Benefit Cost Analysis

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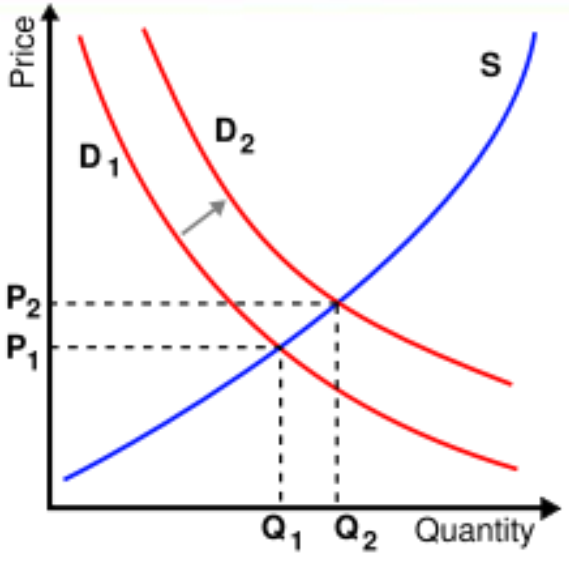
Agenda

- Economic Analysis and Asset Management
- Benefit Cost Analysis
  - Federal Activities
  - Guidance
- Existing Tools



Transportation Economic Analysis(Definition)

"Transportations Economic Analysis is the analysis of the design, construction, preservation, maintenance, and consumption of transportation assets and services and the impact of those activities on direct and indirect users and the environment."

Nat Coley

Economic Analysis Supports the Vision

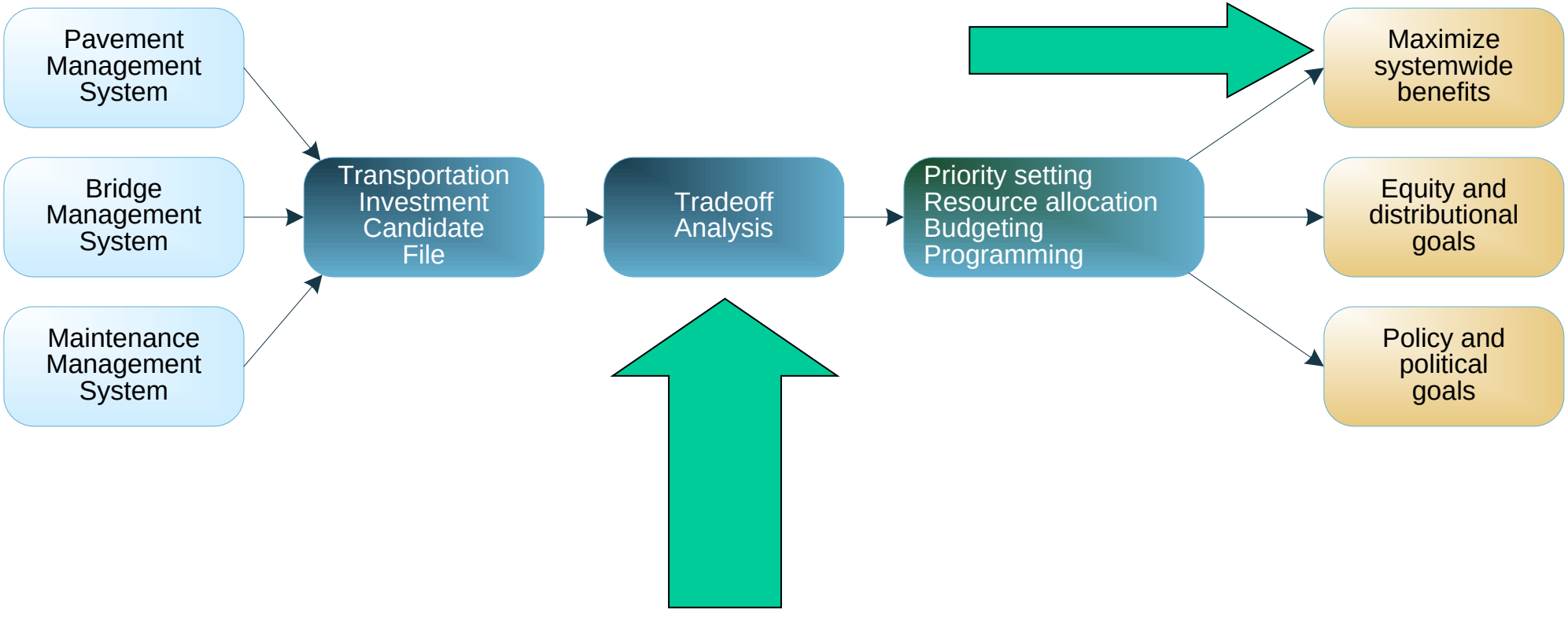
- We maintain, upgrade, and operate our transportation assets to meet or exceed the needs of our transportation users for the long term.
- We seek to link user expectations and needs for system condition, performance, and availability with system management and investment strategies over an extended time horizon.

Asset Management Principles

1. **POLICY DRIVEN** – decisions reflect policy goals and objectives that define desired system condition and service levels
2. **PERFORMANCE BASED** – clear measures of performance and target service levels are established
3. **OPTIONS EVALUATED** – comprehensive choices and tradeoffs are examined at each level of decision-making
4. **DECISIONS BASED ON QUALITY INFORMATION** – management systems and tools are used
5. **CLEAR ACCOUNTABILITY** – performance results are monitored and reported

Leveraging BCA to Support Policies

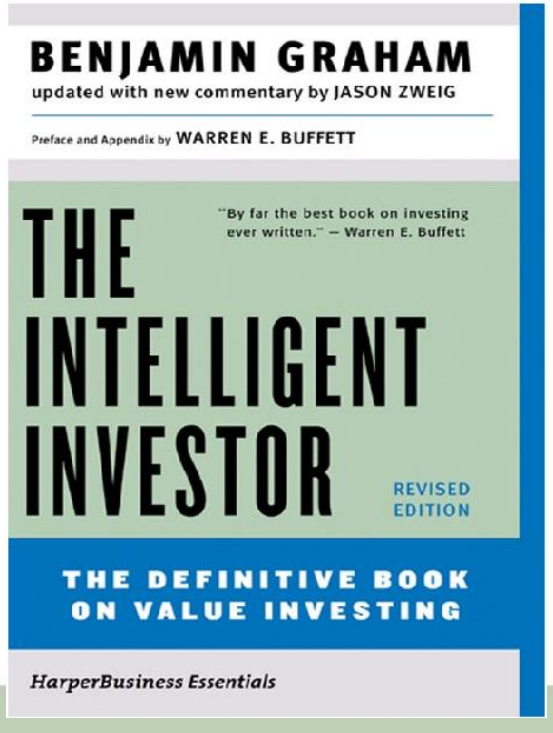
Transportation Asset Management Guide:Vol.2 A Focus on Implementation (Chapter 5)



New Transportation Bill

National Surface Transportation Policy and Revenue Study Commission recommends:

"…Federal funding that is **performance-based** and focused on **cost-beneficial outcomes** with accountability for the full range of economic, environmental, and social costs and benefits of investments;"



