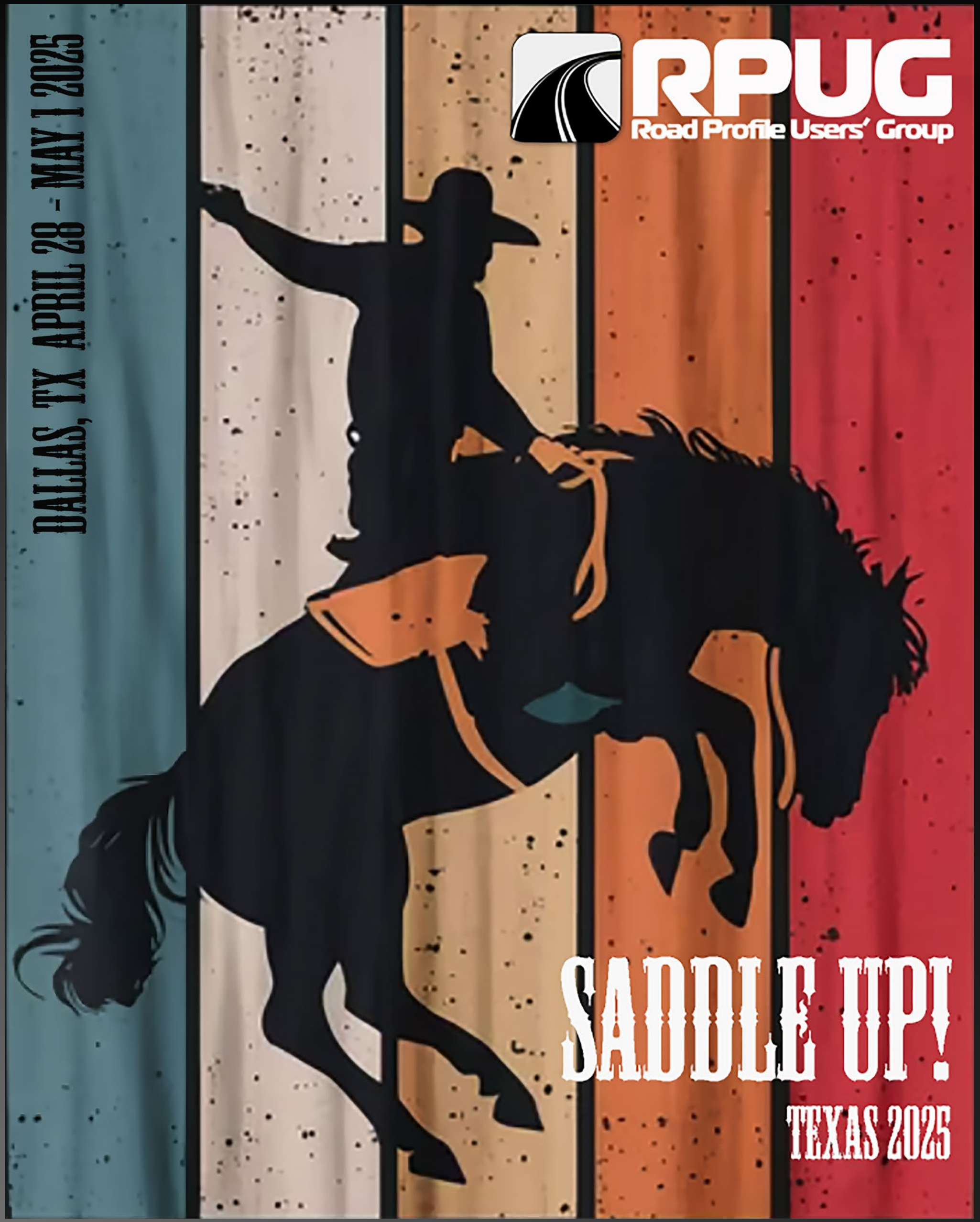

QC/QA FOR PAVEMENT CONDITION DATA
EMPHASIS ON LCMS PAVEMENT DISTRESS IDENTIFICATION

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Transportation Engineer III
Pavement Management Unit
Bureau of Engineering and construction

RPUG
Road Profile Users' Group

Main Topics

- CTDOT DQMP roles and responsibilities
- Control site layout and selection
- CTDOT QA and post-Production pavement condition data
- Is the LCMS crack detection giving us accurate/repeatable
- How we validate automated crack data steps and process

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DQMP Roles and responsibilities

Photolog Unit

- ❑ Data collection all pavement condition with two ARAN vans
- ❑ Data quality checks on all data
- ❑ Assist with control site selection and layout
- ❑ Coordinate and layout control site

Pavement Management

- ❑ Perform quality assurance and acceptance of pavement condition data collect by Photolog Unit
- ❑ Assist with control site selection and layout
- ❑ Manage pavement database and dTIMS Pavement Management Software
- ❑ Produce Annual Condition Report
- ❑ Submit pavement data
  - HPMS, TAMP and Performance Measures Dashboard

CTDOT has been collecting and managing their own data since 1993

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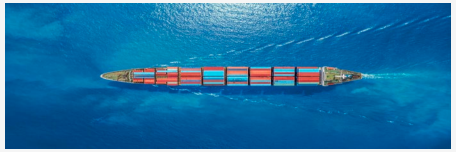
Advantages and disadvantages of in-house pavement data collection and processing

