Stressed about Distress? Calibrating Our Way to Quality in Automated Pavement Data Collection

51st Annual Mid-Atlantic Quality Assurance Workshop

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Presentation Overview

- Introduction
- High-Speed Collection and Automated Analysis - Review
- Data Quality and Challenges
- Case Study: DelDOT Approach and Successes
- Future Trends and Recommendations

Introduction

- Kathy Keegan, P.E.
  - 23 years experience with high-speed data collection and distress analysis.
  - State, municipal, aviation

- Tim Miller, P.E.
  - 10 years experience with high-speed data collection and distress analysis.
  - State, municipal, aviation

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Data Collection Evolution

Manual Collection with Paper

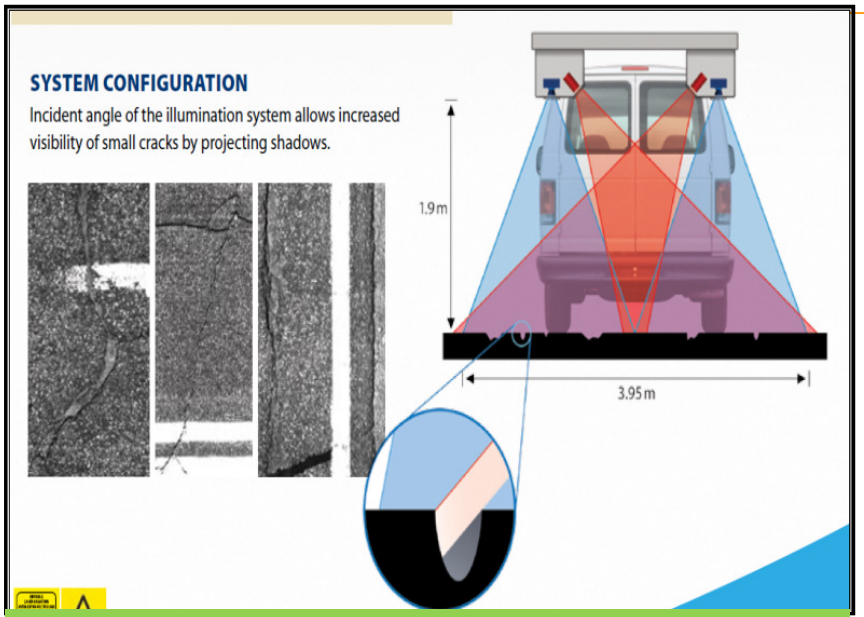
Add Photos (LTPP Pasco)

Add GPS

2D Photos (video-like)

2D and 3D Imagery Combined

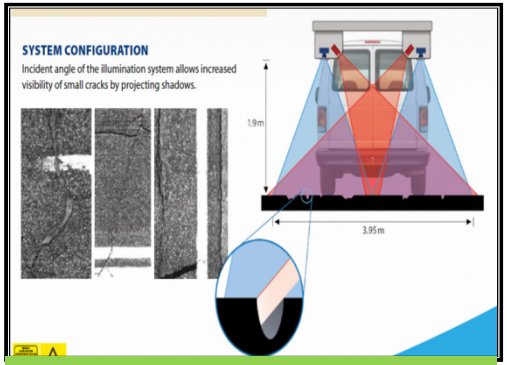
High-Speed Data Collection



2D

2D + 3D

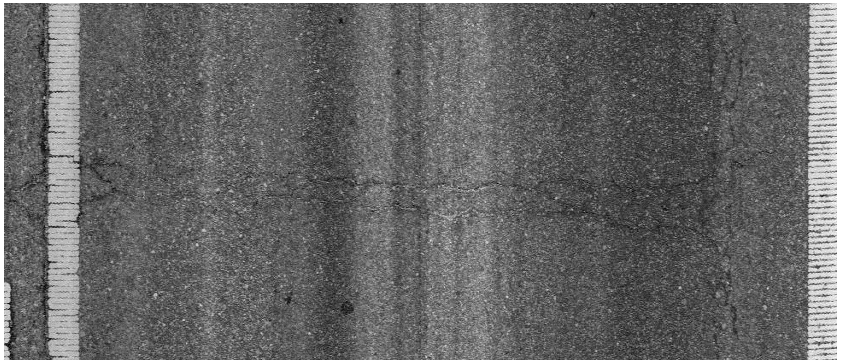
High-Speed Data Collection



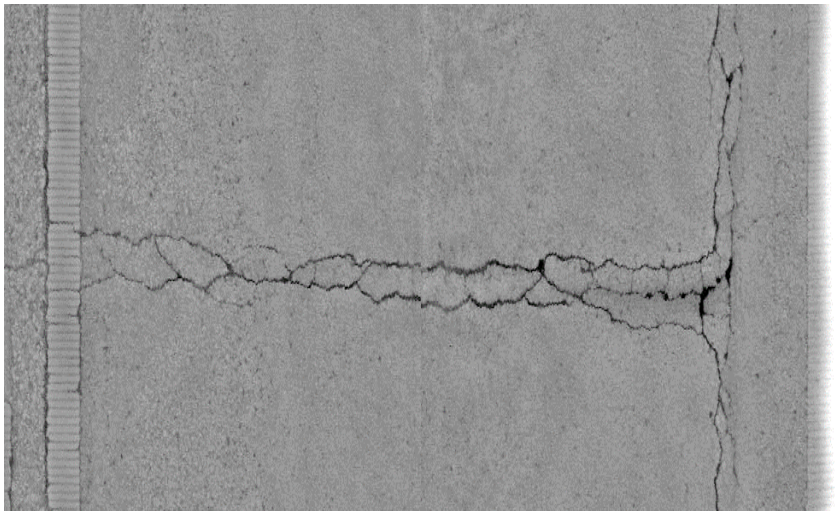
2D

2D + 3D

Conventional 2D Imagery - LRIS



High Definition 3D Imagery - LCMS



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High Speed Data Collection and Automated Analysis

High-Speed Data Collection

- HPMS
  - IRI, Rut, Fault, %Crack
- Collect additional data in support of broader planning
- State of Practice (FHWA 2015)

High-Speed	Self Collect	Vendor	Automated Distress
All	19	31	7

- ‘Semi-automated’

Automated Analysis

- Analysis is driven by a ‘standard’
- Standards can vary!

- Manual
  - ‘Boots on ground’
  - Subjective
- Semi-Automated
  - Mix of Artificial Intelligence (AI) and subjective
- Automated
  - Fully AI
  - Less subjective
  - Accurate and Precise?

