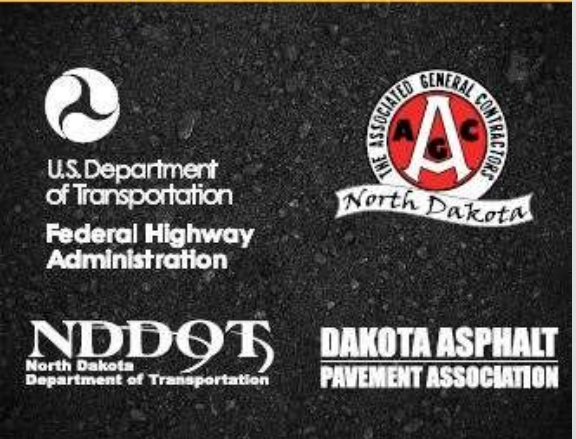


NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM



Using Thermal Imaging & IC Data for Quality Control

Presented by: Todd Mansell



What Problem are we Trying to Solve?

Owner: We are not realizing our design pavement life

- It's not design-related, it's construction-related!!
- The pavement is only as good as its weakest link
- We often give full acceptance when the pavement is not acceptable
- Current methods are “spot tests” – a moment in time and space

Contractor: We are not realizing our full incentive pay!!

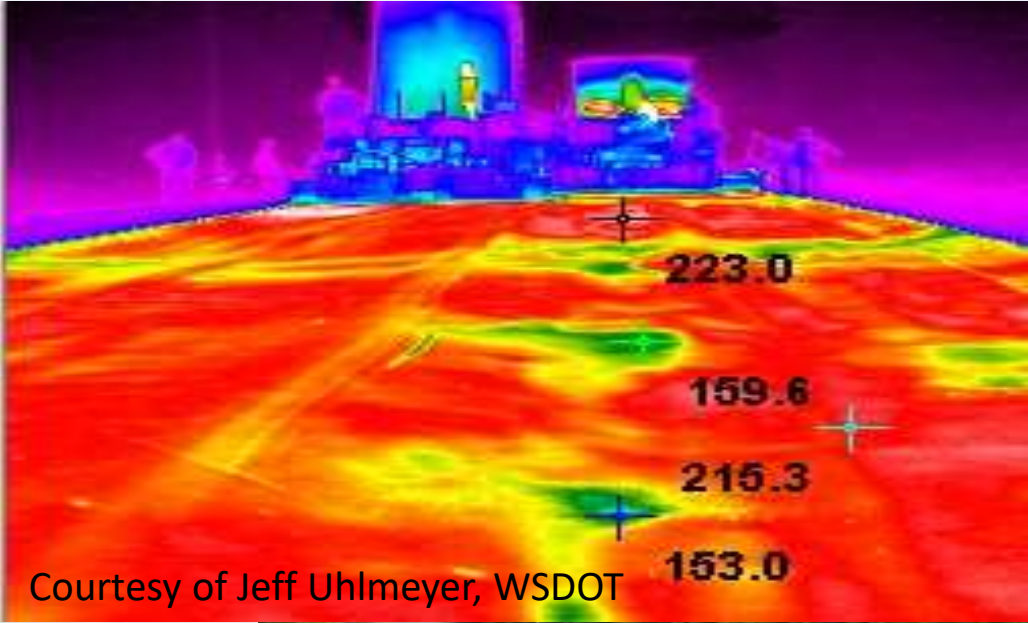
- PWL specifications - consistency
- Efficiencies in process – fewest roller passes, quality, production
- Operator training for quality & efficiency
- Equipment condition/repair

Temperature Differentials = Density Differentials



Courtesy of Jeff Uhlmeyer, WSDOT

This....becomes....this....



Courtesy of Jeff Uhlmeyer, WSDOT



What Percentage Actually Gets Measured?



Applying technology will minimize risk

Thermal Imaging



- Handheld thermal cameras
- Paver-Mounted Thermal Profiling (PMTF)



Paver-Mounted Thermal Profiling (PMTP)



- Continuous
- Real-time on paver
- Stationary infrared camera
- Variable width
- Compatible direct upload to Veta software

Caterpillar Thermal Mapping Product Spec

» SPECIFICATIONS AND DIMENSIONS



TECHNICAL SPECIFICATIONS

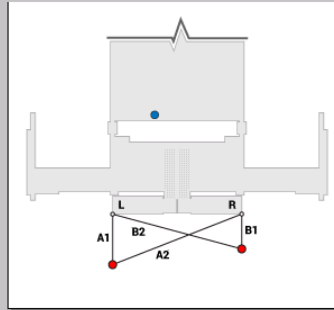
Temperature Mapping Range	60° - 200° C (141° - 392° F)
Temperature Accuracy	±2° C or 2%

DIMENSIONS

Camera Eye Height	A	3.96 m	(13')
Maximum Camera Height	-	4.27 m	(14')
Minimum Camera Height	-	2.93 m	(9' 7")
Calibration Zone			
Distance from Screed Plate - Minimum	B	2.44 m	(8')
Distance from Screed Plate - Maximum	C	3.66 m	(12')
Maximum Mat Width	D	9.14 m	(30')

Calibration - Thermal Camera

This process aligns the camera output with the map being created and should be done when ever a different camera is installed or mounting position changes.

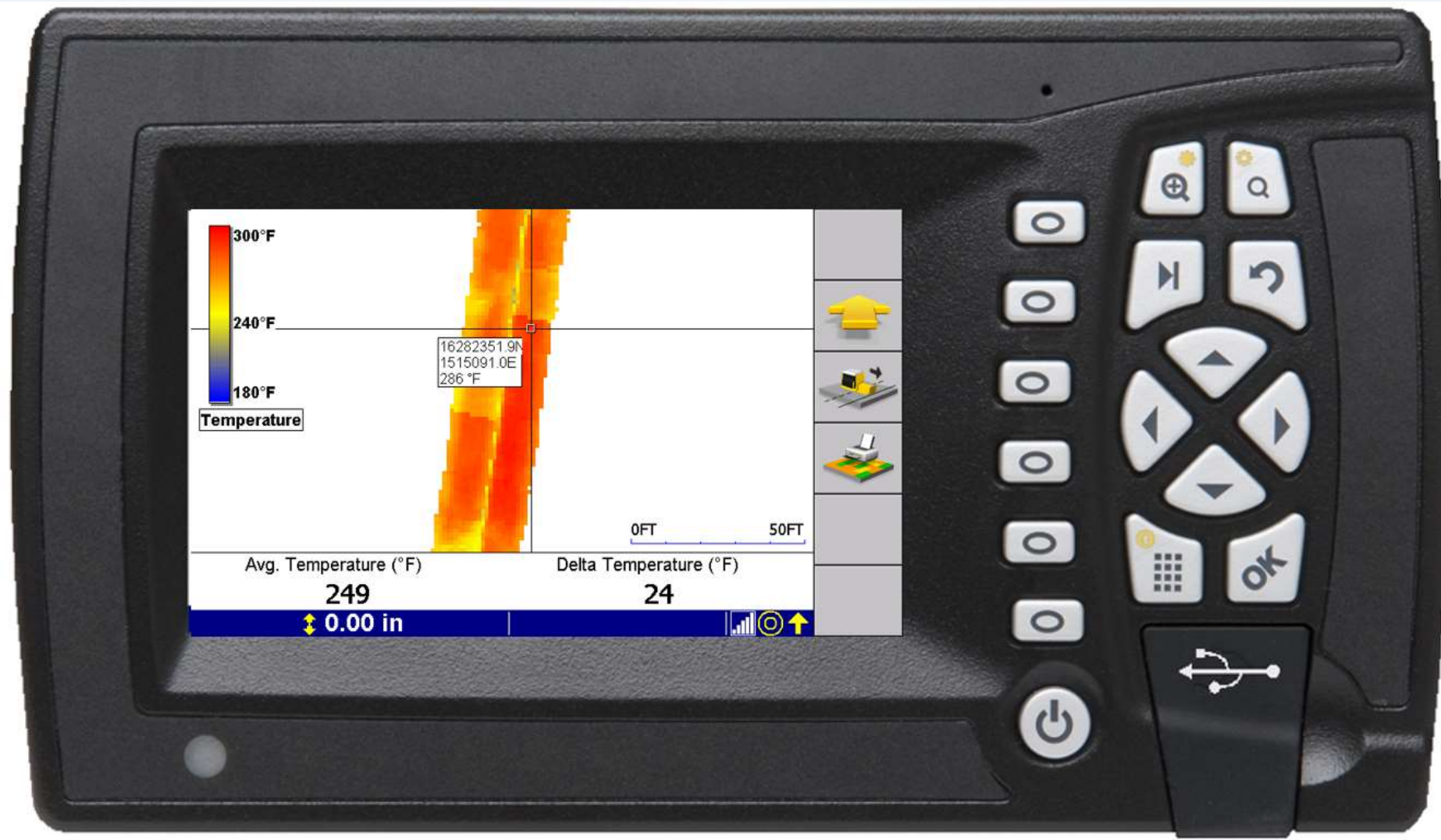


- Steps:
1. Place paver on level ground
 2. Place screed in normal working position
 3. Ensure screed extension measurements are entered

↕ N/A



Thermal Mapping in Real-Time on the Paver



Cat Grade Control In-Field Report

Machine	:	
Start Time	:	19:38:44
Start Date	:	2018/05/29
End Time	:	22:46:08
End Date	:	2018/05/29
Duration	:	187 Minutes
Site Design	:	I10 FLAT
UTM Zone	:	14 N
Start Station	:	
End Station	:	
Total Area Covered	:	14387.9 FT ²
Layer	:	1

Target Temperature Variation Range: 25°F to 50°F

Temperature Percentages:

0- 25°F:	45%
25- 50°F:	21%
> 50°F:	34%

High Temperature Variation Areas: (>50°F, 12.0 FT²)

	Northing	Easting	Temperature Variation
1.	10759554.6	1760971.7	111°F
2.	10759553.4	1760975.1	103°F
3.	10759289.1	1761125.6	98°F
4.	10759559.0	1760963.9	94°F
5.	10759388.4	1761060.9	86°F
6.	10759499.9	1761009.6	85°F
7.	10759283.5	1761139.0	84°F
8.	10759628.2	1760928.2	81°F
9.	10759617.0	1760934.9	80°F
10.	10759188.7	1761200.4	80°F

Approval

Operator

Site Manager

Date

.....

Third Party Inspector

Date

.....

How Can Thermal Imaging Help with QC?

- Consistent mat temperatures = consistent compaction = better smoothness = extended pavement life
- Identify areas of improvement in process and equipment
 - Plant operations
 - Plant repairs
 - Transportation & handling of mix
 - Loading, transfer to paver, through the paver
 - Paving equipment setup & operation
 - Paving equipment repair

Components of IC Roller



Intelligent Compaction



- Pass count mapping
- Temperature monitoring
- ICMVs
- Accurate positioning

How Can IC Help with Quality Control?

- Consistent pass count → uniform density (PWL)
- Rolling in temperature zones → uniform density (PWL)
- Intelligent Compaction Measurement Value (ICMV) → unproven
- “*Operator-assist*” tool for tracking rolling patterns
 - Vibration on/off
 - Length of roller pass relative to temperature zones
 - Night work
 - Overlap of longitudinal joints
 - Stopping at an angle to the mat, coverage/pattern
 - Identifying soft spots
- Safety - reduced field testing

Why These Technologies?

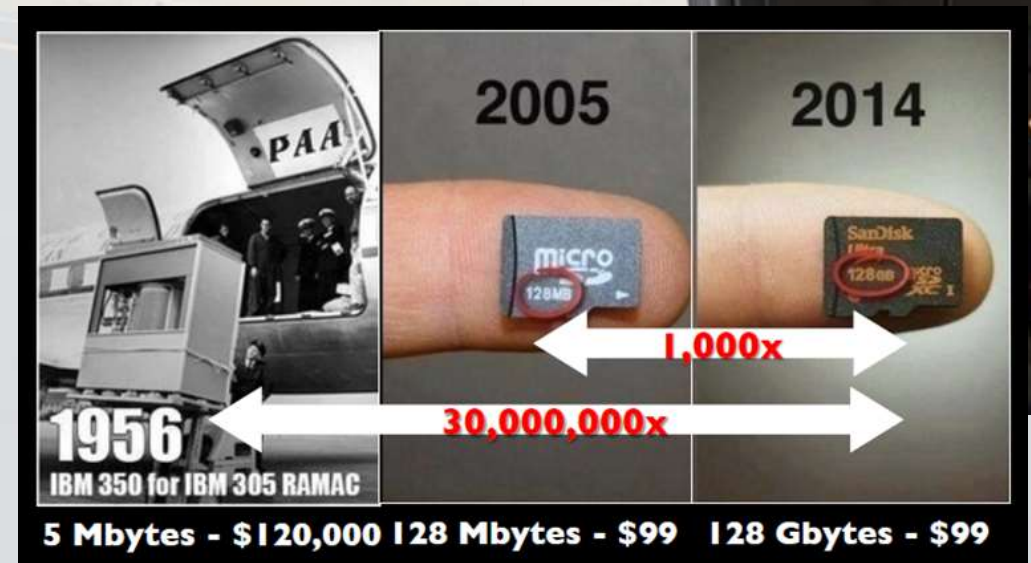


- Combining IC and Thermal data provides sufficient information to “drill down”, isolate and solve quality and efficiency problems anywhere in the paving process



Why Now?

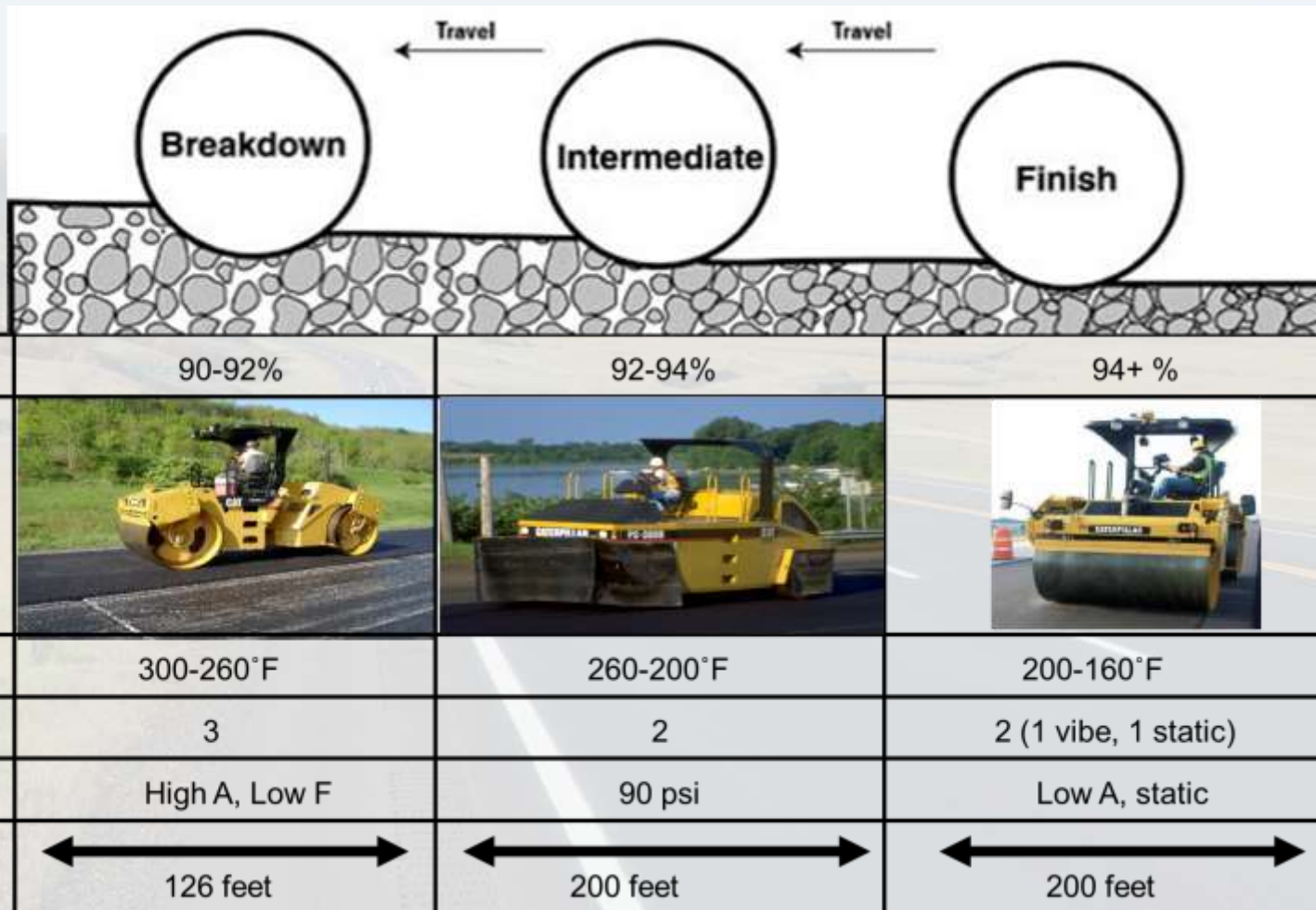
- Wireless data coverage expanding
- Wireless data transfer enables near real-time information
- Technology is becoming less expensive & easier to use (CANBus on equipment)
- Veta analysis software is universal