Advantages

- Staff has a wealth of knowledge and experience
- Van operators have been operating for over 20 years
- In depth knowledge of settings within Vision and distress schema 20 years experience
- Good coordination between Photolog and Pavement Management Unit

Disadvantages

- Doing so long we think we're are the experts
- Slow to embrace change-similar to a big ship changing direction



- Do we always do the daily checks before we go out for collection
- Managing our own settings can be challenging year to year
- Managing big data takes storage and IT support
- Units are under two different bureaus

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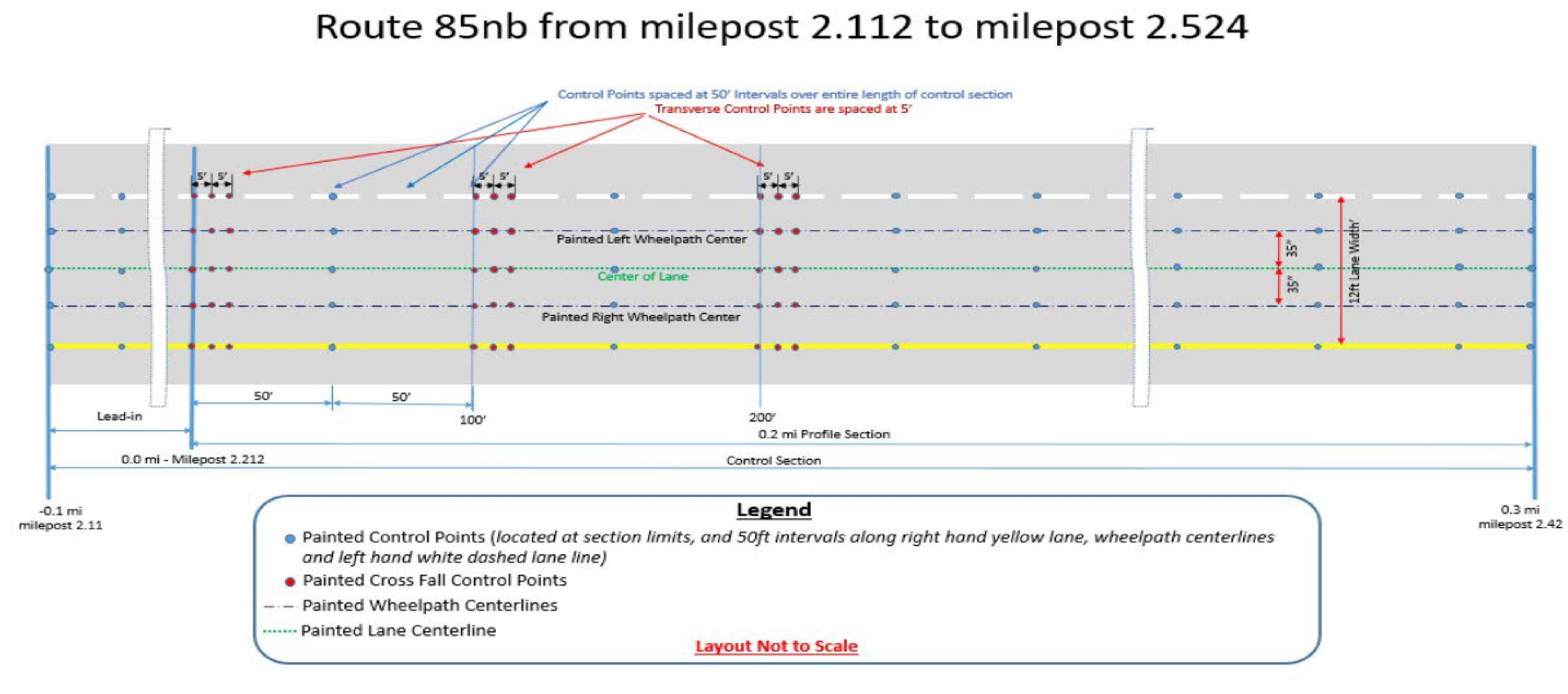
CTDOT Equipment Calibration Site State Route 85 NB



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Site Requirements Cracking Verification/Validation

Site Requirements

Number of Sites	Length	HPMS Condition	HPMS %Crack	ALL_Total Cracking per image [ft/10 lane-m]	WP_Total Cracking per image [%area/10 lane-m]	NWP_Total Cracking per image [ft/10 lane-m]
1	0.5 mile	Fair	10%-15%	50-70	30-45	15-25

Survey Procedures and Equipment

Office Manual Distress Survey

Step1. Collect pavement images from the survey section with ARAN Vans using LCMS System in accordance with AASHTO PP 68-14.

Step 2. Use WiseCrax software in manual mode to identify and rate cracks.

- Note 1: An experienced Distress Rater shall perform this step manually.
- Note 2: The lane zone dimensions setting should match the requirements of the HPMS guide (also see Figure 2.3.4.1)

- Note 3: Crack detection settings including severity thresholds should be finalized and approved by CTDOT's Pavement Management Unit (PMU) prior performing Step 2.

Step 3. Store cracking survey data in tabulated form in accordance with AASHTO R 55-10.

Step 4. Use the above data to determine precision, accuracy (with respect to field manual or ARAN distress surveys), and reproducibility of office manual distress survey.

