



PRODUCT 0-6663-P3
TXDOT PROJECT NUMBER 0-6663

Automated Distress Surveys: Analysis of Network-Level Data

Research Supervisor:
Michael R. Murphy

March 2015; Published April 2017

<http://library.ctr.utexas.edu/ctr-publications/0-6663-P3.pdf>



AUTOMATED DISTRESS SURVEYS: ANALYSIS OF NETWORK LEVEL DATA (PHASE 3)

Pedro Serigos
Kuan-Yu Chen
Andre Smit
Mike Murphy
Jorge Prozzi

AGENDA

- Introduction
- Description of Pilot Study
- Findings
- Recommendations
- Discussion

INTRODUCTION

- **TxDOT Project 0-6663, Phase 1: Rutting**
 - Applus, Dynatest, Fugro, Pathway and TxDOT
 - Reference: detailed project level (24 550-ft sections)
- **Phase 2: Distresses**
 - Dynatest, Fugro, WayLink-OSU and TxDOT
 - Reference: detailed project level (20 550-ft sections)
- **Phase 3: Analysis of Network Level Data**
 - Fugro and Pathway
 - Reference: TxDOT PMIS (Bryan and Houston)

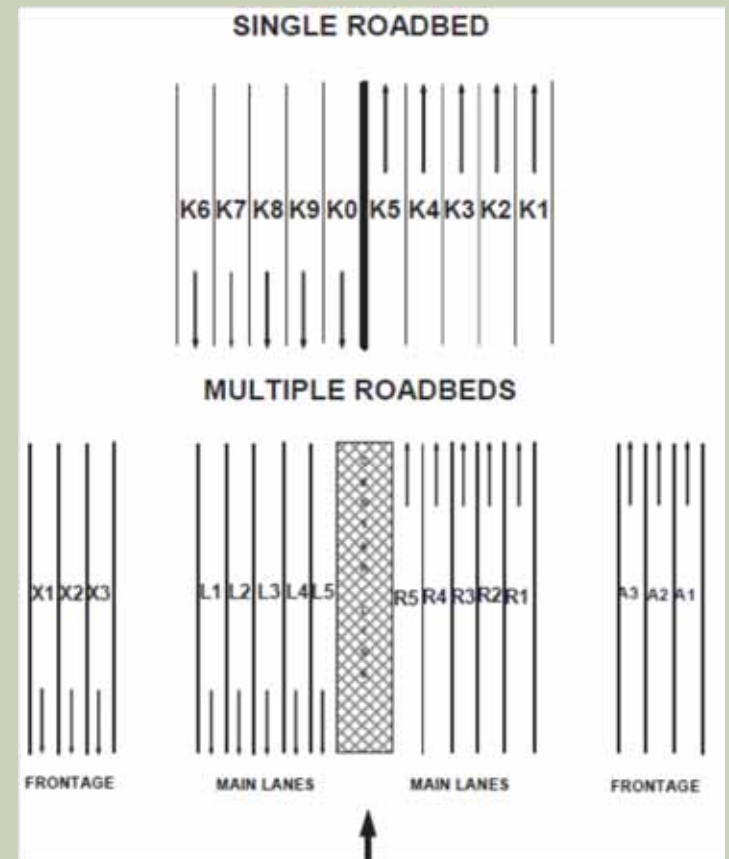
DESCRIPTION OF PILOT STUDY



Bryan (3,456.2 miles)

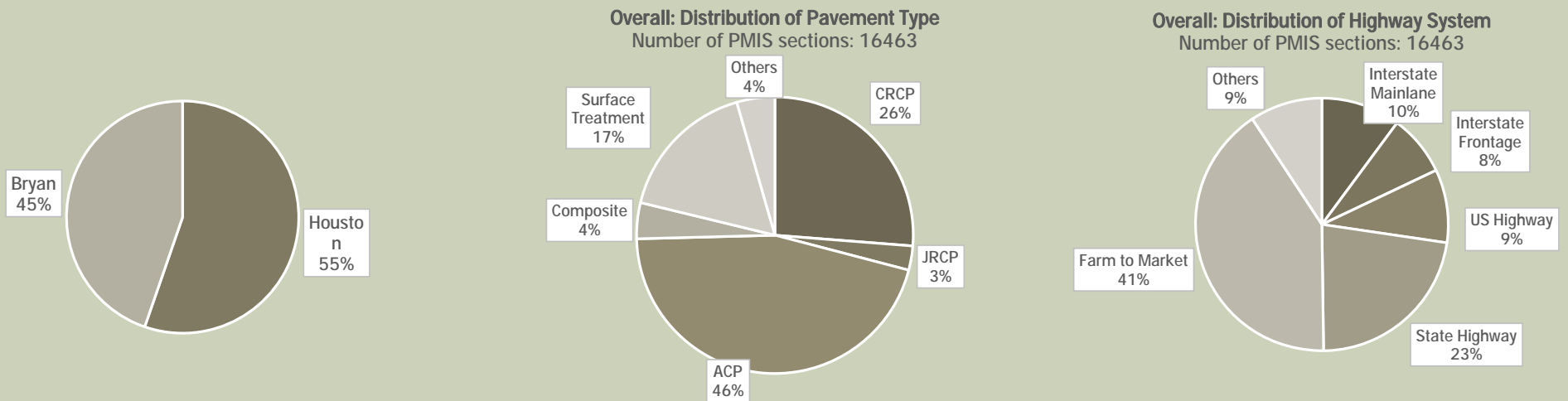


Houston (4,093.3 miles)



DESCRIPTION OF PILOT STUDY

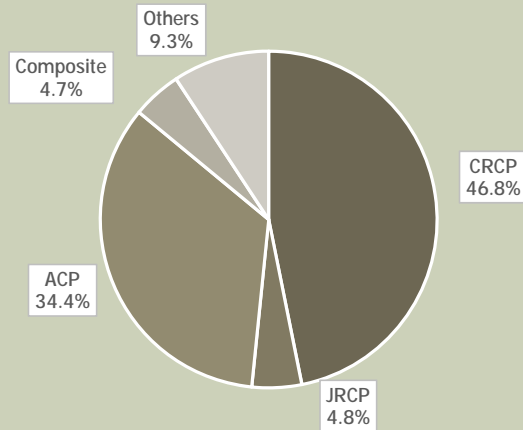
Overall Proportions of Pavement Type and Highway System



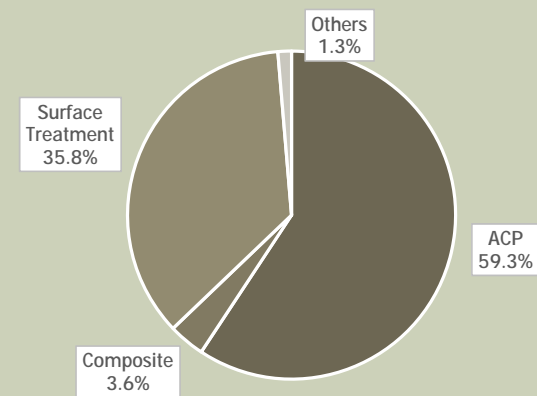
DESCRIPTION OF PILOT STUDY

■ Pavement types by District

Houston: Distribution of Pavement Type
Number of PMIS sections: 9102



Bryan: Distribution of Pavement Type
Number of PMIS sections: 7361

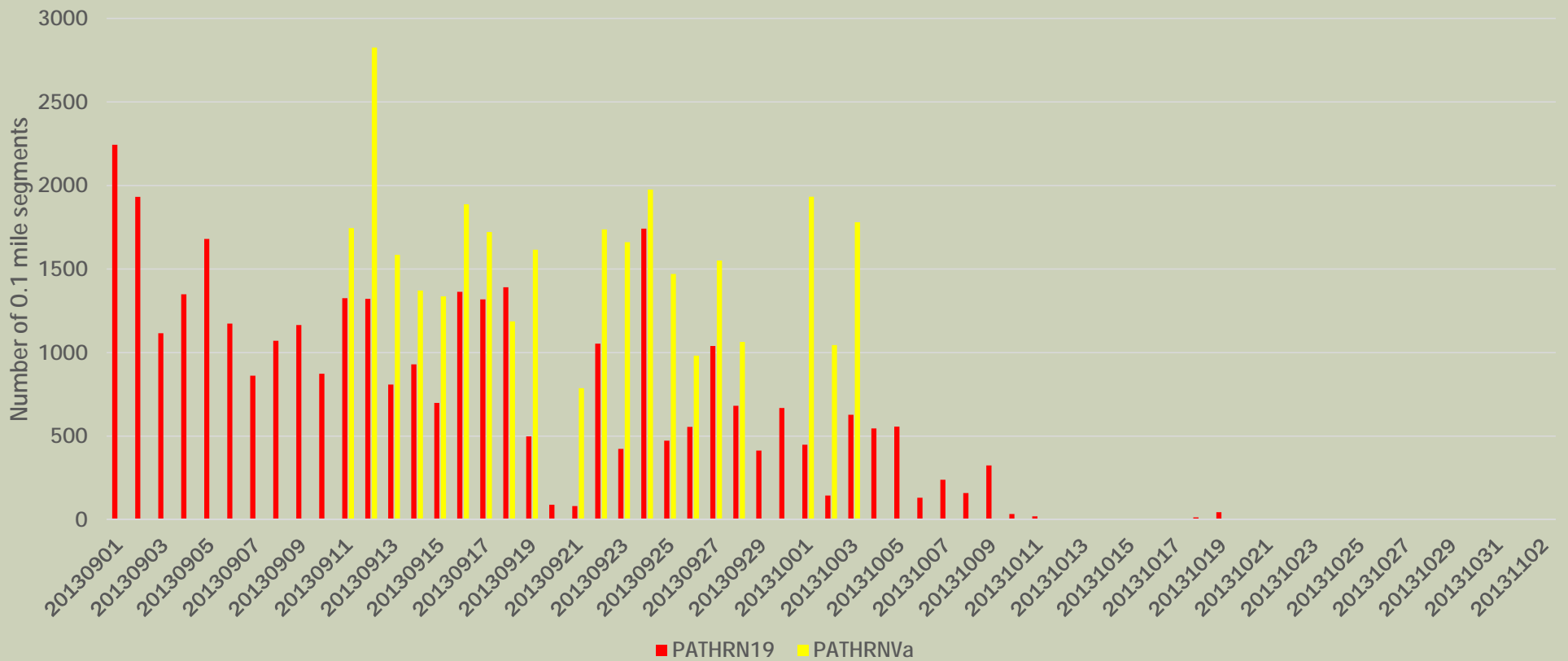


BACKGROUND

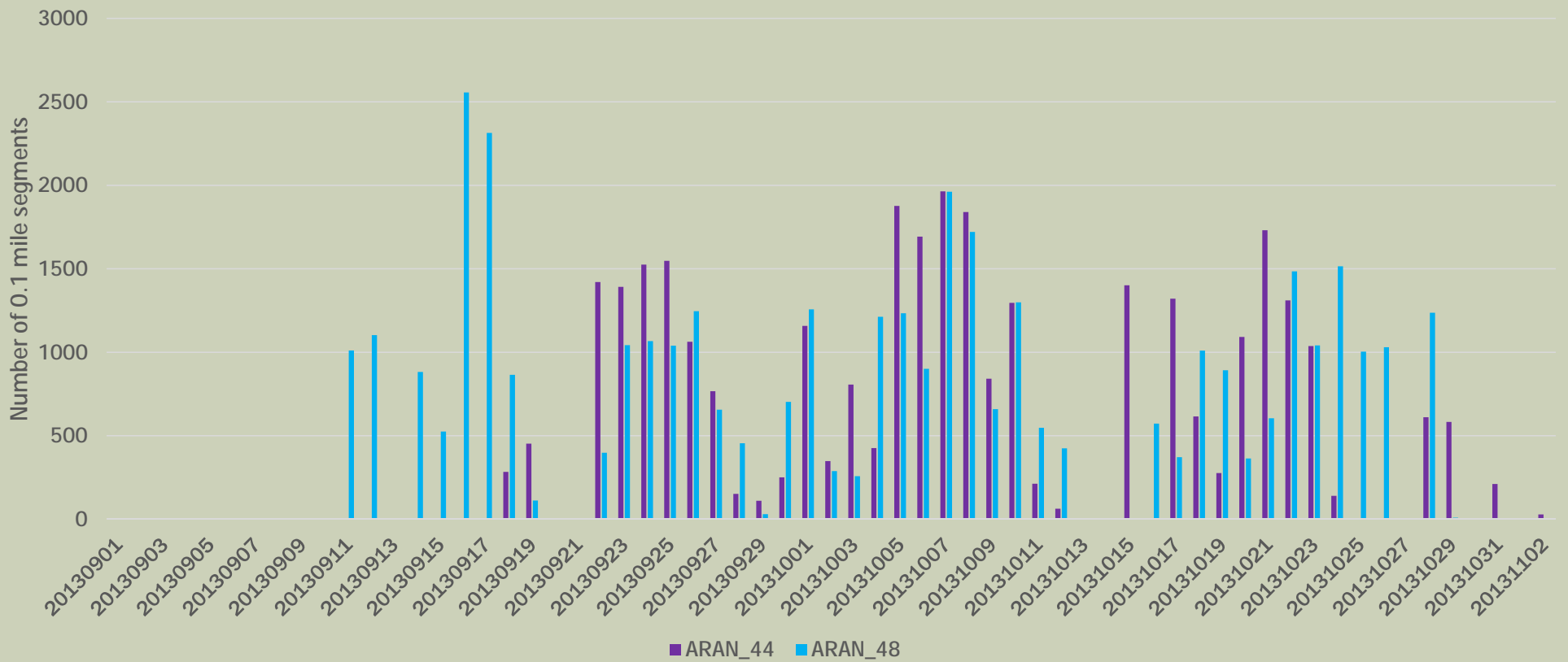
■ Phase 3: Analyzed Data

Dataset	Raw data		Processed data	
	miles	% of PMIS	sections	% of PMIS
PMIS	7,549.5	-	16,463	-
TxDOT	-	-	16,454	99.9%
Fugro	7,550.0	100.0%	15,338	93.2%
Pathway	7,326.1	97.0%	14,405	87.5%

PATHWAY – DATA COLLECTION DATES



FUGRO – DATA COLLECTION DATES



EQUIPMENT PRODUCTION

Production		Fugro		Pathway	
		ARAN_44	ARAN_48	PATHRN19	PATHRNVa
Houston		30%	72%	99.9%	0.0%
Bryan		70%	28%	0.1%	100.0%
Started		18-Sep	11-Sep	1-Sep	11-Sep
Ended		2-Nov	1-Nov	19-Oct	3-Oct
Time (%Active)	<i>days</i>	45 (80%)	51 (84%)	48 (90%)	22 (91%)
Total	<i>miles</i>	3185	3892	3365	3126
Min prod	<i>miles/day</i>	3	1	1	79
Avg prod	<i>miles/day</i>	88	91	78	156
Max prod	<i>miles/day</i>	196	256	224	283
Std prod	<i>miles/day</i>	61	57	57	45

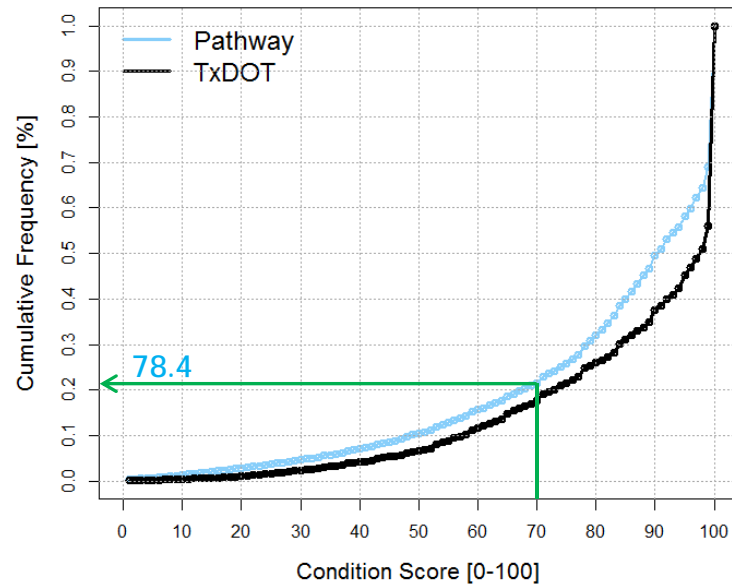
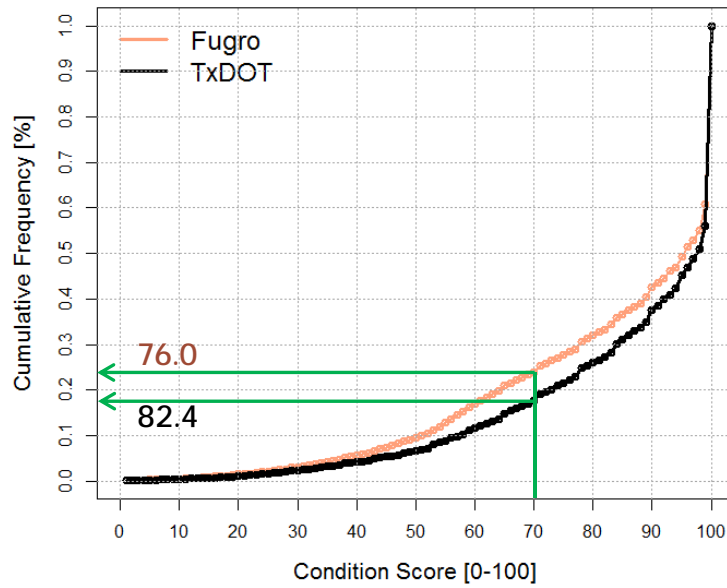
EQUIPMENT PRODUCTION

total roadbed miles in TxDOT Network				90,000.00	miles
positive		pilot study		conservative	
130	miles/day	90	miles/day	70	miles/day
692	days	1000	days	1286	days
122	days/van	122	days/van	122	days/van
0.9	%active	0.85	%active	0.8	%active
6.3	vans	9.6	vans	13.2	vans

**AGGREGATED SCORES:
CONDITION SCORE, RIDE SCORE,
DISTRESS SCORE**

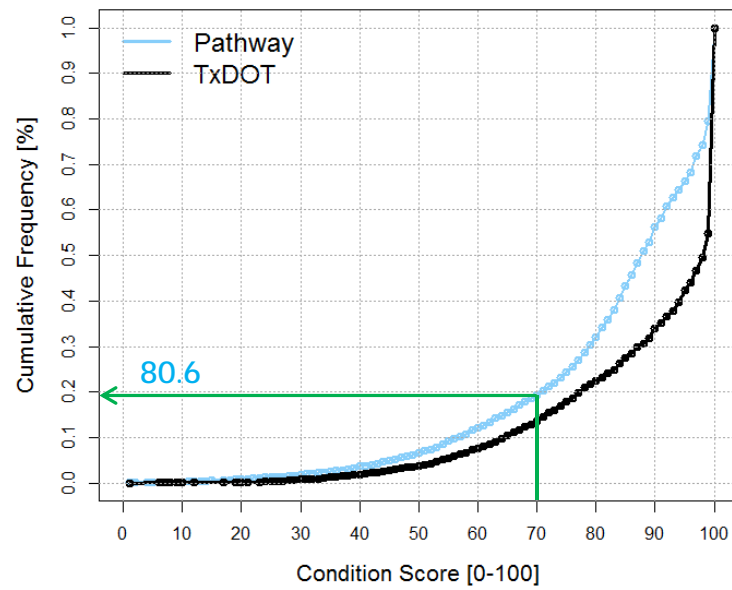
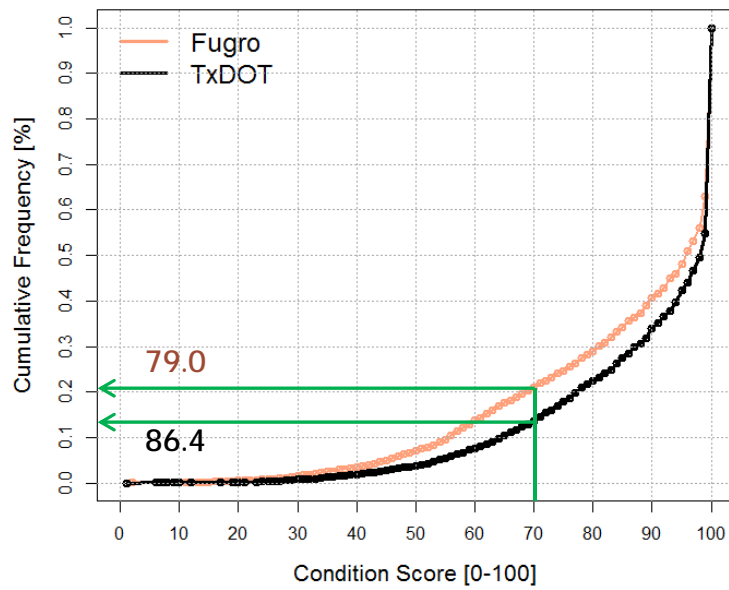
CONDITION SCORE (CS)

Condition Score - Houston and Bryan Districts



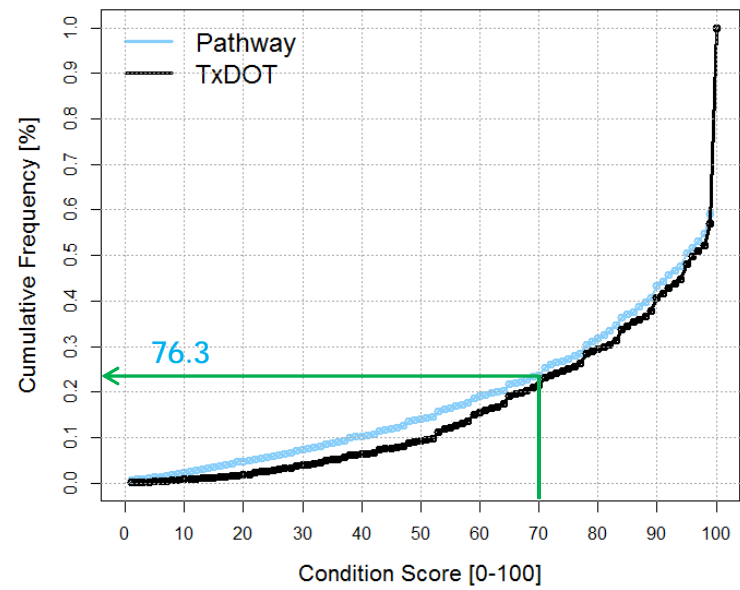
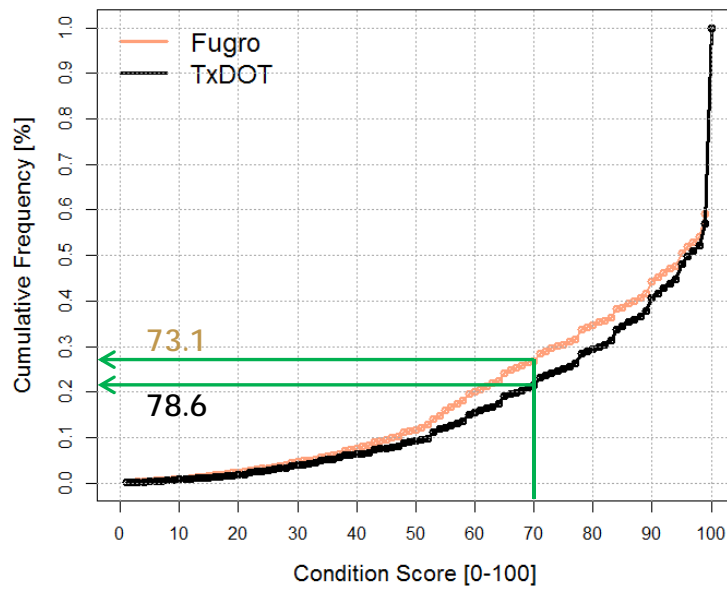
CONDITION SCORE (CS)

Condition Score - Bryan District



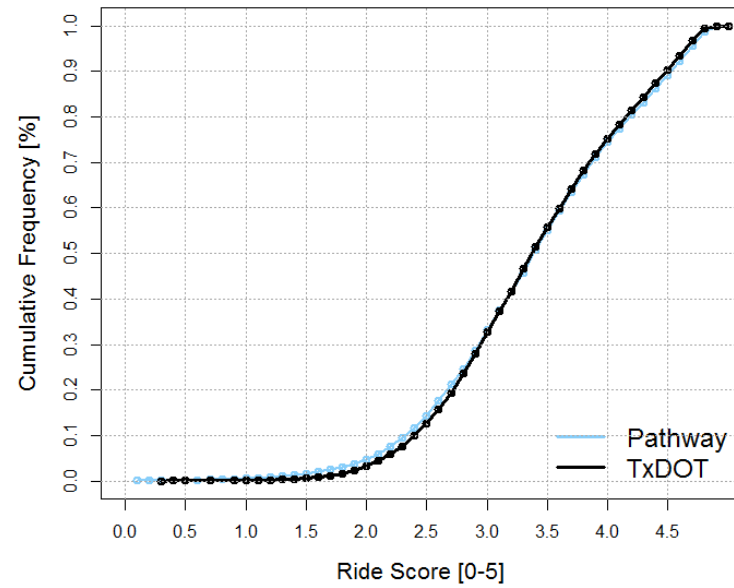
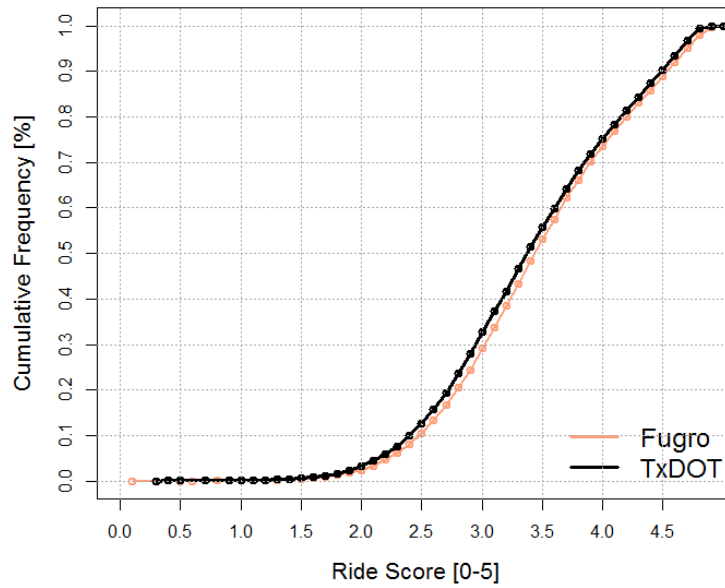
CONDITION SCORE (CS)

