MOBA MOBILE AUTOMATION

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PAVE IR USEAGE NATIONWIDE

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MOBA MOBILE AUTOMATION

New QC/QA Technology for Asphalt Contractors/DOTs

PAVE-IR
Update

4/2010

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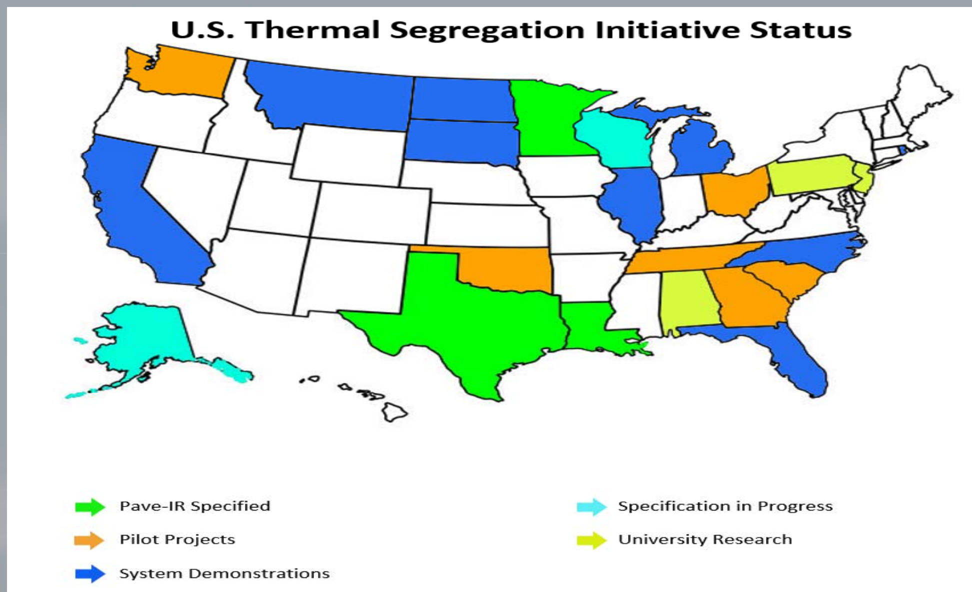
US Useage



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Topics

- The Problem
- Time line: A ten year journey on identifying the problem and how to fix it
  - 1995-1996
  - 1998
  - 1999
  - 2000
  - 2001-2006
- Washington DOT study
- 64 Projects

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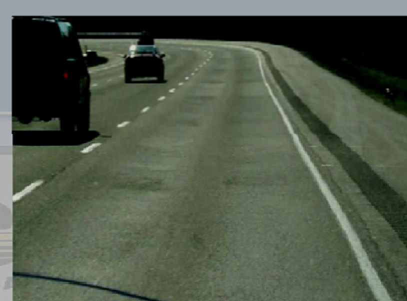
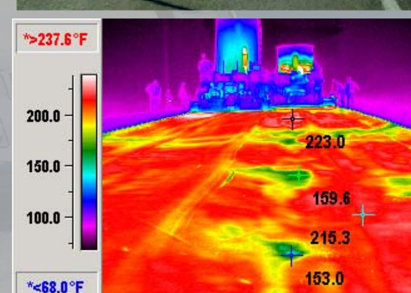
The Problem

- Localized "spots" of coarse surface texture
- Premature failure due to fatigue cracking, raveling, and moisture damage
- Increased roughness

The Problem

- Cooling of mix during transport is not remixed during the laydown process.
- Paver Set-up
- Results in erratic mat temperatures that are not apparent to the laydown crew.

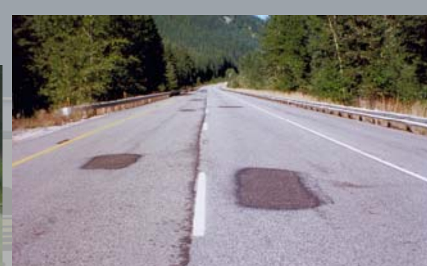




Damage Mechanism

- Placement of this cooler HMA creates pavement areas near cessation temperature (about 175°F)
- No significant compaction occurs below cessation temperature

Effects on Pavement



What Are We Trying to Avoid?

Cool area – usually seen in a cyclic pattern.

Streak – either down the center of the paved lane or either side of center.

1998 Conclusions

- None of the 4 projects experienced significant aggregate segregation.
- All 4 projects experienced significant temperature differentials.
- Concentrated areas of significantly cooler HMA generally resulted in lower than desirable compaction of those areas.

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1998 Conclusions (cont.)

- Concentrated areas of cooler HMA commonly occur during construction (based on this study and others).
- Good rolling practices can partially offset temperature differential related compaction problems.
- MTVs not specifically examined.
- Temperature differentials are easily identified by infrared imaging.

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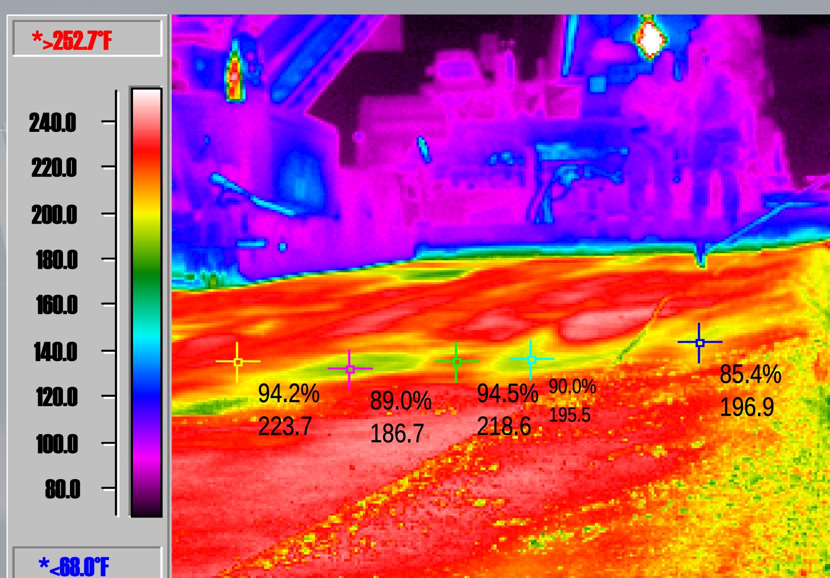
End Dump/No MTV



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1999 Study Objectives

- Investigate the effectiveness of different MTVs and remixing devices/methods
- Investigate other possible mitigation techniques
- Reexamine criteria for when and where to use MTV's
- 64 Projects Studies

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Data Collected

- Haul distance and time
- Weather conditions
- Equipment
  - Type of truck
  - MTV/MTD
  - Paver
  - Roller
- Nuclear density data

- Temperature data
  - Infrared camera
  - Probes
  - Hand held infrared thermometer
- Plant information
  - Temperature of mix
  - Loading operations
- Mat Placement

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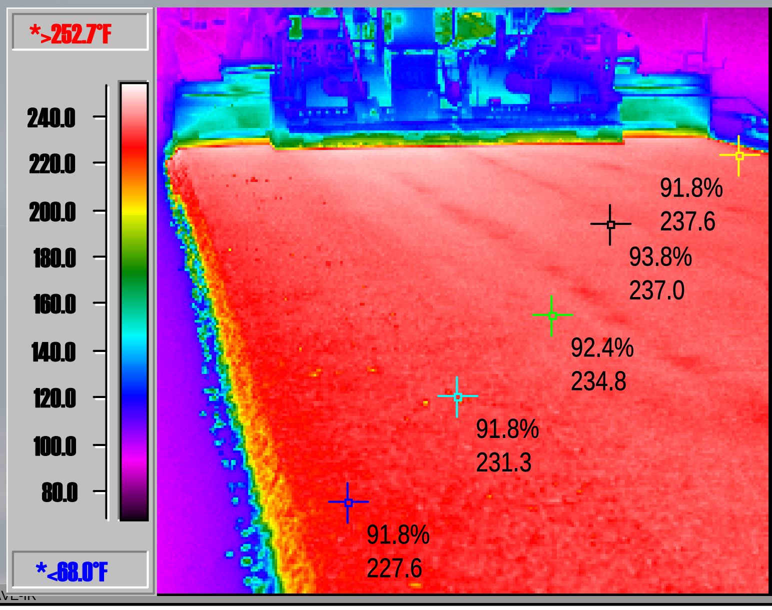
End Dump/ MTV



SR 12

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Effects on Pavement

- Same as insufficient compaction
  - Increased raveling and moisture damage
  - Reduced fatigue life
  - Increased roughness
- One percent increase in air voids results in a minimum of 10% reduction in pavement life (a rule of thumb)
- 25º F Differential=1 to 2% more air voids

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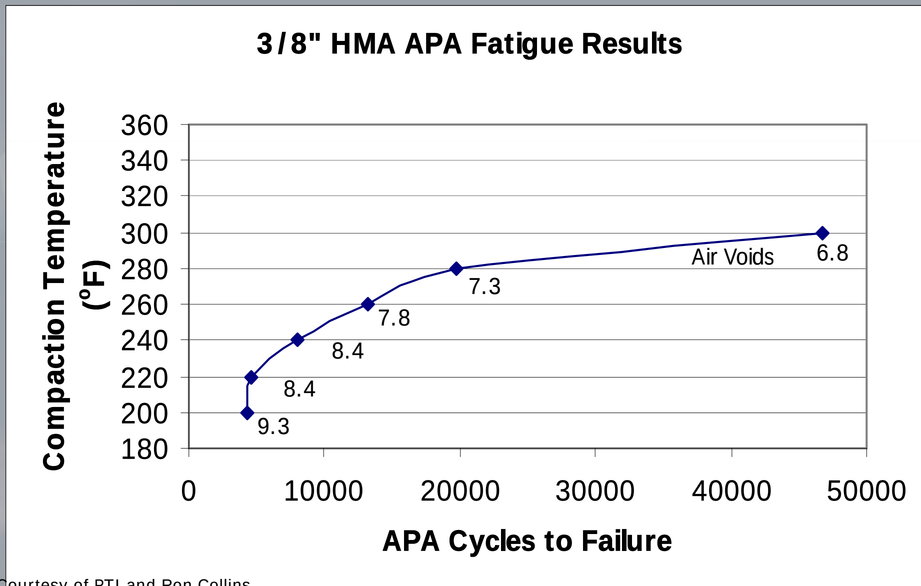

Courtesy of PTI and Ron Collins

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2001-2006

- A number of State DOTs have developed and implemented specifications to address this issue.
- WSDOT's current specification
  - Cyclic density areas are defined as less than 89.0 percent of maximum density.
  - If four or more low cyclic density areas are identified in a lot, a price adjustment will be assessed for that lot (a lot is 400 tons).
  - The price adjustment will be calculated as 15% of the unit bid price of HMA represented by that lot.
  - This assessment starts with examining the mat for temperature differences of 25°F or greater. If these do not exist, then no further special density testing is performed.