Survey Procedures and Equipment

Before conducting survey for validation

Pavement Condition Data – Collection (Photolog)

- Annual state network surveys performed with Automatic Road Analyzer (ARAN) vans
- 7,466 directional miles for the 3,733 centerline miles network
- Capable of measuring 15 different data streams at traffic speeds
- Sensors permanently installed and managed in a climate-controlled environment
- Custom built according to ConnDOT specifications

Survey Procedures and Equipment

Before conducting the survey of a validation site:

- Ensure that DMI, other sensors and lasers, installed on ARAN vans, are calibrated in accordance with manufacturer guidelines.
- Ensure that ARAN LCMS conforms to ASTM E1656 (the latest version).
- Perform diagnostics of DMI, GPS, Grade, LCMS, POS LV, Roughness, and Video systems.

While collecting data on a validation site:

- Follow pre-determined collection procedure (with or without Auto Start) in accordance with Section 9.2 of the ARAN User Manual 2.0.
- Follow the wheelpath center as close as possible to ensure both inner and outer lane markings are visible on downward pavement images.
- Ensure constant speed (not less than 25 mi/hr) within validation site limits.
- Avoid weaving and braking within validation site limits.

Cracking Verification Site Route 85 Layout and Site Requirements

Cracking Measurement Verification Section

Layout

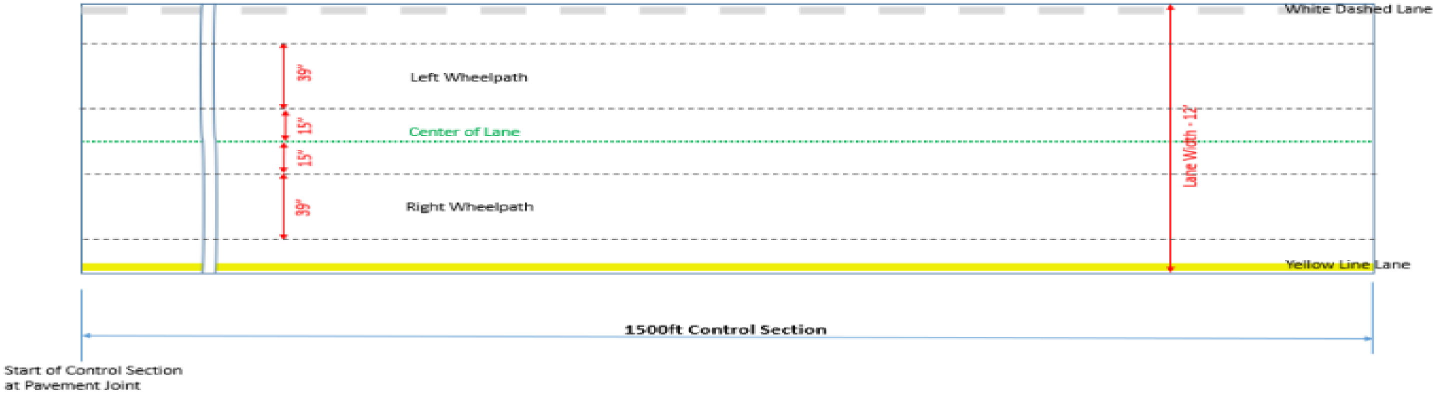

Figure 1-2 CTDOT Photolog Vehicle (One of Two Vehicles Currently Utilized)

Site Requirements

Number of Sites	Length	HPMS Condition	HPMS %Crack	ALL_Total Cracking per image [ft/10 lane-m]	WP_Total Cracking per image [%area/10 lane-m]	NWP_Total Cracking per image [ft/10 lane-m]
1	0.5 mile	Fair	10%-15%	50-70	30-45	15-25

Survey Procedures and Equipment

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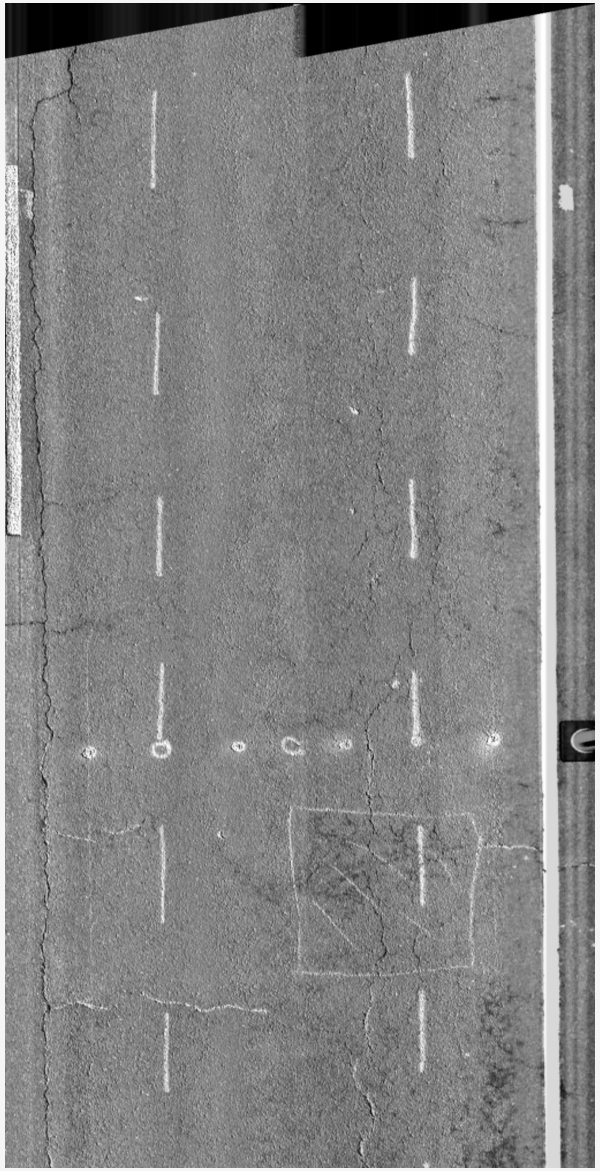
CT 450 /Validation Site 2025
same layout used for route 85 NB

