Presentation Outline

1. Project background
2. Formulation of timing framework
3. Development of timing framework
4. Summary & conclusions
Project Background
Pavement Preservation & Performance

![Diagram of pavement preservation and performance showing condition levels and service life extension.](image)
Preservation Timing

Preservation timing is defined as point in time when benefits and costs are optimized

- Majority of approaches based on Cost-Benefit analysis – definitions of benefit and cost vary
  - Require estimation of pavement performance and expected costs

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

To develop guide for identifying timing for preservation of asphalt-surfaced pavements considering:

- **Condition factors**
  - Pavement condition at time of treatment
  - IRI, cracking, rutting, etc.

- **Non-condition factors**
  - Treatment type
  - Pavement structure
  - Subgrade soil
  - Traffic
  - Climate
Formulation of Timing Framework
Objective:
- To gather relevant information relating to timing of pavement preservation treatments
  - Timing of treatments
  - Definition of costs and benefits
  - Pavement performance after treatment

Findings:
- Preservation timing problem lends itself to CBA
  - Agency pavement management goal is providing acceptable LOS for lowest cost
  - Leverages existing agency practices such as life cycle cost analysis
Defining Costs

- **Approaches:**
  - Net present value
  - Equivalent uniform annual costs

- **Components:**
  - Agency costs – e.g., treatment and traffic control costs
  - User costs – e.g., delays and safety costs associated with crashes

- **Life cycle cost analysis approaches**

**Timing framework needs to accommodate multiple cost approaches and components**
Defining Benefits

Approaches:

- Service life extension
- Change in performance

No preference cited in literature to either approach, but…

Important advantages to “change in performance” approach
Recommended Timing Framework

- Performance and benefit models
- Cost models
- Optimization function
- Uncertainties

Define
- Indicators and cutoff values
- Performance curves and cost function
- Uncertainties on or of each input
- Effect of preservation on performance & costs

Time $t = 0$

For time $t = t + 1$, predict pavement condition

Calculate distribution of benefits (i.e., the range of possible benefits accounting for uncertainties)

Calculate distribution of costs (i.e., the range of possible costs accounting for uncertainties)

Calculate objective function using Monte Carlo simulation

Store expected value, 5th, and 95th percentile values

Cutoff values reached?

Output: Preservation Timing
Development of Timing Framework
## Pavement Data

<table>
<thead>
<tr>
<th>Agency</th>
<th>No. of Years of Condition Data</th>
<th>Thin AC OL</th>
<th>Chip Seal</th>
<th>Micro-surfacing</th>
<th>Slurry Seal</th>
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✓ indicates data received
Blank cell indicates no data were provided
Other Data

- Developed climate and subgrade resilient modulus databases
  - Climate data for every county from NASA’s Modern-Era Retrospective Analysis for Research Application (MERRA) Climate database
  - Subgrade soil from Natural Resources Conservation Service (NRCS) maps and further development in NCHRP Project 9-23A
Pavement Performance Models

- Example models developed using State DOT and LTPP data plus default databases
- Models developed for more frequently used treatments and measures (based on NCHRP 14-33)

<table>
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</table>
Immediate Change in Condition

- Trends generally consistent across DOTs

![Graph showing immediate change in condition with LTPP Data, Agency 1 Data, Agency 2 Data, Line of Maximum Improvement, and Rut Depth After = 0.1 Inch.](image)
Change in Performance

Chip seals do not have immediate effect on IRI, but... they do affect IRI growth

\[
\text{IRI growth rate} = f(\ldots)
\]

- Mean annual freeze thaw cycles
- Mean annual air temperature
- IRI before treatment
- Subgrade modulus
- Mean annual precipitation
- Average annual daily traffic
Benefit Definition

Approaches:
- Service life extension
- Benefit area = Area A / (Area A + Area B)

![Graph showing Benefit Definition](image-url)
Cost Models

- Cost data provided not consistent
  - Contract cost versus expected treatment cost versus expected preservation cost (i.e., preservation cost independent of treatment type)
- Attempted to assess variation in cost with pavement condition
  - Kansas data show increased cost with worsening condition for thin overlays

Flexible approach chosen to accommodate costs in timing framework
Optimizing Costs and Benefits

Approaches – minimizing:
1. Cost / benefit ratio
2. Distance “d” from “hypothetical” optimal solution

Distance approach recommended because CB can be adjusted independently and their contributions weighted separately
Uncertainties

- Performance models – computed during model development effort
- Cost models – estimates to be developed based on information available to agency

Immediate Change in IRI
Timing Framework

• Example performance models that explain effects of preservation were developed for more frequently used treatments and measures
• Benefit was defined as area encompassed by treated and untreated curves
• Flexible approach to costs was selected to accommodate multiple cost approaches and components
• Distance function recommended for optimizing costs and benefits
• Uncertainties can be estimated for performance models, but qualitative approach required for costs
Implementation Guide

Activity 1: Select Performance Measures
Activity 2: Establish Performance Models
Activity 3: Estimate Preservation Benefits
Activity 4: Establish Cost Models
Activity 5: Select Preservation Timing

Output

Process

Graph showing objective function value over years with 50th, 5th, and 95th percentiles.