Life-Cycle Cost Analysis: A Practitioner's Approach

Nathaniel D. Coley Jr.
FHWA Office of Performance Management

Topics

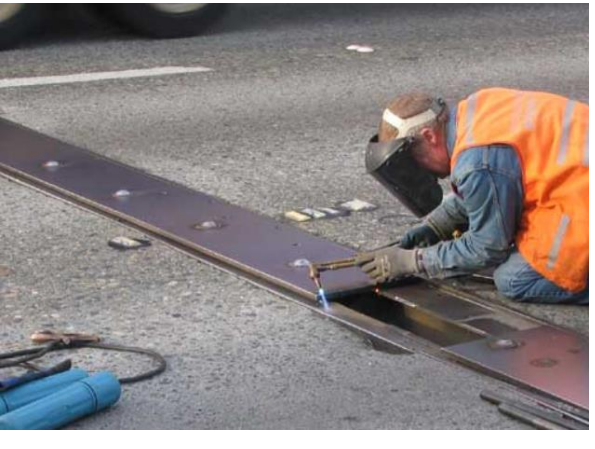
- Fundamentals of Economic Analysis
- Tools and resources
- What to do now

Learning Objectives

By the end of this workshop you should:

- Be familiar with economic analysis concepts, methods and tools
- Where to get help

Project Alternatives for Bridges

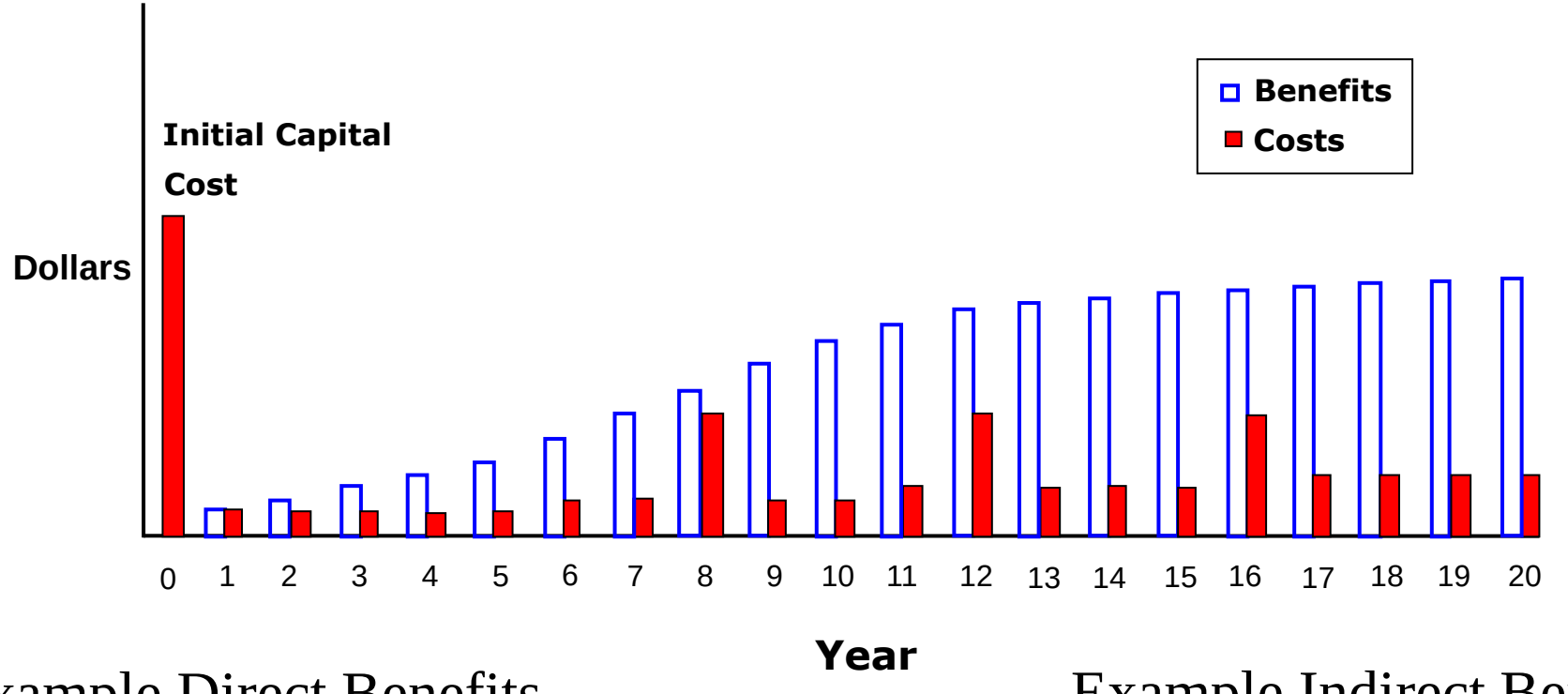


We consider a short list of alternatives for bridge at a project level:

- Replacement
- Rehabilitation
- Painting
- Seismic retrofit
- Systematic preventive maintenance
- Installation of scour countermeasures