Data Quality and Challenges

Quality

- What is Quality?
  - ‘Degree of Excellence’ = Accurate and Precise
- Quality Assurance?
  - ‘The maintenance of a desired level of quality in a service or product, especially by means of attention to every stage of the process of delivery or production.’

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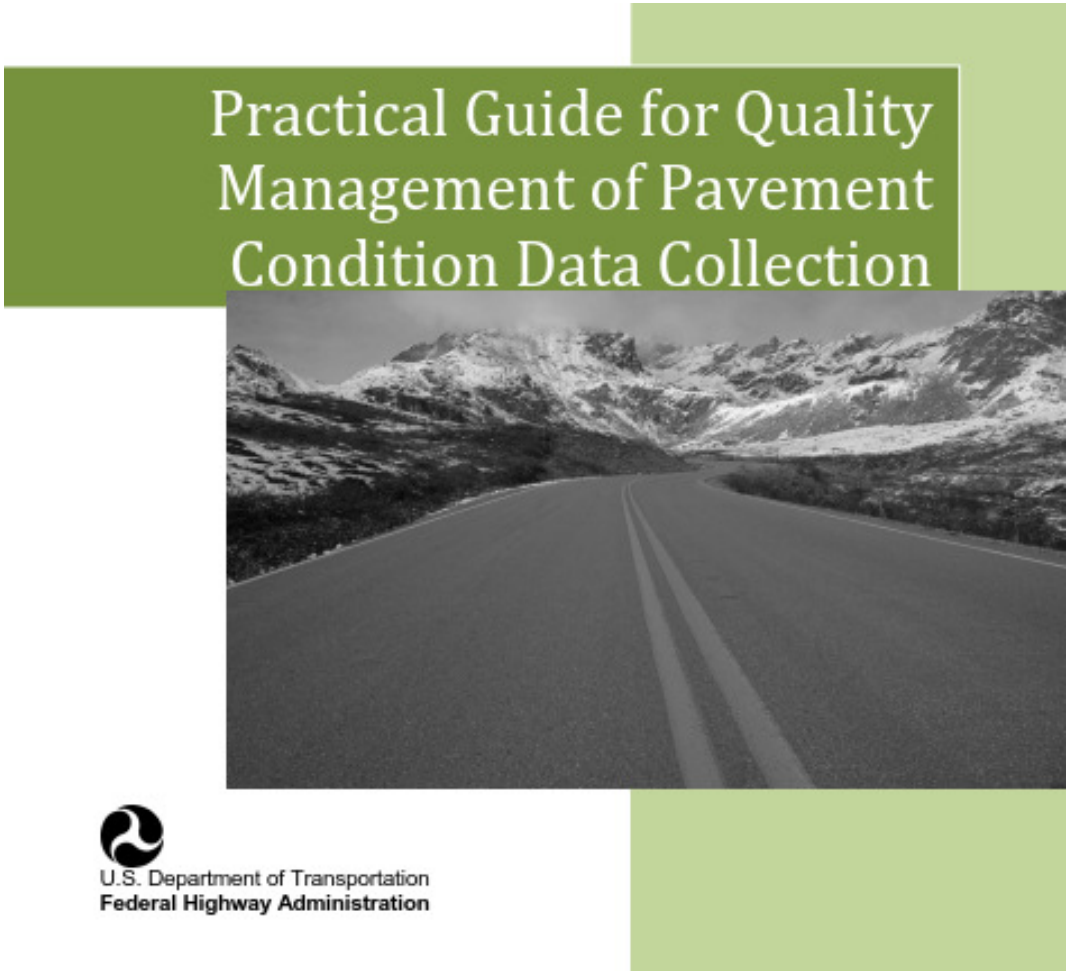
Quality

- Why it matters?
  - Extensive planning and budgeting done as a result of data collected.