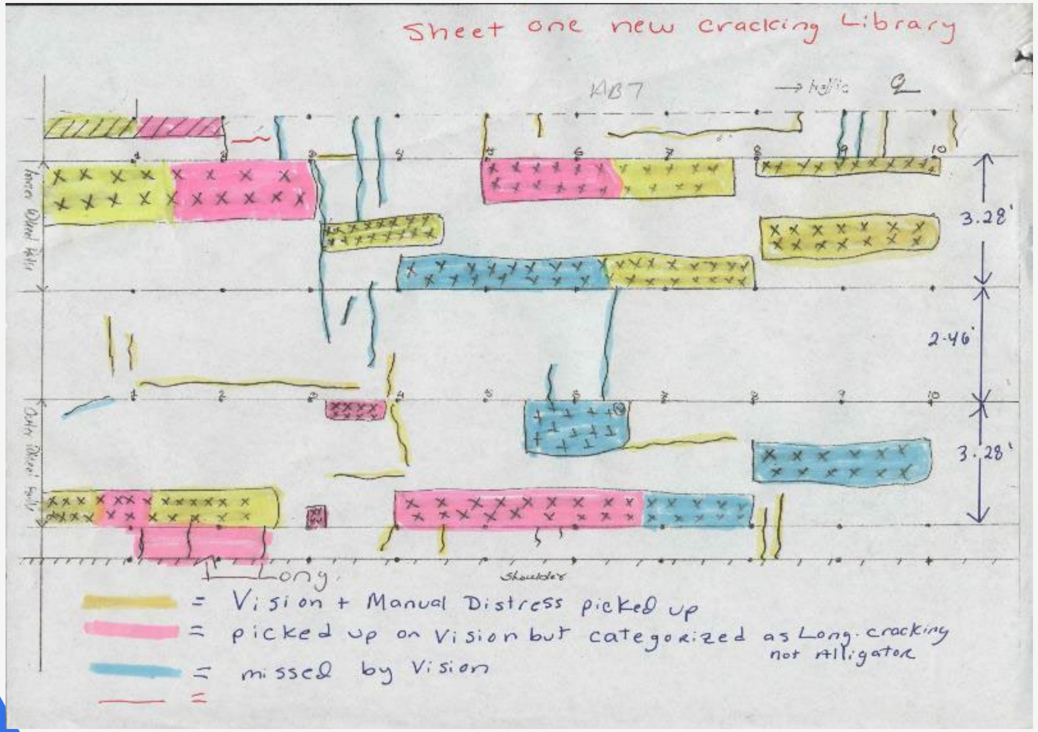
Front image of manual distress (in chalk)
Section 150’ to 175’

Downward pavement image of manual distress 150’ to 175”

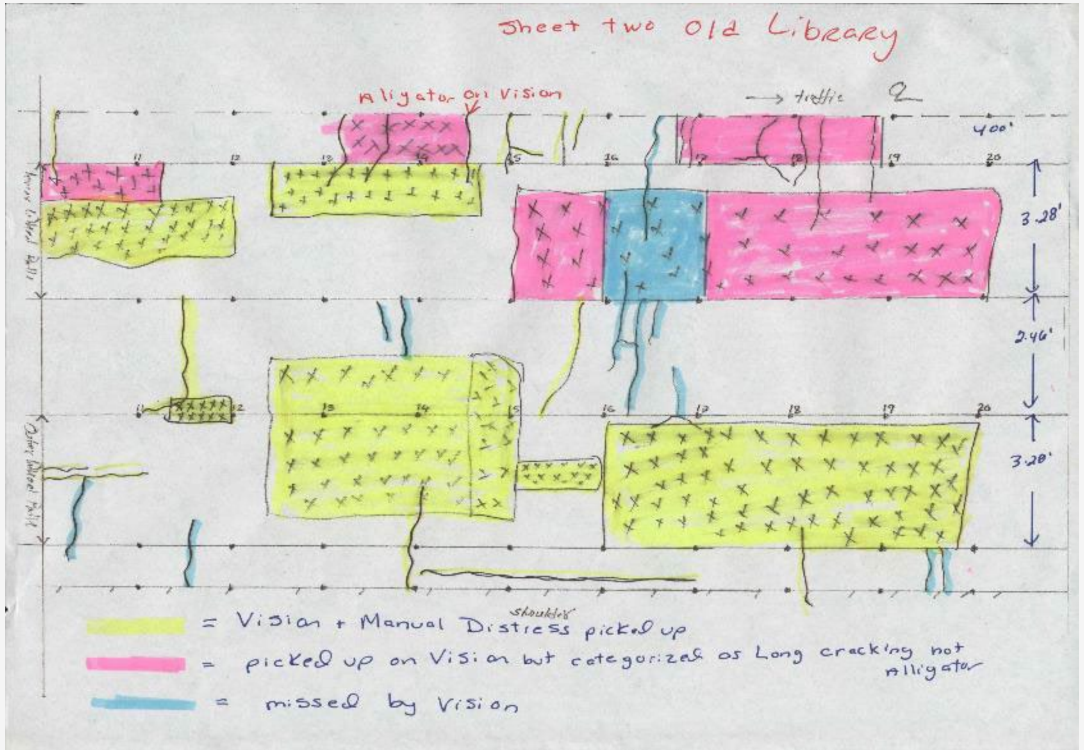


Manually rate distress on engineering sheets 200′ section

Sheet 1 old crack library in Vision



Sheet 2 old crack library in Vision



Results of detection observed in Vision using the crack maps

Yellow =represents section was identified in Vision and Manually

Pink =represents picked in Vision but categorized as Longitudinal crack instead of Alligator