Life-Cycle Comparisons of Alternatives

Typical Life-Cycle Profile



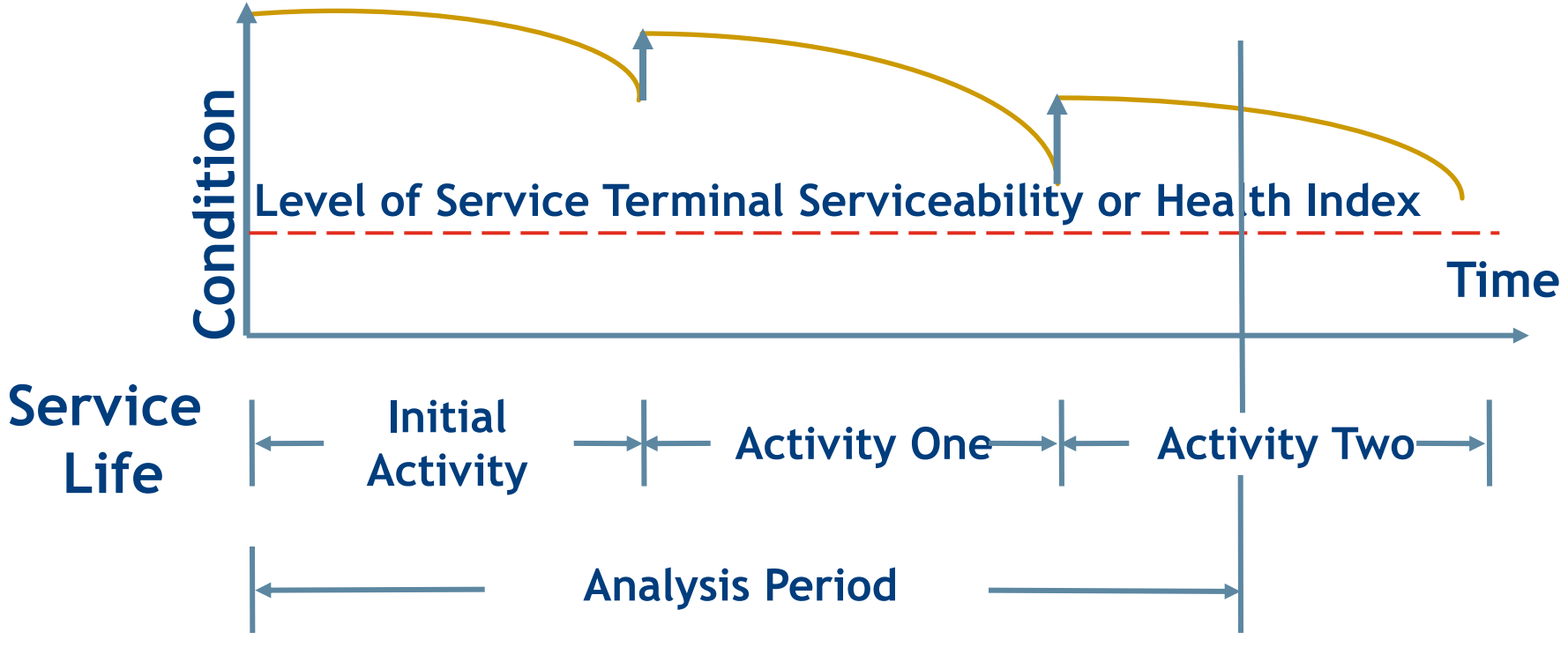
Example Direct Benefits

- Reduced Accident Costs
- Reductions in Delay Costs
- Reduced Life-Cycle Costs

Example Indirect Benefits

- Land use impacts
- Employment
- Non-user benefits

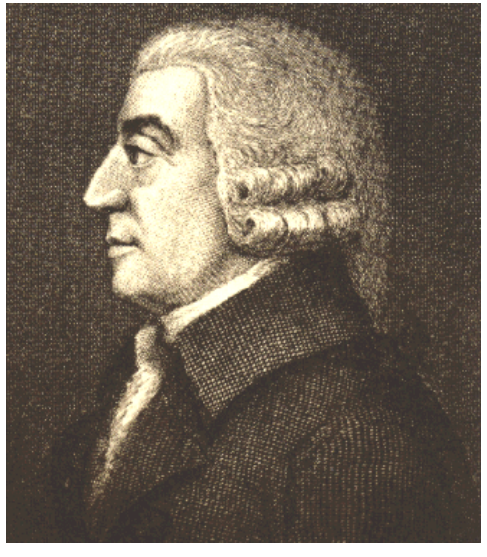
Life-Cycle Comparisons



When will the future deterioration countermeasures be required?

The Role of Economic Analysis

- Mechanism for monetizing, evaluating and comparing long-term costs and benefits of alternatives
- Economic analysis results
  - Help structure project and program level tradeoffs to ensure that resources are allocated efficiently to achieve the maximum ROI(Allocative Efficiency)
  - Quantify & Qualify costs and benefits to the agency and to roadway users
  - Support repeatable and transparent project justification and prioritization



Adam Smith

- Does not provide THE decision. It provides a logical framework to support decisions

Life-Cycle Comparisons

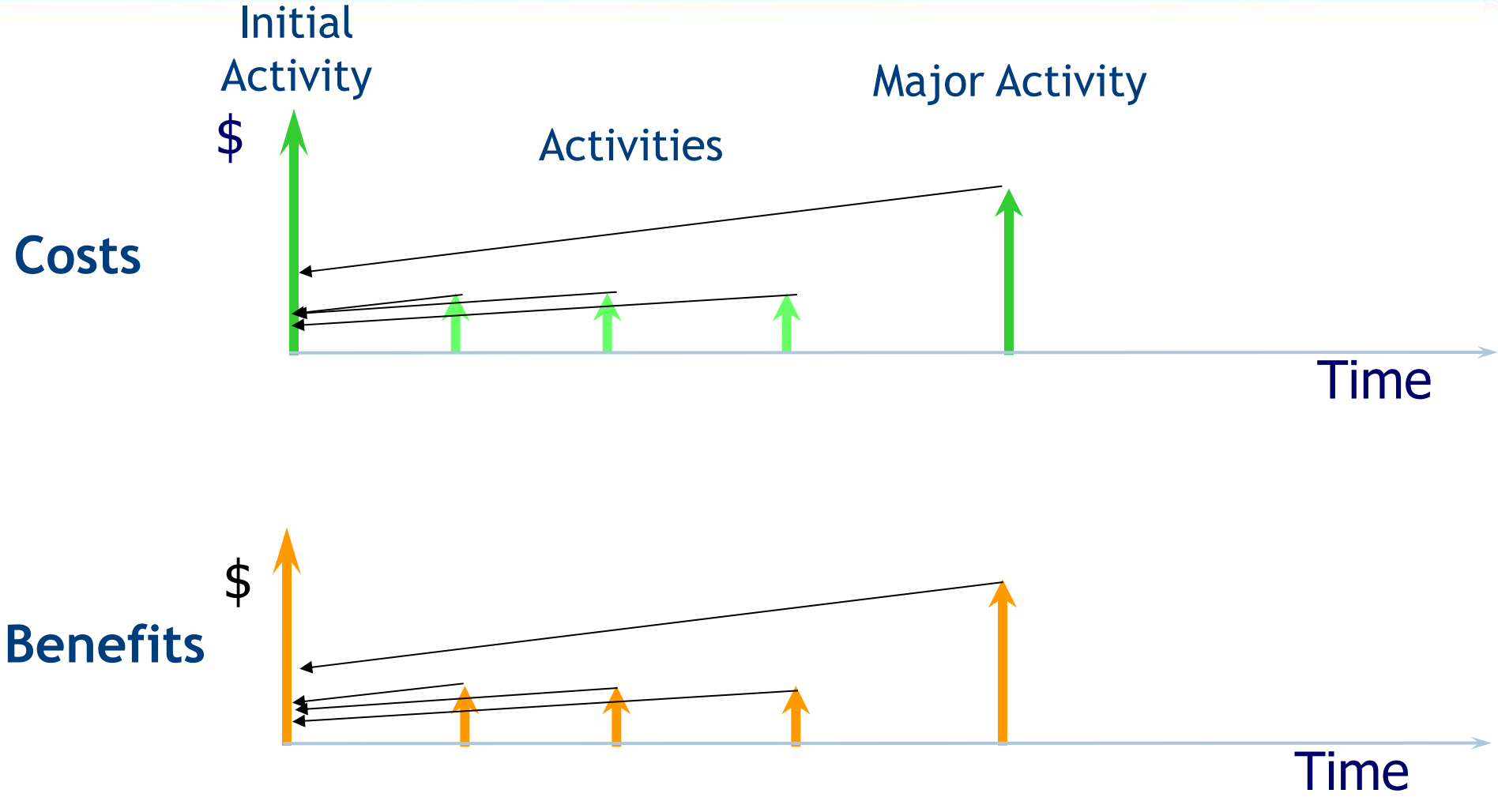
Dollar Now vs. Dollar Later

Two separate and distinct factors account for why the value of a dollar, as seen from the present, diminishes over time

- Inflation

- Time value of a dollar(Discounting)

Calculate Present Values of Costs and Benefits



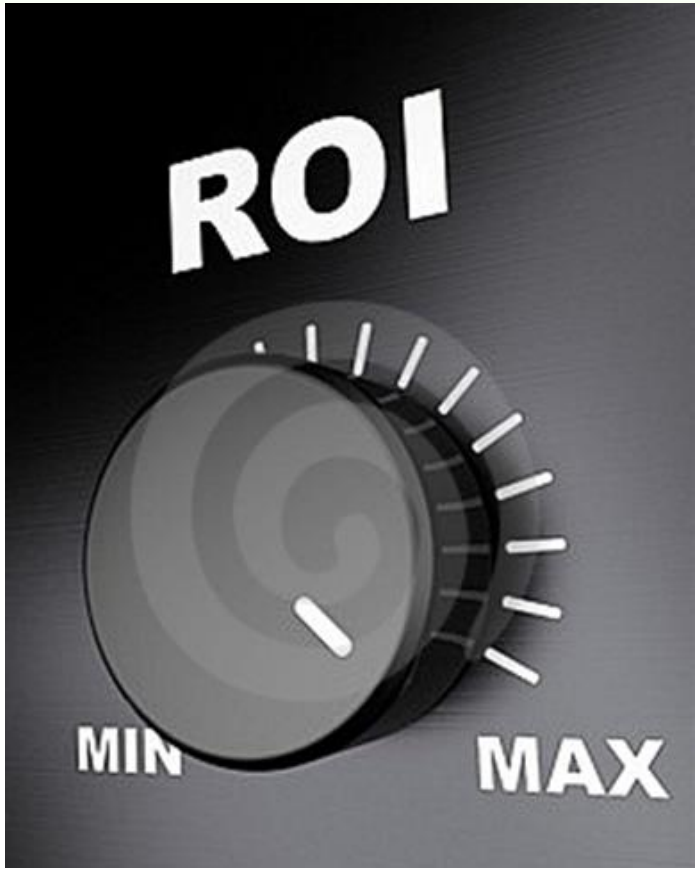
What is the present value of future sums?