Examples of Using Thermal & IC for QC

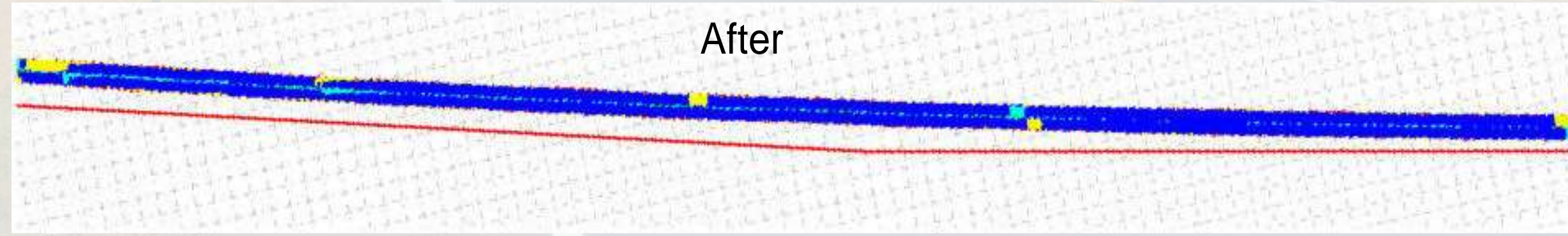
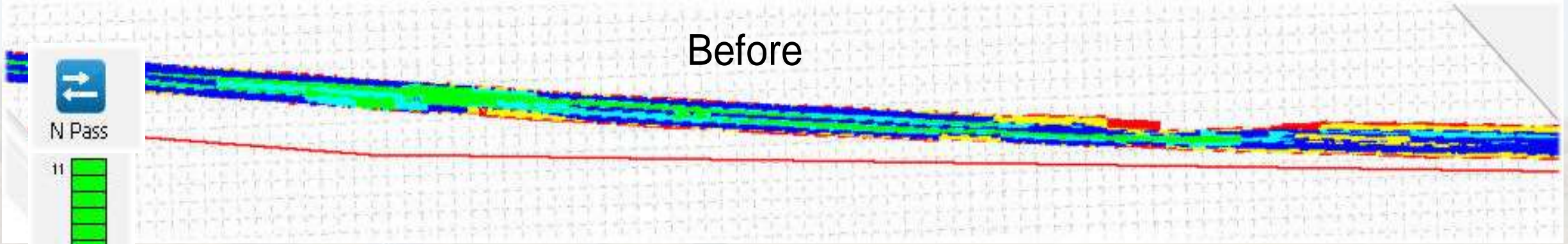


IC: Example of a Rolling Pattern

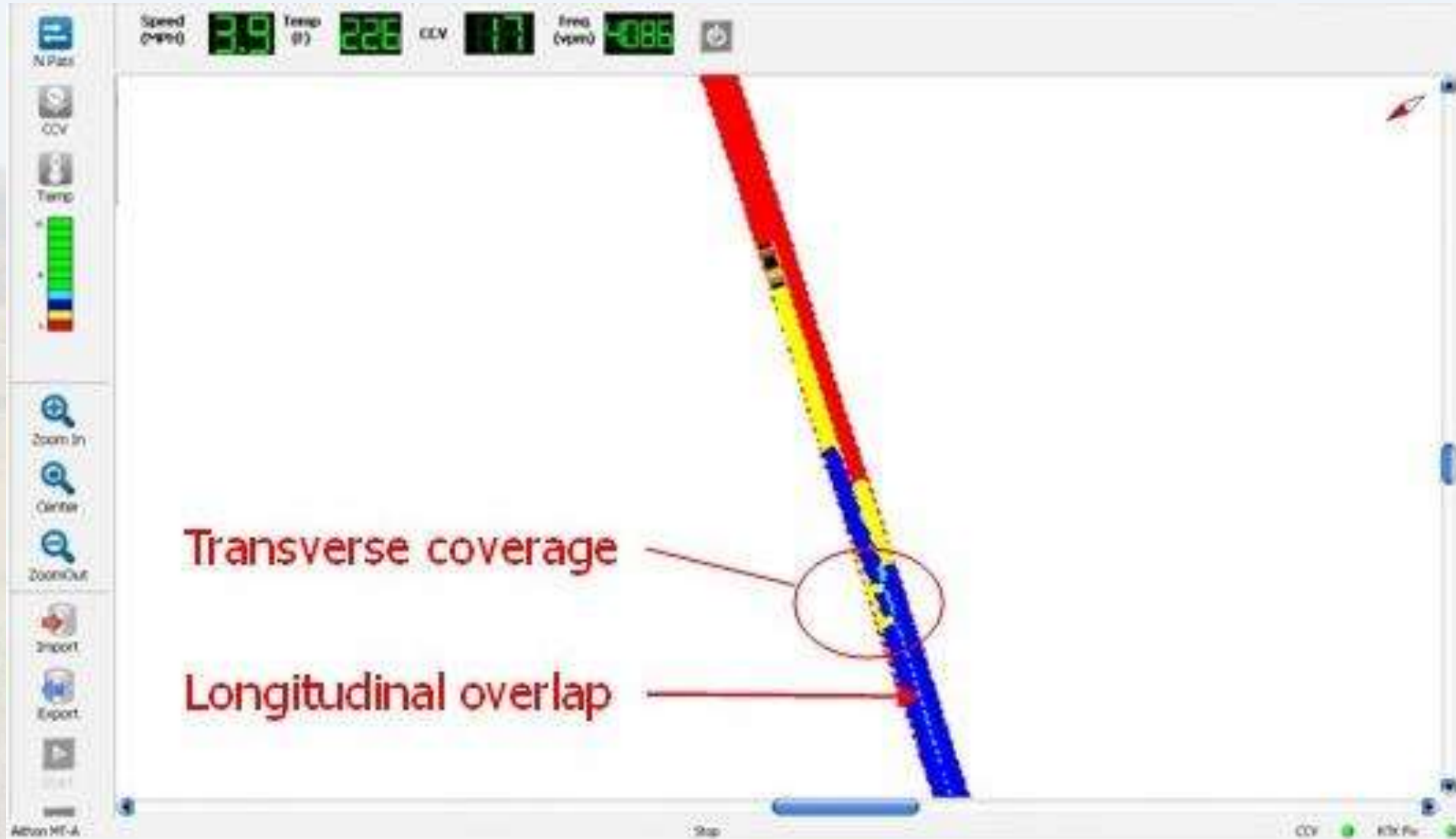


- Stay in established temperature zones
- Keep track pass counts
- Avoid Tender Zones
- Identify & troubleshoot “cold” mix
- Avoid “soft spots”
- See joint overlap

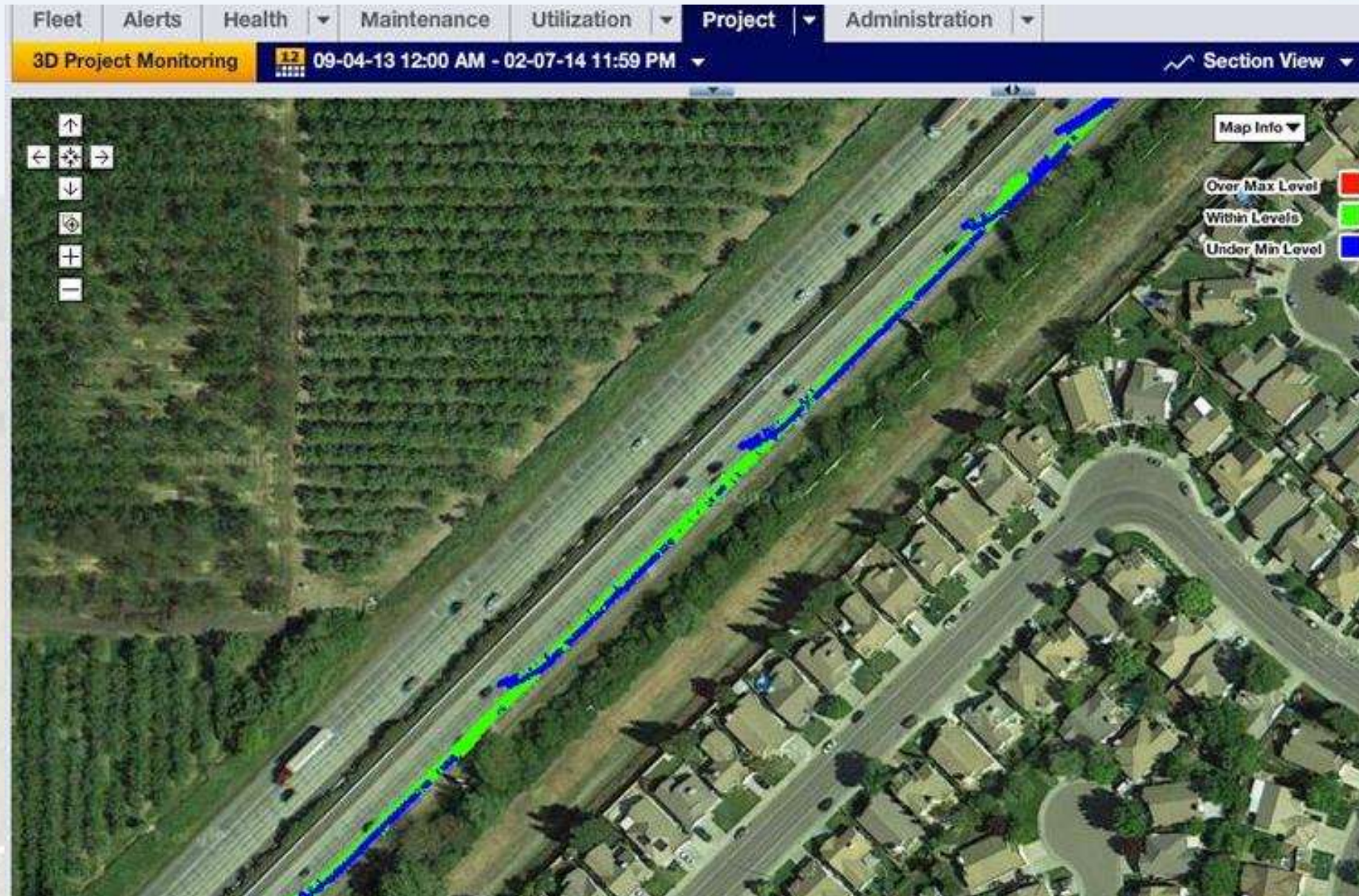
Before & After – Pass Count Consistency!!



Transition zones, longitudinal joints



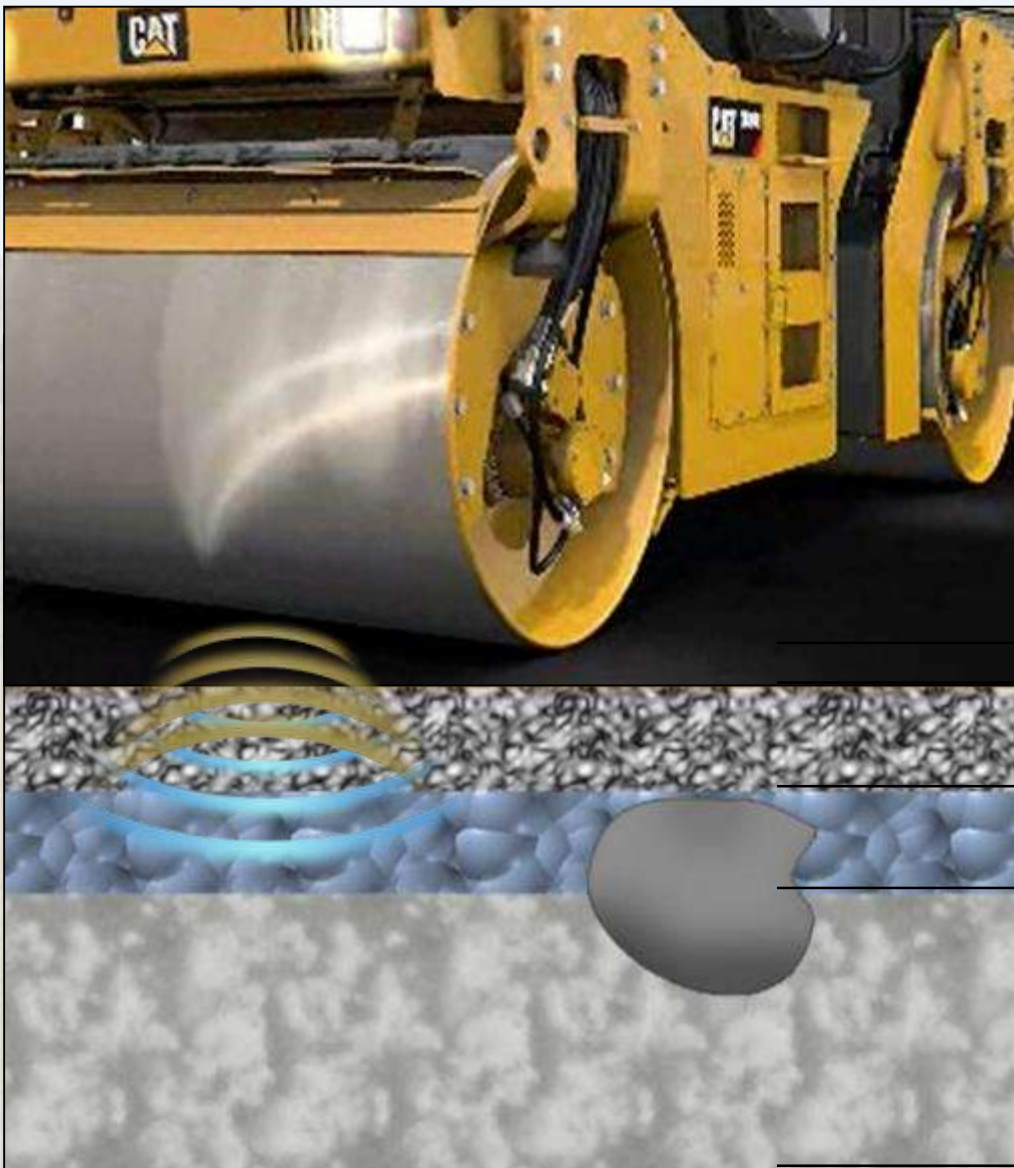
Temperature Challenges



Process control opportunity – you don't know what you don't know!!

Accelerometer measures deep...

- Accelerometer technology measures deeper than the freshly paved lift of asphalt
- CMV value is a *composite* measurement
- Affected by amplitude, speed, direction, etc.



Mat being compacted

Existing HMA lift

Sub-base

Subgrade material

ICMV (accelerometer value) – find soft spots / slabs



Soft base



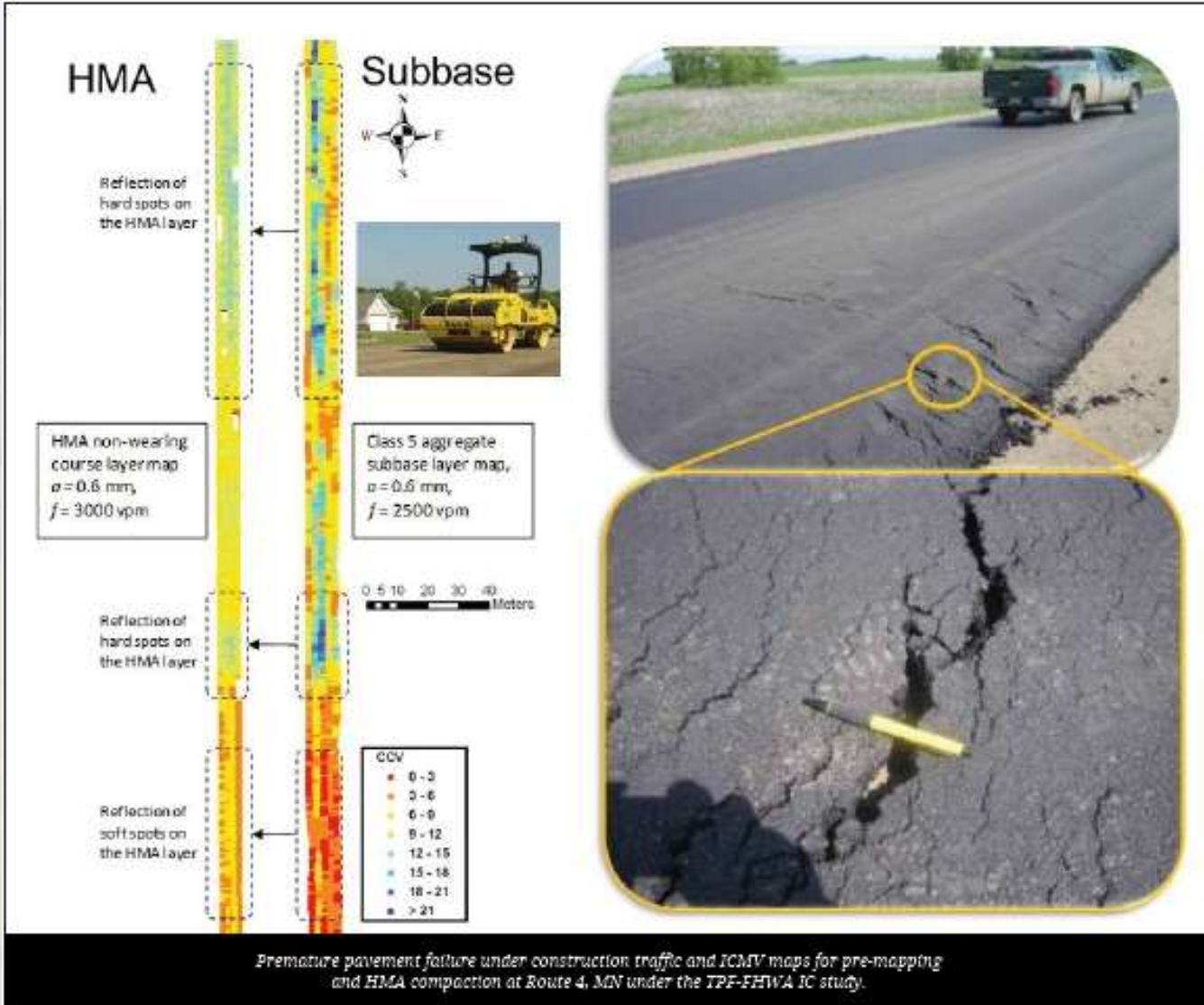
PCC Joints

Pre-mapping to find soft areas



- Can be done in one pass
- ICMVs obtained to identify relative weak areas prior to paving
- Depth and extent of “soft spot” is difficult to identify

Pre-Mapping in MN



TECHNICAL BRIEF

U.S. Department of Transportation
Federal Highway Administration

DEFINITION OF PRE-MAPPING

Pre-mapping is defined as measuring base line stiffness of existing support materials using an IC roller. The IC measurement value (ICMV) system is used to estimate stiffness based on acceleration signals caused by roller drum rotation.

