

2011 Ohio Paving & NCAUPG Conference

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Improving Quality Control with Intelligent Compaction

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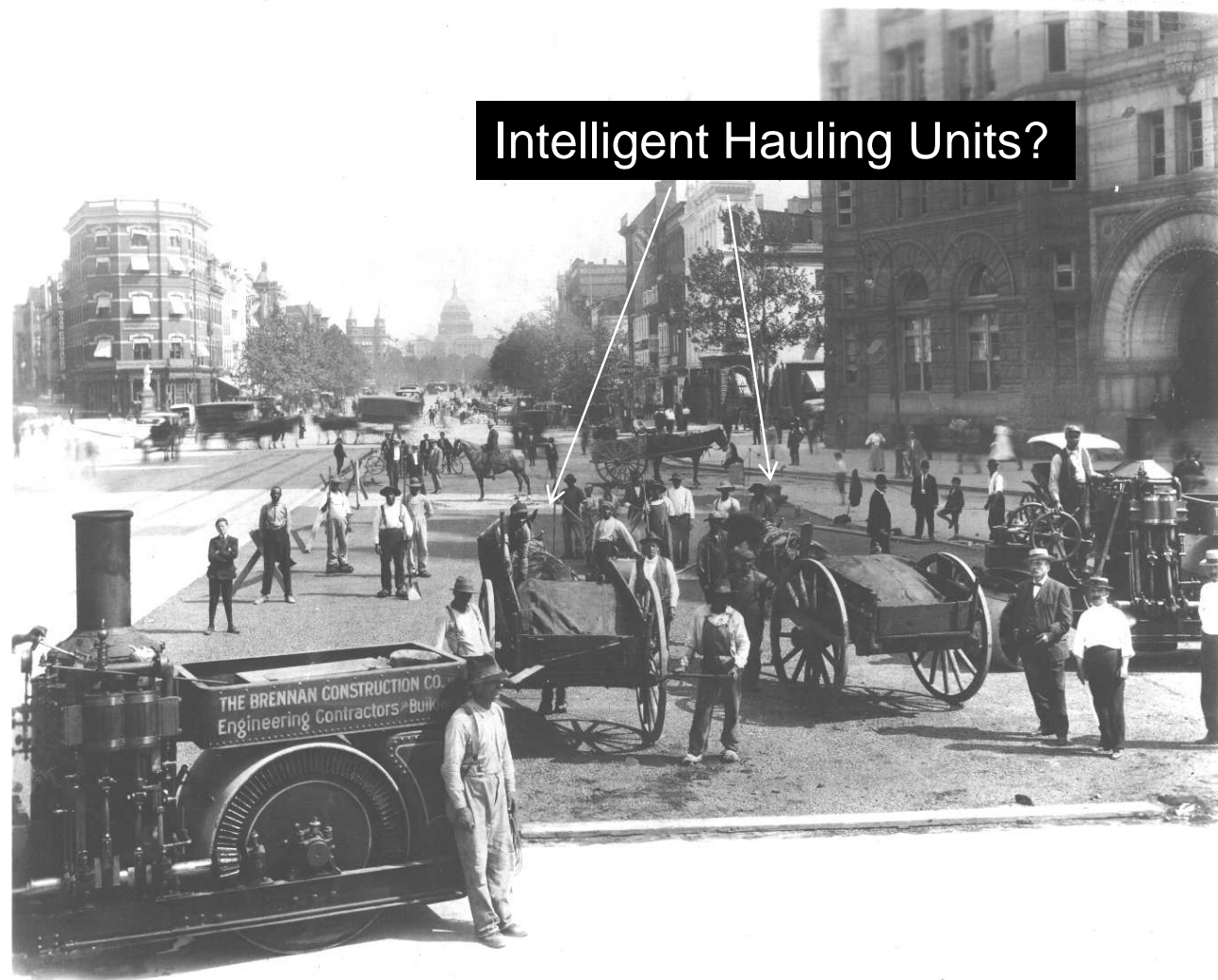
Richmond VA



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Washington DC 1907

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How Does IC Help with QC?

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- “Real-Time” Feedback to Roller Operator
 - On-Board, Color-Coded Mapping
 - Improved roller patterns
 - Improved temperature control
 - Ability to make adjustments “on-the-fly”
- Permanent Records of Compaction Data
- “Mapping” of Underlying Materials
 - RMV (Roller Measurement Values) readings
 - Locates “soft spots”
 - Identifies irregular support for compaction



Why Intelligent Compaction?

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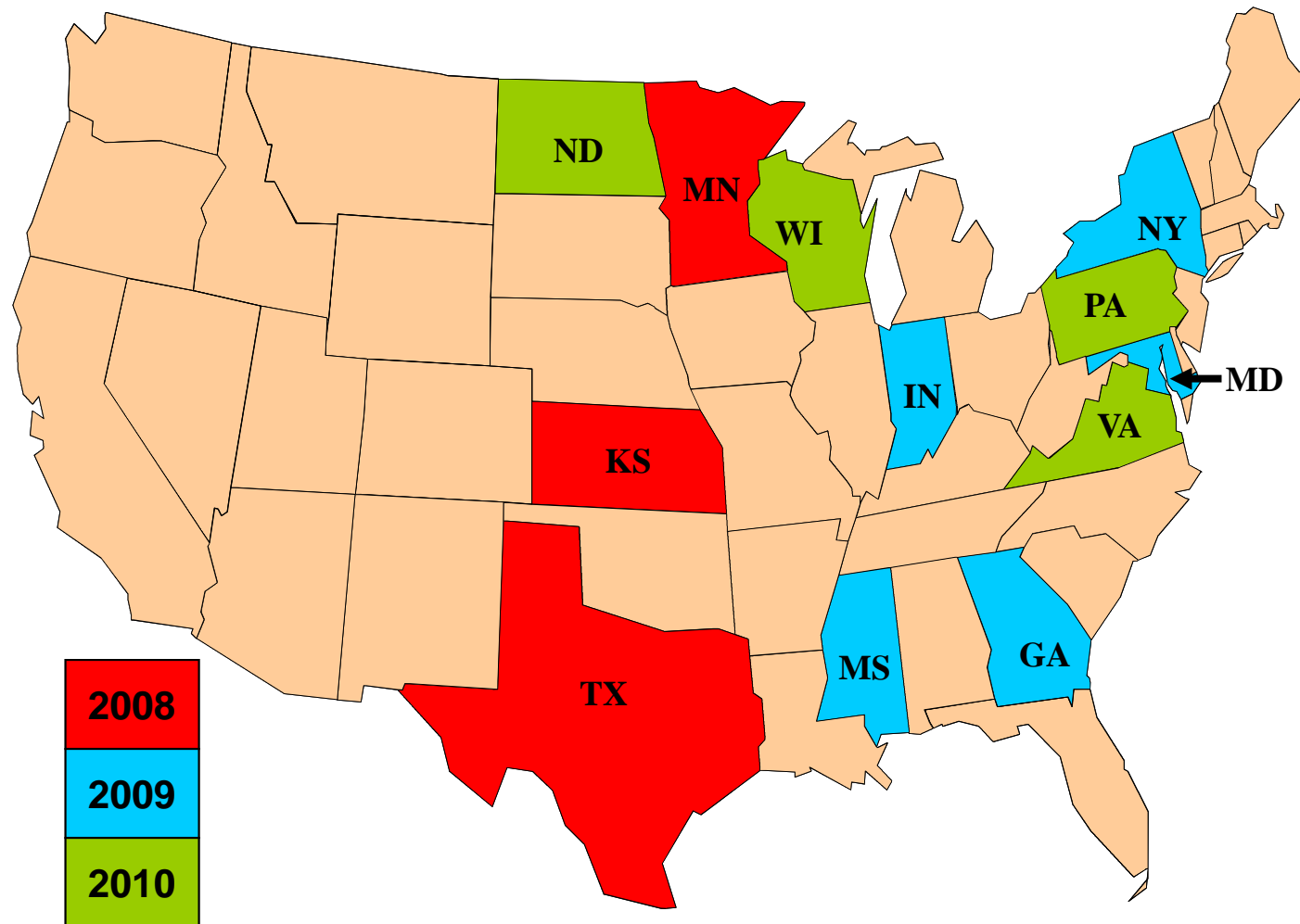
Why Do We Need IC?