Condition Score - Houston District



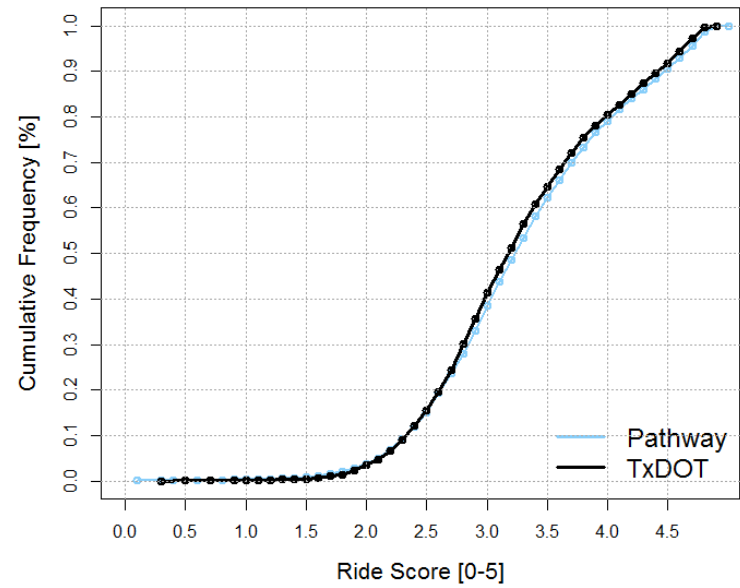
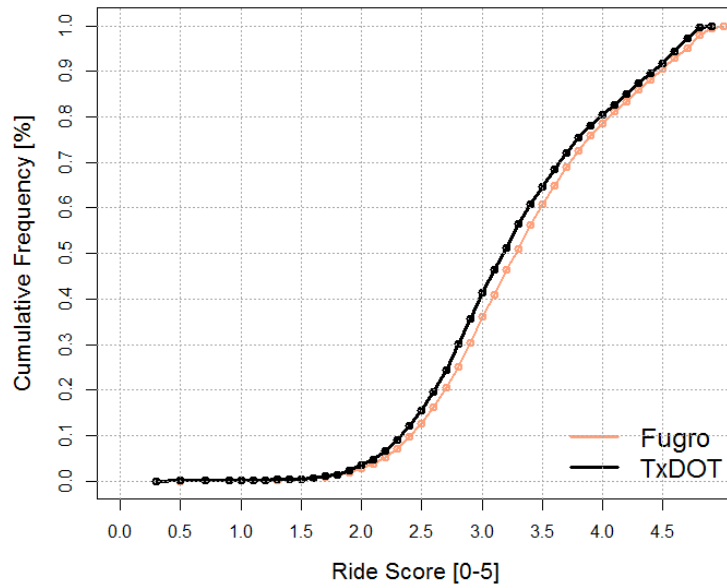
RIDE SCORE (RS)

Ride Score - Houston and Bryan Districts



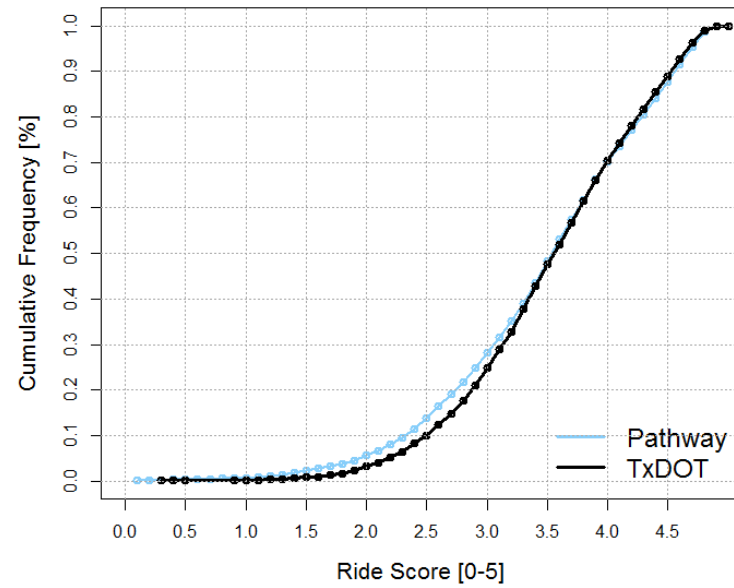
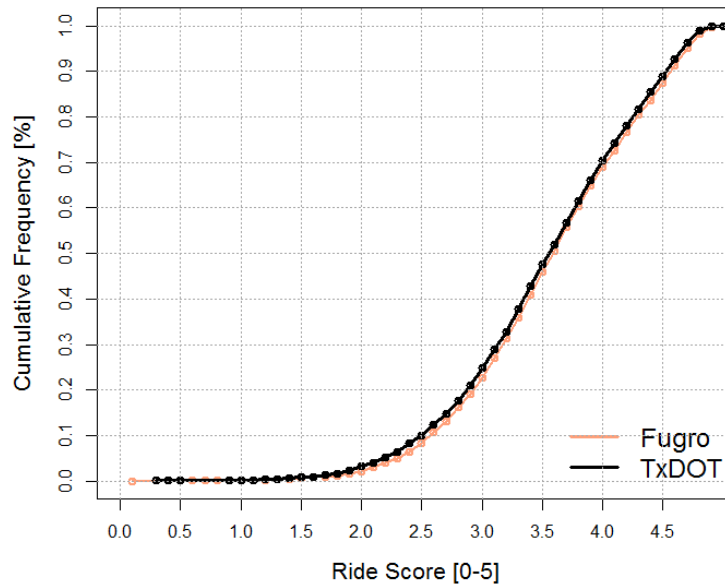
RIDE SCORE (RS)

Ride Score - Bryan District



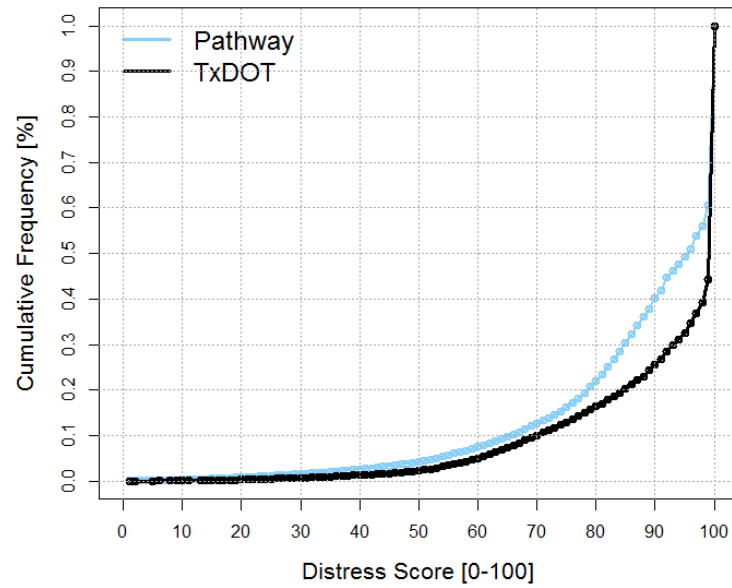
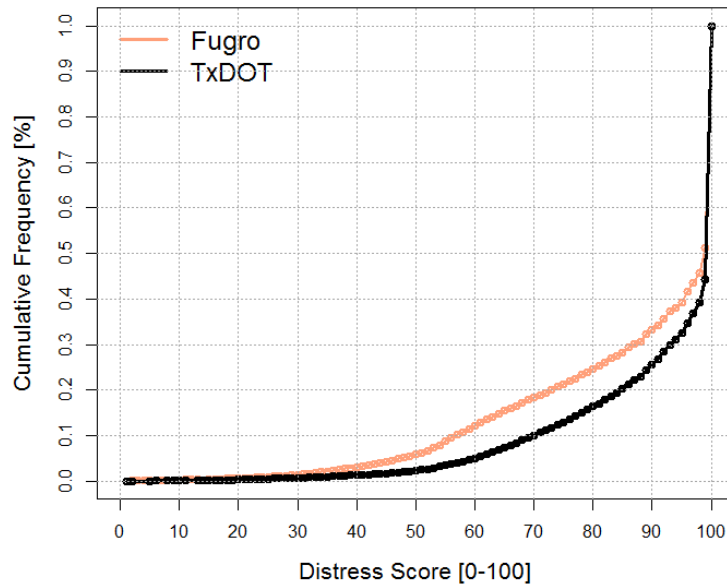
RIDE SCORE (RS)

Ride Score - Houston District



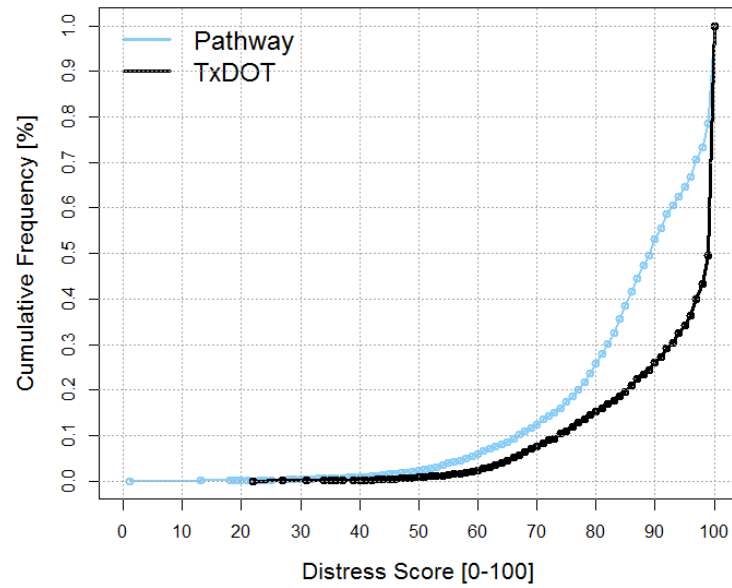
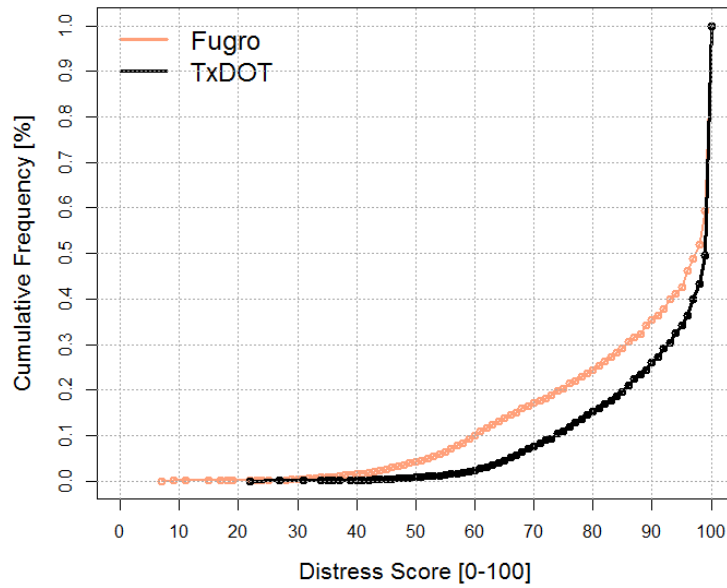
DISTRESS SCORE (DS)

Distress Score - Houston and Bryan Districts



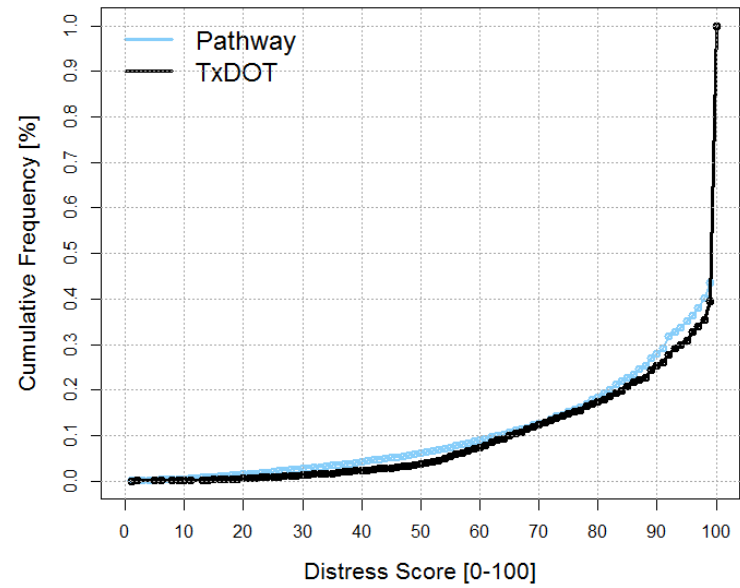
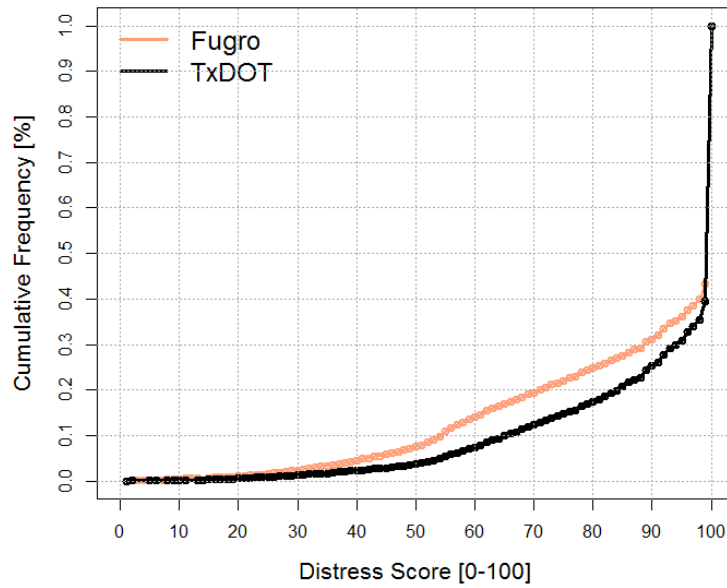
DISTRESS SCORE (DS)

Distress Score - Bryan District



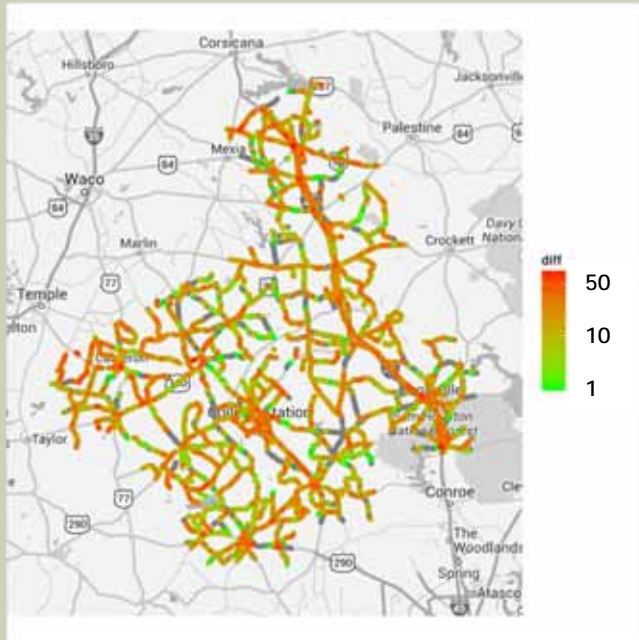
DISTRESS SCORE (DS)

