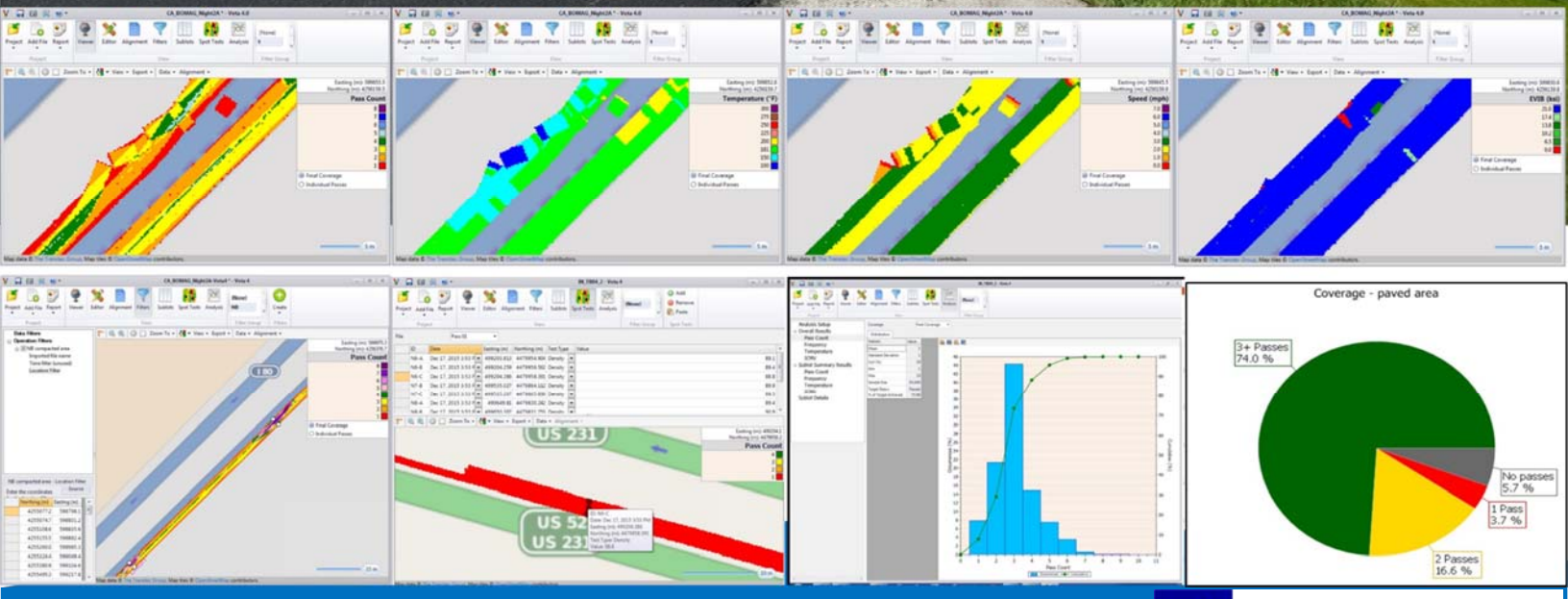
Veta5
INTELLIGENT CONSTRUCTION

ICDM-Veta Workshop

Intelligent Construction Data Management

Flexible Pavements of Ohio
Columbus, OH
16 April 2018



THE TRANSTEC GROUP
The World's Pavement Engineering Specialists

ICDM-Veta Workshop

Intelligent Construction Data Management

TABLE OF CONTENTS

Workshop Agenda

OBJECTIVES

- To understand the basics of the Intelligent Compaction (IC) and Paver-Mounted Thermal Profiles (PMTP) technologies and Veta software.
- To understand DOT IC/PMTP specifications and how to meet the requirements
- To understand the IC/PMTP data collection, data characteristics, and trouble shooting.
- To practice hands-on Veta analysis to understand how to meet DOT's expectation.

WORKSHOP AGENDA

AM

08:30 am	Veta software setup and checks
09:00 am	Session 1 - IC/PMTP Basics
09:45 am	Session 2-1 - IC/PMTP Field Data Collection & Management (I)
10:30 am	Break
10:45 am	Session 2-2 - IC/PMTP Field Data Collection & Management (II)
12:00 pm	Break

PM

01:00 pm	Session 3 - IC/PMTP Data Analysis & Interpretation
02:15 pm	Break
02:30 pm	Session 4 - IC/PMTP Trouble Shooting
03:30 pm	Session 5 - Review and Discussion
04:00 pm	Adjourn

Contact Information

If you would like more information or have questions or comments regarding any of the topics presented at this workshop please contact the following. Thank you for your participation in this workshop.

ICDM TRAINER

Dr. George K. Chang, P.E.

Director of Research
The Transtec Group
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Phone: +1 (512) 451-6233
Email: GKchang@TheTranstecGroup.com

Dr. George Chang is recognized as the expert on pavement smoothness and intelligent compaction/construction technologies. His research, teaching, specification development and software tools (such as ProVAL and Veta) have helped made significant technology advancements in the above fields. Dr Chang has been the principal investigator for numerous projects that enhancing pavement materials/structures, pavement surface characteristics, etc. Recognized for his energetic, lively teaching style, Dr. Chang delivers smoothness and intelligent compaction/construction related workshops around world.

Dr. Chang has been the chairman for the International Intelligent Construction Technologies Group (IICTG), Road Profile Users' Group (RPUG), TRB AFD90 Pavement Surface Properties and Vehicle Interaction committee, etc. Dr. Chang received many awards including a Kummer Lecture Award, Meyer-Horne Award, and ASTM Billiard-Stubstad Award from the ASTM; and NOVA award from Construction Innovation Forum, Founders' Award from RPUG. His research work has been featured in over 50 professional publications and 100+ reports.

Intelligent Compaction website: www.IntelligentCompaction.com

Transtec Group website: www.TheTranstecGroup.com

Workshop Slides

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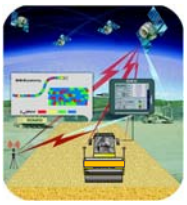
Session 1A
IC Basics

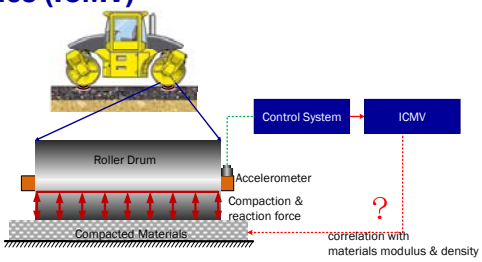


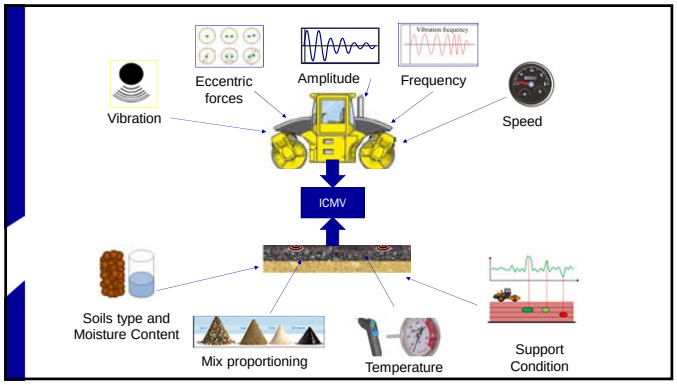
OEM IC Systems

Example IC Retrofit System

Soils IC vs. Asphalt IC

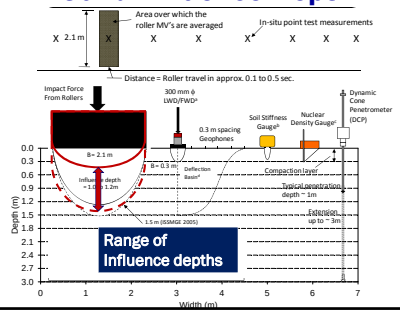
Intelligent Compaction Measurement Values (ICMV)





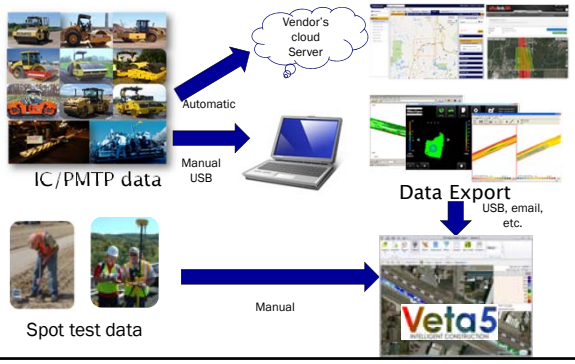
Various ICMVs

Foot Print and Influence Depth



Asphalt Density vs ICMV (Stiffness)

Standard IC Software - Veta



Direct Download from Cloud to Veta

IC/PMTP data

Automatic Wireless Transmission

Manually "Push"

Project and Machines IDs setup

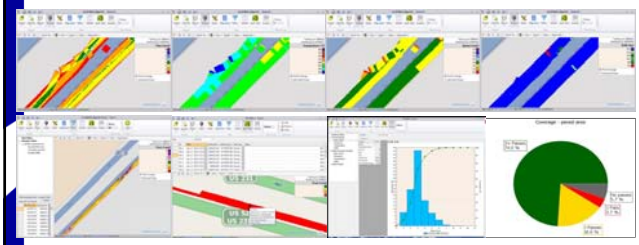
Vendor's cloud Server

Ungridded or gridded data files

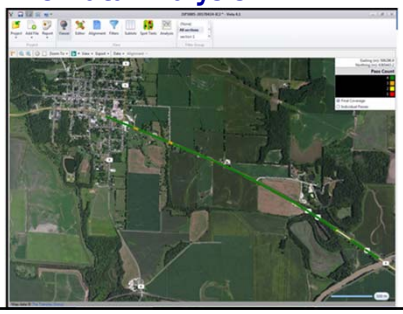
Storage time

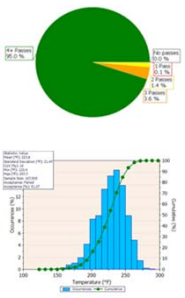
user log-in for access

Veta IC Analysis

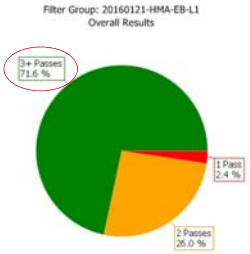


IC Data Analysis

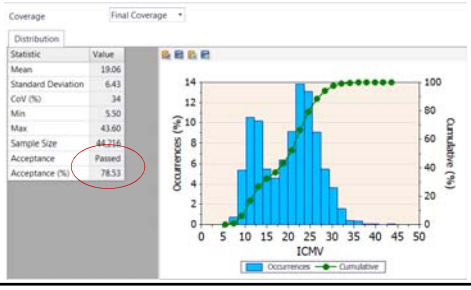




Veta Analysis – Coverage of Target Passes

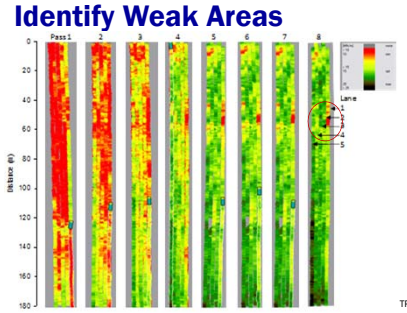


Veta Analysis – Coverage of Target ICMV



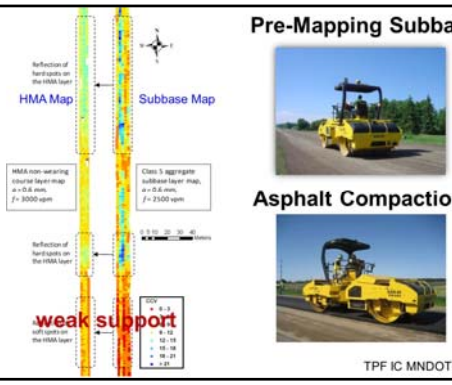
Benefits of Using IC and PMTP

Identify Weak Areas



TPF IC project at TxDOT

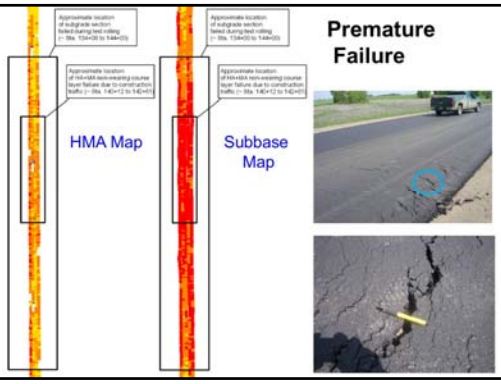
Pre-Mapping Subbase



Asphalt Compaction

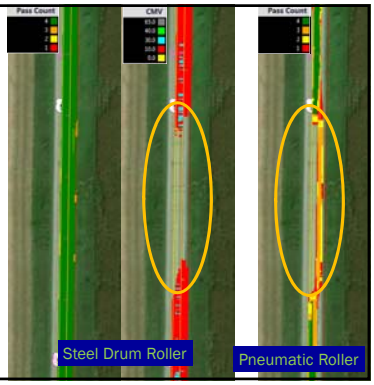
TPF IC MNDOT Project

Premature Failure

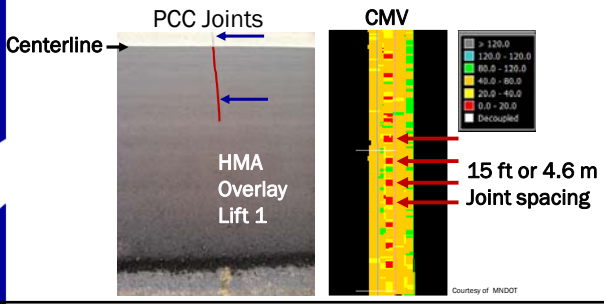


Premature Failure

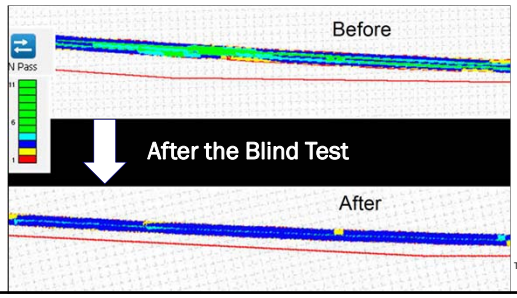
Check for soft spots and repair before any paving is allowed.



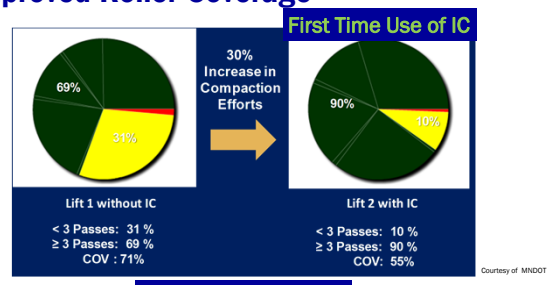
Identify Underlying Joints



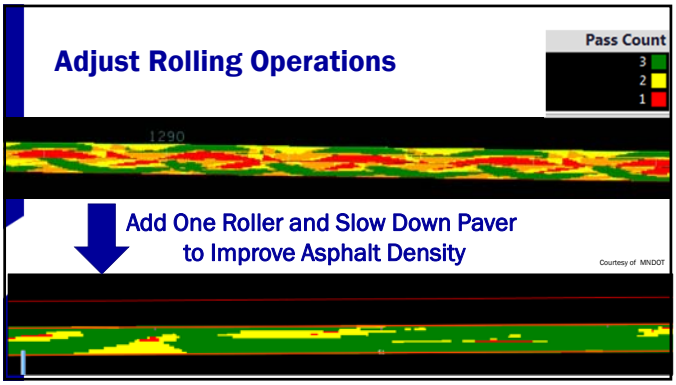
Improved Rolling Pattern



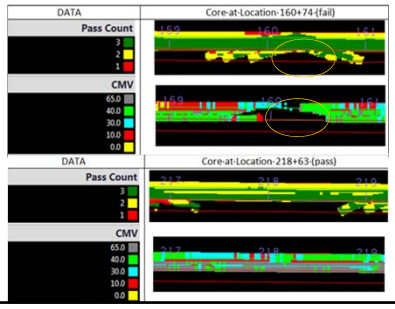
Improved Roller Coverage



Adjust Rolling Operations



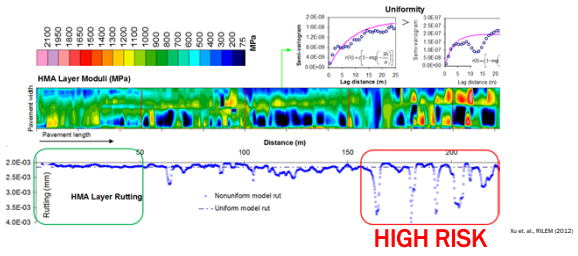
Identify Causes of Failed Density



Failed
Turn off Vib Too Early

Passed
Consistent Vib Thru Out

Improved Uniformity & Performance



Hands-on Exercise with Veta

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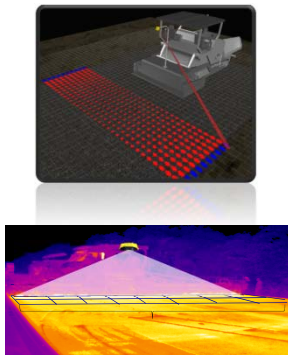
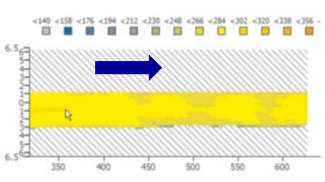
Session 1B
IR/PMTP Basics

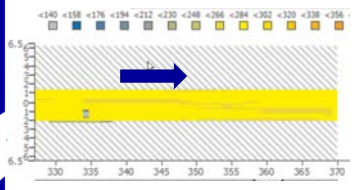


Thermal Segregation



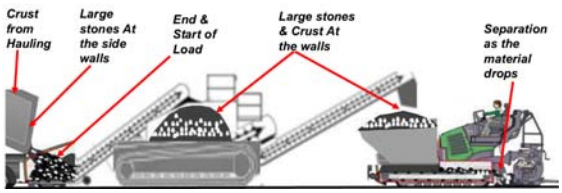
Courtesy of Vogele

Thermal Steaks



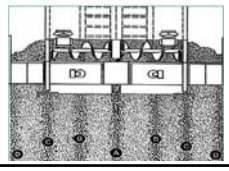
Courtesy of Vogele

Causes of Segregation

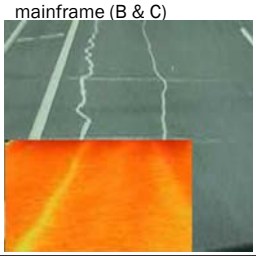


Courtesy of Vogele

Segregation and Thermal Streaks from Tractor

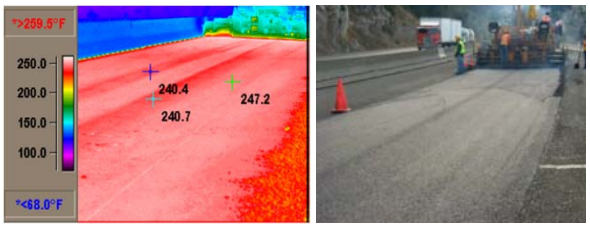


- Center line (A)
- Edge of conveyor tunnel to end of mainframe (B & C)