- Proper in-place density is vital for good performance
- Conventional compaction equipment and procedures have shortcomings and too often produce poor results
- **Intelligent compaction technology appears to offer “a better way”**



IC Pooled Fund (ICPF)

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ICPF States / Year

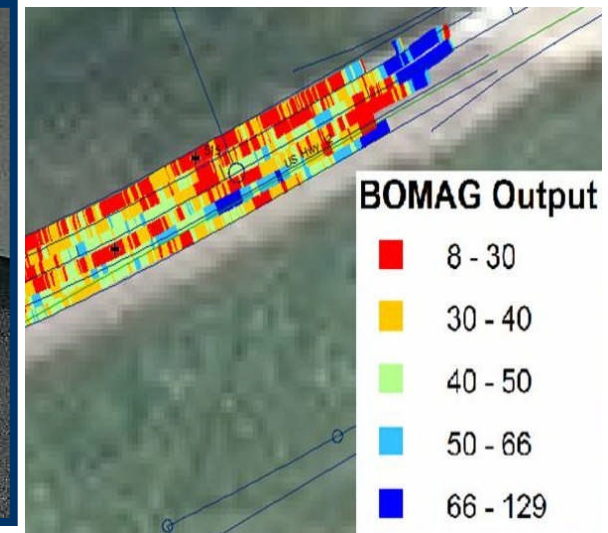


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What is Intelligent Compaction?

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An Innovation in Compaction Control and Acceptance



What is Intelligent Compaction?

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Vibratory Single Drum
Soil Roller



Vibratory Tandem Drum
Asphalt Roller

Tandem Drum IC Roller Suppliers

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Ammann/Case



Volvo



Dynapac



Bomag America



Caterpillar



Sakai America



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IC Roller Requirements

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- IC Roller Requirements
 - Roller Measurement Value (RMV)
 - GPS-Based documentation system
 - Color-coded display (on-board)
 - Surface temperature measurement system
 - **Optional: automatic feedback system**



Available Tandem Drum IC Rollers

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Bomag



Sakai



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Roller Measurement Values (RMVs)

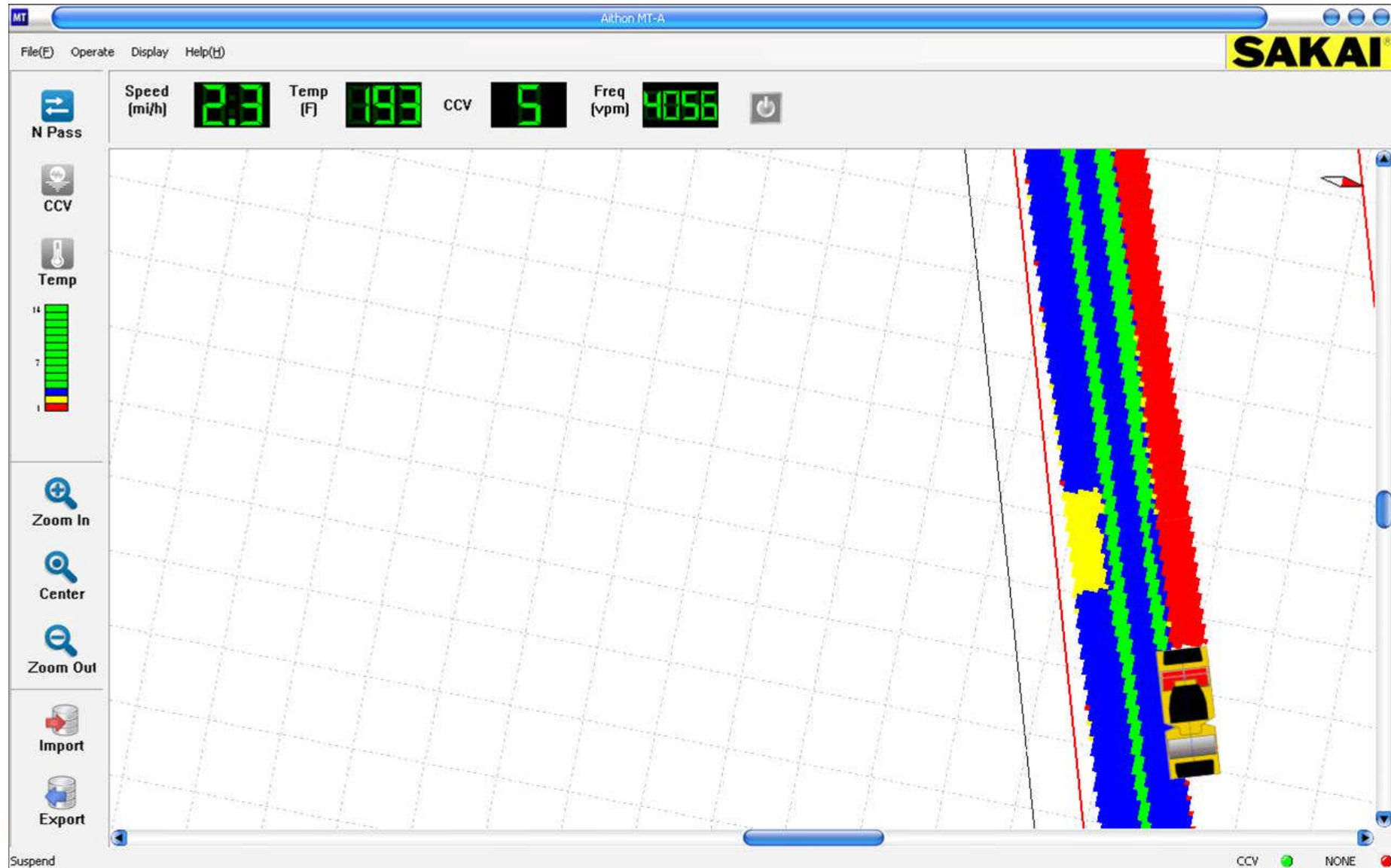
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Supplier	Roller Measurement Value	Measurement Unit
Sakai	Compaction Control Value; CCV	Unitless
Bomag	Vibration Modulus; E_{VIB}	Mn/m ²



Color-Coded On Board Display

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Global Positioning System (GPS)

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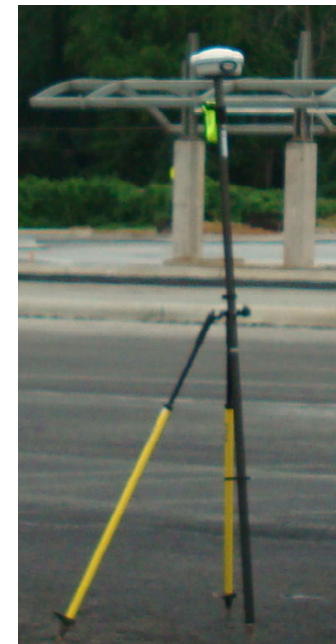
GPS Base Station



GPS Radio & Receiver



GPS Rover



Real Time Kinematic (RTK) GPS Precision



Mat Surface Temperature Measurement

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Infrared Thermal Gauge



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Improving QC using IC

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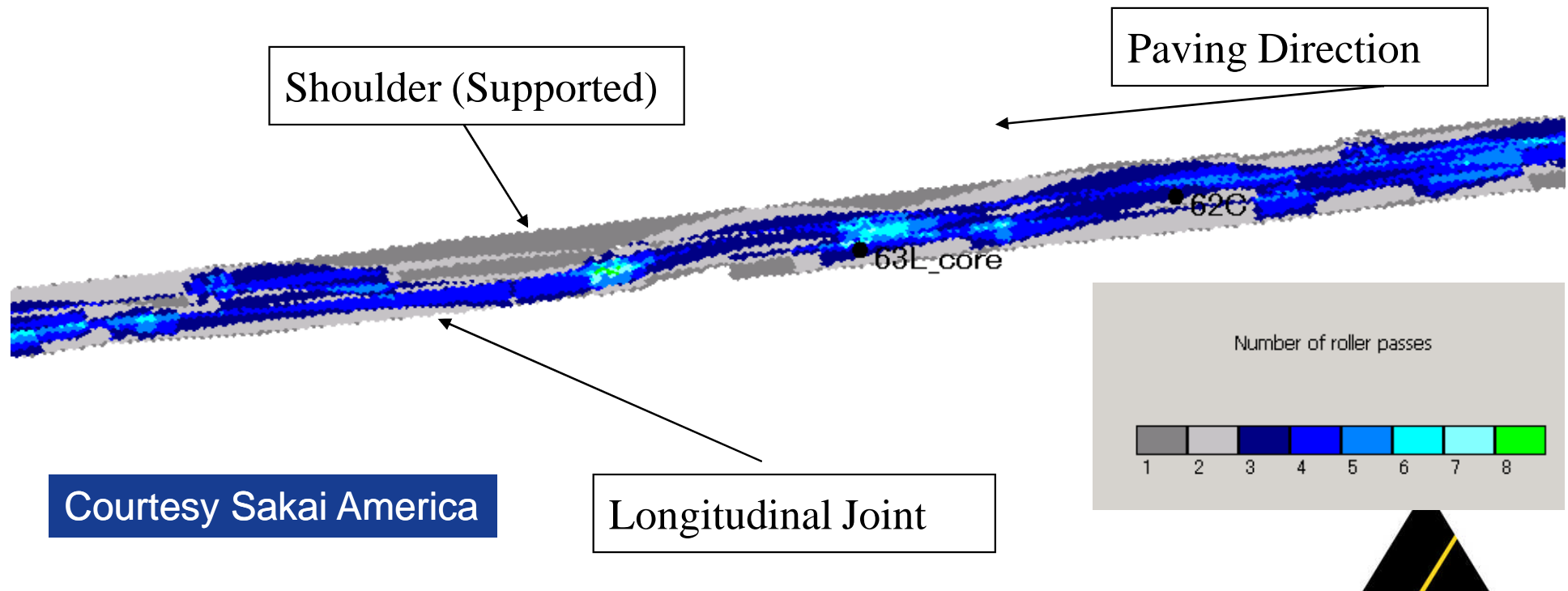
“Real-Time” Feedback to Roller Operator



