2020 WEBINAR SERIES

RPUG Road Profile Users' Group

Updating a State Pavement Condition Framework Using Relative Performance Targets

By

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Overview

- Problem Statement
- Proposed Alternate Concept
- Implementation
- Interpretation

Problem Statement

Problem Statement

Metric	Good	Fair	Poor
IRI (inches/mile)	<95	95-170	>170
Rutting (inches)	<0.20	0.20-0.40	>0.40
Cracking (%)			
- Asphalt	<5	5-20	>20
- Jointed Concrete	<5	5-15	>15
- Continuously Reinforced Concrete	<5	5-10	>10
Faulting (inches)	<0.10	0.10-0.15	>0.15

CT DOT TAMP. (page 2-13) https://portal.ct.gov/-/media/DOT/documents/dplansprojectsstudies/plans/Highway-Transportation-Asset-Management-Plan-FHWA-Certified-072418.pdf?la=en

- Existing National Rating Systems are too stringent for all routes
  - HPMS/MAP21 IRI thresholds for example
- Current State System had been developed during a period of rapid technological advances
- Review of TAMPs and Other State Reports suggested no 'gold standard' state exists for condition rating

The overall PCI is a weighted average of the following metrics, with each metric weight shown in parentheses:

- IRI (10%)
- Rutting (15%)
- Cracking (25%)
- Disintegration (30%)
- Drainage (20%)

Pavement Condition: PCI Ratings and State of Good Repair		
9.0 8.0 7.0 6.0	Good	SOGR
5.0 4.0	Fair	
3.0 2.0 1.0	Poor	

Problem Statement

CT DOT Maintains roadways meeting all functional classifications of HPMS.

It is unrealistic to hold all these roadways to the same pavement performance metrics.

- Continuous Paving vs. Intersection-Restricted Closures
- Utilities / Driveways
- Grading for Intersections, turn lanes
- Access to subsurface utilities by others
- User experience is different (speeds, intersections, etc.)

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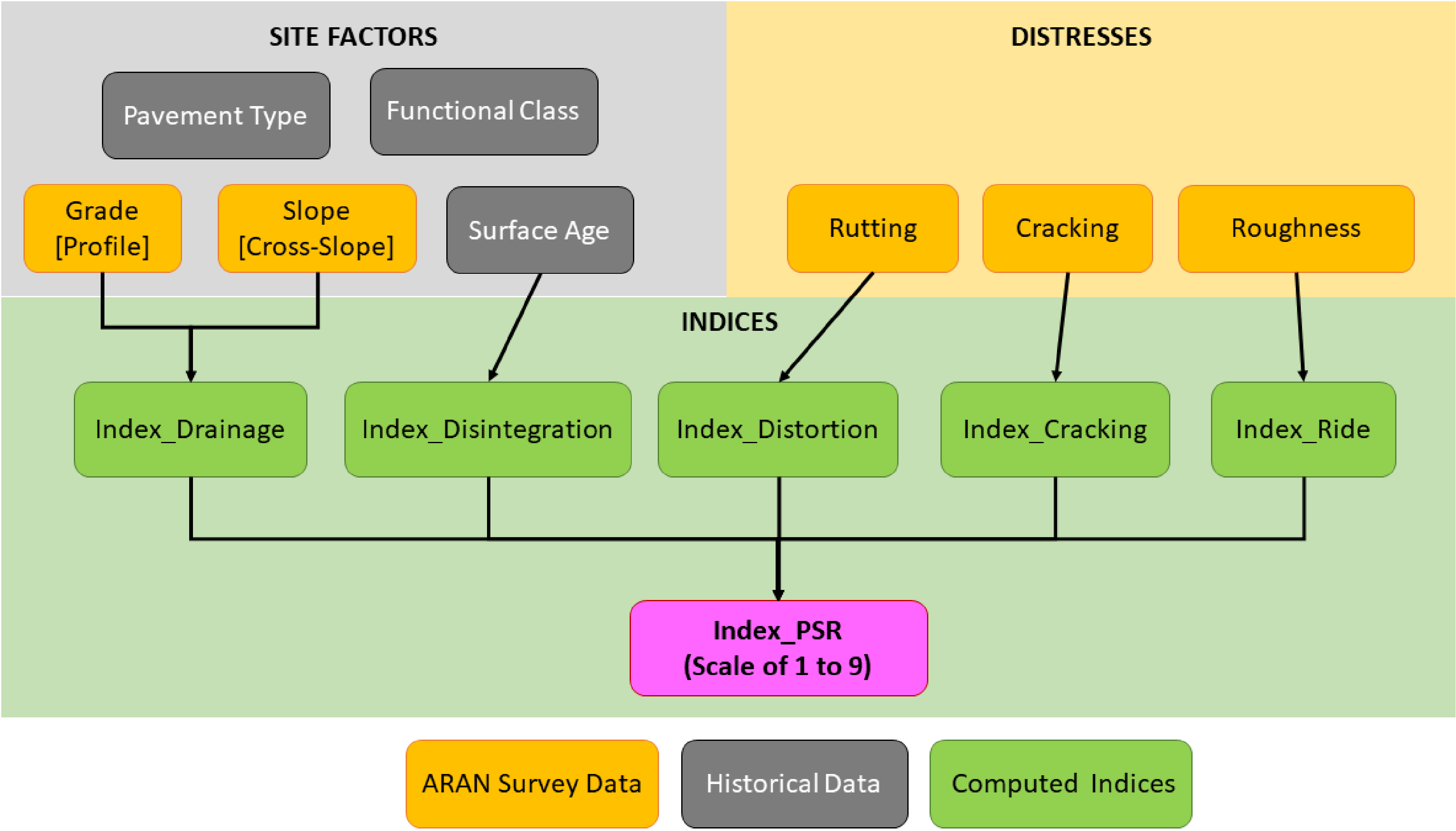
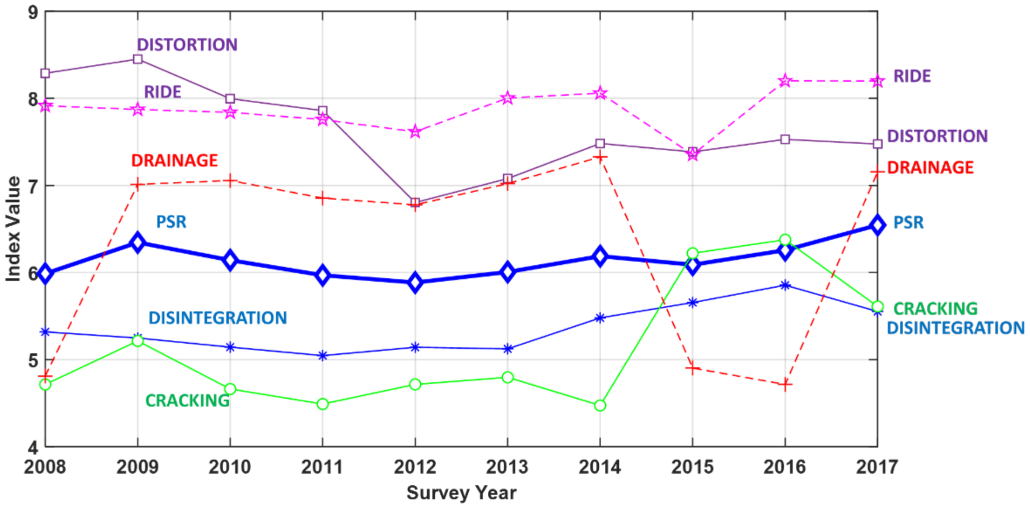
Problem Statement

Diagram of data streams for the state's existing pavement rating system



Problem Statement



Existing Data Streams over time.