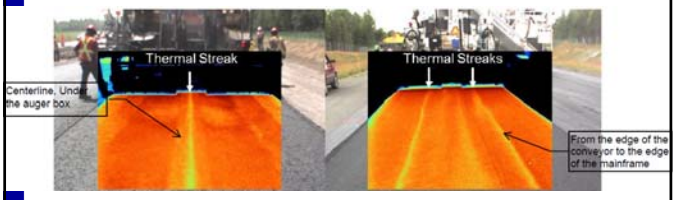
Courtesy of Vogele

Thermal Map to Detect Thermal Streaks



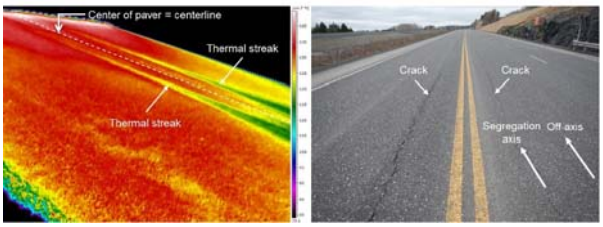
Courtesy of WSDOT

Thermal Map to Detect Thermal Streaks



Courtesy of MTQ, Canada

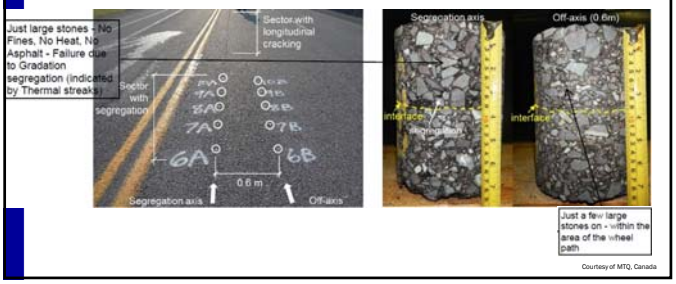
Thermal Streaks and Longitudinal Cracks



< 2 Years Later

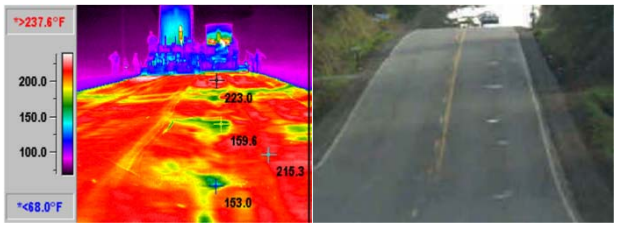
Courtesy of MTQ, Canada

Comparison of Core Samples



Courtesy of MTQ, Canada

Thermal Maps and Surface Distresses



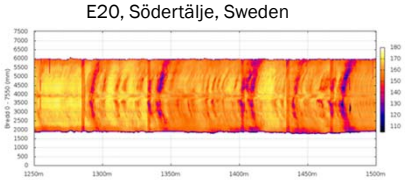
1.5 Years Later

Courtesy of WSDOT

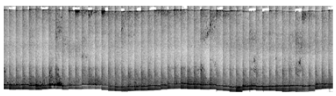
Thermal Maps and Surface Distresses

E20, Södertälje, Sweden

1998



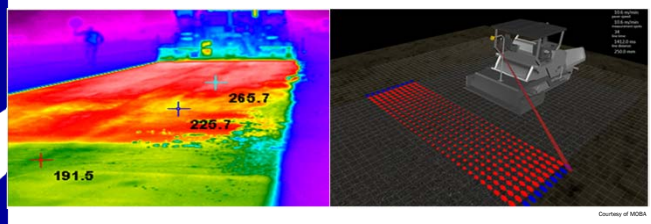
2013



15 Years Later

Courtesy of Volvo

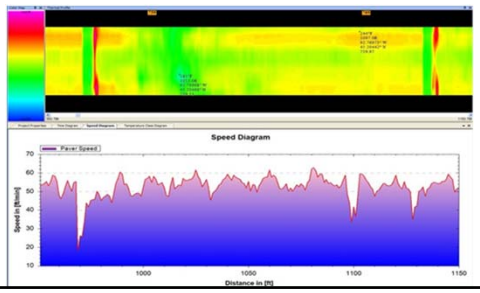
Thermal Camera vs IR/PMTP



Courtesy of MOBA

An Example IR/PMTP (MOBA PAVE-IR)

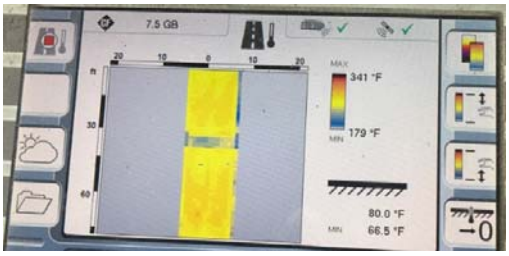
Example IR/PMTP Software (MOBA PPM)



An Example IR/PMTP (Vogele RoadScan)

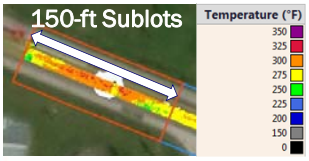
Courtesy of Vogele

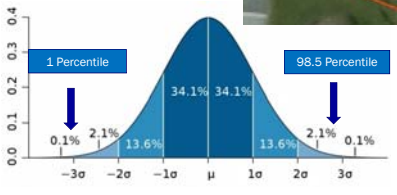
Example IR/PMTP Onboard Display (Vogele RoadScan)



Courtesy of Vogele

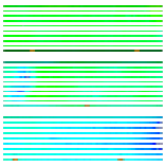
AASHTO PP80 Range Value





Range = $Temp_{98.5Percentile} - Temp_{1Percentile}$

AASHTO PP80 Temperature Segregation

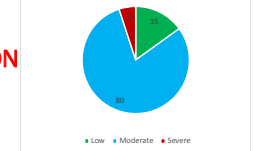
150-ft Sublots	Range	Segregation
	ΔF≤ 25°F	NO SEG
	25°F<ΔF≤ 50°F	MODERATE
	ΔF> 50°F	SEVERE

AASHTO PP80

Temperature Segregation – MTV Usage

% SEVERE SEGREGATION

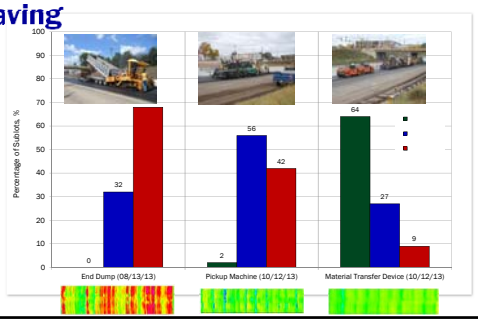
97 5



All Else Are Equal

Courtesy of MDOT

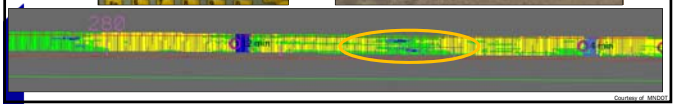
Temperature Segregation – Types of Paving



Courtesy of MNDOT

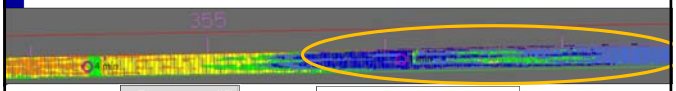
Identify Inconsistent Windrows

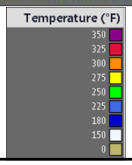
Material and Thermal Segregation



Courtesy of MNDOT

Monitor Material Changes





Courtesy of MNDOT

Mirror of Paver Stops with ALR

IR & Paver Stops

IRI ALR

Courtesy of MDOT

Hands-on Exercise with Veta

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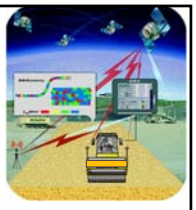
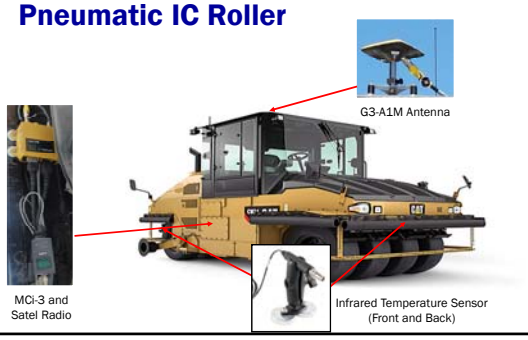
Session 2A
IC Data Collection & Management

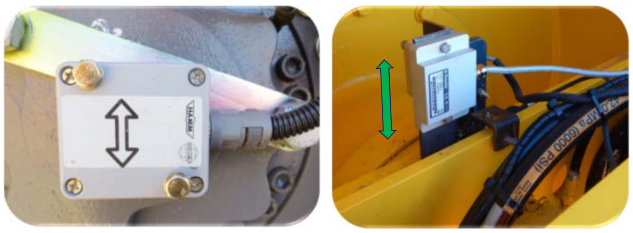


Steel Drum IC Roller

Pneumatic IC Roller



Accelerometer Installation

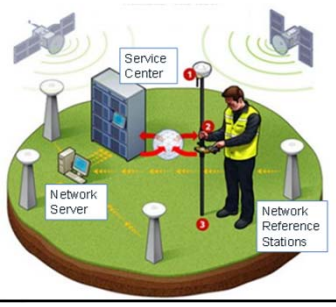


Example RTK GPS Setup

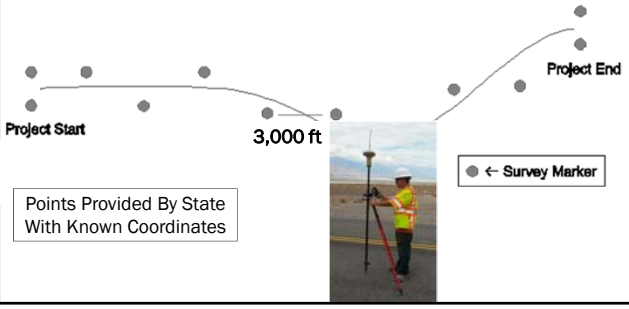

Topcon Base

Topcon rover FC-500

Network RTK VRS



GPS Site Localization



Points Provided By State With Known Coordinates

GPS Validation

GPS Verification Steps (1/2)

1. Move the IC roller around until the GNSS header computation is initialized.
2. Move the IC roller and park at a selected location.
3. Record the GPS measurements from the IC roller ensuring the distance offsets are applied so that the GPS coordinate is at the center or at left/right edges of the front drum.
4. Mark two locations on the ground adjacent to the right and left edges of the front drum contact patch. Move the IC roller from the marked locations.

GPS Verification Steps (2/2)

4. Use a hand-held rover to measure at the marked locations.
5. Average the rover GPS measurements if the roller GPS measurement is at the center of the front drum.
6. The difference should be within **± 6 in.** in both the northing and easting directions.

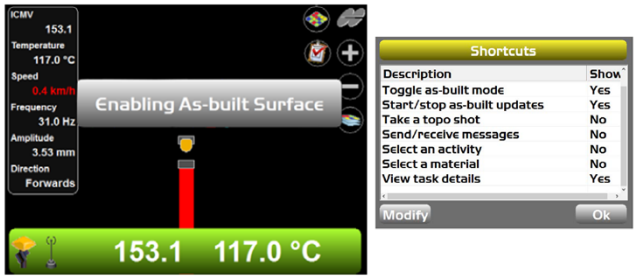
AASHTO PP81: Diff < 6 in.

Temperature Validation

AASHTO PP81: Diff < 5 °F

Example Onboard Display

Example IC Data Recording



Spot Tests and GPS Data

Spot Tests and GPS Data

Correct Data Header

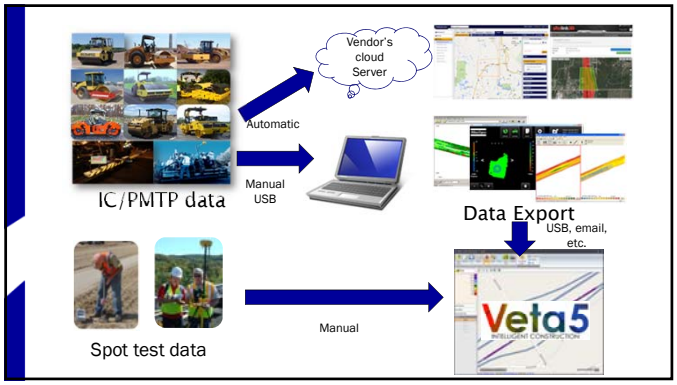
ID	Northing	Easting	Test Type	Value
1L	5102410.802	560248.063	Density	95.63
1R	5102409.890	560249.459	Density	95.25
2L	5102423.595	560256.379	Density	96.02
2R	5102422.497	560258.069	Density	94.54
3L	5102436.060	560265.330	Density	93.71
3R	5102435.396	560266.218	Density	92.55
4L	5102448.572	560273.393	Density	95.12
4R	5102447.924	560275.045	Density	94.93
5L	5102461.003	560281.786	Density	94.35
5R	5102460.098	560283.459	Density	95.18
6L	5102472.913	560289.933	Density	93.96
6R	5102472.107	560291.703	Density	95.76
7L	5102485.355	560298.722	Density	94.86
7R	5102484.580	560300.321	Density	95.76
8L	5102498.166	560307.125	Density	94.41

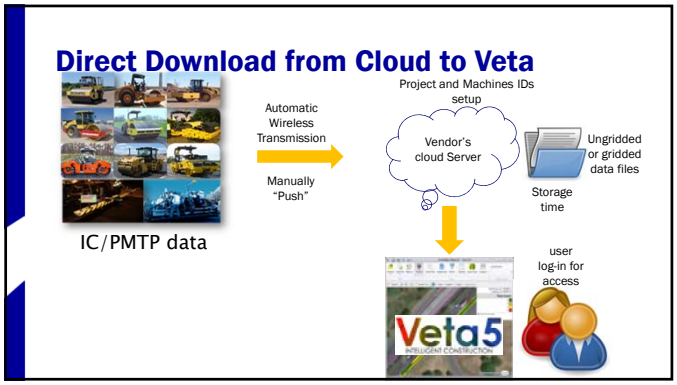
Daily Production Boundary

Example of Daily production boundary

Clockwise or Counter Clockwise

sorted	Northing	Easting
Topo1	4365077.823	527207.6672
Topo3	4365072.49	527235.9402
Topo5	4365063.552	527282.5929
Topo7	4365053.827	527333.843
Topo9	4365044.619	527383.1064
Topo11	4365039.856	527408.6073
Topo13	4365035.326	527432.938
Topo15	4365029.652	527465.2944
Topo17	4365025.619	527491.2948
Topo19	4365021.865	527516.8313
Topo21	4365018.407	527542.3913
Topo23	4365015.46	527567.2319
Topo25	4365012.854	527592.3938
Topo27	4365010.373	527617.8325
Topo29	4365008.086	527644.7281


Vendor's cloud Server
Automatic
Manual USB
IC/PMTP data
Data Export
USB, email, etc.
Manual
Spot test data
Veta5


Direct Download from Cloud to Veta
Project and Machines IDs setup
Automatic Wireless Transmission
Manually "Push"
Vendor's cloud Server
Ungridded or gridded data files
Storage time
IC/PMTP data
user log-in for access
Veta5


Direct Download from Cloud

Hands-on Exercise with Veta

Veta 5
INTELLIGENT CONSTRUCTION

Veta5
INTELLIGENT CONSTRUCTION

ICDM-Veta Workshop

Intelligent Construction Data Management

By
Dr. George K. Chang, PE

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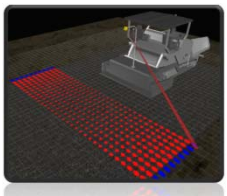
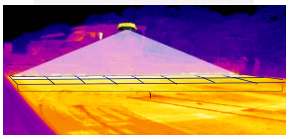
Session 2B
IR/PMTP
Data Collection & Management





Daily PMTP Setup

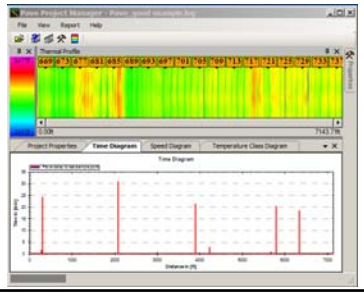
- Mount IR and GPS receiver on the paver
- Start the paver
- Calibrate IR DMI (if needed)
- Start a new IR file for data collection
- Record data
- Upload IR data to cloud or download to USB

MOBA PAVE-IR PMTP

MOBA PAVE-IR Components

Courtesy of MOBA

MOBA Pave-Project Manager



Vogele RoadScan PMTP

Courtesy of Vogele

Vogele RoadScan Hardware Kit

Bracket and Harness

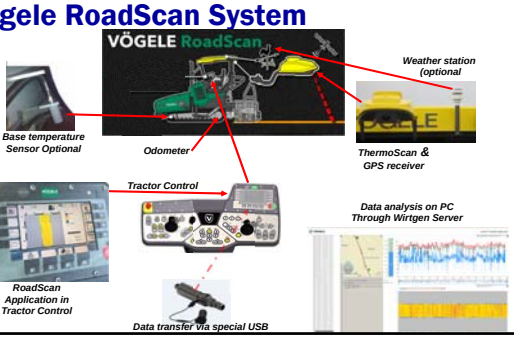
Thermal Camera

Optional Weather Station

Optional Ground Sensor

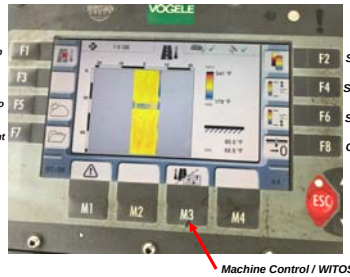
Courtesy of Vogele

Vogele RoadScan System

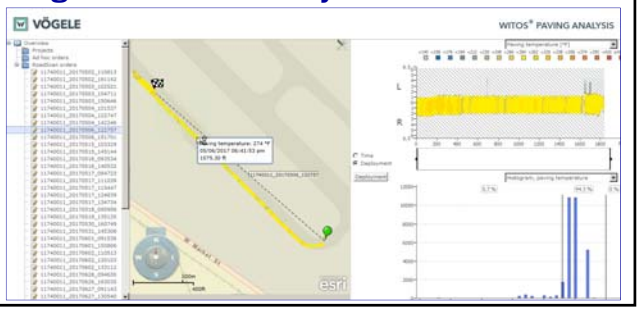


Courtesy of Vogele

Vogele RoadScan Tractor Control Screen



Vogele RoadScan Analysis Software



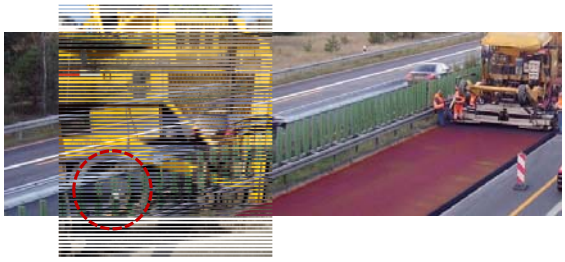
AASHTO PP80 Temperature Calibration

- Before each project, compare the thermal output from the surface temperature reading(s) to a NIST traceable temperature sensor when measuring a material of a known temperature.
- Tolerance 3.6°F or 2.0%

AASHTO PP80 GNSS Calibration

- Before each project, the GNSS output shall be compared to a survey grade rover coordinate over a static point. The comparison is considered acceptable if the X and Y distance between the GNSS system and survey rover are within the required limits (**<4 ft**).

