# Development of A New Pavement Distress Evaluation Guide for Ontario Ministry of Transportation

**Road Profiler User Group (RPUG)**
**Atlanta, Georgia**
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# Presentation Outlines

- MTO Current Practice in Pavement Evaluation
- Issues on Subjective Assessment of Pavement Distresses (14~16 Individual Distresses)
- Studies on Rationalizing Evaluation of Pavement Distresses at Network Level
- Conclusions and Summary
- Move Forward Semi-Automation/Automation of Pavement Distress Assessment

# Current MTO Practice in Pavement Data Collection

- IRI (automated process since 1997)
- Rutting (automated process since 1997)
- DMI (field visual assessment since 1980)
  - Subjective evaluation of pavement condition using Distress Manifestation Index (DMI)
- PCI (Pavement Condition Index) is a function of IRI and DMI

# DMI Background

- Distress Manifestation Index (DMI) is used to indicate an evaluator's overall assessment of a pavement condition based on his/her survey in the field
- DMI is a subjective evaluation of pavement condition rated by trained and experienced pavement evaluators
- DMI represents evaluation of an individual pavement section, typically 10 kilometers in section length and uniform performance
- MTO's Pavement Condition Rating Manuals


# Pavement Condition Rating Manuals

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# Sample Distress Attributes

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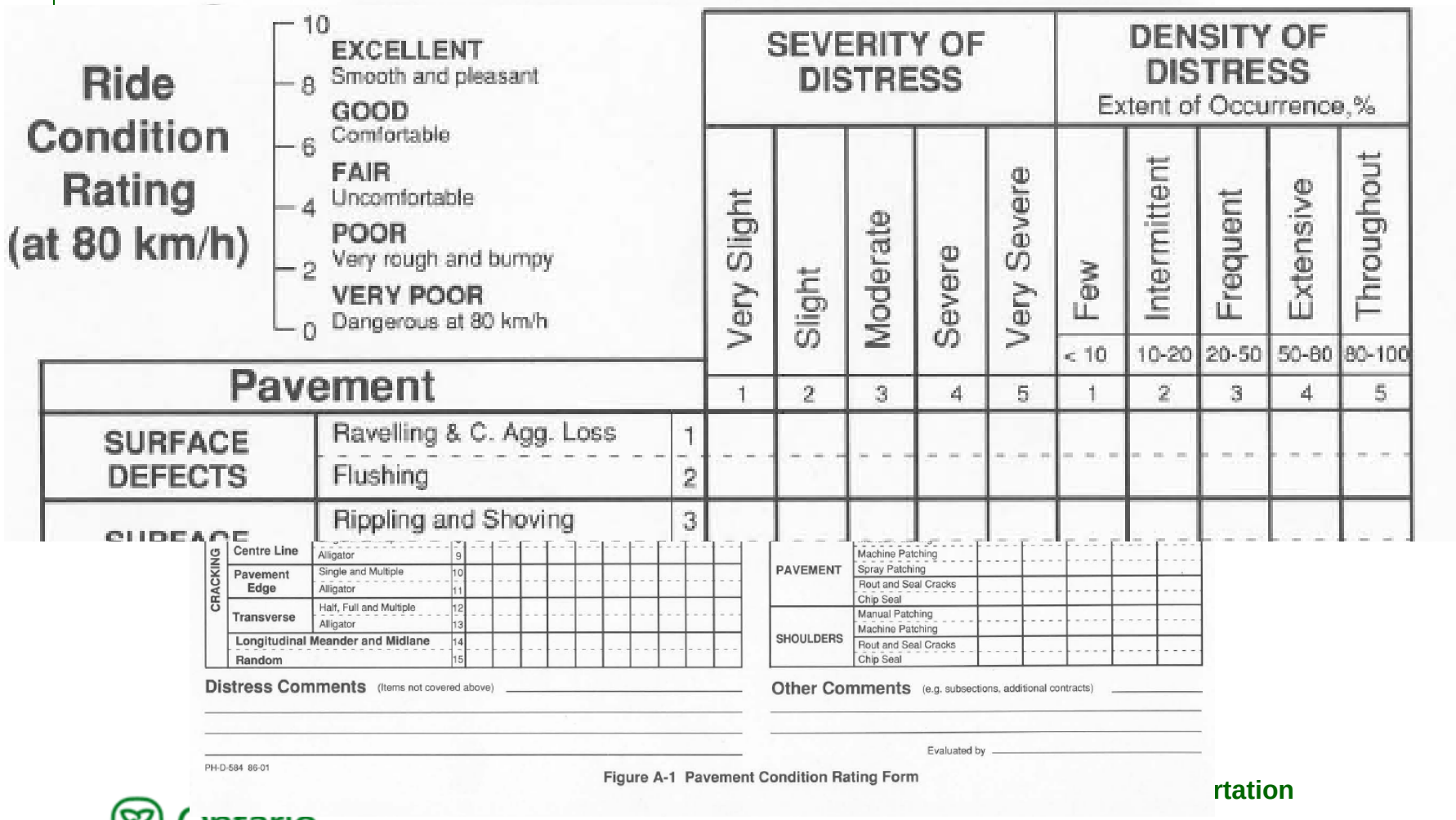
# Typical Pavement Distresses