Note – large variations are associated with technology leaps

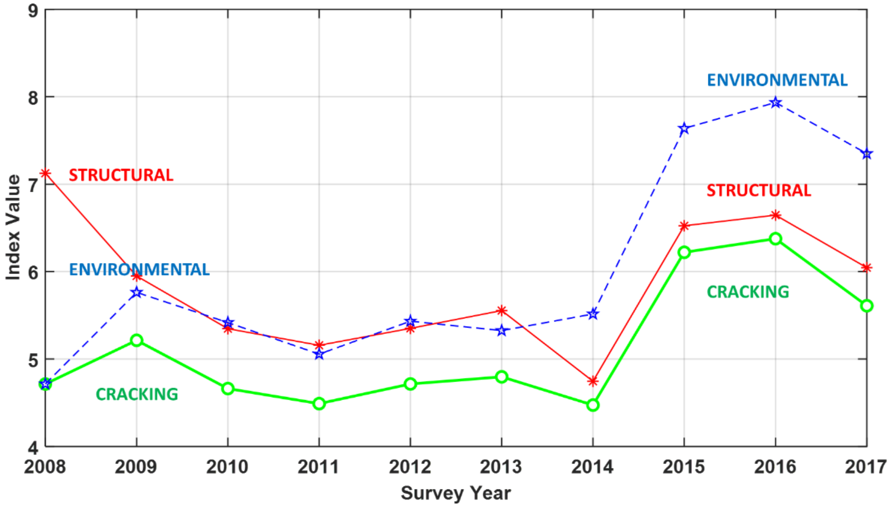


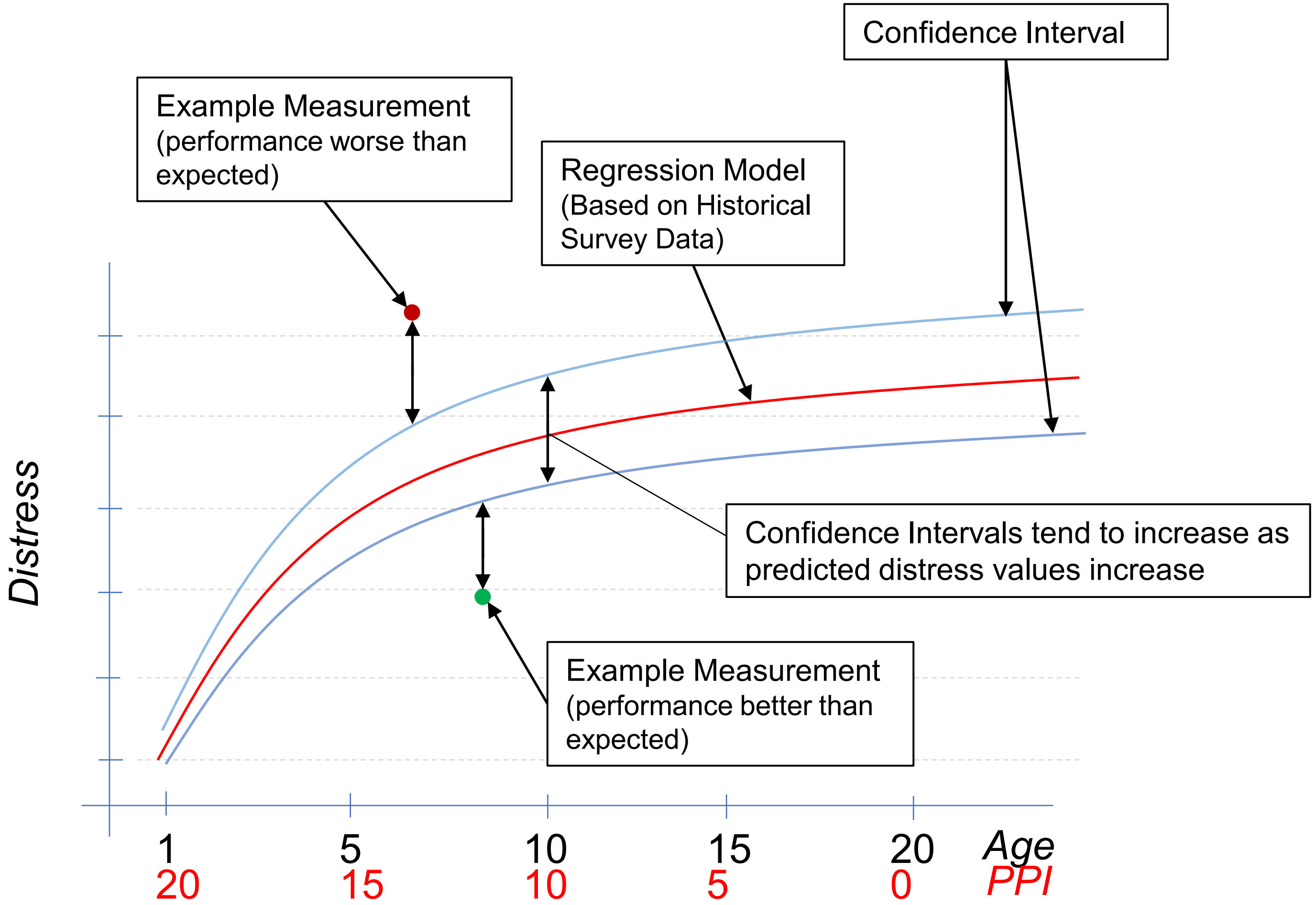
Table 2. Summary of the ANOVA evaluation of the influential factors of distresses.

	Log10 (F) for Influential factors		
Distress Indicators	**Age Group**	**Pavement Type**	**Functional Class**
Ride Quality (MRI)	3.2	1.0	3.1
Rutting (RUT)	3.6	1.4	2.1
Cracking (ALLCRACK)	3.7	1.78	1.79

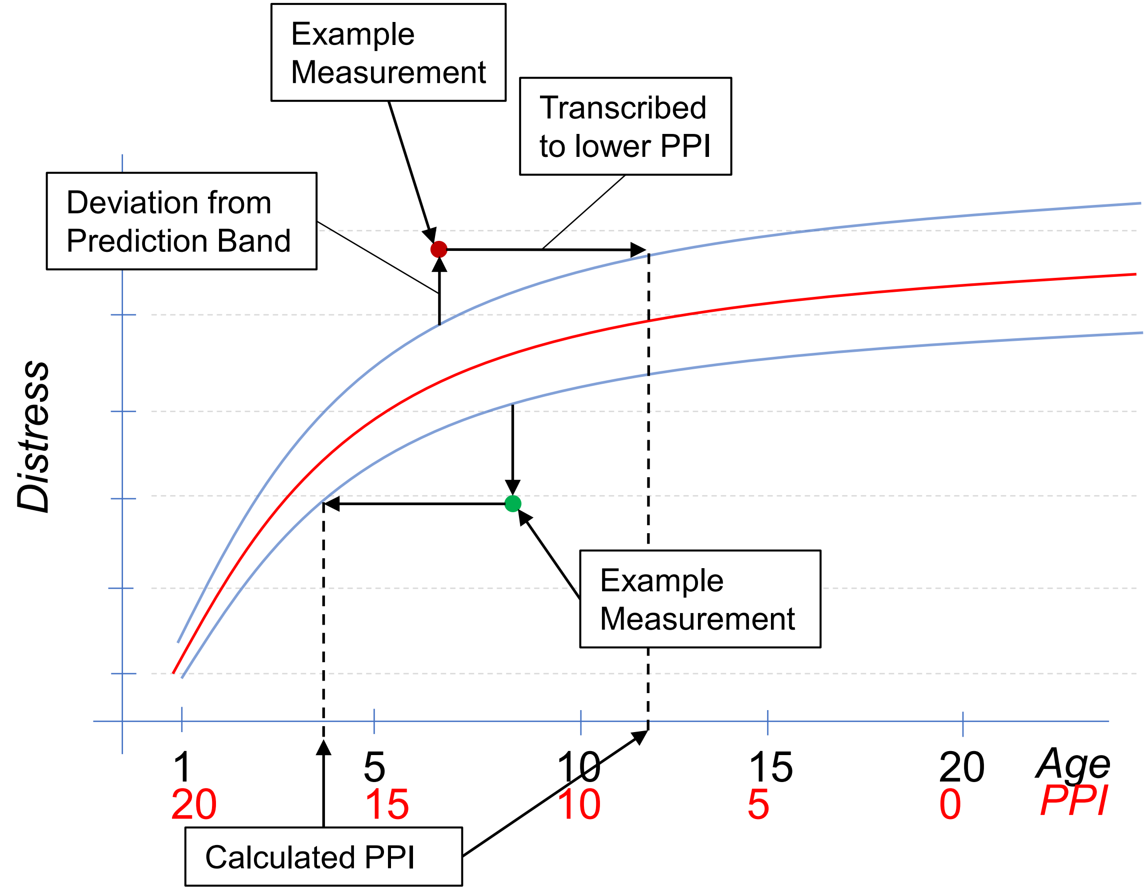
Existing Data Streams over time.

