ASSET MANAGEMENT:
ONE GUY'S OPINION ON WHAT THE INDUSTRY NEEDS TO DO

June 2016
ASSET MANAGEMENT IS STRATEGIC PLAN FOR MANAGING AN ORGANIZATION'S INFRASTRUCTURE

What Asset Management is / does

A business process & decision-making framework
- covers an extended time horizon
- considers a broad range of assets
- draws on economics & engineering disciplines

Incorporates an assessment of tradeoffs between alternative investment options at both:
- the network level,
- the project level

Uses this information to help agencies make cost effective investment decisions

While Asset Management is more than a few pavements, Pavements are most DOT’s biggest asset to be MANAGED

Sources:
FOR CEMENT / CONCRETE BASED SOLUTIONS TO BE CONSIDERED IN AN ASSET MANAGEMENT FRAMEWORK

Industry needs to:

1. Promote for the use of Remaining Service Interval (RSI)
   - Asset management is often considered “code” for preservation activities only
   - RSI is a forward looking the time element that helps agencies properly plan long term & take into account different activity’s expected performance

2. We need to clarify and make known all the cement / concrete based options
   - Most agencies have a limited number concrete options in their planning program, (if any at all)
   - Show the benefit of a “diversified portfolio”

3. We need DATA on concrete / cement based projects that we can give to agencies.
   - Asset Management is a “data driven” process. For each cement / concrete based options, we predictive performance curves, past performance metrics, etc.
   - These into fit into an agency’s AM / PM systems
AGENDA

Remaining Service Interval (RSI)

Clarify Concrete Options & Make Known the Benefits of a Diversified Portfolio

Data on concrete / cement based pavements
MANY AGENCIES USE CONDITION AS PERFORMANCE INDICATORS
The problem is they are “Delayed” Indicators – need something forward looking

### Condition

- **10.39% of system is distressed**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percent of Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Poor</td>
<td>1.87%</td>
</tr>
<tr>
<td>Poor</td>
<td>8.52%</td>
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<tr>
<td>Fair</td>
<td>22.34%</td>
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<tr>
<td>Good</td>
<td>65.08%</td>
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<tr>
<td>V. Good</td>
<td>2.18%</td>
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</tbody>
</table>

### History - % in Fair or Better Condition Rate

- **Target Goal = 85%**

<table>
<thead>
<tr>
<th>Year</th>
<th>% in Fair or Better</th>
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<tbody>
<tr>
<td>2000</td>
<td>85%</td>
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<td>2001</td>
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<td>2011</td>
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<td>2012</td>
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### Shortcomings

- By the time a pavement reaches an unacceptable threshold, rehabilitation should have already been done
- It does not tell how long a section or system will remain in a given condition
  - Cannot distinguish between pavements / systems that are stable and remaining in a given condition and pavements / systems that are deteriorating quickly
- Does not help program activities (promotes “band aid approaches” just to improve condition)
REMAINING SERVICE INTERVAL (RSI) IS THE NUMBER OF YEARS BEFORE A CONSTRUCTION TREATMENT IS REQUIRED
RSI adds a forward looking time element to the pavement condition data

**Definition**
- RSI tells HOW WELL and HOW LONG the pavement will serve the public
  - A RSI=10 means that it is 10 years to next construction treatment for that segment
  - A RSI=0 means that its condition is worse than the agency’s defined trigger value
  - “Treatment” covers everything from preservation activities (i.e. crack sealing) to full reconstruction for the segment

**What it does**
- Two pavement sections at the same condition are not necessarily equal
  - They will require different management strategies
  - RSI takes into account “rate of deterioration”
  - Higher RSI pavements / networks deliver higher value than lower RSI networks

RSI provides greater insight into future condition and required investment strategies
RSI IS DETERMINED USING A MULTI-CONDITION APPROACH
Uses Current Conditional & Performance Data

RSI builds on each DOT’s “condition” measures already being used

- For each roadway segment, DOT determines “Time to Next Treatment” for each distress
  - Time to next treat. (IRI) = 16 years
  - Time to next treat. (cracking) = 12 years
  - Time to next treat. (faulting) = 10 years

- RSI determination can be based on any distress or performance indicator

Distress targets are set by each DOT

- Performance predictions are based on modeling (Pavement-ME models, LTPP Models, FHWA PHT, state AM models, straight line predictions, etc.)

