



Cal-B/C Training Module 1

What is Benefit-Cost Analysis?

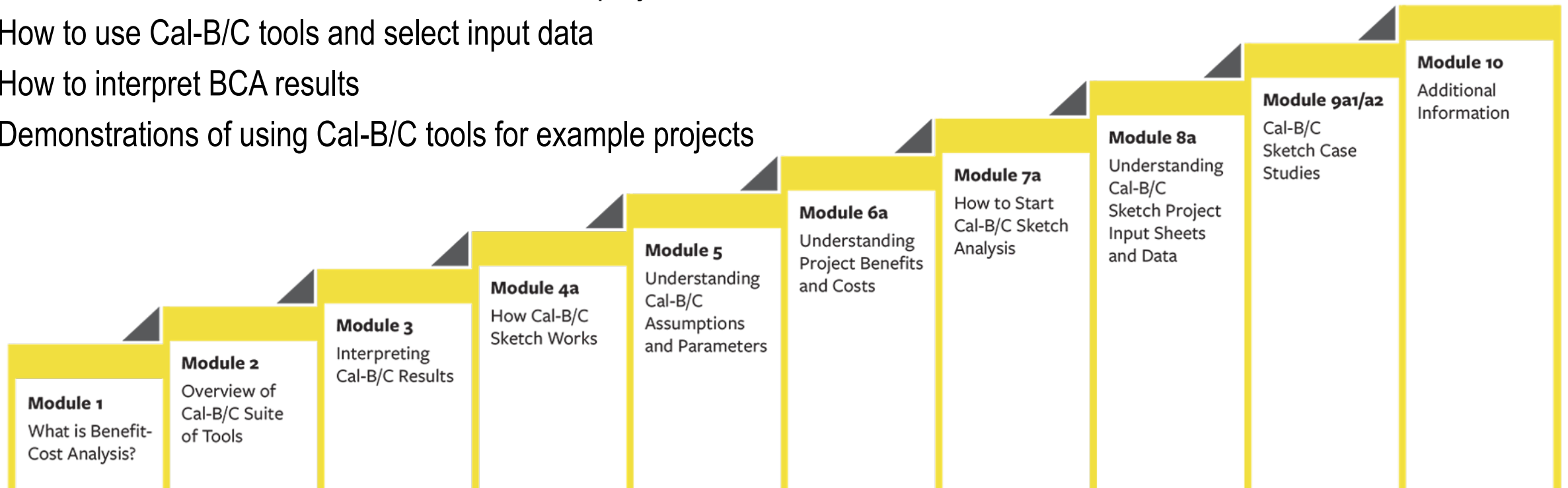


01

About the Cal-B/C Training

Course topics include...

- What is BCA and how is it used to evaluate projects
- Overview of Cal-B/C suite of tools
- Cal-B/C assumptions and parameters
- How Cal-B/C tools calculate benefits and uses project costs
- How to use Cal-B/C tools and select input data
- How to interpret BCA results
- Demonstrations of using Cal-B/C tools for example projects



Learning Objectives – What will you learn in the Cal-B/C training program?

Attendees will:

- Gain an understanding of the Cal-B/C suite of tools
- Learn the basic concepts of BCA
- Learn how to use the tools in the Cal-B/C suite to perform BCAs
- Understand what benefit categories are monetized as part of BCA

Audience – Who should attend?

- This course is intended for:
 - Transportation planners and transportation engineers at local, regional, and state agencies
 - Consultants for local, regional, and state agencies

- This course would also be useful for California Transportation Commission (CTC) employees
 - Grant Application Reviewers
 - Grant Administrators
 - Grant Application Evaluators

Both new and experienced users of the Cal-B/C tools will benefit from this course

Materials – What will you need?

▪ System Requirements

- Designed for Windows environment with Microsoft Excel 2013 or later version installed

▪ Recommendations

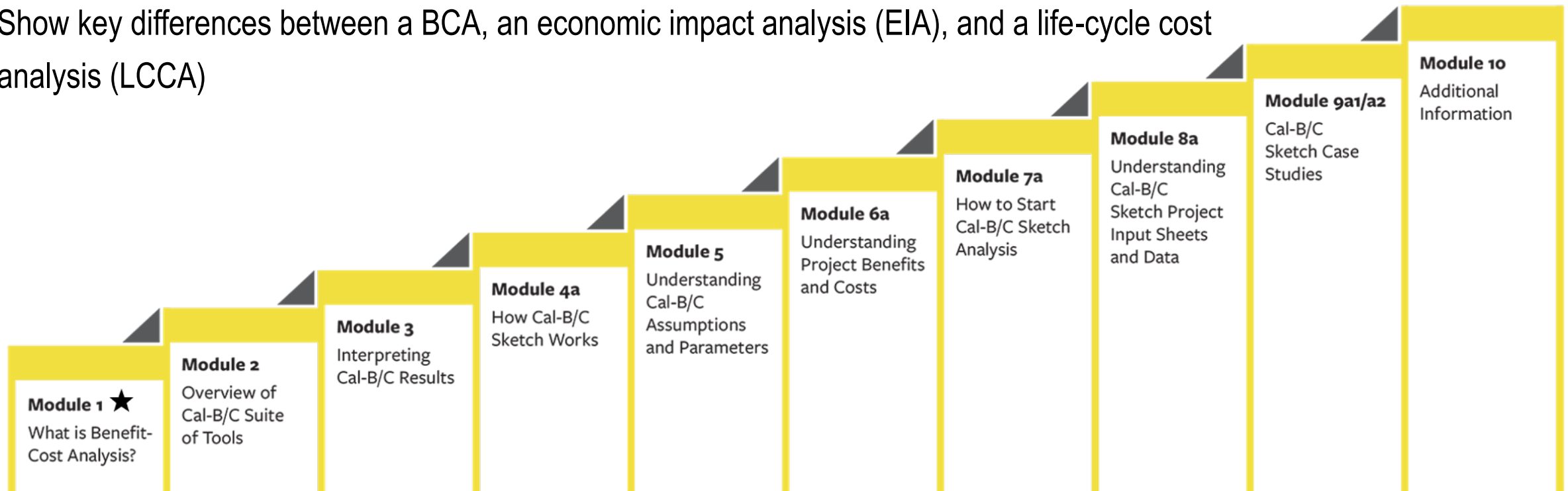
- PDF reader to download the user guides on the [Caltrans Transportation Economics Branch website](#)
 - User Guide links are near the bottom of this webpage
- Audio and YouTube-viewing capacity for viewing the online recordings

02

About This Module

This module will...

