Life-Cycle Cost Analysis
What's Working?

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Topics

- Transportation Asset Management
  - Definition
  - FHWA Office of Asset Management
- Life-Cycle Cost Analysis
  - Definition
  - Process/LCCA Survey Results
    - 2007 AASHTO(Colorado)
    - 2007 AASHTO RAC(Mississippi)
    - 2006 South Carolina
  - Resources

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.

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."

FHWA Office of Asset Management

Three Teams

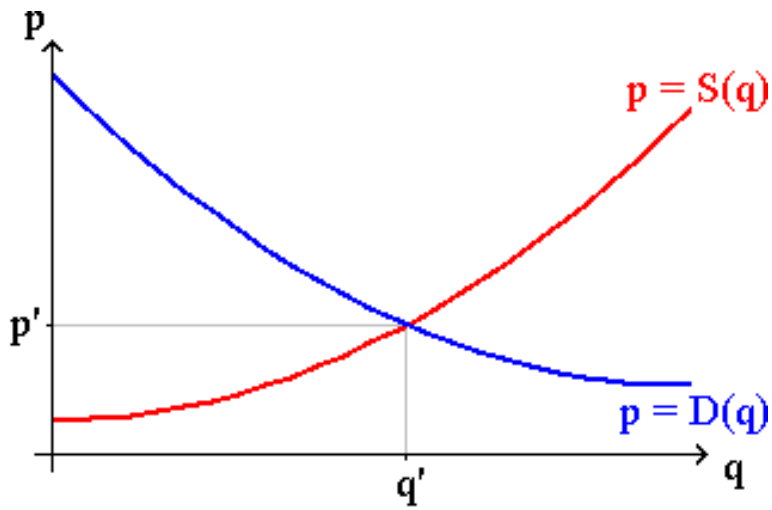
- **Construction and System Preservation** responsible for construction and maintenance program policy, technical support, and national outreach. Specific areas of responsibility include accelerated construction, transportation system preservation, and continuous quality improvement initiatives such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

FHWA Office of Asset Management

- **The System Management and Monitoring Team**: responsible for developing & 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.

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).



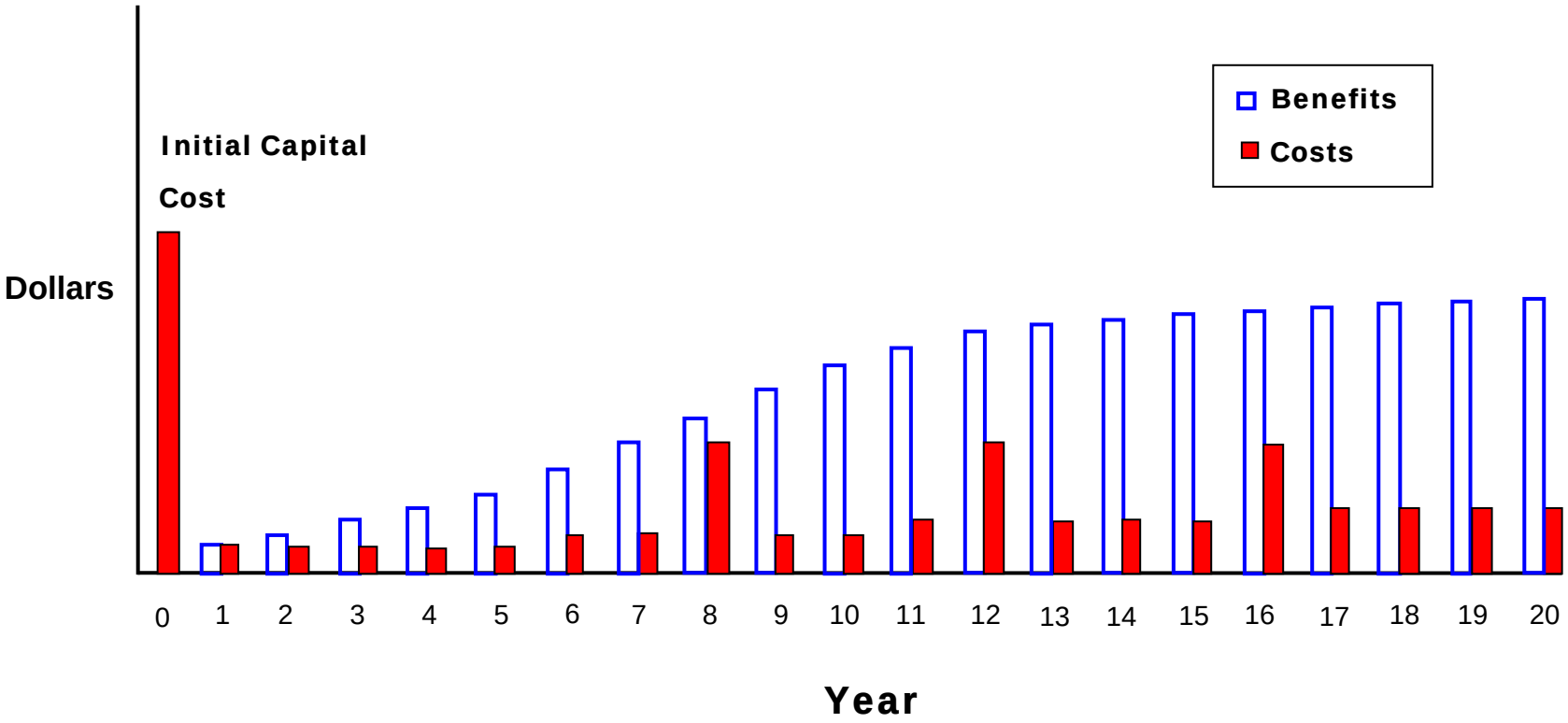
Life-Cycle Cost Analysis Definition

- 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

Life-Cycle Comparisons

Typical Life-Cycle Profile



Life-Cycle Cost Analysis in Regulations

- SAFETEA-LU
- Value Engineering *Code of Federal Regulations (CFR)*
  - The systematic application of recognized techniques by a multi-disciplined team to identify the function of a product or service, establish a worth for that function, generate alternatives through the use of creative thinking, and provide the needed functions to accomplish the original purpose of the project, reliably, and at **the lowest life-cycle cost** without sacrificing safety, necessary quality, and environmental attributes of the project.
  - OIG Report

Applying LCCA

- Compares costs(differential)
- Requires equal benefits
- Comparing designs/materials for a bridge, pavement, roadway markings, etc.

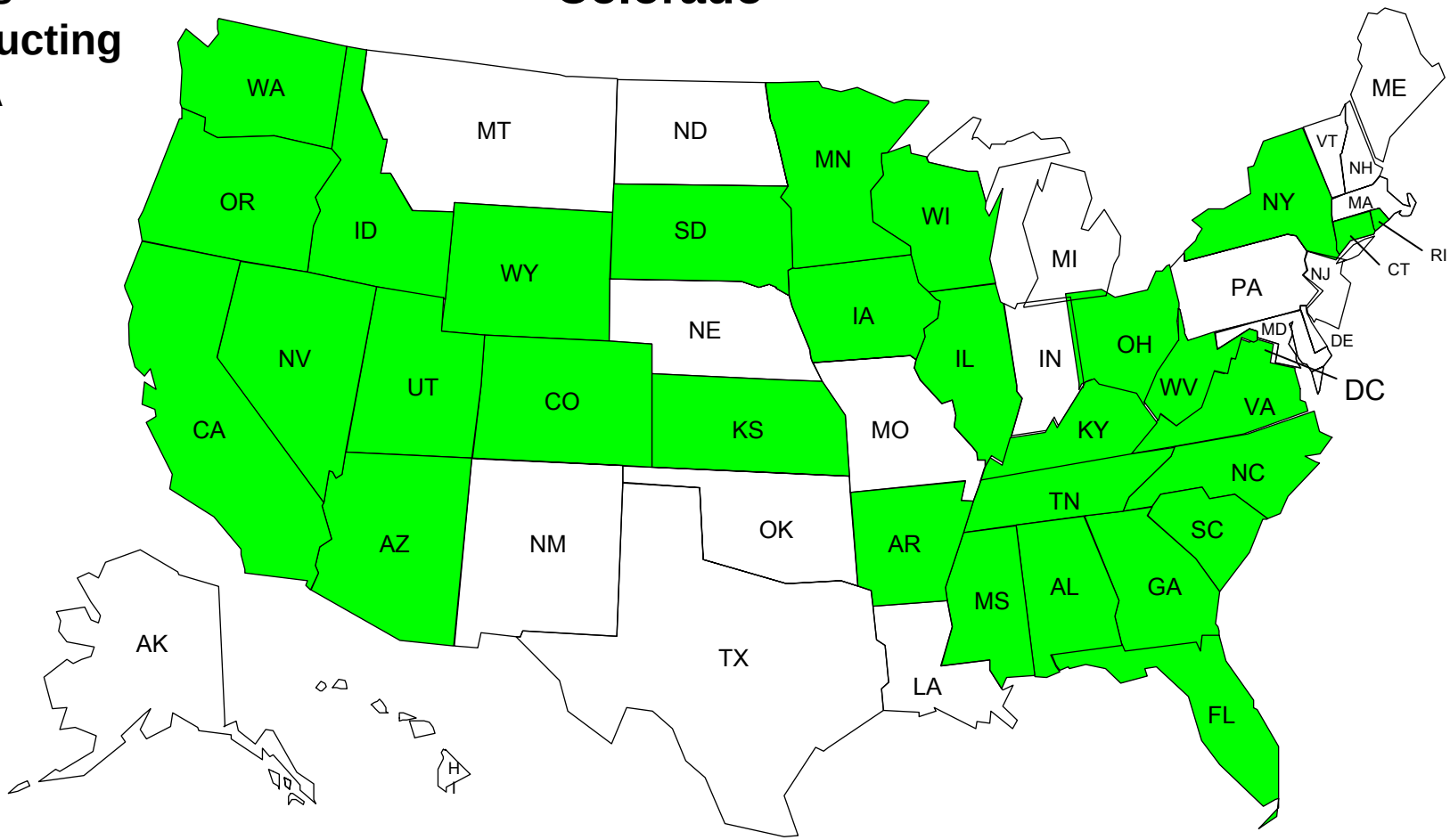
- Comparing management strategies
- Comparing work zone effects
- Occurs early in the project development process