FHWA Economic Analysis Activities

- Code of Federal Regulations Section 650 Various bridge projects require a Benefit Cost Analysis
- Section 627 Value Engineering – Projects over $25 million "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. "

FHWA Economic Analysis Activities

- Section 450.320- Identification and evaluation of the anticipated **performance and expected benefits** of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems based on the established performance measures.
- Also Section 450 –"all of the reasonable alternatives under consideration must be fully evaluated in terms of their transportation impacts; capital and operating **costs; social, economic, and environmental impacts**; and technical considerations" The benefit cost analysis model also assists practitioners develop reports required specifically by various National Environmental Policy Act(NEPA) requirements

FHWA Economic Analysis Activities

- US Code Title 23 Section §101 –Projects of National and Regional Significance: COMPETITIVE GRANT SELECTION AND CRITERIA FOR GRANTS.

  ii. to reduce congestion, including impacts in the State, region, and Nation;

  iii. to improve transportation safety, including reducing transportation accidents, injuries, and fatalities

- Grants for Transportation Investment Generating Economic Recovery(T.I.G.E.R.) requirements

FHWA Economic Analysis Activities

- The Transportation Infrastructure Finance and Innovation Act (TIFIA)
- Engineering Economic Analysis Practices for Highway Investment (NCHRP 20-05/Topic 41-03)
- FHWA's Office of Operations Technology Services Developing a Benefit-Cost Analysis desk reference to assess investments in management and operations
- BCA in Freight

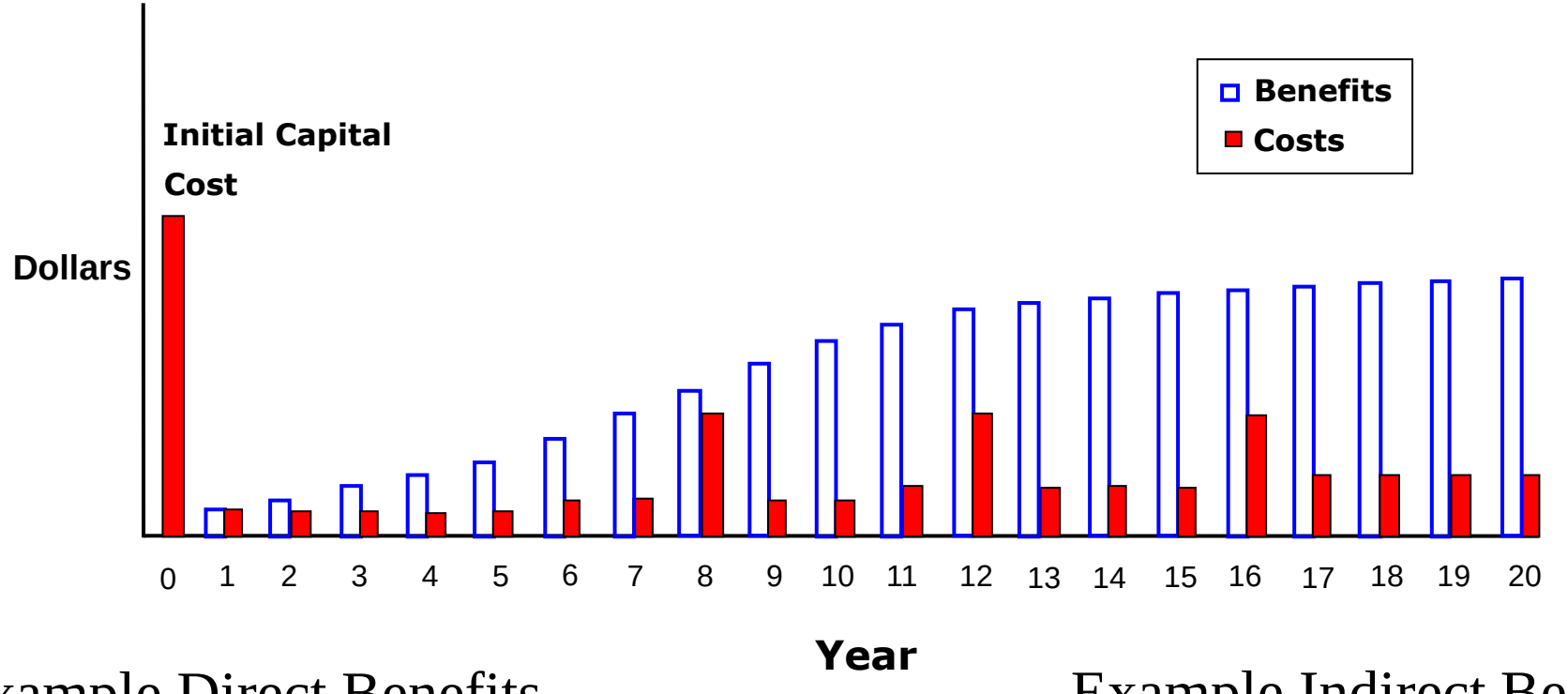
Benefit Cost Analysis

"Benefit Cost Analysis is a calculation of the stream of both benefits and costs over the lifetime of the facility or strategy."