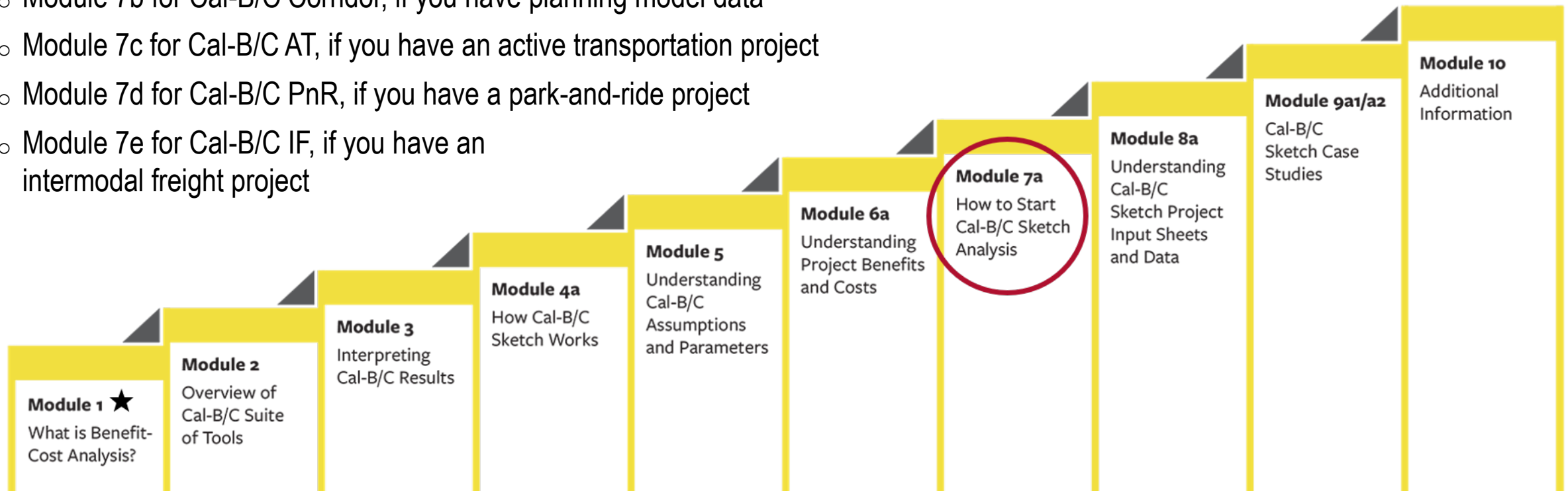
- Provide a basic introduction to benefit-cost analysis (BCA)
- Present a general overview of how you conduct a BCA
- Explain how to quantify benefits and costs and measure benefits in the future
- Show key differences between a BCA, an economic impact analysis (EIA), and a life-cycle cost analysis (LCCA)



★ *This module is covered in this presentation*

Quick Start Guide

- Need to perform a BCA in Cal-B/C right away?
- Skip ahead to Module 7 for a quick start guide on how to conduct a Cal-B/C analysis:
 - Module 7a for Cal-B/C Sketch, if you have limited data for a highway or transit project
 - Module 7b for Cal-B/C Corridor, if you have planning model data
 - Module 7c for Cal-B/C AT, if you have an active transportation project
 - Module 7d for Cal-B/C PnR, if you have a park-and-ride project
 - Module 7e for Cal-B/C IF, if you have an intermodal freight project



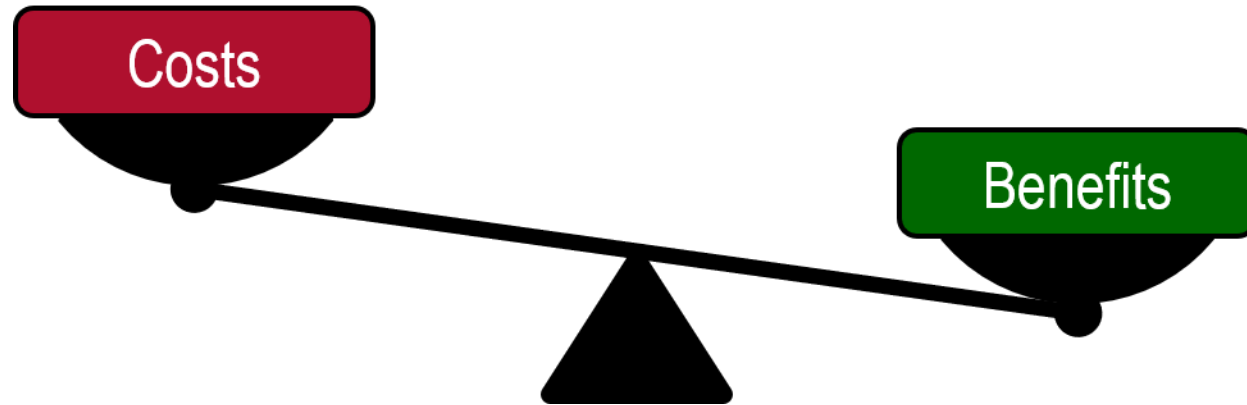
★ *This module is covered in this presentation*

03

What is Benefit-Cost Analysis?

What is Benefit-Cost Analysis?