Blue = missed by Vision but picked up on the field

Proposed validation at control site for automated crack detection

Data Quality assessment steps:

- ❑ Manual drawings composed on engineering worksheets in the field
- ❑ Had to use colored chalk instead of paint (safety unit-use chalk only)
- ❑ Compare automated detection to manual drawn crack maps
- ❑ Accuracy of automated crack detection done in Vision software utilizing the Pavement Tool option

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Challenges and improvements to manual drawn crack maps in field

- ❑ Tried to do 100’ sections on paper had to change to 25’ sections
- ❑ Not enough room to locate all distress types in the road zones
- ❑ The first day we started to map out all cracks and then later the rain erased most cracks had to redo
- ❑ Ran out of same colored chalk (have plenty of supplies on hand)
- ❑ Need wheel paths painted with LE, RE and center lanes marked –made it difficult to transcribe to engineering sheets
- ❑ Used only two raters for drawing the masterpiece-we did both agree to crack types and locations
- ❑ All Starts and end point were clearly marked with paint-easy to see in Vison
- ❑ Arrive at site after CDDOT surveyors are completed with layout
- ❑ Purchase a 130’ Giant chalk line reel for marking out cracking area

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2023 Quality Acceptance Procedures for automated crack distress

First step to run LCMS 3D files through the Global Processor data extraction procedure

- Data sample review post processed data
- We use a semi-automated image-based method within Vision software
- Vison software processes all pavement condition data utilizing a global processor
- This QA process includes crack maps (see figure 1)
- Image extraction provides 4 types of Images for QA:
    1. 3D Image
    2. Intensity Image
    3. Range Image used t0 detect cracks (see Figure 1-2)
    4 . ROW front images

Pavement image quality clarity and focus
Is also reviewed in this step

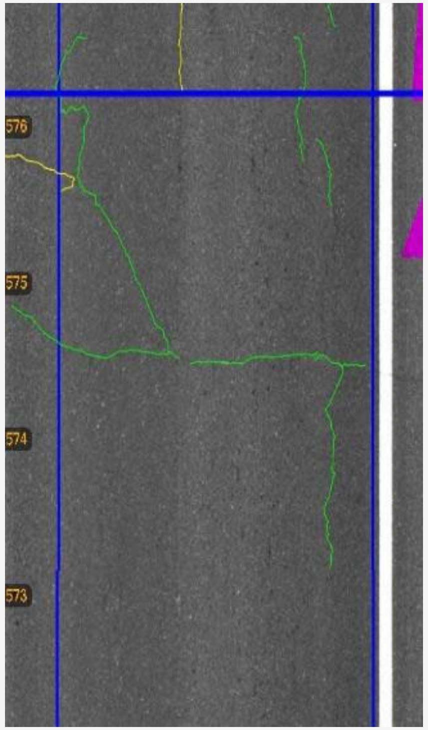

Figure 1-1 Vision Crack Map used for quality acceptance checks.

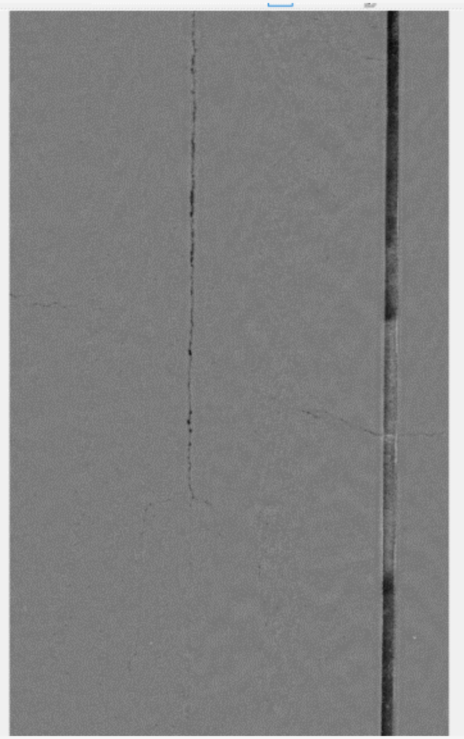

Figure 1-2 Image of range (crack detection image)

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2023 Quality Acceptance Procedures for automated crack distress

Second step run Global Processor extraction to get detailed crack properties

1. Crack detection: detect all cracks in segment view3D Image

2. Classification: groups cracks into groups-longitudinal, transverse or alligator cracks

3. Rating: assigns cracks to distress groups, severity high, to moderate or low

4 . Automated lane detection: lane will default to 11.5 ft if there is no lane markings

(See figure 1-3 crack properties within image)