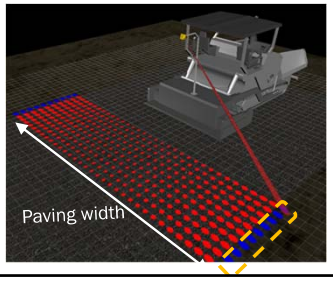
PMTP DMI Calibration



Courtesy of MOBA

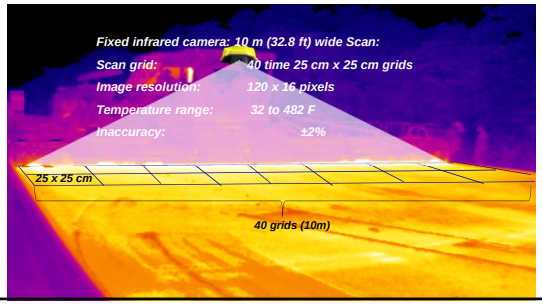
MOBA PAVE-IR Measurements

1 ft X 1 ft grids

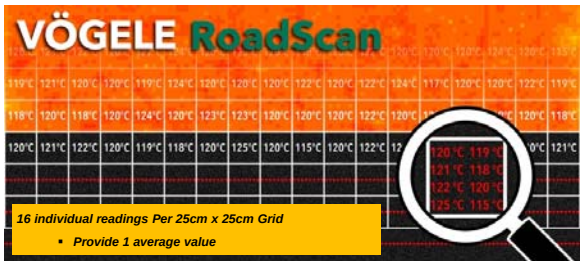


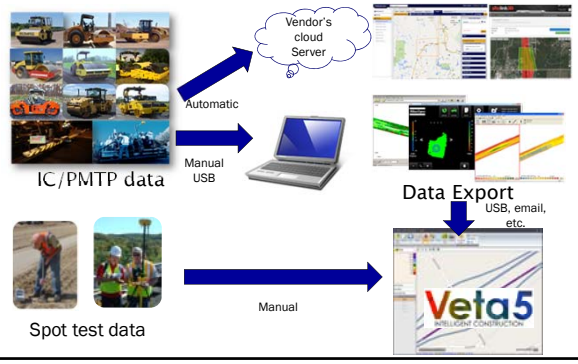
Adjacent Pavements /shoulder

Vogele RoadScan Measurements



Vogele RoadScan Measurements





Direct Download from Cloud to Veta

IC/PMTP data

Automatic Wireless Transmission

Manually "Push"

Project and Machines IDs setup

Vendor's cloud Server

Ungridded or gridded data files

Storage time

user log-in for access

Veta5 INTELLIGENT CONSTRUCTION

Hands-on Exercise with Veta

Veta5 INTELLIGENT CONSTRUCTION

Veta5
INTELLIGENT CONSTRUCTION

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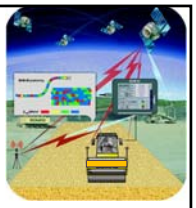
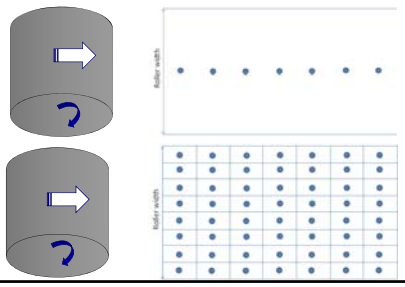
Session 3A
IC Data Analysis & Interpretation

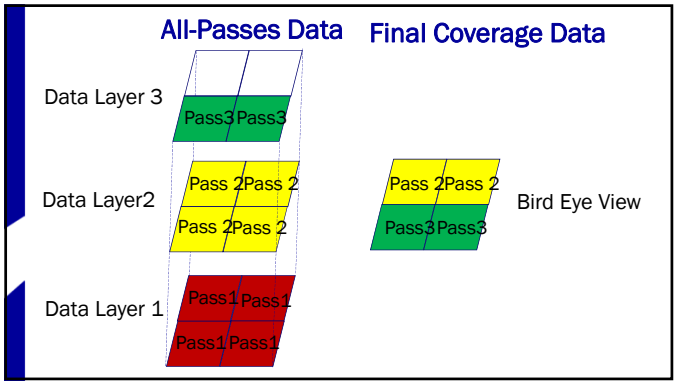


IC Raw and Gridded Data



Raw Data

Gridded Data



Vendors IC Data Formats

Features	BOMAG	Caterpillar/ Trimble	Dynapac	Hamm/ Wirtgen
Filename extension(s)	*.csva	*.csv	*.txt	*amd.vexp
Text/Binary	Text	Text	Text	Text
Raw Ungridded	✓			
Geographic GPS data (Long./Lat.)		✓	✓	✓
Grid data (Northing/Easting)	✓	✓	✓	
Coordinate zone in header	✓		✓	✓
Mesh size (horizontal)	0.3m X 0.3m	1.0m X 0.15m	0.4mX 0.4m	0.6m X 0.5m

Vendors IC Data Formats (cont'd)

Features	Sakai/ Topcon**	Volvo	MOBA***	Leica***
Filename extension(s)	*.pln	*.csv	*.csv	*.cgt
Geographic GPS data (Long./Lat.)	Text	Text	Text	Text
Raw Ungridded	✓			✓
Grid data (Northing/Easting)	✓	✓	✓	✓
Coordinate zone in header	✓		✓	✓
Mesh size (horizontal)	0.2m X 0.2m	0.3m X 0.3m	0.25m X 0.25m	?

** Direct Download from the Cloud to Veta 5.0+

*** Veta 5.1+

Draft AASHTO ICT Data Standard


Standard Specification for

File Format of Intelligent Construction Data

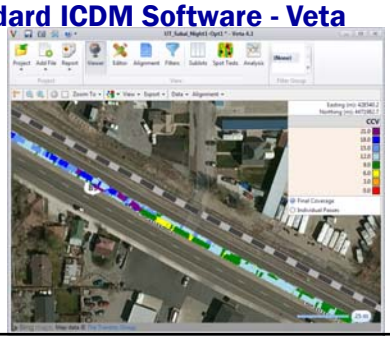
AASHTO Designation: MP NN-18[1]

AASHTO

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

Referenced in PP80 & PP81

Standard ICDM Software - Veta



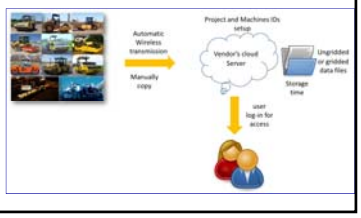
Required in PP81

IC Data Import to Veta

- Specific vendor's data
- Multiple days' data
- Multiple rollers' data from the same vendor
- Mix different vendors' data (not yet)
- Mix IC data with other types of data – IR, GPR, smoothness (not yet)

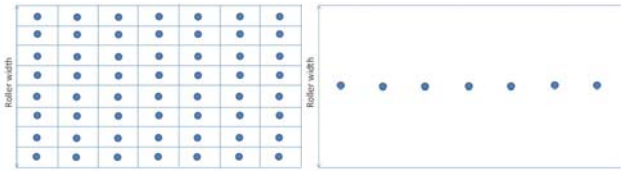
IC Data Import to Veta – Local vs. Cloud

- From local files
- Direct import from the Cloud (not yet)



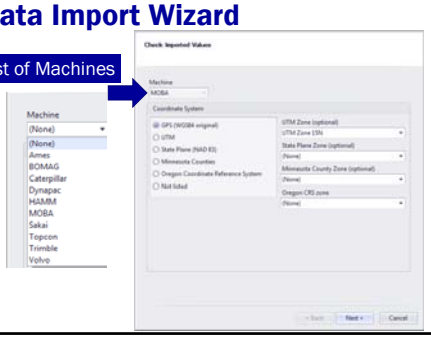
IC Data Import to Veta – Gridded vs. Raw

- Gridded All-passes data (Veta 4.0+)
- Raw ungridded data (BOMAG and TOPCON Cloud)

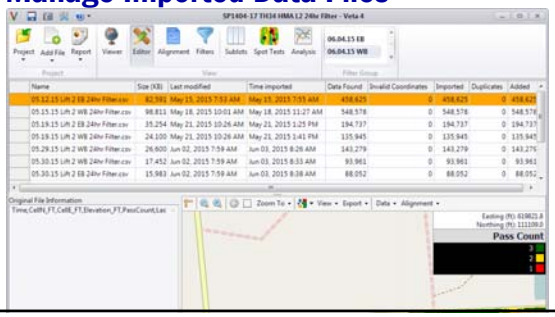


Data Import Wizard

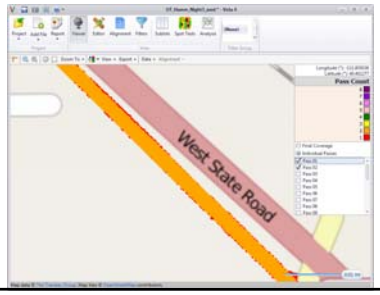
List of Machines



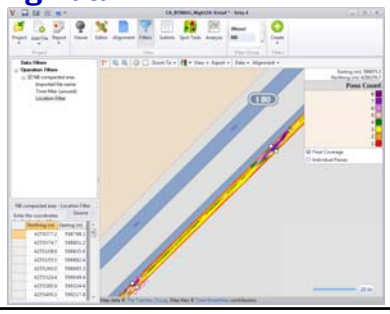
Manage Imported Data Files



View IC Data Maps

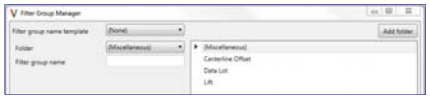


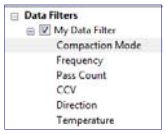
Filtering Data

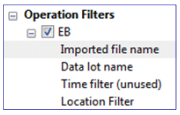


Filter Group

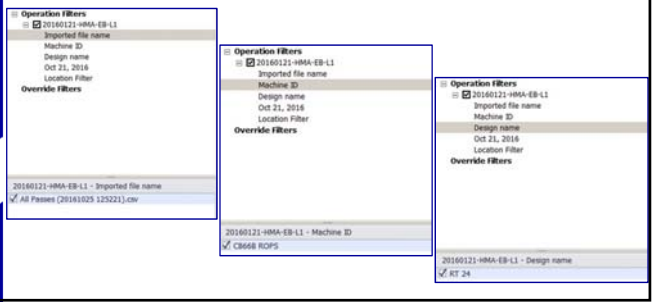
- Data Filter
- Operation Filter
- Overwrite Filter







Veta Operation Filter



Daily Production Boundary

Clockwise
or
Counter Clockwise

sorted	Northing	Easting
Topo1	4365077.823	527207.6672
Topo3	4365072.49	527235.9402
Topo5	4365063.552	527282.5929
Topo7	4365053.827	527333.843
Topo9	4365044.619	527383.1064
Topo11	4365039.856	527408.6073
Topo13	4365035.326	527432.938
Topo15	4365029.652	527465.2944
Topo17	4365025.619	527491.2948
Topo19	4365021.865	527516.8313
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Topo23	4365015.46	527567.2319
Topo25	4365012.854	527592.3938
Topo27	4365010.373	527617.8325
Topo29	4365008.086	527644.7281

Veta Location Filter

Sorted Daily Production Boundary

sorted	Northing	Easting
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Topo5	4365063.552	527282.59
Topo7	4365053.827	527333.843
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Topo11	4365039.856	527408.6073
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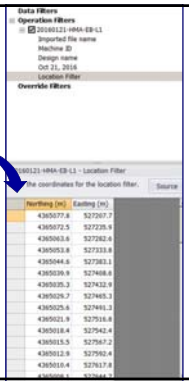
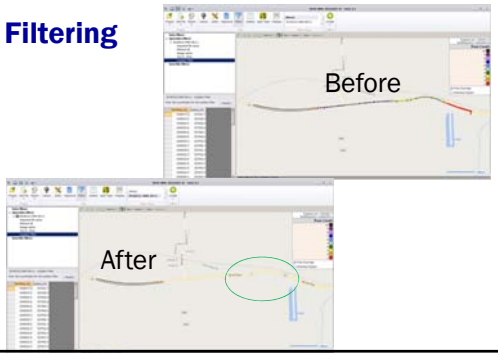
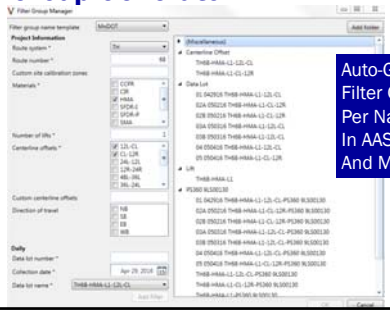


IC Data Filtering

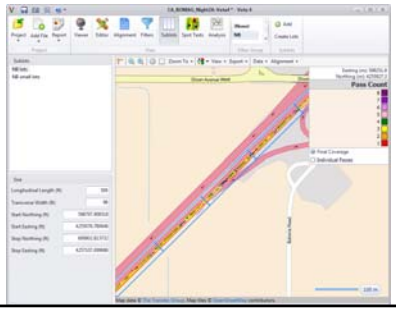


Filter Group Generator



Auto-Generated
Filter Groups
Per Naming Convention
In AASHTO PP81
And MnDOT specs

Create Sublots



Spot Tests and GPS data

Correct Data Header

ID	Northing	Easting	Test Type	Value
1L	5102410.802	560248.063	Density	95.63
1R	5102409.890	560249.459	Density	95.25
2L	5102423.595	560256.379	Density	96.02
2R	5102422.497	560258.069	Density	94.54
3L	5102436.060	560265.330	Density	93.71
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7R	5102484.580	560300.321	Density	95.76
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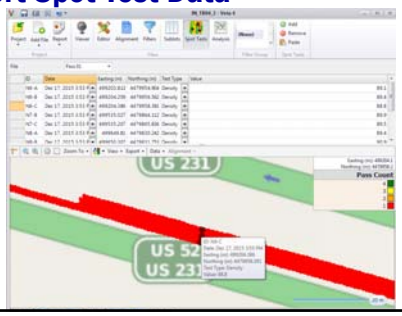
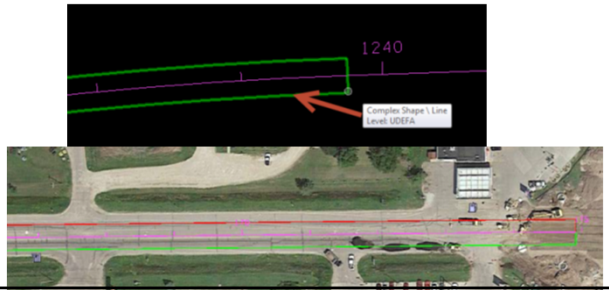
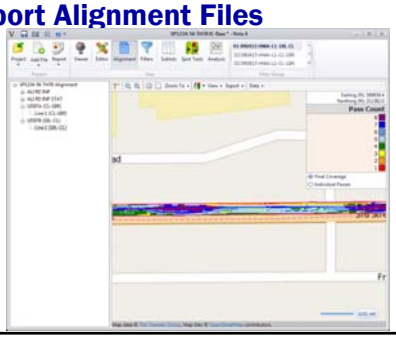
Import Spot Test Data



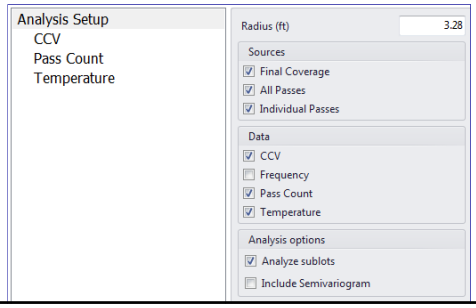
Alignment File - KMZ



Import Alignment Files



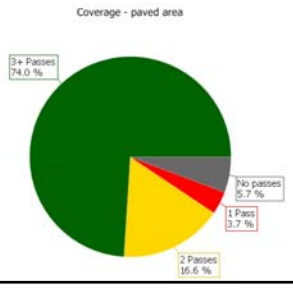
Veta Analysis Options



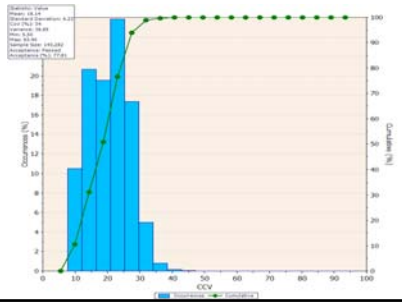
Veta Analysis Results

- Analysis Setup
  - CCV
  - Pass Count
  - Temperature
- Coverage
- Overall Results
  - CCV
  - Pass Count
  - Temperature
- Sublot Results
  - CCV
  - Pass Count
  - Temperature