FHWA Procedural Guidelines
for Highway Feasibility Studies

Status of Economic Analysis – FHWA Guidance

Typical Life-Cycle Profile



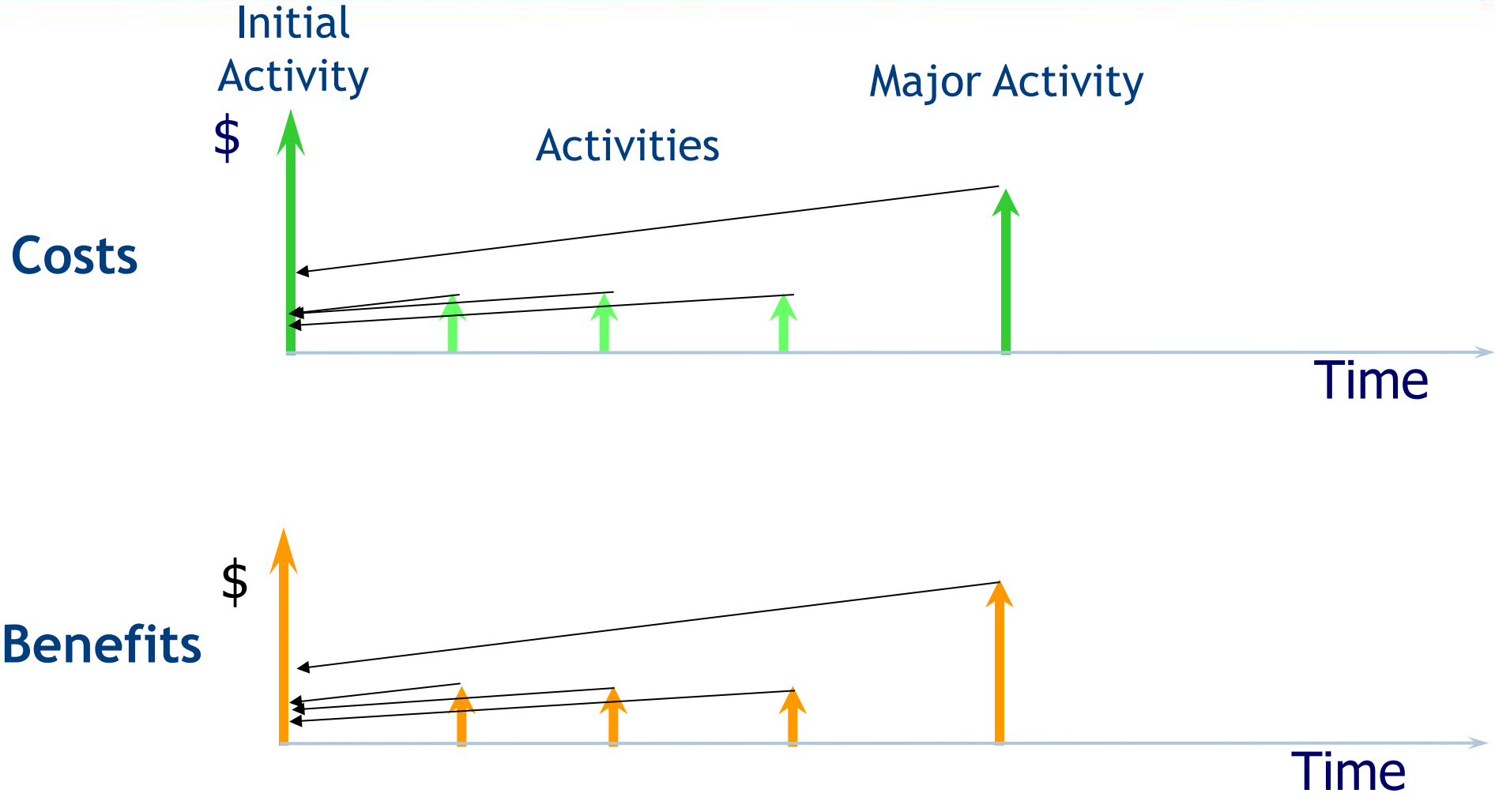
Example Direct Benefits

- Reduced Accident Costs
- Reductions in Delay Costs
- Reduced noise or emissions

Example Indirect Benefits

- Land use impacts
- Employment
- Non-user benefits

Calculate Present Values of Costs and Benefits



What is the present value of future sums?

Method

BCA Process

1. Define objectives
2. Specify assumptions
3. Identify base case and alternatives
4. Set analysis period
5. Define level of effort
6. Analyze traffic
7. Estimate benefits and costs
8. Evaluate risk
9. Compare net benefits and rank alternatives
10. Make recommendations

Status of Economic Analysis – FHWA Guidance

Recommended BCA Measures

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

User Costs in LCCA

User Costs in the LCCA are **differential** Costs resulting from periods of construction, preservation, and/or rehabilitation activities between the alternates that generally **restrict the capacity of the facility** and disrupt normal traffic flow .

User Cost Components

- Vehicle Operating Costs(VOC)
- Delay Costs
- Crash Costs

User Cost Components

- Vehicle Operating Costs (VOC)

  additional costs incurred by the vehicle for the additional speed changes, stops, miles for detours, hours of idling, etc. that are incurred because of work zone activities
- Delay Costs

  Value($) of time for each vehicle classification used in the LCCA
- Crash Costs

  the dollar value of the additional crash types attributed to the work-zone activities.

Calculating User Costs

User costs are

…based on **capacity flow analysis**.

…a **function of workzone impacts** for the M&R strategy that you select for maintaining the alternate designs.

…are directly dependent on the **volume and operating characteristics** of the traffic on the facility.