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Bottom Line Results 2010

- 50% Increase in HMA Pavement Life

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COST IMPACTS: A WSDOT Example

Washington State

US Highway 12 (MP 102 – 118)

Approximately 32 lane miles

Thermal segregation resulted in failure five years prior to anticipated 20 year life

ESTIMATED EXTRA COST: $2.4 MILLION

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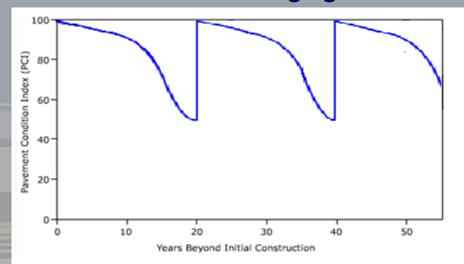
COST IMPACTS: A WSDOT Example

Calculations:

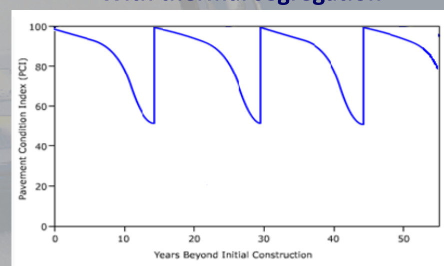
- **If this trend continues, over a 60 year period, an entire additional overlay will be needed**
- **Mill and Overlay of 1.8" on average cost of about $200,000 per lane mile**
- **For this stretch of highway, thermal segregation risks a cost increase of:**
  - **$2.4 million in present dollars**

    - or -
  - **$24.9 million in year 60 dollars**

Without thermal segregation



With thermal segregation



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Time Line for Temperature and Density Differentials—Washington State

- 1998: Four paving projects examined
- 1999: Approximately 40 paving projects examined
- 2000: Eighteen paving projects examined
- 2001-2006: Continued field monitoring and the development and evolution of specifications to address the problem

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1998 Study Objectives

- Are WSDOT dense-graded mixes experiencing aggregation segregation, temperature differentials resulting in higher air voids, or a combination thereof?
- What specific roles do mix temperature differentials play in the “cyclic segregation” problem?

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Study Description

- Four WSDOT paving projects—summer 1998
- Use infrared camera and material tests by WSDOT Mat Lab
- Look for segregation
- Look for temperature differentials
- Measure effects

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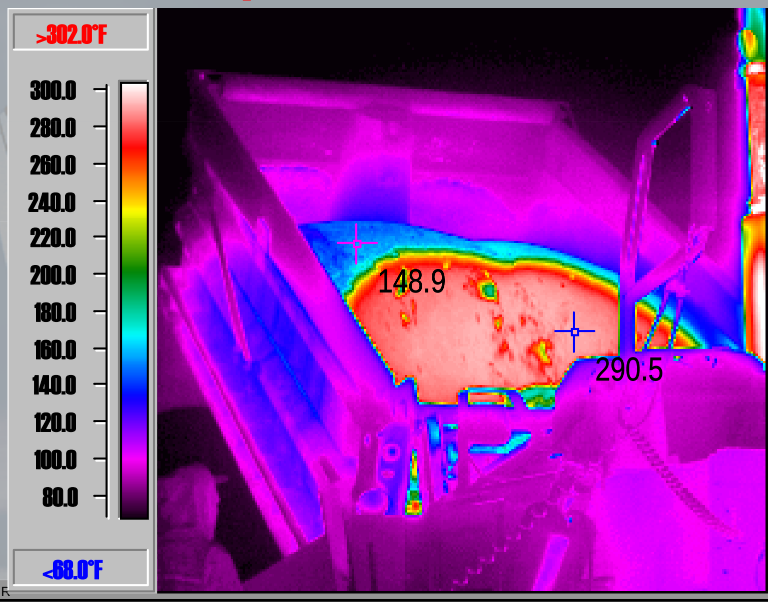
End Dump/No MTV



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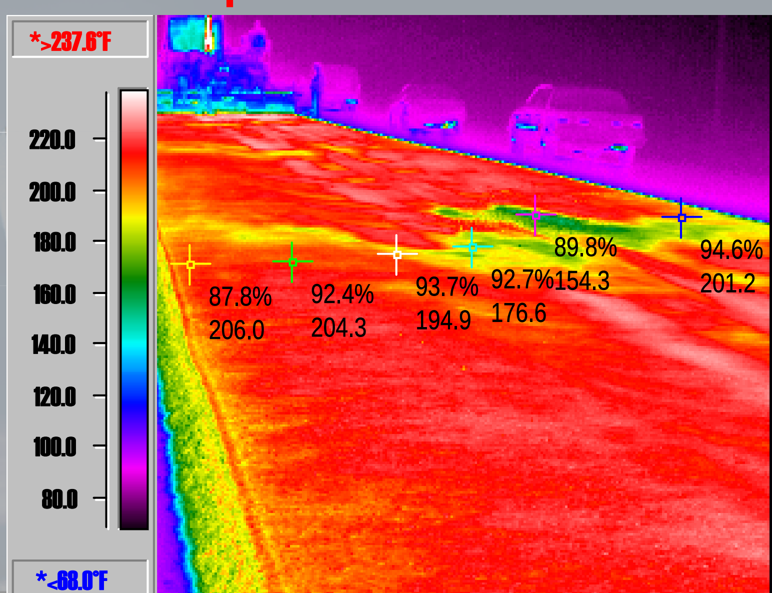
End Dump/No MTV



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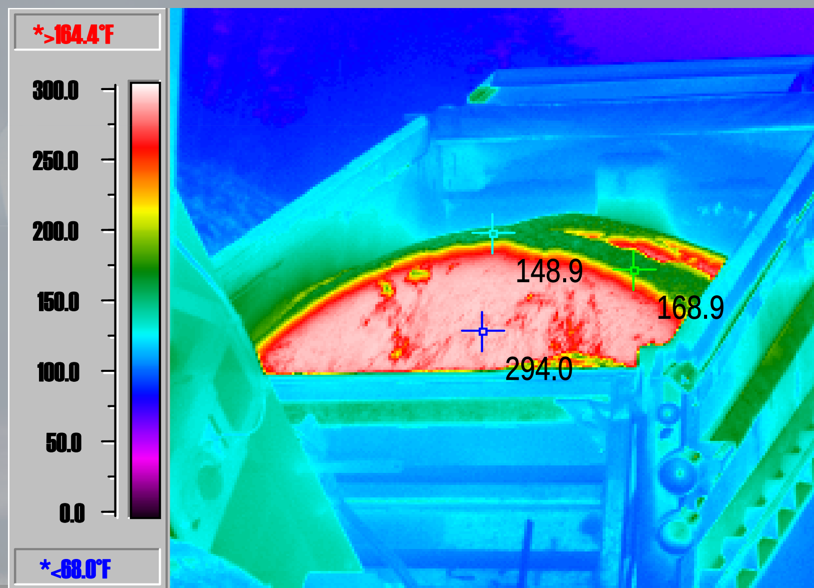
End Dump/ MTV



SR 2

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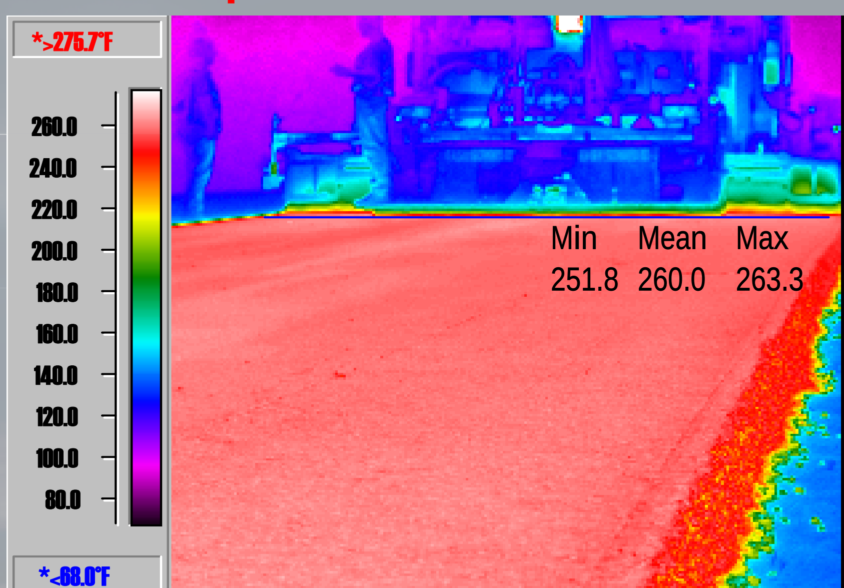
End Dump/ MTV



SR 2

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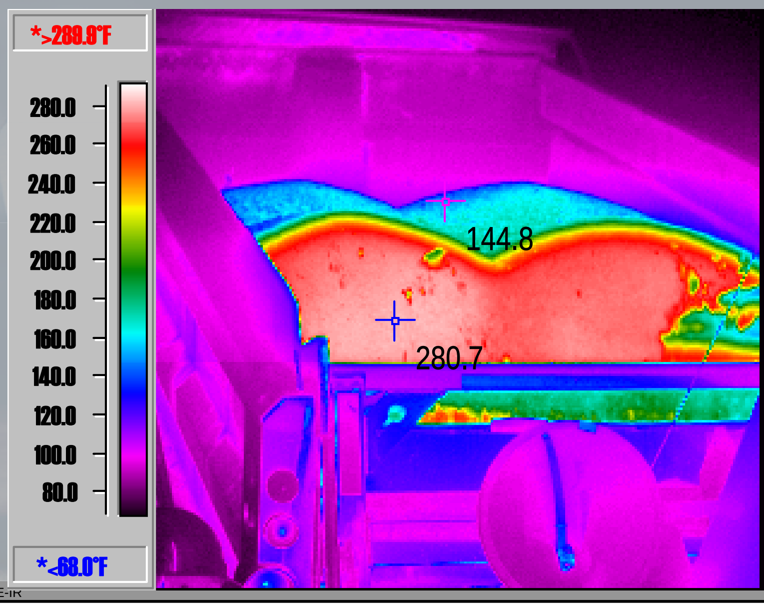
End Dump/ MTV



