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# EVALUATING CRACKING DATA QUALITY USING FIELD-LABELED CRACK MAP GROUND REFERENCE


**Haolin Wang (Presenting), Ph.D. Student, Zhongyu Yang, Ph.D., Research Engineer II, Yi-Chang (James) Tsai, Ph.D., Professor**

School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, Georgia

**Jeannine Moriarty (Presenting), Transportation Engineer III**

Pavement Management Unit, Connecticut Department of Transportation


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2026 RPUG CONFERENCE ★ PITTSBURGH, PA ★ APRIL 28 – MAY 1

# OUTLINE

- Needs for cracking data quality assessment
  - Lack of crack-specific data quality assessment
  - Connecticut department of transportation practice
- Proposed ground reference procedures
- Proposed comparison method for assessment

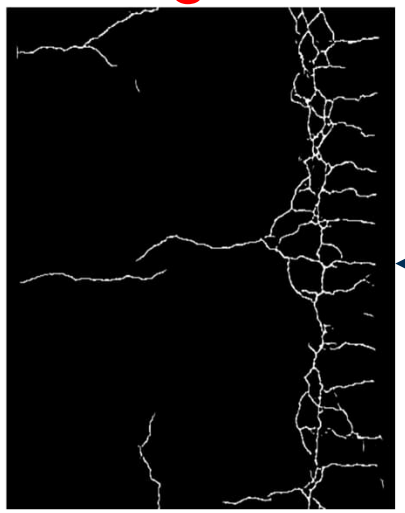
# What Were We Lacking? – Cracking Data Quality Assessment

**A lack of effective and practical approaches remains for agencies to assess crack-specific data quality.**

Existing methods for **sensor** and **pavement image quality** assessment:

- Sensor certification (hardware-focused)
  TPP Standard (PP 106-111)
- Pavement image quality assessment
  NCHRP 1106 / PP 119
- Vendor own calibration
  Manufacturer Calibration

**Lacking:**



*Detected Crack Map*

**Reflect Real Crack Condition**

**?**

*Real-world Crack (Ground Reference)*

1) How to obtain **ground reference.**
2) How to assess quality (**quantify missing crack**).
3) **Diagnostic and reasoning for any missing crack.**



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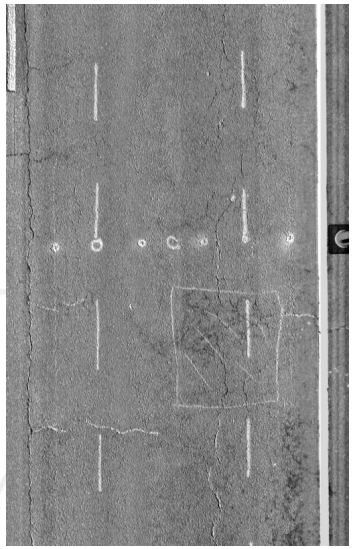
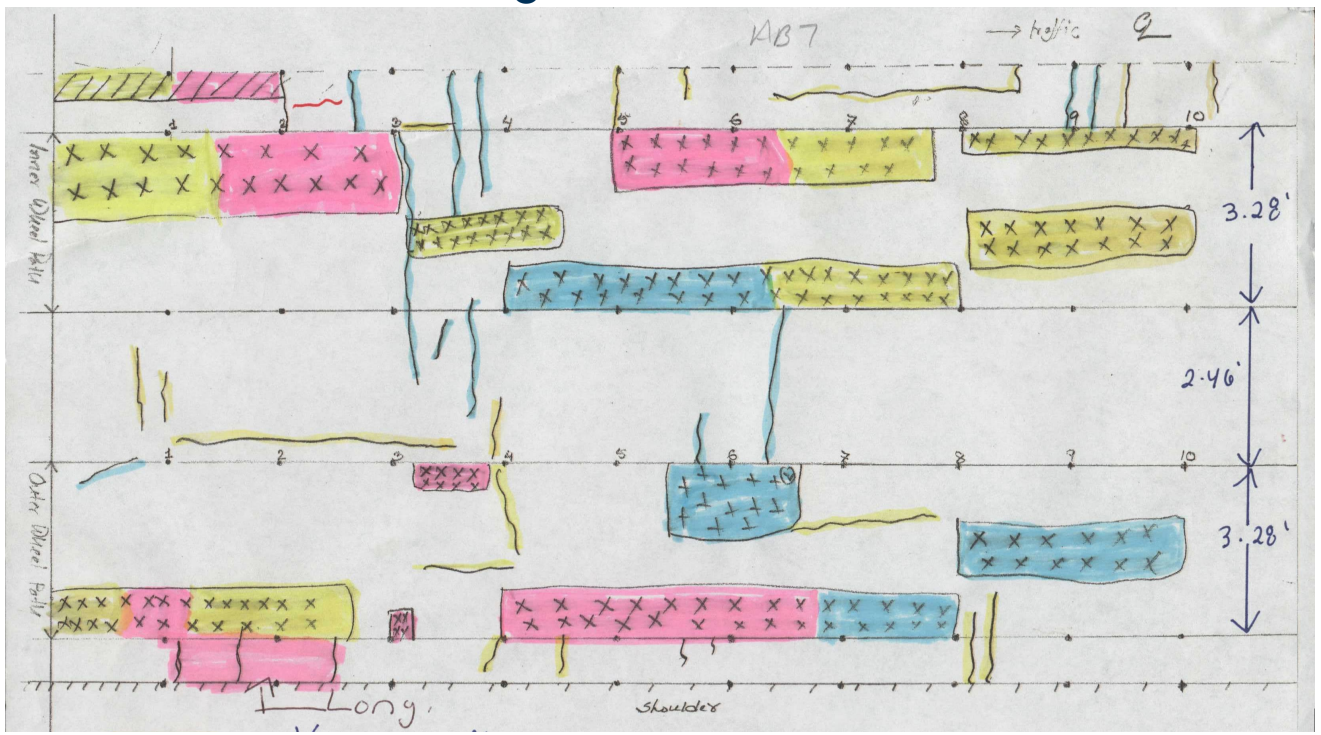
# CTDOT Practices in 2025- Manual Validation

