Using Automatically Collected Data to Improve Pavement Performance Evaluation and Rehabilitation Programming

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Ontario Ministry of Transportation

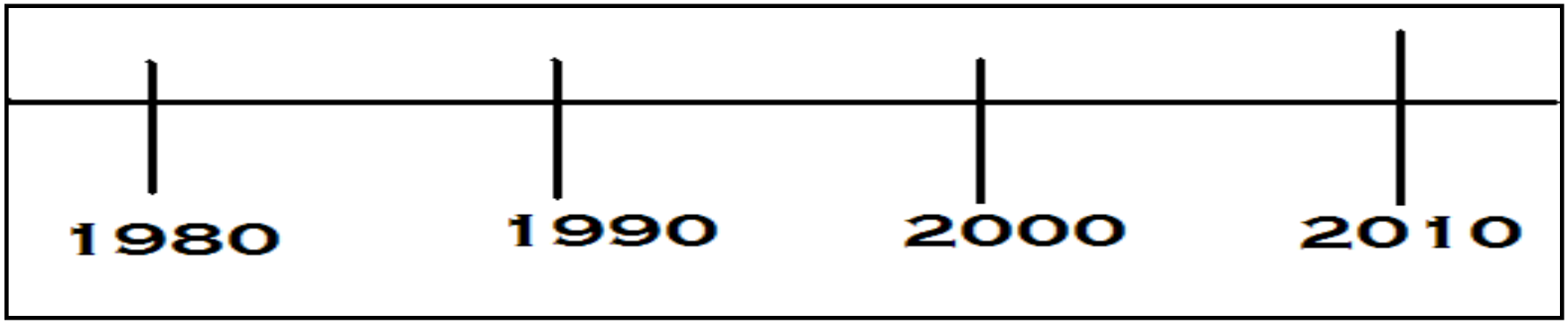
Pavement Evaluation and RPUG 2014
Blacksburg, Virginia

Highlights of Presentation

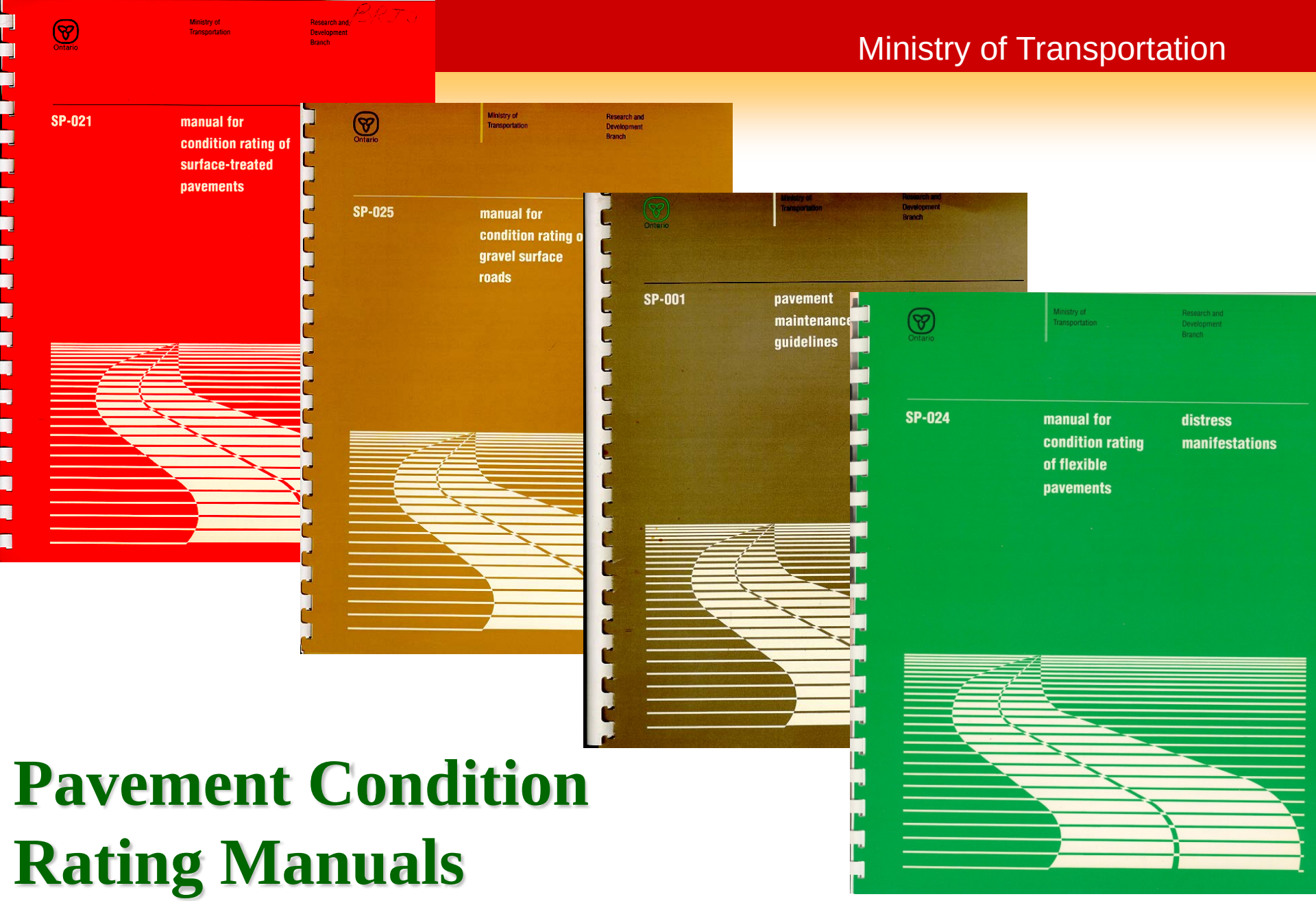
- Changing Data Collection Methods at MTO
- More Objective Pavement Evaluation and Condition Assessment Reporting
- Practical Applications of the Data Collected
- Ongoing Process for Validating ARAN Outputs
- Summary and Discussions

