SITECH

IAPA Annual Conference

I.C. for HMA

03/13/2017

Intelligent Compaction for HMA

- Keys to success
- What is Intelligent Compaction?
- Why use Intelligent Compaction?
- Systems
- Options
- Benefits
- Weaknesses
- Data. Lots and Lots (probably some sublots) of Data.

Keys to Success (Rebecca Embacher, MnDOT)

- No one should be asked to bid on something they don’t understand
- Staged implementation, learn to walk before you run
- Collaboration between Agency and Contractors
- Agency flexibility during the early stages
- Get local Equipment and Technology dealers involved early
- Work with Equipment and Technology Dealers to involve factory SME’s when needed
- Get familiar with VETA

Contractor Collaboration

- Meeting Platforms
  - Asphalt Pavement Quality and Technology Committee (*3-4 times / year*)
  - Specification Committee (*1-2 times / year*)
  - Association of General Contractors (*2 times / year*)
  - Ad-Hoc Committees (*as needed*)
  - Minnesota Asphalt Paving Association (*all meeting platforms*)
  - Workshops
  - Training
- Discussions
  - Specification development
  - Implementation Schedules
  - Debriefings
  - New technologies, practices & opportunities
  - Solutions to existing problems
  - Needs / Resources

What does Intelligent Compaction do?

- Displays and records:
  - Pass count of a roller
    - Can be used on entire roller train
      - Breakdown, intermediate, finish
  - Temperature of asphalt surface
    - Operator notified if mat temperature is outside of user-defined range
  - CMV (Compaction Meter Value)
    - CMV is an indication of mat stiffness and is recorded using an accelerometer
    - It is not density

Why use IC Technology?

- To solve a problem
  - If there is no problem to solve, we have an answer in search of a question.

- Does anyone have problems with Compaction?
  - Yes: We'll move on with the presentation.
  - No: Thank You and have a nice day! See you at the bar!

Why use IC Technology?

- To achieve the desired compaction the compactor operator needs to achieve a ***specified pass count*** target at a ***specified speed*** (or ipf) within a ***specified temperature range***.
  - The problem; No one can effectively keep track of all these things all day every day?

Why use IC Technology?

- Common issues we see today in the field:
  - The operator can easily lose track and the job becomes guesswork
  - Increasing speed to catch up with the paving train
    - Are there enough compactors on site?
  - Machines running “tandem”
    - You got that covered while I was getting water, right?
  - The supervisor cannot monitor pass count performance and cannot verify accurate completion of the compaction job
  - Inconsistent density
    - Under compaction
    - Over compaction
    - Outlying cores
  - Penalties, missed bonuses, premature road failure and legal issues

Why use IC Technology?

- Beneficial for all operators, especially inexperienced operators/night work
- Ensures proper mat compaction
- Ensures compaction efforts during temp windows
- Financial incentives
- Implementing IC Technology gives us actionable data
  - Real Time Data
  - Historical Data

Benefit: Pass Count Mapping

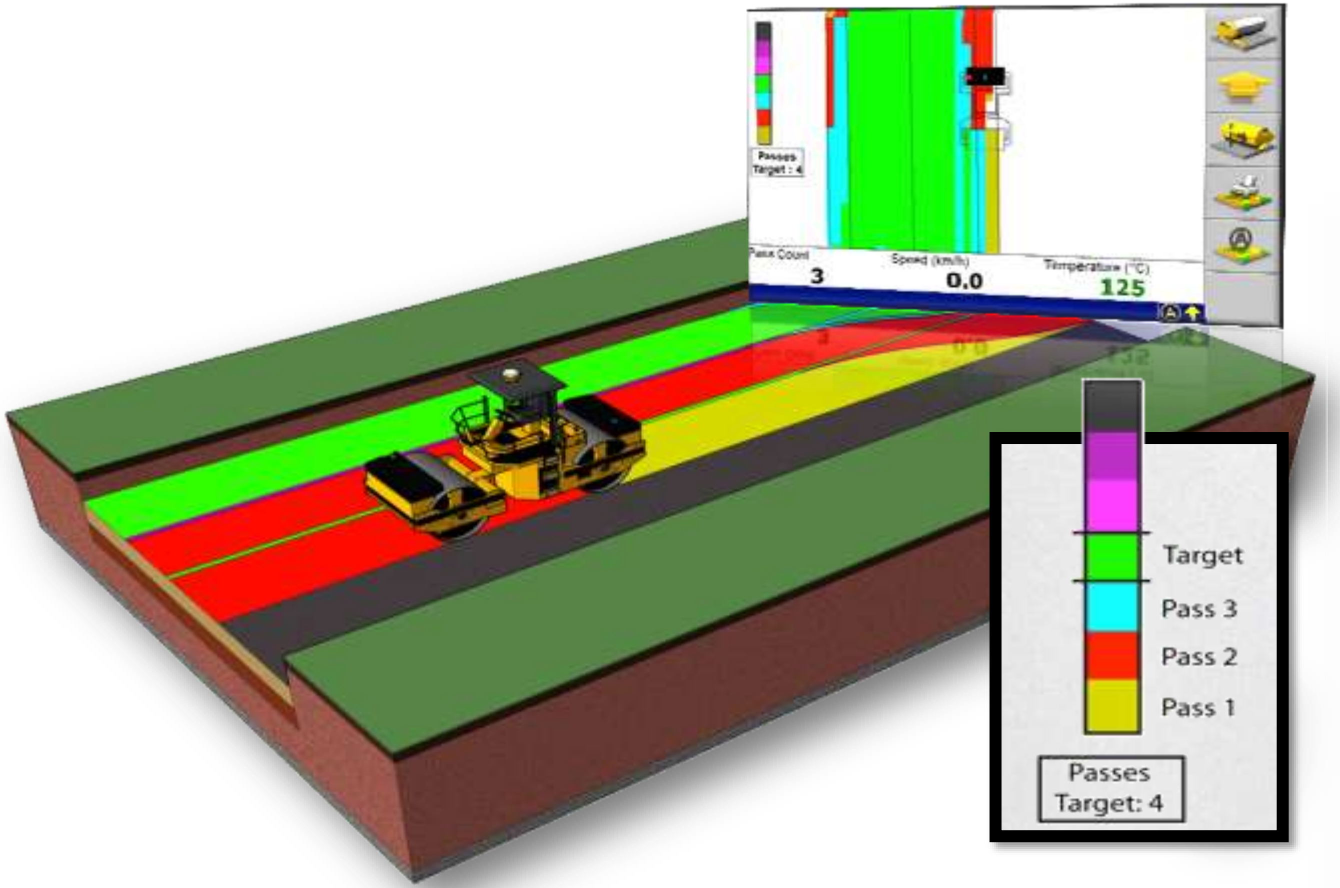
- **To achieve the desired compaction the compactor operator needs to achieve a *specified pass count* target at a *specified speed* (or ipf) within a specified temperature range.**
  - **Operator doesn’t have to guess**
  - **Display gives operator real time pass count**
  - **Ensure uniform compaction efforts**
  - **Ensure complete coverage**

Pass Count Mapping

Avoid over or under-compaction

- Displays pass count maps, allowing operator to track where pass count target has been met

- Pass count mapping allows you to monitor the number of passes over an area and adjust your effort



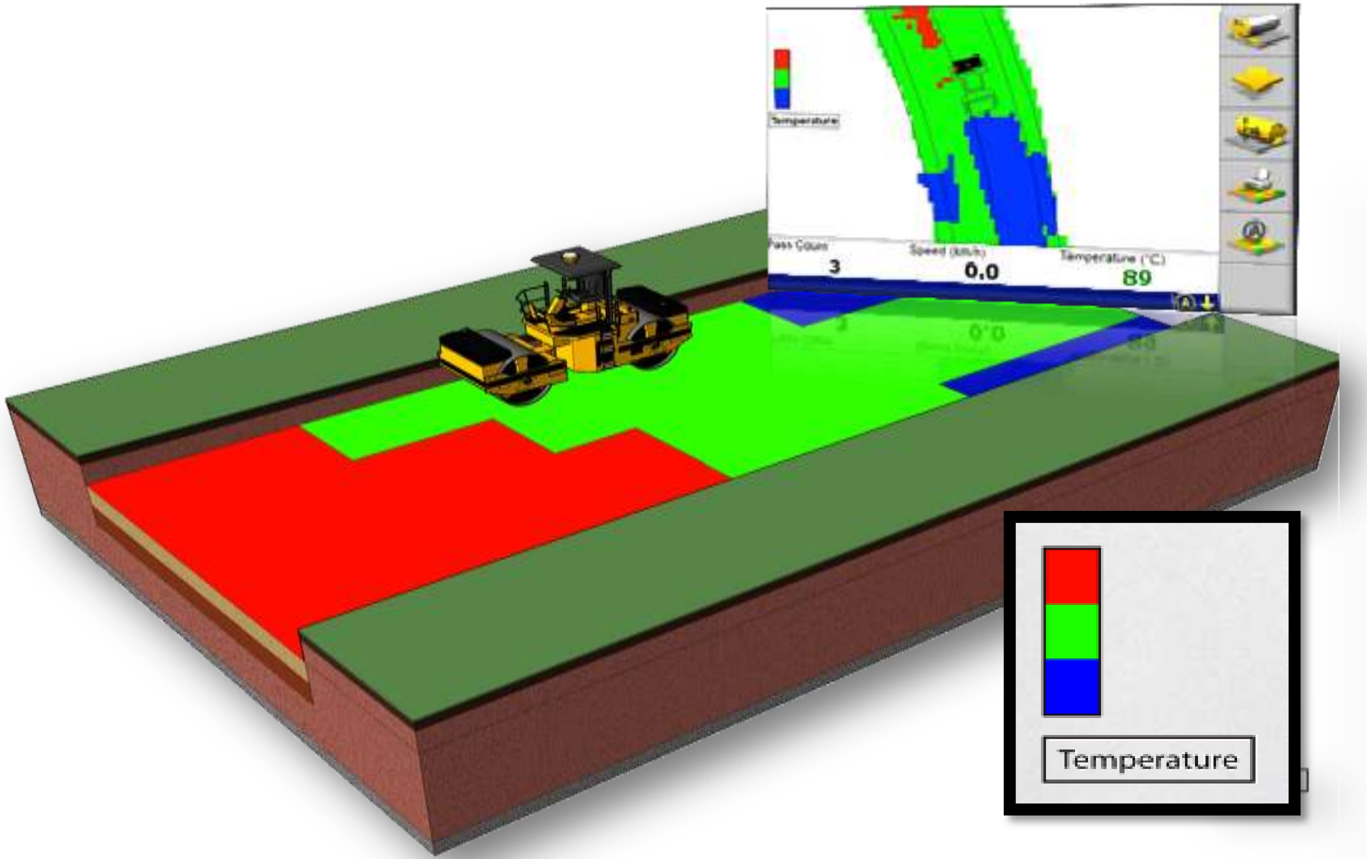
Benefit: Temperature Mapping

- **To achieve the desired compaction the compactor operator needs to achieve a certain pass count target at a specified speed (or ipf) within a *specified temperature* range.**
- **Common issues we see today in the field:**
  - **Rollers too far behind the paver, mat too cool**
  - **Rollers in the "Tender Zone"**