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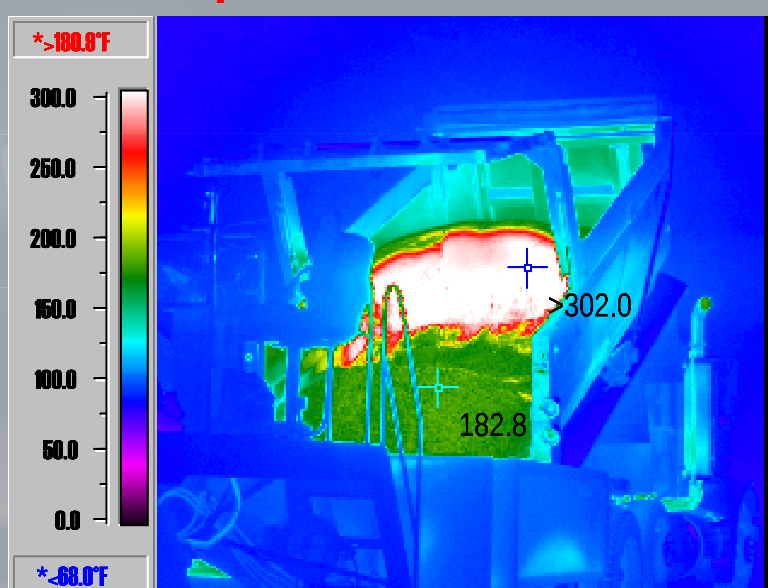
End Dump/ MTV



SR 507

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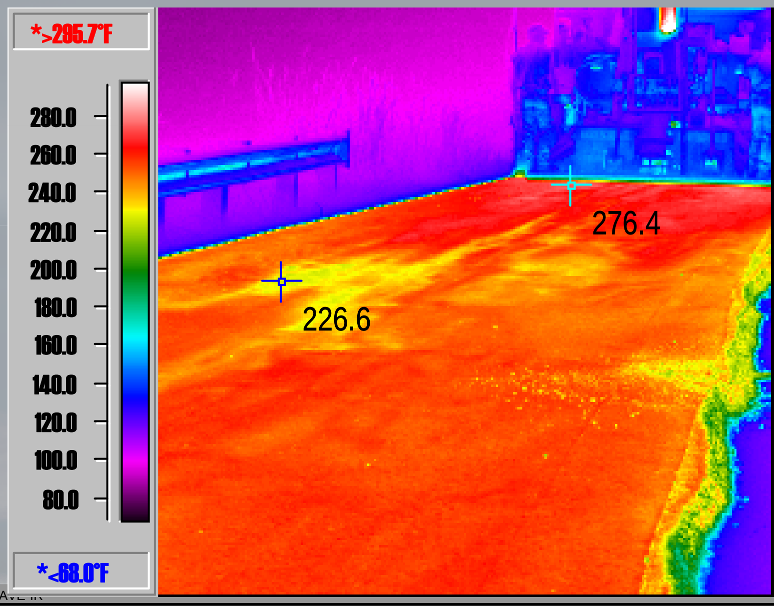
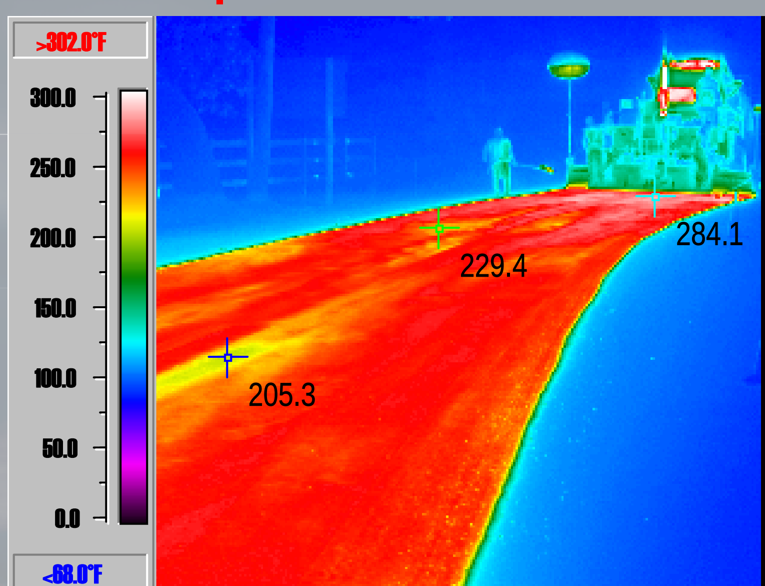
End Dump/ MTV



SR 507

MOBA PAVE-IR 31

End Dump/ MTV



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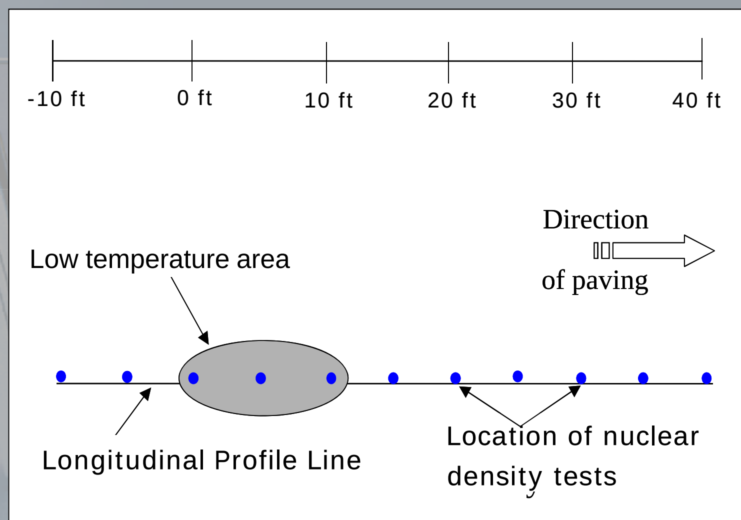
Temperature Differential Spots



Passing Density Profile

ΔT=2°F	Average Readings (pcf)
Average	134.6
Maximum	135.4
Minimum	133.5
	Ranges
Max-Min	1.9
Ave-Min	1.1

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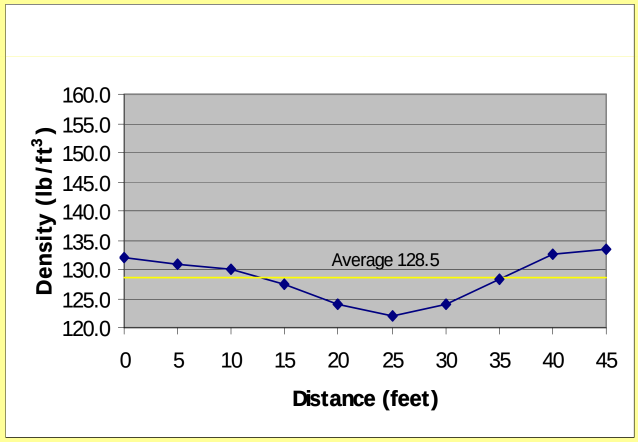
Failing Density Profile

ΔT=66°F	Average Readings (pcf)
Average	128.5
Maximum	133.5
Minimum	121.9
	Ranges
Max-Min	11.6
Ave-Min	6.6



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Summary of Findings—1999

- Density profiles
  - Maximum – minimum = 6.0 pcf
  - Mean – minimum = 3.0 pcf
- Criteria used for all types of mixes (12.5mm, 19.0mm, and SMA)

	ΔT ≥ 25°F	ΔT < 25°F
Number of Profiles	28	41
Failed both density criteria	20	3
Passed both density criteria	3	33
Failed only high - low	3	3
Failed only mean - low	2	2
Percent passing	10.7	80.5
Percent failing	89.3	19.5

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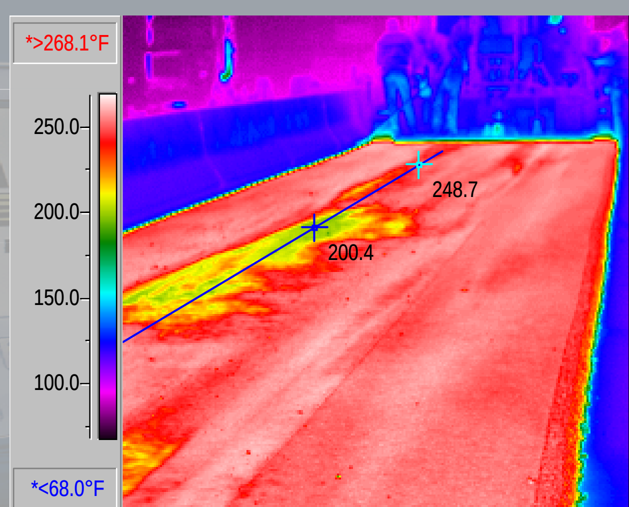
Summary of Findings—1999

- Large temperature differentials were observed under a variety of paving conditions
- Generally, the higher the temperature differentials the higher the as-compacted air voids associated with the cooler portions of the mat
- Temperature differentials generally decreased when the air temperature ≥ 85 °F (limited data)
- Large temperature differentials occurred over a wide range of pavement surface temperatures

End Dump/No MTV

- Density Profile #1
- Readings
  - Average 152.7
  - High 156.4
  - Low 149.8
- Ranges
  - High – Low = 6.6
  - Ave – Low = 2.9
- ΔT = 48ºF

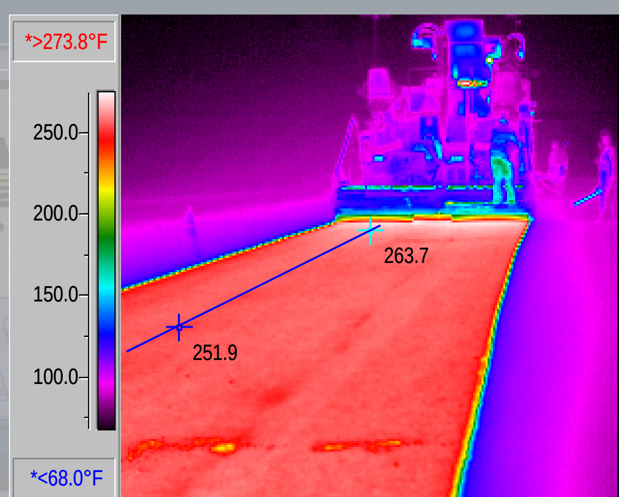


Data Collected

- Nuclear density profiles
- Temperature data
  - Infrared camera
  - Probes
  - Hand held infrared thermometer
- Weather conditions
- Equipment
  - Truck
  - MTV/MTD
  - Paver
  - Rollers
- Haul distance and time
- Mat Placement

End Dump/MTV

- Density Profile #3
- Readings
  - Average 140.7
  - High 142.9
  - Low 138.4
- Ranges
  - High – Low = 4.5
  - Ave – Low = 2.3
- $\Delta T = 11^{o}F$



Summary of Findings—2000

	$\Delta T \geq 25^0F$		$\Delta T < 25^0F$	
	Pneumatic	Steel	Pneumatic	Steel
Number of Profiles	15	13	21	20
Failed both density criteria	8	10	2	1
Passed both density criteria	3	0	18	15
Failed only high - low	3	2	1	2
Failed only mean - low	1	1	0	2
Percent passing	20.0	0.0	85.7	75.0
Percent failing	80.0	100.0	14.3	25.0

Summary of 1999-2000 Projects

Equipment	Number of Projects
MTVs	22
Windrow Elevators	20
No MTV/End Dumps	9
Other Combinations	2

Summary of 1999-2000 Projects

Equipment	Number of Projects		
	Normal	Cool	Total
No MTV	0	9	9
Blaw-Knox MC-30	3	9	12
Paddles working	3	4	
Paddles not working	0	5	
Roadtec Shuttle Buggy	10	0	10
Cedarapids MS-3	1	2	3
Cedarapids MS-2	6	5	11
Other Windrow Elevator	3	3	6
CMI MTP-400	1	0	1
Windrow Elevator/MC-30	1	0	1

"Cool" defined as $\Delta T \geq 25°F$-To all Pass 18° F

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Bottom Line 1999-2000 Projects

- How significant is the problem?
- Densities 3 pcf less than the density lot mean result in an air void increases of about 2%.
- The following table provides examples.