Time Value of Resources

Guidance on Discount Rates

- Real discount rate of 3% with a sensitivity analysis ranging from 2% to 5%(More on “Sensitivity Analysis” later)
- States may select higher or lower rates, but rate should be justified.(e.g. borrowing or bond rates)
- Do not adjust discount rate for risk because the risk that society places on forgoing consumption is already built in. This is different from risk of returns in bond or stock markets

Definition of Benefit Cost Analysis



For public agencies benefit-cost analysis benefit-cost analysis is essentially ROI. Traditional benefit cost analysis and ROI analysis for transportation includes user benefits (time, cost, safety) for travelers and select environmental effects (air, quality, noise) along with capital, operations, and maintenance(O&M) costs.

Definition of LCCA

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

Cost Effectiveness Analysis(OMB Circular A-94)

- CEA compares alternatives on the basis of the ratio of their costs and a single quantified but not monetized effectiveness measure(e.g. dollars per lives saved Programs that cost less per life saved are more cost-effective than other programs)
- It is a measure of technical efficiency and is not necessarily a good measure of allocative efficiency.
  - Allocative efficiency - are funds directed to activities which will produce the greatest gains.(MAX ROI)
  - Technical efficiency - once resources are allocated, are they being combined to produce the greatest output (Spread The Butter Thin)

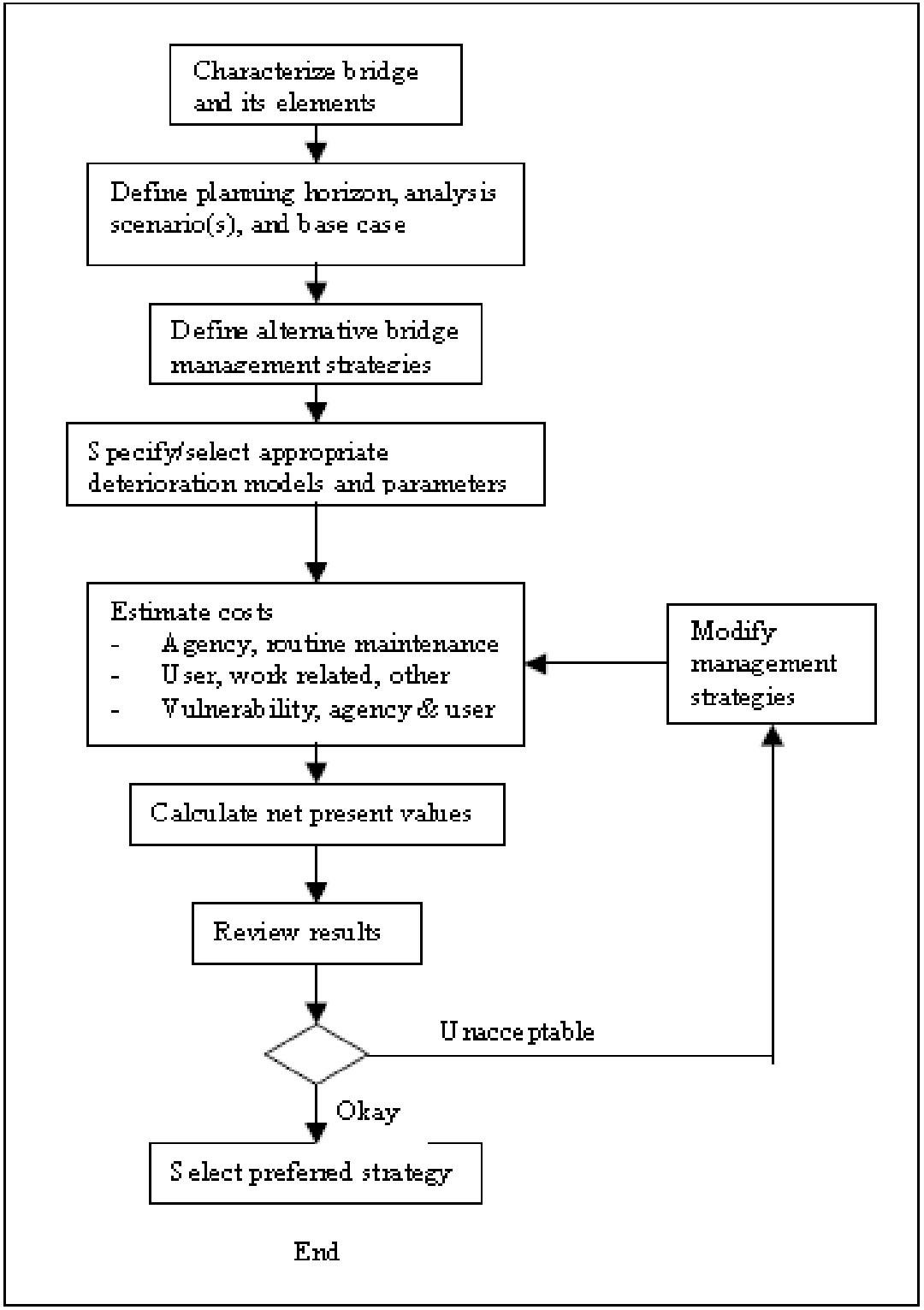
U.S. Department of Transportation
Federal Highway Administration

The Process

NCHRP
REPORT 483

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Bridge Life-Cycle Cost Analysis



Method

BCA Formula

- BCA is done using the basic multi-year discounting formula:

$$PV = \sum_{t=0}^{N} \left(\frac{1}{(1+r)^t} \right) (Benefit_t - Cost_t)$$

HBR Eligibility Determination - Compare Rehab Option vs Replacement Life Cycle Costs

Retain 29 year old bridge (BR_08282, constructed 1965) with deteriorated timber substructure (SR-517 10/2996)) versus replacement

PW=(1+f)^n/(1+i)^n

Interest rate, i = 7%

Inflation rate, f = 4%

Notes: Widen from 9.14 m roadway to 13.200 m roadway; actual widening - 5.8m x 134 m @ $1950/m2.

1992-1997 9.20 accidents per year; total 46 (1 accident at the bridge between 1993 & 1997)@ $10400/accident; accident cost $2080/year*

*Based upon cost/PDO accident - $8400 & cost/injury accident - $14400

Replacement cost for 14.02 m x 134.788m structure based on Final Structure Cost Estimate.

(Detour structure not required for either option.)

Retain and Widen Old Bridge, Bridge No. 08282

Year	PW Factor	Widening	New Rail #	Total Capital Cost	Accidents	PW Accid	Borings	Repl. Piles	Bracing	Girders	Repave Deck	Drains & Gutterlines	PW Maint	Total PW
0	1.000	1520000	0	1520000	20800	20800	0	596000	2000	3000	0	0	601000	2141800
10	0.752	0	0	0	20800	15652	1000	5000	500	3000	13000	15000	28218	43870
20	0.566	0	0	0	20800	11778	1000	10000	500	3000	13000	15000	24065	35842
30	0.426	0	0	0	20800	8862	500	876000	2000	3000	13000	15000	387516	396378
40	0.321	0	0	0	20800	6669	1000	5000	500	3000	13000	15000	12023	18692
50	0.241	0	0	0	20800	5018	1000	10000	500	3000	13000	15000	10253	15272
60	0.182	0	0	0	20800	3776	500	876000	2000	3000	13000	15000	165111	168887
70	0.137	0	0	0	20800	2841	1000	5000	500	3000	13000	15000	5123	7964
80	0.103	0	0	0	20800	2138	1000	10000	500	3000	13000	15000	4369	6507

#Rail cost included in widening costs

Total Present Worth= $2,835,212

Replace with New Bridge, Bridge No. 18628

Year	PW Factor	Capital Cost	Accidents	PW Accid	Annual Maintenance (cleaning)	PW Maint	Total PW
0	1.000	2570000	0	0	0	0	2570000
10	0.752	0	0	0	9000	6772	6772
20	0.566	0	0	0	9000	5096	5096
30	0.426	0	0	0	9000	3835	3835
40	0.321	0	0	0	9000	2886	2886
50	0.241	0	0	0	9000	2171	2171
60	0.182	0	0	0	9000	1634	1634
70	0.137	0	0	0	9000	1229	1229
80	0.103	0	0	0	9000	925	925
						Total Present Value=	$2,594,548

