Pavement Preservation Integration with Pavement Management

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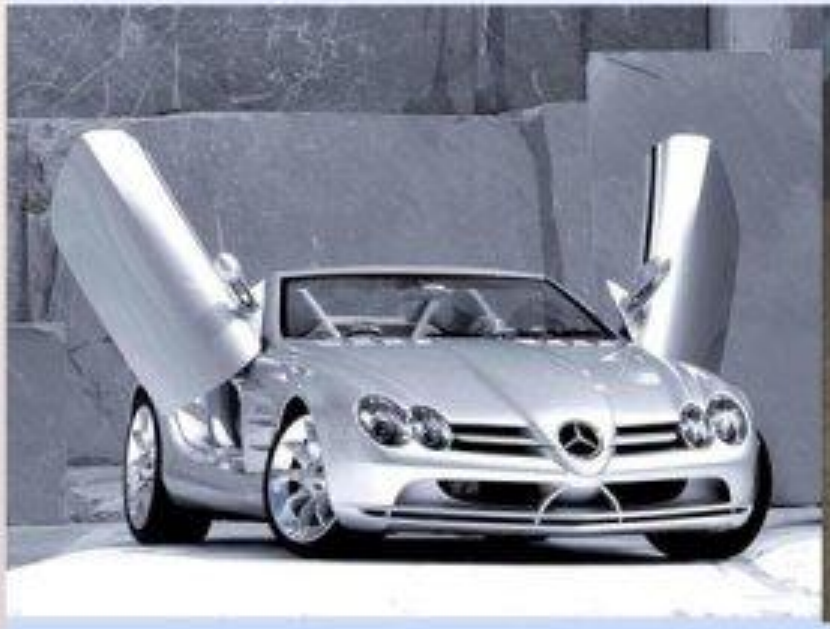
Pop Quiz #1

YOU HAVE TWO CARS. HOWEVER, YOU HAVE MONEY FOR ONLY ONE OIL CHANGE. WHICH CAR GETS THE OIL CHANGE?

CAR #1



CAR #2

Pop Quiz #2

You have bought your dream house.

Pop Quiz #2

How would you prevent it from becoming this?

National Context

- 4,000,000 + Miles of Pavement Structures
- $1,000,000,000,000 (1Trillion) Network asset worth
- Each US citizen
  - "owns" 70 ft of highway
  - $17,000 personal investment
- 3" thick, 12' wide AC Pavt paved from NY to LA / day
- Enormous Portion of our National Economy

FULTON School of Engineering
Thomas B. Deen Distinguished Lecture, TRB Jan 2008
Dr. Matthew Witczak

National Context

- US Highway Network Backbone of US Economy (in Fact, Backbone of any Country's Economic Vitality)
  - Lifeline of Public Travel Mode (Work and Leisure)
- Difficult to Visualize System will Become Obsolete in Intermediate to Long Term
- As a Nation, We Have NO ALTERNATIVE but to maintain Current Network Infrastructure

National Context

Budget Needs	Proj Rev.	Exp. deficit
2010 $54.0 B	$34.2 B	$19.3 B
2015 $61.5 B	$40.5 B	$21.0 B

Pavement Management

"...a management approach used by personnel to make cost-effective decisions about a road network."

AASHTO Pavement Management Guide (2001)

Pavement Management System

"...a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time."

AASHTO Guide for Design of Pavement Structures (1993)

Decision Criteria

- Highest Benefit for Lowest Lifecycle Cost
- Condition Constraints set by Agency
- Budget Constraints on Agency
- In reality, not one highway segment but many
  - 3800 centerline miles in Connecticut
- How do we do this?

