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Life-Cycle Cost Analysis

Using Life-Cycle Cost Analysis for Optimizing Pavement Selection



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Life-Cycle Cost Analysis

Overview

- Transportation Asset Management
 - Definition
 - FHWA Office of Asset Management
- Life-Cycle Cost Analysis
 - Definition
 - Process
 - LCCA in Pavement Type Selection
 - Resources



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Definition of Asset Management

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.

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FHWA Office of Asset Management

Mission

- “provide leadership and expertise in the systematic management of highway infrastructure assets.”
- “serves as an advocate for asset management, system preservation, pavement management and analysis, bridge management and inspection, and construction and maintenance activities, as well as technology development, outreach, and partnering initiatives.”

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Three Teams

- **Construction and System Preservation**
responsible for construction and maintenance program policy, technical support, and national outreach. Specific areas of responsibility include quality management initiatives, transportation system preservation, and continuous quality improvement initiatives such as system preservation.



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- **The System Management and Monitoring Team:** responsible for developing and promoting systematic approaches to the management of highway assets. This work includes refining and advancing the use of pavement and bridge management systems and developing systems where they presently do not exist, such as for tunnels and roadway hardware. The team is made up of a Pavement Management Group and a Bridge Management Group.

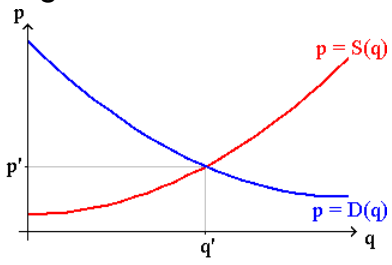
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FHWA Office of Asset Management

- **Evaluation and Economic Investment Team**
 - development and promotion of an array of procedures for inclusion in an engineering economic analysis toolbox, identification and dissemination of alternatives for developing data systems to support asset management, and providing assistance with implementation of relevant standards issued by the Governmental Accounting Standards Board (GASB).



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Life-Cycle Cost Analysis Definition

- Life-Cycle Cost Analysis is a **process** for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment.

Source: Transportation Equity Act for the 21st Century

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When to Apply LCCA

- Compares only costs(differential)
- Requires equal benefits
- Project-level analysis
- Comparing Designs or materials for a bridge, pavement, roadway marking, etc.
- Comparing rehabilitation strategies
- Comparing work zone effects


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Before the LCCA Process Begins...

- Policy Decisions in place
- Project performance requirements have been established
- Decision has been made to build the project
- Scope of project warrants the rigors of LCCA
- Basic roadway parameters have been established




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The LCCA Process

1. Establish Design Alternatives
2. Determine Activity Timing
3. Estimate Agency and User Costs
4. Compute Life-Cycle Costs
5. Analyze the Results



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LCCA Process Step 1

Step 1: Establish Design Alternatives

- Activities to Ensure Performance
- Initial construction or rehabilitation activity
- Future rehabilitation and maintenance activities
- Analysis period long enough to demonstrate differences between alternatives




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Step 1: Establish Design Alternatives

Example Design Alternatives to Consider



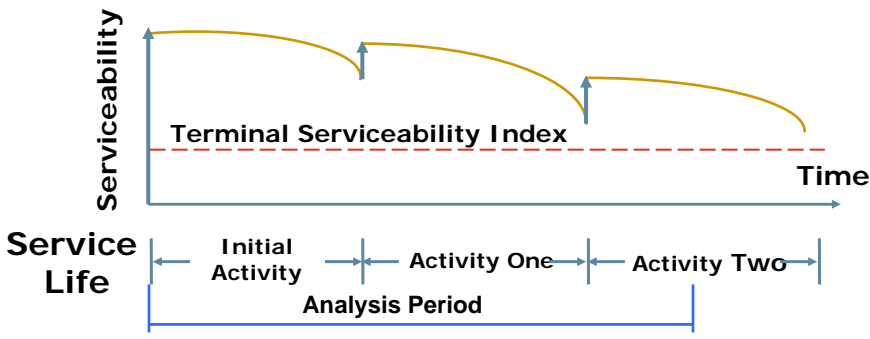
- Portland cement concrete pavement vs. Hot mix asphalt
- Mill and fill vs. overlay
- Preservation vs. major rehabilitation

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Step 2: Determine Activity Timing



Serviceability

Terminal Serviceability Index

Time

Service Life

Initial Activity

Activity One

Activity Two

Analysis Period

When will the future maintenance and rehabilitation costs be incurred?

