Lecture 10

Highway Asset Management

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Why Asset Management ?

- Ned to meet national and societal goals.
- Need to be accountable in using public funds.
- The concepts and principles of asset management, which are extensively and successfully used by for-profit companies, can be effectively applied to the management of public sector transportation facilities.
- Driving the asset management process are performance goals that reflect customer preferences as well as organizational policies, budgets, and objectives.
- Promise of asset management is highly compelling.

1997 -- AASHTO “Transportation Asset Management Task Force”

1999 -- FHWA “Office of Asset Management”

Highway Asset Management

<u>Definition by FHWA (1996)</u> :

A systematic process of maintaining, upgrading, and operating physical highway assets cost-effectively

- Combines engineering principles with sound **business practices** and **economic theory;**
- Provides tools to facilitate a more organized, logical approach to decision-making;
- Provides a framework for handling both short- and long-range planning.

Highway Asset Management

Definition by Austroads (1997) :

A comprehensive and structured approach to the long-termed management of assets as tools for the efficient and effective delivery of **community benefits**.

Definition by OECD (2002) :

… goes beyond the traditional management practice of examining singular systems within the road network, and looks at the universal system of a network of roads, …makes more effective **investments** and decreases overall costs, including **social and economic impacts** …

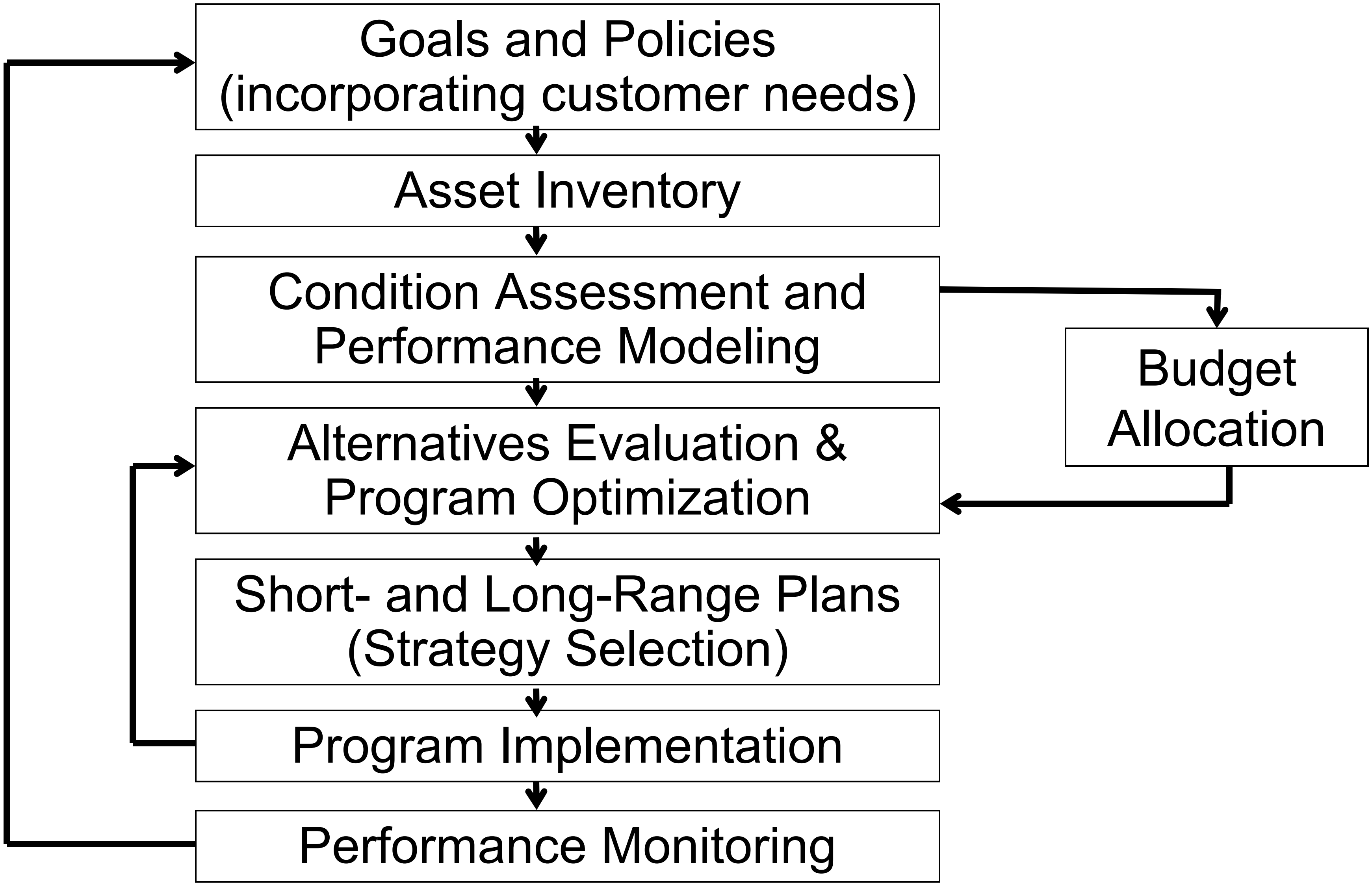
Highway Asset Management

Definition by New York State DOT (1998) :