Sakai Project - CA

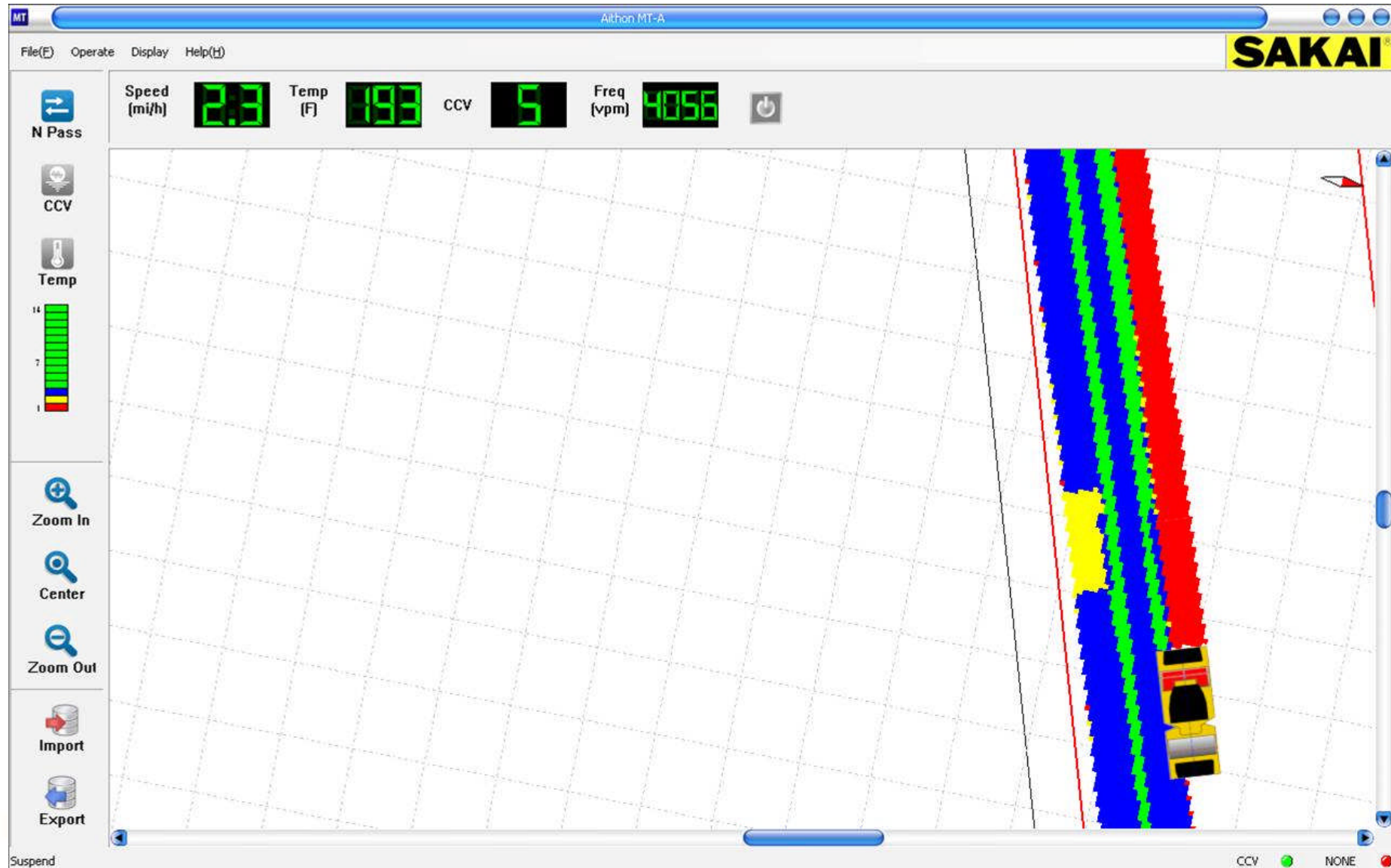
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- Roller Passes



Color-Coded On Board Display

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Roller Operator Training

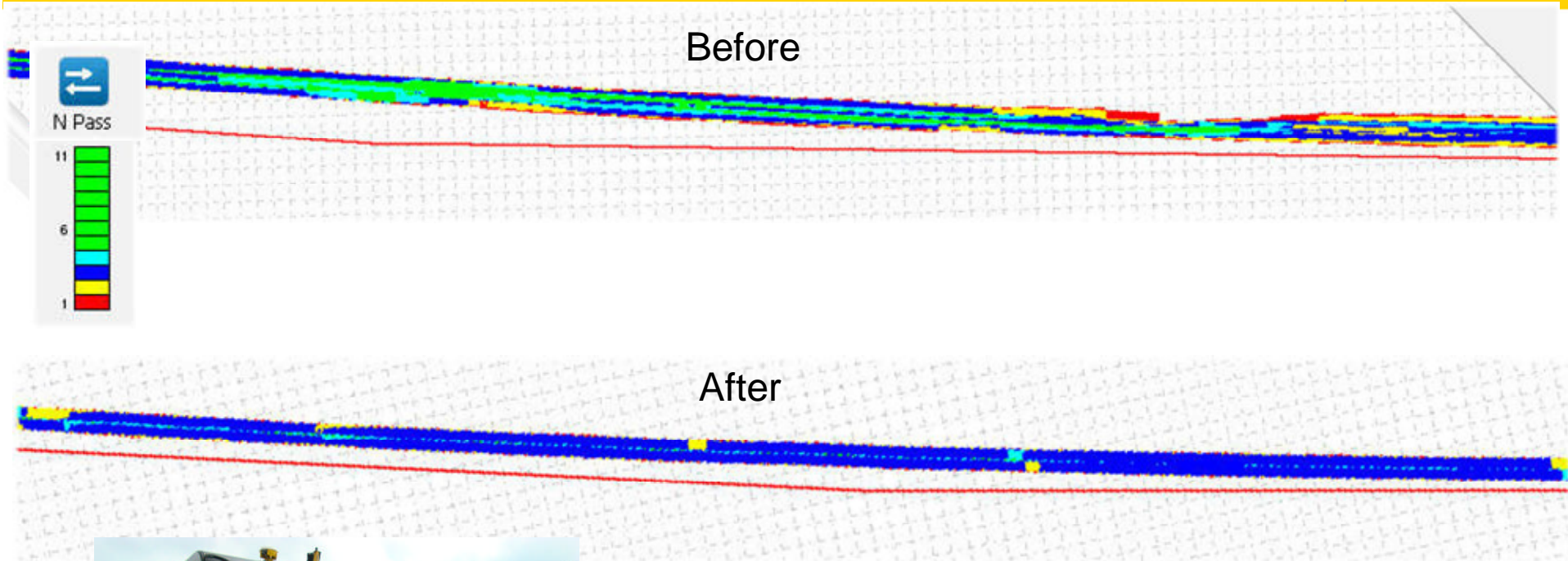
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Improved Rolling Patterns