# Overview of Old System



**Ride Condition Rating (at 80 km/h)**

10 **EXCELLENT** Smooth and pleasant
8 **GOOD** Comfortable
6 **FAIR** Uncomfortable
4 **POOR** Very rough and bumpy
2 **VERY POOR** Dangerous at 80 km/h
0 Dangerous at 80 km/h

| Pavement | | | SEVERITY OF DISTRESS | | | | | DENSITY OF DISTRESS Extent of Occurrence,% | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Very Slight | Slight | Moderate | Severe | Very Severe | Few | Intermittent | Frequent | Extensive | Throughout |
| | | | | | | | | < 10 | 10-20 | 20-50 | 50-80 | 80-100 |
| | | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| SURFACE DEFECTS | Ravelling & C. Agg. Loss | 1 | | | | | | | | | | |
| | Flushing | 2 | | | | | | | | | | |
| SURFACE | Rippling and Shoving | 3 | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CRACKING | Centre Line | Alligator | 9 | | | | | | | | | | | | |
| | Pavement Edge | Single and Multiple | 10 | | | | | | | | | | | | |
| | | Alligator | 11 | | | | | | | | | | | | |
| | Transverse | Half, Full and Multiple | 12 | | | | | | | | | | | | |
| | | Alligator | 13 | | | | | | | | | | | | |
| | Longitudinal Meander and Midlane | | 14 | | | | | | | | | | | | |
| | Random | | 15 | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAVEMENT | Machine Patching | | | | | | | | | | | | | | |
| | Spray Patching | | | | | | | | | | | | | | |
| | Rout and Seal Cracks | | | | | | | | | | | | | | |
| | Chip Seal | | | | | | | | | | | | | | |
| SHOULDERS | Manual Patching | | | | | | | | | | | | | | |
| | Machine Patching | | | | | | | | | | | | | | |
| | Rout and Seal Cracks | | | | | | | | | | | | | | |
| | Chip Seal | | | | | | | | | | | | | | |

Distress Comments (Items not covered above) _____

Other Comments (e.g. subsections, additional contracts) _____

Evaluated by _____

PH-D-584 86-01

Figure A-1 Pavement Condition Rating Form

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

**The scale of DMI is ranged from 0 to 10 in MTO PMS**

# Weights of Individual Distresses

| Asphalt Concrete Pavement (AC) | Weight ($W_i$) |
|---|---|
| Ravelling and Coarse Aggregate Loss | 3 |
| Flushing | 1.5 |
| Rippling and Shoving | 1 |
| Wheel Track Rutting | 3 |
| Distortion | 3 |
| Longitudinal Wheel Track: Sing. / Multi. | 1.5 |
| Longitudinal Wheel Track: Alligator | 3 |
| Longitudinal Meandering and Midlane | 1 |
| Transverse: Half, Full and Multiple | 1 |
| Transverse: Alligator | 3 |
| Centreline: Single and Multiple | 0.5 |
| Centreline: Alligator | 2 |
| Pavement Edge: Single and Multiple | 0.5 |
| Pavement Edge: Alligator | 1.5 |
| Random/Map | 0.5 |

| Portland Cement Concrete (PCC) | Weight ($W_i$) |
|---|---|
| Ravelling and Coarse Aggregate Loss | 0.5 |
| Polishing | 1.5 |
| Scaling | 1.5 |
| Potholing | 1 |
| Joint and Crack Spalling | 2 |
| Faulting | 2.5 |
| Distortion | 1 |
| Joint Failure | 3 |
| Longitudinal Joint Separation | 1 |
| Longitudinal and Meandering Cracking | 2 |
| Transverse Joint Creep | 0.5 |
| Transverse Cracking | 2 |
| Joint Sealant Loss | 0.5 |
| Diagonal Corner and Edge Crescent | 2.5 |
| “D” Cracking | 3 |