Changing Data Collection Methods

- Before 1970's: Manual or Visual Collection of Pavement surface distresses, rutting, riding quality data
- After 1980's:
  - PURD and ARAN to collect Riding Quality
  - Manual methods for rutting and surface distresses
- After 1990's
  - ARAN to collect Riding Quality and Rutting data
  - Manual methods for surface distresses
- After 2000's
  - ARAN to collect Riding Quality and Rutting data
  - Manual and semi-automated methods for surface distresses
- After 2010's – Fully automated/objective data collection



Four Generations of MTO ARAN System



Pavement Condition Rating Manuals

PDDC V.2.7.1.0

File Edit Subject Record Reports Tools Help

Section Search | Tick-sheet View of Section | Section Attributes | Pavement Distress | Shoulder Distress | Maintenance Treatment

Survey Month/Year : 6 2006

Evaluator : Todd Filson

Under Construction ☐ 677

HWY : 41

LHRS : 29610

Offset : 4

Direction : B BOTH

Facility : A ALL LANES

Class : A ARTERIAL

Distance From : 108.63 **To :** 121.02

From : DENBIGH LAKE RD

To : 6.6 KM N OF HWY 28

Reg : Eastern **Dist:** Bancroft

Pavement and Shoulders Distress Comments (Maximum - 255 Characters)

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

Indexes/Ratios :

PCI : 76 **RCI :** 7.57 **DMI :** 8.05

PCR : 83 **RCR :** 7.9 **IRI :** 1.36

FLEXIBLE PAVEMENT CONDITION EVALUATION

AC - PAVEMENT DISTRESS TYPES

			SEVERITY OF DISTRESS 1 2 3 4 5	SEVERITY OF DISTRESS 1 2 3 4 5
SURFACE DEFECTS		Ravelling and Course Aggregate Loss	1	1
		Flushing	0	0
SURFACE DEFORMATIONS		Rippling and Shoving	0	0
		Wheel Track Rutting	0	0
		Distortion	3	1
CRACKING	LONGITUDINAL WHEEL TRACK	Single and Multiple	2	4
		Alligator	2	3
	CENTRE LINE	Single and Multiple	2	2
		Alligator	0	0
	PAVEMENT EDGE	Single and Multiple	1	1
		Alligator	1	1
	TRANSVERSE	Half, Full and Multiple	2	5
		Alligator	1	1
		Longitudinal Meander and Midlane	2	4
		Random	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

There are about 15 individual distresses

The DMI was reported on pavement sections ranging from 500 to 500,000 meters in the past

Current MTO ARAN/LCMS

- Is able to identify and report 8 individual distresses with 6 quantitative metrics at every 10 meters

- **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 (m^2)
  4. Length (m)
  5. Width (m)
  6. Transverse Extent (m)

Distresses not be identified by ARAN

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

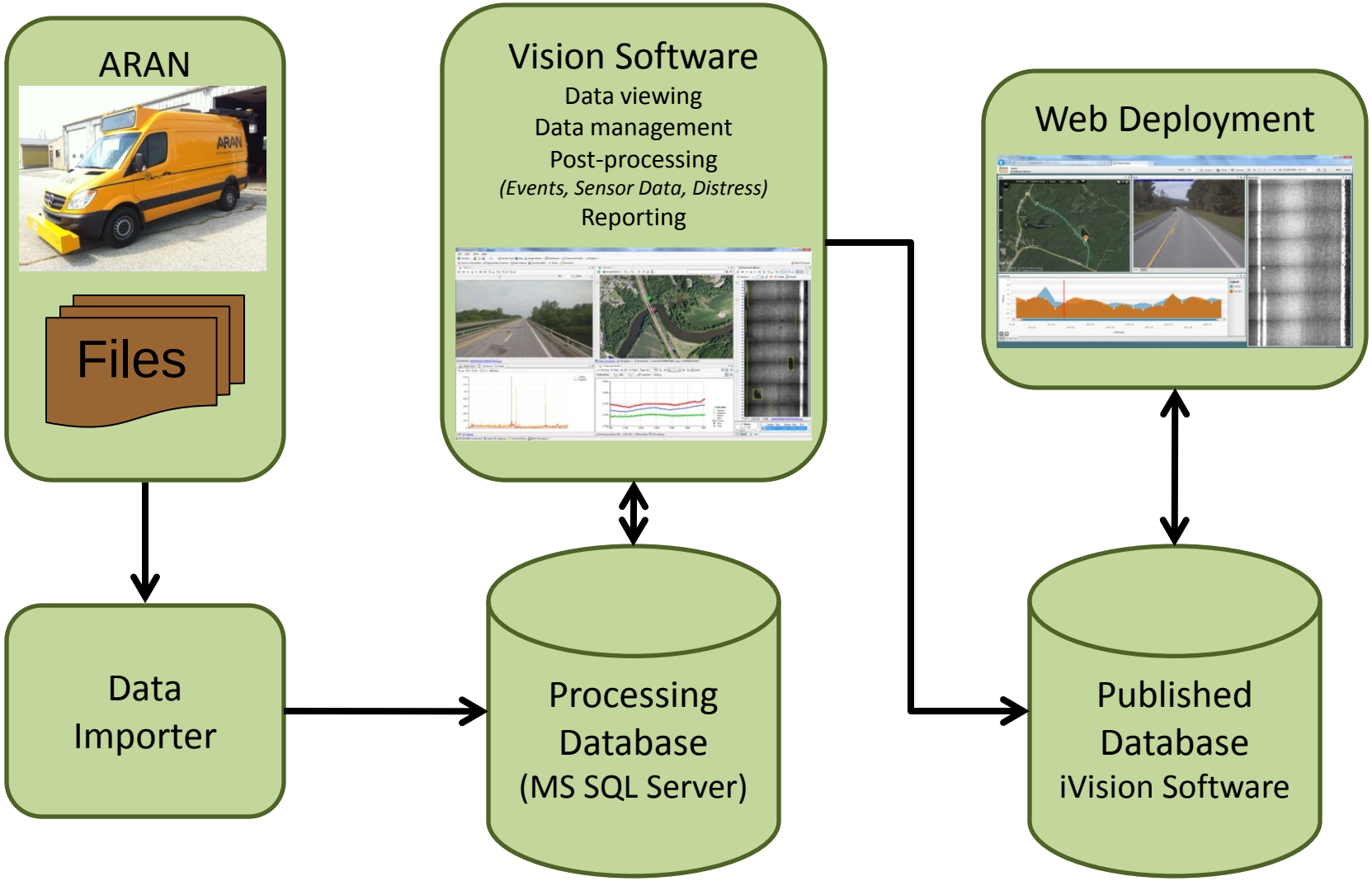
- Of the 15 individual distresses known to effect AC pavements the ARAN registers eight
- Ravelling and Course Aggregate Loss, Distortion, and Flushing have been omitted. Texture data is collected but not readily usable
- Map and random cracks are re-classified as alligator cracks
- Rutting data will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

