

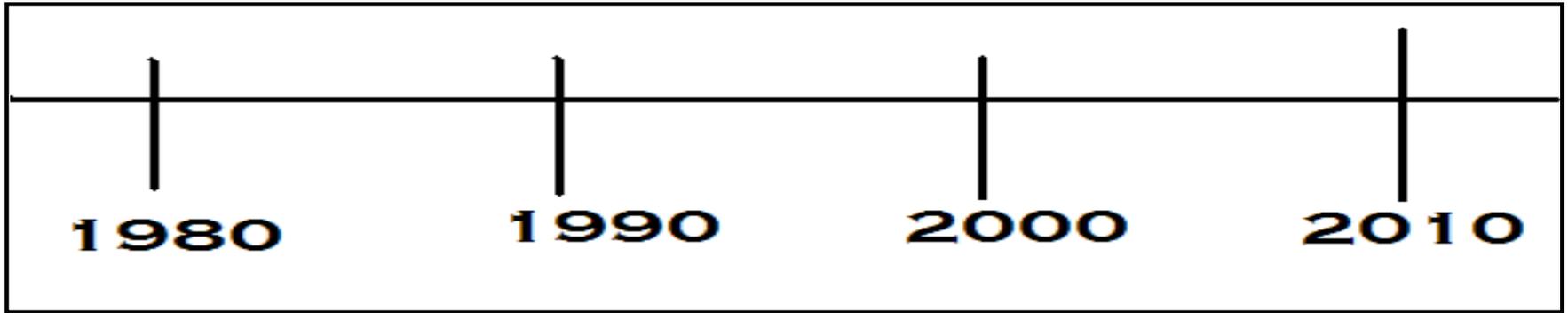
Evolution of Pavement Condition Survey, Data Collection and Performance Evaluation Technologies – Canadian Experience

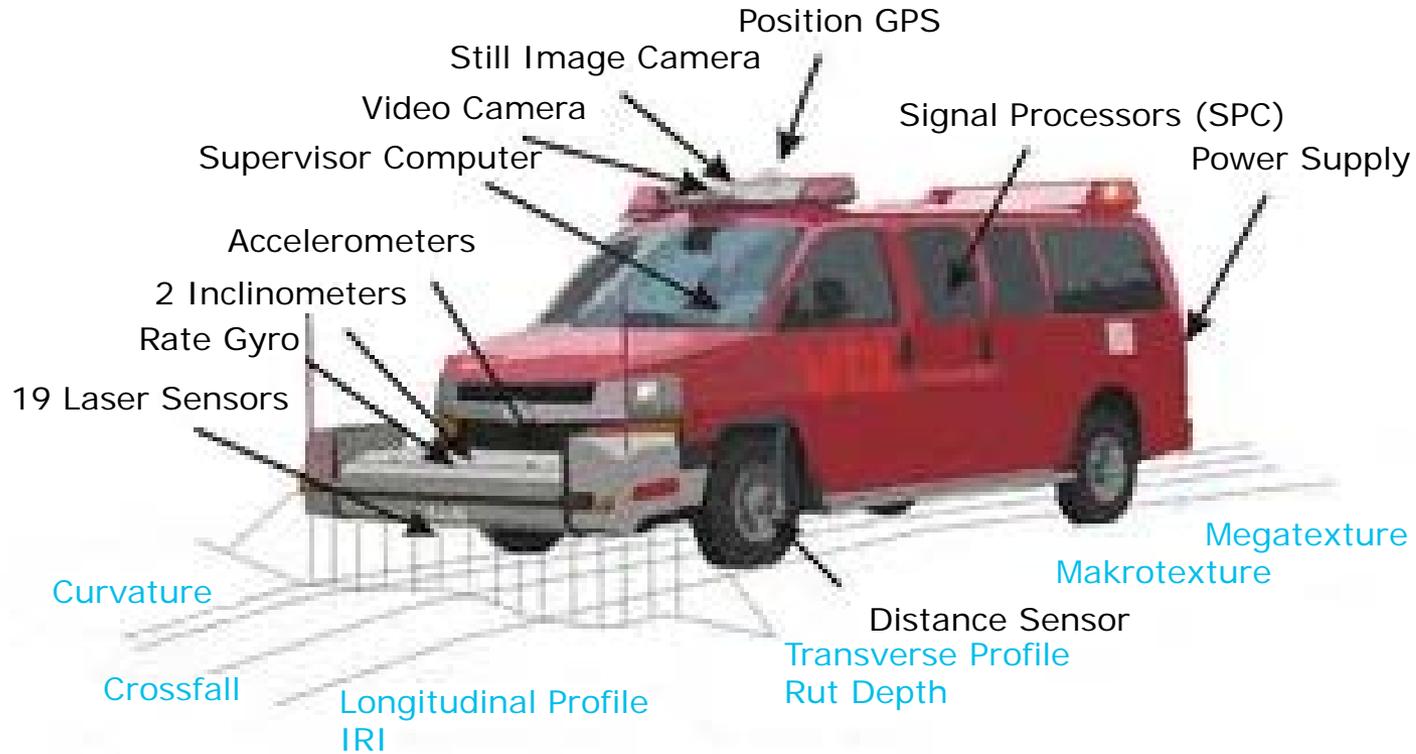
**Li Ningyuan
Ministry of Transportation of Ontario**

**RPUG 2012
Minneapolis, MN, September 26, 2012**

Highlights of Presentation

- Overview of MTO ARAN History
- Current ARAN System Components/Functions
- Automated Pavement Distress Data Collection, Evaluation and Reporting with ARAN/LCMS
- What can and can't be done with current ARAN/LCMS?
- What are the on-going work with current ARAN/LCMS?
- Potential Roles of ARAN/LCMS in supporting and implementing MTO Warranty Projects
- Issues and Discussions







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SP-021

manual for
condition rating of
surface-treated
pavements



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SP-025

manual for
condition rating of
gravel surface
roads



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guidelines



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SP-024

manual for
condition rating
of flexible
pavements

distress
manifestations

Pavement Condition Rating Manuals

Survey Month/Year :

Evaluator :

Under Construction

HWY :

LHRS :

Offset :

Direction :

Facility :

Class :

Distance From : To :

From :

To :

Reg : Dist :

**Pavement and Shoulders Distress Comments
(Maximum - 255 Characters)**

Consider Micro or Ultrathin in future. Cracks are beyond the R&S window.