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Bottom Line 1999-2000 Projects

Percent of Rice Density Mean	Mix Air Voids @ Density Mean	Mix Air Voids @ Mean – 3 pcf	Mix Air Voids @ Mean – 6 pcf
95%	5.0%	7.0%	9.0%
94%	6.0%	8.0%	10.0%
93%	7.0%	9.0%	11.0%
92%	8.0%	10.0%	12.0%

(1) Assumed Rice Density of 155 lb/ft^3; (2) Long Term WSDOT Average 92.7%

WSDOT Study

- Visit 18 WSDOT 2000 paving projects
- Conduct infrared imaging (both digital and handheld infrared gun)
- Use surface temperatures to select longitudinal profile locations (3 to 4 profiles per paving project—uniform and non-uniform mat surface temperatures)
- Longitudinal profile: Obtain nuclear based densities—minimum of 10 tests in 50 foot long profile
- Calculate density differences for each profile
  - Maximum – Minimum
  - Mean – Minimum

Data Collected

- Nuclear density profiles
- Temperature data
  - Infrared camera
  - Probes
  - Hand held infrared thermometer
- Weather conditions
- Equipment
  - Truck
  - MTV/MTD
  - Paver
  - Rollers
- Haul distance and time
- Mat Placement

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Summary of Findings—2000

- In general, the occurrence of temperature differentials decreased when compared to the 1999 data (more transfer devices used)
- The higher the temperature differentials, the higher the in-place air voids associated with the cooler portions of the mat
- Temperature differentials decreased when remixing occurred

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Bottom Line 1999-2000 Projects

- Temperature and density differentials can be a significant issue on paving projects.
- Approximately ½ of projects (28 out of 53) studied during 1999 and 2000 regularly had temperature differentials ≥ 25°F.
- Following three years of data collection and analyses, differential densities resulting from cooler than desirable mix can be significant. How significant?

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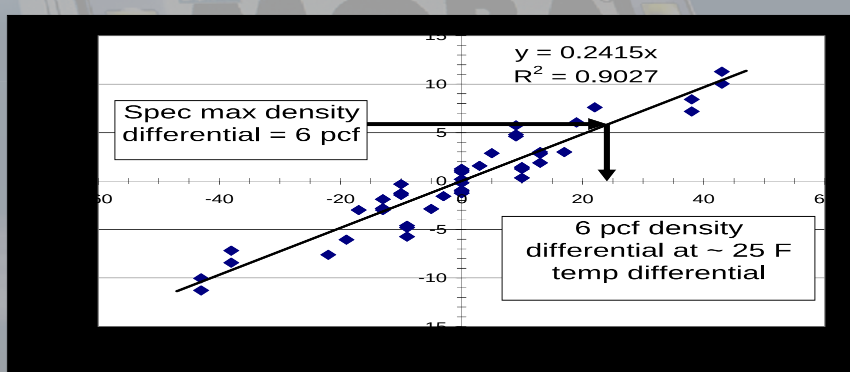
- NCAT (2000) and TTI (2002) similarly found thermal uniformity suitable for detecting segregation
  - NCAT – low severity segregation/density when Δt > 18 °F
  - TTI – when Δt > 25 °F, TxDOT density uniformity requirements not met



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HISTORY OF PAVE-IR

TxDOT funded research conducted by Texas Transportation Institute (TTI) to study the relationship between thermal segregation and density, in addition to developing a method for practical data collection.

Initial research included the use of a thermal camera operated by a researcher in the back of a pickup truck. In addition to obvious safety considerations, this initial method was found not to be practical. A series of infrared images had to be manually combined to produce a complete profile. Distance and position data were also difficult to incorporate.

HISTORY OF PAVE-IR

First generation Pave-IR system was first used in October 2003.

- Propelled manually
- Long setup time
- Loose connection wires
- Unstable wheel design
- Battery powered
- Required two operators

HISTORY OF PAVE-IR

Second generation Pave-IR system was first used in May 2004.

IMPROVEMENTS
- Faster setup time
- Central master control
- Stable wheel design

CHALLENGES
- Added weight
- Propelled manually
- Tight space requirements
- Battery powered
- Two operators required

MOBA PAVE-IR 53

HISTORY OF PAVE-IR

Third generation Pave-IR system was first used in January 2005.

IMPROVEMENTS
- Paver mounted
- Rapid setup time
- Central master control
- No dedicated operator

CHALLENGES
- Battery powered
- Distance measuring wheel
- Components not suitable for everyday use on heavy equipment.

MOBA PAVE-IR 54

HISTORY OF PAVE-IR

• In 2005 TTI published research reports outlining the relationship between thermal segregation and density. These reports also outline the methods used for thermal data collection supporting Pave-IR as the preferred tool for thermal data collection.

Reports available online at:

http://tti.tamu.edu/documents/0-4577-2.pdf

http://tti.tamu.edu/documents/5-4577-01-1.pdf

• Following the completion of this research, TTI & TxDOT were interested in finding a commercial partner for development and production of Pave-IR systems for future implementation into TxDOT specifications.

MOBA PAVE-IR

MOBA PAVE-IR SYSTEM COMPONENTS

- 12 – Infrared sensors (standard)
- Absolute encoder used for distance measurement
- MOBA OPERAND™ computer
- GPS antenna
- Includes PAVE PROJECT MANAGER™ software for post analysis and reports
- Kit includes system cabling and all necessary screed mounting hardware.

WHAT IS PAVE-IR?

- Paver mounted system used to identify thermal segregation in newly placed asphalt surfaces.
- Uses a series of infrared, GPS, and distance measuring sensors.
- Sensors are networked together and connected to a mobile computer with color display.
- Computer processes and displays data from all sensors.
- Areas where thermal segregation is present are displayed in real-time.
- Data stored on flash drive for post processing on PC

PAVE-IR INSTALLATION

The MOBA Operand™ computer attaches to sensor beam.

GPS antenna mounts above the Operand™ computer.

Memory drive connects directly to Operand™ computer

System is powered by machine voltage (10-28 VDC).

Sensor beam is hinged in center for easy setup and storage.

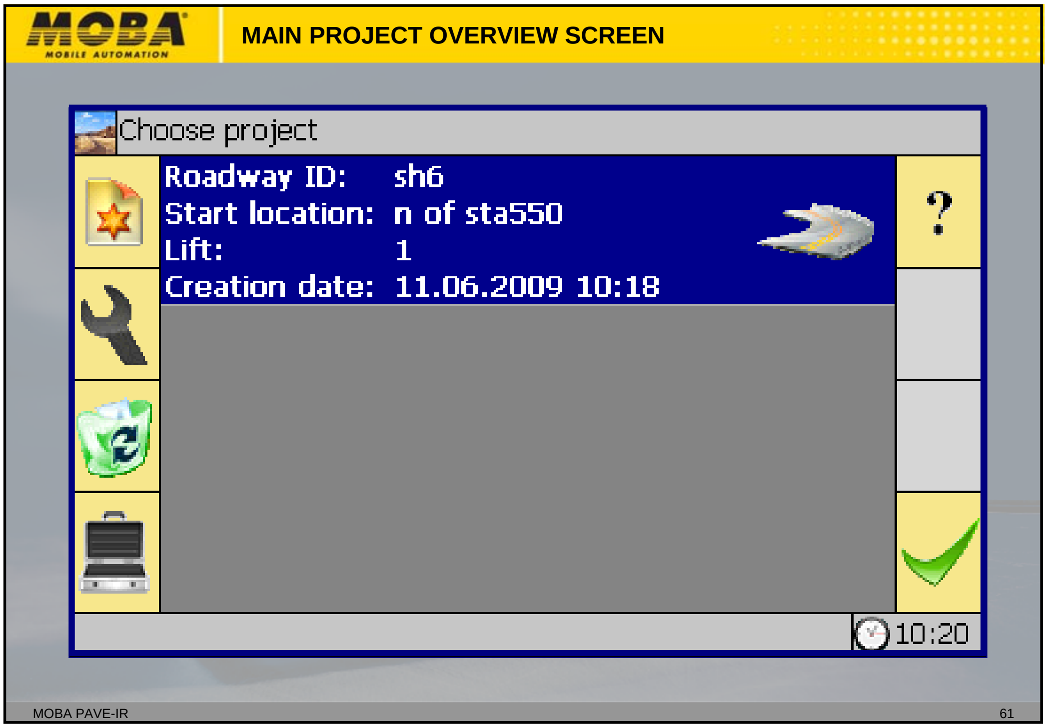
PAVE-IR INSTALLATION

The PAVE-IR™ system mounts to the screed walkway by bolting or welding.

The distance encoder mounts to the wheel or torque hub using a magnet.

