An Introduction to Life-Cycle Cost Analysis for Pavements: Part I—Fundamentals

SUSTAINABLE PAVEMENTS PROGRAM

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Federal Highway Administration

What Can I Learn from This Presentation?

- What is life-cycle cost analysis (LCCA) and how can it help highway agencies?
- What are the steps in the pavement LCCA process?
- What are some tools available to conduct LCCA?
- Where can I find more information on LCCA?

FHWA SUSTAINABLE PAVEMENTS PROGRAM

Program and Products

Vision and Mission

- To advance the knowledge and practice of designing, constructing, and maintaining more sustainable pavement through:
  - Stakeholder engagement
  - Education
  - Development of guidance and tools

WHAT IS LIFE-CYCLE COST ANALYSIS (LCCA)?

What Is LCCA?

- Analytical tool to provide cost comparisons between two or more competing alternatives on a project
- Alternatives are assumed to produce equivalent benefits
- For pavements, LCCA considers
  - Direct agency costs
  - User costs

What Are the Benefits of Conducting LCCA?

- Reduced pavement life-cycle costs and impact to users

- Reduced energy
- Reduced noise
- Improved air quality

- Improved safety
- Improved ride
- Conservation of resources

Primary LCCA Benefit

LCCA can be used with Life Cycle Assessment (LCA) and Sustainability Rating Systems to improve environmental and social performance

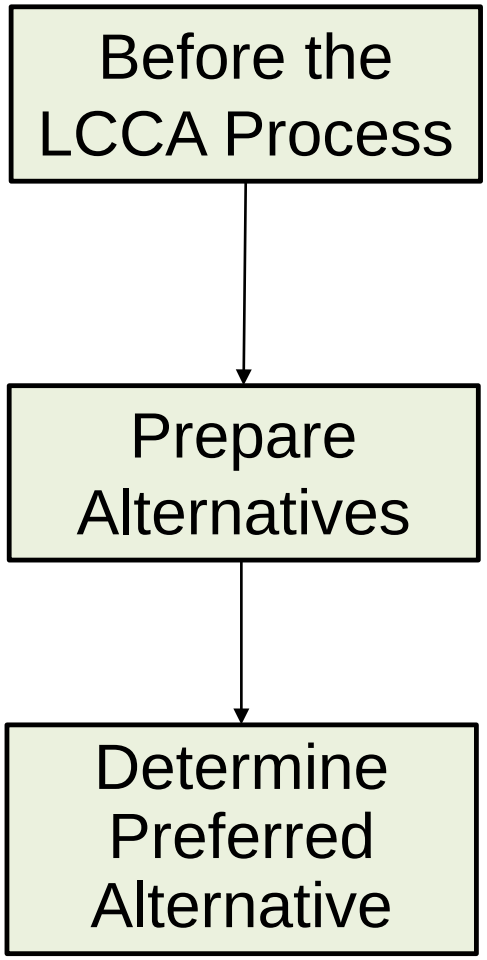
How Can LCCA Help Highway Agencies?

- Comparing materials for pavements
- Comparing maintenance, preservation, and rehabilitation strategies
- Comparing construction work zone effects
- Comparing alternative bids

- LCCA helps identify opportunities to reduce agency and user costs throughout the pavement life cycle
- LCCA helps inform and guide decision-making for policy, planning, or design

WHAT ARE THE STEPS IN THE PAVEMENT LCCA PROCESS?