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Sakai IC roller

Indiana ICPF Project



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Improving QC using IC

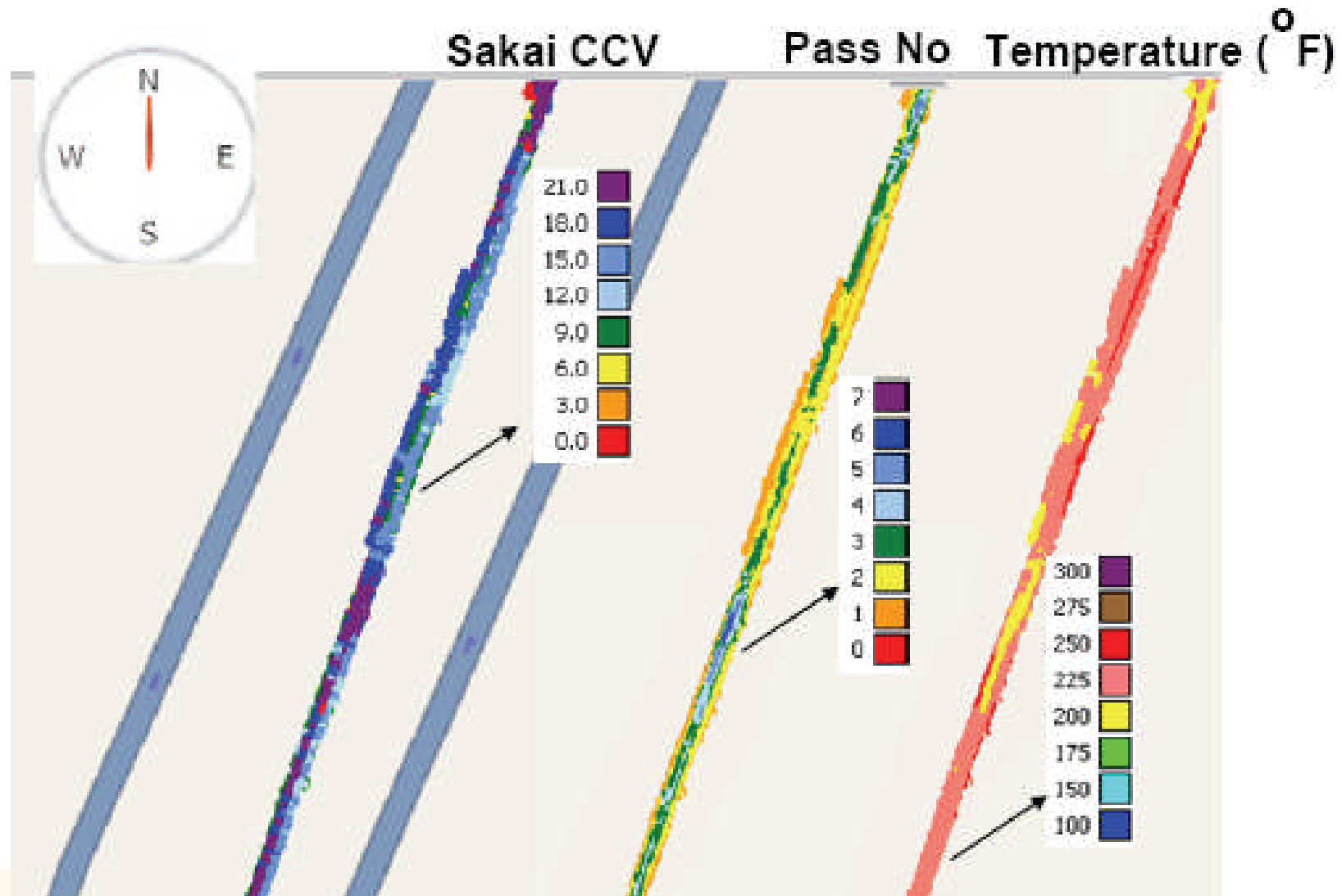
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Permanent Records of Compaction Related Data and Data Analysis



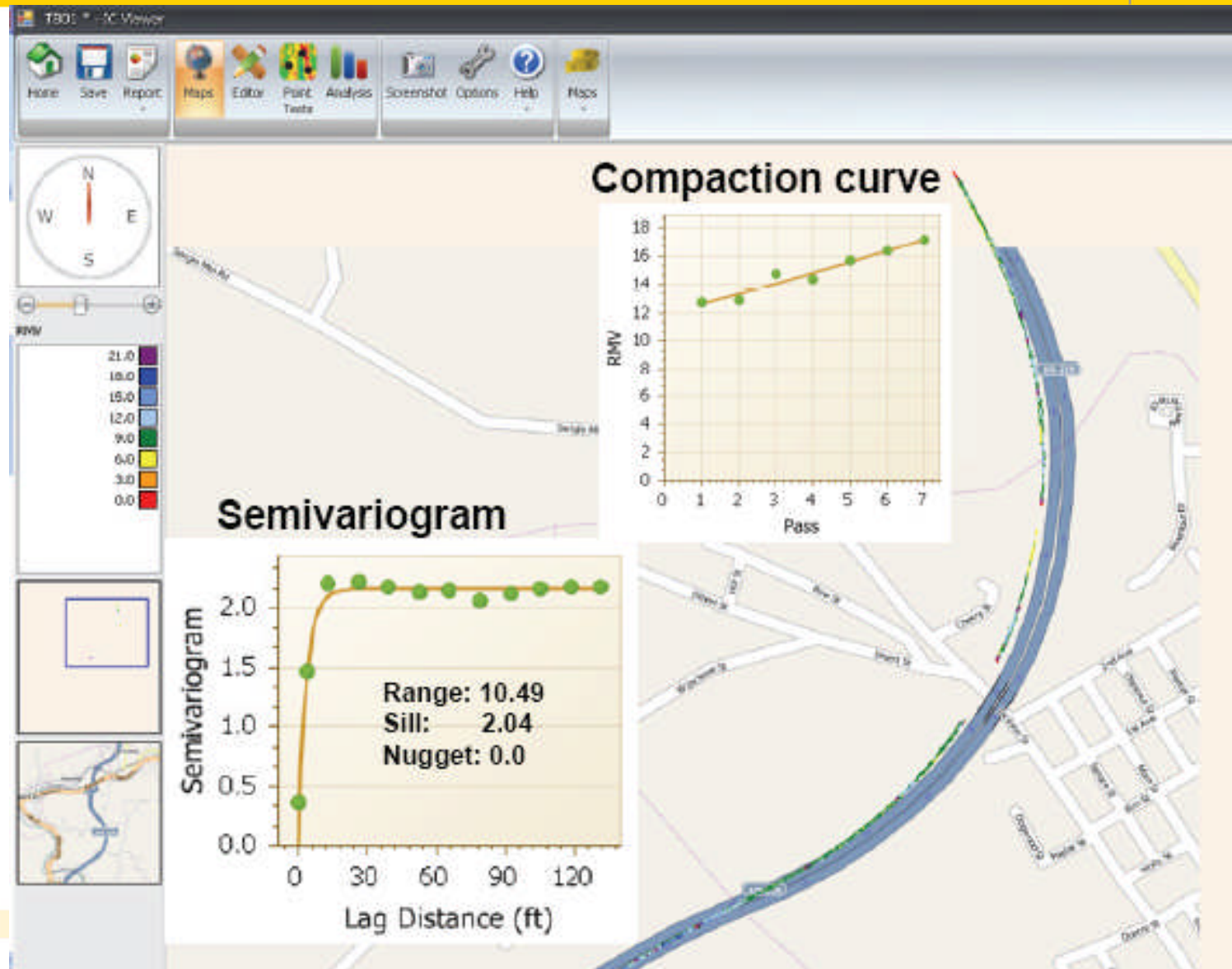
Data Analysis - PA ICPF

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Data Analysis - PA ICPF

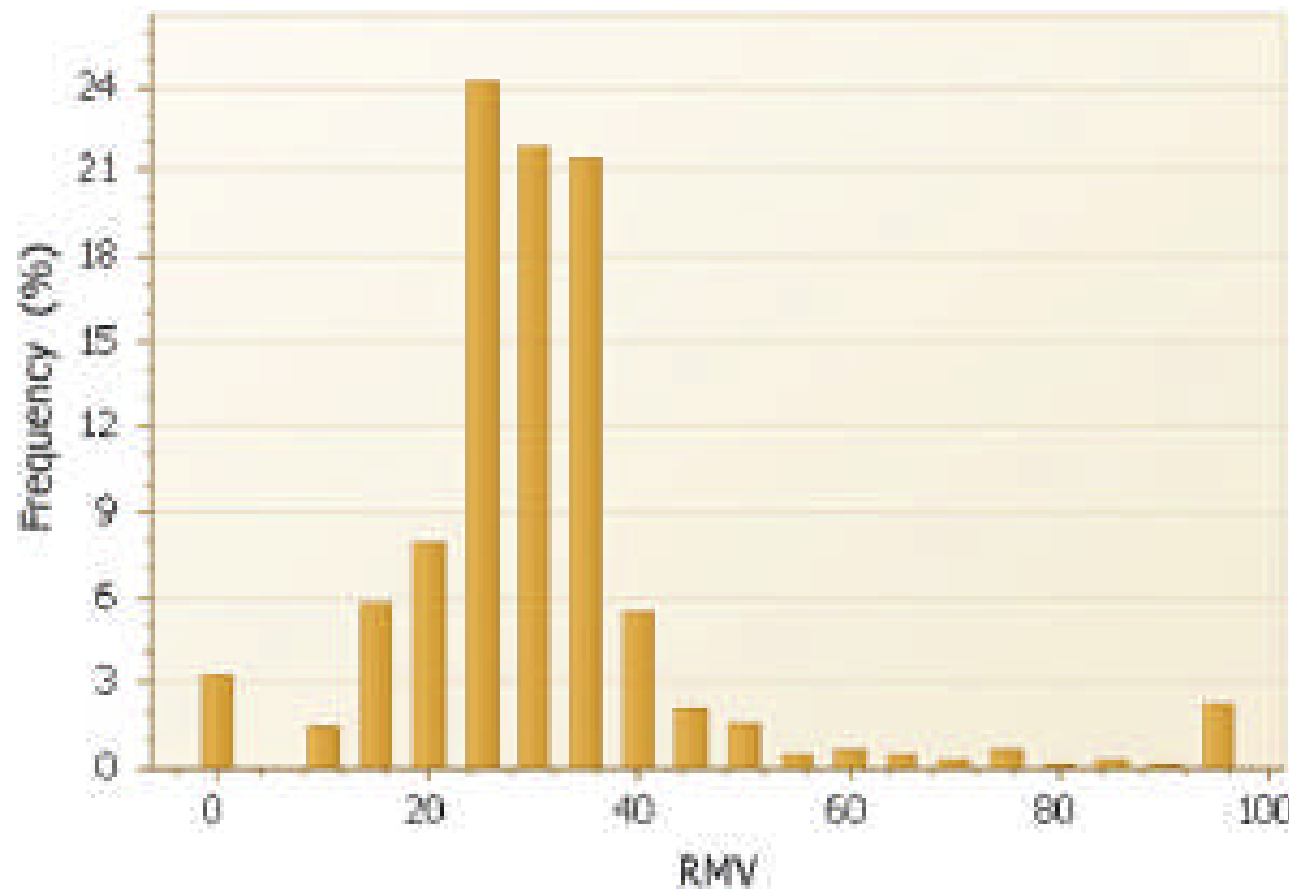
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Data Analysis – PA ICPF

