Asset Management
Ruminations

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Why Transportation Asset Management Has Nothing to Do With Systems to Manage Individual Transportation Assets

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I really didn’t intend to confuse you more

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What Is Asset Management

- **FHWA office of Asset Management**
  
  “Asset management is a business process and a decision-making framework that covers an extended time horizon, draws from economics as well as engineering, and considers a broad range of assets. The asset management approach incorporates the economic assessment of trade-offs among alternative investment options and uses this information to help make cost-effective investment decisions.”

- **AASHTO**
  
  “Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines Engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.”

- **UK Asset Management Institute**
  
  “The set of disciplines, methods, procedures and tools to optimise the whole life business impact of costs, performance and risk exposures of the company’s physical assets.”
TAM Definitions

• Commonwealth of Victoria, Australia
  “Asset management is the process of guiding the acquisition, use and disposal of assets to make the most of their service delivery potential and manage the relate risks and costs over their entire life.”
  – Steps
    • Needs analysis (demand analysis)
    • Economic appraisal (valuation)
    • Integrate with planning process
    • Budgeting (over entire life-cycle)
    • Pricing
    • Economic evaluation of acquisition and disposal options
    • Recording, valuation and reporting (condition/performance appraisal)
    • Management in use (maintenance management)
TAM Definitions Continue

• Lou Lambert (formerly with the Michigan DOT)
  – “Transportation Asset Management views infrastructure as an investment rather than a cost.”
  – Using Lou’s definition, what should be our criteria for determining how to allocate our financial resources?

  – In the public sector, how do we measure return on investment?
Important Difference Between Private and Public Sectors

The private sector internalizes user benefits and costs.

The public sector cannot internalize user benefits and costs. This results in sub-optimal solutions.
Agency Optimum Example
Switching Gears

Let's look at how we use systems to manage individual assets
Technical Process for System Used to Manage an Asset

- **Inventory of Assets**
  - Pavements
  - Bridges
  - Sewer lines
  - Traffic Control

- **Assessment of Asset Condition**
  - Asset description and location

- **Impact Models**
  - User or condition impact

- **Forecast Asset Condition**
  - Present and future condition

- **Resource Allocation Model**

- **Agency’s Operation and Capital Plan**

- **Performance Measures**
  - Feedback

- **Forecast Infrastructure Condition**

- **Infrastructure Budget**

- **M & R Strategies**
Performance Under Alternative Scenarios

Example of network level analysis

Average Network Condition

- Do Nothing
- $50 M
- $40 M
- $30 M
- DOT$
Pavement Performance Measures

![IRI Trends (Iowa DOT)](image)
# International Roughness Index

<table>
<thead>
<tr>
<th>Condition</th>
<th>iri (m/km)</th>
<th>in/mi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>1.50</td>
<td>95.00</td>
</tr>
<tr>
<td>Fair</td>
<td>2.68</td>
<td>170.00</td>
</tr>
<tr>
<td>Poor</td>
<td>3.95</td>
<td>250.00</td>
</tr>
<tr>
<td>Failed</td>
<td>5.52</td>
<td>350.00</td>
</tr>
<tr>
<td>Impassible</td>
<td>7.89</td>
<td>500.00</td>
</tr>
</tbody>
</table>
Pavement Performance Measures

PCI Trends (Iowa DOT)
PCI Equation

Jointed PC Pavements on the interstate
PCI = (-1.025063*age) - (0.225302*lifeused) - (0.125296*CRACK) + 102.238903

lifeused - ESALs since resurfacing divided by design or predicted lifetime ESALs
CRACK - cracking in sq.m per 800 meter test section

For full depth asphalt on the interstate
PCI = (-3.772517*age + (0.232149*basethick) - 4.044342*IRI + 23.073049

basethick - Base thickness in mm
# Bridge Health Rating

## Severity weighting factor

<table>
<thead>
<tr>
<th>Number of Possible Condition States</th>
<th>State 1 WF</th>
<th>State 2 WF</th>
<th>State 3 WF</th>
<th>State 4 WF</th>
<th>State 5 WF</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Condition States</td>
<td>1.00</td>
<td>0.50</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Condition States</td>
<td>1.00</td>
<td>0.67</td>
<td>0.33</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>5 Condition States</td>
<td>1.00</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Current value of each element

Current element value = (quantity in Condition state x WF x FC)
WF = Weight factor for the severity of the deterioration as determined in table.
FC = Failure costs of the element (cost to rehabilitate or replace an element if it fails.)
## Core Element Condition & Extent Data

