The TAM Rule and Pavement Management

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The Transportation Asset Management rule in MAP-21 requires the development and implementation of a Transportation Asset Management Plan (TAMP) for highways, with two core assets required to be included:

- Bridges
- Pavements
TAMP

- Plan has a 10-year horizon and must include performance targets for bridge and pavement national measures.
TPM FRAMEWORK

01 – Strategic Direction
02 – Target Setting
03 – Performance-based planning
04 – Performance-based programming
05 – Monitoring and adjustment
06 – Reporting and communication
Pavement target-setting

• Three key questions need to be answered to do this:
  • At what scale do we invest in pavements?
  • At what scale do we predict performance?
  • At what scale do we report performance?
At what scale do we invest in pavements?

• Set goals, conduct strategic analysis at the network and program level, but:

• Act on individual analysis units, or “sections,” generally in the 0.5 to 5.0 mile range

• Not likely to change wholesale to a 0.10-mile basis
  ➢ User costs (delays) and project mobilization costs probably dwarf efficiency gains in conditions.
At what scale do we predict performance?

- Option A: At the program (network) level
- Option B: At the section level
- Option C: At the performance reporting interval level
At what scale do we predict performance?

- Option A: At the program (network) level
- Option B: At the section level (CTDOT)
- Option C: At the performance reporting interval level
At what scale do we measure and report performance?

- HPMS basis, typically 0.10-mile segments.
  - Will capture performance variability that is not captured in a measurement aggregated over the pavement management analysis units (sections.)

**KEY QUESTION**

How do we set performance targets that are accurately reflected in the measurements?
Guiding principle 1

- The Transportation Asset Management Plan (TAMP) is the basis for pavement investment
  - Uses Pavement Management System
    - Pavement Management System focuses on State of Good Repair
  - Uses appropriate time horizon for pavement strategy development
  - Takes into consideration cross-asset resource allocation and constraints
  - Performance is a reflection (outcome) of the implementation of a TAMP
Guiding principle 2

• Pavement investments are made at the section (project) level
  ➢ Reflects current (and future) agency practice
  ➢ Investing at 0.10-mile level not realistic
  ➢ All program-scale investment needs to be translated into a candidate project list to relate to specific pavement performance
  ➢ PMS uses project-level investments to optimize network outcomes
Guiding principle 3

- Investments during the performance period need to reflect reality (likelihood of those projects being completed)
  - Performance will reflect actual projects being done within 4 years
  - Significant portion of 4-year program is probably in the delivery pipeline
    - In particular, capital program and rehabilitation projects
  - Need to reflect projects (pavement interventions) that do not follow PMS rules (i.e. worst-first, band-aid treatments)
Guiding principle 4

• Agency should be able to measure performance at the reporting interval and explain it in terms of its actions

➢ Should make the progress determination discussion about performance as much as possible (and as little about explaining uncertainty)
Guiding principle 5

• Agency needs to keep accounting of actions (projects)
  ➢ Things are likely to vary from expected value of future performance
  ➢ Helps explain variation due to execution of projects that were not planned, and variation due to cancellation of projects that were planned
    • Likely important in the progress determination step
Information needed to integrate pavement target setting with the TAMP

- Simulation of treatments that do not follow PMS rules (to reflect reality)
- List of projects in pipeline (10 years)
- Selected investment level (core TAM function)
- Pavement condition data in HPMS format
Target-setting exercise

1. Strategic analysis using PMS to inform TAMP
2. Investment level decision made within the TAMP
   • This is the “real” target-setting exercise
   • Yields recommended program (including projects in the pipeline)
3. Performance predictions in terms of national measures
4. Assignment of “within-segment variability”
5. “Setting” of national performance targets
Investment Level Selection

Length in Backlog for Funding Scenarios
(V = Legacy Paving, P = Preservation, T = Unconstrained, C = Committed)
Interstate Pavements: Lane Miles in Good/Fair/Poor condition
($25M VIP + $69M Preservation)

Interstate Pavements: Lane Miles in Good/Fair/Poor condition
($69M VIP + $25M Preservation)
RSI as a Performance Measure

Instead of “this is the current condition of pavement”, RSI asks “what intervention is needed for this pavement”.