Temperature Mapping

Know exactly where to be for ideal compaction timing

- When installed with two optional IS310 Infrared Sensors, CCS900 maps the surface temperature of the mat
- Displays temperature maps, allowing operator to judge his time window for compaction across the surface

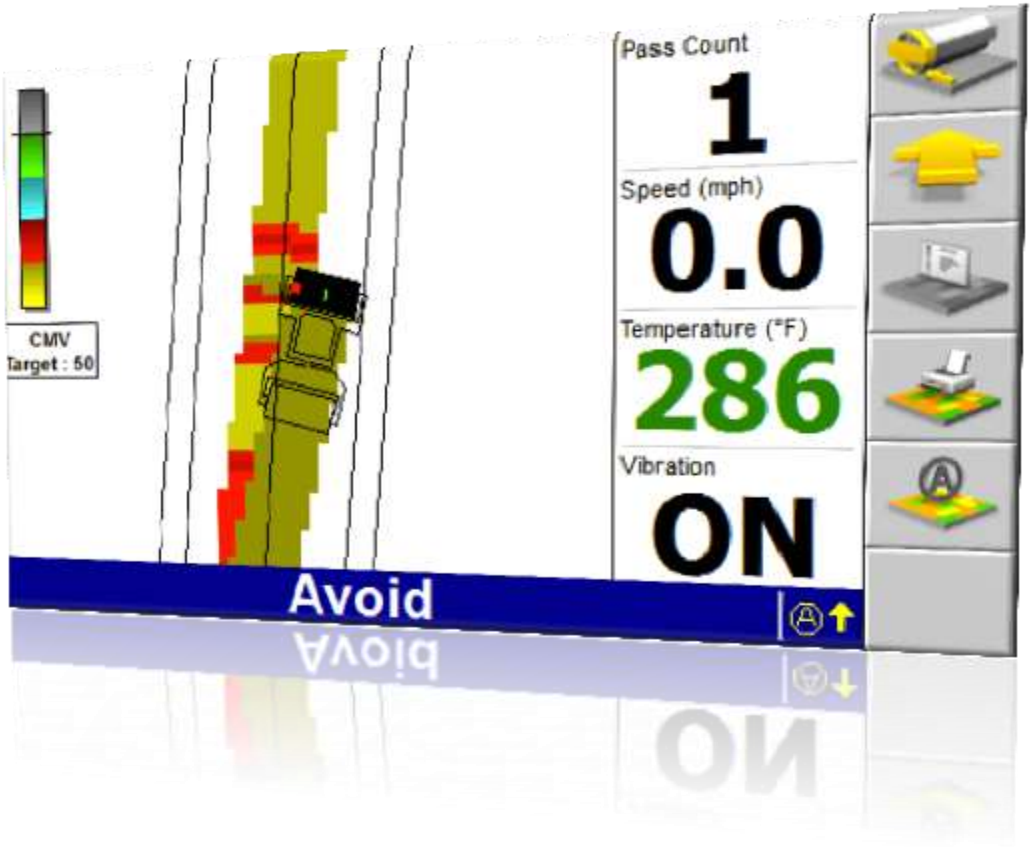


Benefit: CMV Mapping

- Ensure proper vibe state during compaction effort
- Ensure proper machine settings (freq and amp)
- Knowledge of results of compaction effort
- Historical Data

CMV – Compaction Meter Value
Understand your compaction

- CMV is an accelerometer based sensor that gives the operator an indication of the stiffness and consolidation of the material below the roller
- The value may be correlated to the accepted static density test being used on the project
- Takes into account the level of compaction taking place with respect to the vibratory effort, roller size, weight, speed, vibratory frequency and amplitude of the drum



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Benefit: Historical Data

- Though it is an "After the fact" analysis, historical data can help us improve our work flow and our final product by helping us to plan intelligently.
- Proof that work was performed as per specification.
- Data can be analyzed to determine root cause of some problems.

What is being specified in IC?

- Common Specifications:
  - Pass count of vibratory roller
    - Have seen requirements for entire roller train
  - Temperature mapping of asphalt mat
  - Typically, RTK precision is required
  - Coordinate systems vary by project
  - In US, VETA output is expected
  - CMV often specified, although does not usually affect pay

Systems

- Pass Count, Temperature Mapping, ICMV
  - Atlas Copco (Dynapac); Dyn@lyzer
  - Bomag; Asphalt Manager
  - Caterpillar; Cat Compaction Control
  - Hamm/ Wirtgen; HCQ
  - Sakai; Compaction Information System2
  - Volvo; Volvo IC w/Density Direct
  - Topcon; C-63 Intelligent Compaction System
  - Trimble; CCS900 Intelligent Compaction System

Accelerometer

- Weaknesses
  - Too many variables. Temperature, thickness, depth of reading, mix design, speed, direction, amplitude, frequency.
  - Cannot read density. Density=mass/volume. An accelerometer knows neither of those.
  - A reasonable correlation can be made between Density and “stiffness” (CMV) in a very controlled situation. Real world paving and compaction can’t be controlled that tightly.
  - Accelerometer reads ~3-10’ deep. We only care about top layer.
  - Accelerometer will indicate a stiff mat regardless of its density once the mat has cooled.

Accelerometer

- Benefits
  - Can help us understand underlying deficiencies (Weak areas)
    - Plan for future rehabilitation
  - Lets us understand vibe state, amplitude, and frequency
  - Can give us a reasonable understanding of density if we control the other variables

GNSS Accuracy

- Differing levels of GNSS Accuracy
  - Differential GNSS using SBAS (WAAS) ~3’ accuracy
    - UTM Coordinate System
    - Not repeatable
  - RTK GNSS .1’ accuracy
    - State Plane, Arbitrary Localization, you pick.
    - Pass to pass repeatability
    - Navigate to problem areas
    - Utilize 3D Design if available
    - Requires a correction stream; Local Base or VRS (CORS)

Temperature Sensors

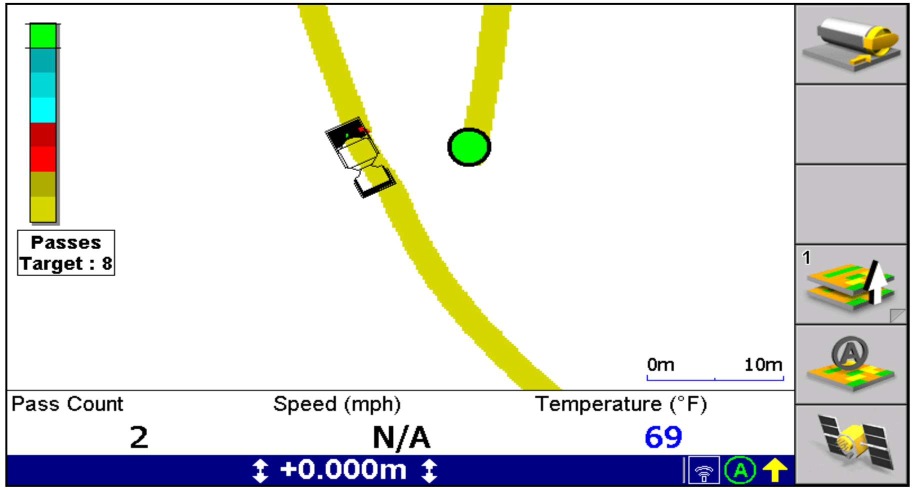
- Temperature Sensors
  - Center Mounted Sensor; Always reading a “wet” mat
  - Front and Rear Mounted Sensors; Always reading a “dry” mat

