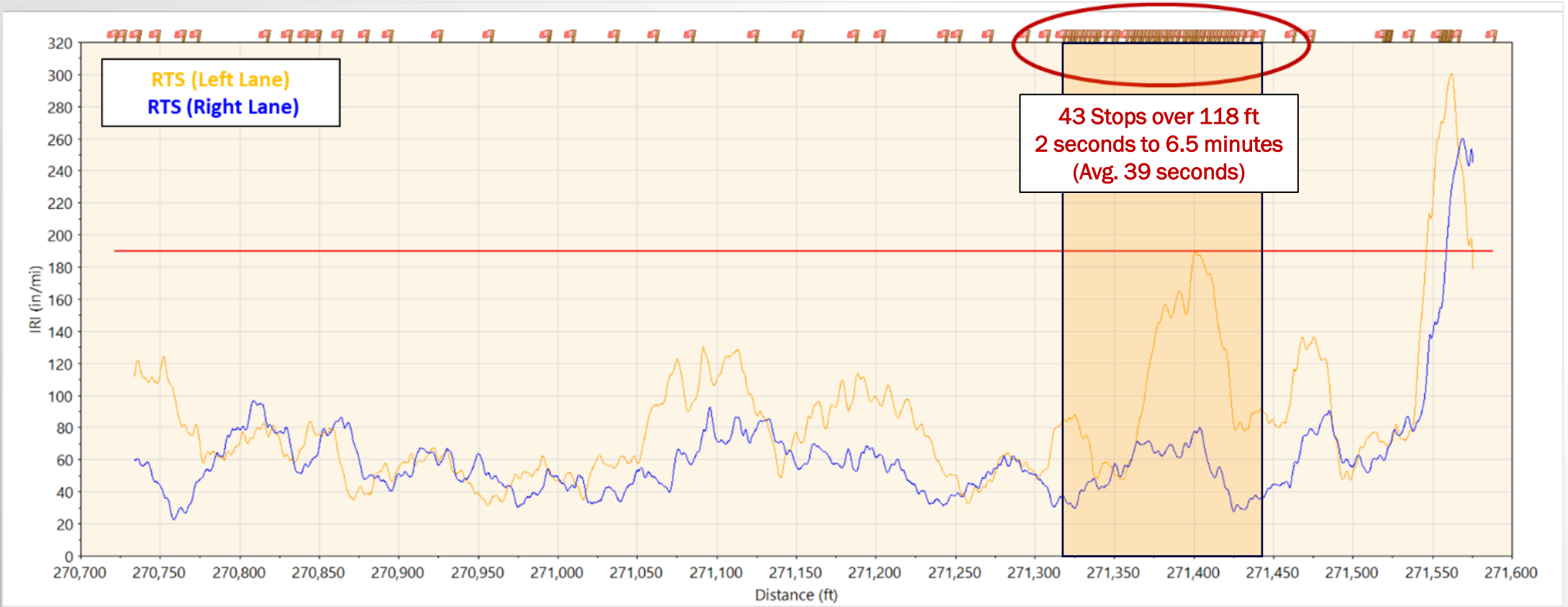
Impact of Paving Operation Changes

- Paver Stops – Do They Matter?



Impact of Paving Operation Changes

- Paver Stops – Do They Matter?