# Weights of Individual Distresses (Cont')

| Composite Pavement COM | Weight ($W_i$) |
|---|---|
| Ravelling and Coarse Aggregate Loss | 3 |
| Flushing | 1.5 |
| Spalling | 2 |
| Tenting/Cupping | 2.5 |
| Wheel Track Rutting | 3 |
| Joint Failures | 3 |
| Distortion and Settlement | 1 |
| Longitudinal Meandering (Single & Multiple) | 2 |
| Transverse: Single | 1 |
| Transverse: Multiple | 1 |
| Transverse Joints: Sawed | 0.5 |
| Transverse Joints: Reflective | 2 |
| Centreline: Single | 0.5 |
| Centreline: Multiple | 1.5 |
| Diagonal, Corner and Edge Crescent | 2.5 |
| Random/Map | 0.5 |

| Surface Treated ST | Weight ($W_i$) |
|---|---|
| Cover Aggregate Loss | 3 |
| Flushing | 2 |
| Streaking | 1 |
| Potholing | 1 |
| Rippling and Shoving | 2 |
| Wheel Track Rutting | 3 |
| Distortion | 3 |
| Longitudinal Cracking | 1 |
| Transverse Cracking | 0.5 |
| Pavement Edge Break | 2 |
| Pavement Edge Cracking | 1 |
| Alligator Cracking | 3 |

# Scale for Severity Rating

- Five (5) severity Levels for AC, PCC and COM type of pavement, ranging from 1 to 5

$$S_i(n) = \begin{Bmatrix} VerySlight, & n = 1 \\ Slight & n = 2 \\ Moderate & n = 3 \\ Severe & n = 4 \\ VerySevere, & n = 5 \end{Bmatrix}$$

- Three (3) severity Levels for ST pavement

$$S_i(n) = \begin{Bmatrix} light & n = 2 \\ Moderate, & n = 3 \\ Severe & n = 4 \end{Bmatrix}$$

# Scale for Density Rating

- Five (5) Density/Extent levels for AC, PCC and COM pavement, in terms of percentage %

$$D_i(n) = \begin{Bmatrix} 0-20\%, & n=1 \\ 20-40\%, & n=2 \\ 40-60\%, & n=3 \\ 60-80\%, & n=4 \\ 80-100\%, & n=5 \end{Bmatrix}$$

- Three (3) Density/Extent levels for ST pavement

$$D_i(n) = \begin{Bmatrix} 0-20\%, & n=2 \\ 20-50\% & n=3 \\ 50-100\%, & n=4 \end{Bmatrix}$$

# Issues Concerned with DMI

- Safety and Accessibility in Field Operation
  - Impossible to operate on high-volume traffic freeways
  - Restricted by vehicle operation speed and visual assessment
- Quality and Productivity of Data Collection
  - Poor quality (accuracy, repeatability and accountability)
  - Subjective bias and errors in evaluation
- Impacts on Pavement Management Process
  - Performance evaluation and needs analysis
  - Decisions in selecting pavement treatments
  - Maintenance programming and investment planning

# Facts Considered in Reducing Some individual Distresses

- Type and number of distresses
- Weighting factors of individual distresses
- Distress severity and density
- Minimize impacts on current practice
- Preserve historic data and consistency
- Six years of data were used in performing this study, covering four pavement types, AC, PCC, COM, ST

