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AN IMPLEMENTABLE FRAMEWORK FOR STANDARDIZING NATIONAL PAVEMENT CRACK MEASURES

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- The views, opinions, findings and conclusions reflected in this paper are the responsibility of the authors only and do not represent the official policy or position of the USDOT RITA, the GDOT, or any State or other entity.

Background

- **Cracking is one of the most common types of pavement surface distresses** and an important symptom of potential pavement failure. Crack evaluation is an necessary component in most pavement surface condition surveys:
  - Required by the Highway Performance Monitoring System (HPMS);
  - Suggested to AASHTO as part of pavement performance measures to fulfill the need of MAP-21;
  - Commonly used in state DOT's survey practice to support their pavement management.

- However, due to the significant diversity among the federal and state DOT's pavement distress protocols, it remains a challenge to establish nationwide consistent crack measures.
  - State DOTs have invested major resources to collect and maintain their **legacy data over decades for pavement management**, and are not willing to change their distress protocol.
  - Collecting crack data following both DOT's legacy protocols and an irrelevant national standard requires extra resources, which is not optimal given the current and projected budgetary constraints.

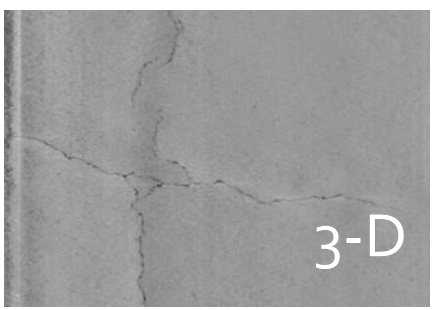
Background (cont'd)

- The automatic crack survey is gradually replacing traditional manual field survey in many highway agencies.