Impact of Paving Operation Changes

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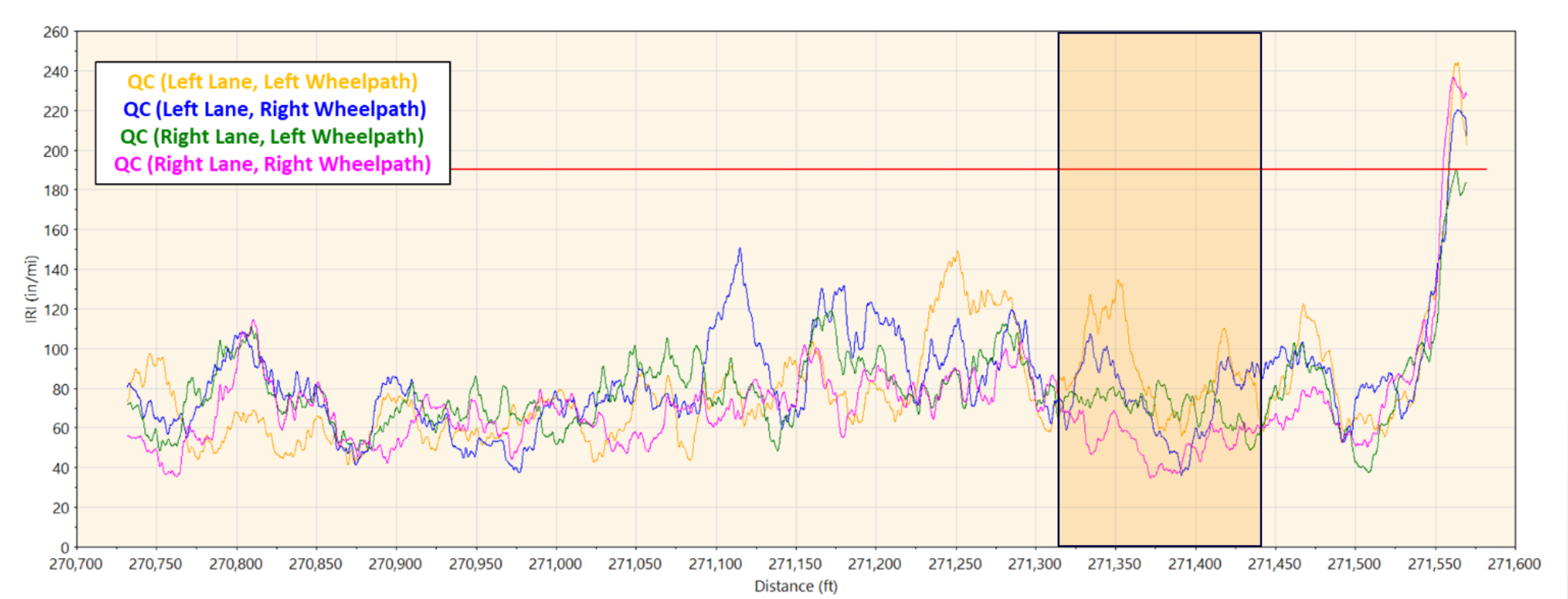
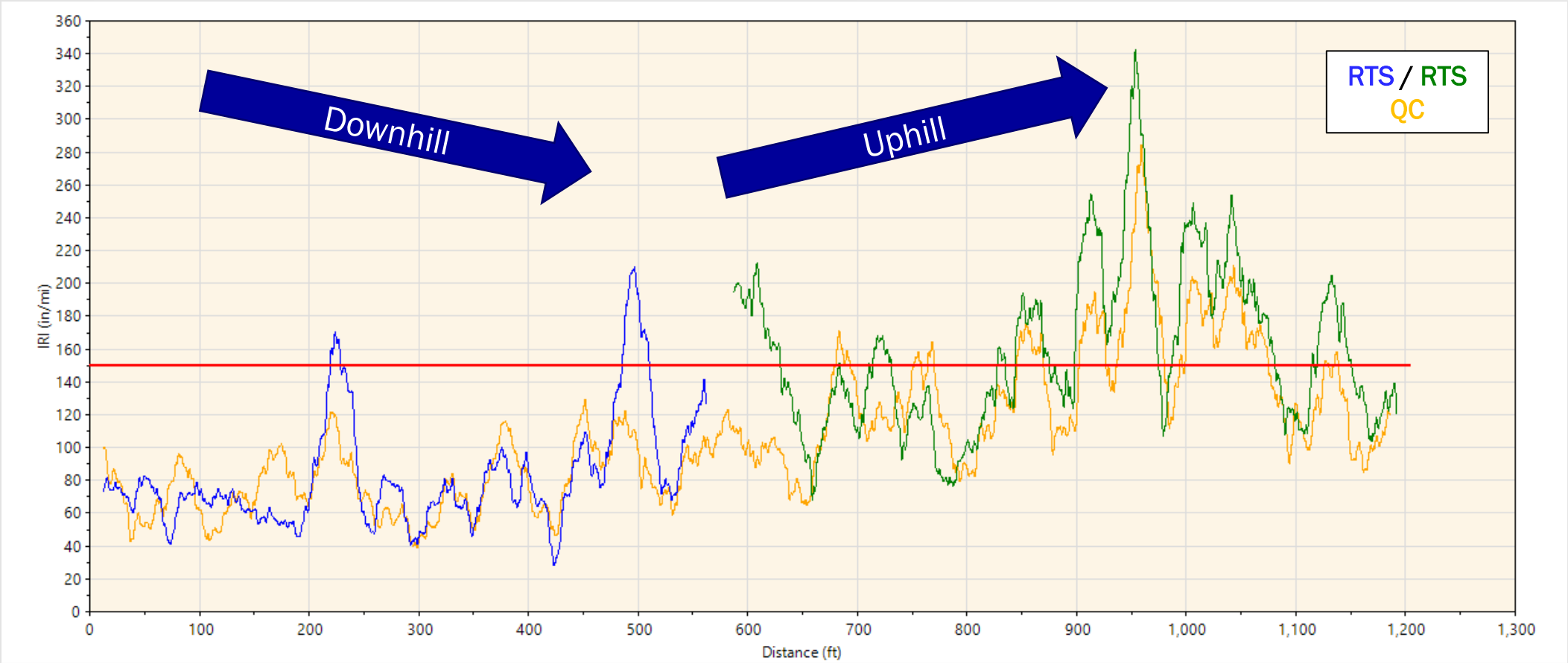