Pavement Deterioration Curve

Pavement Deterioration Curve

Inventory Data

- **Network data:**
  - *Physical location*
  - *Dimensions (number of lanes)*
  - *Traffic volumes and classification*
- **Pavement data:**
  - *Type (flexible, composite, rigid)*
  - *Construction history*
  - *Surface age*
  - *Material properties*
  - *Pavement Condition*

Condition Data

- Structural condition
  - Cracking
  - Rutting
  - Roughness
  - Patching/Deterioration
- Structural capacity: modulus (σ/ε)
  - Falling Weight Deflectometer (FWD)
  - Seismic Pavement Analyzer

Condition Data

- AASHTO Road Test:
  - Serviceability criteria (% of 14-person panel rating the road "unacceptable")
  - Proxy: Pavement Serviceability Index (PSI)
    - Roughness, Cracking, Rutting, Patching & Deterioration
    - $\mathbf{PSI} = 5.03 - 1.9 * \mathbf{log}(1 + \mathbf{SV}) - 1.38 * \mathbf{RD}^2 - 0.01 * (\mathbf{C} + \mathbf{P})^{0.5}$

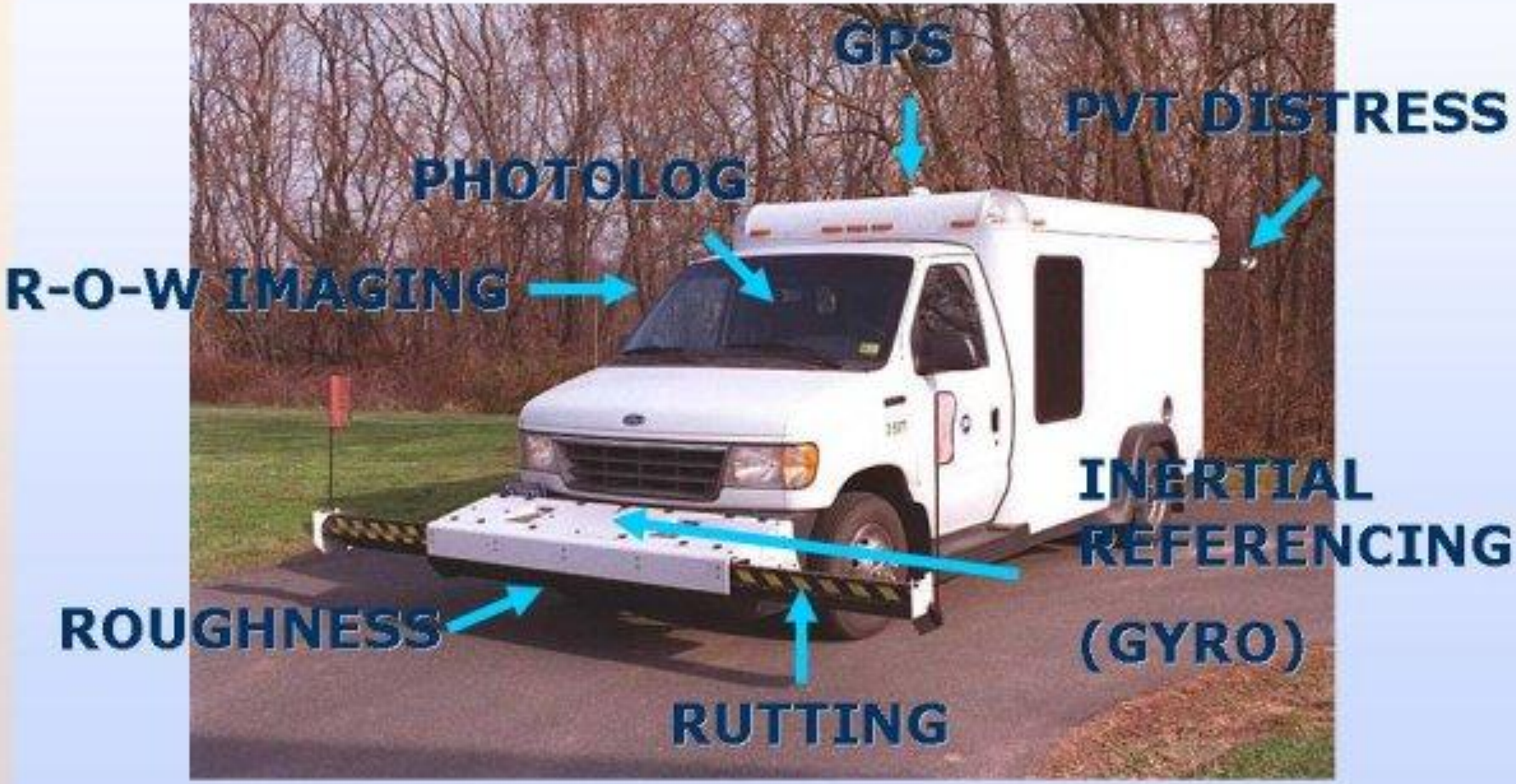
Functional vs. Structural Condition

- Serviceable pavements which have failed structurally (cracked but smooth)
- Structurally sound pavements with low serviceability (not cracked but rough)
- Treatments differ based on cause
  - Re-profile to make smooth
  - Major rehabilitation to make structurally sound
  - Costs vary
- Pavement engineers must address both