An Example of Reporting an Identified Distress by ARAN/LCMS

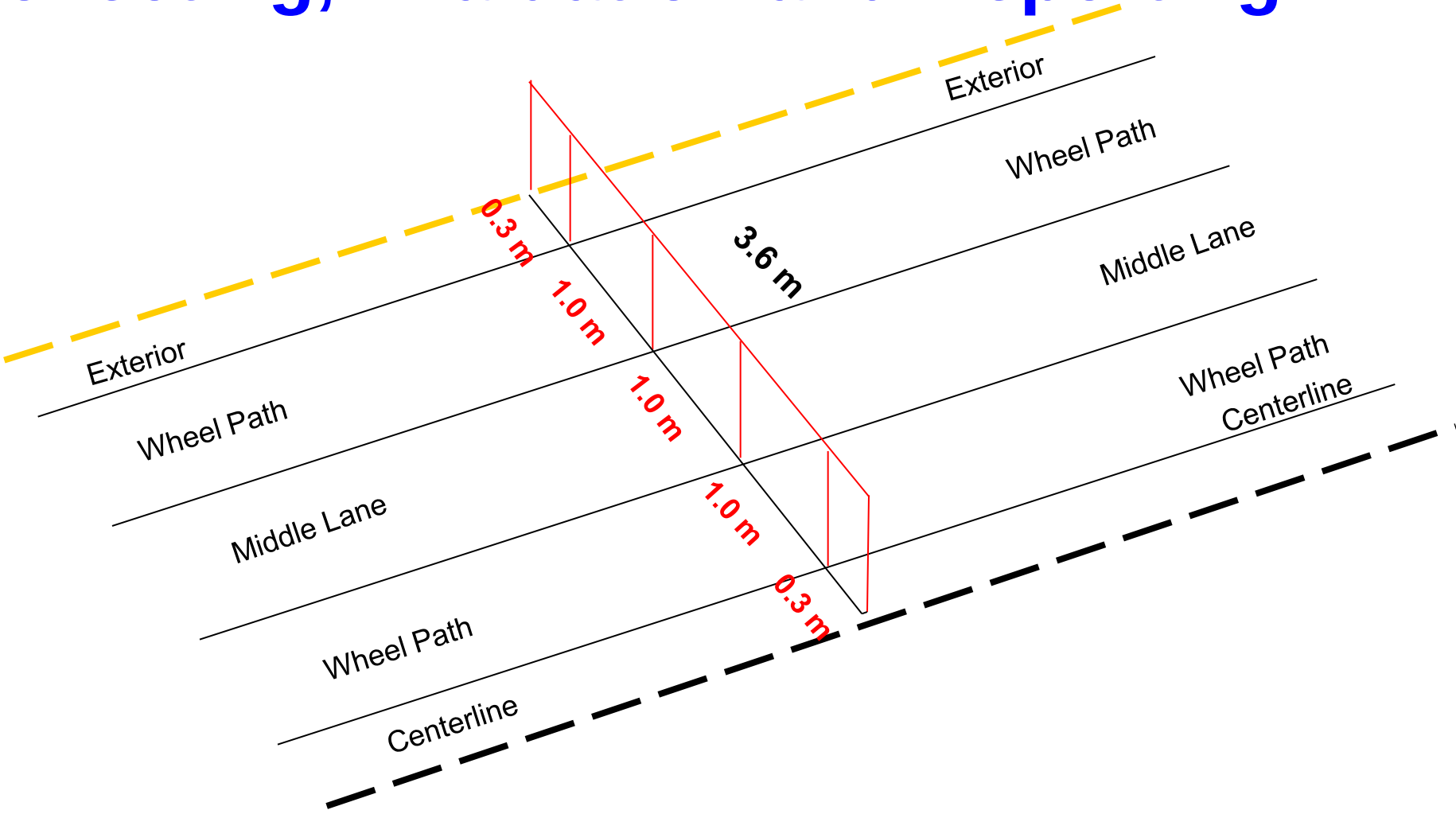
Identification Metrics	Slight	Moderate	Severe
Count	2	1	1
Crack Area (m^2)	1.59	1.44	0.23
Length (m)	5	3	2.5
Extent (m)	2.6	1.8	1.5
Transverse Extent (m)	1	0.8	0.5
Width (m)	0.004	0.012	0.025

- 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.