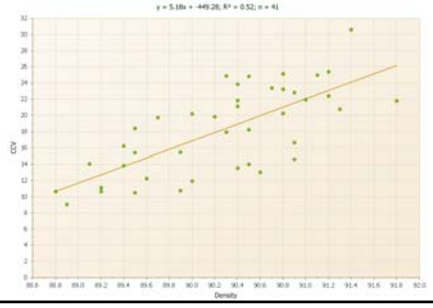
Coverage Result



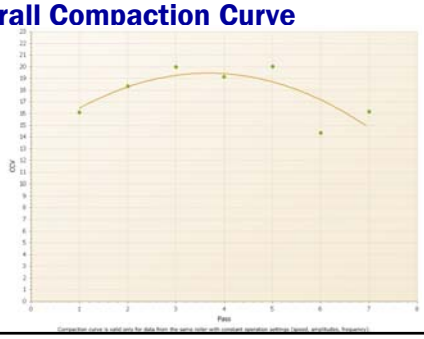
Overall Statistical Analysis



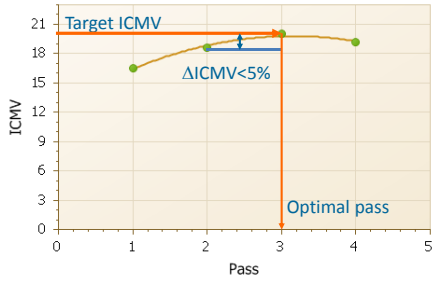
Overall Correlation Results



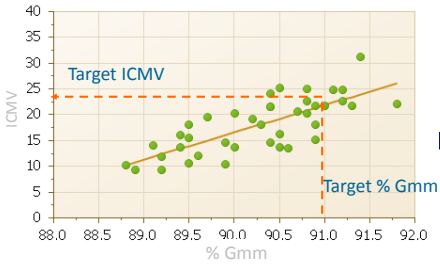
Overall Compaction Curve



Target ICMV for QC

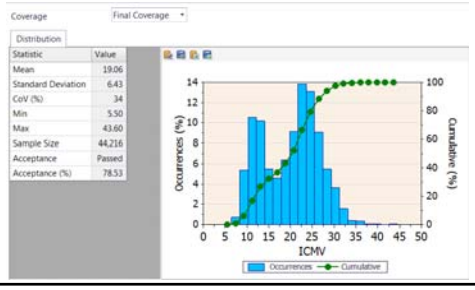


Target ICMV from Trial Section Data

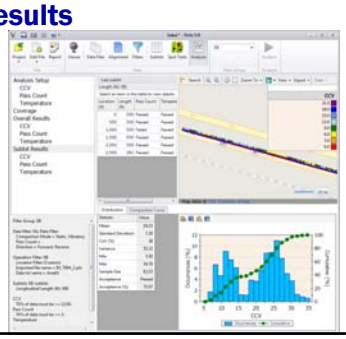


Passing
$R > 0.7$
Or
$R^2 > 0.5$

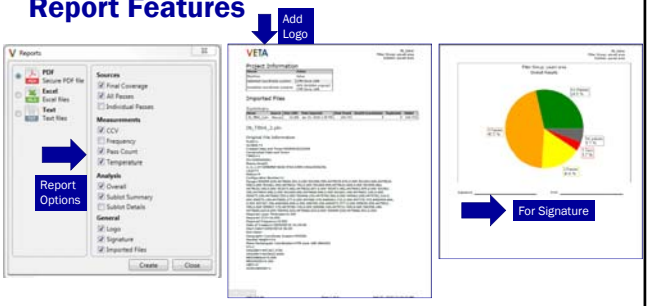
Coverage of Target ICMV



Sublot Results



Report Features



Hands-on Exercise with Veta

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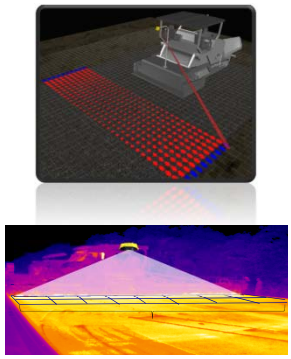
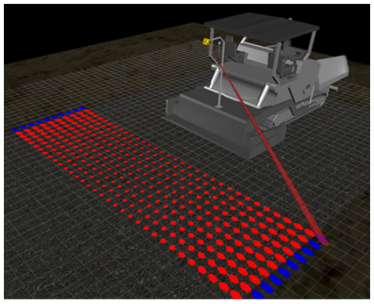
Session 3B
IR/PMTP
Data Analysis & Interpretation



IR/PMTP Measurements



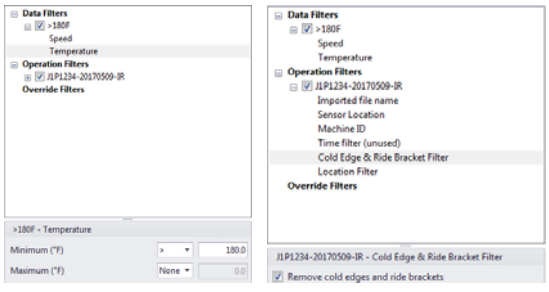
Standard ICDM Software - Veta

AASHTO

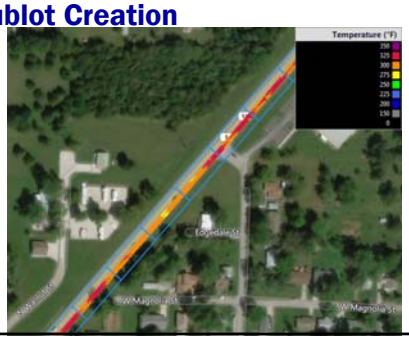
Required in PP80

Import IR/PMTP Data to Veta

Data Filter and Location Filter

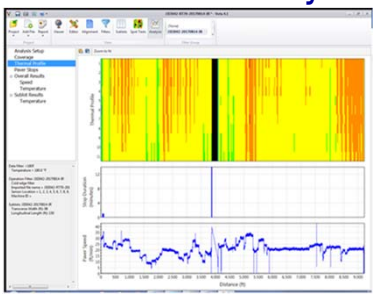


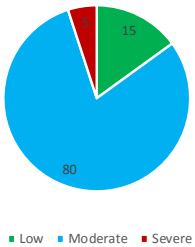
Sublot Creation



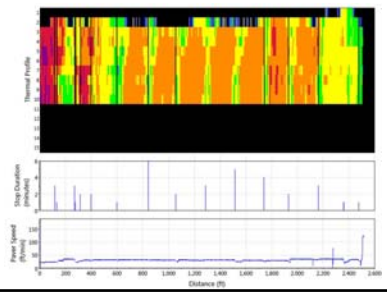
Automated
In
Veta 5.0+

Veta PMTP Data Analysis

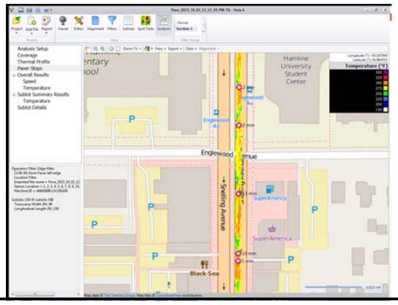




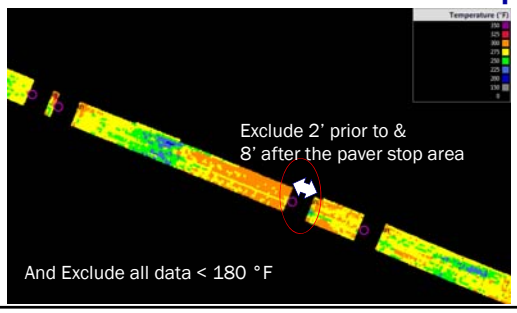
Thermal Profile, Paver Stops/Speeds



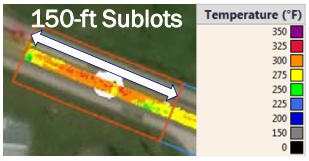
Veta Paver Stop Map

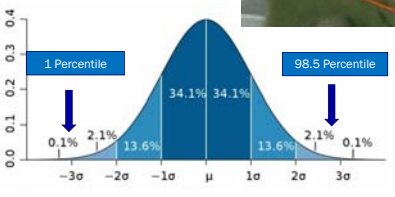


AASHTO PP80 Exclusion of Paver Stops



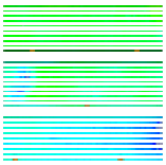
AASHTO PP80 Range Value





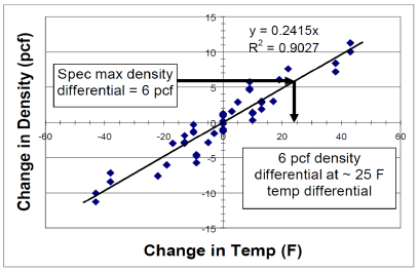
Range = $Temp_{98.5Percentile} - Temp_{1Percentile}$

AASHTO PP80 Temperature Segregation

150-ft Sublots	Range	Segregation
	ΔF≤ 25.0°F	NO SEG
	25.1°F<ΔF≤ 50.0°F	MODERATE
	ΔF> 50.1°F	SEVERE

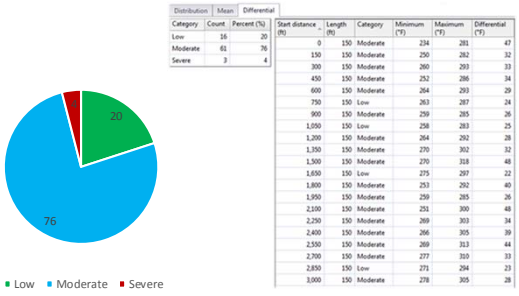
AASHTO PP80

Criteria for Severity of Temperature Segregation



Courtesy of TXDOT

Veta AASHTO Thermal Segregation Report



Temperature Segregation Index (TSI)

$$TSI = c \times TSI_{StDev} + (100 - c) \times TSI_{TSV}$$

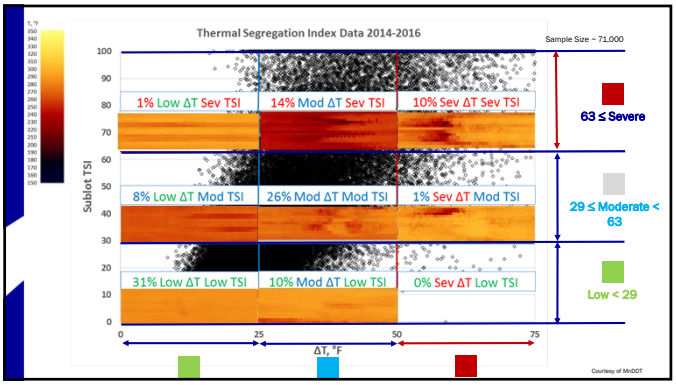
$$TSI \leq 100$$

where

$$TSI_{StDev} = 0.77 \times \frac{StDev}{StDev_{SevereStart}}$$

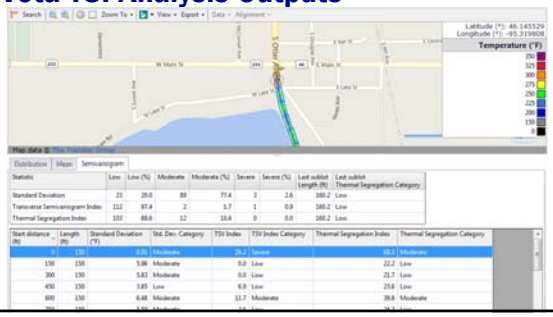
$$TSI_{TSV} = 0.77 \times \frac{TSV}{TSV_{SevereStart}}$$

$c = \%\ contribution\ of TSI_{StDev} to\ TSI,$
typical value = 50



Veta Temperature Segregation Index (TSI) Inputs

Veta TSI Analysis Outputs



Hands-on Exercise with Veta

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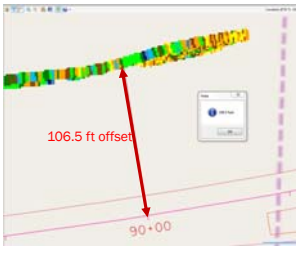
Session 4A
IC Trouble Shooting

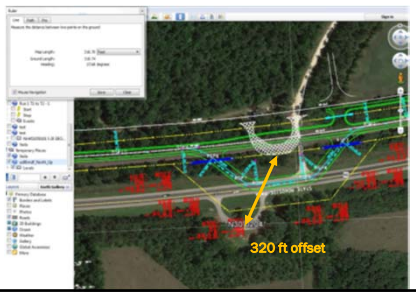
GPS Offset – IC Data and Alignment



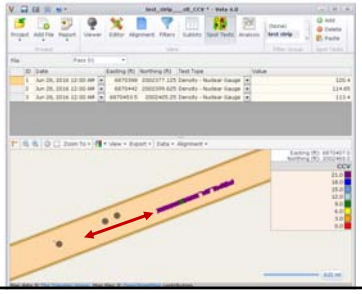
GPS Offset – IC data and Alignment

IC Data Offset

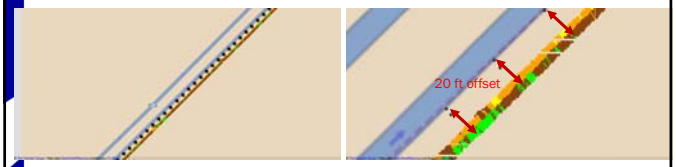
Offset of Alignment



GPS Offset – IC data and Spot Tests



GPS Offset – IC data and Spot Tests



IC roller GPS Receiver and Radio

- Inspection of radio and cable
- Radio status indicator light (Solid/Flashing)
- Onboard diagnostics
- Communicate with Radio via machine display
- Restart radio: power down, remove cable and reapply cable.
- Antennas-switch in known good antennas
- Communicate with Radio via PC

Courtesy of Trimble

GPS Issues

- Calibration of site or of machine
- Control points or bad network
- Base station moved
- All rovers and machines offset at equal amount
- Design or data model

Courtesy of Trimble

Failed GPS Verification

UTM-10N (WGS 84) RTK

	Raw data		Converted (m to US survey ft)	
ID	Northing (m)	Easting (m)	Northing (US ft)	Easting (US ft)
B1	4255846.700000	599662.700000	13962723.715	1967393.375
B2	4255844.300000	599663.800000	13962715.841	1967396.984
T (static)	4255829	599663.1		

Diff ([redacted])

		Pass/Fail (0.5')	
Northing (survey	Easting (survey ft)	Northing	Easting
-1.81	3.2	Failed	Failed
-0.45	6.6	Passed	Failed
-1.68	3.9	Failed	Failed

Failed GPS Verification

- Inconsistent datum (WGS84, NAD83, HARN)
- Incorrect channel of GPS correctional signals
- Outdated firmware
- Incorrect offset values from the receiver to the center or both edges of front roller drum
- Incorrect datum and/or unit conversion
- Software bugs

GPS Coordinate Unit Conversion

- US Survey Feet
- International Feet
- Meters

Meters * 3937/1200 = U.S. Survey Feet

1 meter = 3.280833333333 US Survey Feet

1 US Survey Feet = 0.3048006096 meters

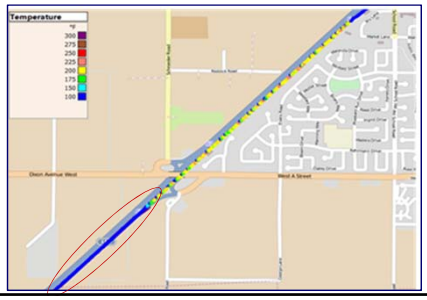
1 int'l Feet = 0.3048 meters

Diff (int'l feet & US Survey Feet) = 2 PPM (parts per million)

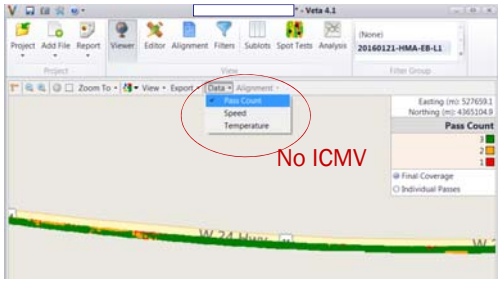
Missing Data

- Incorrect setup for data collection
- IC system not turned on
- No GPS signals or inaccurate signals
- Loose connections of sensors
- Out of ranges for sensors
- Failed telematics for wireless transmission

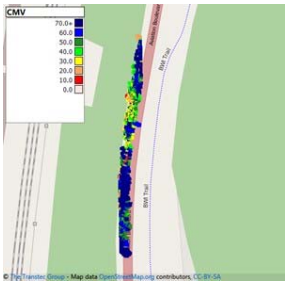
Loose Connections of IC Components



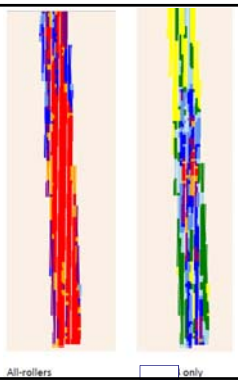
Missing ICMV



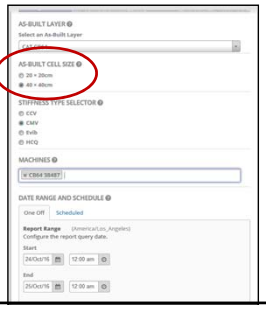
Bad GPS Signals



Low GPS Accuracy



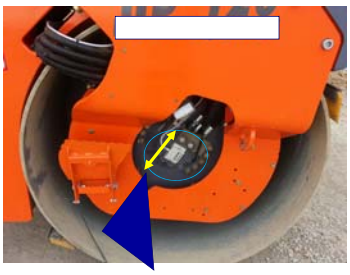
Incorrect Export Setting from IC Systems



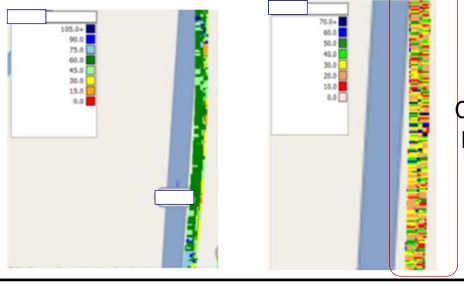
Design Filter for Data Export

- Create design filters for each roller and all-roller combined corresponding to each lift for each day of operation.
- Organize data files properly.
- Ensure the machine names are spelled out correctly in order to create proper filter for each machine or all machines combined.
- Create deign filter for each lift of paving.