BENEFITS OF PAVE-IR

- Provides full coverage of entire paved surface.
- Ensures compliance with most existing DOT temperature specification requirements.
- Data is logged automatically and can be stored permanently.
- More cost effective versus infrared cameras.
- System also records paving speed and paver stops.
- System can be moved from one machine to another.
- System is scaleable from 2-8 meters depending on paving width


MOBA
MOBILE AUTOMATION
MAIN PROJECT OVERVIEW SCREEN
Choose project
Roadway ID: sh6
Start location: n of sta550
Lift: 1
Creation date: 11.06.2009 10:18
?
10:20
MOBA PAVE-IR
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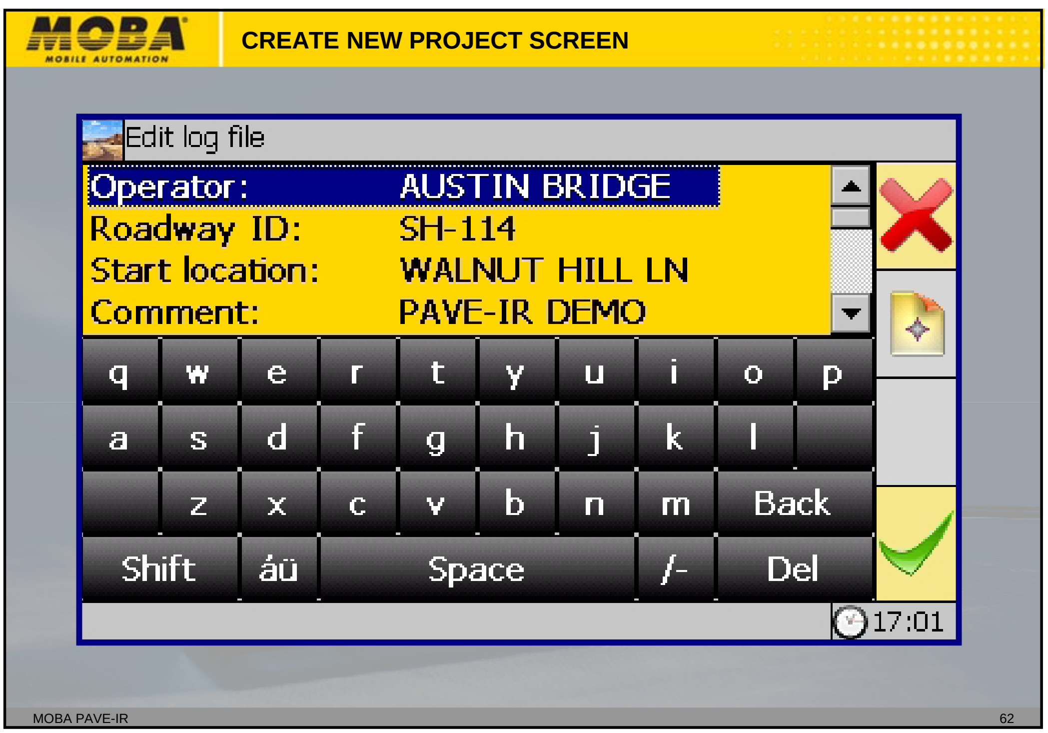
MOBA
MOBILE AUTOMATION
CREATE NEW PROJECT SCREEN
Edit log file
Operator: AUSTIN BRIDGE
Roadway ID: SH-114
Start location: WALNUT HILL LN
Comment: PAVE-IR DEMO
q w e r t y u i o p
a s d f g h j k l
z x c v b n m Back
Shift áü Space /- Del
17:01
MOBA PAVE-IR
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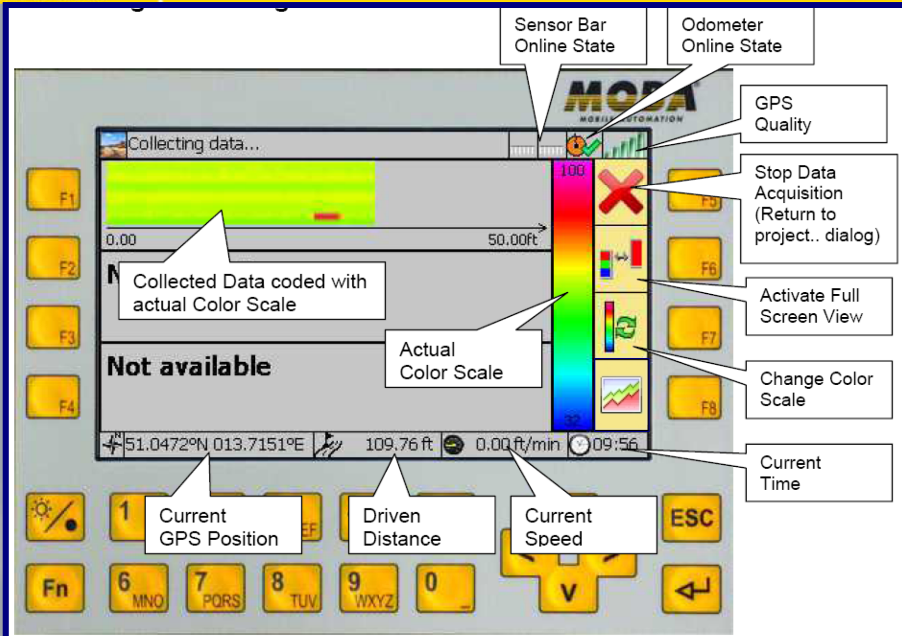
DATA COLLECTION SCREEN



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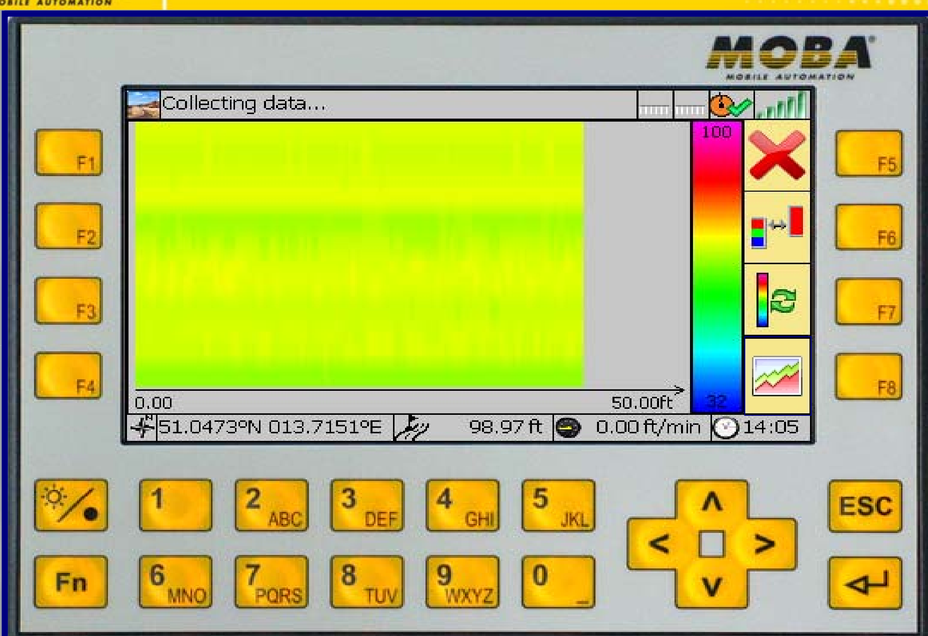
FULL SCREEN MODE



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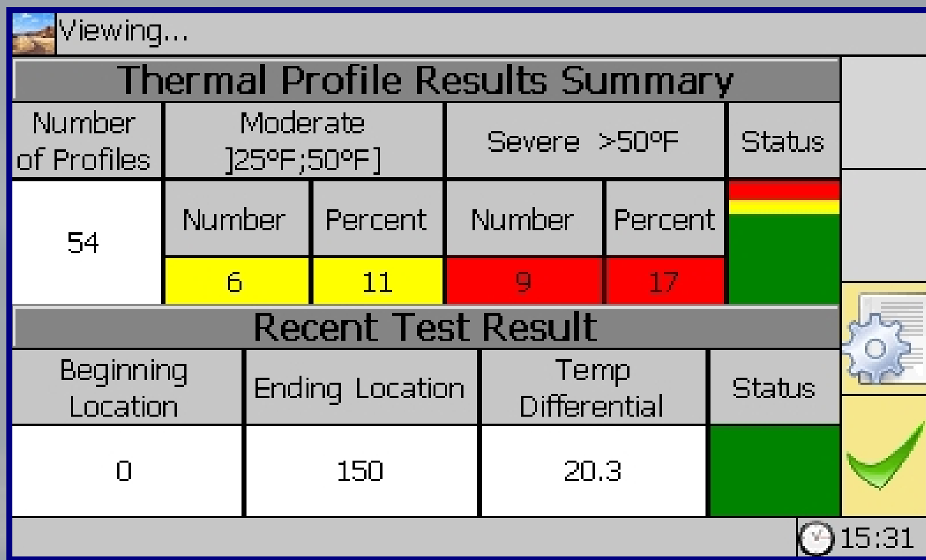
REAL-TIME ANALYSIS SCREEN



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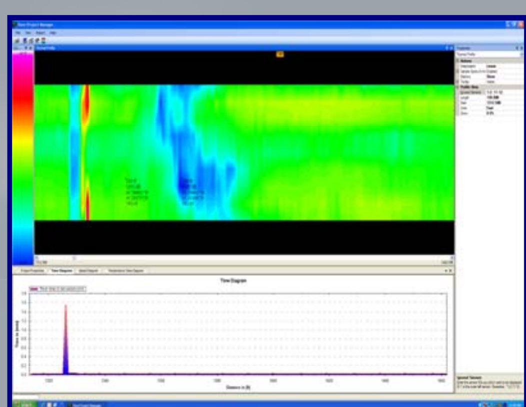
PAVE PROJECT MANAGER (PPM)



After data collection, the project file is transferred to PC via USB cable.

PPM allows contractor to evaluate the project in detail.

PPM displays thermal data, stations, paving speed, paver stops, and GPS location for any position in the project.

QC/QA reports are generated by PPM.

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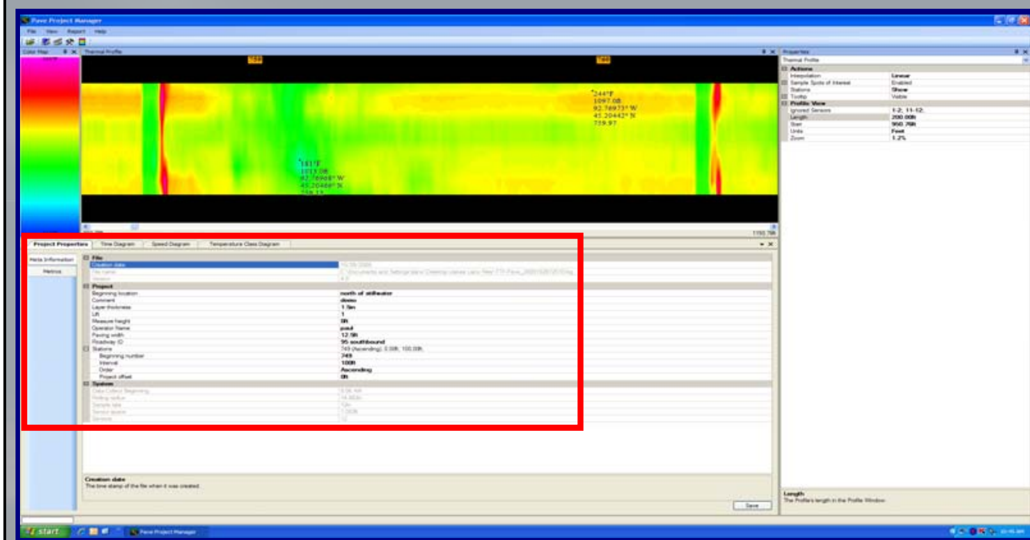
PAVE PROJECT MANAGER (PPM)