MTO ARAN Data Collection and Process Workflow



Zones Defined for Distress Data Collecting, Evaluation and Reporting



Pavement Distress Index (DMI)

$$DMI_{long} = 100 \times \left(1 - \frac{\sum_{i}^{4} W(LongitudinalExtent)}{4 \times SectionLength} \right)$$

$$DMI_{trans} = 100 \times \left(1 - \frac{\sum_{i}^{1} W_i(TransverseExtent)}{3.6} \right)$$

$$DMI_{gator} = 100 \times \left(1 - \frac{\sum_{i}^{3} W_i(AlligatorCrackArea)}{3.6 \times SectionLength} \right)$$

$$DMI = \left(a \times DMI_{long}\right) + \left(b \times DMI_{trans}\right) + \left(c \times DMI_{gator}\right)$$

Calculation of DMI Defined in MTO ARAN

- With 3 separate calculations yielding 3 DMI values for each classified DMI subcomponents, an overall DMI value is calculated in the following formula:

$$DMI = \left(a \times DMI_{long}\right) + \left(b \times DMI_{trans}\right) + \left(c \times DMI_{gator}\right)$$

(where A/B/C are factored in such as A + B + C = 1)

- Adjustable series of a / b / c weighting factors were examined for many scenarios by using 2013 ARAN data. DMI module such as 0.40 / 0.40 / 0.20 was used for long/trans/gator cracking, and 0.80 / 1.00 / 1.00 was used for the severity distinction calculation component (slight, moderate and severe).

Pavement Condition Index (PCI)

- A PCI value ranges from 0 to 100, with 100 representing perfect pavement condition, and 0 representing the poorest condition

- PCI is a function of IRI, DMI, RUT independent variables and it is calculated as:

$$PCI = (\alpha \times IRI) + (\beta \times DMI) + (\gamma \times RUT)$$

(where α, β and γ are coefficients such that α + β + γ = 1)

- The weighting factors are analyzed to adjust PCI values in consideration of historical pavement performance values

Overview of Formulae Developed

$$PCI = (0.70 \times IRI_{scaled}) + (0.20 \times DMI) + (0.10 \times RUT_{scaled})$$

$$IRI_{scaled} = \max\left[0,\ 100 \times \left(1 - \frac{IRI}{5}\right)\right]$$

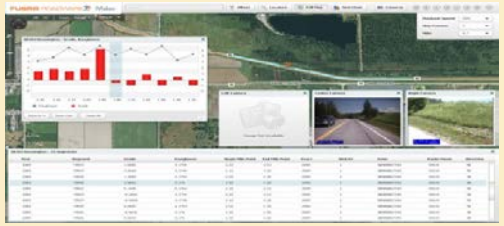
$$DMI = \max\left[0, \left((0.4 \times DMI_{long}) + (0.5 \times DMI_{trans}) + (0.1 \times DMI_{gator})\right)\right]$$

$$RUT_{scaled} = \max\left[0,100 \times \left(1 - \frac{RUT}{30}\right)\right]$$

MTO ARAN System Functions

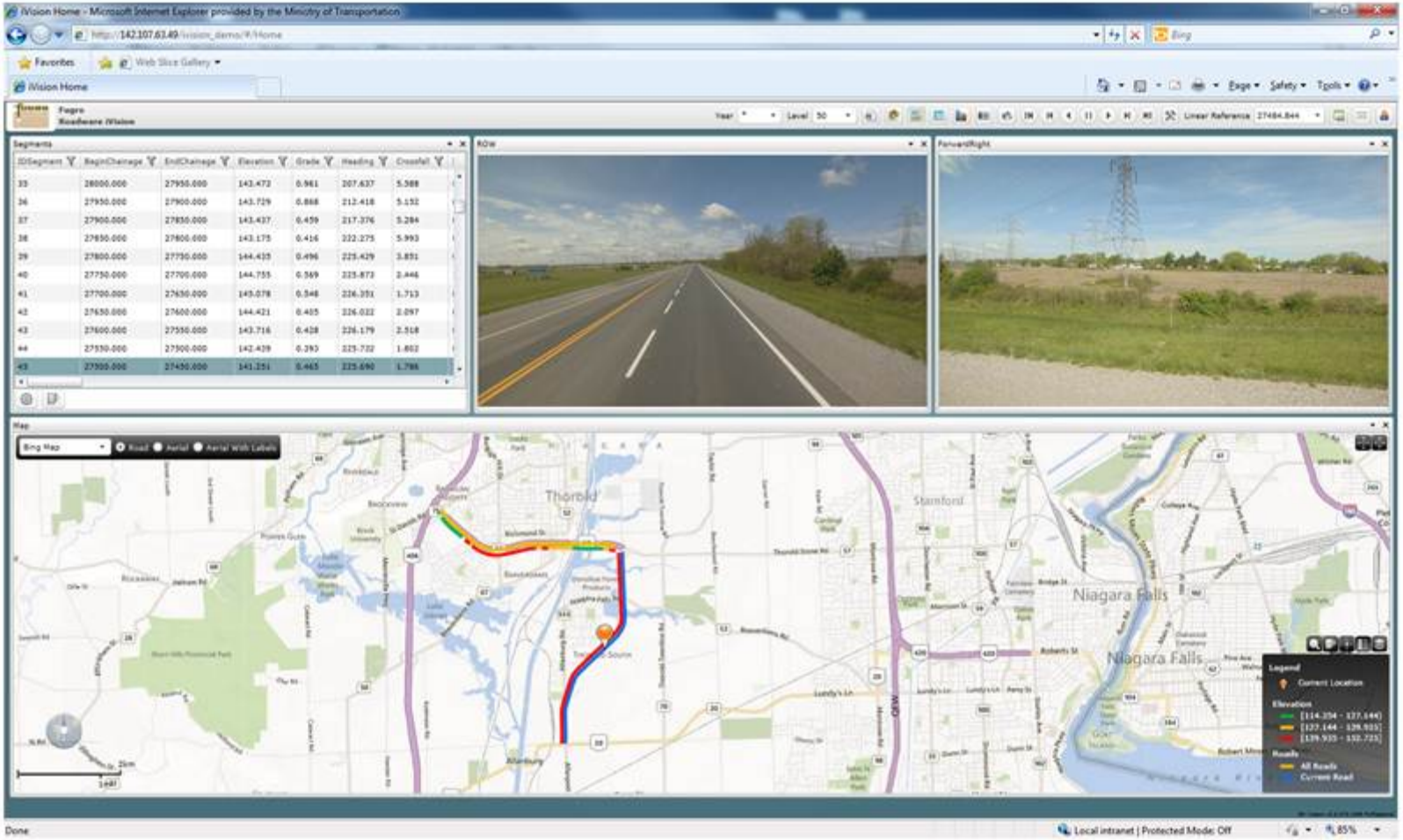
- High-speed collection of road location and condition data
  - Right of Way Asset Data Collection - Road Asset Management
  - Pavement Surface Profiles - IRI and RUT
  - Pavement Distresses – LCMS Integration
  - Road Location – GPS and Map
  - Performance Assessment Reporting