Manual Field Survey **Automatic Survey**

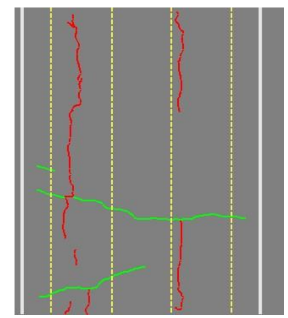
Automatic Crack Measurement/Evaluation

Data Acquisition



Crack Detection

Crack Classification



Left Wheelpath
LC Level 1 14.1

Right Wheelpath
LC Level 1 10.1

Non Wheelpath
BT Level 1 17.4

3 Steps of Crack Measurement/Evaluation

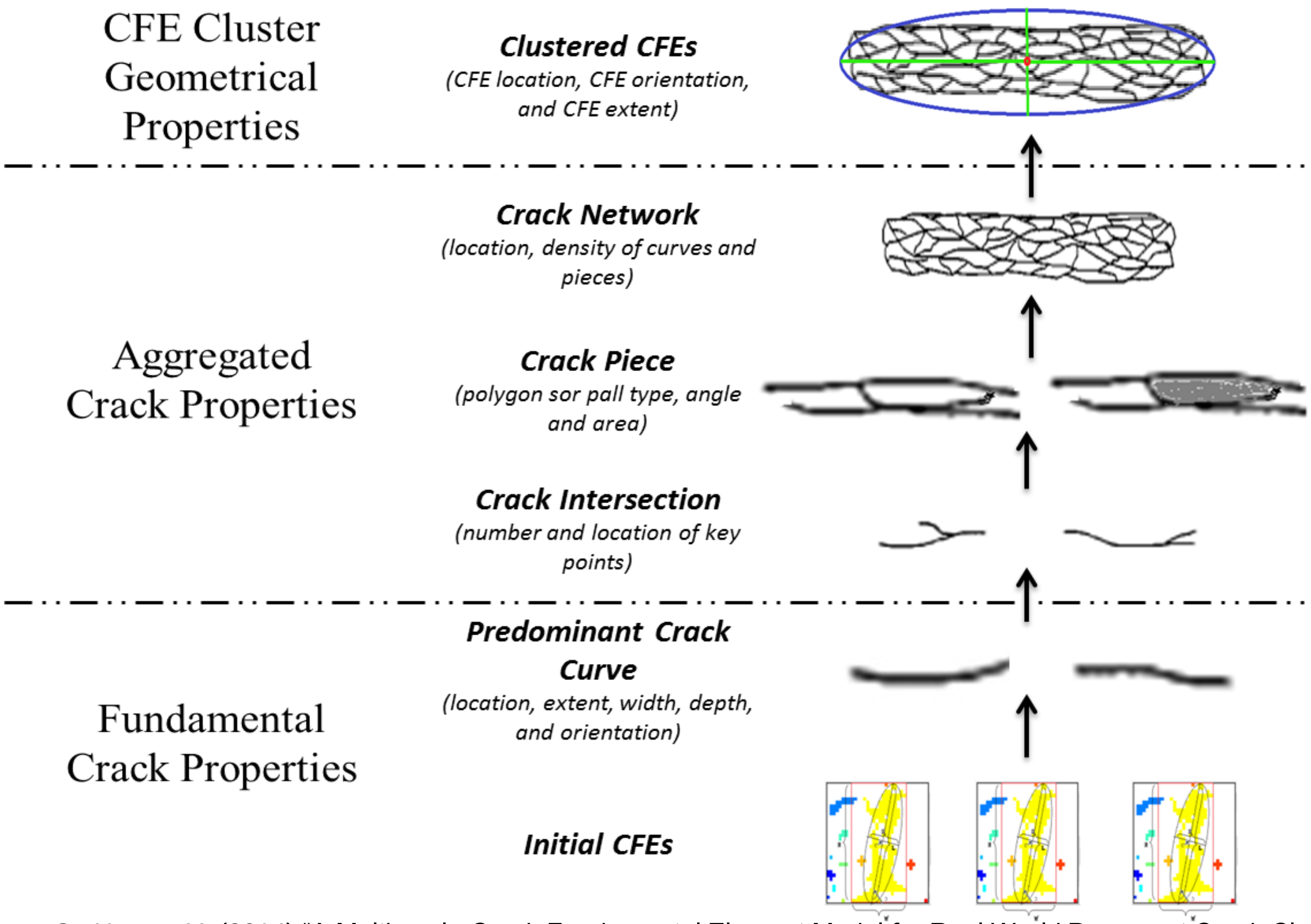
Research Objective

- The objective of this study is to propose **an implementable framework for standardizing national pavement crack measures**, which
  - Utilizes the data derived from emerging 2D imaging and 3D technology
  - Characterizes pavement surface cracks in a systematic and comprehensive manner;
  - **<u>Converts flexibly and easily among different crack protocols (crack types and severity levels)</u>**.

Crack Fundamental Elements (CFE) - Multi-scale Crack Analysis

- Crack pattern is crucial for differentiating crack types and severity levels
- A multi-scale CFE model is developed, which provides rich crack properties at three scales:
  - ***Fundamental crack properties***: fundamental and physical characteristics of each basic crack line;
  - ***Aggregated crack properties***: crack patterns, representing how cracks interact with each other;
  - ***Clustered CFE geometrical properties***: overall properties of clustered CFE

Crack Properties at Three Scales



1. Tsai, Y., Jiang, C., Huang, Y. (2014) “A Multi-scale Crack Fundamental Element Model for Real World Pavement Crack Classification”, ASCE Journal of Computing in Civil Engineering, Vol. 28, No. 4.

2. Huang Y., Tsai, Y. (2012) “Crack Fundamental Element (CFE) for Multi-scale Crack Classification”, 7th RILEM International Conference on Cracking in Pavements, Delft, Netherlands, June 20, 2012.