Incorrect Accelerometer Installation

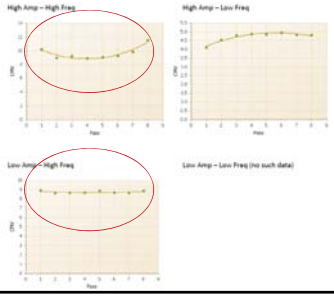


Incorrect Accelerometer Setup



Checkerboard Pattern

Incorrect Roller Settings



Unsorted daily boundary data for filtering

sorted in clockwise
or counter clockwise

Incorrect Boundary Points

Missing Data due to Bad GPS Reception

Other Issues

- Miss-handling of Data Files
- Incorrect File Naming Convention
- File Transmission Errors

Hands-on Exercise with Veta

Veta 5
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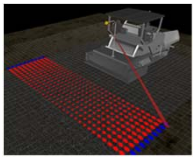
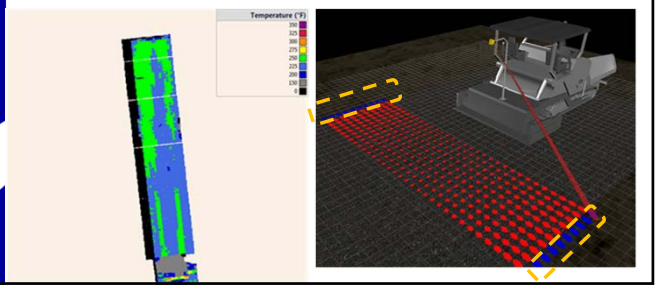
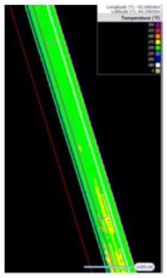
Session 4B
IR-PMTP
Trouble Shooting



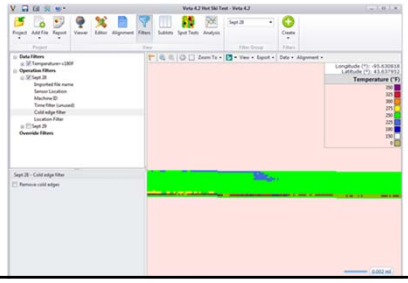
Cold Edges



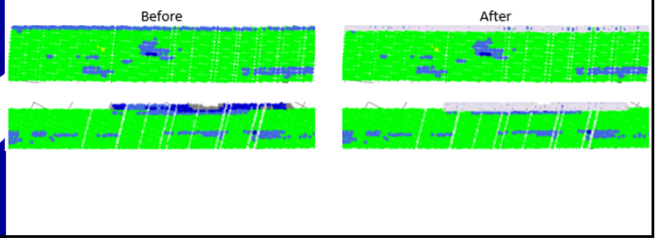
Hot Streaking



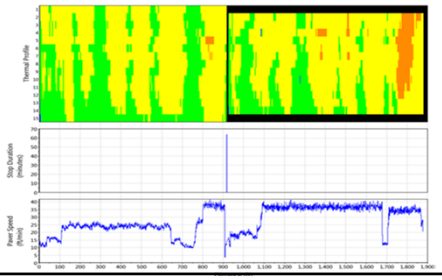
Correct Cold Edges and Streaking with Filter



Cold Edge Filter

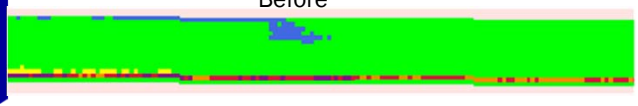


Excluded Cold Edges

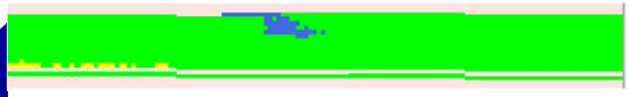


Cold Edge & Streaking Filter

Before



After



Lack of DMI Calibration

Thermal Profile Results Summary				
Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
90	3	3	87	97

10% DMI Error
1,280 ft

Correction with Proper DMI Calibration

Courtesy of MOBA

Missing Data

Thermal Profile Results Summary				
Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
77	15	19	62	81

Distribution | Mean | Differential

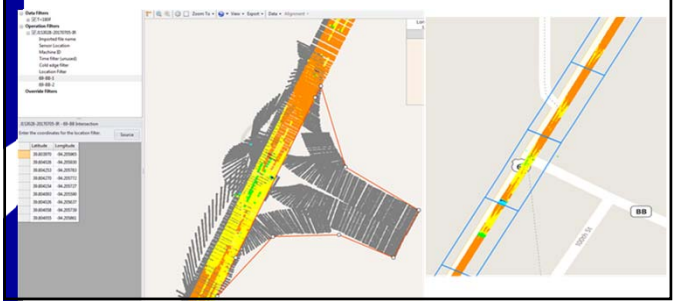
Category	Count	Percent (%)
Low	1	1
Moderate	39	30
Severe	91	69

Start distance (ft)	Length (ft)	Category	Minimum (°F)	Maximum (°F)	Differential (°F)
0	150	Severe	242	310	69
150	150	Severe	238	351	113
300	150	Severe	251	330	80
450	150	Severe	257	324	68
600	150	Moderate	263	306	43
750	150	Severe	254	308	54
900	150	Moderate	265	307	42
1,050	150	Severe	241	307	66
1,200	150	Moderate	266	309	44
1,350	150	Severe	232	308	76
1,500	150	Moderate	268	311	44
1,650	150	Severe	242	311	70
1,800	150	Severe	245	314	68
1,950	150	Moderate	291	321	30
2,100	150	Severe	247	314	67
2,250	150	Moderate	289	316	27

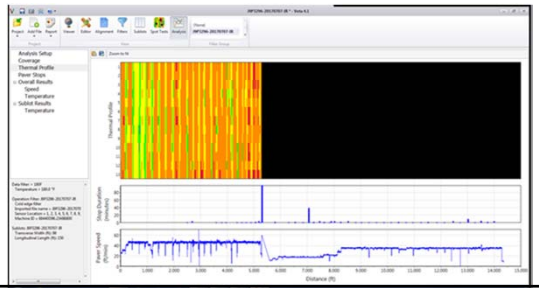
Missing 8,400 ft

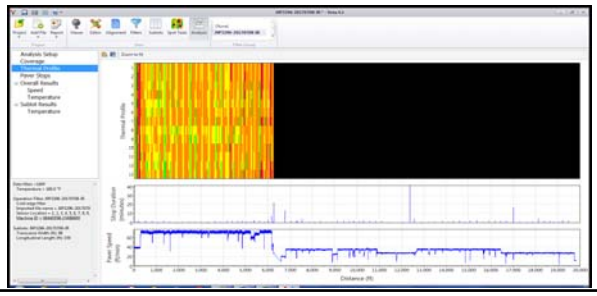
Paved at Adjacent Street

Correction with Exclusion Filter

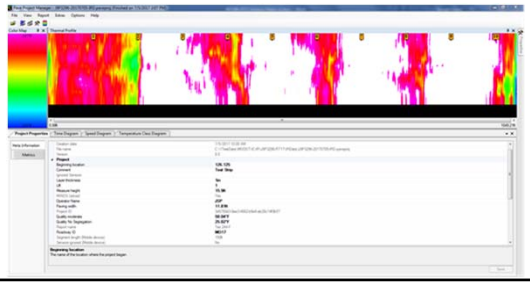


Issues with Sampling Intervals

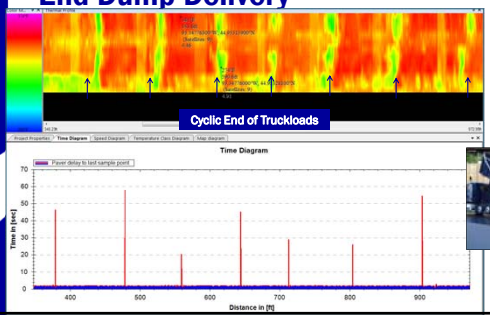




Out of Range Color Palette

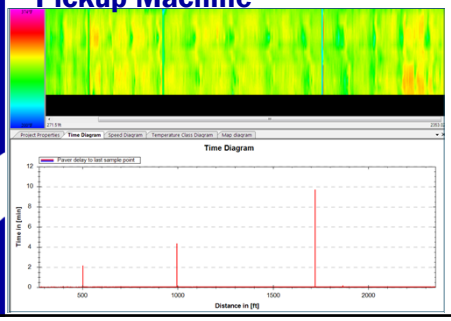


End Dump Delivery



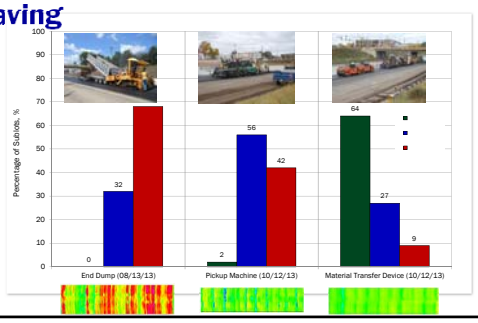
Thermal Segregation Category	Percent of Sublots
Low	0
Moderate	0
Severe	100

Pickup Machine



Thermal Segregation Category	Percent of Sublots
Low	0
Moderate	88
Severe	13

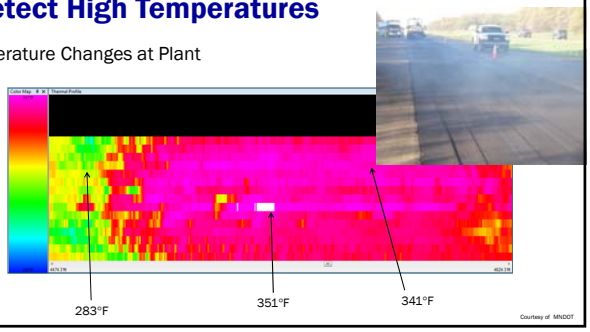
Temperature Segregation – Types of Paving



Courtesy of MNDOT

Detect High Temperatures

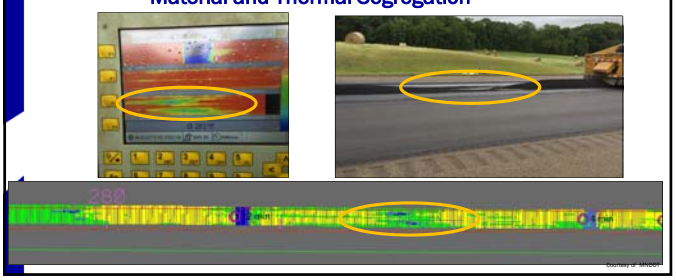
Temperature Changes at Plant



Courtesy of MNDOT

Identify Inconsistent Windrows

Material and Thermal Segregation

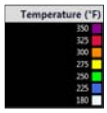


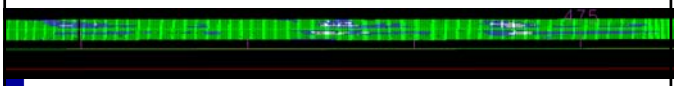
Courtesy of MNDOT

Running Paver Dry

Pave Hopper Empty

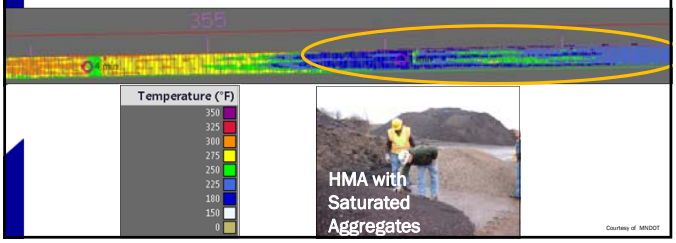
Pave Hopper Half Full





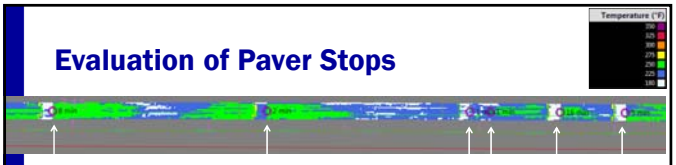
Courtesy of MNDOT

Monitor Material Changes



Courtesy of MNDOT

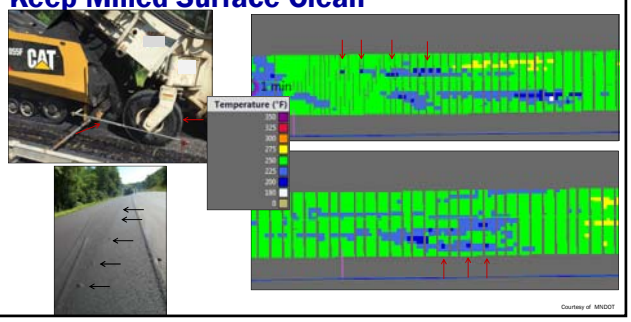
Evaluation of Paver Stops



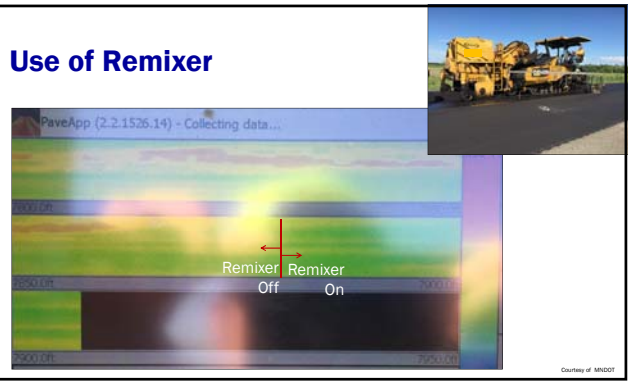
Overall graph of paver stops verses paving distance for 12L-CL

Courtesy of MNDOT

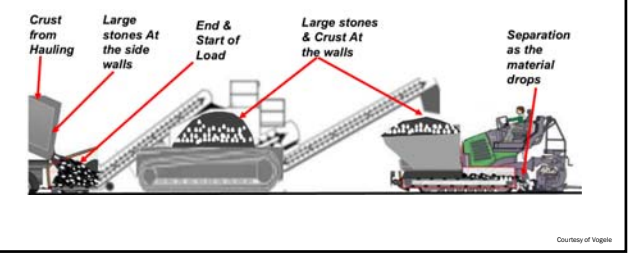
Keep Milled Surface Clean



Use of Remixer



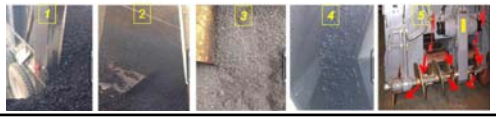
Trace Causes of Segregation



Remixing Opportunities

1. Remix Stones that rolled to the truck bed Side Walls
2. Remix Segregation from End & Start of Dumping
3. Remix Cold Crust on surface & side wall of truck bed & Insert
4. Remix Segregated stones from Pile in Insert during filling
5. Remix Segregation Created During Tractor to Screed Delivery

4 & 5 occurs after the MTV



Courtesy of Vogele

Remix at Last Point of Handling

Paver Stops

Screed Hold/ Lock/ Freeze

Mirror of Paver Stops with ALR

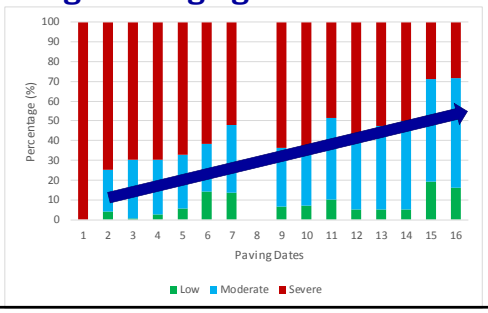
IR & Paver Stops

IRI ALR

Courtesy of MODOT

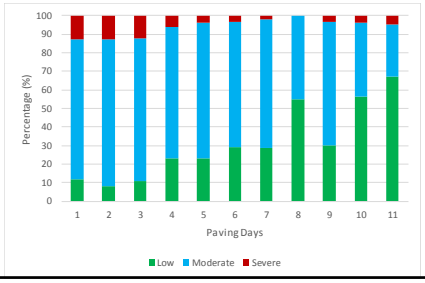
EB, 2017-04-24

Changes of Segregations



Courtesy of MODOT

Improvements Over Time



Hands-on Exercise with Veta

Veta 5
INTELLIGENT CONSTRUCTION

Veta Software

All workshop participants will be required to bring their laptop computers for the hands-on exercises with the Veta software.

VETA SOFTWARE

The Veta software **5.0.49** can be downloaded from the following weblink (~ 50MB)

http://www.intelligentcompaction.com/downloads/software/Veta-5.0.49.msi

VETA SAMPLES

The Veta example files can be downloaded from the following weblink (~ 100 MB)

http://www.intelligentcompaction.com/downloads/software/Veta-Samples-5.0.zip

COMPUTER SYSTEM REQUIREMENTS

The system requirements are: **64-bit versions of Windows 7** SP1 or later with Microsoft .NET 4.6.2+ installed.

SOFTWARE INSTALLATION

Participants need to pre-install the Veta software on their laptop computers prior to the workshop.

You must have sufficient privileges to install applications on your computer. If you receive an error message during the installation, ask your administrator to install the software for you. Email any installation questions to ICSupport@TheTranstecGroup.com .

REFERENCES

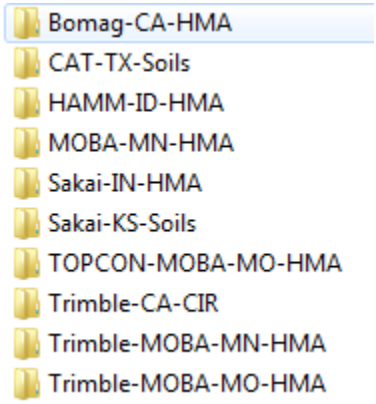
For Veta 4.x users, the following **Veta 5.0 Features document** will be useful:

http://www.intelligentcompaction.com/downloads/software/Veta-5.0-Features.pdf

Hands-on Sample Files

It is recommended to unzip the downloaded Veta sample files to your desktop:

There are several subfolders under the Veta sample files:



Step-by-Step instructions for the samples in PDFs are also within each sample folder.

BOMAG_CA_HMA

Learning Objectives:

- Import asphalt IC data from a BOMAG system
- Customize color legend to facilitate observation and recognize the importance of color palette
- Create filters group to extract desired data
- Create sublots for detailed analysis

Test Bed #2 (9/5-6/2013)

Description:

This is a long-life asphalt overlay project in Vacaville, CA.
Test bed #2 is located on I-80 in eastbound direction from Station 325+00 to 425+00 for 10,000 ft.
Three IC rollers (Caterpillar, Hamm, and BOMAG) and one conventional roller (BOMAG) were used.
The Caterpillar and Hamm IC rollers were used at the breakdown position in echelon. The BOMAG IC roller was used at the intermediate position, while the conventional Bomag roller was used as the finishing roller. Three roller passes were designated for each roller operation.

Site	I-80, Vacaville, CA
Project	FHWA IC and HMA In-Place Density Study
Test Bed	TB02 (Night No. 2 paving)
Date	9/5-6/2013 (night paving)
Manufacturer	BOMAG
Machine	BOMAG 278AD-4 Double-Drum IC Roller
Material Type	Asphalt Base Course
Data Files	CA_BOMAG_Night2A.csva (all-passes IC data) NB-boundary.xlsx

Instructions	Notes
1. Import IC data file with the following settings. - Coordinate system : UTM (auto-detected) - Location unit : Meters (auto-detected) - UTM zone : 10N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None - Location Unit : Meter Save the Veta project file as CA_BOMAG_Night2A.vetaproj 2. View the IC maps (EVIB, Frequency, Amplitude, Roller Speed, and Temperature). - Select the Evib map. Change the color pallet by right-clicking the color legend and select Customize. In the legend dialogue, change the Lower Bounds and Color to the following settings. Use Add/Remove if necessary. Note that software will re-order the pallet based on the Lower Bound values.	