Structured Approach to Pavement LCCA



- Step 0: Get Organized
  - Establish LCCA framework and when to apply
  - Establish project scope

- Step 1: Establish alternatives
- Step 2: Determine activity timing
- Step 3: Estimate costs

Step 4: Compute life-cycle costs

- Step 5: Analyze results

Step 0: Establish LCCA Framework

- Select analysis period
  - Same for all alternatives being considered
  - Long enough to include at least one major rehabilitation activity
  - Not to be confused with design life
- Determine how inflation will be addressed
- Establish discount rate to be used
- Establish economic analysis indicator
  - Net Present Value (NPV)
  - Equivalent Uniform Annual Cost (EUAC)

Discount Rate

- Time value of money, accounting for:
  - Interest Rate, or cost of borrowing or value of investing money
  - Inflation Rate, or the change in price levels over time

$$\text{Discount Rate} = \text{Real Interest Rate} = \frac{\text{Nominal Interest Rate} - \text{Inflation}}{1 + \text{Inflation}}$$

- Allows users to input constant (today's) dollars in the analysis

Discount Rate: Selection

- Use a “real” (inflation-adjusted) discount rate reflective of long-term historical trends
- Use long-term Real Interest Rates, are based on Treasury Bill yields and forecast inflation
- Selected as part of LCCA policy framework

Circular A-94
Appendix C
Rev. Nov. 2017

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)					
3-Yr	**5-Yr**	**7-Yr**	**10-Yr**	**20-Yr**	**30-Yr**
-0.8	-0.6	-0.3	-0.1	0.2	0.6

Step 0: Determine Project Scope

- Roadway geometry
- Traffic data
- Agency and user cost data
- Pavement treatment service life data
- Design alternatives under consideration
  - Examples:
    - Flexible vs. Rigid
    - Reconstruction vs. Rehabilitation

LCAA Inputs

- Analysis period
- Roadway geometry
- Timing, performance, and cost of each activity
- Discount rate
- Traffic data
- Construction work zone inputs
- User cost inputs

Step 1: Establish Design Alternatives

- Identify range of possible alternatives
- Consider at least two alternatives that satisfy the performance objective being sought