Quality Management

- Example:
  - FHWA
  - Individual State Protocols



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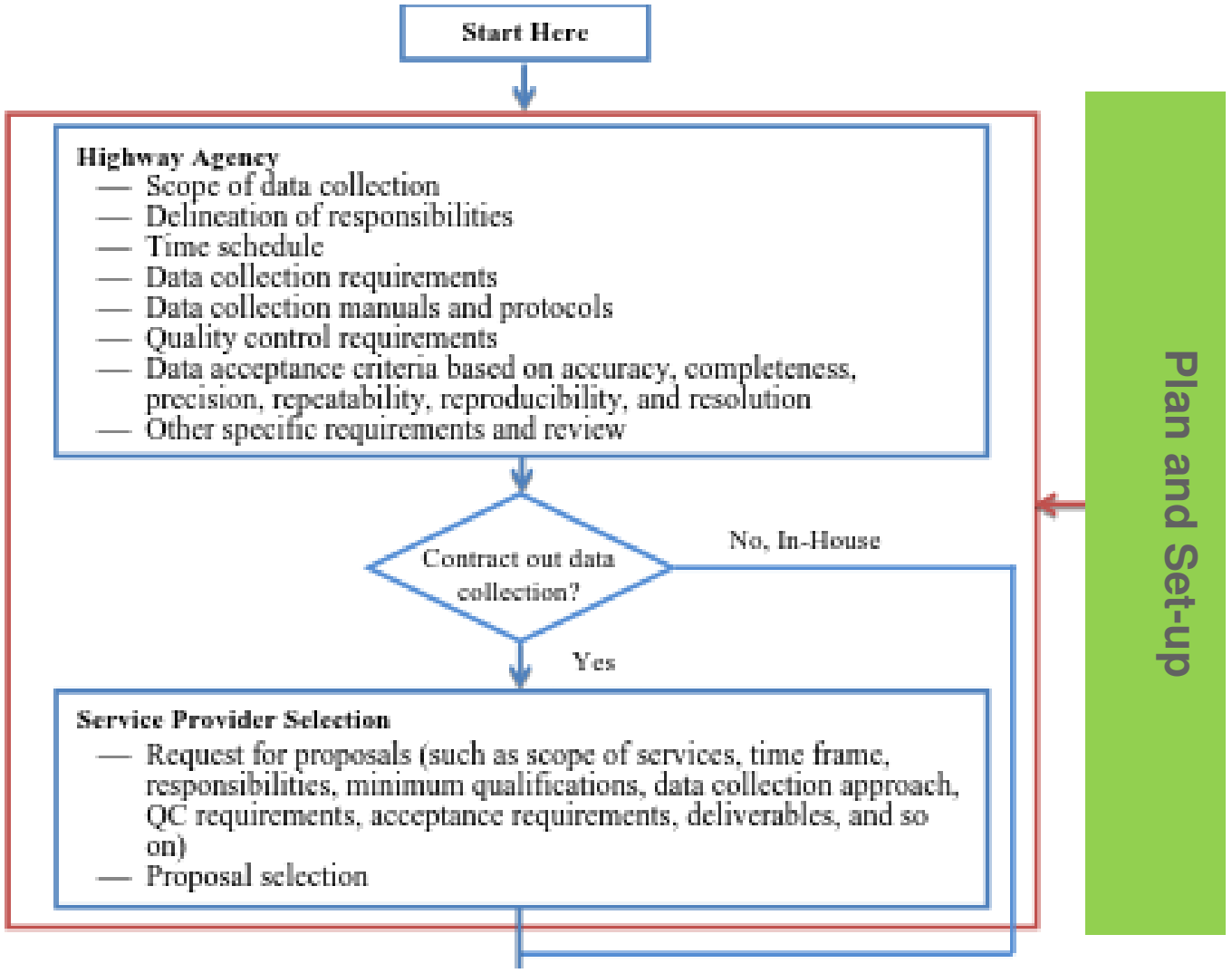
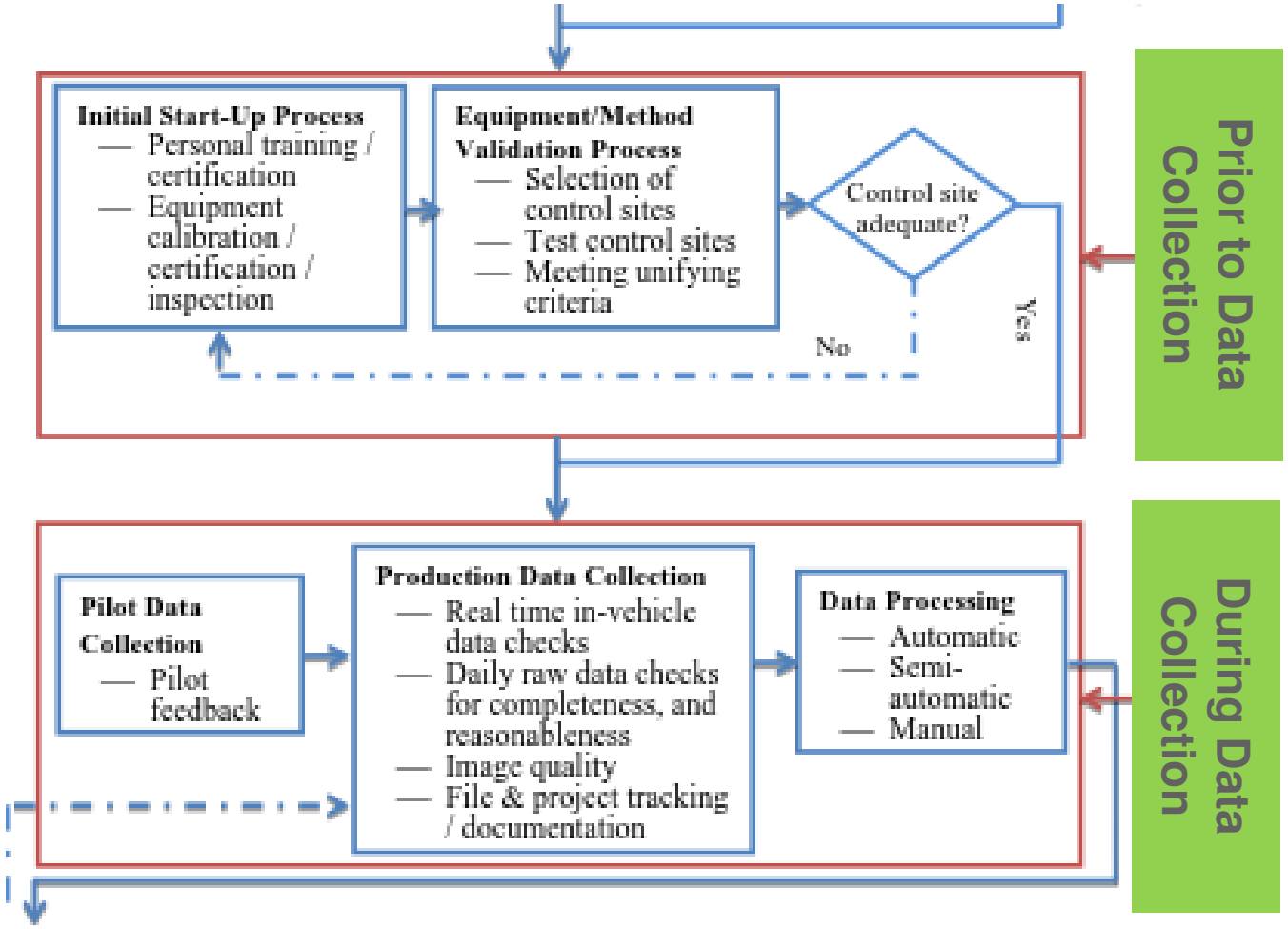
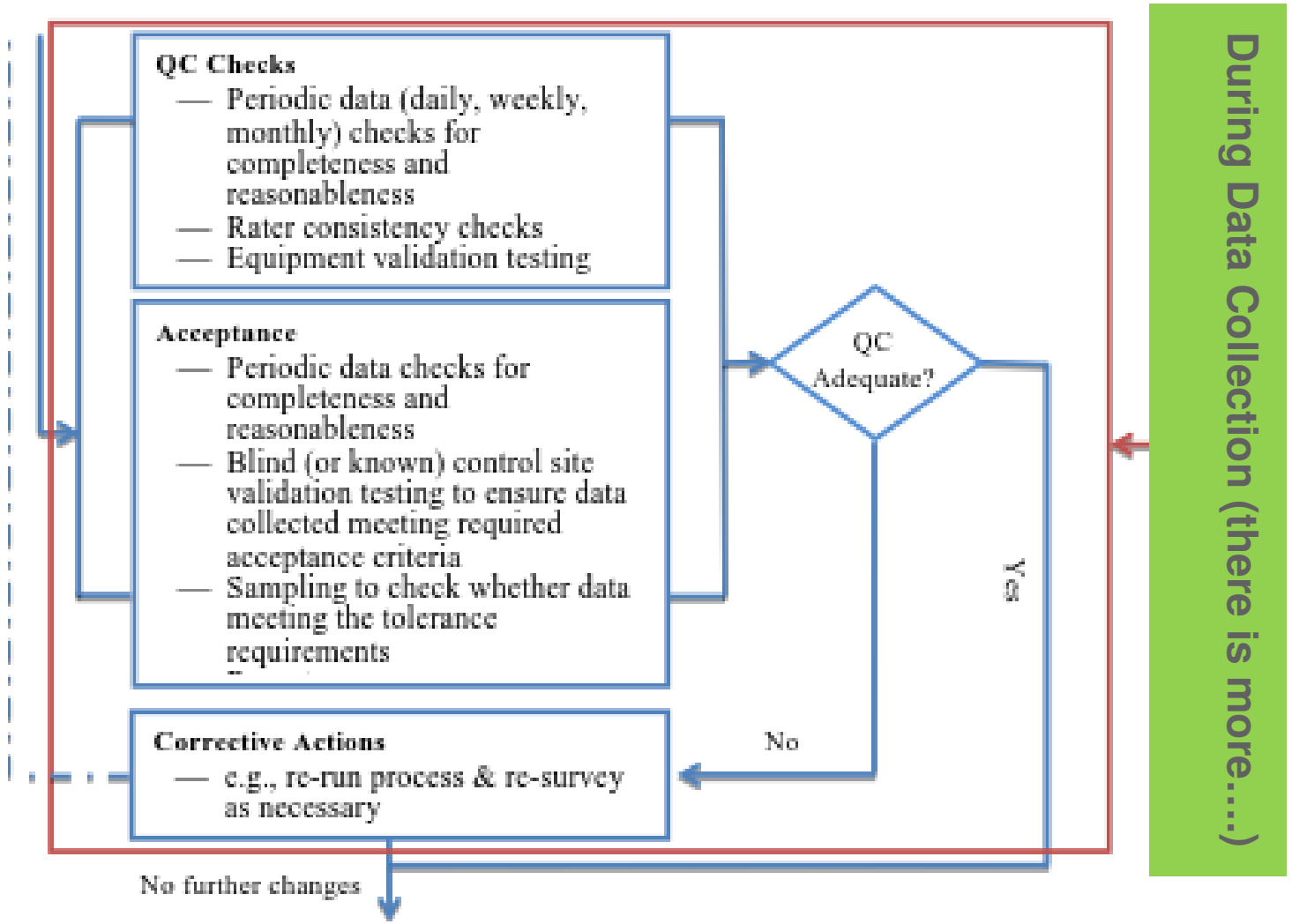
Quality Management