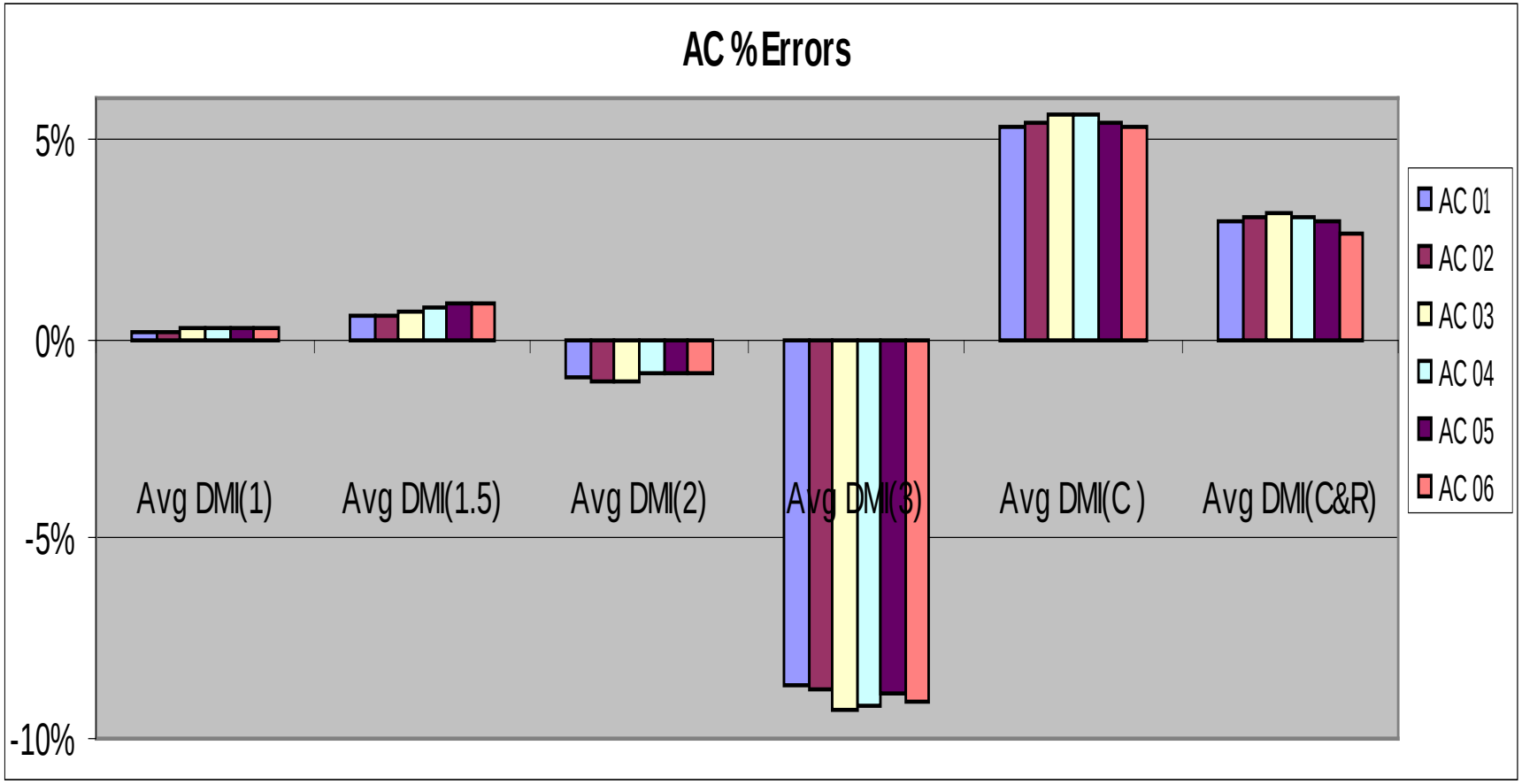
# Test Design and Analysis

- Group distress and re-define DMI(#)
- DMI(#) stands for DMI that is calculated by use of the existing formula but excluding individual distresses that have weight factors lower than #
  - DMI(1) contains distresses with weight >=1
  - Similar definition for DMI(1.5), DMI(2) and DMI(3)
- DMI(C) and DMI(C&R) include only cracking / cracking & rutting as distresses
- DMI (T) is the original DMI (including all distresses)

