Elemental Decomposition and Multi-Criteria Method for Valuing Transportation Infrastructure

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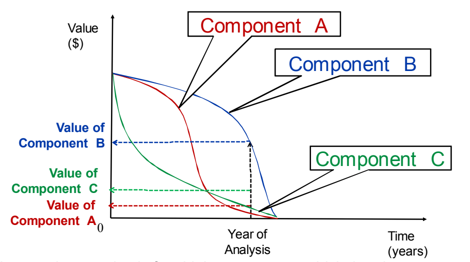
Study Motivation

- 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



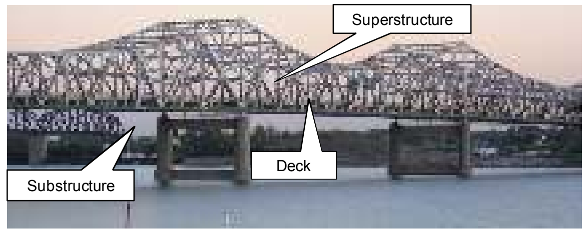
A single asset is comprised of multiple components which deteriorate at different rates and in different patterns. Simply basing the value of an asset on one component's deterioration detracts from the actual asset value.

Assets Considered in this Valuation

Components

(Illustration: JFK Bridge, Jeffersonville, IN)

Value using EDMC: $18.6M
Value using RC: $36.1M



Stakeholder Perspectives & Attribute Ratios

Remaining Service Life Attribute	Condition Attribute	Any Attribute
$\dfrac{RSL_{t,i}}{SL_i}$	$\dfrac{P_{t,i} - P_{worst,i}}{P_{best,i} - P_{worst,i}}$	$AR_K = \dfrac{AR_k}{AR_{max} or AR_{range}}$

RSL: remaining service life; SL: service life; P: condition; AR_k: level of performance attribute at year t; AR_{max}: max of performance attribute; AR_{range}: range of performance attribute

Attribute Ratio Weights

$$\sum_{k=1}^{K} w_k \left(\frac{AR_k}{AR_{max} or AR_{range}} \right)$$

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

Asset Value Computation

$$V_t = \sum_{i=1}^{I} \sum_{k=1}^{K} (w_k \cdot cost\_comp_i) \left(\frac{AR_k}{AR_{max} or AR_{range}} \right)$$

Where,
V_t is the value of the asset at time *t*
$w_{k=1}$ is the relative importance of the SL perspective (agency)
$w_{k=2}$ is the relative importance of the condition perspective (user)
AR_k is the attribute ratio performance criteria or attributes
$Cost\_comp_i$ is the cost for an asset component *i*

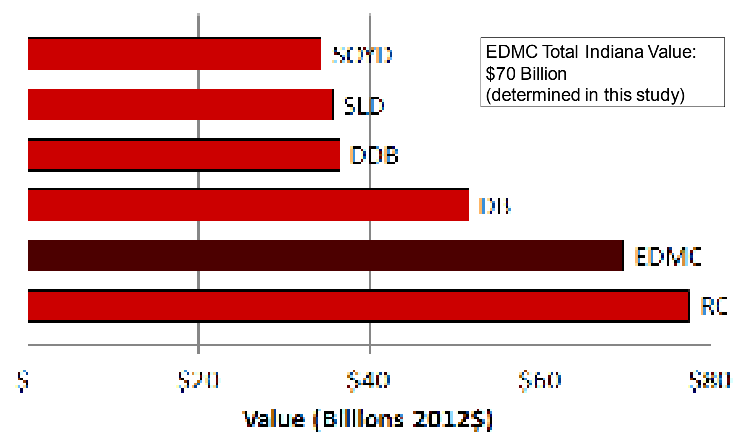
Benefits of using (EDMC) Method

Considerations \ Method	EDMC	RC	SLD	DB	SOYD
Asset Decomposition into Multiple Components	✓				
Dichotomy between Condition (agency) & Service Life (user) Perspectives	✓				
Inclusion of Real Estate Value	✓	✓	✓	✓	✓
Probabilistic Considerations	✓ (Monte Carlo)	✓	✓	✓	✓

Results: Values of Indiana's Highway Assets

	Pavements	Bridges	Culverts	Guardrails	Road Signs	Underdrains	ROW
EDMC Value	$48B	$8B	$0.22B	$0.33B	$0.02B	$0.006B	$12.3B

Indiana Network Valuation Results using different Valuation Methods



EDMC: Elemental Decomposition & Multi-Criteria; SLD: Straight Line Depreciation ; DB: Declining Balance; DDB: Double Declining Balance; SOYD: Sum-of-Years-Digits; RC: Replacement Cost