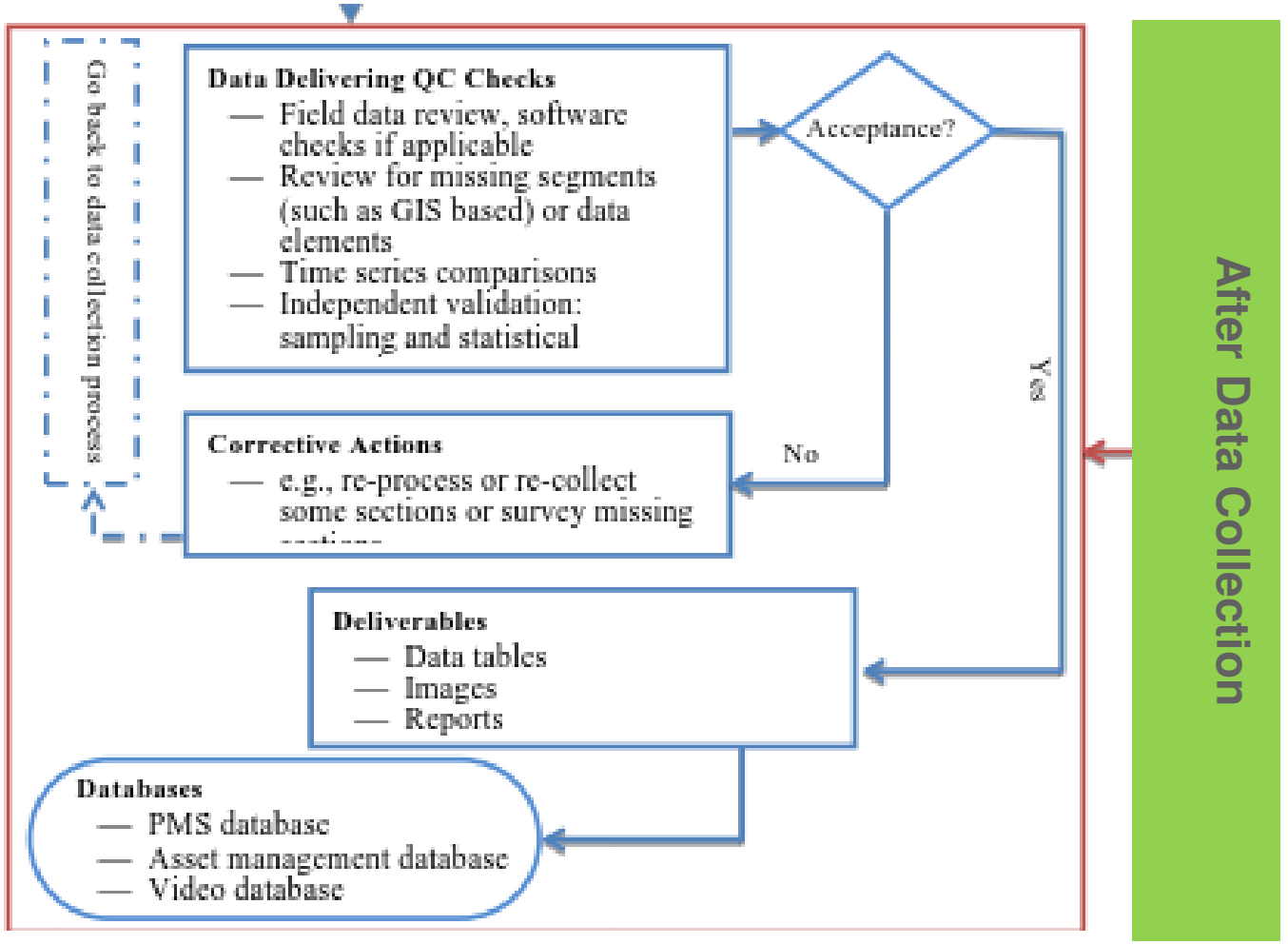
Quality Management



Quality Management



Quality Management



Challenges

- Variables
  - Equipment
  - Vendors
  - Collection Protocols
  - Analysis Protocols
  - Software / Analysis Tools
- Technology
  - Continues to advance, so should our approach.
- Interpretation of Data
  - Does resultant data match with expert opinion?
  - Does data yield the correct treatment / timing?