# Test Design and Analysis (Cont's)

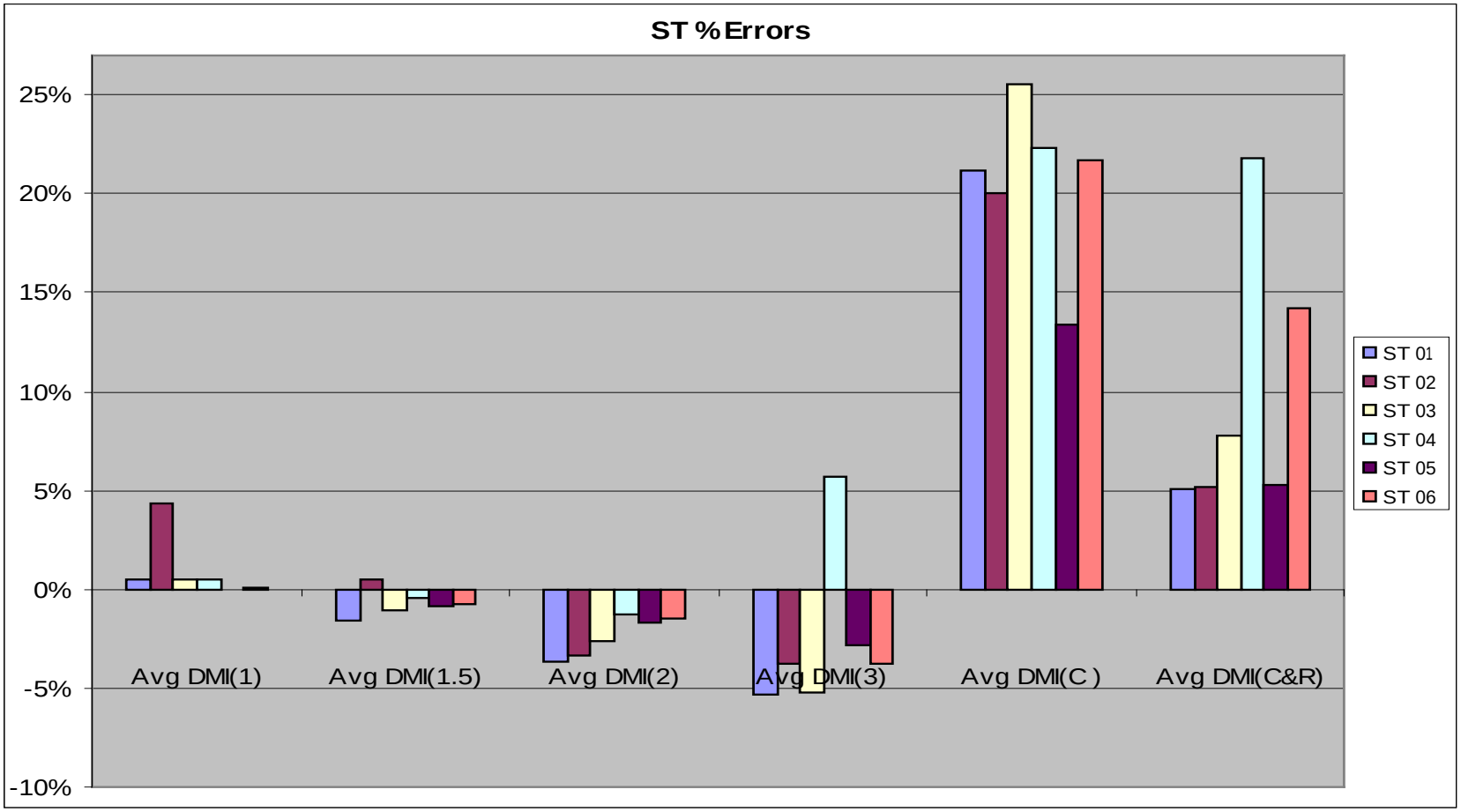
- Use six years historic data (from 2001 to 2006) extracted form MTO pavement management databases
- DMI (#) were calculated and then compared with the DMI (T) to produce an error percentage
- Note that the sample size varies significantly between the four pavement types:
  - *1344 AC Sections, 26 PCC Sections, 22 COM Sections, and 271 ST Sections*