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SW880 breakdown compaction



Mean: 28.48

STD: 15.45

COV: 0.54

Improving QC using IC

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“Mapping of Underlying Layers Prior to Paving



“Mapping” of Underlying Materials

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- Use of RMV color-coded mapping to measure support prior to paving of:
 - Subgrade soil materials
 - Stabilized subbase materials
 - Aggregate base materials
 - Existing asphalt pavements
 - Rubblized concrete pavements
- Underlying Support affects compatibility of subsequent layers



“Mapping” of underling layers

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Mapping of the subgrade / agg. base layer



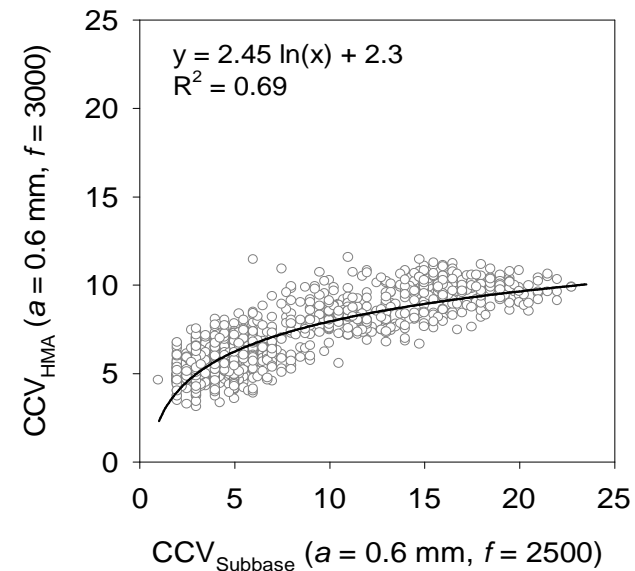
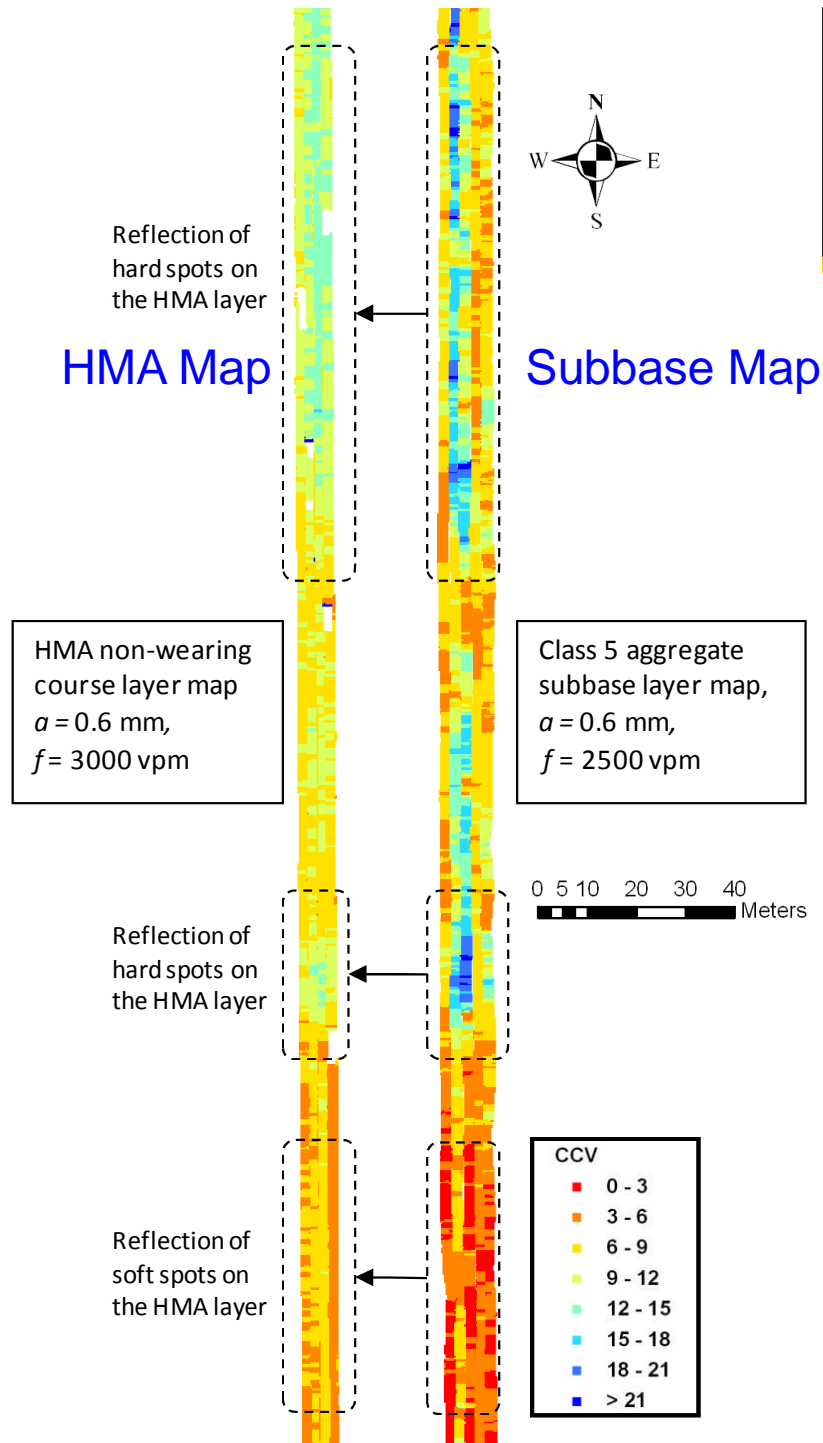
Minnesota ICPF Project

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MN ICPF Project

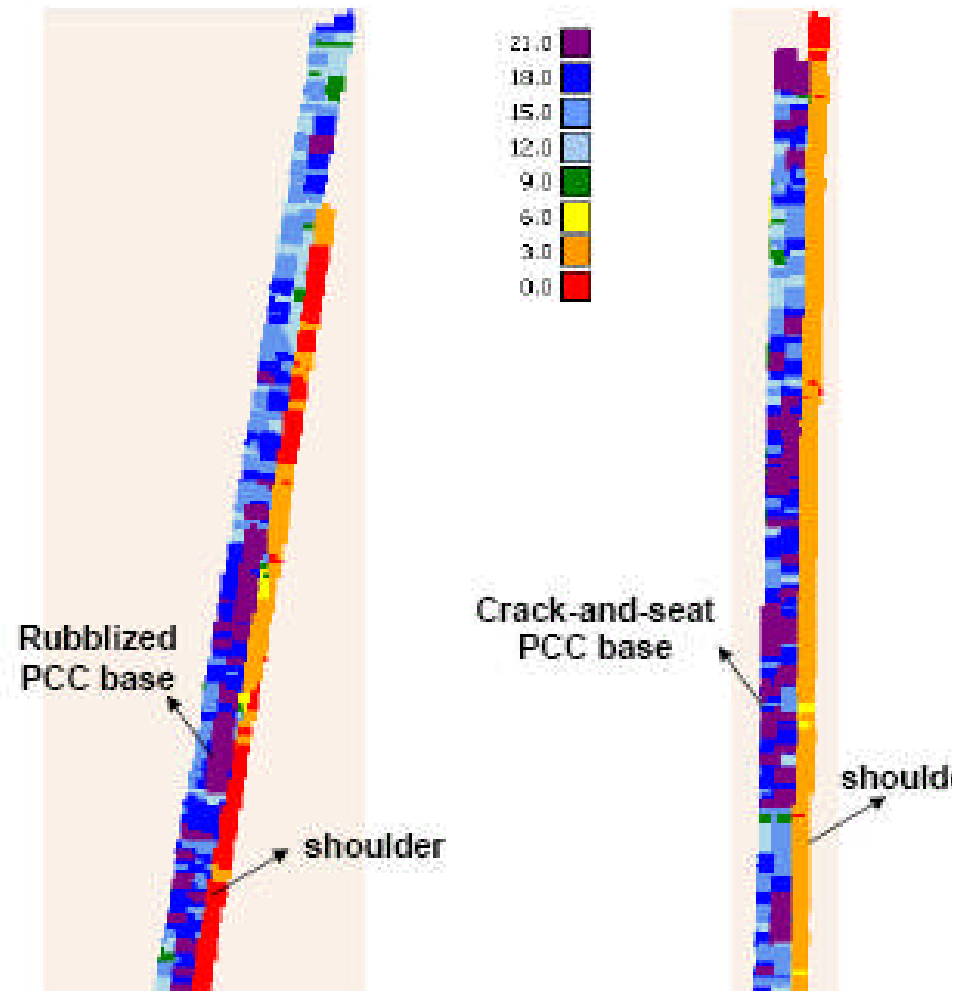
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Sakai IC roller