Status of Economic Analysis – FHWA Guidance

Risk and Uncertainty

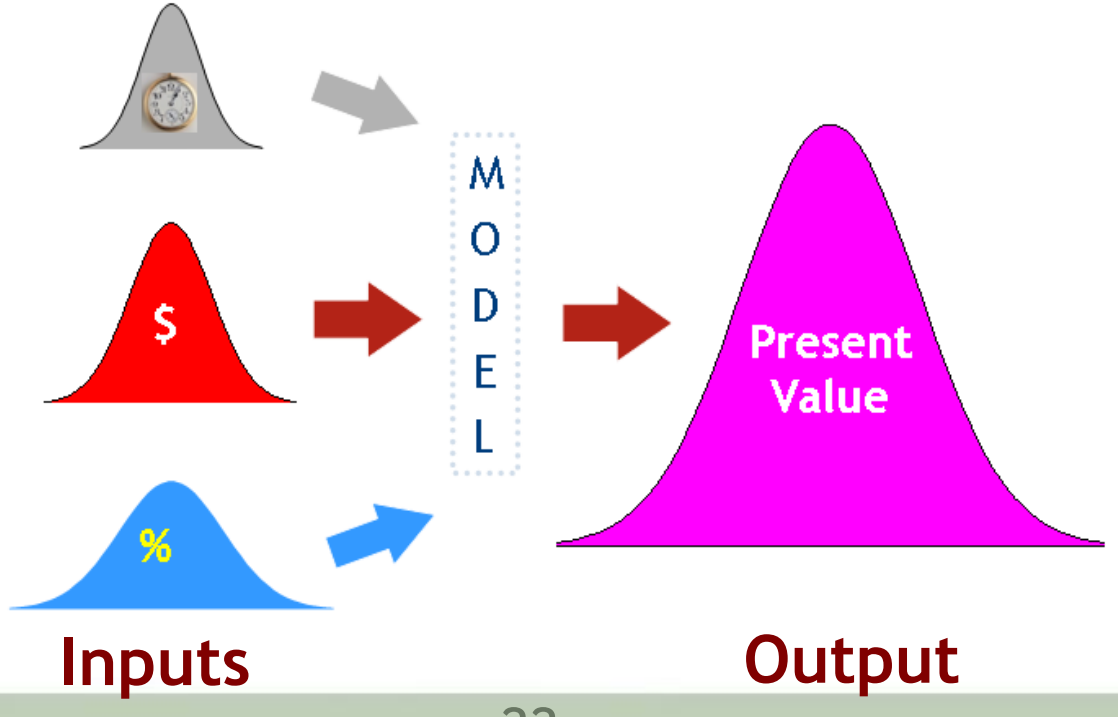
Boston Central Artery

1985-2007 $2.5 to $14+ Billion

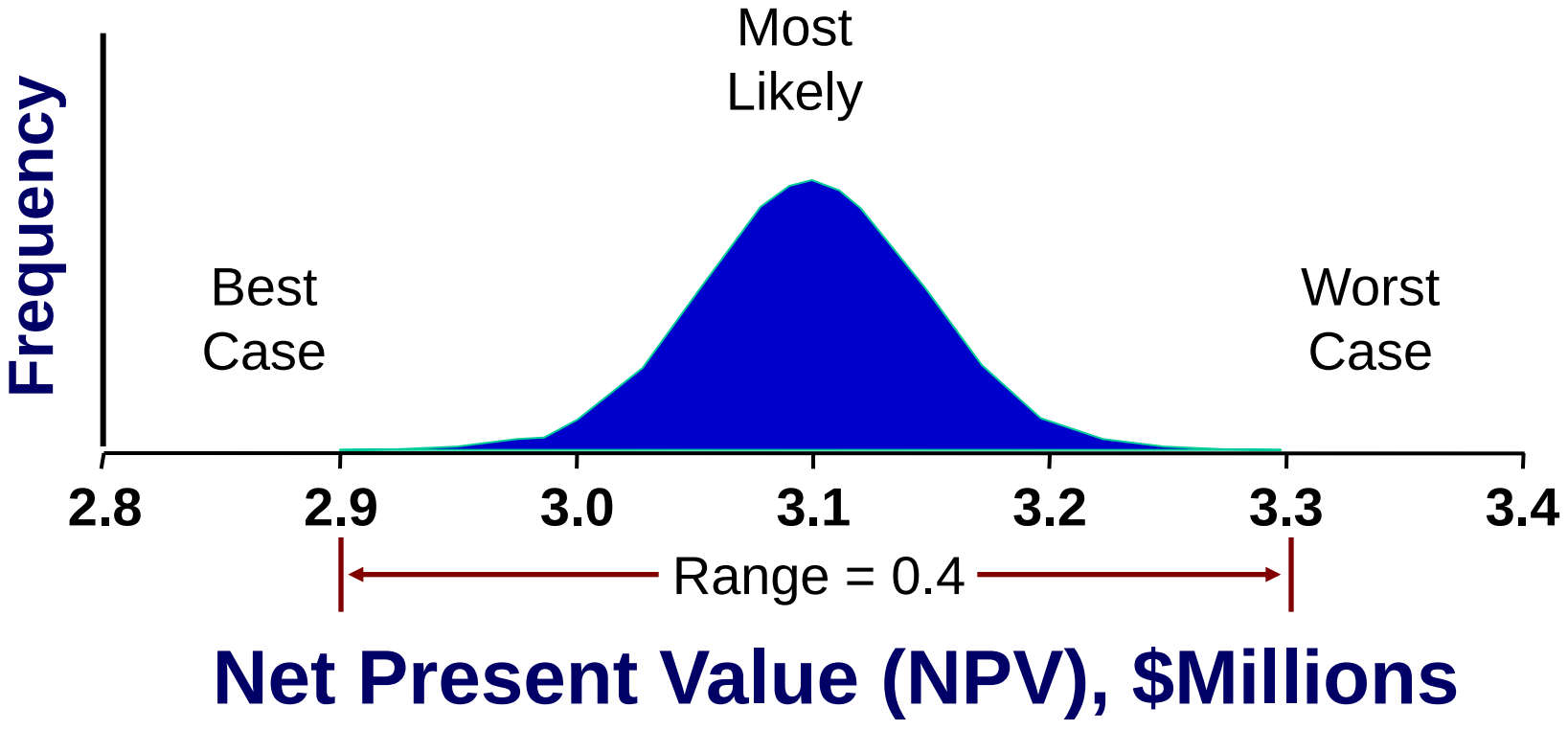
Status of Economic Analysis – FHWA Guidance

Probabilistic Analysis

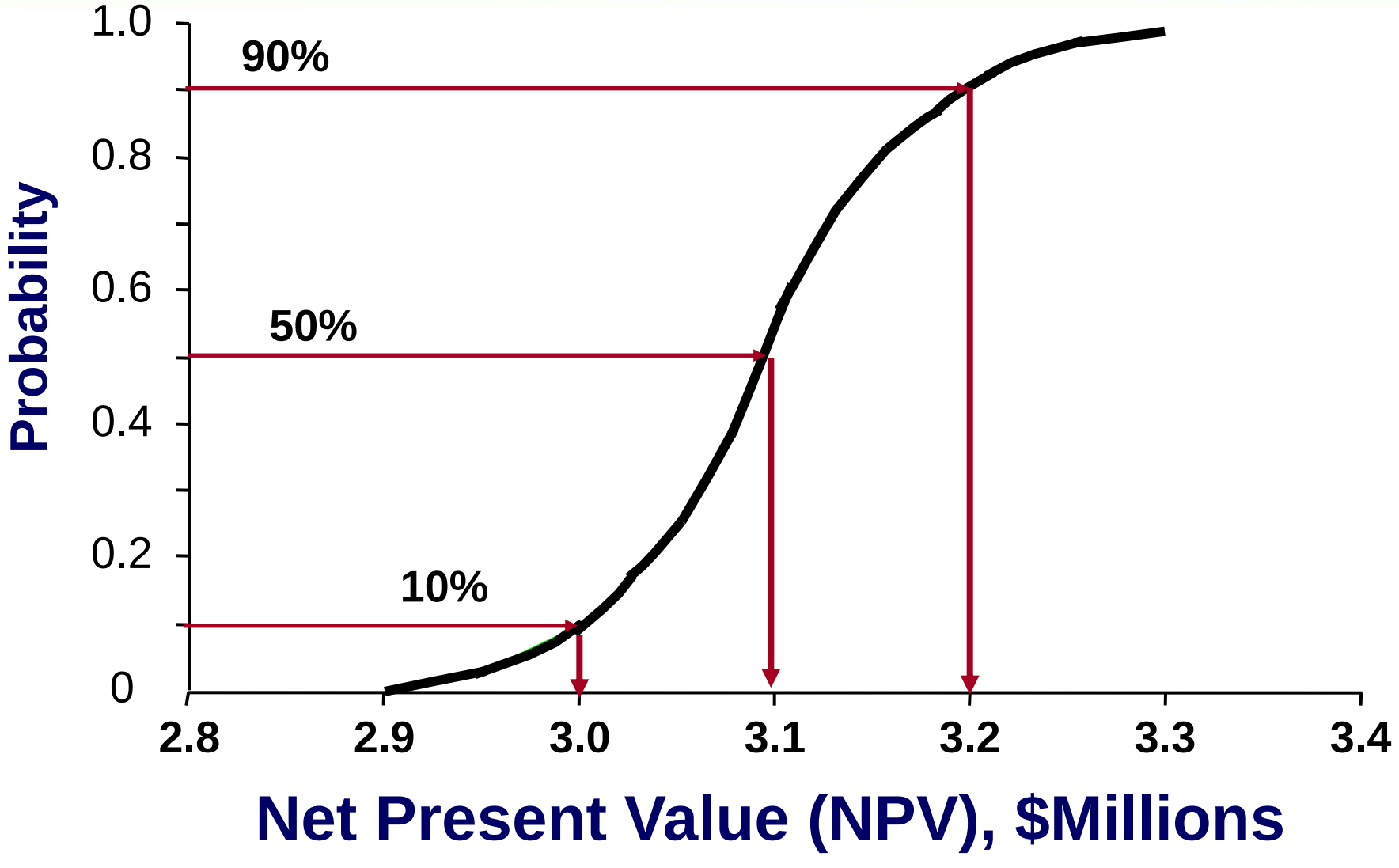
- Inputs are defined by their range of values and probability of occurrence (probability distribution)
- Through simulation, outputs are expressed as ranges of values with probabilities of occurrence



