NCHRP Project 14-38: Guide for Timing of Asphalt-Surfaced Pavement Preservation

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25 October 2018

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Outline

- Objective of research
- Costs and benefits
  - Modeling pavement preservation performance
- Preservation timing with uncertainties
- Major findings / conclusions

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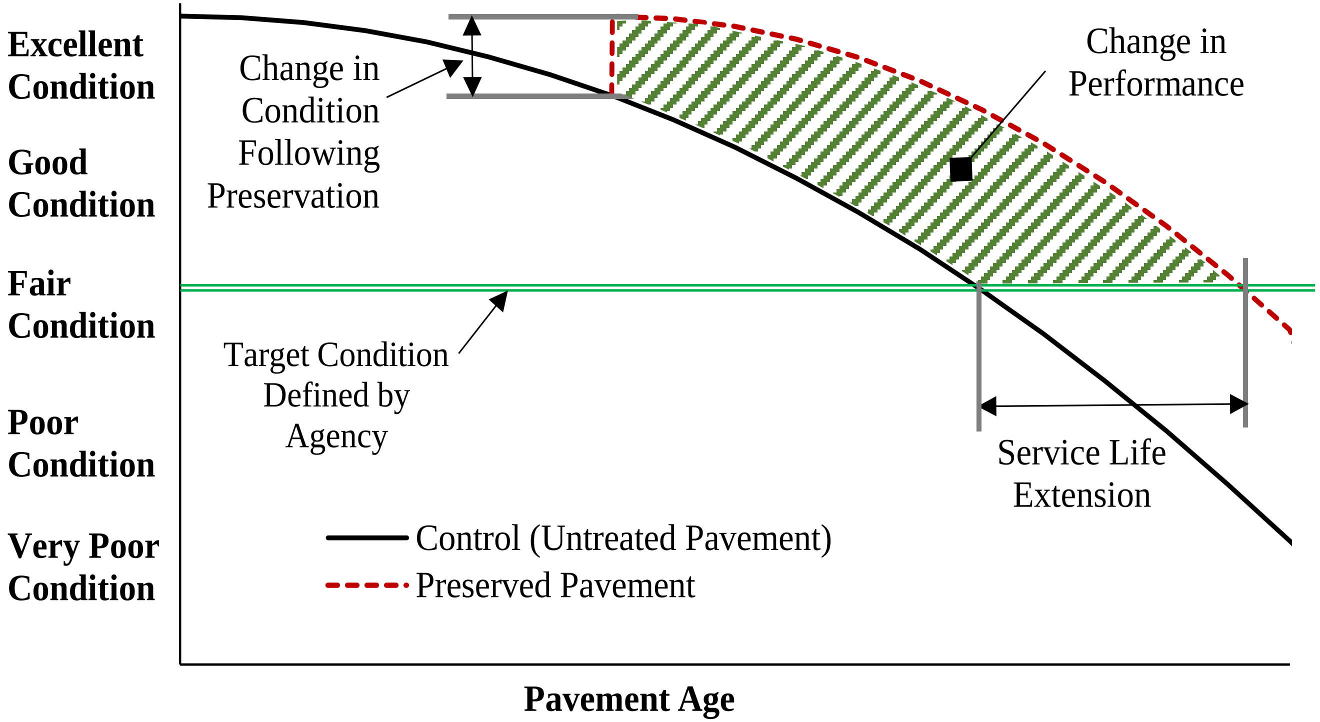
Pavement Preservation & Performance

- Preservation essential to maintaining and improving pavement functional condition at relatively low cost
- Generally applied when pavement is still in good condition



Project Objectives

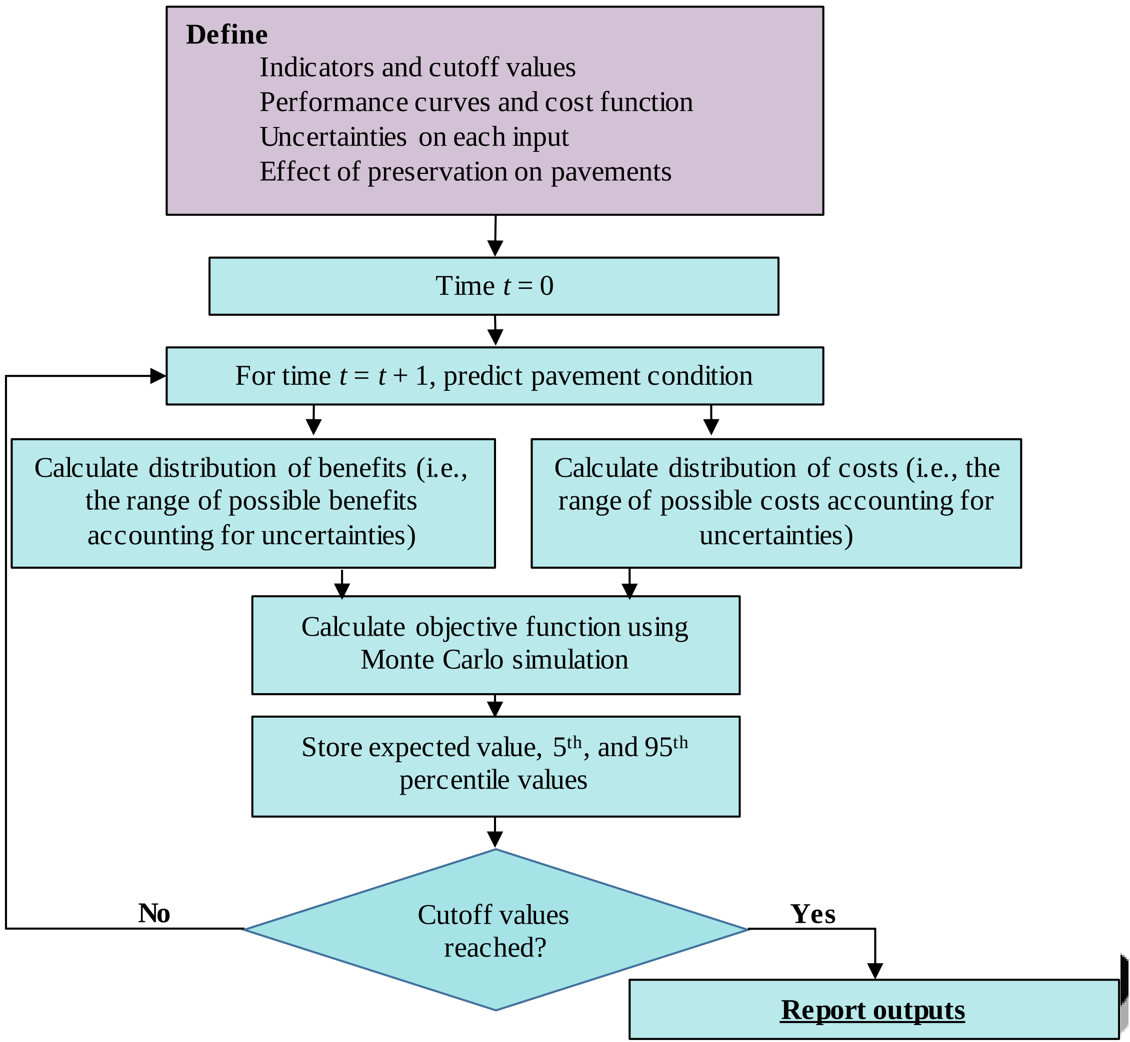
To develop guide for identifying timing for preservation of asphalt-surfaced pavements considering condition and non-condition-based factors

- Treatment
- Pavement structure
- Pavement condition at time of treatment
- Traffic
- Climate, etc.