Benefit and Cost Elements

- **Agency Cost/Benefit**
  - Design and Engineering
  - Land Acquisition
  - Construction
  - Reconstruction/Rehabilitation
  - Preservation/Routine Maintenance
  - Remaining Asset Value (end of analysis period)
- **User Cost/Benefit**
  - Delay/Time Saving
  - Crashes/Avoided Crashes
  - Vehicle Operating Costs
- **Externalities**

Roadway User Costs Components

Definition

Costs to highway users over the life of a Highway Project

Components

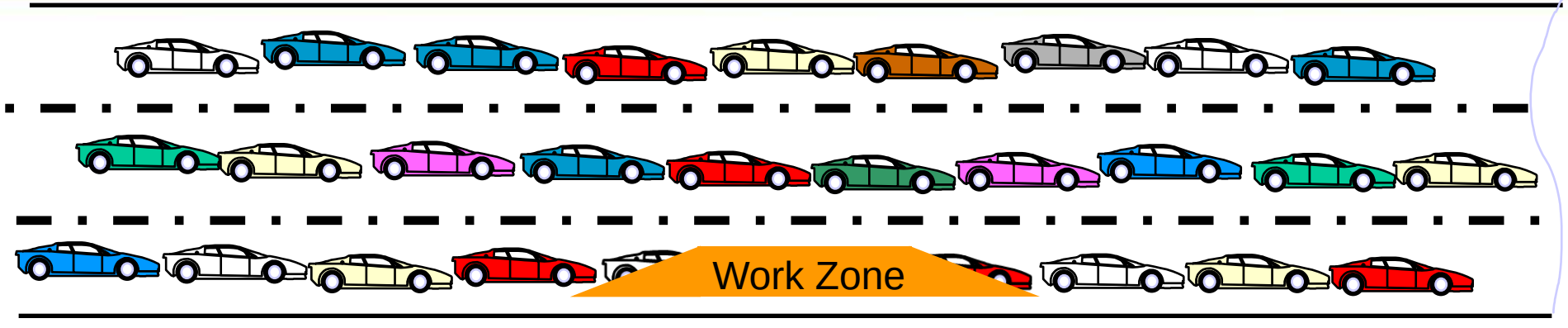
- **Delay Costs** – Costs associated with an increase (or decrease) in the amount of time it takes for a user to travel from point A to B. (In our case, navigating through or around a work zone)

- **Vehicle Operating Costs** – Costs attributable to the operation or maintenance of a vehicle(brake wear, idling, fuel consumption, tire ware, etc.)
- **Crash costs**-Cost resulting from property damage, injuries, or loss of life

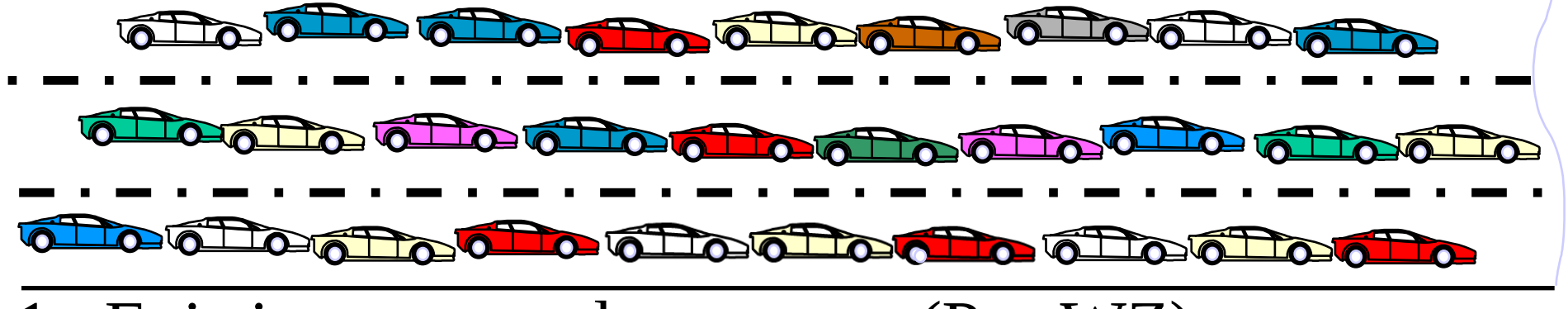
Comparing Work Zones Strategies

- Each construction/WZ strategy involves tradeoffs
  - Agency vs. user costs
  - Initial vs. long-term costs
- An analysis of roadway user costs permits comparison of cost tradeoffs