For each Roadway Segment, RSI converts “Performance Data” to “Operational Information”
ONCE RSI’s ARE DETERMINED FOR EACH SEGMENT
Data is combined to give the Network RSI Graph

Segment 1
RSI = 10 years
10 Miles (0.02% of system)

Segment 2
RSI = 27 years
5 Miles (0.01% of system)

Segment X
RSI = T years
10 Miles (0.02% of system)

Network Length = 3849 Lane Miles
Network RSI = 51,269 lane-mi-yrs
Avg RSI = 13.3 years

Remaining Service Interval (before repairs are needed)
A NETWORK’S RSI PLOT TELLS WHAT IS NEEDED FROM A PAVEMENT MANAGEMENT / TREATMENT PROGRAM

RSI Plot shows:
• How long portions of the pavement will last
• What future obligations will be
It also shows what performance is needed in upcoming treatment activities
• Cannot do rehabilitation activities that last 10 years
  - Increases amount to repair in 10 years from 22% to 46%
  - Creates a funding crises in 10 years

Goal is to Increase Network RSI

Network Length = 3849 Lane Miles
Network RSI = 51,269 lane-mi-yrs
Avg RSI = 13.3 years

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Network Length = 3849 Lane Miles
Network RSI = 43,263 lane-mi-yrs
Avg RSI = 11.2 years

Agencies need to find the best combination of activities that increase RSI without piling work onto a time that already has a large amount of the repair
AN EFFECTIVE MANAGEMENT PROGRAM REQUIRES A “MIX OF FIXES”
Agencies need to design their state’s program of projects and pavement treatments to meet minimum performance requirements

A Network’s RSI plot defines the minimum performance requirements for the state’s program of projects

Treatment strategies are based on falling into “time frames” that do not have a high percentage of pavements needing repair

- Yrs 4-8, 16-20, 20-24, 24-28 & 32+

“Mix of Fixes”
- Short-, medium-, & long-term pavement treatment activities that provide different service lives

“Mix of Fixes” reduces the amount to be repaired at any given time, increases the Network RSI, lessens likelihood of funding crisis, and lowers annual cost requirements
EXAMPLE OF TWO ALTERNATE INVESTMENT STRATEGIES
Short-term (8 to 15-Year Fixes) vs Mix of Fixes (8 to 30-Year Fixes)
Same Budget & Expenditures

Current Network RSI

Network RSI in 20 years

RSI (Lane-mile-years)

Network Length = 3849 Lane Miles
Network RSI = 51,269 lane-mi-yrs
Avg RSI = 13.3 years

Mix of Fixes Strategy is providing Greater Service (but not enough dollars going into either case)
RSI defines the allocation of funds across a variety of investment categories

**Step 1 – Allocation of Funds at the network level based on “Time to Next Treatment”**

- Construction – 5% (30+ years)
- Maintenance – 20% (4-8 years)
- Preservation – 5% (8-15 years)
- Minor Rehab – 30% (12-20 years)
- Major Rehab – 25% (15-30+ years)
- Replacement – 15% (30+ years)

**Step 2 – Selection of Activities that meet “Time to Next treatment ” based on lowest LCC**

LCCA determines which treatment – that meets or exceeds the performance requirements – is the lowest cost alternate
AGENDA

Remaining Service Interval (RSI)

Clarify Concrete Options & Make Known the Benefits of a Diversified Portfolio

Data on concrete / cement based pavements
## CONCRETE / CEMENT BASED PAVEMENT SOLUTIONS

Most agencies do not look at all these treatments

### Mix of Fix treatments applicable to existing Concrete Pavements

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### Mix of Fix treatments applicable to existing Asphalt and Composite Pavements

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- Performance Period gives typical range for the activity until next treatment. Actual performance will vary based on the specific parameters used for each activity and project. For example, a 8-inch overlay will provide longer service than a 5-inch overlay. The numbers given here are used to indicate what length of "Service Life" can be designed.
FOR ANY FUNDING LEVEL, THE OPTIMUM ALLOCATION OF “FIXES” BUYS THE MOST SERVICE LIFE FOR THE NETWORK
Maximize total lane-mile-years for that funding level

<table>
<thead>
<tr>
<th>Two Dimensions of Paving</th>
<th>Example: Two options with Budget = $100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage: lane-miles</strong></td>
<td>• Low cost, short life, touch many pavements</td>
</tr>
<tr>
<td><strong>Service Life: years</strong></td>
<td>Cost = $5/mile; Life = 5 years; touch – 20 miles</td>
</tr>
<tr>
<td></td>
<td>Return = 20 miles x 5-year life / $100</td>
</tr>
<tr>
<td></td>
<td>= 100 lane-mi-yrs / $100 = 1 lane-mi-yr/$</td>
</tr>
<tr>
<td></td>
<td>• High cost, long life, touch fewer pavements</td>
</tr>
<tr>
<td></td>
<td>Cost = $20/mile; Life = 20 years; touch – 5 miles</td>
</tr>
<tr>
<td></td>
<td>Return = 5 miles x 20-year life / $100</td>
</tr>
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</tbody>
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*Agencies should be “indifferent” to these options, but should care how they fit in the RSI Network Graph*

