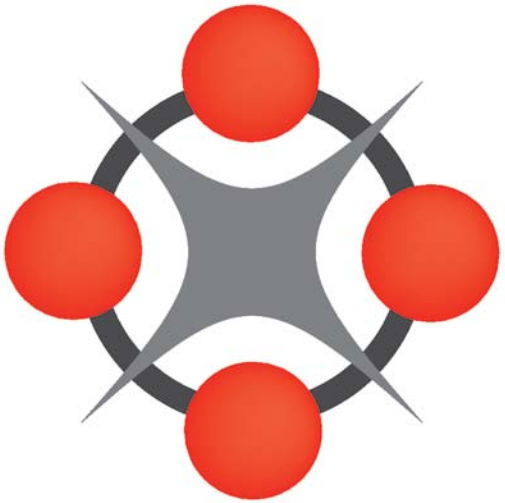
Analysis of Transportation Infrastructure Maintenance Strategy Using Comparative Efficiency Analysis Method

9th National Conference on Transportation Asset Management



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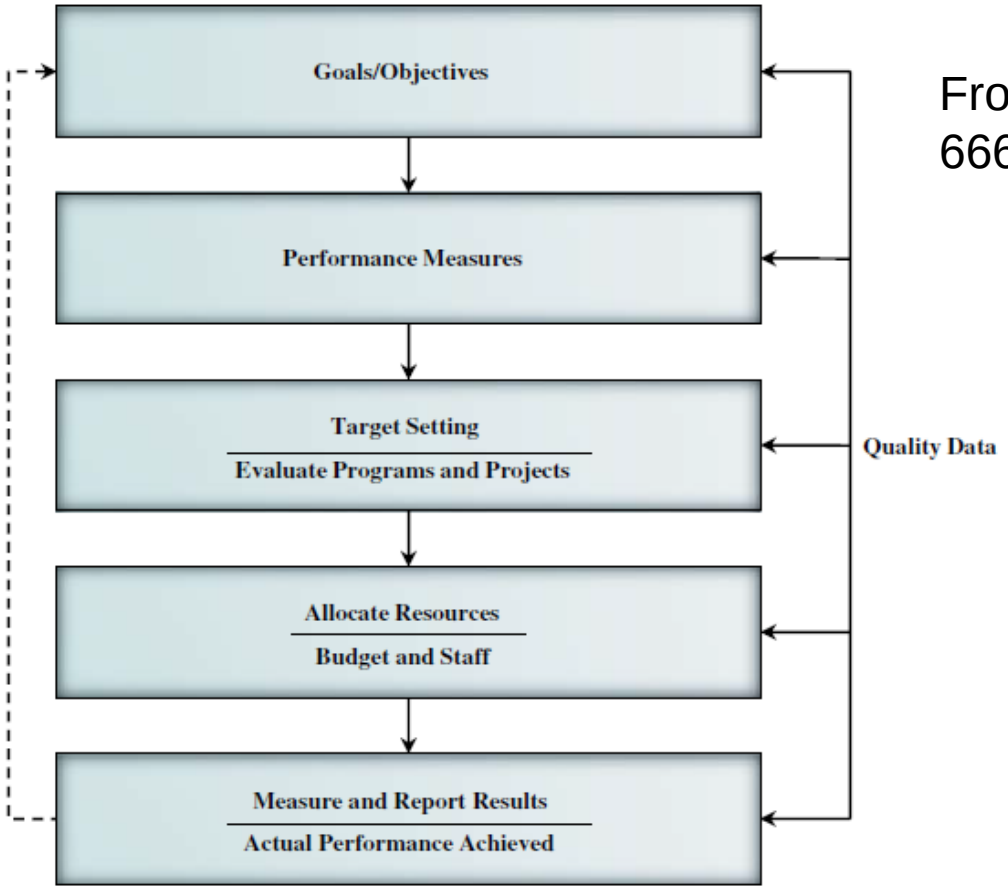
Overview