Proposed Concept

Proposed Concept

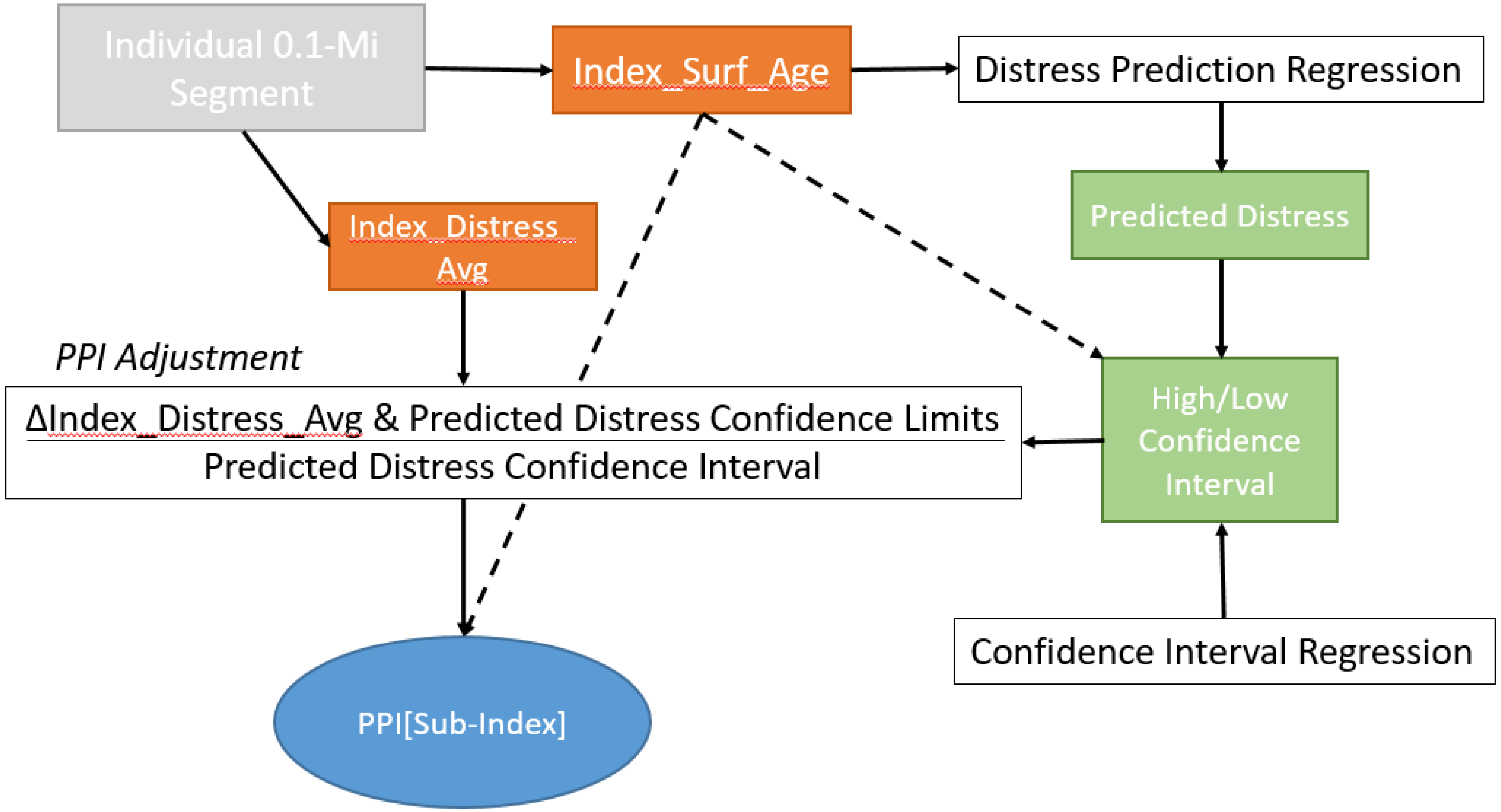


Proposed Concept



Proposed Concept

PPI Sub-Index Calculation

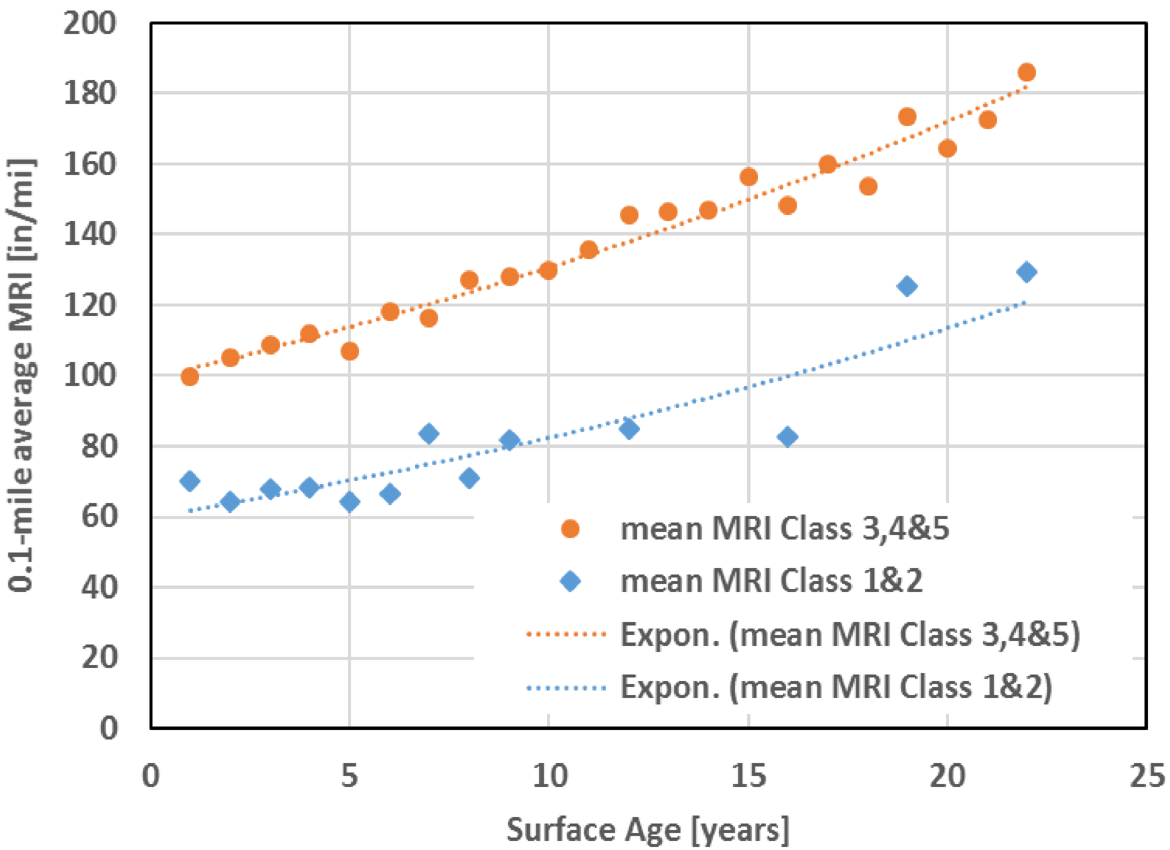


Implementation

Implementation

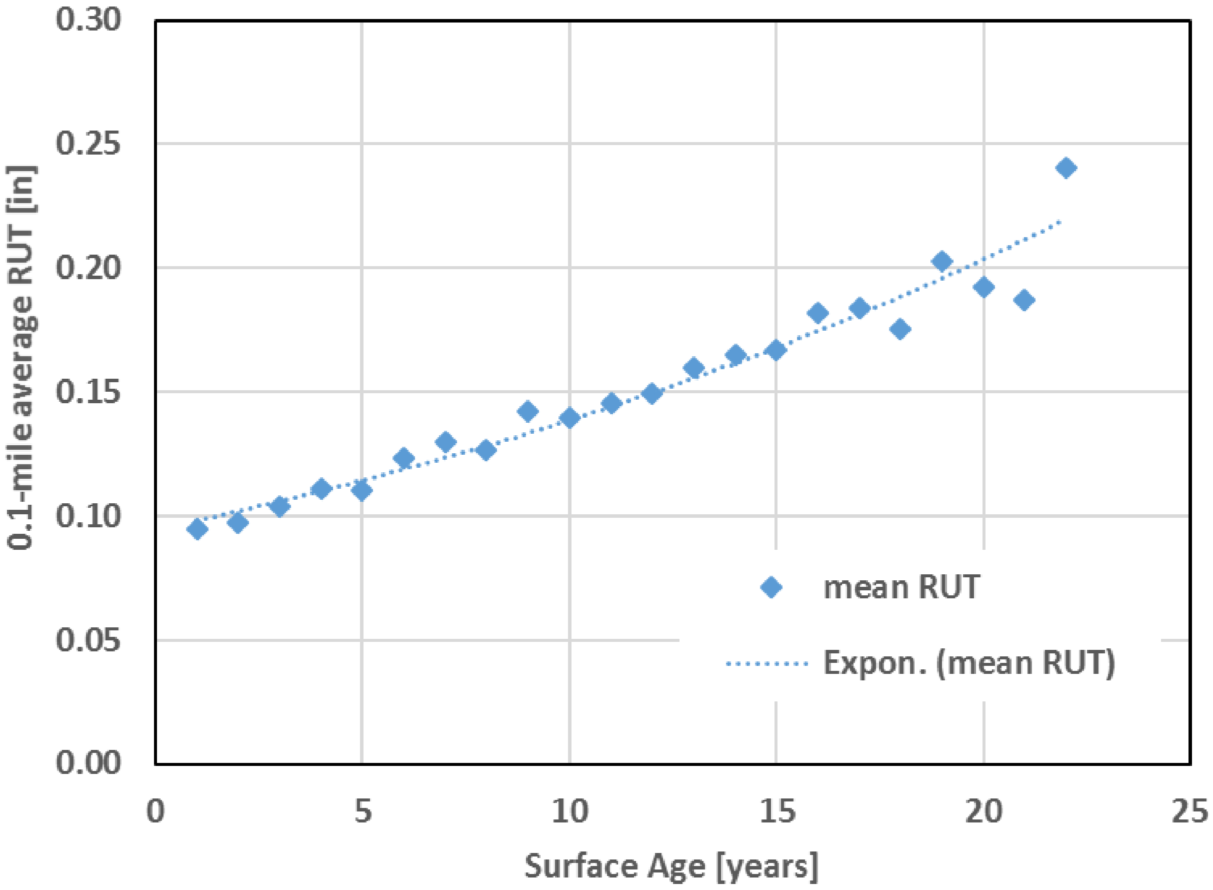
Predictor (x=Age)	Response (y=Distress Sub-Index)	Functional Classes	Pavement Type	Model Type	Model Formula
Age_{12}	MRI_{12}	1&2	Flex, Comp	exponential	$y=a*e^{bx}$
Age_{345}	MRI_{345}	3-5	Flex, Comp	exponential	$y=a*e^{bx}$
Age	RUT	1-5	Flex, Comp	exponential	$=a*e^{bx})$
Age_{Flex}	$WP\_Cracking_{Flex}$	1-5	Flex	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$
Age_{Comp}	$WP\_Cracking_{Comp}$	1-5	Comp	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$
Age_{Flex}	$NWP\_Cracking_{Flex}$	1-5	Flex	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$
Age_{Comp}	$NWP\_Cracking_{Comp}$	1-5	Comp	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$
Age_{Flex}	$ALL\_Cracking_{Flex}$	1-5	Flex	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$
Age_{Comp}	$ALL\_Cracking_{Comp}$	1-5	Comp	5-degree polynomial	$y=a*x^5 +b*x^4+ c*x^3 +d*x^2$ $e*x+f$

Implementation



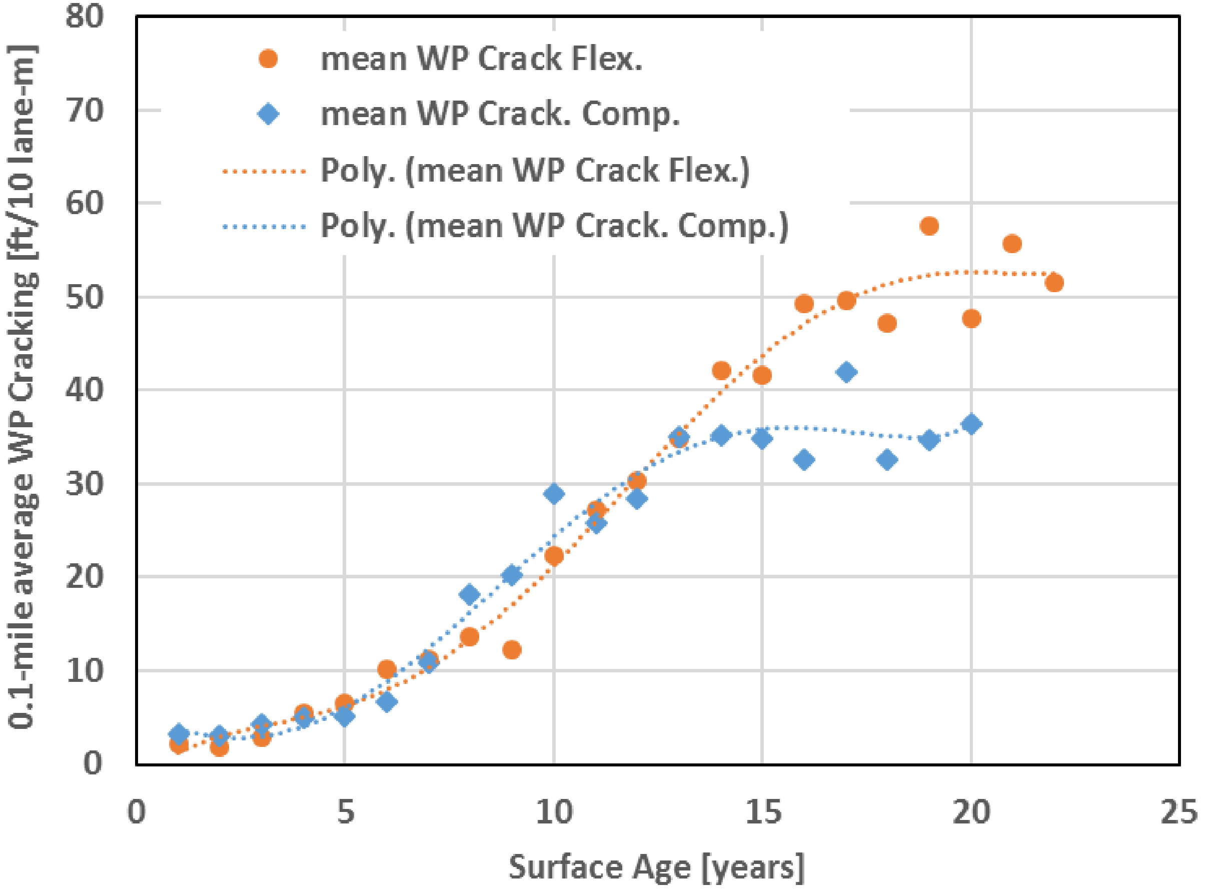
Formula for Mean	RMSE	R-Square
$58.485e^{0.0343Age}$	8.74	0.85
$99.686e^{0.0272Age}$	4.79	0.96