Indexes/Ratios :

PCI : RCI : DMI :

PCR : RCR : IRI :

FLEXIBLE PAVEMENT CONDITION EVALUATION

AC - PAVEMENT DISTRESS TYPES

SURFACE DEFECTS	Ravelling and Course Aggregate Loss
	Flushing
SURFACE DEFORMATIONS	Rippling and Shoving
	Wheel Track Rutting
	Distortion
	Single and Multiple
LONGITUDINAL WHEEL TRACK	Alligator
	Single and Multiple
CENTRE LINE	Alligator
	Single and Multiple
PAVEMENT EDGE	Alligator
	Single and Multiple
TRANSVERSE	Half, Full and Multiple
	Alligator
CRACKING	Longitudinal Meander and Midlane
	Random

SEVERITY OF DISTRESS					SEVERITY OF DISTRESS				
1	2	3	4	5	1	2	3	4	5
1	█				1	█			
0					0				
0					0				
0					0				
3		█			1	█			
2	█				4			█	
2	█				3		█		
2	█				2	█			
0					0				
1	█				1	█			
1	█				1	█			
2	█				5			█	
1	█				1	█			
2	█				4			█	
0					0				

Re-Set All Distress To Zero

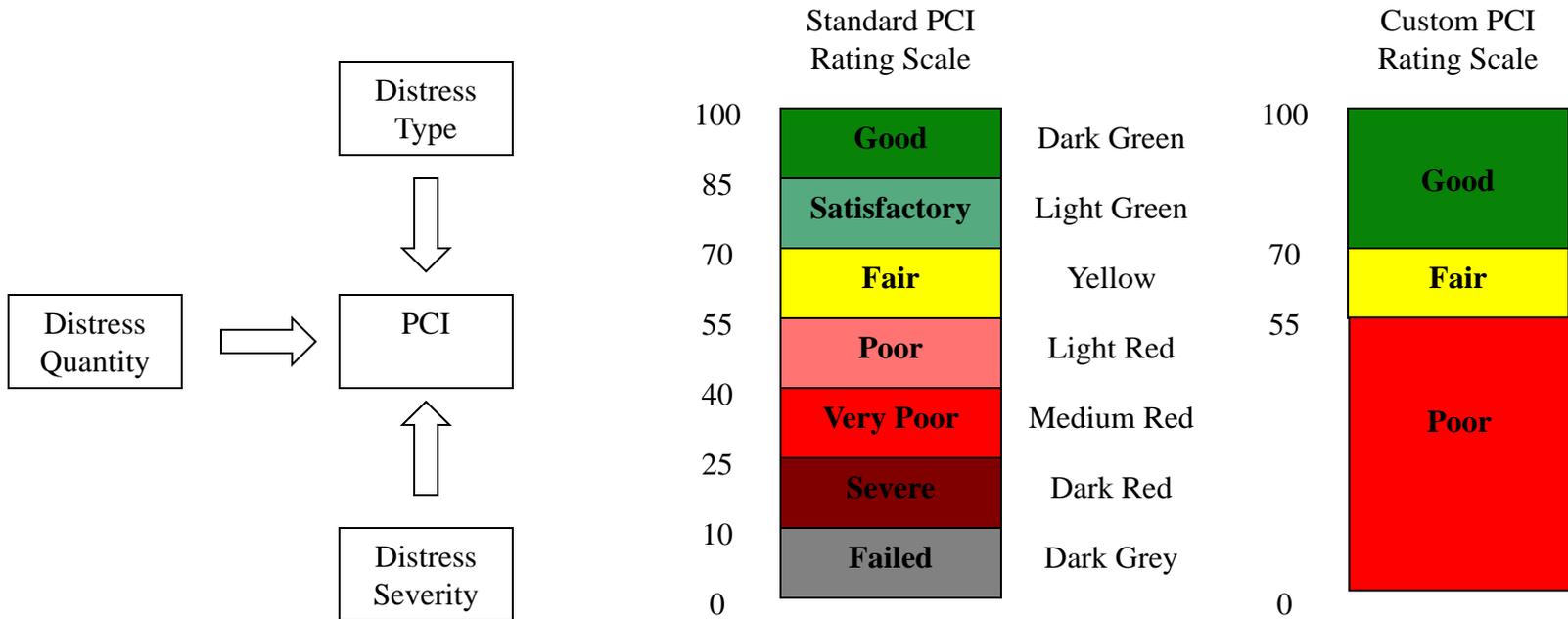
Distress Manifestation Index (DMI)

$$DMI = \sum_{i=1}^{15} w_i (s_i + e_i)$$

- i = distress type i**
- w_i = weighting factor assigned to distress i**
- s_i = severity of distress i**
- e_i = extent of distress i**

The scale of DMI is ranged from 0 to 10

Pavement Performance Ratings



Key Performance Indicators

➤ Pavement Condition Index (PCI)

- Used for evaluation of overall pavement condition
- Scaled from 0 and 100 (worst to best).
- Calculated from IRI and DMI through their functional relationship:

$$PCI = a + b \times DMI - c \times IRI$$

where, a, b, and c are the coefficients that are developed through regression analysis for each of the individual pavement types.

Performance Indicator VS Condition Category

Condition Category Ranges
3-1-cat

Condition Category

Categories:

#	Category	Color for Map	Value
1:	Poor		3
2:	Fair		3
3:	Good		3
4:	Excellent		1
5:			1
6:			1
7:			1
8:			1
9:			1
10:			1

Numeric Ranges

Functional Class:

	RCI	DMI	SAI	PCI	IRI
<=	5.50	5.50	5.50	55.00	>= 3.50
<=	7.50	7.50	7.50	75.00	>= 3.00
<=	10.00	10.00	10.00	100.00	>= 2.00
<=	10.00	10.00	10.00	100.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00
<=	0.00	0.00	0.00	0.00	>= 0.00

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Current ARAN Sub-systems



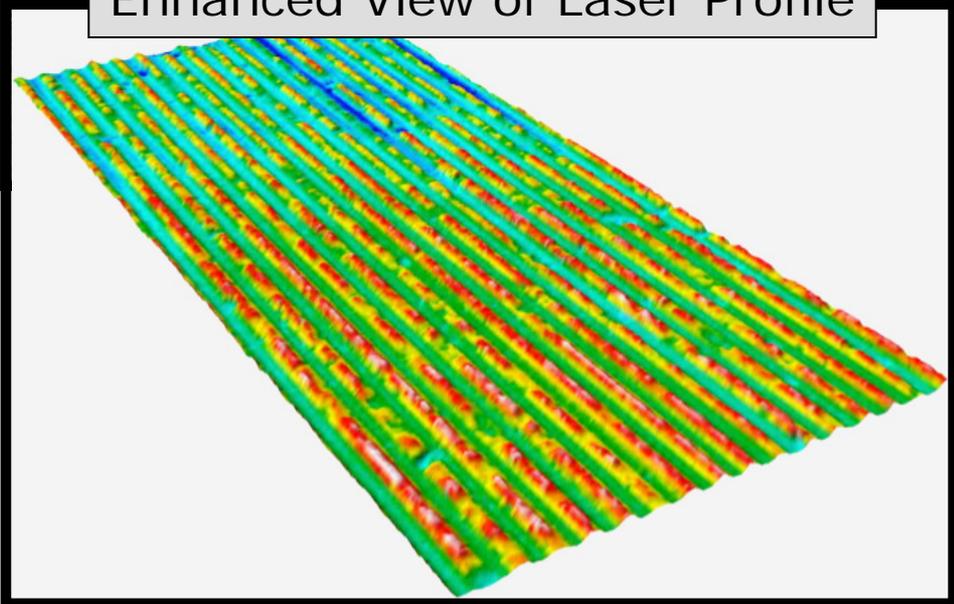
- Diabase Roughness Sub-System
- LCM Struckling, Rolling and Vibration (SRM)

Pavement Roughness (IRI)

- RoLine Laser
- 100mm footprint
- Samples longitudinally every 25mm continuously



Enhanced View of Laser Profile



Right Of Way Images:

- Approx. 140 degree Field of View between two cameras
- High definition
- Calibrated for feature extraction using software tools