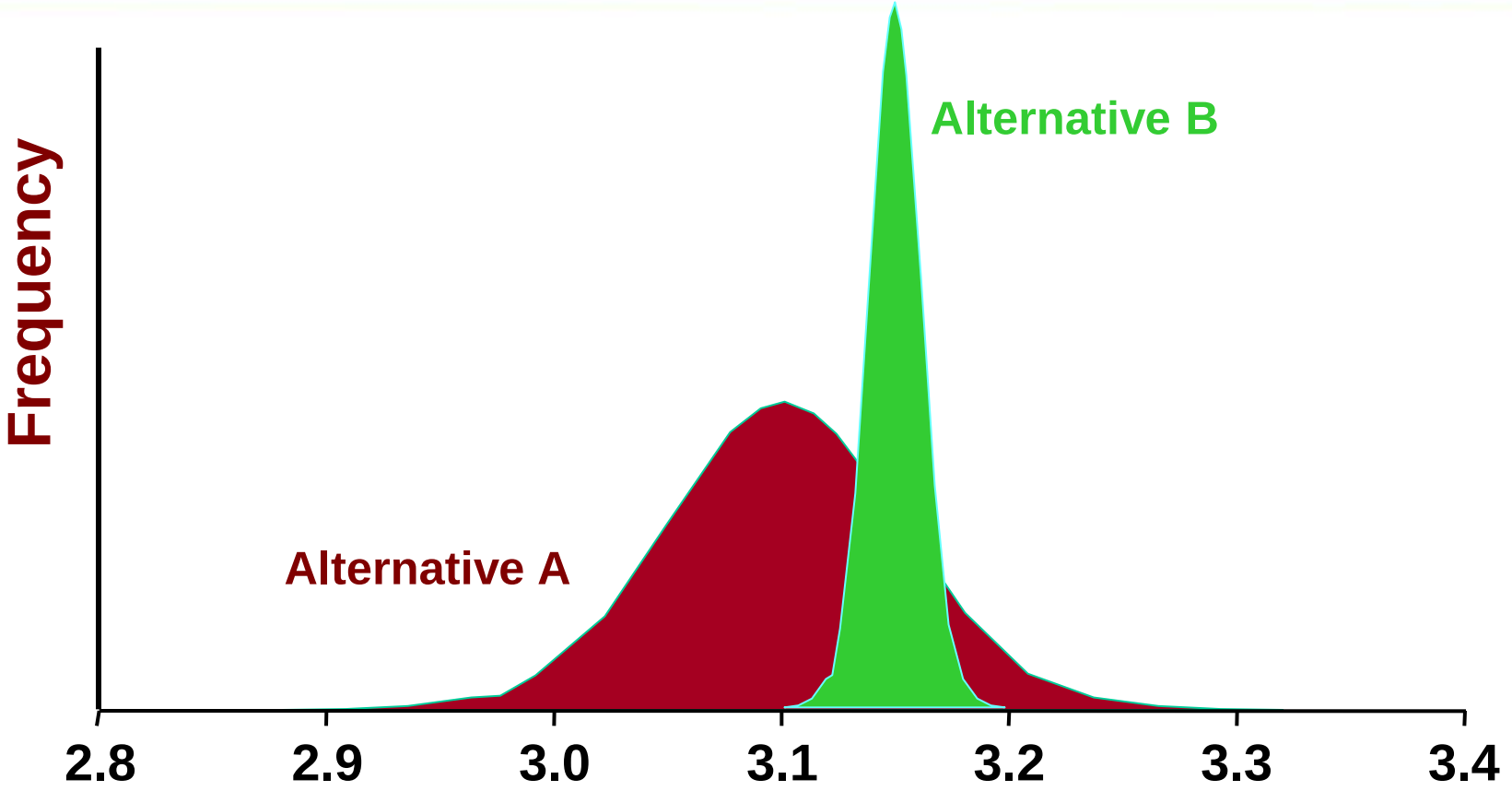
Simulation Results: Histogram



Results: Cumulative Distribution

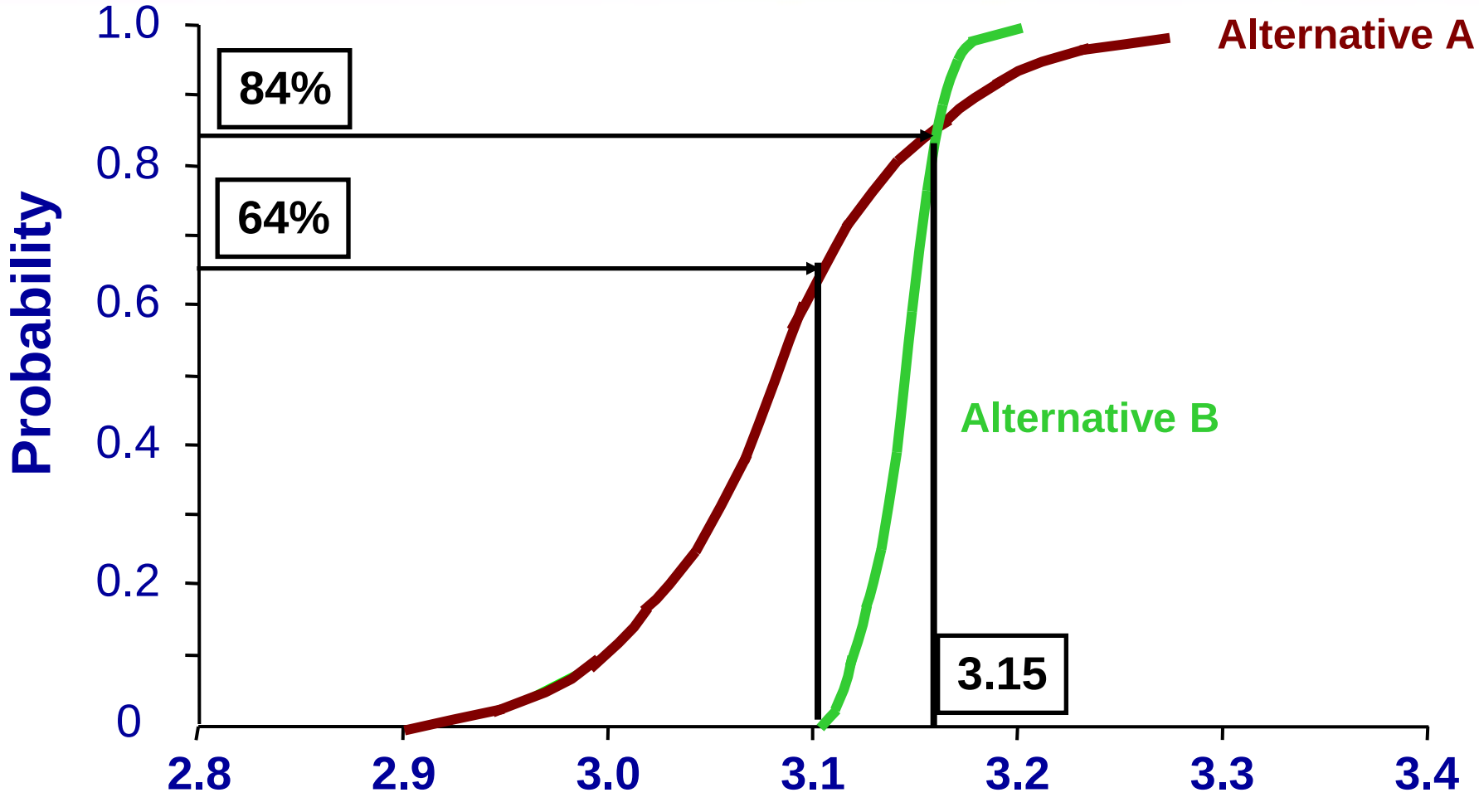


Comparing Alternatives



Net Present Value (NPV), $Millions

Comparing Alternatives



Status of Economic Analysis – FHWA Guidance

FHWA Economic Analysis Primer

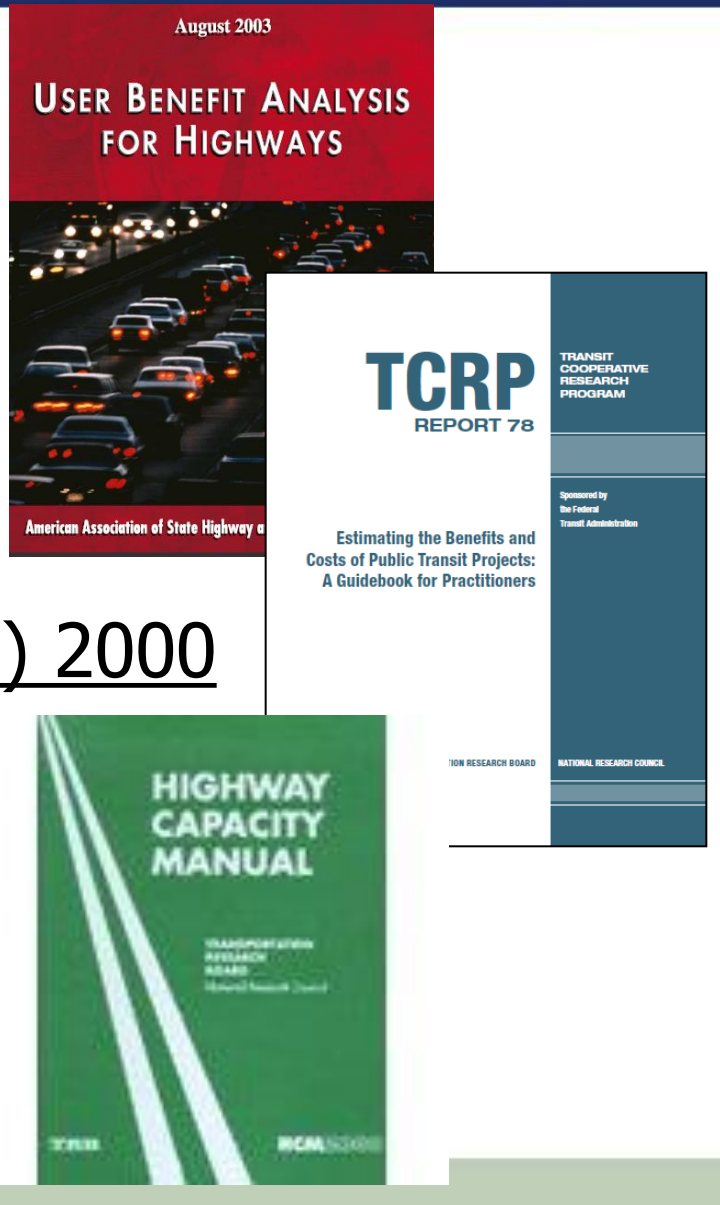
- Benefit Cost and Life-Cycle Cost Analysis Fundamentals and Steps
- Provides guidance, recommended values for discount rates and sources of indexes for inflation, values of user time.
- Discusses the consideration of forecasted traffic flows
- Provides guidance on BCA in NEPA

Status of Economic Analysis – FHWA Guidance

- Grants for Transportation Investment Generating Economic Recovery(T.I.G.E.R.) requirements (See Handout)
- Interchange Access Approval Information Guide
- FHWA Federal Guidelines for Highway Feasibility Studies: Economic Justifications are based on BCA
- Office of Secretary of Transportation(OST) Value of time and value of life guidance
- Office of Management and Budget Circular A-94 Guidance on Discount Rates

BCA.net and BCA

- AASHTO Red Book
- Transit Cooperatice Research Program(TCRP) Report 78 Environmental Impacts
- Highway Capacity Manual(HCM) 2000 Developing Traffic inputs



Economic Analysis Tools: BCA.net

- web-based benefit-cost analysis tool
- develop strategies for improving and managing assets; evaluate & compare the benefits and costs of the alternative strategies; provide summary metrics for investment decisions.
- Calculates the traffic impacts and the present values of agency and user costs and externalities for the base case & alternative then compares them to arrive at measures including the net present value, benefit-cost ratio, and internal rate of return

Economic Analysis Tools: BCA.net

- Allows for multi-phased, multi-year programs of preservation or improvements enabling a lifecycle comparison of alternate strategies.
- Enables the analysis of a range of capacity improvement strategies including lane widening, adding lanes and reversible lanes for roadways with skewed directional flows.