- Improving the practice of maintenance
- Cycle of maintenance: expenditures → maintenance → condition assessment (money-action-result)
- Comparative efficiency with Data envelopment analysis method
- Examples
- Follow-up plans

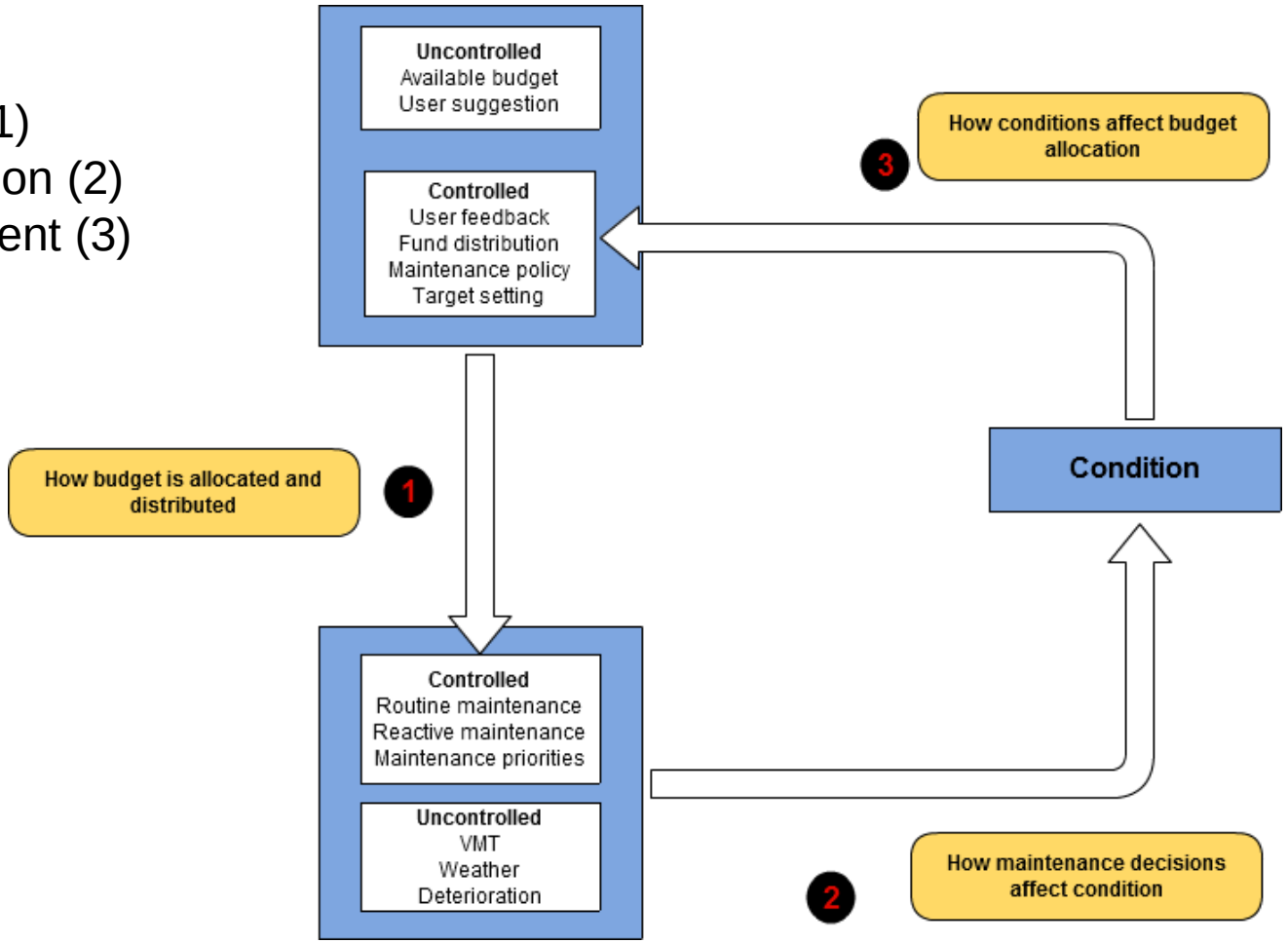
Performance Management Framework



From NCHRP Report No. 666:

Cost-Condition Cycle

- Budget allocation (1)
- Maintenance decision (2)
- Condition assessment (3)



Improving Maintenance Practice

- Closing the loop
  - Statistical modeling.
- Issues
    - Different characteristics (weather, traffic, etc)
    - Different maintenance practices
    - Different maintenance policy
- Analyze Efficiency (of the maintenance practice/strategy)
  - May not know details
  - Will enable us to identify maintenance practices
  - Observe efficient vs. inefficient

Comparative Efficiency Analysis

- Optimizing cost-condition cycle by improving spending efficiencies → optimizing funds allocation and sustain it throughout the maintenance cycle
- Cost-condition cycle will be most optimized (best overall performance) when resource allocation process is the most efficient
- Compare historical data from year to year to figure out which year the process is the most efficient → this is called comparative efficiency analysis

Data Envelopment Analysis

- Popular implementation for comparative efficiency analysis
- Non-parametric models
- Does not assume that the model structure is fixed
- Assumption: 100% efficient system is impossible, but the method will identify the most efficient system out of many

Data Envelopment Analysis

- Common usage of DEA
  - Benchmarking peer units (companies, branch offices, counties in the same state, etc)
  - Enables the assessment of how efficiently a particular unit is performing if compared with its peers
  - Formula:

$$Max\ h_0 = \frac{\sum_r U_r Y_{rj_0}}{\sum_i V_i X_{ij_0}}$$

$$Subject\ to:$$

$$\frac{\sum_r U_r Y_{rj_0}}{\sum_i V_i X_{ij_0}} \leq 1\ (for\ each\ j)$$

$$u_r, v_i, \geq \epsilon$$

DEA for Cost-Condition Cycle Analysis

- Comparing annual cycles of one particular unit, instead of comparing peer units
- Looking into trend of data for several years, comparing them to see which year this unit performs the most efficiently

Advantages of DEA in C-C-C Analysis

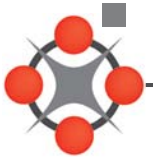
- There is no need to explicitly specify a mathematical form
- It has proven to be useful in uncovering relationships that remain hidden for other methodologies
- Capability of handling multiple inputs and outputs
- Capability of being used with any input-output measurement
- Allows analysis and quantification of the sources of inefficiency in every evaluated unit

Examples

- County A bridge maintenance data from 2003 to 2008

County	Year	Maintenance	ADT	Improvement
County A	2003	$1,136,387.00	12,575	0.99
County A	2004	$504,674.00	22,064	1.18
County A	2005	$250,346.00	13,100	1.18
County A	2006	$904,270.00	11,694	1.45
County A	2007	$1,582,618.00	9,986	1.11
County A	2008	$251,166.00	11,304	1.25

  - *Improvement = condition improvement from the previous year (larger is better)*
- Input: Maintenance expenditures, ADT
- Output: Improvement



Examples (continued)

- Result from DEA

County	Year	Maintenance	ADT	Improvement	Efficiency Scores
County A	2003	$1,136,387.00	12,575	0.99	0.6349
County A	2004	$504,674.00	22,064	1.18	0.4829
County A	2005	$250,346.00	13,100	1.18	0.9471
County A	2006	$904,270.00	11,694	1.45	1.0000
County A	2007	$1,582,618.00	9,986	1.11	0.8965
County A	2008	$251,166.00	11,304	1.25	1.0000

  - *Efficiency scores show that maintenance was:*
    - *Most efficient in 2006 and 2008*
    - *Most inefficient in 2004*

Examples (continued)

- Investigating the efficient and inefficient years
  - Which parameters have the most significant effect
  - Sensitivity analysis
  - Different strategy for different units

Follow-up Plans

- Define study cases
- More thorough investigation of parameters identification
- Testing input-output interaction of parameters
- Additional analysis
  - Different parameters for input/output
  - Sensitivity/significance of different input/output parameters
  - Partitioning data based on parameter type/age/size to examine change of behaviors