Lower Bound (ksi)	Color
60	Black
50	Purple
40	Blue
30	Green
20	Yellow
10	Orange
0	Red

- Select "Final Coverage" under the Files on the left panel of the Viewer screen. Select each map and zoom in/out to see local details and overall trends. - Unselect "Final Coverage" under the Files on the left panel of the Viewer screen, then click each pass to view the data. Switch to the pass count map and zoom in to maximum. Note that this set of data consists of compaction and mobilization. Toggle on/off each pass map to observe the main roller passes and overlaps. Observe the rolling patterns. Use the Viewer/Ruler control to measure the length of the rolling zone. Note the data “scattered” around the overpass of Dixon Avenue. Discuss what happens. Toggle between the pass count and Evib maps to identify common areas for vibratory passes and the different areas for static passes (since only vibratory passes will produce Evib values). 3. Create a filter group - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “Paved Area”. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “Paved Area” Check this operation filter so that it is linked to the filter group. Imported file name: select the only file. Time filter: unused. Location Filter: (see below) Click the “Source” button at lower left panel, and select “Custom” Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings.	

Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data. 4. Create a sublot Click the tool bar Sublots button. Make sure that the created filter group is active. Select the Final Coverage IC map Click tool bar Add button and name the sublots “Paved area” Click chart tool bar Zoom to/Zoom to first location. Right click the western end of the map and select “Set start location. Click chart tool bar Zoom to/Zoom to last location. Right click the eastern end of the map and select “Set stop location. In the lower left panel, Use the default longitudinal length to be “500” ft. Click the tool bar “Create Lots” button and inspect the created sublots. 6. Analyze the filtered data and examine the results. A: Analysis without any filter group and sublots Select “None” for the filter group. Select “None” for the Sublots. Click Analyze and observe the results for the unfiltered data. Conduct the following analysis and compare the results. B: Analysis with a filter group and sublots Make sure the created filter group is selected. - Analysis Setup: Radius : 3.28 ft EVIB: Cumulative Specification Minimum: > 25 Maximum: none Acceptance (%): 70	

Pass Count: Cumulative Specification Minimum: ≥ 2 Maximum: none Acceptance (%): 70 Temperature: Cumulative Specification Minimum: > 200F Maximum: none Acceptance (%): 70 - Perform analysis and observe the results by selecting menu on the left from top down. -Coverage Inspect the coverage pie chart and results table. - Overall Results/EVIB Select coverage: Final Coverage. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Select coverage: Pass 01. Observe the correlation analysis results. Repeat the above for Pass 02, and 03. Select coverage: All Passes. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined. Examine the compaction curve and observe the trend. - Repeat the Overall analysis for Frequency, Pass Count, and Temperature. - Sublot Details Select each row to examine pass/fail parameters, and compaction curve for each sublot. There are lots of detailed reports. - Sublot Results/EVIB Observe the sublot summary table, the mean value bar chart, and the acceptance chart based on the specification target, if defined.	

- Repeat the Sublot Summary for Frequency, Pass Count, and Temperature. 7. Report - Click the “Report” button and select “PDF” to generate the report. By default, the file name is the data file name tagged with sublot name and a date/time stamp. Select options to customize your report. - The PDF report is a secured file with randomly generated password protection ideal for agency and contractor’s permanent records.	

CAT-TX-Soils

Learning Objectives:

- Import soils IC data from a Caterpillar system
- Use filter to clean up data
- Perform statistical analysis and compare results
- Compare the construction data and proof rolling data

Test Bed 3A and 3B (11/19/2014)

Test Bed 3A is compaction of clayey soils using a Caterpillar CS74B single smooth drum roller with a padfoot shell kit at US-67, Cleburne, TX.

Nuclear density tests were conducted after each roller pass at selected locations.

After the compaction (roller "walked-out"), a proofing run was performed at a constant speed, vibration frequency/amplitude, and in forward direction. The proofing run was labeled as Test Bed 3B.

The finished surface was mapped with three different IC rollers with smooth drums (CAT, Hamm, and Sakai) one day later.

Site	US-67, Cleburne, TX
Project	FHWA-TXDOT IC Retrofit Evaluation Study
Test Bed	TB03A
Date	11/19/2014
Manufacturer	Caterpillar
Machine	Caterpillar CS74B single smooth drum with a padfoot shell kit
Material Type	Soils
Data Files	CAT-TX-soils-Const (all-passes construction data) CAT-TX-soils-Proof (all-passes proof data)

Instructions	Notes
1. Import the IC "construction data" file using the following settings. - Coordinate system : GPS (auto-detected) - UTM zone : 14N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None Save as CAT-TX-soils.vetaproj 2. View the IC maps (CMV, pass count, frequency, amplitude and roller speed). - Select "Final Coverage" under the Files on the left panel of the Viewer screen. - Select each pass under the Files on the left panel of the Viewer screen. 3. Analyze the unfiltered data and examine the results. - Setup: Filter Group : (empty group) Radius : 3.28 ft (not used) - Perform analysis and observe the results by selecting menu on the left from top down.	

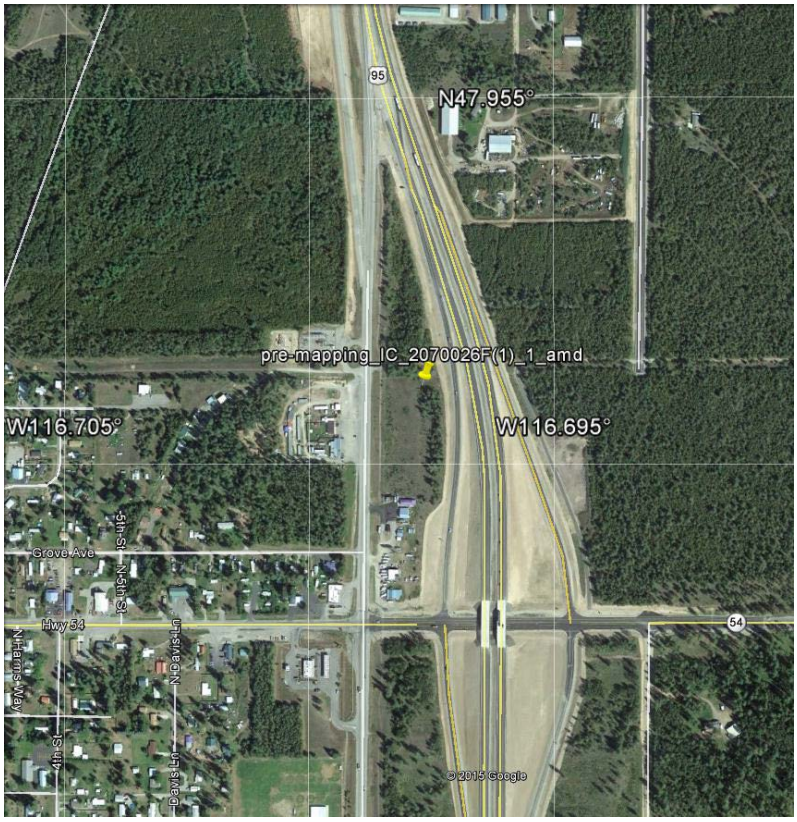
- Overall Results Observe statistical results for each parameter w.r.t. Final Coverage and All Passes: histogram and accumulated distribution under the Distribution tab. Under CMV/Coverage: All Passes, examine the compaction curve (mean CMVs vs. pass count) and observe the trend. 4. Filter and clean data. -Use Filters to create a section for the compacted area. Start a filter group: Filter group name template: None Folder : (Miscellaneous) Filter group name : Compacted area Add an Operation Filter and name it “Compacted area” Check/select this Operation filter and go through the following settings: Imported file name: (select the only option) Machine ID : (automatically selected) Design lot name : (select the only option) Time filter (unused) Location Filter: (see below) Click “Source” and Select “Custom”. Right-click with mouse and select four points at the corner of the compacted areas in counter-clockwise fashion (or clockwise, as long as it is consistent) “add location” to create an area that envelope the compacted area. Click the created points on the map to adjust locations. So that the selection would exclude the static data during mobilization and turning-around areas. Click “Apply filter group” on the menu bar to update the map. Observe the filtered map. 5. Analyze the filtered data and examine the results. - Setup:	

Filter Group :Compacted Area Radius : 3.28 ft (not used) - Perform analysis and observe the results by selecting menu on the left from top down. - Overall Results Observe statistical results for each parameter w.r.t. Final Coverage and All Passes: histogram and accumulated distribution under the Distribution tab. Discuss the differences between the results from unfiltered data and filtered data. Under CMV/Coverage: All Passes, examine the compaction curve (mean CMVs vs. pass count) and observe the trend. -Close the project. 5. Repeat the above analysis with the “proof data”. Observe the CMV results and the differences between the final coverage of the construction runs vs. the proofing runs. Discuss whether the proofing runs can be eliminated if the above two data sets are similar.	

Hamm-ID-HMA

Learning Objectives:

- Import of all-passes asphalt IC data from a Hamm system
- Compare IC data from pre-mapping, and compaction of each lift



Site	US 95, Garwood to Sagle, ID
Project	FHWA IC Idaho HMA demo
Test Bed	TB00, TB01, TB02, and TB03
Date	5/5-8/2014
Manufacturer	Hamm (Wirtgen)
Machine	HD+120 double-drum roller
Material Type	HMA
Data Files	Day 0 pre-mapping_IC_2070026F(1)_1_amd.vexp (pre-mapping on subbase) Day1 Asphalt Base_IC_2070026F(1)_1_amd.vexp (asphalt lift no. 1)

Instructions	Notes
1. Import the pre-mapping data file using the following settings. - Coordinate system : GPS (auto-detected) - UTM zone : 12N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None Save as Day 0 pre-mapping.vetaproj 2. View the IC maps (HMV, Frequency, Amplitude, Roller Speed, and Temperature). 3. Create Filter Groups -Create a filter group for Day 0 premapping data: Filter group name template: None Folder : (Miscellaneous) Filter group name : Day 0 Add an Operation Filter and name it “Day 0” Check/select this Operation filter and go through the following settings: Imported file name: (select the Day 0 data) Machine ID : (automatically selected) Design name : (select the only option) Time filter (unused) Location Filter (unused)	

Click “Apply filter group” on the menu bar to update the map. 4. Analyze the data and examine the results. - Setup: Filter Group : (empty group) Radius : 3.28 ft (not used) - Perform analysis and observe the results by selecting menu on the left from top down. - Overall Results Observe statistical results for each parameter w.r.t. Final Coverage (ignore All Passes due to only one pass for pre-mapping): histogram and accumulated distribution under the Distribution tab. 5. Import the Day 1 Asphalt lift 1 data for comparison. Click “Add File” and select “data”. Select the Day 1 Asphalt Base Data. 6. Create Filter Groups -Create a filter group for Day 1 compaction data: Filter group name template: None Folder : (Miscellaneous) Filter group name : Day 1 Add an Operation Filter and name it “Day 1” Check/select this Operation filter and go through the following settings: Imported file name: (select the Day 1 data) Machine ID : (automatically selected) Design name : (select the only option) Time filter (unused) Location Filter (unused) Click “Apply filter group” on the menu bar to update the map. 7. Analyze the data and examine the results.	

- Setup: Filter Group : Day 1 Radius : 3.28 ft (not used) - Perform analysis and observe the results by selecting menu on the left from top down. - Overall Results Observe statistical results for each parameter w.r.t. Final Coverage and All Passes: histogram and accumulated distribution under the Distribution tab. Under HMV/Coverage: All Passes, examine the compaction curve (mean HMVs vs. pass count) and observe the trend. Compare the results between premapping and lift one compaction data.	

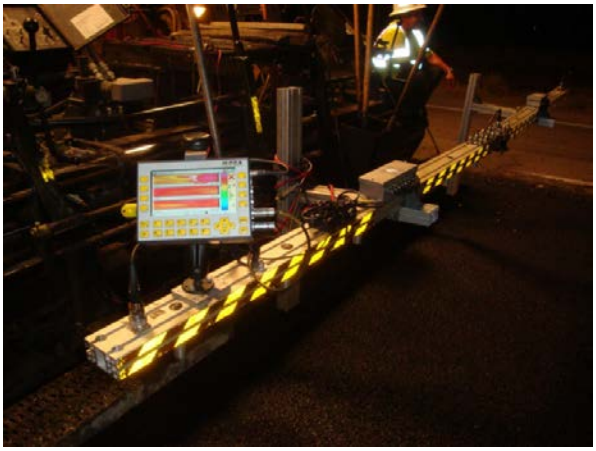
MOBA-MN-HMA

Learning Objectives:

- Import and analyze paver-mounted thermal profile data from MOBA Pave-IR system
- Create filter groups and sublots
- Observe temperature map patterns
- Produce thermal segregation reports and compare results

MN5, US59, and US51 Projects

MOBA PAVE-IR Bar and Scanner



Site	Multiple Sites, MN
Project	Multiple projects
Test Bed	Multiple
Date	Multiple dates
Manufacturer	MOBA
Machine	PAVE-IR thermal profile system
Material Type	HMA
Data Files	US51-NB-2015_10_02.paveproj US59-NB-2015_08_26.paveproj MN5-WB_2015_09_21.paveproj

Instructions	Notes
1. Import the US51 thermal profile data file - Coordinate system: GPS (auto-detected) - UTM zone : 15N (auto-detected) - State Plane Zone: : N/A - Minnesota County Zone : N/A - Oregon CRS Zone : N/A Save as US59-NB.vetproj 2. View the thermal profile maps. - Select "Temperature" and/or “Speed” under Data . - Observe Paver Speed and Temperature maps and their patterns. Notice the “cold edges”. 3. Create a filter group - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “Cold edge filter”. - Right click the Data Filter and select “Create Data Filter” in the option menu. Name the Operation filter as instructed. Select Temperature and set Min. temperature to be > 180°F - Right click the Operation filter and select “Create Data Filter” in the option menu. Name the Operation filter as instructed. Imported file name: (select the US 51 data) Sensor Location : (leave all selected) Machine ID : (automatically selected)	

Time filter (unused) Cold Edge & Ride Bracket Filter (check and select "Remove cold edges and ride brackets") Location Filter (unused) Click Apply filter group. Switch the filter groups between (cold edge filter) and (empty group) to compare the temperature maps. 4. Create Sublots - Click on Sublots and the "Add" speed button and name as instructed. Sublots will be automated created. Observe the sublots. 5. Analyze the data and examine the results. -Analysis Setup: Minimum stop duration (min.): 1. Remove paver stop areas from analysis: checked …Include Semivariogram: unchecked Select Analyze sublots Analysis Setup/Temperature Check "Differential Specification" Moderate start: 25 °F Severe start: 50 °F - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down. Coverage: The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop). Thermal Profile: View the thermal profile, Stop Duration, and paver speed vs. distance plots. Zoom in to paver stop areas and compare the results. Paver Stops: View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns.	

Overall Results/Speed: Examine the statistical analysis results, histogram, and accumulated distribution of paver speed. Overall Results/Temperature: Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the "Distribution" tab. Sublot Results Examine the statistical distribution for selected sublots and compare with the temperature maps. Select the Temperature tab. Click Distribution, Mean, or Differential to examine the results. Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heighted temperature map. Under Mean, compare the mean temperatures for all sublots. Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation. Report 6. Repeat the analysis for the US59 NB data file. - NB paving - moderate to severe temperature segregation 7. Repeat the analysis for the MN5 WB data file. - WB paving - temperature segregation changes at midway	

Sakai-IN-HMA

Learning Objectives:

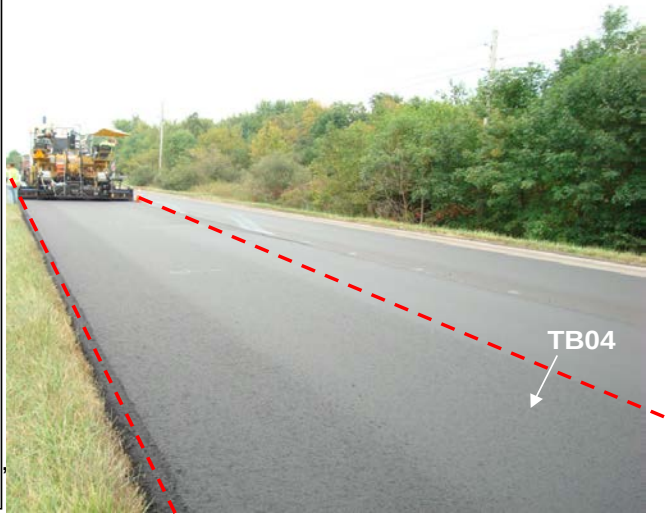
- Import asphalt IC data from a Sakai system
- Create a filter group and sublots
- Use spot test data and perform correlation analysis
- Generation of reports

Description

This test bed consists of paving the HMA surface layer on the HMA intermediate layer US 52 EB fast lane. A Bomag double-drum IC roller was used as the break down roller and a Sakai IC roller was used as the intermediate roller for TB04-1, then they are shifted to each other for TB04-2, and then shifted back again for TB04-3. The NNG densities were measured after each roller pass of both Bamag and Sakai at 5 stations with 3 spots at each station (outer edge, lane center, and inner joint).

Machine nominal setting:

Vibration frequency of 4000 vpm, low amplitude, and speed of 3 mph.



Sakai IC roller

Bomag IC roller


NG measurement


GPS measurement

Site	US 52, West Lafayette, IN
Project	FHWA/TPF IC IN HMA demo
Test Bed	TB04A EB Lane 2 surface course
Date	9/22/2009
Manufacturer	Sakai
Machine	SW880 double-drum IC roller
Material Type	HMA overlay
Data Files	IN_Sakai_TB04_2.pln (all-passes IC data) IN_SpotTests_TB04.xlsx (spot test data) BoundaryCoordinate.xlsx (paving boundary)

Instructions	Notes
1. Import both IC data files using the following settings: - Coordinate system : UTM (auto-detected) - UTM zone : 16N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None - Location unit : Meters Save it as IN_Sakai.vetproj 2. View the IC maps. - select "final coverage" on the right panel of the Viewer screen to view passes, frequency, temperature, CCV. - select "individual passes" on the right panel of the Viewer screen, then select to view any pass data. 2. Create a boundary filter group - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “Paved Area”. - Right click the Operation Filter and select “Create Operation Filter” in the option menu. Name the Operation filter as “Paved Area” Check this operation filter so that it is linked to the filter group. Imported file name: (select the only option)	

Design lot name : (select the only option) Time filter (unused) Location Filter: (see below) Click “Source” and Select “Custom”. Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings. Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data. 4. Create Sublots Click the tool bar Sublots button. Make sure that the created filter group is active. Select the Final Coverage IC map Click chart tool bar Zoom to/Zoom to first location. Right click the western end of the map and select “Add sublot from here” and use the default name. Click chart tool bar Zoom to/Zoom to last location. Right click the eastern end of the map and select “Set stop location and create sublot”. Inspect the created sublots. 5. Spot Tests - Open the spot test file. Highlight the yellow-coded cells (including the column headers) under Pass 01 and copy to the clipboard. - Switch back to Veta/Spot Tests, select “Pass 01” and click the “Paste” button to paste the data to the table. Examine the data table and the plot. Observe the black dots (spot test locations) drawn on the IC map. Hover over some dots to display their information. - Repeat for Pass No. 2 and 3.	