PROJECT PROPERTIES WINDOW (Meta Information)



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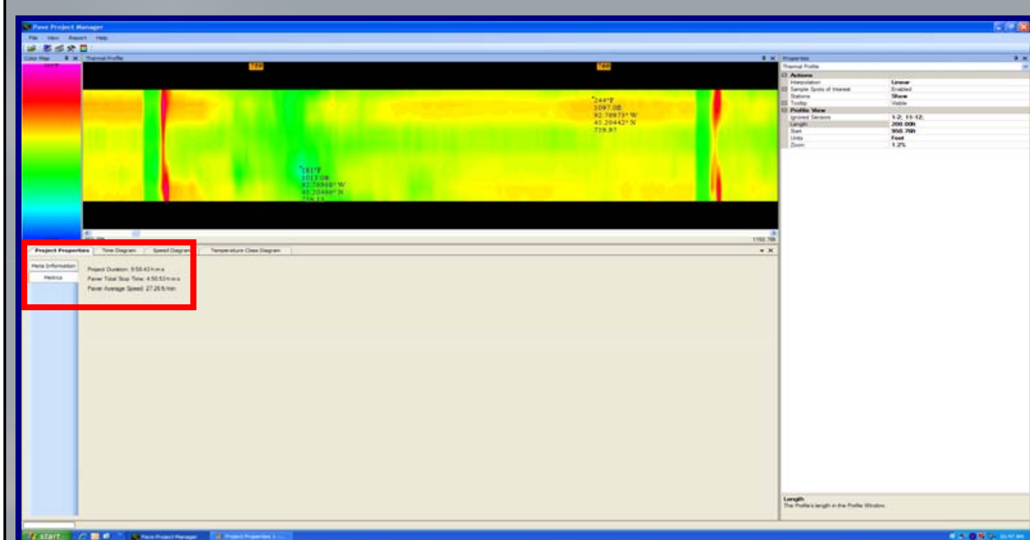
PAVE PROJECT MANAGER (PPM)

PROJECT PROPERTIES WINDOW (Metrics)



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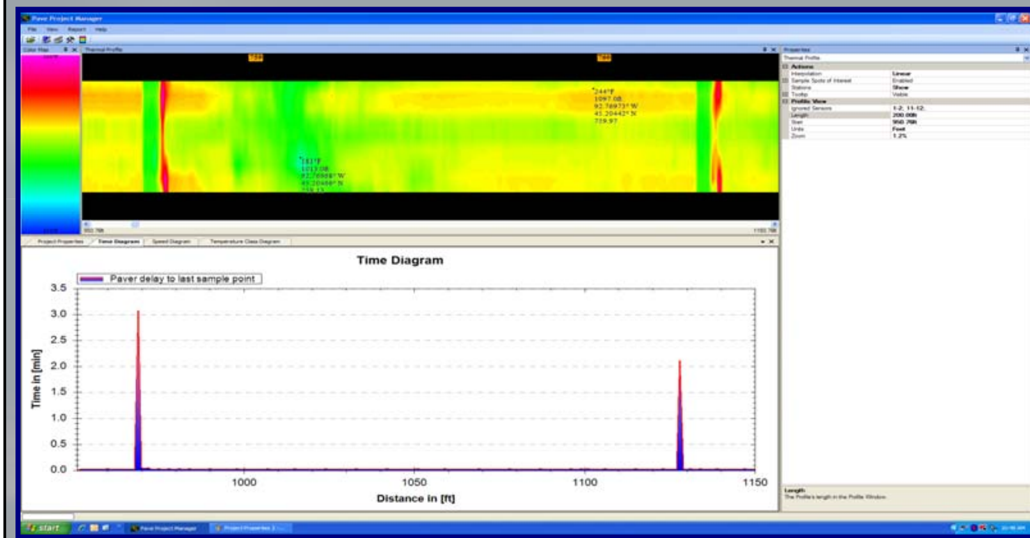
PAVE PROJECT MANAGER (PPM)

TIME DIAGRAM DISPLAYS PAVER STOPS



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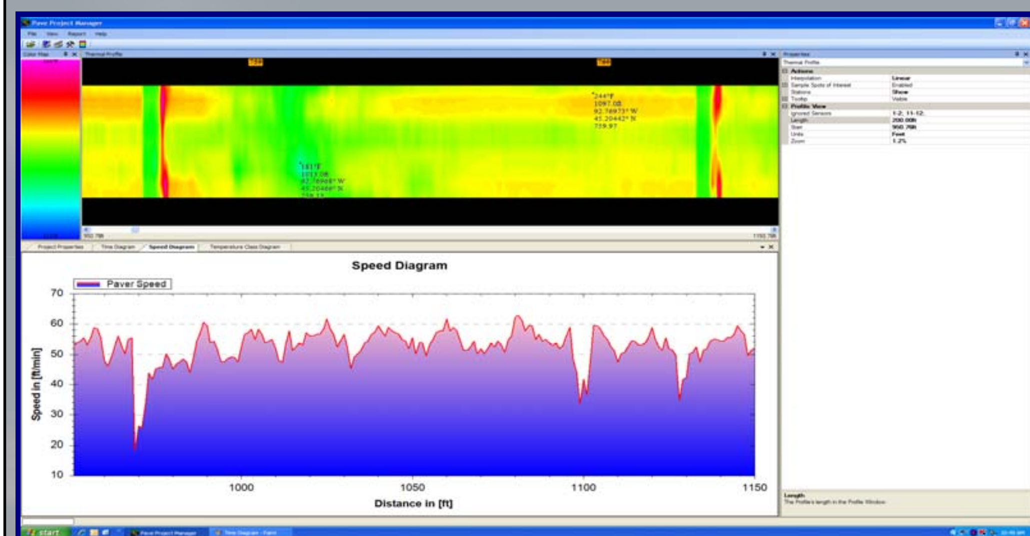
PAVE PROJECT MANAGER (PPM)

SPEED DIAGRAM DISPLAYS PAVING SPEED

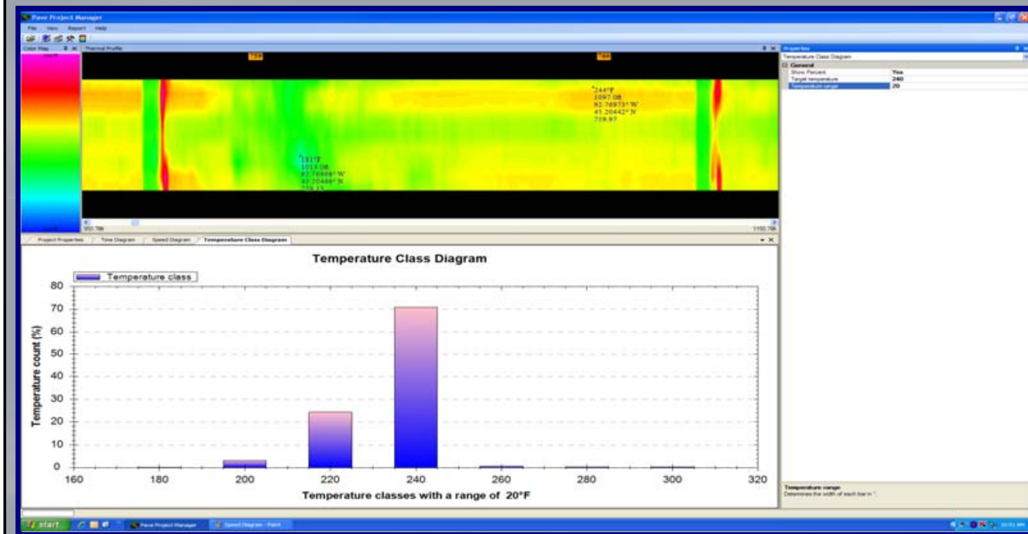


MOBA PAVE-IR 70

MOBA MOBILE AUTOMATION

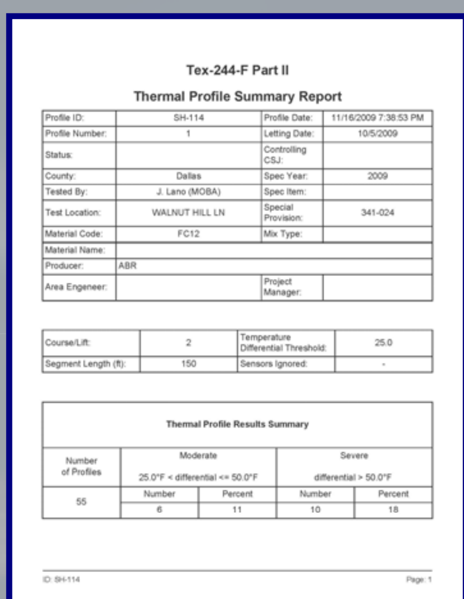
PAVE PROJECT MANAGER (PPM)

TEMPERATURE DIAGRAM DISPLAYS TEMPERATURE GRAPH



MOBA MOBILE AUTOMATION

PPM QC/QA REPORT GENERATION



Tex-244-F Part II

Thermal Profile Summary Report

Profile ID:	SH-114	Profile Date:	11/16/2009 7:38:53 PM
Profile Number:	1	Letting Date:	10/5/2009
Status:		Controlling CSJ:	
County:	Dallas	Spec Year:	2009
Tested By:	J. Lano (MOBA)	Spec Item:	
Test Location:	WALNUT HILL LN	Special Provision:	341-024
Material Code:	FC12	Mix Type:	
Material Name:			
Producer:	ABR		
Area Engeneer:		Project Manager:	

Course/Lift:	2	Temperature Differential Threshold:	25.0
Segment Length (ft):	150	Sensors Ignored:	-

Thermal Profile Results Summary

Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
55	6	11	10	18

ID: SH-114 Page: 1

Reports specific to various DOT specifications can be generated in PPM.