WZ Impacts

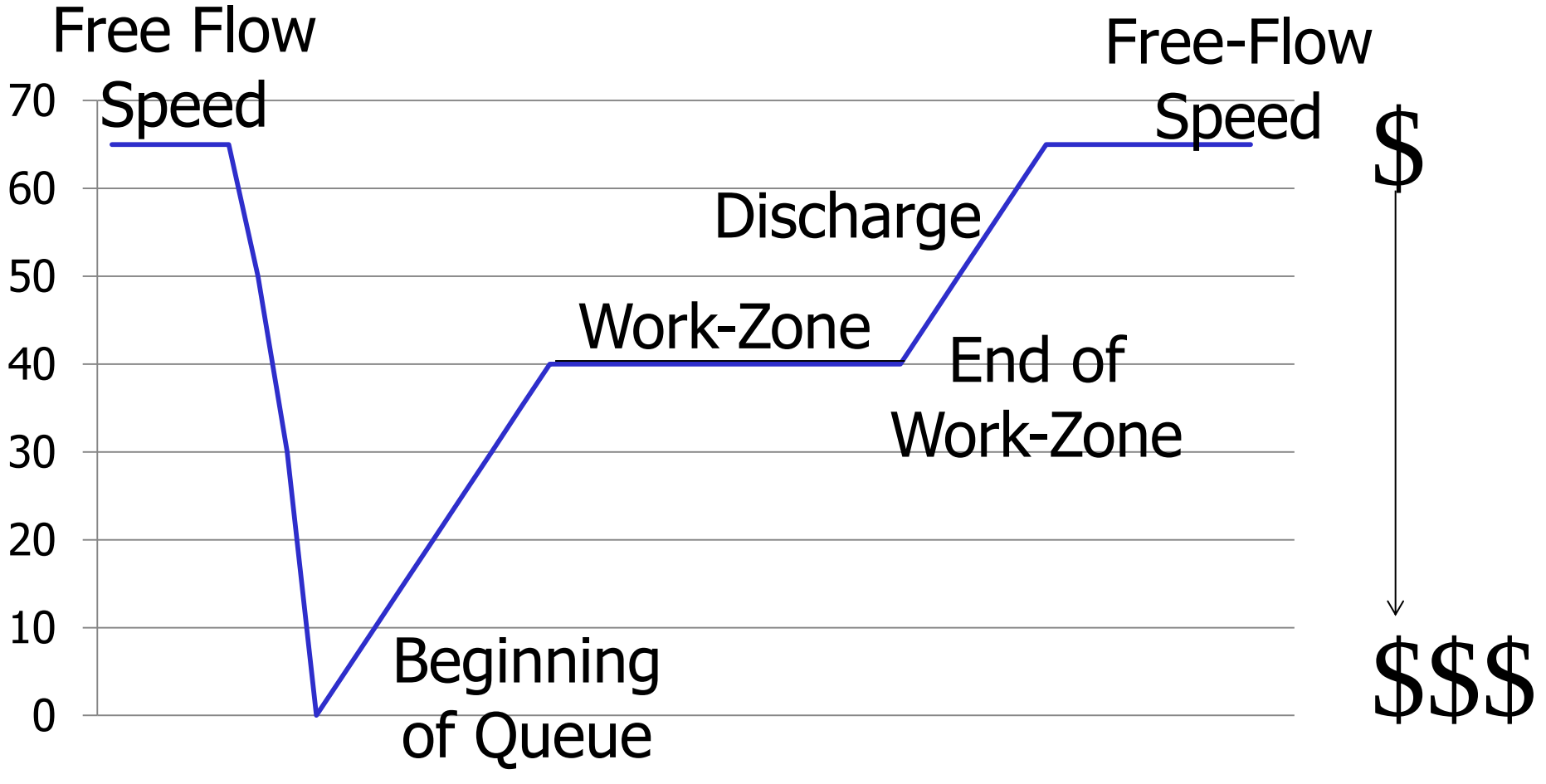


1. Existing Costs on construction Route(Pre-WZ)
2. Additional Costs from WZ



1. Existing cost on detour route(Pre-WZ)
2. Additional Costs of detoured traffic on Detour Route

Conceptual Work-Zone impact on travel speed



Comparing Benefits To Costs

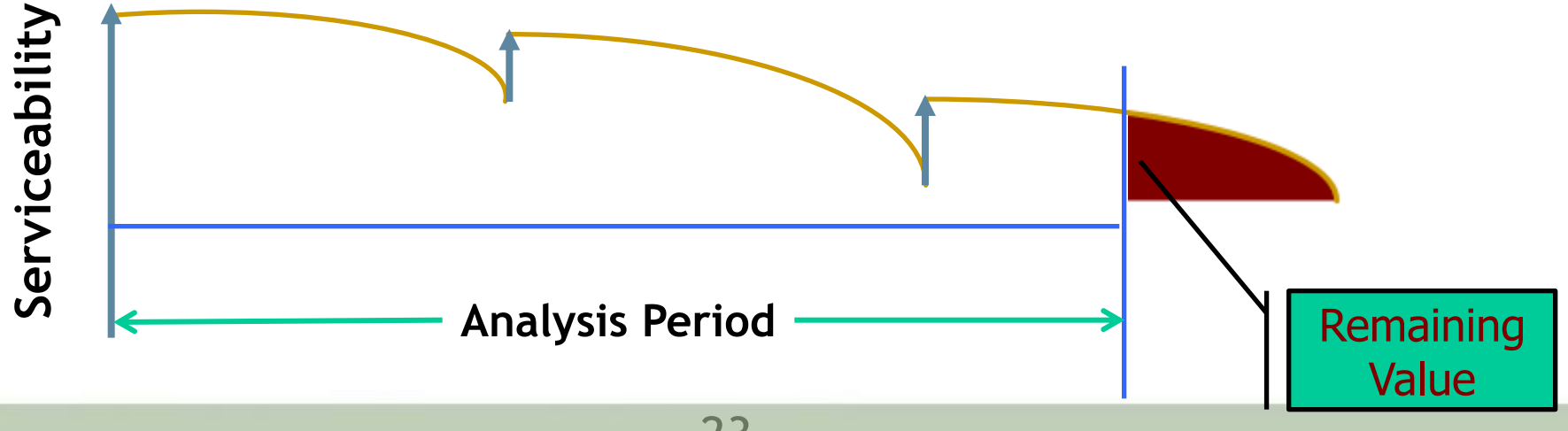
Different BCA Measures

- Net Present Value (NPV)
- Other measures include:
  - Equivalent Uniform Annual Value (EUAV)
  - Internal Rate of Return (IRR)

Remaining Value

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

- Accounts for end-of-analysis period "differences" between alternatives
- Removes economic bias between alternatives



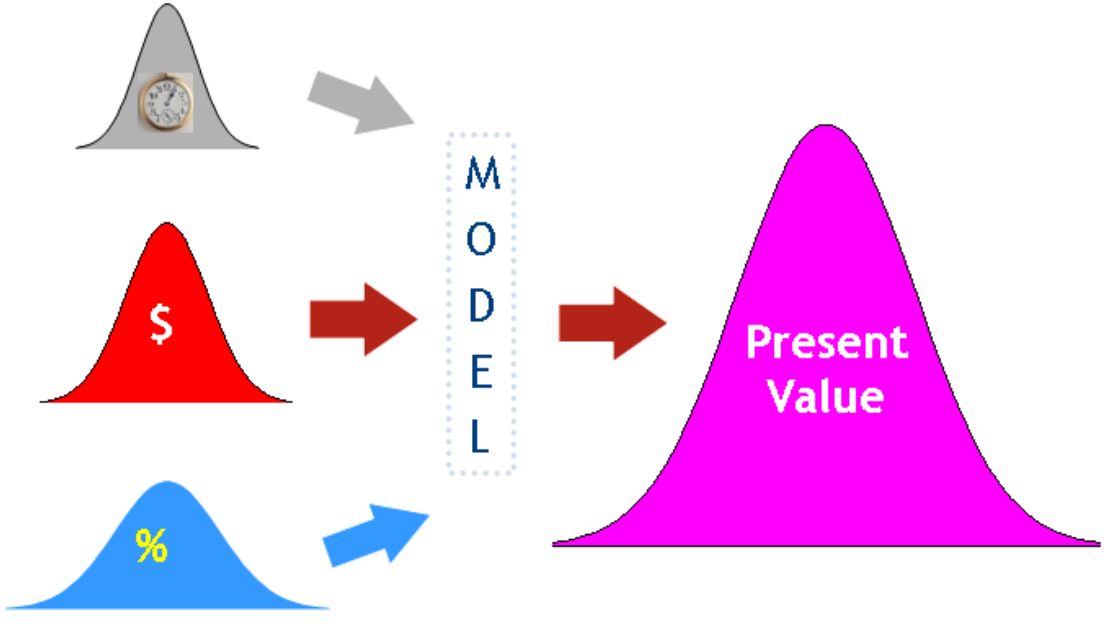
Salvage Value

The value of recovered or recyclable materials

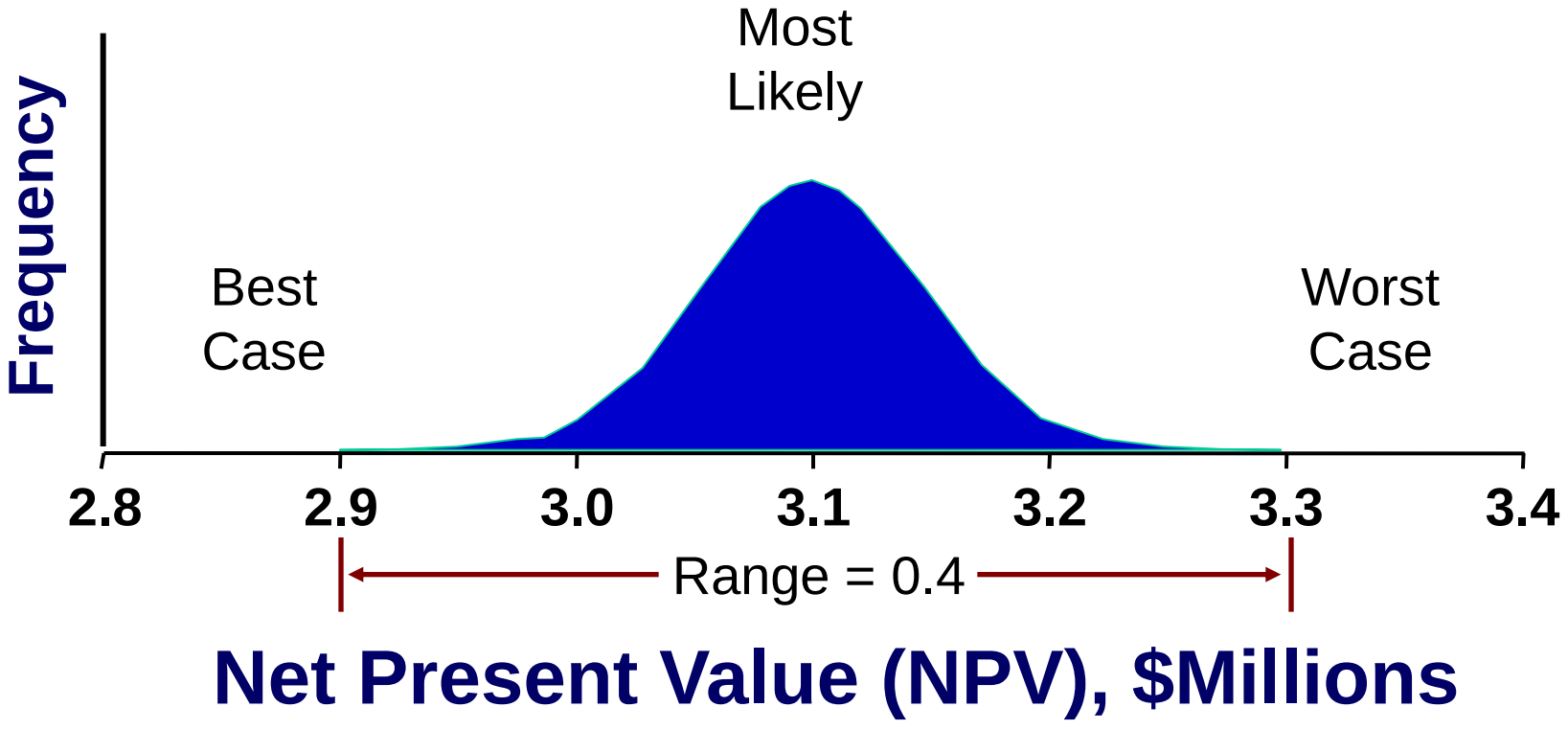
- Assumes material is removed from service at the end the analysis period
- Salvage value is only realized when materials are actually reclaimed