DelDOT Case Study

Acknowledgements

- DelDOT: Sarah McDougall, Rhonda Lewis, Mike Beulah, Sanjay Kumar
- AECOM: Tim Miller, Kathy Keegan, Amir Arshadi, Tamim Khan, Mike Papakostas
- Kercher: Aaron Gerber, Qazi Aurangzeb, Eric Perrone
- Mandli: Mike Richardson, Celly Chrisinger, Larry Mattke, Ryan Well

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Project Motivation

- Over decade: change in vendor, collection equipment, and survey method.
- Result: Overall Pavement Condition Index (OPC) values did not make sense (not following expected trends).
- Advancing technology means time for change in approach!

Project Motivation

- Key changes included:
- Transition from 3x3 matrix definitions to a data dictionary encompassing all distress types at all severity levels.
  - Now that we can easily quantify accurately, why don't we?

Severity/Extent	Low	Med	High
Low			✓
Med	✓		
High	✓		

- Undertake calibration exercises to align OPC values, treatment recommendations, and expectations.

Project Objectives

- Narrow the discrepancies between LCMS (3D)-based pavement distress data and network-level treatment selections.
- Select calibration sites and collect baseline measurements
- Reconcile differences in manual and automated surveys
- Adjust PMS index models

Fatigue Cracking Matrix Definitions

- OPC influenced by dominant distress index severity only
- Issues in calculating the most representative OPC for a pavement section
- Limited number of distresses captured per pavement type
- Relies on estimated quantity

Severity Level	Low Extent	Medium Extent	High Extent
Low Severity	Ext: 1 - 9% (wheel path) Sev: Fine parallel hairline cracks	Ext: 10 - 25% Sev: Fine parallel hairline cracks	Ext: > 25% Sev: Fine parallel hairline cracks
Medium Severity	Ext: 1 - 9% (wheel path) Sev: Alligator crack pattern clearly developed	Ext: 10 - 25% Sev: Alligator crack pattern clearly developed	Ext: > 25% Sev: Alligator crack pattern clearly developed
High Severity	Ext: 1 - 9% (wheel path) Sev: Alligator crack pattern clearly developed with spalling and/or distortion	Ext: 10 - 25% Sev: Alligator crack pattern clearly developed with spalling and/or distortion	Ext: > 25% Sev: Alligator crack pattern clearly developed with spalling and/or distortion

Data Dictionary Development

- Defines all distress types and severity levels
- Defines methods of measurement for automated road rating data collection
- Includes four pavement types
- Utilizes actual extent measurements rather than discrete extent ranges (% estimates)

Data Dictionary Revisions

Distress	Pavement Type				Measurement Type
	Asphalt	Composite	Surface Treated	PCC	
Fatigue Cracking	H	H	H		Square Feet
Transverse Cracking	H		R		Count
Block Cracking	H	H	R		Square Feet
Joint Reflective Cracking		H			Count
Edge Cracking			H		Linear Feet
Non-Wheel Path Longitudinal Cracking	R	R			Linear Feet
Patches/Potholes	H	R	R		Square Feet
Bleeding			H		Square Feet
Raveling	H	H	H		Square Feet
Crown/Cross-Slope			H		Percent
Slab Cracking				H	Slab Count
Joint Deterioration				H	Joint Count
Joint Seal Loss				H	Joint Count
Patch Deterioration				H	Square Feet
Alkali-Silica Reactivity (ASR)				H	Slab Count

Items denoted as ‘H’ have been used historically by DelDOT, while items denoted with ‘R’ are revisions to the process.

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Data Progression

Distress Raw Data

% Extent of Distress

IDI Calculations

Structural Index

Non-structural Index

OPC Calculation

IRI, Rut

ASR

Million Dollar Question!

What is the best type of treatment?

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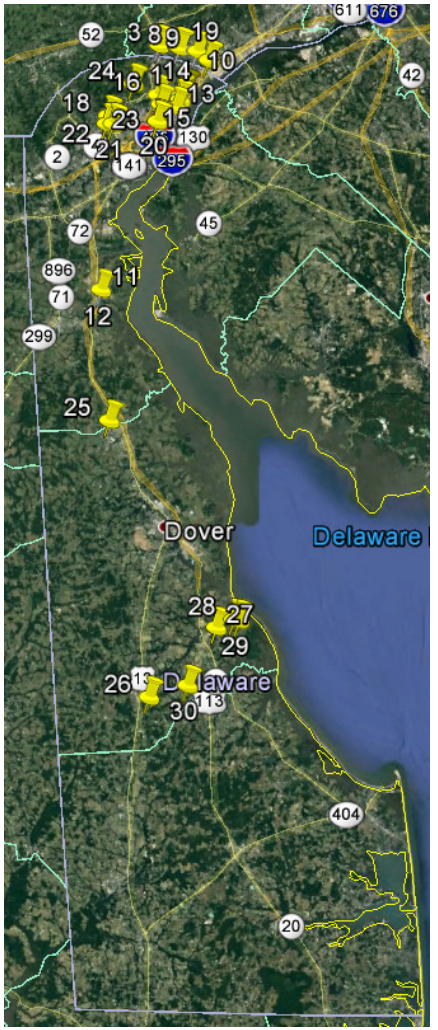
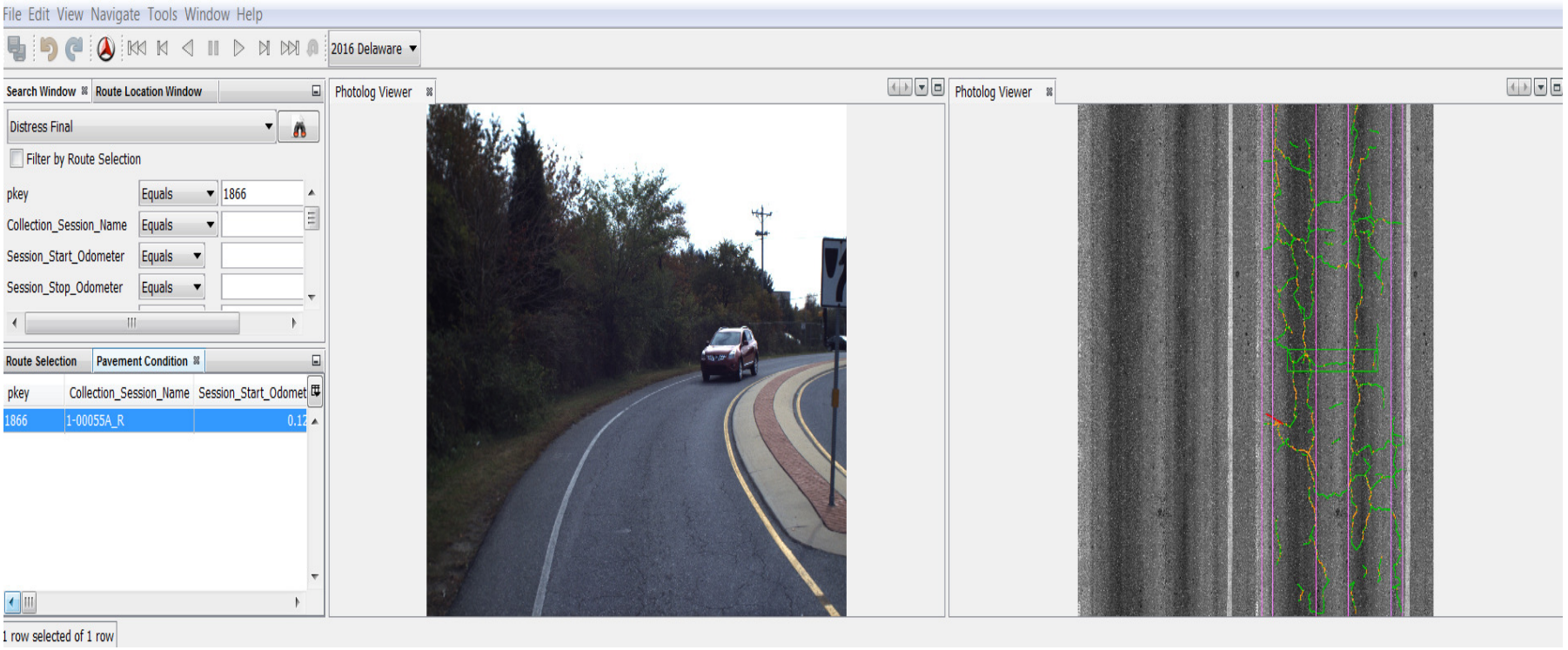
Site Locations