<table>
<thead>
<tr>
<th>Element</th>
<th>Total Quantity</th>
<th>Units</th>
<th>State 1</th>
<th>State 2</th>
<th>State 3</th>
<th>State 4</th>
<th>State 5</th>
<th>Unit Failure Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Deck</td>
<td>300</td>
<td>Sq Meters</td>
<td>0</td>
<td>0</td>
<td>300</td>
<td>0</td>
<td>0</td>
<td>$600</td>
</tr>
<tr>
<td>Steel Girder</td>
<td>100</td>
<td>Meters</td>
<td>61</td>
<td>34</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>$3,500</td>
</tr>
<tr>
<td>Reinforced Concrete Abutment</td>
<td>24</td>
<td>Meters</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$7,700</td>
</tr>
<tr>
<td>Reinforced Concrete Column</td>
<td>4</td>
<td>Each</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$9,000</td>
</tr>
<tr>
<td>Joint Seal</td>
<td>24</td>
<td>Meters</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>na</td>
<td>na</td>
<td>$556</td>
</tr>
</tbody>
</table>
# Bridge valuation calculation

<table>
<thead>
<tr>
<th>Element</th>
<th>Calculation</th>
<th>Current Element Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Deck</td>
<td>300 x 0.5 x 600</td>
<td>$90,000</td>
</tr>
<tr>
<td>Steel Girder</td>
<td>((61 x 1.0) + (34 x 0.75) + (5 x 0.5)) x 3,500</td>
<td>$311,500</td>
</tr>
<tr>
<td>RC Abutment</td>
<td>24 x 1.0 x 7,700</td>
<td>$184,800</td>
</tr>
<tr>
<td>RC Column</td>
<td>4 x 1.0 x 9,000</td>
<td>$36,000</td>
</tr>
<tr>
<td>Joint Seal</td>
<td>24 x 0.0 x 556</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total Current Value of Bridge</strong></td>
<td></td>
<td><strong>$622,300</strong></td>
</tr>
</tbody>
</table>
## Total valuation calculation

<table>
<thead>
<tr>
<th>Element</th>
<th>Calculation</th>
<th>Current Element Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Deck</td>
<td>300 x 600</td>
<td>$180,000</td>
</tr>
<tr>
<td>Steel Girder</td>
<td>1,000 x 3,500</td>
<td>$350,500</td>
</tr>
<tr>
<td>RC Abutment</td>
<td>24 x 7,700</td>
<td>$184,800</td>
</tr>
<tr>
<td>RC Column</td>
<td>4 x 9,000</td>
<td>$36,000</td>
</tr>
<tr>
<td>Joint Seal</td>
<td>24 x 556</td>
<td>$13,344</td>
</tr>
<tr>
<td><strong>Total Current Value of Bridge</strong></td>
<td></td>
<td><strong>$764,114</strong></td>
</tr>
</tbody>
</table>
Bridge Health Index (Example)

\[ H = \frac{\$622,300}{\$764,144} \times 100\% = 81.4\% \]
Performance Measure

Osborne and Gaebler, Reinventing Government
If you don’t measure results, you can’t tell success from failure. If you can’t see success, you can’t reward it. If you can’t reward success you are probably rewarding failure. If you can’t see success, you can’t learn from it. If you can’t recognize failure, you can’t correct it. If you can demonstrate results, you can win public support.
Performance Measurement

Tom Maze – The Soviet Union was very good at identifying performance measures and setting performance goals. Performance measurement and goals by themselves are not enough.
Defining performance

– Performance measurement needs to capture inventory, and condition - the “supply side”
  • Financial perspective indicators
  • Internal business and engineering indicators
  • Change and growth indicators

– Performance assessments also depends on usage - the “demand side”
  • Customer prospective indicators
Performance Measurement Example – Understanding Desired Outcomes

• What is the desired outcome for winter maintenance?

• What technical resources does a transportation agency have to achieve its objectives?

• What non-technical resources does a transportation agency have to achieve its objectives?

• What is a transportation agency’s core business when it comes to winter maintenance?
System Mapping Diagram

**Technical Inputs:** Routing, Communications Technology, Equipment

**Inputs:**
- Brine Use per Lane Mile
- Salt Used per Lane Mile
- Process Performance Measure
- Process Targets
- Cost per Mile
- Labor per Mile
- Bare Pavement Target
- Time Till Recovery of Bare Pavement
- Brine Use Target
- Salt Use Target

**Core Business (Removing Snow and Ice)**

**Non-Technical Inputs:** Labor, Workforce Agreement, Field Supervisors

**Desired Outcomes:**
- Meet or Exceed Customer Expectations
MnDOT Dashboard Examples
Example, MnDOT’s bridge condition dashboard

**Bridge Condition**
*Trunk Highway Principal Arterials*
*Bridges 20 Feet and Over*

- **Bridge Structural Condition**
  - 50% Good
  - 65% Good
  - 2% Poor

- **Bridge Geometric Rating**
  - 40% Good
  - 50% Good
  - 5% Poor

- **Bridge Load Capacity**
  - 40% Good
  - 50% Good

**Targets for the Year 2017:**
- Structural Condition: ≥ 65% Good and 2% Poor
- Geometric Rating: ≥ 50% Good and 5% Poor
- Load Capacity: ≥ 50% Good and 0% Poor

**Performance (January, 2000):**
- Structural Condition: 57.2% Good and 3.9% Poor
- Geometric Rating: 48.9% Good and 6.1% Poor
- Load Capacity: 42.2% Good and 0.1% Poor

Source: Office of Bridges & Structures, Bridge Management Unit
How Do We make Trade Offs Between Performance Measure?