- Models traffic conditions for multiple "representative days" to describe forecast facility use.
- Evaluates interchange/intersection improvements including the replacement or introduction of traffic control devices and signals.
- Accounts for the effects of roadway conditions on trip cost and, in turn, the impact of trip cost changes on travel demand.

Economic Analysis Tools: BCA.net

- Has a full-featured risk analysis capability.
- Models and calculates the life-cycle impacts on the environment
- Project Benefits Calculated by BCA.net include
  - Time savings – the reduction in travel time by users of the roadway
  - Vehicle Costs reductions – the reduction in expenditures by users on fuel, oil, tires, vehicle maintenance and depreciation
  - Safety – the reduction in casualties and property damage from roadway crashes.
  - Emissions (CO, NOx)

Economic Analysis Tools: BCA.net

U.S. Department of Transportation
Federal Highway Administration

BCA.Net Highway Project Benefit-Cost Analysis System
Office of Asset Management

Navigation Bar and Menu (Ctrl+1) ==> ›Manage ›Strategies ›Project ›Parameters ›Scenario ›Simulation **Results** ›Admin Help Logout

Current Settings ==> | **User: dbrod** | **Dataset: Initial** | **Project: US-88 Improvement Design Alt.1** | **Scenario: Base, with ranges** | **Results: US-88 Design**

Results: US-88 Design Alt. 1

Selected results data group: Benefit-Cost Summary Go

	Variable	Mean Value	Standard Deviation
View	Travel time savings, thous. PV$	88.3	14.82222
View	Vehicle operating cost savings, thous. PV$	77.2	9.594951
View	Safety benefits, thous. PV$	-2.9	0.4961381
View	Environmental benefits, thous. PV$	0.0	0
View	Project residual value, thous. PV$	121.1	7.057887
View	Disbenefit of traffic disruption from construction, thous. PV$	0.0	0
View	Total benefits, thous. PV$	283.8	24.80117
View	Of this, benefits to new users, thous. PV$	0.0	0.004338904
View	Total costs, thous. PV$	1129.7	51.36357
View	Net benefits, thous. PV$	-846.0	46.4683
View	Benefit-cost ratio	0.25	0.01990146
View	Rate of return, percent	-6.19	0.5805153