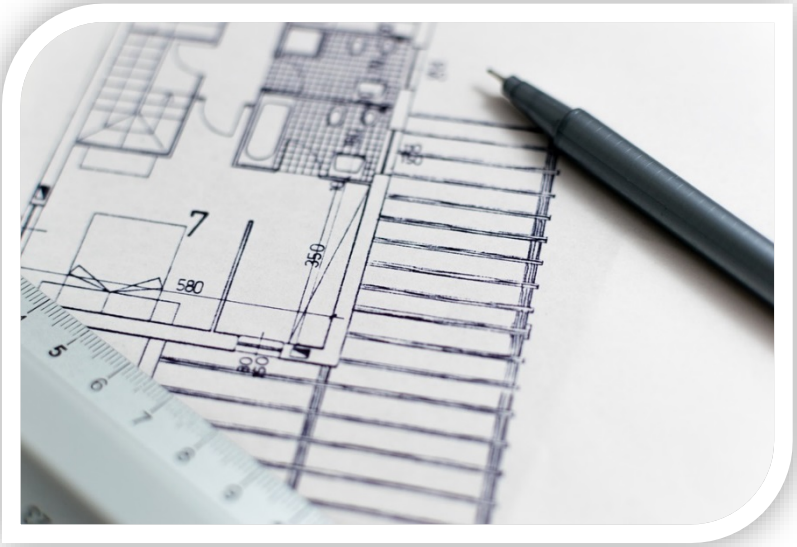


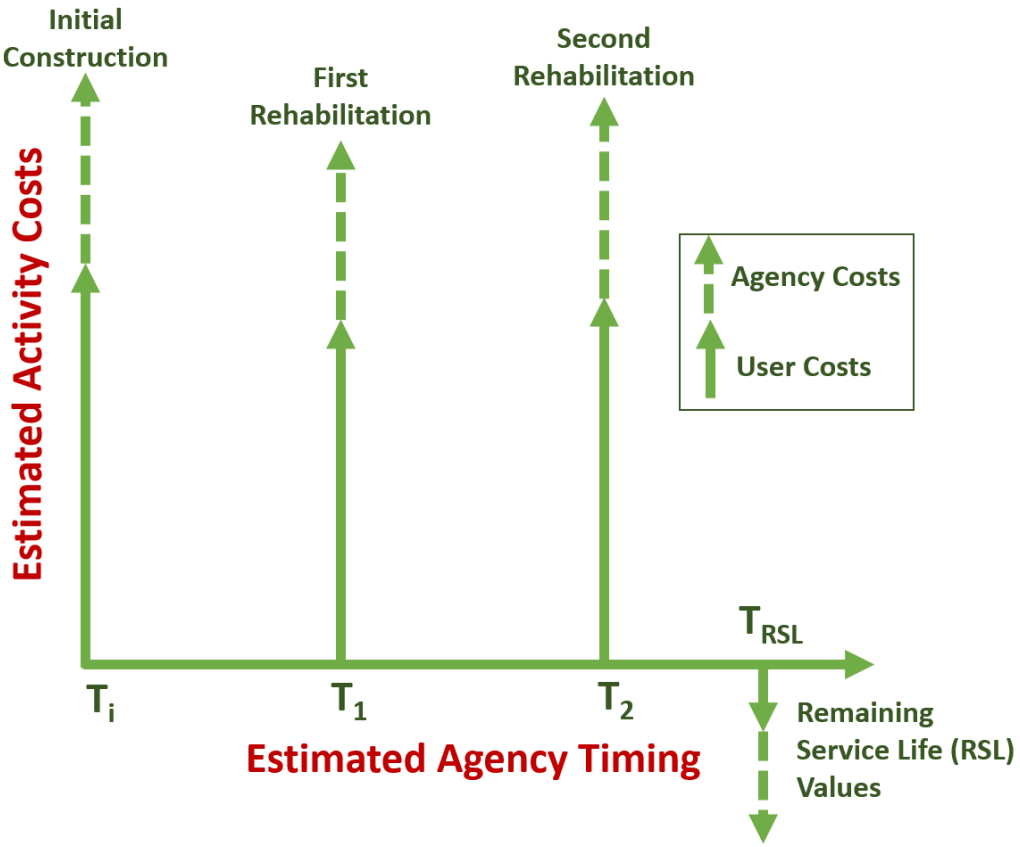
Image Source: Pixabay

Step 2: Determine Activity Timing

- Define schedule of initial and future activities (e.g., maintenance, rehabilitation)
  - Year of occurrence
  - Performance life
- Consider data from pavement management systems (PMS) for:
  - Activity timings
  - Treatment service lives

Step 3: Estimate Costs

- Estimate agency and work zone user costs for each activity over the selected analysis period