It expands the scope of conventional infrastructure management systems, explicitly addresses **integration** of decisions made across all program areas.

Its purpose is simple – to maximize benefits of a transportation program to its **customers and users**, based on **well-defined goals** and with available resources.

Elements of Highway Asset Management System



Elements of Highway Asset Management System

Goals and Policies
(incorporating customer needs)

- Customer-based performance targets and organizational goals

  (i.e. Incorporating input from citizens, legislators, and policy makers)

- Strategic goals are long term. They serve as the foundation for policy-making, funding allocations, and short-range programming decisions.

- Performance targets must be consistent with customers' expectations, organizational goals and policies.

Elements of Highway Asset Management System

Alternatives Evaluation & Program Optimization

Two key aspects :

(A) Multi-agency multi-system multi-level decision-making environment

- **Different management units**
- **Not restricted to singular system**
- **Different decision-making levels**

(B) Multi-goal multi-objective requirements

- **Economic considerations: Agency costs**
  User benefits
- **Social needs**
- **Environmental impacts**

Elements of Highway Asset Management System

Alternatives Evaluation &
Program Optimization

(cont'd)

Analytical tools needed to facilitate an organized, logical approach for :

- **Budget allocation**
- **Resource utilization**
- **Activity scheduling & programming**
- **Optimization**

Elements of Highway Asset Management System

Short- and Long-Range Plans
(Strategy Selection)

Integration of decisions across all program areas and management levels based on engineering considerations, economic analysis, and business practices.