The LCCA Process

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

2007 AASHTO Survey on Pavement Type Selection

States Conducting LCCA

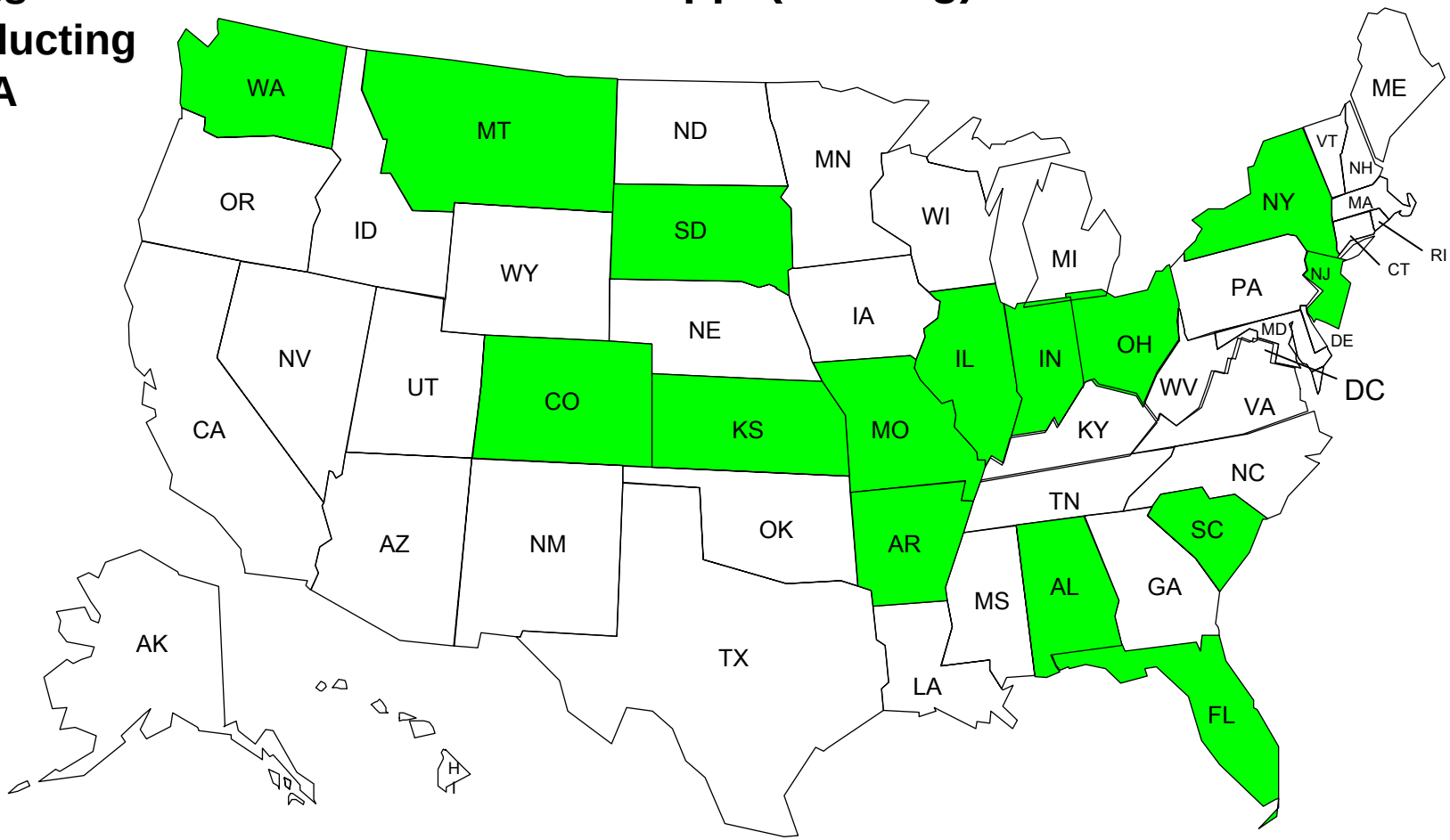


2007 AASHTO Survey on Pavement Type Selection

1. Does your agency currently utilize LCCA for determining pavement type?
2. How many years long is your analysis period?
3. What discount rate do you utilize?
4. Do you include user costs in your analysis and if so, please briefly explain how that cost is determined?
5. Flexible Alternative Maintenance Treatments Please list below the treatments you account for in your LCCA for HMA and at what year(s) during the analysis period do you assume they will occur
6. Rigid Alternative Maintenance Treatments Please list below the treatments you account for in your LCCA for PCC and at what year(s) during the analysis period do you assume they will occur
7. Does your agency utilize LCCA to develop alternate pavement type bidding procedures?

2007 AASHTO RAC Survey LCCA for Pavement Type Selection

States Conducting LCCA



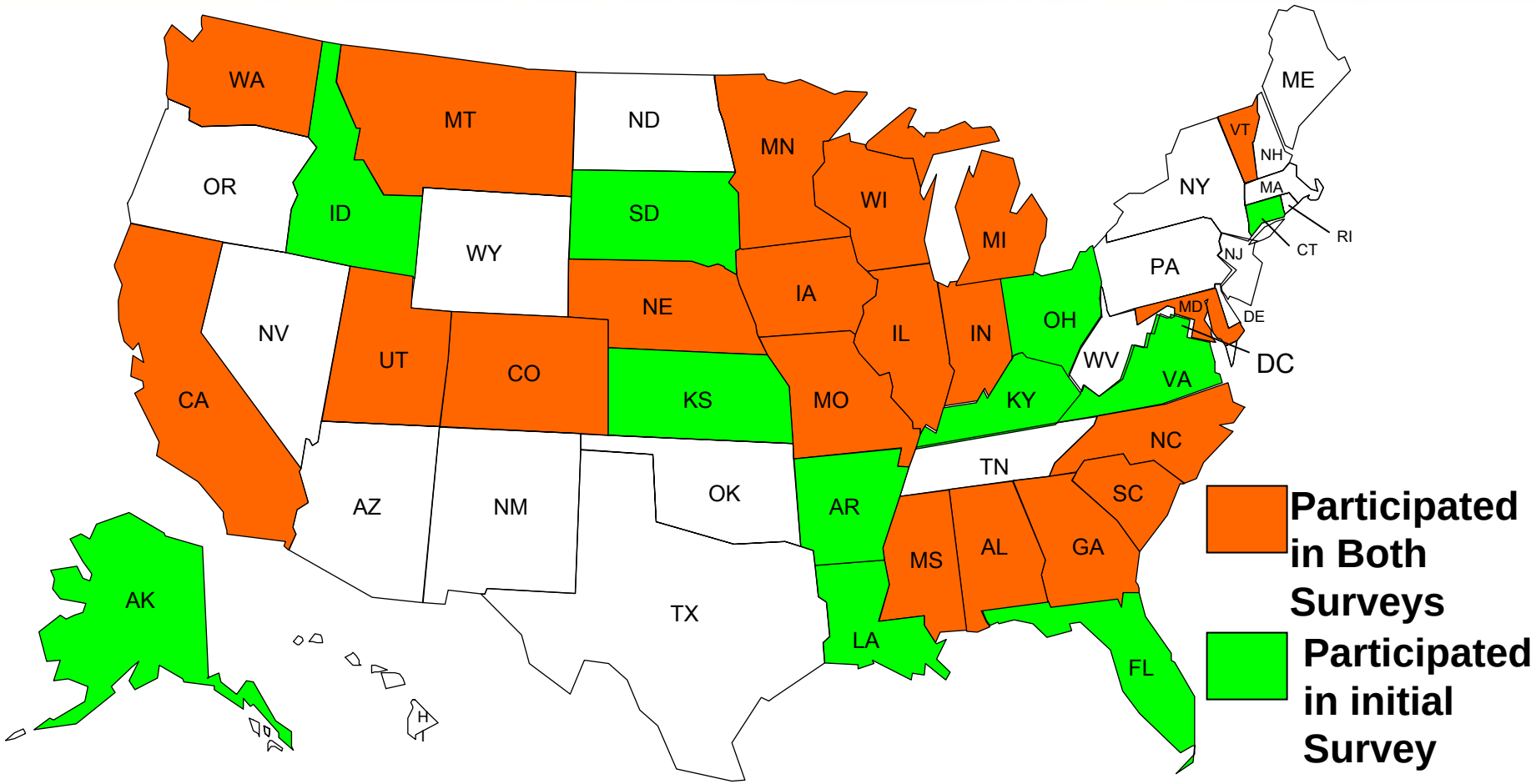
2007 AASHTO RAC Survey LCCA for Pavement Type Selection

1. What is the standard process(es) for selecting the pavement type?
2. What experimental methods have been used for selecting the pavement type that show promise?
3. What experimental methods have been used for selecting the pavement type that you are not planning to use again?
4. Several methods for selecting the pavement type are listed for your information.
   a) Owner makes the selection
   b) Owner makes the selection with the use of life cycle cost analysis
   c) Owner makes the selection with the use of life cycle cost analysis and a pavement type selection committee.
   d) Alternate bids are used with a life cycle cost adjustment factor.
   e) Some type of pavement warranty is included with the pavement type selection.

2006 South Carolina LCCA Survey

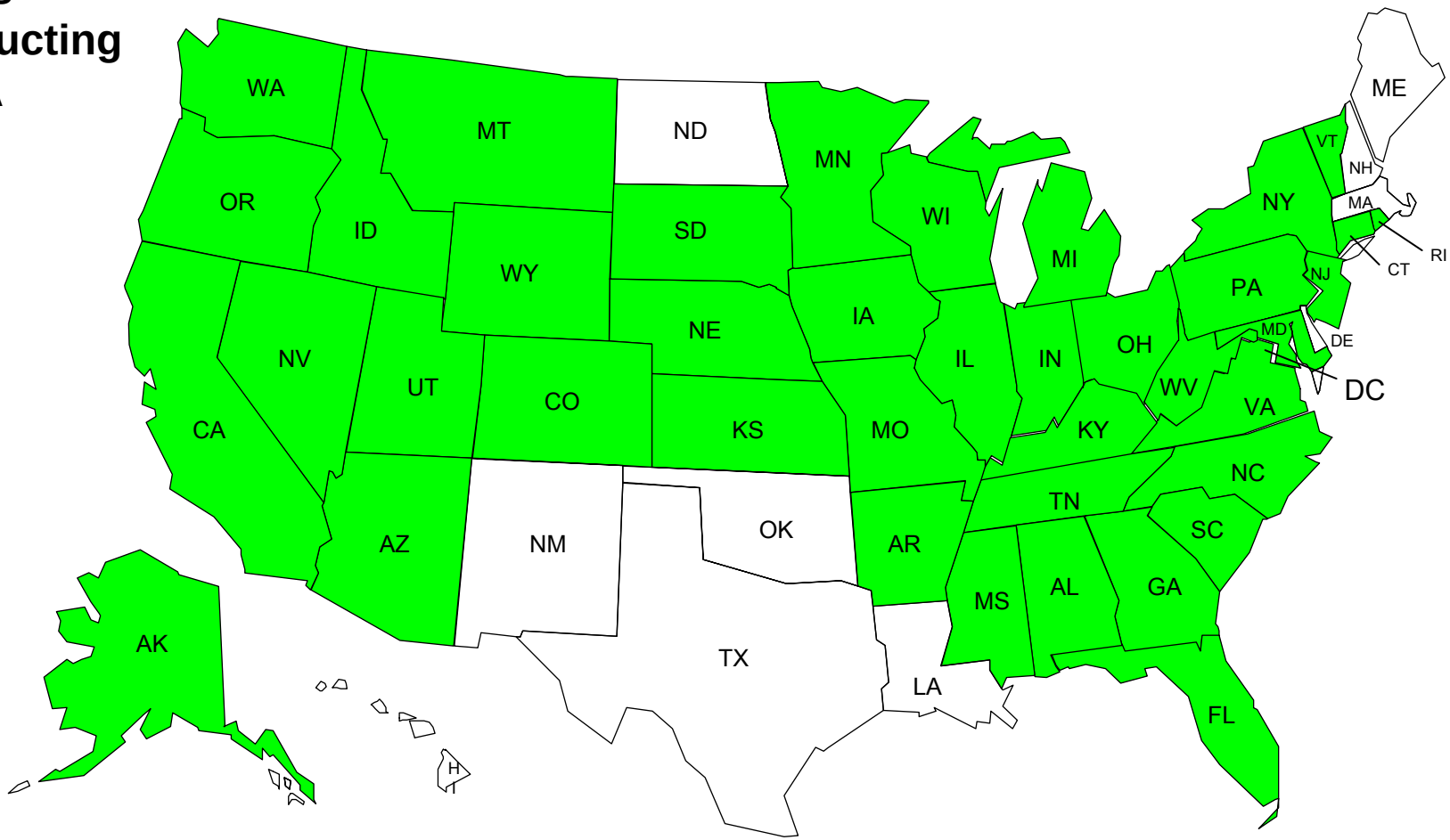
- Two Step Process:
  - initial survey (identify resources)
  - focused survey
- Objectives:
  - improve the existing SC LCCA approach for pavement type selection
  - determine which states are conducting an LCCA and how
  - compare present results to previous surveys

Who Participated



Who is Using LCCA?