BCA.Net – User Interface

Format the data set that we will be analyzing

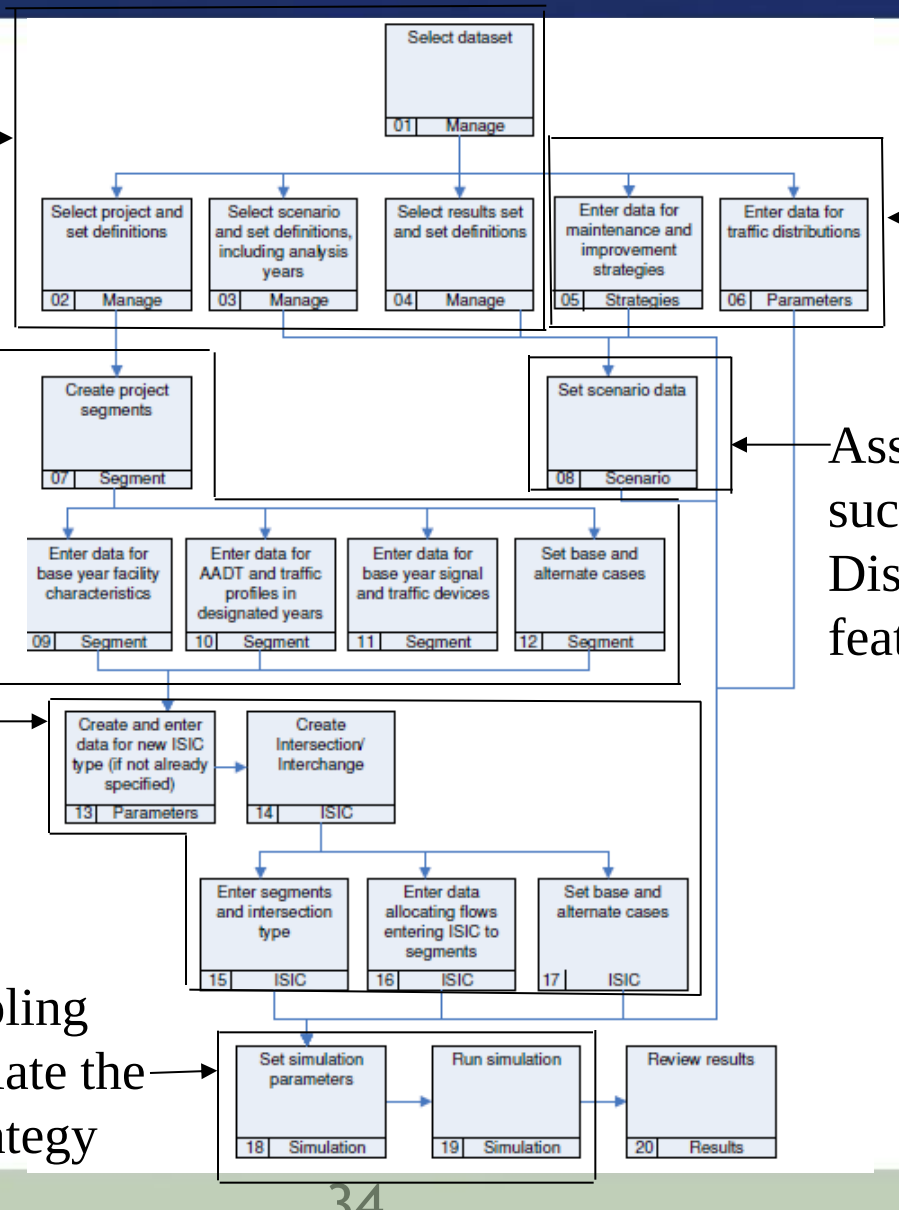
Define the base case values for traffic stream, input forecasts and assign our available strategies

Specify the Distribution of traffic streams, delay times for interchange/intersection Parameters

Specify our sampling routine and simulate the effects of our strategy

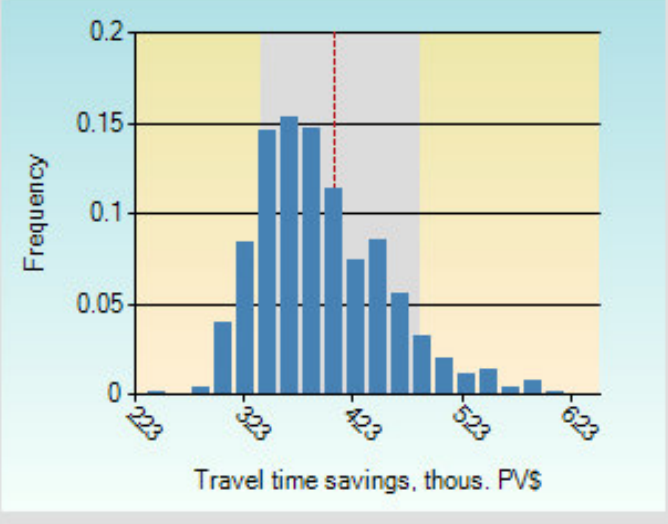
How we plan to meet the objective of the project and specify the effects

Assign Values inputs such as User costs, Discount Rate, set risk features of input values



Economic Analysis Tools: BCA.net

Variable: Travel time savings, thous. PV$



Summary Statistics	
Mean	405.4258
Std. Deviation	60.23414
Minimum	243.0547
Maximum	649.5156
Skewness	0.8867129
Kurtosis	0.9656861

Percentiles	
1%	308.9688
5%	327.6875
10%	339.2188
20%	354.5313
30%	367.8281
40%	381.5
50%	394.7969
60%	408.625
70%	428.2656
80%	453.125
90%	484.0781
95%	520.3281
99%	596.9531

Select chart type: (•) Histogram ( ) Cumul ( ) De-cumul ( ) Tornado [Refresh] Bins: 20

The chart shows the probability distribution for the result variable.
For the Histogram, Cumulative and De-Cumulative Charts:
The shaded gray region of the chart is the 80% confidence interval.
The dotted red line is the mean value.
For the Tornado Chart
The bars show the percent change in the mean of the result when the input varies within its 80% confidence interval while the other inputs are held constant at their central value.

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

LCCA Process

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

Bridge LCCA Resources

- Bridge Life Cycle Cost Analysis(BLCCA)
  NCHRP Project 12-43

- Bridge Life-Cycle Cost(BLCC)
  National Institute of Technology(NIST)

- PONTIS and FHWA RealCost Software

- Webinar in February with example applications

BLCCA – NCHRP

- Defines the Bridge Using NBI Data
- Has costing models for bridge condition and load capacity
- Includes many costs for various bridge items
- Performs a sensitivity analysis
- Can't analyze individual elements

BLCC NIST

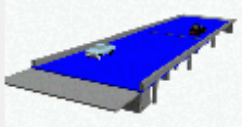
- Performs the LCCA per individual Bridge Components
- Can simulate randomness of variables through a probabilistic analysis(Monte Carlo Simulation)
- Incorporates detailed costs of workzones
- Does not provide detailed models for various costs

BridgeLCC(NIST)

- Analyzes preliminary design of highway bridges, roadways, piers, and other civil infrastructure
  - –includes sensitivity analysis, Monte Carlo simulations
  - –Includes FHWA CoRe Element System, user costs, probabilistic events, probabilistic costs, and exportable data and results.