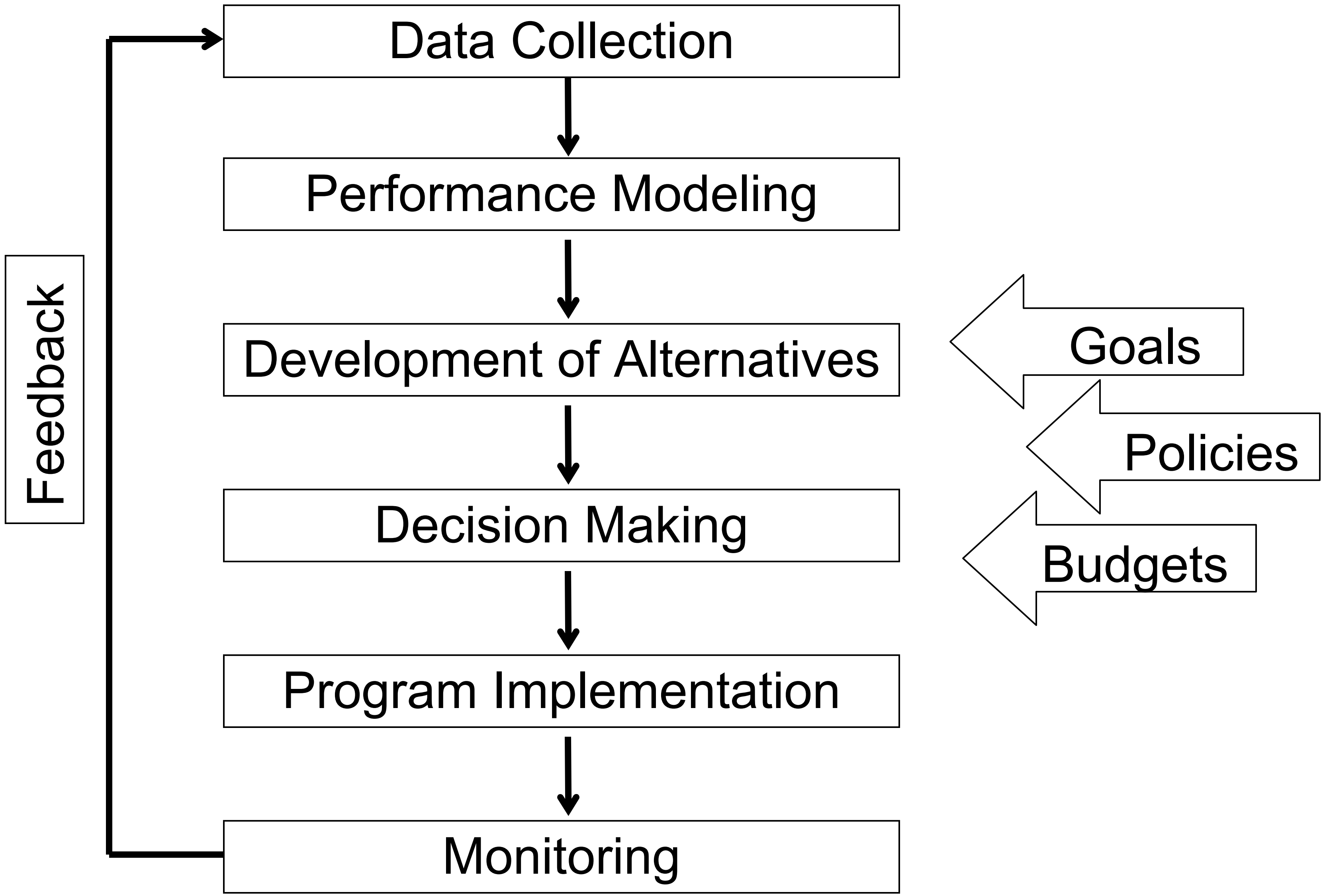
- Engineering -- Design, materials, standard & quality of work, data collection/processing/management, performance monitoring & prediction, testing & evaluation, project management & control.
- Economics -- Optimization, life-cycle cost analysis, return of investment, financial strategies.
- Business -- Strategic planning, business performance measures, audit and feedback, credibility & accountability

Highway Assets

- **Physical Highway Assets**
- **Operational Highway Asset**

Physical Highway Assets	Operational Highway Assets
• Pavements • Bridges • Tunnels • Other structures & hardware (guardrail, signs, lighting, barriers, impact attenuators, surveillance and monitoring equipment, and other operating facilities)	• Vehicles of highway authority • Construction & maintenance equipment • Real estate • Materials • Human resources • Office facilities • Corporate data • Budget

Asset Management Framework



LIFE-CYCLE COST ANALYSIS FOR ASSET MANAGEMENT

Objective: To determine the alternative which will provide the desired service at the least cost.

Controversy: The procedure of measuring costs is not a system of precise calculations, it is subject to a certain amount of question.

Life-cycle cost of a system is the summation of all expenditures and incomes occurring over the lifetime or analysis period of the system.

LCCA is a quantitative analytical tool to compare different strategies and identify the lowest life-cycle cost strategy that will achieve the goals best.