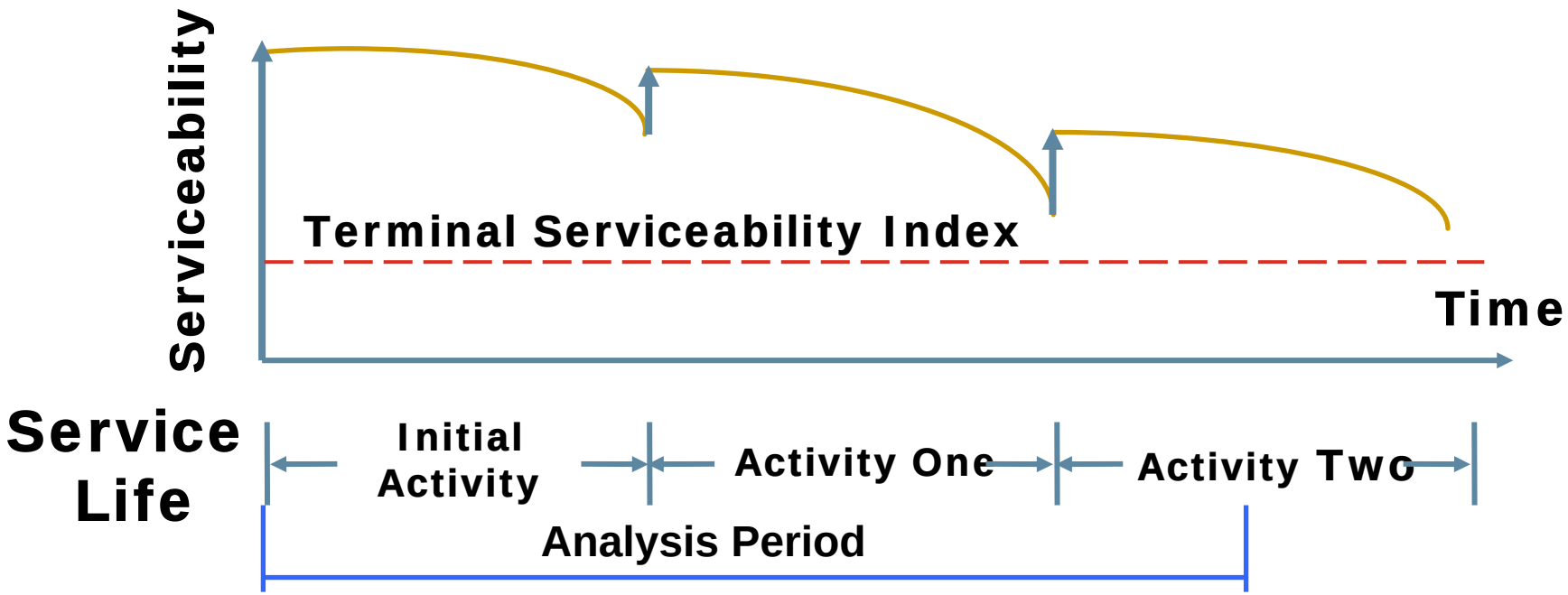
States Conducting LCCA



Step 1:Establish Alternatives

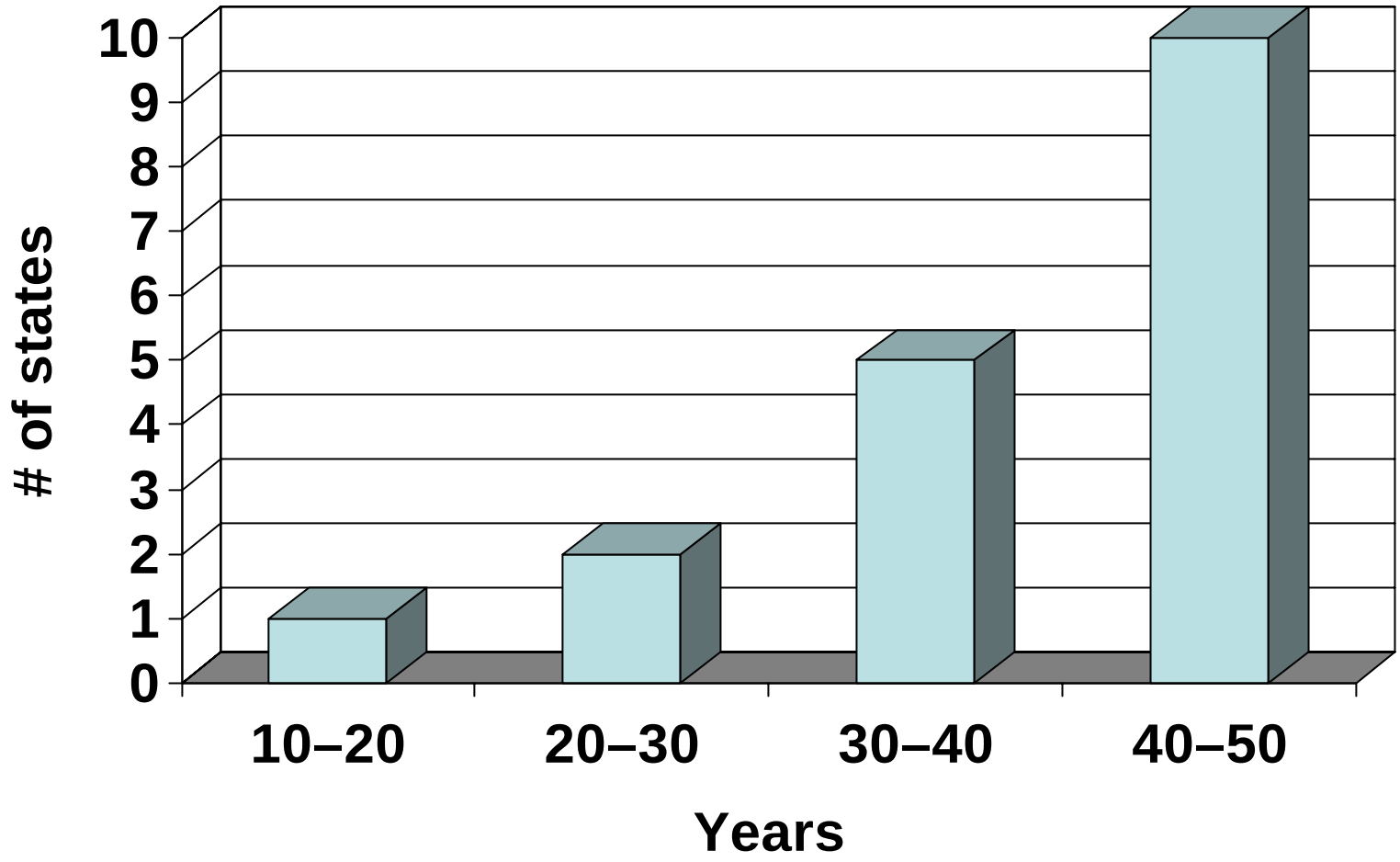
- Rigid Pavement
- Flexible Pavement
- Slurry Seals
- Diamond grinding
- Joint Repairs
- Crack Sealing
- Chip Seals
- Mill and Overlays

Step 2: Determine Activity Timing

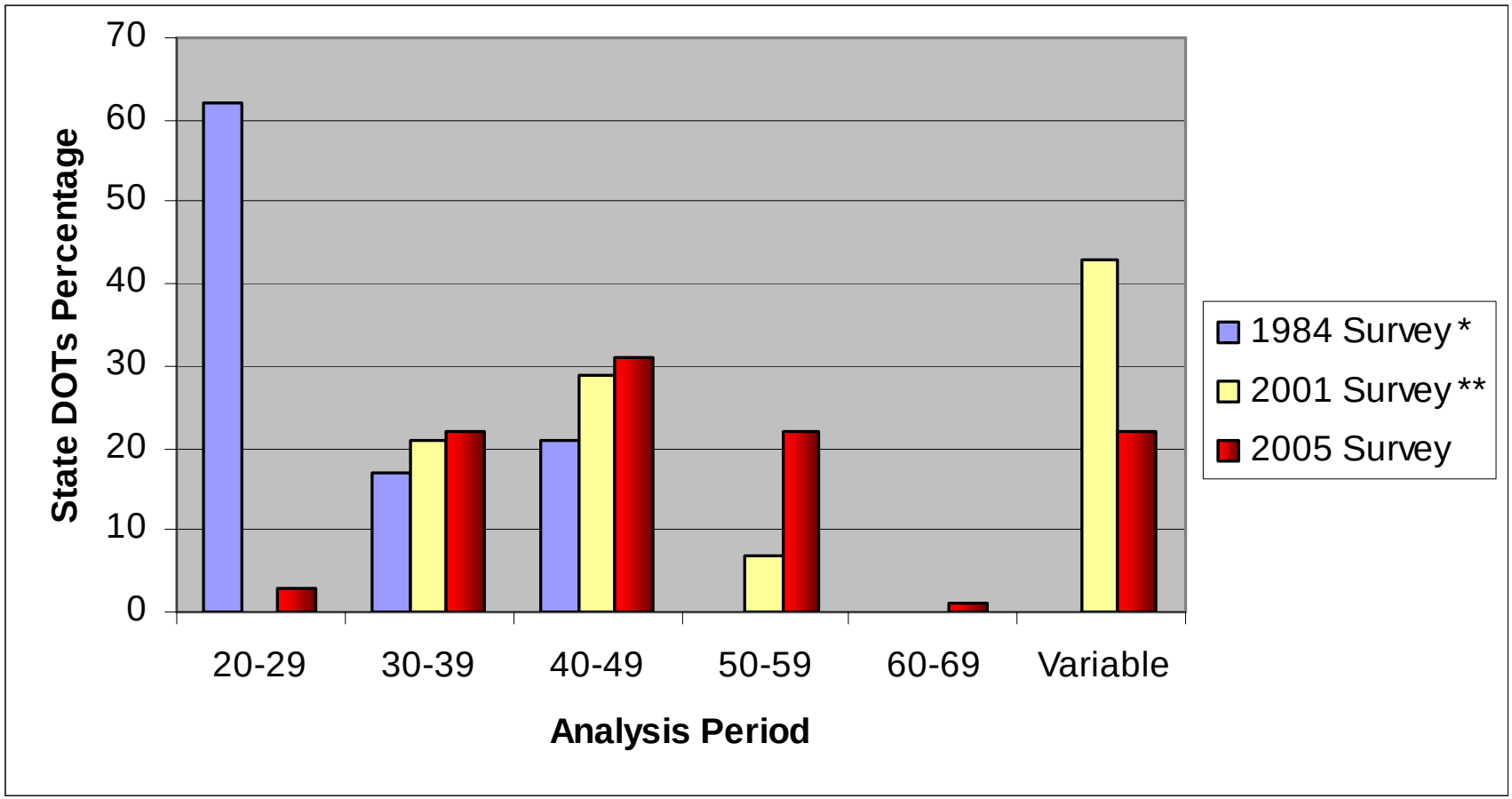


When will the future preservation and/or countermeasure costs be incurred?

