9th International Conference on MANAGING PAVEMENT ASSETS (ICMPA9)

MAY 18-21, 2015 • Washington D.C.

ICMPA9 • International Conference on Managing Pavement Assets

Use of Performance Metrics on The Pennsylvania Turnpike

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AASHTO THE VOICE OF TRANSPORTATION

VirginiaTech Transportation Institute

TRB

U.S. Department of Transportation Federal Highway Administration

WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE 1909-2009

VDOT Virginia Department of Transportation

PENNA TURN-PIKE

ARA

Presentation Outline

- Background- Turnpike Construction
- Pavement Data Collection
- Pavement Data Processing
- Pavement Condition Analyses
- Planned Improvements to Pavement Management Process
- Summary

Background

- PA Turnpike 55 years before it opened. (1883 to 1885)
- SPRR never opened.
- Seven abandoned tunnels and some 137 miles of RR grade sat for six decades.
- Great Depression

Birth of PA Turnpike: Historical Context

- "New Deal" provided new jobs
- President F.D.R. approved the idea…but gave no federal funding.
- Act 211 of 1937 is signed by Pa. Gov. George Earle.
- Act set up 5-member Turnpike Commission.

Nothing Else Like it In U.S.: "Autobahn-inspired"

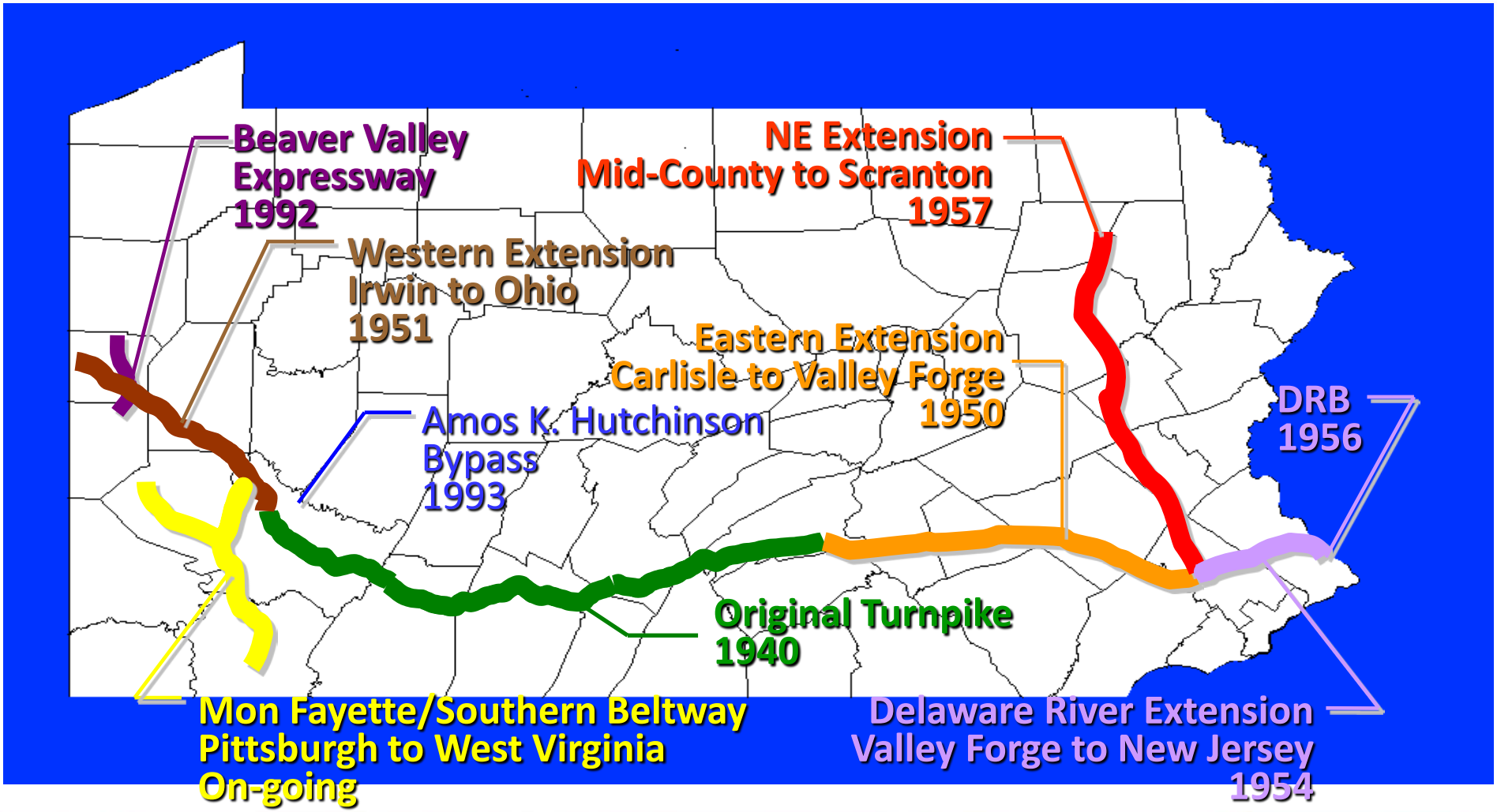
- Consistent design:
  - Curves (≥ 3˚)
  - grades (slopes)
  - lane width (4-12')
  - median (10')
- Limited Access; on and off at select points only.
- No cross streets, stop signs, red lights.
- All roads/rails either under or over Turnpike.