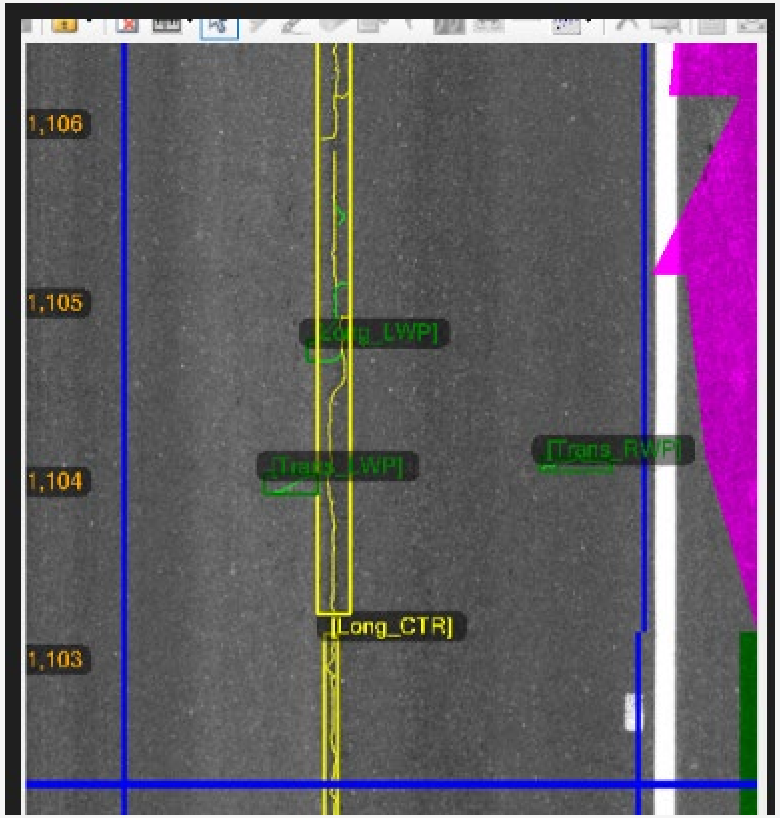

Figure 1-13 Crack properties detected within pavement image-lane markers in blue)

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2023 Image based QA procedure methods using Vision

Third step -verify crack position detection (road zone assignment of cracks)

Location of cracks are tracked in meters in pavement image. Crack number is also identified on each individual crack
(detection and classification)

1. Road zones
2. Crack ID which is crack number
3. Crack categories Longitudinal, Transverse and Alligator
4. Show crack type Long CTR and Alligator LWP etc.

(See figure 1-5 crack map with crack number and location)

Figure 1-5 Crack map with crack number

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2023 Quality Acceptance Procedures for automated crack distress

Fourth step -you need to toggle/click on all distress cracking to view all the cracking features.

This step allows you to see all the crack types within the image-and you can see if the allocation /assignment of crack type is correct.

(see figure 1-6 all crack detection and rating details in pavement module)

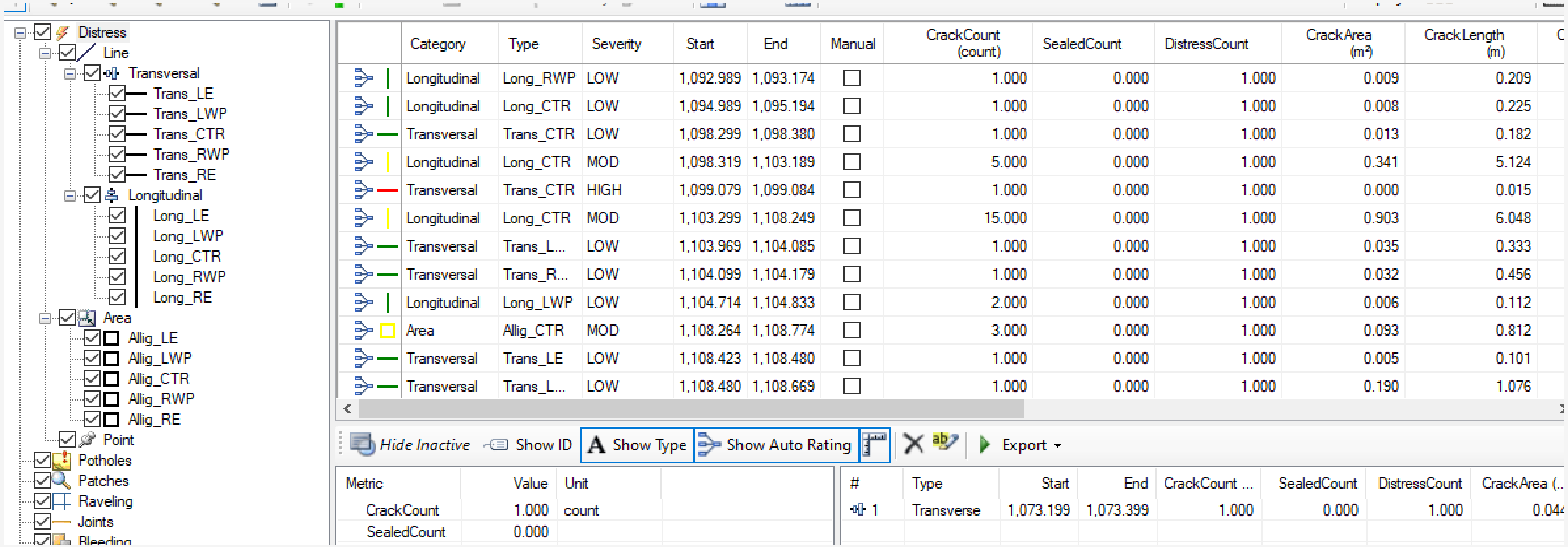

Figure 1-6 Crack details and rating in distress schema

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2023 Quality Acceptance Procedures for automated crack distress

Fifth step –log results into QA Excel Worksheet to track random sample sections with crack results.