- 30 sites selected for initial calibration
- 4 pavement types
- Range of pavement conditions
- Lengths range from 0.05 to 0.1 mi

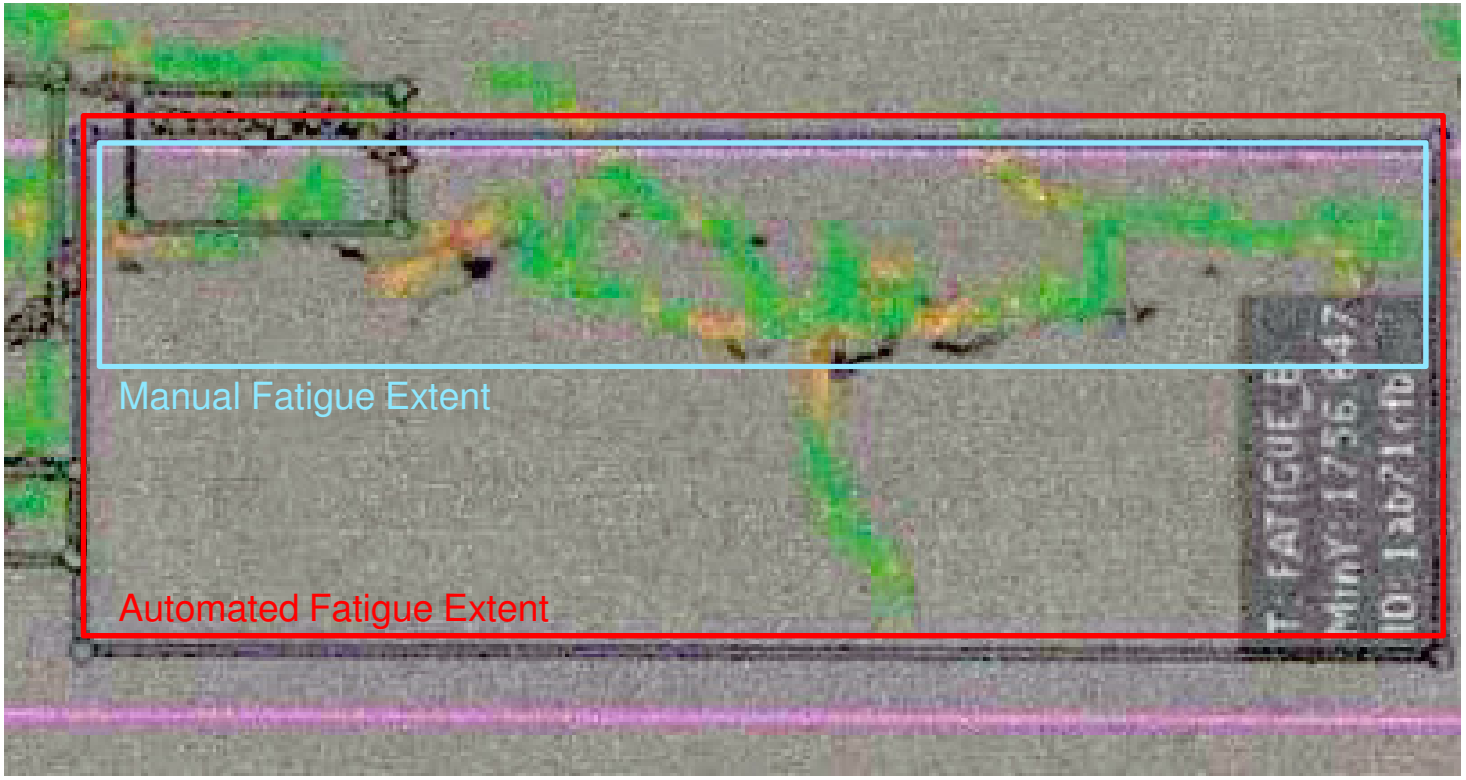


Distress Characterization & Image Analysis



- Training and re-training of AI algorithms is critical to accurate distress detection and characterization.

Distress Characterization & Image Analysis



Minimize differences between automated and manual measurements.