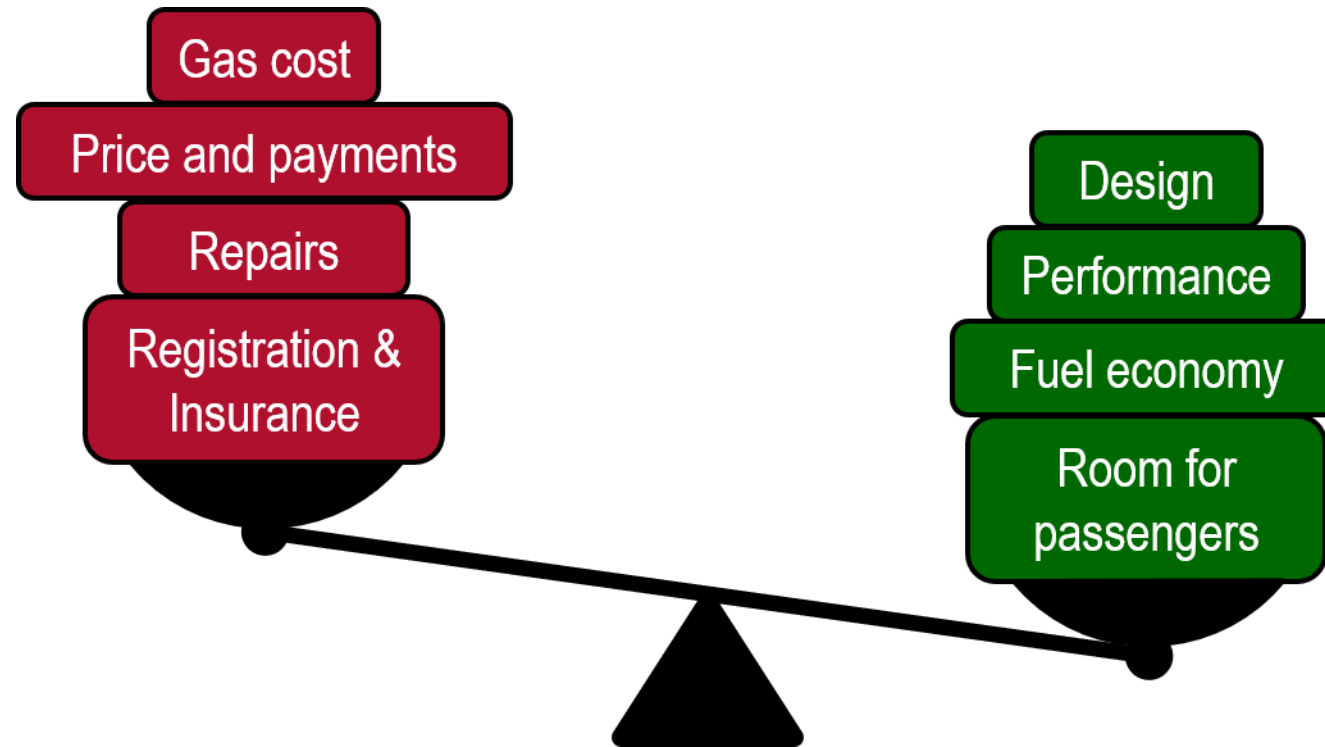
A method to compare costs with potential benefits that are derived from the money spent.



What is Benefit-Cost Analysis?

A method to compare costs with potential benefits that are derived from the money spent.

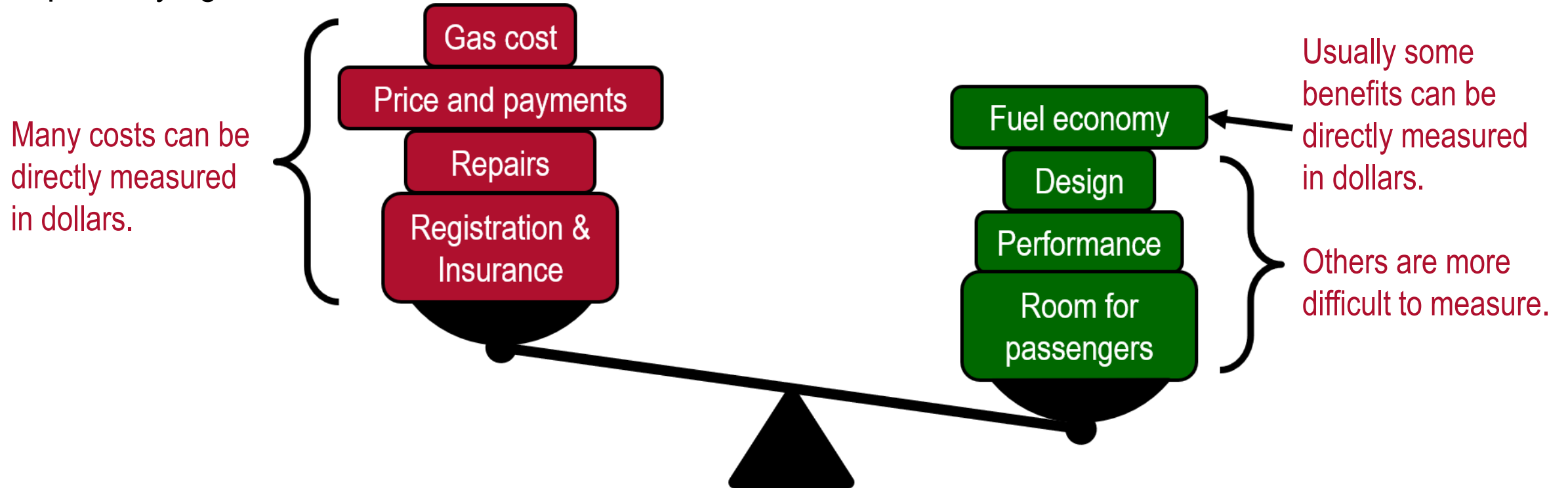
Example: Buying a car



What is Benefit-Cost Analysis?

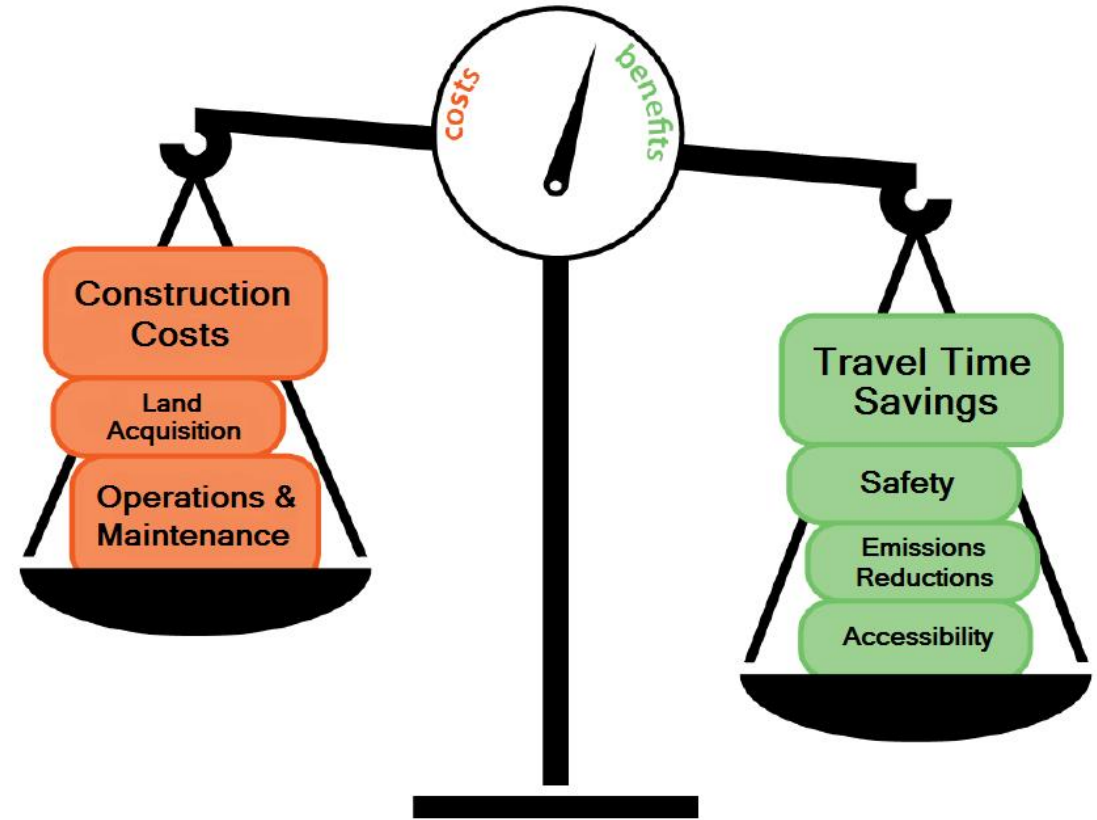
A method to compare costs with potential benefits that are derived from the money spent. BCA uses monetary terms (i.e. the dollar) as a common measure for comparison.