Other Options

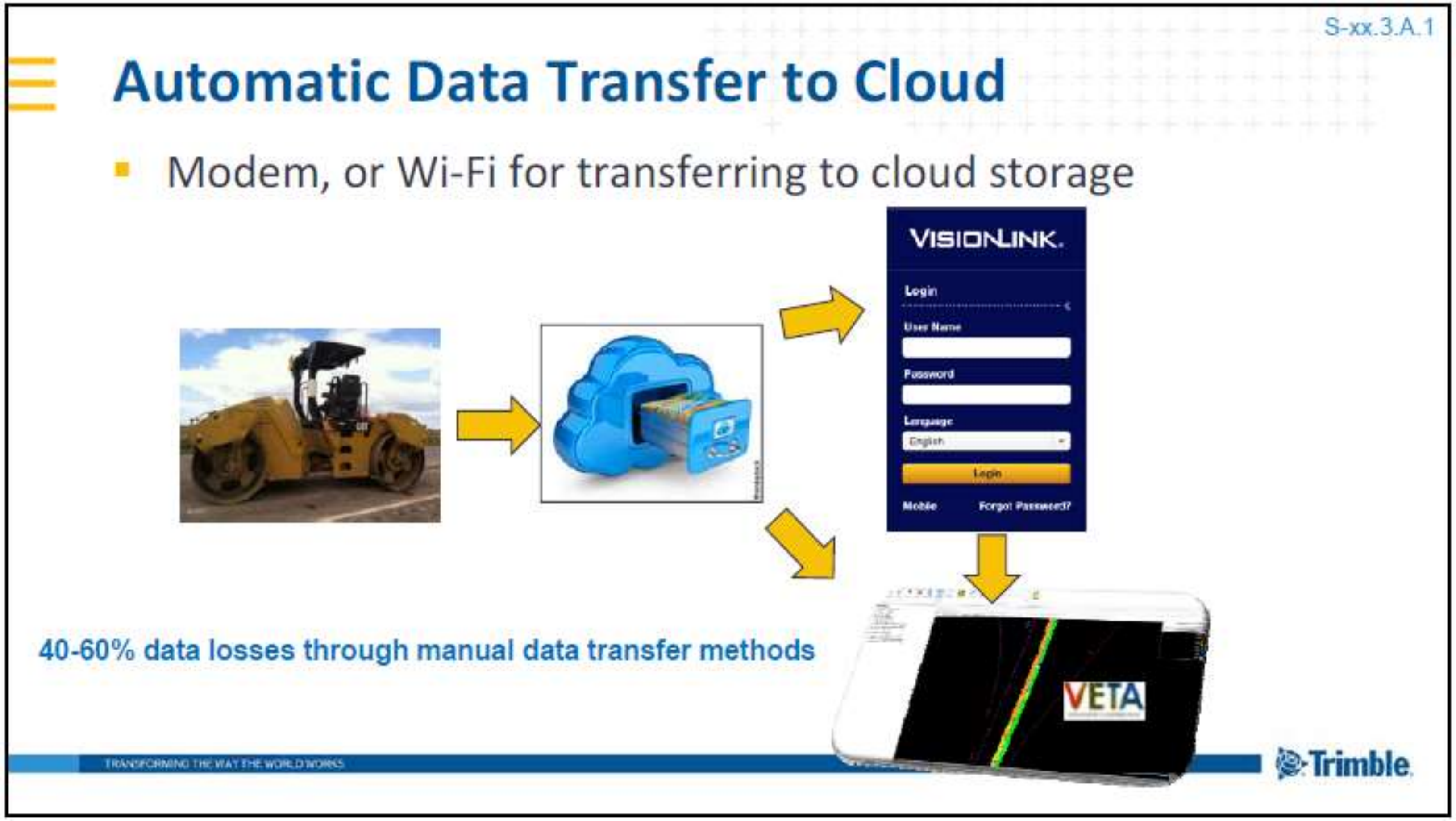
- Map Sharing
  - Operators of multiple machines share mapping information.
  - Several manufacturers offer map sharing
- Web based data
- Veta (Veda)
- In field reporting

What is Machine to Machine Mapping?

- Enables 2 or more machines to share mapping data in real time
- Machines able to work from a common updated map



Cloud Based Data



IC- Benefits

- **Uniform efforts make more uniform cores.**
- **Operator has data required to make decisions and adjustments in real time.**
- **Supervisor has actionable data at his fingertips.**
- **Huge amount of Data!**

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IC- Weaknesses

- No Common Data Platform
  - Veta helps
- Continued disagreement regarding what is “important”
- FHWA definition of Intelligent Compaction is too narrow
  - Emerging technologies
  - Trans Tech PQI380 OTR (Coming Soon)
- Huge amount of data! Planning ahead will make the difference between success and failure.

What is VETA?

- VETA is a software for viewing and analyzing geospatial data
- Developed by The Transtec Group and sponsored by Minnesota Department of Transportation (MnDOT).
- VETA can import data from various intelligent compaction (IC) machines and MOBA PAVE-IR thermal profile data to perform viewing, editing/layering, point tests, and analysis.
- Download at intelligentcompaction.com

VETA


VETA
INTELLIGENT CONSTRUCTION
Intelligent Compaction – All Current Vendors
Paver Mounted Thermal Profile System
Scanning System & Static Bar
VETA
QC / QA Spot Tests
Future Imports: GPR, Smoothness (ProVal Export), Digital Test Rolling
Trimble

VETA

Why MnDOT is using Veta?

Non-Proprietary Software

- Low Bid Build
- Ease of Statewide deployment within State Agency

Database

- Construction/As-Built Record
- Correlate to Pavement Performance
- Compaction Curves – Rolling Pattern Development

Specification Refinements

Support Multiple Technologies

- Intelligent Compaction
- Paver Mounted Thermal Profiling
- Ground Penetrating Radar
- Digital Test Rolling
- Spot Tests (Density, FWD, etc.)
- ...other geospatial technologies

Training / Field Support

- Effects of Paver Stops on Ride & compaction efforts
- Effects of Compaction Efforts on Uniformity
- ...and more

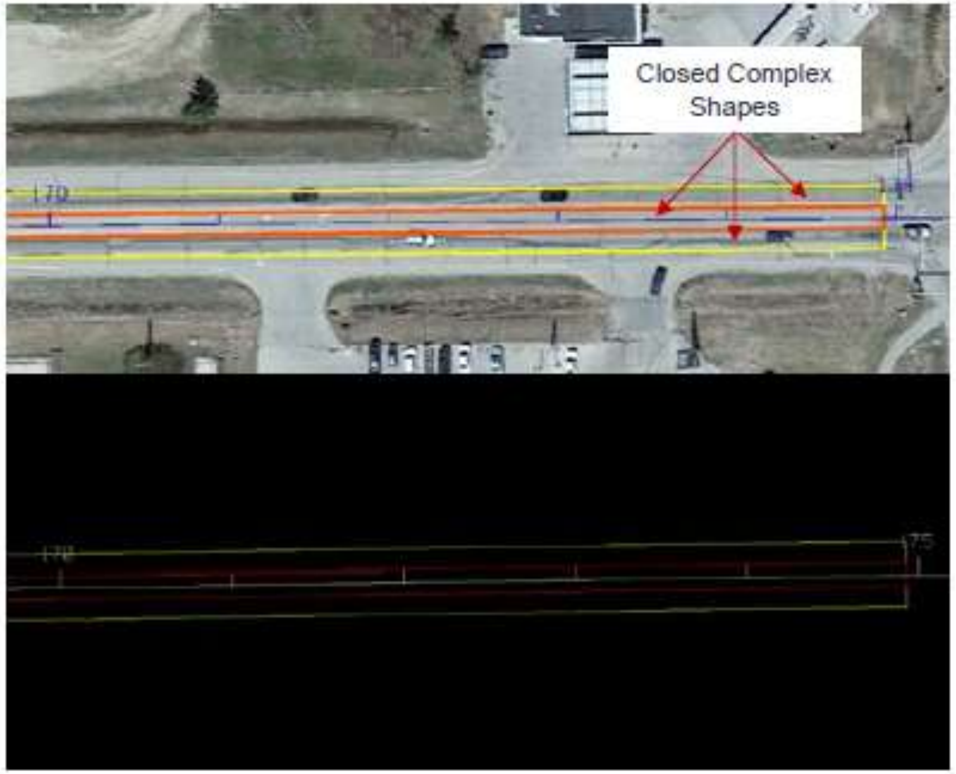
S-xx.3.A.1

Instrumentation of Entire Rolling Train

Data

S-xx.3.C

Design File (Background, Alignment File)



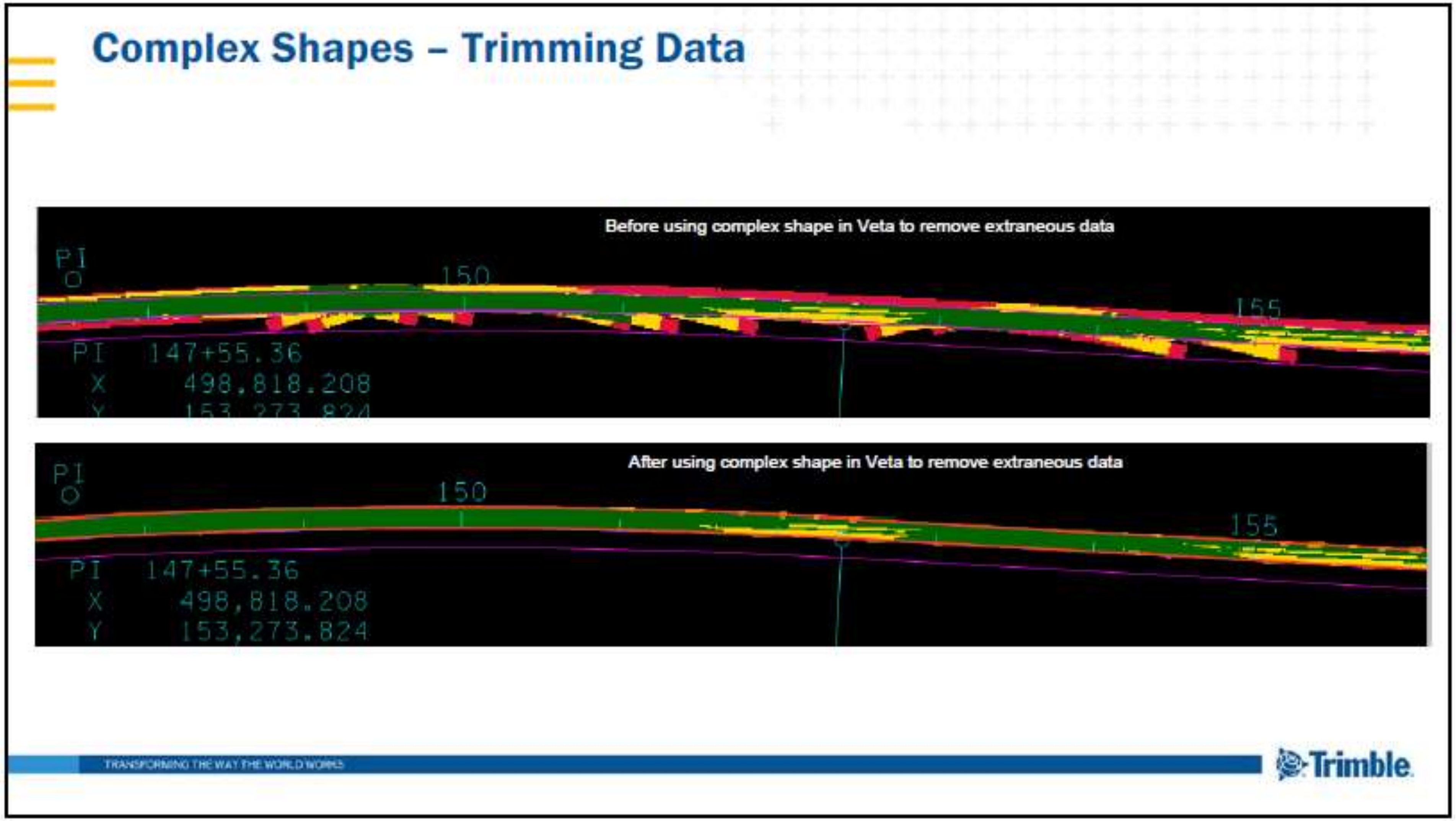
Goal: Eliminate need of complex shapes by 2018!