Framework for Sensor-based Standardized Crack Measures

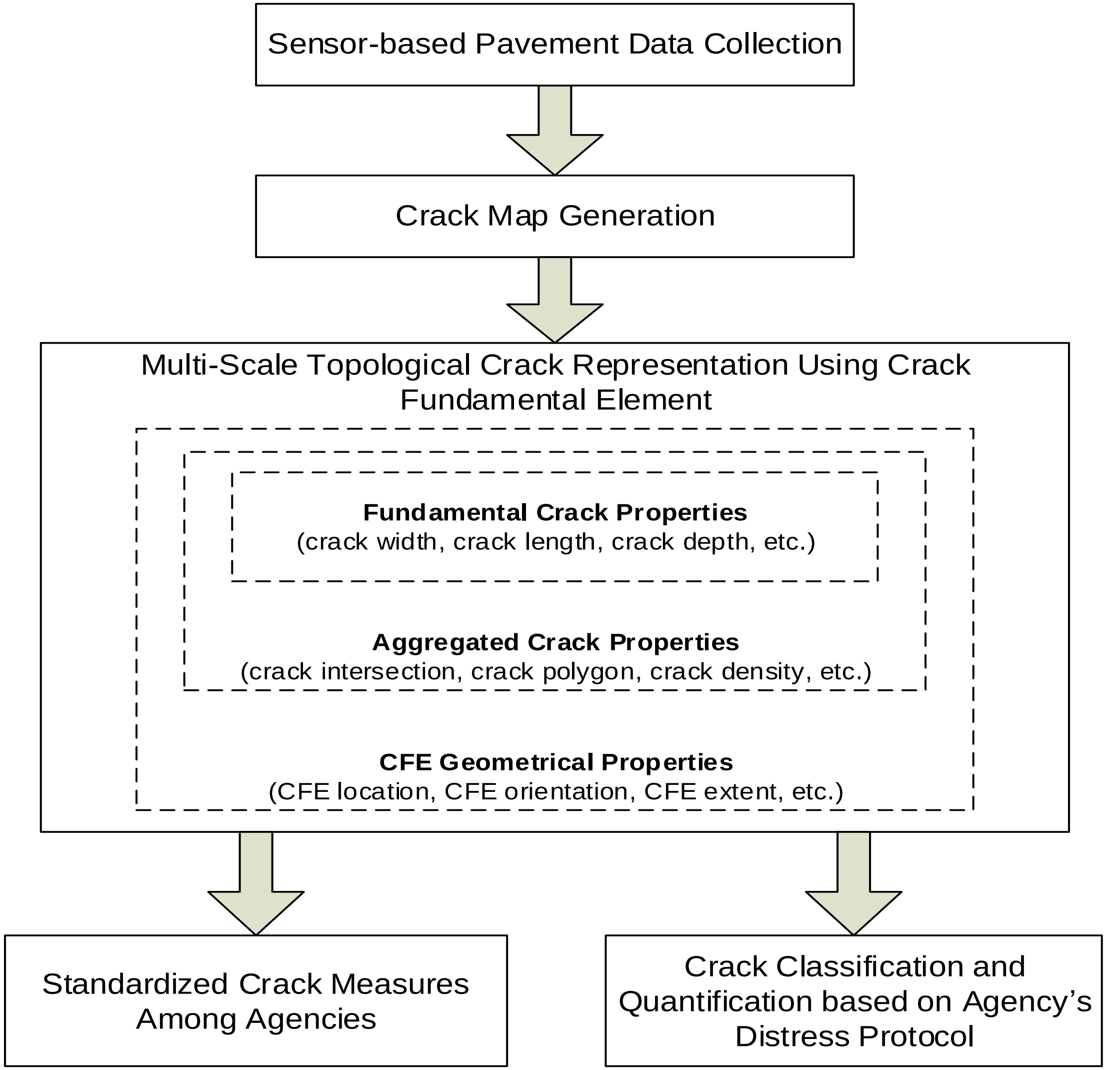
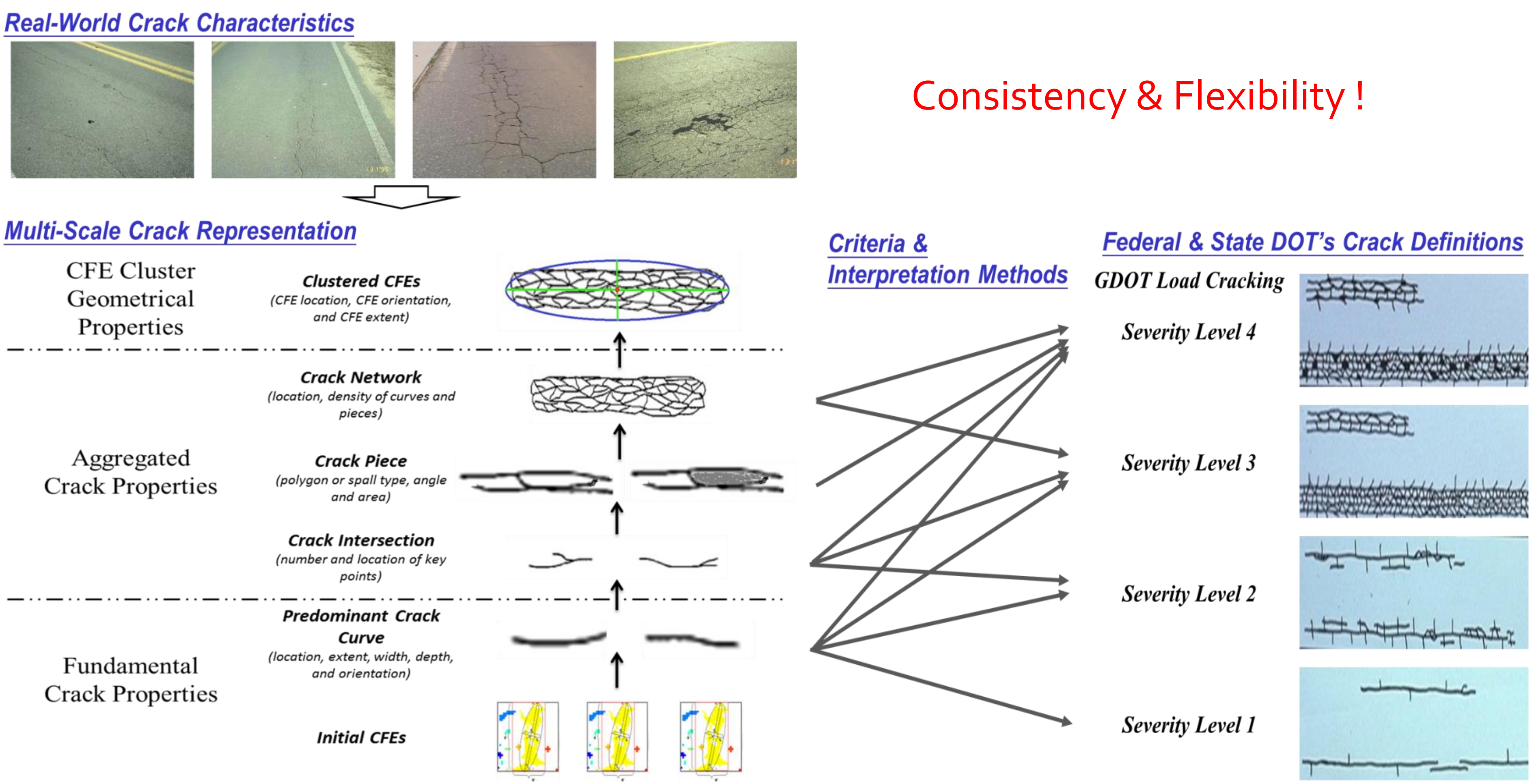