Grand Opening of the "Tunnel Highway"

- Finished in two years. Opened at midnight on Oct. 1, 1940.
- Considered an engineering marvel.
- Nothing like it ever seen in the U.S.
- Built from a motorist's point-of-view – not for "constructability."

Rows of cars line up at "ticket offices" (tollbooths) to be first on the heralded highway.

Extensions - Timeline



PA Turnpike Traffic Comparisons Today versus first full year

- ANNUAL TRAFFIC:
  - 1941: 2.4 million
  - 2014: 196.5 million
- AVERAGE DAILY TRAFFIC:
  - 1941: 6,575
  - 2014: 538,000

The Turnpike bridge over the Susquehanna River was replaced in 2007 with this sleek concrete one.

By the Numbers: PA Turnpike Today

- 553 + miles of toll road
- 65 fare-collection facilities.
- 27 maintenance sheds.
- 2,100 employees.
- Annual toll revenue of $788 million (2012) – about 2.1 million a day.

The M-52 toll barrier on the Mon/Fayette Expressway ("PA Turnpike 43") south of Pittsburgh.

PA Turnpike Current Pavement Management

- Pavement data collected on 1 lane each direction
- Automated Data Collection:
  - International Ride Index (IRI)
  - Rutting
  - Friction (skid resistance)
  - Pavement and ROW images
- Windshield Survey:
  - Determine Pavement Condition Rating (PCR)

Data Collection Procedures Pavement Profiling & Images

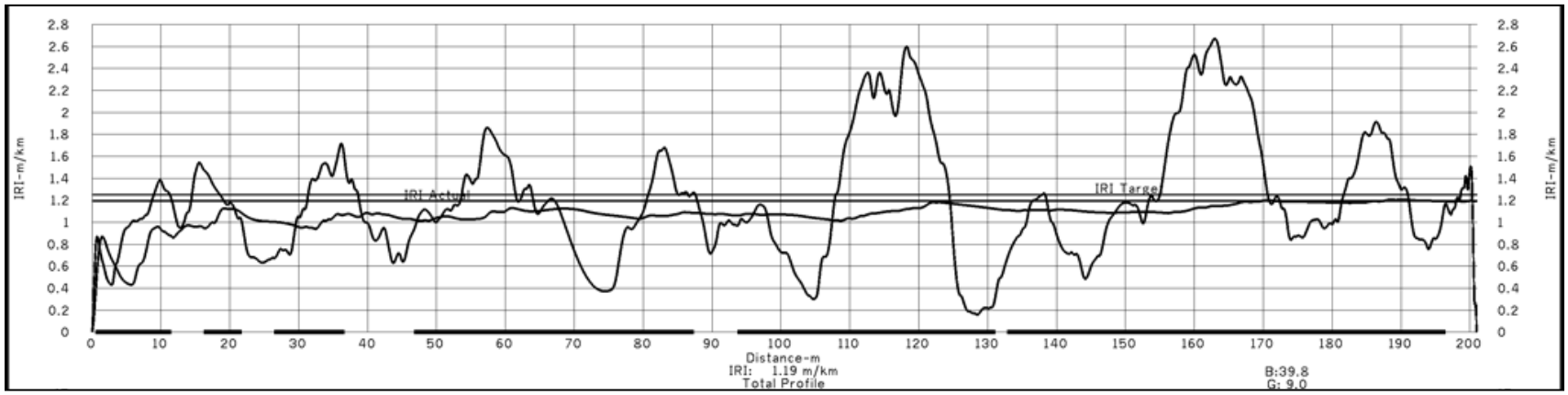
- Digital Survey Vehicle with ASTM E-950 (2) road profiler
  - Surveys at or near highway speed
  - Longitudinal profile every 3 inches
  - 5 transverse profile points
  - Digital video images at 20 ft

IRI- A Simple But Useful Parameter

- Useful overall assessment
- Ride most important parameter to paying customers

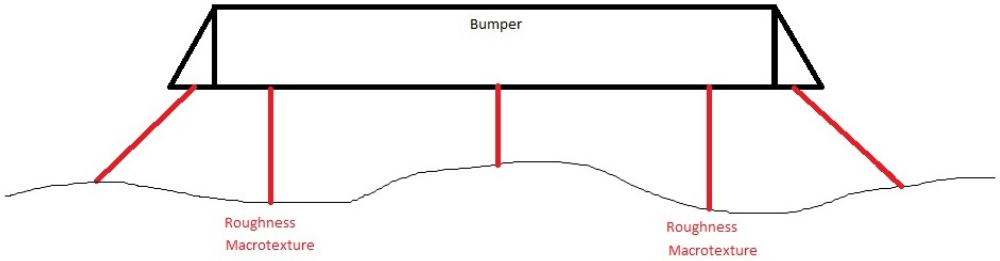
IRI Data Processing

- Longitudinal profile processed to produce IRI for each 0.1 mile interval (in/mi.)
- Data summarized:
  - By PMS section (typically 6-8 miles)
  - By mile & tenth mile