Distress Score - Houston District

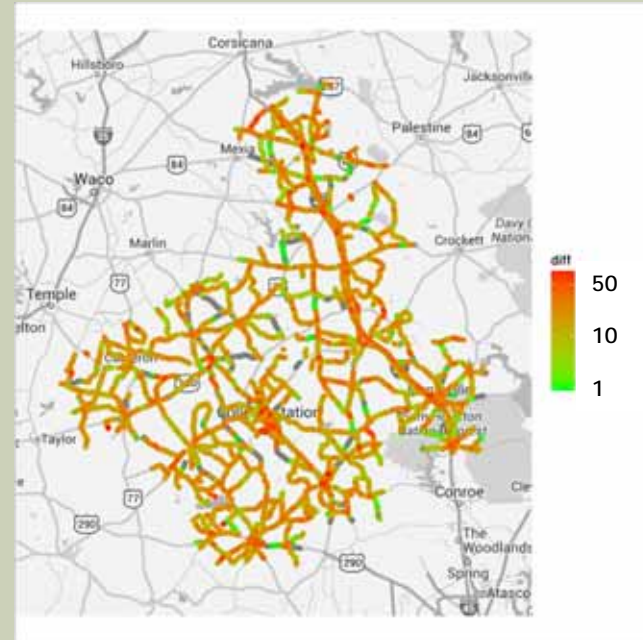


DIFFERENCE IN CONDITION SCORE - BRYAN

Fugro vs. TxDOT

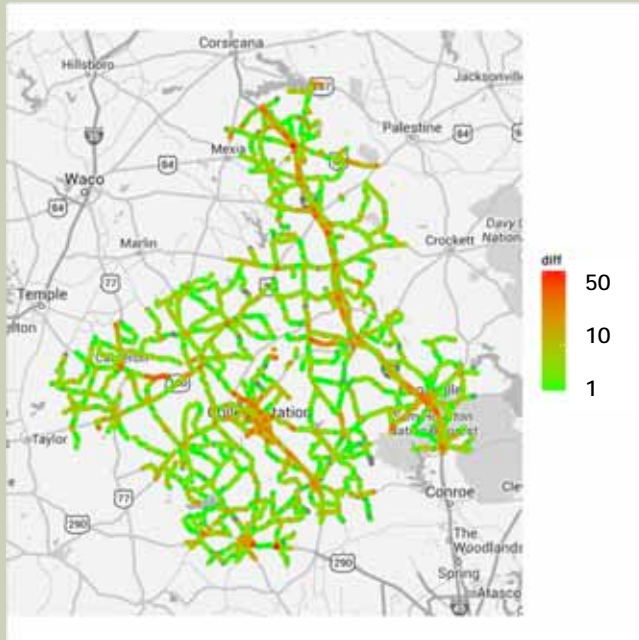


Pathway vs. TxDOT

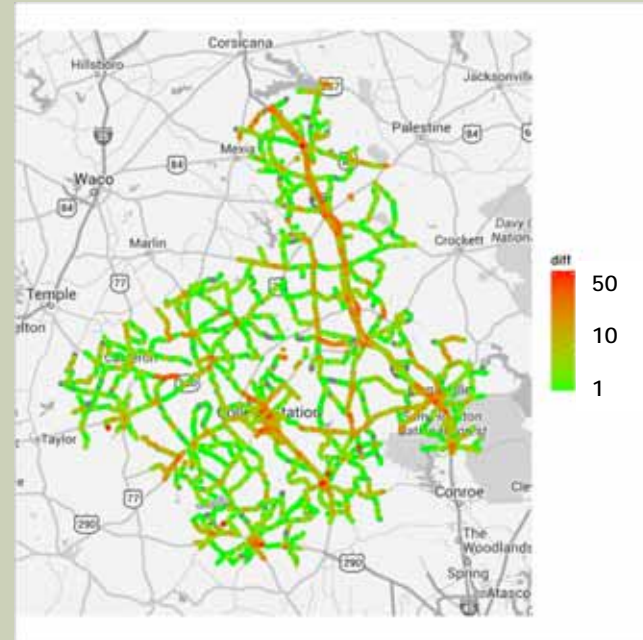


DIFFERENCE IN RIDE SCORE - BRYAN

Fugro vs. TxDOT

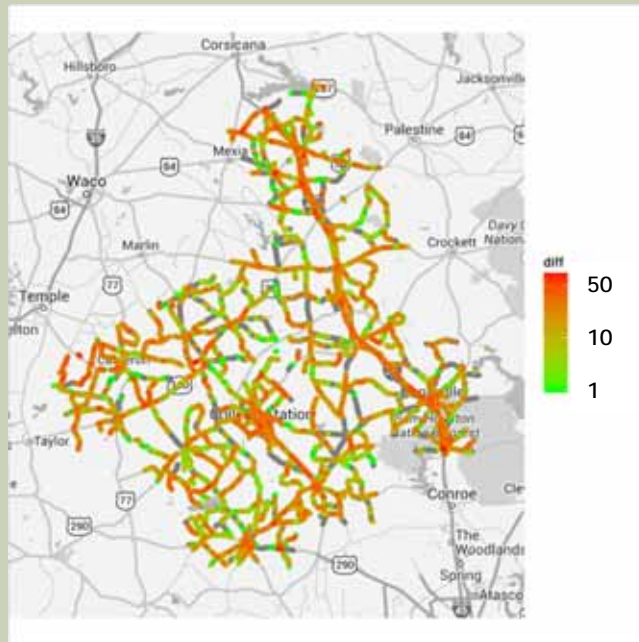


Pathway vs. TxDOT

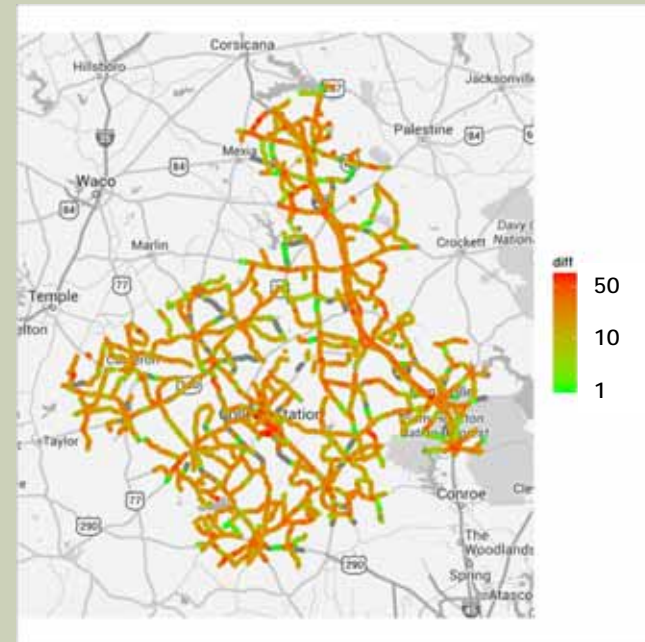


DIFFERENCE IN DISTRESS SCORE - BRYAN

Fugro vs. TxDOT

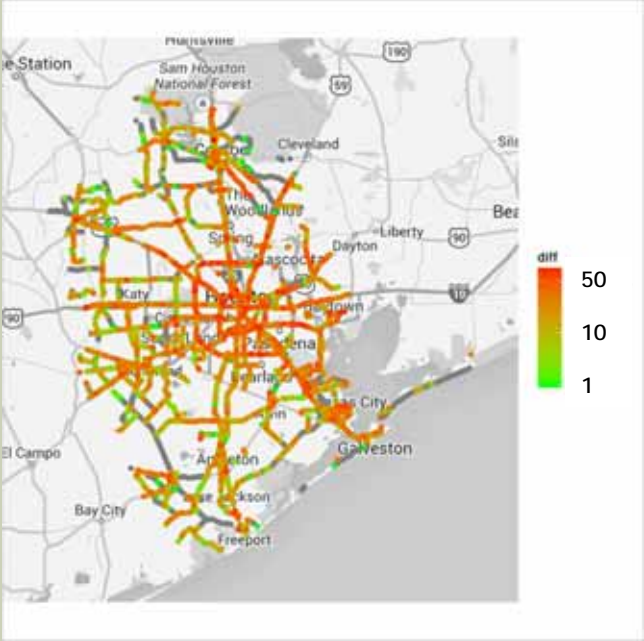


Pathway vs. TxDOT

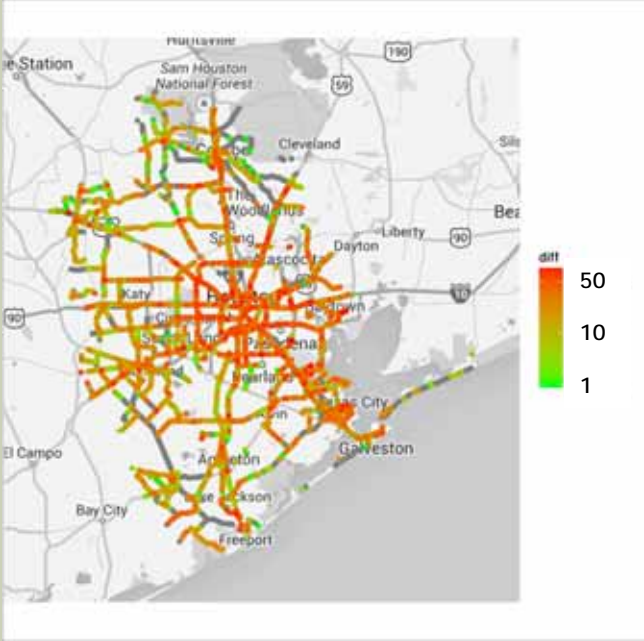


DIFFERENCE IN CONDITION SCORE - HOUSTON

Fugro vs. TxDOT

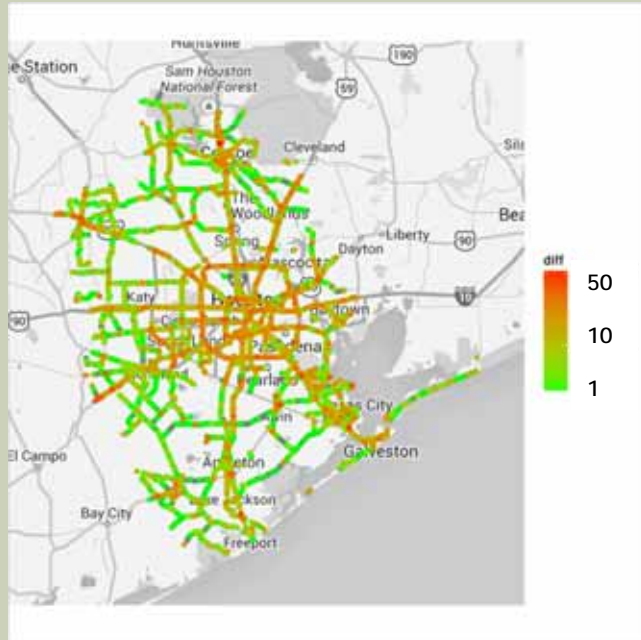


Pathway vs. TxDOT

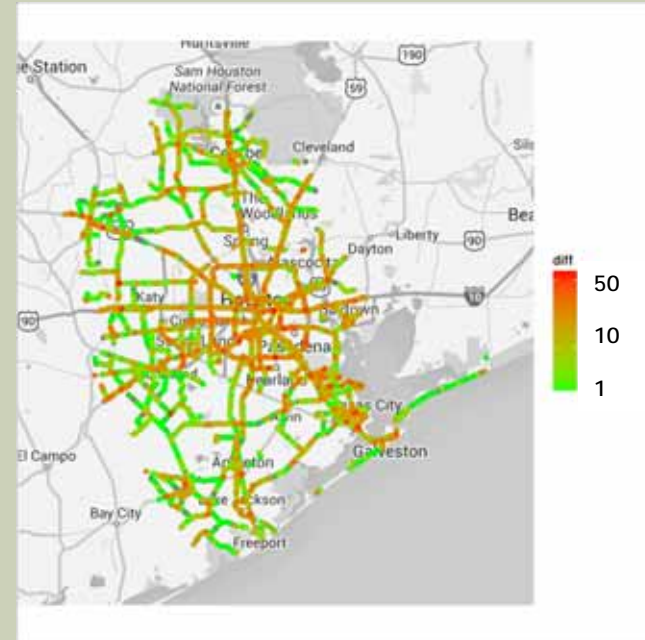


DIFFERENCE IN RIDE SCORE - HOUSTON

Fugro vs. TxDOT

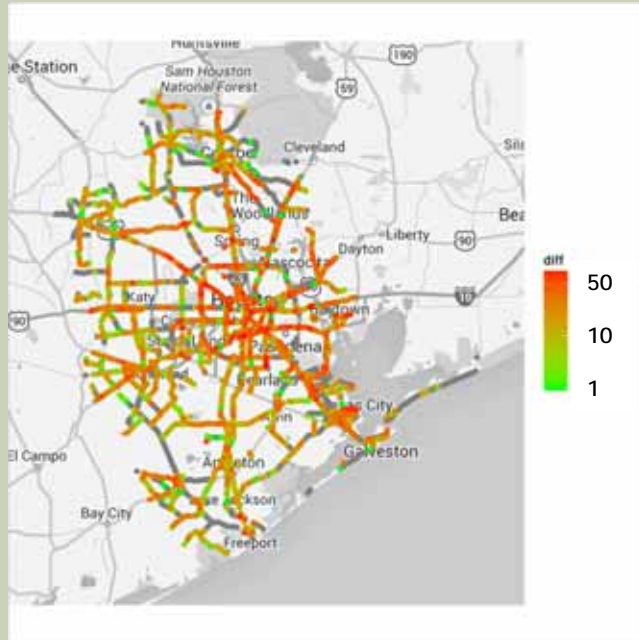


Pathway vs. TxDOT

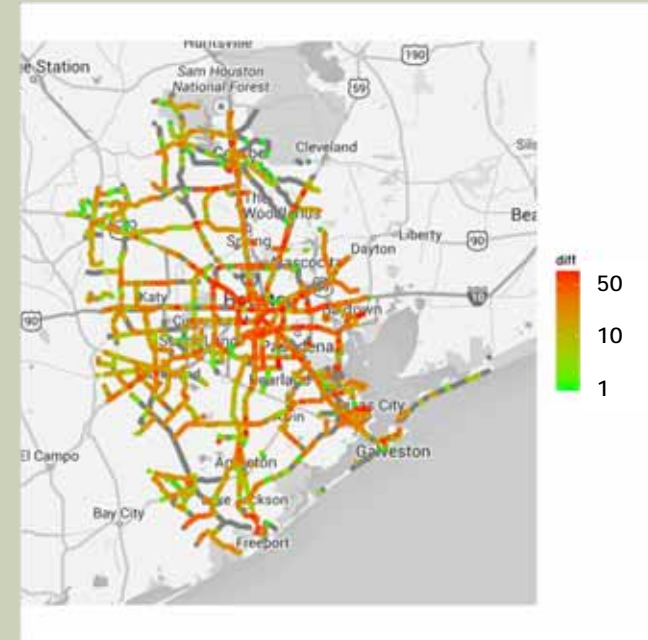


DIFFERENCE IN DISTRESS SCORE - HOUSTON

Fugro vs. TxDOT



Pathway vs. TxDOT



MAIN LANES VS. FRONTAGE (IH-10)



MAIN LANES VS. FRONTAGE (IH-45)



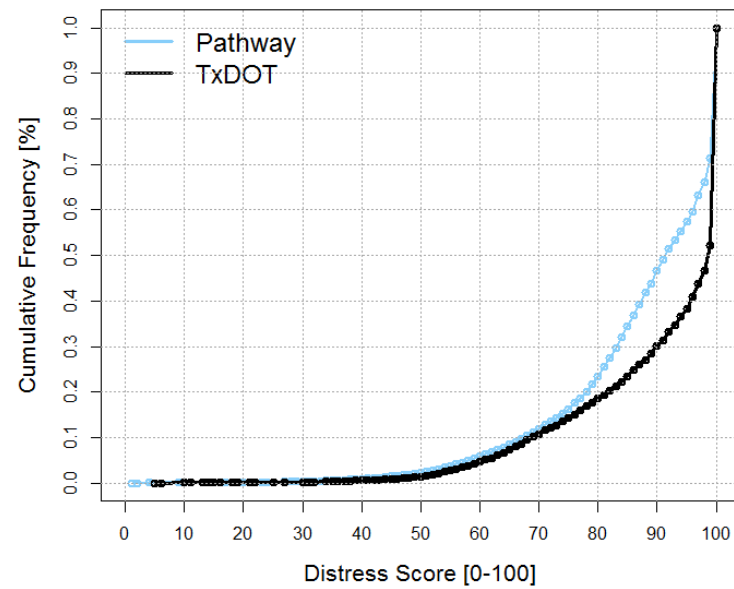
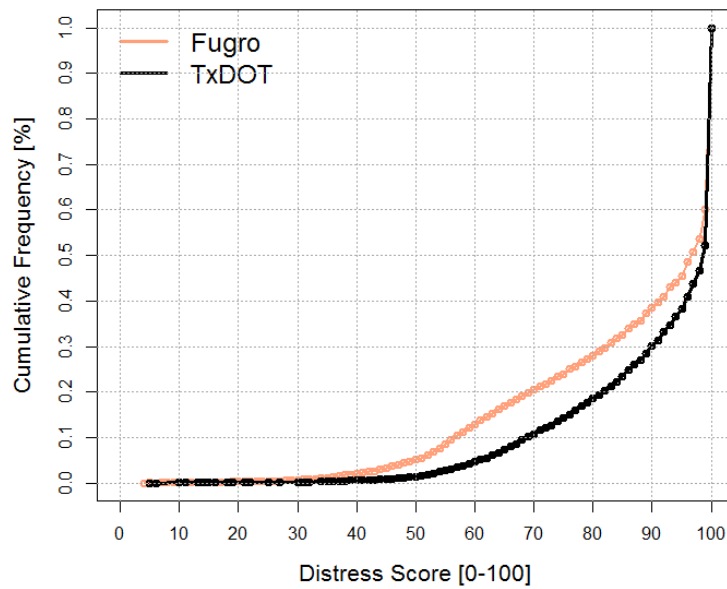
MAIN OBSERVATIONS (SCORES)

- Both vendors reported lower Condition Scores than TxDOT PMIS.
- Differences are not consistent and vary with District.
- Differences in CS are mainly due to differences in Distress Scores.
 - Differences in DS between Pathway and TxDOT were more significant in Bryan.
- Very good agreement in terms of Ride Scores.
 - Larger differences for RS were observed along main corridors on frontage roads.
- Differences are larger when more distress is present.

**AGGREGATE SCORES:
DISTRESS SCORE BY PAVEMENT
TYPE**

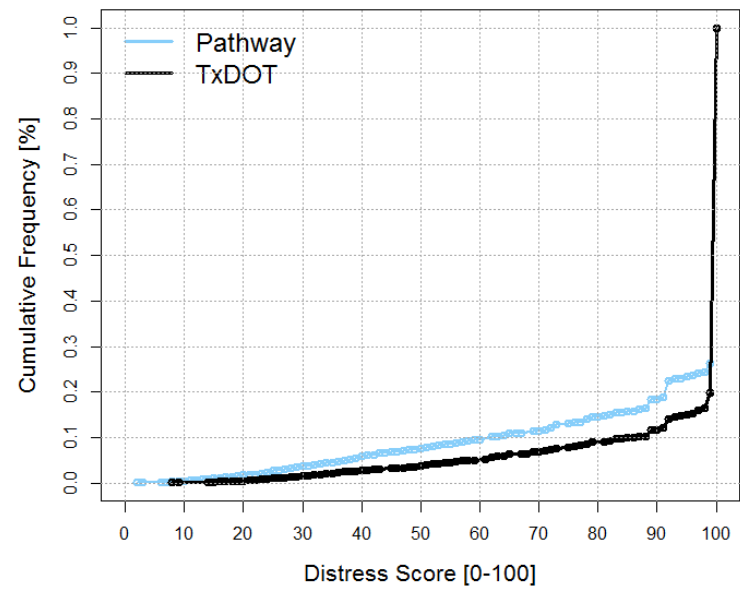
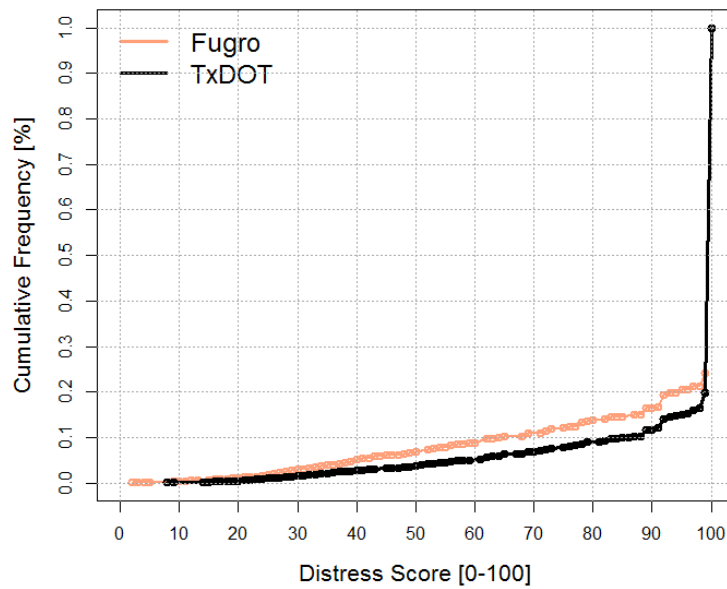
ACP BRYAN AND HOUSTON

Distress Score - Houston and Bryan Districts - ACP



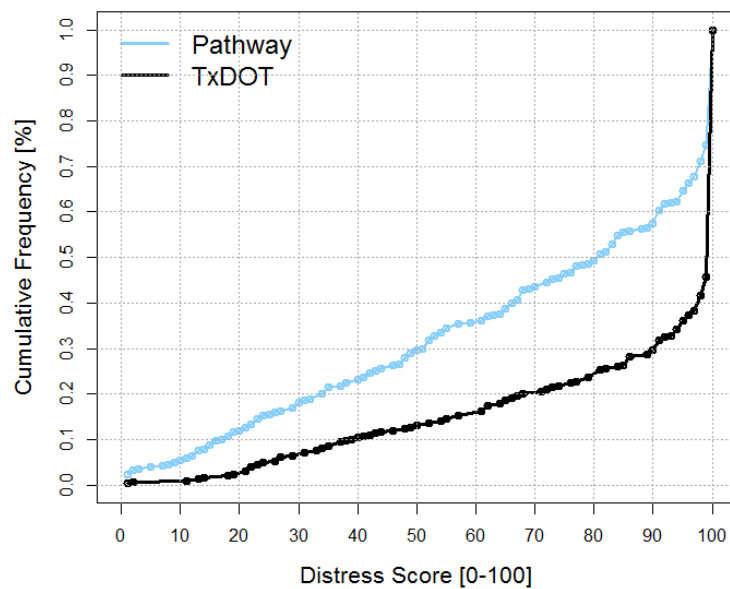
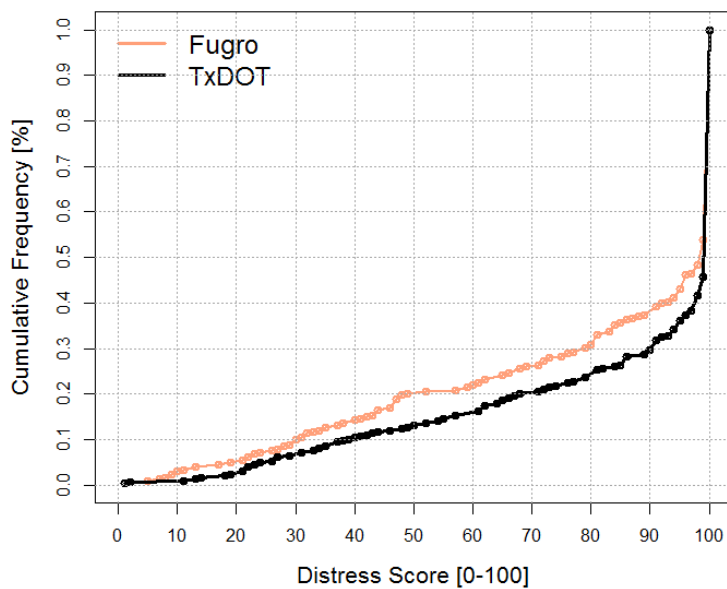
CRCP BRYAN AND HOUSTON

Distress Score - Houston and Bryan Districts - CRCP



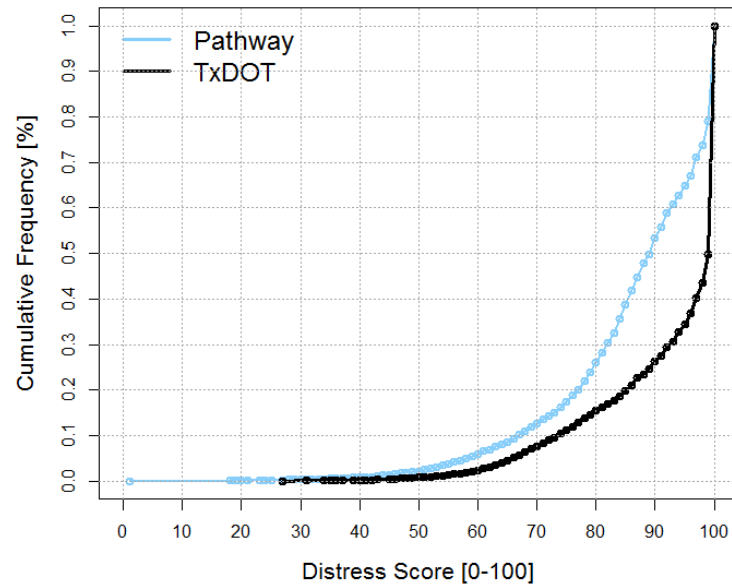
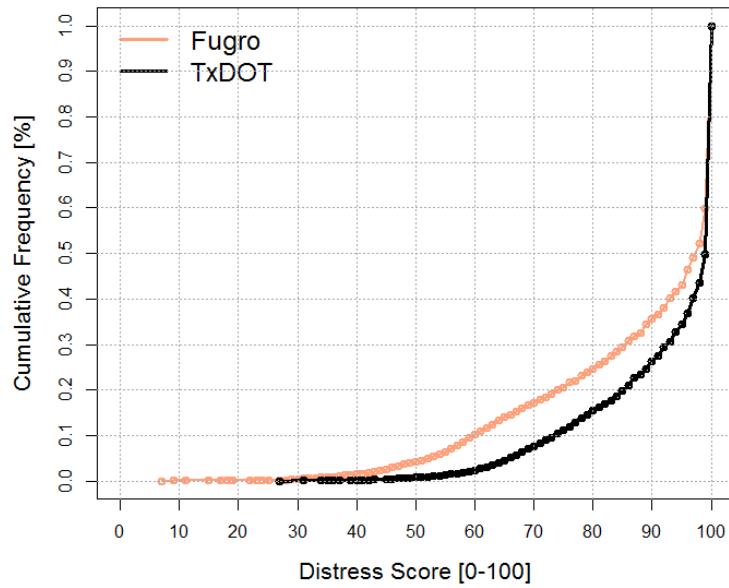
JCP BRYAN AND HOUSTON

Distress Score - Houston and Bryan Districts - JCP



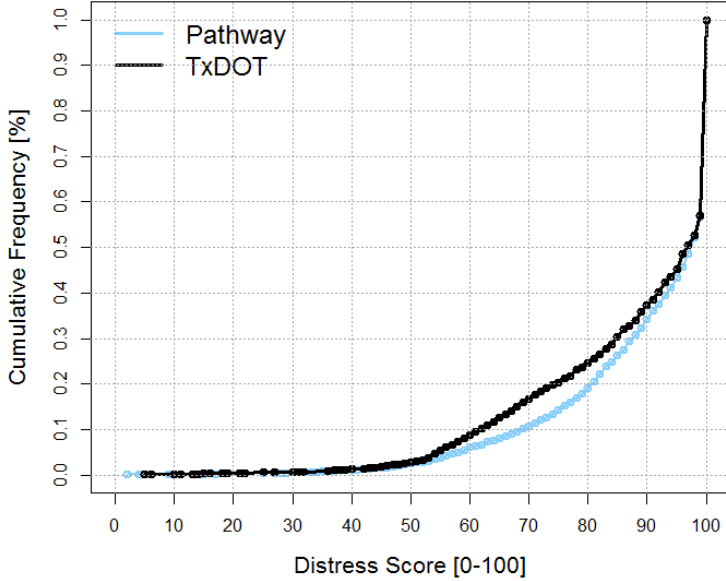
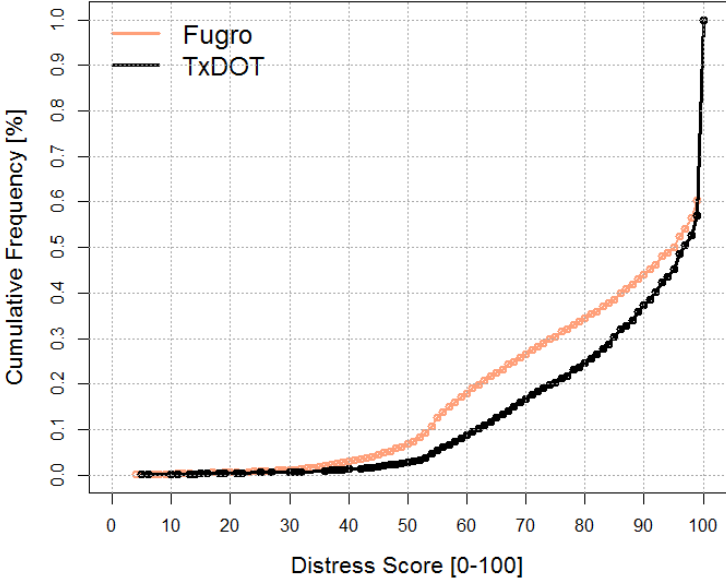
ACP BRYAN

Distress Score - Bryan District - ACP



ACP HOUSTON

Distress Score - Houston District - ACP

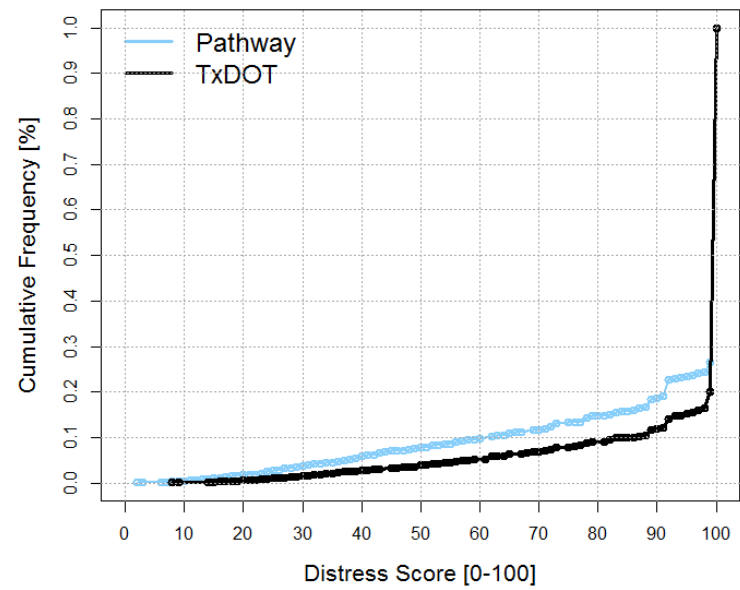
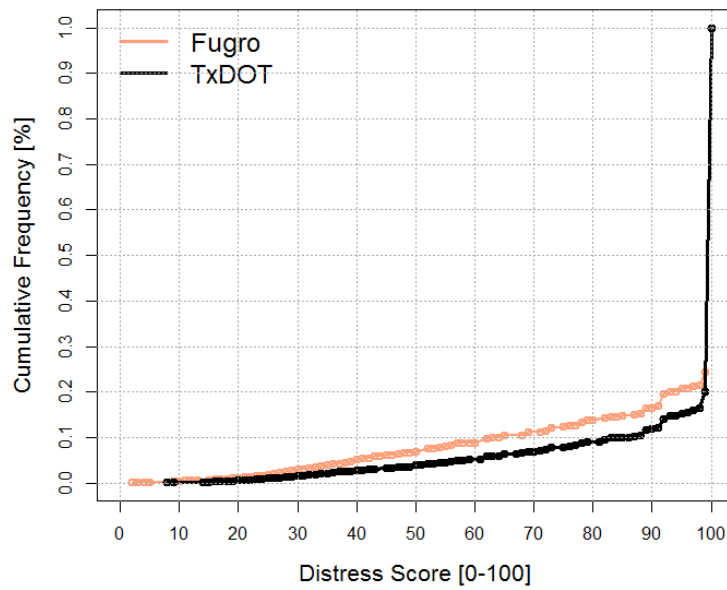


USE OF EQUIPMENT PER DISTRICT

District	Fugro		Pathway	
	ARAN_44	ARAN_48	PATHRN19	PATHRNVa
Houston	30%	72%	99.9%	0.0%
Bryan	70%	28%	0.1%	100.0%