Illustration of abstracting crack properties from the data and transforming them into specific distress protocol



Flexible Shell Applications

Invariant Multi-scale Crack Characteristics

4.N Large-Scale Crack Network
(Extent)

4.2 Medium-Scale Crack Network
(density of curves and pieces)

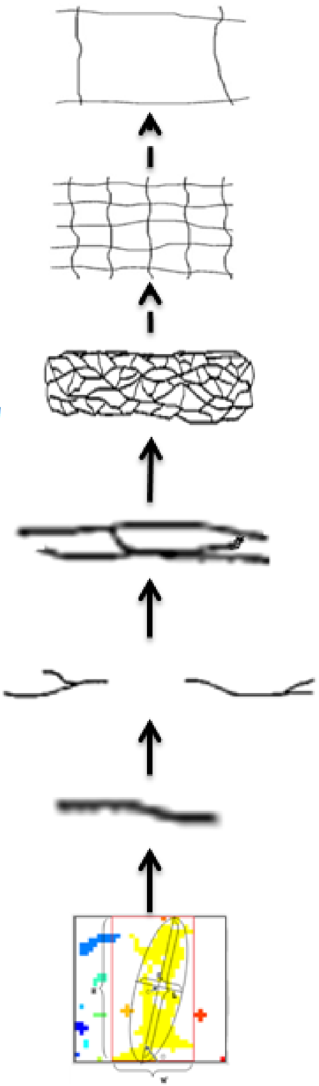
4.1 Small-Scale Crack Network
(location, density of curves and pieces)

3. Crack Piece
(polygon or spall type, angle and area)

2. Crack Intersection
(number and location of key points)

1. Predominant Crack Curve
(location, extent, width, depth, and orientation)

0. Fundamental Crack Element



Various Shell Applications

Standardized Pavement Crack Measures

(e.g. wheelpath crack, intensity 20%)

Agencies' legacy Protocols (LTTP, GDOT, etc)

(e.g. GDOT load cracking, severity level 2, 10%)

GDOT - Load Cracking (crack type and severity level)

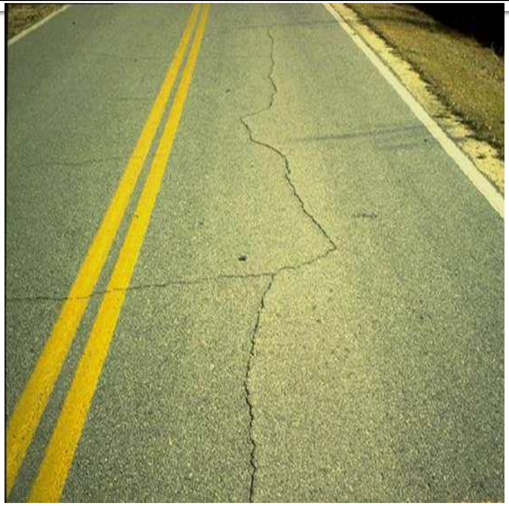
Severity Level 1

Severity Level 2

Severity Level 3

Severity Level 4

GDOT - B/T Cracking (crack type and severity level)