Rutting Determination

- Computer models simulate 5’ straightedge



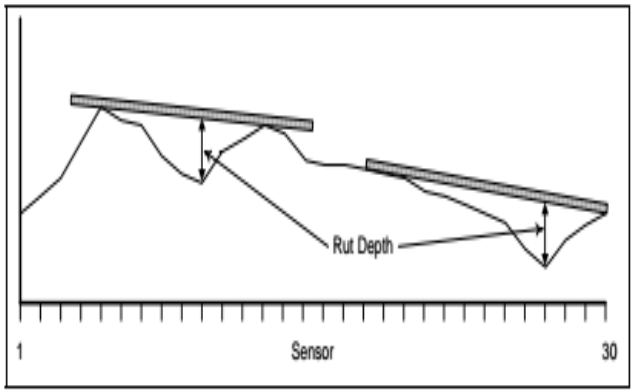


Figure 4.33 C. Bennett, et al 2007

IRI & Rutting Reports

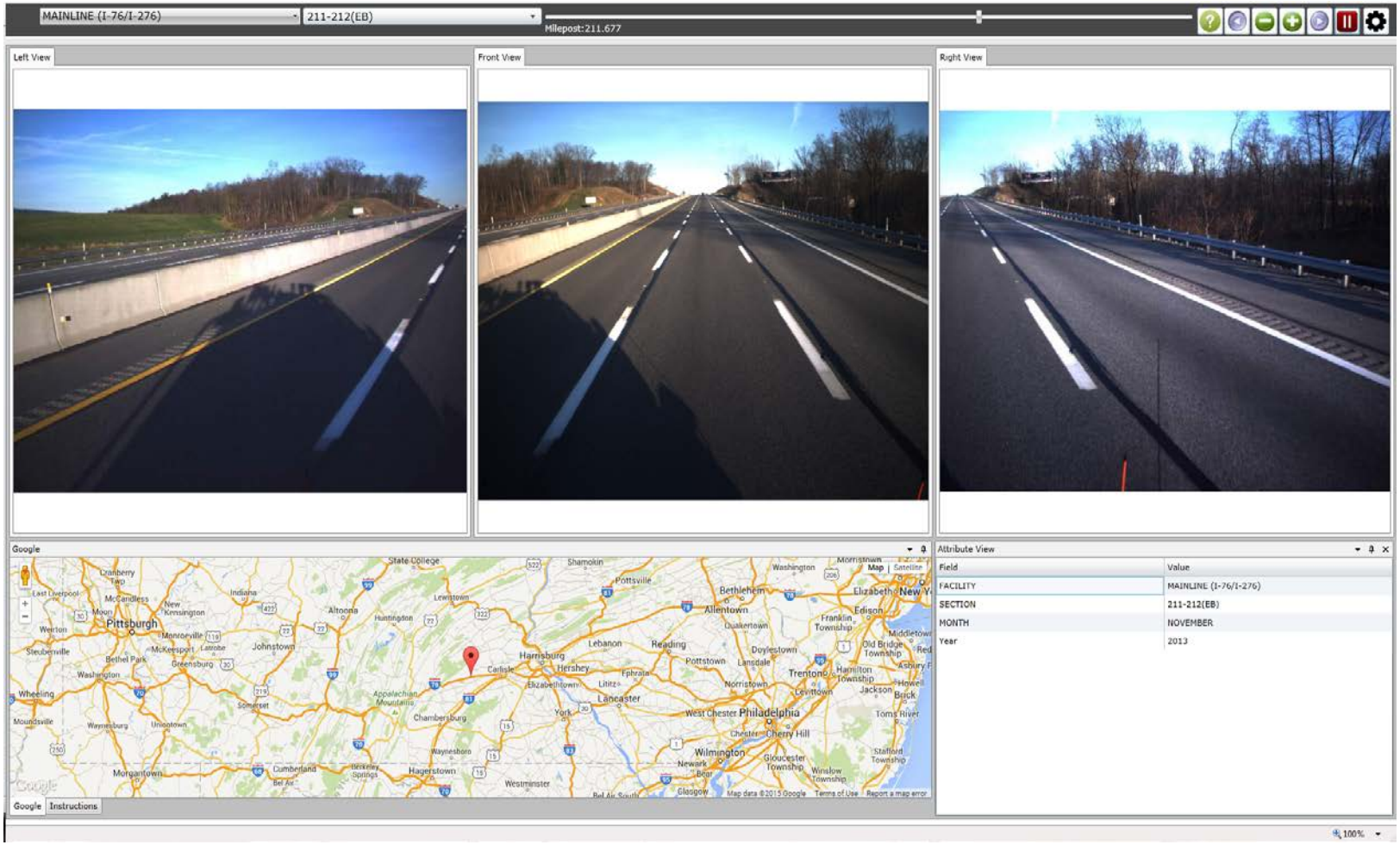
IRI (East)			Rutting (East)					MP				IRI (West)			Rutting (West)		
IRI (inches/mile)			Rut Dist	LWP Avg	RWP Avg	Event				Event		IRI (inches/mile)			Rut Dist	LWP Avg	RWP Avg
LWP	RWP	Avg	(mi)	Rut (in)	Rut (in)	MP	Event	From	To	MP	Event	LWP	RWP	Avg	(mi)	Rut (in)	Rut (in)
98	94	96	0.0953	0.120	0.040			0.00	0.10			61	55	58	0.1000	0.130	0.040
65	62	63	0.1000	0.140	0.060			0.10	0.20			59	53	56	0.1000	0.140	0.070
58	71	64	0.1000	0.100	0.030			0.20	0.30			44	49	47	0.1000	0.160	0.060
53	68	60	0.1000	0.140	0.040			0.30	0.40			77	69	73	0.1000	0.180	0.020
62	55	59	0.1000	0.120	0.030			0.40	0.50			86	66	76	0.1000	0.180	0.030
62	67	65	0.1000	0.090	0.020			0.50	0.60			61	70	65	0.1000	0.160	0.030
56	66	61	0.1000	0.100	0.060			0.60	0.70			84	84	84	0.1000	0.180	0.020
64	62	63	0.1000	0.100	0.060			0.70	0.80			82	84	83	0.1000	0.170	0.030
64	61	62	0.1000	0.110	0.080			0.80	0.90			66	59	63	0.1000	0.170	0.030
57	65	61	0.1000	0.060	0.070			0.90	1.00			59	56	57	0.1000	0.140	0.050
118	138	128	0.1000	0.060	0.180	1.044	Bridge Begin	1.00	1.10	1.053	Bridge End	174	180	177	0.1000	0.090	0.060
						1.056	Bridge End	1.00	1.10	1.063	Bridge Begin						
128	99	113	0.1000	0.130	0.100			1.10	1.20			80	70	75	0.1000	0.140	0.070
91	92	92	0.1000	0.130	0.070	1.217	Toll Plaza Begin	1.20	1.30			49	57	53	0.1000	0.070	0.020
58	59	58	0.1000	0.100	0.030			1.30	1.40			72	65	69	0.1000	0.090	0.030
55	57	56	0.1000	0.120	0.020			1.40	1.50			61	58	59	0.1000	0.100	0.020
91	84	88	0.1000	0.140	0.020			1.50	1.60			61	55	58			
84	72	78	0.1000	0.100	0.060			1.60	1.70			60	66	63			
106	112	109	0.1000	0.120	0.080	1.754	Toll Plaza End	1.70	1.80			62	58	60	0.1000	0.060	0.030
109	109	109	0.1000	0.080	0.030			1.80	1.90			84	79	82	0.1000	0.090	0.040
77	54	65	0.1000	0.080	0.020			1.90	2.00			70	81	75	0.1000	0.050	0.070
102	73	87	0.1000	0.130	0.020			2.00	2.10			54	57	56	0.0997	0.130	0.030
59	67	63	0.1000	0.080	0.090			2.10	2.20			66	68	67	0.1000	0.110	0.030
112	132	122	0.1000	0.090	0.100	2.223	Bridge Begin	2.20	2.30	2.213	Bridge End	123	164	143	0.1000	0.100	0.060
						2.249	Bridge End	2.20	2.30	2.236	Bridge Begin						
						2.284	Bridge Begin	2.20	2.30	2.289	Bridge End						
						2.298	Bridge End	2.20	2.30	2.293	Bridge Begin						
55	78	66	0.1000	0.090	0.040			2.30	2.40			61	80	71	0.1000	0.110	0.030
48	62	55	0.1000	0.090	0.040			2.40	2.50			58	78	68	0.1000	0.110	0.050
46	46	46	0.1000	0.110	0.020			2.50	2.60			57	71	64	0.1000	0.110	0.040