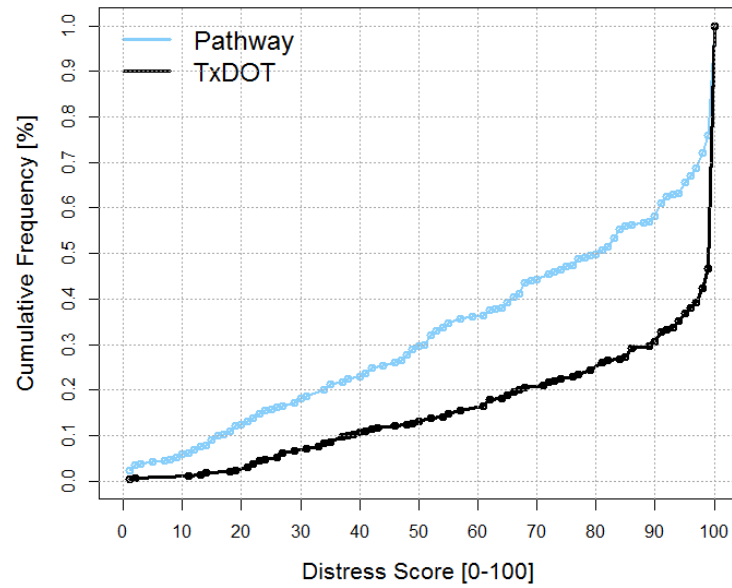
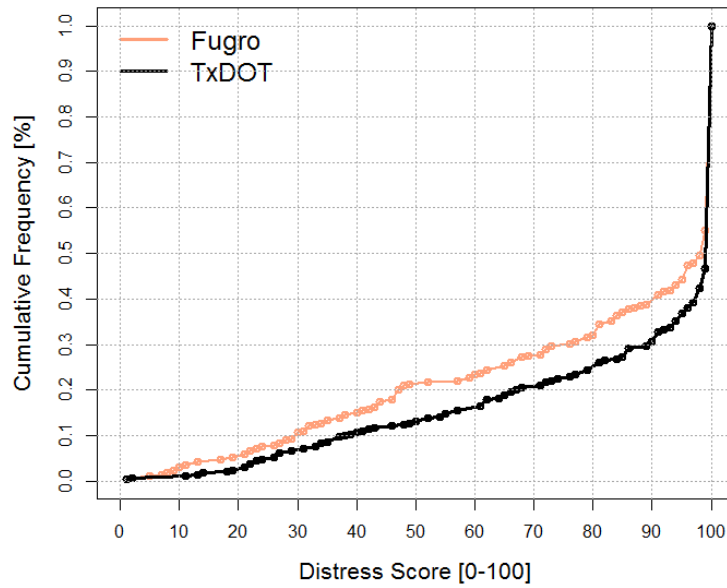
CRCP HOUSTON

Distress Score - Houston District - CRCP



JCP HOUSTON

Distress Score - Houston District - JCP



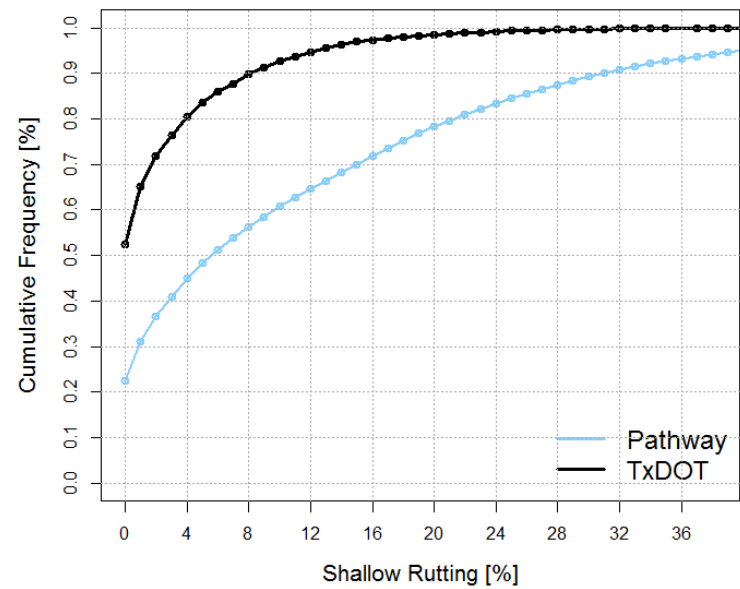
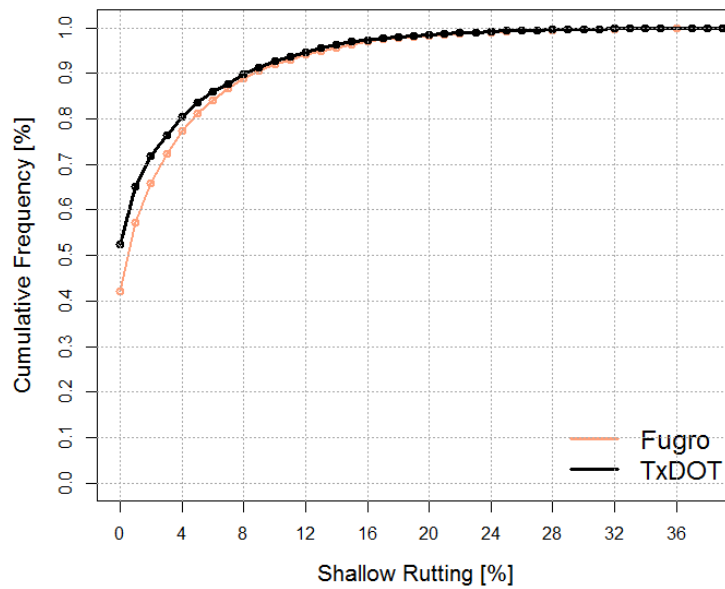
MAIN OBSERVATIONS (DISTRESS SCORE)

- Pathway showed larger differences for ACP and JCP sections.
- Fugro showed slightly larger differences for ACP.
- As compared to PMIS, for ACP, Pathway presented
 - higher DS in Houston
 - lower DS in Bryan
- Aside from this, differences in DS distribution by pavement type, were similar for the two Districts.
- Consistently, both systems capture more distress than visual ratings.

**SPECIFIC DISTRESS TYPES:
FOCUS ON DIFFERENCES**

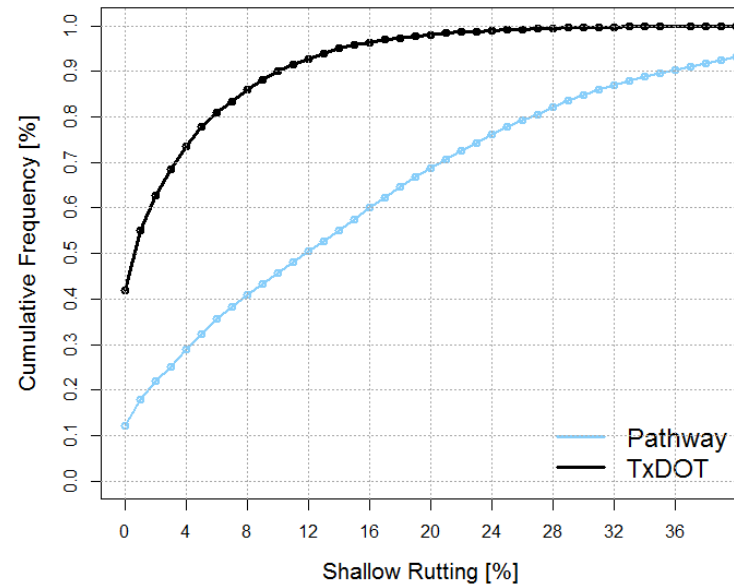
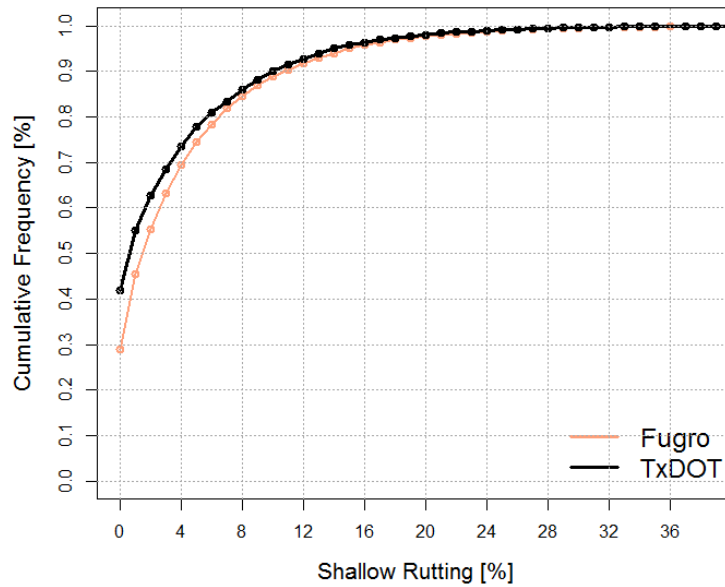
SHALLOW RUTTING (BETWEEN ¼" AND ½")

Shallow Rutting - Houston and Bryan Districts - ACP



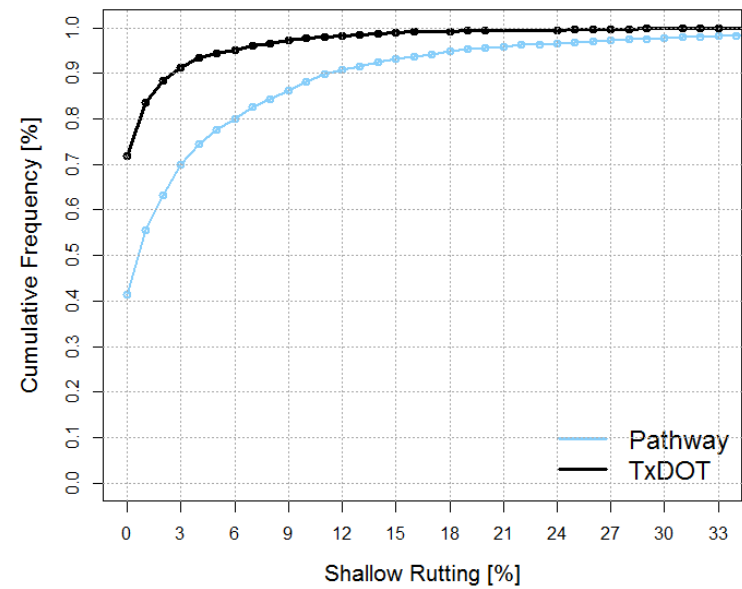
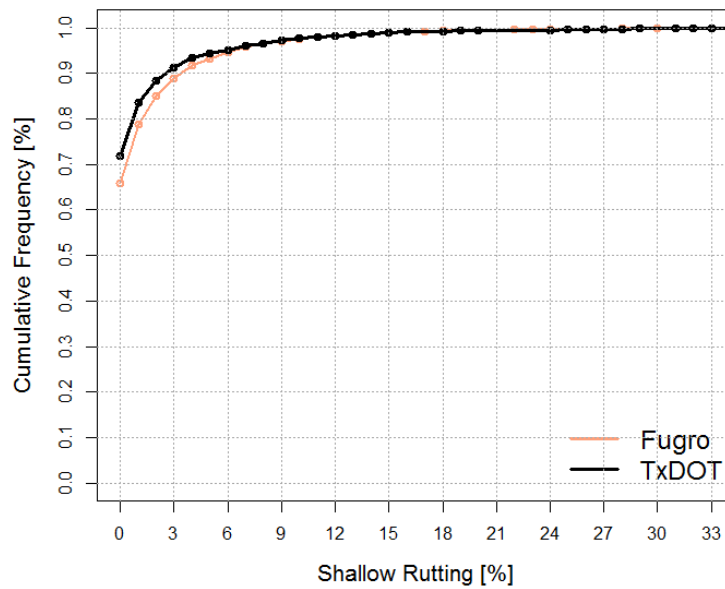
SHALLOW RUTTING (BETWEEN ¼" AND ½")

Shallow Rutting - Bryan District - ACP



SHALLOW RUTTING (BETWEEN ¼" AND ½")

Shallow Rutting - Houston District - ACP

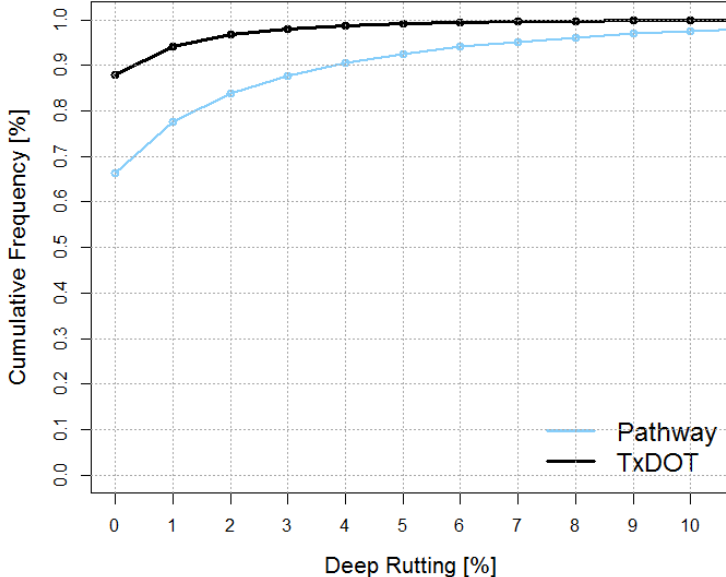
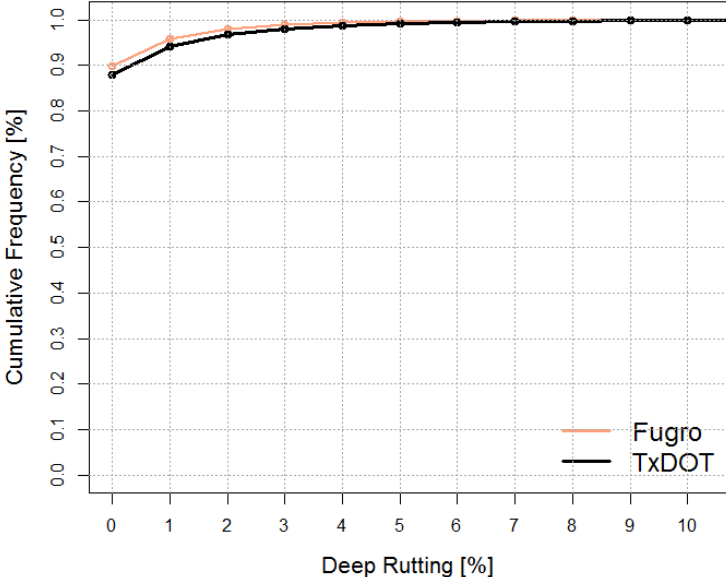


SHALLOW RUTTING (BETWEEN ¼" AND ½")



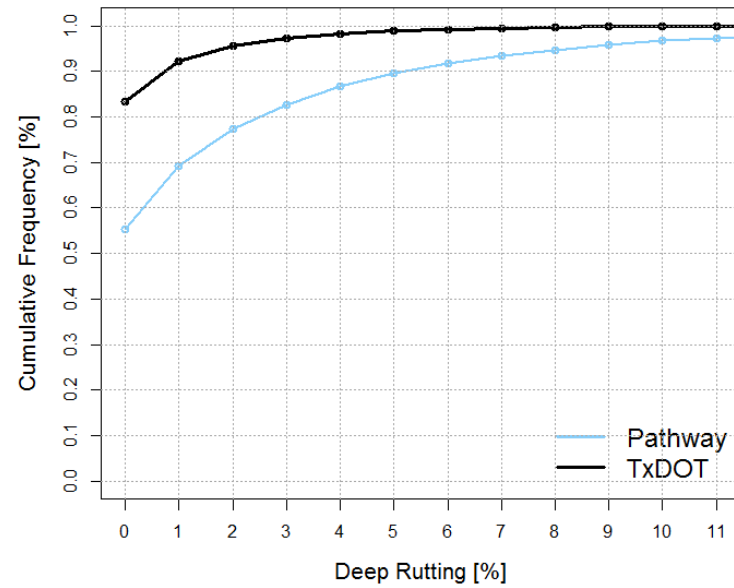
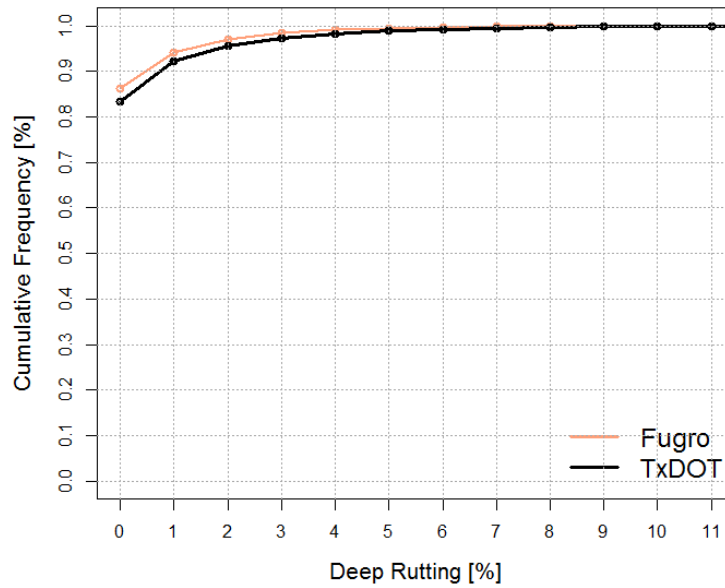
DEEP RUTTING (BETWEEN ½" AND 1")

Deep Rutting - Houston and Bryan Districts - ACP



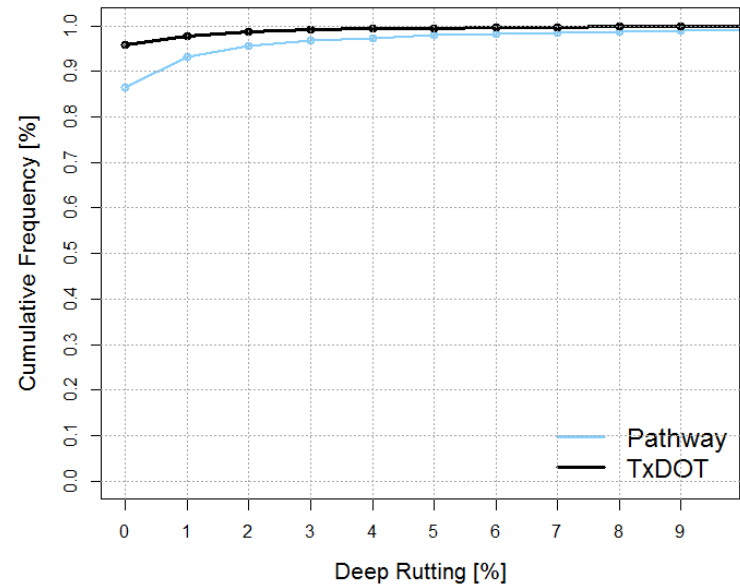
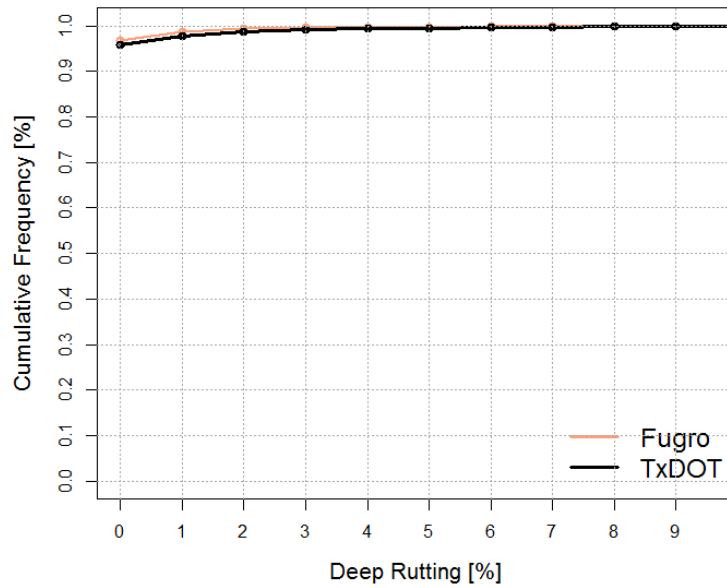
DEEP RUTTING (BETWEEN ½" AND 1")

Deep Rutting - Bryan District - ACP



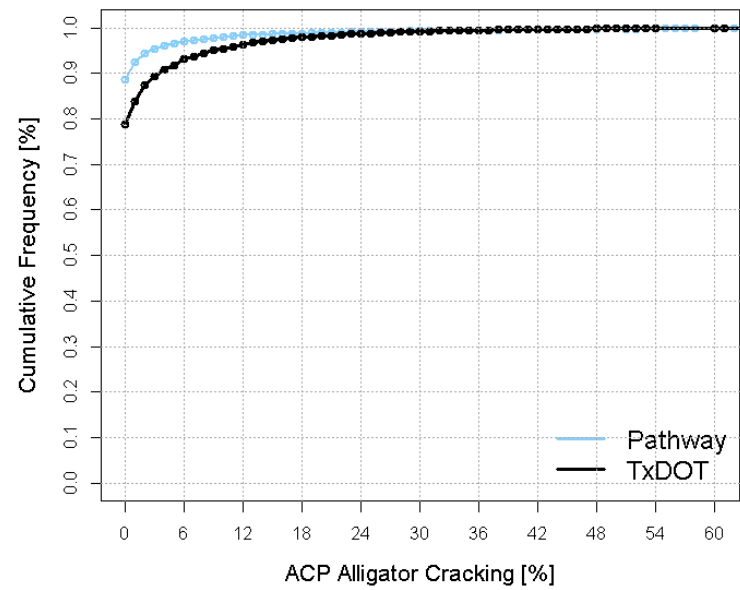
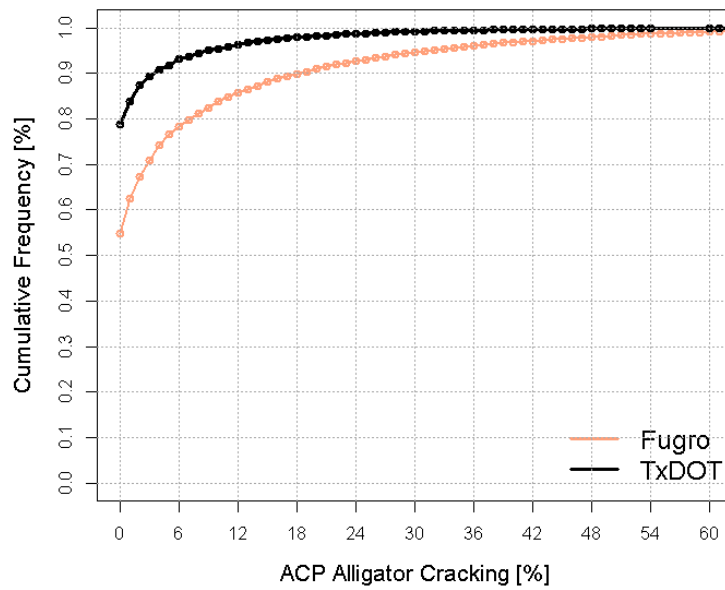
DEEP RUTTING (BETWEEN ½" AND 1")

Deep Rutting - Houston District - ACP



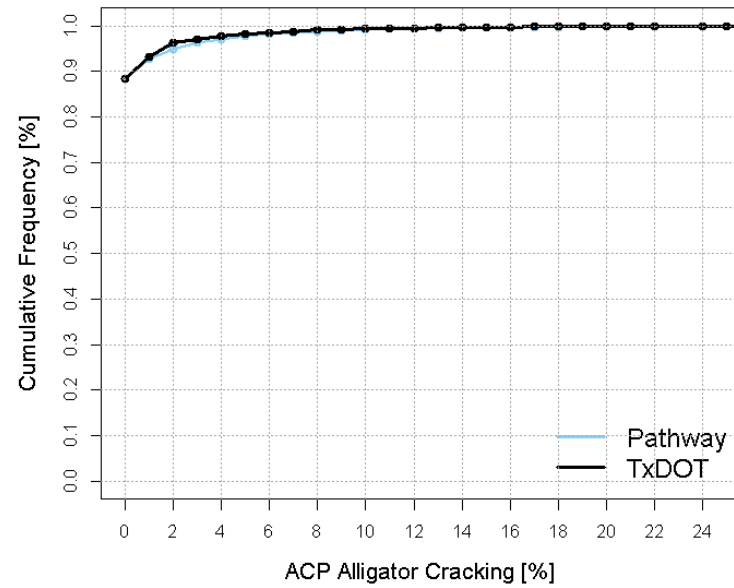
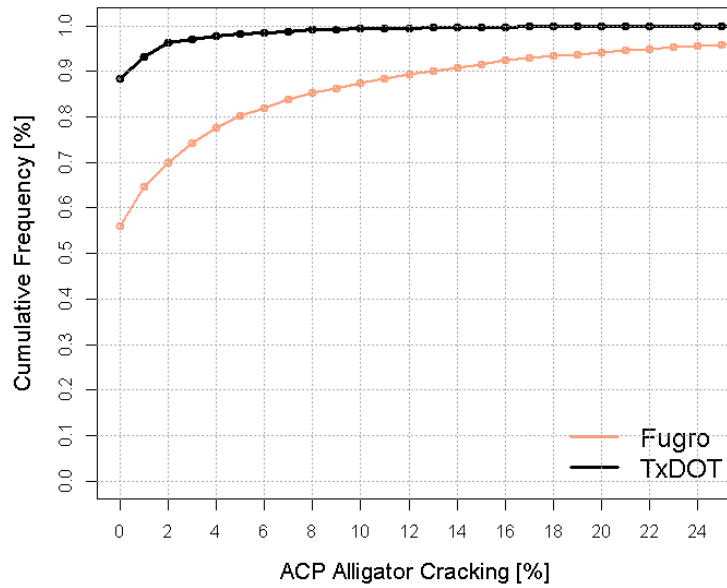
ALLIGATOR CRACKING