Probabilistic Analysis

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



Simulation Results: Histogram



Comparing BCA and EIA Metrics

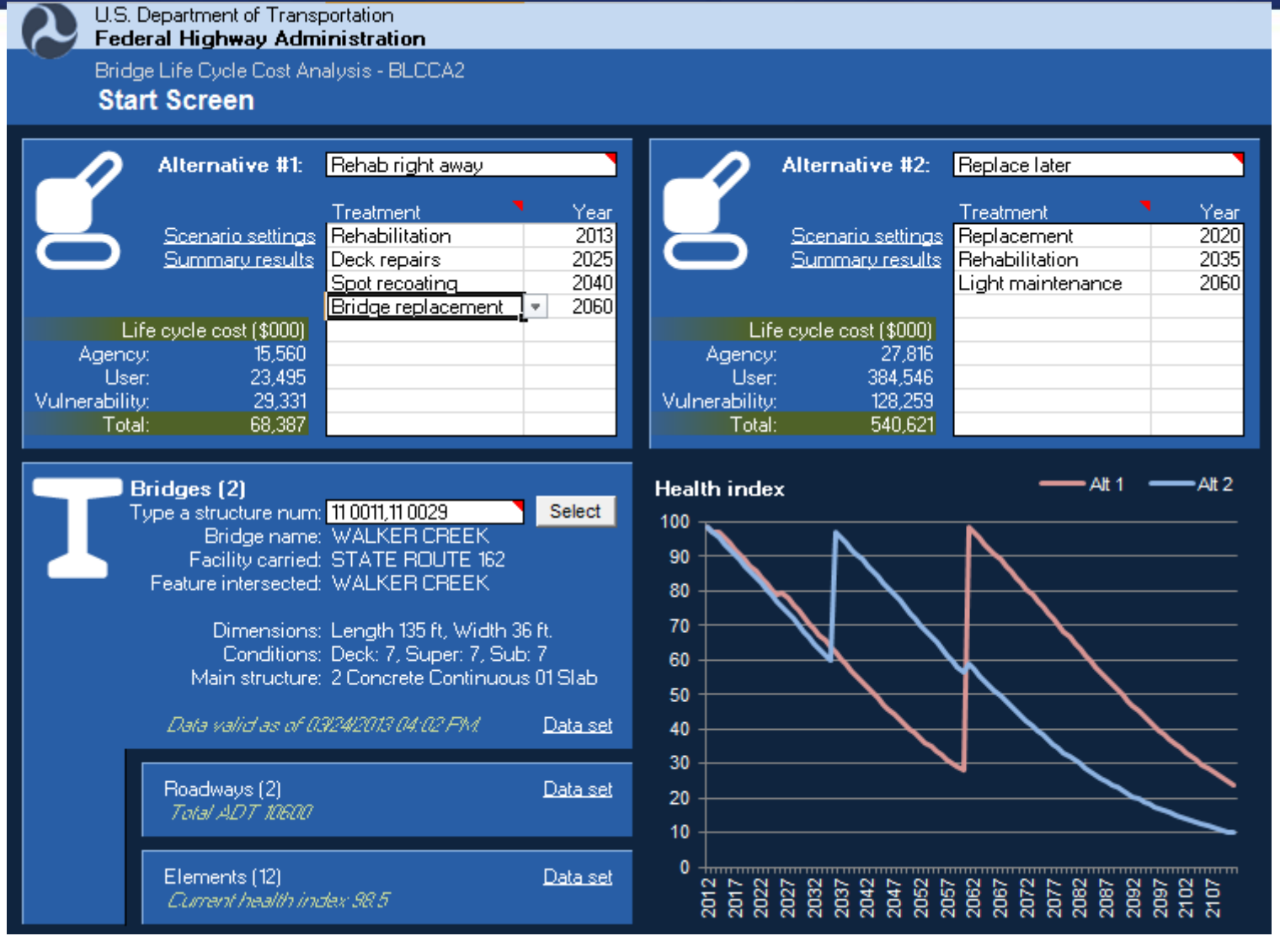
Metric	BCA/LCCA	EIA(NEPA)
User Benefits	✓	
Societal Benefits	✓	
Net Benefits	✓	
Jobs		✓
Income		✓
GDP		✓

Economic Analysis Tools

Tools to assist organizations with economic analysis

- **BLCCA 2**(NCHRP 483 Software Revamped)
- **NBIAs:** network level pavement needs assessment tool
- **FHWA Division Bridge Engineer:** Simple spread sheet in their Bridge Manual

BLCCA2 –Project Level



BLCCA2 –Project Level

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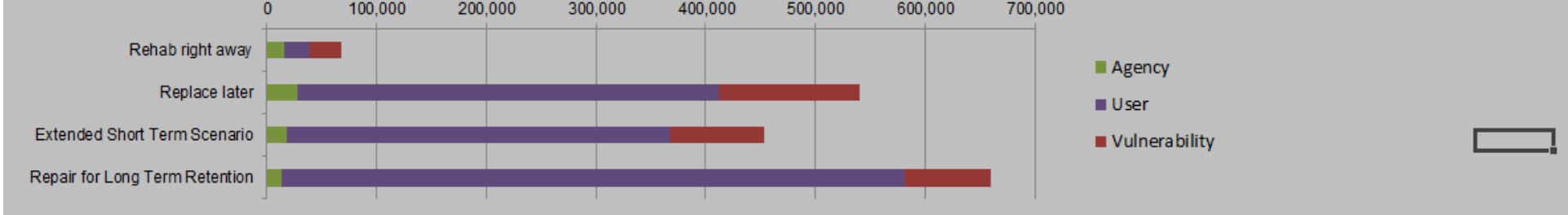
Bridge Life Cycle Cost Analysis - BLCCA2

Main

Scenario description: Pattullo Bridge Draft Assessment
Bridges included: 11 0011,11 0029

Total present value of life cycle cost ($000)



Summary	Present value life cycle costs ($000)				Health	Remarks
Alternative	Agency	User	Vulnerability	Total	Index	
Rehab right away	15,560	23,495	29,331	68,387	23.7	
Replace later	27,816	384,546	128,259	540,621	9.9	
Extended Short Term Scenario	18,854	348,399	85,643	452,896	3.7	
Repair for Long Term Retention	13,511	567,713	78,426	659,650	3.7	