This report is based on TxDOT thermal specification Tex-244-F

TEX-244-F REPORT

Summary of Locations with Thermal Segregation

Profile Nr	Beginning Location Distance (ft)	Beginning Location GPS in °	Ending Location Distance (ft)	Ending Location GPS in °	Max Temp	Min Temp	Temperature Differential
2	150.50	96.95501 W, 32.88593 N	300.00	96.95462 W, 32.88572 N	309.9	283.8	26.1
20	2850.07	96.94865 W, 32.88120 N	2999.58	96.94837 W, 32.88087 N	316.8	257.9	58.9
21	3000.08	96.94837 W, 32.88087 N	3149.58	96.94813 W, 32.88054 N	311.2	248.9	62.3
23	3300.09	96.94787 W, 32.88020 N	3449.56	96.94762 W, 32.87986 N	327.2	297.3	29.9
31	4500.17	96.94655 W, 32.87720 N	4649.61	96.94649 W, 32.87680 N	324.1	296.6	27.5
33	4800.06	96.94645 W, 32.87639 N	4949.50	96.94642 W, 32.87600 N	310.1	284.5	25.6
36	5250.39	96.9464 W, 32.87519 N	5399.84	96.94639 W, 32.87480 N	318.9	291.4	27.5
47	6900.28	96.94559 W, 32.87085 N	7049.73	96.94546 W, 32.87045 N	336.7	307.0	29.7
48	7050.23	96.94546 W, 32.87045 N	7199.67	96.9452 W, 32.87014 N	351.7	294.1	57.6
49	7200.17	96.9452 W, 32.87014 N	7349.62	96.94497 W, 32.86979 N	351.0	284.7	66.2
50	7350.12	96.94497 W, 32.86979 N	7499.56	96.94474 W, 32.86944 N	349.7	264.4	85.3
51	7500.06	96.94474 W, 32.86943 N	7649.50	96.94451 W, 32.86909 N	348.8	268.3	80.5
52	7650.00	96.94451 W, 32.86909 N	7799.95	96.94425 W, 32.86876 N	349.7	257.9	91.8
53	7800.45	96.94425 W, 32.86876 N	7949.89	96.94399 W, 32.86842 N	352.0	247.3	104.8
54	7950.39	96.94399 W, 32.86842 N	8099.84	96.9437 W, 32.86809 N	348.4	262.9	85.5

ID: SH-114 Page: 2

Summary of Locations with Thermal Segregation

Profile Nr	Beginning Location Distance (ft)	Beginning Location GPS in °	Ending Location Distance (ft)	Ending Location GPS in °	Max Temp	Min Temp	Temperature Differential
55	8100.34	96.9437 W, 32.86809 N	8214.80	96.94349 W, 32.86786 N	328.8	243.9	85.0

Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location Distance (ft)	Beginning Location GPS in °	Ending Location Distance (ft)	Ending Location GPS in °	Max Temp	Min Temp	Temperature Differential
1	0.00	96.95544 W, 32.88615 N	150.00	96.95501 W, 32.88593 N	295.9	275.5	20.3
3	300.50	96.95462 W, 32.88572 N	450.00	96.95423 W, 32.88550 N	311.9	288.1	23.8
4	450.50	96.95422 W, 32.88550 N	599.50	96.95384 W, 32.88529 N	318.4	305.1	13.3
5	600.00	96.95383 W, 32.88529 N	749.51	96.95344 W, 32.88507 N	319.6	305.2	14.4
6	750.01	96.95344 W, 32.88507 N	899.51	96.95303 W, 32.88485 N	317.3	303.3	14.0
7	900.01	96.95303 W, 32.88485 N	1049.52	96.95262 W, 32.88462 N	313.0	290.1	22.9
8	1050.02	96.95262 W, 32.88462 N	1199.52	96.95223 W, 32.88441 N	300.9	283.5	17.5
9	1200.02	96.95222 W, 32.88441 N	1349.53	96.95182 W, 32.88418 N	303.1	285.6	17.5
10	1350.03	96.95182 W, 32.88418 N	1499.53	96.95145 W, 32.88394 N	305.1	291.7	13.3
11	1500.03	96.95145 W, 32.88393 N	1649.54	96.95109 W, 32.88368 N	308.3	294.6	13.7

ID: SH-114 Page: 3

MOBA PAVE-IR 73

IMPLEMENTATION IN TEXAS

- **TxDOT implemented PAVE-IR into their specification in Special Provision 341-024.**
  - **Use of PAVE-IR is voluntary.**
  - **Incentives offered for contractors using PAVE-IR**
    - **Start paving at 32° F**
    - **Density profiles not required**
    - **Placement bonuses protected***

***Contractors not using Pave-IR must take density measurements whenever the paver stops, and in areas where thermal segregation is detected using handheld IR gun (or a minimum of once per sub-lot). If the section also fails density, all placement bonus are automatically waived, and is subject to removal and replacement.**

MOBA PAVE-IR 74

TEXAS

- Pave IR, Temperature Guns, Thermography Cameras
- Eliminate Guns / Cameras
- Change Spec (Base Temp, Density Profiles)

Texas Implementation

- Revised Specification introduced Sept 2012-Item 341
- W/O Thermal Profile no longer eligible for bonus on density.
- All Projects over 5000 tons

MINNESOTA

- Thermal Studies Flir Camera
- Thermal Studies Pave IR
- Pilot projects MPLS Metro
- Spec Pilot Projects 4 Corners
- Remote Monitoring

Louisiana

- Copied Texas Spec, Changed headers (2012)
- Contractor Driven
- Monitor MTV Operation

OHIO

- Thermal Studies FLIR Camera (2009-2010)
- Thermal Studies Pave IR (2011)
- Spec 2012 with pilot Projects
- Add pilot projects with MTVs (2013)

MOBA PAVE-IR 79

WISCONSIN

- Contractor Driven
- Warranty (5 yrs)

MOBA PAVE-IR 80

TEX-244-F REPORT

Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Distance (ft)	GPS in °	Distance (ft)	GPS in °			
12	1650.04	96.95109 W, 32.88368 N	1799.54	96.95073 W, 32.88340 N	308.1	298.8	9.4
13	1800.04	96.95073 W, 32.88339 N	1949.54	96.95041 W, 32.88311 N	307.4	297.5	9.9
14	1950.04	96.95041 W, 32.88310 N	2099.55	96.95008 W, 32.88280 N	309.2	294.8	14.4
15	2100.05	96.95008 W, 32.88279 N	2249.55	96.94979 W, 32.88247 N	311.2	288.0	23.2
16	2250.05	96.94979 W, 32.88247 N	2399.56	96.94953 W, 32.88215 N	310.1	291.9	18.2
17	2400.06	96.94953 W, 32.88215 N	2549.56	96.94923 W, 32.88183 N	306.0	291.6	14.4
18	2550.06	96.94923 W, 32.88183 N	2699.57	96.94897 W, 32.88151 N	305.8	293.4	12.4
19	2700.07	96.94897 W, 32.88151 N	2849.57	96.94865 W, 32.88120 N	309.4	290.8	18.5
22	3150.08	96.94813 W, 32.88054 N	3299.59	96.94787 W, 32.88020 N	320.2	298.8	21.4
24	3450.06	96.94762 W, 32.87986 N	3600.00	96.94728 W, 32.87948 N	325.4	307.9	17.5
25	3600.50	96.94728 W, 32.87948 N	3749.94	96.94724 W, 32.87912 N	327.7	311.9	15.8
26	3750.44	96.94724 W, 32.87912 N	3899.89	96.94705 W, 32.87876 N	323.6	309.9	13.7
27	3900.39	96.94705 W, 32.87876 N	4049.83	96.94689 W, 32.87840 N	322.3	311.0	11.3
28	4050.33	96.94689 W, 32.87840 N	4199.78	96.94675 W, 32.87800 N	322.9	310.5	12.4
29	4200.28	96.94675 W, 32.87800 N	4349.72	96.94663 W, 32.87760 N	322.5	306.3	16.2

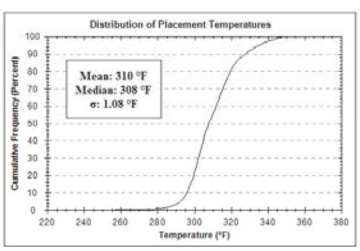
ID: SH-114 Page: 4

Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Distance (ft)	GPS in °	Distance (ft)	GPS in °			
30	4350.22	96.94663 W, 32.87760 N	4499.67	96.94655 W, 32.87720 N	322.7	302.2	20.5
32	4650.11	96.94649 W, 32.87680 N	4799.56	96.94645 W, 32.87639 N	315.0	298.0	16.9
34	4950.00	96.94642 W, 32.87599 N	5099.95	96.9464 W, 32.87560 N	310.8	296.6	14.2
35	5100.45	96.9464 W, 32.87560 N	5249.89	96.9464 W, 32.87519 N	314.1	299.8	14.2
37	5400.33	96.94639 W, 32.87480 N	5549.78	96.94637 W, 32.87439 N	316.4	302.7	13.7
38	5550.28	96.94637 W, 32.87439 N	5699.72	96.94637 W, 32.87400 N	318.6	303.3	15.3
39	5700.22	96.94637 W, 32.87399 N	5849.67	96.94632 W, 32.87361 N	313.2	291.4	21.8
40	5850.17	96.94632 W, 32.87361 N	5999.61	96.94627 W, 32.87321 N	308.5	292.8	15.7
41	6000.11	96.94627 W, 32.87321 N	6149.56	96.94619 W, 32.87282 N	311.0	294.6	16.4
42	6150.06	96.94619 W, 32.87282 N	6299.50	96.94609 W, 32.87242 N	303.8	288.0	15.8
43	6300.00	96.94609 W, 32.87242 N	6449.95	96.94598 W, 32.87202 N	313.0	291.7	21.2
44	6450.45	96.94598 W, 32.87202 N	6599.89	96.94585 W, 32.87163 N	325.4	304.7	20.7
45	6600.39	96.94585 W, 32.87163 N	6749.84	96.94572 W, 32.87124 N	333.1	313.9	19.3
46	6750.34	96.94572 W, 32.87124 N	6899.78	96.94559 W, 32.87085 N	336.2	319.3	16.9

ID: SH-114 Page: 5

TEX-244-F REPORT



Location of Paver Stops greater than One Minute

Location (ft)	Duration (h:min:sec)
0.50	0:7:5
1215.02	0:3:54
2203.05	0:1:29
2215.55	0:1:20
2076.07	0:9:11
3099.08	0:19:34
3100.58	0:1:38
3396.57	0:1:41
3467.55	0:1:4
3541.02	0:3:12

ID: SH-114 Page: 6

Location of Paver Stops greater than One Minute

Location (ft)	Duration (h:min:sec)
3710.96	0:1:2
4290.24	0:2:2
5194.91	0:5:15
5626.25	0:25:16
5681.73	0:1:40
5703.72	0:1:38
6302.00	0:4:43
6684.86	0:3:52
6918.27	0:8:1
6968.26	0:3:5
7130.20	0:38:11
7165.18	0:1:37
7253.15	0:1:54
7371.11	0:1:13
7463.07	0:2:32
7566.54	0:1:18
7655.00	0:1:26
7780.96	0:1:17
7868.42	0:2:21
7954.39	0:2:9
8068.85	0:1:30
8196.80	0:4:4

ID: SH-114 Page: 7

Prototype Scanner

MOBA PAVE-IR 83

WAPA

- Specified in Texas, Ohio, Louisiana, Minnesota, Washington
- SHRP 2 Study completed(Recommend Implementation)
- SHRP 2 Research extension of 18 month to help states implement
- EveryDayCounts/IC
- TRB Recommended
- NCAT Alabama Study
- AASHTO Spec Draft

MOBA PAVE-IR 84

MOBA
MOBILE AUTOMATION

Compaction Assistant Pass-Counting System

MCA-2000

MOBA CORPORATION • 180 Walter Way Suite 102 • Fayetteville, GA 30214
Telephone: (678) 817-9646 • Fax: (678) 817-0996 • www.moba.de

MOBA
MOBILE AUTOMATION

Moba Compaction Assistant Pass Counter

Why MCA-2000?