Inventory Data Collection

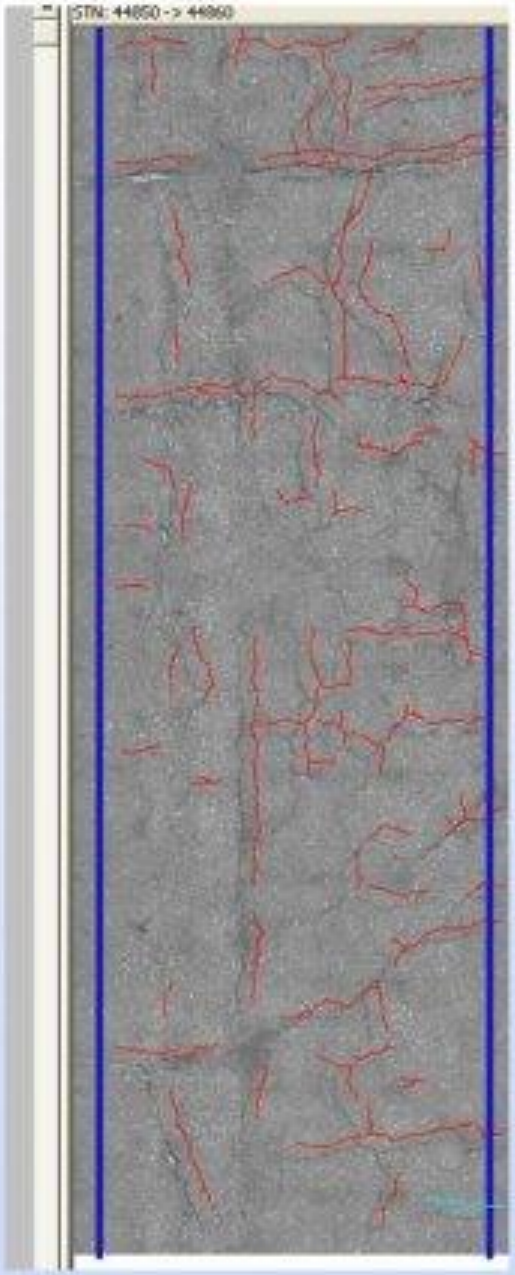
- Planning, Inventory, and Data
  - Traffic, pavement type, dimensions
- Geographic Information Systems
  - Climate, soils
- ConnDOT ARAN vehicles (Photolog)