The pre-mapping ICMV and its measurement depth (typically 2 to 3 feet) depend on the roller type, weight, drum diameter, vibration frequency and amplitude, speed, direction of travel, and the stiffness of the mapped material.

Candidate support materials for pre-mapping include granular full-depth restoration materials or their equivalent. Typically, the IC machines used to pre-map existing pavement subbase structural support are the same as those used to construct subsequent layers. In order to prevent "double jarring" during pre-mapping, the IC machine settings (including speed, vibration frequency, and amplitude) must be carefully selected.

With IC, teams can identify soft spots during construction and make corrective actions. If the soft spot was caused by excess moisture in the soil, the materials can be diked and aired out before reconstruction. If the soft spot occurred due to insufficient moisture, water can be added to the materials before reconstruction.

INTELLIGENT COMPACTION FOR PRE-MAPPING

TECHNICAL BRIEF

A Salsol double drum IC roller pre-mapping the granular base at Route 4, MN under the TPF-FHWA IC study.

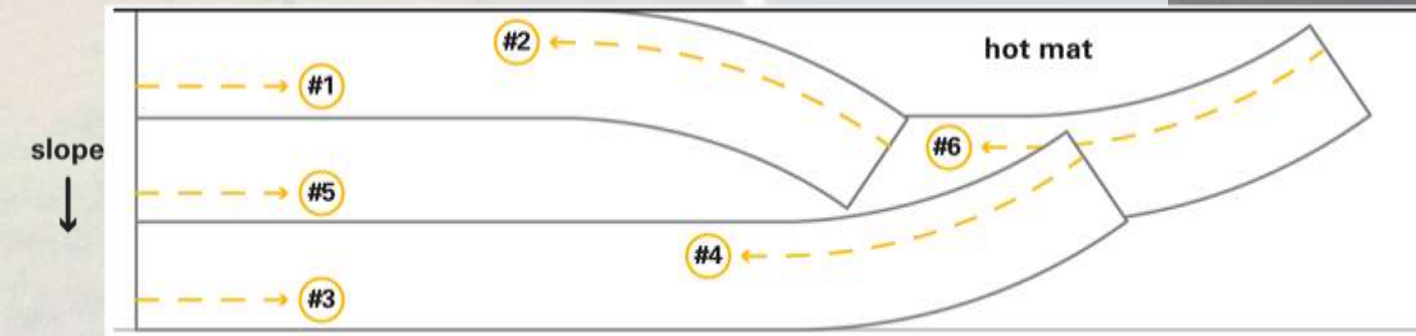
BACKGROUND

Intelligent compaction (IC) is an equipment-based technology to improve quality control of compaction. IC vibratory rollers are equipped with a high precision global positioning system (GPS), in-laid temperature sensors, an accelerometer-based measurement system, and an onboard color-coded display. IC has been used to improve compaction control for various pavement materials including granular and clayey soils, subbase materials, and asphalt materials.

Pre-mapping originated as a research activity on the 2008 FHWA TPF IC project in Minnesota. The project team used a Salsol double-drum IC roller to measure the baseline support condition by mapping subbase materials at low vibration frequency and amplitude prior to the asphalt layer construction at Route 4. Later during paving, construction traffic caused the asphalt layer to fail prematurely. A soft spot had occurred—and the team later realized they could identify the soft spot in the pre-mapping data. Due to this discovery, the industry now recognizes the value of pre-mapping: the data collected by pre-mapping can help construction teams identify potential soft spots before pavement failure.

As of today, several state departments of transportation (DOT) IC specifications include pre-mapping as an option or requirement. This tech brief intends to provide the best available technical information regarding pre-mapping in order to clarify its advantages and limitations.

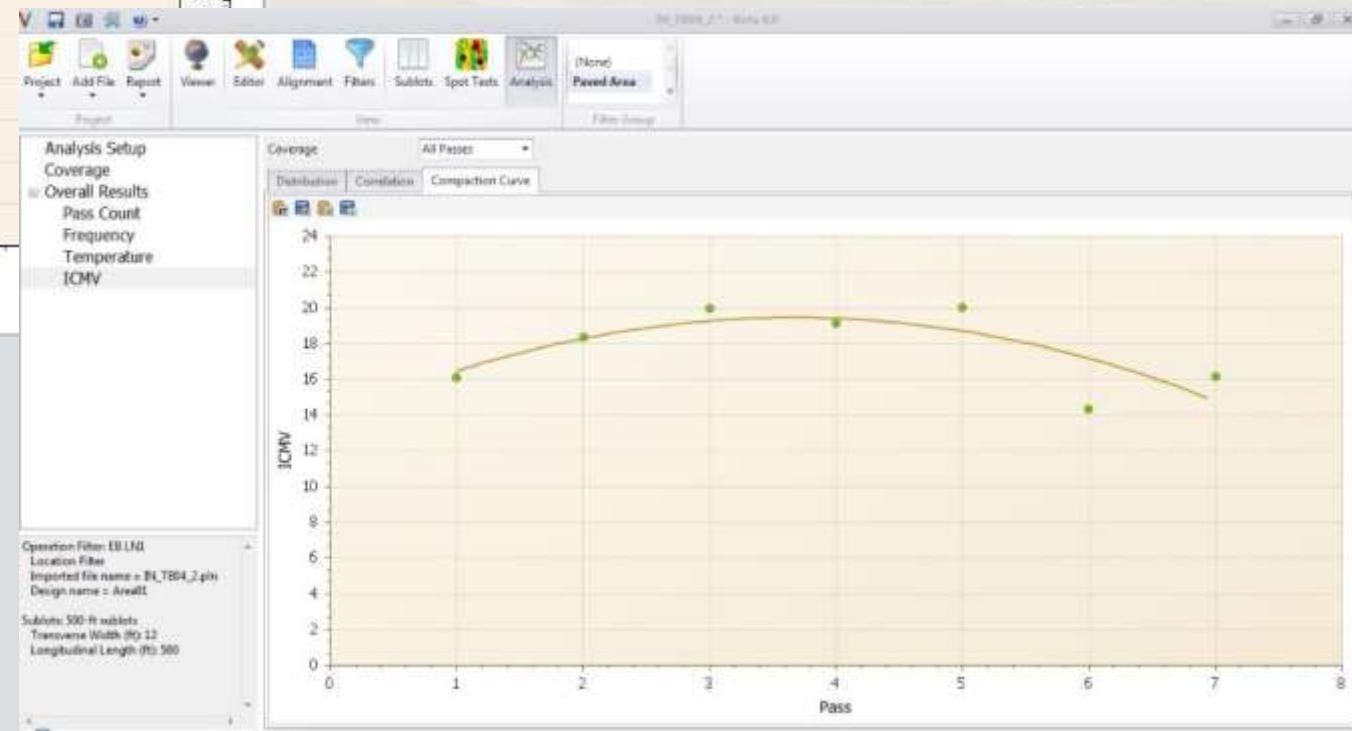
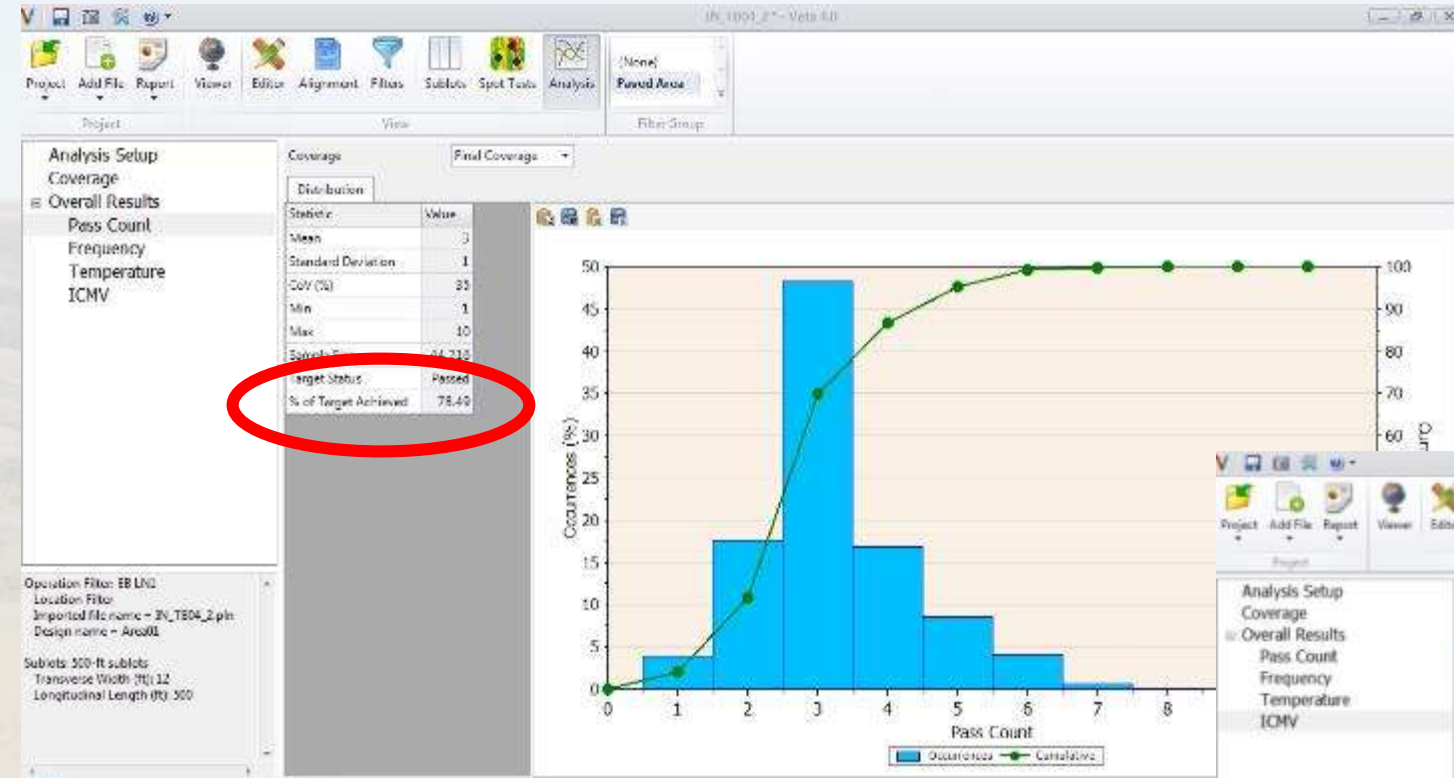
Rolling Pattern Training Tool



Roller Speed should be 10 - 14 ipf



Using VETA to Manage Pass Count & ICMV



Thermal Patterns: What do they Mean?



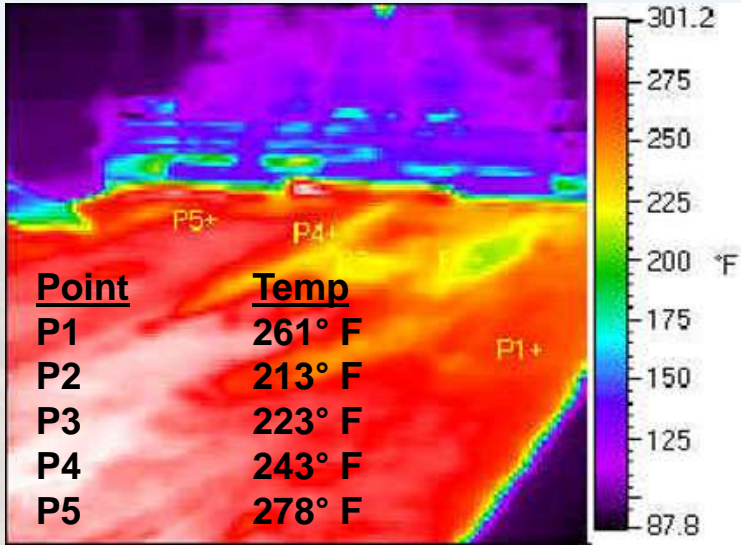
- What temperature pattern am I seeing?
- What is this pattern telling me?
- What can I do to reduce temperature differentials?



Truck loadout



End dumping 4-Step Procedure



1. Pave at normal speed between trucks
2. Fold hopper wings every truck when allowed
3. Never pave out material in hopper
4. Cycle hopper wings when conveyors are still covered with mix



Segregation – End-of-load – Segregation in Hopper



- Large aggregate accumulates at sides of hopper
- Folding hopper wings
- Keep conveyors full during truck exchange



Paver Stop – hopper level

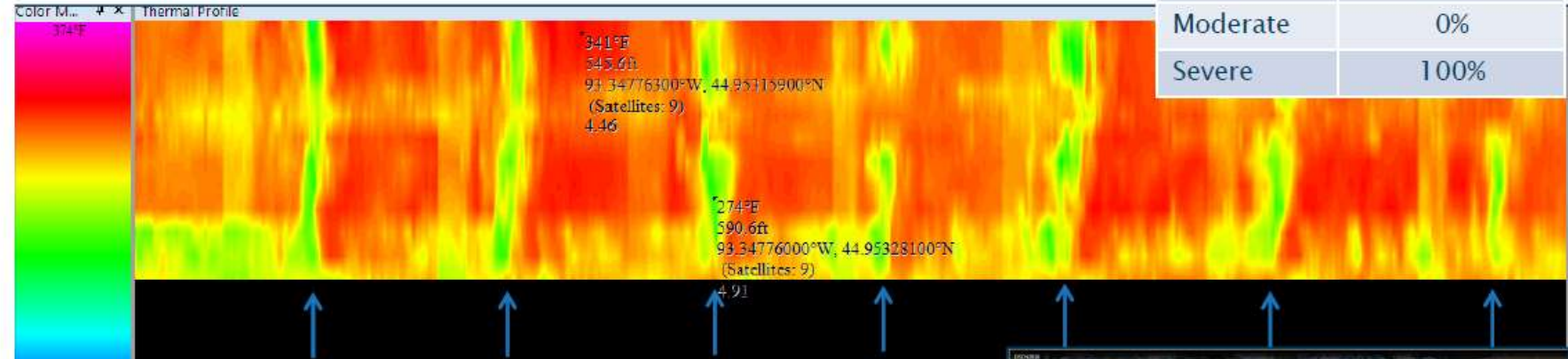


End dumping

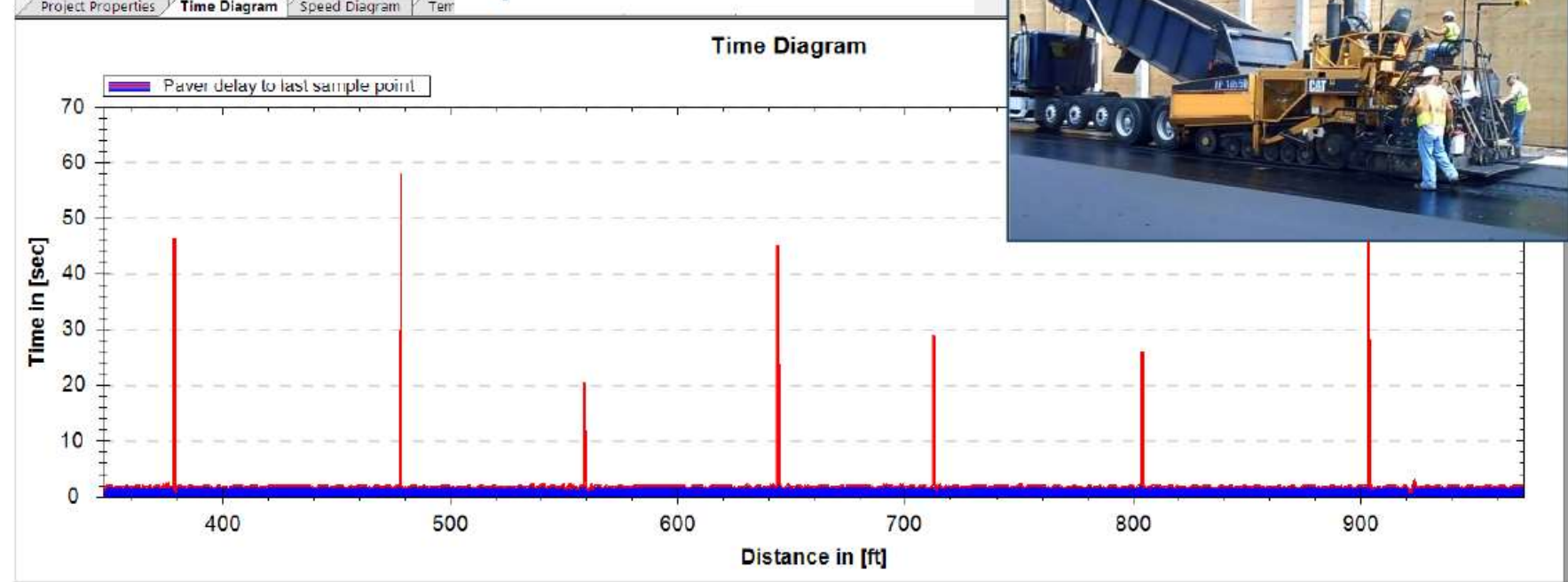
Thermal Segregation – End Dump

Project C

Thermal Segregation Category	Percent of Sublots
Low	0%
Moderate	0%
Severe	100%



Cyclic End of Truckloads



Courtesy of MnDOT

Silo Management



Hot on one side?