BridgeLCC: Cost Summary

Cost Summary: HPC vs. Conventional Concrete Bridge



Inflation: 2.20% Real discount: 3.80%
Nominal: 6.08%

Current mode: Basic
Go Advanced | Set as default

Edit costs of alternatives

BC	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Conve (24)	HPC B (25)	<create>	<create>	<create>	<create>

Data
- Description
- Alternatives
- Assumptions
- Edit Costs
- Browse Costs
- Edit Events
- Event/Cost Map
- Image Gallery

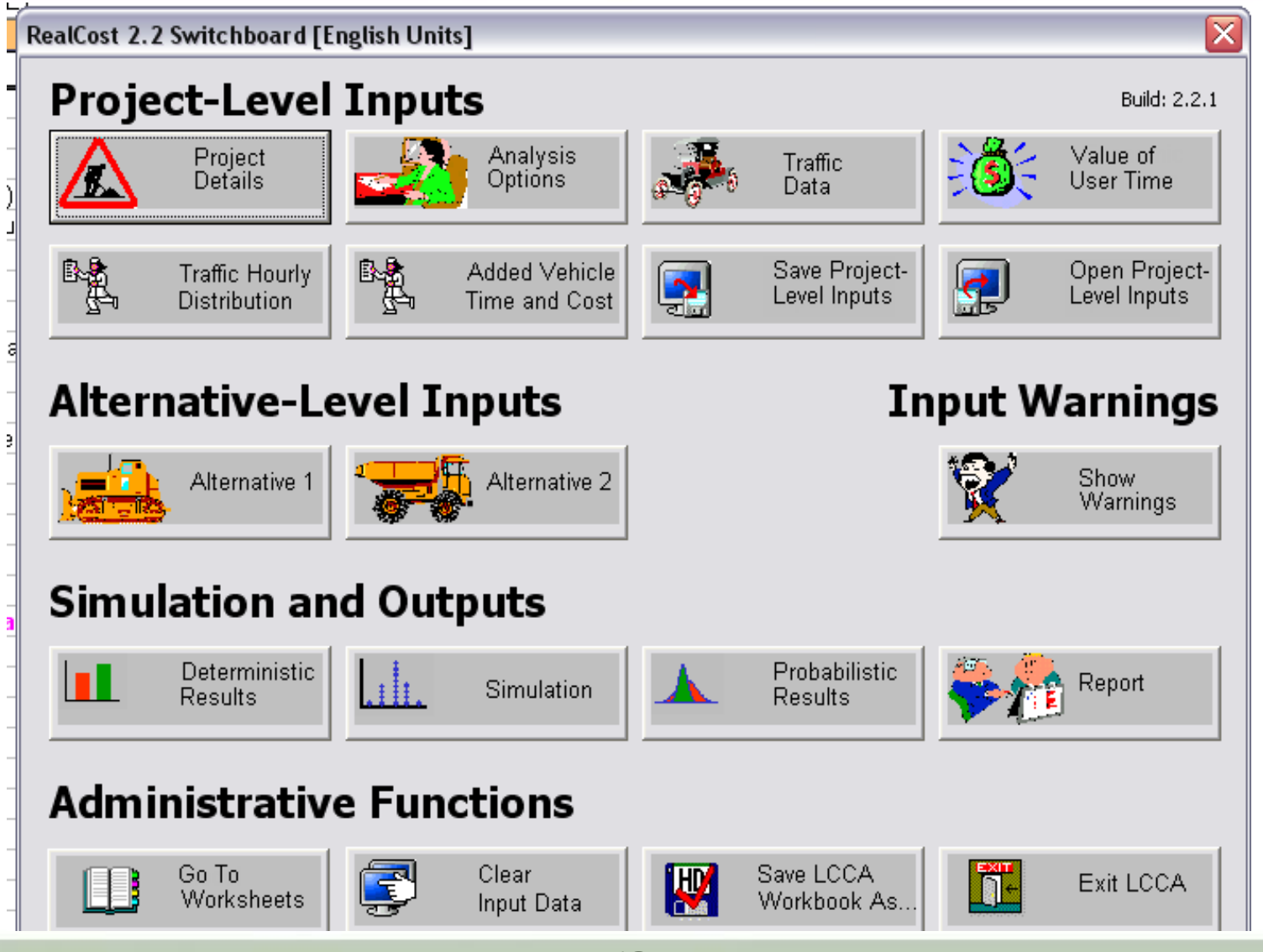
Tools
- Workzones
- Concrete

Analysis
- Compute LCC
- Sensitivity
- Summary Grphs
- Cost Timelines

Results
- Results Log
- Reports

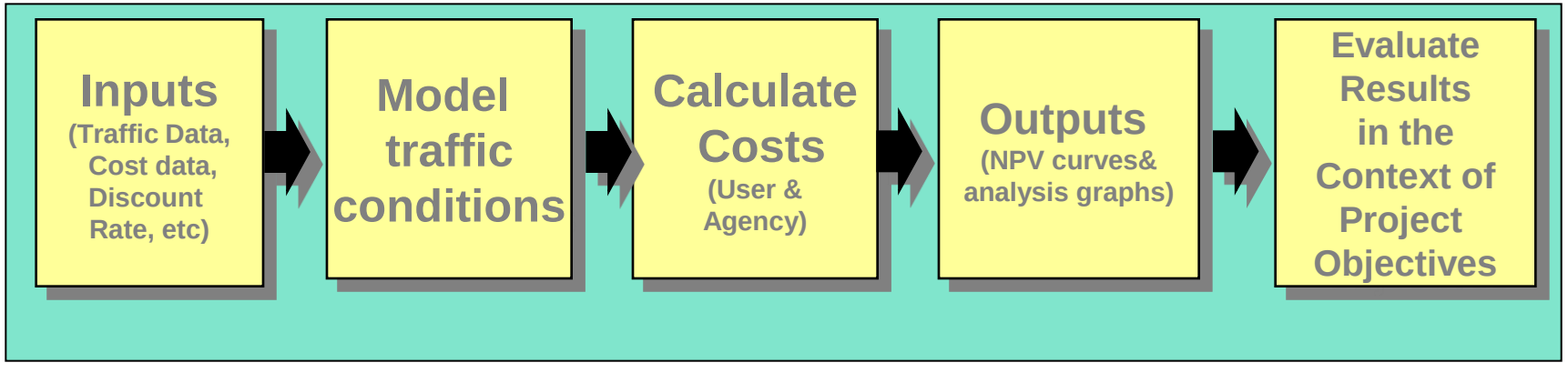
Total ($)	$724,369	$675,675	$0	$0	$0	$0
Costs by bearer						
Agency	$715,495	$671,761	$0	$0	$0	$0
User	$8,874	$3,914	$0	$0	$0	$0
Third Party	$0	$0	$0	$0	$0	$0
Costs by timing						
Initial Construction	$678,484	$652,484	$0	$0	$0	$0
O, M, and R	$40,820	$18,127	$0	$0	$0	$0
Disposal	$5,064	$5,064	$0	$0	$0	$0
Costs by component						
Elemental						
Deck	$201,813	$179,119	$0	$0	$0	$0
Superstructure	$212,328	$156,328	$0	$0	$0	$0
Substructure	$260,221	$260,221	$0	$0	$0	$0
Other	$48,124	$48,124	$0	$0	$0	$0
Non-elemental	$1,883	$1,883	$0	$0	$0	$0
New-technology introduction	$0	$30,000	$0	$0	$0	$0

FHWA LCCA Software



The LCCA Process in RealCost

Analyst Function — REALCOST FUNCTIONS — Analyst Function



Thank You

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