ConnDOT Data-Collection Vehicle

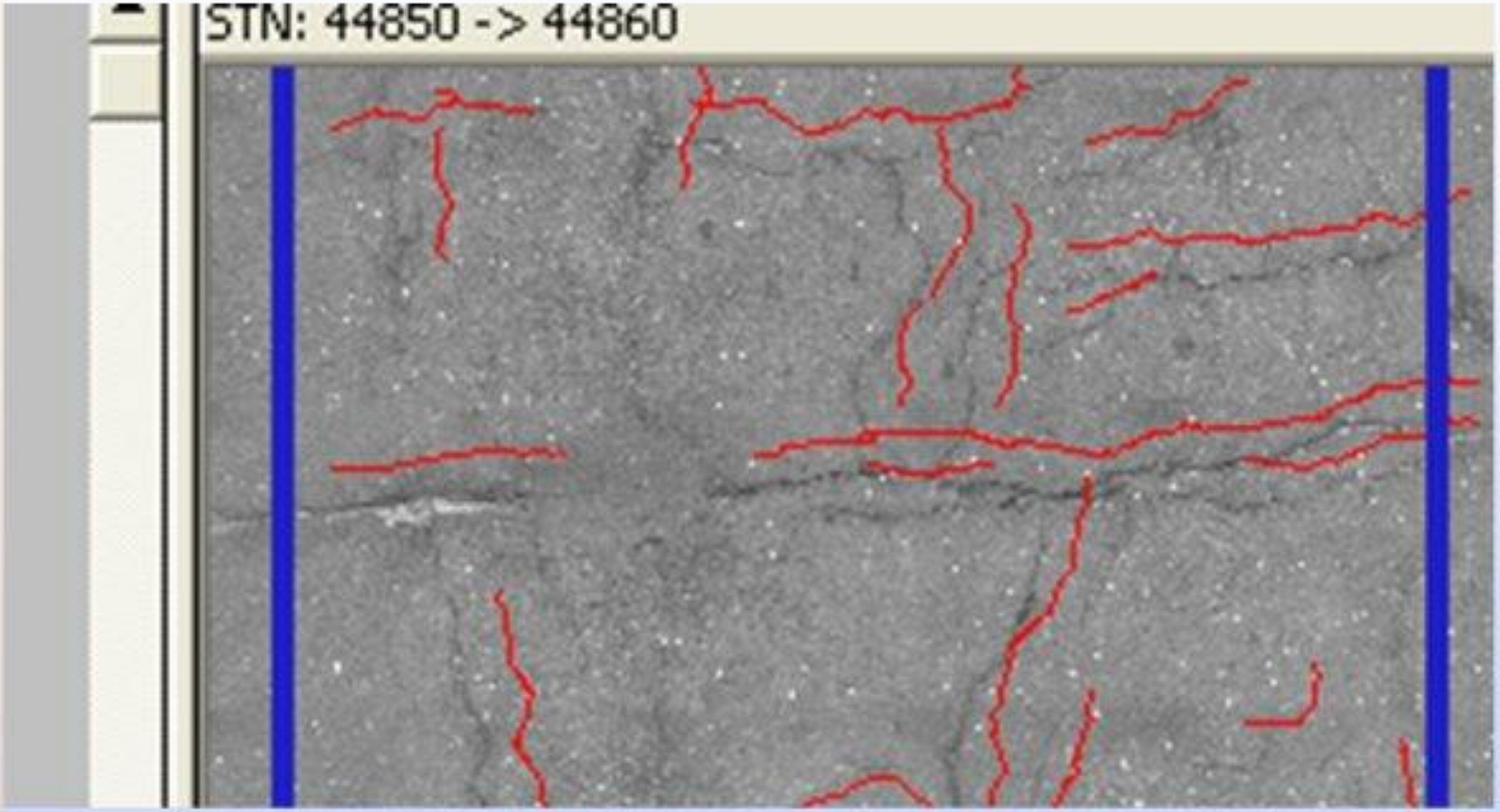


Wisecrax Image

- Lane identification
- Red lines are detected cracks
- Summarized for every 10 meters of pavement length
- Stored on database