Preservation treatments are applied to preserve, slow deterioration, and maintain/improve pavement functional condition without substantially increasing structural capacity

Findings of Timing Approaches in Literature

- Preservation timing problem lends itself to cost-benefit analysis
- Biggest shortfall – performance models are complex and uncertainties are not considered
- Preservation is proactive
  - Requires performance comparison to control



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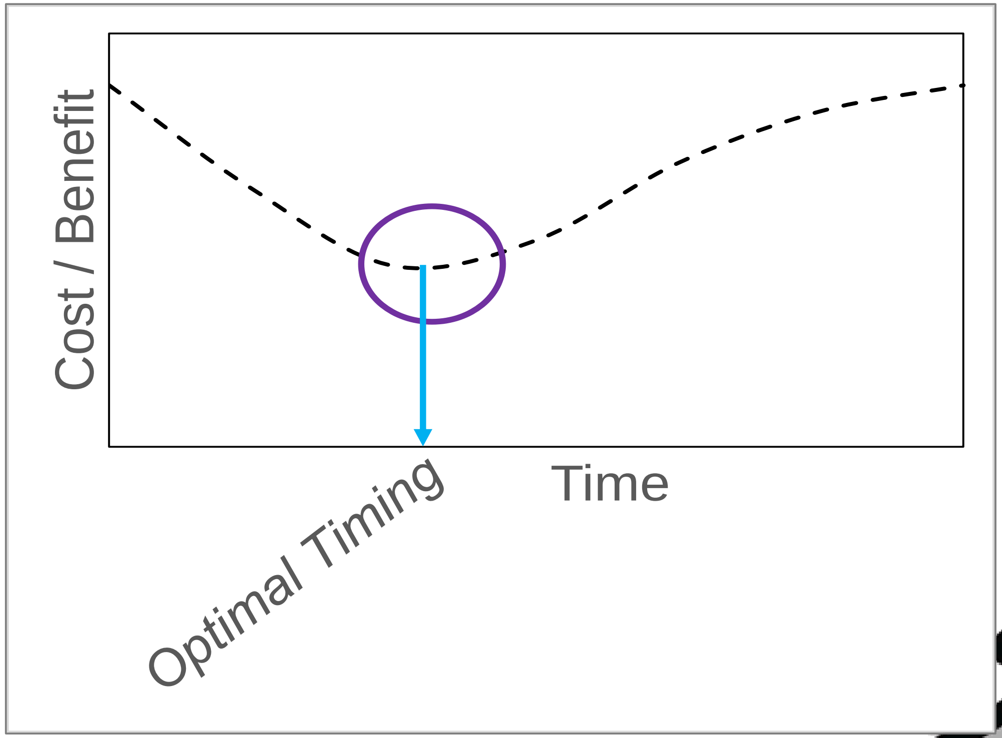
Preservation Timing

Preservation timing is question of when benefits are maximized and costs minimized

- Majority of approaches based on Cost-Benefit analysis – definitions of benefit and cost vary

- Timing is affected by condition and non-condition factors
  - Factors that affect pavement performance affect timing



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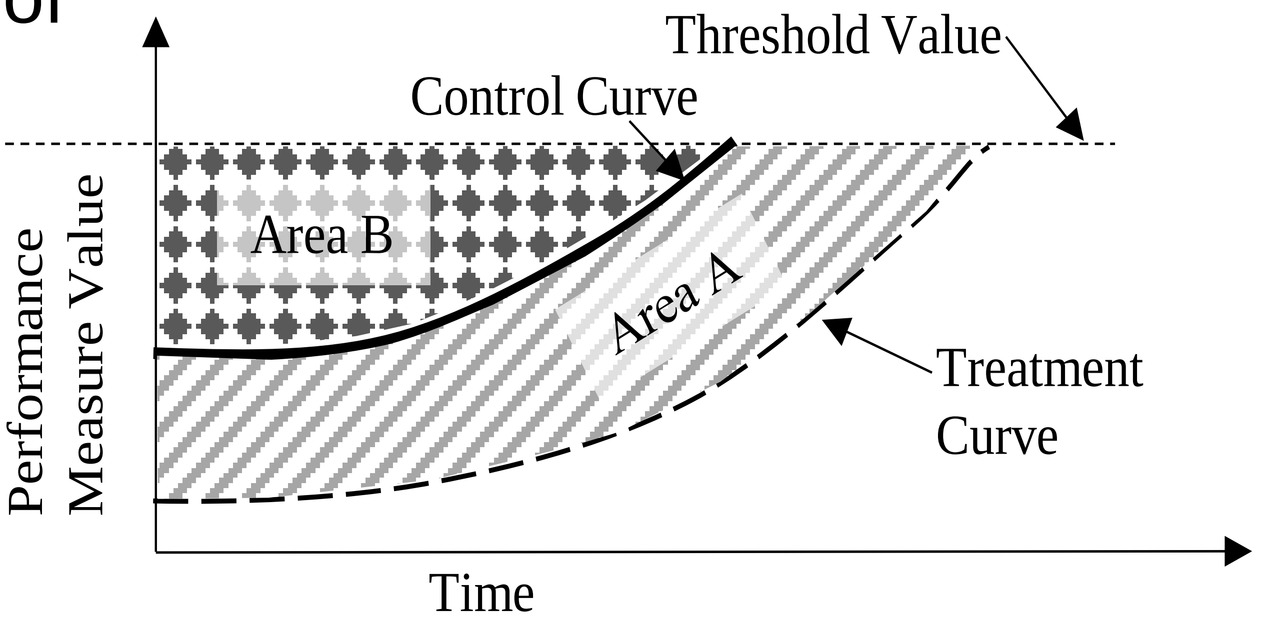
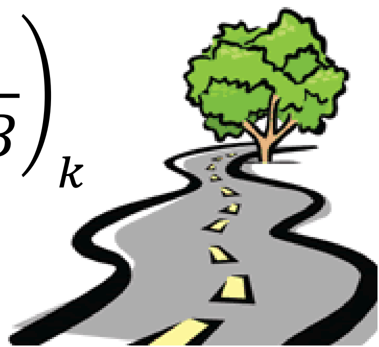
Answering to Preservation Timing

- Can we define a consistent set of costs?
- How do we define benefits?
  - Can we model the effects of preservation?
  - How do we consider multiple performance measures?
- How to consider uncertainties?
- How to compare costs and benefits?



$$WB = \sum_{k=1}^{n} w_k \left(\frac{Area\ A}{Area\ A + Area\ B} \right)_k$$



Phase II:
Obtain Performance & Cost Data

Agency	Number of Years in Condition Data	Thin AC OL	Chip Seal	Micro-surfacing	Slurry Seal
MD-SHA	15	✓		✓	
VDOT	8	✓	✓		
KSDOT	30+ (Entire Database)	✓	✓		✓
IDDOT	15		✓		✓
UTDOT	3		✓	✓	
TXDOT	10		✓		
OHDOT	30+ (Entire Database)	✓	✓	✓	
TNDOT	16	✓			
MEDOT	16	✓		✓	
LADOTD	15	✓	✓	✓	
LTPP	10-15 (Site Dependent)	✓	✓		✓

✓ indicates data received

Blank cell indicates that a given State did not provide data for a given treatment