Impact of Paving Operation Changes

- Uphill vs. Downhill Paving



Impact of Paving Operation Changes

- Left Side vs. Right Side of Paver

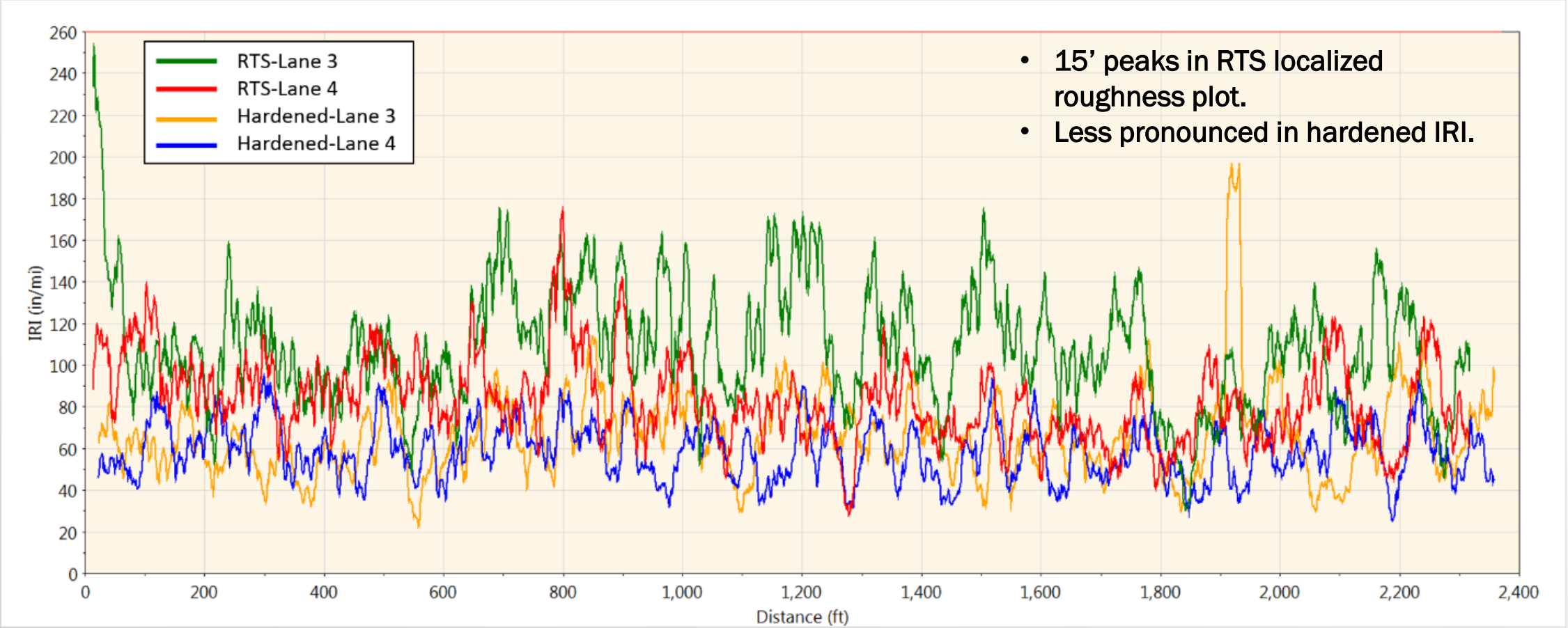
Using RTS Systems

3. **Identify (and mitigate) systematic paving factors that may be impacting smoothness.**
   - "Patterns" in pavement profile related to paving factors.
   - What shows up in both the RTS and QC profiles.