ACP Alligator Cracking - Houston and Bryan Districts - ACP



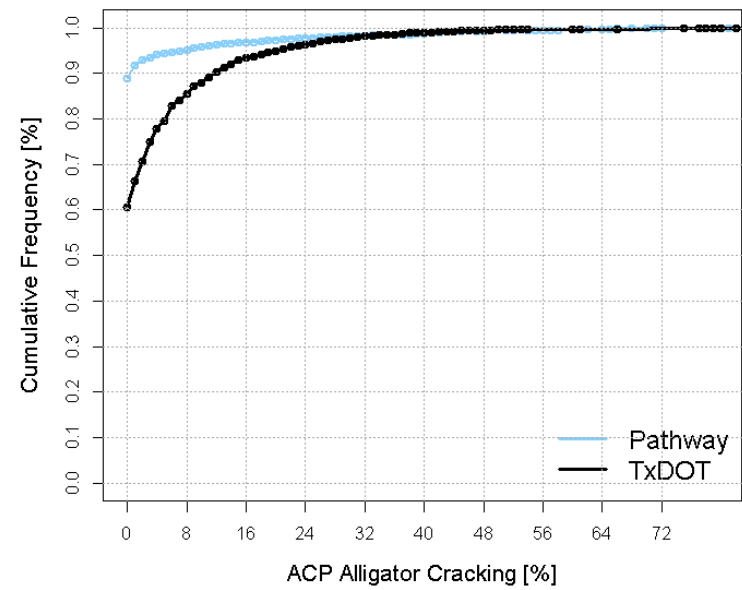
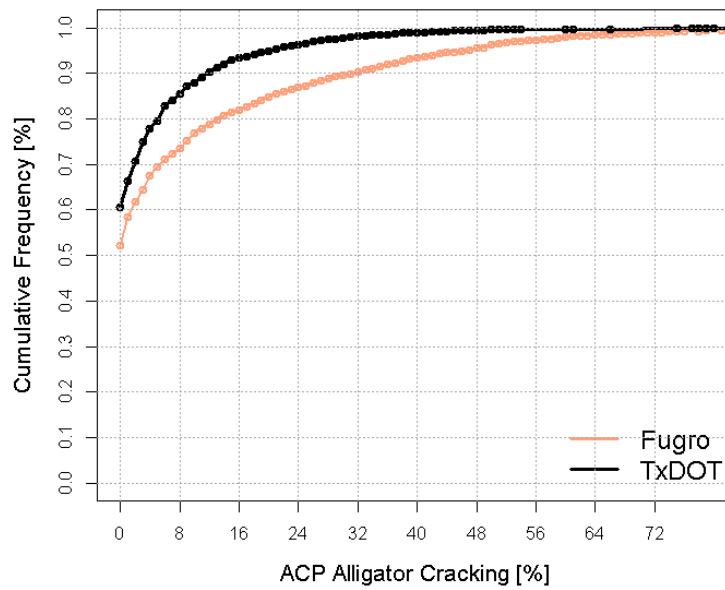
ALLIGATOR CRACKING

ACP Alligator Cracking - Bryan District - ACP



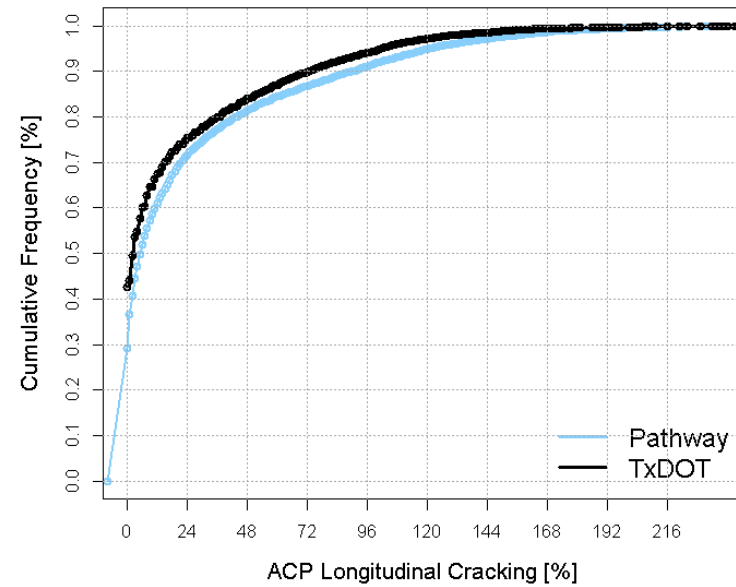
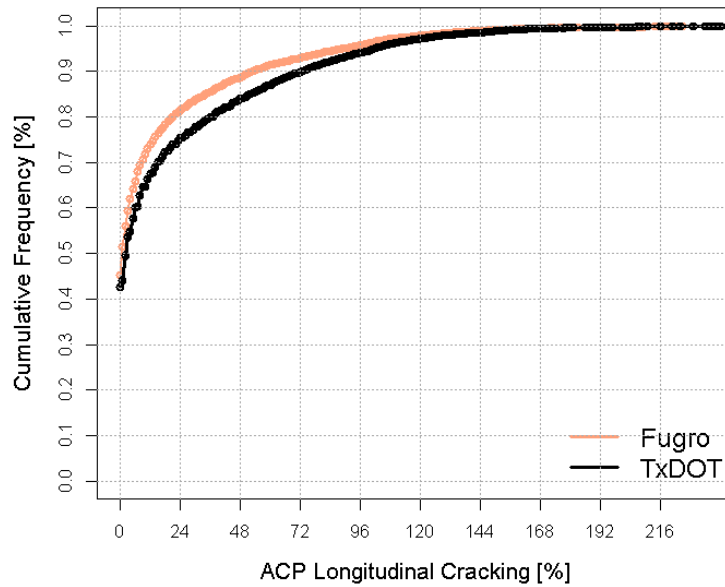
ALLIGATOR CRACKING

ACP Alligator Cracking - Houston District - ACP



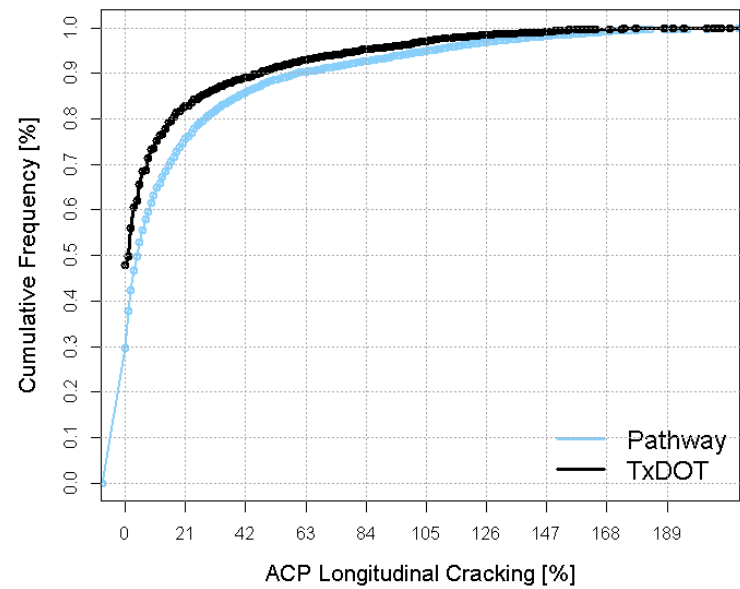
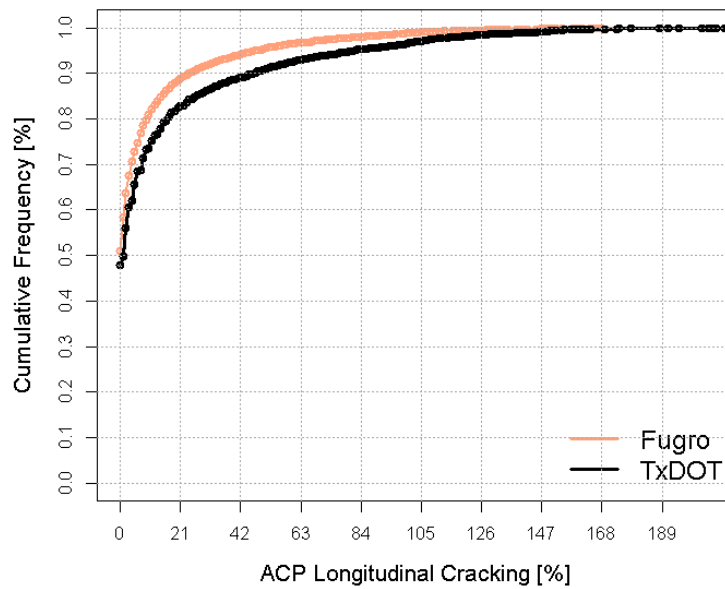
ACP LONGITUDINAL CRACKING

ACP Longitudinal Cracking - Houston and Bryan Districts - ACP



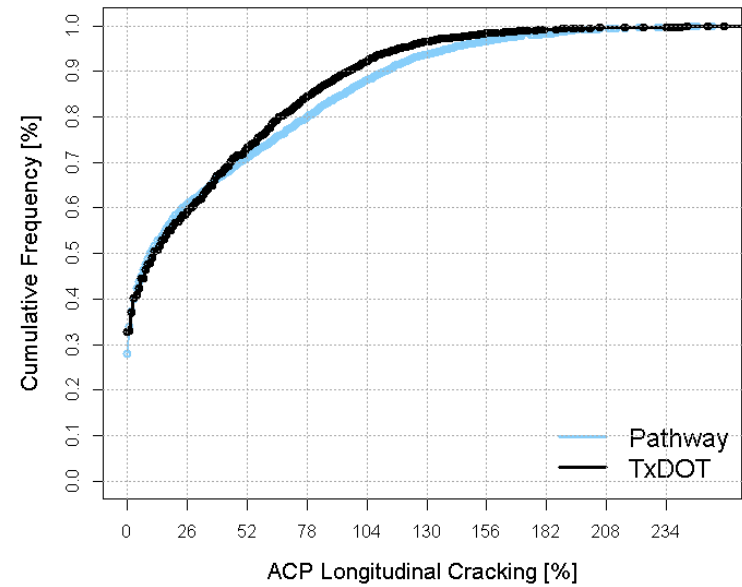
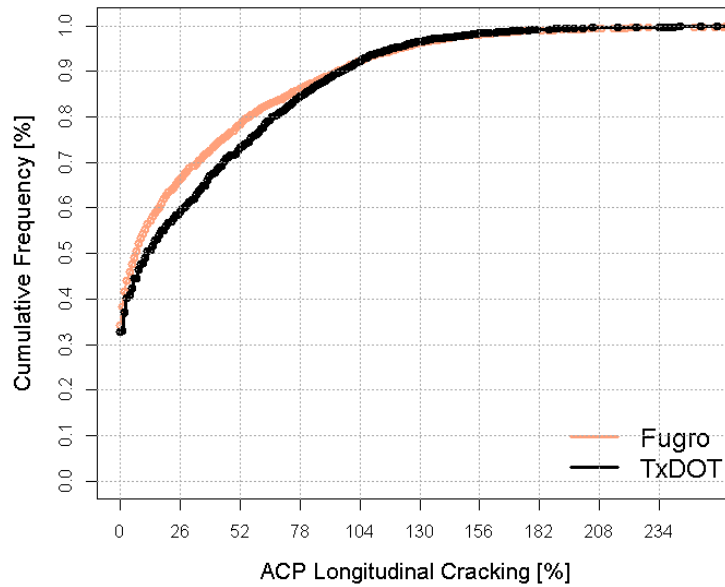
ACP LONGITUDINAL CRACKING

ACP Longitudinal Cracking - Bryan District - ACP



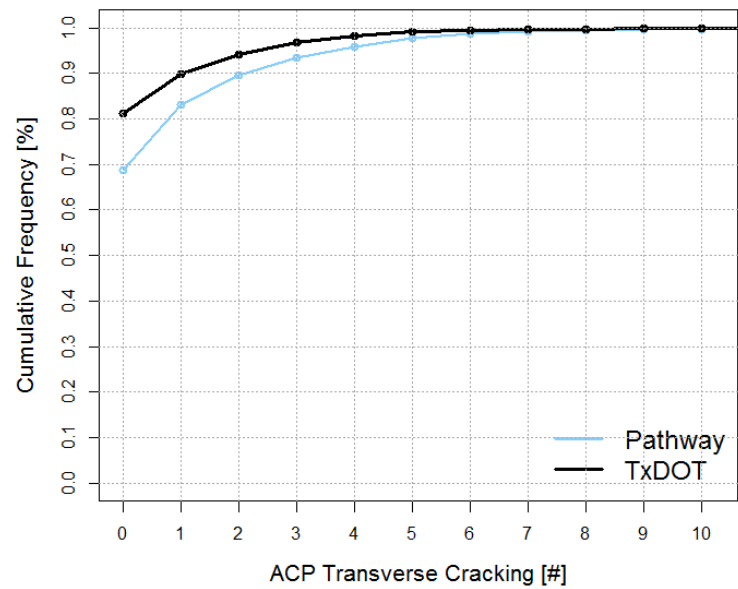
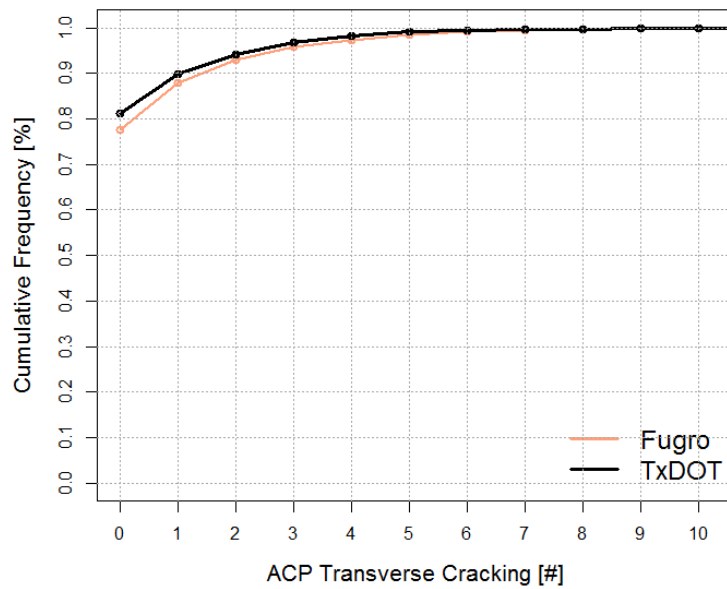
ACP LONGITUDINAL CRACKING

ACP Longitudinal Cracking - Houston District - ACP



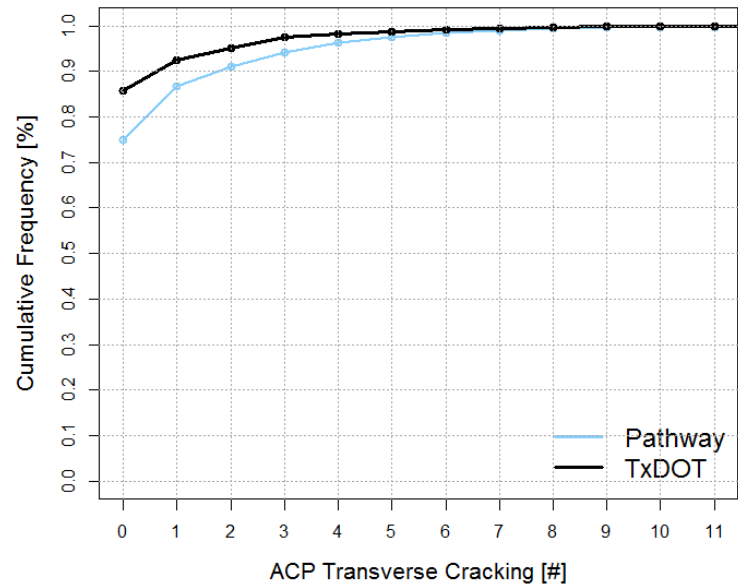
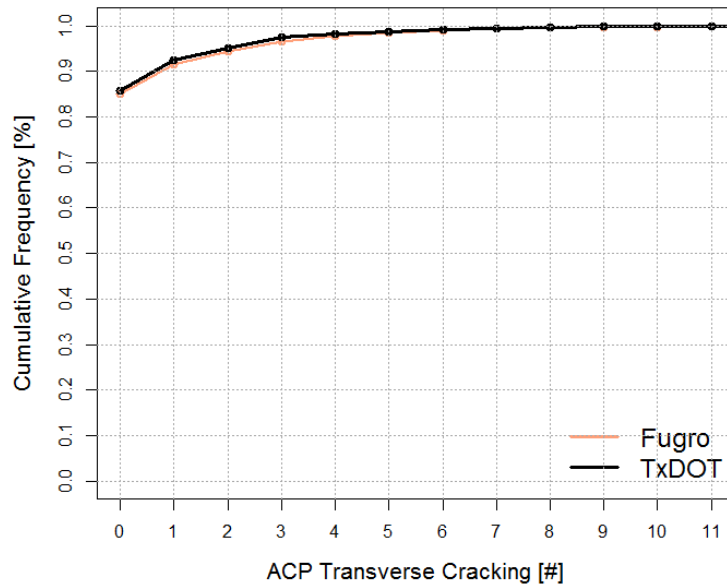
ACP TRANSVERSE CRACKING

ACP Transverse Cracking - Houston and Bryan Districts - ACP



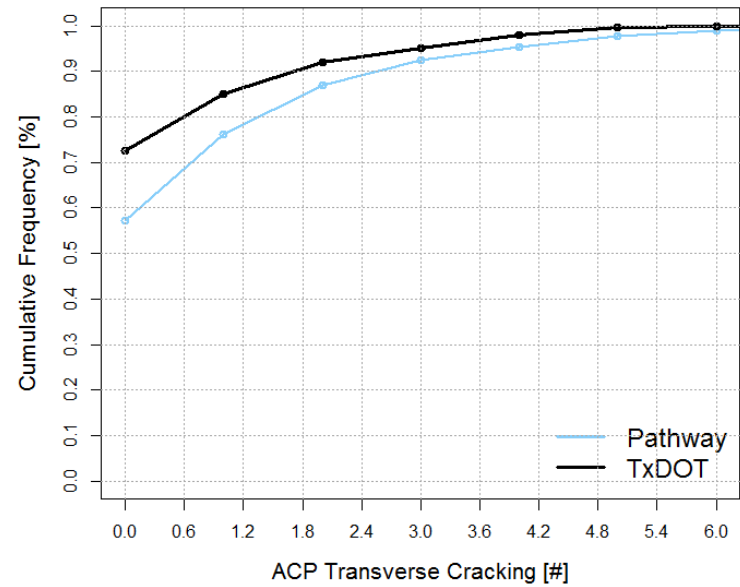
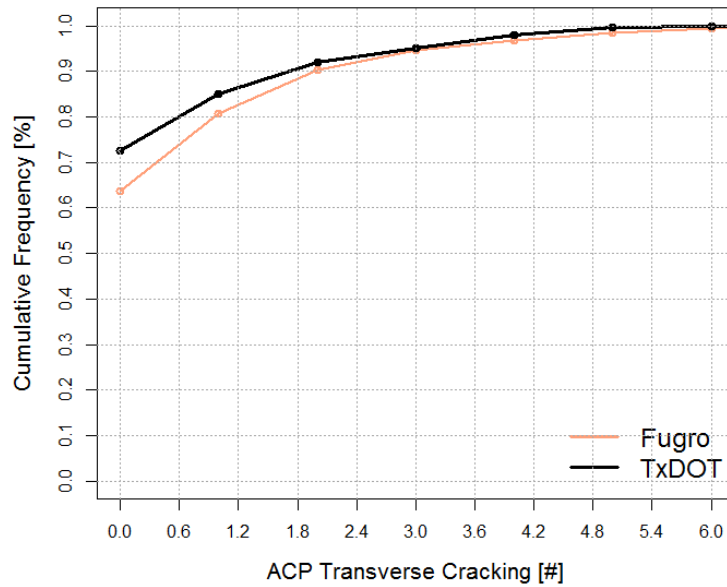
ACP TRANSVERSE CRACKING

ACP Transverse Cracking - Bryan District - ACP



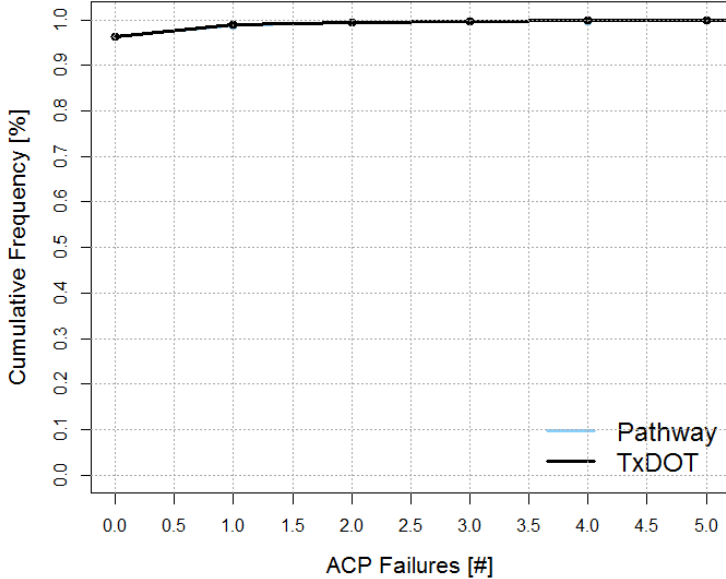
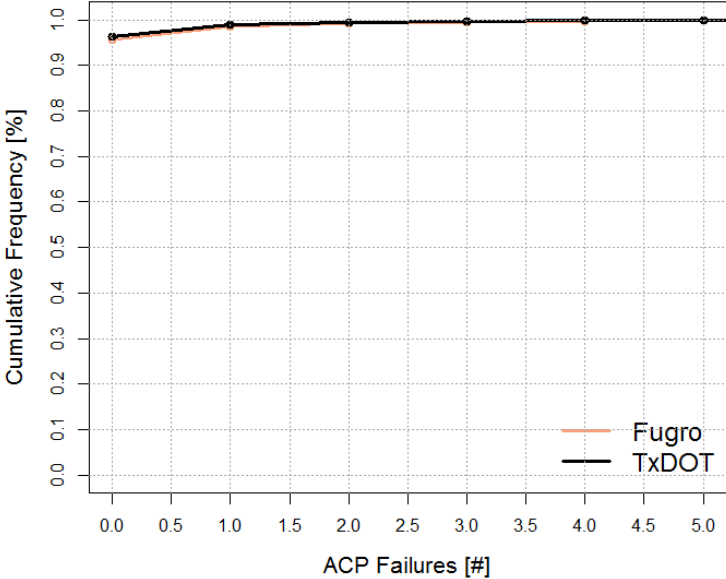
ACP TRANSVERSE CRACKING

ACP Transverse Cracking - Houston District - ACP



ACP FAILURES

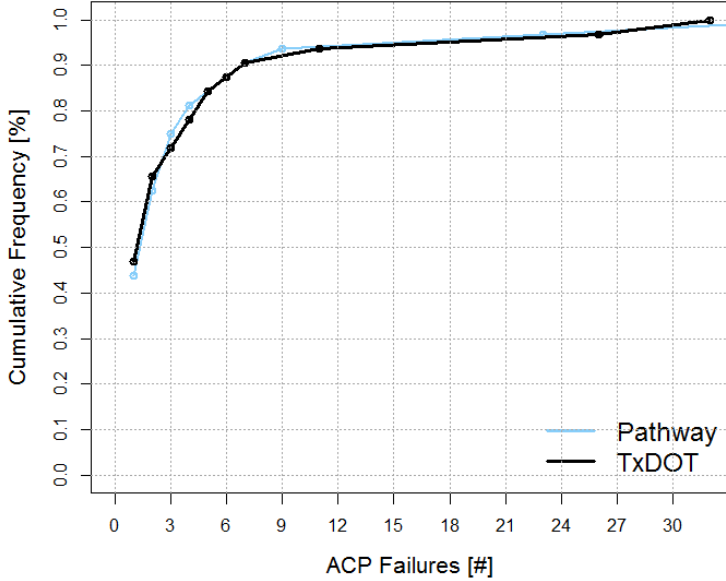
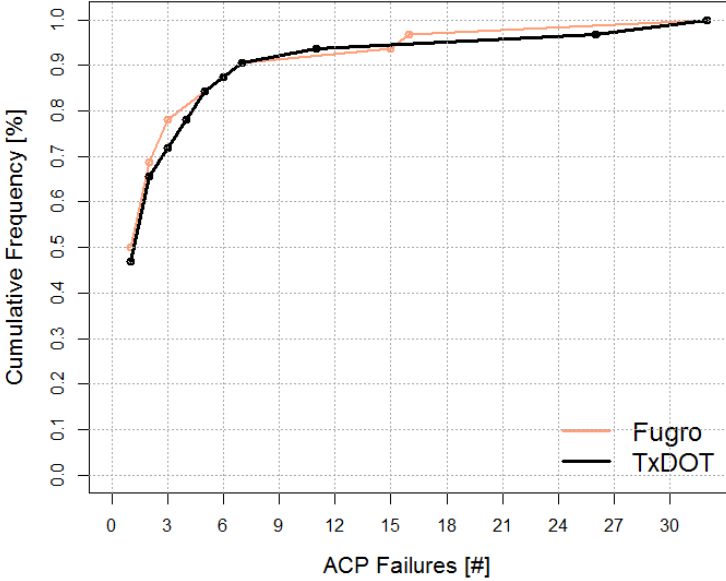
ACP Failures - Houston and Bryan Districts - ACP