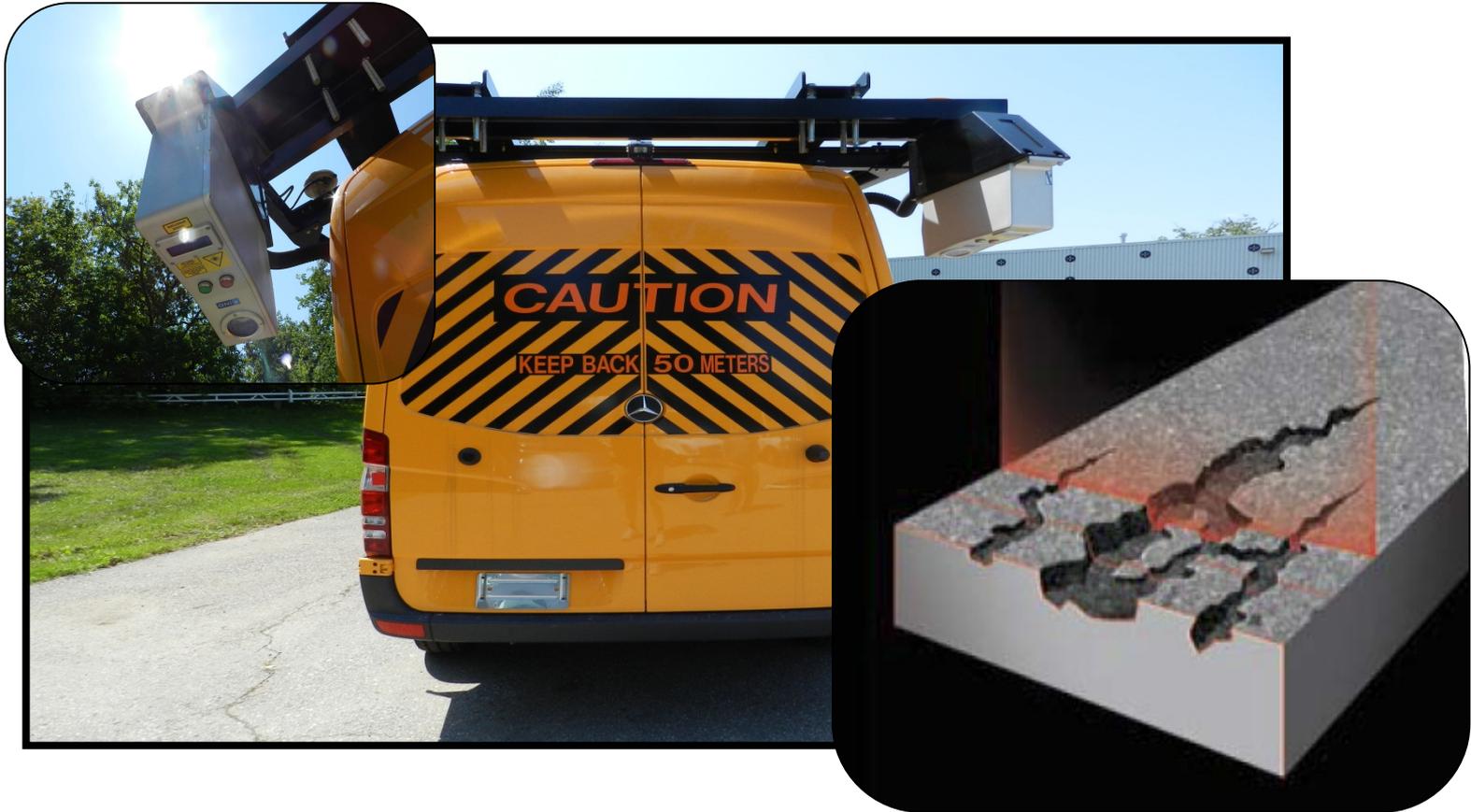


MTO/LCMS - 3D Pavement System

- INO/Pavemetrics
- LCMS – Laser Crack Measurement System
- LRMS - Laser Rut Measurement System