Front image of manual distress



Downward pavement image of manual distress

**Testing** vs **Manual** Results




Yellow represents section identified both in **testing** and **manually**
Pink represents picked in **testing** but categorized as Longitudinal crack instead of Alligator
Blue missed by **testing** but picked up **manually**

# Pavement Cracking Data Quality Assessment

**Deliverable-focused:** *Are the cracking data as delivered good enough for the intended use?*

**Proposed Ground Reference Method**

**Field labeled crack map** on pavement surface (draw using paint).

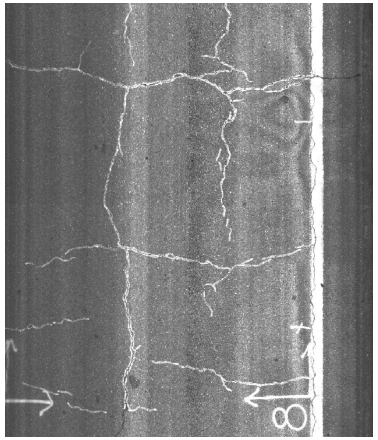
**Any difference?**

**Traditional Ground Reference Method**

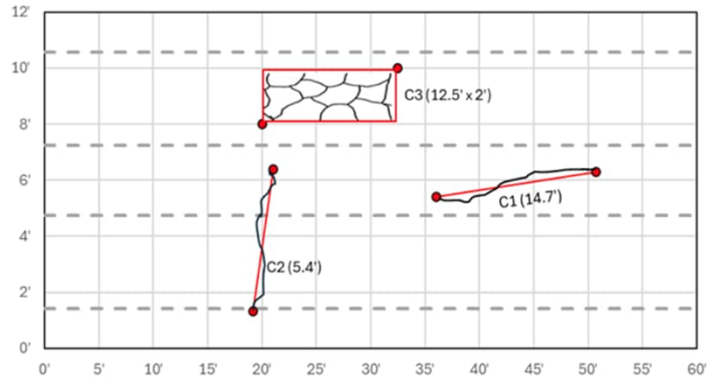
**Crack survey** using engineering sheets.

**Assessments**

1. Visual crack map comparison
2. HPMS % comparison
3. Pixel-level quantification (EHD, missed crack, spurious crack)



**Proposed Field Labeled Crack Map**




Traditional Crack Survey on Engineering Sheet



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# Preparation for Ground Reference Procedure

- **Test site** selection:
  1. Cover **single surface type** (asphalt pavement, JPCP, or CRCP)
  2. **50-ft (15-m) sections** for cracking painting practicality (section length justifiable for JPCP to include complete slabs)
  3. **Crack condition** shall be representative, but severity shall be suitable for labeling ease
  4. **Mark selected section** for identification ease
- **Traffic control**: ensure safety

- **Resource** allocation
  1. Test 3D system for data collection + smartphone/drone for supportive data collection
  2. Manual survey-related equipment (e.g., engineering sheets, pens, and measuring wheels)
  3. **Field-labeling-related equipment** (e.g., washable paint, brushes)

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# Ground Reference Procedure

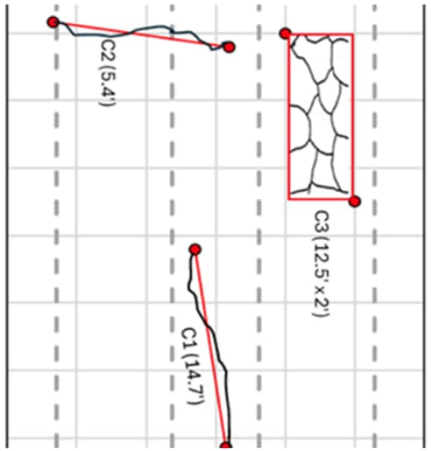
## Preparation

- **Resource** allocation
- **Test site** selection and marking for visualization
- **Traffic control**