WI ICPF Project

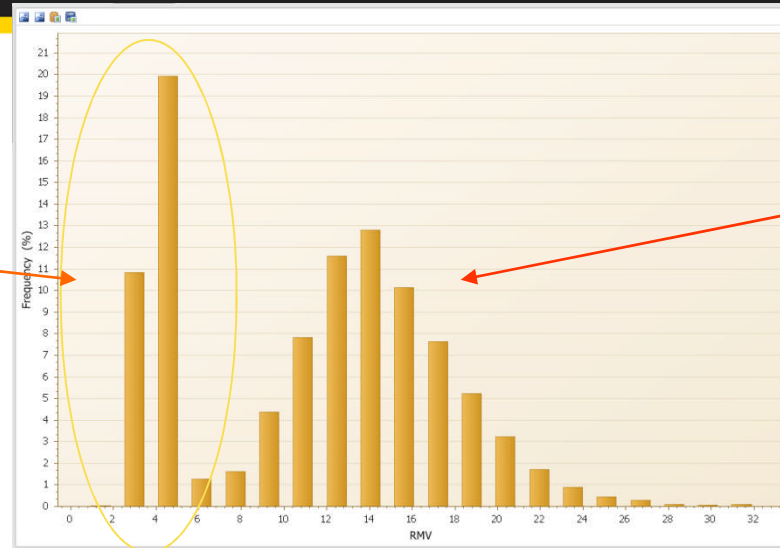
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IC Mapping (SB passing lane)

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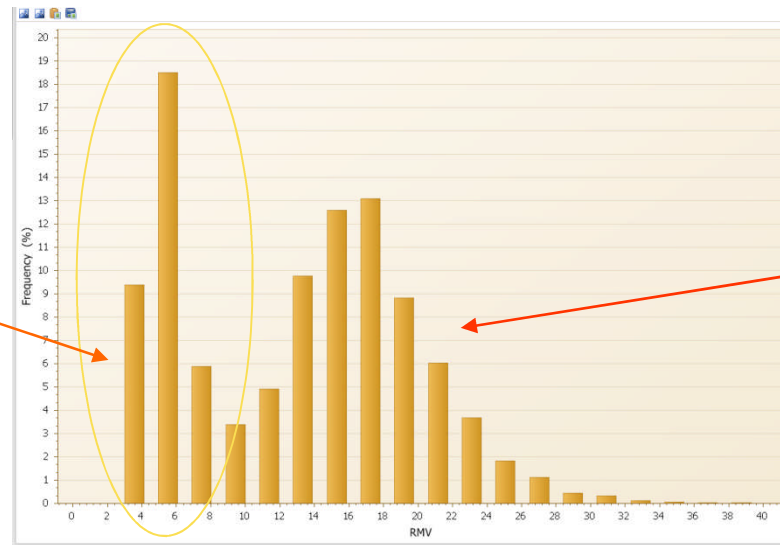
Soil subgrade
mean CCV ~ 5



Rubblized PCCP
mean CCV ~ 14

2800 vpm
Low amp

Soil subgrade
mean CCV ~ 6



Crack&Seat PCCP
mean CCV ~ 18

Future Research Needs - IC

- Improve correlation of Density vs. RMV
- Standardization of RMV
- Explore GPS Technology
 - Use of advanced, high prec. GPS technology
 - “Stand-Alone” (non RTK) GPS Technology
- IC Data Management
 - Improvements in on-board roller software
 - Data collection/storage
 - Data analysis/reporting



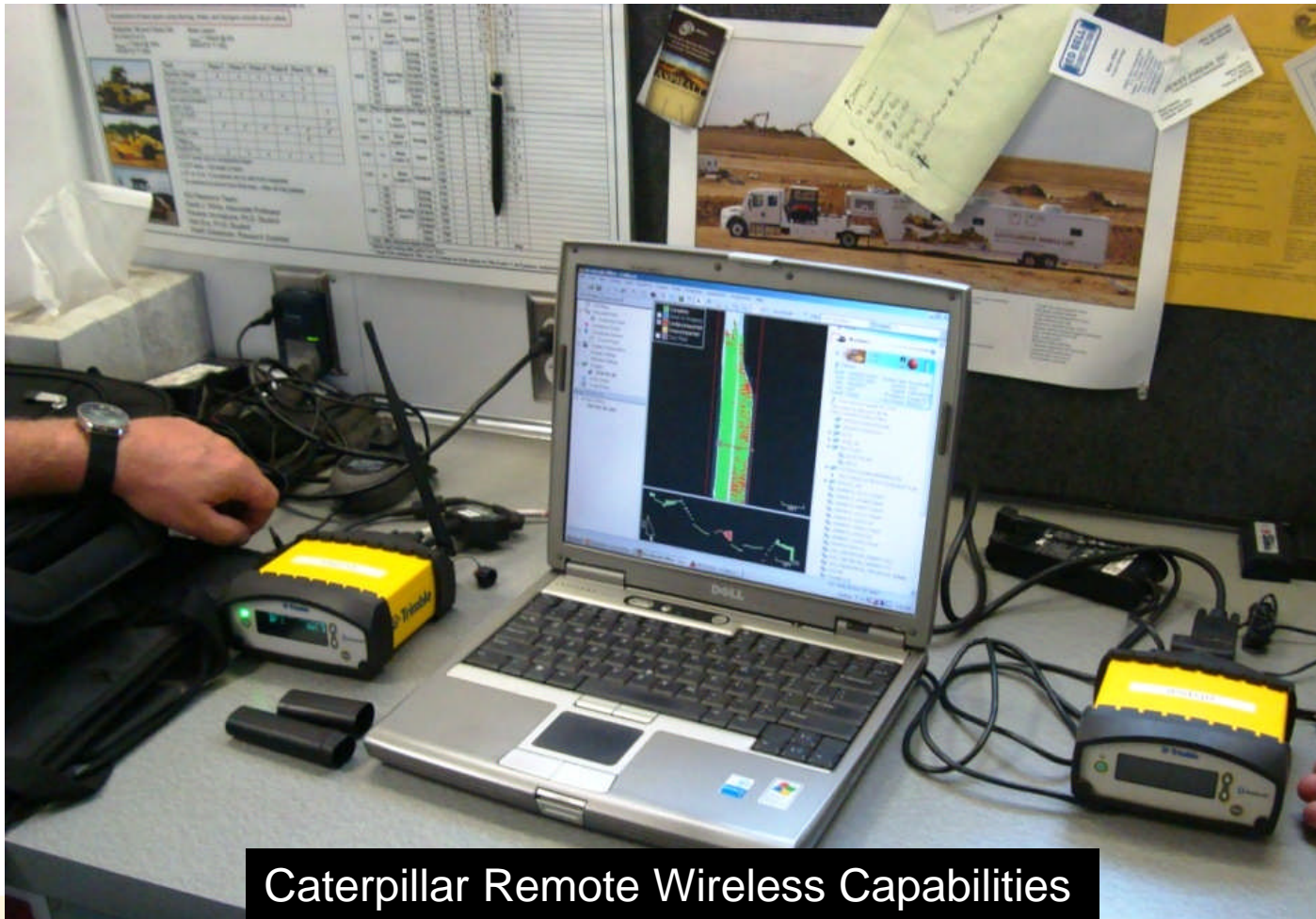
Summary

- Intelligent Compaction is a major innovation in compaction technology
- Research/field projects show that IC can offer a valuable tool to improve QC of the compaction process
- IC technology is now readily available in U.S.
- More work is need to address various issues
- Stay tuned!