A network of $x$ lane-miles of pavement requires an addition of $x$ lane-mile-years of service life each year to maintain status quo

*A Quick Check of Your Highway Network Health: FHWA-IF-07-006*
FOR ANY FUNDING LEVEL, THE OPTIMUM ALLOCATION OF “FIXES” BUYS THE MOST SERVICE LIFE FOR THE NETWORK
Maximize total lane-mile-years for that funding level

Example: Two options with Budget = $100

- **Low cost, short life, touch many pavements**
  Cost = $5/mile; Life = 5 years; touch – 20 miles
  Return = 20 miles x 5-year life / $100
  = 100 lane-mi-yr / $100 = 1 lane-mi-yr/$

- **High cost, long life, touch fewer pavements**
  Cost = $20/mile; Life = 20 years; touch – 5 miles
  Return = 5 miles x 20-year life / $100
  = 100 lane-mi-yr / $100 = 1 lane-mi-yr/$

_Agencies should be “indifferent” to these options, but should care how they fit in the RSI Network Graph_

- An agency should prefer this activity:
  Cost = $12/mile, Life = 15 years, touch – 8.33 miles
  Return = 8.33 miles x 15-year life / $100
  = 125 lane-mi-yr / $100 = 1.25 lane-mi-yr/$

Maximizing lane-mile-years / $ determines how to allocate funds across a variety of investments
(in the form of construction, maintenance, preservation, repair, rehabilitation, and replacement)
MIT network-level research is about showing how different treatments impact a Network’s Performance

• Project-level decisions
  – Material selection
  – New pavement

• Uncertainty
  – Pavement deterioration
  – Immediate & future price of actions

• Real-world scale problems
  – Virginia and California

How do you efficiently maintain a pavement network?
What Has Been Learned?
A diversified system improves performance at constant cost

<table>
<thead>
<tr>
<th></th>
<th>Current Composition of System</th>
<th>Expected Composition in Year 50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asphalt</td>
<td>Asphalt &amp; Concrete</td>
</tr>
<tr>
<td>Deterministic</td>
<td>100.0</td>
<td>93.1</td>
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<tr>
<td>Probabilistic</td>
<td>101.7</td>
<td>89.8</td>
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</tbody>
</table>

Takeaway 1: The inclusion of concrete increases overall performance

Takeaway 2: The benefit of concrete is larger in the risk-aware case

Takeaway 3: Concrete should be used on high volume roadways
What have we learned?

Diversification particularly helps avoid poor performance

Asphalt and Concrete

Asphalt

18% difference

11% difference

Cumulative Probability

Average Traffic-Weighted IRI over Analysis Period (in/mile)
AGENDA

Remaining Service Interval (RSI)

Clarify Concrete Options & Make Known the Benefits of a Diversified Portfolio

Data on concrete / cement based pavements
CONCRETE / CEMENT BASED PAVEMENT SOLUTIONS

Industry needs a performance prediction for each of these solutions

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<td>RCC overlay (&gt;8”)</td>
<td>RCC</td>
<td>15-25+</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>New asphalt</td>
<td>AC</td>
<td>10-20</td>
</tr>
<tr>
<td></td>
<td>New concrete</td>
<td>PCC</td>
<td>25-35+</td>
</tr>
<tr>
<td></td>
<td>New Roller Compacted Concrete</td>
<td>RCC</td>
<td>15-30+</td>
</tr>
</tbody>
</table>

Mix of Fix treatments applicable to existing Asphalt and Composite Pavements

- Performance Period gives typical range for the activity until next treatment. Actual performance will vary based the specific parameters used for each activity and project. For example, a 8-inch overlay will provide longer service than a 5-inch overlay. The numbers given here are used to indicate what length of “Service Life” can be designed.
FOR THE NETWORK ANALYSIS, NEED PAVEMENT PERFORMANCE DETERIORATION MODELS

Need to match models to “each pavement activity” so we can cover most activities

1. Must be robust to fit a “family” of Pavements (can not be individual models)
   - Need to match models to “each pavement activity” so we can cover most activities

2. Models need to predict “distresses” to fit into RSI framework
   - At a minimum, MAP-21 Performance Measurement distresses (cracking, faulting, rutting and IRI)

3. Models must be recognized as a “unbiased” model
   - This does not mean we can’t have our own model or data to supply to DOT to update their modeling