## Step 1

**Crack survey** on engineering sheets

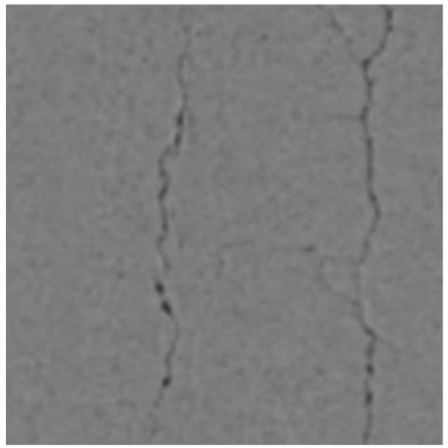
Avoid impact of painted cracks on the survey judgment




## Step 2

Test system scan for **test crack map**

Avoid impact of painted cracks on crack attributes



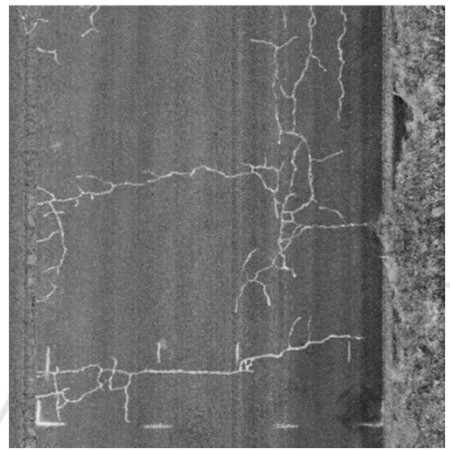
## Step 3

Paint on the pavement surface for the **field-labeled crack map** as the ground reference

## Step 4

Pavement scan for **digitizing filed-labeled crack map**

Photos from smartphone/drone can serve as the supporting resource



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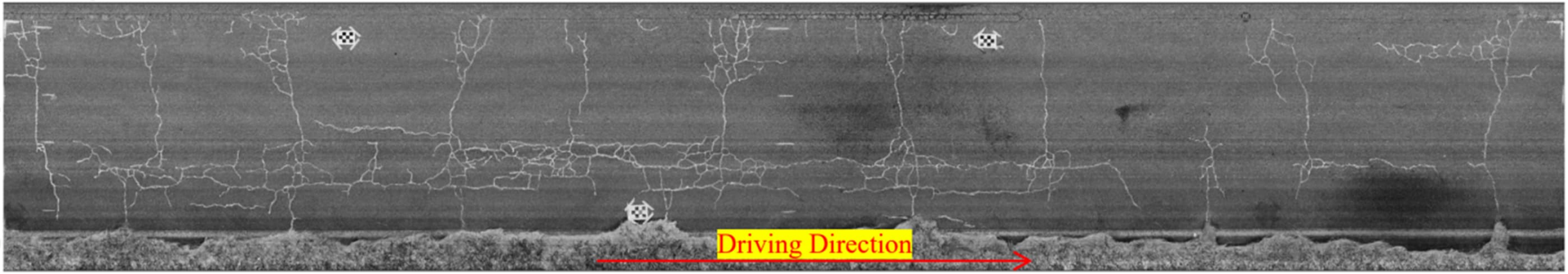
# Case Study

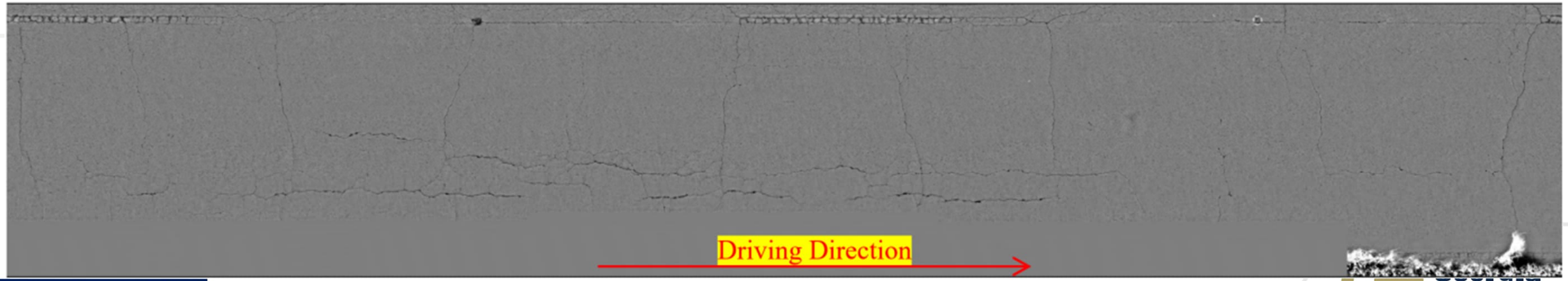
**Asphalt pavement**

**Crack detection is done using the test system manufacturer's proprietary algorithm**

**Test system specs:**
1 mm driving directional scanning interval.
1 mm transverse resolution.
0.25 mm vertical accuracy.
**4 mm output resolution for intensity and depth images**.