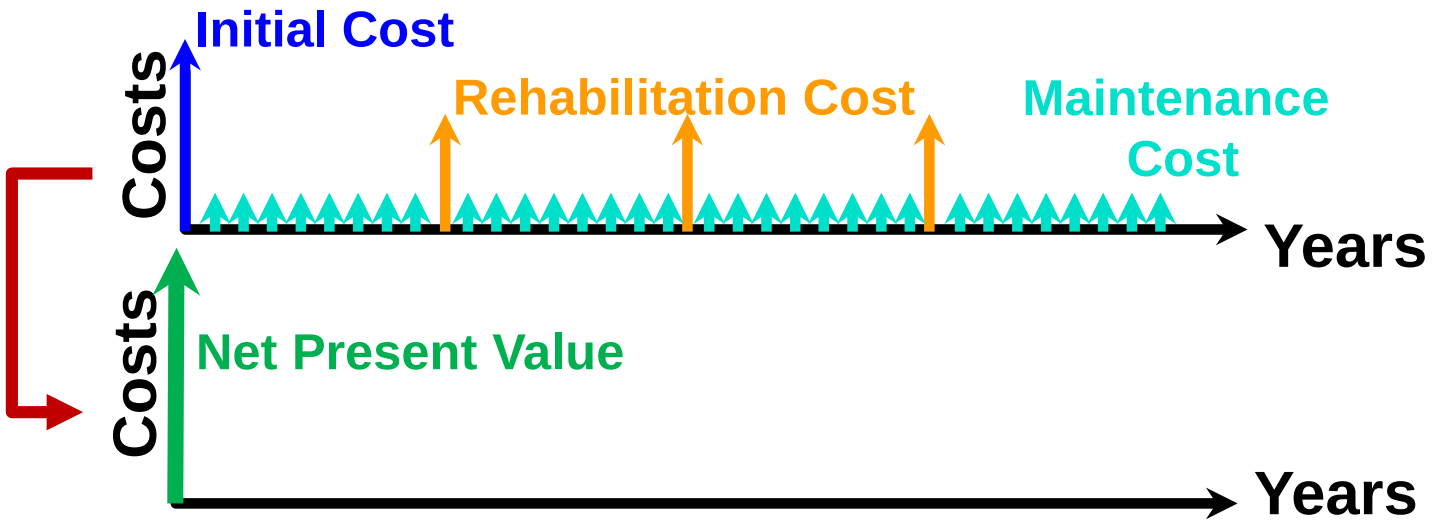


Work Zone User Costs

- Costs borne by road users due to presence of construction work zones
- Can be important in decision-making process
- Monetized in terms of:
  - Vehicle operating costs
  - Delay costs
  - Crash costs (not typically considered)
- Typically analyzed separately from agency costs

Step 4: Compute Life-Cycle Costs

- Calculate total agency & user life-cycle costs
  - Convert cost to present dollars through "discounting"
  - Sum all discounted costs to produce a net present value (NPV)

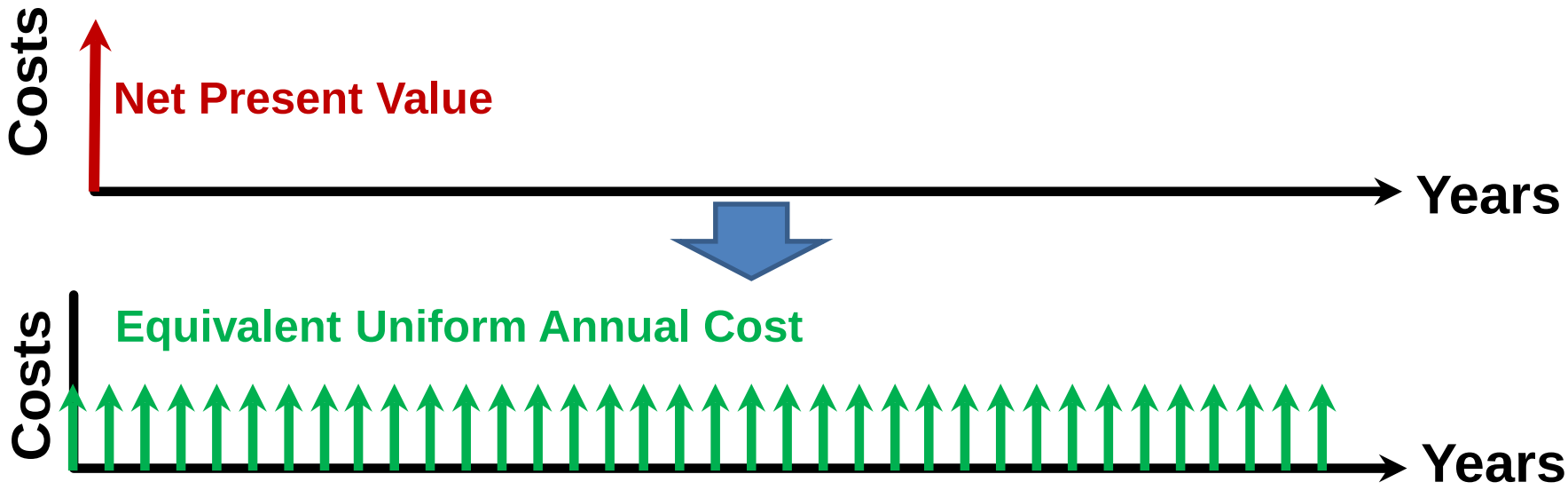


What if Design Lives Differ?