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Step 3: Estimate Agency and User Costs

Include cost elements that are different between alternatives

Exclude cost elements that are the same between alternatives

- Agency overhead costs
- Normal operations user costs
- Agency and user costs associated with routine maintenance


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User Cost Components

- Three components
 - Vehicle Operating Costs (VOC)
 - Delay Costs
 - **Crash Costs**



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User Costs

- **Vehicle Operating Costs (VOC)**
additional costs incurred by the vehicle for the additional speed changes, stops, miles for detours, hours of idling, etc. caused by work zone activities
- **Delay Costs**
– Value(\$) of time for each vehicle classification used in the LCCA

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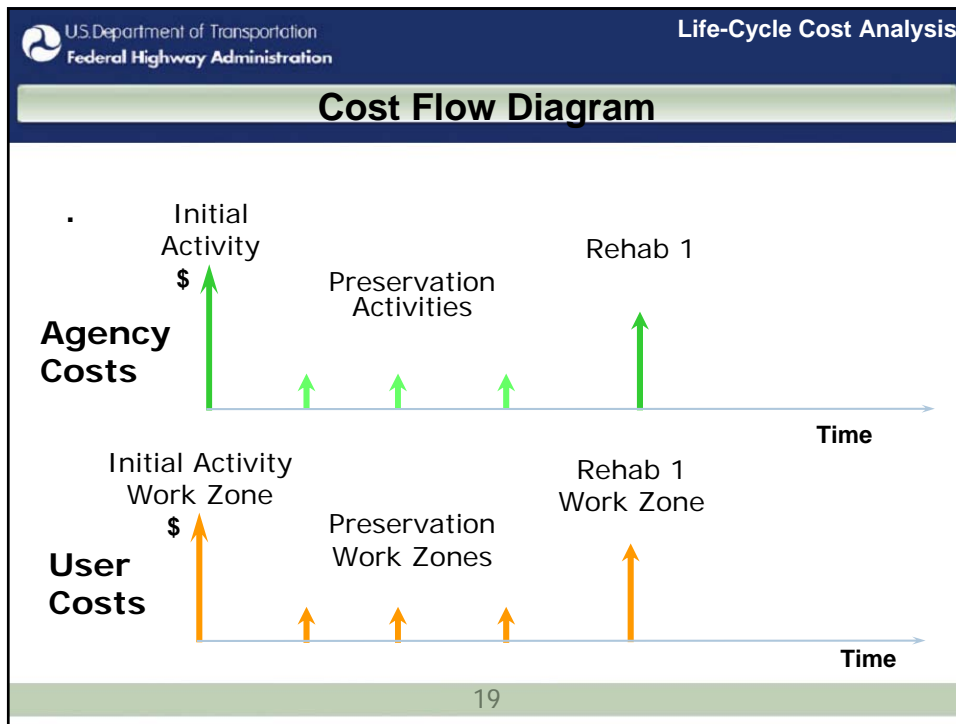
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User Costs

- User costs are
 - ...based on capacity flow analysis.
 - ...a function of workzone impacts for the M&R strategy for maintaining the alternate designs.
 - ...are directly dependent on the volume and operating characteristics of the traffic on the facility.