Intensity Image of Case Study Section (After Field Label)

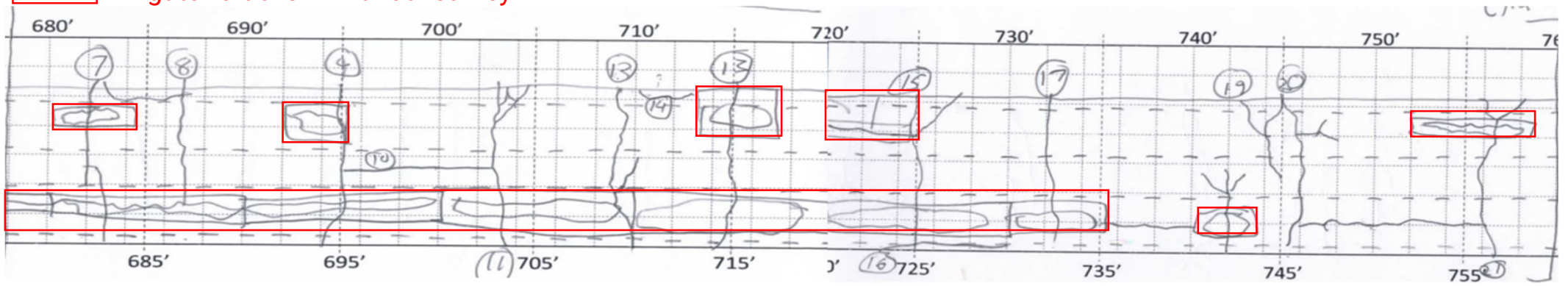



Depth (Range) Image of Case Study Section

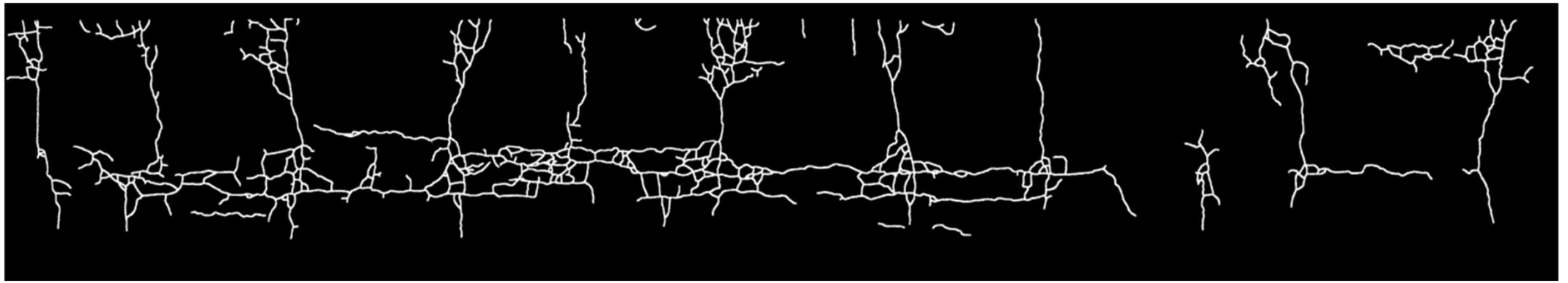
# Visual Crack Map Comparison

**Traditional**
Survey Sheet

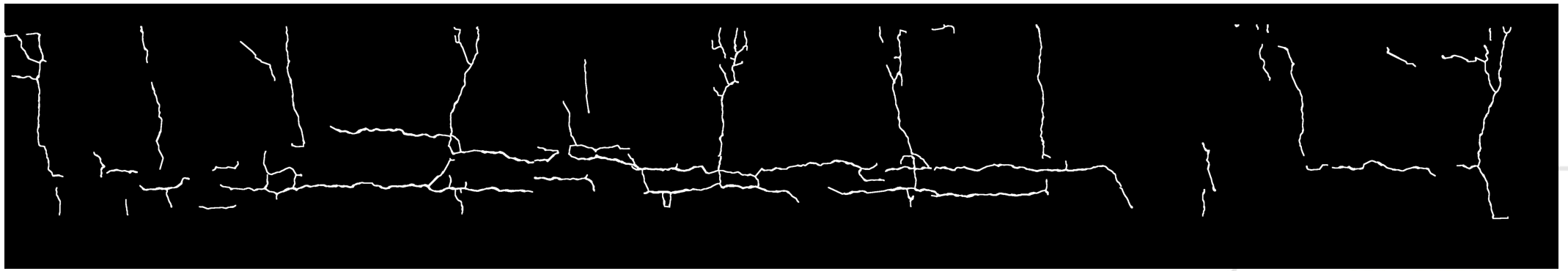
Alligator cracks in manual survey




**Proposed**
Field Labeled
Crack Map



Testing
Crack Map



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# HPMS Cracking Percentage Reporting Using Crack Maps