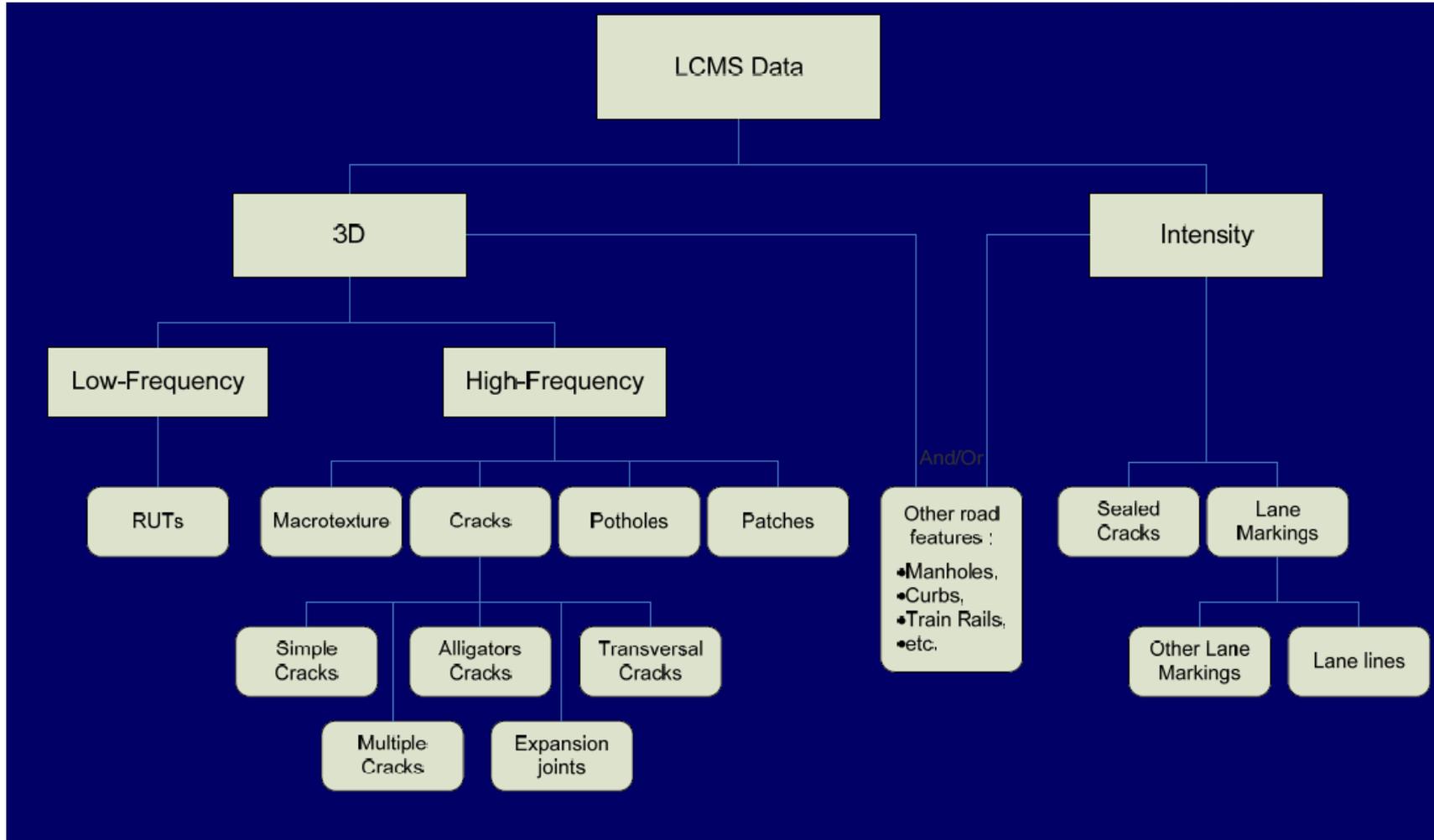


LCMS Capabilities and Applications

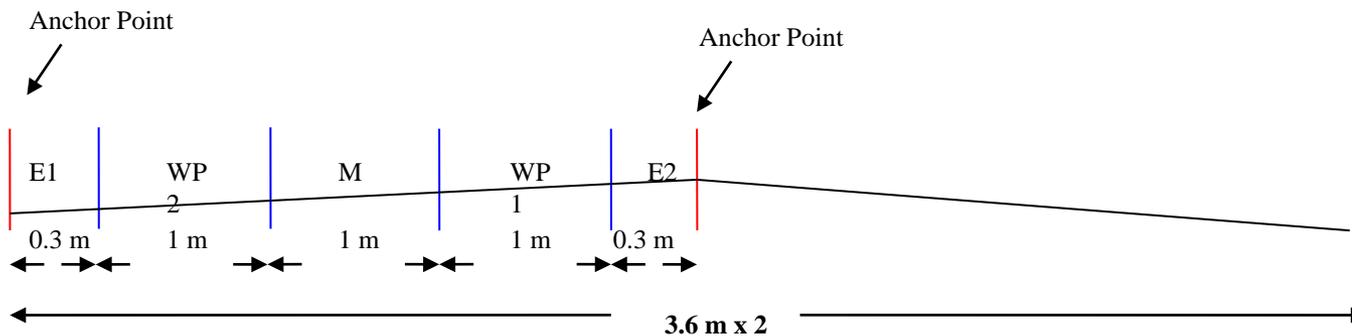


- LCMS – Calculates Rutting in Both Wheel Paths
- Determines Crack, Width, Depth, and Extent.