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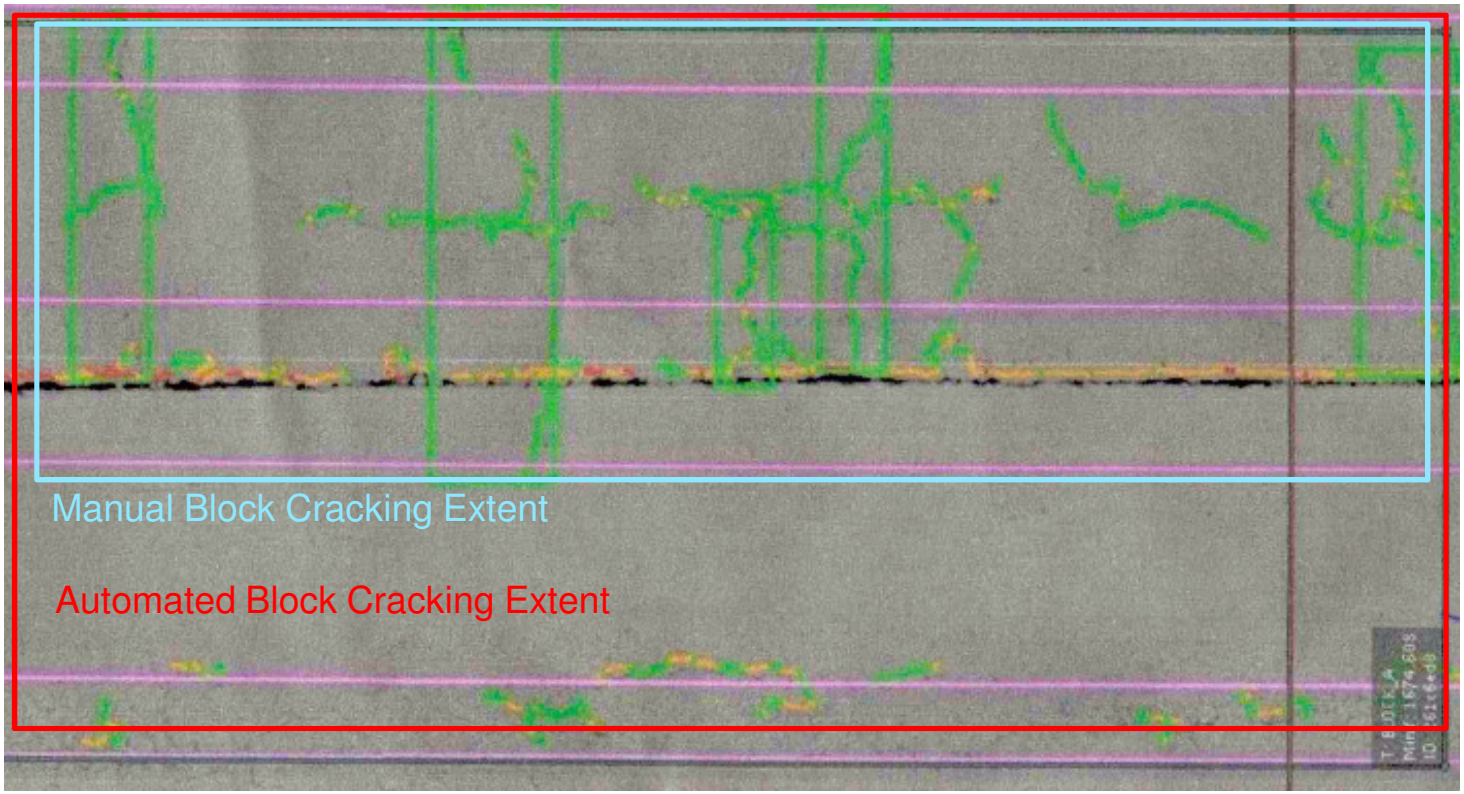
Distress Characterization & Image Analysis



Minimize differences between automated and manual measurements.

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Calibration Iterations

- Adjust wheelpath width in accordance with AASHTO protocols
- Correct lane areas for vehicle deviations
- Adjusted limits for block cracking, transverse cracking, and patching
- Characterized full range of distress types
- Now consider adjustments to OPC calculation

OPC Distress Index Structure

OPC = (Functional Index, Structural Index, Non-Structural Index)

The right treatment?

Yes = Stop

No = Iterate

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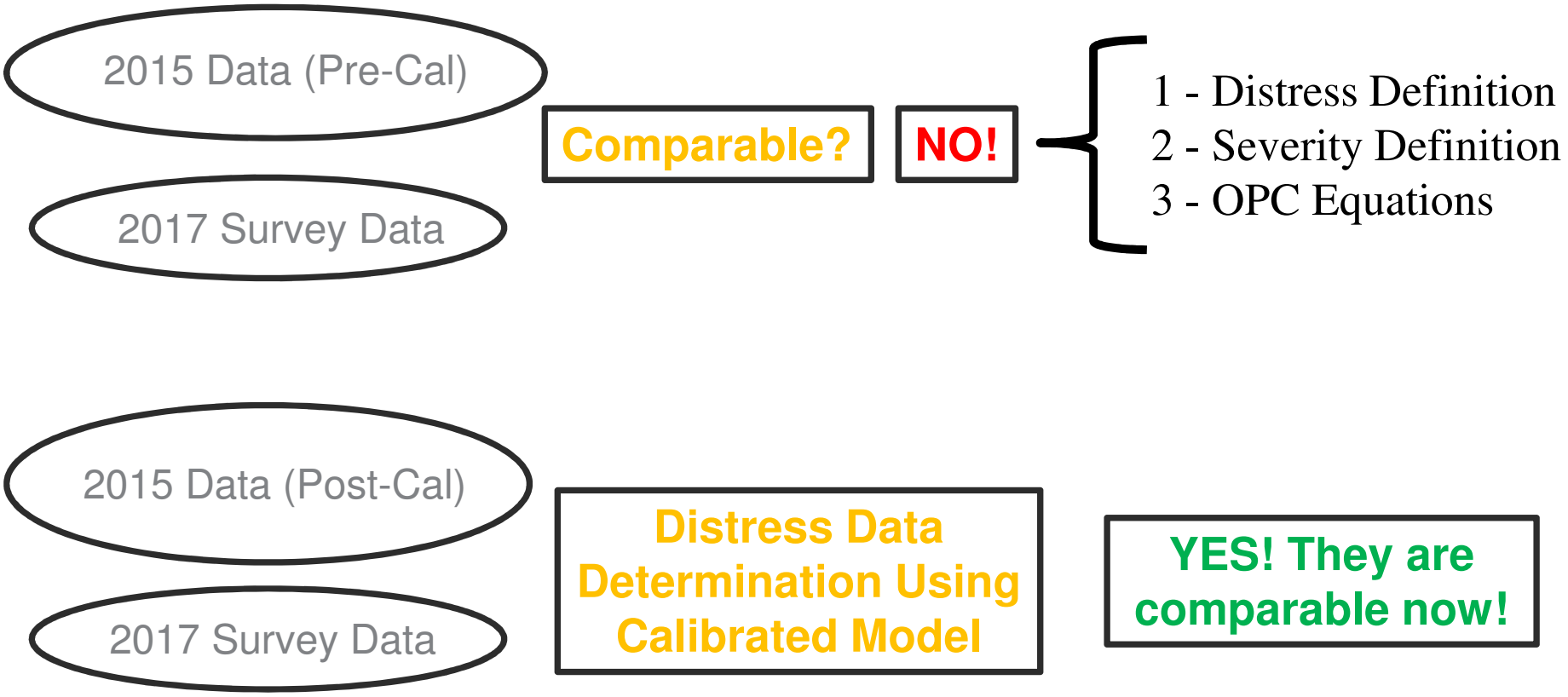
Data Comparison