Pavement Condition Analyses

Data Collection
Skid Resistance (Friction)

- Locked Wheel Skid Resistance Testing (ASTM E-274)
- Smooth (ASTM E-524) and/or Ribbed (ASTM E-501) Test Tire
- Measures friction under flooded conditions
- Tests performed at 40 MPH
- Test at 0.1 mile intervals

Pavement & ROW Images



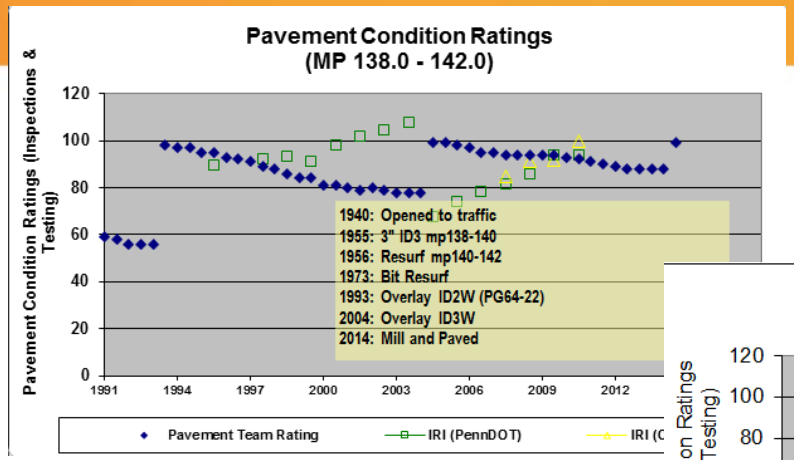
Pavement Condition Rating (PCR)

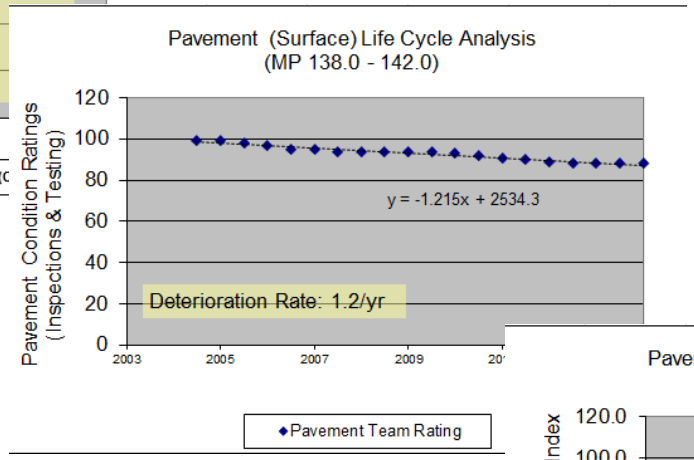
- Developed in May 1991.
- Re-evaluated in 2000 to better analyze the distress for the type of pavement that exist on our system.
- Three different survey sheets were developed:
  - composite
  - flexible
  - rigid.
- “Distress Identification Manual for the Long-Term Pavement Performance Project”, Strategic Highway Research Program (SHRP-P-338; 1993) as a guide.