Plant Loadout

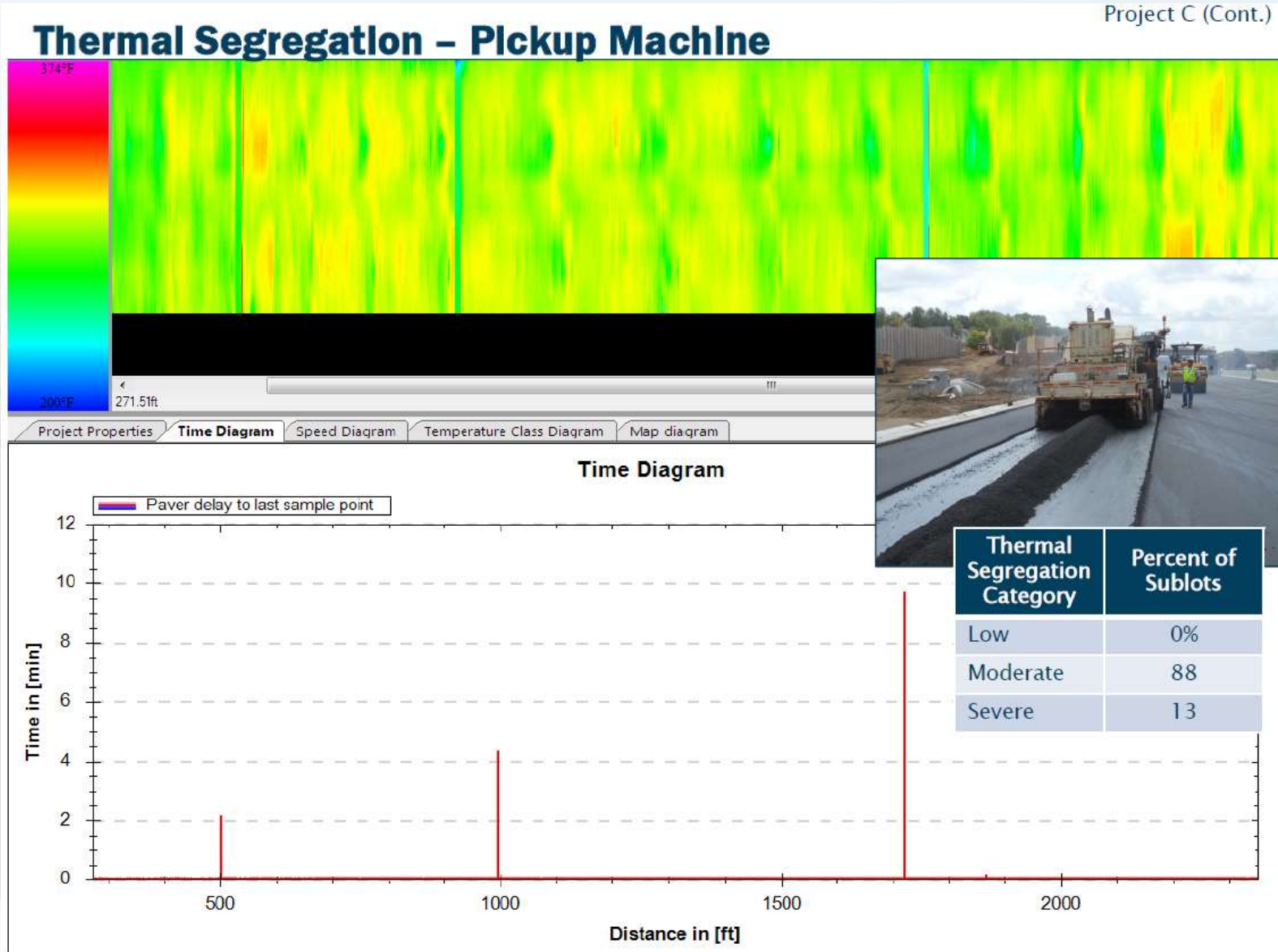


Plants



Pickup Machine (windrow elevator)

Project C (Cont.)



Courtesy of MnDOT

Keep windrows short



- Temperature!
- Good dump person is key!