6. Analyze the data and examine the results. Make sure the created filter group is selected. - Analysis Setup: Radius : 3.28 ft Select “Analyze sublots” CCV: Cumulative Specification Minimum: > 12 Maximum: none Acceptance (%): 70 Pass Count: Cumulative Specification Minimum: ≥ 3 Maximum: none Acceptance (%): 70 Temperature: Cumulative Specification Minimum: > 150F Maximum: none Acceptance (%): 70 - Perform analysis and observe the results by selecting menu on the left from top down. -Coverage Inspect the coverage pie chart and results table. - Overall Results/CCV Select coverage: Final Coverage. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Select coverage: All Passes. Observe the correlation analysis results. Select coverage: All Passes. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined. Examine the compaction curve and observe the trend. - Repeat the Overall analysis for Frequency, Pass Count, and Temperature.	

- Sublot Summary/ICMV Observe the sublot summary table, the mean value bar chart, and the acceptance chart based on the specification target, if defined. - Repeat the Sublot Summary for Frequency, Pass Count, and Temperature. - Sublot Details Select each row to examine pass/fail parameters, and compaction curve for each sublot. There are lots of detailed reports. 7. Report - Click the “Report” button and select “PDF” to generate the report. Include sublot results. By default, the file name is the data file name tagged with sublot name and a date/time stamp. - The PDF report is a secured file with randomly generated password protection ideal for agency and contractor’s permanent records.	

Sakai_KS_Soils

Learning Objectives:

- Import of all-passes soils test strip IC data from Sakai system
- Define the sections for three test lanes
- Compare compaction curves to determine roller settings

Description: The test bed was constructed by scarifying the compacted TB2 to a depth of about 250 mm (10 inches). The area was then compacted in three roller lanes using Sakai SV610 padfoot roller for 13 roller passes. Lanes 1, 2, and 3 were compacted using nominal high, low, and high amplitude settings, respectively. In-situ point measurements were obtained on lanes 2 and 3. The objectives of this test bed were to obtain correlations between padfoot roller MVs and in-situ soil properties.

Machine Nominal settings:
Lane 1 (high amp) – f = 26 Hz, a = 2.19 mm, v = 6 km/h
Lane 2 (low amp) – f = 33 Hz, a = 0.93 mm, v = 6 km/h
Lane 1 (high amp) – f = 26 Hz, a = 2.19 mm, v = 6 km/h

Subgrade compaction and testing in three lanes

Summary of point measurements			
Lane	Measurements	Pass No.	No. of Tests
2, 3	w , γ_d, and E_{LWD}	0	6
2, 3	CBR	1, 2, 4, and 13	6
2, 3	E_{FWD}	13	6

Dynatest 450 mm plate diameter FWD

Sakai SV610 padfoot roller used for compaction

Site	US 69, Pleasanton, KS
Project	FHWA/TPF IC Kansas Soils demo
Test Bed	TB04
Date	8/19/2008
Manufacturer	Sakai
Machine	SV610T single-drum padfoot IC roller
Material Type	clayey soils (test strip)
Data Files	Sakai-KS-TB04.pln (IC data) KS-TB04-CompactionCurves.xlsx (compaction curve data)

Instructions	Notes
It's a test strip that contains of 3 test lanes (from west to east) using different machine settings. Machine settings for Lane2 are different from those for Lane1 and Lane3. 1. Import the data file using the following settings. - Coordinate system: UTM (auto-detected) - Location unit : Meters (auto-detected) - UTM zone : 15N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone: None - Location Unit : meter Save as Sakai-KS.vetaproj 2. View the IC maps (CCV, Frequency, and pass count). - Select "Final Coverage" under the Files on the left panel of the Viewer screen. 3. Filters - On the Filters screen, click “Create” and select “Create a Filter Group”. Name it “Lane1”. - Right click the left panel and select “Create Operation Filter”. Name it “Lane1”. Imported file name: (select the only option) Design lot name : (select the only option) Machine ID : (automatically selected) Time filter (unused) Location Filter: (follow the subsequent instructions) Click “Source” and Select “Custom”.	

On the IC map, right click to add points to define the four corners of the left most lane (in counter clockwise manner) as Lane 1. Click the created locations to adjust the position. Then, click the “Apply filter group” speed button. Observe the filtered data map. Switch the filter group to (Empty group). Repeat the above process to defined Lane2 and Lane3 for the middle lane and right most lane. 4. Analyze the data and examine the results. - Setup: Filter : Lane1 Radius : 3.28 ft - Perform analysis and observe the results by selecting menu on the left from top down. - Overall Results/CCV Select coverage: Final Coverage. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Select coverage: All Passes. Observe statistical results, histogram, and accumulated distribution under the Distribution tab. Examine the correlation analysis results for all passes combined. Examine the compaction curve and observe the trend. Use the “Copy Data to Clipboard” mapping tool and paste to a “Veta outputs” tab in the Excel file at the upper left corner of the yellow coded cells. - Repeat the analysis for Lane2 (paste to blue coded cells) and Lane3 (paste to green coded cells). Compare the compaction curves for the above 3 results on a spreadsheet and determine the roller settings for producing adequate compaction curves.	

Trimble-MOBA-MO-HMA

Learning Objectives:

- Import of asphalt IC data from TOPCON IC system
- Use daily boundary coordinates to define paving section for IC coverage analysis
- Define sublots for detailed IC analysis
- Import thermal profile data from MOBA PAVE-IR system
- Define sublots for temperature segregation analysis

TOPCON IC Retrofit on two steel drum rollers and one rubber tire roller

MOBA PAVE-IR thermal Scanner

Site	US NN, MO (all project info is fictitious)
Project	MODOT US NN
Test Beds	US NN EB Lift No. 1
Date	5/9/2017
Manufacturer	TOPCON and MOBA
Machine	TOPCON IC Retrofit on two steel drum rollers and one rubber tire roller MOBA PAVE-IR thermal scanner
Material Type	HMA
Data Files	J1P1234-20170509-Roller1- ICD.pln (roller no. 1 steel drum IC data) J1P1234-20170509-Roller2- ICD.pln (roller no. 2 steel drum IC data) J1P1234-20170509-Roller3- ICD.pln (roller no. 3 rubber tire IC data) J1P1234-20170509-IRD.paveproj (thermal profile data) J1P1234-20170509-bnd.xlsx (paving boundary coordinates) J1P1234-20170509-spt.xlsx (spot test data and coordinates)

Instructions	Notes
TOPCON IC Retrofit on two steel drum roller (break down compaction in echelon) and one rubber tire roller (finishing). Based on the test strip data, both steel drum rollers operated with 4 vibratory passes while the rubber tire roller operated with 4 static passes. A: IC Data Viewing and Analysis 1. Import the steel drum IC roller data files using the following settings. - Coordinate system : UTM (auto-detected) - UTM zone : 15N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None - Location unit : Meters Save the Veta project file as J1P1234-20170509-IC.vetaproj 2. View the IC maps - Select "Final Coverage" on the right panel of the Viewer screen. Select tool bar Zoom to/Extent of data. - Select Pass Counts, Roller Speed, Temperature or CCV. Use the view tools to zoom in/out, pan, etc. Observe the patterns of data of final coverage data and each individual passes data.	

3. Use Filters to define paving boundary - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “J1P1234-20170509-IC”. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “J1P1234-20170509” Check this operation filter so that it is linked to the filter group. Imported file name: (select the IC data files) Machine ID : (automatically selected) Design lot name : (select the only option) Time filter (unused) Location Filter : (see below) Select Location Filter and click the “Source” button at lower left panel, and select “Custom” Open the paving boundary Excel file from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings. Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data. 4. Create sublots Click the tool bar Sublots button. Make sure that the created filter group is active. Click map tool bar Zoom to/Zoom to first location. Right click the eastern end of the map and select “Add sublots from here” and use default sublot name. Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map.	

5. Spot tests Switch the Spot tests screen. Open the spot test Excel file from the file explorer. Highlight/copy the yellow-coded cells including the column headings. Switch back to Veta. Select File/Final Coverage. Right click the blank table and select “Paste Location” from the menu. Examine the spot location plots on the map. 5. Analyze the data and examine the results. Click the tool bar Analysis button Make sure that the created filter group is active. - Analysis/Setup: Filter Group : “J1P1234-20170509-IC” Radius : 3.28 ft (area surrounding spot test location to extract IC data for correlation analysis) - Click Analyze and observe the analysis results - Coverage Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group. Since there is only one filter group, the overall and the filtered group result is the same. Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed. - Overall Results Select Pass count, Speed, Temperature and CCV to view the statistical results for final coverage and individual passes. Examine the correlation results with the final coverage data. Examine the compaction curve of CCV of the all passes data. - Sublot Results Select Pass count, Speed, Frequency, Amplitude, Temperature and CCV to view the statistical results.	

- Sublot Details
  Select Pass count, Speed, or Temperature to view the statistical results for all sublots. Select each lot and inspect the corresponding IC map and statistics.

5. Close the IC project.

Homework: Analyze the rubber tire IC roller data.

B: Thermal Profile Data Viewing and Analysis

1. Start a new project to analyze the thermal profile.
Import the PAVE-IR data file.

- Coordinate system: GPS (auto-detected)
- UTM zone : 15N (auto-detected)
- State Plane zone : None
- Minnesota County zone : None

Save the Veta project file as J1P1234-20170509-IR.vetaproj

2. View the thermal profile maps.

- Observe Paver Speed and Temperature maps. Note the temperature consists of a cold edge and some erroneous data at the eastern end. Also, the data is split into two sections with a gap in between.

3. Use Filters to clean data

- In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “J1P1234-20170509-IR”.

- Right click the left panel and select “Create Data Filter” in the option menu. Name the Data filter as “> 180F”. Check the box to select this filter to associate it with selected filter group. Select Temperature and set the Minimum be > = 180.

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “Check the box to select this filter.”
  Select the operation filter to associate it with the selected filter group

Imported file name: (select the imported IR data file) Sensor location : (leave all sensors in) Machine ID : (automatically selected) Time filter (unused) Cold Edge & Ride Bracket Filter: (check to select) Location Filter : (unused) Click tool bar Apply Filter Group. Inspect the filtered map. Observe the differences between the raw data and filtered data. 4. Create a sublot Click the tool bar Sublots button. Make sure that the created filter group is active. Click the tool bar Sublots button. Make sure that the created filter group is active. Click map tool bar Zoom to/Zoom to first location. Right click the eastern end of the map and select “Add sublots from here” and use default sublot name. Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map. Note that the sublots can also be created automatically by Veta. 5. Analyze the data and examine the results. -Analysis Setup: Filter Group “J1P1234-20170509-IR”. Minimum stop duration (min.): 1. Remove paver stop areas from analysis: checked …Include Semivariogram: unchecked Select Analyze sublots Analysis Setup/Temperature Check “Differential Specification” Moderate start: 25 °F Severe start: 50 °F - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down.	

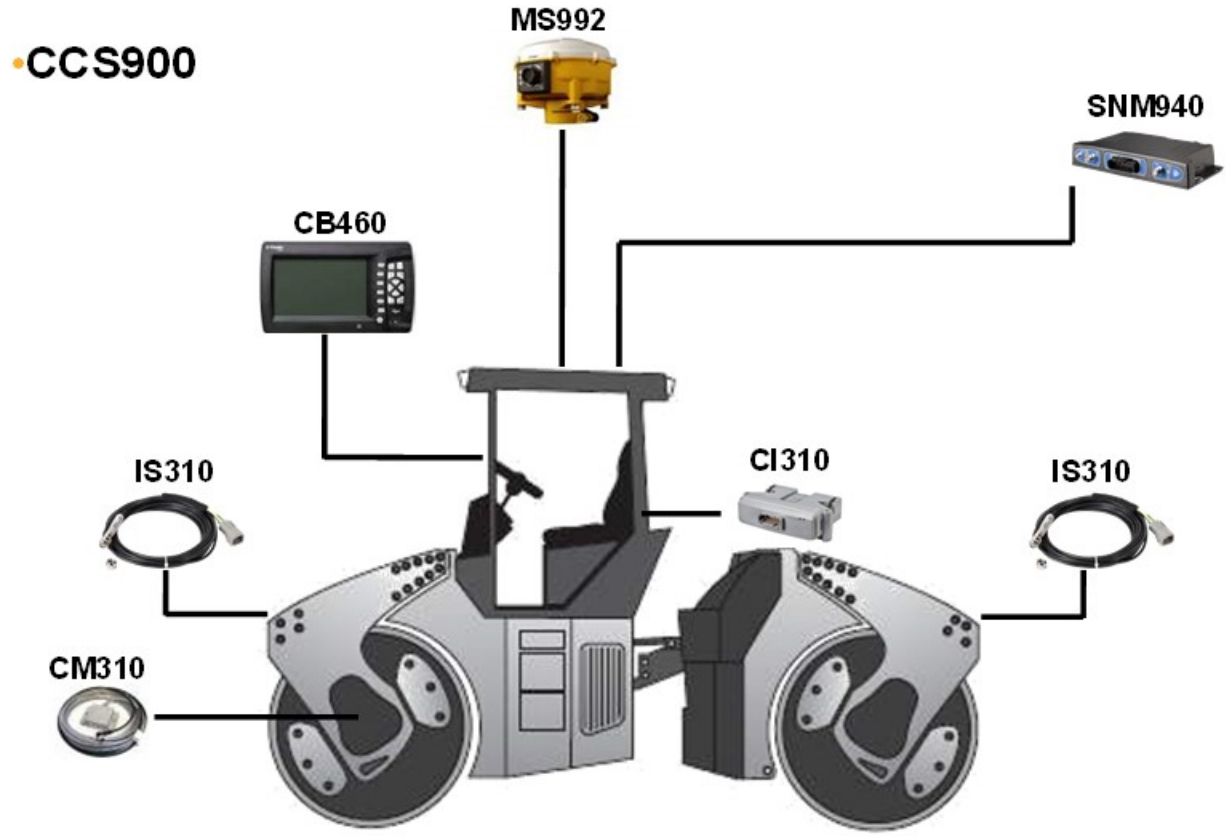
Coverage: The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop). Thermal Profile: View the thermal profile, Stop Duration, and paver speed vs. distance plots. Zoom in to paver stop areas and compare the results. Paver Stops: View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns. Overall Results/Speed: Examine the statistical analysis results, histogram, and accumulated distribution of paver speed. Overall Results/Temperature: Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the "Distribution" tab. Sublot Results Examine the statistical distribution for selected sublots and compare with the temperature maps. Select the Temperature tab. Click Distribution, Mean, or Differential to examine the results. Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heighted temperature map. Under Mean, compare the mean temperatures for all sublots. Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation.	

Trimble-CA-CIR

Learning Objectives:

- Import of Cold-in-Place Recycling (CIR) IC data from Trimble IC retrofit system
- Input spot test data for correlation
- Produce extensive reports
- Analyze single roller data and combined roller data

Trimble IC Retrofit



Site	Hwy 198, Armona, CA
Project	Caltrans CIR project
Test Bed	WB
Date	6/15/2015
Material Type	Cold-in-Place Recycling (CIR)
IC System	Trimble IC Retrofit
Host Rollers	steel drum (ID: 10584), rubber tire (ID: 19390)
Data Files	All-passes data for the steel drum roller (CA198-20150615-steeldrum.csv) All-passes data for the rubber tires roller (CA198-20150615-rubbertires.csv) spot test data (HWY198-SpotTests.xlsx) boundary file (HWY198-Boundary.xlsx) *The above are simplified names instead of following Caltrans file naming convention.*

Instructions	Notes
1. Import the IC data files (steel drum, target passes: 4) using the following settings. - Coordinate system : GPS (auto-detected) - UTM zone : 11N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None Saved as CA-HWY198.vetaproj 2. View the IC maps - Select "Final Coverage" under the Files on the left panel of the Viewer screen. - Select CMV, Frequency, Amplitude, Pass Counts, Roller Speed, and Temperature. - Pan the View screen to view the northern portion of the data. Zoom in to observe further details. - Unselect Final Coverage, then select each pass consecutively. Observe the accumulated data maps. 3. Analyze the data without filtering (i.e., include all data) and examine the results. - Analysis/Setup:	

Filter Group : (empty group) Radius : 3.28 ft (not used) - Click Analyze and observe the analysis results. Note that the results include non-compaction data. 4. Use Filters to define paving boundary - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “CA198-20150615-IC”. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “CA198-20150615-IC” Check this operation filter so that it is linked to the filter group. Imported file name: (select the steel drum data file) Machine ID : (automatically selected) Design lot name : (select the only option) Time filter (unused) Location Filter : (see below) Select Location Filter and click the “Source” button at lower left panel, and select “Custom” Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings. Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data. 5. Click the tool bar Sublots button. Make sure that the created filter group is active. Select the Final Coverage IC map Click map tool bar Zoom to/Zoom to first location. Right click the eastern end of the map and select “Add sublots from here” and use default sublot name.	

In the lower left panel, Change the longitudinal length to be "100" ft. Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select "Set stop location and create sublots". Inspect sublots on the map. 6. Spot tests. Enter the spot test results from the spreadsheet following the trainer's instructions. 6. Analyze the filtered data (i.e., only include compaction data within the lanes) and examine the results. - Analysis/Setup: Filter Group: CA198-20150615-IC Radius : 3.28 ft Use the following specification target: CMV: Cumulative Specification Minimum: >= 6 (within 20% of the target CMV determined by test strip data) Maximum: None Acceptance (%): 90 Pass Count: Cumulative Specification Minimum: >= 3 (determined by test strip data) Maximum: None Acceptance (%): 90 - Click Analyze and observe the analysis results. Note that the results include only compaction data. The Coverage report include % coverage for each pass. Users may adjust the pass count color palette to set the target pass count and above as one color. Therefore, the coverage report will include the accumulated % coverage for the target pass and above. Examine results under both Overall and Sublot Summary. Investigate the areas that fail the target values.	