Main issues in LCCA:

- Defining length of “life cycle” (i.e. length of **analysis period**)
- Time value of money
- Choice of discount rate

<u>Length of “Life Cycle”</u> (i.e. Analysis Period)

- “Life cycle” is the analysis period which is the selected length of time period over which the various systems/ schemes are evaluated.
- Depends on

  -- time horizon of investor (e.g. operator’s contract)
  -- expected life of project (e.g. lease of land)
  -- service life of systems/schemes

Options for defining “Analysis Period”

- The least common multiple of the service-life periods of all the strategies/sub-systems
- The longest of the service-life periods of the strategies/ sub-systems
- Some other time period
  (e.g. investor’s contract, lease of land)

Note:

(a) Analysis period should be selected sufficiently long to reflect significant differences in performance among the different strategies.

(b) Any shorter would not fully capture the anticipated differences in performance of different strategies.

Element of System Costs

Agency Costs

- Initial capital cost of construction
- Maintenance costs – all costs that are essential to maintain the pavement at a desirable level of service
- Future capital costs of rehabilitation or reconstruction
- Salvage cost – residual value of system at the end of its design/service period (may be negative)
- Engineering and administration costs

Element of System Costs *(cont'd)*

User Costs -- related to the serviceability and deterioration history of the system

- Vehicle operating cost – fuel consumption, tyre wear, vehicle maintenance, oil consumption, parts replacement and vehicle depreciation
- Traffic delay cost – maintenance and rehabilitation operations disrupt traffic flow and cause delay, inconvenience
- Travel time cost – related to conditions of road
- Accident cost – safety cost
- Discomfort cost

Non-User Costs

Air pollution, noise, social economic impacts, environmental impacts, political implications.

Difficult to quantify, but some of these factors may turn out to be the most important criteria in the final decision making.

Life-Cycle Cost Computation

Time Value of Money

- The fact that the value of money changes with time makes life-cycle cost analysis somewhat complicated.
- Methods for comparing costs by different systems/ schemes:
  - Present Worth
  - Equivalent Uniform Annual Cost
  - Future Worth
  - Benefit/Cost Ratio
  - Payback Period
- The **Present Worth method** is commonly adopted. A "**discount rate**" is used to reduce future expected costs to present-day worth to provide a basis for comparing alternative uses of funds.

Life-Cycle Cost Computation *(cont'd)*

Choice of Discount Rate

- Discount rate refers to the rate of change of true value of money over time, considering fluctuations in both investment interest rates and the rate of inflation.
- It provides a means to compare alternative uses of funds, but it should not be confused with interest rates which are associated with borrowing money.
- Discount rate represents the opportunity cost of money. It is approximately equal to the interest rate *minus* the inflation rate.
- Discount rates in life cycle cost analysis of transportation infrastructure projects usually vary from 4 to 12%. Different discount rates may produce different results LCCA.
- Economics textbooks and engineering studies suggest that it is justifiable to use a constant discount rate for economic analysis of investments of a given constant risk.

Life-Cycle Cost Computation *(cont'd)*

Present Worth of Single Payment

How much is a future sum F, invested n years from now, worth if invested today at a discount rate i ?

Present worth

$$\mathbf{P} = \mathbf{F}\left(\frac{\mathbf{1}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}\right)$$

<u>*Example:*</u> *What is P of a sum of $200,000, invested 10 years from now, with a discount rate of 5%?*

$P = 200{,}000\ [1/(1+0.05)^{10}] = 122{,}783$

Life-Cycle Cost Computation *(cont'd)*

Present Worth of a Series of Equal Payment

How much is a series of equal payment , invested at the end of each year for n years at a discount rate i, worth today ?

Present worth

$$\mathbf{P = A\left(\frac{(1+i)^n - 1}{i\,(1+i)^n}\right)}$$

<u>Example:</u> *What is P of a series of payments of $3000, invested each year for a period of 10 years at a discount rate of 5% ?*

$$P = 3000\ [(1+0.05)^{10} - 1]\ /\ [0.05(1+0.05)^{10}]\ = 23{,}165$$

Life-Cycle Cost Computation *(cont'd)*

<u>**Salvage Value**</u> (Residual / Resale Values, or Disposal Costs)