Wisecrax Image



Pavement Performance Models

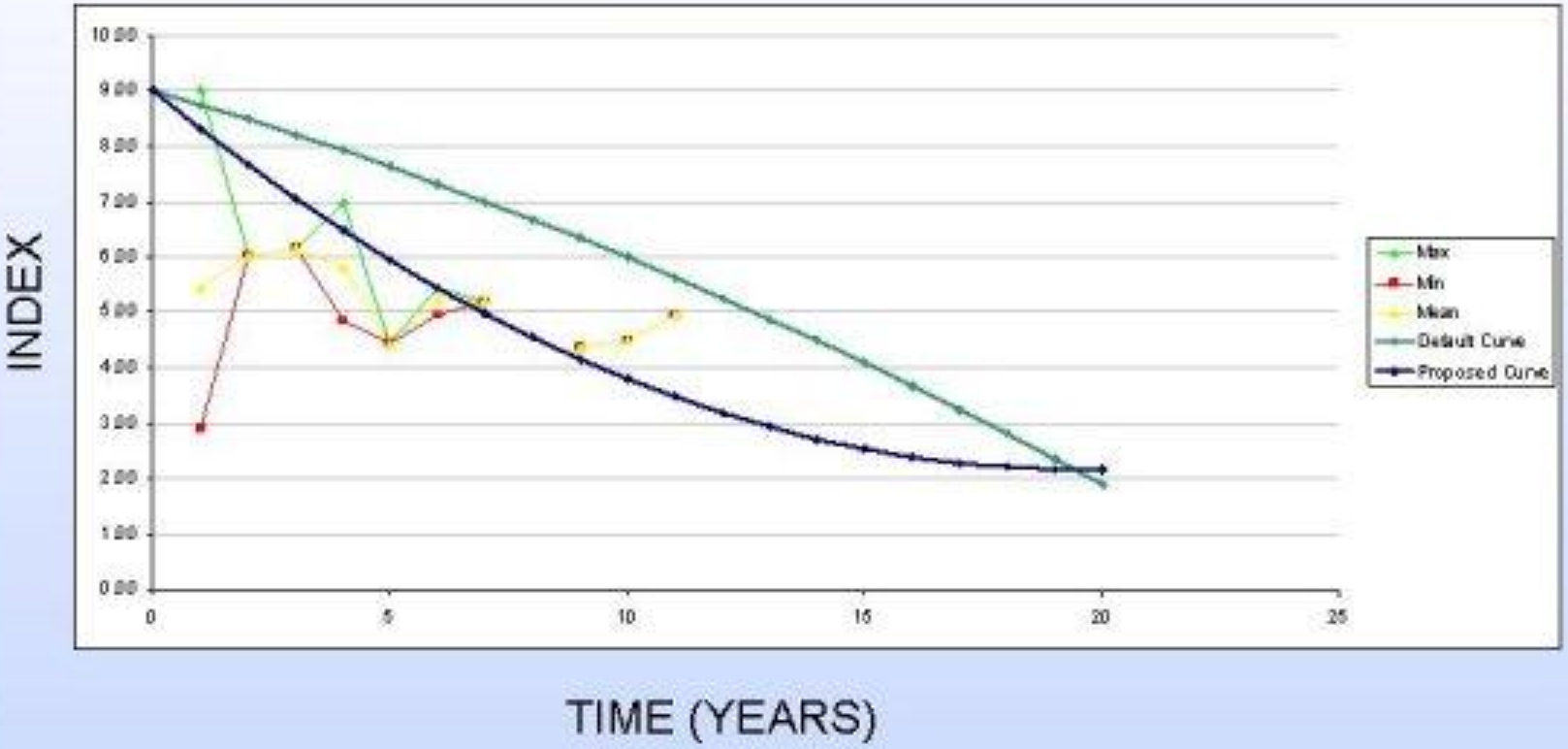
- Condition vs. Time
  - Environmental cracking index
    - TRANSVERSE CRACKS
  - Structural cracking index
    - WHEELPATH LONGITUDINAL CRACKS
  - Rutting index
    - MAXIMUM RUT
  - Roughness (ride) index
    - IRI
- Panels
- Existing condition data

Pavement Performance

- Pavement performance is modeled based on pavement families
  - "Flexible pavements with high traffic in a coastal zone and clayey soils in a poorly drained area"
- Condition versus time

Pavement Performance Models

ENVIRONMENTAL CRACKING for Family: {Flexible, Thin, Light Traffic, Inland, Good Soil}



Putting it all together

- Network optimization using a single condition index
  - Replicate the analysis for all segments in the network
  - Optimize over the long term (network goals)
- Treatments triggered by specific conditions
  - Nature of distress
- PMS software used to produce program and impacts
  - Deighton Associates' dTIMS-CT, 2007-2008

Condition Index

- Pavement Condition Index
- Scale 1-9
- Historically collected via windshield survey
  - *Roughness, Distortion, Cracking, Disintegration, Drainage*
- "Synthetically" produced by PMS now
- Used for network optimization, but treatments are triggered by individual indicators (structural, functional)

Treatments Considered

- Reconstruction ☺
- Quasi-reconstruction ☺
- Structural Rehabilitation (significant milling, repair, and/or overlay)☺
- Functional overlay / diamond grind☺
- Thin and Ultra-thin resurfacing☺
- Not crack sealing ☹

Cost/benefit analysis

- Costs
  - Agency Costs
    - Construction, maintenance
  - User Costs
    - Delays during construction
    - Vehicle operating costs
- Benefits
  - Difficult to quantify
  - Area under the curve that includes the treatment

Costs and Benefits

Outputs of PMS

- Required funding, impact on network with available funding
  - Multi-year program (3-5 years)
  - Multi-year impacts (10-20 years)
- Relative size of programs by treatment

Pavement Preservation

- A set of planned actions that are done on structurally sound pavements to extend their life.
  - The RIGHT treatment on the RIGHT road at the RIGHT time.