- Option 1: Increase analysis period to the longest design life alternative
  - Add additional rehab or reconstruction to the shorter design life alternative
  - Include remaining value at the end of analysis period
    - Removes economic bias between alternatives

What if Design Lives Differ?

- Option 2: Compute equivalent uniform annual cost (EUAC) for each alternative
  - Implies that strategies are repeated at end of analysis period
  - Note: This approach may favor short-term fixes



Step 5: Analyze Results

- Compare alternatives using common metric such as NPV or EUAC
  - How do agency and user costs compare?
  - What trade-offs should be considered?
  - Can work zone strategies be changed to reduce user costs?
- Determine most influential parameters affecting outcomes (i.e., what drives the results)?
  - Sensitivity analysis
  - Probabilistic LCCA

LCCA Caveats

Garbage In = Garbage Out

Image Source: Pixabay

- Accuracy and usefulness are limited by quality of inputs
- Most important factors:
  - Reasonable estimates of activity timing
  - Reasonable estimates of activity costs
- There are many additional considerations

WHAT ARE SOME TOOLS AVAILABLE TO CONDUCT LCCA?

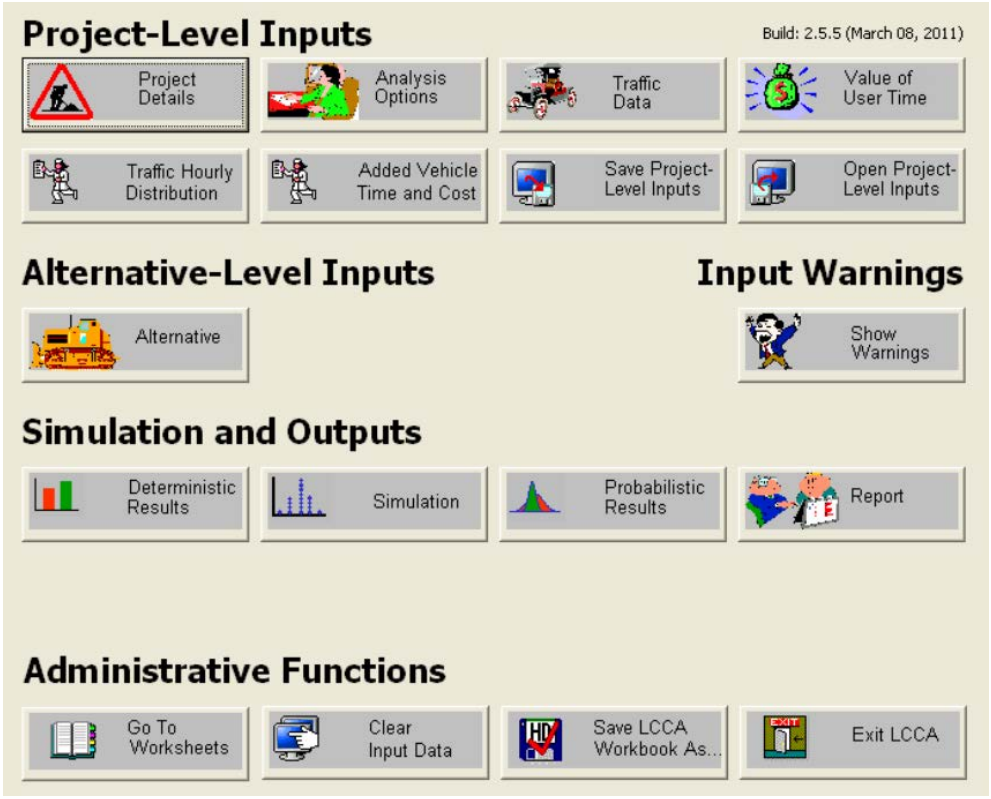
Basic LCCA Tools

- Many simple LCCA tools are available
  - Spreadsheets
  - Hand calculations
- Many SHAs have developed their own LCCA software (usually deterministic)
- FHWA's *RealCost* software