Example: Buying a car



What is Benefit-Cost Analysis in Transportation?

BCA in transportation compares project costs to societal benefits which are derived from the project and which can be monetized.



Focus on Monetized Effects

- Monetization allows summation of effects and comparison with project investment costs
- Uncertainty in monetary valuation (most impacts not traded in markets)
- Not all impacts that matter to people can be monetized!

Monetized Costs and Benefits in Cal-B/C tools

Project Costs

- Initial Project Costs
 - Project Support
 - Right-of-Way
 - Construction
- Subsequent Costs
 - Maintenance and Operating Costs
 - Rehabilitation

Main Benefit Categories for Transportation Projects

- Travel Time Savings
- Vehicle Operating Cost Savings
- Accident Cost Savings
- Emission Cost Savings

Benefits calculated in each tool are relevant to the project type and transportation mode

04

Benefit-Cost Analysis, Why We Do It?

Why Benefit-Cost Analysis?

Determine whether to invest

Determine when to invest

Compare and prioritize projects

Identify most important benefits

Why Benefit-Cost Analysis?

Determine whether to invest

Determine when to invest

Benefit / Cost Ratio

Net Present Value

Internal Rate of Return

Payback Period

Whether to Invest

Benefit/Cost Ratio (B/C Ratio)

- Present-discounted value of benefits *divided* by present-discounted value of investment costs
- Dollars of benefits per dollar of cost
- A ratio greater than 1 suggests project is worth the investment
- With budget constraint, prioritization based on B/C ratio maximizes total net benefits

Whether to Invest

Interpreting the B/C Ratio – Hypothetical Example

BCR
3.8

BCR
1.2

BCR
0.6

*Strong evidence
of a beneficial project*

Weaker evidence

*Some benefits may
not be captured*

Whether to Invest

Net Present Value (NPV)

- Present-discounted value of benefits *minus* present-discounted value of investment costs
- NPV greater than zero suggests project is worth the investment
- Without budget constraint, projects typically ranked according to NPV

Whether to Invest

Internal Rate of Return (IRR)

- Discount rate at which the NPV is zero
- IRR should exceed pre-set hurdle for project to proceed
- IRR is estimated with benefits and costs before (without) discounting

Whether to Invest

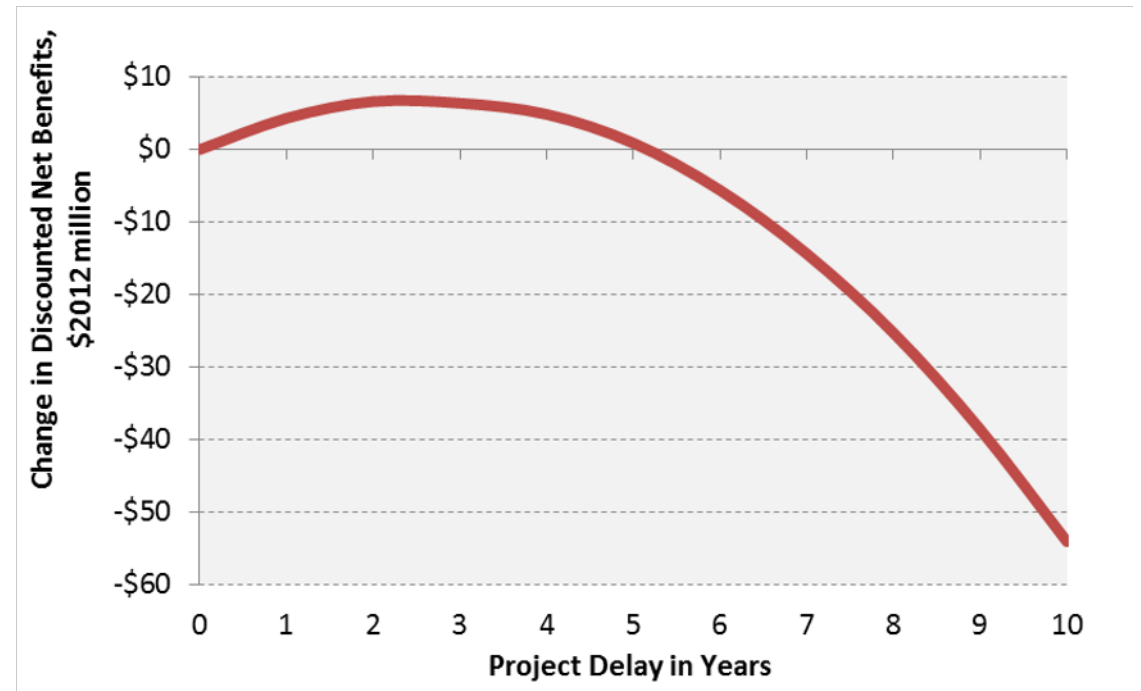
Other Indicators

- VMT Reduction
- Emission Reduction

Refer to your specific **grant program guidelines** to determine which indicator(s) to highlight in your application

When to Invest

- When is the socially optimal year to open the project?
- Does delaying a project increase or decrease discounted net benefits?
- This depends on:
 - Change in underlying conditions (e.g., highway congestion, demand growth)
 - Timing of project costs and benefits
 - Real escalation
 - Discount rate



How Project Delay May Impact Net Present Value, an Illustration

When to Invest

Payback Period

- Number of years until cumulative investment is recouped through accrual of benefits, where both benefits and costs are either discounted or left in constant dollars
- A long payback period may suggest that the project is premature

Refer to Module 3 for more information on BCA metrics, Cal-B/C results, and how to interpret them

Key Takeaways

- BCA is a comparison of benefits vs. project costs
- Monetary valuation – as much as possible
- The purpose of a BCA is to...
 - Help determine whether to invest (NPV, B/C ratio, IRR)
 - Help determine when to invest (payback period)
 - Prioritize projects
 - Identify impactful benefits to society from project

05

Benefit-Cost Analysis, How Do We Do It?