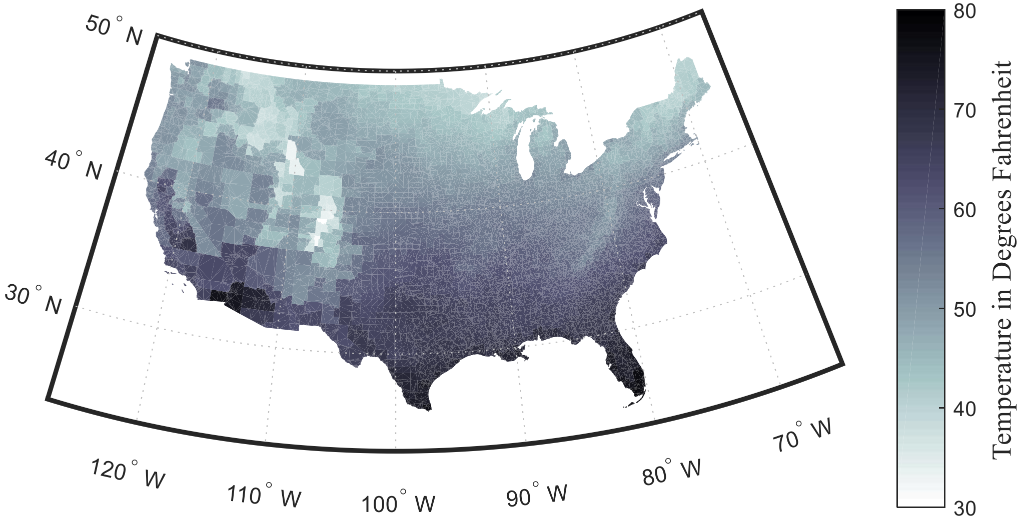
Effects of Preservation

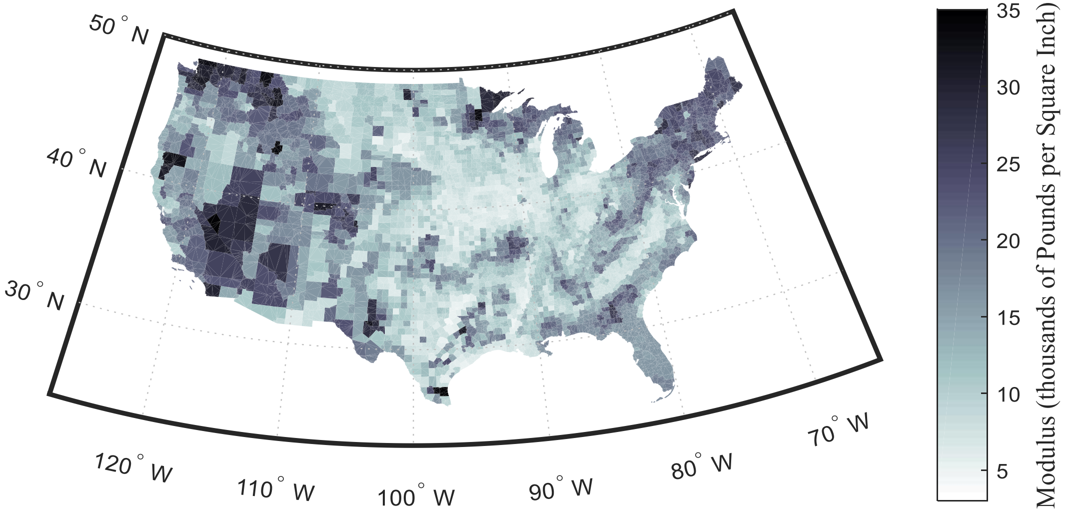
Modeling the effects of preservation on a consistent set of measures

- No single model functional form fit the data
- Climate data were significant in each case, subgrade modulus in some cases

Database for climate and subgrade resilient modulus values developed

- Climate data for every county in from LTPP MERRA Climate database
- Subgrade soil from NRCS maps and NCHRP Project 9-23A



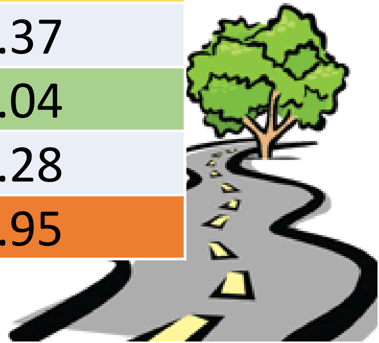


Evaluate or Develop Required Models

Identify untreated segments to treat as control

- Used DOT treatment selection criteria to identify pavements that were candidate for preservation
- Filtered out those with high probability of maintenance or rehabilitation performed
- Trained machine learning algorithm to identify unrecorded maintenance

Segment Number	IRI Year 1	IRI Year 2	Rut Year 1	Rut Year 2	Equivalent Cracking Year 1	Equivalent Cracking Year 2	Probability of Work
1	125	115	0.1	0.05	0.1	0.1	0.44
2	200	170	0.15	0.16	1.5	1.5	0.37
3	75	82	0.05	0.08	1	0.8	0.04
4	150	155	0.1	0.05	1.2	1	0.28
5	164	130	0.15	0.1	0.8	0	0.95



Evaluate or Develop Required Models

State and LTPP data used to develop models

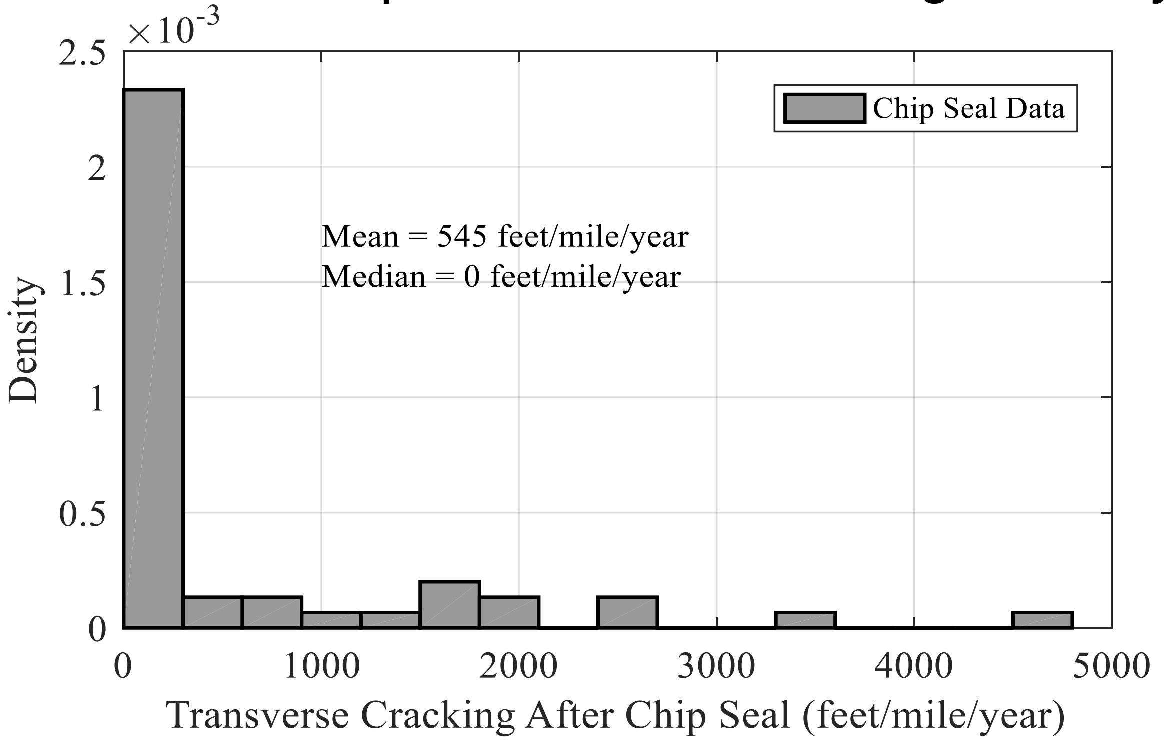
- Fits evaluated using simulation
- Few cases that model could not be developed from data
- Inconsistent cracking definitions across States
- Only LTPP data for slurry seals

	IRI	Rutting	Transverse Cracking	Fatigue Cracking	NWP Long. Cracking
Thin Overlay	✓	✓	✓	✓	✓
Chip Seal	✓	✓	✓		✓
Microsurfacing		✓	✓		✓
Slurry Seal	✓	✓	✓	✓	✓

Evaluate or Develop Required Models

Immediate change in condition

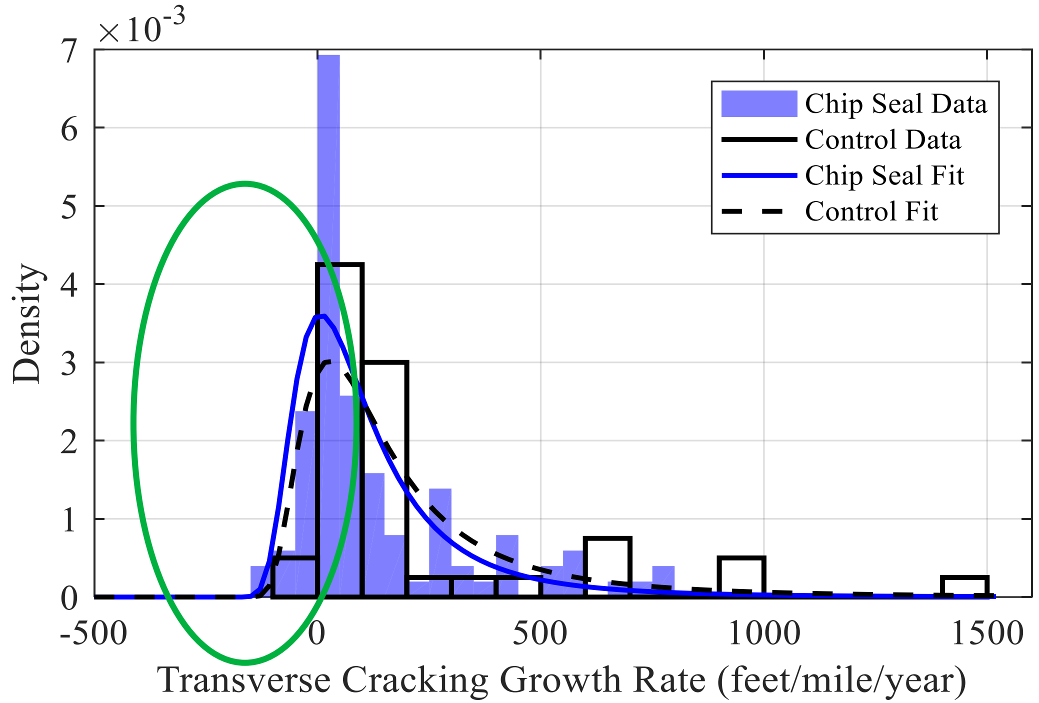
- Generally consistent across DOTs and LTPP
- Transverse cracking not zero after chip seal, microsurfacing or slurry seal