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Step 4: Calculate PV of Life-Cycle Costs

Present Value of Costs =
$$\sum_{k=0}^N \left[(\text{Cost}_k) \times \underbrace{\left[\frac{1}{(1+d)^{n_k}} \right]}_{\text{Present Value Factor}} \right]$$

N = length of analysis period
 d = discount rate
 n_k = year of expenditure

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LCCA Output

Present Value Examples

Activity	Year	Cost	PV Factor	PV
Initial Construction	0	\$11M	1.0	\$11M
Activity 1	8	\$5M	0.73	\$3.7M
Activity 2	16	\$5M	0.53	\$2.7M
Rehab	24	\$8M	0.39	\$3.1M
Using a 4% discount rate	Sum of Present Values			\$20.5M



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Step 5: Analyze the Results

- How do agency costs compare?
- How do user costs compare?
- Can trade-offs be made?


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Components and Issues

- Design Life vs. Performance Period
- Analysis period
- Remaining service life
- Discounting and inflation
- Uncertainty (Risk)
- User Costs



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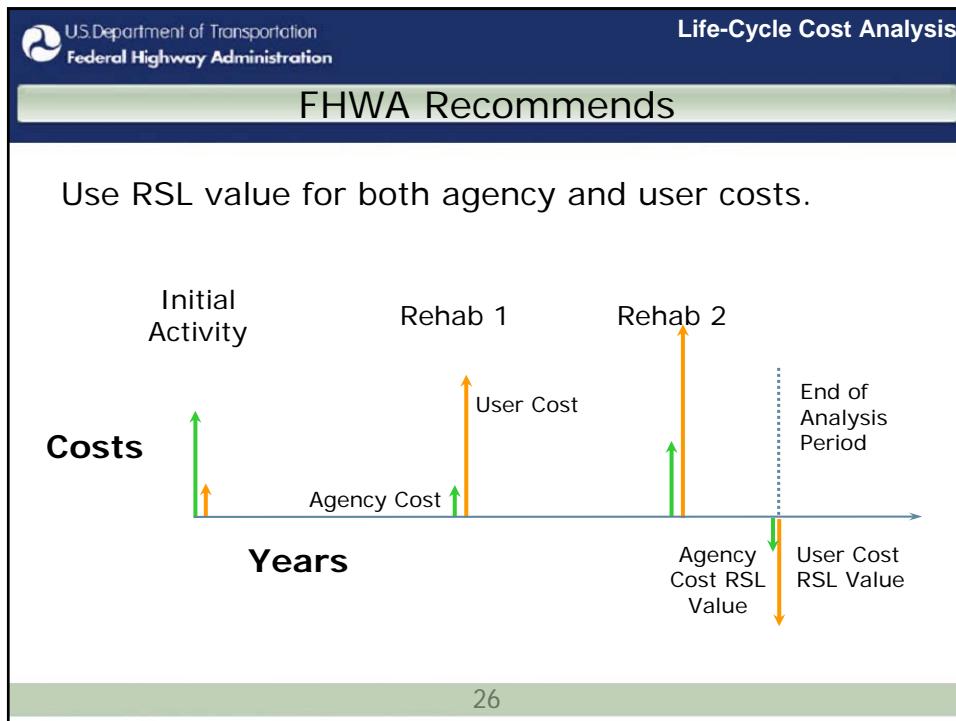
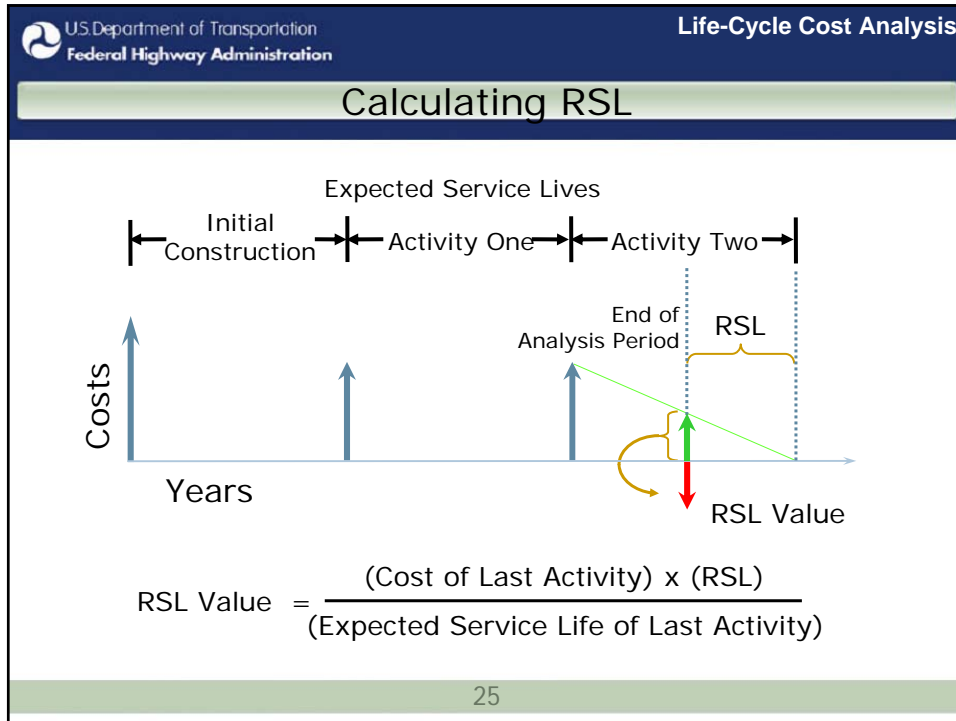
Remaining Service Life Value