STEP 1: Understand Project

- Before conducting BCA, consider the context and expected “payoffs” of the project
- Ask yourself the following questions:

**What needs
are addressed?**
[e.g., traffic congestion]

**What are the
project details?**
[e.g., add two lanes]

**What are the
potential effects?**
[e.g., travel time savings]

STEP 2: Define Base Case & Alternatives

- Benefits and costs are estimated by comparing two future states of the world:
 - With the project
 - Without the project
- Base Case = state of the world **WITHOUT** project
 - aka No Build Case, Do Nothing, Do Minimum, Programmed
- Alternative Case = state of the world **WITH** project
 - aka Build Case, Project Case

STEP 2: Define Base Case & Alternatives

- The Base Case against which a project is assessed must be realistic
 - Not Purely Status Quo or Do-Absolutely-Nothing
- For example, a large capital investment may be compared to a Base Case that includes:
 - Productive low-cost capital solutions
 - Productive non-capital solutions



STEP 3: Develop or Obtain Transportation Data

1.

Identify data needs and adequate resources and tools

2.

Obtain projections for the Base Case and the Project Case(s)

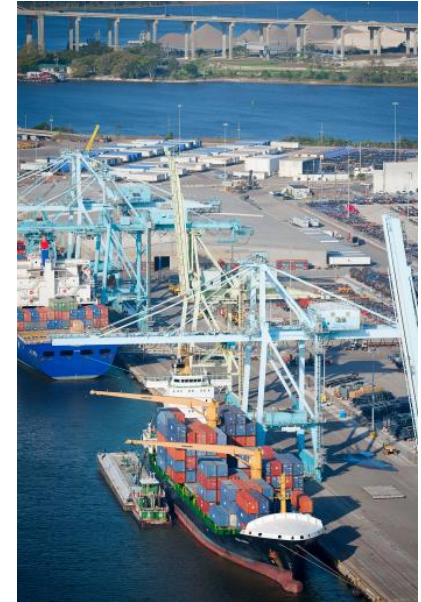
3.

Review, organize, and process the projections for use in BCA

STEP 3: Develop or Obtain Transportation Data

- Future Travel Demand or Traffic Volumes
 - e.g., daily ridership, ton-miles of freight shipments, vehicle-miles traveled
- Transportation System Performance
 - e.g., average vehicle speed, travel times, hours of congestion, level of service

Refer to Modules 8a to 8e for more detail on project data required for an analysis in each Cal-B/C tool



STEP 3: Develop or Obtain Transportation Data

Other Data Requirements



Project Schedule



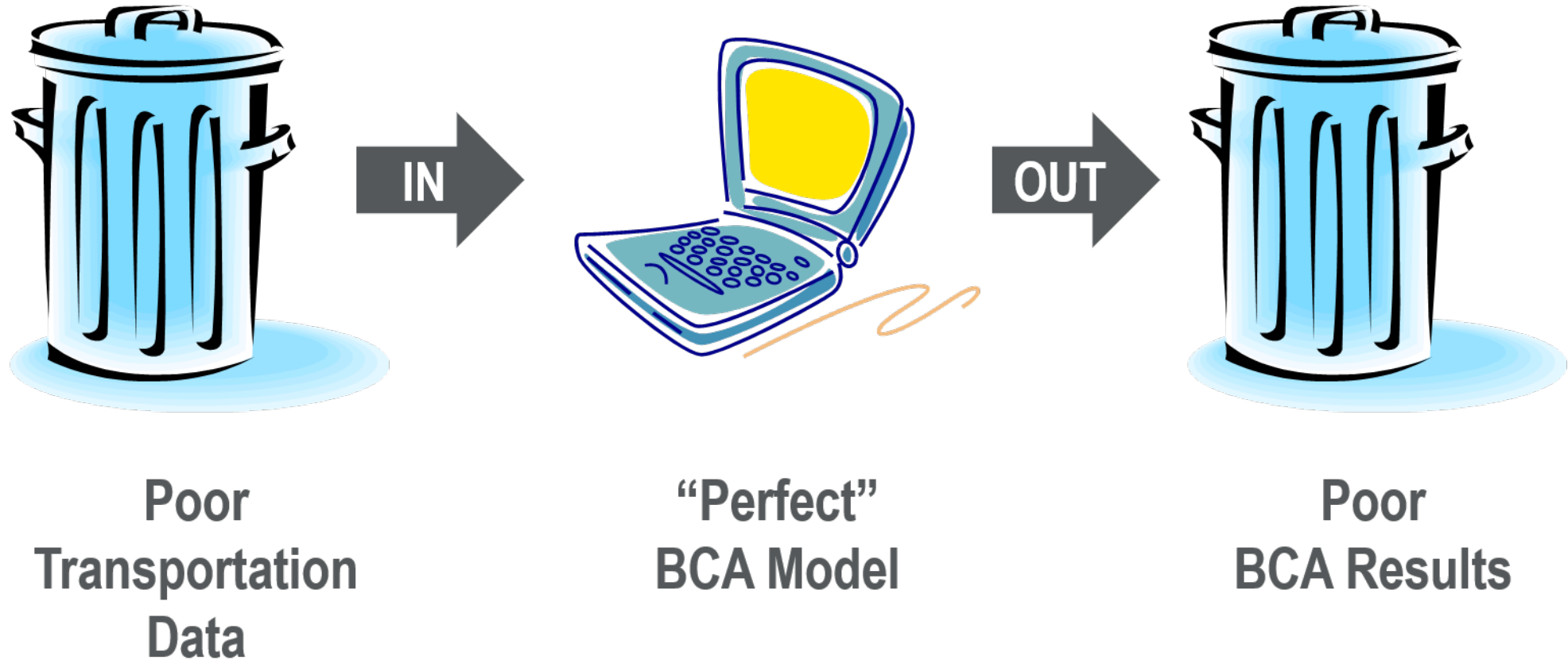
Capital and O&M Costs



Safety Data

STEP 3: Develop or Obtain Transportation Data

Keep in mind that quality data is important



STEP 4: Identify and Calculate Benefits & Costs

- Identify **quantity** and **value** components for each benefit category
- Assemble data and specify input values
- Estimate BCA metrics

This is done automatically within Cal-B/C tools

STEP 4: Identify and Calculate Benefits & Costs

Identify quantity and value components for each benefit category

Benefit categories generally have two components:

- **Quantity component**, expressed in any unit of measurement

Hours of Travel
Time Saved

Number of
Fatalities Avoided

Change in Tons of
CO2 Emissions

In Cal-B/C, quantity components are calculated from project data (traffic, speed, safety, etc.)