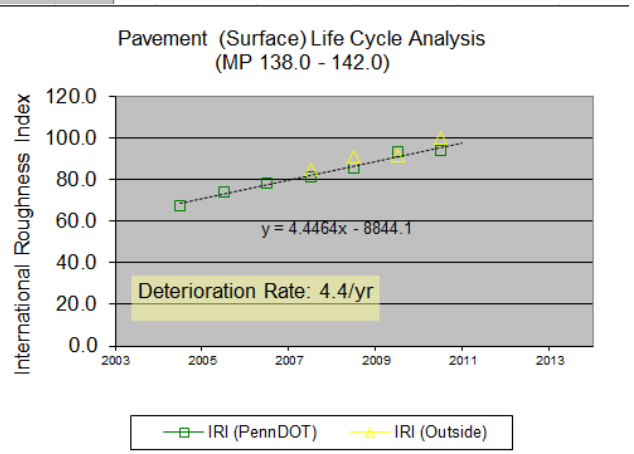
Pavement Condition Rating

Composite Pavement	Point Range		Flexible Pavement	Point Range		Rigid Pavement	Point Range
Overall riding quality	0-40		Overall riding quality	0-40		Overall riding quality	0-40
Transverse and Longitudinal cracks/joints	0-15		Surface defects (Polished Aggregate, Potholes, Flushing, Excess Asphalt, and Oxidation)	0-10		Transverse and Longitudinal (Joint Deterioration and Sealant Loss)	0-15
Surface defects (Polished Aggregate, Potholes, Flushing, Excess Asphalt, and Oxidation)	0-15		Surface Deformation (Rutting, Raveling, Shoving, and Corrugation)	0-25		Structural Defects (Settlement and ASR)	0-15
Surface Deformation (Rutting, Raveling, Shoving, and Corrugation)	0-15		Surface cracking (Alligator, Shrinkage and Longitudinal)	0-25		Surface Deformation (Polished and Delamination)	0-15
Surface cracking (Alligator and Shrinkage)	0-15		Total	100		Cracking (Corner, Longitudinal and Transverse)	0-15
Total	100					Total	100

Pavement Condition Analyses







Pavement Condition Data Thresholds

- Pavement Condition Rating
- International Roughness Index
- Rutting
- Skid Resistance

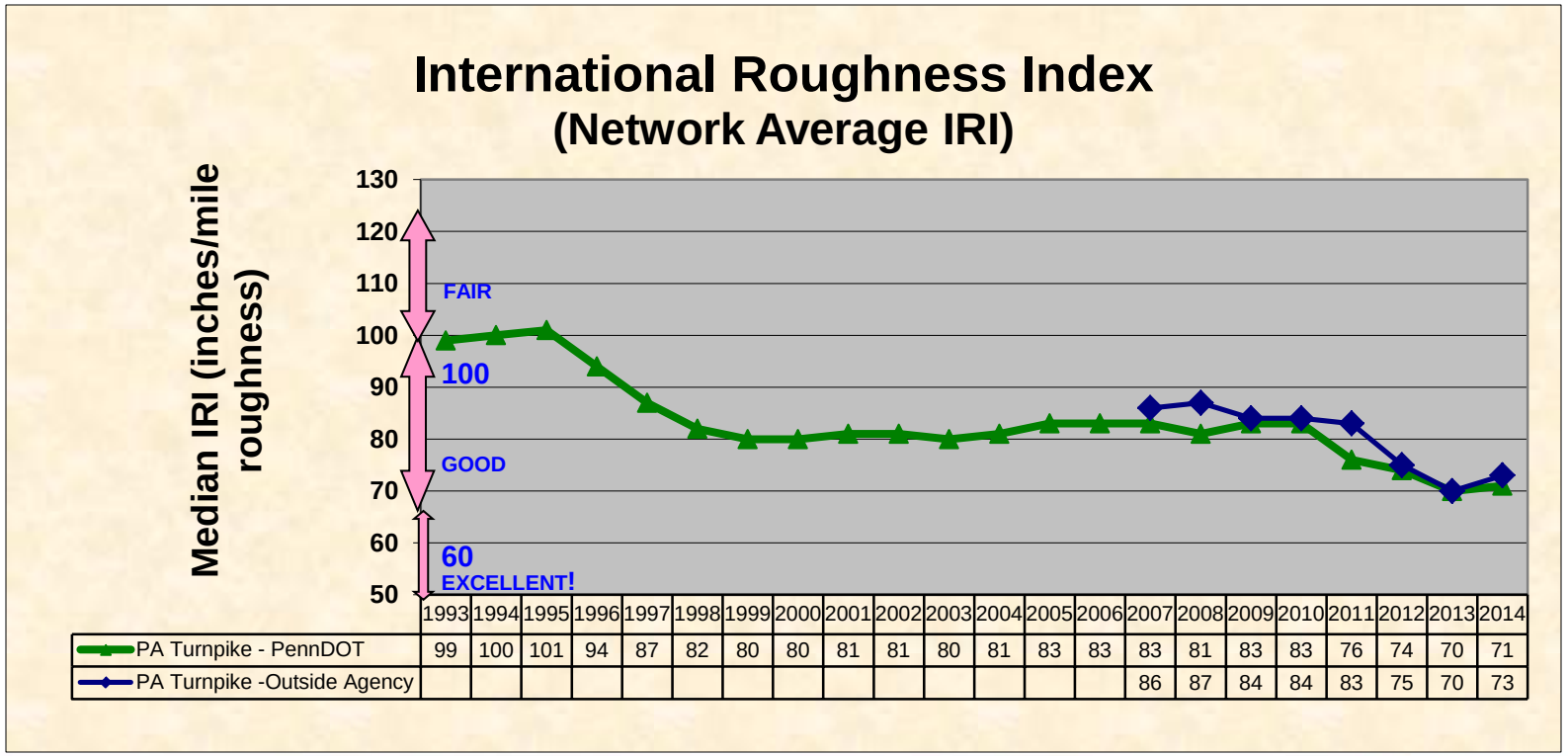
Pavement Condition Data Thresholds for PCR