Develop Required Models

Change in performance

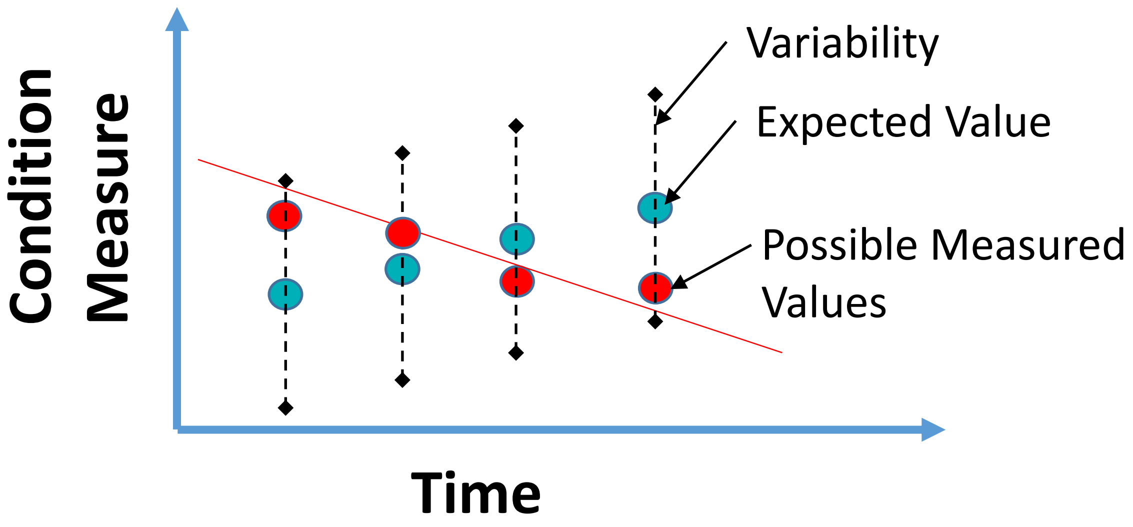
- Results varied across DOTs
- Quality of fit ranged from good to poor
- Regression identified statistically significant factors

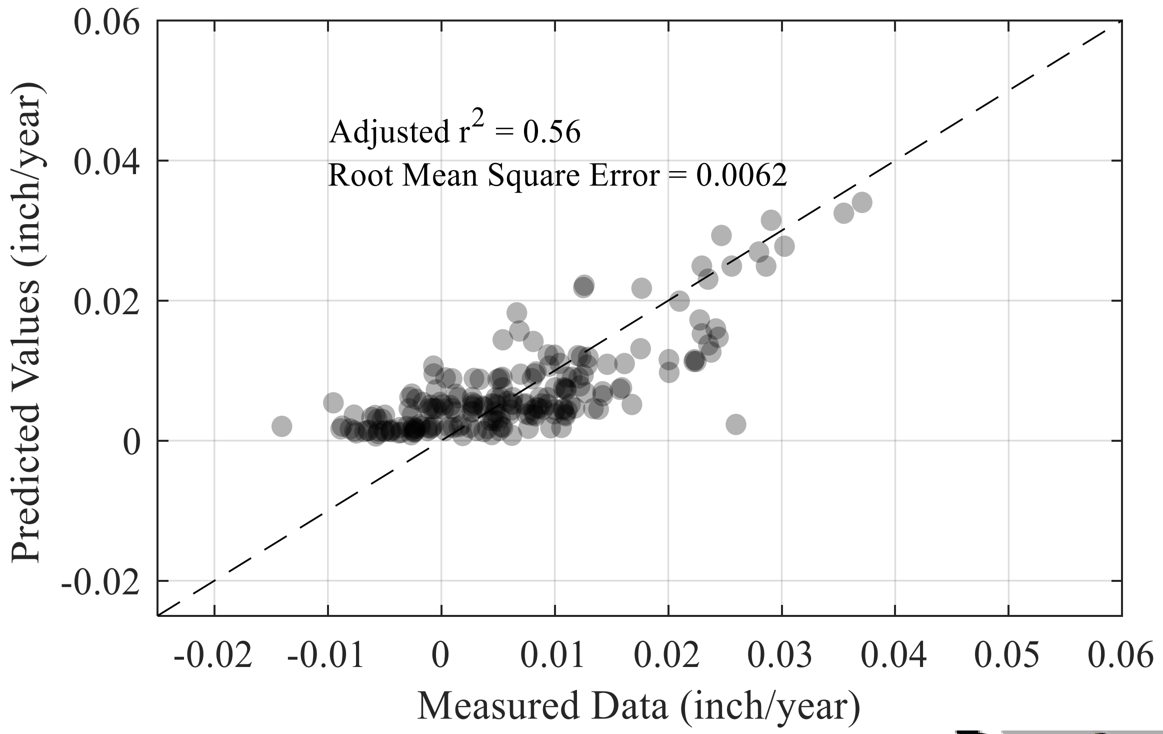


What to do with negative growth rates?

Negative Growth Rates

- Engineering knowledge versus statistical phenomena
  - Deleting negative values will significantly bias models





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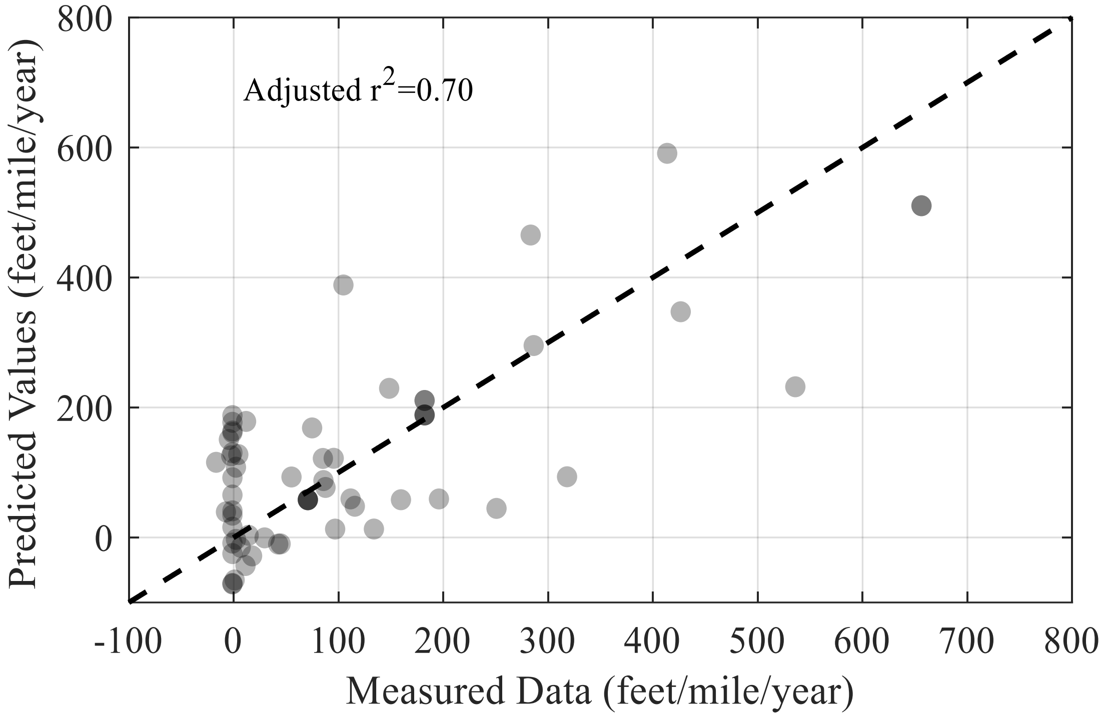
Evaluate or Develop Required Models