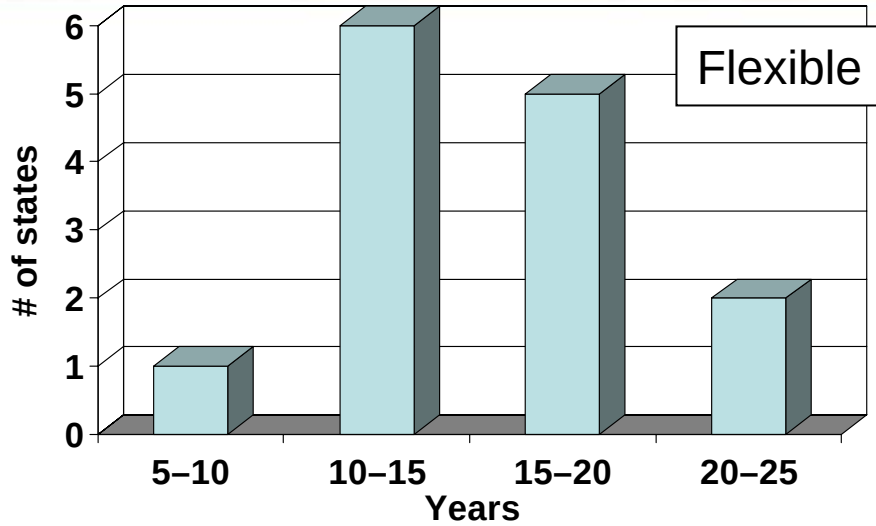
Analysis Period(AASHTO RAC Survey)

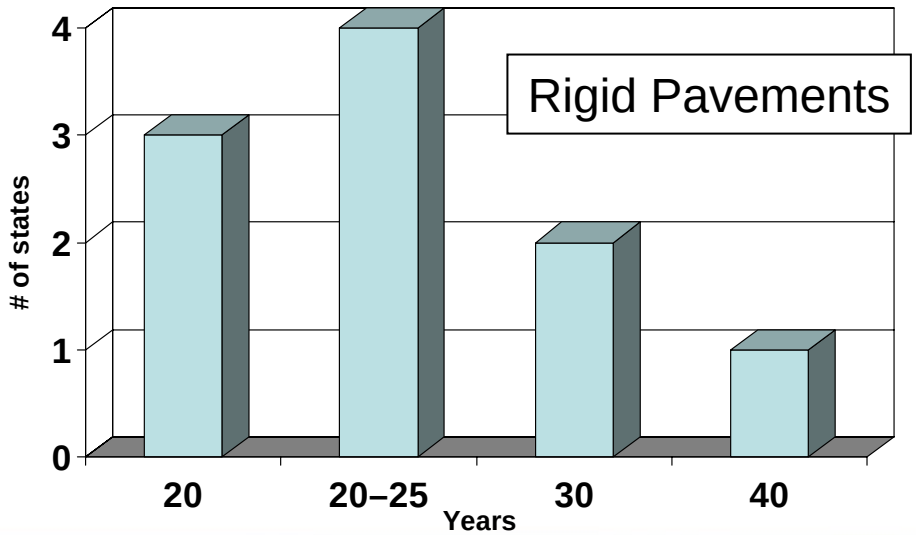


Analysis Period(SC Survey)



Time to First Rehab(AASHTO RAC Survey)





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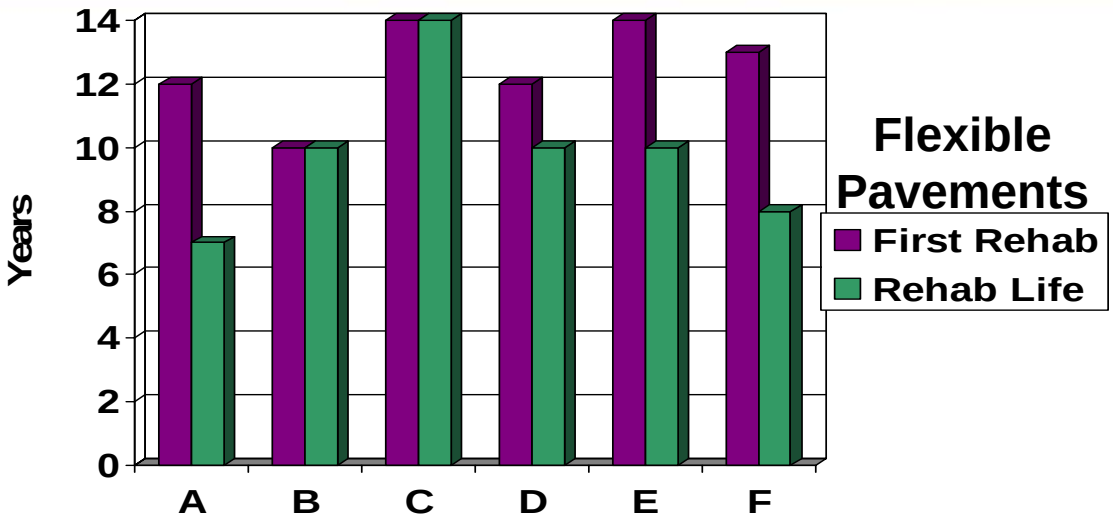
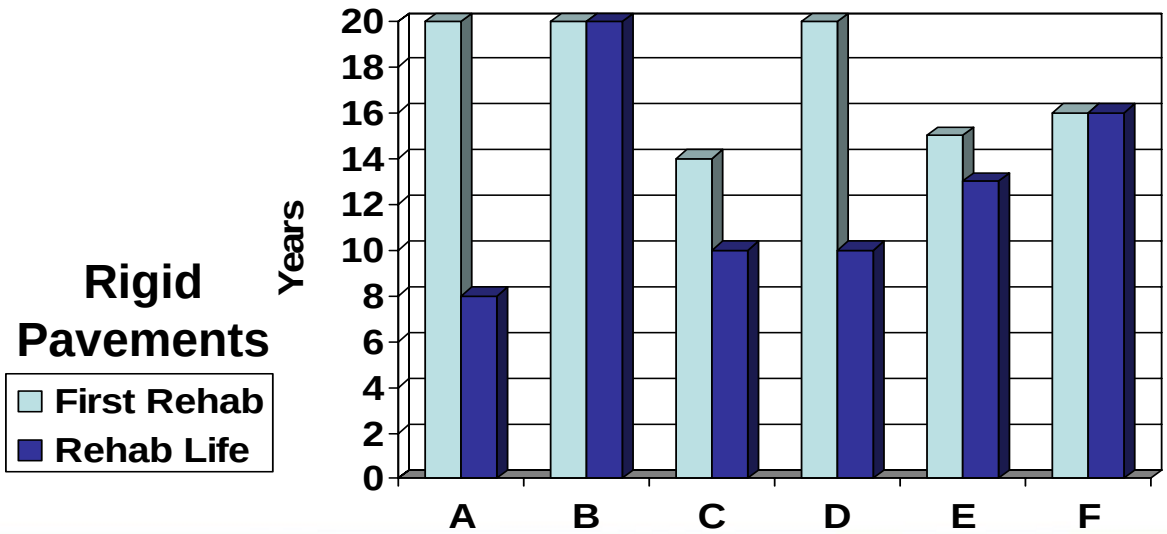




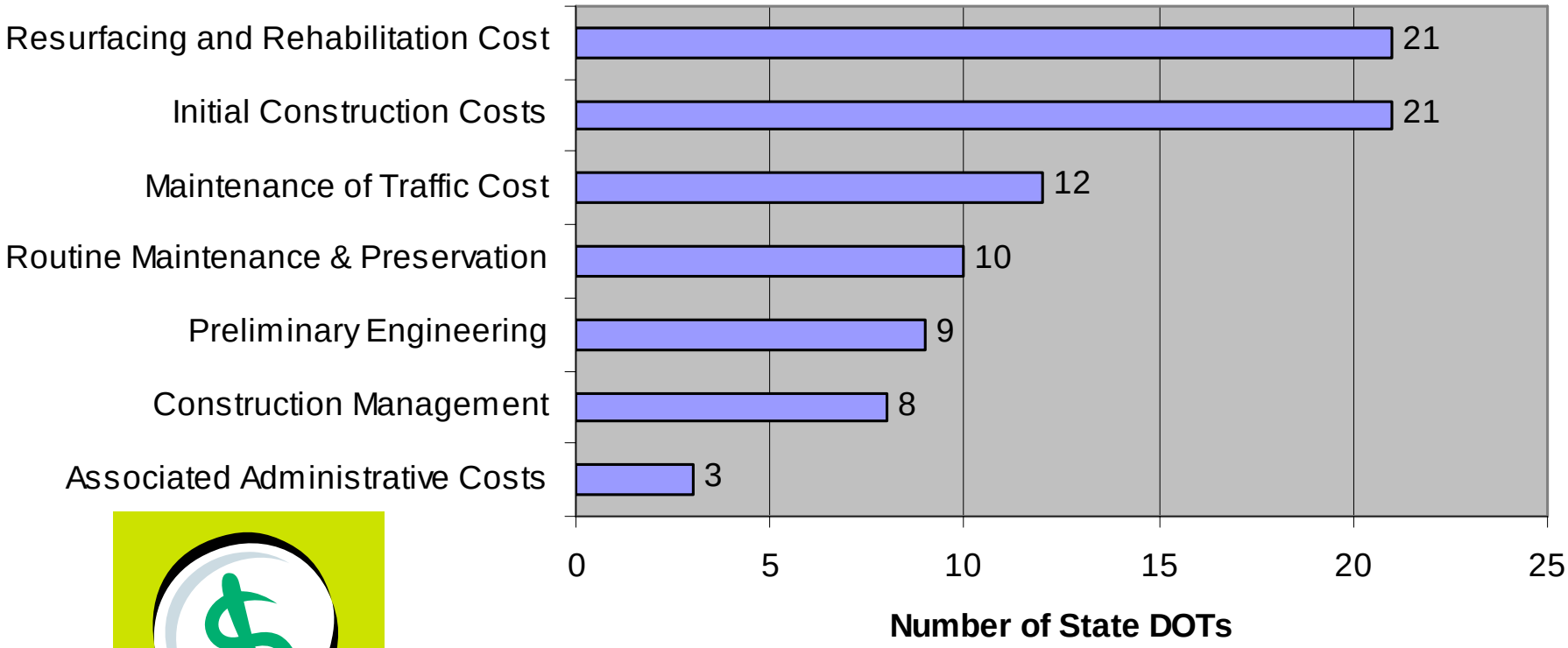
Step 3: Estimate Agency and User Costs

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

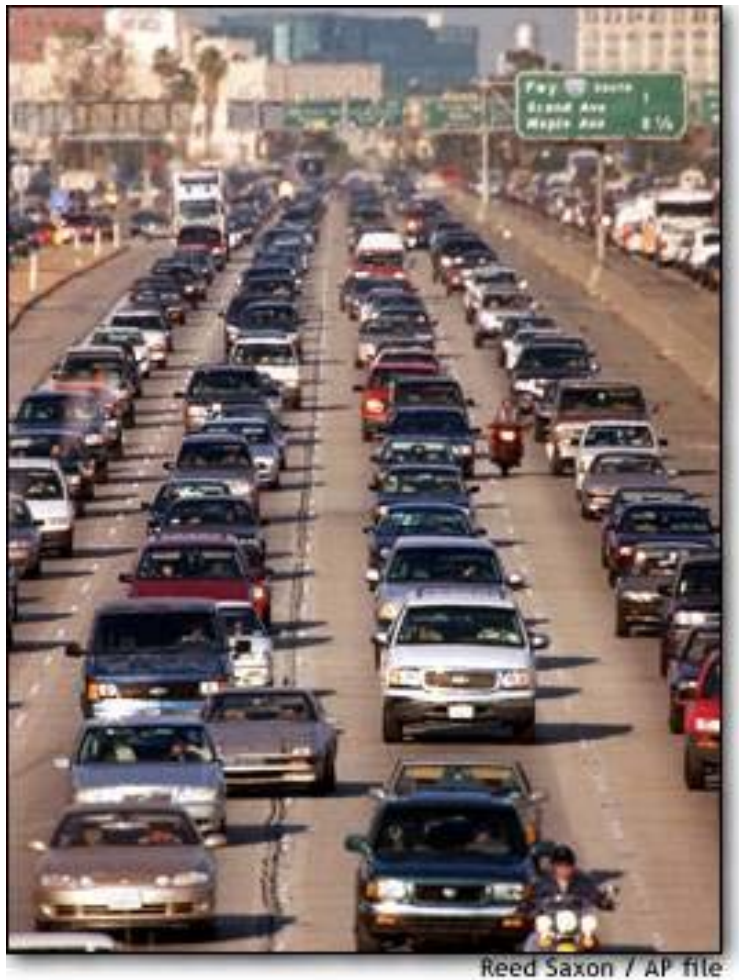
Included Agency Costs(SC Survey)