# Analysis Results for AC Pavements




**Comparison between errors from each modified DMI (AC)**

# Analysis Results for ST Pavements



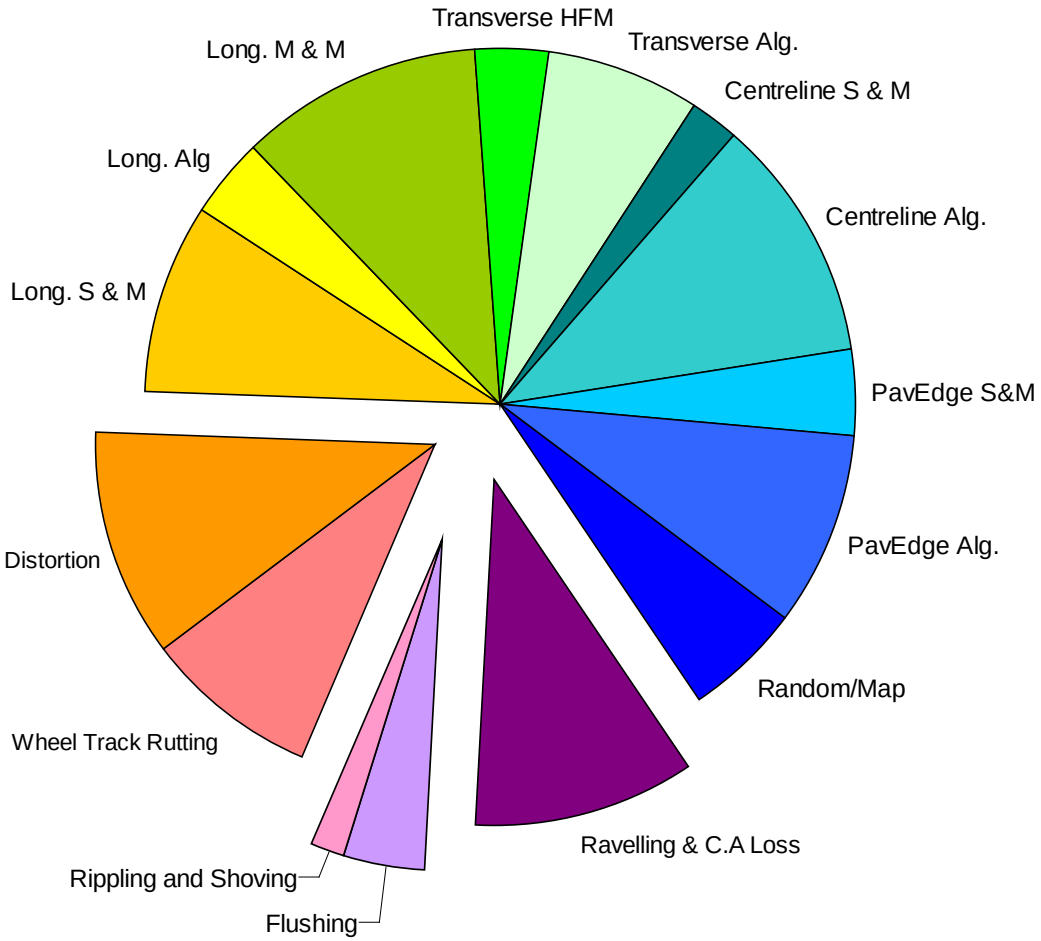

**Comparison between errors from each modified DMI (ST)**

# Remaining Distress Components of DMI(2) for AC Pavement

| Asphalt Concrete Pavement (AC) | Weight ($W_i$) |
|---|---|
| Ravelling and Coarse Aggregate Loss | 3 |
| Flushing | 1.5 |
| Rippling and Shoving | 1 |
| Wheel Track Rutting | 3 |
| Distortion | 3 |
| Longitudinal Wheel Track: Sing. / Multi. | 1.5 |
| Longitudinal Wheel Track: Alligator | 3 |
| Longitudinal Meandering and Midlane | 1 |
| Transverse: Half, Full and Multiple | 1 |
| Transverse: Alligator | 3 |
| Centreline: Single and Multiple | 0.5 |
| Centreline: Alligator | 2 |
| Pavement Edge: Single and Multiple | 0.5 |
| Pavement Edge: Alligator | 1.5 |
| Random/Map | 0.5 |

| Asphalt Concrete Pavement (AC) | Weight ($W_i$) |
|---|---|
| Ravelling and Coarse Aggregate Loss | 3 |
| Wheel Track Rutting | 3 |
| Distortion | 3 |
| Longitudinal Wheel Track: Alligator | 3 |
| Transverse: Alligator | 3 |
| Centreline: Alligator | 2 |

# Frequency of Distresses

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# List of Remaining Distresses

| # | Distress Name |
|---|---|
| 1 | Potholing |
| 2 | Ravelling and C. A. Loss |
| 3 | Longitudinal Cracking |
| 4 | Transverse Cracking |
| 5 | Map/Alligator Cracking |

- Taking weighting and frequency into account, a list of proposed distresses was made
- Using these distresses calculations show that a DMI calculated with only these values is accurate to 1.5% in flexible pavement

# Network Level Program

- Collection of:
  - Transverse Profile (Rutting)
  - Longitudinal Profile (Roughness)
  - Orientation (Crossfall)
  - GPS data
- Over 1390 PMS Sections
- North and West on non-divided highways
- Both directions on freeways

# ARAN Data Delivery

- Currently in Excel Format
- Main delivery at year end
  - CD to each region with all pavement data incl:
    - 50m Detailed Data
    - Chart File
    - Summary sheet
- *New for 2007 plotted network/monitor data by region/district