- Maintain an overall average of 80 or better for the entire system with a minimum PCR of 70 for any section of roadway.

MP SECTION	Last O/L	Oct-14	Apr-14	Oct-13	Apr-13	Oct-12	Apr-12	Oct-11	Apr-11	Oct-10	Apr-10
A020.4 to A025.7	2014	99	80	80	80	80	80	80	80	80	83
A025.7 to A031.1	2011	92	92	92	93	96	96	99	80	80	83
A031.1 to A040.0	2014*	99	74	74	78	81	81	83	86	89	90
A040.0 to A049.0	1998	72	74	75	78	81	81	83	86	89	90
A049.0 to A059.4	2007	80	80	87	89	92	93	95	95	96	97
A059.4 to A068.0	2000	81	81	81	81	81	81	83	85	87	89
T340.1 to T345.7	2000	73	73	73	73	77	77	80	80	83	83
T345.7 to T351.7	2013	99	99	100	77	77	77	80	80	83	83
T351.7 to T353.4	2003	75	75	75	75	78	78	82	85	87	88
T353.4 to T358.0	2012	97	98	99	99	78	78	82	85	87	88
T358.0 to T359.0	2003	78	78	78	78	78	78	82	85	87	88
	AVG. RATING:	91.9	90.8	91.6	90.2	90.4	88.8	88.8	88.4	89.0	88.6

Pavement Condition Data Thresholds for IRI

- Maintain an overall rating between 71 and 100 for the entire system with a maximum IRI of 130 for any section of roadway.



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PA Turnpike - PennDOT	99	100	101	94	87	82	80	80	81	81	80	81	83	83	83	81	83	83	76	74	70	71
PA Turnpike -Outside Agency															86	87	84	84	83	75	70	73

Pavement Condition Data Thresholds for Rutting

Using the 0.1-mile (160 m) data points, no three tenths of a mile (0.3-mile) (0.5 km) in length can be equal to, or greater than, 0.5-inch (13 mm).

IRI (East)			Rutting (East)					MP				IRI (West)			Rutting (West)		
IRI (inches/mile)			Rut Dist	LWP Avg	RWP Avg	Event				Event		IRI (inches/mile)			Rut Dist	LWP Avg	RWP Avg
LWP	RWP	Avg	(mi)	Rut (in)	Rut (in)	MP	Event	From	To	MP	Event	LWP	RWP	Avg	(mi)	Rut (in)	Rut (in)
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62	67	65	0.1000	0.090	0.020			0.50	0.60			61	70	65	0.1000	0.160	0.030
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64	61	62	0.1000	0.110	0.080			0.80	0.90			66	59	63	0.1000	0.170	0.030
57	65	61	0.1000	0.060	0.070			0.90	1.00			59	56	57	0.1000	0.140	0.050
118	138	128	0.1000	0.060	0.180	1.044	Bridge Begin	1.00	1.10	1.053	Bridge End	174	180	177	0.1000	0.090	0.060
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55	57	56	0.1000	0.120	0.020			1.40	1.50			61	58	59	0.1000	0.100	0.020
91	84	88	0.1000	0.140	0.020			1.50	1.60			61	55	58			
84	72	78	0.1000	0.100	0.060			1.60	1.70			60	66	63			
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46	46	46	0.1000	0.110	0.020			2.50	2.60			57	71	64	0.1000	0.110	0.040

Pavement Condition Analyses

Pavement Condition Data Thresholds Skid Resistance

No three tenths of a mile (0.3-mile) (0.5 km) in length can have a FN_{smooth} less than 20, or a FN_{ribbed} less than 35