What's Next?

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Caterpillar Remote Wireless Capabilities



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We've Come a Long Way

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1924 Buffalo Springfield Steam Roller

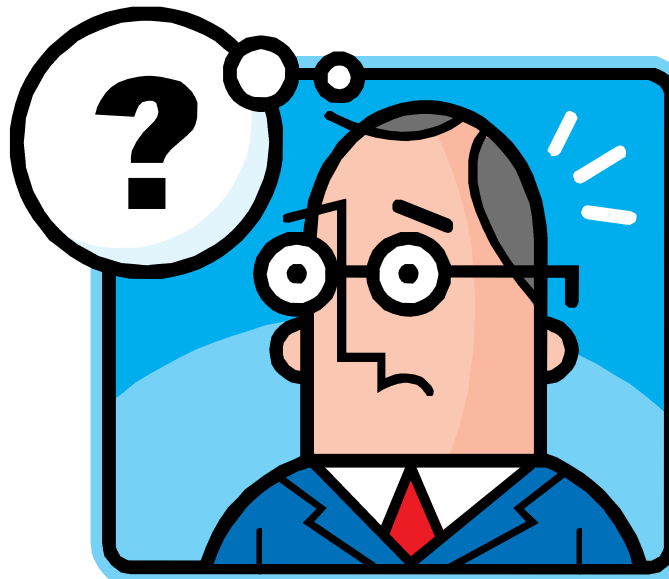


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Improving QC with IC

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Questions?



Improving QC with IC

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- Shortcomings in the Compaction Process...



Limited “On The Fly” Feedback



Over or Under-Compaction
Can Occur



Improving QC with IC

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- Shortcomings in Density Acceptance Process...



Limited Number of Locations



After Compaction is Complete

Mountainous, Curvy, Heavily Forested Roadways

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Pennsylvania ICPF Project



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User Comment - Data Management

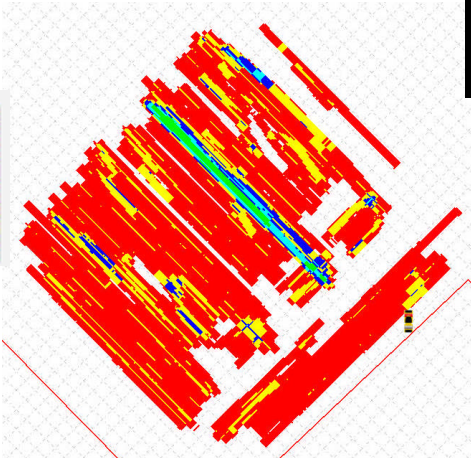
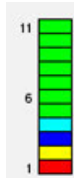
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- Operational Instructions (for data collection and transfer) are fairly quick and easy
- However, where manufacturer support is not on-site, collection and transfer of data to agency is problematic
- IC software supplied to agencies and contractors for data analysis is difficult to use

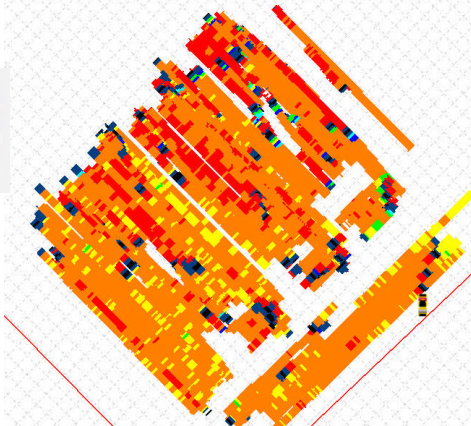
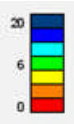


TB 01A Intermediate HMA Layer

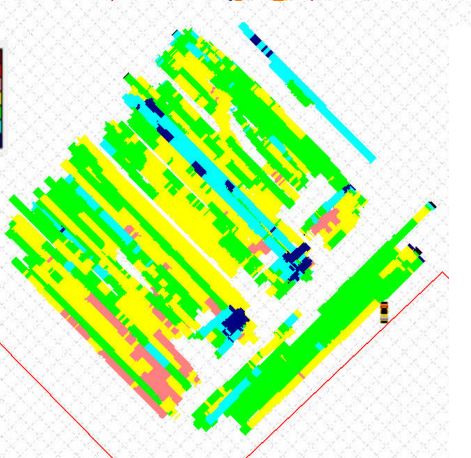
Roller pass



Sakai CCV



Surface temperature (°C)



Georgia ICPF Project

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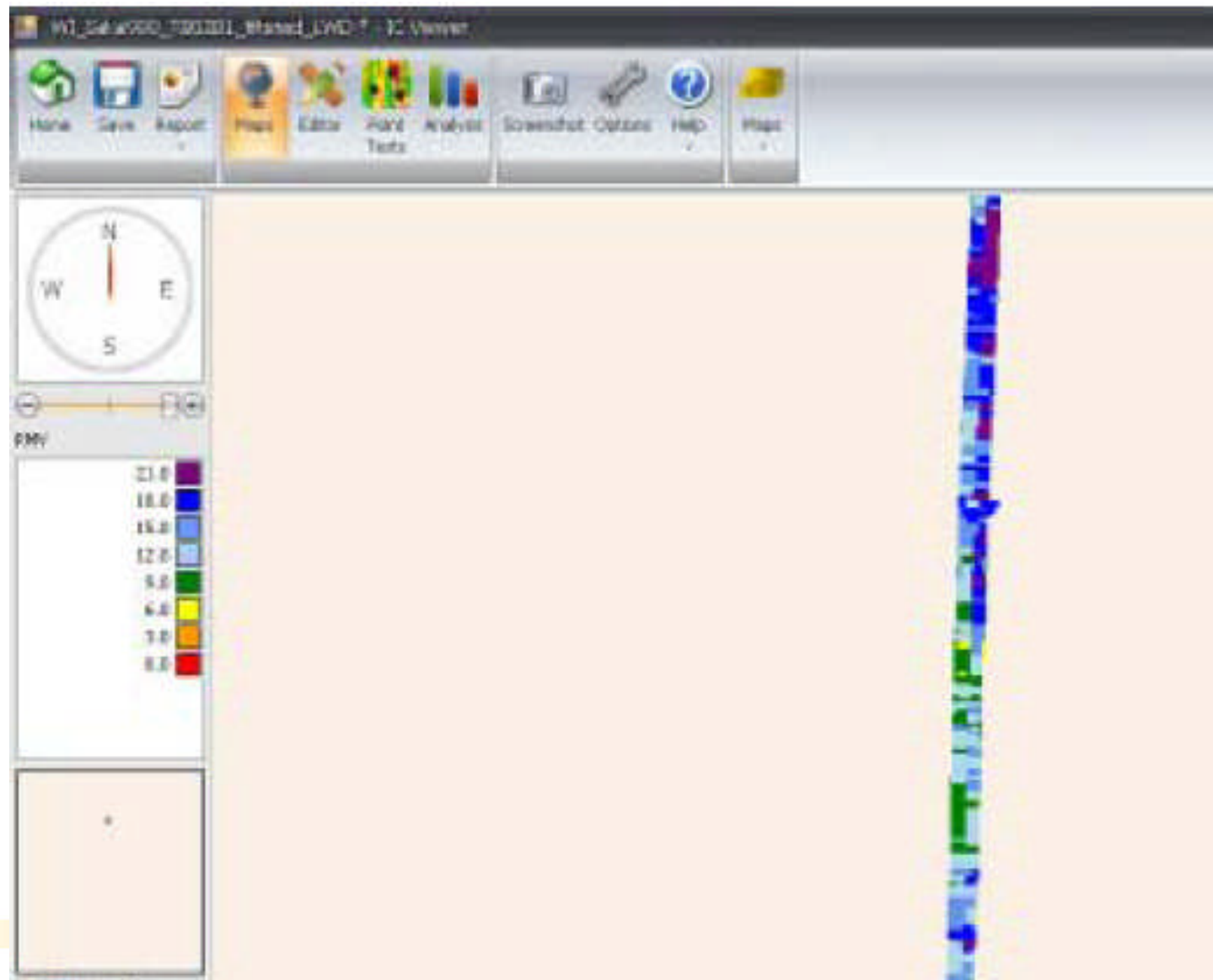
Sakai IC roller