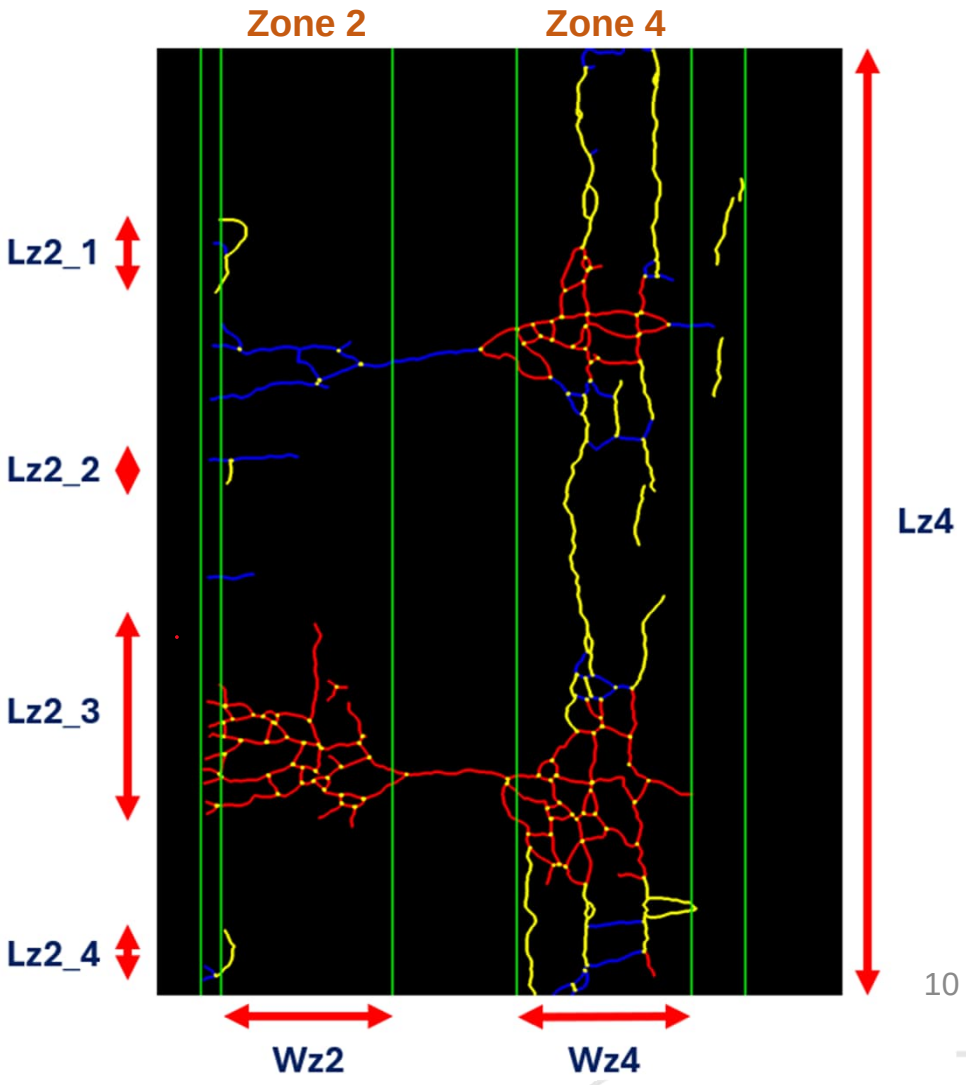
HPMS Definition for Asphalt Pavements:

***Cracking Percent is the percentage of the total area exhibiting visible fatigue-type cracking (alligator cracks + longitudinal cracks) for all severity levels in the wheelpath in each section.***

**HPMS Cracking Percentage for crack maps:**

$$\frac{W_{Z2} * L_{Z2} + W_{Z4} * L_{Z4}}{A}$$

- **W = zone width (zones 2&4 are wheelpath)**
- **L = total length of the affected wheelpath area by *alligator cracks* + *longitudinal cracks***
- **A = area of whole lane (calculated using 12 ft width * crack map height)**



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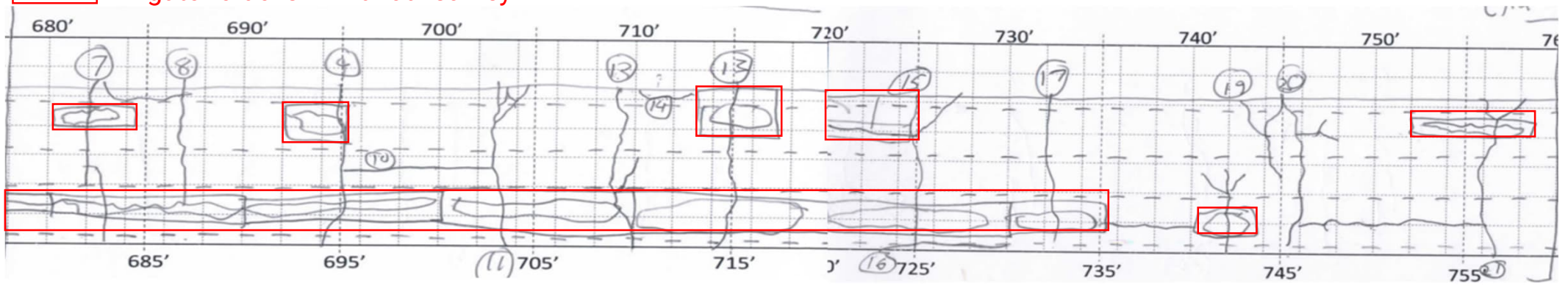
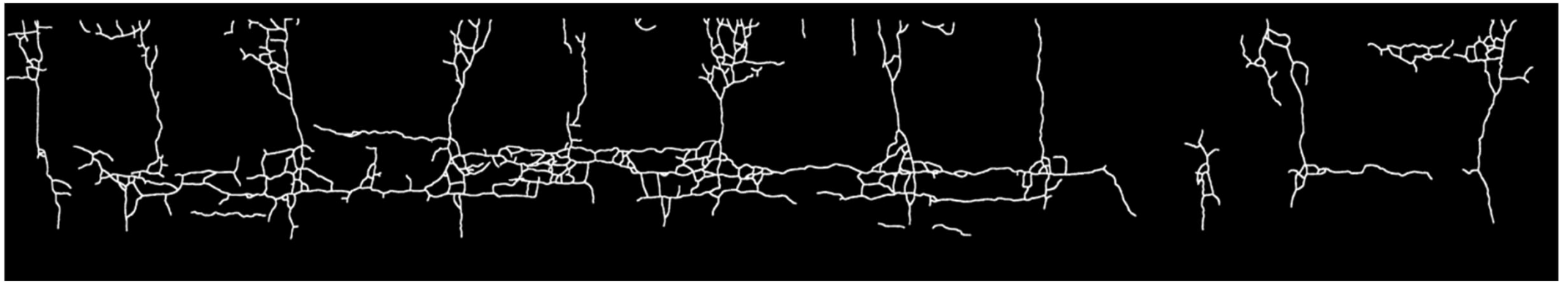
# HPMS Reporting Comparison