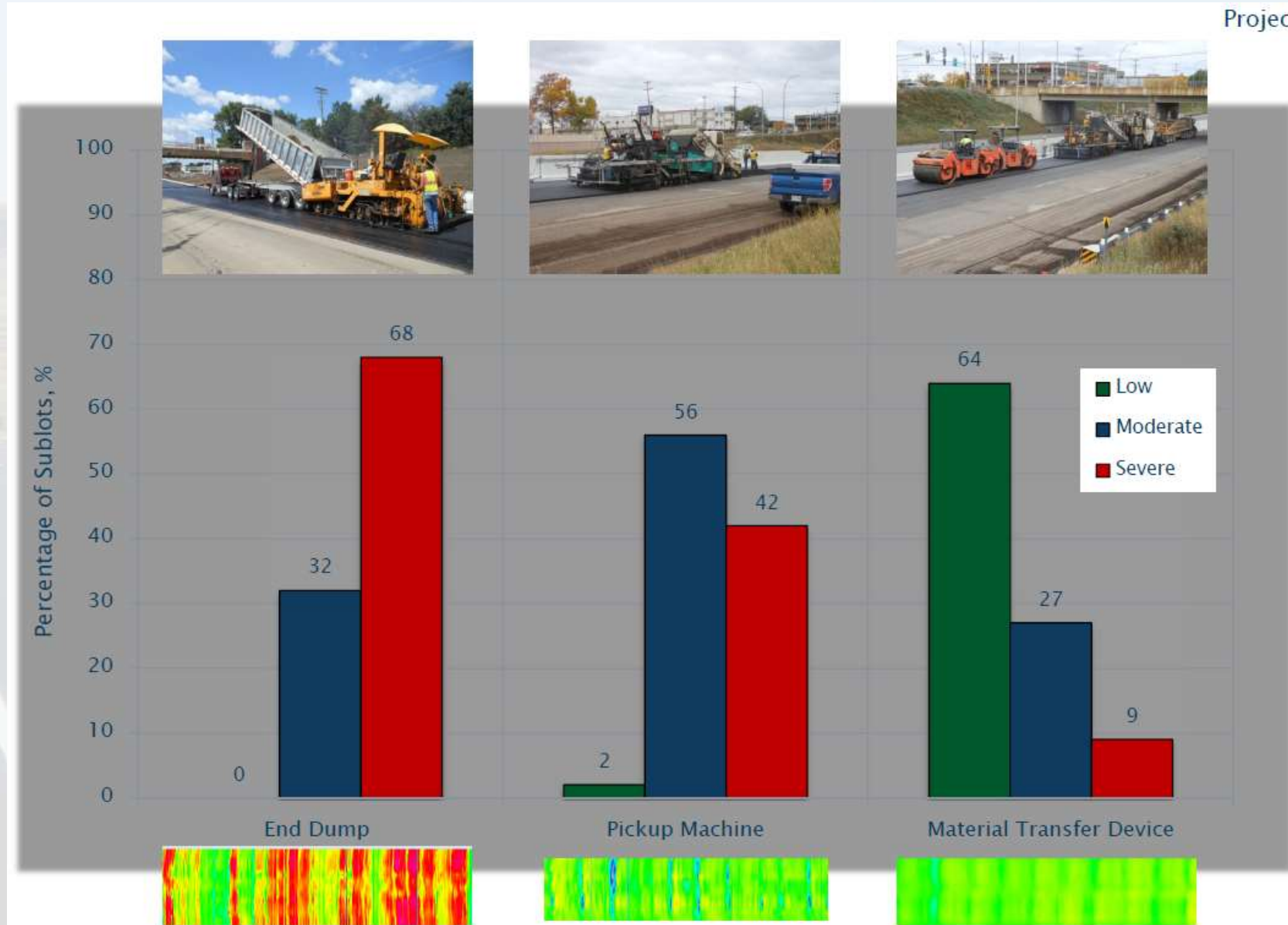
Overlap windrows



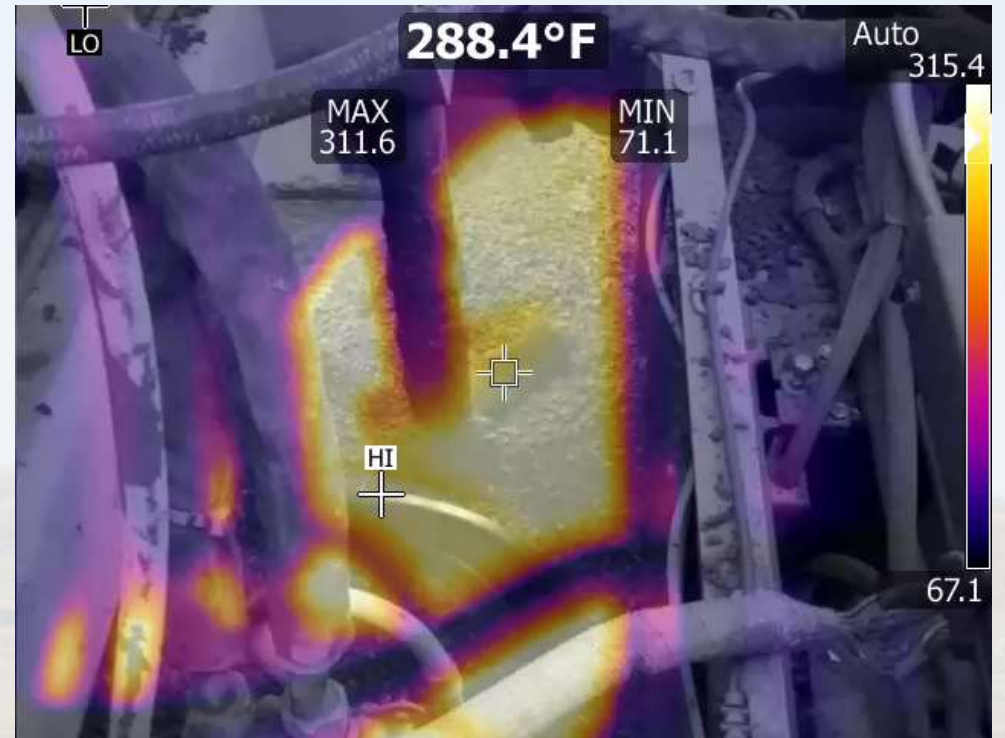
Material Transfer Device



Project D



Auger Speed

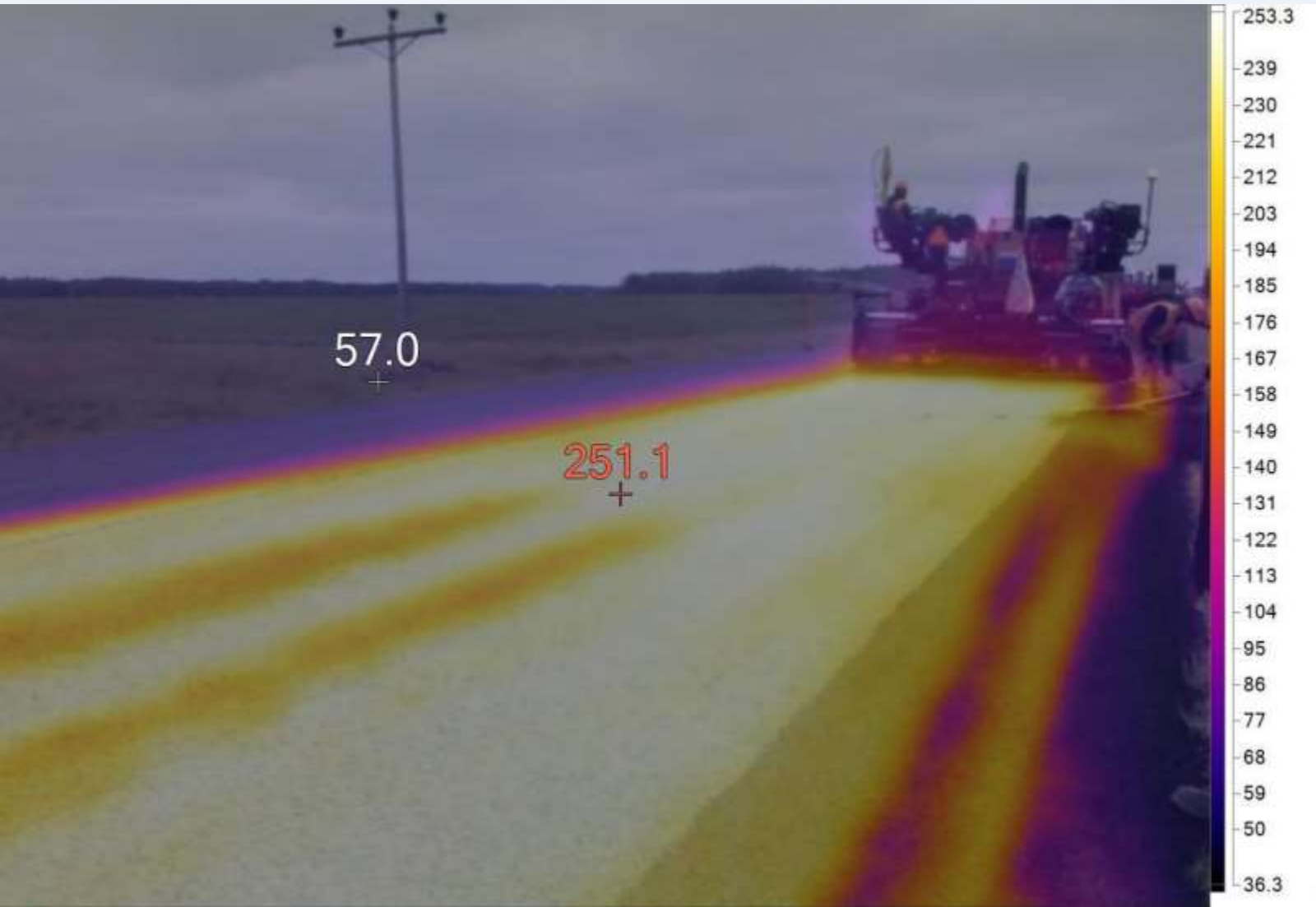


Auger Height



Slight change in auger height can change surface texture and thus temperature

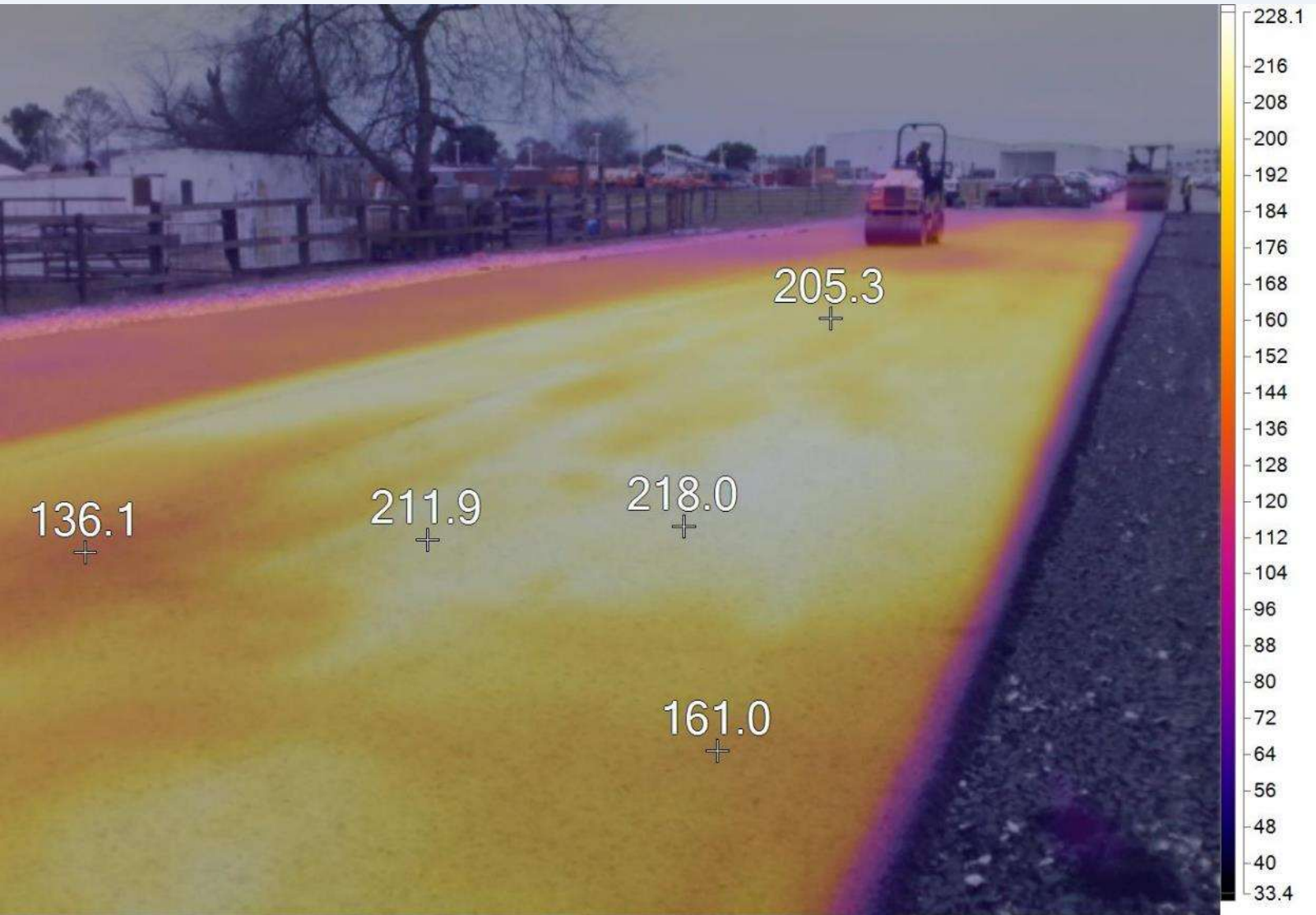
Conveyor Speed



- Streaks after take off could be conveyor speed
- Low hopper and feed system starts quickly, then slows



Feeds Sensor position - on/off augers



- Feed sensor position (aim) causing augers to go on/off



Aiming Sonic Feed Sensors

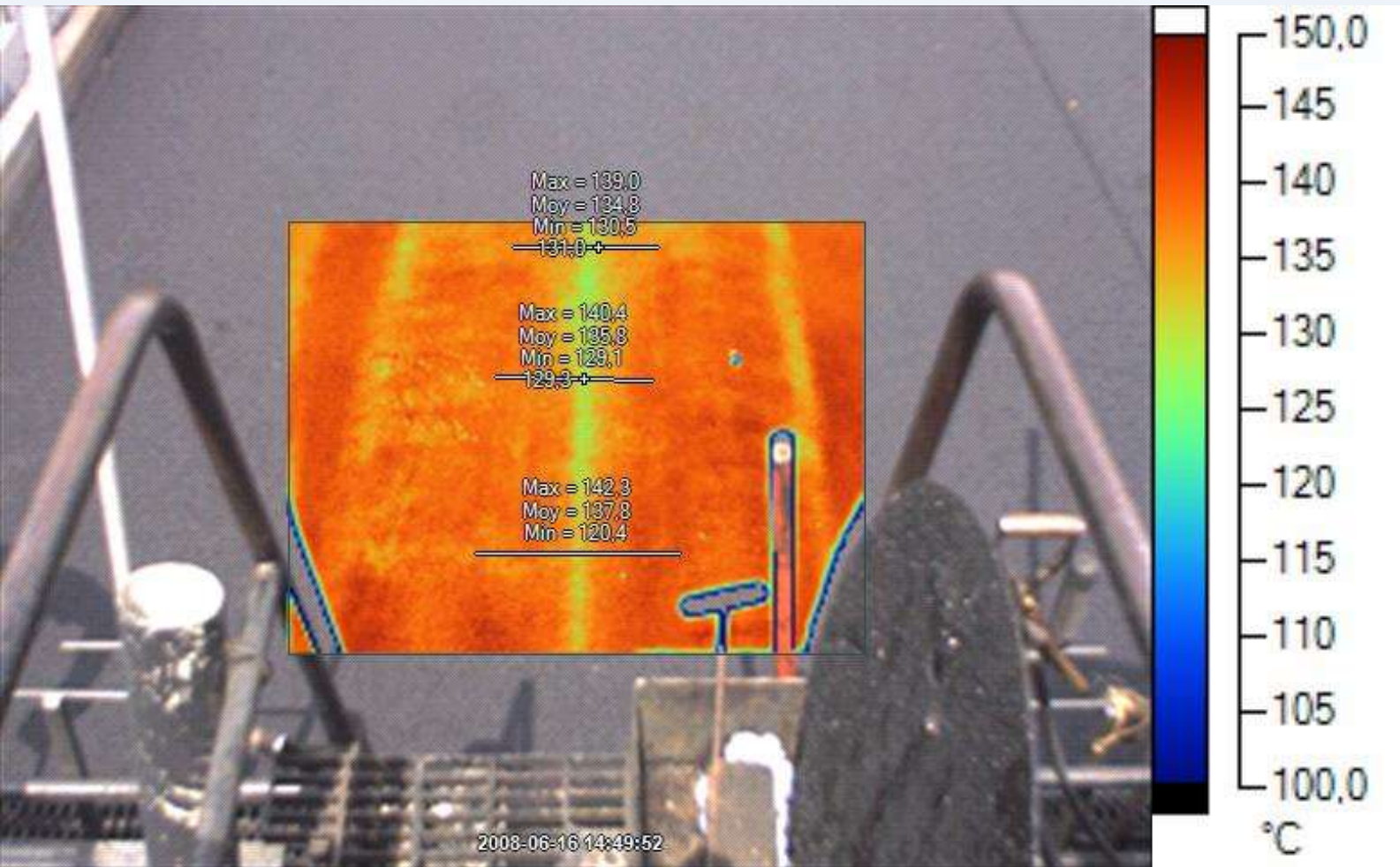
- Mechanical or sonic
- Control level of material
- Position Sensor 18" from end of augers



Centerline streak



Centerline streaks

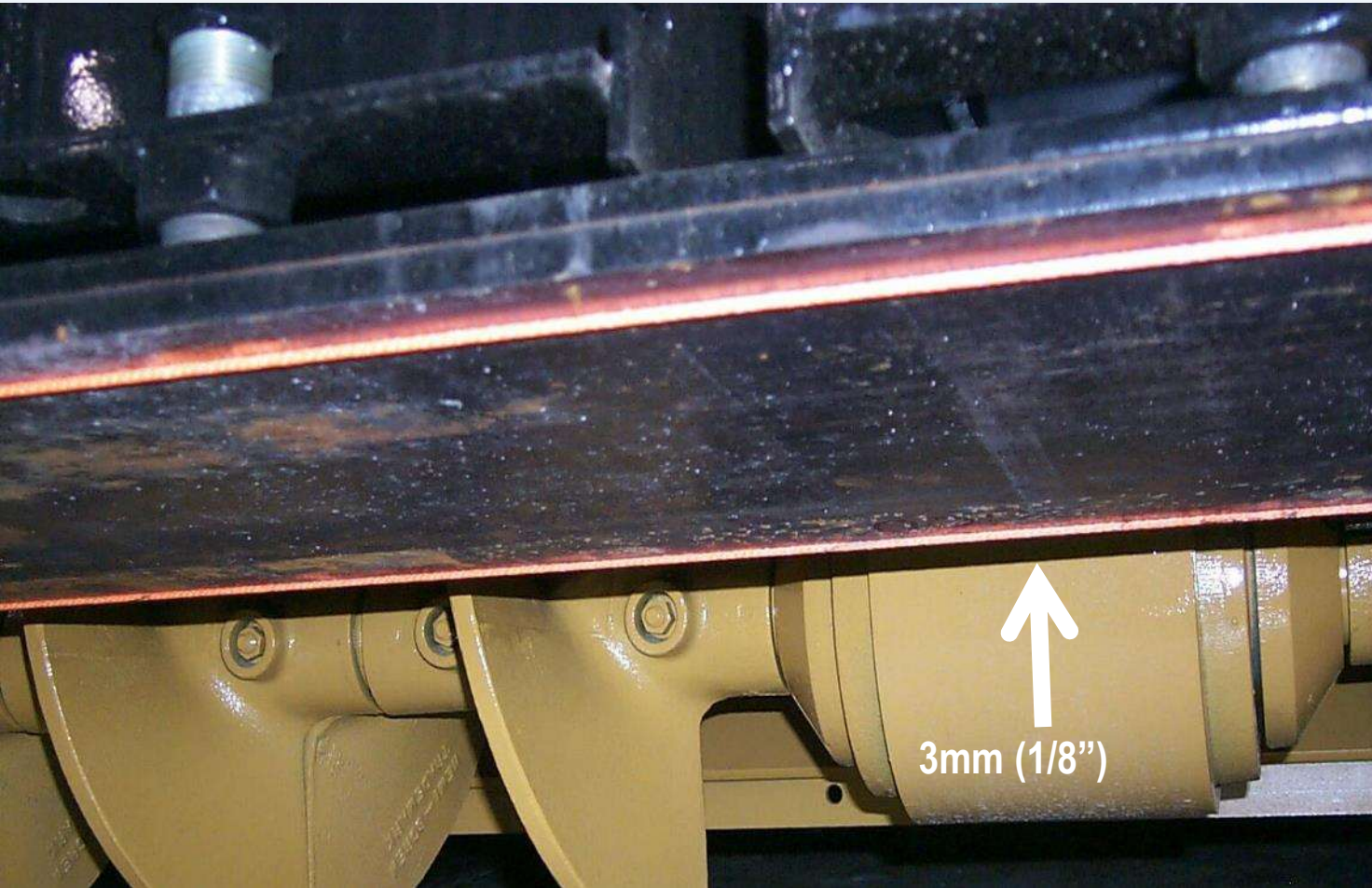


- Lead crown installed?
- Worn deflector plate(s)
- Reversing auger(s)
 - Do you have them?
 - Are they installed correctly?

Dead material on deflector plate



Centerline streak – Lead Crown



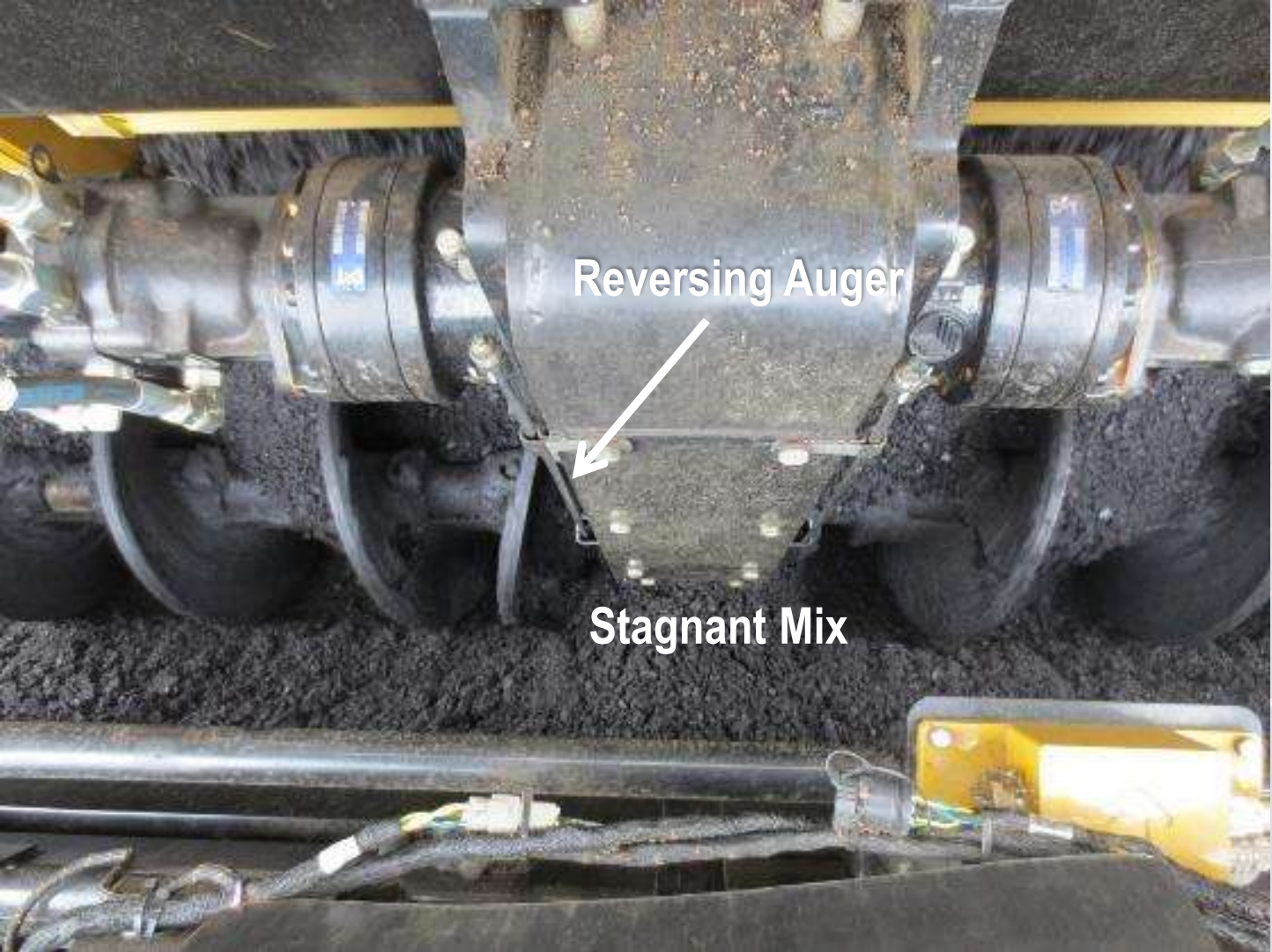
- Place stringline on front and rear of main screed.
- Adjust main screed crown until 3mm (1/8'') gap is present in center of main screed
- Helps large aggregate tuck under center of screed plate