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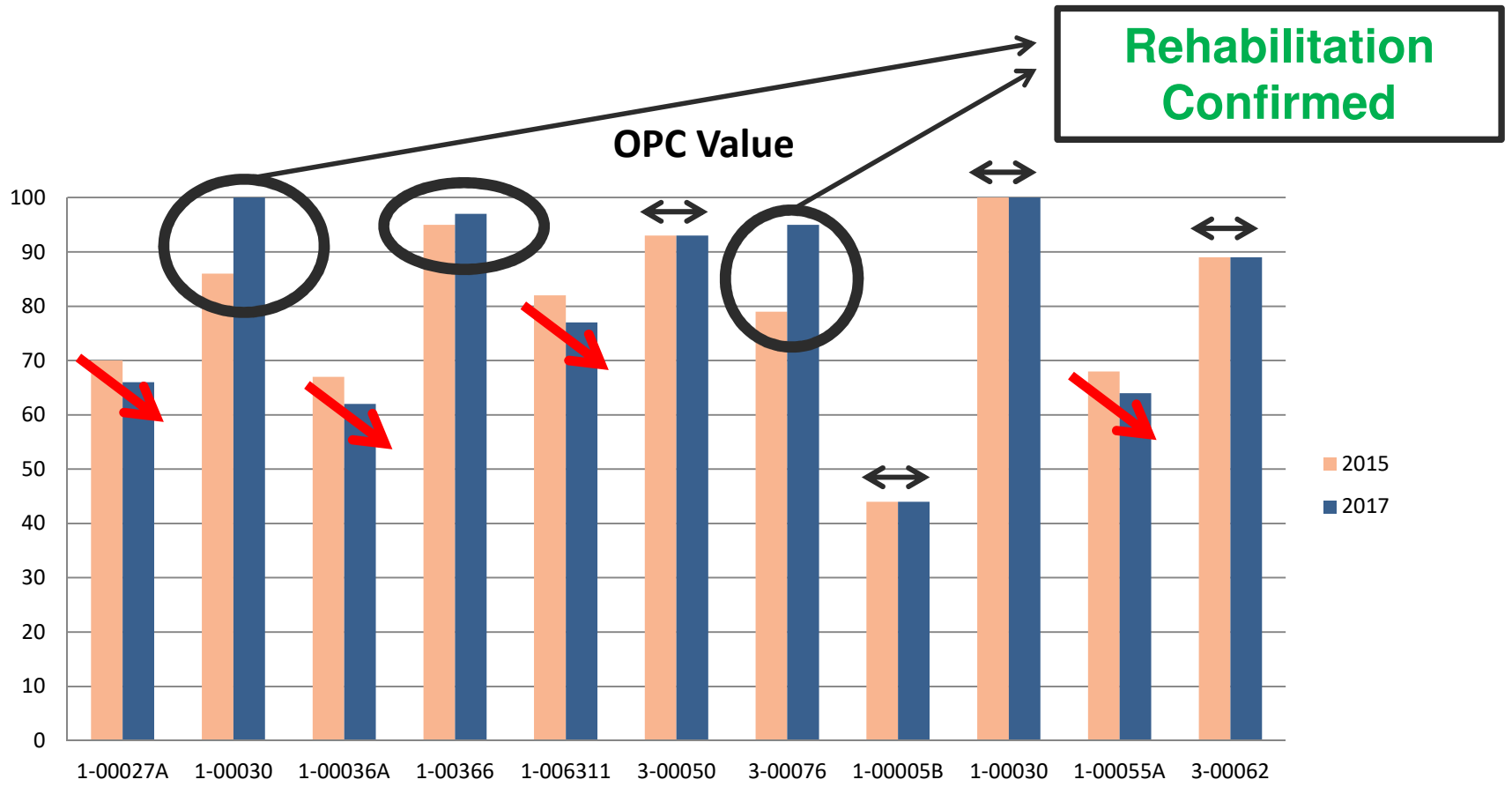
Historical Data Check of OPC Values
2015 Survey Post-Calibration vs. 2017 Survey



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Key Findings

- **Raveling**: difficult to characterize using automated methods, reduce impact on OPC scores
- **Coarse Texture and Debris**: high macro-texture and roadway debris limits measurement accuracy
- **Crack Characterization**: challenges in differentiating between block cracking and linear cracking combinations

Key Findings

- **Wheel Path Location**: expanding WP width to incorporate more fatigue
- **Limited Distress Types**: inclusion of all distress types in OPC calculation
- **Technology Enhancements**: raveling, ASR, and joint seal deterioration still pose challenges in automated detection

Recommendations

- Expand calibration effort by setting up permanent control sites
- Retrain AI algorithms to reduce differences in raw measurements
- Tweak index models and decision trees
- Establish data acceptance criteria

Future Trends and Recommendations

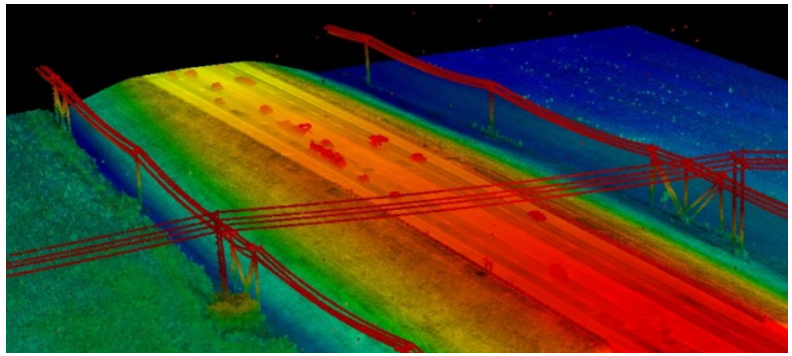
Future Trends

- AI will continue to advance
- Data collection equipment and methods will change
- Cost to collect and analyze should go down
- Return to the beginning again in our thinking….

Future Trends

- AI will continue to advance
  - Improvements to raveling, texture characterization
  - Improvements in crack characterization

- Data collection equipment and methods will change



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Future Trends

- Cost to collect and analyze should go down
- Return to the beginning again in our thinking (keeping it simple)….

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Recommendations

- Pavement owner (State, Municipality) should own the protocols for validation, collection, and analysis
- Consider technology advances and vehicle life when purchasing equipment
- Staying current will yield benefits:
  - Cost savings
  - Precision and accuracy

Questions & Discussion

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