Implementation



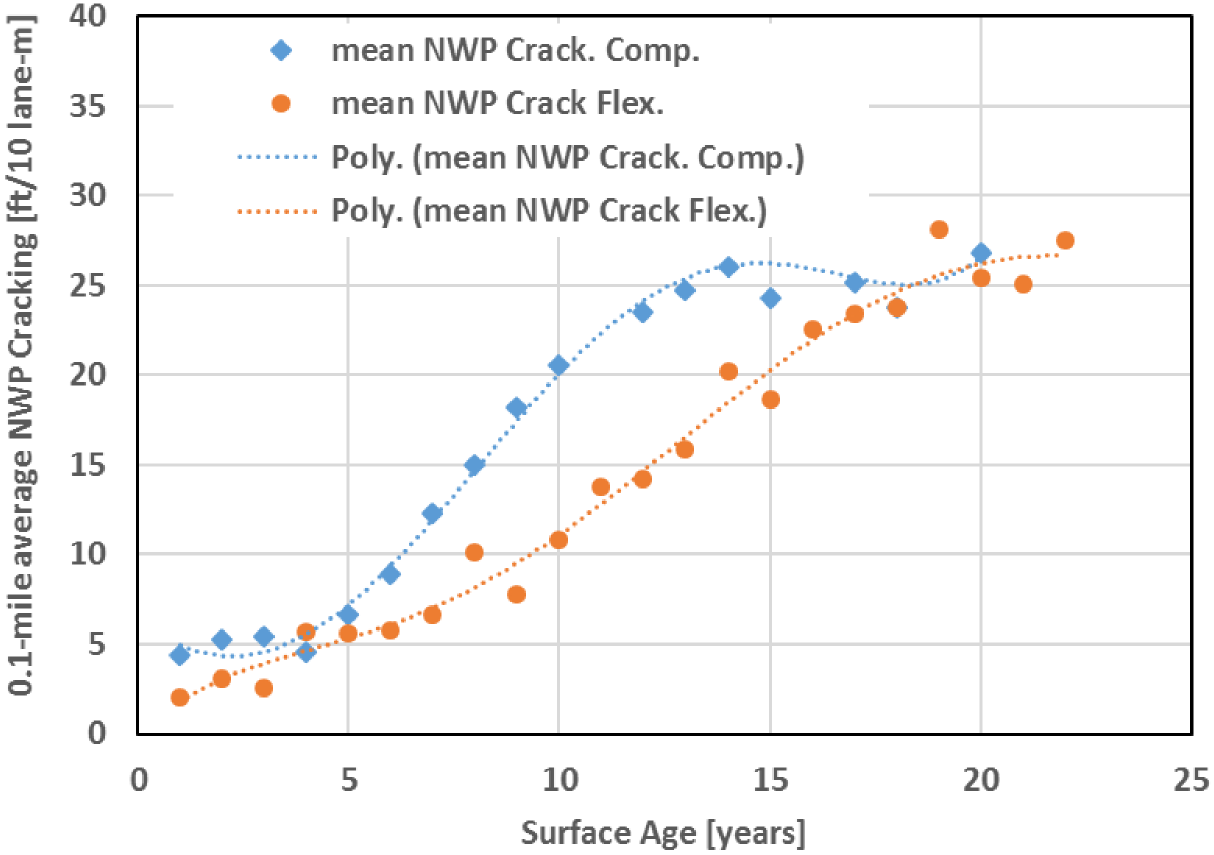
Formula for Mean	RMSE	R-Square
$0.0956e^{0.0376Age}$	0.01	0.95

Proposed Concept



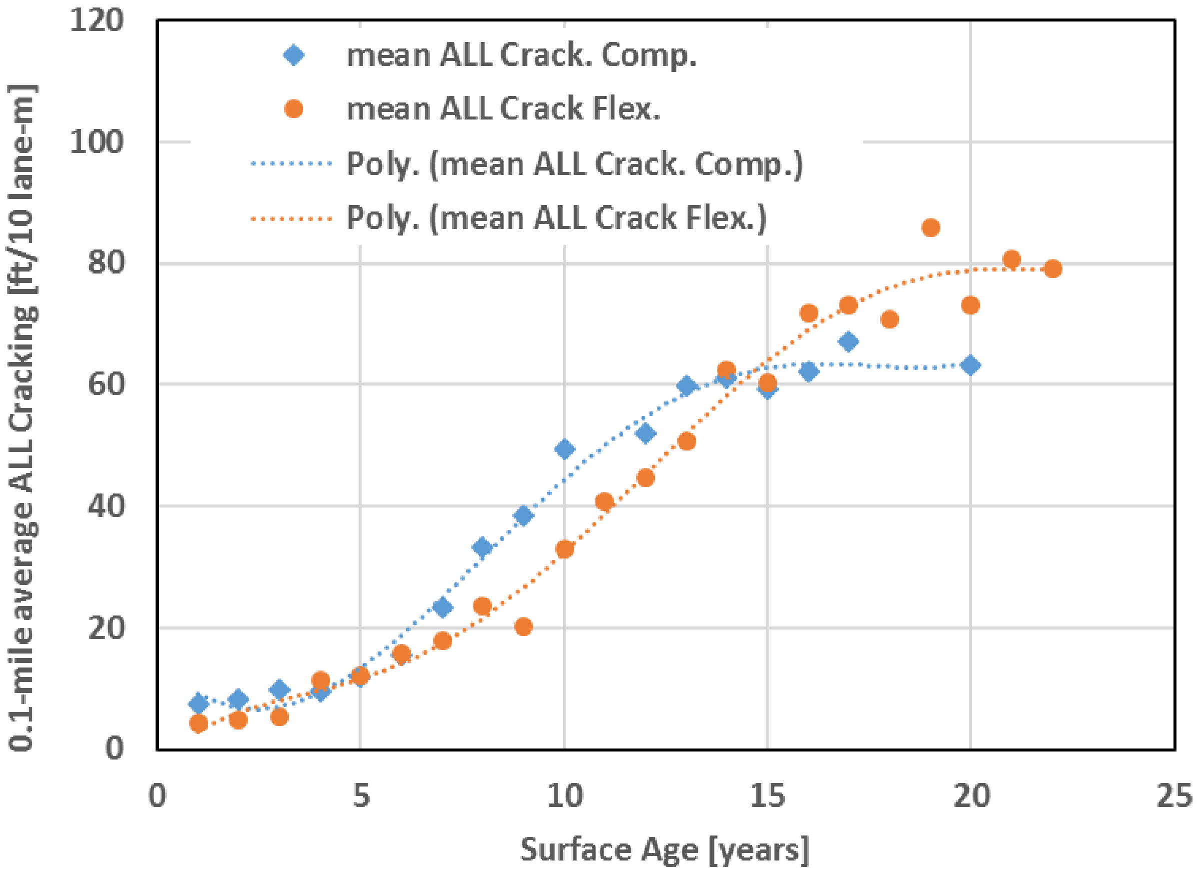
Formula for Mean	RMSE	R-Square
$0.0001Age^5-0.0083Age^4+0.16Age^3-1.11Age^2+4.07Age-1.92$	2.88	0.98
$0.00004Age^5-0.0025Age^4+0.06Age^3-0.47Age^2+2.34Age-0.16$	1.36	0.98

Proposed Concept



Formula for Mean	RMSE	R-Square
$0.0002Age^5-0.0109Age^4+0.22Age^3-1.596Age^2+6.44Age-2.08$	3.82	0.99
$0.00015Age^5-0.006Age^4+0.063Age^3+0.23Age^2-1.88Age+5.36$	2.80	0.97

Proposed Concept



Formula for Mean	RMSE	R-Square
$0.0001Age^5-0.0038Age^4+0.026Age^3+0.33Age^2-1.68Age+6.27$	1.41	0.98
$0.0001Age^5-0.0024Age^4-0.05Age^3+1.63Age^2-6.81Age+14.38$	2.95	0.99