Pavement Preservation in PMS

- Are preservation treatments included in PMS?
- What impacts on pavement performance are modeled?
- To what level of detail can actions be programmed?
- Is my pavement condition data sufficiently timely for use in preservation treatments?

Pavement Preservation in PMS

- Are preservation treatments included in PMS?
  - YES, except for crack seal

Pavement Preservation in PMS

- What impacts on pavement performance are modeled?
  - Rubberized chip seal:
    - Moves a pavement 10 years back up the "environmental" condition index
    - Resets "disintegration" distress.
    - Shifts the condition index up.

Pavement Preservation in PMS

- What impacts on pavement performance are modeled?
  - Reclamation:
    - Moves a pavement back 18 years in age
    - Resets all condition indices to 9 (excellent).
    - May change the pavement family

Pavement Preservation in PMS

- To what level of detail can actions be programmed?
  - Depends on how detailed (given: accurate and precise) the data are and whether it relates to the causes of distress.
- Can always go back to condition data

Using PMS data at a project level

- Treatment specific
- Look at driving distress
- Find threshold value
  - Would rather have more detail in data
- Filter out segments above threshold value
- Have a prioritization scheme
  - A. Oldest, B. Best condition

Distress					Crack seal	Crack fill	Rubberized Chip seal	Micro-surfacing	Ultra-thin HMA	Thin HMA	Mill and Fill
	Traffic	**Cause**	**Ext.**	**Sev.**	E/M/N/X	E/M/N/X	E/M/N/X	E/M/N/X	E/M/N/X	E/M/N/X	E/M/N/X
IRI	3000-6000	Cracks	N/A	< 100 in/mi	N	M	M	M	E	E	E
				100-190 in/mi	N	N	M	M	M	M	E
				> 190 in/mi	N	N	N	N	N	M	M
IRI	> 10000	Mat/Rvl	N/A	< 100 in/mi	N	N	N	E	E	E	E
Rutting	< 3000	Densification	N/A	< 0.375 in	N	N	N	E	E	E	E
				0.375-0.75 in	N	N	N	E	E	E	E
				> 0.75 in	N	N	N	M	M	M	E
Cracking	>6000	Environmental	< 2.7 m/10 m	Low	E	N/A	N/A	E	E	E	E
				Med	E	N/A	N/A	M	M	M	M
				High	M	E	N/A	N	M	M	M
			2.7-6.0	Low	E	N/A	N/A	N	N	M	E
				Med	E	N/A	N/A	N	N	N	N
				High	M	E	N/A	N	N	N	N
			> 6.0	Low	M	N/A	N/A	N	N	M	M
				Med	M	N/A	N/A	N	N	N	N
				High	N	E	N/A	N	N	N	N

Indicator of environmental cracking for thin HMA

- Transverse cracks
  - *Threshold value: 3 meters / 10 meters of lane*
- Transverse cracks as fraction of total
  - *Indication of predominance of this distress*
- (Pavement age)
  - *If it's too new then it could be reflection cracking*

Next Steps

- Review Pavement Families – preserved vs. unpreserved curves
  - Allows for benefit of crack-sealing (preserved curves flatter)
- Finalize the Pavement Preservation Matrix using PMS data
- Refine relative costs (M&P of traffic, safety, etc.)

Pavement Preservation in PMS

- **Is my pavement condition data sufficiently timely for use in preservation treatments?**
  - At present, we have found the limits of our data (maybe with more time to look at the data?)
  - Pavement Preservation decisions from distress data require higher accuracy and precision because achieving cost-benefit ratio with project scope is very time-sensitive (but "bad is bad")

Thank you for your attention!

Questions?