ARAN-9000 iVision



- Automatic Process of Integrated Pavement Location and Condition Evaluation Data – Vision Software
- Analysis Result Data Generating and Reporting – iVision Website

Example of Web Deployment Software (iVision)



Sample Reports Generated by ARAN/LCMS Vision

Microsoft Excel - SENSOR DATA-Metric_10.csv

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10 B I U

N54 181.960532400306

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	IDLocator	L_HWY	L_Dir	L_Fac	UniqueRun	CollectionV	DCSTimeS	IDSession	BeginDista	EndDistan	BeginChai	EndChaina	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	28
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.
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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.
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21	2	6	N	A	1A602M00	1742	########	3	155.6195	163.81	190	200	Matched	180.7969	-0.67317	266.
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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.
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39	2	6	N	A	1A602M00	1742	########	3	303.0486	311.2391	370	380	Matched	181.769	-0.61377	270.
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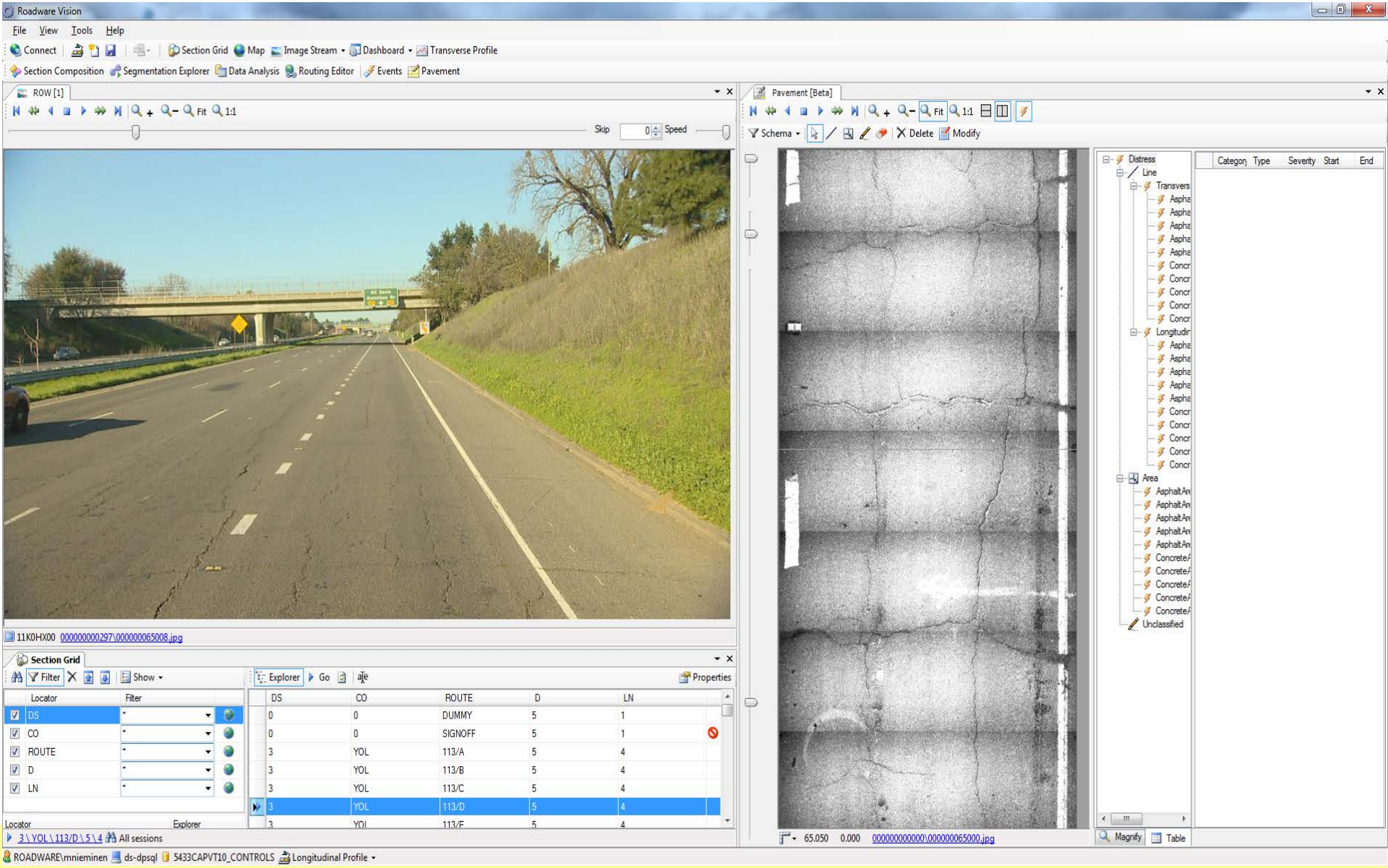
42	2	6	N	A	1A602M00	1742	########	3	327.6201	335.8106	400	410	Matched	181.8073	-1.0003	271.