STEP 4: Identify and Calculate Benefits & Costs

Identify quantity and value components for each benefit category

Benefit categories generally have two components:

- **Quantity component**, expressed in any unit of measurement

Hours of Travel
Time Saved

Number of
Fatalities Avoided

Change in Tons of
CO2 Emissions

In Cal-B/C, quantity components are calculated from project data (traffic, speed, safety, etc.)

- **Value component** or dollar-equivalent component, expressed in dollar per unit of measurement

\$ per Hour
Saved

\$ per Life Saved

\$ per Ton
of CO2

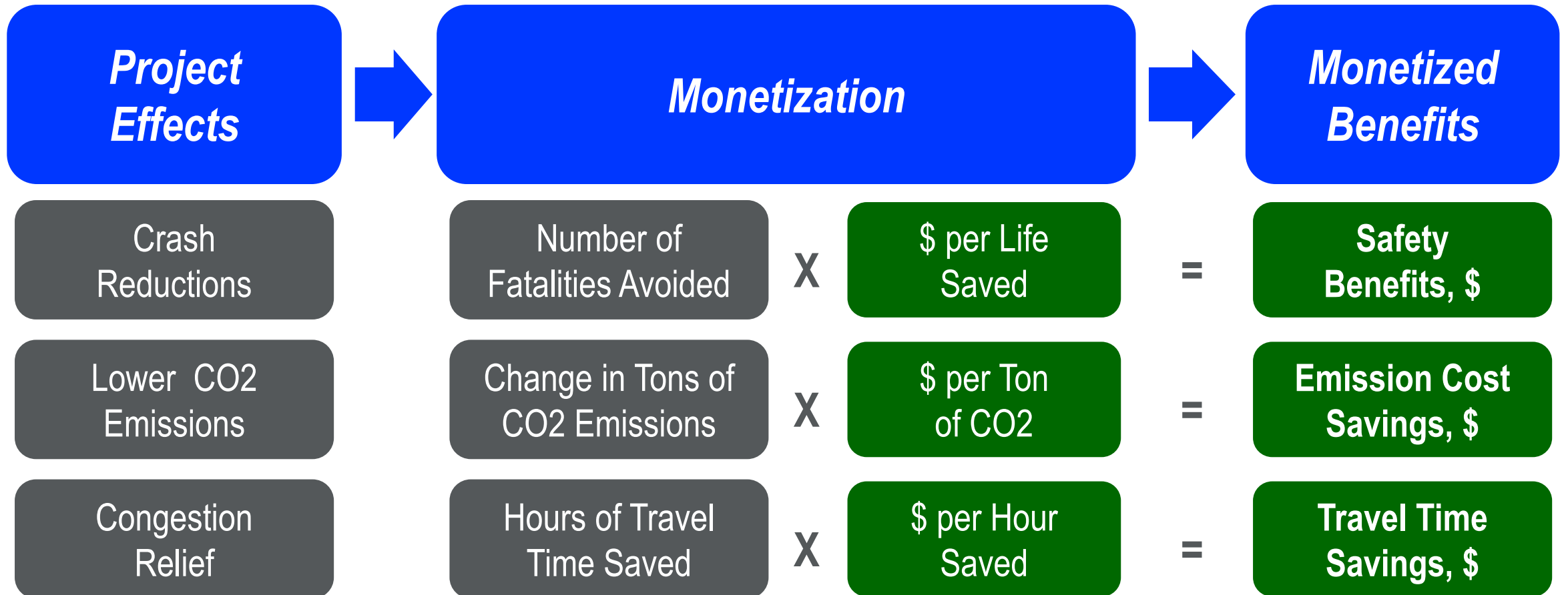
In Cal-B/C, value components are determined by default values (parameters)

Refer to Module 5 for more information on Cal-B/C parameters and assumptions

STEP 4: Identify and Calculate Benefits & Costs

Assemble data, specify input values, and estimate BCA metrics.

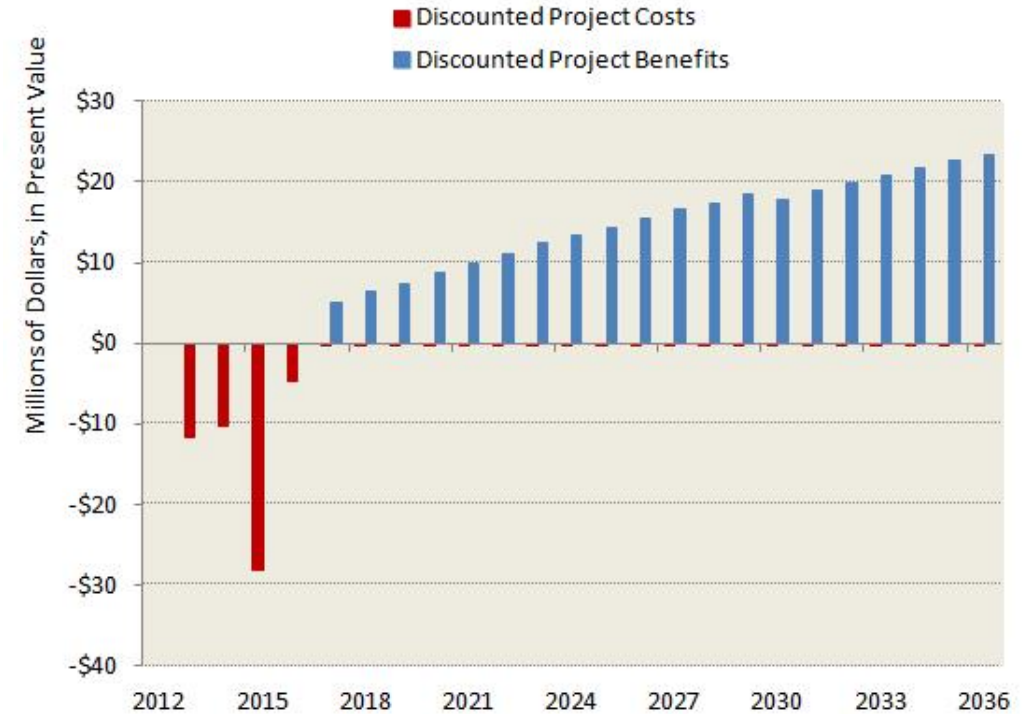
Examples:



STEP 5: Interpolate and Discount

Interpolation

- Benefits and costs estimated over project's "useful life"
 - Generally 20 or 30 years in transportation
- All variables are projected to the horizon year
 - Volumes, measures of transportation system performance, and monetization assumptions
- Benefits and cost expressed in **REAL** terms (no monetary inflation) and discounted to present-day value



STEP 5: Interpolate and Discount

Discounting

- Analysis needs to compare projects or actions with costs and benefits from different time periods
- One dollar tomorrow is worth LESS than one dollar today, **even with no inflation** (~due to a general preference for the present)
- FUTURE benefits and costs are expressed in their PRESENT value to “level the playing field” in comparing projects
- The procedure to express future values in their present value is called DISCOUNTING

STEP 5: Interpolate and Discount

Impacts of Discounting

- With higher discount rates, a lower value is assigned to future outcomes:

DISCOUNT RATE	PRESENT VALUE OF \$10 MILLION IN BENEFITS ARISING 30 YEARS FROM NOW	PRESENT VALUE OF \$10 MILLION IN BENEFITS ARISING 50 YEARS FROM NOW
0%	\$10 M	\$10 M
3%	\$4.1 M	\$2.3 M
4%	\$3.1 M	\$1.4 M
7%	\$1.3 M	\$0.3 M

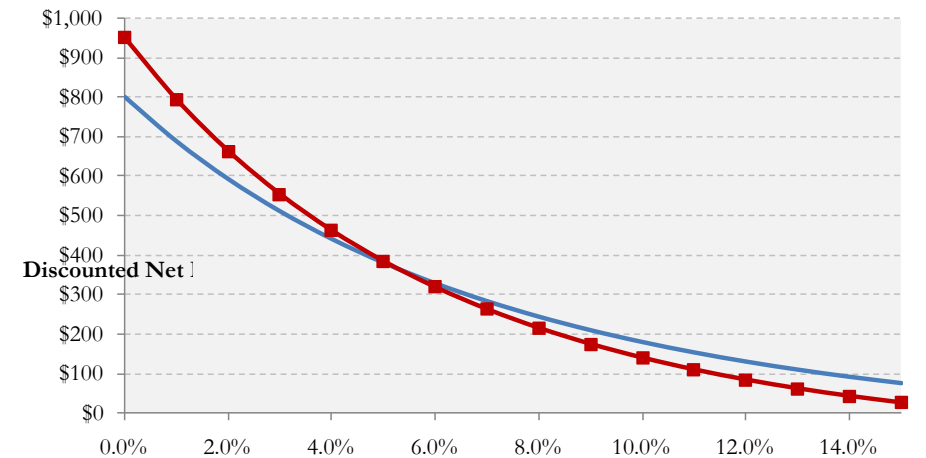
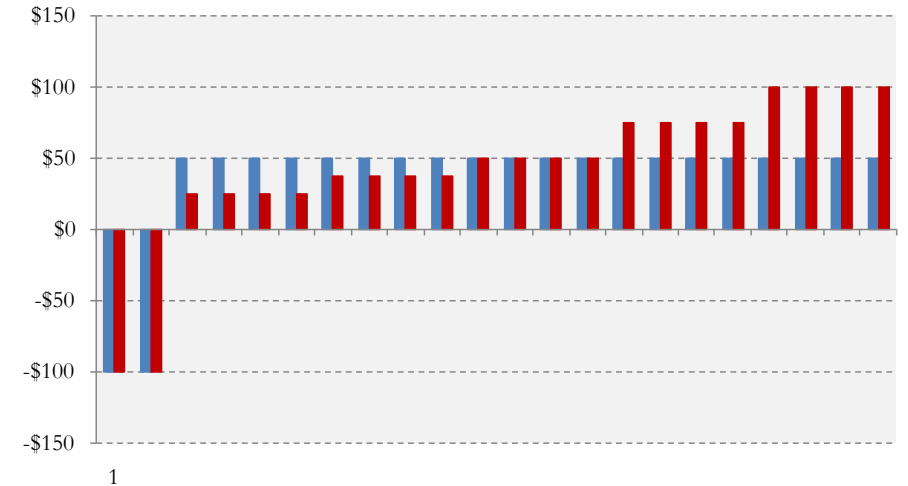
STEP 5: Interpolate and Discount

Impacts of Discounting

- Discounting affects benefits more than costs (because benefits tend to arise later than costs)
- Changes in the discount rate may alter the relative ranking of options
 - Other things being equal, a higher rate will penalize options whose benefits arise relatively late

Cal-B/C tools contains a default parameter for the discount rate which the user can override

Refer to Module 5 for more information on Cal-B/C parameters



STEP 6: Produce Summary Indicators

Example of BCA Results

Refer to Module 3 for more information on BCA metrics, Cal-B/C results, and how to interpret them

Hypothetical Project - Capacity Enhancements

Period of Analysis, years 20
Discount Rate, percent 4.0%

DISCOUNTED BENEFITS, Millions of Dollars

TRAVEL TIME SAVINGS	\$7.7
OUT-OF-POCKET COST SAVINGS	(\$2.8)
SAFETY BENEFITS	\$29.6

TOTAL DISCOUNTED BENEFITS	\$34.6
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DISCOUNTED COSTS, Millions of Dollars

CAPITAL COSTS	(\$24.9)
MAINTENANCE COSTS	(\$3.1)

TOTAL DISCOUNTED COSTS	(\$28.0)
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Net Present Value, Millions of Dollars	\$6.6
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Benefit-Cost Ratio	1.24
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Discounted Payback Period, years	19
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Overall Rate of Return, percent	6.3%
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Relatively Large Safety Benefits

Positive Net Present Value

B/C Ratio Greater than 1.0

06

**Benefit Distribution,
Benefit-Cost Analysis vs.
EIA and LCCA**

BCA vs. Economic Impact Analysis (EIA)