Alligator cracks in manual survey

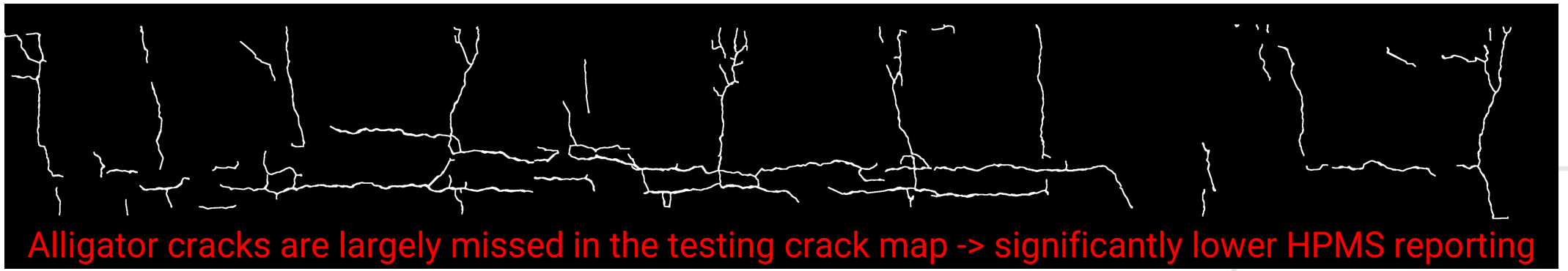
**Traditional**
Survey Sheet
**HPMS 38%**




**Proposed**
Field Labeled
Crack Map
**HPMS 34%**



Test
Crack Map
**HPMS 17%**



Alligator cracks are largely missed in the testing crack map -> significantly lower HPMS reporting

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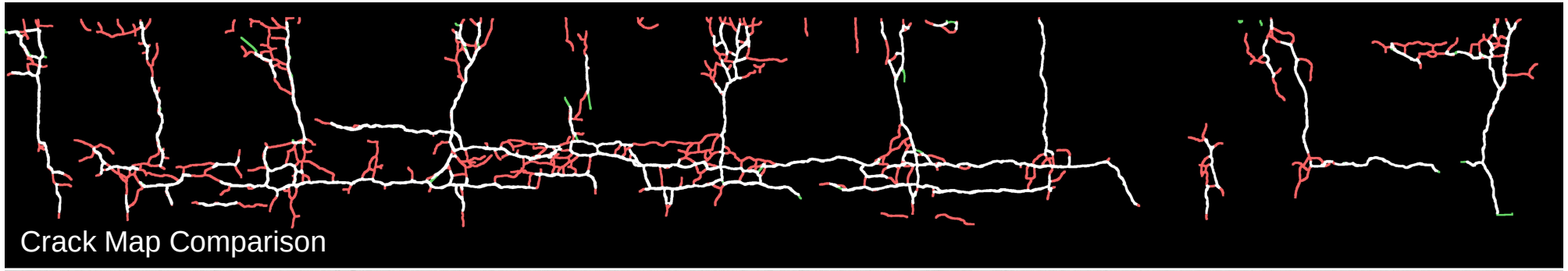
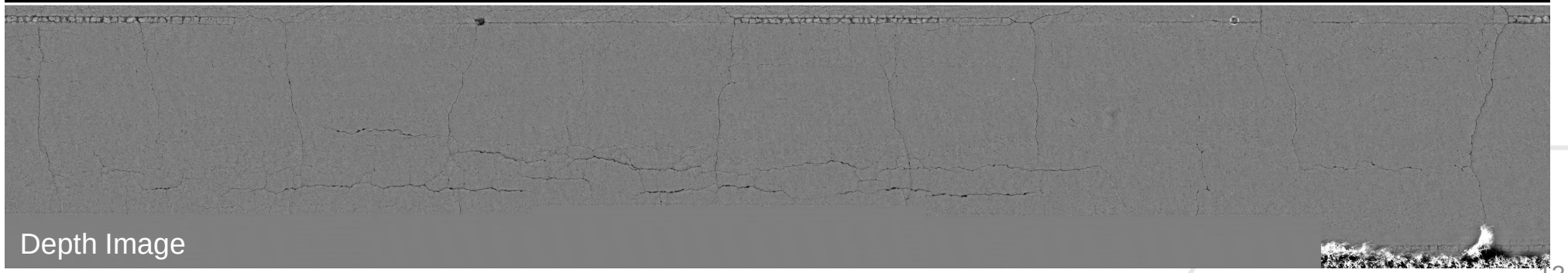
# Pixel-level Comparison Using Field-Labeled Crack Map