ACP FAILURES

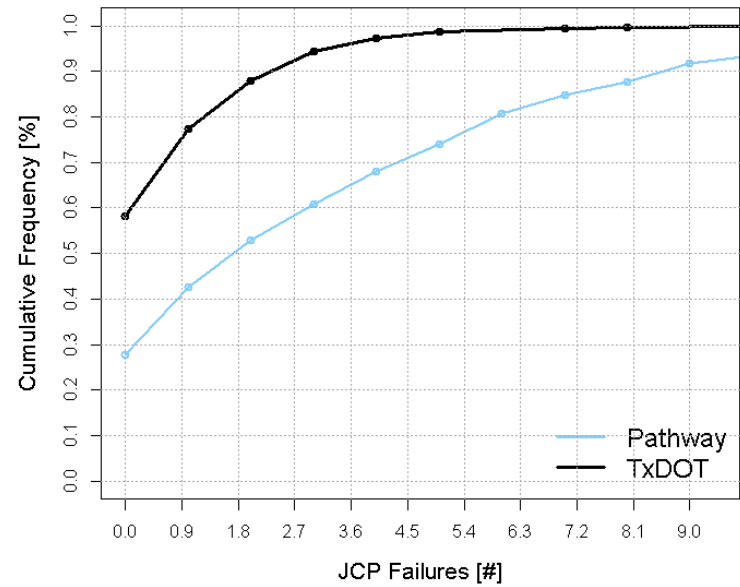
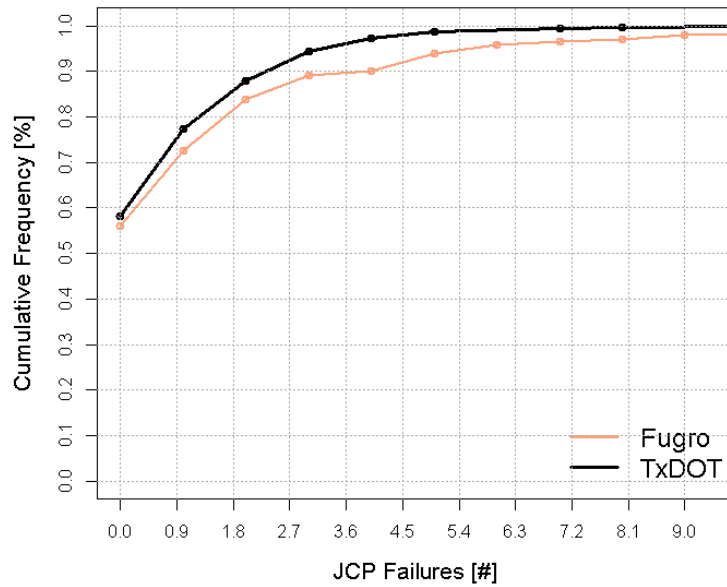
ACP Failures - Houston and Bryan Districts - ACP

Excluding sections with zero ACP failures = 32 cases



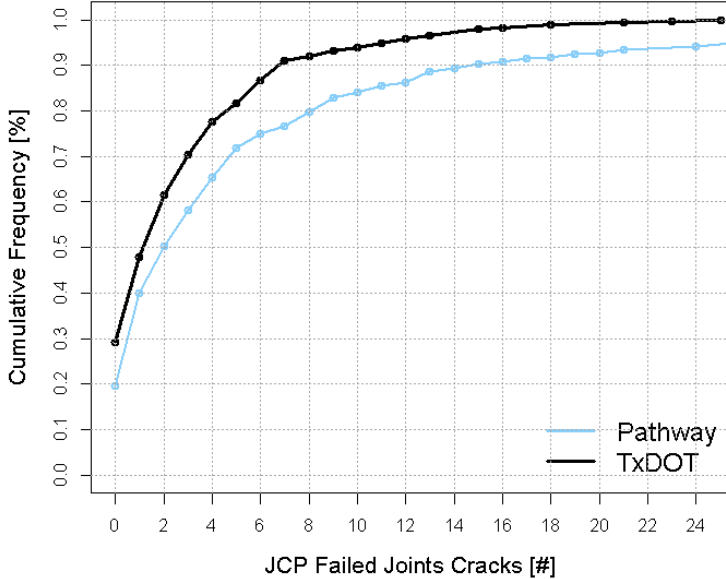
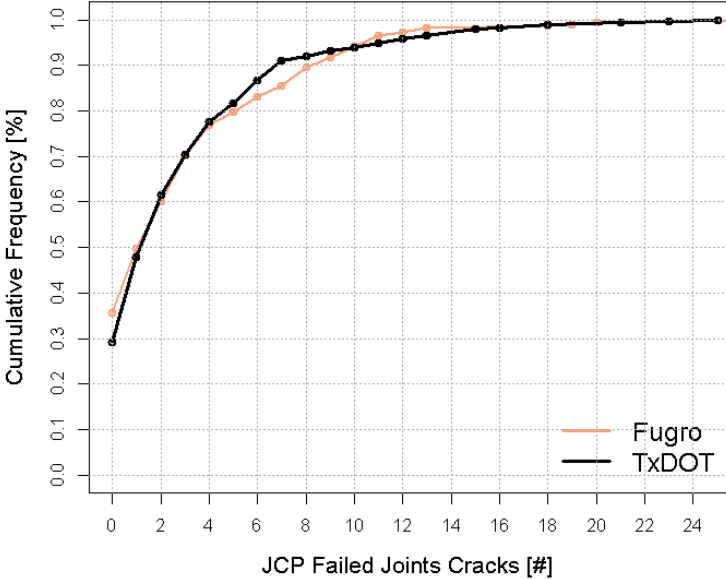
JCP FAILURES

JCP Failures - Houston District - JCP



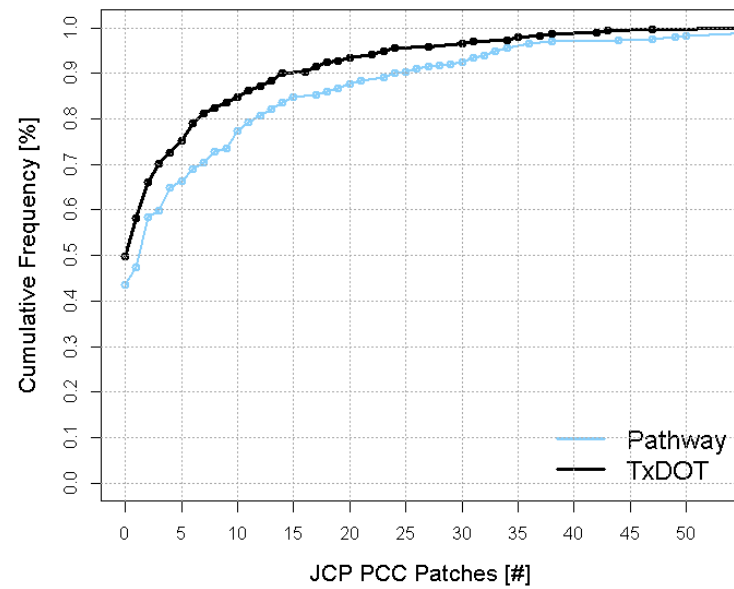
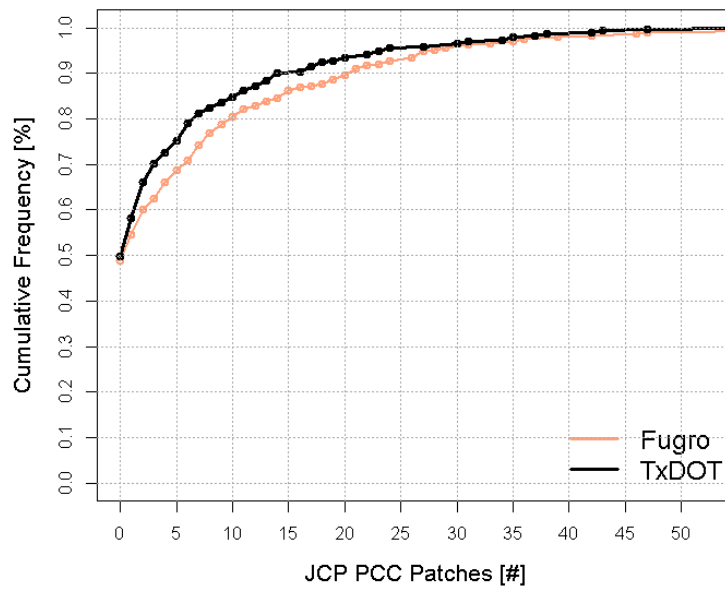
JCP FAILED JOINT CRACKS

JCP Failed Joints Cracks - Houston District - JCP



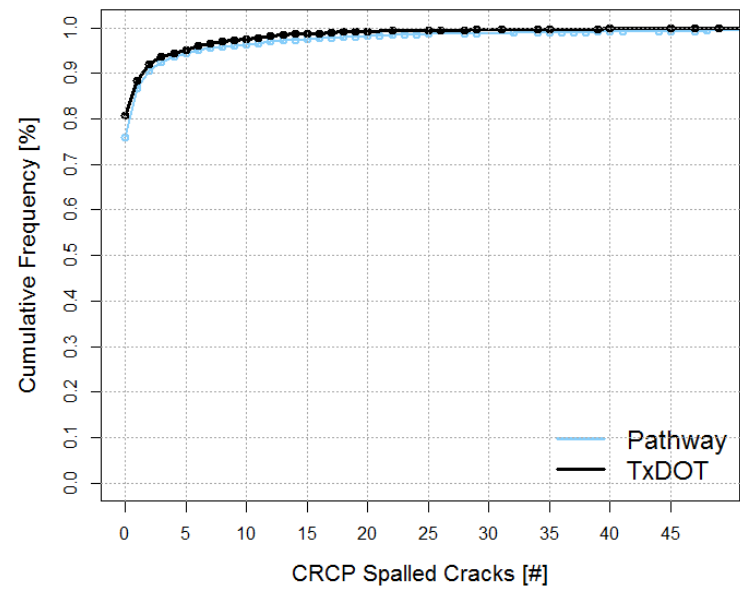
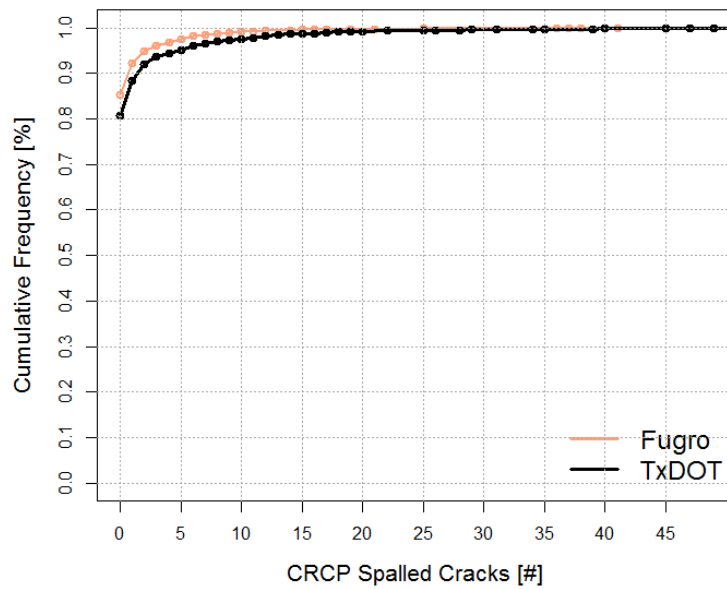
JCP PCC PATCHES

JCP PCC Patches - Houston District - JCP



CRCP SPALLED CRACKS

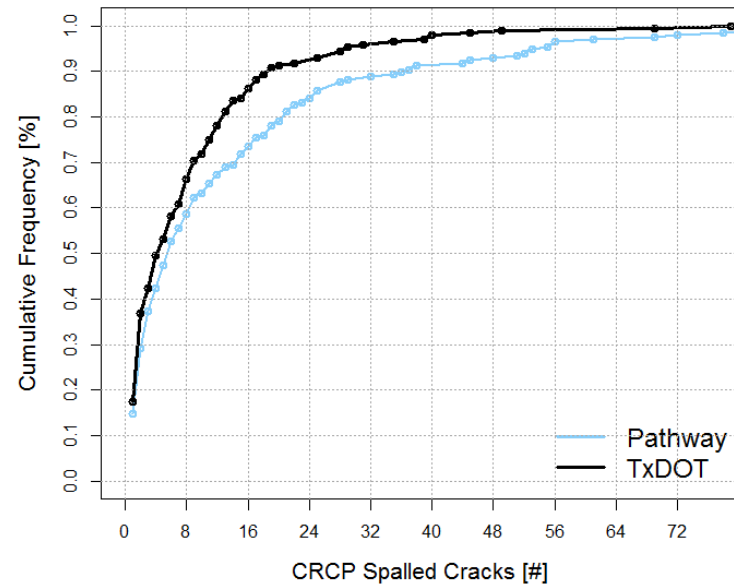
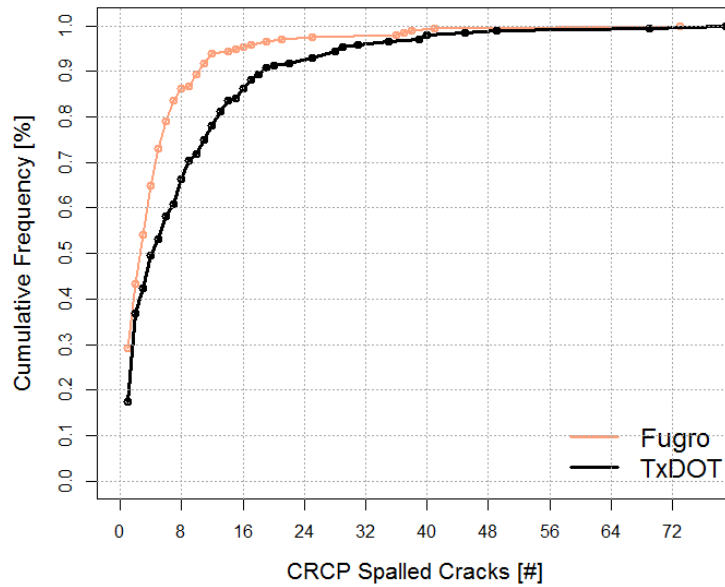
CRCP Spalled Cracks - Houston District - CRCP



CRCP SPALLED CRACKS

CRCP Spalled Cracks - Houston District - CRCP

Excluding sections with zero ACP failures = 196 cases



MAIN OBSERVATIONS (SPECIFIC DISTRESSES)

- Differences between Pathway and PMIS can be explained by differences in Shallow Rutting and Deep Rutting.
 - Pathway reported more rutting and the difference was higher for the Bryan District.
 - Fugro presented very similar values for rutting.
- Differences between Fugro and PMIS are mainly explained by differences in Alligator Cracking.
 - Fugro reported more alligator cracking.
 - Pathway reported less alligator cracking.
 - Pathway's differences are more pronounced in Houston.
 - Fugro's differences are more pronounced in Bryan.
- Pathway's differences in DS for JCP pavements are mainly due to failures.

SUMMARY CONCLUSIONS

CONCLUSIONS FROM PHASE 1 RUT DATA

- All five systems tested were capable of capturing surface transverse profiles with the necessary accuracy;
- No single vendor performed better overall;
- Dynatest, Fugro, and TxDOT outperformed Applus and Pathway Services;
- Data processing algorithms (software) can be modified to improve accuracy.
- Moving from a 5-point system to a continuous system will result in improved accuracy and higher levels of rutting.
- From the Quantification of impact on PMIS Scores:
 - CS dropped significantly based on a network simulation
 - The drop in CS was, on average, 19.23 points (24.35, 8.02)

CONCLUSIONS FROM PHASE 2 VISUAL DISTRESS (1 OF 2)

- TxDOT was the only participating system capable of reporting data just after collection (but not in the format requested for the experiment)
- 2-day analysis: WayLink-OSU system outperformed the other systems in terms of crack detection.
- Dynatest and Fugro showed a significant improvement in accuracy after applying manual post-processing (4-week analysis).
- Results reported within 4 weeks included more types of distresses.
- Manual corrections were more effective at removing cracks incorrectly detected than at adding cracks missed by their algorithm.
- None of the vendor's precision improved after manual post-processing.

CONCLUSIONS FROM PHASE 2 VISUAL DISTRESS (2 OF 2)

- Several types of distresses, such as patching, punchouts, spalling, and joint damage, were reported only after manual post-processing of the crack maps by Fugro and Dynatest.
- WayLink-OSU reported some of these types of distresses at the 2-day time frame.
- Dynatest and Fugro produced texture results close to the reference in magnitude with minor error.
- It is recommended that WayLink-OSU and TxDOT review their texture data processing as all measurements were significantly different than the reference

CONCLUSIONS FROM PHASE 3 PILOT STUDY HOUSTON AND BRYAN DISTRICTS

- Vendor results appear reasonable for Condition, Distress or Ride scores summed for both Districts, or for each individual District
 - Ride Scores are very similar to TxDOT data;
 - Distress Scores are lower than TxDOT (more distress measured);
 - Vendor's data resulted in lower percent 'Good' or better condition scores for both districts; lowest Condition Score for Houston.
- The vendors reported lower Condition Scores compared to PMIS mainly due to differences in Distress Scores.
- Major differences in Distress Scores with TxDOT:
 - Fugro: Flexible Pavement Cracking
 - Pathway Services: Flexible Pavement Rutting and JCP Failures
 - Pathway Services: Flexible Pavement fatigue might be rated as longitudinal cracking in some cases

CONCLUSIONS FROM PHASE 3 PILOT STUDY

Review of Selected Corridors to evaluate localized data trends

- Examination of individual corridors showed that vendor data trends for specific distresses can exhibit large variations compared to TxDOT data when viewed on shorter segment lengths of approximately 20 to 30 miles
- This is significant since districts will rely on accurate PMIS data to aid in candidate project selection and ranking
- These variations could potentially be addressed through calibration of the vendor's algorithms
- Improving the accuracy of PMIS surface type designations may benefit vendor's distress identification and measurement processes

MOVING FORWARD

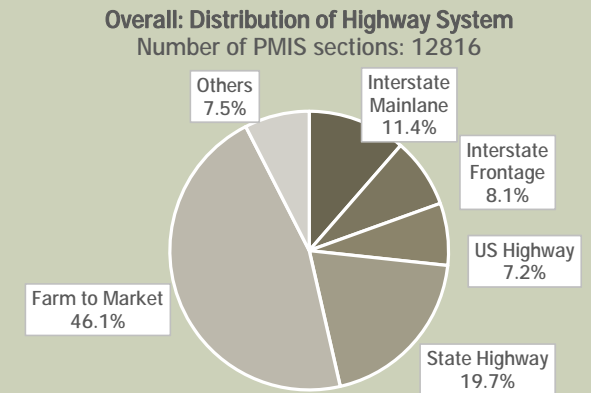
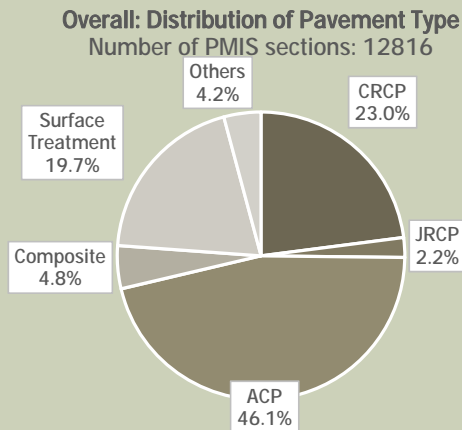
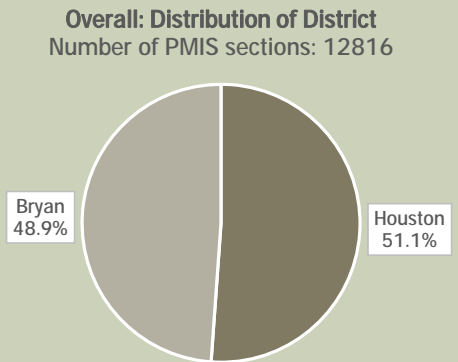
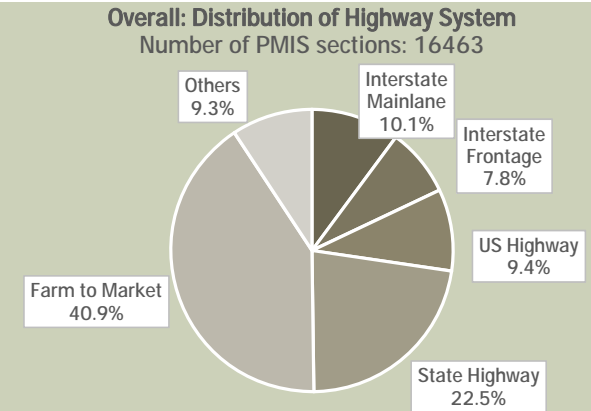
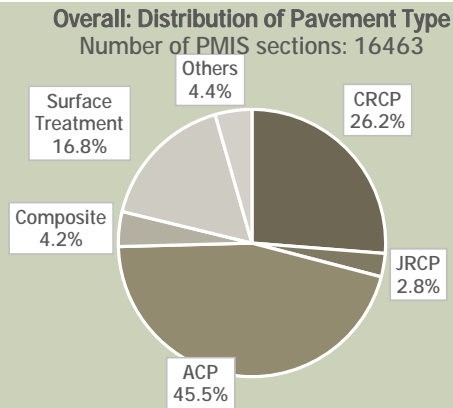
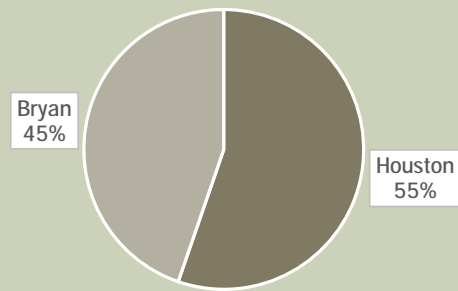
IMPLEMENTATION ISSUES

- We recommend transition from manual to semi-automated distress measurements with a transition period (manual + semi-automated):
 - Semi-Automated more efficient,
 - Safer,
 - Captures more distresses (scores will go down),
 - Measurements are objective and consistent, and
 - Automated distress measurement components are evolving rapidly:
 - Improved accuracy and reduced costs every year
- Some advantages and additional issues:
 - Significant personnel and equipment resources are required for manual network distress surveys
 - Automated system trends are similar to TxDOT (however, calibration is required)
 - Automated system accuracy can improve over time depending on DOT contract specifications
 - Automated systems can have capabilities to collect other types of data simultaneously with PMIS distress, ride and rut data (e.g., LIDAR bridge clearances, texture data)
 - Quality Control issues need to be addressed before transitioning

Thanks for your attention!