LCMS Capabilities and Applications

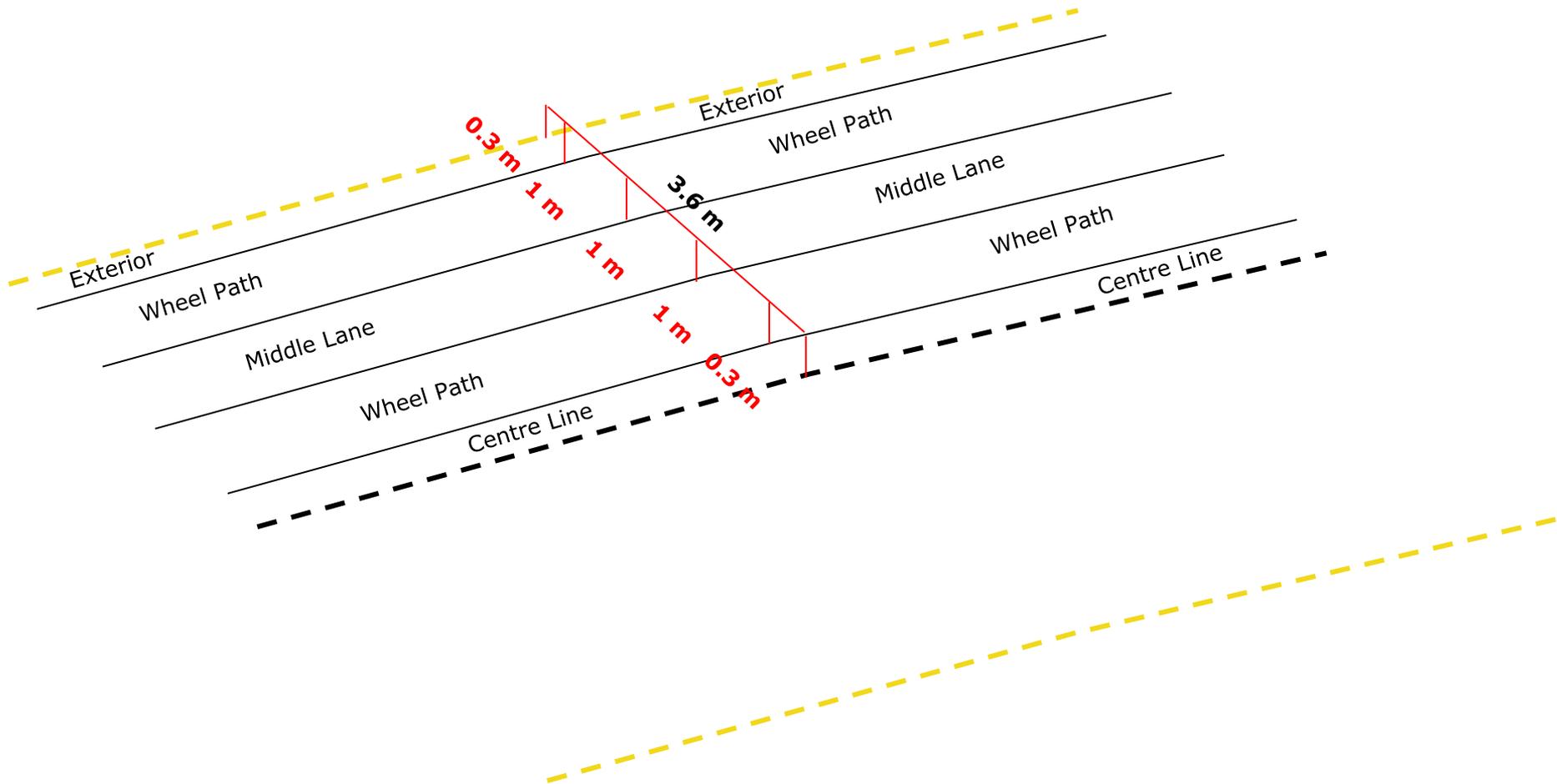


Zones Defined for Distress Data Collecting, Evaluation and Reporting

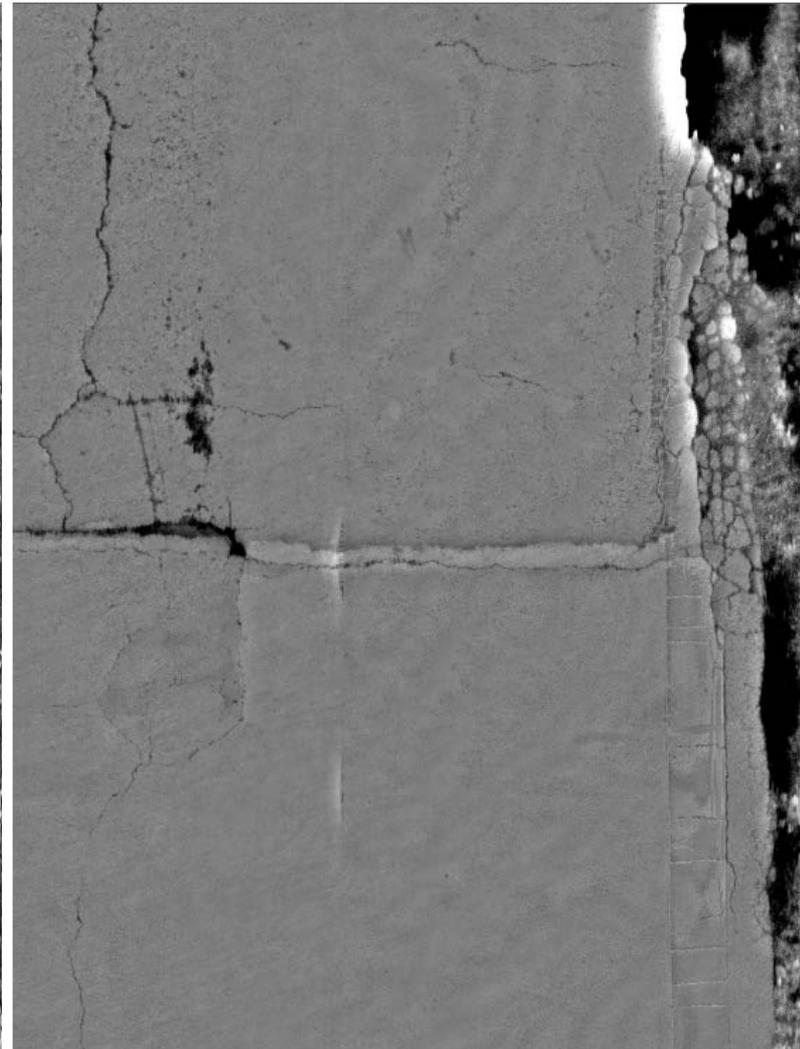
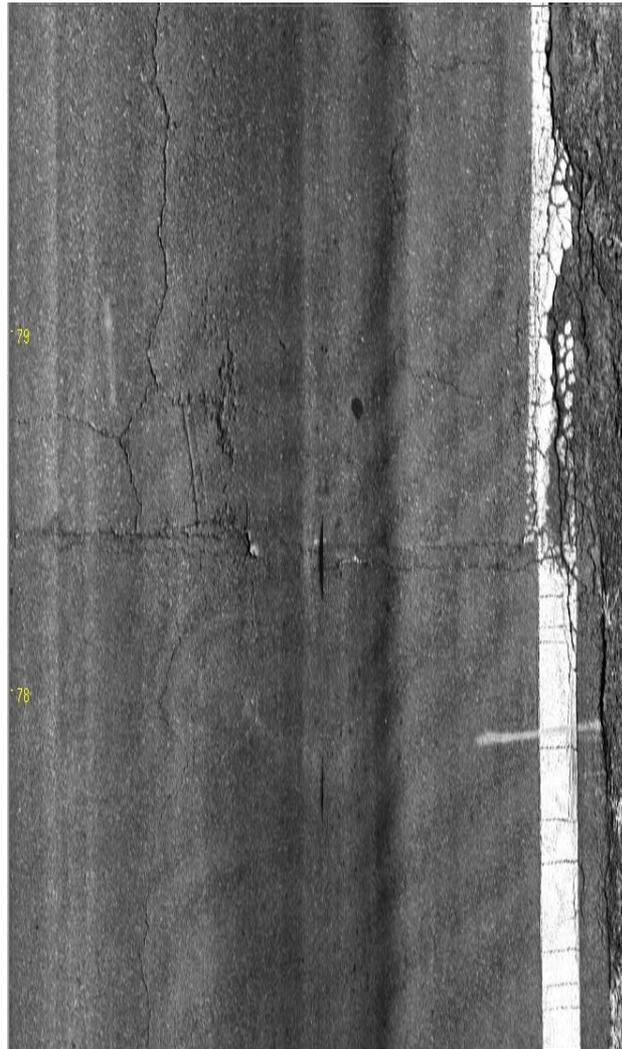
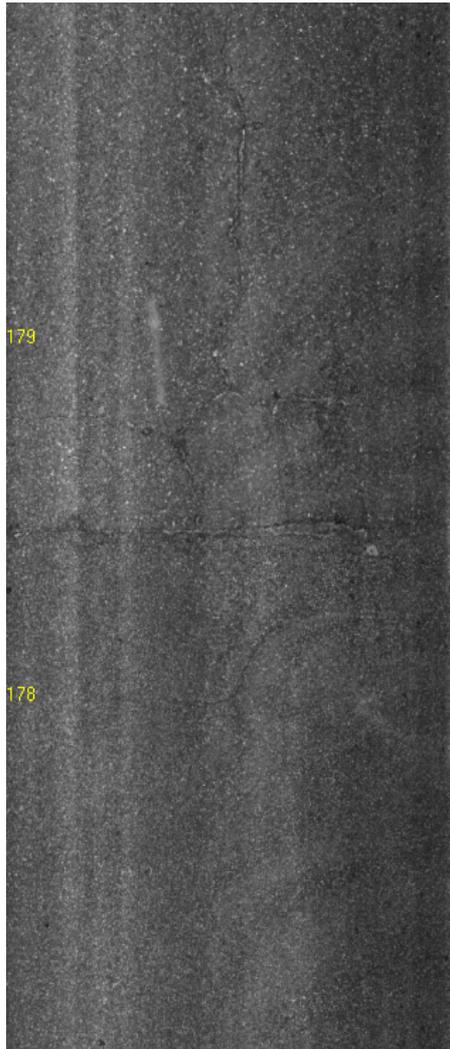


Anchor points can be either on edge or centreline and they can be allocated by ARAN. 3.6 m wide pavement image is used for evaluating pavement conditions

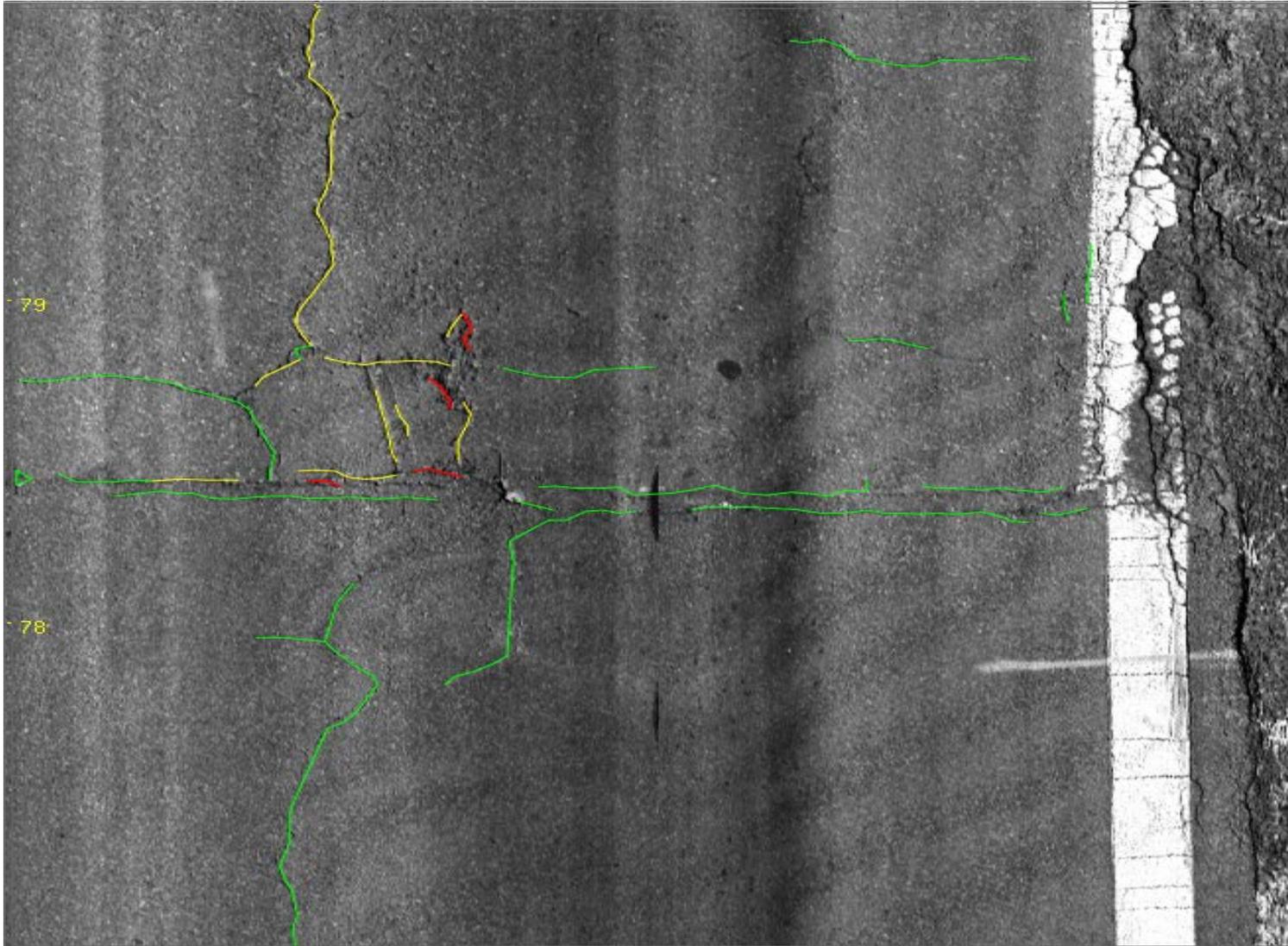
Zones Defined for Distresses Data Collecting, Evaluation and Reporting