   - *NOTE: Always keep it in context of overall IRI values.*

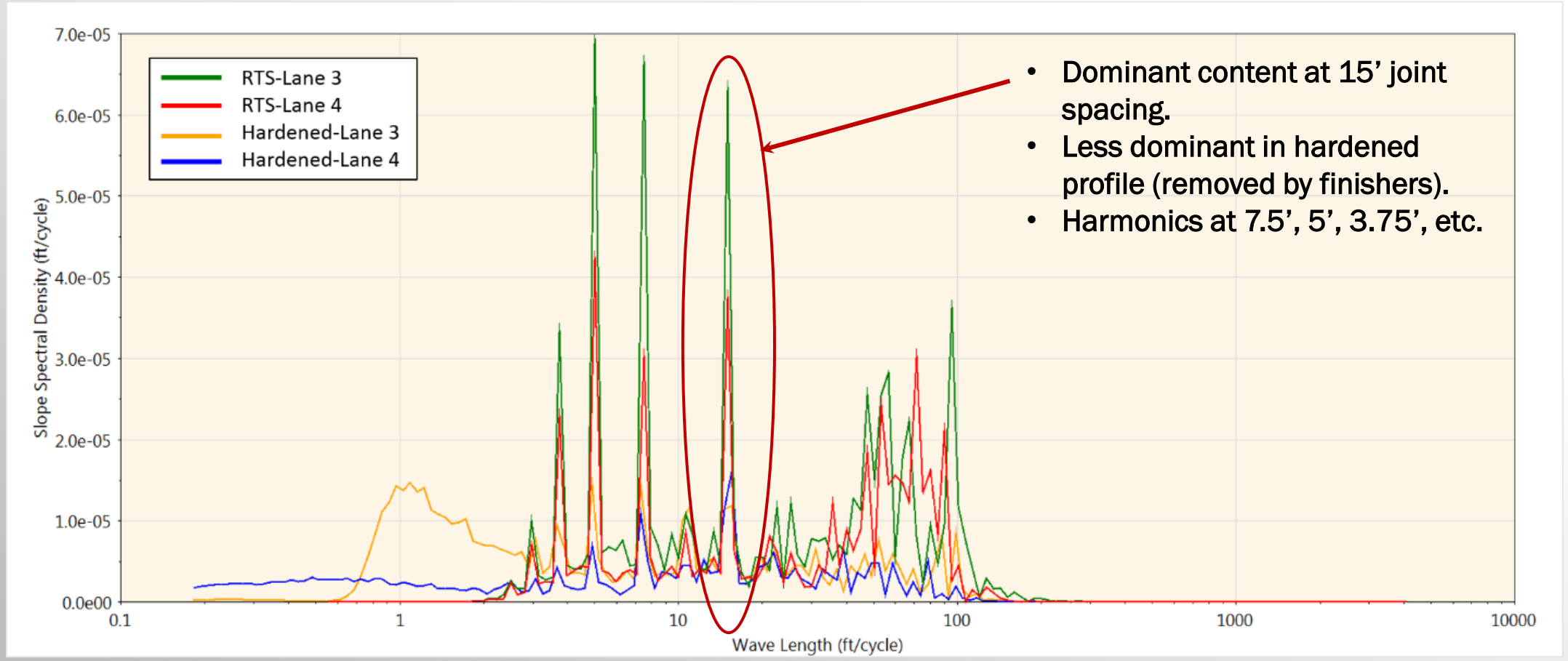
Identifying Systematic Factors

- Joint spacing/dowel basket effects



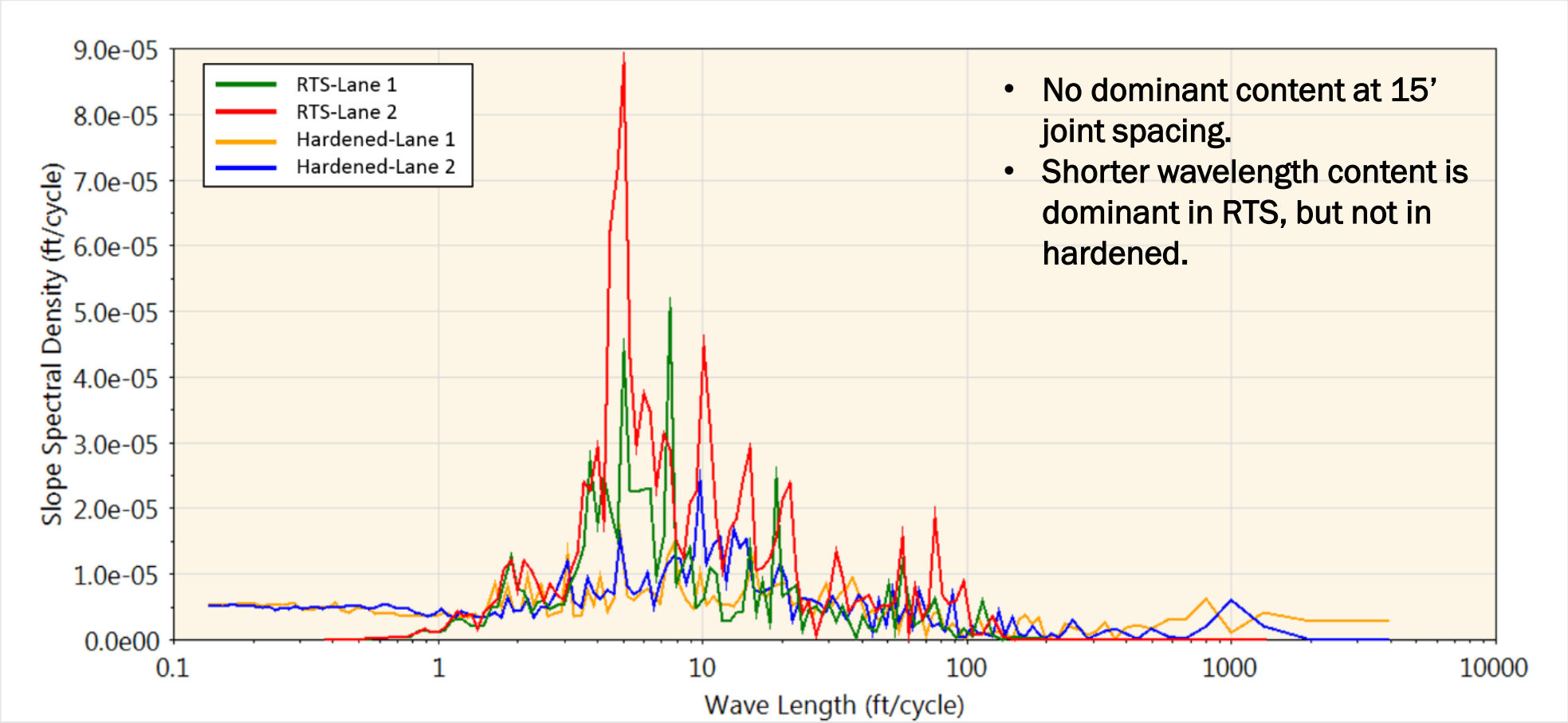
Identifying Systematic Factors

- Joint spacing/dowel basket effects



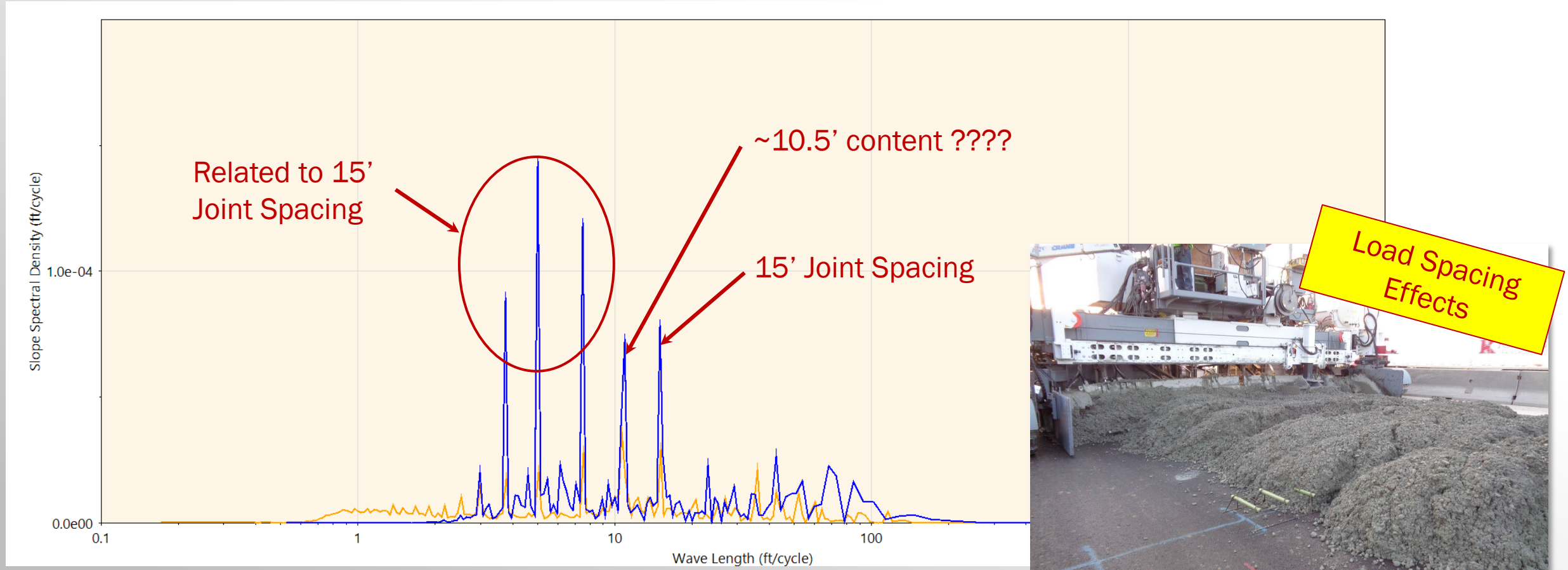
Identifying Systematic Factors

- Project utilizing Dowel Bar Inserter



