Elemental Decomposition and Multi-Criteria Method for Valuing Transportation Infrastructure

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Study Motivation
• Government Accounting Standards Board agency requirement
• Numerous valuation methods exist
• Traditional methods have a number of shortcomings:
  • Assumption (implicit) that assets are monolithic
  • Assume one perspective (service life or condition)
  • Do not consider user perspective
  • Do not consider real estate value
  • Do not probabilistic analysis
• Elemental decomposition and multi-criteria (EDMC) method accounts for:
  • Multiple perspectives (agency, user)
  • Asset components (different deterioration rates)

Realistic Nature of Asset Deterioration

A single asset is comprised of multiple components which deteriorate at different rates and in different patterns. Simply basing the value of an asset on one component’s deterioration detracts from the actual asset value.

Component A

Component B

Component C

Year of Analysis

Value of Component A

Value of Component B

Value of Component C

Value ($)

Time (years)

Component

Substructure

Deck

Superstructure

Asset Value Computation

\[ V = \sum_{i=1}^{K} \left( w_i \cdot \text{cost}_{\text{comp}} \cdot \frac{A_{R_i}}{A_{R_{\text{max}}} \text{or} A_{R_{\text{range}}}} \right) \]

Where,

\( V \) is the value of the asset at time \( t \)

\( w_{\text{i,j}} \) is the relative importance of the SL perspective (agency)

\( w_{\text{u,j}} \) is the relative importance of the condition perspective (user)

\( A_{R_i} \) is the attribute ratio performance criteria or attributes

Cost\_comp, is the cost for an asset component \( i \)

Components (Illustration: JFK Bridge, Jeffersonville, IN)

Benefits of using (EDMC) Method

<table>
<thead>
<tr>
<th>Method</th>
<th>EDMC</th>
<th>RC</th>
<th>SLD</th>
<th>DB</th>
<th>SOYD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Decomposition into Multiple Components</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dichotomy between Condition (agency) &amp; Service Life (user) Perspectives</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Inclusion of Real Estate Value</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Probabilistic Considerations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Stakeholder Perspectives & Attribute Ratios

Remaining Service Life Attribute  Condition Attribute  Any Attribute

RSL\(_{ij}\)  \( P_{ij} - P_{worst,j} \)  \( AR_i = \frac{AR_{\text{max}}}{AR_{\text{max}} \text{or} AR_{\text{range}}} \)

RSL: remaining service life; SL: service life; P: condition; AR\(_i\): level of performance attribute at year \( t \); AR\(_{\text{max}}\): max of performance attribute; AR\(_{\text{range}}\): range of performance attribute

Attribute Ratio Weights

\[ \sum_{k=1}^{K} w_k \left( \frac{AR_i}{AR_{\text{max}} \text{or} AR_{\text{range}}} \right) \]

Thus, for a given asset component \( i \), and criteria (attributes) \( k=1,2,\ldots,K \), the value, \( V_c \), is given by the following equation where \( w_k \) is the relative importance of each perspective

Indiana Network Valuation Results using different Valuation Methods

EDMC Total Indiana Value: $70 Billion (determined in this study)

Results: Values of Indiana’s Highway Assets

<table>
<thead>
<tr>
<th>Pavements</th>
<th>Bridges</th>
<th>Culverts</th>
<th>Guardrails</th>
<th>Road Signs</th>
<th>Underdrains</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDMC Value</td>
<td>$48B</td>
<td>$8B</td>
<td>$0.22B</td>
<td>$0.33B</td>
<td>$0.02B</td>
<td>$12.3B</td>
</tr>
</tbody>
</table>


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Considerations

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  • Asset components (different deterioration rates)