User Cost Components

Three Components

1. Vehicle Operating Costs (VOC)
2. Delay Costs
3. Crash Costs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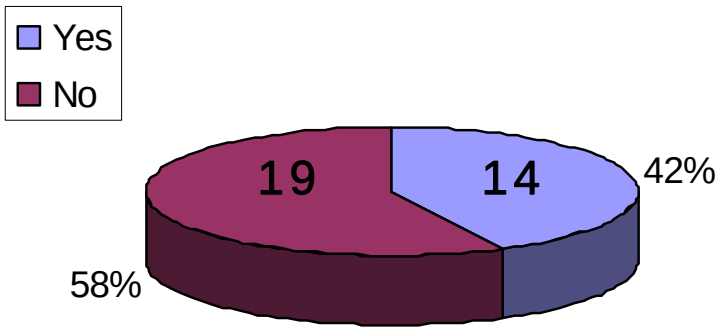
User Costs(SC Survey)



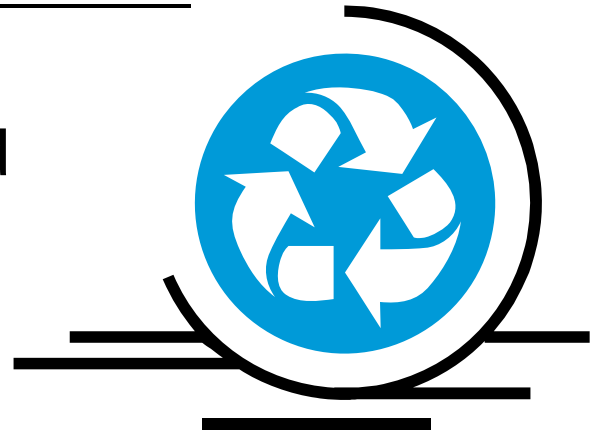
Out of 14 DOTs that include user costs in the analysis

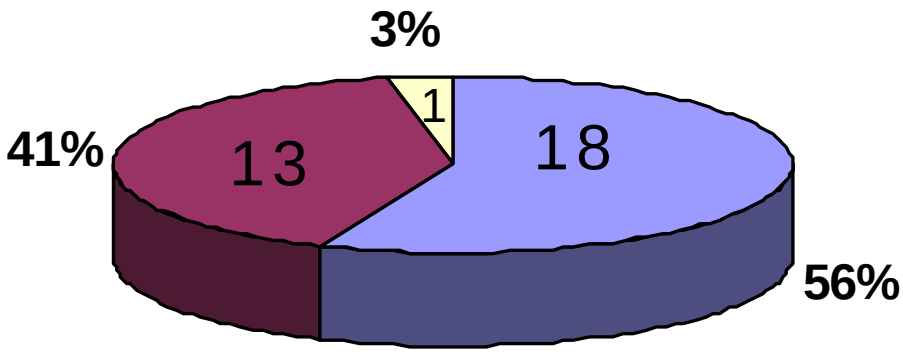
- 10 DOTs consider work zone user delay costs
- 1 DOT uses all user cost components outlined in the FHWA Bulletin
- 4 DOTs are planning to include user costs in the future

Is Salvage Value used in LCCA calculations?

The value of recovered or recycled materials

- Assumes roadway is removed from service at the end the analysis period
- Salvage value is only realized when materials are actually reclaimed





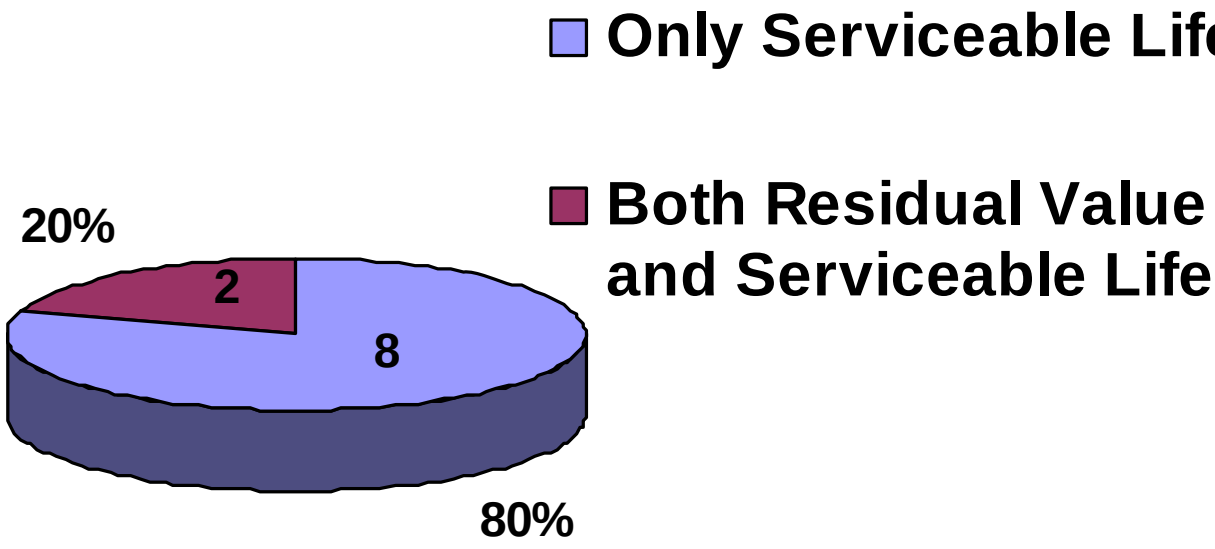
2
2

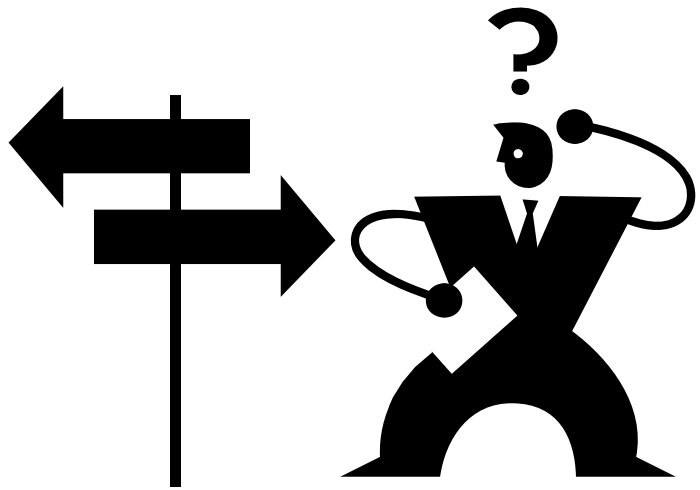
Yes

No

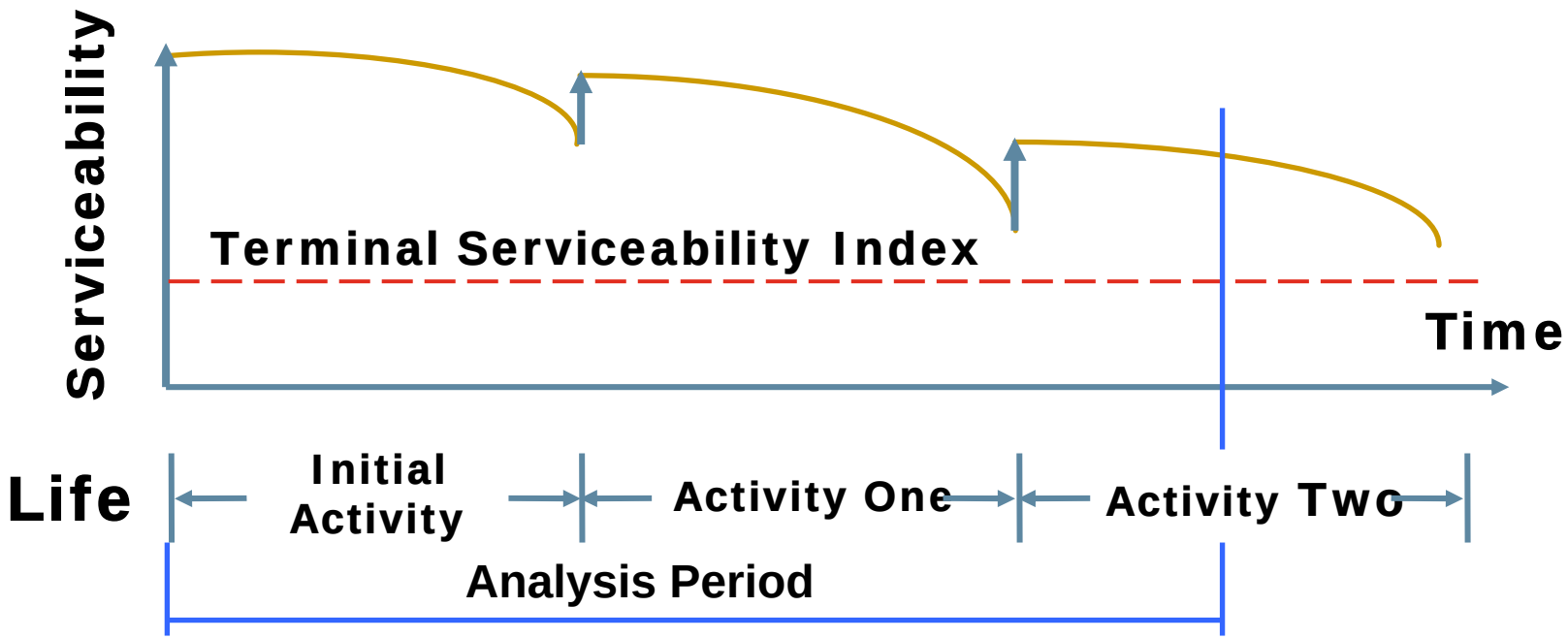
No for Deterministic Approach, Yes for RealCost