The value of the service remaining at the end of the analysis period

- Computed as the prorated value of the last rehab
- Assumes roadway remains in service beyond the analysis period
- Accounts for the differences of expected performance of the alternate strategies
- Used to remove economic bias between alternatives



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Uncertainty

Inability to know the exact outcome of future events (traffic, Costs, etc)

- Variability in inputs creates uncertainty in outputs

Two Ways to Account for risk:

- Sensitivity analysis in the deterministic approach
- Simulation in the probabilistic approach



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Deterministic Example

Activity	Year	Cost	PV Factor	PV
Initial Construction	0	\$11M	1.0	\$11M
Activities 1	8	\$5M	0.73	\$3.7M
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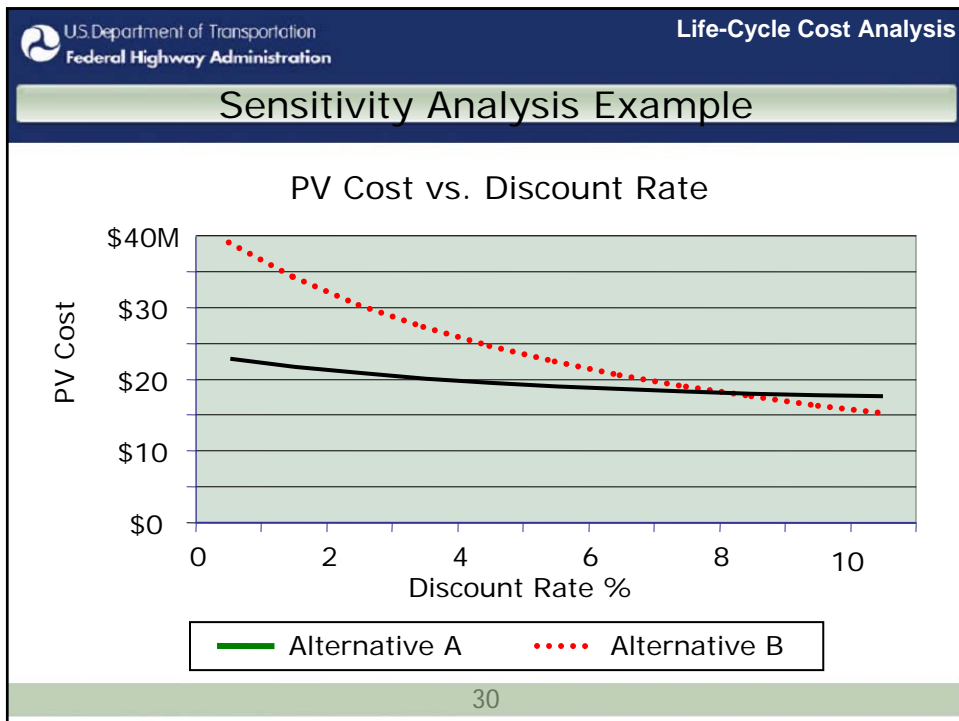
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Sensitivity Analysis