- **EHD: 45.29 (0-100 with 100 best crack map quality)**
  - Medium poor performance.
- **Missed detection: ~48%**
  - Missed majorly short, thin cracks, leading to the omission of dense, interconnected crack networks, with only major longitudinal and transverse cracks left.
- **Spurious detection: ~5%**
  - The testing system had limited spurious detection.

***Wet surface + coarse surface (chip seal)*** *may be the reason for* ***missed detection****.*

**Red: Missed detection**
**Green: Spurious detection**
**White: Correct detection**

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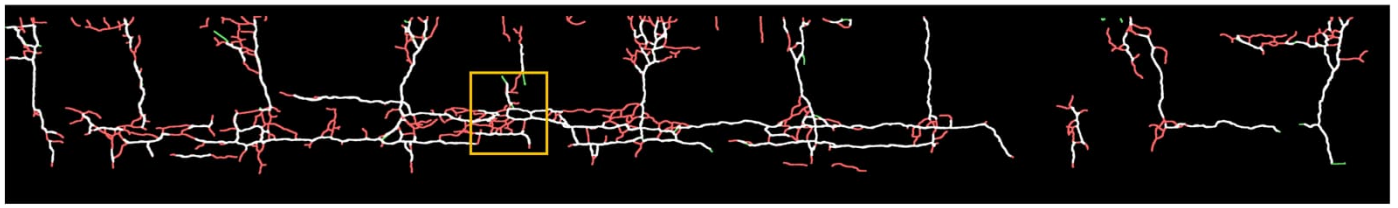
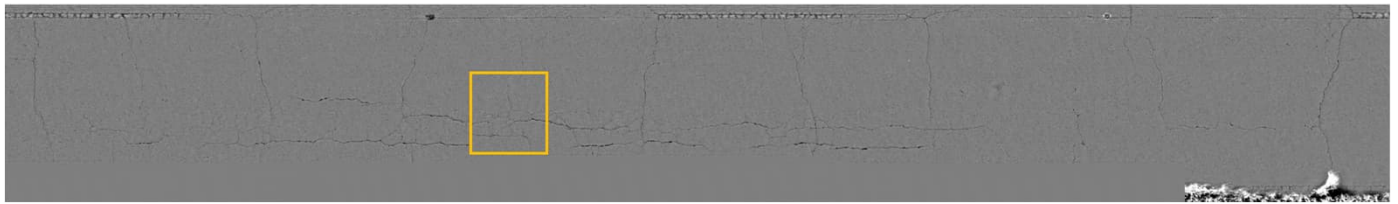
# A Closer Look on Crack Map Issue

- **Missed detection**
  Omitted dense, interconnected crack networks, with only major longitudinal and transverse cracks left
- **Spurious detection**
  Algorithm performance variance

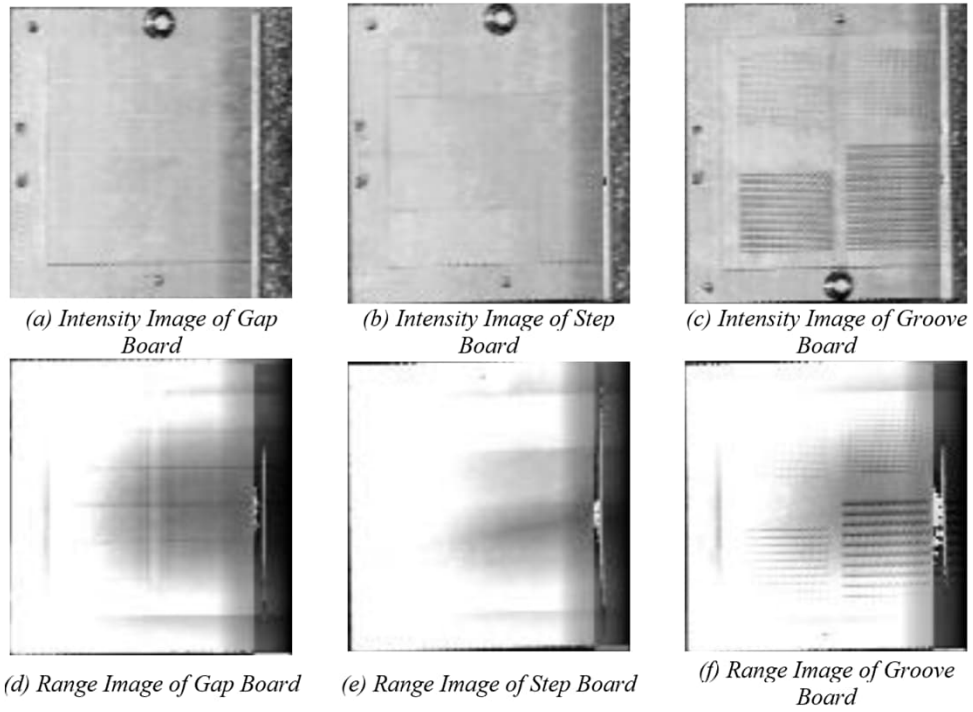




# One Step Further: Diagnosing Missing Cracks

Identify **sensor issues** (e.g., pavement image quality) or **crack-detection issues** that result in missing cracks.