* Still have to determine best method of delivery

# Sony HDTV Video Camera

# Video Collection

- Images captured by a Sony HDTV wide angle camera.
  - Great image quality and contrast
    - 1920 x 1080 resolution
    - 16:9 aspect ratio
    - 90 degree field of view
  - Camera mounted inside ARAN cabin
    - This allows environmental control
- Capture Interval is 5 meters, total storage per year ~ 2 TB
  - Network Level: Primary Highways, North/West bound, Lane 2
  - Bidirectional information acquired from all of Central, Southern & Eastern Ontario
    - – Also where possible in Northern and Northwestern Ontario
  - Project Level testing - as requested

# Quality Examples - Acceptable

# Proposed Method

- ARAN will continue to collect HD video-logs
- Raters will then be able to play these video-logs at the office, and manually evaluate roads from images
- This would take care of safety and accessibility issues for high-volume roads, as well as allow raters to make more accurate evaluations

# Suggested Implementation

- Images must be viewed on large monitors to ensure that the resolution of HD images is not lost

- Video software must be installed, and videos can be viewed on a secondary monitor so that section data and other information can be viewed on the first

# Potholing

# Coarse Aggregate Loss


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# Ravelling


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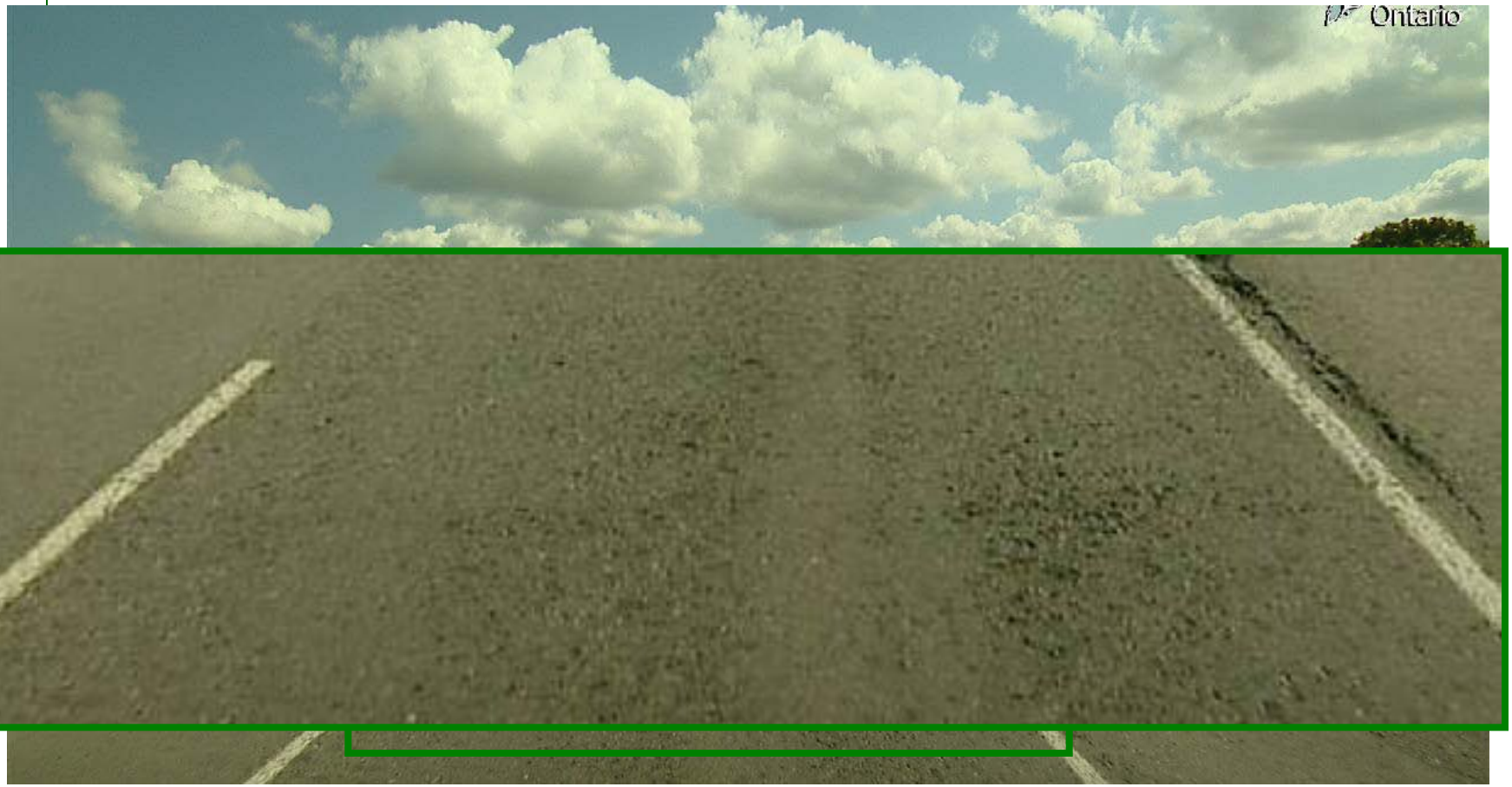
# Ravelling 2