Annual forecast for ALT1 Rehab right away

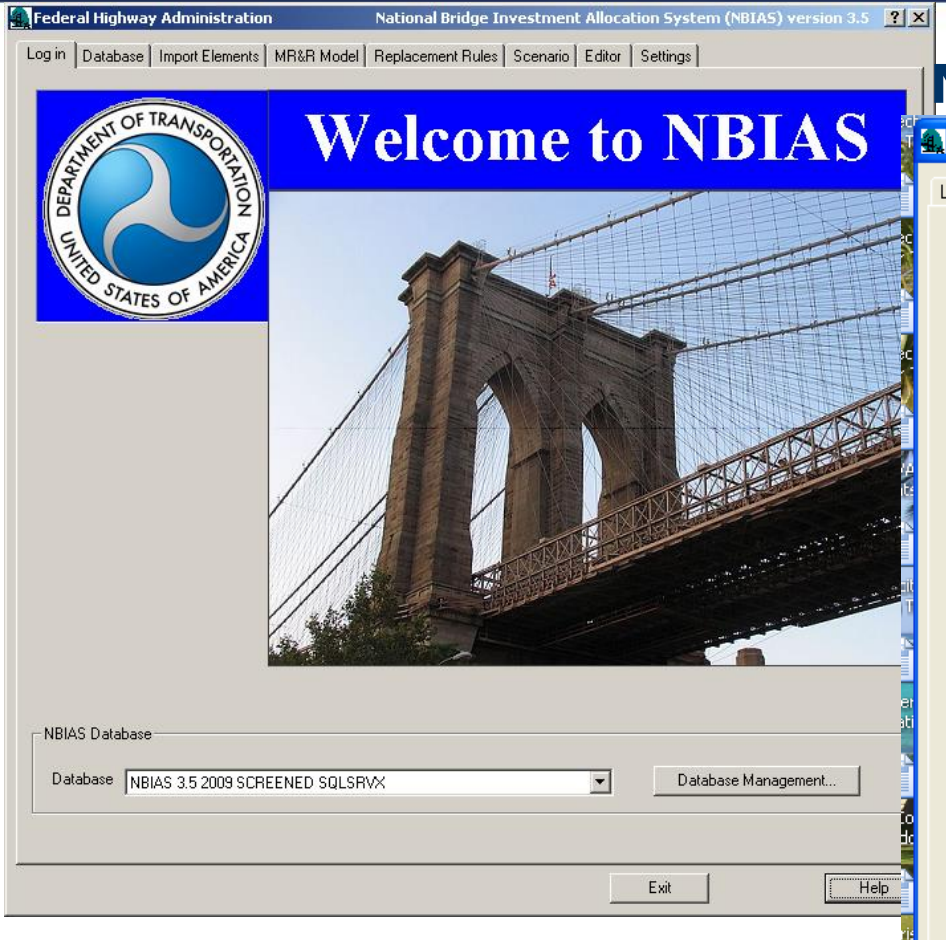
Life cycle costs ($000)

	ADT	ADT	ADT	Health	Load capy	Agency cost			User cost				
Year	On	Under	Total	index	(m ton)	Initial	Annual	Total	Width	Height	Weight	Congest	Environ

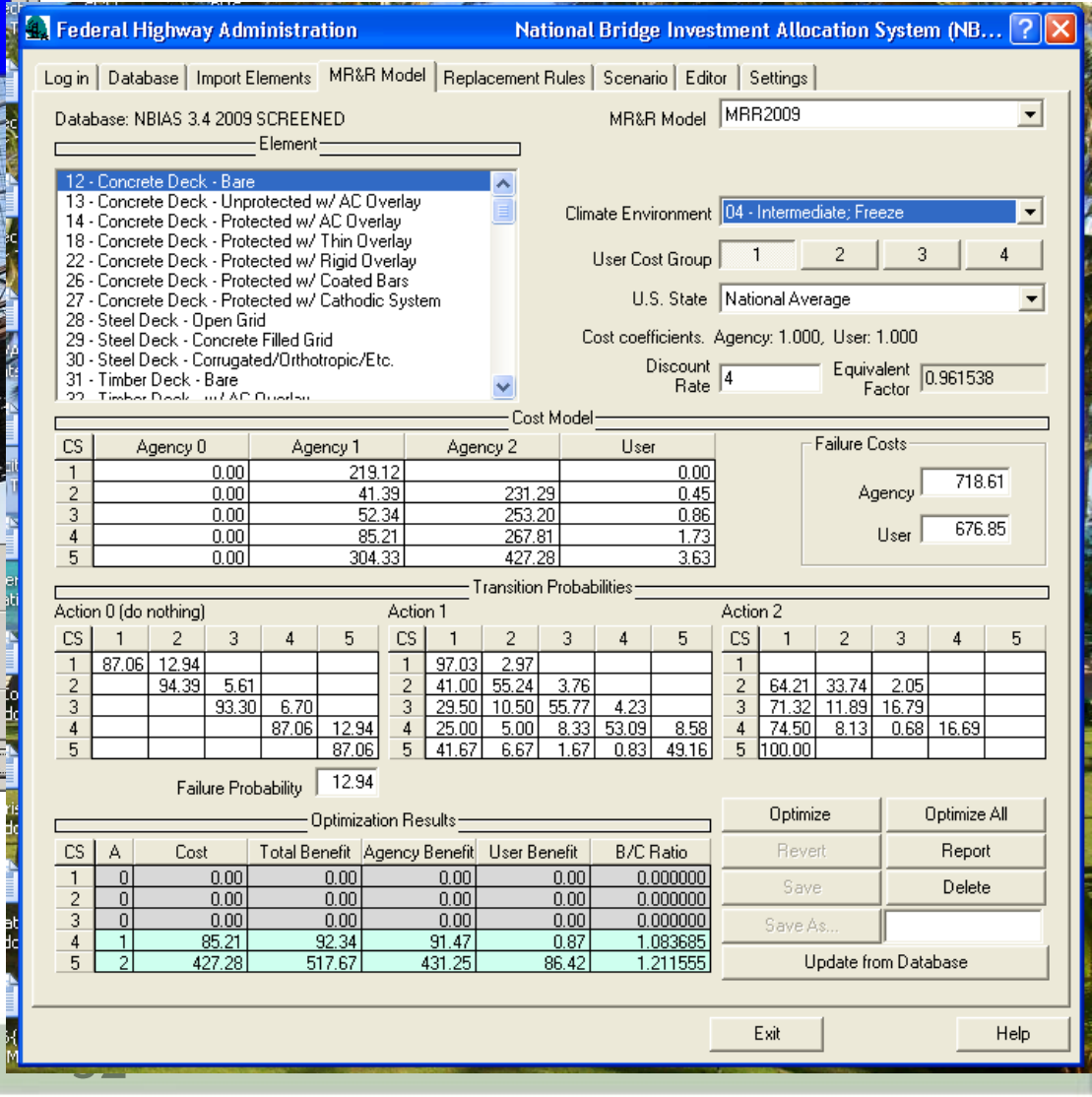
MAP-21

- Transportation Performance Management:
  - States will manage Their Networks so that no more than 10% bridges by deck are structurally deficient
  - Risk Based Asset Management Plan
  - Performance Targets
  - Progress Assessment Reports
  - States & MPOs
- Element Inspections
- Management Systems
- Value Engineering (LCCA Required for Bridges)

National Bridge Investment Analysis System(NBIAS)