Example fit – transverse cracking growth following chip seal

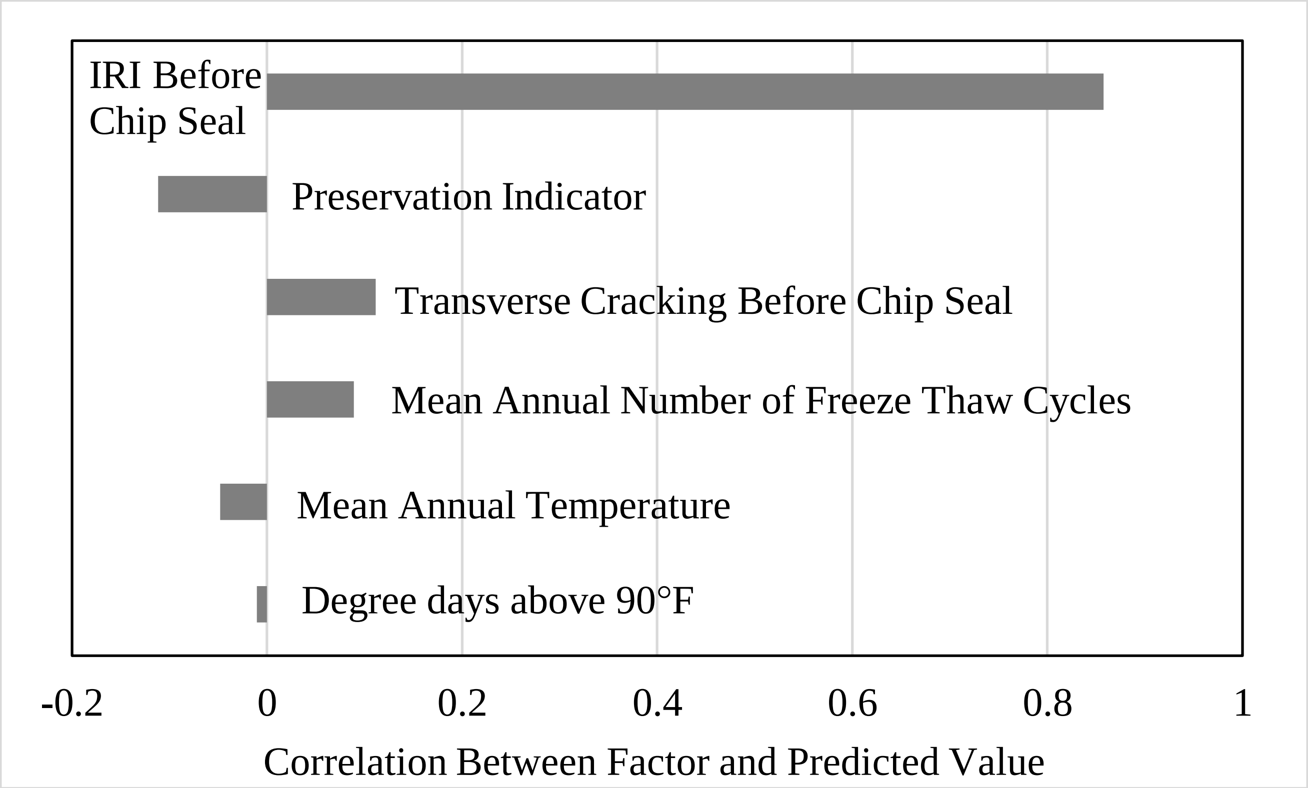


Factor	Coefficient
b_0	-234
$TRCK_{Pre}^2$	$3.74*10^{-5}$
IRI_{Pre}	-11.8
IRI_{Pre}^2	0.106
MAAT	10.04
FTC	2.70
HiTemp	-7.57
$HiTemp^2$	0.070
$TRCK_{Pre} *Pres_{Ind}$	-0.118

Evaluate or Develop Required Models

Transverse cracking growth following chip seal

- Simulation and sensitivity analysis



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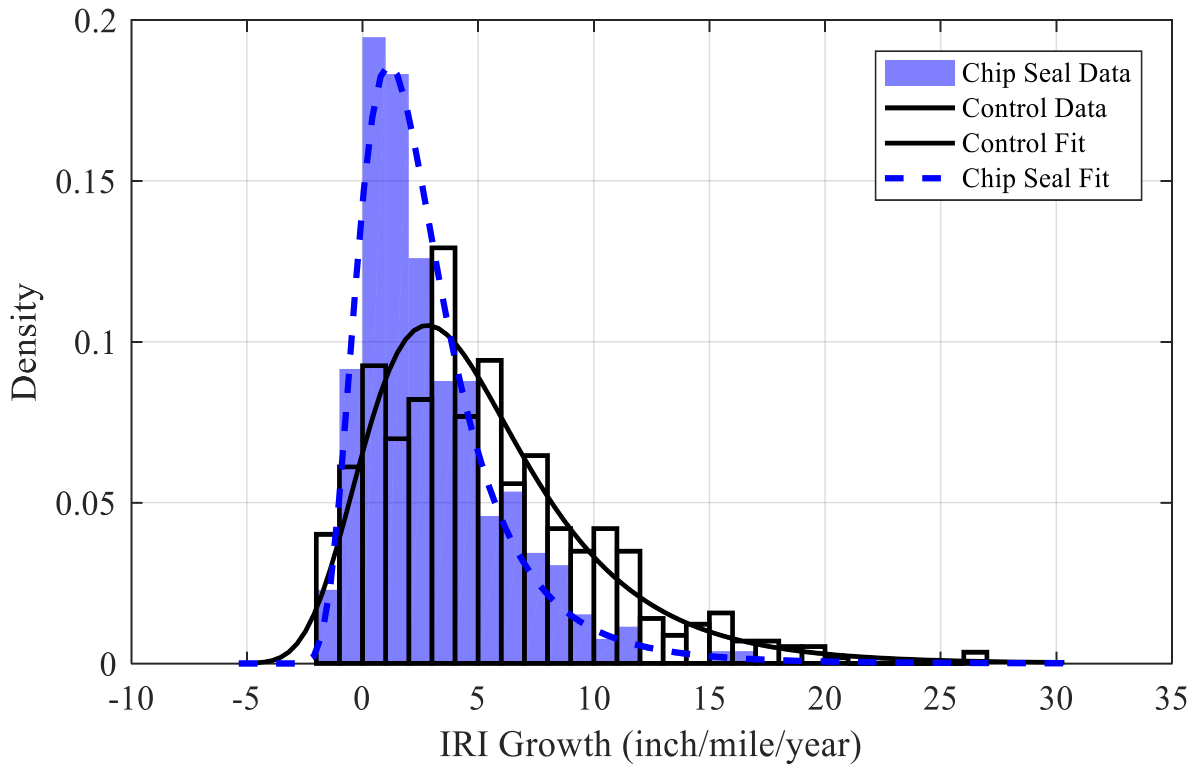
Evaluate or Develop Required Models

Example poor fit with informative results

- IRI growth following chip seal



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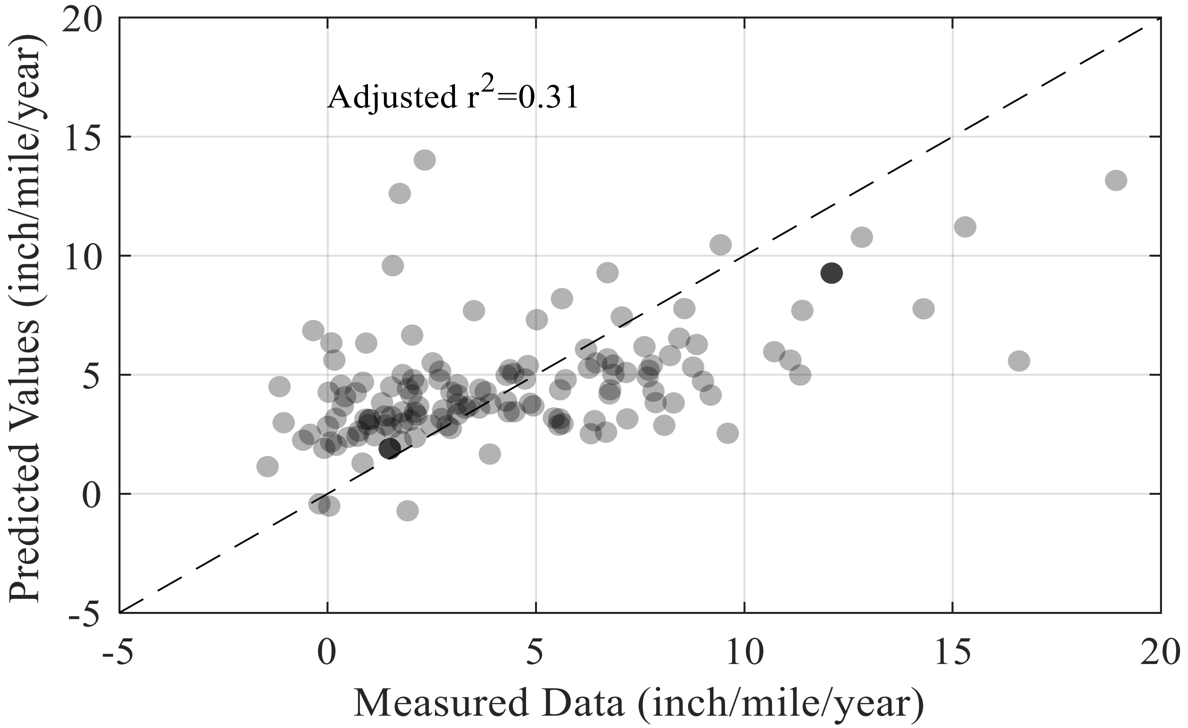
Evaluate or Develop Required Models