- Poor pavements are those that require reconstruction
- Good pavements are those that can be maintained with minimal maintenance (e.g., preservation)

<table>
<thead>
<tr>
<th>Good Condition</th>
<th>Fair Condition</th>
<th>Poor Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing or preservation as</td>
<td>Light rehabilitation as</td>
<td>Heavy rehabilitation or</td>
</tr>
<tr>
<td>first treatment in a 10 year</td>
<td>first treatment in a 10 year</td>
<td>reconstruction as</td>
</tr>
<tr>
<td>horizon</td>
<td>horizon</td>
<td>first treatment in a 10 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>horizon</td>
</tr>
</tbody>
</table>
Example: HPMS (2012) and HERS Models

To demonstrate performance measures: calculated RSI and compared to NPRM Good-Fair-Poor

- 25 sites pseudo randomly selected
- HERS performance prediction models coded into Matlab™

<table>
<thead>
<tr>
<th>Do-Nothing</th>
<th>Light Rehabilitation (e.g., 2.5” mill and overlay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The IRI ≤ 170 in/mile for the 10 yrs.</td>
<td>• IRI exceeds 120 in/mile, but not 220 in/mile.</td>
</tr>
<tr>
<td>• Rutting ≤ 0.2 inches.</td>
<td>• Fatigue cracking exceeds 10 percent.</td>
</tr>
<tr>
<td>• Fatigue cracking ≤ 10.</td>
<td>• Rutting exceeds 0.2 inches, but not 0.4 inches.</td>
</tr>
<tr>
<td>• Transverse cracking ≤ 50 per lane mile.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preservation (e.g., micro surfacing)</th>
<th>Heavy Rehabilitation (e.g., work extends into base layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• IRI less than 120 in/mile.</td>
<td>• IRI exceeds 220 in/mile.</td>
</tr>
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</tr>
</tbody>
</table>
Results

- 8% poor, corresponded to heavy rehab
- One fair segment needed heavy rehab
- ‘Good’ pavements = ‘Do Nothing’ or ‘Preservation’
  - One required light rehab, fatigue cracking increased rapidly
De-facto secondary objective: Must address these.
Convert section-level predictions to 0.10-mile predictions

• Deal with the Aggregation Problem

“In its most general form the aggregation problem can be defined as the information loss which occurs in the substitution of aggregate, or macrolevel, data for individual, or microlevel, data.”


• In pavements, deal with “within-segment variability“ in section-level predictions
What information is lost?

- **Within segment-variability**

<table>
<thead>
<tr>
<th>Case</th>
<th>Length Good</th>
<th>Length Fair</th>
<th>Length Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.00 miles</td>
<td>0.00 miles</td>
<td>0.00 miles</td>
</tr>
<tr>
<td>B</td>
<td>0.90 miles</td>
<td>0.10 miles</td>
<td>0.00 miles</td>
</tr>
<tr>
<td>C</td>
<td>0.70 miles</td>
<td>0.30 miles</td>
<td>0.00 miles</td>
</tr>
</tbody>
</table>
What information is lost?

• **Within segment-variability**

<table>
<thead>
<tr>
<th>Case</th>
<th>Length “Good”</th>
<th>Length “Fair”</th>
<th>Length “Poor”</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.60 miles</td>
<td>0.40 miles</td>
<td>0.00 miles</td>
</tr>
<tr>
<td>E</td>
<td>0.00 miles</td>
<td>1.00 miles</td>
<td>0.00 miles</td>
</tr>
<tr>
<td>F</td>
<td>0.70 miles</td>
<td>0.00 miles</td>
<td>0.30 miles</td>
</tr>
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</table>
Solving the Aggregation problem (first cut)

- Assigned Good/Fair/Poor distribution within a segment based on measurements of similar in-place pavement sections
- Used a lookup table from measured data
  - Measured within-segment variability for various pavement families in existence: Surface Age, Pavement Type, Functional Class
  - The family definition should be that which is relevant to each agency and could be replaced by single-segment performance measurements if PMS is set up that way.
Example of assignment of performance variability