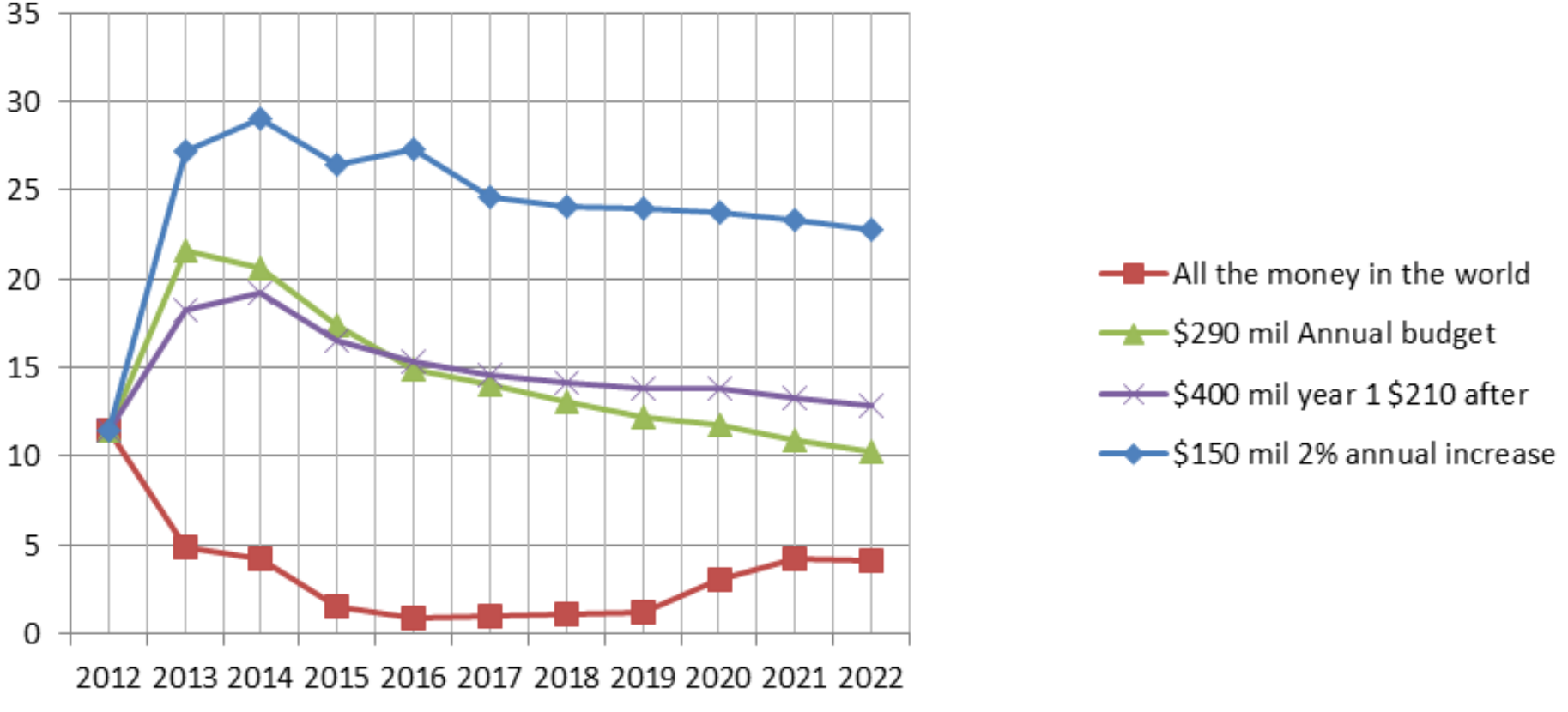


NBIAS: Element Transition Probabilities



NBIAS Risk Based Bridge Investment Analysis

Figure 2: Deck area percentage of structurally deficient bridges



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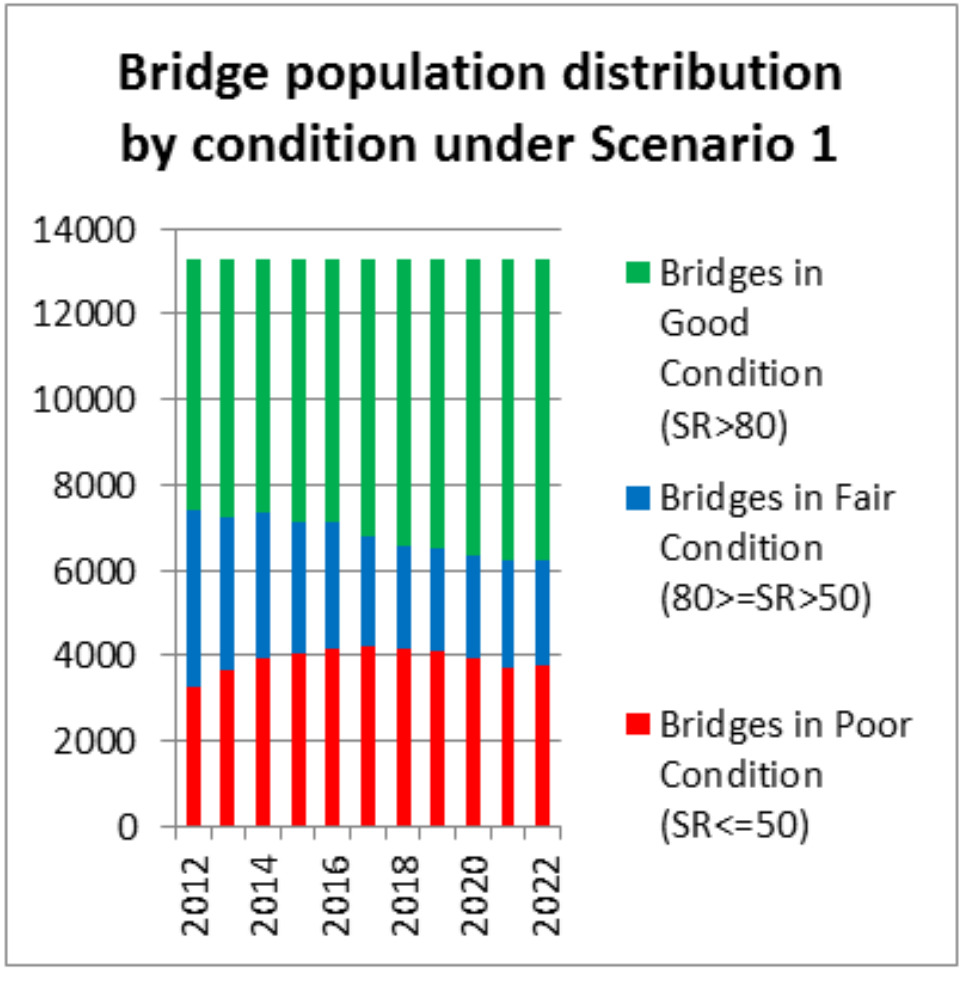

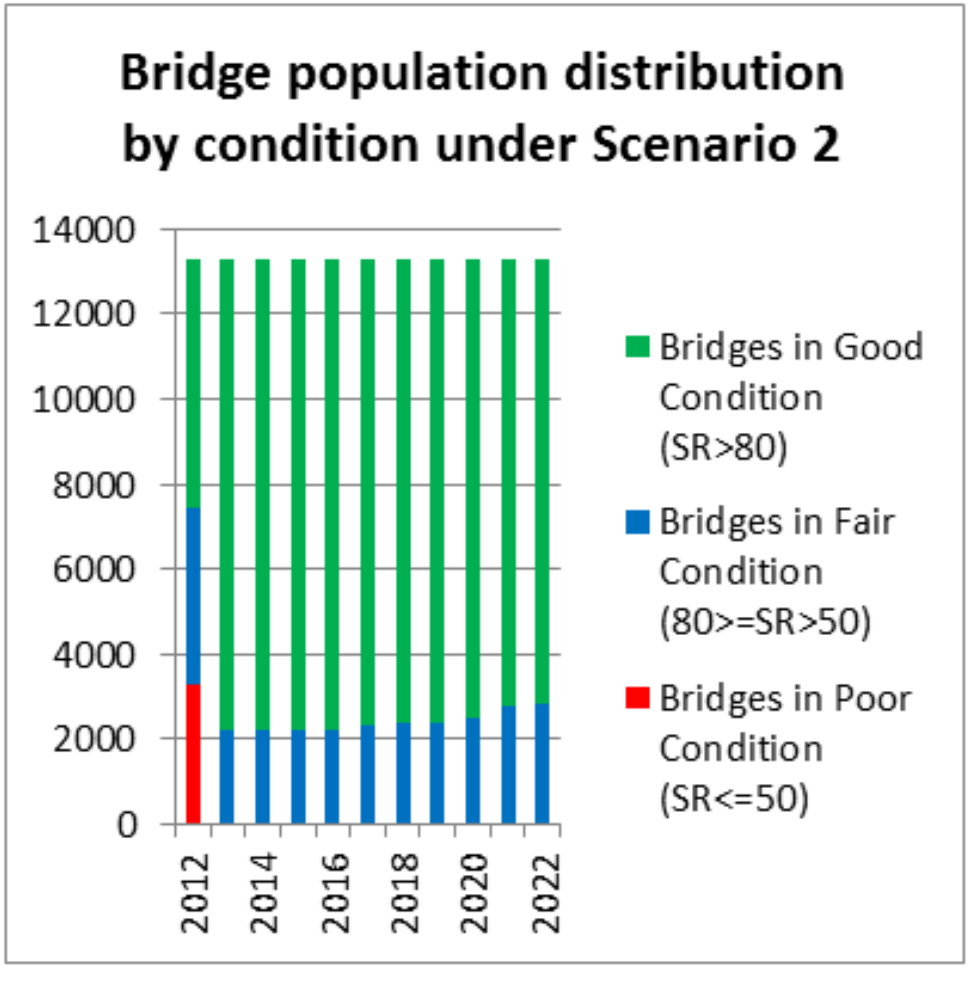

Thank You

Nathaniel D. Coley Jr.

FHWA

Washington, DC
NColey@dot.gov
202-366-2171

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