- **Sensor issue**– Using reference objects with designed geometry to evaluate the sensor quality.
- **Crack detection issue**– Crack annotation on pavement images to evaluate crack detection algorithms.




Ground Reference Objects Scanning

Crack Manual Annotation



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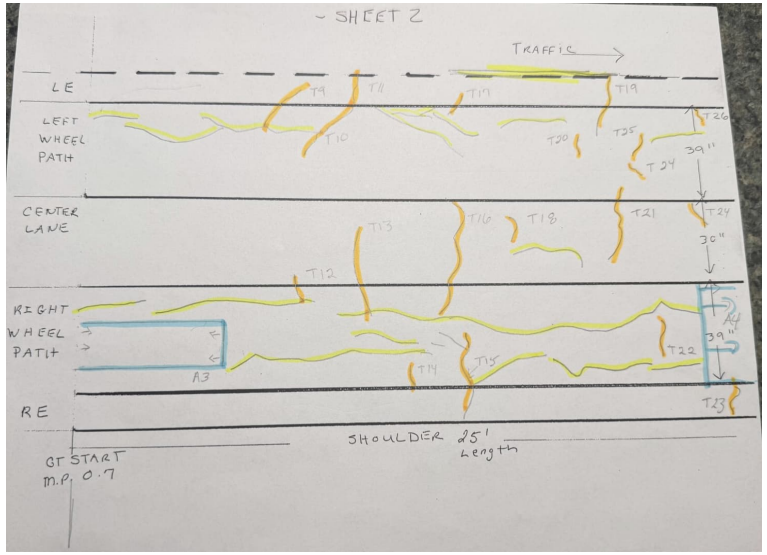
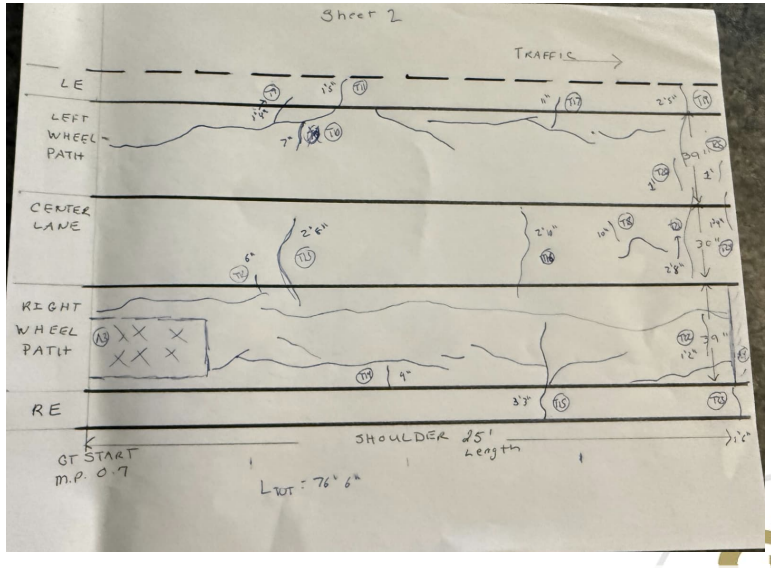
# CTDOT Practices in 2026-Data Collected


Field Labeled Crack Map




Manual Sheet Crack Map

# Conclusions

## Crack-specific Data Quality Assessment Methods

1. Proposed executable **ground reference** procedures: **field-labeled crack map**
   - Test site selection, equipment, and material
   - Step-by-step procedure for field labeling and ground reference crack map generation
2. Proposed **assessment methods** to evaluate crack map quality
   - Visual assessment for straightforward comparison
   - HPMS reporting assessment for comparison in routine practice
   - Pixel-level assessment for quantitative comparison
3. Introduced useful methods to **diagnose sensor vs. detection algorithm issues** that lead to missing cracks

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# Recommendations

1. **Establish Routine Test**
   Prepare routine test sites for ground reference and test data collection, covering different pavement types for broader applicability validation
2. **Multi-System Testing**
   Conduct cross-system comparisons of different collection systems
3. **Acceptance Determination**
   Determine the acceptance of the cracking data quality with per agencies' own needs
4. **Incorporating into Agencies' Data Quality Management Plan**
   Recommend the work with the vendor (or using the in-house system) on the state's own situation regarding the crack type classification, providing more state-specific information

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# THANK YOU!

# QUESTIONS?


**Haolin Wang, Zhongyu Yang, Yi-Chang (James) Tsai**

Georgia Institute of Technology

**Jeannine Moriarty**

Connecticut Department of Transportation



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