- ❑ Excel Worksheet is used to track random samples crack detection results. (see figure 1-7 QA Excel Worksheet)

- ❑ Record percentages of all detection (viewed with the image) within the image. Comments row describes any issues and possible corrections.

- ❑ Meters column is location of data checks in meters within the road segment .

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2023 Quality Acceptance Procedures for automated crack distress

A	B	C	D	E
QC 2023 Route 85, 71, 120 Processed data cracking classification and detection				
372	3203	Transverse cracking	100 % of al crack detected	100% detected
372	3203	Alligator cracking		100% detected
372	3213	Long cracking		100% detected
372	3213	Transverse cracking	100 % of al crack detected	100% detected
372	3213	Alligator cracking		100% detected
372	3223	Long cracking		70% missed classified as Alligator
372	3223	Transverse cracking	issues with the classification	60% missed classified as Alligator
372	3223	Alligator cracking		getting 80% more than it should wrong classification
372	3233	Long cracking		missing 20% being classified as Alligator
372	3233	Transverse cracking	98% of all cracks detected	60% missed classified as Alligator
372	3233	Alligator cracking		classifying trans as alligator (look at fine tuning the Alligator setting)
372	3243	Long cracking		missing 50% of long classifying as Alligator
372	3243	Transverse cracking	99% of cracks detected	missing 50% of transverse classifying as Alligator
372	3243	Alligator cracking		getting 80% more than it should wrong classification (RWP over classify)
372	3253	Long cracking		missing 40% of long classifying as Alligator
372	3253	Transverse cracking	98% of all cracks detected	60% missed classified as Alligator
372	3253	Alligator cracking		getting 80% more than it should wrong classification (RWP, LWP and center over classify)
372	3263	Long cracking		getting 80% more than it should wrong classification
372	3263	Transverse cracking	98% of all cracks detected	missing 50% of transverse classifying as Alligator
372	3263	Alligator cracking		getting 60% more than it should wrong classification (RWP, LWP and center over classify)
372	3273	Long cracking		missing 40% of long classifying as Alligator
372	3273	Transverse cracking	100 % of al crack detected	missing 50% of transverse classifying as Alligator
372	3273	Alligator cracking		getting 60% more than it should wrong classification (RWP

Figure 1-7 Excel Worksheet

2023 QA Conclusion for Crack Detection Results

Conclusion of crack detection results:

- Crack detection, classification and rating detecting was achieving 80% to 90% of all cracks.
- Some of the Alligator detection is off, in some sections it was incorrectly categorizing transverse and longitudinal crack as Alligator.
- There were some focus issues with the right pavement LCMS camera as a result some cracks weren't being detected along the right side of the pavement image. (see figure 1-7 of focus issue)

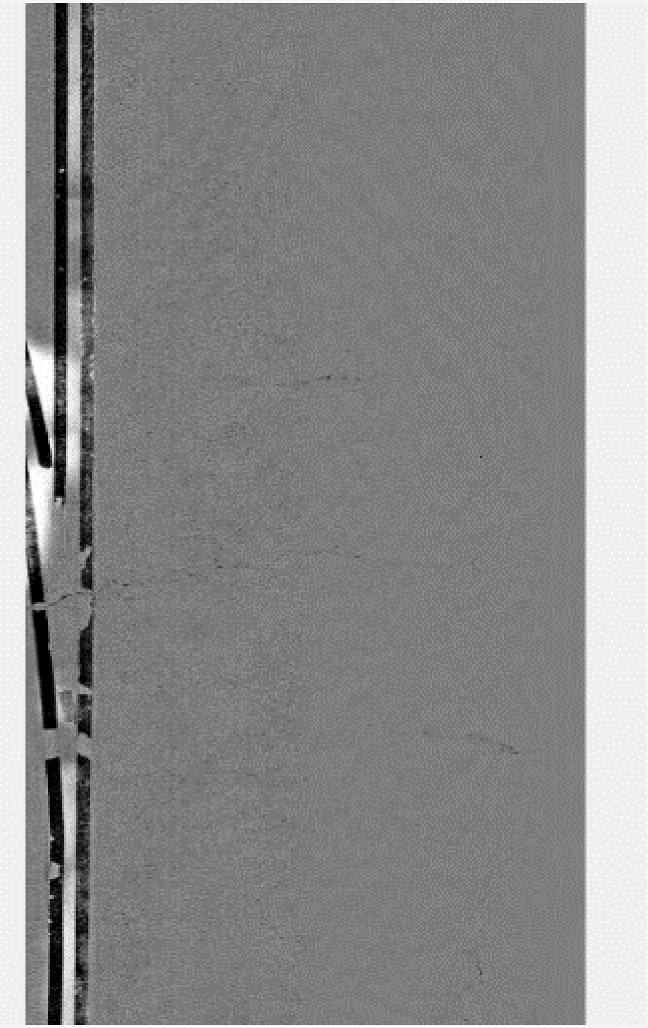

Figure 1-7 route 114 right side camera out of focus-range image

Improvements to Imaged Based QA Procedure

- ❑ Camera focus issue could be regulated by adhering to NCHRP -01-60 （Measuring the Characteristics of Pavement Surface Images and Developing Standard Practices for, and Verification of Imaging Systems Calibration, Certification.). This step could be part of our yearly calibration/maintenance of the vans done in early Spring
- ❑ Alligator crack detection parameters should be fined tuned with the help of Fugro and Pavemetrics
- ❑ Improve QA process by checking the width measurements if we have the time and resources.
- ❑ Ability in Vision to draw cracks manually in crack map vendor had a hard time getting this option to work