Image Source: Pixabay

FHWA *RealCost* Software

- Widely accepted and adopted LCCA tool for pavements (in the U.S.)



https://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.cfm

FHWA *RealCost* Software: Capabilities

- LCCA using both deterministic and probabilistic approaches
- Computes LCC for agency and work zone user costs for new construction, M&R
- Comprehensive economic analysis tool to aid in decision-making processes

WHERE CAN I FIND MORE INFORMATION ON LCCA?

Available Resources and Tools

- FHWA LCCA Technical Bulletin
- FHWA RealCost Tool
- FHWA LCCA Primer
- FHWA LCCA Factsheet
- FHWA LCCA Webpage

SUMMARY

Key Takeaways

- Economic impact is an important component of pavement sustainability
- LCCA is a well-established process for assessing and comparing the monetarily quantifiable aspects of competing pavement design and rehab alternatives
- LCCA should be used with appropriate inputs
- *RealCost* is a pavement LCCA tool available.

Example Products

- Guide Documents:
  - *Towards Sustainable Pavement Systems*
  - *Pavement Life Cycle Assessment Framework*
- Tech Briefs on:
  - *Pavement Sustainability*
  - *Life Cycle Assessment*
  - *Improving Resiliency of Pavement Systems*
  - *Strategies for Improving Sustainability of Asphalt/Concrete Pavements*
- Webinar series on pavement sustainability
- *Sustainable Pavements Program Road Map*

To Learn More:

	WEBINAR EVENT	WHAT WILL YOU LEARN?	DATE & TIME
1	Pavement Sustainability Basics	Sustainability concepts and assessment tools	October 17, 2019 2:30–3:30 PM ET
2	Sustainable Pavement Materials	Sustainability implications of aggregate, asphalt, and concrete pavement materials	November 21, 2019 2:30–3:30 PM ET
3	Sustainable Design Approaches	Design considerations related to sustainability, general and specific design strategies, emerging trends	December 19, 2019 2:30–3:30 PM ET
4	Sustainable Pavement Construction	Construction considerations to improve pavement sustainability, future directions, and emerging trends	January 30, 2020 2:30–3:30 PM ET
5	Maintenance and Preservation	Pavement preservation basics, impacts of preservation on sustainability, sustainable preservation techniques	February 13, 2020 2:30–3:30 PM ET
6	EOL Considerations	End-of-Life (EOL) considerations related to pavement sustainability, EOL options for asphalt and concrete pavements	March 19, 2020 2:30–3:30 PM ET
7	LCCA Part I: Fundamentals	Life-Cycle Cost Analysis (LCCA) concepts, steps in pavement LCCA process, tools to conduct LCCA	April 16, 2020 2:30–3:30 PM ET
8	LCCA Part II: Applications	Key considerations in pavement LCCA, example LCCA applications in sustainability-related applications	May 21, 2020 2:30–3:30 PM ET
9	LCA Part I: Fundamentals	Life-Cycle Assessment (LCA) concepts, benefits and uses; steps in the pavement LCA process; tools and resources on LCA	June 18, 2020 2:30–3:30 PM ET
10	LCA Part II: EPDs and PCRs	Fundamentals on Environmental Product Declarations (EPDs) and Product Category Rules (PCRs)	July 23, 2020 2:30–3:30 PM ET

For More Information

- FHWA Sustainable Pavements Website
  - www.fhwa.dot.gov/pavement/sustainability

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http://www.fhwa.dot.gov/pavement/sustainability

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