- Layers
  - Centerline
  - Station Text
  - Station Tick Marks
  - Exceptions
  - Closed Complex Shapes
- Horizontal Accuracy
  - ± 2 in (50 mm)
- 3 Working Days of Contract Approval
  - Format
    - DGN
    - 2D-KMZ (Veta)
  - County coordinate system
  - Total lane miles per material type/lift

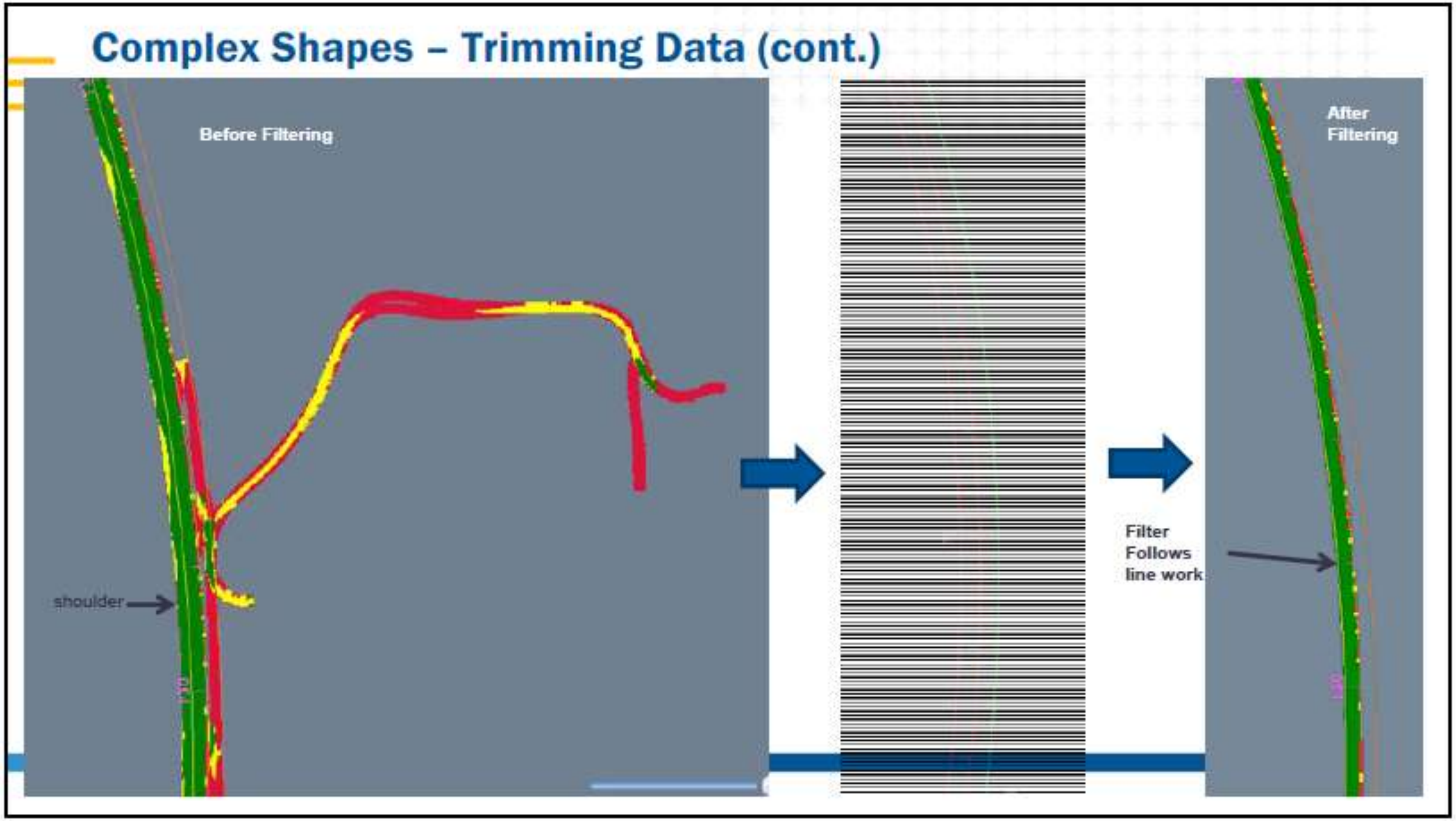
TRANSFORMING THE WAY THE WORLD WORKS

Trimble

Data


Complex Shapes – Trimming Data
Before using complex shape in Veta to remove extraneous data
PI
O
150
155
PI 147+55.36
X 498,818.208
After using complex shape in Veta to remove extraneous data
PI
O
150
155
PI 147+55.36
X 498,818.208
Y 153,273.824
TRANSFORMING THE WAY THE WORLD WORKS
Trimble

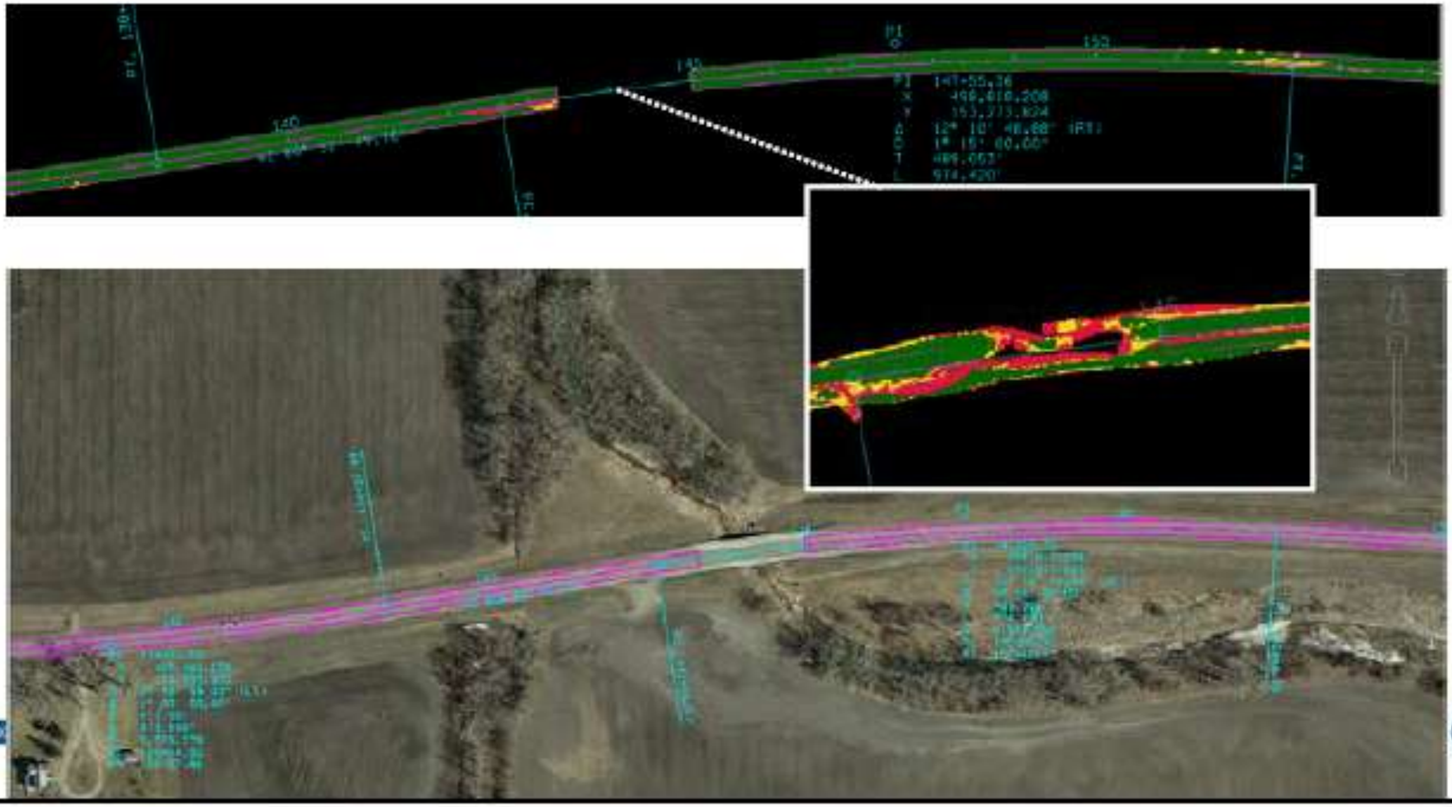
Data


Complex Shapes – Trimming Data (cont.)
Before Filtering
shoulder
Filter
Follows
line work
After
Filtering

Data

Complex Shapes – Trimming Data (cont.)

- Create separate complex shape, per lane, for each side of exception



Data

S-xx.3.F.1

Lot Establishment (not lots used for density!)