4. Need to adjust the models to fit existing or past pavement performance data,
   - Predict the time when pavement conditions will reach a level of service construction trigger threshold
   - Predict post treatment performance
STANDARD DESIGN MODELS ARE BASED OFF LOTS OF DIFFERENT TEST SECTIONS

Allows for very robust models

\[
\text{IRI} = \text{IRI}_0 + C_1 X_1 + C_2 X_2 + C_3 X_3 + C_4 X_4
\]

Models do a good job at predicting average performance, but may not relate to a specific pavement
HOWEVER, STATES NEED TO MODEL A SPECIFIC PAVEMENT USING THAT SECTION’S DATA
And project performance from the last point – Gives the RSI

Can requires lots of simple models that may not accurately capture future performance
WE NEED “STANDARD” MODEL TO BE “SHIFTED” TO PREDICT a SPECIFIC PAVEMENT SECTION’S FUTURE PERFORMANCE

Captures site specific performance and can use built in robustness

Model Shift ≈ IRI_{current} + C'1 x (IRI model)^C'2
RECOMMENDATIONS

1 Asset / Pavement Management is data drive process. Industry needs to develop a database of its products performance.
   • Recommendation: Ask each state for the PMS data on concrete pavements.

2 Remaining Service Interval (RSI) is the time until the next construction treatment. It can help manage assets.
   • Recommendation: Work with states to show the benefits RSI as a process to manage their network systems over an extended, long term timeframe. Show the benefits of a diversified system. Incorporate into the “competition messaging”

3 To be evaluated, concrete options need to be included in the process
   • Recommendation: Promote all concrete / cement based solutions on a united front
   • Recommendation: Develop performance projections models for all concrete / cement based solutions. Define when different “levels of treatments” are required.
What is the Issue?

• Current tools
  – Consider few options
  – Do not value technology diversification

• Aspects of the problem make it computationally challenging
  – Size of network (thousands of segments)
  – Timeframe (10’s of years)
  – Maintenance and construction options
  – Uncertainty

• Need to find modeling strategy that balances
  – Fidelity
  – Comprehensiveness
    • Most tools only consider a few options
    • Must be able to resolve impact of different materials
  – Speed
    • Needs to be scalable to real roadway network problems
Goal of MIT network-level research is to develop a tool that can consider...

- Project-level decisions
  - Material selection
  - New pavement

- Uncertainty
  - Pavement deterioration
  - Immediate & future price of actions

- Real-world scale problems
  - Virginia and California

How do you efficiently maintain a pavement network?
Components of MIT Model

Objective of Analysis:
Minimize Traffic-Weighted IRI across a roadway network

Current State of System
- IRI
- Material
- Age
- Traffic Volume

Available Actions
- Diamond Grinding
- Mill and Fill
- Thick Asphalt Overlays
- Concrete white topping
- New JPCP and HMA reconstructions

Projection Model of Future Conditions
- Pavement deterioration based upon LTPP
- CSHub forecasting and initial-cost models
What Have We Learned?

A diversified system improves performance at constant cost

• Risk-based model shows benefit of
  – Considering uncertainty
  – Technology diversification within the system

• Compare, different options for optimizing the Virginia system @ constant budget
  (50 years, $50m (2015 dollars)/year budget)
  – Conventional analysis (no risk)
    • Asphalt only
    • Asphalt and concrete options
  – Risk-aware model
    • Asphalt only
    • Asphalt and concrete options
What have we learned?

Takeaway 1: The inclusion of concrete increases overall performance

Takeaway 2: The benefit of concrete is larger in the risk-aware case

![Traffic-Weighted IRI (in/mi)]

<table>
<thead>
<tr>
<th></th>
<th>Asphalt</th>
<th>Asphalt &amp; Concrete</th>
<th>Asphalt</th>
<th>Asphalt &amp; Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deterministic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probabilistic</td>
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</tbody>
</table>
Under an optimal allocation strategy, we would use concrete on high volume roadways.
What have we learned?
Diversification particularly helps avoid poor performance
Asset management can not be series of low preservation treatments applied indefinitely.

- Pavements require different sets of treatments as they age.
- Our pavement network already has pavements at aged from 1 year to 125 years (Bellfontaine)

A network needs is a "balance" of activities and we need to show that allocating investment to “non preservation” activities does not hurt a network – it helps it.

What the and that is what I am trying to show in these slides. The last slide set contains and add-on to the slides I gave at TRB. At TRB, I focused on what the impacts of competition mean to an agency. In this last slide set (slides 8-13), I try to show how improving a network impacts a States GDP. It still needs work, but I hope you see where I am going.