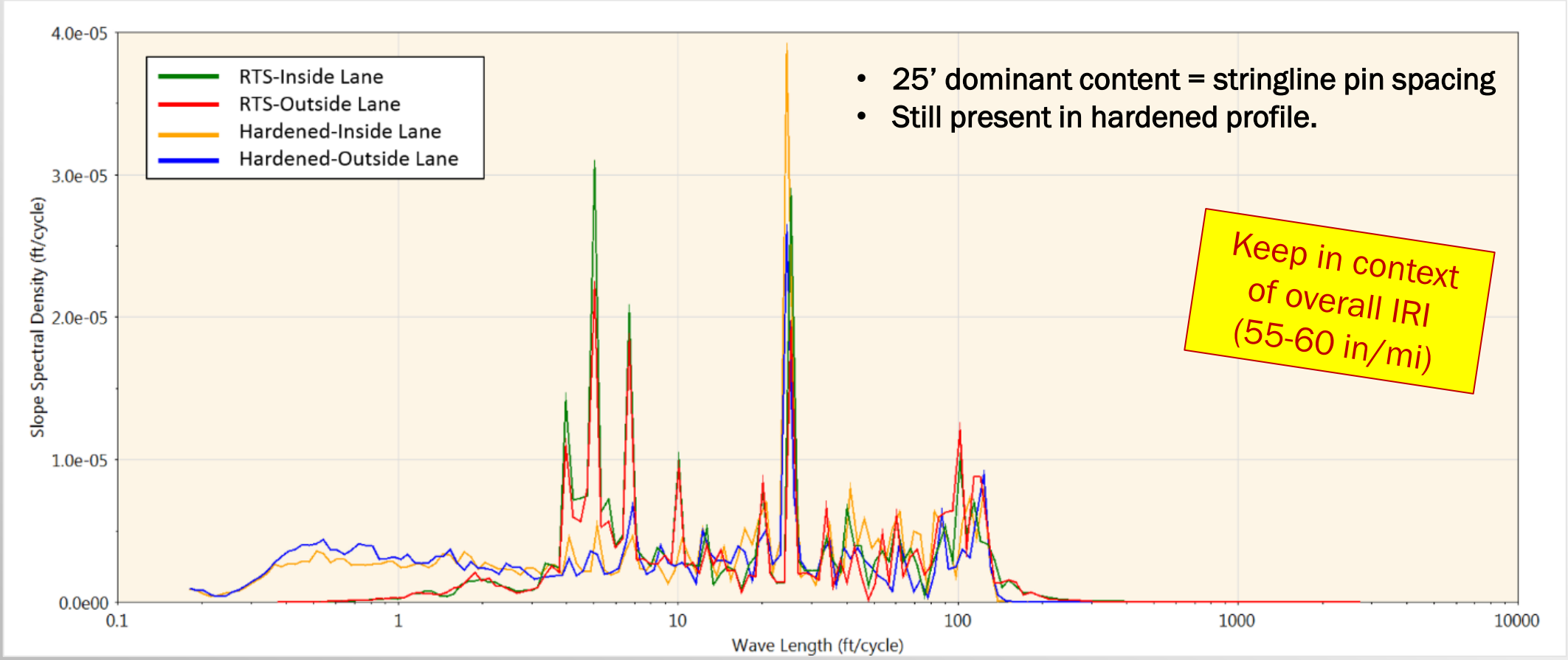
Identifying Systematic Factors

- Concrete Delivery Effects



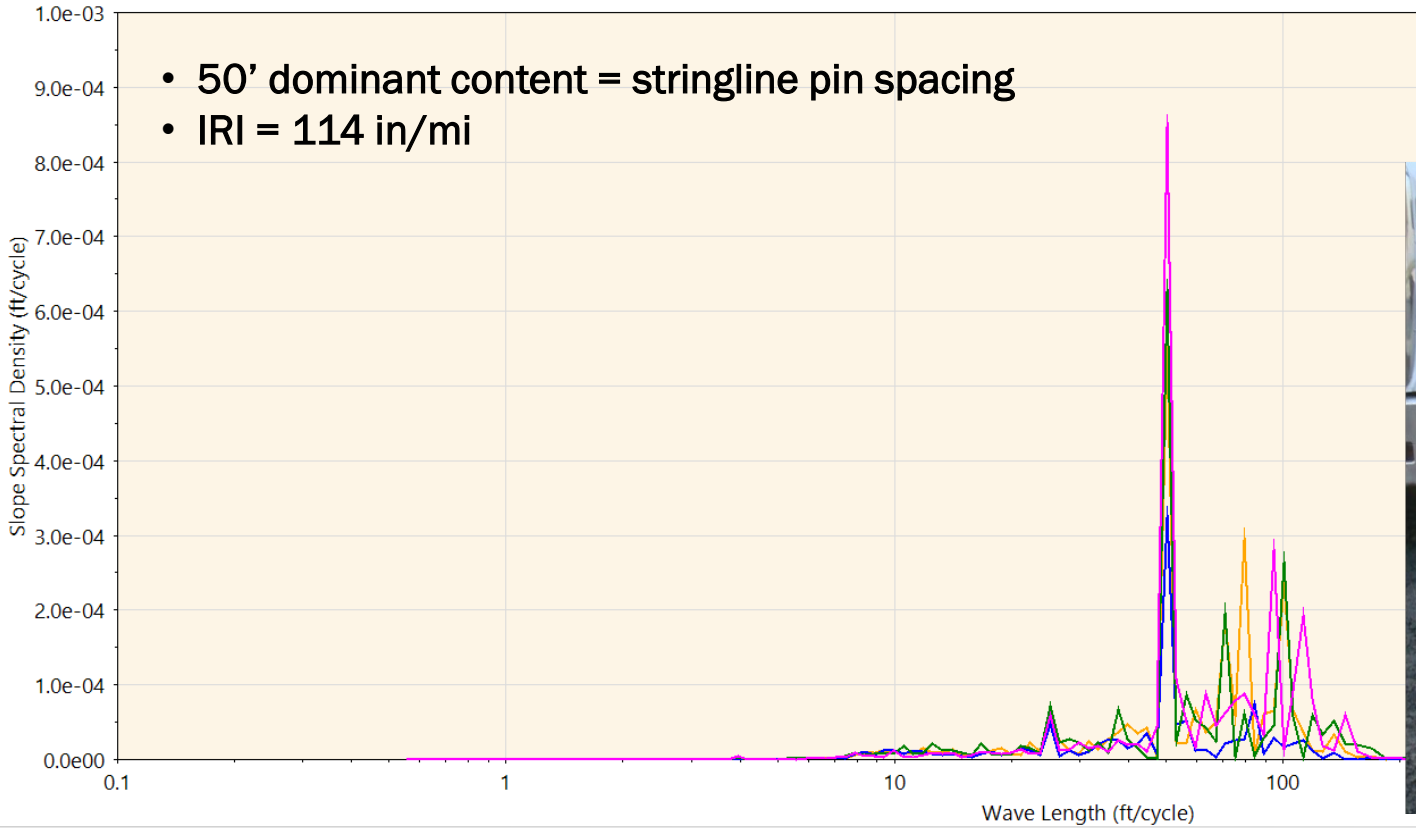
Identifying Systematic Factors

- Stringline Effects



Identifying Systematic Factors

- Stringline Effects



Real Time Smoothness (RTS)

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Value Proposition for RTS

- As a QC tool, value of RTS is primarily realized by contractors:
  - Cost
    - Initial cost: $60k-70k
    - Routine maintenance: <$5k/year
    - Initial training: minimal
    - Regular operation (setup, daily startup/shutdown): negligible
  - Benefits
    - Reduced corrective action (diamond grinding, remove/replace)

Diamond Grinding
$5-$7/SY = $3,500-$4,900
(per 0.1-mile defective segment)

Value Proposition for RTS

- As a QC tool, value of RTS is primarily realized by contractors:
  - Benefits
    - Maximizing incentive/minimizing disincentive pay adjustments

Incentive/Disincentive Basis		Max Incentive	Max Disincentive
$ per 0.1 mi lot	Min	$200	-$250
	Max	$1,600	-$1,750
	Avg.	$825	-$831
	Median	**$813**	**-$750**
Pct. Contract Price	Min	102%	90%
	Max	108%	50%
	Avg.	105%	75%
	Median	**105%**	**80%**