Calculation of Salvage Value



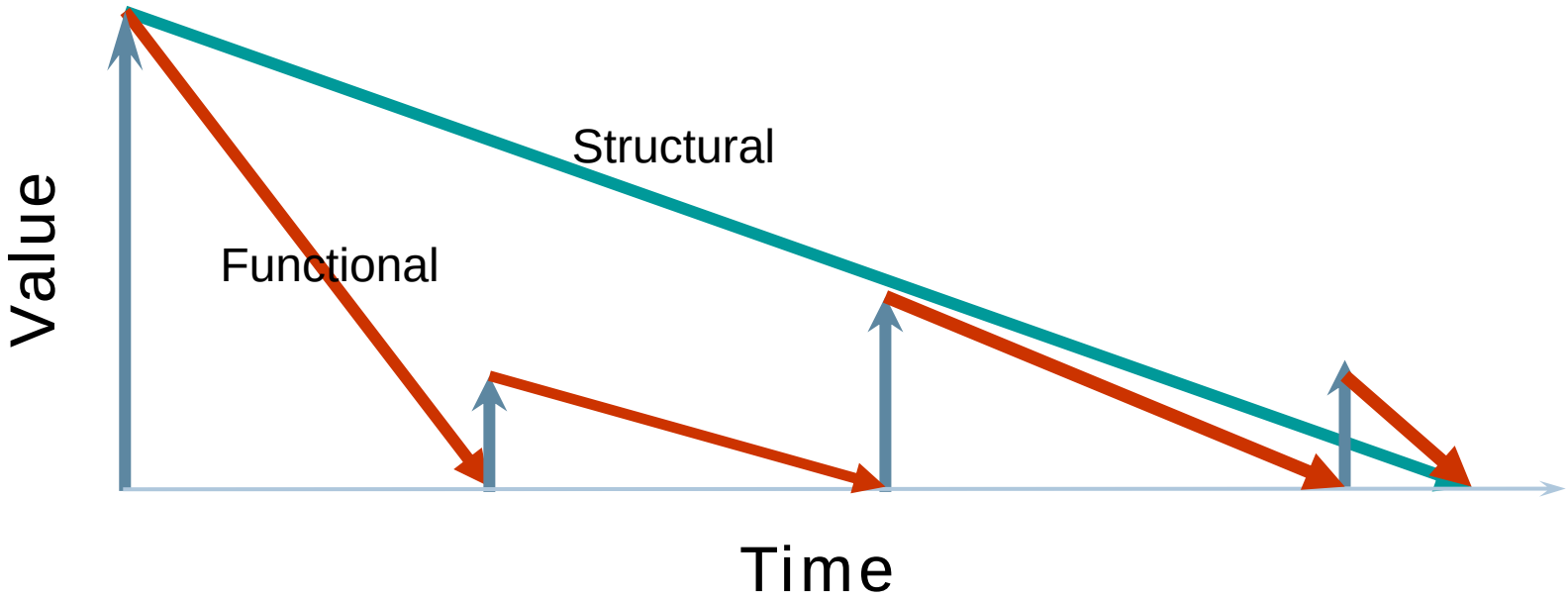


Remaining Value



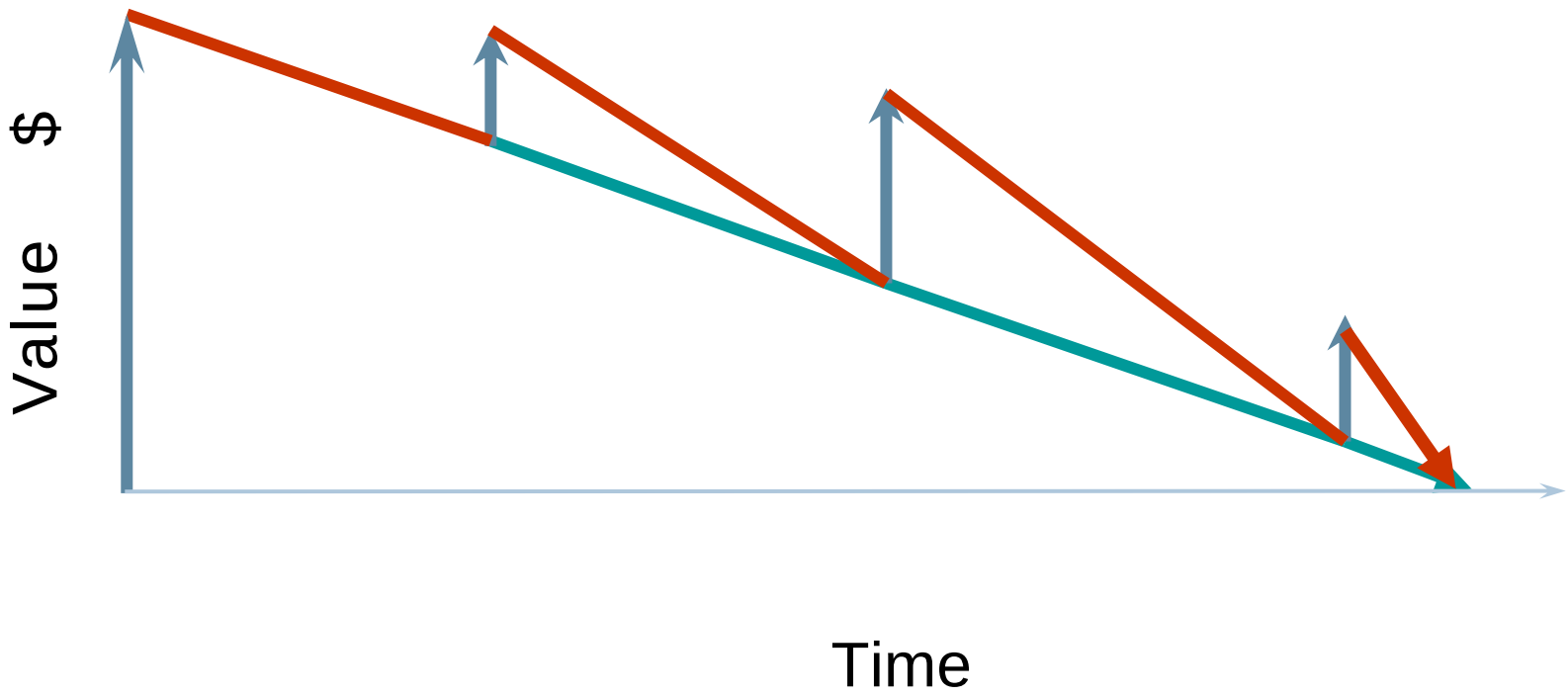
Remaining Value

- Depreciation of initial costs (straight line) over the usefulness



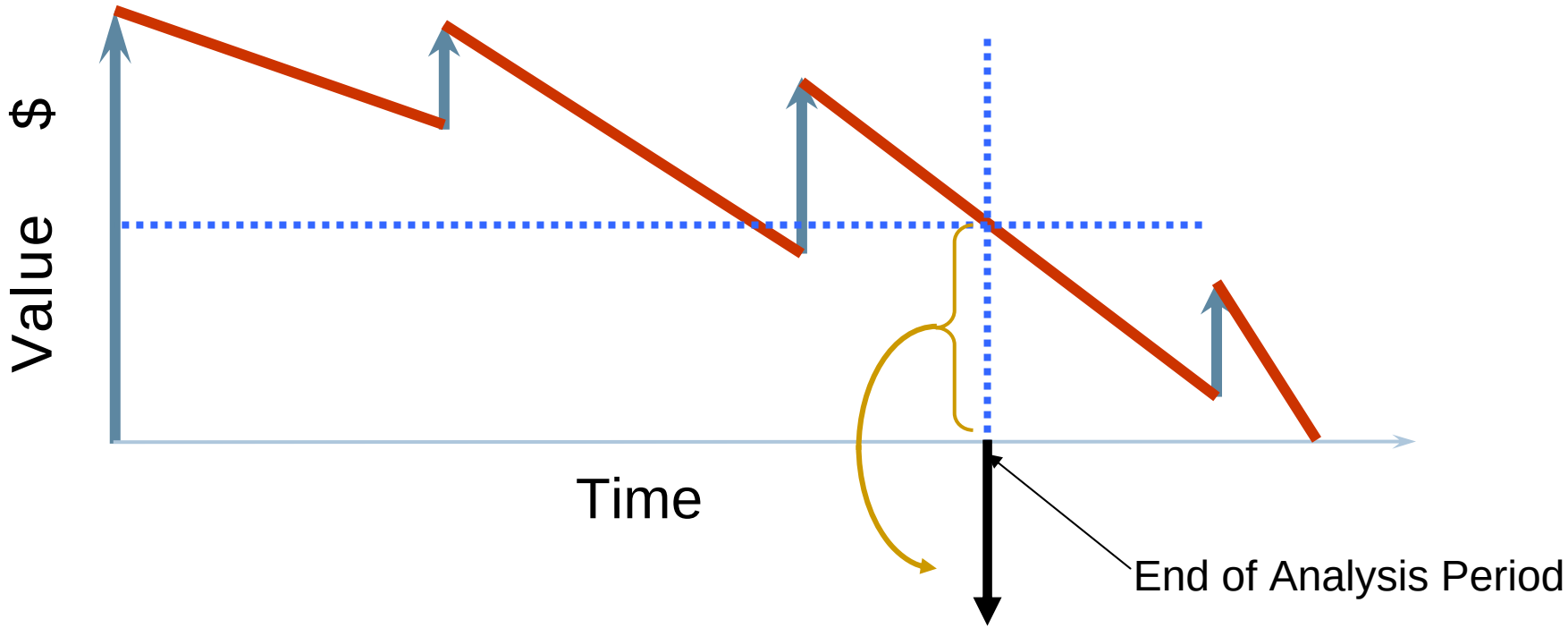
Remaining Value

- Costs are additive to the depreciated Structural value baseline in the year of expenditure



Remaining Value

- Using the depreciated value curve to get the RV at the end of the analysis



Step 4: Calculate PV of Life-Cycle Costs

Present Value = of Costs

$$\sum_{k=0}^{N}\left[(Cost_k) \times \left[\frac{1}{(1+d)^{n_k}}\right]\right]$$

Present Value Factor

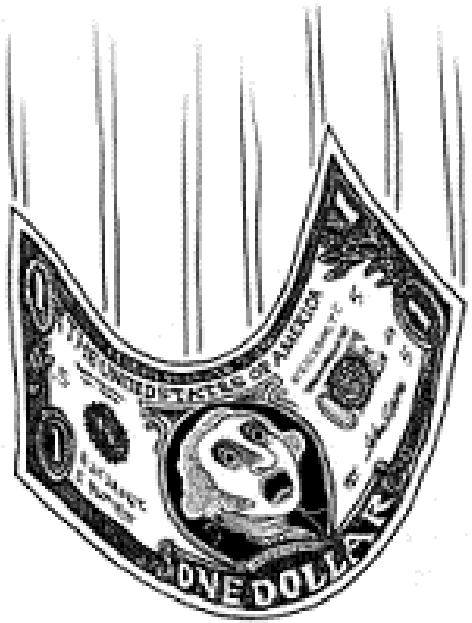
N = length of analysis period
d = discount rate
n_k = year of expenditure