Extra slides

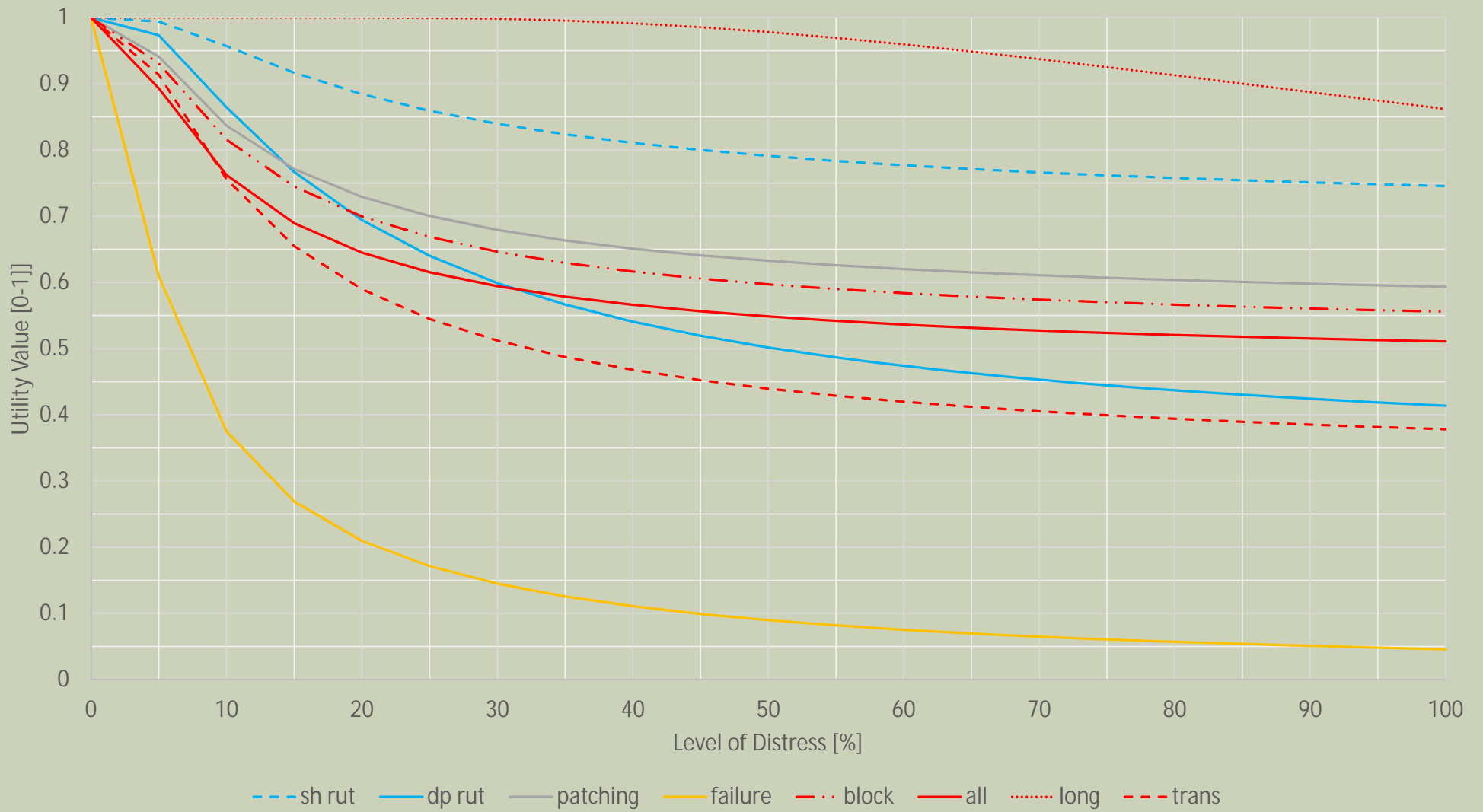
DESCRIPTION OF PILOT STUDY



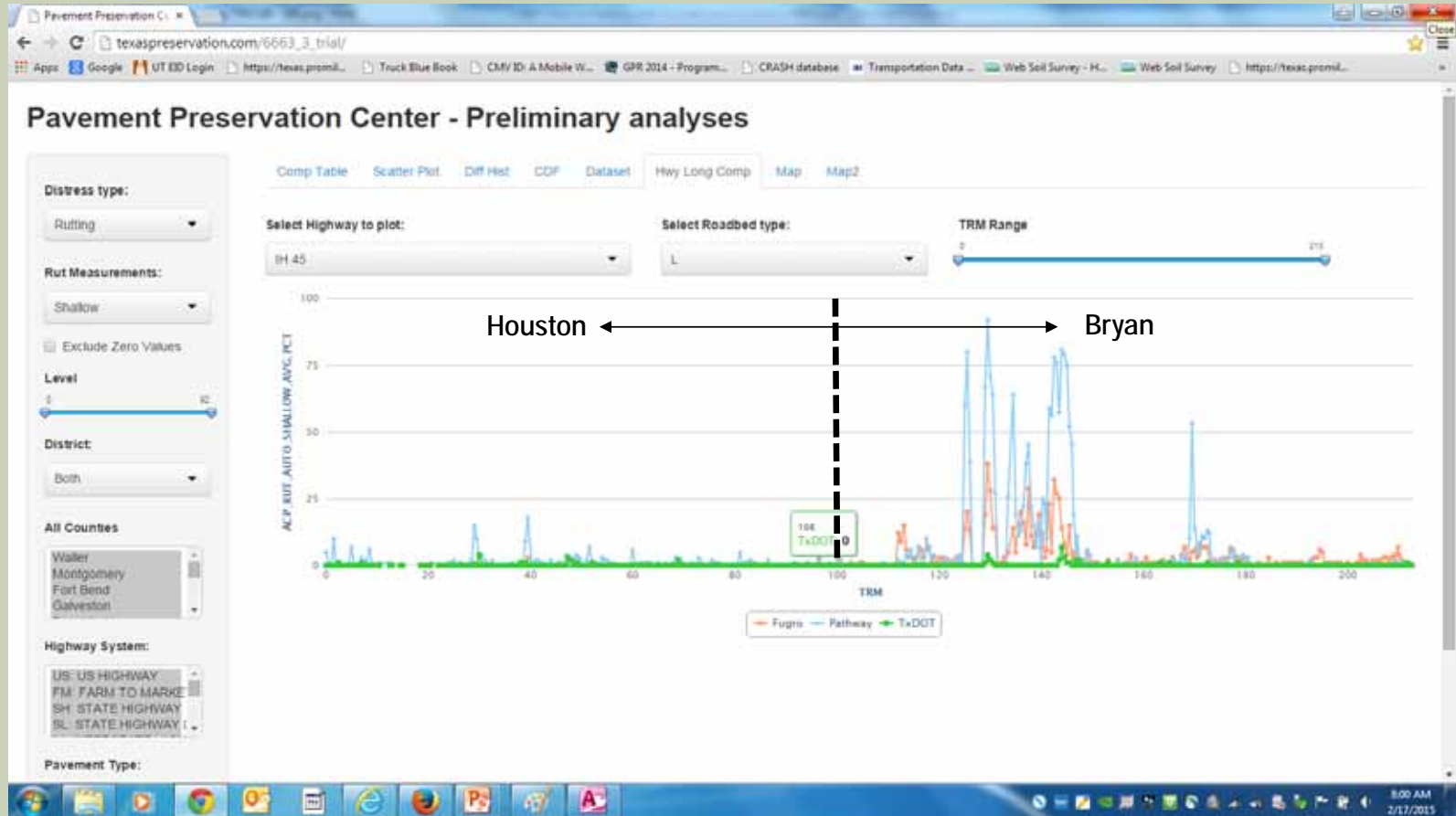
EQUIPMENT PRODUCTION

total roadbed miles in TxDOT Network				100,966.40	miles
positive		pilot study		conservative	
130	miles/day	90	miles/day	70	miles/day
777	days	1122	days	1442	days
122	days/van	122	days/van	122	days/van
0.9	%active	0.85	%active	0.8	%active
7.1	vans	10.8	vans	14.8	vans

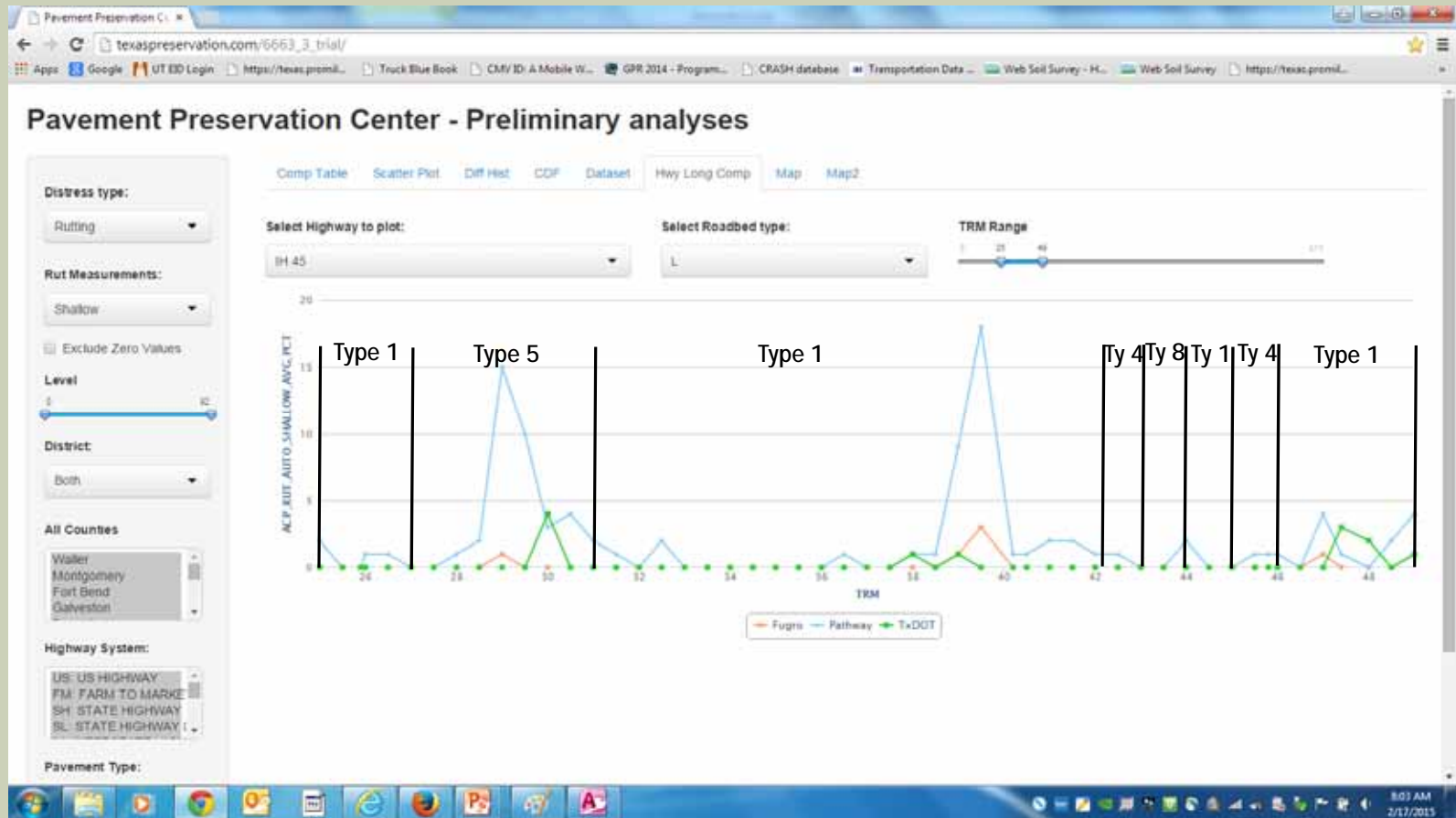
PMIS Utility Curves for Flexible Pavements (type 5)



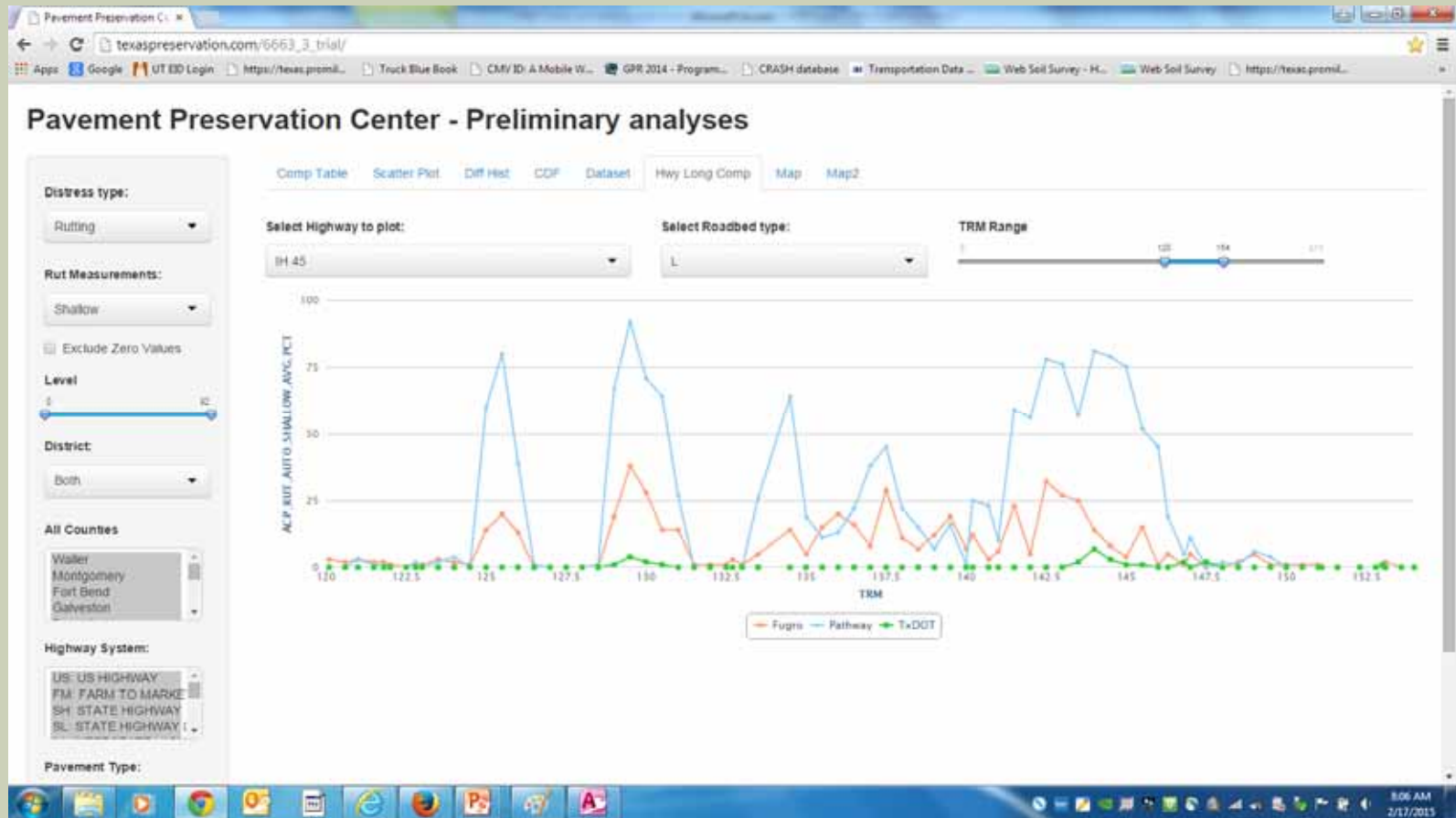
IH 45 L Main Lanes Shallow Rutting (PMIS 1, 2, 4, 5, 8 and 9) Houston - Bryan



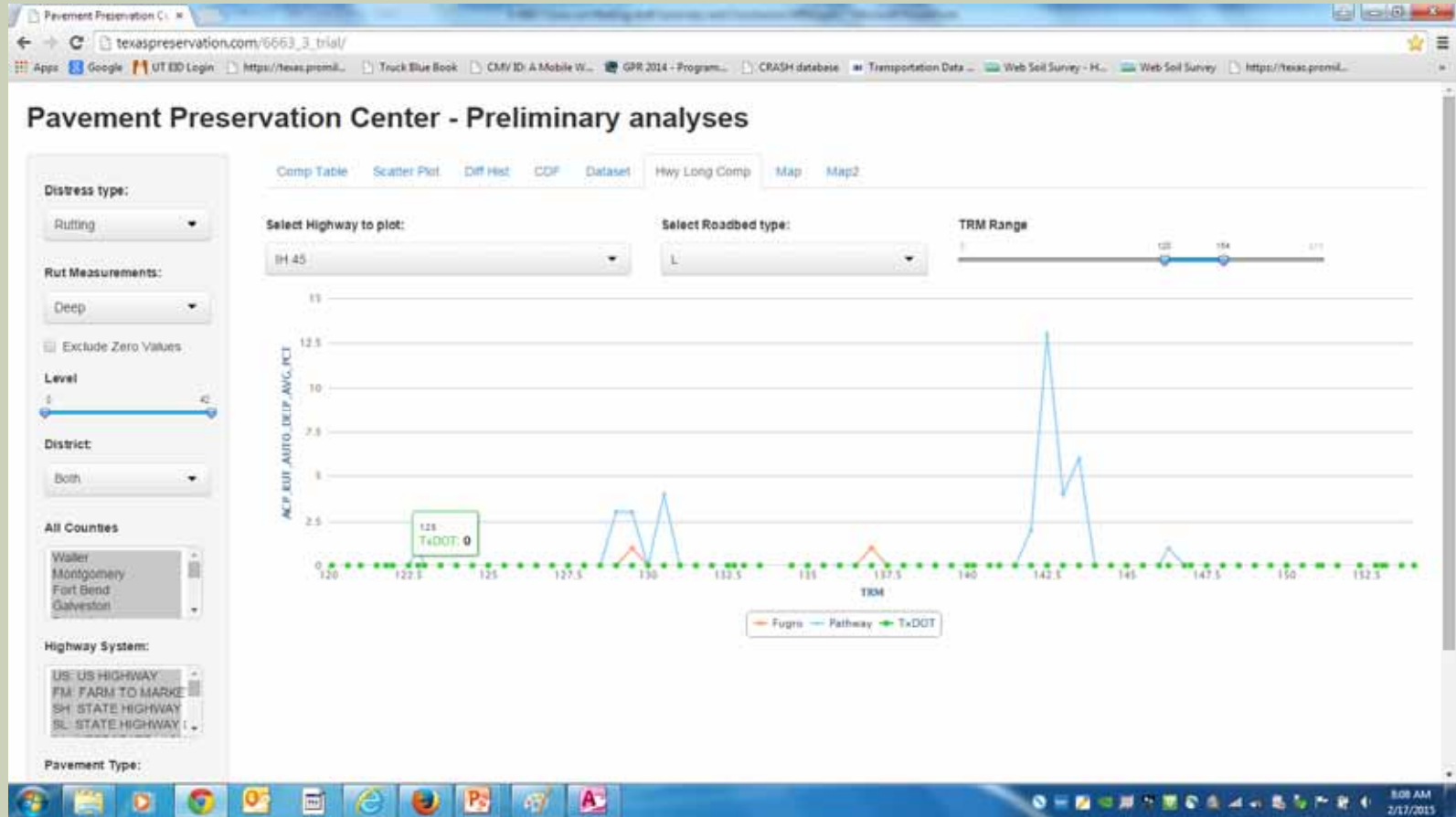
IH 45 L Main Lanes Shallow Rutting TRM 25 – 49 (PMIS Type 1, 4, 5, 8) Houston



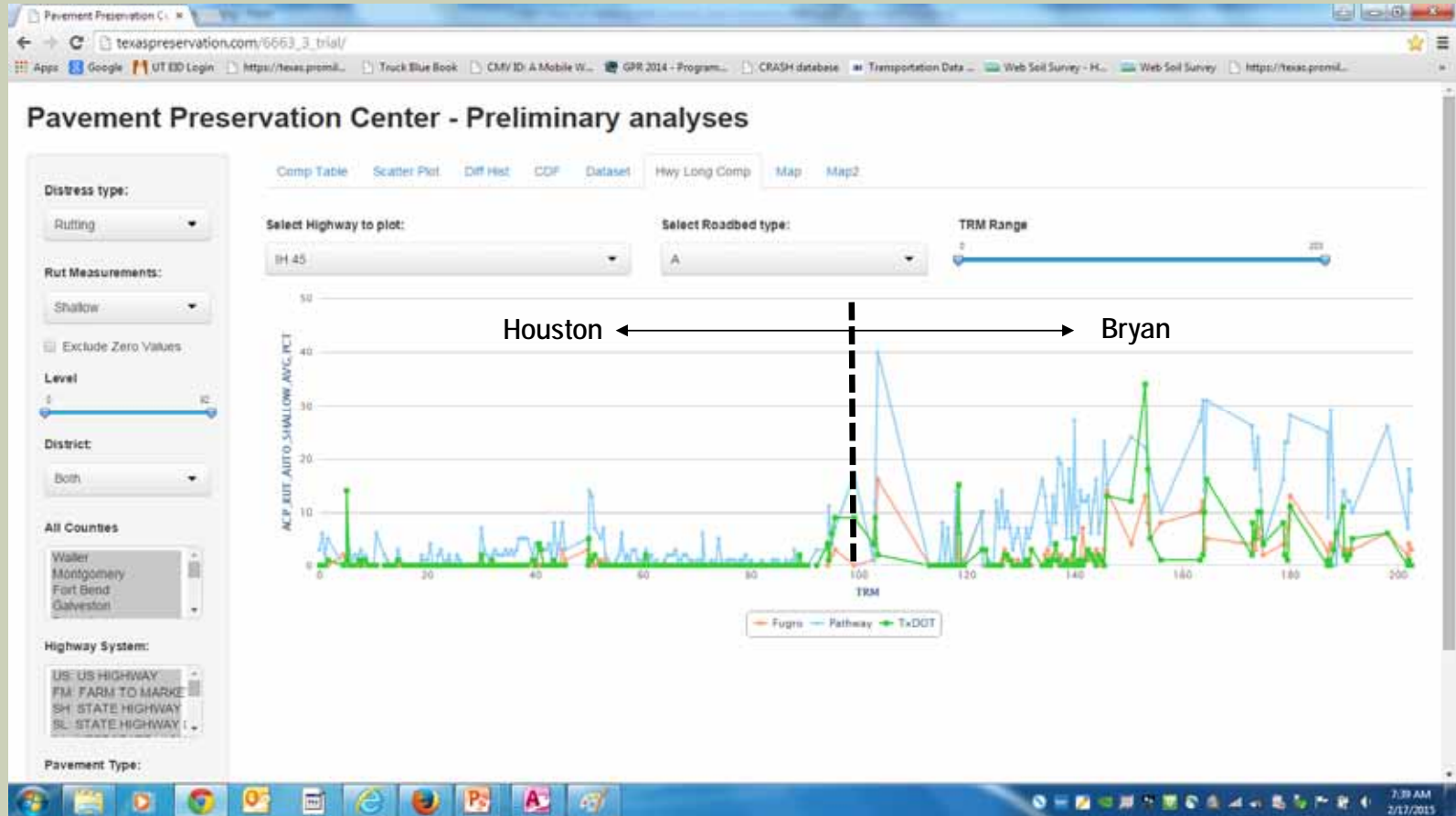
IH 45 L Main Lanes Shallow Rutting TRM 120 - 154 (PMIS Type 5) Bryan



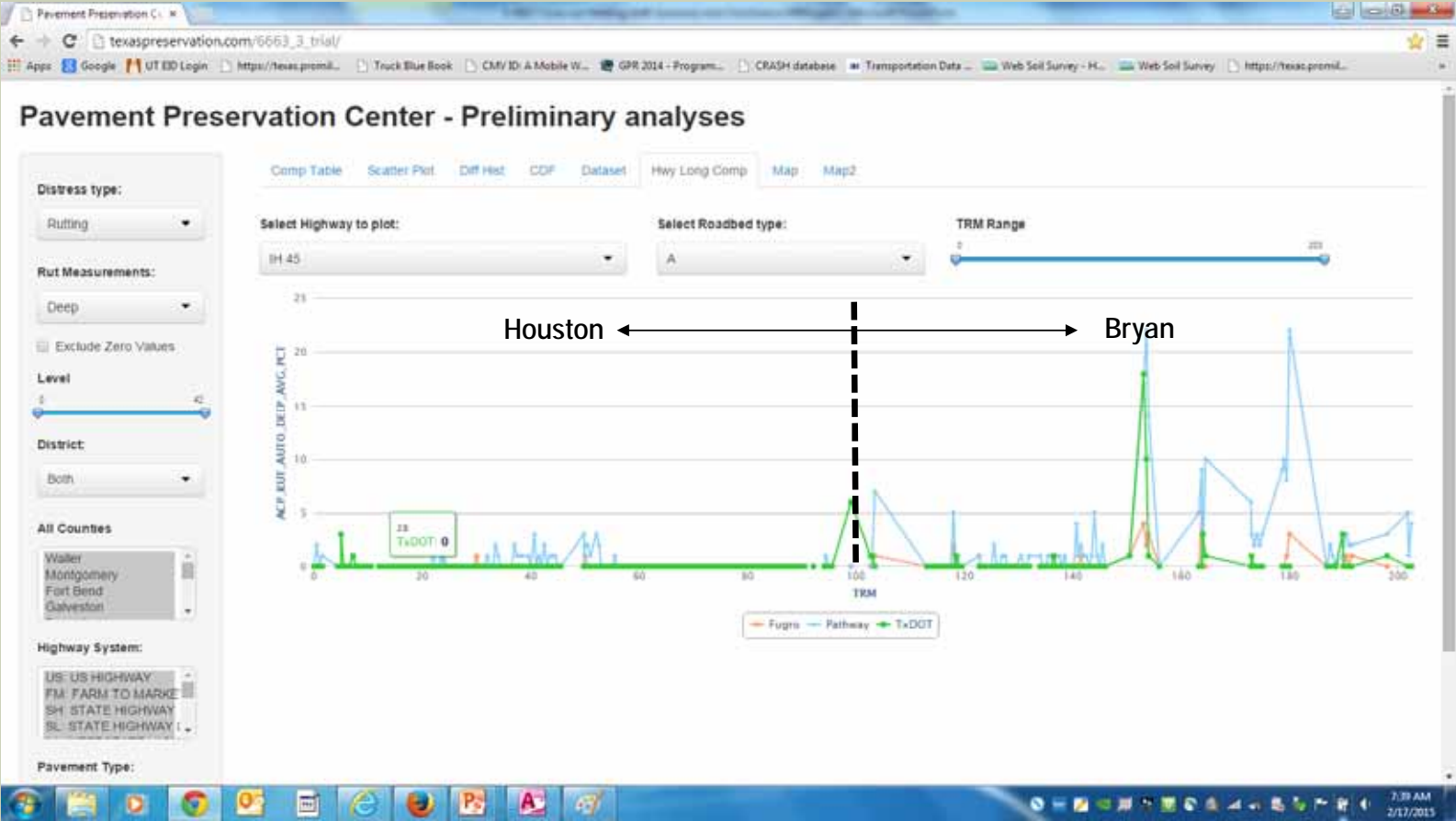
IH 45 L Main Lanes Deep Rutting TRM 120 - 154 (PMIS Type 5) Bryan