Friction Number - Eastbound							Friction Number - Westbound				
	Collected	FN		Event	MP		Event	FN		Collected	
Comments	Date	L-Ribbed	R-Smooth	MP	From	To	MP	L-Ribbed	R-Smooth	Date	Comments
	11/5/2014		53		36.00	36.10			54	11/5/2014	
	11/5/2014	58			36.10	36.20		65		11/5/2014	
	11/5/2014		52		36.20	36.30			53	11/5/2014	
	11/5/2014	58			36.30	36.40		66		11/5/2014	
	11/5/2014	58	54		36.40	36.50		65	51	11/5/2014	
	11/5/2014		53		36.50	36.60			52	11/5/2014	
	11/5/2014	57			36.60	36.70		60		11/5/2014	
	11/5/2014		53		36.70	36.80			49	11/5/2014	
	11/5/2014	57			36.80	36.90		59		11/5/2014	
	11/5/2014	58	52		36.90	37.00		60	51	11/5/2014	
	11/5/2014		48		37.00	37.10			54	11/5/2014	
	11/5/2014	63			37.10	37.20		59		11/5/2014	
	11/5/2014		51		37.20	37.30			49	11/5/2014	
	11/5/2014	61			37.30	37.40		55		11/5/2014	
	11/5/2014	52	46		37.40	37.50		54	50	11/5/2014	
	11/5/2014		42		37.50	37.60			47	11/5/2014	
	11/5/2014	54			37.60	37.70		55		11/5/2014	
	11/5/2014		48		37.70	37.80			50	11/5/2014	
Bridge Begin	11/5/2014	56		37.831	37.80	37.90	37.829		43	11/5/2014	Bridge End
Bridge End	11/5/2014	47		37.946	37.90	38.00	37.940	*31*	43	11/5/2014	Bridge Begin
	11/5/2014		44		38.00	38.10		50		11/5/2014	
	11/5/2014	48			38.10	38.20			41	11/5/2014	

Pavement Project Selection

- Regression analysis for each section of the Turnpike using the PCR and IRI data Deterioration rates are calculated for both PCR and IRI.
- Utilizing the deterioration rates and threshold values, the year of expected section failure is predicted.
- With the failure predictions, the Commission's ten year capital plan is created

Planned Improvements to Pavement Management

Two Areas of improvement

- Automated Data Collection
- Pavement Asset Management System

Planned Improvements to Pavement Management

Turnpike moving towards a more automated data collection Distress that will be collected in accordance to PennDOT's Pub 336 Automated Pavement Condition Survey Field Manual

Rigid	Composite	Flexible
IRI		
Rutting		
Skid Resistance		
Faulted Joints		Fatigue Cracking
Broken Slab		Transverse Cracking
Transverse Joint Spall		Miscellaneous Cracking
Transverse Cracking		Edge Deterioration
Longitudinal Joint Spall		Left Edge Joint
Longitudinal Cracking		Bituminous Patching
Bituminous Patching		

Pavement Asset Management System Phase Approach

Initial Deployment	Stabilization	Enhancements and EAM
• Pavement Condition Rating • IRI – Rutting – Friction • Pavement Age • Treatment Matrices • Distress Categories • Milepost Stationing • Pavement Cores, History and Families • Decay Charts • Resurfacing Schedule • Lane Miles • Open End Work • Roadway 10 Yr Plan • Related 10 Yr Plans: Bridge , Total Reconstruction, Toll Plaza, All Electronic Tolling (for work scheduling)	• Maintenance • County & Township Database (GIS) • Roadway Valuation	• Tunnel and Bridge Pavements • FEMO (Horizontal Structures) • Interchange -Toll Plaza • Access Roads • Service Plaza • Cell Tower Roads • New Distress Categories • Equipment and Inventory (Attenuators, Delineators, Signs, Barriers, Guiderails, Signals) • Pavement Design and Mix Design • AET • Intelligent Transportation Devices • Drainage