Used for ease in mapping and data analyses in Trimble VisionLink Legacy & Veta

Specification	Definition
2353 (UTBWC) 2360 (HMA, WMA) 2365 (SMA)	Measurements for a given: • Day • Material Type • Lift • Centerline Offsets • Direction of Travel (Divided Highway)
2215 (SFDR) 2331 (CIR)	Measurements for a given: • Material Type • Lift • Centerline Offsets • Direction of Travel (Divided Highway)

Data

S-xx.3.F.1

Standardized Naming Convention of Lots

- Creative naming conventions.
- Multiple names for one lot.
- Roller operators selecting different names.

Standardized Format*	Definition
ROUTE-MATL-L#-XXX-XXX	Undivided Highways (e.g., TH12-HMA-L1-CL-12R)
ROUTE-MATL-L#-XXX-XXX-DT	Divided Highways (e.g., TH12-HMA-L1-CL-12R-NB)
*Add an additional designation behind route for instances where more than one site calibration is needed within the project limits (e.g., TH12**N**-HMA-L1-12L-CL, TH12**S**-HMA-L1-12L-CL)	

Data

S-xx.3.F.1

Lot Naming Standardization: Route

ROUTE-MATL-L# -XXX-XXX

Acronym or Short Form	Full Name or Meaning
CR	County Road
CSAH	County State Aid Highway
MS	Municipal Street
MSAS	Municipal State Aid Street
TH	Trunk Highway

Replace ROUTE with route system followed by the route number (e.g., TH12)

Data

S-xx.3.F.1

Lot Naming Standardization: Material / Surface Type

ROUTE-**MATL**-L# -XXX-XXX

Acronym or Short Form	Specification	Full Name or Meaning
SFDR-P	2215	SFDR - Pulverization
SFDR-I		SFDR – Mixing/Injecting
CIR	2331	Cold In-Place Recycling
UTBWC	2353	Ultrathin Bonded Wearing Course
HMA	2360	Hot Mix Asphalt
WMA		Warm Mix Asphalt
SMA	2365	Stone Matrix Asphalt

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Data

S-xx.3.F.1

Lot Naming Standardization: Lift Number

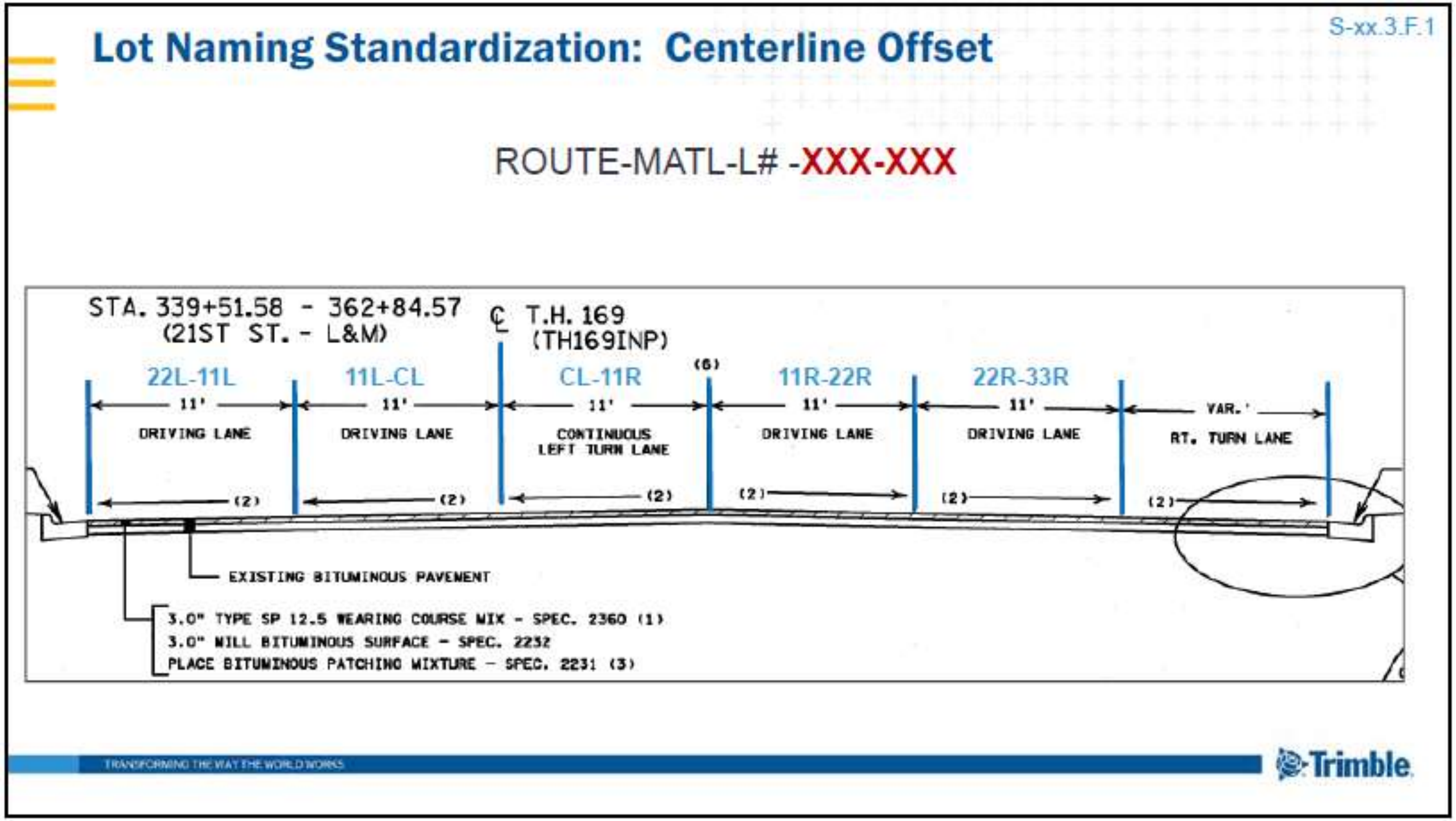
ROUTE-MATL-**L#** -XXX-XXX

Acronym or Short Form	Full Name or Meaning
L1	Lift 1
L2	Lift 2
L3	Lift 3
…	…
Ln	Lift n

TRANSFORMING THE WAY THE WORLD WORKS

Trimble

Data



S-xx.3.F.1
Lot Naming Standardization: Centerline Offset
ROUTE-MATL-L# -XXX-XXX
STA. 339+51.58 - 362+84.57
(21ST ST. - L&M)
℄ T.H. 169
(TH169INP)
22L-11L
11L-CL
CL-11R
11R-22R
22R-33R
(6)
11'
DRIVING LANE
CONTINUOUS LEFT TURN LANE
VAR.'
RT. TURN LANE
(2)
EXISTING BITUMINOUS PAVEMENT
3.0" TYPE SP 12.5 WEARING COURSE MIX - SPEC. 2360 (1)
3.0" MILL BITUMINOUS SURFACE - SPEC. 2232
PLACE BITUMINOUS PATCHING MIXTURE - SPEC. 2231 (3)
TRANSFORMING THE WAY THE WORLD WORKS
Trimble

Data

S-xx.3.F.1

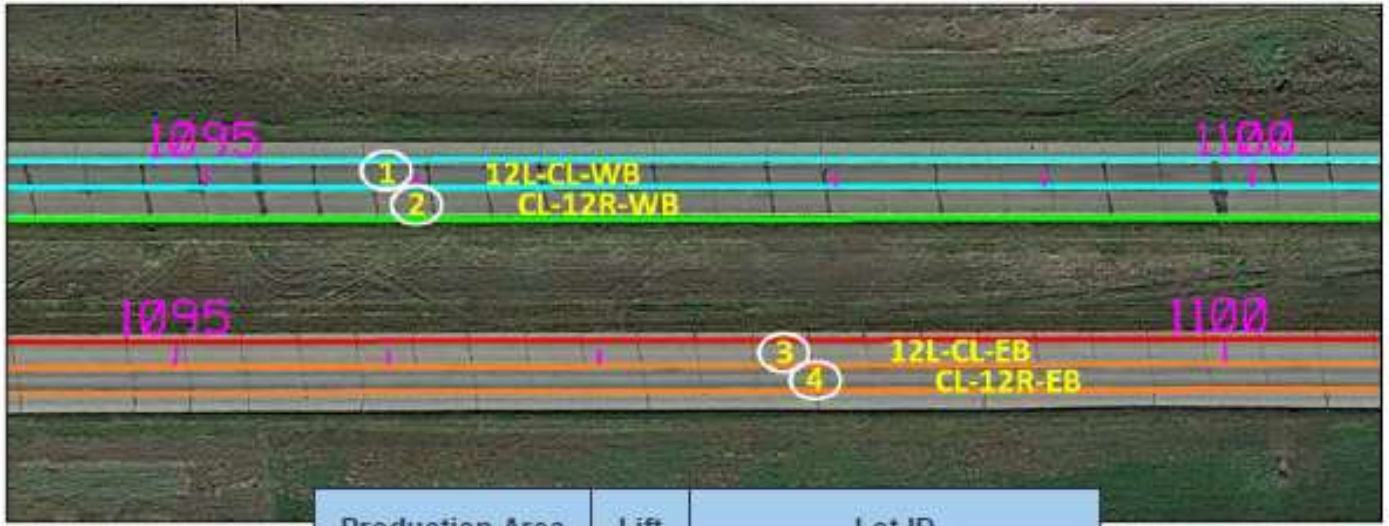
Lot Naming Standardization: Direction of Travel (Divided Highways)

ROUTE-MATL-L# -XXX-XXX-**DT**

Table 2016-6 (IC) – cont.	
Acronym or Short Form	**Full Name or Meaning**
NB	North Bound
SB	South Bound
EB	East Bound
WB	West Bound