Potential Pay Adjustments
+$8,100/lane-mile
-$7,500/lane-mile

Potential Pay Adjustments:
+$31,700/lane-mile*
-$126,700/lane-mile*

*Assuming $90/SY bid price

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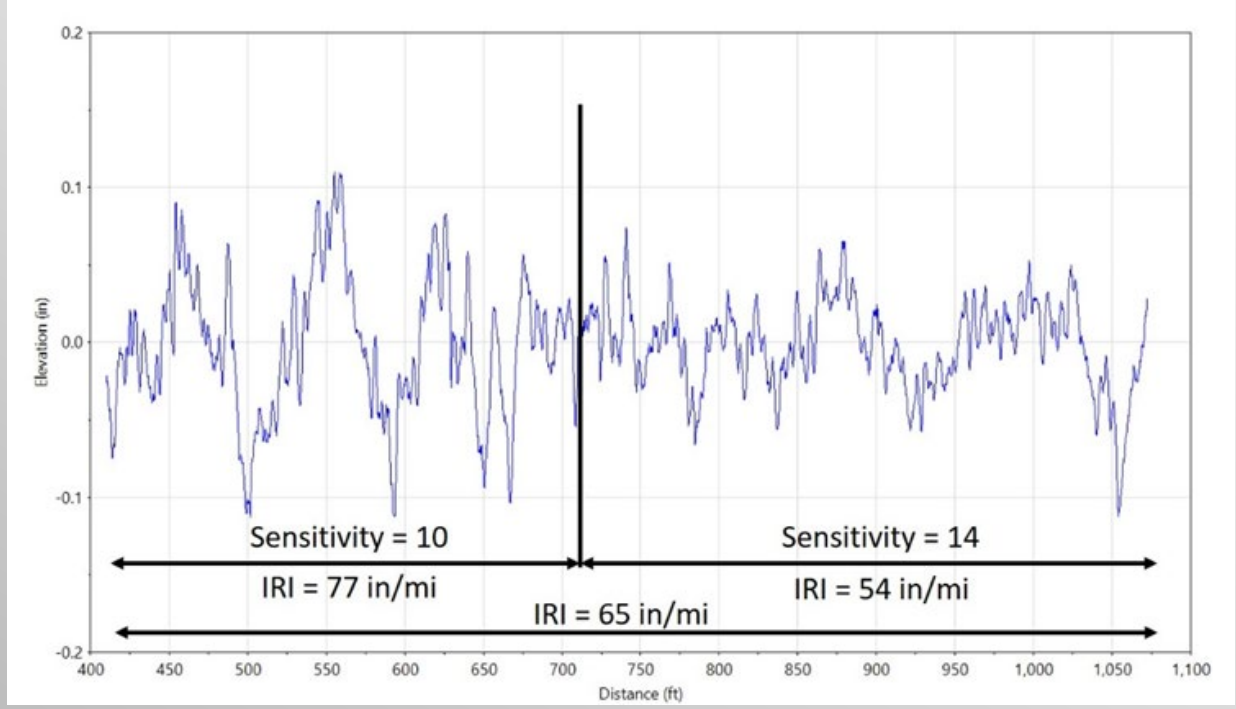
Value Proposition for RTS

- As a QC tool, value of RTS is primarily realized by contractors:
  - Example of improvement in smoothness after using RTS to monitor effects of process changes (sensitivity):



77 in/mi (-) Pay Adjustment

54 in/mi (+) Pay Adjustment

(65 in/mi overall) Full Pay

Value Proposition for RTS

- Value to Agencies
  - Superior final product from the contractor.
  - Smoothness is typically a key indicator of construction quality.
  - High level of smoothness relative to what is achievable.
  - Increased market competition
    - Conscientious contractors may build smoothness incentives into their bid price.
    - Result is a superior product built by a quality-conscious contractor.

Value Proposition for RTS

- Value to Agencies
  - Indiana DOT Research Study:
    - Estimated future smoothness (IRI) based on initial smoothness (IRI) using historical pavement performance data.
    - Looked at observed to expected pavement life and life-cycle costs to capture M&R costs.
    - Incentive and pay reduction factors based on findings.

Smoothness Requirement (IRI)	Pay Adjustment
< 35 to 59 in/mi	Graduated Incentive (up to 8% at 35 in/mi)
60 to 70 in/mi	Full Pay
71 to 90 in/mi	Graduated Reduction (to 95% at 90 in/mi)
> 90 in/mi	Corrective Action Required

Value Proposition for RTS

- Value to Traveling Public
  - Superior final product from the contractor – smoother, longer lasting pavement.
  - Drivers judge the quality or a roadway primarily by ride quality.
  - Smoother pavement results in less wear and tear on vehicles.
  - Smoother pavement results in reduced fuel consumption.

Smoothness Improvement	Annual Fuel Savings (per lane mile)	Annual C*rb@n Savings (per lane mile)
77 in/mi → 54 in/mi	200 gal (regular) 477 gal (diesel)	6.7 metric tons

AADT: 2,790, Trucks: 43%, Design Speed: 70 mph

Recap

- Real Time Smoothness (RTS) is a Quality Control tool for assessing pavement smoothness during construction:
  1) Provides a general idea of smoothness (IRI) values during paving.
  2) Assess the impact of changes to paving operations on smoothness during paving.
  3) Identify (and mitigate) systematic paving factors that may be impacting smoothness.
- Provides potential value to contractors, agencies, and traveling public.

Thank you.

David Merritt, P.E.
The Transtec Group (Kansas City)
DMerritt@TheTranstecGroup.com
512-451-6233

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