# Longitudinal Cracking

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# Transverse Cracking


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# Transverse Cracking 2

# Alligator Cracking

# More Benefits of Video-logging

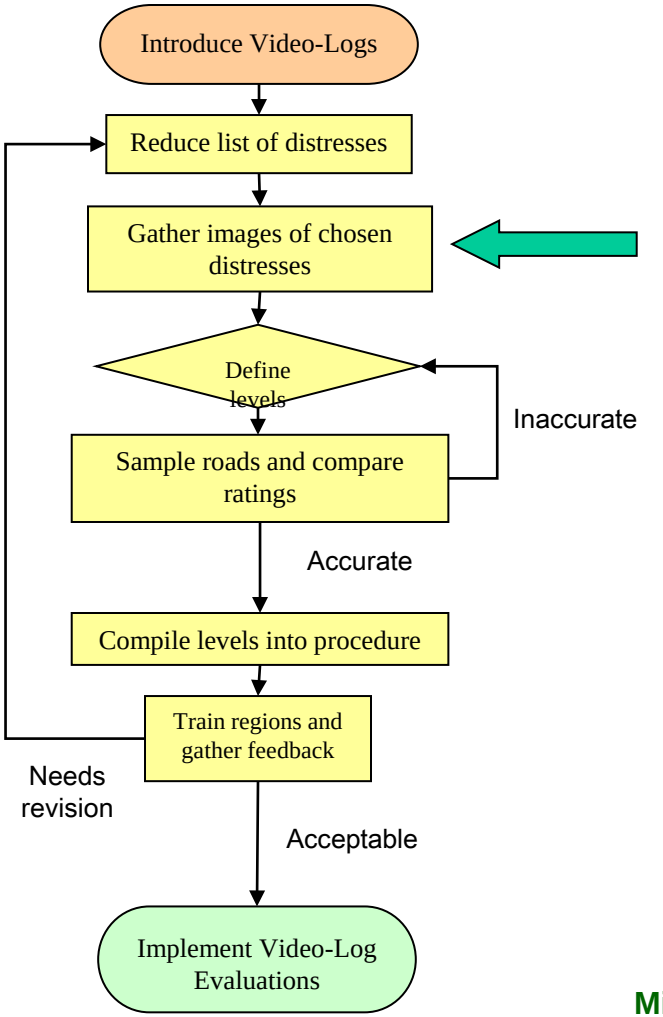
- Repeatability is also increased, as any video-log can be revisited for verification purposes
- Video logs can be paused, rewound, and even played backwards at any time for further inspection
- Images are tied to GPS, roughness and retting, and positioning data allowing raters to return to areas of high distress as necessary

# Next Steps

- Determine severity and density levels from video-logs
- Literature review of current evaluation methods
- Develop evaluation procedure methods
- Timing, follow-up

- [FLOW CHART]

# Next Steps

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# Identifying Severity & Density Levels

- Images of different severity and density levels will be gathered from video-logs
- Corresponding level guidelines will then be made for raters
- The number of severity levels will be decreased to 3 to make evaluations easier

# Study of Current Evaluation Methods

- A more thorough study of current evaluation methods will be done in order to determine how video-logging can be incorporated in the future

- There is no standard definitions for severity, so an inter-region group study will be carried out for determining bench marks

# Developing Evaluation Procedure

- By combining the new distress list with severity levels, current evaluation methods, and video-logging, an evaluation procedure will be developed

- Once the procedure is developed, training can be implemented and tested for quality by comparing manual ratings from roadside evaluations and manual ratings from video-logs

# Following up

- As distresses are chosen, current PDDC data will be compared to data collected from video-logging evaluations

- This will be followed up by gathering feedback from regions to ensure standard methods are used within MTO

# Benefits

- In-office view of highway network
  - reduction of field trips
  - faster response to inquiries
- Historical record of highway conditions
- Validation/QA of field data
- Roadside asset inventory data collection

# Thank You!


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