Sample Images of Pavement Distresses Taken from ARAN/LCMS



LCMS- Crack Detection & Classification



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Which distresses can't be identified

Individual Distresses for Asphalt Concrete (AC) Pavement	ARAN/LCMS Capability
Ravelling and Coarse Aggregate Loss	x
Flushing	x
Rippling and Shoving	x
Wheel Track Rutting	✓
Distortion	x
Longitudinal Wheel Track: Sing. / Multi.	✓
Longitudinal Wheel Track: Alligator	✓
Longitudinal Meandering and Midlane	✓
Transverse: Half, Full and Multiple	✓
Transverse: Alligator	x
Centreline: Single and Multiple	✓
Centreline: Alligator	✓
Pavement Edge: Single and Multiple	✓
Pavement Edge: Alligator	✓
Random/Map	x

- Of the 15 individual distresses known to effect AC pavements the ARAN registers eight
- Ravelling and Course Aggregate Loss, Distortion, and Flushing have been omitted. Texture data is collected but not readily usable
- Map and random cracks are re-classified as alligator cracks
- Rutting data will be used as an independent component in PCI Calculation

MTO ARAN/LCMS Capabilities

- The ARAN/LCMS identifies and reporting 8 individual distresses, and providing evaluation results with 6 quantitative Metrics for a given highway section, at every 10 m pavement section
- **Eight Individual Distresses:**
 1. Midlane Single & Multiple Cracking
 2. Single & Multiple Pavement Edge Cracking
 3. Longitudinal Wheel Track Cracking
 4. Single & Multiple Transverse Cracking
 5. Centre Line Single & Multiple Cracking
 6. Centre Line Alligator Cracking
 7. Wheel Path Alligator Cracking
 8. Alligator Pavement Edge Cracking
- **Quantitative Metrics**
 1. Extent (m)
 2. Count
 3. Area (m²)
 4. Length (m)
 5. Width (m)
 6. Transverse Extent (m)

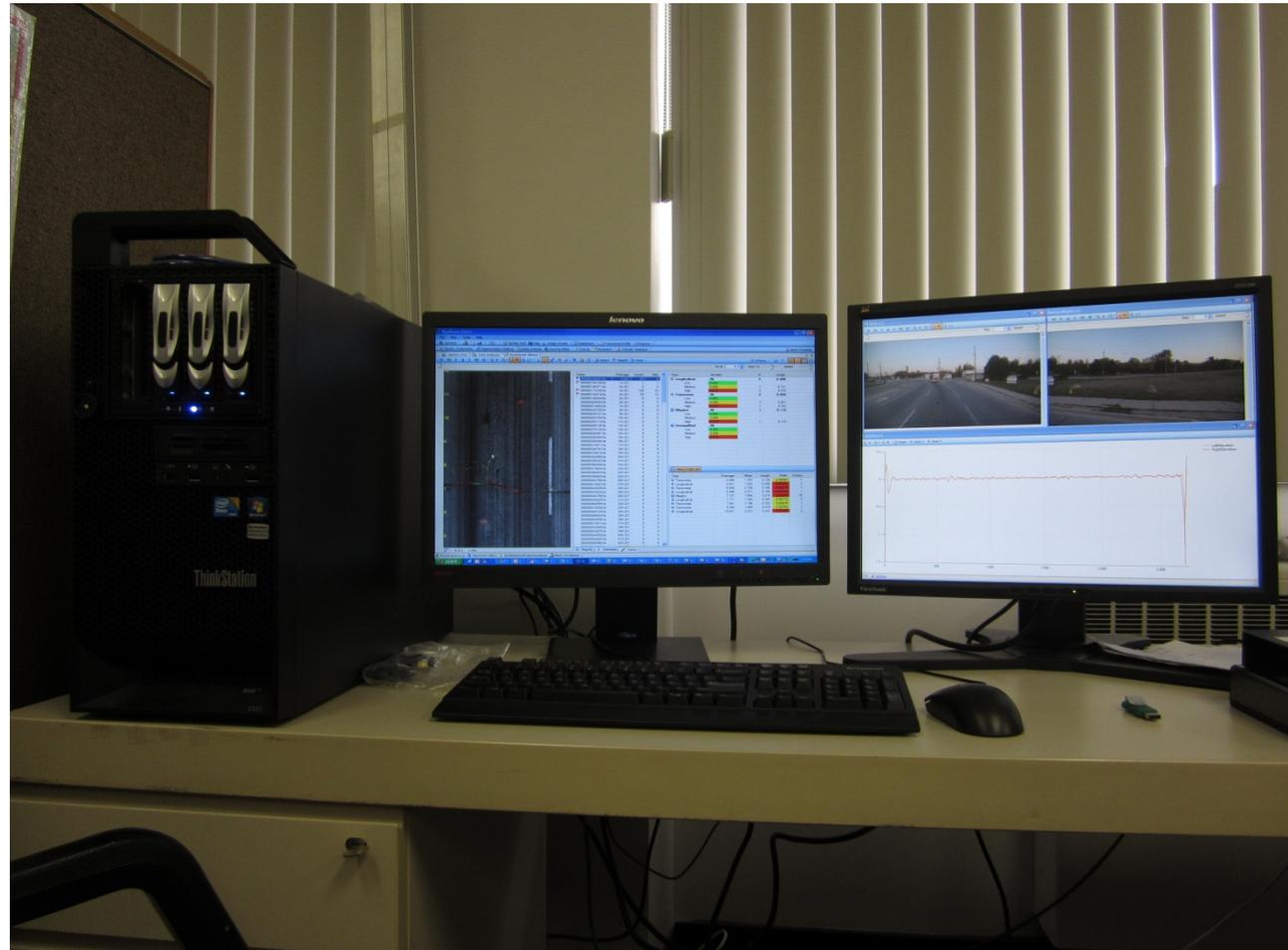
An Example of Reporting Quantitative Metrics for an Identified Distress by ARAN/LCMS