Example poor fit with informative results

- IRI growth following chip seal

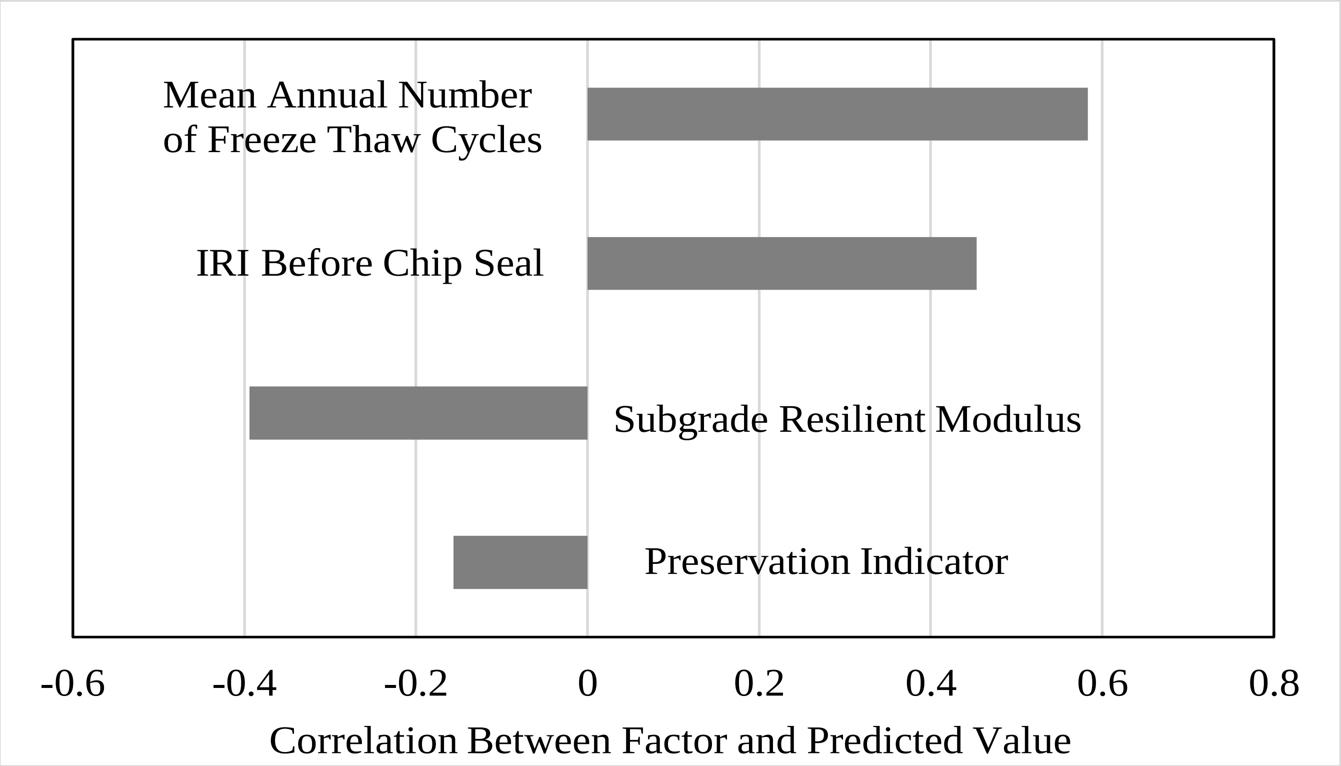


Factor	Coefficient
b_0	57.16
IRI_{Pre}	$2.66*10^{-3}$
$Log_{10}(M_R)$	-13.7
FTC	-0.035
$Pres_{Ind}$	-46.1
FTC^2	$4.70*10^{-4}$
$IRI_{Pre}*FTC$	$7.69*10^{-4}$
$Log_{10}(M_R)*Pres_{Ind}$	11.9
$FTC*Pres_{Ind}$	-0.071

Evaluate or Develop Required Models

Example poor fit with informative results

- Simulation and sensitivity analysis



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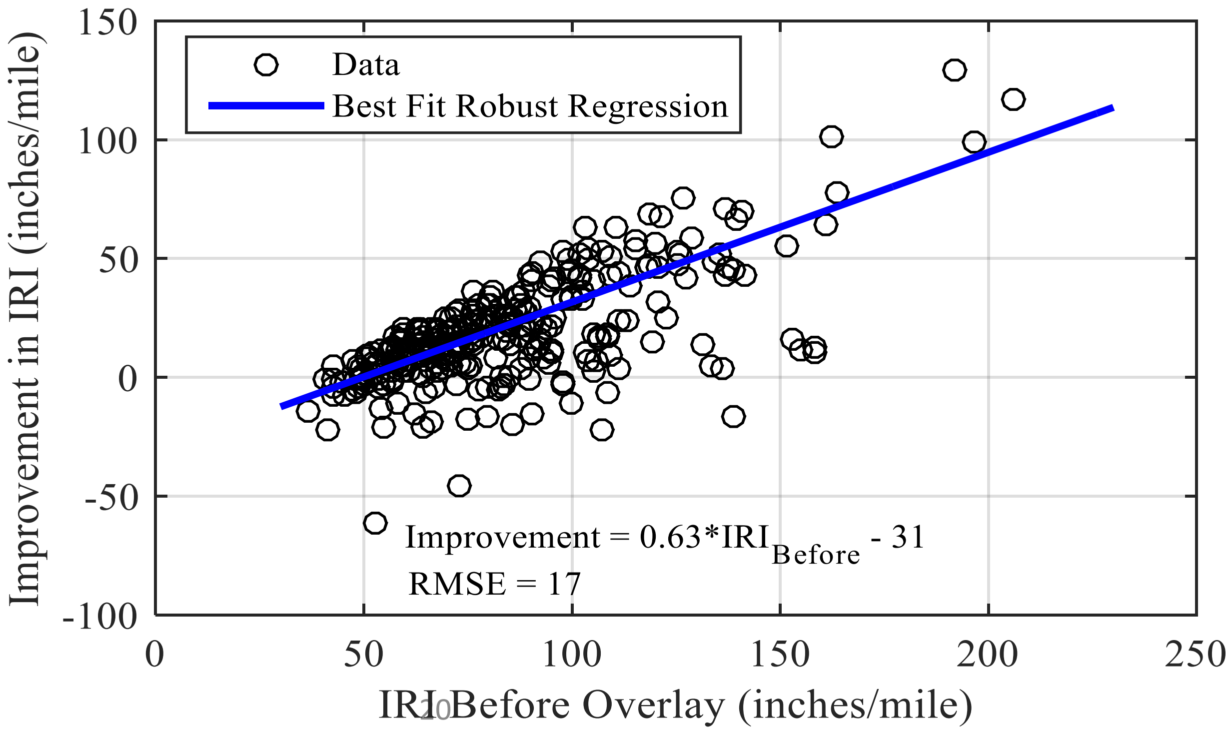
Evaluate or Develop Required Models

Model development included uncertainties in change in condition and performance prediction

- e.g., IRI change following thin overlay
- Guide will include recommendations on how to address uncertainties



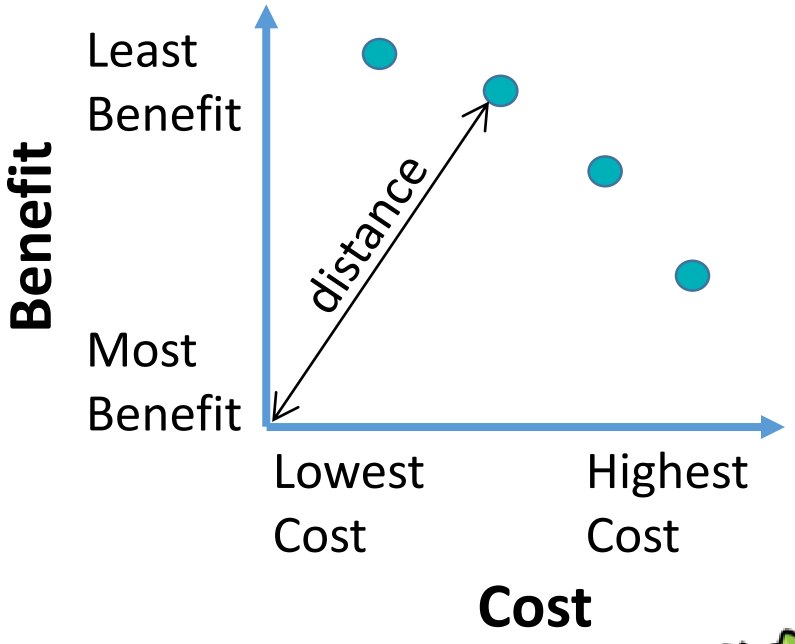
Evaluate or Develop Required Models

- Evaluate how costs and benefits are combined
  - Cost per unit value of benefit