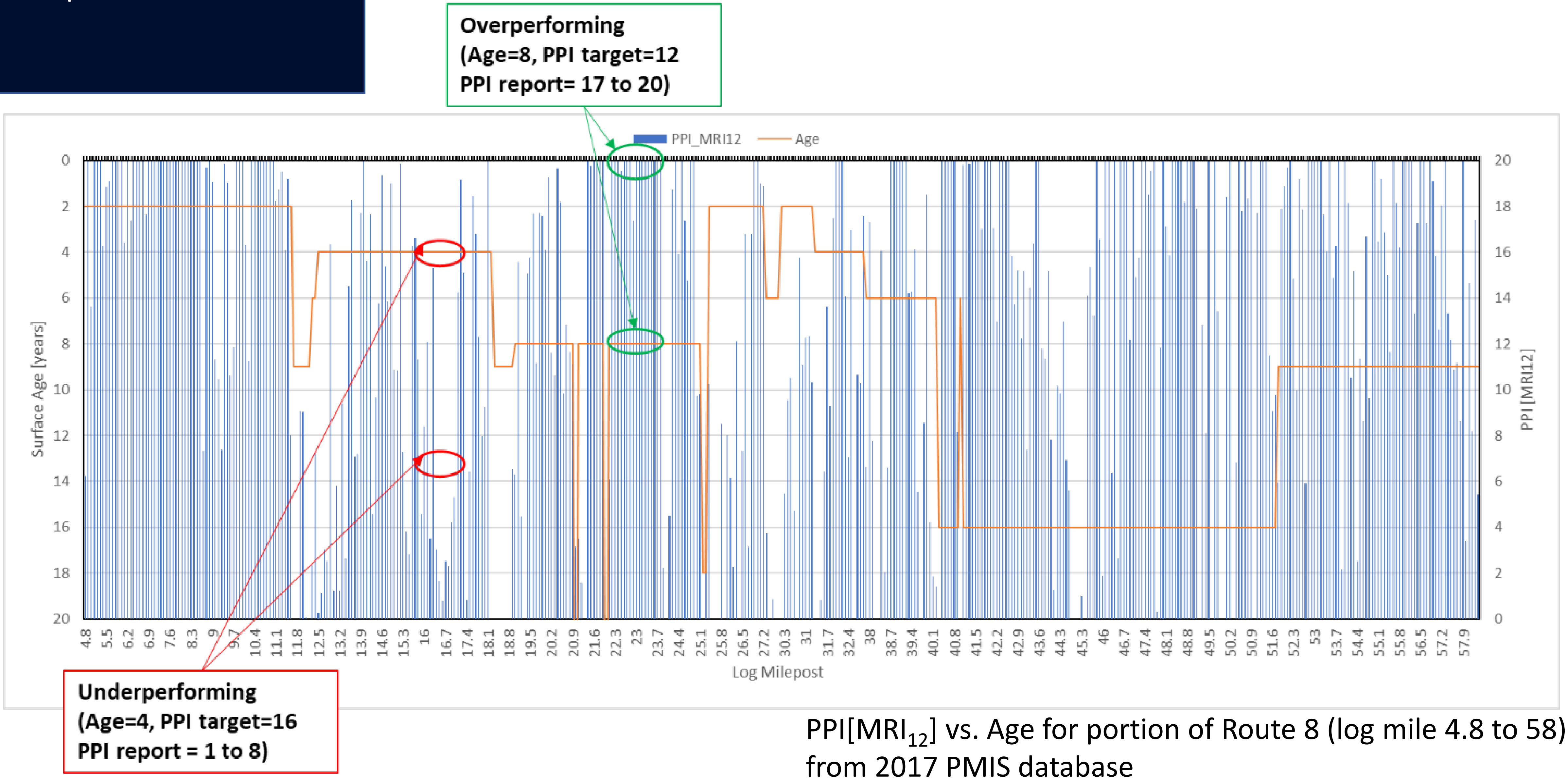
Implementation

PPI SubIndex (y)	Formula for Mean	RMSE	R-Square
PPI_MRI12	y=20-ln(x/58.485)/0.0343	0.65	0.98
PPI_MRI345	y=20-ln(x/99.686)/0.0272	0.47	0.99
PPI_RUTall	y=20-ln(x/0.0956)/0.0376	0.66	0.99
PPI_WPflex	$-4.1E-7*x^5+5.5E-5*x^4-0.003x^3+0.079x^2-1.308x+20.85$	0.28	0.99
PPI_NWPflex	$5.4E-6*x^5-4.4E-4*x^4+0.011x^3-0.088x^2-0.911x+21.06$	0.20	0.99
PPI_ALLCRACKflex	$-2.9E-8*x^5+5.9E-6*x^4-5.0E-3*x^3+0.023x^2-0.759x+21.45$	0.25	0.99
PPI_WPcomp	$-4.2E-6*x^5+3.8E-4*x^4-0.013*x^3+0.228x^2-2.196x+22.75$	1.56	0.95
PPI_NWPcomp	$4.4E-6*x^5-3.6E-4*x^4+7.2E-3*x^3+0.003x^2-1.48x+24.00$	1.98	0.92
PPI_PPI_ALLCRACKcomp	$-4.1E-7*x^5+6.6E-5*x^4-3.9E-3*x^3+0.112x^2-1.68x+25.44$	1.28	0.97

$$PPI_n = \min_n\Big(PPI[MRI_{12}] + PPI[MRI_{345}], PPI[RUT], PPI[WP\_Crack_{Flex}] + PPI\big[WP\_Crack_{Comp}\big], PPI[NWP\_Crack_{Flex}] + PPI\big[NWP\_Crack_{Comp}\big]\Big)$$

Interpretation

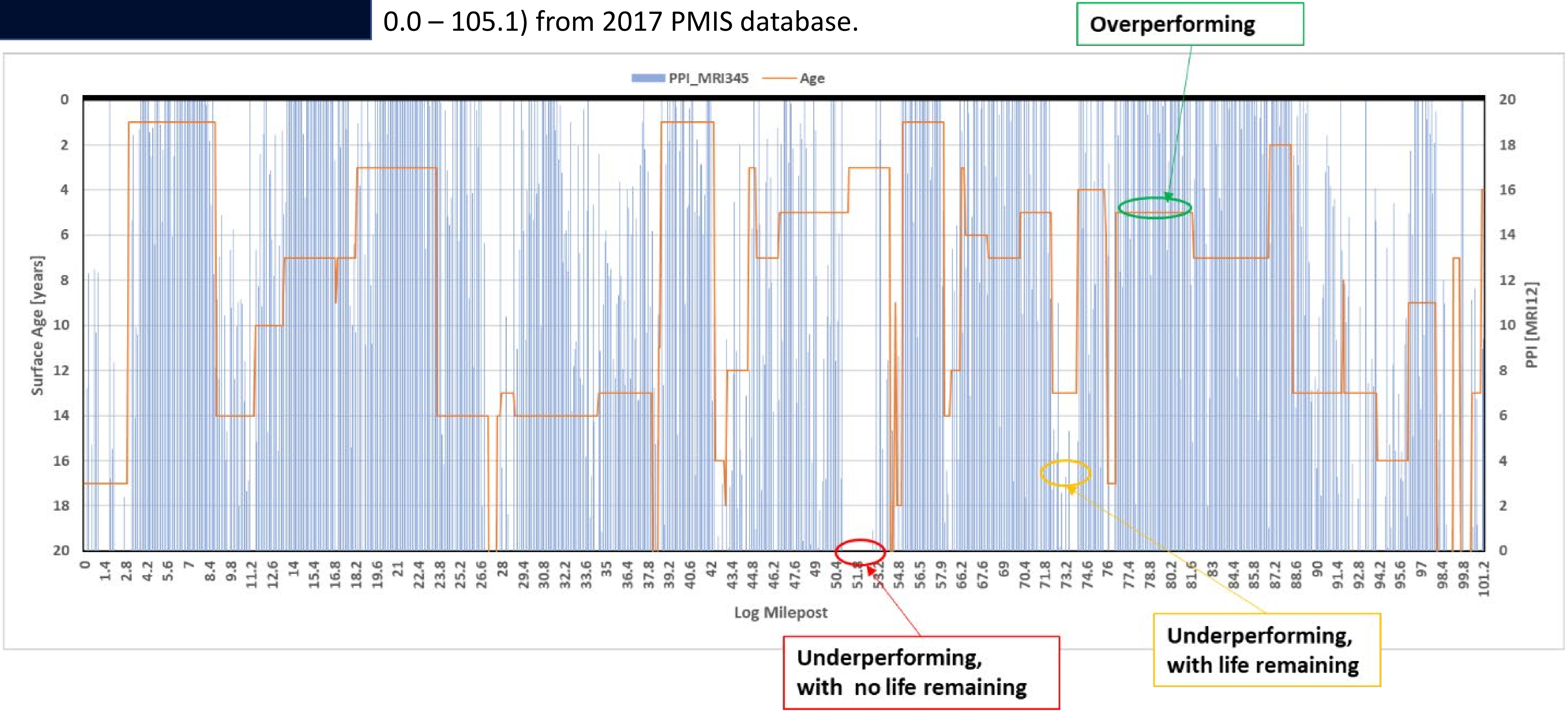
Interpretation



PPI[MRI_{12}] vs. Age for portion of Route 8 (log mile 4.8 to 58) from 2017 PMIS database

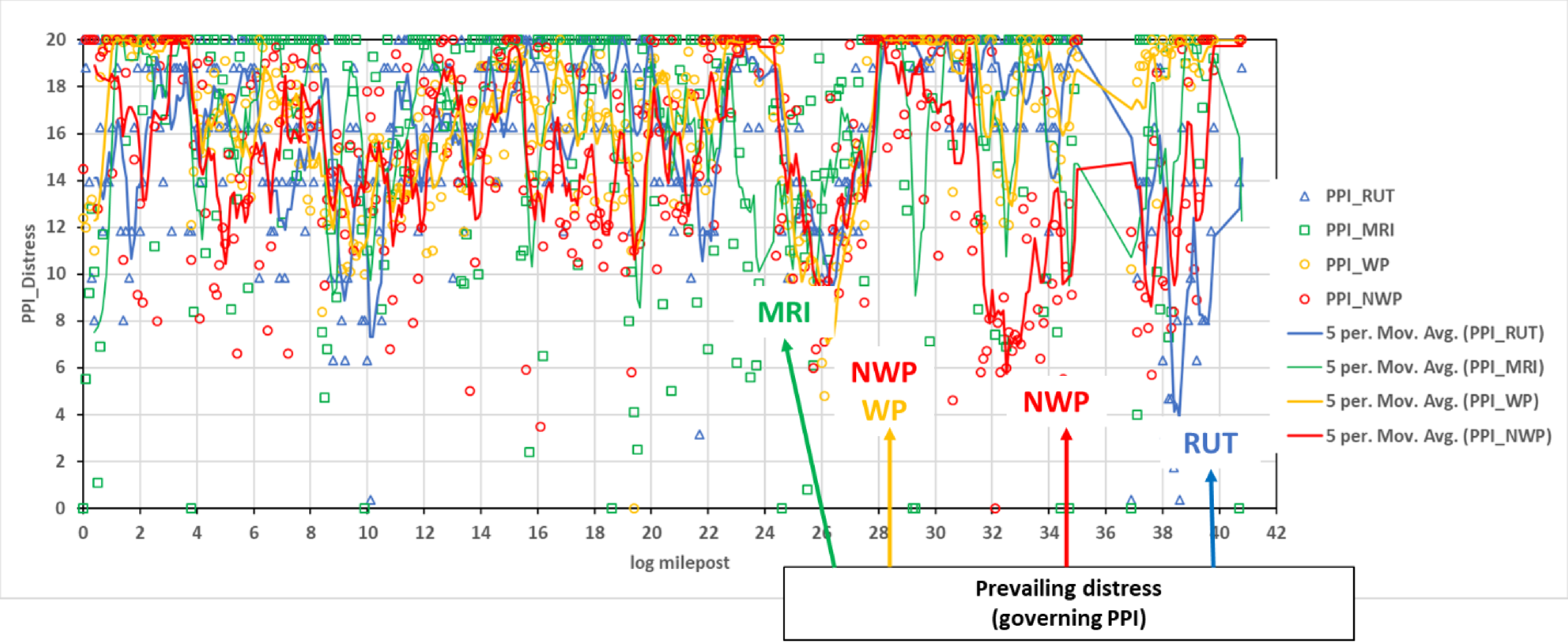
Interpretation

PPI[MRI345] vs. Age for Portions of Route 44 (within log mile 0.0 – 105.1) from 2017 PMIS database.