Keep deflector plates clean

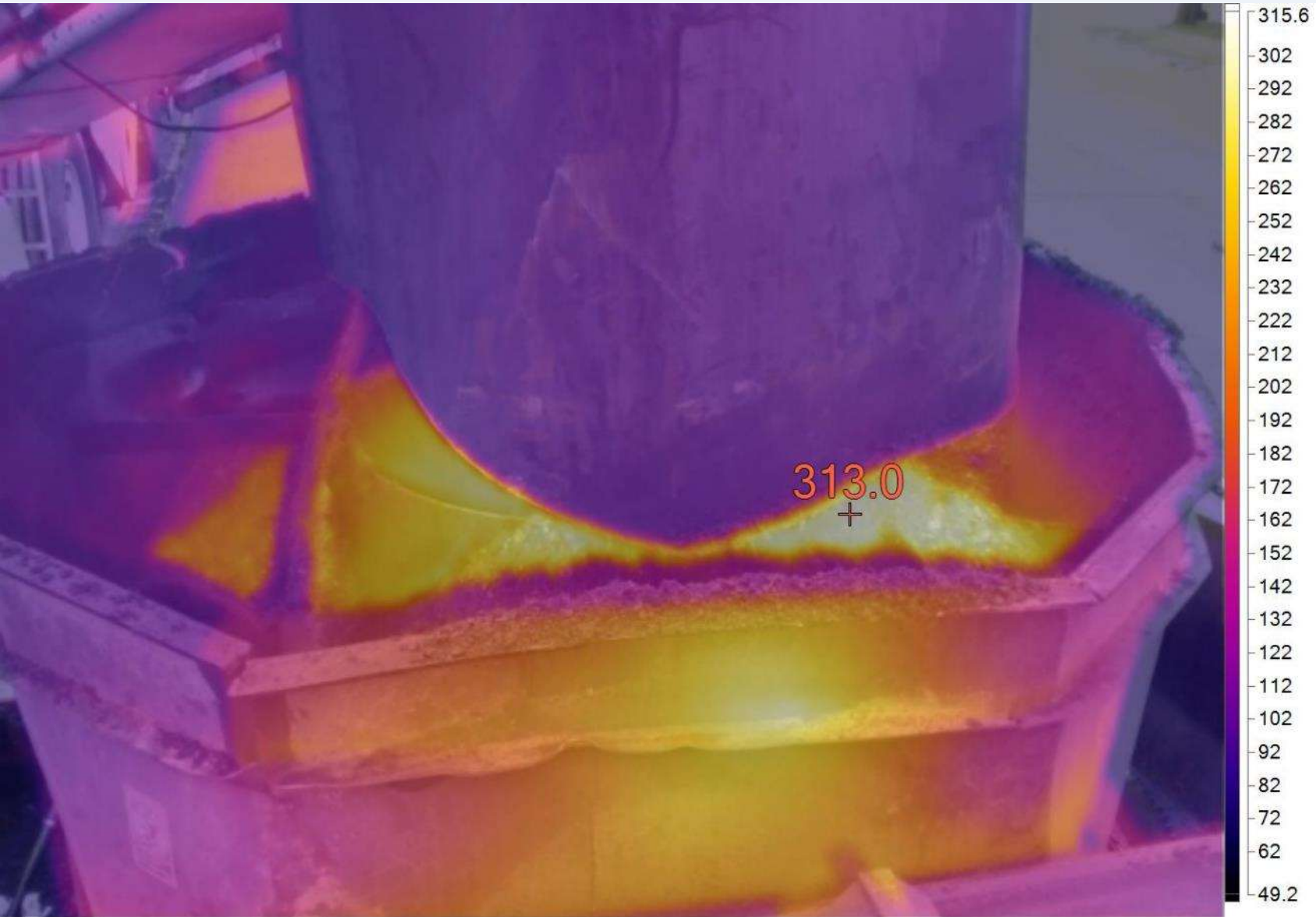


- Wear item to be replaced
- Needs daily cleaning
- Knock down with shovel handle
- Centerline streak

Reversing Augers



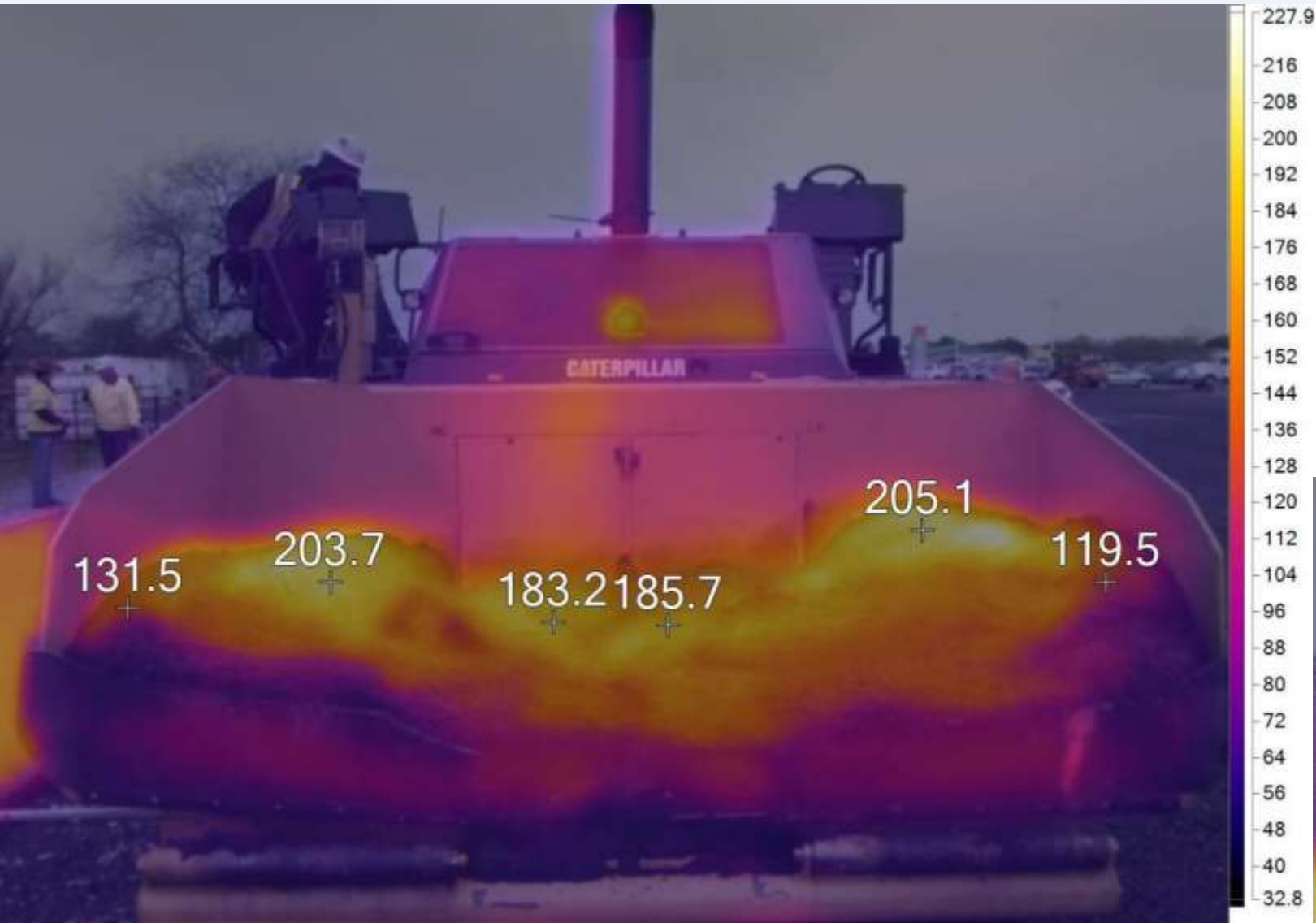
Hopper Inserts



- Various designs/modification to hopper inserts
- Can change configuration if needed
- Drop height



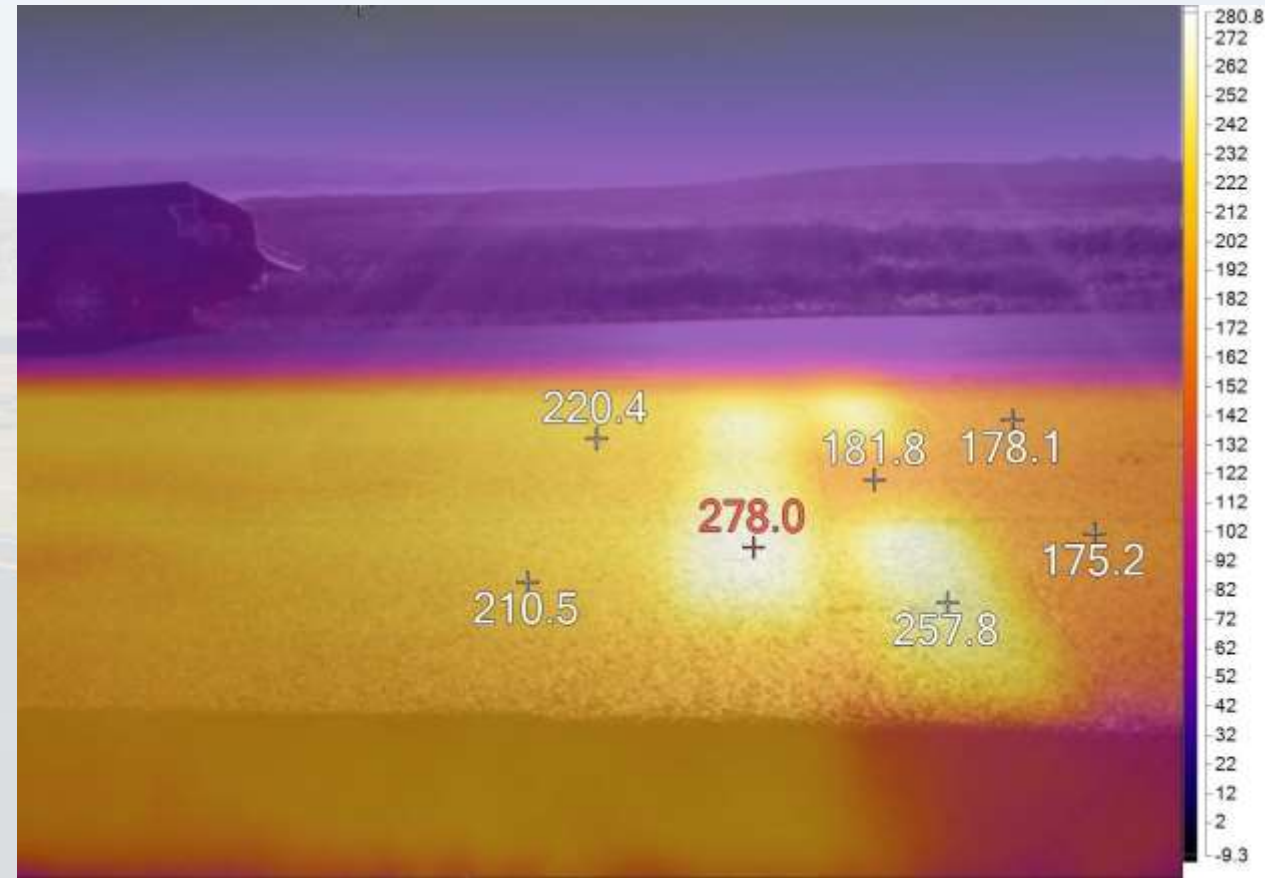
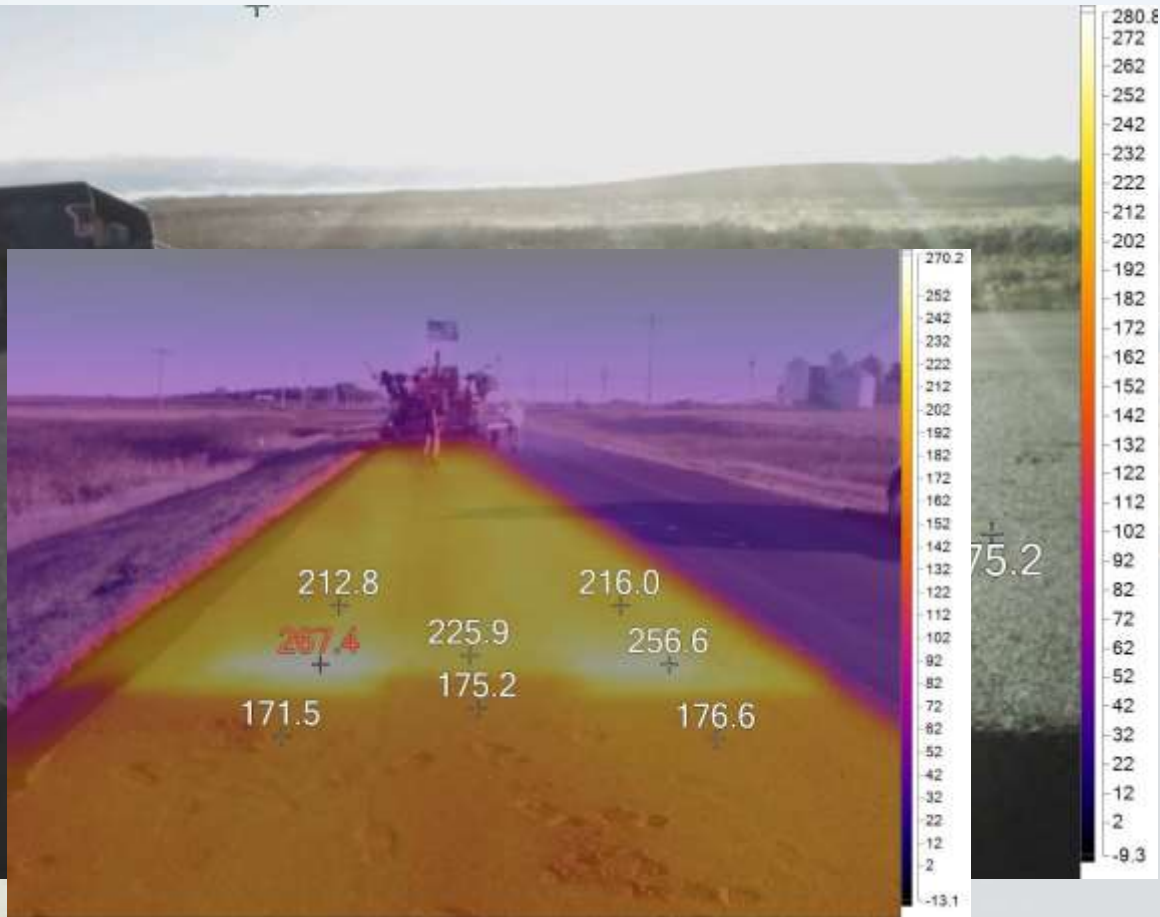
Head of Material



- Low hopper can lead to low head of material



Paver Stop – screed settlement



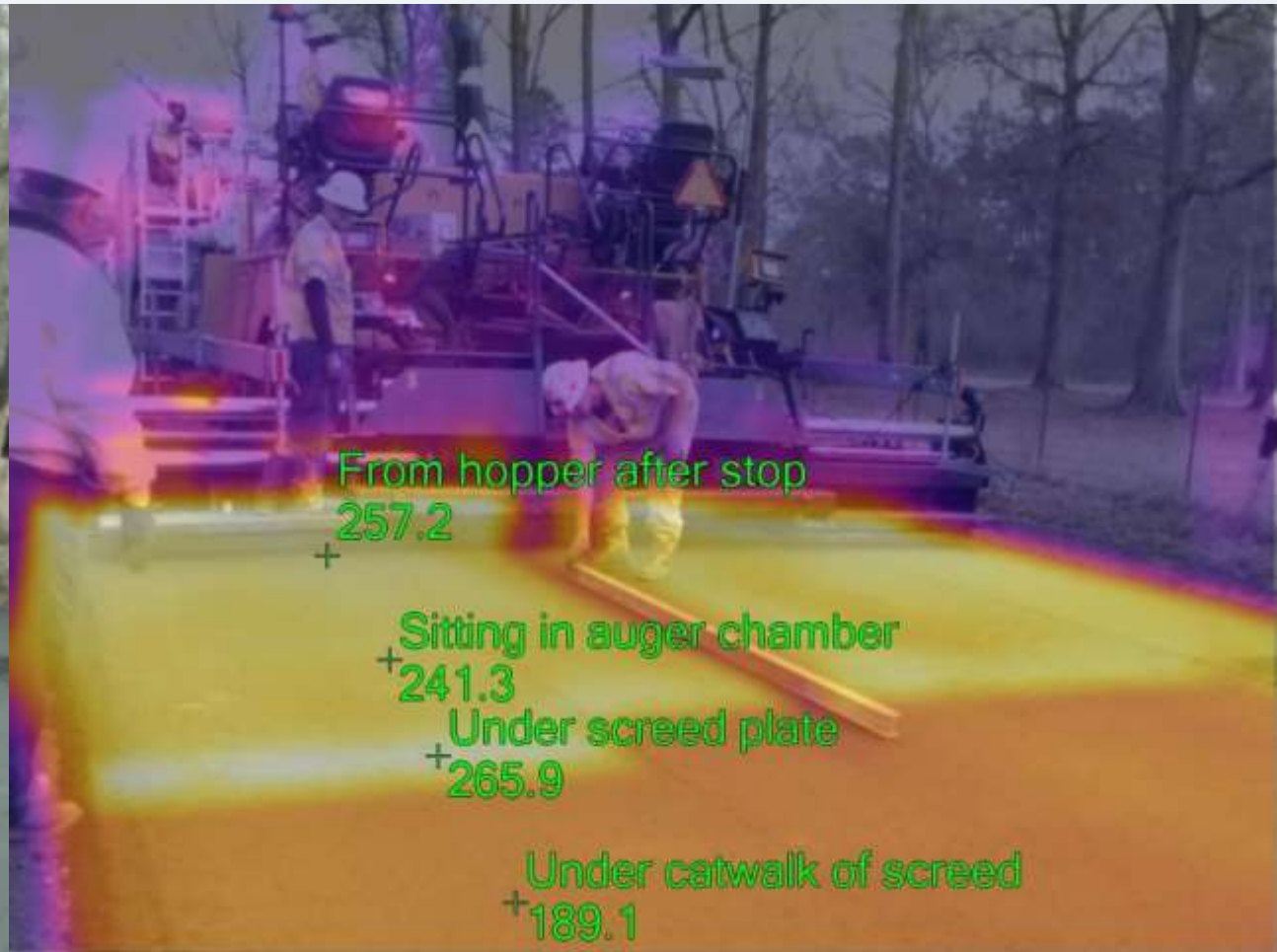
Same photo!