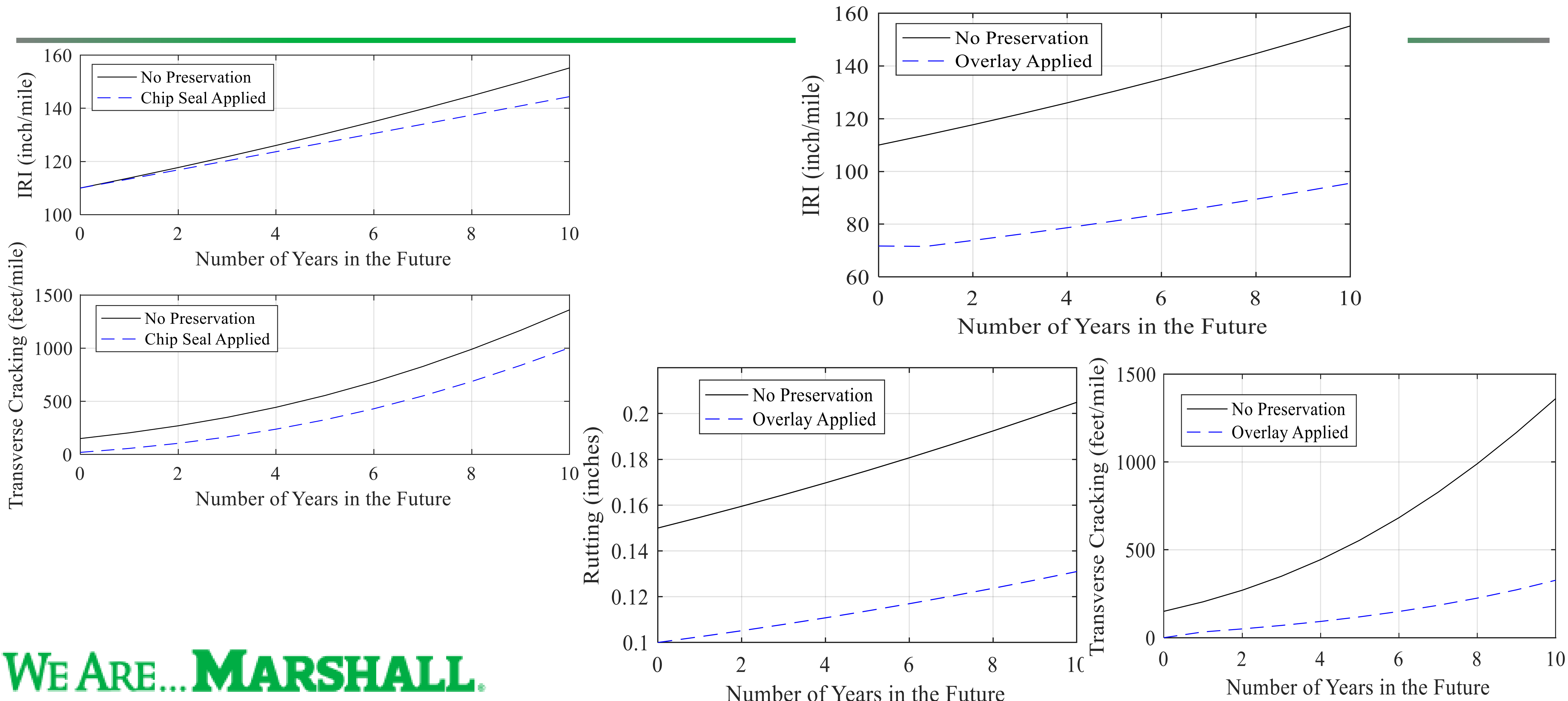
$$\min z = \frac{\left(\frac{Cost_i}{\max(Cost_i)}\right)}{WB_i}$$

  - Distance from hypothetical optimal solution

$$\min z = \left[\left(\frac{a}{WB_i}\right)^n + \left(\frac{Cost_i}{\min(Cost_i)}\right)^n\right]^{\frac{1}{n}}$$



What Does This Mean for Timing?



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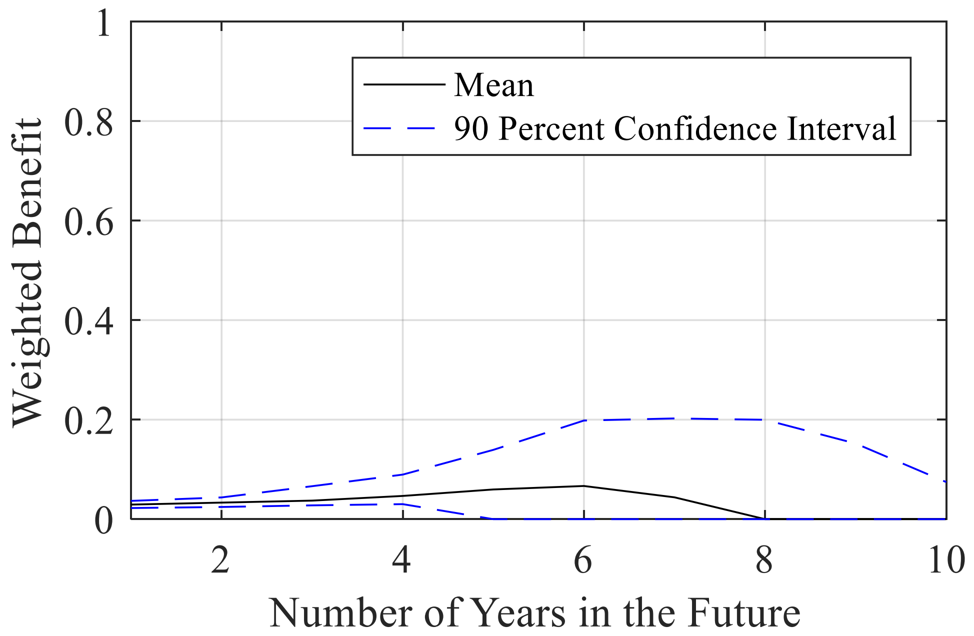
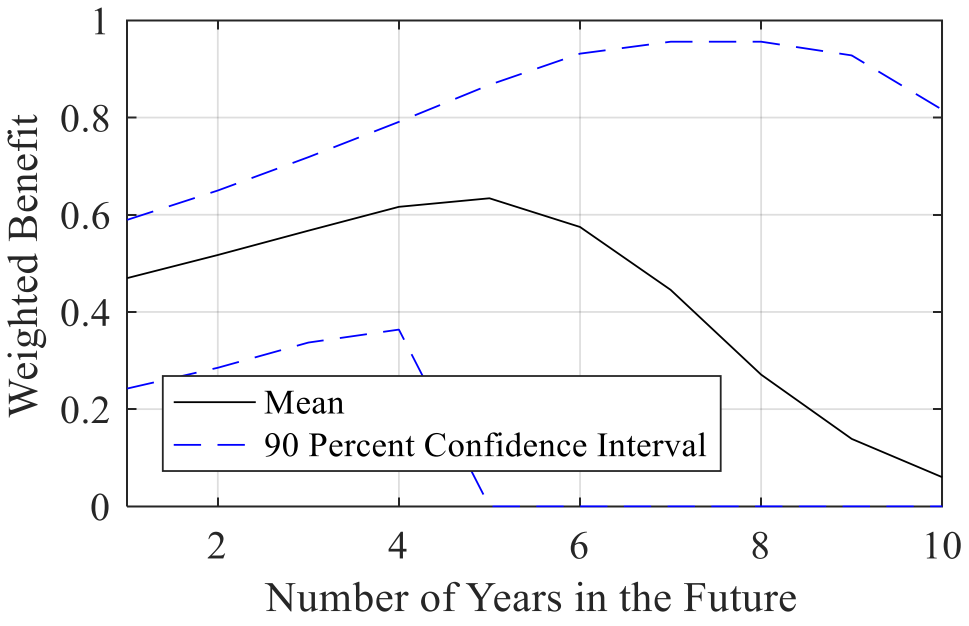