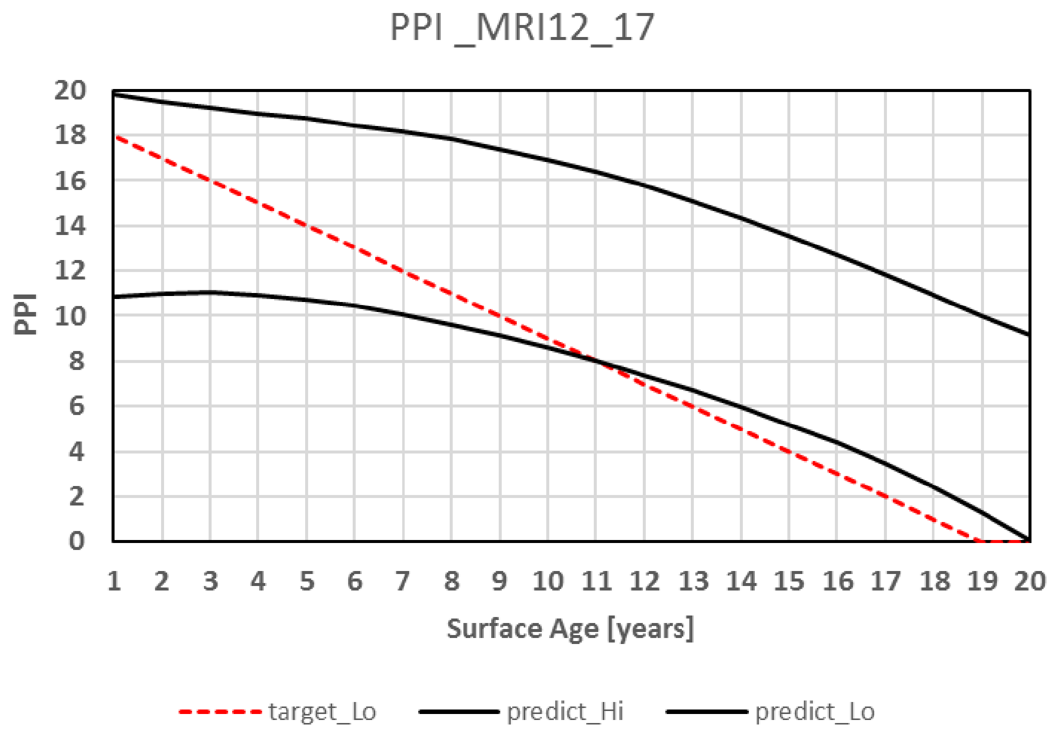
Interpretation

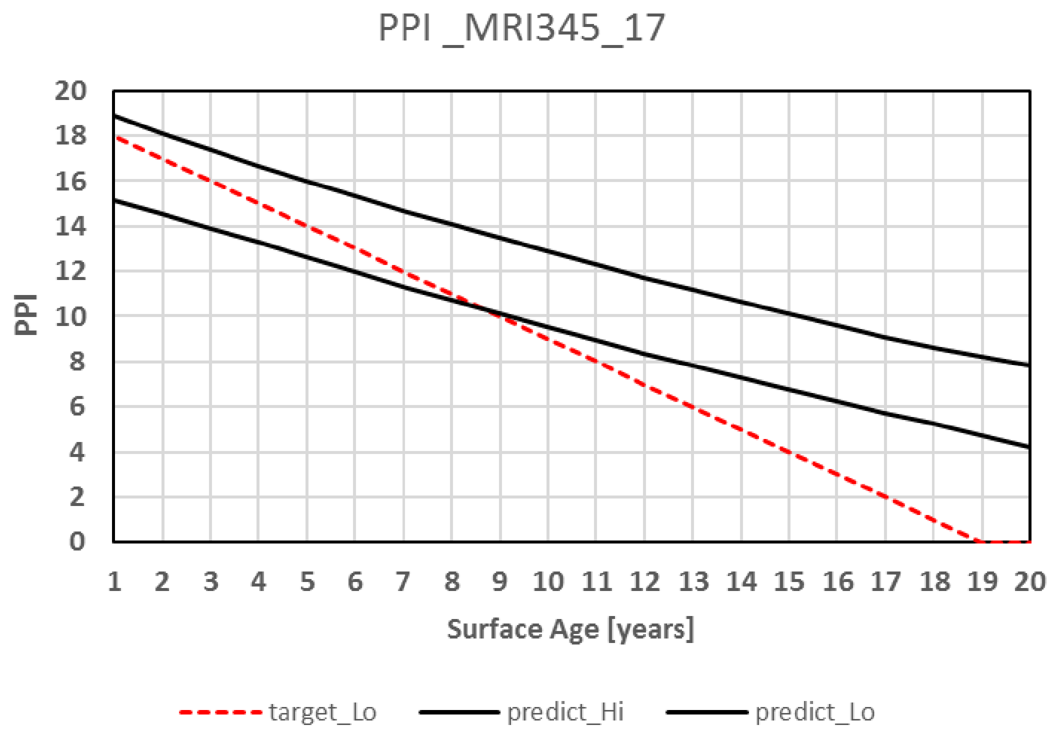
Scatter plot with 0.5-mile trends of PPI Sub-Indices for Route 9 (log mile 0-41)



Interpretation

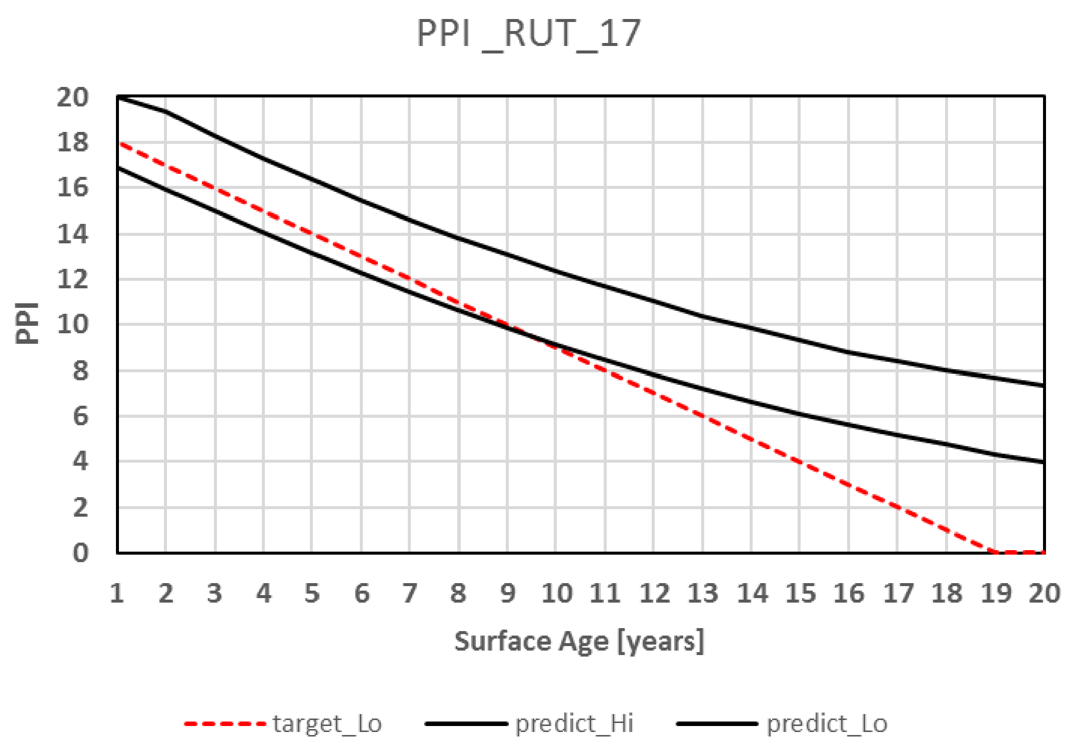
Predicted and target PPI for MRI_{12} (left) and MRI_{345} (right).