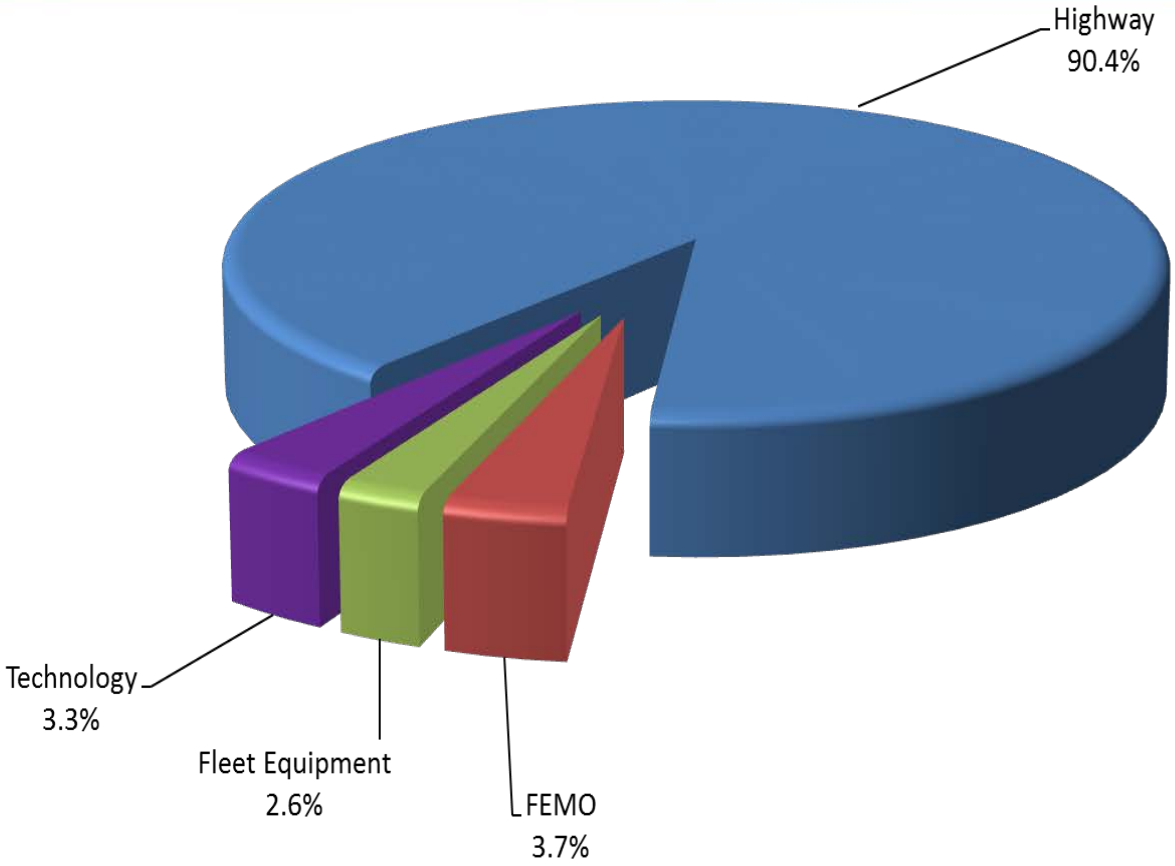
PTC Major Initiatives

- Total Reconstruction Projects
- Major Bridges
- Roadway Resurfacing
- Structurally Deficient Bridges
- Tunnel Upgrades
- I-95/Turnpike Interchange
- SR 22 to I-79 Expansion Project
- ITS Projects
- All Electronic Tolling

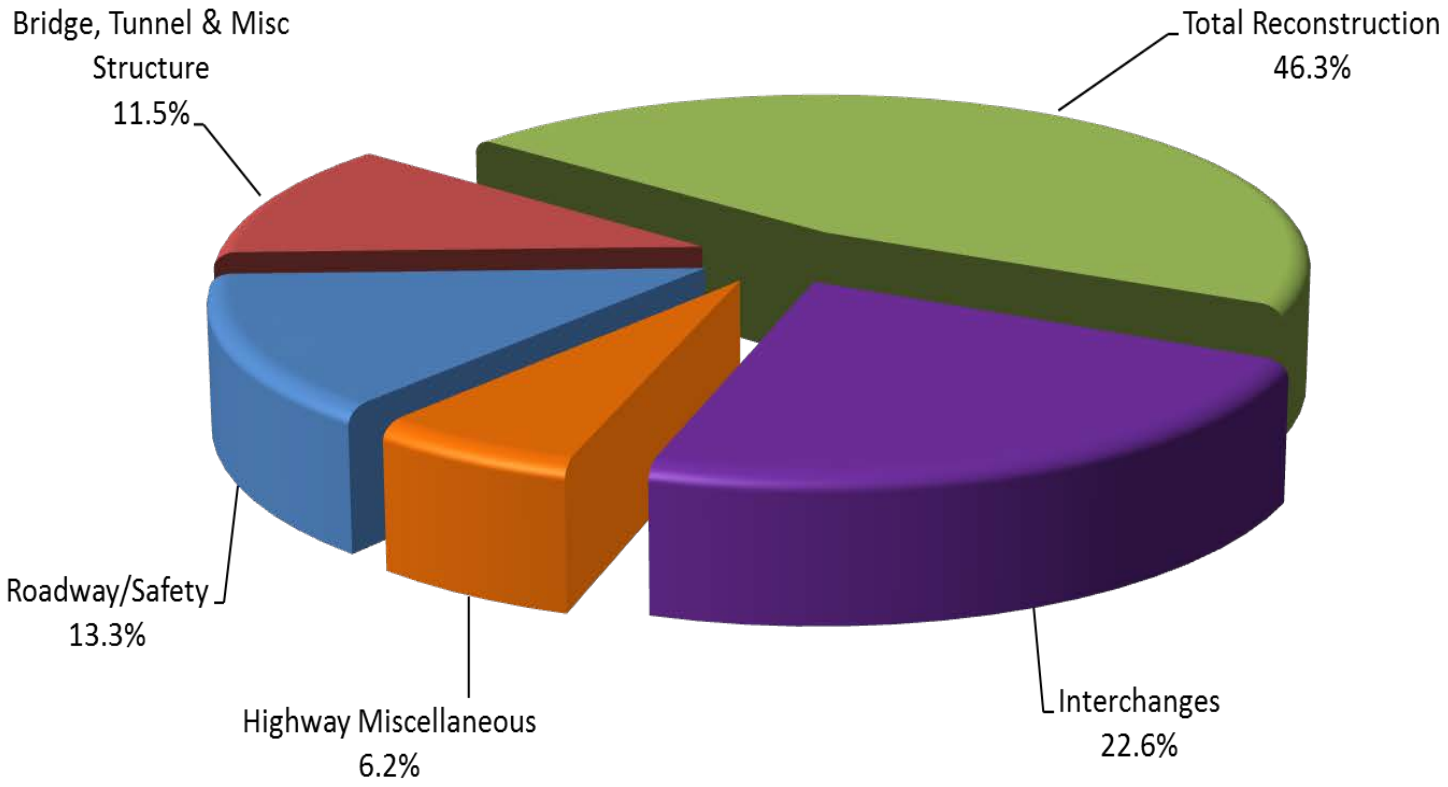
FY 2016 Capital Plan Challenges

- Proposed Capital Plan in FY2016 is $736M.
- Highway Program spending averages approximately $600M/year.
- Continued financial constraints from Act 44 and Act 89.

FY 2016 Capital Plan Ten Year Total = $6.55Billion
By Program



FY 2016 Highway Program First Year Spending = $660,110,000 By Category



Summary & Conclusions

- PA Turnpike Commission has substantial investment in infrastructure
- Pavement management is a critical tool in managing infrastructure
- Current data collection & analyses allow proactive decision making based on objective data
- Future improvements include more robust data collection & analysis

Thank you

Questions?

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