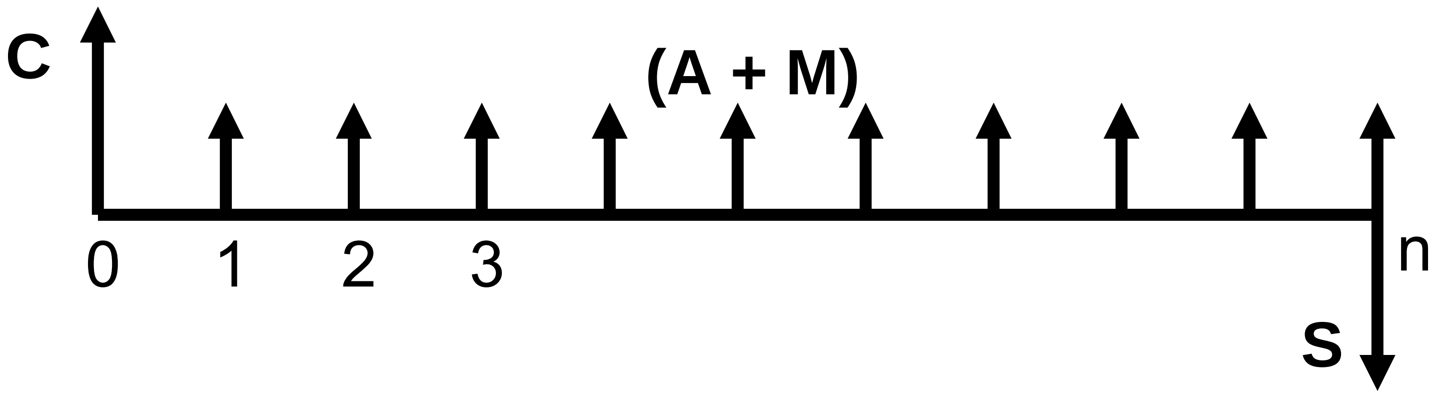
- Represents the value of an investment at the end of the analysis period. It accounts for the ***<u>economic depreciation</u>*** and ***<u>physical deterioration</u>*** of the system analyzed.
- It is the residual value of a system (or component) at the end of the analysis period, or at the time it is replaced during the analysis period.
- It can be based on value in place, resale value, or scrap value, net of any selling, conversion, less disposal costs.
- Usual method: Considering the system's remaining useful life, calculate by linearly prorating between its initial cost and end-of-service-life value.

<u>Example</u> *A system costing $100,000 has a service life of 20 years and an end-of-service life value of $20,000. What is the salvage value at the end of 15 years?*

Salvage value = $20,000 + ($100,000 - $20,000) x (20 – 15)/20 = $ 40,000

Life-Cycle Cost Computation *(cont'd)*

Present worth life-cycle cost of a system for an analysis period of n years :



$$P = C + (A+M)\left(\frac{(1+i)^n - 1}{i\,(1+i)^n}\right) - S\left(\frac{1}{(1+i)^n}\right)$$

where C = initial investment cost
A = annual overhead expenditures
M = annual operation and maintenance cost
S = salvage value at the end of n years

Practical Realities

- Institutional considerations, social objectives, and political goals tend to dominate the resource allocation and project selection process.
- Budgets of a highway agency generally cover time horizons of 1 to 2 years. Committing available funds over the long term is difficult.
- Short budget cycle, combined with uncertain future funding levels, creates pressure to select project with the lowest initial cost, regardless of total life-cycle cost and return of investment. i.e. A cost-effective solution may not be the most politically practical solution.

References

- Chapter 17 “Asset Management” in The Handbook of Highway Engineering, edited by T. F. Fwa. (2006)
- Fwa T. F. and Sinha K. C. (1991) Pavement Performance and Life-Cycle Cost Analysis. Journal of Transportation Engineering, Vol. 117, No. 1 pp. 33-46.
- AUSTROADS (1997) Strategy for Improving Asset Management Practices, AP-53/97.
- FHWA (1996) Asset Management: Advancing the State of the Art into the 21st Century Through Public-Private Dialogue.
- New York State DOT (1998) Blueprint for Developing and Implementing an Asset Management System
- OECD (1999) Asset Management system, Project Description.