SENSOR DATA-Metric_10

Ready NUM

Image and Reporting Data by ARAN/LCMS Vision



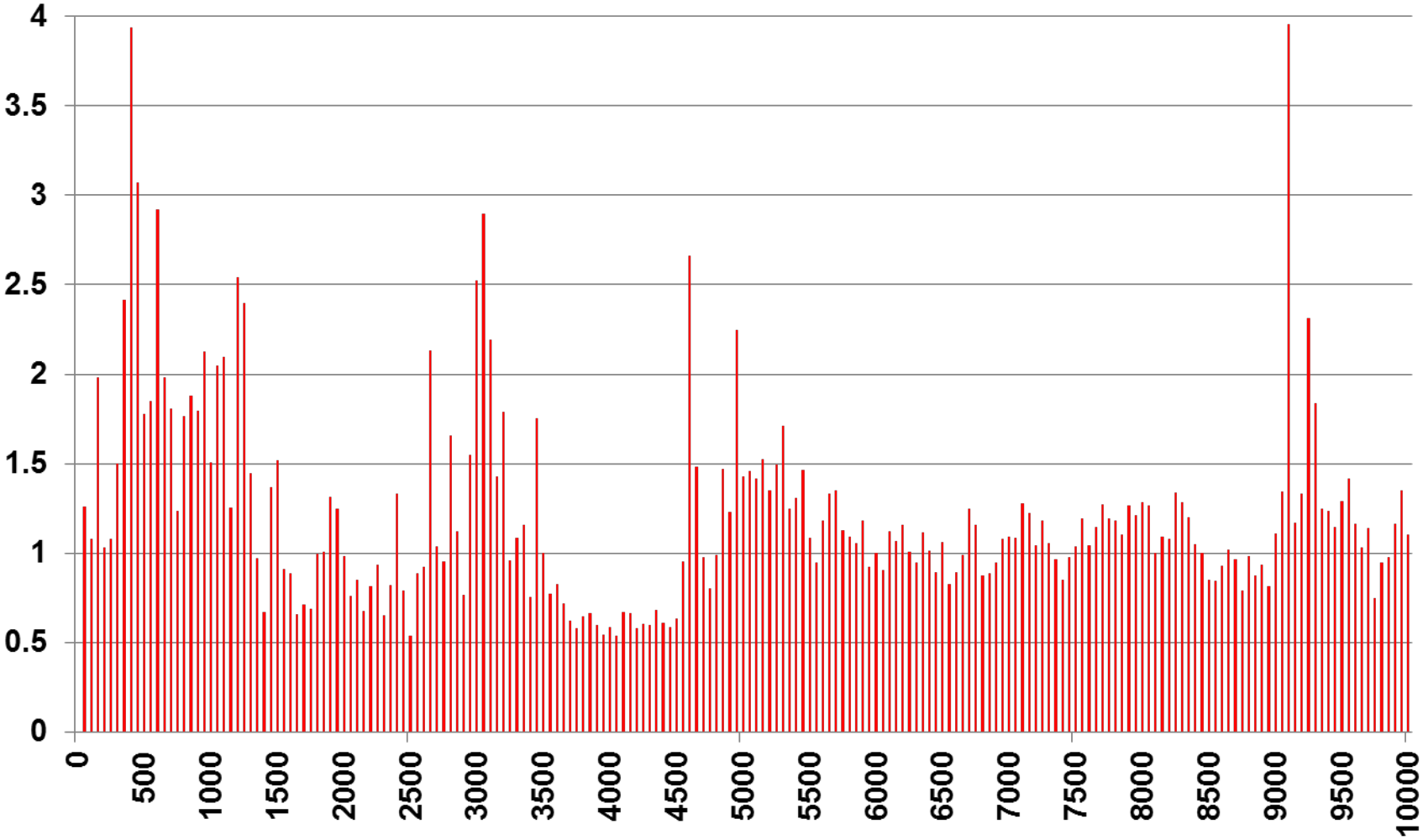
Data Collection Applications

- Before 2013
  - Pavement management at network Level (for projects planning and budgeting)
  - Data summarized and reported by pre-defined sections (ranging from 500 meters to 500,000 meters)
- After 2013
  - Pavement management at network Level
  - Data Accessed by MTO Functional Offices or Users via iVision Web-browser Program (project level)
  - Management of 7 Year Performance-based maintenance contracts (Maintenance and Rehabilitation Programs)
  - **Data summarized and reported by 50 meters**