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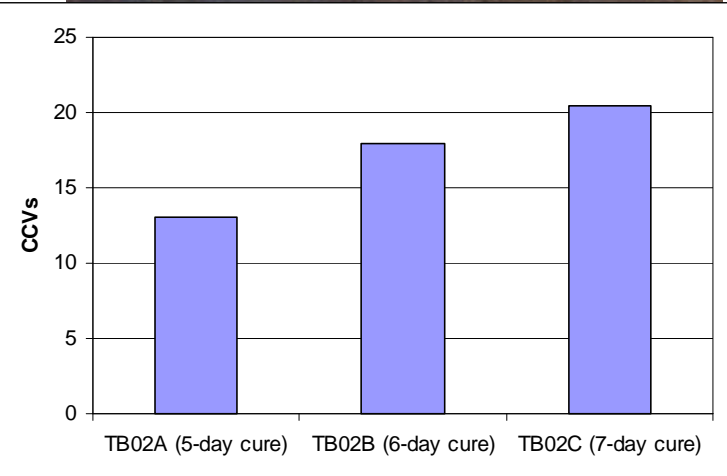
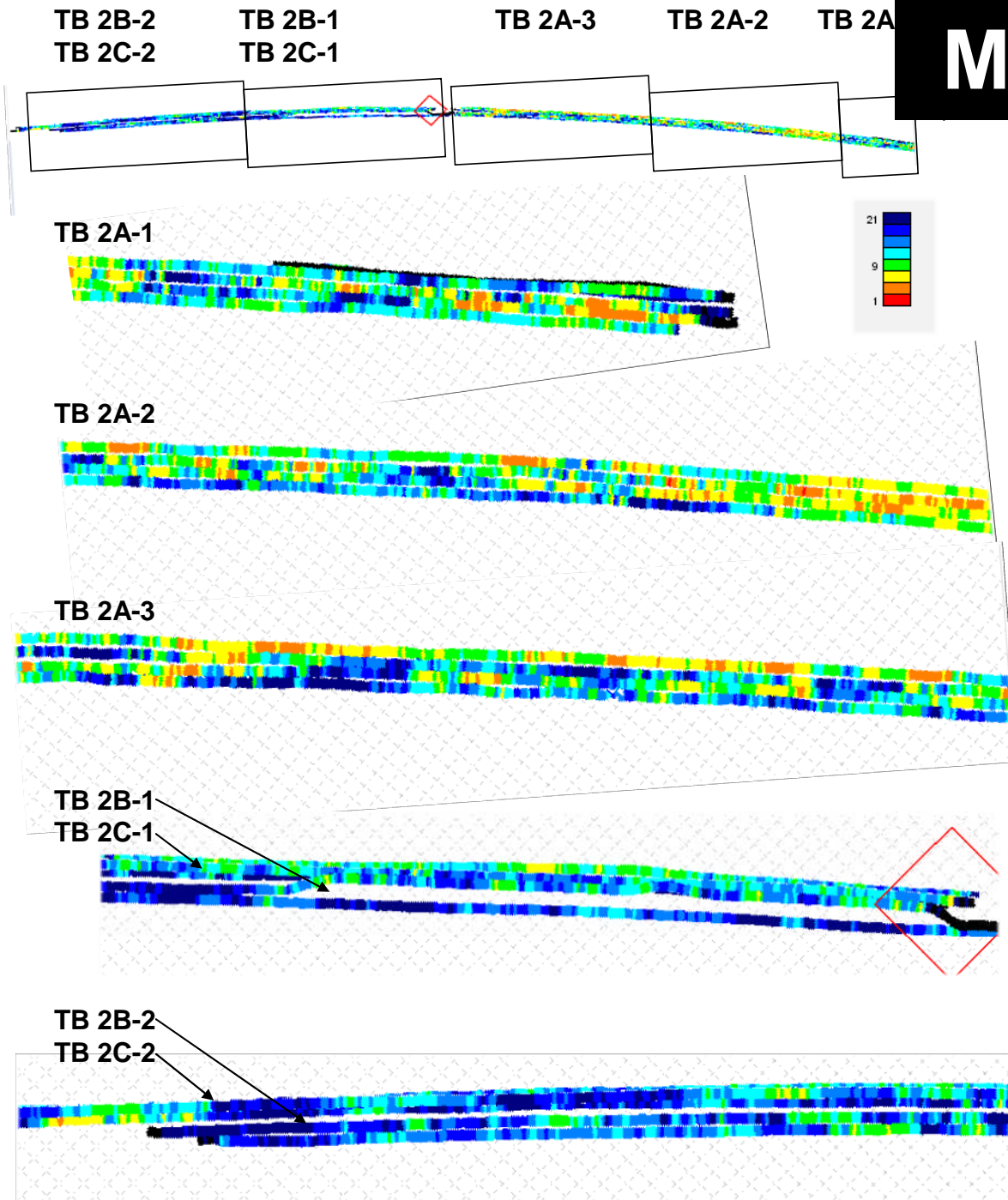
Data Analysis - VA ICPF

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MS ICPF Project

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“Mapping” of Base and HMA Layers

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Minnesota ICPF Project



test bed 02 Mapping

Bomag Evib

Done	650	m²
Start date	12:35:17 PM	7/21/2009
End date	12:41:51 PM	7/21/2009

	AVG	Min	Max
EVIB [MN/m²]	286	101	350
Amplitude [mm]	0.3	0.2	0.6
Frequency [Hz]	50	16	67
Speed [km/h]	5.5	1.0	6.6

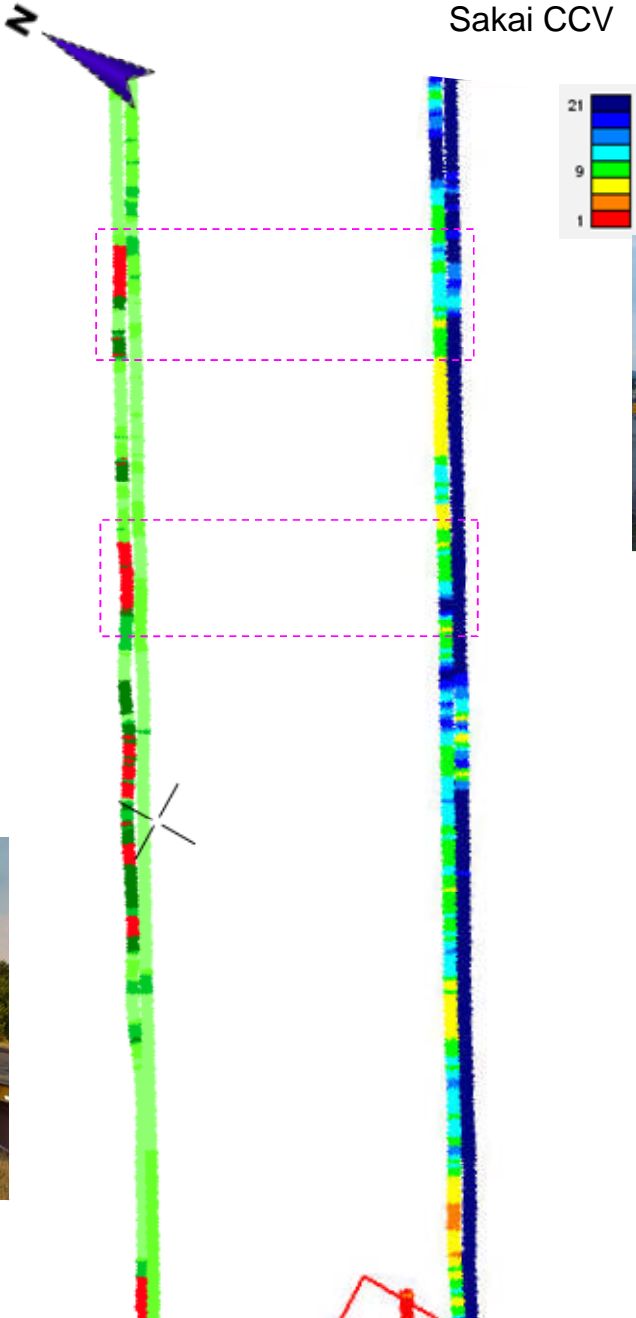
	EVIB [MN/m²]	
	> 350	19 %
	313 -350	29 %
	276 -313	21 %
	238 -276	7 %
	200 -238	8 %
	< 200	16 %
Σ	200 -350	65 %

AVG-value [MN/m²]	286
Increase	8
Standard deviation	66



Bomag Sakai

Sakai CCV



MD ICPF Project

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MD US 340 EBL

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Future GPS Research?

- Increase practical knowledge of research, agency and contractor personnel
- Simplify GPS setup and use
 - Any improvements to make GPS “plug and play” will speed acceptance of IC technology
- Use of “advanced” GPS technologies
 - Virtual Reference System (VRS)
 - GPS repeaters
 - Internet base stations and server/client systems
 - Stand-alone, high precision GPS



Issues with IC Data Management

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- Data format
- Data collection
- Data storage
- Data processing
- Develop independent software tool
 - Efficient
 - Accurate
 - Fast



Summary

- Research and field projects have shown:
 - Intelligent Compaction is an important innovation that can improve the compaction process and QC practices
 - IC equipment is available now
 - Generally, roller operators and project personnel find IC technology “user friendly” and a valuable tool
 - More research is needed to address issues with standardizing RMV, with data management and with GPS