Data

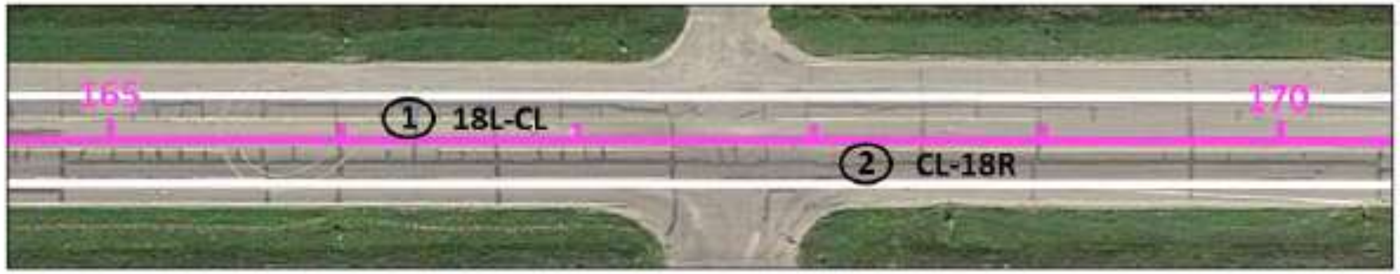
Example 1 – Divided Highway, 12-ft Asphalt Paving



Production Area	Lift	Lot ID
1	1	TH12-HMA-L1-12L-CL-WB
	2	TH12-HMA-L2-12L-CL-WB
2	1	TH12-HMA-L1-CL-12R-WB
	2	TH12-HMA-L2-CL-12R-WB
3	1	TH12-HMA-L1-12L-CL-EB
	2	TH12-HMA-L2-12L-CL-EB
4	1	TH12-HMA-L1-CL-12R-EB
	2	TH12-HMA-L2-CL-12R-EB

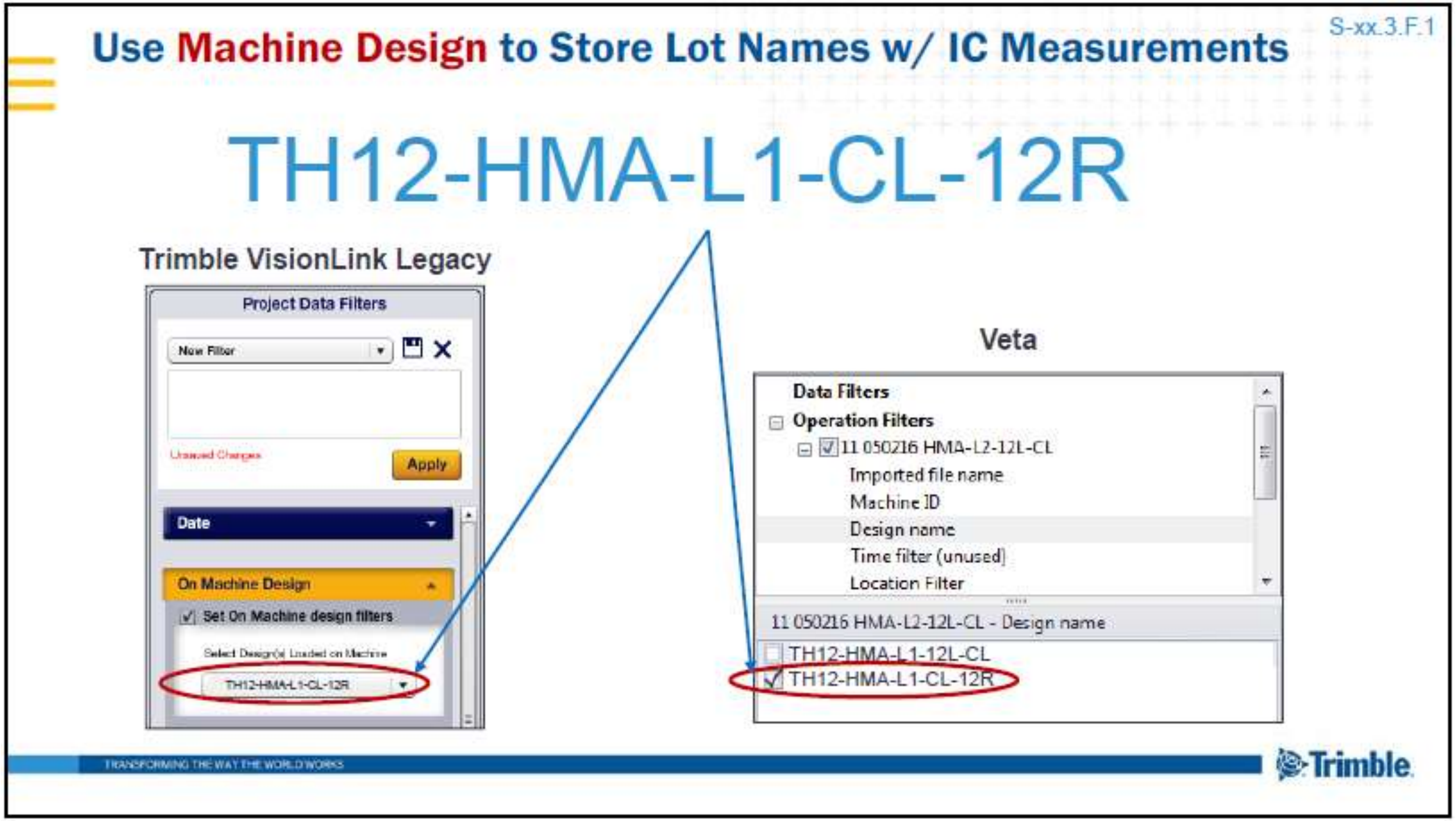
Data

Undivided Highway, Auxiliary Lane, 18-ft Asphalt Paving



Production Area	Lift	Lot ID
1	1	TH12-HMA-L1-18L-CL
	2	TH12-HMA-L2-18L-CL
2	1	TH12-HMA-L1-CL-18R
	2	TH12-HMA-L2-CL-18R

Data


Use Machine Design to Store Lot Names w/ IC Measurements
S-xx.3.F.1
TH12-HMA-L1-CL-12R
Trimble VisionLink Legacy
Project Data Filters
New Filter
Apply
Date
On Machine Design
Set On Machine design filters
TH12-HMA-L1-CL-12R
Veta
Data Filters
Operation Filters
11 050216 HMA-L2-12L-CL
Imported file name
Machine ID
Design name
Time filter (unused)
Location Filter
11 050216 HMA-L2-12L-CL - Design name
TH12-HMA-L1-12L-CL
TH12-HMA-L1-CL-12R
TRANSFORMING THE WAY THE WORLD WORKS
Trimble