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Wish list for CTDOT

- One stop shop for all pavement condition data calibration/verification site for the Northeast Region

- Find a control site in Connecticut that meets all criteria for calibration and verification. Currently we have one site but really need two to meet all criteria. Rut and cross slope need a separate control site

- More Peer Exchanges for updates on State DOT DQMP practices

Successes and looking forward

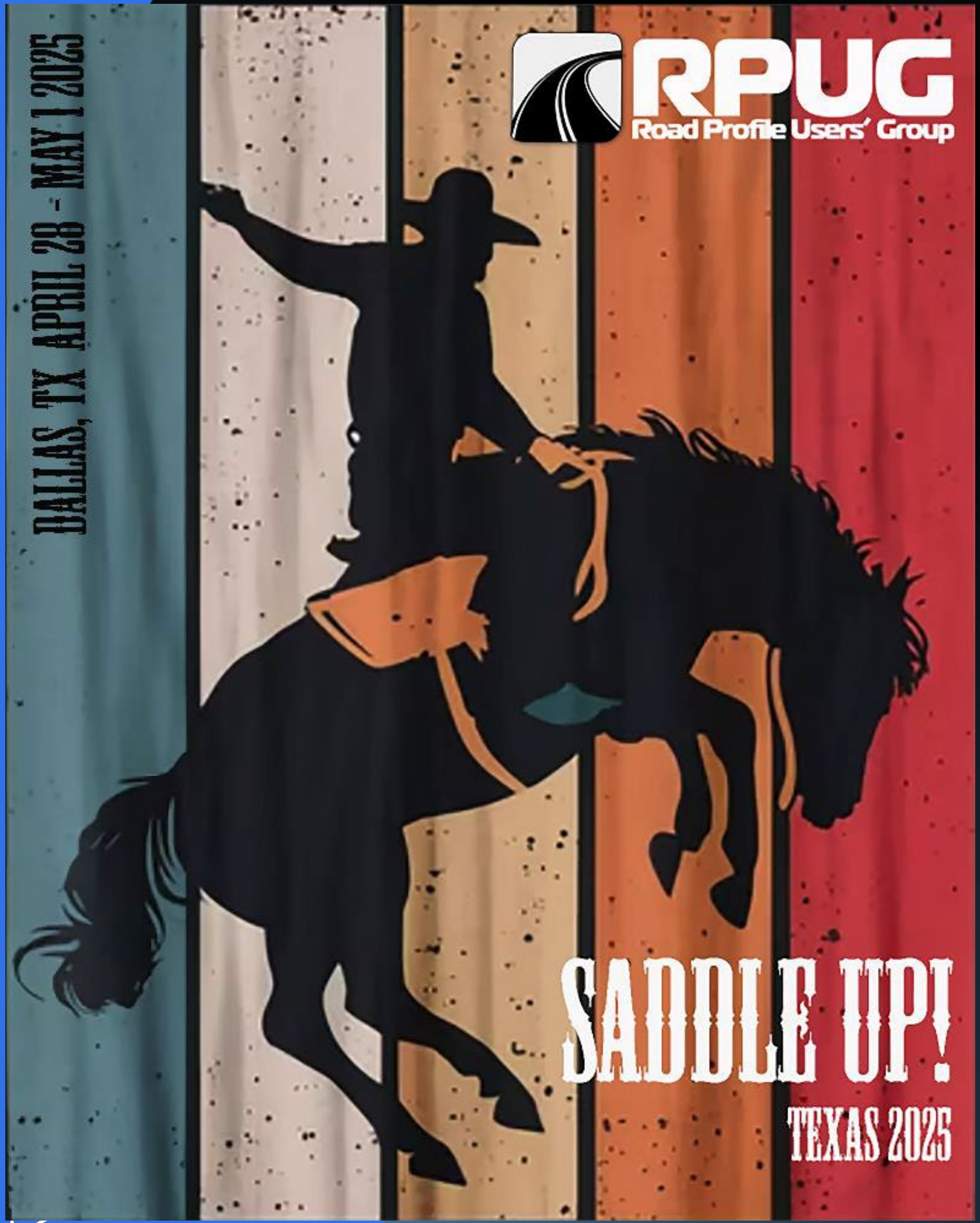
- New RFP for High-Speed Data Collection to be out this year 2025
- Need to keep up with Data Collection Changes (Laser and sensors)
- More Focus on Quality Assurance Data Collection
- New strip maps for Pavement Activity back to 2018-great tool to track pavement history
- Steps to improve Pavement Activity especially Construction Projects-hard to track
- NCHRP Project 01-57B: Validating Standard Definitions for Comparable Pavement Cracking Data
- Added a new full-time employee to our Unit

Acknowledgments

- Photolog Group – Control Site Layout and Coordination and Quality Control
- DOT District Maintenance provided protection of traffic on control sites
- UCONN CAPLAB assist with Control Site Validation and DQMP
- Pavement Design Group
- Pavement Management Staff

Thank You

Jeannine Moriarty
Connecticut Department of Transportation
Pavement Management Group



Thank You

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