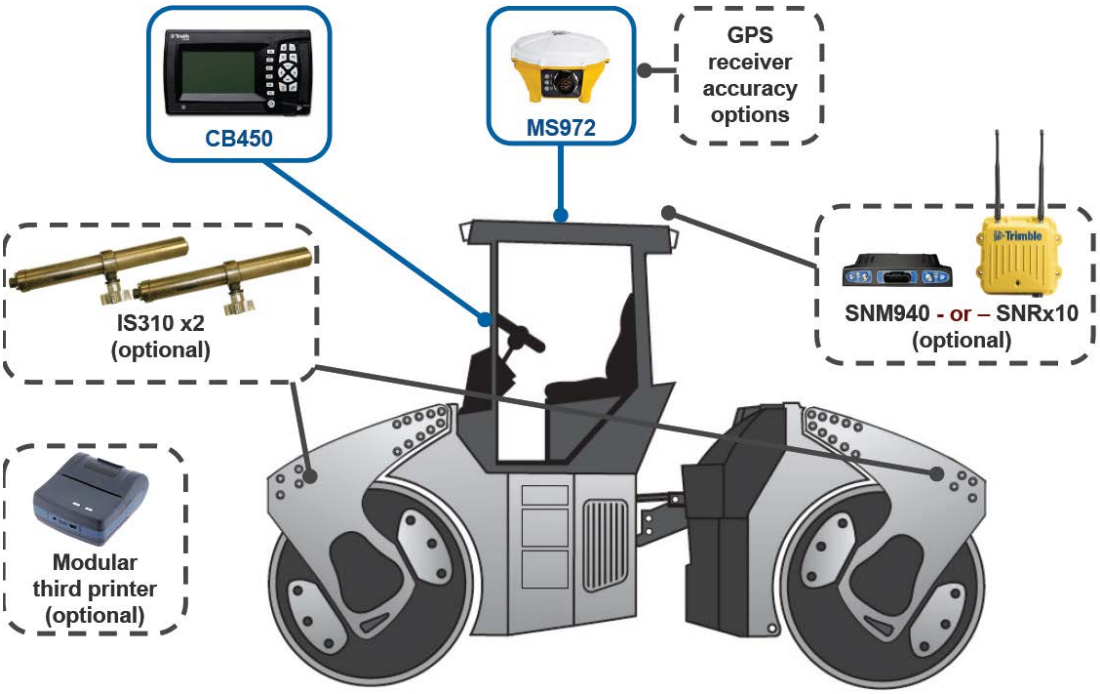
7. Produce report. Use the Report speed button to generate a PDF report. Scan through this 400+ pages report. 8. Close the IC project. Repeat a similar analysis with the rubber tire roller (target passes: 7) data.	

Trimble-MOBA-MN-HMA

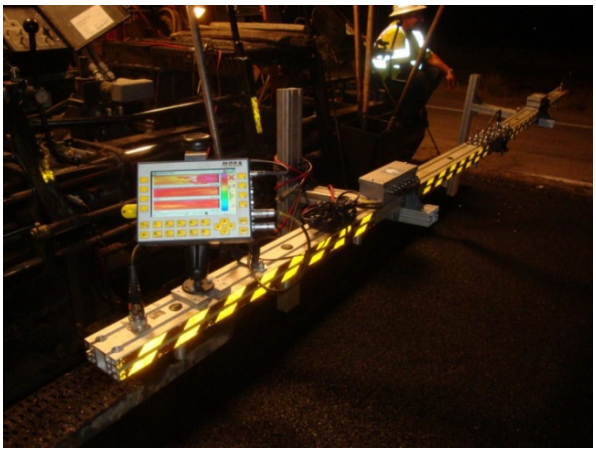
Learning Objectives:

- Import of final coverage asphalt IC data from Trimble IC retrofit system
- Import alignment file and use it to define paving section for coverage analysis
- Import and analyze paver-mounted thermal profile data from MOBA Pave-IR system
- Use MnDOT naming convention
- Compare analysis results between the IC data and thermal profile data

Trimble IC Retrofit



MOBA PAVE-IR Bar and Scanner



Site	TH89, MN (all project info are fictitious)
Project	MNDOT SP12345-67 TH89
Test Bed	NB right lane
Date	5/14/2014
Manufacturer	Trimble and MOBA
Machine	3 retrofitted rollers with Trimble IC Retrofit Systems MOBA PAVE-IR thermal scanner
Material Type	HMA
Data Files	SP12345-67 TH89.csv (final coverage IC data) SP12345-67 TH89 PMTP.paveproj (thermal profile data) SP12345-67 TH89-Alignment.kmz (alignment file) SP12345-67 TH89 Paving Boundary.xlsx (Paving Boundary coordinates)

Instructions	Notes
A: IC Data Viewing and Analysis 1. Import the IC data file using the following settings. - Coordinate system : Minnesota Counties - State Plane Zone : None - Minnesota County Zone: Otter Tail - Location unit : US Survey Feet Saved as MN-HMA.vetaproj 2. View the IC maps - Select "Final Coverage" on the right panel of the Viewer screen. - Select CMV, Frequency, Amplitude, Pass Counts, Roller Speed, and Temperature. - Pan the View screen to view the northern portion of the data. Zoom in to observe further details. 3. Add the alignment file - At the Alignment screen, click the “Add File” speed button, select Add Alignment and browse/select the alignment file. Click on “Alignment” speed button	

- On the tree view on the left panel, select “CNST LIM (1)” then Line 1 underneath which is the NB LN1 alignment. Rename the drawing and line to: “CNST LIM (1) (CL-12R)” and “Line 1(CL-12R)” Pan the View screen to view the northern portion of the data. Zoom in to observe further details of the notes/lines. 4. Use the Filters to define an area based on the alignment and paving boundary files - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “01 051414 HMA-L1-CL-12R”. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “01 051414 HMA-L1-CL-12R” Check this operation filter so that it is linked to the filter group. Imported file name: (select the only data file) Machine ID : (automatically selected for all rollers) Design lot name : (select the only option) Time filter (unused) Location Filter : see below Select Location Filter and click the “Source” button at lower left panel, and enter the selection as follows: Selection > Use a Portion of an alignment drawing ...Alignment > SP21013-35 TH-29-Alignment …Drawing > CNST LIM (1) (CL-12R) …Object > Line 1 (CL-12R) Click the Options button on the ribbon and confirm US Survey Feet under Location Unit. Switch to Excel or open the paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings. Switch back to Veta. Right click the blank table and select “Paste Location” from the menu. The boundaries of the paving is defined based on the portion of the alignment file and the 4 boundary coordinates.	

Select the checkbox for the created operation filter and click the “Apply Filter” speed button. Inspect the filtered IC map. 5. Create a sublot Click the Sublots speed button. Make sure that the created filter group is active. Use the map tool, “zoom to the first location”. Click the middle of the northern end of paved lane and select “Add sublots from here” and use the default name. Use the map tool, “zoom to the last location” and scroll down a little bit (since the roller may not stop the operation at the very end point). Click the middle of the southern end of paved lane and select “Set stop location and create sublots”. Inspect sublots on the map. 5. Analyze the data and examine the results. Make sure that the created filter group is active. - Analysis/Setup: Filter Group: “01 051414 HMA-L1-CL-12R” Radius : 3.28 ft - Click Analyze and observe the analysis results - Coverage Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group. Since there is only one filter group, the overall and the filtered group result is the same. Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed (e.g., use color palette for only 1 to 4 passes). - Overall Results Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results. - Sublot Summary Results Select Pass count, Speed, Frequency, Amplitude,	

Temperature and CMV to view the statistical results. - Sublot Details Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results. Select each lot and inspect the corresponding IC map and statistics. 5. Close the IC project. B: Thermal Profile Data Viewing and Analysis 1. Start a new project to analyze the thermal profile. Import the PAVE-IR data file. - Coordinate system : GPS (auto-detected) - UTM zone : 15N (auto-detected) - State Plane Zone : None - Minnesota County Zone : None - Oregon CRS Zone : None Saved as MN-IR.vetaproj 2. View the thermal profile maps. - Observe Paver Speed and Temperature maps. Note the temperature consists of erroneous data at the left edge. 3. Use the Filters to clean up data - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “01 051414 HMA-L1-CL-12R”. - Right click the left panel and select “Create Data Filter” in the option menu. Name the Data filter as “> 180F”. Select Temperature and set the Minimum be > = 180. Check the box to select this filter. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “01 051414 HMA-L1-CL-12R” Under the created operation filter	

Import file name: (select the only file) Sensor location: (leave all in) Machine ID: (auto selected) Time filter (unused) Cold Edge & Ride Bracket Filter: (check the selection) Location filter (unused) Click “Apply filter group” on the speed button bar. Examine the filtered data. Toggle between “Empty Filter Group” and the created filter to compare areas that are filtered by the latter. 4. Create a sublot Click the Sublots speed button. Make sure that the created filter group is active. Use the “Zoom to the first location” map tool and click the intersection of TH 29 and Southern Otter Avenue and select “Add sublots from here” and use the default name Use the “Zoom to the last location” map tool and click the middle of the southern end of the temperature map. Select “Set stop location and create sublots”. Inspect the sublots on the map. The sublot creation is automated in Veta 5.0+. 5. Analyze the data and examine the results. -Setup: Filter Group: “01 051414 HMA L1-CL-12R”. Minimum stop duration (min.): 1. Remove paver stop areas from analysis: checked Select Analyze sublots …Include Semivariogram: unchecked Temperature/Differential Specification Check “Use differential target in sublots” Moderate start: 25 °F Severe start: 50 °F - Perform analysis and observe the results by selecting menu on the left from top down. Coverage: The actual area is the sensors-covered areas excluding	

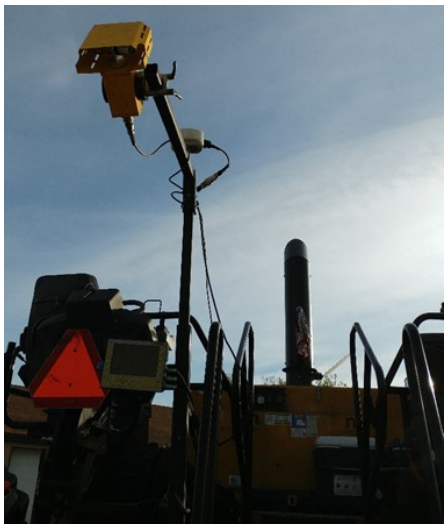
the paver stop areas (2-ft before and 8-ft after each stop). Thermal Profile: View the thermal profile (note that specific locations from 19 to 21 are filtered out), Duration (paver stops), and paver speed vs. distance plots. Zoom in to paver stop areas and compare the results. Paver Stops: View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns. Overall Results/Speed: Examine the statistical analysis results, histogram, and accumulated distribution of paver speed. Overall Results/Temperature: Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the "Distribution" tab. Switch to the "Differential" tab, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Map view: Hover over the lots to view data. Sublot Results/Temperature: Examine the statistical distribution for selected sublots and compare with the temperature maps. Select the Mean tab and compare mean temperature for all sublots. Sublot Details /Temperatures Select any row output of temperature and examine the statistical distribution results and histogram/accumulated distribution for all sublots. Compare those results with the heighted temperature map. 6. Compare analysis results between the IC data and thermal profile data (e.g., paver stop locations).	

Trimble-MOBA-MO-HMA

Learning Objectives:

- Import of all-passes asphalt IC data from CAT/Trimble IC system
- Use daily boundary coordinates to define paving section for IC coverage analysis
- Define sublots for detailed IC analysis
- Import thermal profile data from MOBA PAVE-IR system
- Define sublots for temperature segregation analysis

Trimble IC Retrofit on a CAT roller and MOBA PAVE-IR Scanner



A Material Transfer Vehicle (MTV) used on Day 2

Site	US NN, MO (all project info are fictitious)
Project	MODOT US NN
Test Beds	US NN WB Lift No. 1
Date	4/24-25/2017
Manufacturer	Trimble and MOBA
Machine	1 roller with Trimble IC Retrofit Systems MOBA PAVE-IR thermal scanner
Material Type	HMA
Data Files	J1P1234-20170424-ICD.csv (Day 1 all-passes IC data) J1P1234-20170424-IRD.paveproj (Day 1 thermal profile data) J1P1234-20170424-BND.xlsx (Day 1 paving boundary coordinates) J1P1234-20170424-SPT.xlsx (Day 1 spot tests) J1P1234-20170425-ICD.csv (Day 2 all-passes IC data) J1P1234-20170425-IRD.paveproj (Day 2 thermal profile data) J1P1234-20170425-BND.xlsx (Day 2 paving boundary coordinates)

Instructions	Notes
A: IC Data Viewing and Analysis 1. Import the Day 1 IC data file using the following settings. - Coordinate system : GPS (auto-detected) - UTM zone : 15N (auto-detected) - State Plane Zone : None - Minnesota County Zone: None - Oregon CRS Zone : None Save the Veta project file as J1P1234-20170424-IC.vetaproj 2. View the IC maps - Select "Final Coverage" on the right panel of the Viewer screen. Select tool bar Zoom to/Extent of data. - Select CMV, Pass Counts, Roller Speed, or Temperature. Use the view tools to zoom in/out, pan, and etc. Observe the patterns of data of final coverage data and each individual passes data. 3. Use Filters to define paving boundary - At the Filters screen, click the “Create” speed button, and select “Create Filter Group”. Name this filter group as “J1P1234-20170424-IC”.	

- Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “J1P1234-20170424” Check this operation filter so that it is linked to the filter group. Imported file name: (select the Day 1 IC data file) Machine ID : (automatically selected) Design lot name : (select all options) Time filter (unused) Location Filter : see below Select Location Filter and click the “Source” button at lower left panel, and select “Custom” Switch to Excel or open the Day 1 paving boundary Excel file directly from the file explorer. Highlight/copy the yellow-coded boundary coordinates including the column headings. Switch back to Veta. Select Project/Properties from the menu and select UTM as the coordinate system. Switch back to Filters. Right click the blank table and select “Paste Location” from the menu. Click the “Apply filter group” speed button. Inspect the filtered IC map by selecting Final Coverage with viewing tools. Observe the differences between raw data and filtered data. 4. Create sublots Click the tool bar Sublots button. Make sure that the created filter group is active. Click map tool bar Zoom to/Zoom to first location. Right click the eastern end of the map and select “Add sublots from here” and use default sublot name. Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map. 5. Spot tests Switch the Spot tests screen.	

Select File/Final Coverage. Open the Day 1 Spot test spreadsheet. Select the highlighted cells and copy-and-paste back to Veta. Inspect the spot tests locations on the map. 5. Analyze the data and examine the results. Click the tool bar Analysis button Make sure that the created filter group is active. - Analysis/Setup: Filter Group : "J1P1234-20170424-IC" Radius : 3.28 ft (not used) - Click Analyze and observe the analysis results - Coverage Inspect the coverage report table and charts. The coverage are combined passes from all the machines selected in the filter group. Since there is only one filter group, the overall and the filtered group result is the same. Note that the color palette of the pie chart mirror that of the IC pass count map palette. Adjust the palette as needed. - Overall Results Select Pass count, Speed, Temperature and CMV to view the statistical results for final coverage and individual passes. Examine the correlation results with the final coverage data. Examine the compaction curve of CMV of the all passes data. - Sublot Results Select Pass count, Speed, Frequency, Amplitude, Temperature and CMV to view the statistical results. - Sublot Details Select Pass count, Speed, or Temperature to view the statistical results for all sublots. Select each lot and inspect the corresponding IC map and statistics.	

5. Close the IC project. B: Thermal Profile Data Viewing and Analysis 1. Start a new project to analyze the thermal profile. Import the Day 1 PAVE-IR data file. - Coordinate system: GPS (auto-detected) - UTM zone : 15N (auto-detected) - State Plane zone : None - Minnesota County zone : None Save the Veta project file as J1P1234-20170424-IR.vetaproj 2. View the thermal profile maps. - Observe Paver Speed and Temperature maps. Note the temperature consists of a cold edge and some erroneous data at the eastern end. Also, the data is split into two sections with a gap in between. 3. Use Filters to clean data - In the Filters screen, click the “Create” speed button and select “Create filter group”. Name this filter group as “J1P1234-20170424-IR”. - Right click the left panel and select “Create Data Filter” in the option menu. Name the Data filter as “> 180F”. Check the box to select this filter to associate it with selected filter group. Select Temperature and set the Minimum be > = 180. - Right click the left panel and select “Create Operation Filter” in the option menu. Name the Operation filter as “Check the box to select this filter.” Select the operation filter to associate it with the selected filter group Imported file name: (select the Day 1 IR data file) Sensor location : (leave all sensors in) Machine ID : (automatically selected) Design name : (select the only option) Time filter (unused) Cold Edge & Ride Bracket Filter: (check to select) Location Filter : (unused)	

Click tool bar Apply Filter Group. Inspect the filtered map. Observe the differences between the raw data and filtered data. 4. Create a sublot Click the tool bar Sublots button. Make sure that the created filter group is active. Click the tool bar Sublots button. Make sure that the created filter group is active. Click map tool bar Zoom to/Zoom to first location. Right click the eastern end of the map and select “Add sublots from here” and use default sublot name. Click chart tool bar Zoom to/Zoom to last location. Right click the western end of the map and select “Set stop location and create sublots”. Inspect sublots on the map. 5. Analyze the data and examine the results. -Setup: Filter Group “J1P1234-20170424-IR”. Minimum stop duration (min.): 1. Remove paver stop areas from analysis: checked Select Analyze sublots …Include Semivariogram: unchecked Temperature/Differential Specification Check “Use differential target in sublots” Moderate start: 25 °F Severe start: 50 °F - Click Analyze button to perform analysis. Observe the results by selecting menu on the left from top down. Coverage: The actual area is the sensors-covered areas excluding the paver stop areas (2-ft before and 8-ft after each stop). Thermal Profile: View the thermal profile, Stop Duration, and paver speed vs. distance plots. Zoom in to paver stop areas and compare the results. Paver Stops:	

View the paver stops map and identify the long paver stop locations. Zoom in any paver stop areas to observe the temperature patterns. Overall Results/Speed: Examine the statistical analysis results, histogram, and accumulated distribution of paver speed. Overall Results/Temperature: Examine the statistical analysis results, histogram, and accumulated distribution of temperature under the "Distribution" tab. Sublot Results Examine the statistical distribution for selected sublots and compare with the temperature maps. Select the Mean tab and compare mean temperature for all sublots. Sublot Details Click Distribution, Lean, or Differential to examine the results. Under Distribution: Select any row output of temperature and examine the statistical distribution results for the selected sublot. Compare those results with the heighted temperature map. Under Mean, compare the mean temperatures for all sublots. Under Differential, examine of temperature segregation summary table and identify the sublots with severe and moderate temperature segregation under the Category. Examine the corresponding temperature map within a selected sublot with moderate or severe segregation. C: (homework) Analyze Day 2 IC and IR data. Then, compare results between Day 1 and Day 2. Note that a Material Transfer Vehicle (MTV) was used on Day 2 but not Day 1.	

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