- Pavement Condition Rating
- Bridge Health
Issues with existing asset management process

• Existing methods seek to satisfy performance requirements while minimizing costs
• Existing methods do not address system growth or system abandonment
• There is no assurance that existing standards for performance are reaching desirable solutions
• No ability to measure the user impact of adjustment investment levels between alternative asset categories – supply side oriented
• Therefore, there is not means to measure return on investment!
Issue

Some how asset management got confused with systems used to manage assets!!!

How did this happen???
Problem Solving approaches

Deductive Approach

Theory → Hypothesis → Observation → Confirmation

Inductive Approach

Theory → Tentative Hypothesis → Pattern → Observation
How did we get to this point?

• The state-of-the-art took the inductive approach (the follow your noise approach)
  – Started with a conventional approach involving
    • Managing assets to performance standards
    • Minimizing internal costs
  – Look for best practices involving best decision making tools
  – Accumulate best practices into a state-of-the-practice
    • Declare victory
Alternative model for the development asset management

• Develop a theoretical model for asset management
  – Develop the science of asset management

• Develop practical models based on a sound theory

• Develop institutional processes which support approaches based on sound theory
Asset Management

• Maze Definition: The efficient allocation of resources between competing demands

Requirements

– The allocating agency must have a free hand to move resources to most efficient use
– The allocating agencies must give equal weight to internal and external costs and benefits
Resource Allocation Decision

• Level 1 – Public versus private
• Level 2 – Transportation versus all other public purposes
• Level 3 – Category of transportation service or asset
• Level 4 – Network level analysis
• Level 5 – Project selection
• Level 6 – Project alternative evaluation
• Level 7 – Project design selection
  – Maintenance resource allocation decisions are determined by level 7
Public Vs Private

• The public sector provides goods and services where delivery through the market is inefficient
  – The division becomes very murky
History of private sector delivery in transportation
Question - Levels of resource (funding)allocation decisions

• How do we decide what category of investment to fund at what level?
  – Example – we can spend public funds on parks, roads, sewer, schools, etc.
  – Analogy – how would private company (GM) decide whether to invest more in making Geos or Cadilacs
Answer - Levels of resource (funding)allocation decisions

• At the margin (the last dollar invested in all investments) should earn the same return
  – Return on the last dollar invested highways should equal the return on the last dollar in water supplies.
Question - Given a level of resource devoted to category, which project do we invest in?

- How do we decide which project to invest in?

Characteristics of the decision – is non-mutually exclusive
Network level decision (planning level decisions)
Answer - Given a level of resource devoted to category, which project do we invest in?

• Select projects starting with the greatest benefits to cost ratio (return) until
  – There are no more projects with benefit to cost ratios greater than one
  Or
  – You run out of resources
Question - Within a project how do we make choices?

• How do we decide to invest given multiple options for a project?

Characteristics of the decision – mutually exclusive
Project level decision (planning level decisions)
Answer - Within a project how do we make choices?

• We select the most expensive project where the incremental benefits exceed the incremental costs when compared to all other projects
  – Incremental benefits = incremental reduction in user costs
  – Incremental cost = increment facility related costs (including O&M) compared to the less costly facilities
Question - Within a design how do we make decisions

- Once we pick alignment A, how decided whether to use one pavement design or another?

Characteristics of the decision – mutually exclusive, benefits are essentially the same. Design level decision
Answer - Within a design how do we make decisions

- Assuming both designs offer the same benefits
- Select the design with the minimum life cycle cost
- The performance standard for the asset are made at this level
Question - Maintenance and Operations Decisions?

• After the asset is built how do we make comparisons between deferring maintenance and using the savings to build a new project?
  – Competition between O&M and capital decisions
Answer - Maintenance and Operations Decisions?

- O&M decisions have already been made as part of the design decision
- At the margin, O&M resource allocation decisions should be made based on the opportunity cost of decision
  - What are the costs associate with not performing the planned maintenance?
Summary of Decision Making Levels

- Public Versus Private – Level 1
  - Invest where the return is the greatest
- Public Sector Category – Level 2
  - The last dollar invested in each category should offer the same return
- Category of Investment - Level 3
  - The last dollar invested in each category should offer the same return
- Network level analysis – Level 4
  - Budget for category fixed
  - Non-mutually exclusive alternatives
  - Select treatments which maximize performance
- Project selection analysis – Level 5
  - Non-mutually exclusive alternatives
  - Select specific alternatives with greatest B/C ratio
- Project alternatives analysis – level 6
  - Mutually exclusive alternatives
  - Select option based on incremental B/C ratio
- Project design alternative analysis
  - Options offer the same user costs
  - Select based on minimum life cycle costs
  - Design to meet performance standard