Paver Stop – correlate with IRI ? Minutes ?



Same photo!

Effects of paver stops...

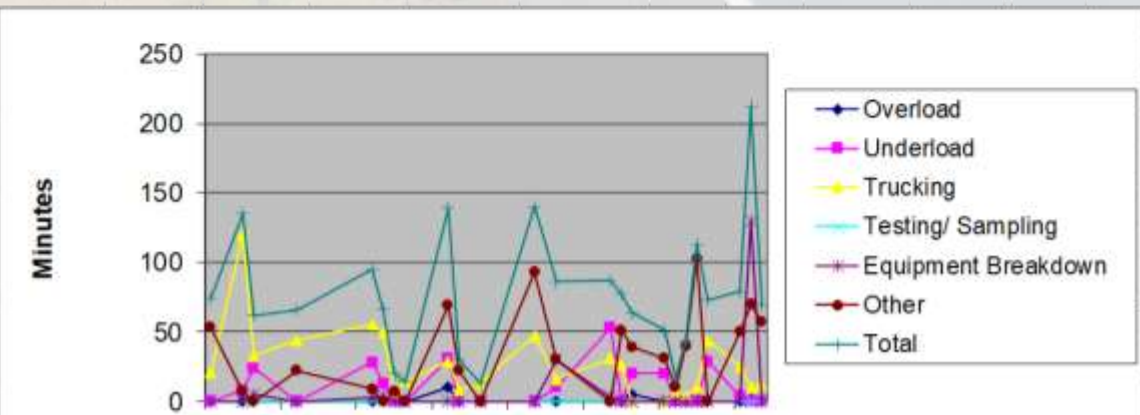
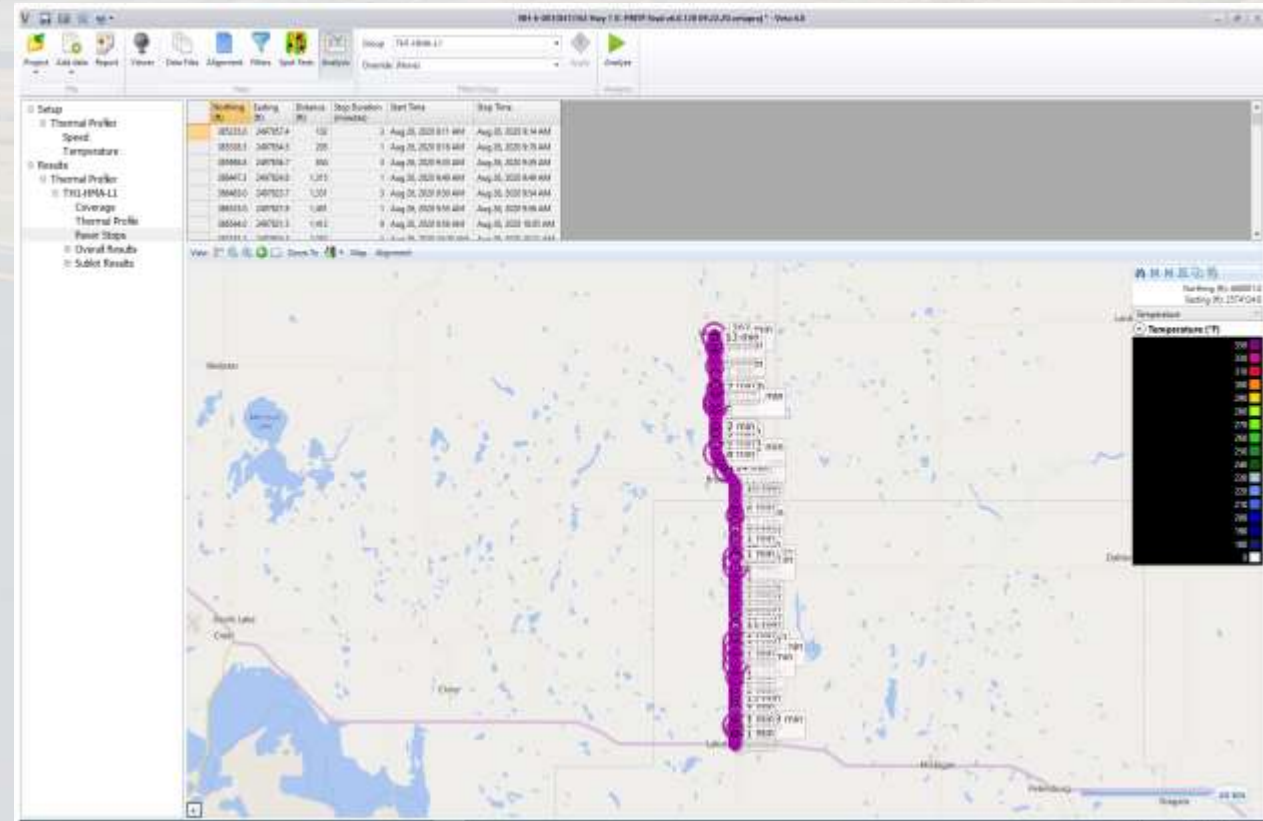


Paver Stop report – lost time

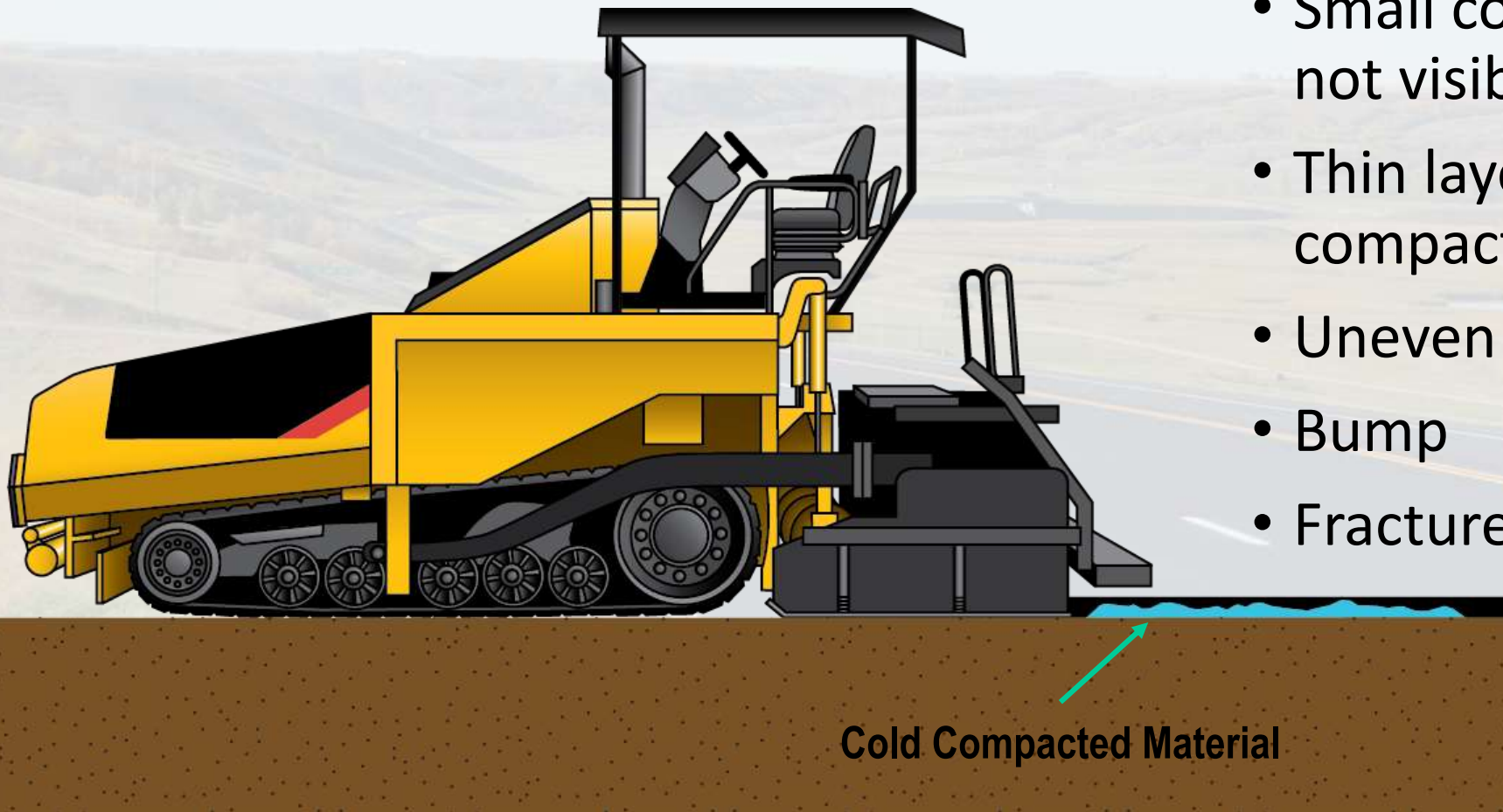
JOB / 83

Date	Overload	Underload	Trucking	Testing/ Sampling	Equipment Breakdown	Other	Total	Number of Stops	Paving Time	Tons	Actual TPH
#####	0	0	21	0	0	53	74	9	5.5	1080	253
#####	0	8	120	0	0	7	135	29	8	2014	350
#####	0	24	33	0	5	0	62	14	8	1998	287
#####	0	0	44	0	0	22	66	11	8	1750	254
#####	0	28	55	0	3	9	95	14	8	2050	319
#####	0	13	49	0	4	0	66	13	8	2150	312
#####	6	0	7	0	0	7	20	6	8	2079	271
#####	0	0	14	0	0	0	14	4	7	1842	272
#####	10	31	29	0	0	69	139	14	8	1300	229
#####	0	0	8	0	0	22	30	3	3	266	106
#####	0	0	13	0	0	0	13	5	8	1928	248
#####	0	0	47	0	0	93	140	16	8	1673	295
#####	0	10	16	0	30	30	86	9	8	1863	284
#####	0	53	31	0	3	0	87	13	8	2061	315
#####	0	0	26	0	0	51	77	10	6	1368	290
#####	5	20	0	0	0	39	64	8	6	1484	301
#####	0	20	0	0	0	31	51	5	6	1146	223
#####	0	0	7	0	0	10	17	4	8	1706	221
#####	0	0	4	0	0	40	44	5	8	1018	140
#####	0	0	10	0	0	103	113	5	8	1533	251
#####	0	29	44	0	0	0	73	11	8	2030	299
#####	0	4	25	0	0	50	79	6	8	1153	173
#####	2	0	10	0	130	70	212	6	8	1137	255
#####	0	0	12	0	0	57	69	9	8	1941	283

- Find efficiencies / downtime
- 25% or more is very typical
- Example: Painting out lines!



Grade Conditions – Spills



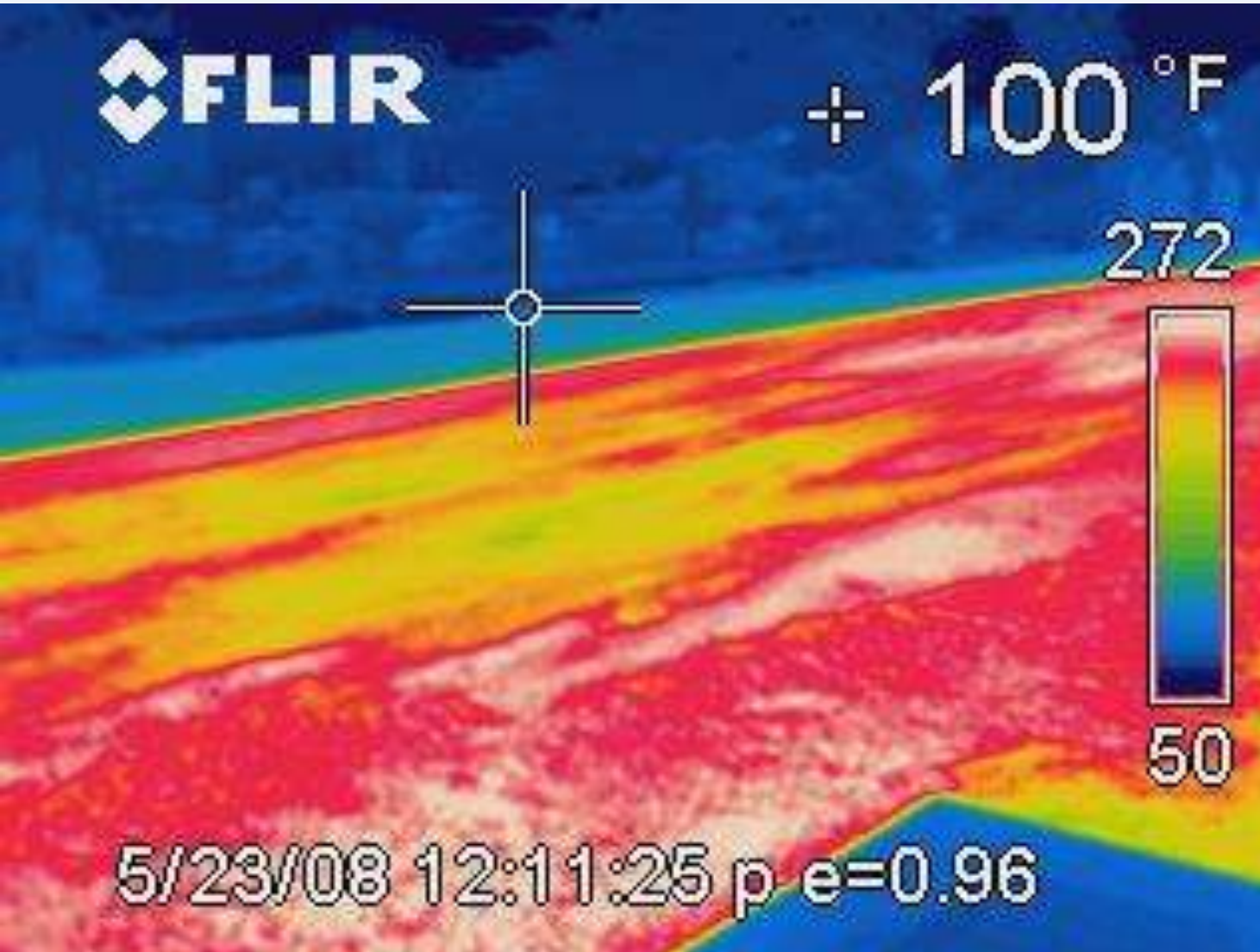
- Small compacted pile usually not visible in mat surface
- Thin layer of fresh mix for compaction
- Uneven compaction
- Bump
- Fractured aggregates

Grade Conditions – Spills



- Caused by folding hopper wings too soon
- Caused by damaged or missing flashing
- Becomes cooler mix covered by mat

Grade Conditions – Spills



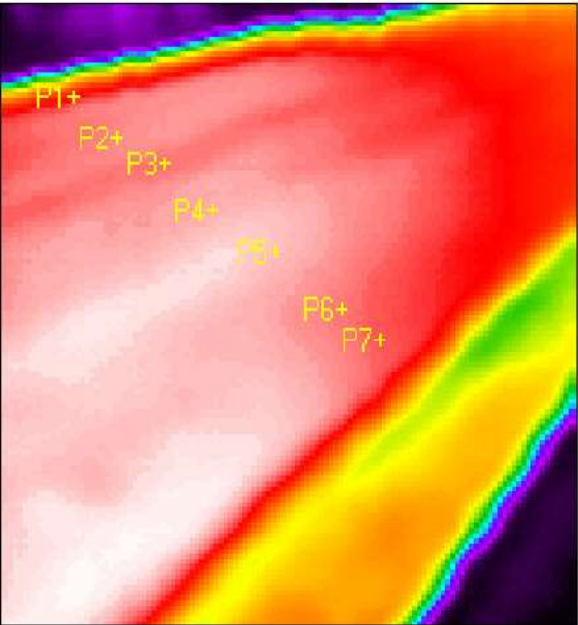
- Spilled material dragged out by screed
- Shows up as open texture
- Infrared image shows large temp. differential
- Density variation
- Rough ride