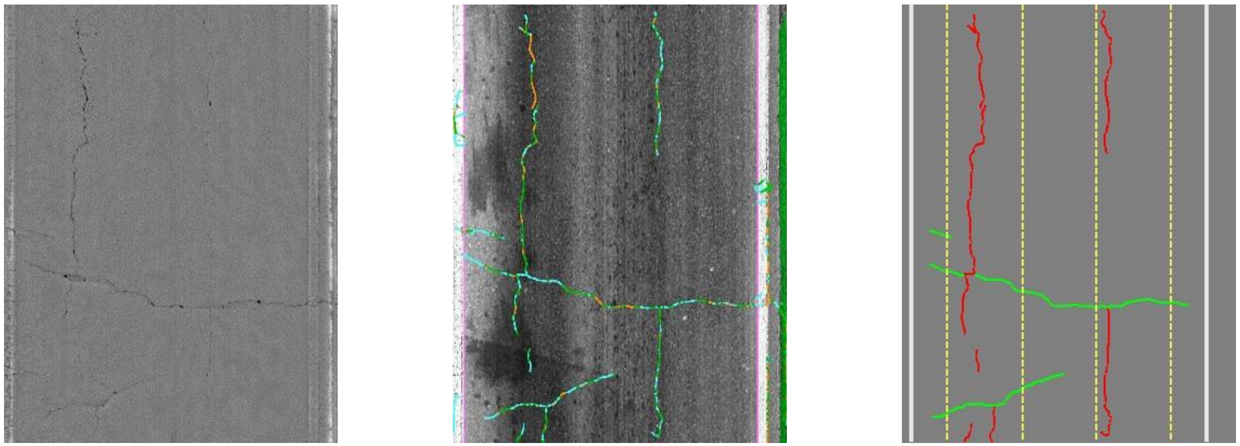


Severity Level 1

Severity Level 2

Severity Level 3

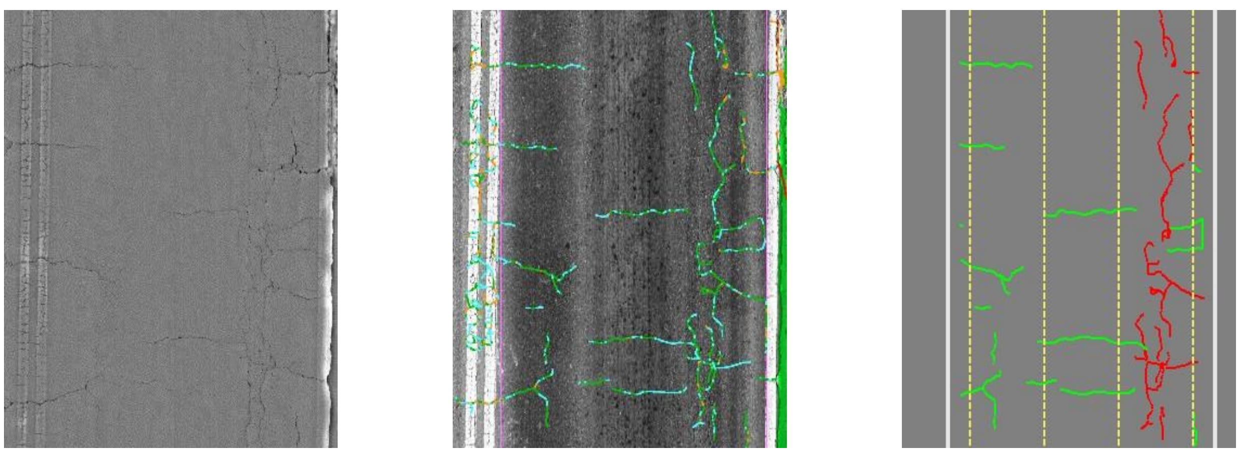
Implementation with GDOT's protocol



Left Wheelpath
LC Level 1 14.1

Right Wheelpath
LC Level 1 10.1

Non Wheelpath
BT Level 1 17.4



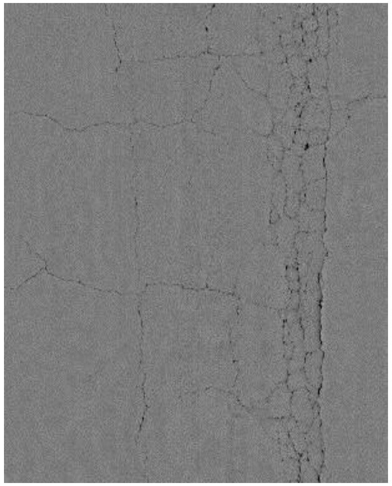
Left Wheelpath
None 0

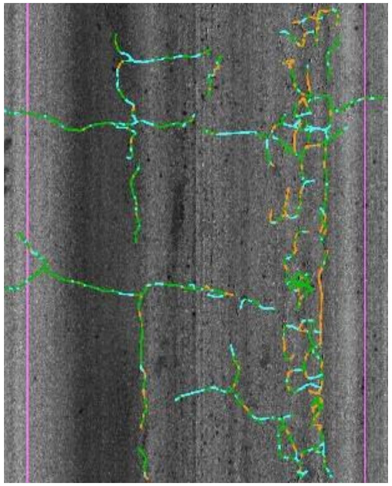
Right Wheelpath
LC Level 2 16.0

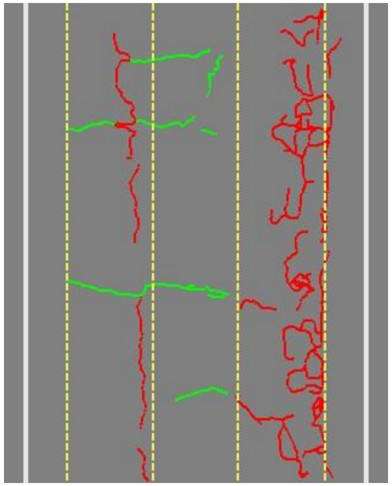
Non Wheelpath
BT Level 1 32.7

Measurement Unit: Foot

Implementation with GDOT's protocol (cont'd)