Identification Metrics	Slight	Moderate	Severe
Count	2	1	1
Crack Area (m ²)	1.59	1.44	0.23
Length (m)	5	3	2.5
Extent (m)	2.6	1.8	1.5
Transverse Extent (m)	1	0.8	0.5
Width (m)	0.004	0.012	0.025

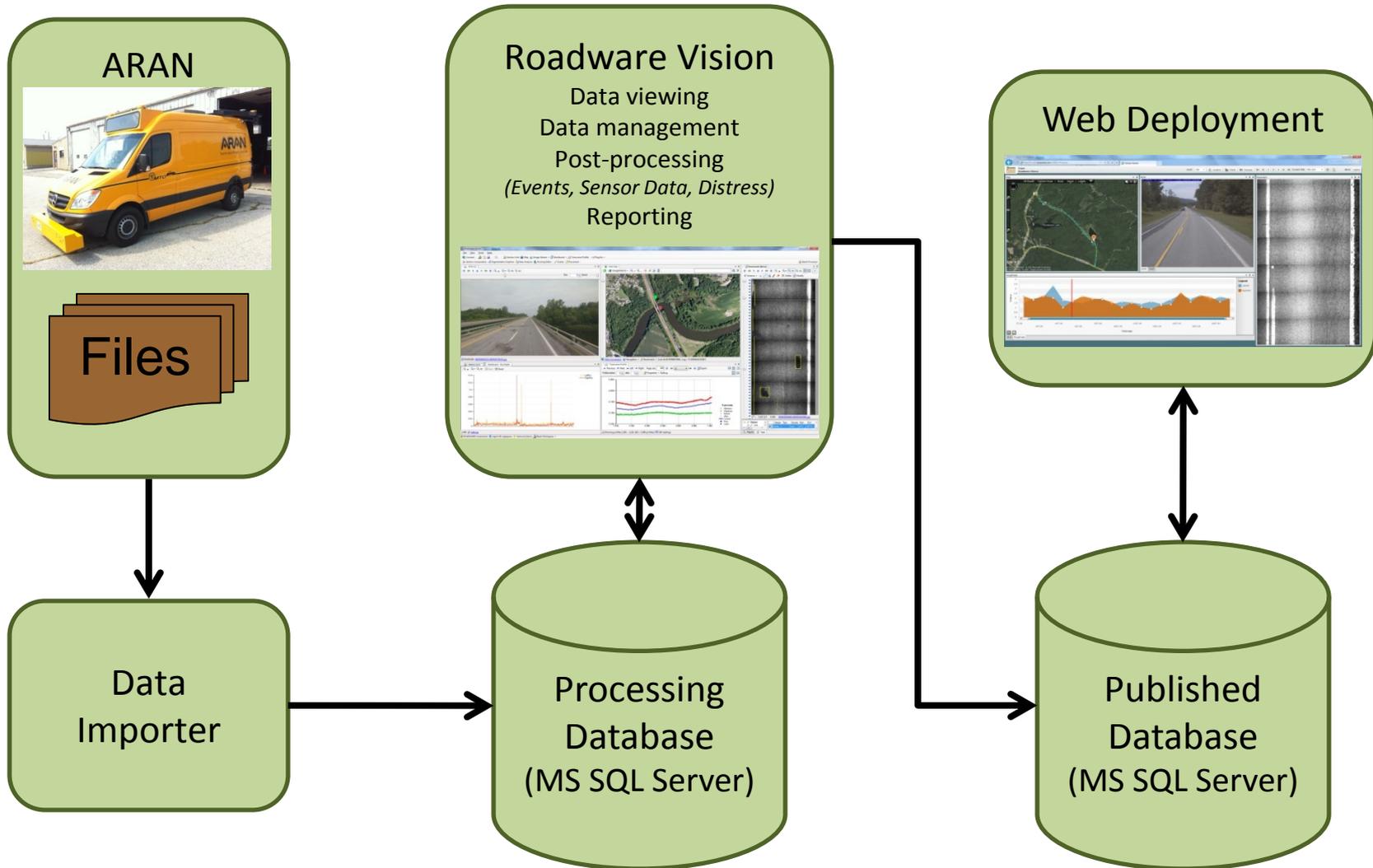
- When multiple cracks of the same type are evident then aggregation is applied to sum the identified distresses occurs in different severities
- Crack length and area are summed, crack width is averaged.
- Count represents the number of cracks identified. For alligator cracking, count represents the number of times the distress appears.

Data Import/Vision Workstation

- Premium Desktop Workstation;
- Removable hard drives allow for fastest transfer rate of data;
- Dual monitors for optimal data display;
- (not shown) 12 TB data storage unit.

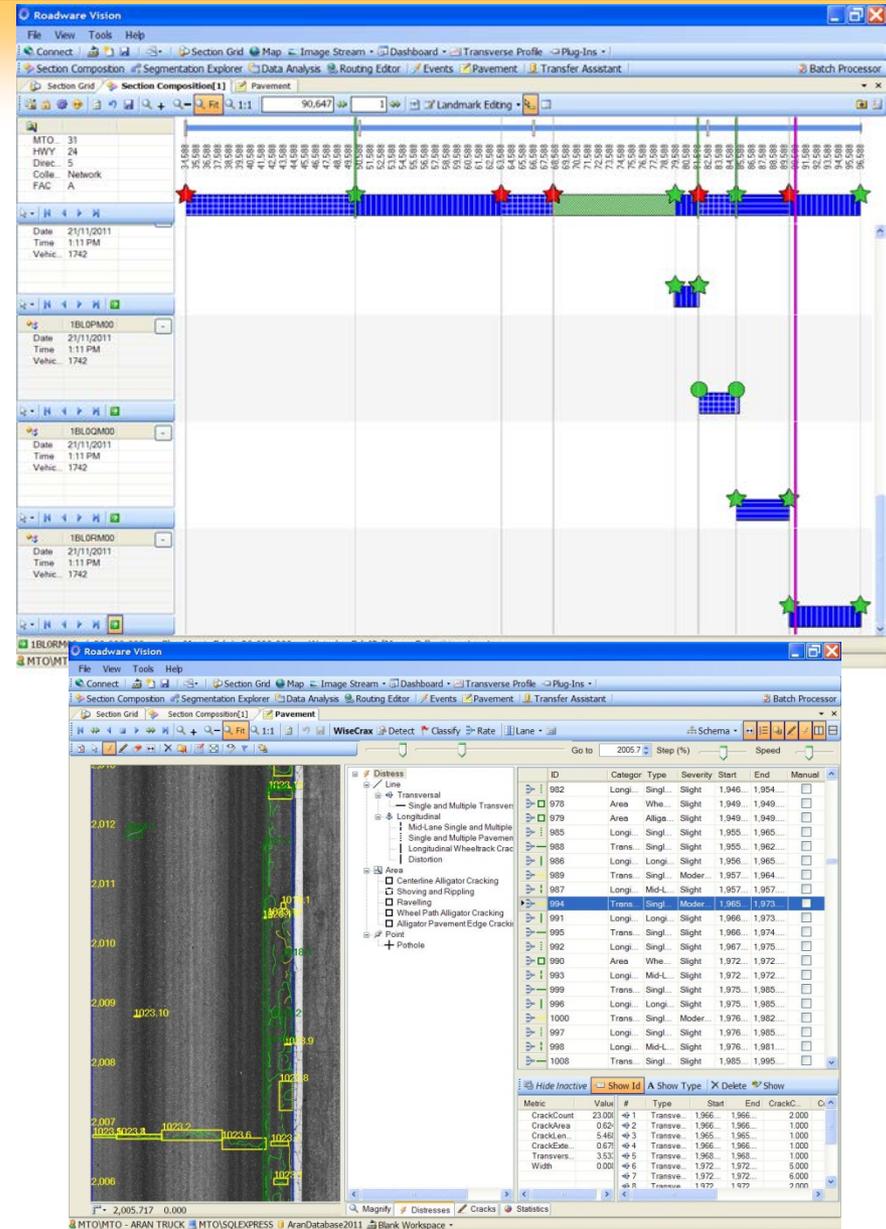


Collection and Process Workflow



Vision Software

- Run Quality Control Checks on Imported Data to detect missing data or imagery;
- Auto Segment (by GPS) Collected Data to LHRs Routes;
- Extract/Detect pavement data characteristics and crack distresses, i.e. cracking, rutting and texture.