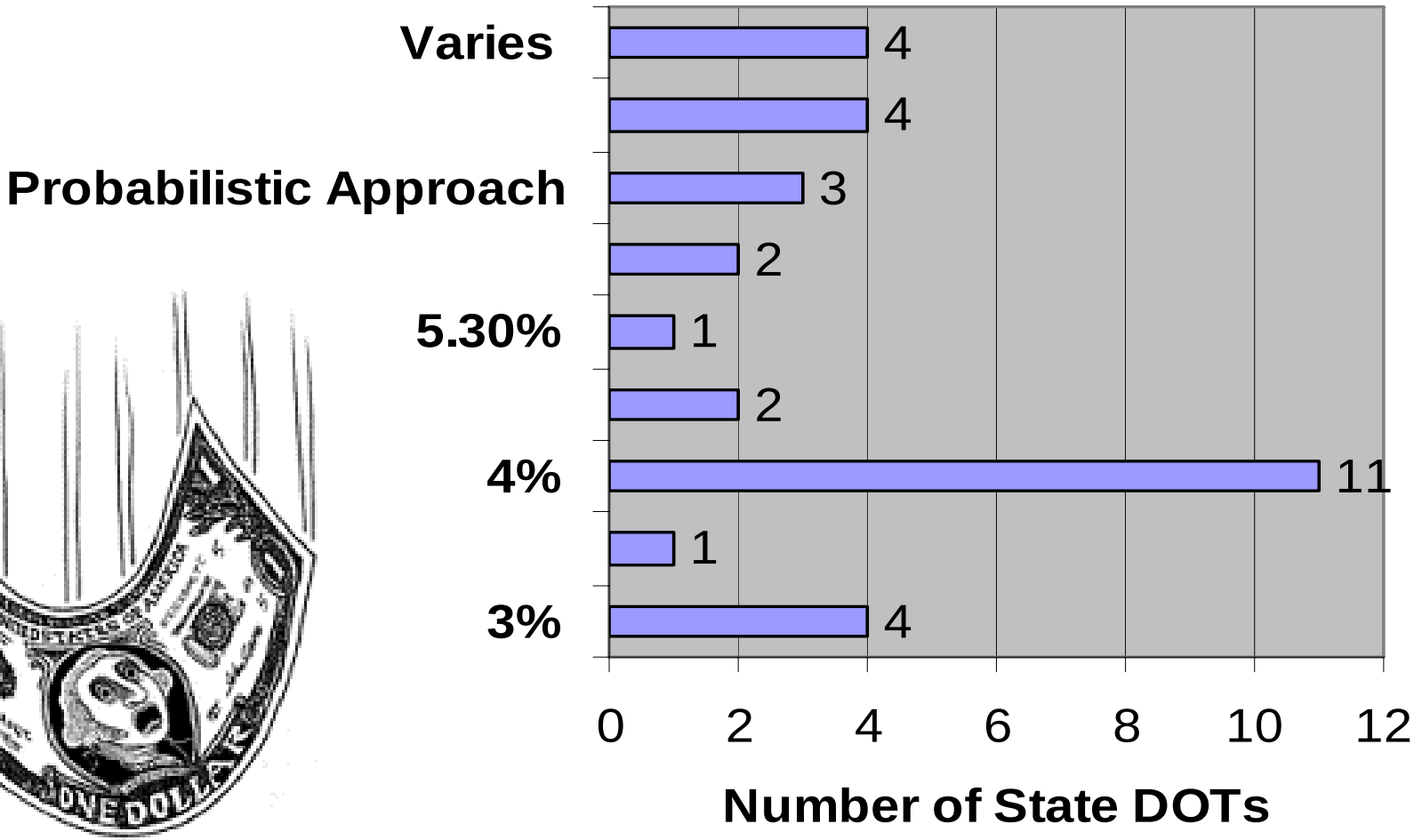
Discounting/Inflation?

- Discounting is what a future sum is worth to us now regardless of inflation. What we require in return for forgoing other benefits

- Inflation is a general rise in prices due to more demand than supply. Measured by various “price indices” and effects purchasing power. Critical for budgeting exercises.

Discount Rate Utilized by State DOTs

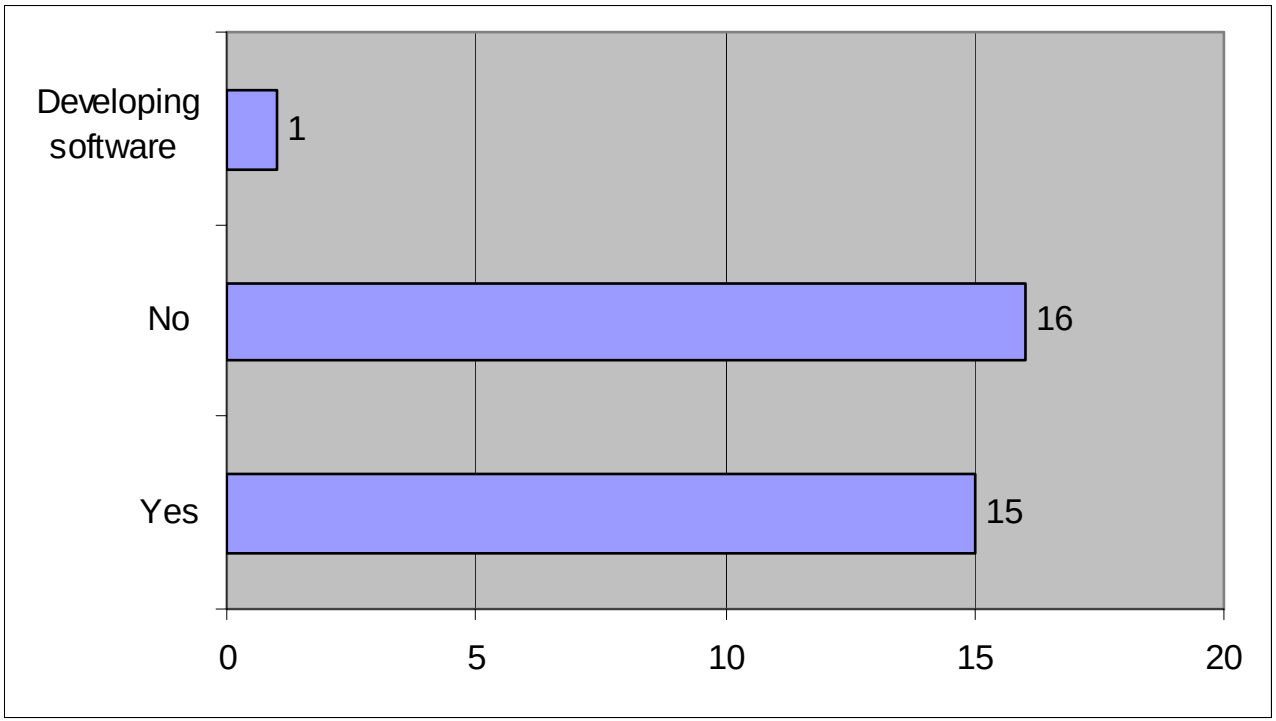




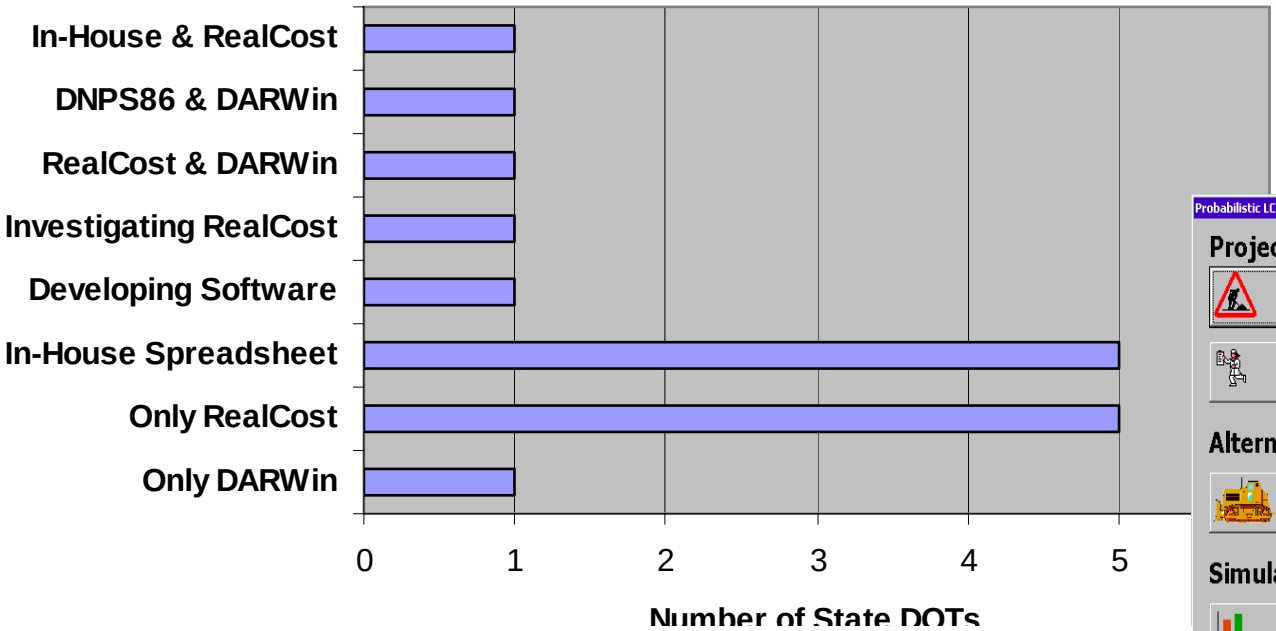
Step 5: Analyze the Results

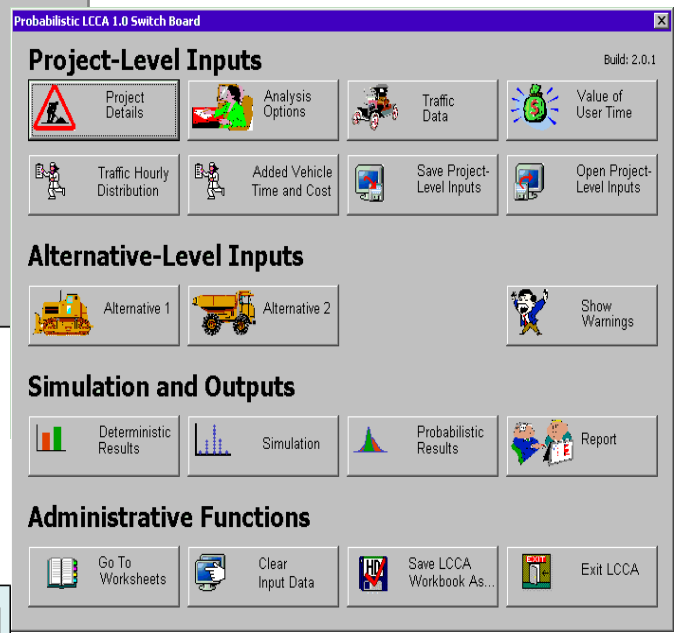
- How do agency costs compare?
- How do user costs compare?
- Can trade-offs be made?