Weighted Benefit
Mean
90 Percent Confidence Interval
Number of Years in the Future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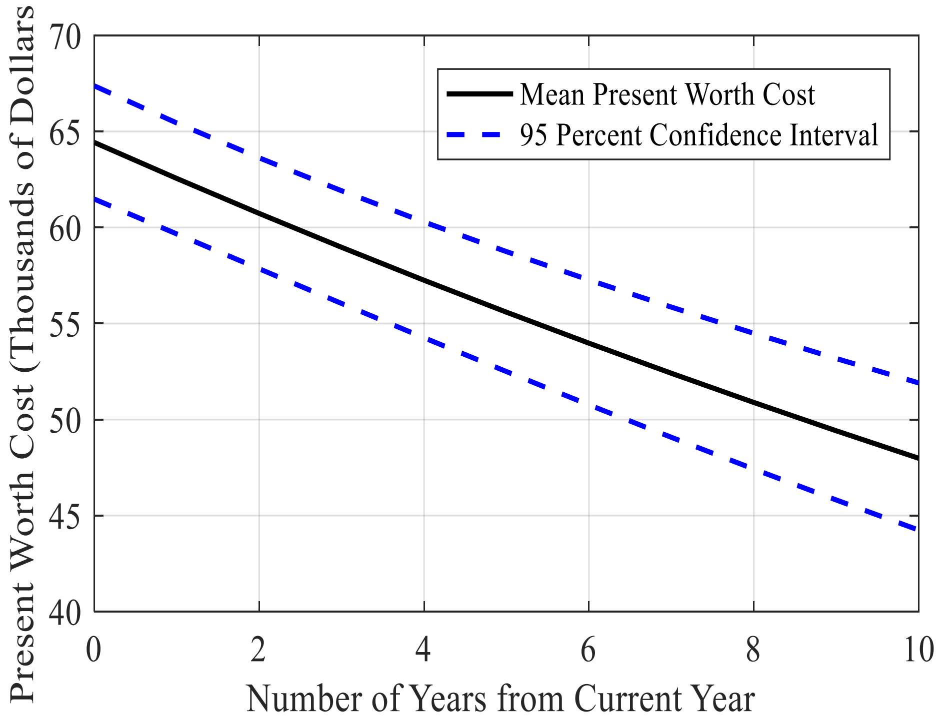
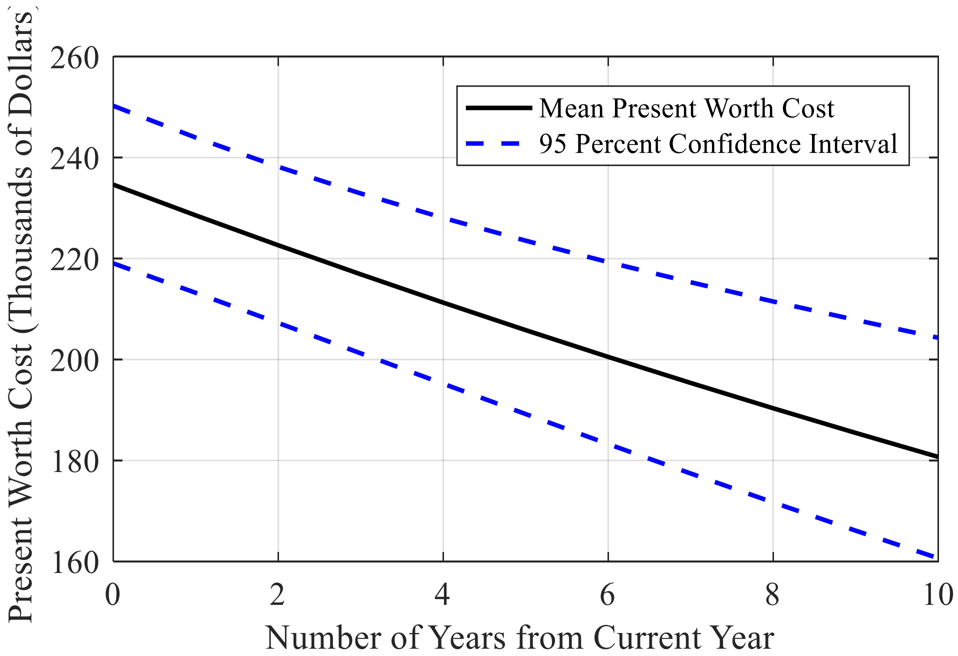
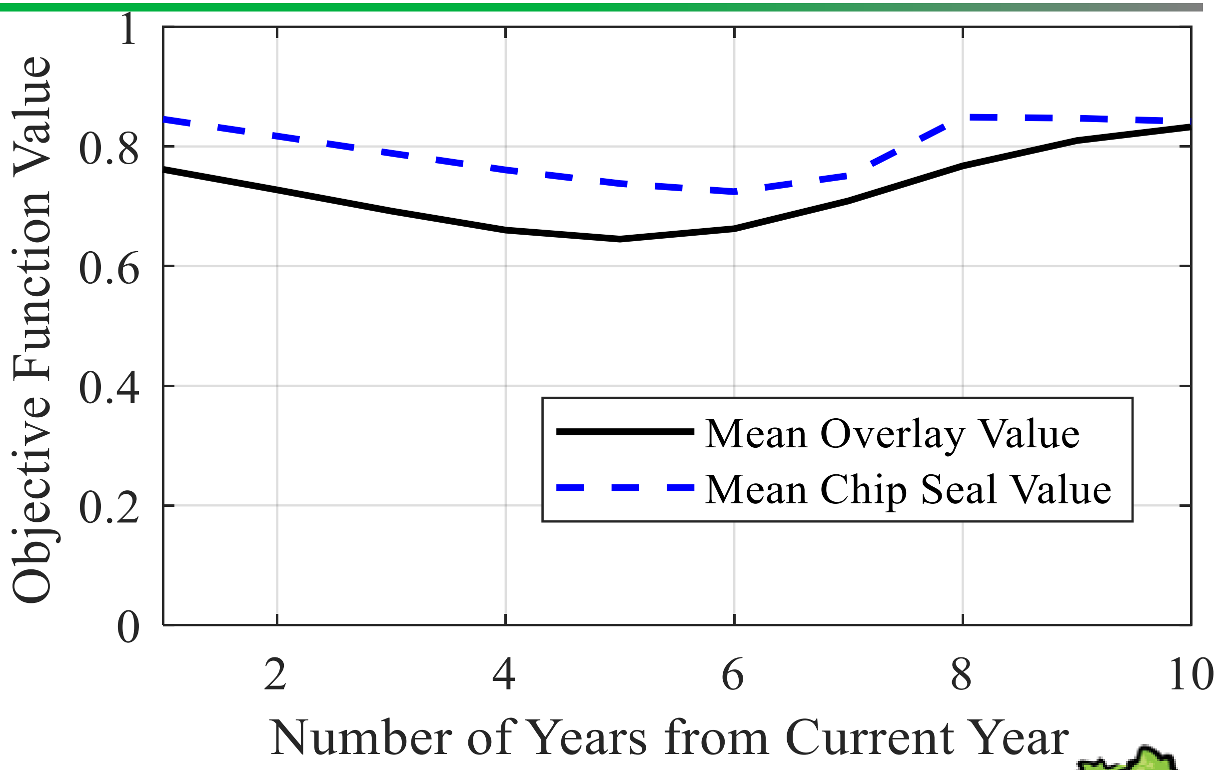

Present Worth Cost (Thousands of Dollars
Mean Present Worth Cost
95 Percent Confidence Interval
Number of Years from Current Year


Present Worth Cost (Thousands of Dollars)
Mean Present Worth Cost
95 Percent Confidence Interval
Number of Years from Current Year

Results of Comparison

- Overlay should be placed in year 5
  - Driven primarily by benefits at that time
  - Immediate change in all measures providing primary benefit
- Chip seal placed in year 6
  - More influenced by cost
  - Immediate change in transverse cracking and reduction in IRI growth driving recommendation



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Conclusions / Discussion

- Preservation timing is driven by:
  - Performance measures / models
  - Preservation treatment
  - Condition and non-condition factors
  - Costs, uncertainties and assumptions
- The answer is not always to apply preservation right now
  - If benefit is primarily driven by immediate change in condition (e.g., thin overlay – cracking/rutting) – apply preservation later in time
  - If benefit is primarily driven by change in performance (e.g., chip seal – IRI) – apply preservation earlier in time

Thank you!!!