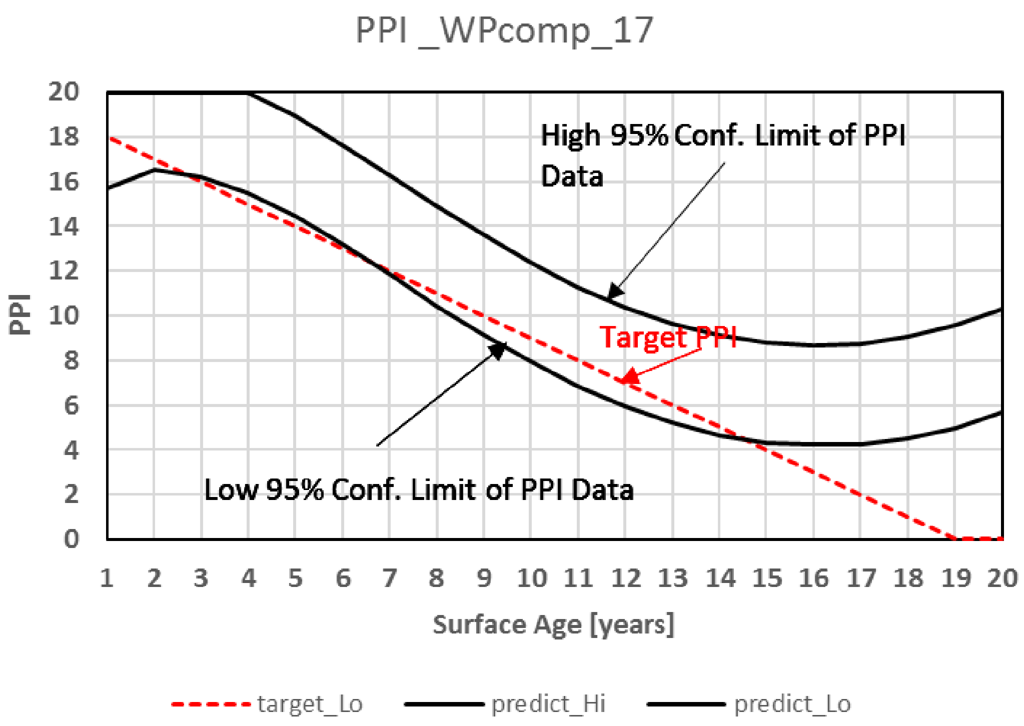
Proposed Concept

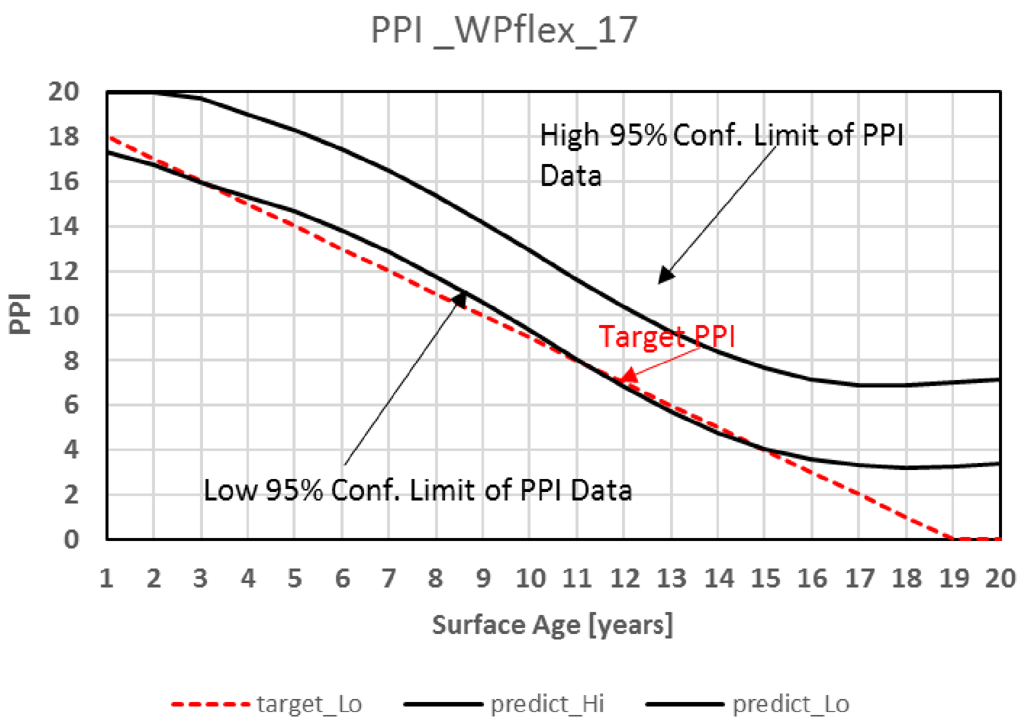
Predicted and target PPI for RUT



Interpretation

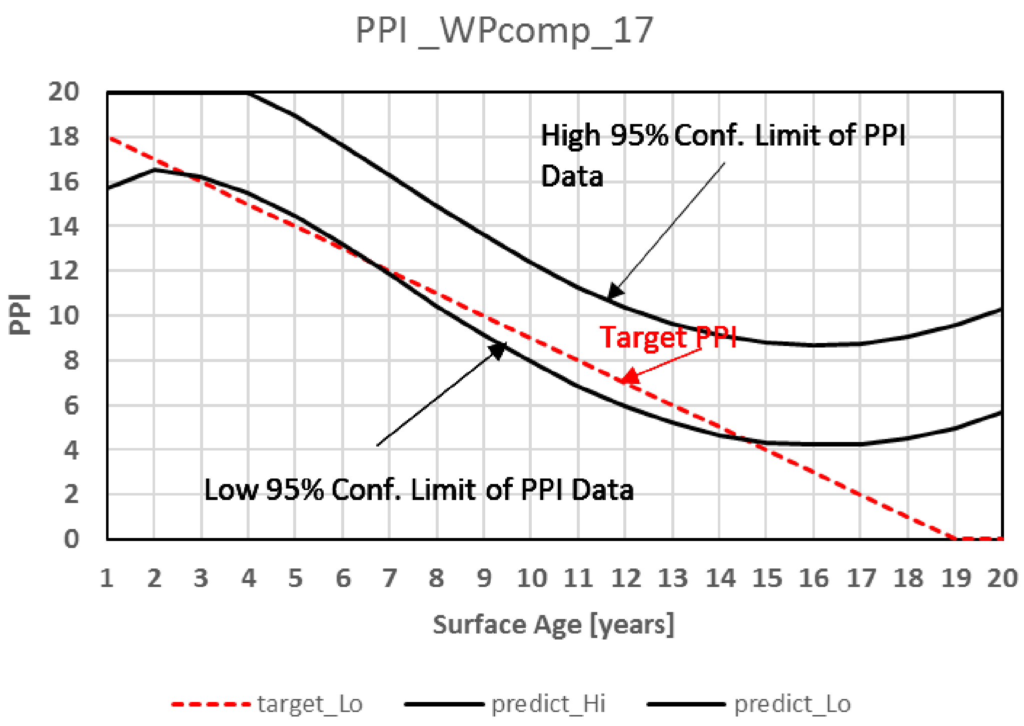
Predicted and target PPI for WP_Cracking$_{comp}$ (left) and WP_Cracking$_{flex}$ (right).

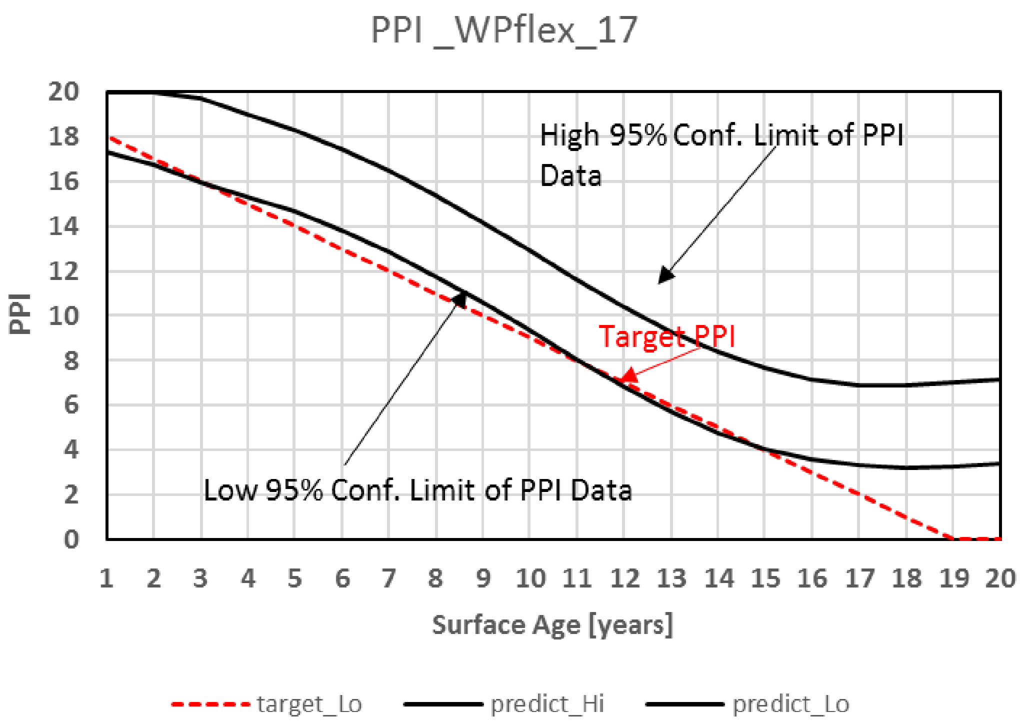




Interpretation

Predicted and target PPI for WP_Cracking$_{comp}$ (left) and WP_Cracking$_{flex}$ (right).