Software Utilization in LCCA

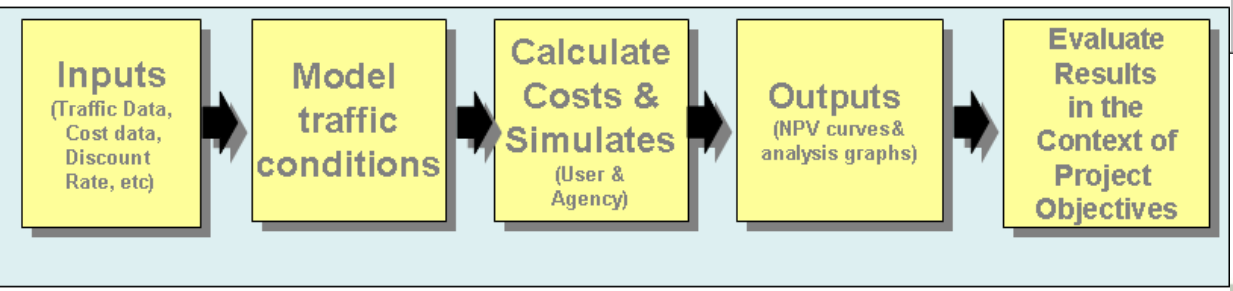


Software Utilization in LCCA





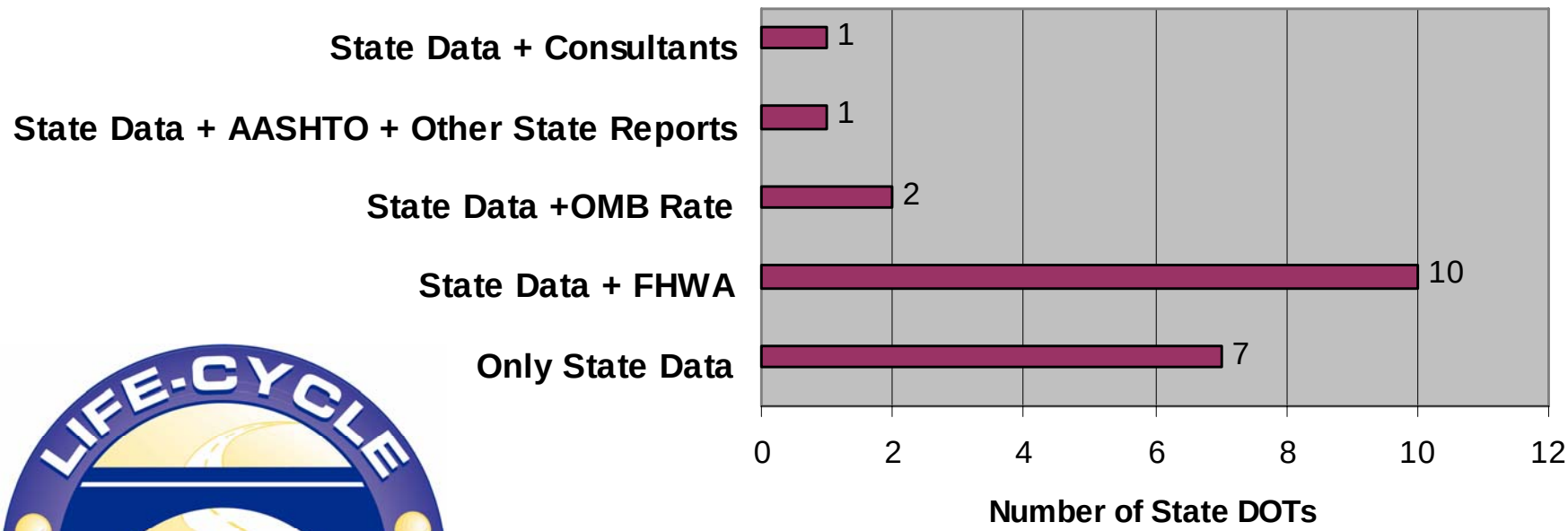
Use Function — REALCOST FUNCTIONS — User Function



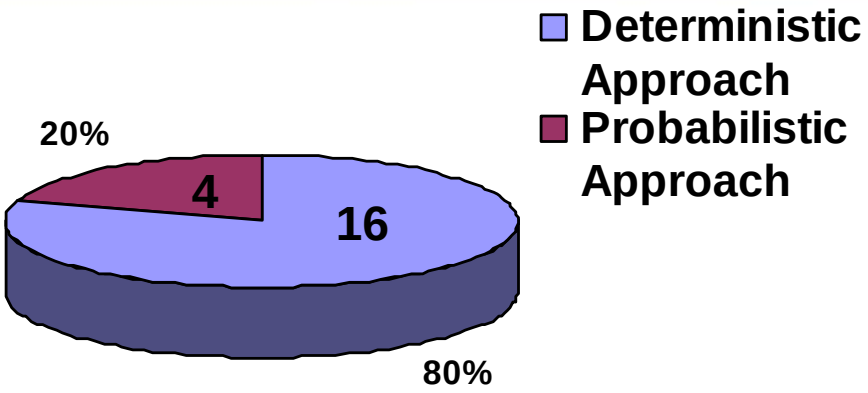
RealCost Software

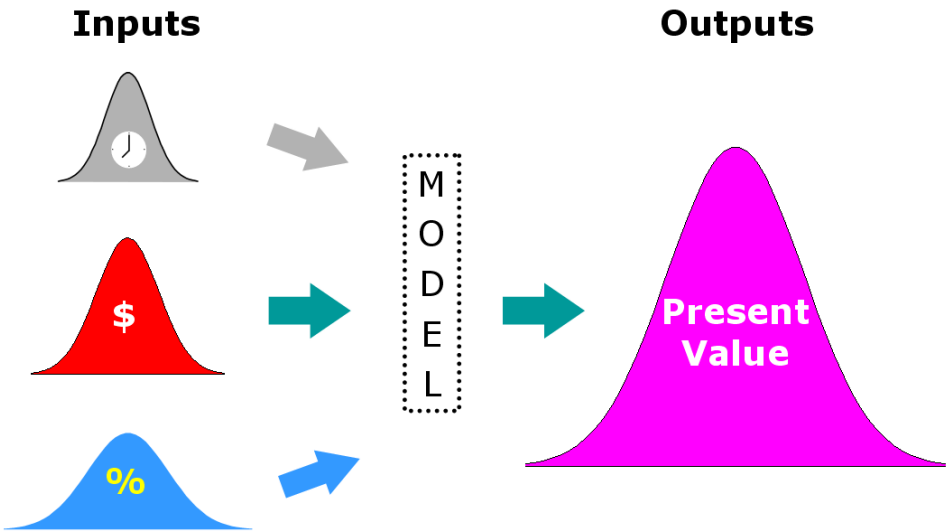
Inputs to the LCCA

Data Sources Used in Selecting the Input Parameters



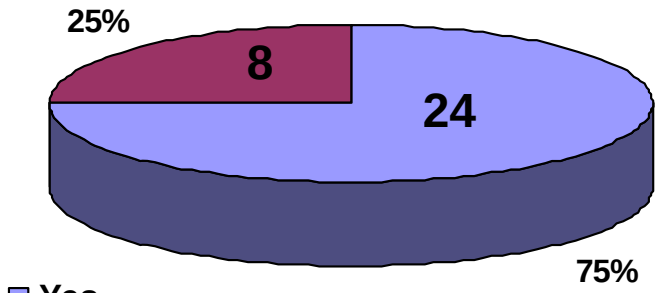
Approach Used

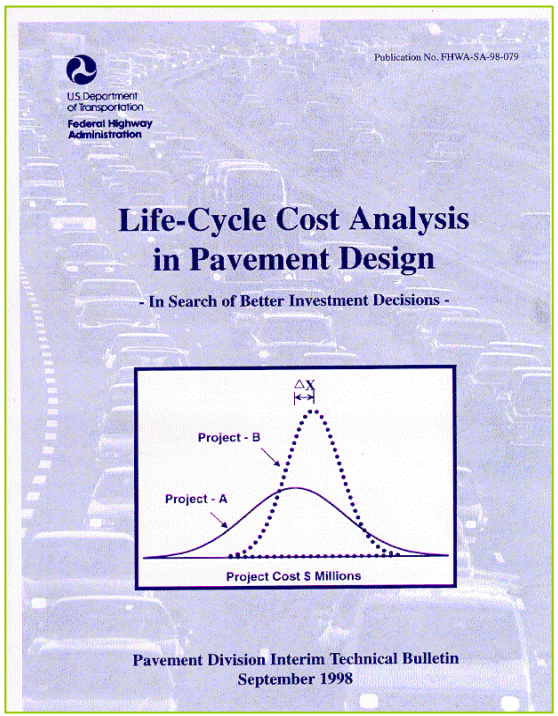




- **Deterministic Analysis**
  Static Inputs(No Uncertainty)
- **Sensitivity Analysis**
  Vary one input at a time
- **Probabilistic Analysis**
  Simulating/Modeling inherent uncertainty in variables and there effect on investment choices

Policy or Guidelines for Type Selection

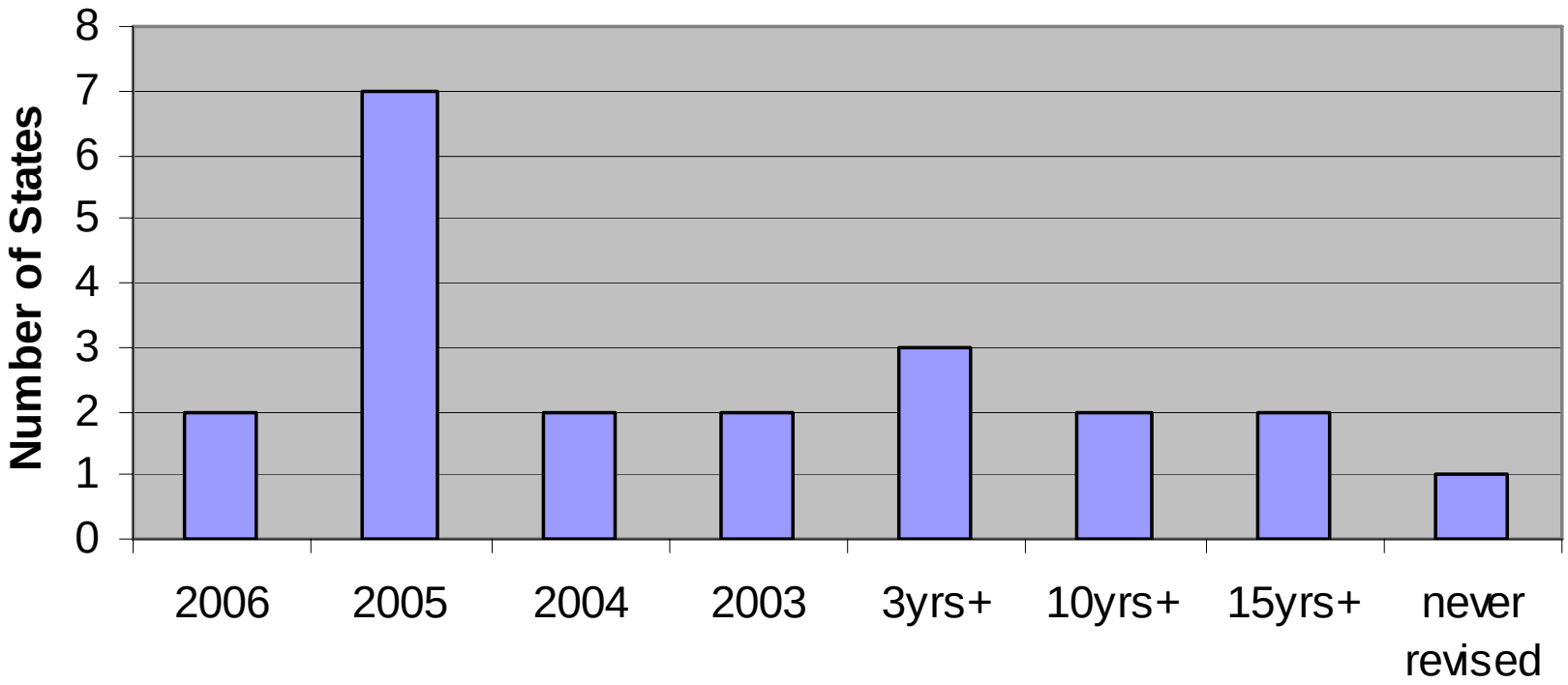




- California DOT LCCA Manual
- New York DOT Pavement Design Manual
- Washington State Pavement Design Manual
- FHWA LCCA in Pavement Design Technical Bulletin
- Other References available on FHWA LCCA Webpage

Policy

Time of the Last LCCA Policy Revision



Summary – What's Working

- Choose an Analysis Period between 30 to 50 years
- Establish triggers for the LCCA
- Use Software to support the analysis
- Evaluate impact to Users(User Costs)
- Implement policy guide for practitioners
- Identify performance periods for activities
- Perform a probabilistic analysis to quantify uncertainty
- Use a discount rate between 3% & 5%
- Use available data sources(PMS, etc)
- Get Industry input

Available Resources from FHWA

- **Fundamentals of LCCA Live Instructor Led Distance Learning Course**
- **RealCost Onsite Implementation Workshop**
- **RealCost LCCA Software**
- **Case Studies**
- **LCCA Technical Bulletin**
- **LCCA Primer.**
- **LCCA Web Page.**
- **Technical Support.**

Thank You

Nat Coley

FHWA Office of Asset Management

202.366.2171

http://www.fhwa.dot.gov/infrastructure/asstmgmt/