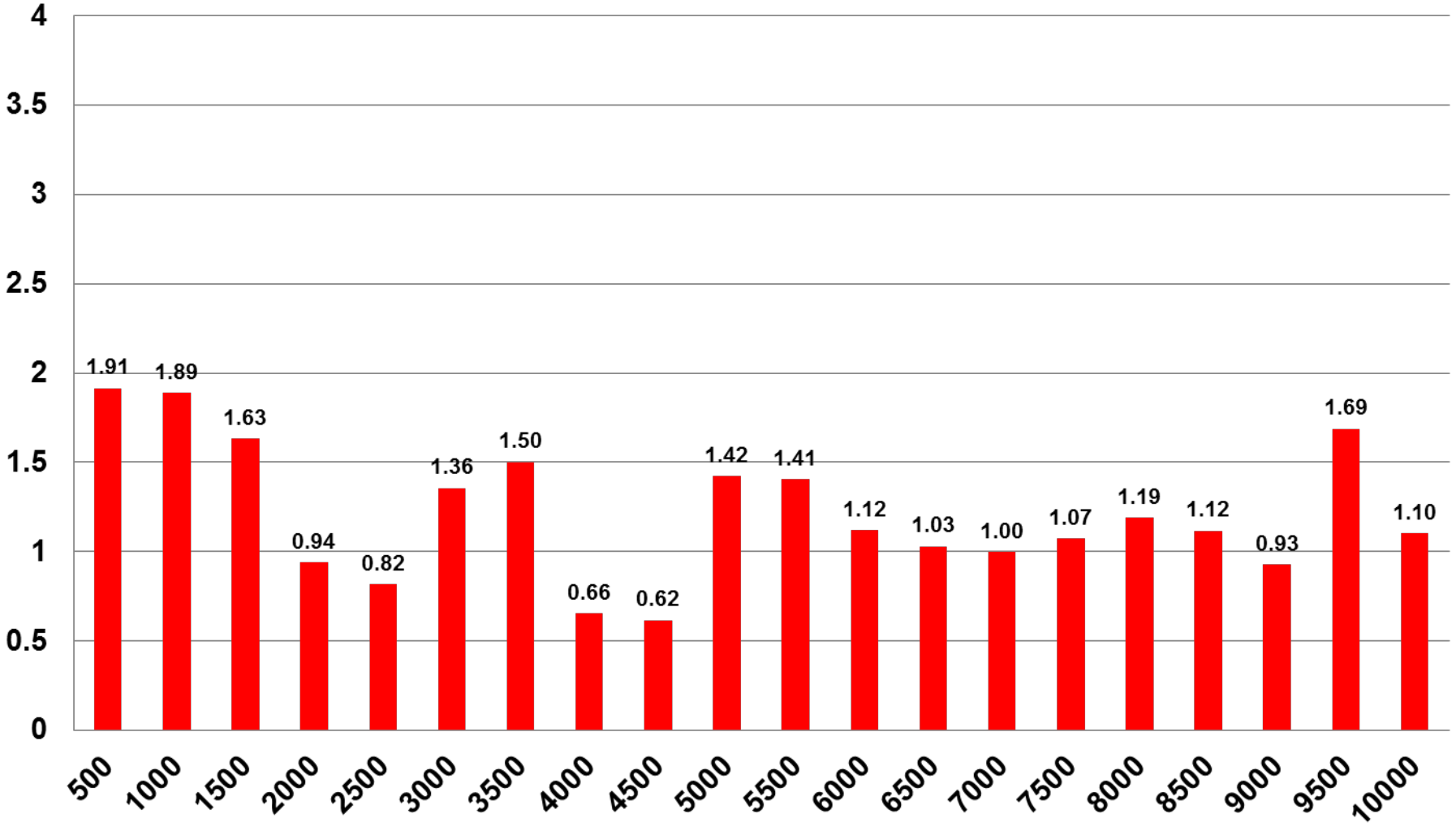
Pavement Performance Reporting

1. All individual distresses and performance indices (IRI, DMI, RUT and PCI) are to be reported in 50 meter intervals
2. All individual distresses and performance indices (IRI, DMI, RUT and PCI) are to be reported in every 500 meters for warranty projects
3. All individual distresses and performance indices will be monitored and reported in 150 meters to manage performance-based long-term maintenance contracts