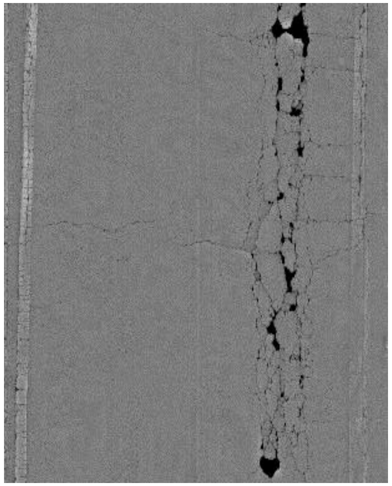


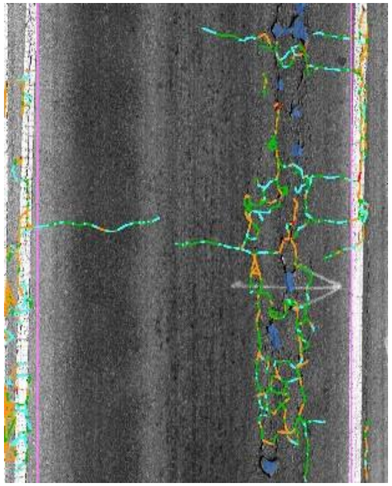


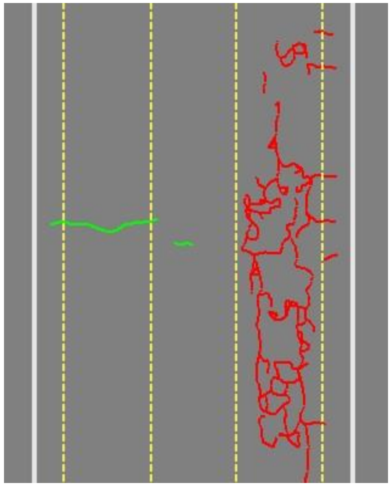
Left Wheelpath
LC Level 1 12.6

Right Wheelpath
LC Level 3 15.9

Non Wheelpath
BT Level 1 18.8







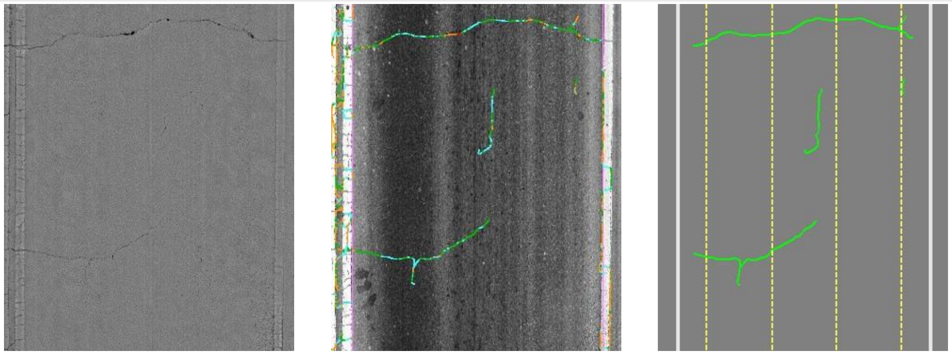
Left Wheelpath
None 0

Right Wheelpath
LC Level 4 14.7

Non Wheelpath
BT Level 1 4.1

Measurement Unit: Foot

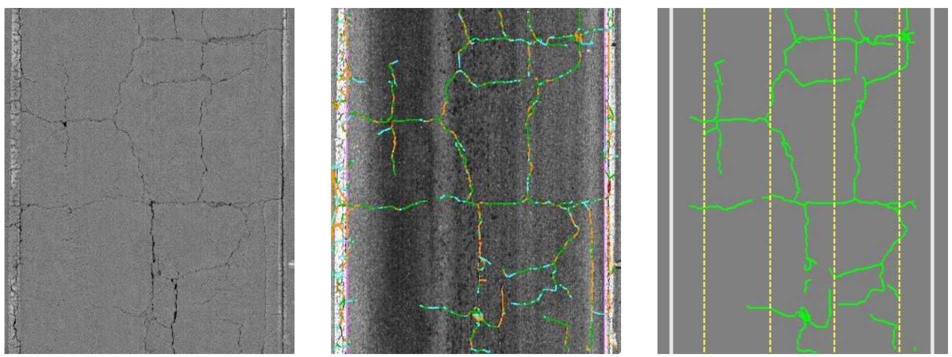
Implementation with GDOT's protocol (cont'd)



Left Wheelpath
None 0

Right Wheelpath
None 0

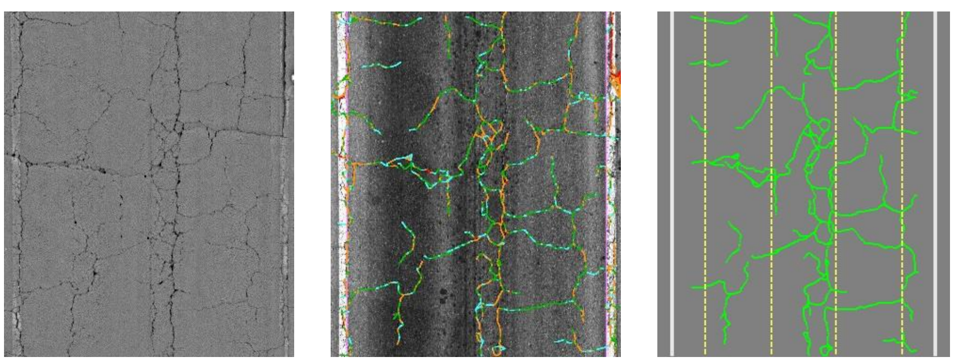
Non Wheelpath
BT Level 1 23.9



Left Wheelpath
None 0

Right Wheelpath
None 0

Non Wheelpath
BT Level 2 N/A



Left Wheelpath
None 0

Right Wheelpath
None 0

Non Wheelpath
BT Level 3 N/A

Measurement Unit: Foot

In-field Comparison Results (1)

SR 236 Site #1

	Field Measurement		Automatic Evaluation	
	Extent(%)	Deduct	Extent(%)	Deduct
Load Lvl 1	56	15	48	15
B/T Lvl 1	100	18	100	18
Overall		33		33

SR 236 Site #2

	Field Measurement		Automatic Evaluation	
	Extent(%)	Deduct	Extent(%)	Deduct
Load Lvl 1	41	13	27	9
Load Lvl 2	2	2	0	0
B/T Lvl 1	100	18	100	18
Overall		31		27

*** Note: the total deduct value is computed using the predominant deduct value for each crack type, following PACES.**

In-field Comparison Summary

- The average absolute difference for four sections is 3.25.

- The overall performance is promising, within the error tolerance in GDOT's decision making practice (5 deduct points).

Conclusions and Recommendations

- The concept of multi-scale crack analysis using Crack Fundamental Element (CFE) model is proposed. Based on this concept, this study develops **a framework that can flexibly and easily convert among different crack protocols**. It
  - Provides nationwide consistent crack measures to fulfill the need of MAP-21; and also
  - Maintains the legacy of state DOT's historical data and pavement management practice.
- Methods and procedures need to be developed to transform the multi-scale crack properties into agency's crack definitions, i.e. automatic crack classification using federal and state DOT's distress protocols.

Thank you for your attention!

Questions?