<table>
<thead>
<tr>
<th>Pavement “Family” Pavement type, Functional Class</th>
<th>Overall Condition (as per MAP-21)</th>
<th>Surface Age</th>
<th>% Good</th>
<th>% Fair</th>
<th>% Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible F.C. 2</td>
<td>Good</td>
<td>0-3 years</td>
<td>0.95</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-9 years</td>
<td>0.82</td>
<td>0.15</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10+ years</td>
<td>0.65</td>
<td>0.27</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Example of assignment of performance variability

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</thead>
<tbody>
<tr>
<td>Flexible F.C. 2</td>
<td>Fair</td>
<td>0-3 years</td>
<td>0.45</td>
<td>0.50</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-9 years</td>
<td>0.26</td>
<td>0.63</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10+ years</td>
<td>0.13</td>
<td>0.69</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Issues encountered

• Having sufficient data to reliably assign “condition distribution” to 0.10-mile segments from the pavement sections
  ➢ Using measured data can, for example, lead to higher expected % poor for higher investments if insufficient data are available.

• Preference for not introducing prediction error wherever possible
  ➢ Instead, measure (or account for) variability
Dealing with the Aggregation Problem (next generation)

- Find ways to avoid having to do this
- Expand PMS capability to conduct strategic analysis using actions on analysis units (sections) and have those actions be reflected in 0.10-mile segments.
  - Take the list of projects (including multiple treatments) and apply as a fixed program to the 0.10-mile segments, including multiple treatments
Communicating target-setting

• Target-setting methodology (maturity)
• Top risks in adopting the target
• Confidence in achieving target
Target-Setting Maturity Model

1. Aspirational
   - Target based on desired outcome, little data used

2. Extrapolation
   - Use historical time series and extend into future

3. Forecasting model
   - Include explanatory variables/covariates in a model, forecast outcome

4. Systems approach
   - Systems techniques (simulation, system dynamics) & cause-effect relationship
Risks

• Where are our headaches going to come from?
  • Insufficient investment → declining targets
  • Abstract target definitions
  • Perception (headlines)

• We should have a strategy to address the risks
  • Develop a communications strategy (telling our story first)
Confidence

• Are we confident we achieve the targets?

Confidence is higher with:

• More and better data
• Better understanding, more powerful models
• Control over outcomes
## Pavement Condition Measures

- **% of Interstate system in “Good” and “Poor” condition**
  - **MAX % Poor (Interstates): 5%**

- **% of National Highway System in “Good” and “Poor” condition**

### Pavement Condition Measures Table

<table>
<thead>
<tr>
<th>Asset (unit of measure)</th>
<th>Current Condition (HPMS submittal 6/2017)</th>
<th>2-year targets (2020)</th>
<th>4-year targets (2022)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good %</td>
<td>Poor %</td>
<td>Good %</td>
</tr>
<tr>
<td>Interstate Pavement (lane miles)</td>
<td>66.2</td>
<td>2.2</td>
<td>65.5</td>
</tr>
<tr>
<td>Non-Interstate NHS Pavement (lane miles)</td>
<td>37.9</td>
<td>8.6</td>
<td>36.0</td>
</tr>
</tbody>
</table>

### MATURITY

| Forecasting/Systems | 3.5 |

### TOP RISK(S)

1. Budgetary uncertainty
2. State of Good Repair definition is not captured well
3. Declining targets need to be communicated properly

### CONFIDENCE

High
## System Reliability Measures

- % person-miles of Interstate that are “reliable”
- % person-miles of non-Interstate NHS that are “reliable”

### System (unit of measure)

<table>
<thead>
<tr>
<th>System (person-miles)</th>
<th>Current Condition</th>
<th>2-year targets (2020)</th>
<th>4-year targets (2022)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate</td>
<td>78.3</td>
<td>75.2</td>
<td>72.1</td>
</tr>
<tr>
<td>Non-Interstate NHS</td>
<td>83.6</td>
<td>80.0</td>
<td>76.4</td>
</tr>
</tbody>
</table>

### MATURITY

| Maturity                     | 1.5               |

### TOP RISK(S)

1. Reliability definition new, abstract, and may not capture individual user experience
2. Outcomes subject to external factors
3. Worsening reliability has to be communicated

### CONFIDENCE

Low