1. Vary ONE key input (such as costs, timing, or discount rate), while holding all others constant
2. Compute best, worst, and most-likely case scenarios
3. Determine how sensitive the output is to the selected input



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Probabilistic Approach

Inputs are defined by their range of values and likelihoods of occurrence (probability distribution)
Through simulation, outputs are expressed as ranges of values with probabilities of occurrence



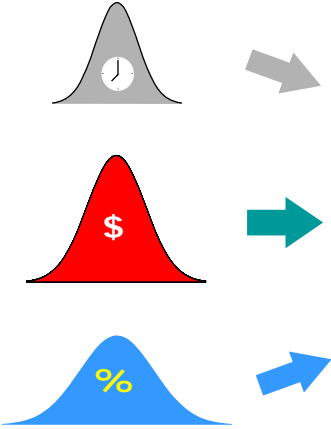
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Simulation Modeling

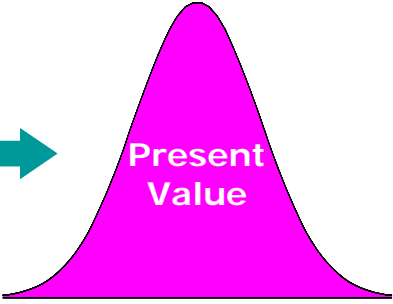
Inputs



MODEL



Outputs



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FHWA LCCA Software

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LCCA Resources

LCCA Case Study

LCCA Primer

LCCA Software

LCCA Technical Bulletin

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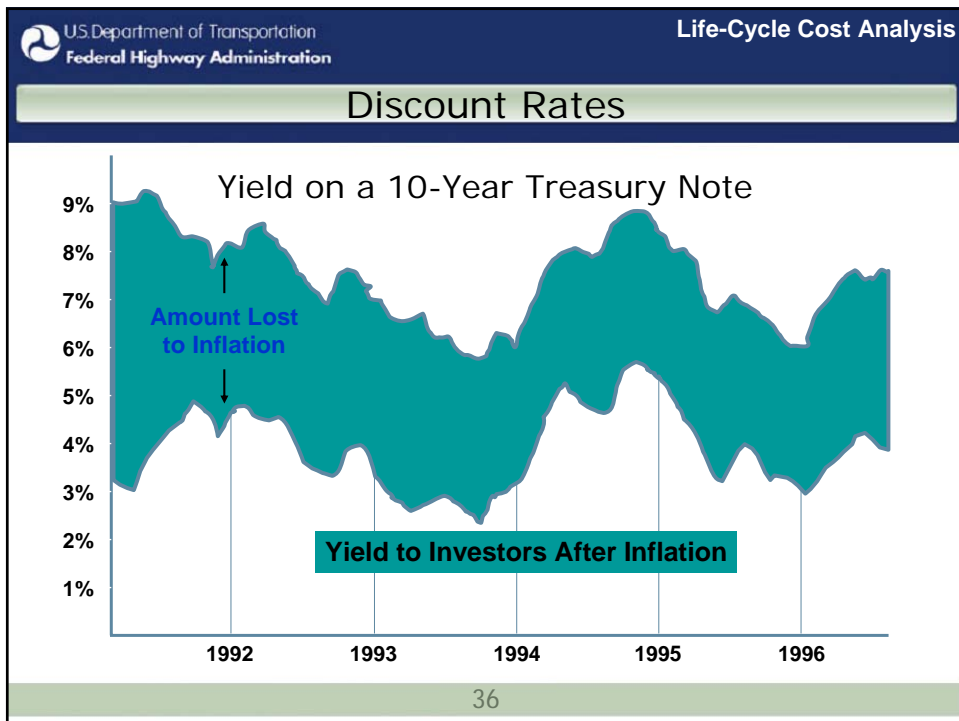
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Photo courtesy of Concrete Industries, Inc.

<http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.htm>

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