Data

Selection of Lot Name using the CB460

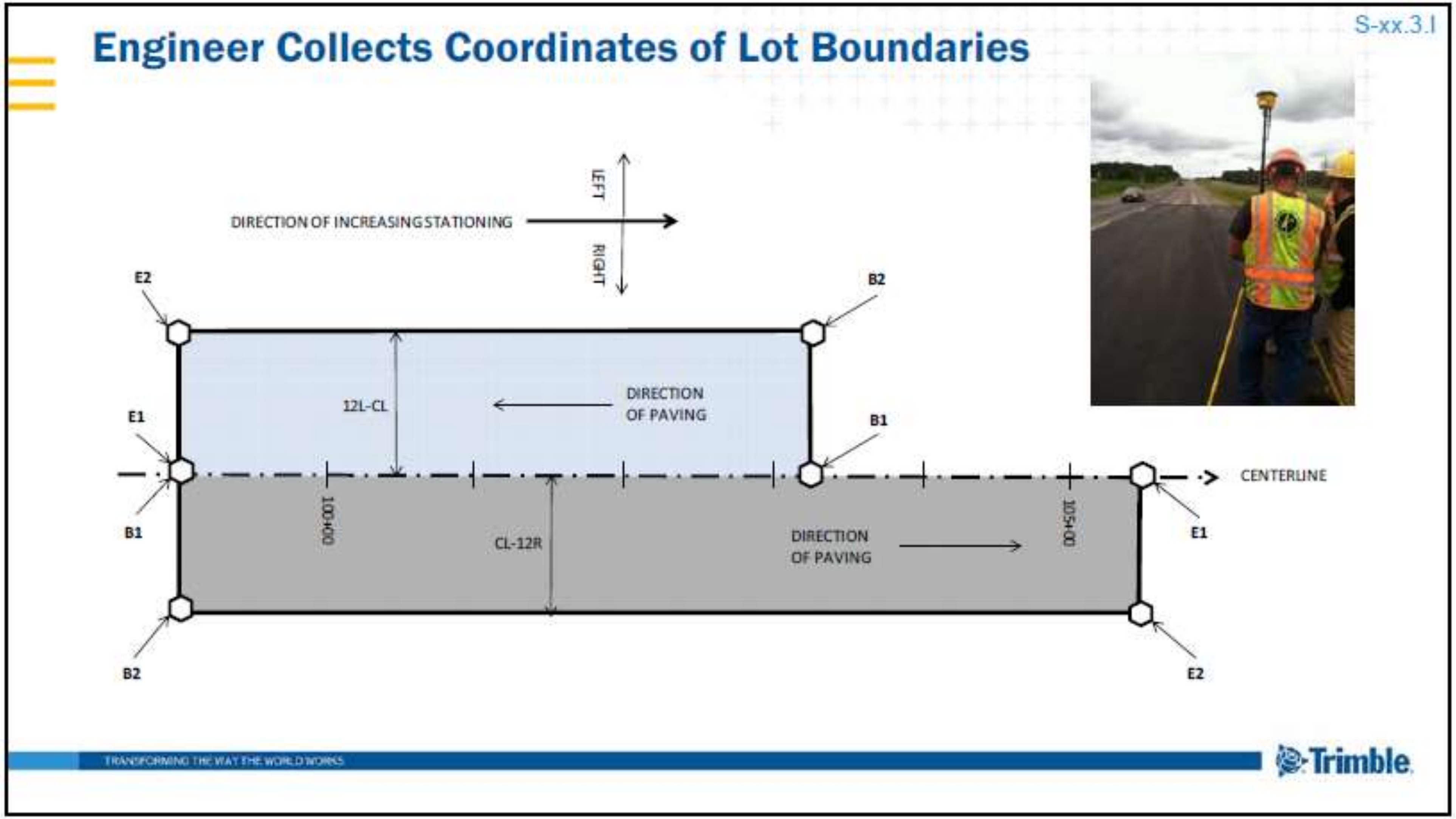
Figure Courtesy of Ziegler CAT

Data

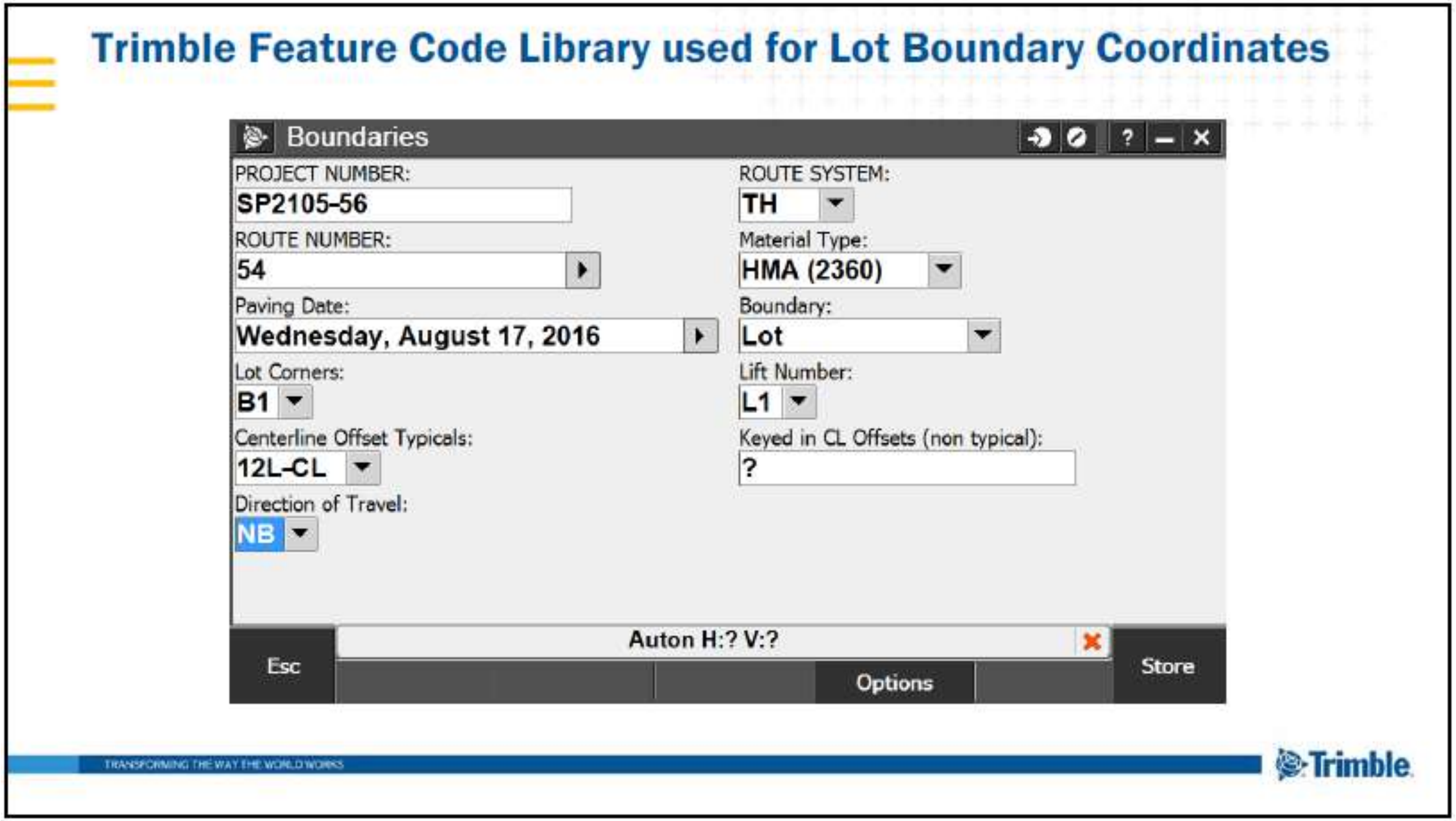
Verification of Selected Lot Name on CB460

Figure Courtesy of Ziegler CAT

Data

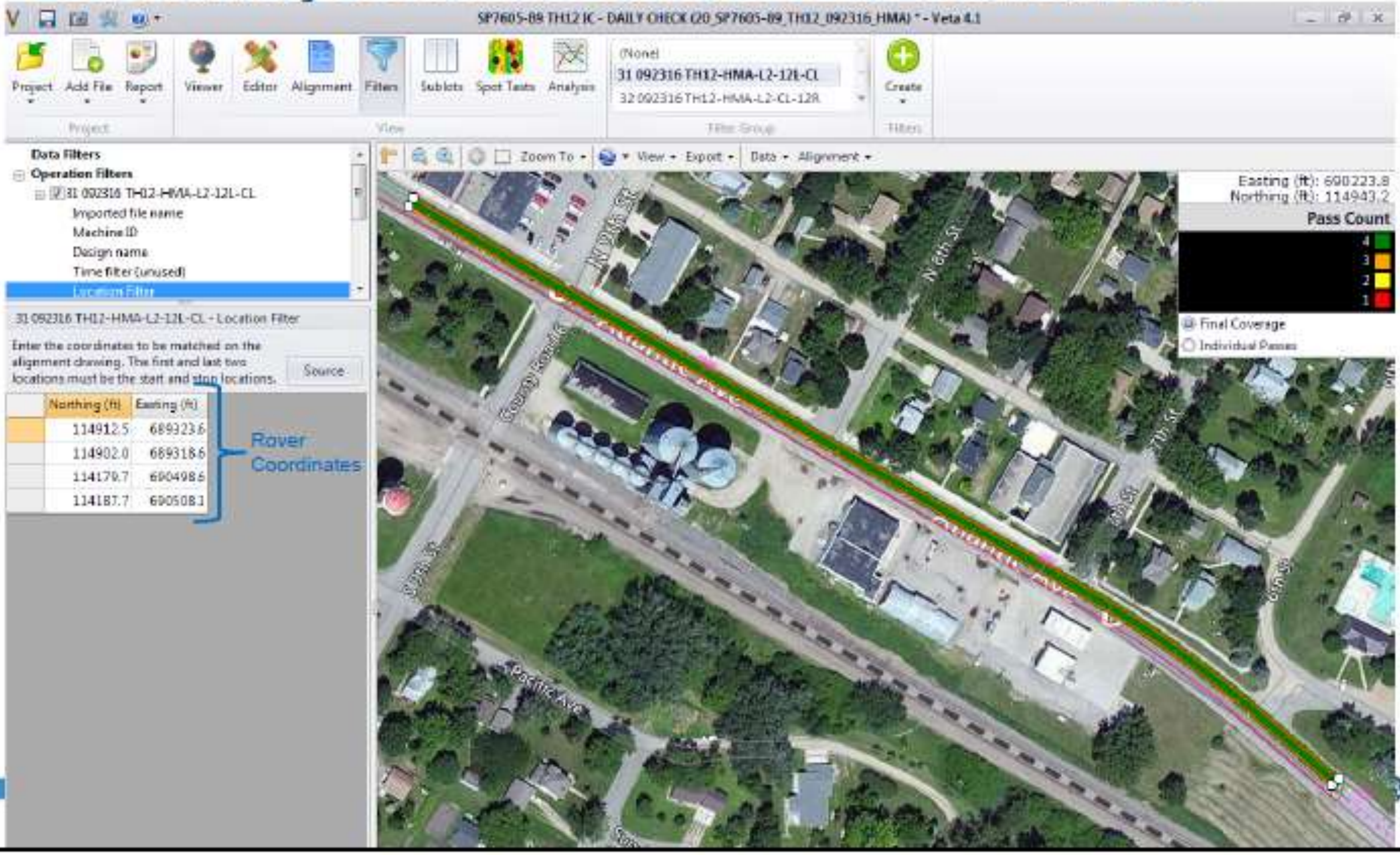

S-xx.3.I
Engineer Collects Coordinates of Lot Boundaries
DIRECTION OF INCREASING STATIONING
LEFT
RIGHT
E2
B2
12L-CL
DIRECTION
OF PAVING
E1
B1
100+00
CL-12R
DIRECTION
OF PAVING
105+00
CENTERLINE
E1
B2
E2
TRANSFORMING THE WAY THE WORLD WORKS
Trimble

Data


Trimble Feature Code Library used for Lot Boundary Coordinates
Boundaries
PROJECT NUMBER:
SP2105-56
ROUTE SYSTEM:
TH
ROUTE NUMBER:
54
Material Type:
HMA (2360)
Paving Date:
Wednesday, August 17, 2016
Boundary:
Lot
Lot Corners:
B1
Lift Number:
L1
Centerline Offset Typicals:
12L-CL
Keyed in CL Offsets (non typical):
?
Direction of Travel:
NB
Esc
Auton H:? V:?
Options
Store
TRANSFORMING THE WAY THE WORLD WORKS
Trimble