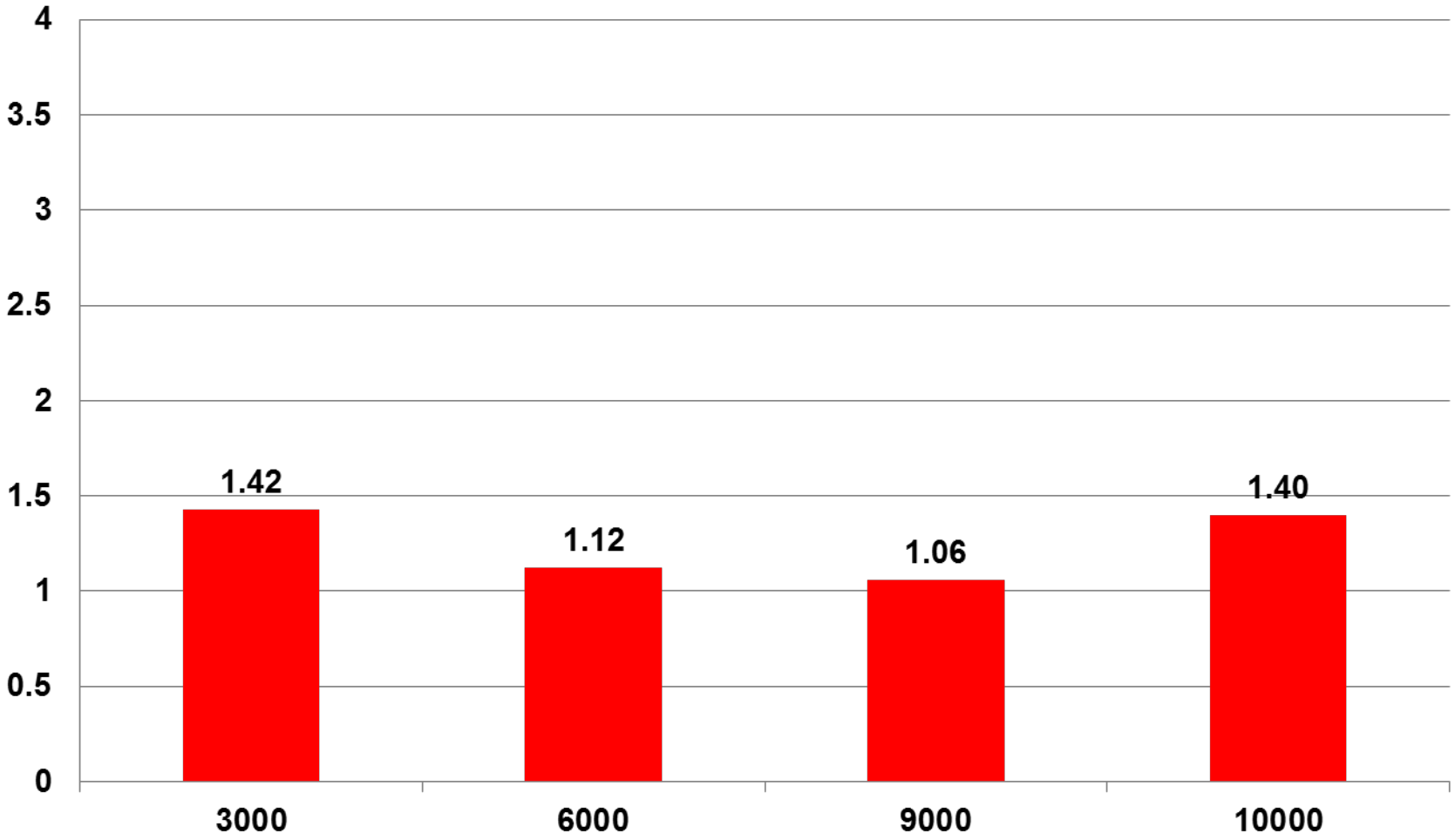
IRI at 50m per Section



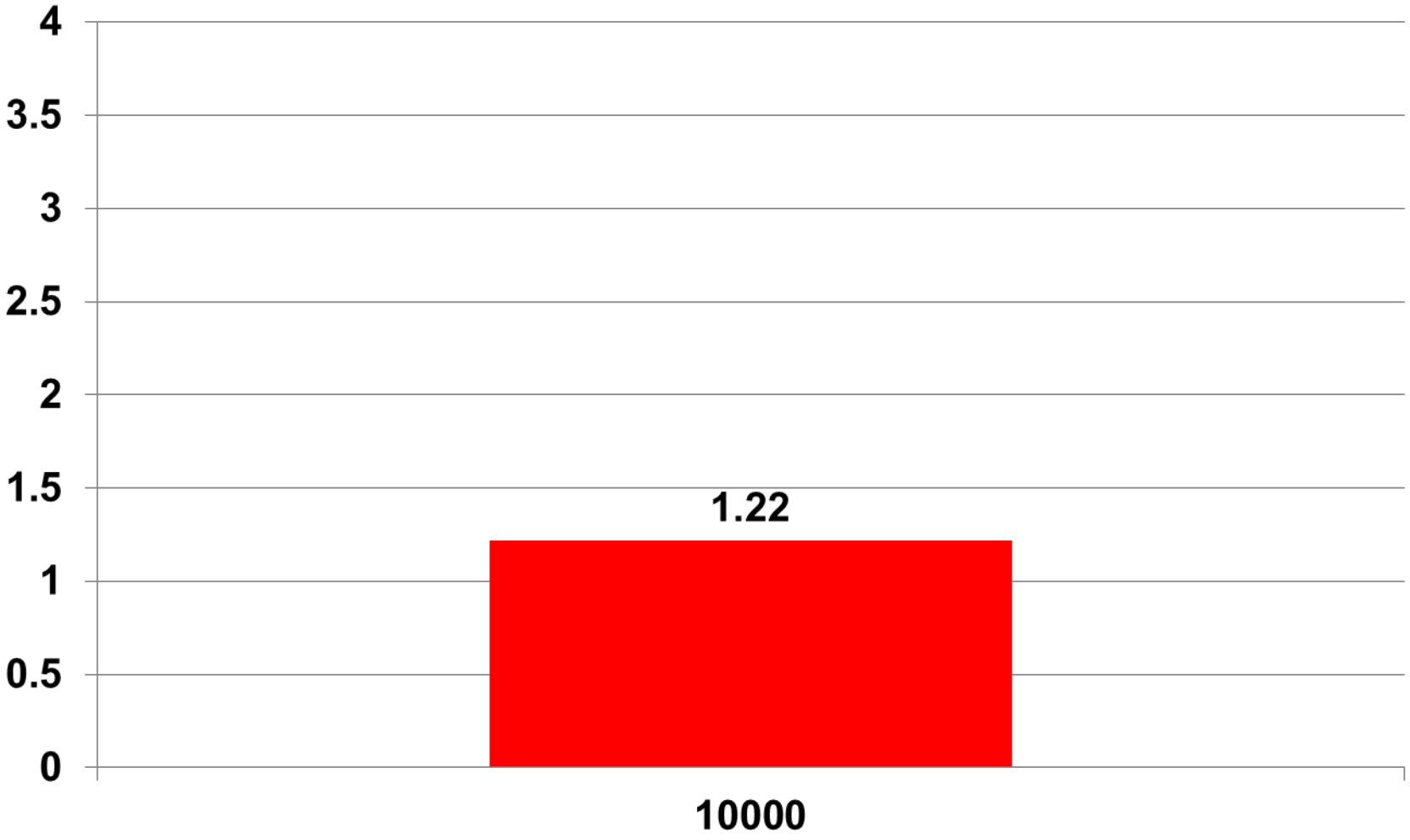
IRI at 500m per Section



IRI at 3000m per Section



IRI at 10000m per Section



Data Validation Testing Sites

- Patrol yard used to verify and validate individual distresses reported manually vs ARAN/LCMS
- Highway used to compare evaluation report on Rutting and individual distresses
- Artificial Saw-cut cracks used to verify distress classification and evaluation reporting

05/08/2013 10:56

05/08/2013 10:23

Due to time constraint, 90 m was evaluated without zones.
05/08/2013 12:16

05/29/2013 14:38

05/29/2013 14:05

05/29/2013 14:03

05/29/2013 15:09

Ruts Measured on Right and Left Wheel Paths

Right (ARAN)	Manual	Left (ARAN)	Manual
3.99	X	2.26	X
4.00	X	2.25	X
3.95	2.00	2.10	3.00
4.51	2.00	1.76	3.00
5.80	5.00	2.27	3.00
6.091	5.00	2.39	3.00
4.705	3.00	1.95	3.00
4.09	4.00	2.34	3.00
4.94	3.00	2.37	3.00
4.46	4.00	2.76	3.00

Summary of MTO Data Collection

- Moving towards fully automated data collection and evaluation of pavement conditions at network level
- More objective assessment of pavement condition indexes (IRI, DMI, RDI, PCI) becomes available for pavement management
- Extended applications to manage quality of performance-based long-term pavement maintenance contracts
- Improving maintenance and rehabilitation (M&R) treatments programming and investment planning in more reliable, expeditious and cost-effective manner

QUESTIONS?

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