Banging tailgates in front of paver

- Same effect as “spills” from the hopper

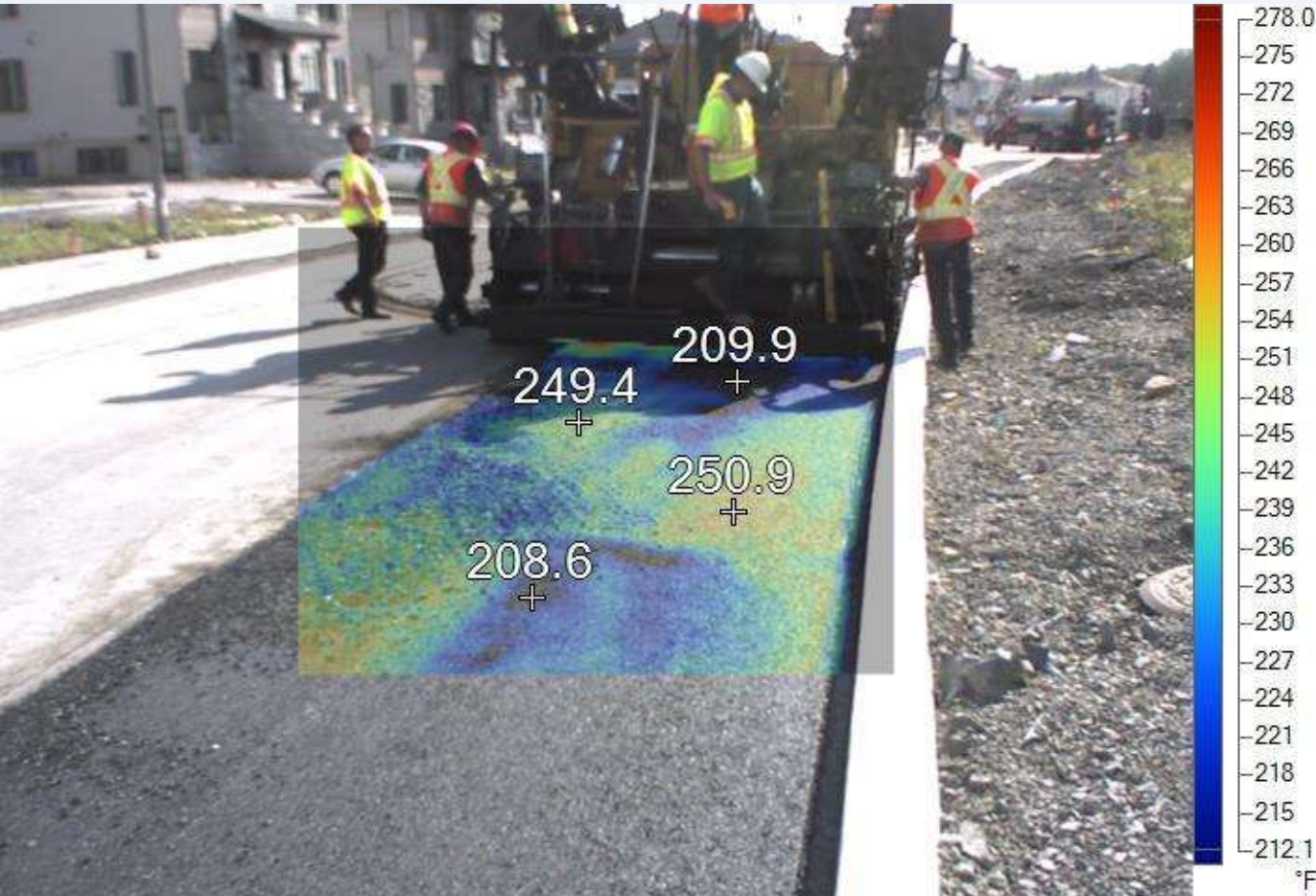


Outside Edges – Variable Grade



- Step between shoulder and driving lane
- Mat thinner over shoulder portion
- Visually little difference
- Large temperature difference
- Density variation

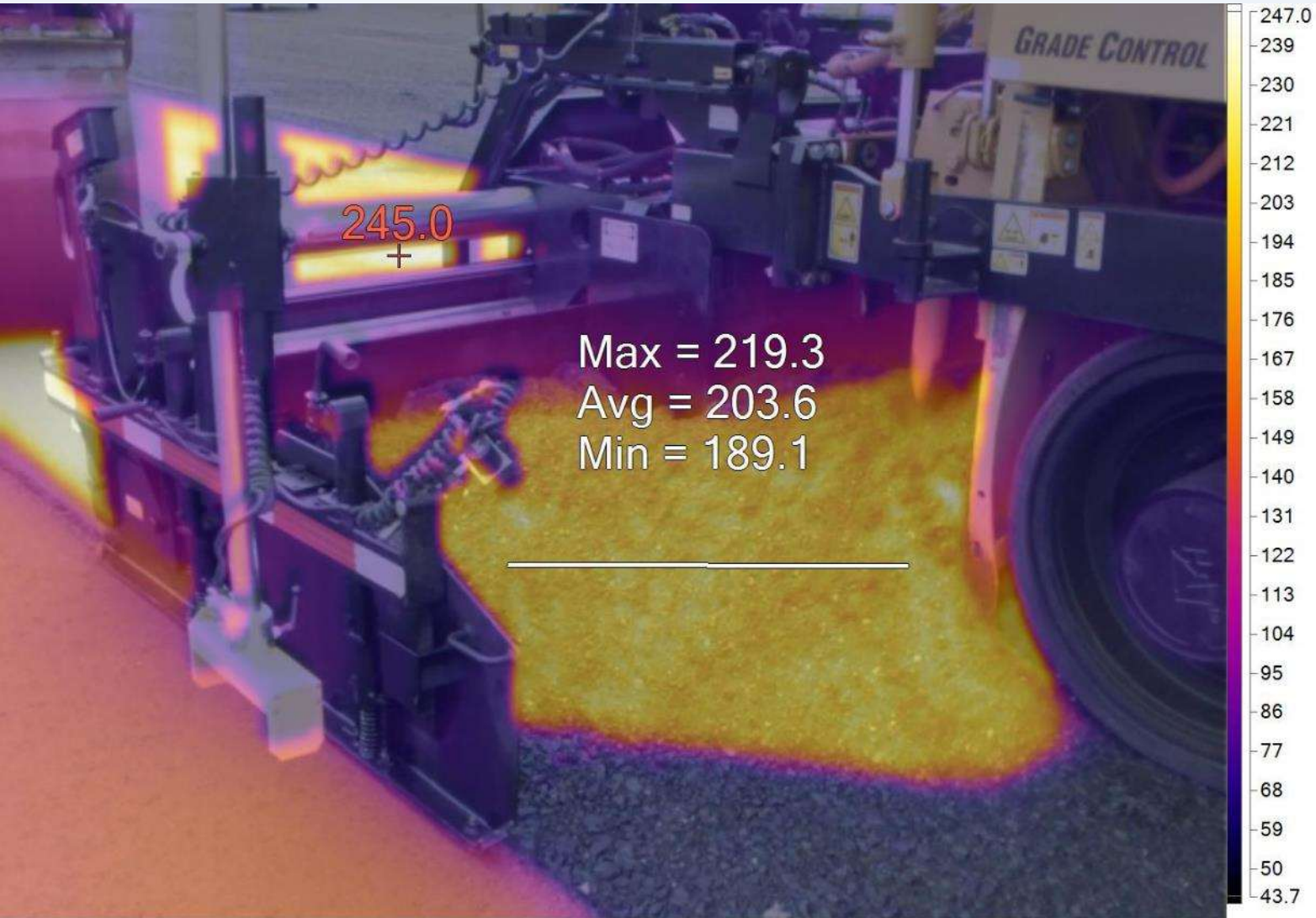
Grade Conditions – High Spot



- High spot in grade will drag and show cooler, irregularly-shaped patch pattern



Auger Extensions & Tunnels



- Mix can run out and segregate
- Pattern could be observed in mat behind paver as cooler stripes



Auger Extensions & Tunnels



- Fixed width paving
- Variable width paving
- Front-mount screeds
- Rear-mount screeds



Auger Extensions



18" with front-mount

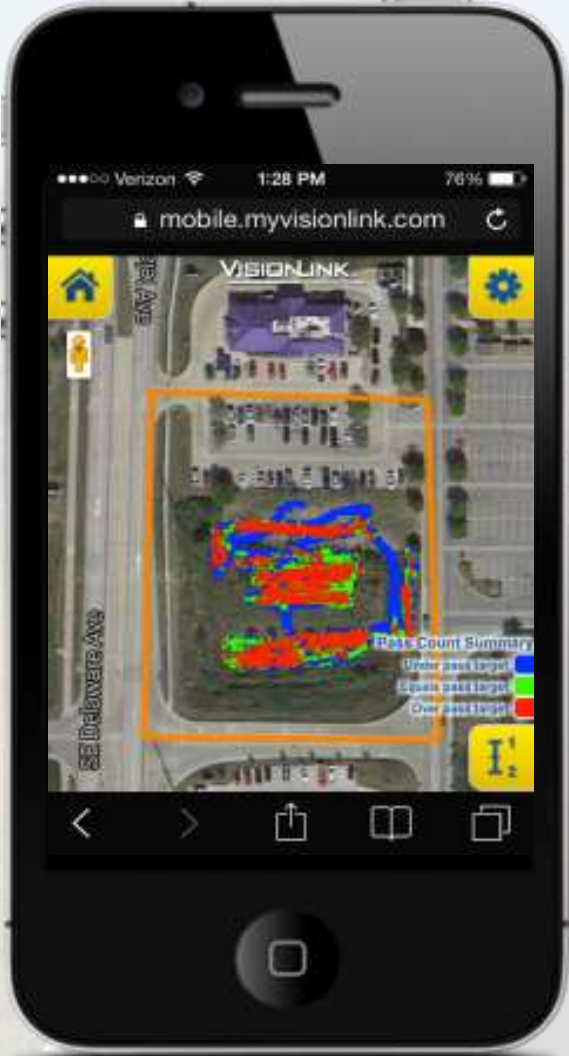


36" with rear-mount

Always Extend Tunnel in front of Augers



Wireless data near 'real-time'



What data is going to help me?



Integrating Technologies for Quality

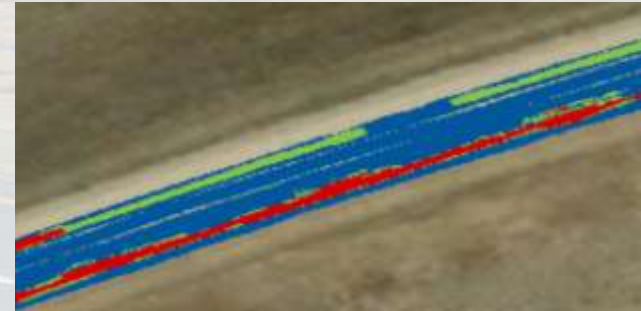
IC Data - Consistency

- Base Section Performance
- Keeping Roller Operations smooth
- Roll Out Areas (Size of Rolling Pattern)
- Managing Roller Operators



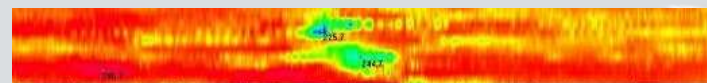
Thermal Data - Segregation

- Paver Screed
- Paver Start and Stops
- Material Hauling and Distribution
- Weather Conditions

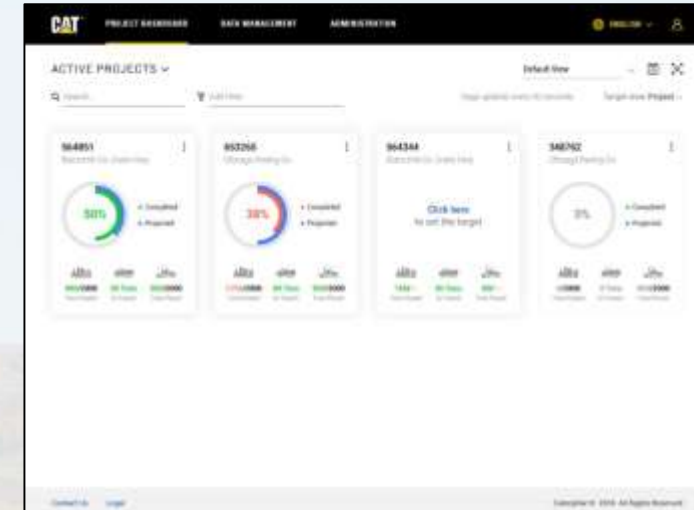
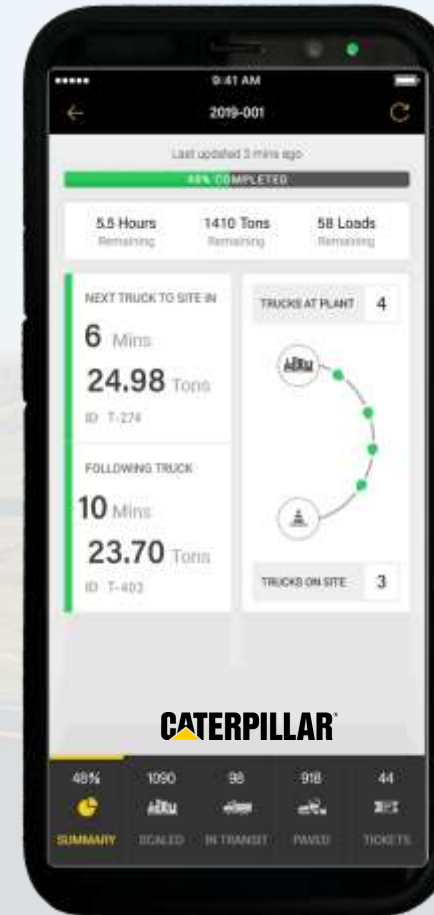
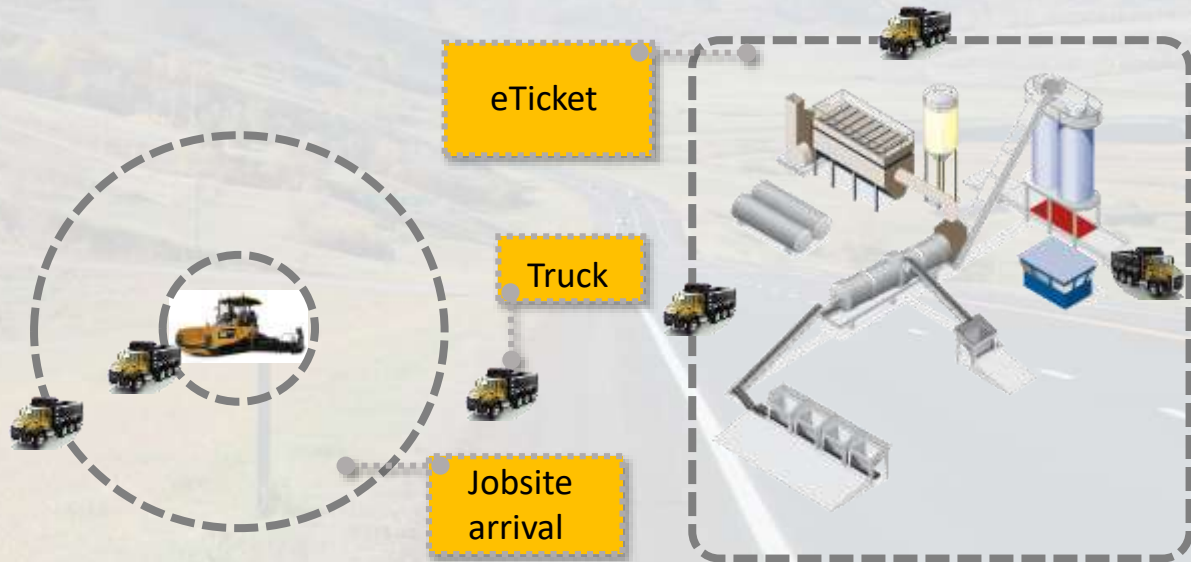


GPR Data - Uniformity

- Areas of low conformity (Shoulder, Joint, etc.)
- Areas that need more attention



eRoutes (e-ticketing)



Web-based user interface primarily for management employees to monitor realtime information as well as post-process jobsite data.

Mobile application primarily for paving foremen and paving crew members giving them the information they need to do their jobs better.

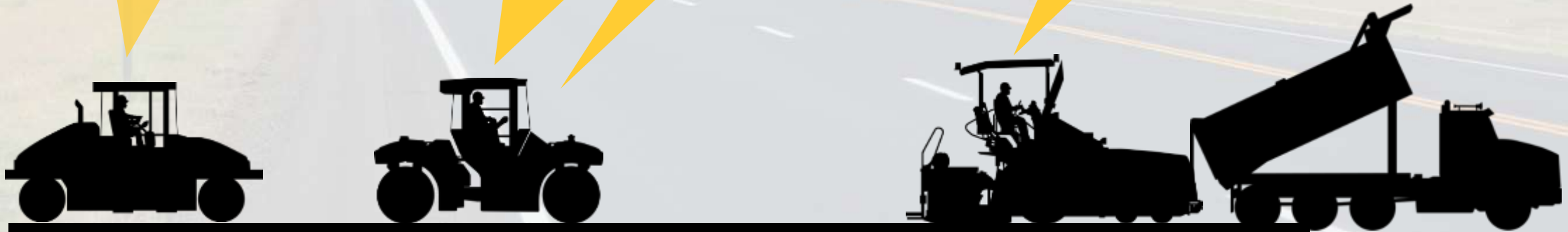
Real-time information I can work with!!

I finished my 4 passes, it's time for me to move up!

What pass am I on? I lost count...

That's a cooler load, I better hit it one more time!

When's the next truck coming?



Thank you for your attention!

Questions?



Cat Paving YouTube Channel



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