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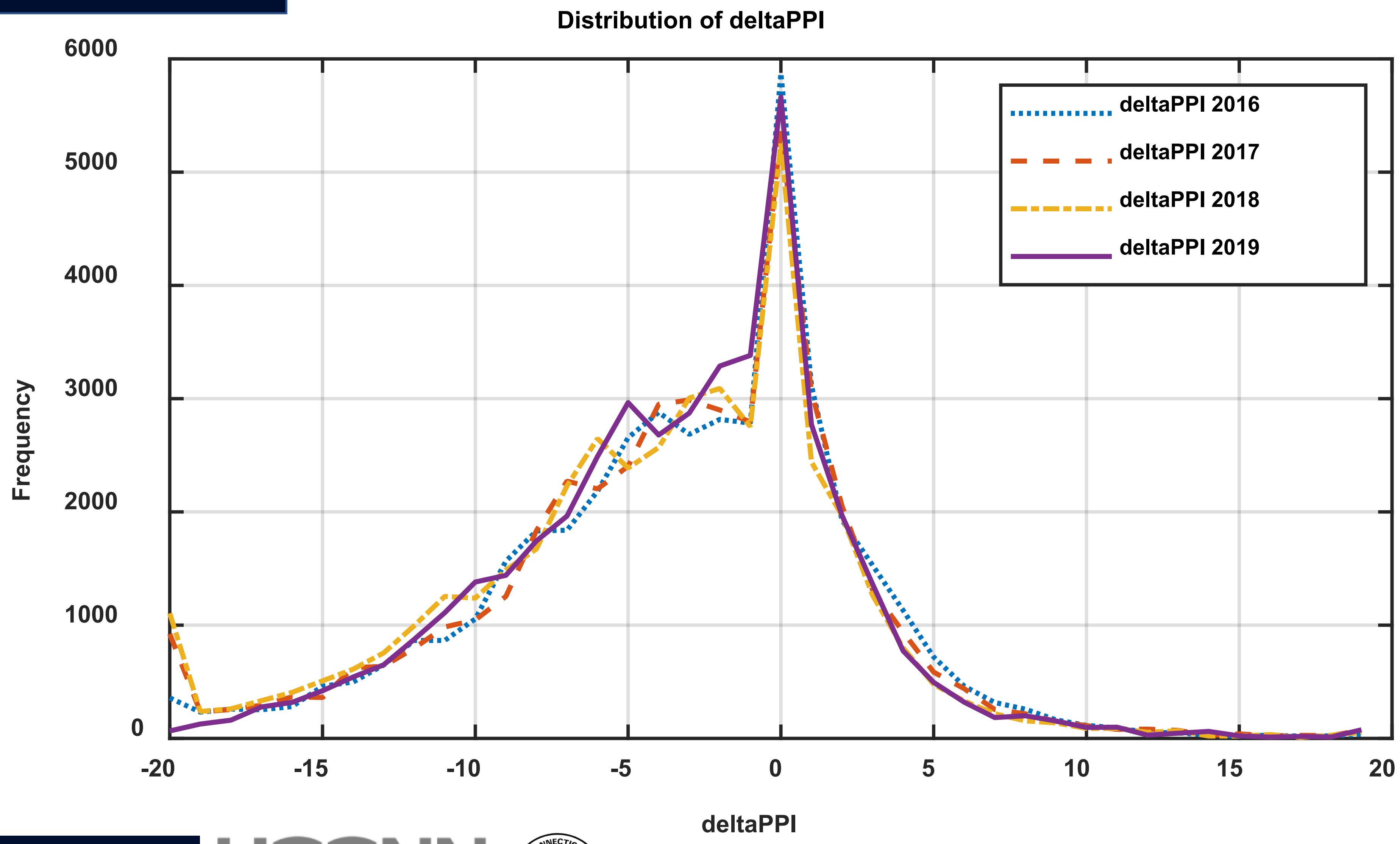
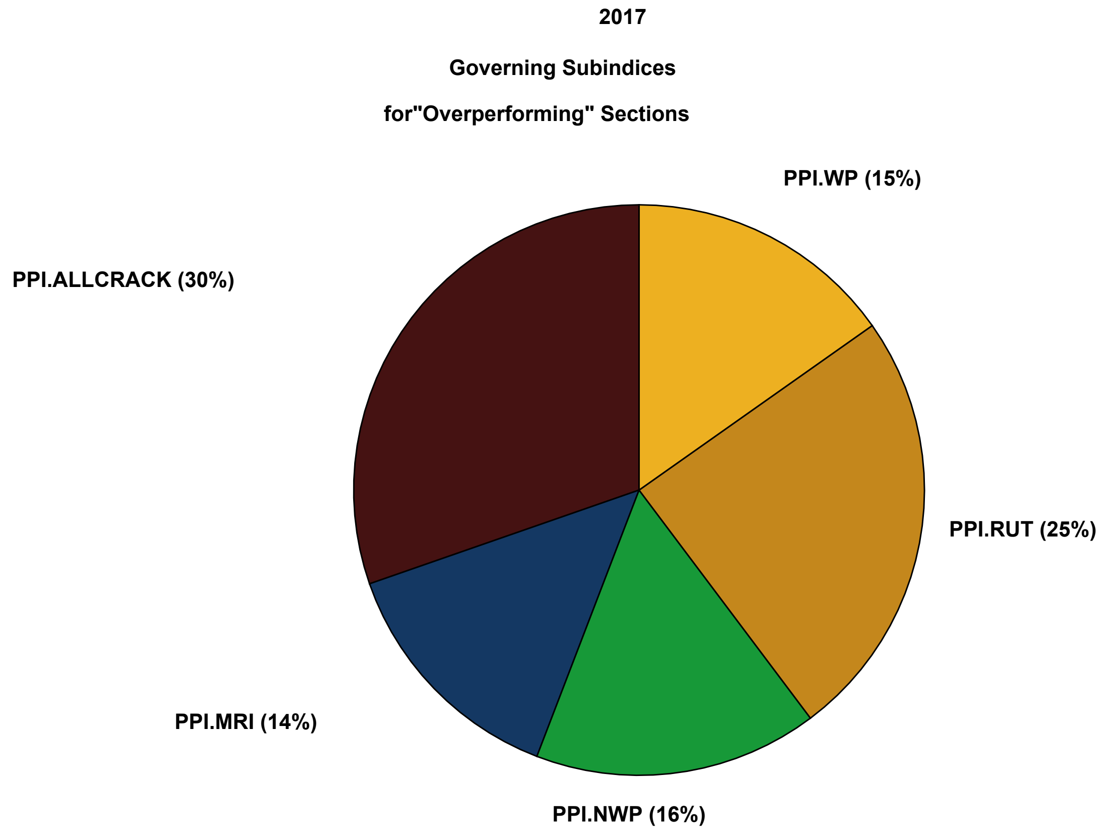
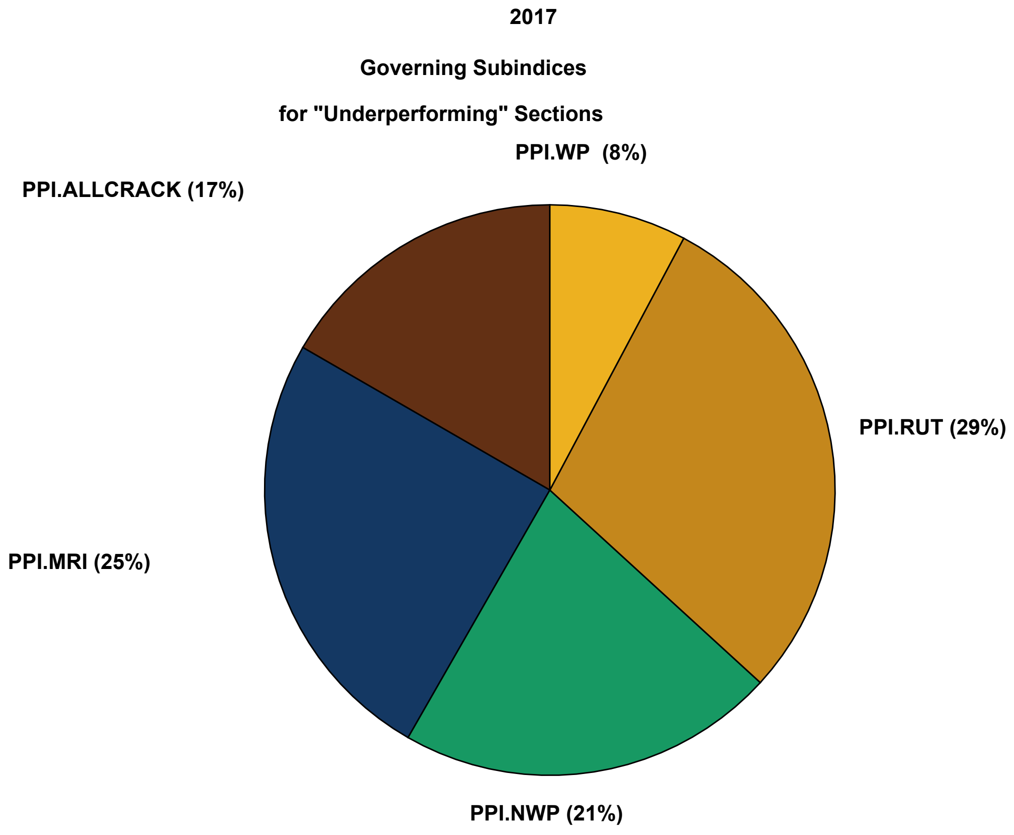
Interpretation



Interpretation

Governing Subindices for Over- and Underperforming Sections in 2017





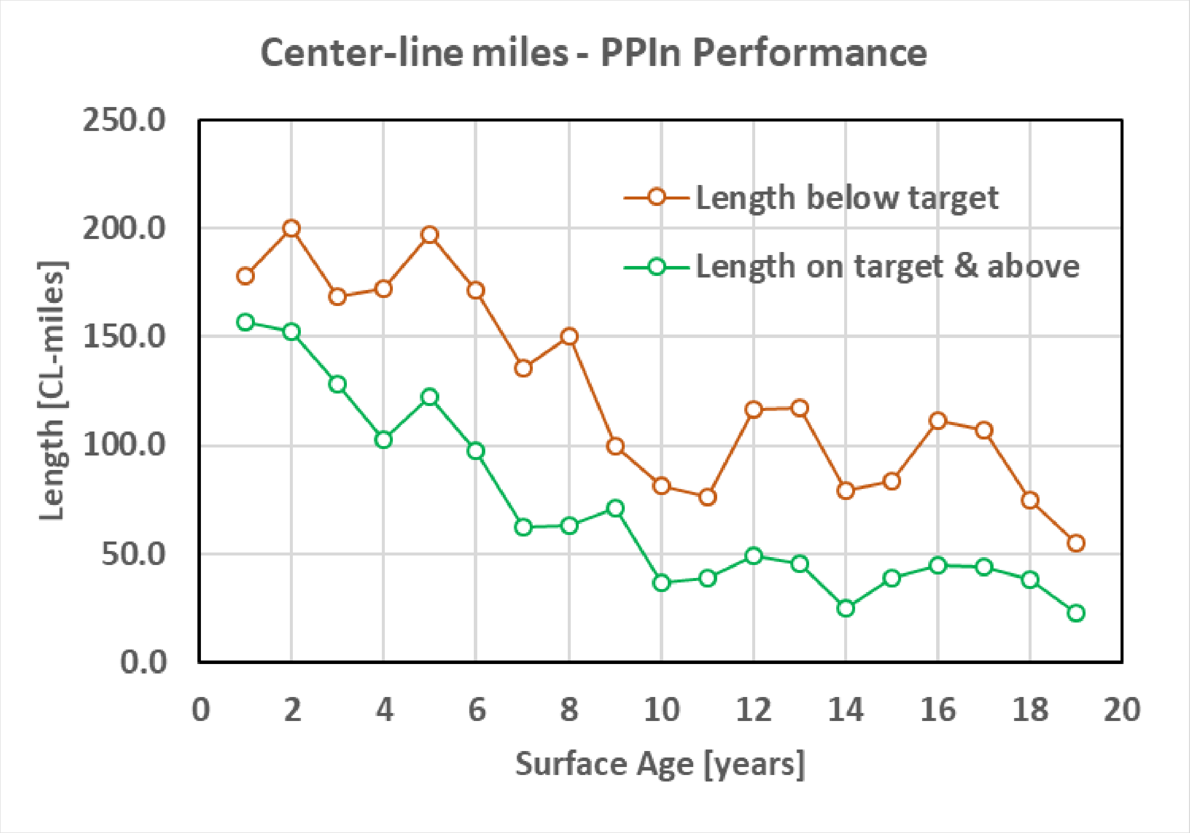
Notes: * Underperforming: deltaPPI<-1
** Overperforming: deltaPPI>=-1

Interpretation

Breakdown of 2017 network performance by surface age in centerline miles

Notes:

- Currently validating data against more recent years of data
- Determining best approach to “deal” with rutting, since statewide data suggests minimal rutting distresses in general
- Ensuring the confidence intervals used in PPI models are adequate
- Determining ‘action values’ for PPI for state engineers to work from to utilize this system for asset prioritization.



Thank You!