Data

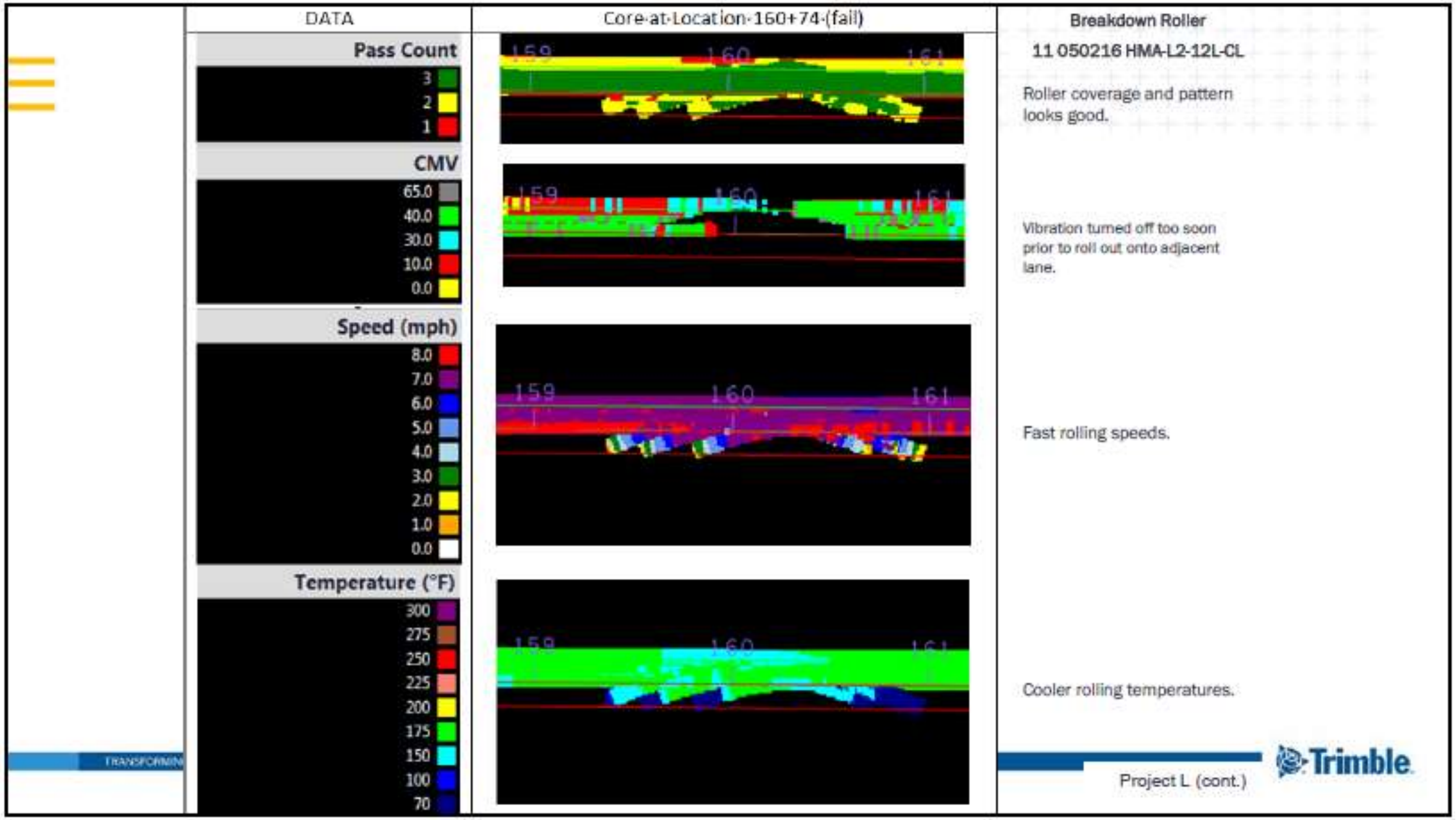
Lot Boundary Coordinates used in Veta Location Filter



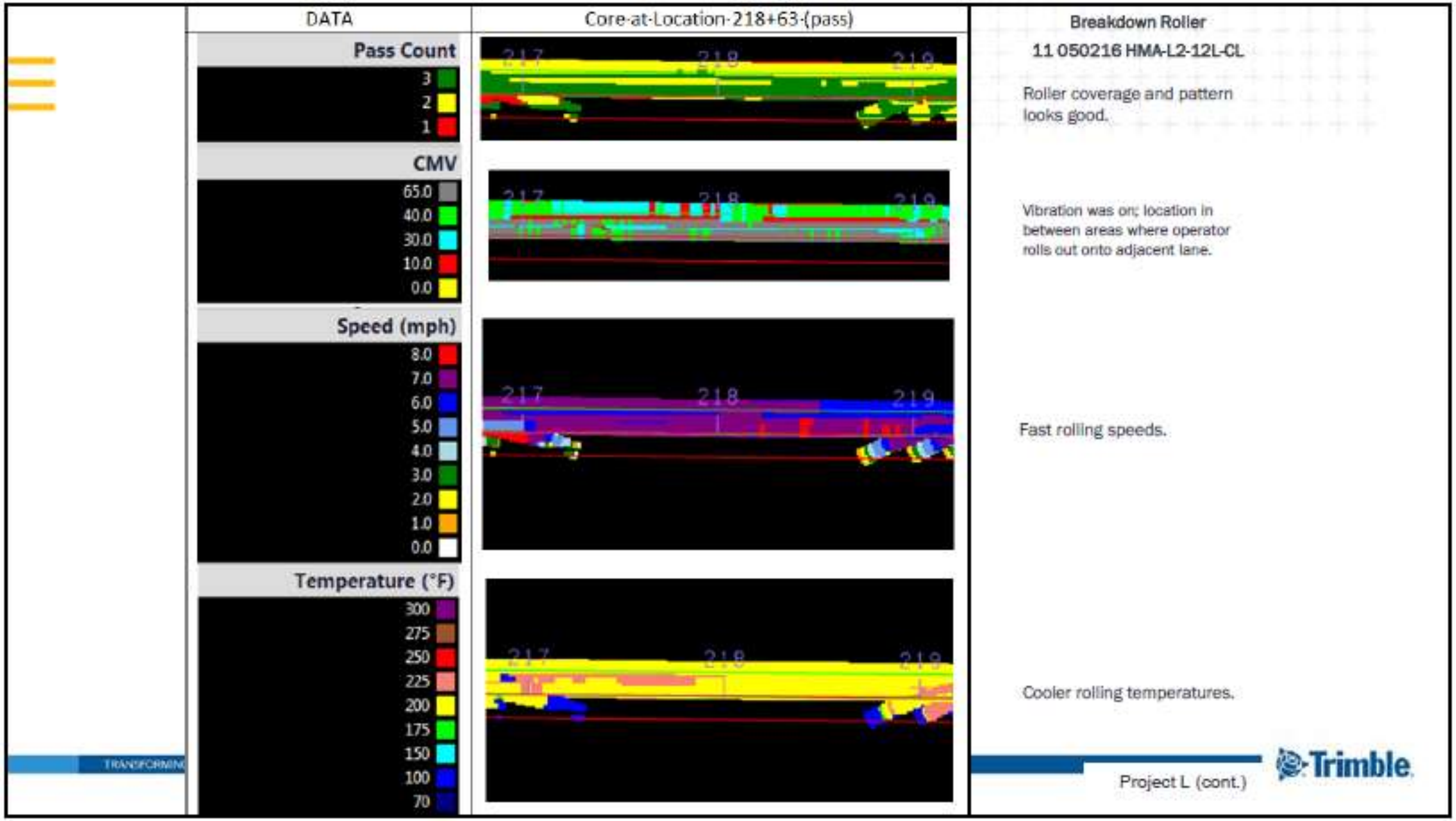
Data


S-xx.3.J
Use Standardized Naming Convention for Filters in Veta
LOT# MMDDYY LOTNAME
Filter Group Names
SP5503-45 TH14 IC * - Veta 4.1
Project
Add File
Report
Viewer
Editor
Alignment
Filters
Sublots
Spot Tests
Analysis
Create
(None)
01 080816 TH14-HMA-L1-12L-CL
02 080916 TH14-HMA-L1-12L-CL
03 081016 TH14-HMA-L1-12L-CL
04 081216 TH14-HMA-L1-12L-CL
05 081516 TH14-HMA-L1-12L-CL
06 081616 TH14-HMA-L1-12L-CL
07A 081716 TH14-HMA-L1-CL-12R
07B 081716 TH14-HMA-L1-CL-12R
08 081816 TH14-HMA-L1-12L-CL
Data Filters
Operation Filters
09 081816 TH14-HMA-L1-CL-12R
10 082216 TH14-HMA-L1-CL-12R
11A 082316 TH14-HMA-L1-CL-12R
11B 082316 TH14-HMA-L1-CL-12R
12 082416 TH14-HMA-L1-CL-12R
13 082916 TH14-HMA-L2-CL-12R
14 082916 TH14-HMA-L2-12L-CL
15 083016 TH14-HMA-L2-CL-12R
16 083016 TH14-HMA-L2-12L-CL
17 083116 TH14-HMA-L2-CL-12R
18 083116 TH14-HMA-L2-12L-CL
19 090116 TH14-HMA-L2-CL-12R
20 090116 TH14-HMA-L2-12L-CL
21 090616 TH14-HMA-L2-CL-12R
22 090616 TH14-HMA-L2-12L-CL
23 090816 TH14-HMA-L2-CL-12R
24 090816 TH14-HMA-L2-12L-CL
Zoom To
View
Chester
Chester Woods Park
CMV
65.0
40.0
30.0
10.0
0.0
Final Coverage
Individual Passes

Data


DATA
Core at Location 160+74 (fail)
Breakdown Roller
11 050216 HMA-L2-12L-CL
Pass Count
3
2
1
CMV
65.0
40.0
30.0
10.0
0.0
Speed (mph)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Temperature (°F)
300
275
250
225
200
175
150
100
70
159
160
161
Roller coverage and pattern looks good.
Vibration turned off too soon prior to roll out onto adjacent lane.
Fast rolling speeds.
Cooler rolling temperatures.
Project L (cont.)
Trimble

Data


DATA
Core-at-Location-218+63-(pass)
Breakdown Roller
11 050216 HMA-L2-12L-CL
Pass Count
3
2
1
217
218
219
Roller coverage and pattern looks good.
CMV
65.0
40.0
30.0
10.0
0.0
Vibration was on; location in between areas where operator rolls out onto adjacent lane.
Speed (mph)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Fast rolling speeds.
Temperature (°F)
300
275
250
225
200
175
150
100
70
Cooler rolling temperatures.
Project L (cont.)
Trimble

- www.intelligentcompaction.com
- Thank You!
- Questions?
- If you want to discuss more, I will probably be at the bar with a glass of Bourbon in my hand this evening.