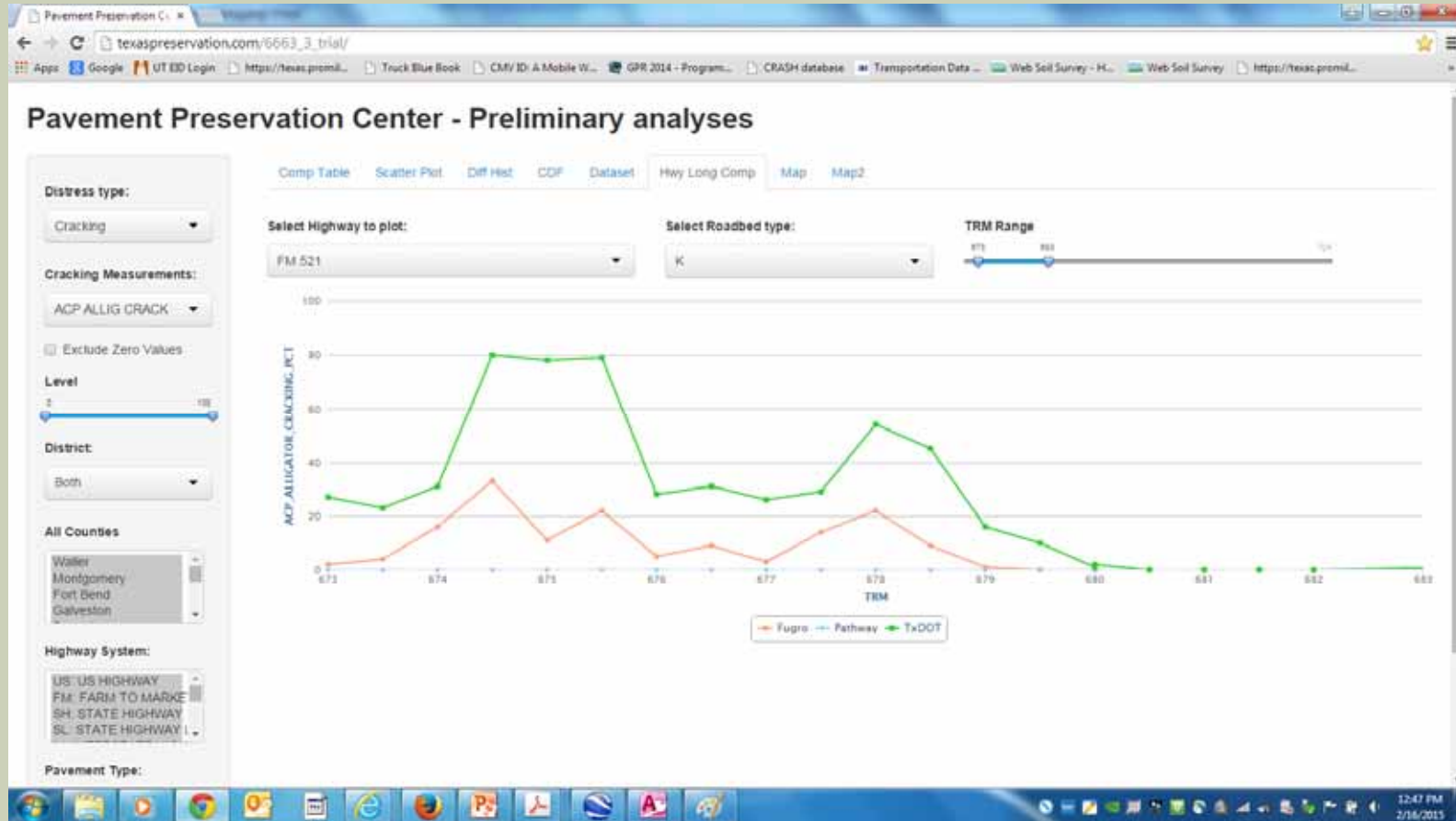
IH 45 A frontage road Shallow Rutting (PMIS 1, 2, 5, 6, 8 and 10) Bryan and Houston



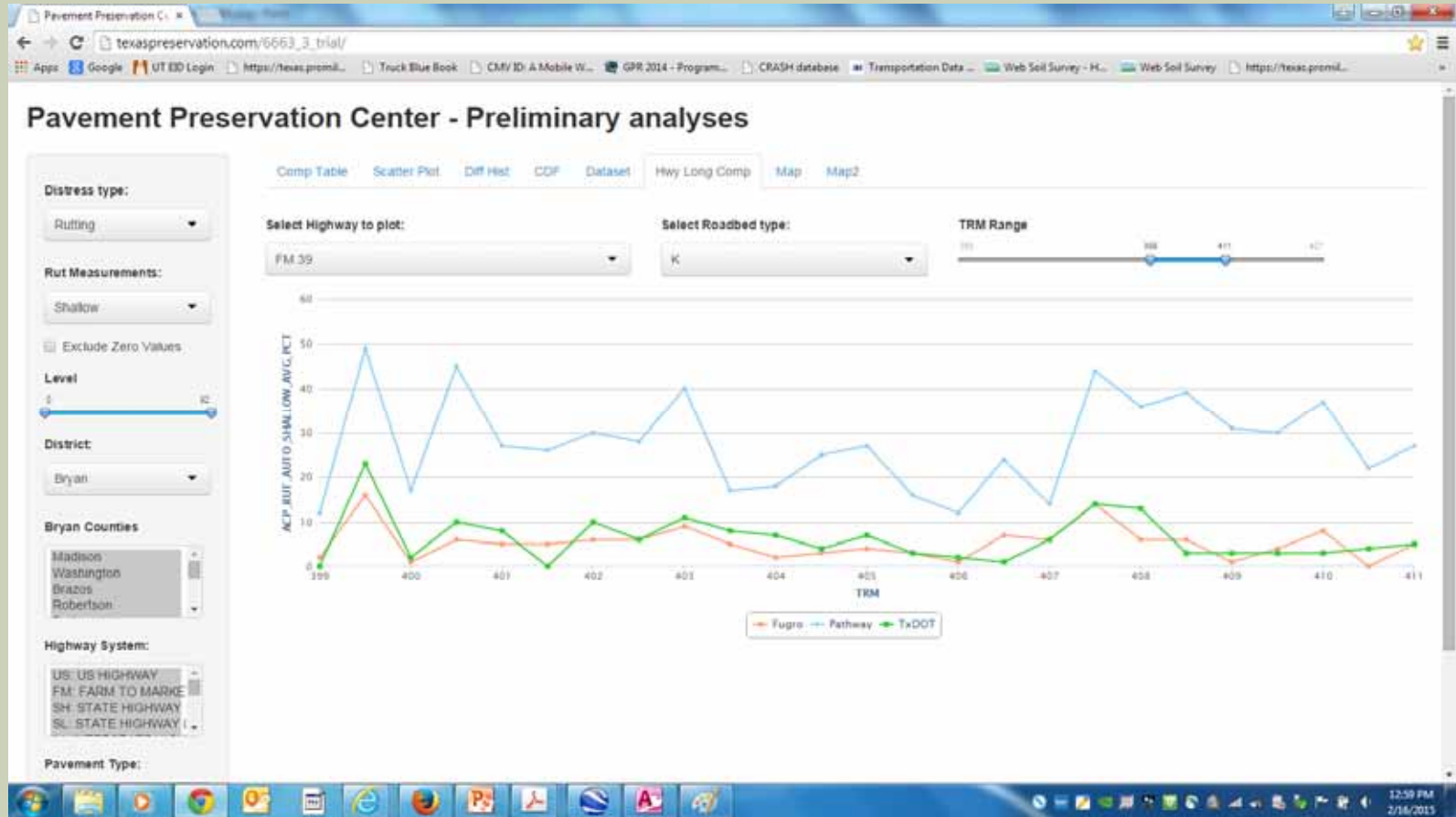
IH 45 A frontage road Deep Rutting



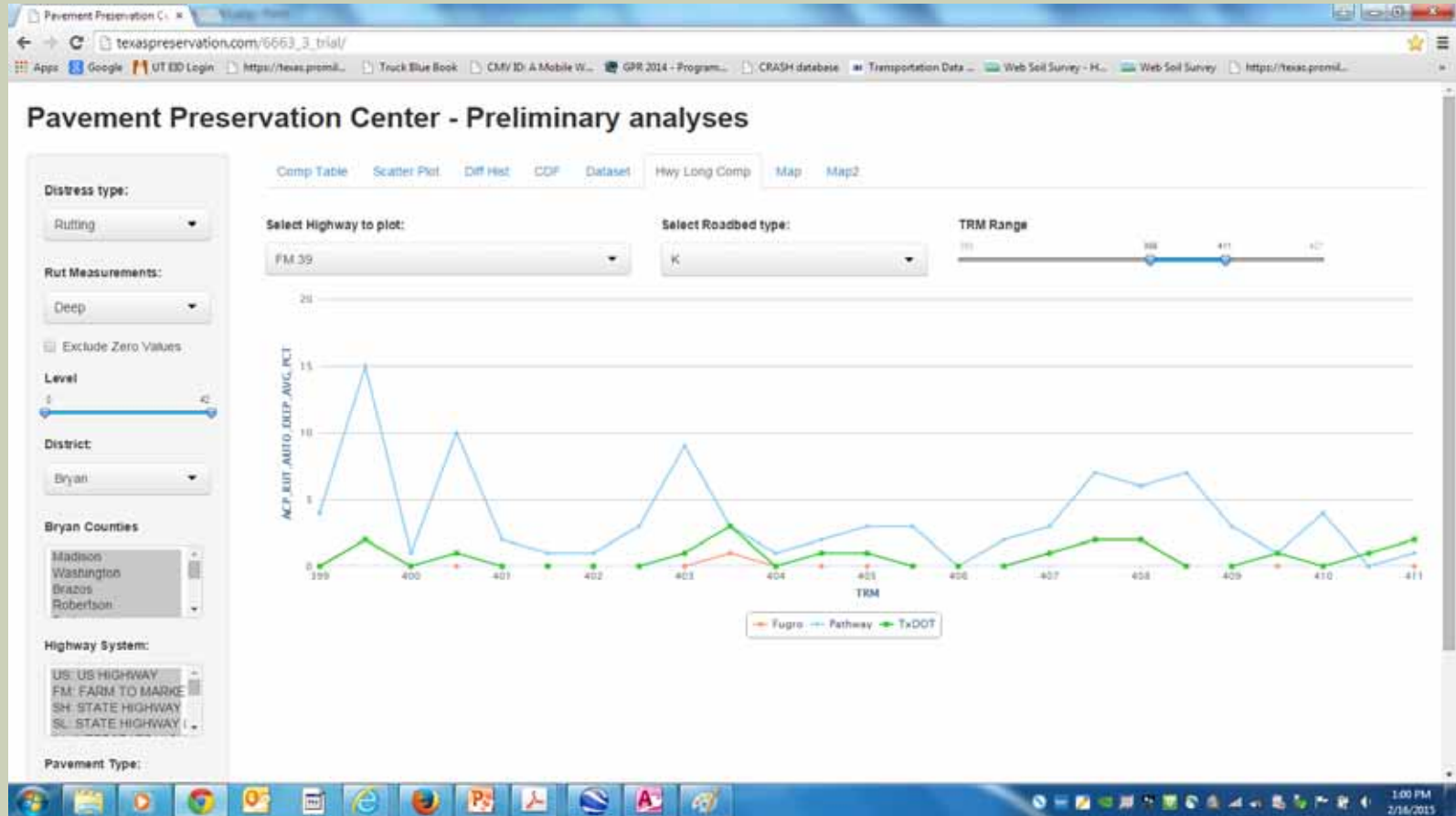
FM 521 TRM 673 – 683 Alligator Cracking



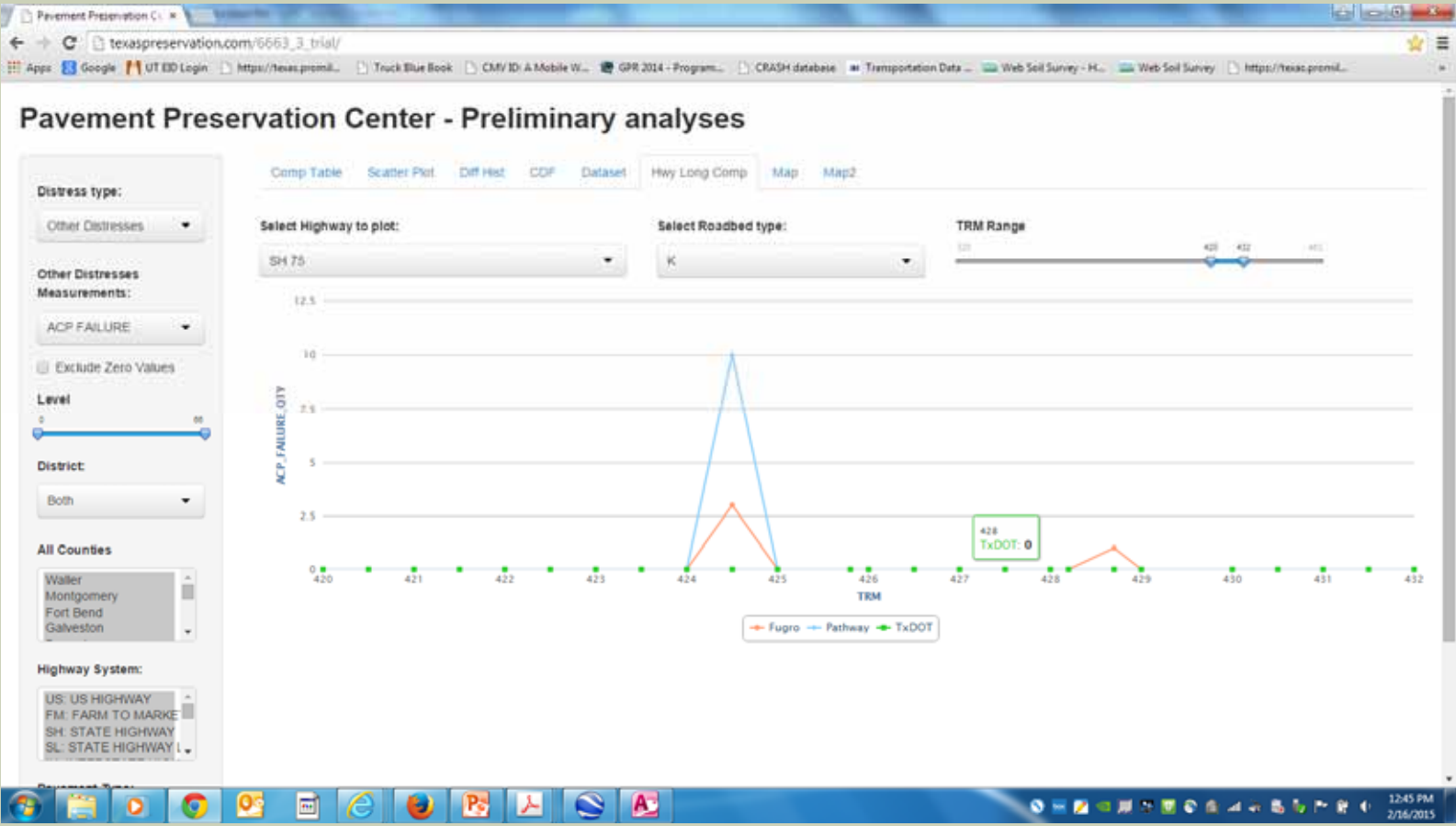
FM 39 TRM 399 – 411 Shallow Rutting



FM 39 TRM 399 – 411 Deep Rutting

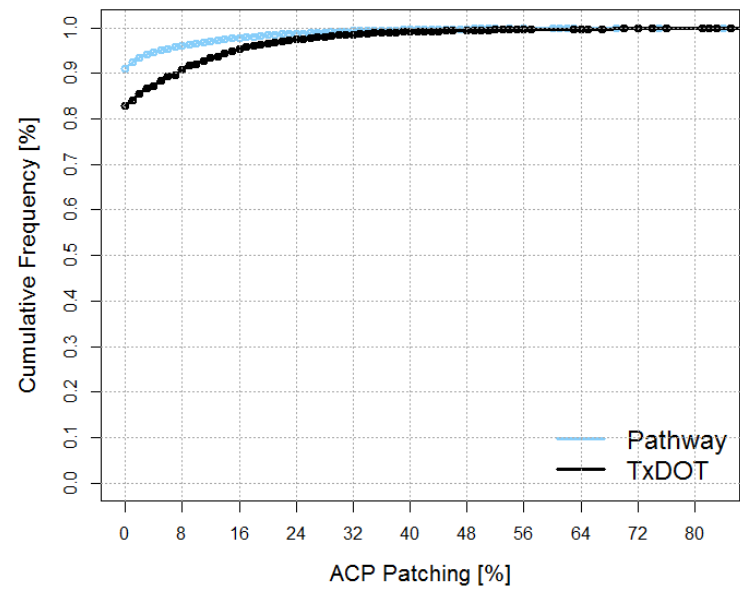
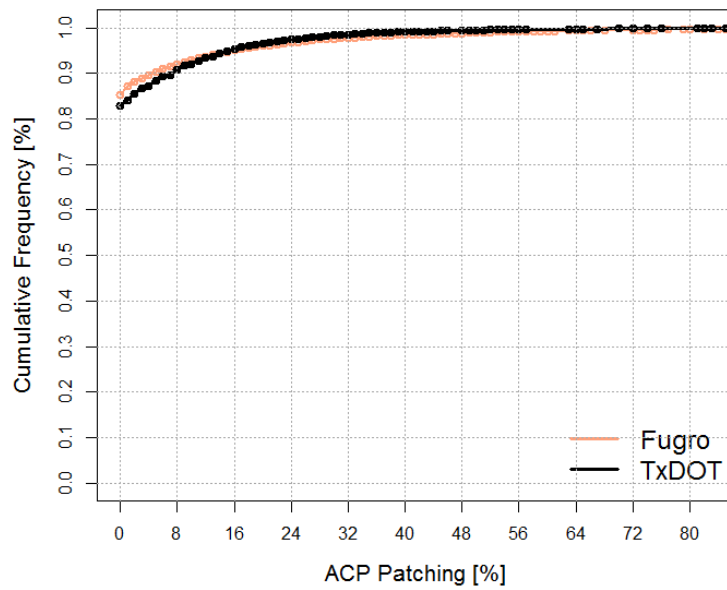


SH 75 Failures TRM 420 - 432



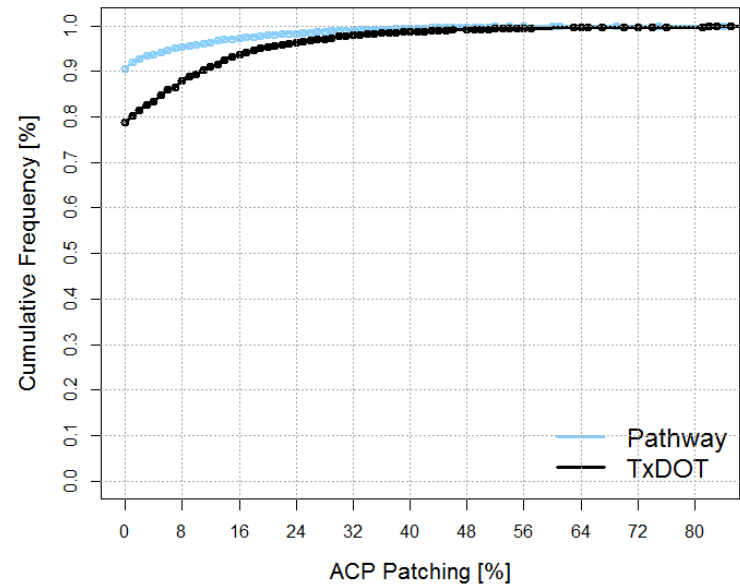
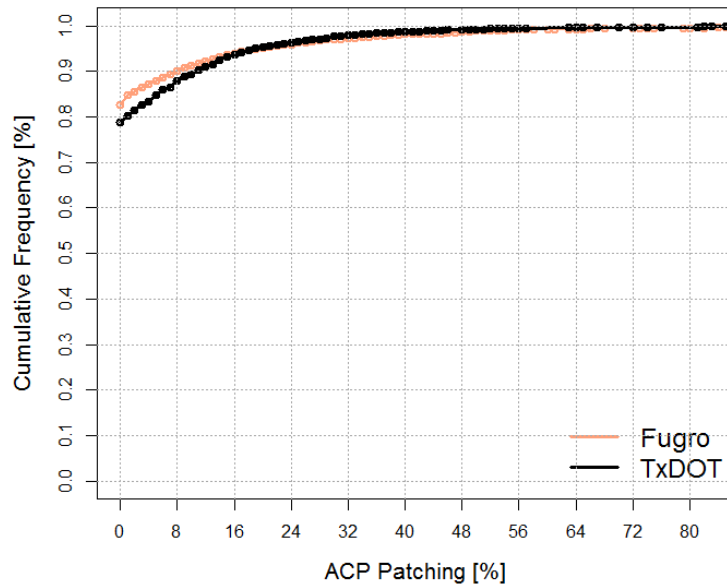
ACP PATCHING

ACP Patching - Houston and Bryan Districts - ACP



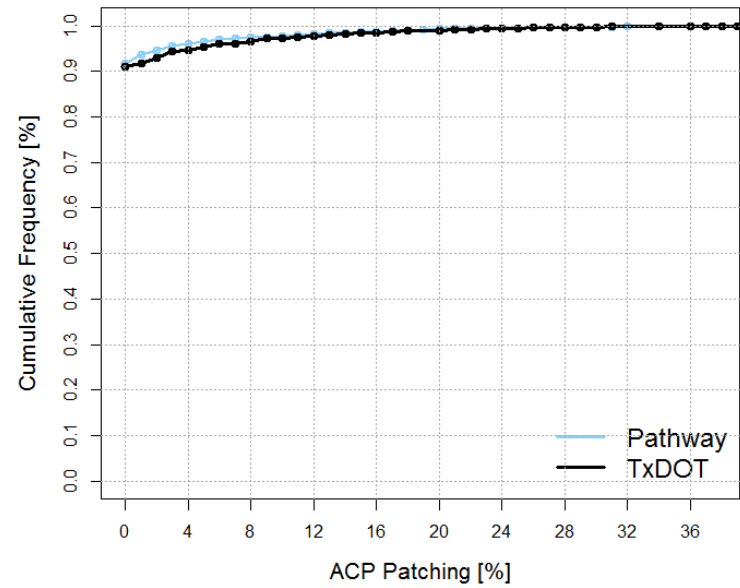
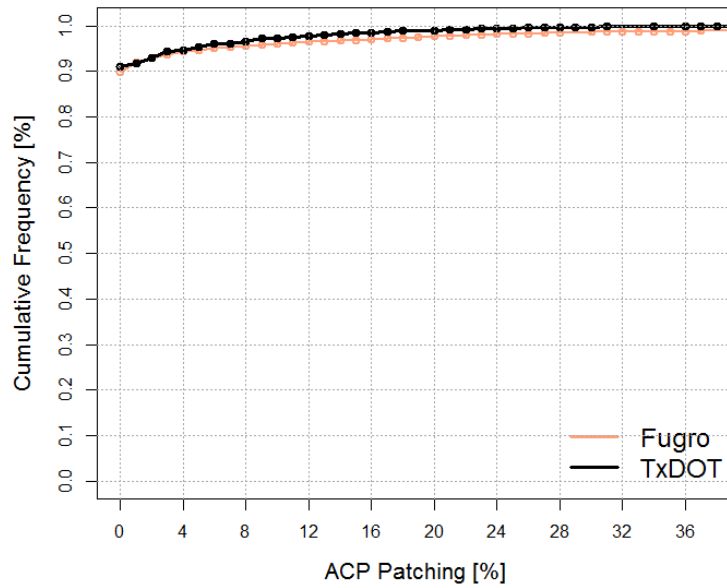
ACP PATCHING

ACP Patching - Bryan District - ACP



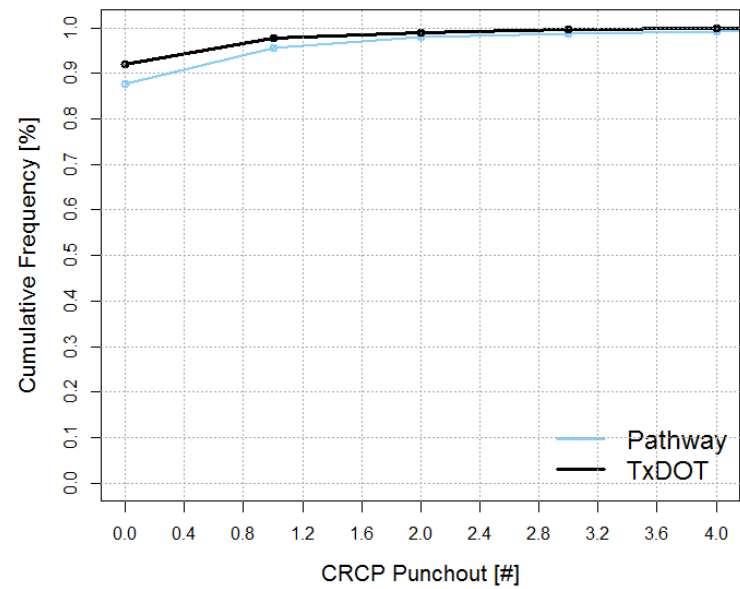
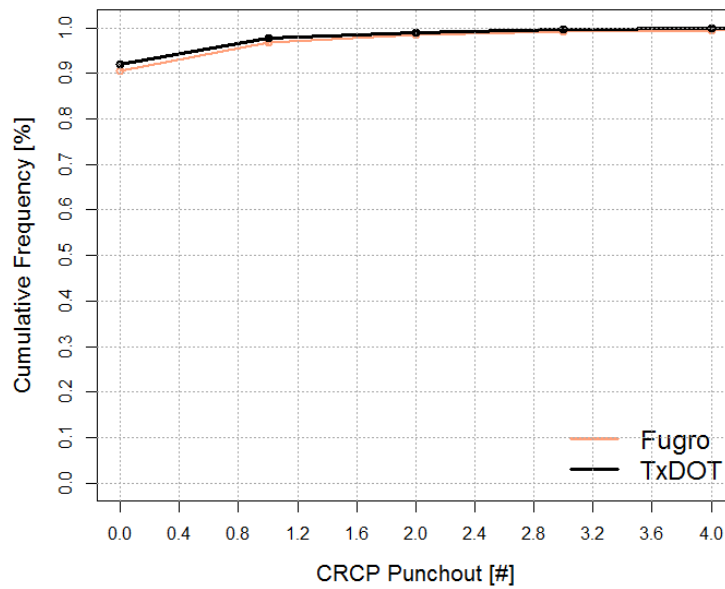
ACP PATCHING

ACP Patching - Houston District - ACP



CRCP PUNCHOUT

CRCP Punchout - Houston District - CRCP



CRCP PUNCHOUT

CRCP Punchout - Houston District - CRCP

Excluding sections with zero ACP failures = 66 cases