ARAN/LCMS Report Generator

Microsoft Excel - SENSOR DATA-Metric_10.csv

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10

N54 181.960532400306

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	F
1	IDLocator	L_HWY	L_Dir	L_Fac	UniqueRur	Collection\	DCSTimeS	IDSession	BeginDista	EndDistan	BeginChai	EndChains	Status	Elevation	Grade	Head
2	2	6 N	A	1A602M00	1742	#####		3	0	8.190501	0	10	Matched	173.3751	-2.04299	283.
3	2	6 N	A	1A602M00	1742	#####		3	8.190501	16.381	10	20	Matched	173.7658	-2.66501	282.
4	2	6 N	A	1A602M00	1742	#####		3	16.381	24.5715	20	30	Matched	174.1564	-2.18515	281.
5	2	6 N	A	1A602M00	1742	#####		3	24.5715	32.76201	30	40	Matched	174.547	-1.78994	279.
6	2	6 N	A	1A602M00	1742	#####		3	32.76201	40.95251	40	50	Matched	174.9376	-1.75291	278.
7	2	6 N	A	1A602M00	1742	#####		3	40.95251	49.14301	50	60	Matched	175.3282	-1.31677	276.
8	2	6 N	A	1A602M00	1742	#####		3	49.14301	57.33351	60	70	Matched	175.7188	-1.02126	275.
9	2	6 N	A	1A602M00	1742	#####		3	57.33351	65.52401	70	80	Matched	176.1095	-1.28006	273.
10	2	6 N	A	1A602M00	1742	#####		3	65.52401	73.71451	80	90	Matched	176.5001	-1.25979	272.
11	2	6 N	A	1A602M00	1742	#####		3	73.71451	81.90501	90	100	Matched	176.8907	-1.22515	271.
12	2	6 N	A	1A602M00	1742	#####		3	81.90501	90.09552	100	110	Matched	177.2813	-1.25065	270.
13	2	6 N	A	1A602M00	1742	#####		3	90.09552	98.28602	110	120	Matched	177.6719	-1.37881	269.
14	2	6 N	A	1A602M00	1742	#####		3	98.28602	106.4765	120	130	Matched	178.0625	-1.45778	268.
15	2	6 N	A	1A602M00	1742	#####		3	106.4765	114.667	130	140	Matched	178.4532	-1.25995	268.
16	2	6 N	A	1A602M00	1742	#####		3	114.667	122.8575	140	150	Matched	178.8438	-1.17782	267.
17	2	6 N	A	1A602M00	1742	#####		3	122.8575	131.048	150	160	Matched	179.2344	-1.09857	267.
18	2	6 N	A	1A602M00	1742	#####		3	131.048	139.2385	160	170	Matched	179.625	-0.9967	267.
19	2	6 N	A	1A602M00	1742	#####		3	139.2385	147.429	170	180	Matched	180.0156	-0.94662	266.
20	2	6 N	A	1A602M00	1742	#####		3	147.429	155.6195	180	190	Matched	180.4062	-0.72685	266.
21	2	6 N	A	1A602M00	1742	#####		3	155.6195	163.81	190	200	Matched	180.7969	-0.67317	266.
22	2	6 N	A	1A602M00	1742	#####		3	163.81	172.0005	200	210	Matched	181.1875	-0.70178	266.
23	2	6 N	A	1A602M00	1742	#####		3	172.0005	180.191	210	220	Matched	181.5532	-0.85455	266.
24	2	6 N	A	1A602M00	1742	#####		3	180.191	188.3815	220	230	Matched	181.5707	-0.533	266.
25	2	6 N	A	1A602M00	1742	#####		3	188.3815	196.572	230	240	Matched	181.5963	-0.40771	266.
26	2	6 N	A	1A602M00	1742	#####		3	196.572	204.7625	240	250	Matched	181.6031	-0.46196	267.
27	2	6 N	A	1A602M00	1742	#####		3	204.7625	212.953	250	260	Matched	181.6159	-0.51105	267.
28	2	6 N	A	1A602M00	1742	#####		3	212.953	221.1435	260	270	Matched	181.6286	-0.50006	267.
29	2	6 N	A	1A602M00	1742	#####		3	221.1435	229.334	270	280	Matched	181.6414	-0.48452	267.
30	2	6 N	A	1A602M00	1742	#####		3	229.334	237.5245	280	290	Matched	181.6541	-0.56733	267.
31	2	6 N	A	1A602M00	1742	#####		3	237.5245	245.715	290	300	Matched	181.6669	-0.45968	267.
32	2	6 N	A	1A602M00	1742	#####		3	245.715	253.9055	300	310	Matched	181.6797	-0.49102	267.
33	2	6 N	A	1A602M00	1742	#####		3	253.9055	262.096	310	320	Matched	181.6924	-0.61326	267.
34	2	6 N	A	1A602M00	1742	#####		3	262.096	270.2865	320	330	Matched	181.7052	-0.84999	267.
35	2	6 N	A	1A602M00	1742	#####		3	270.2865	278.477	330	340	Matched	181.718	-0.73262	267.
36	2	6 N	A	1A602M00	1742	#####		3	278.477	286.6675	340	350	Matched	181.7307	-0.84849	267.
37	2	6 N	A	1A602M00	1742	#####		3	286.6675	294.8581	350	360	Matched	181.7435	-0.8672	268.
38	2	6 N	A	1A602M00	1742	#####		3	294.8581	303.0486	360	370	Matched	181.7563	-0.74487	269.
39	2	6 N	A	1A602M00	1742	#####		3	303.0486	311.2391	370	380	Matched	181.769	-0.61377	270.
40	2	6 N	A	1A602M00	1742	#####		3	311.2391	319.4296	380	390	Matched	181.7818	-0.56723	271.
41	2	6 N	A	1A602M00	1742	#####		3	319.4296	327.6201	390	400	Matched	181.7946	-0.61454	271.
42	2	6 N	A	1A602M00	1742	#####		3	327.6201	335.8106	400	410	Matched	181.8073	-1.0003	271.

Ready

Model for Calculating DMI with ARAN/LCMS

$$DMI_{auto} = \sum_{I=1}^8 W_I (Metric I_L + Metric I_M + Metric I_S)$$

Where:

- DMI_{auto} = DMI value calculated from automated distress evaluation
- W_i = Weighting factor assigned to distress I
- $Metric I_l$ = Sum of all metrics for Distress I at the slight severity level
- $Metric I_m$ = Sum of all metrics for Distress I at the moderate severity level
- $Metric I_s$ = Sum of all metrics for Distress I at the severe severity level
- MAX = The worst case scenario for an individual distress.

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QUESTIONS?

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