- Visual indicator for the area to be compacted
  - Makes operators work easier and more efficient
- Safeguards proper compaction
  - Averts under compaction and diminishes un compacted regions
  - Deters over compaction and fractured aggregate
- Increases the quality of compaction & lifetime of road
  - Avoids compacting cold asphalt
  - Aids compaction work in compliance with regulations
- Increases the efficiency of the roller & the production rate on site
  - Less time required to obtain proper coverage
- Reduces the operating cost of the compactor
  - Targeted and documented rolling patterns = less fuel consumption = $$
  - Reduced wear on the roller = increased roller lifespan = $$
- Documents and reports the project specific metrics

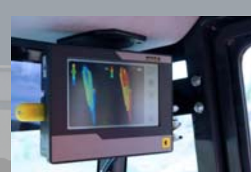
Features and Benefits

- Add-on system for all types of compacting machines
- Intuitive and simple user interface
- CAN based on machine communication
- SBAS based position with high pass-to-pass precision
- No need for reference base station or GPRS service
- Surface temperature measurement
- Automated logging and work report generation
- Full logs can be converted to KML files for detailed analization

MOBA PAVE-IR 87

System Components

- Operand (Mobile Computer)
- Temperature Sensor
- GNSS Antenna



Operand computer

GNSS Antenna

Temperature Sensor and Electronics

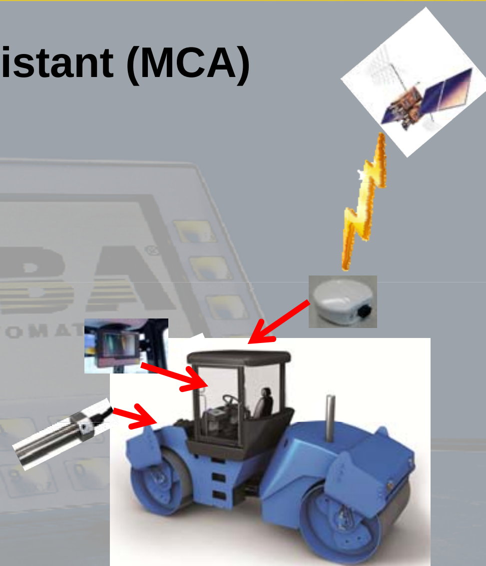
MOBA PAVE-IR 88

MOBA MOBILE AUTOMATION

System Components

MOBA Compaction Assistant (MCA)

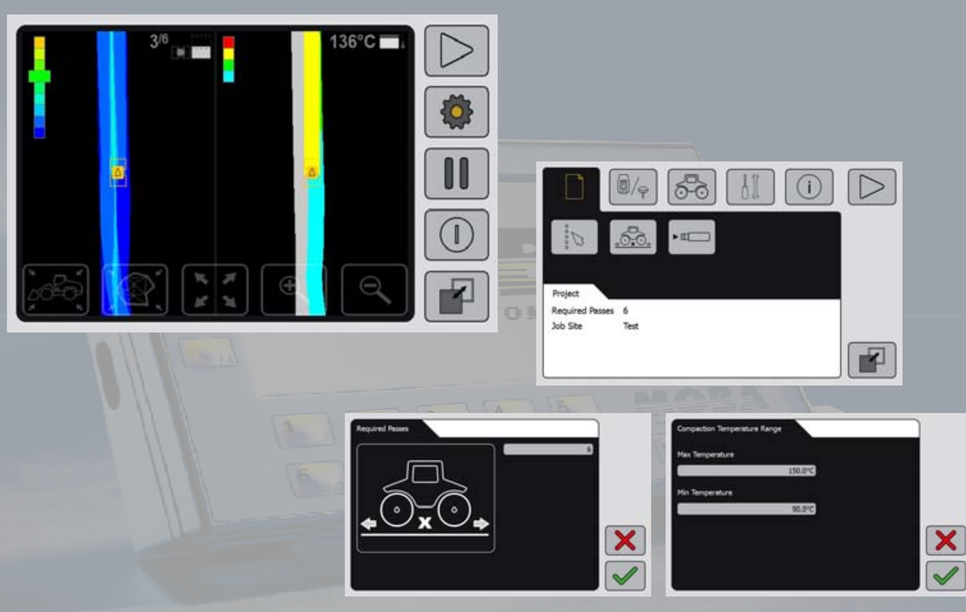
- GNSS Antenna
  - GNSS position
- IR temperature sensor
  - Surface temperature of asphalt
- Controller with Display
  - Controller for filtering and data preparation
  - Shows position, number of passes, track number and temperature



MOBA PAVE-IR 89

MOBA MOBILE AUTOMATION

Operator Interface



MOBA PAVE-IR 90

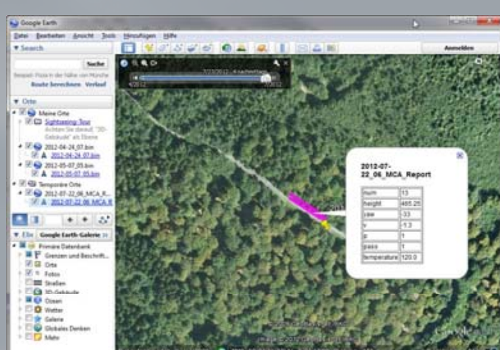
Screen View

Number of passes and position of the machine clearly indicated

Surface temperature of the material and position of the machine

Example Log-File

- Log files can be converted to KML Files to be shown as GPS track together with collected data
- Reports are generated on USB stick

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14:00:24.556,  109, 8.1614507, 50.4900662, -60, 1.1, 1, 1,
14:00:25.586,  110, 8.161451,  50.4900659, -60, 0.7, 1, 1,
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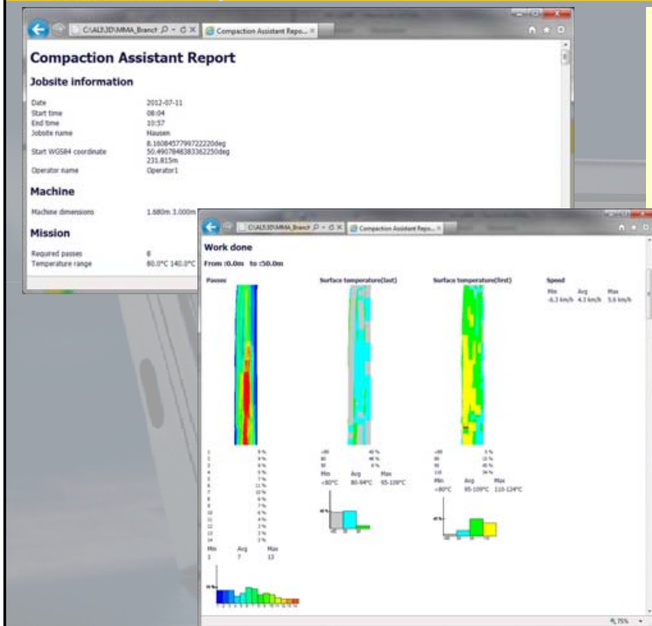
Report Example

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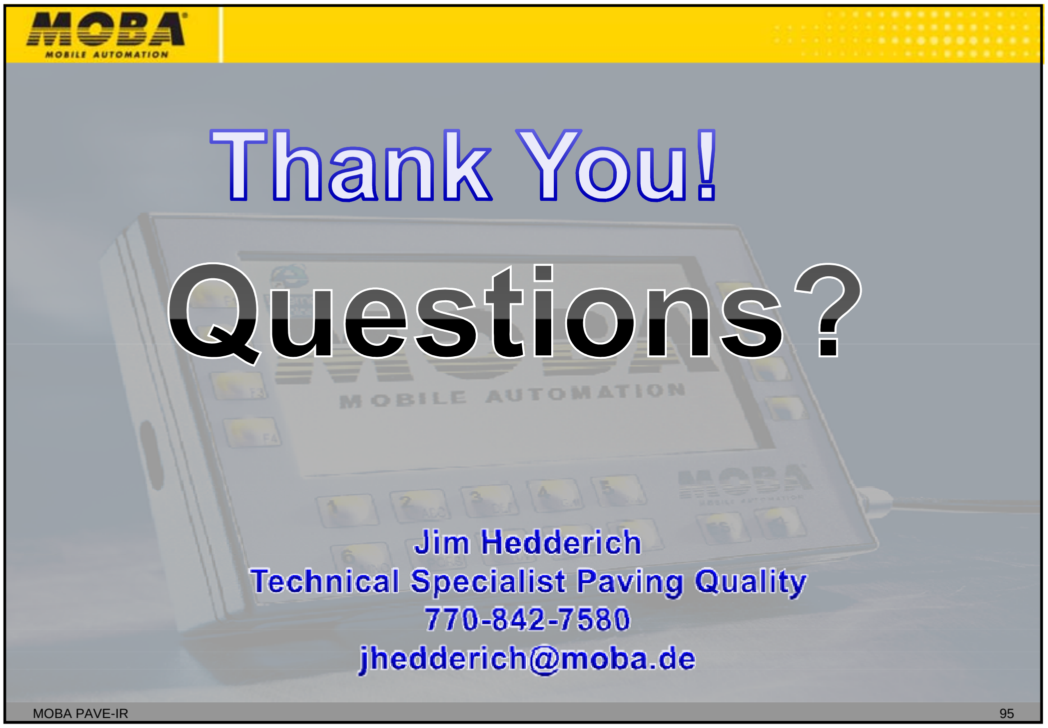
MOBA PAVE-IR 93

ONGOING DEVELOPMENT

- Next Generation PAVE-IR(I)
  - Real-time (pre-compacted) IRI smoothness measurement.
  - Network (wireless) to onboard compaction systems.
  - Wireless transmission of job data to QC office or plant.
  - Grade and slope control monitoring.
  - Material control (auger/conveyor) system monitoring.
  - Infrared scanner mounted above paver deck.

MOBA PAVE-IR 94


MOBA
MOBILE AUTOMATION
Thank You!
Questions?
Jim Hedderich
Technical Specialist Paving Quality
770-842-7580
jhedderich@moba.de
MOBA PAVE-IR
95


MOBA
MOBILE AUTOMATION
Merry Christmas
MOBA PAVE-IR
96