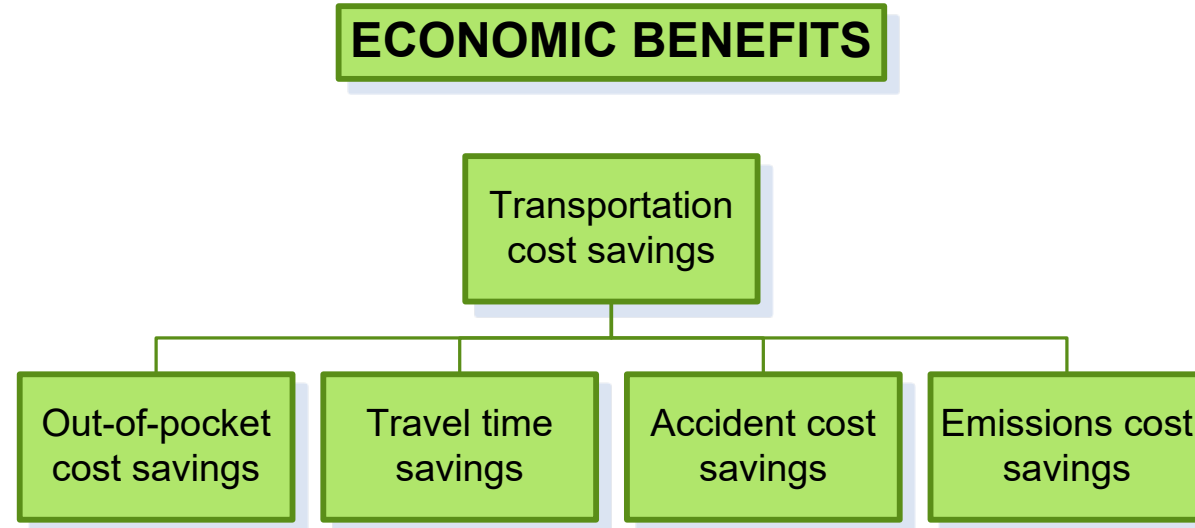
Benefit-Cost Analysis	Economic Impact Analysis
Estimates effects of project on people's "well-being"	Estimates effects of project on the Economy
Primarily concerned with economic efficiency and welfare gains	Primarily concerned with changes in economic activity
Benefits expressed as resource cost savings or changes in "well-being"	Impacts expressed as changes in business sales, employment, income, or tax revenue

BCA vs. Life-Cycle Cost Analysis (LCCA)

Benefit-Cost Analysis	Life-Cycle Cost Analysis
Estimates effects of project on people's "well-being"	Estimates full cost of project over the asset's life
Primarily concerned with economic efficiency and welfare gains	Primarily concerned with total cost of project alternatives
Benefits expressed as resource cost savings or changes in "well-being"	"Benefits" are captured as changes in cost across project alternatives with similar user benefits

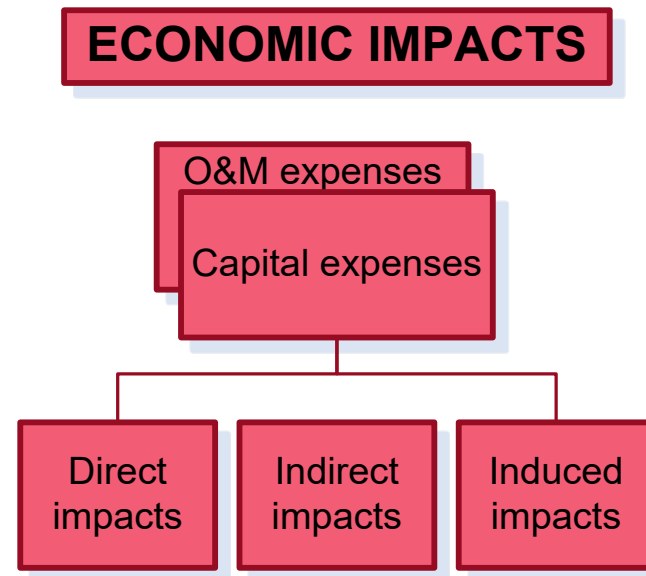
Benefit-Cost Analysis

- Measures the dollar value of the benefits and the costs to all members of society
- Focuses on the **net** increase in **society's welfare** (and not just the welfare of the project beneficiaries)
- Examples of **economic benefits** estimated for transportation projects:
 - Travel time savings
 - Safety benefits
 - Out-of-pocket cost savings
 - Pavement cost savings
 - Environmental benefits
 - Community development benefits
 - Low-cost mobility benefits



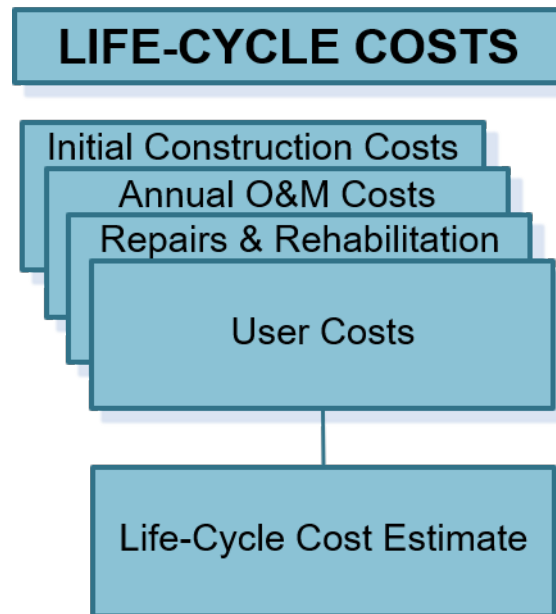
Economic Impact Analysis

- Measures the effects of decisions or events on the **economy** in a specific area
- Focuses on the **macro-economic impacts**, typically at the local or regional level
- Examples of economic impact metrics:
 - Output added
 - Total value added
 - Jobs added
 - Labor income
 - Tax revenue



Life-Cycle Cost Analysis

- Measures the **total economic worth** of a project by analyzing initial costs and discounted future costs, over the expected life of the project
- Focuses on all costs to compare the **total costs** of project alternatives with similar user benefits
- Examples of life-cycle cost results:
 - Total present value cost for each project
 - Equivalent annual cost for each project



07

Conclusion

In this module, you learned...

- What a BCA is
- Why a BCA should be performed
- How a BCA is performed
- The differences between BCA, EIA, and LCCA

What's Next?

- Overview of tools in the Cal-B/C suite
 - **Module 2: Overview of Cal-B/C Suite of Tools**
- Get more information on one Cal-B/C tool and how it works
 - **Module 4a** (Cal-B/C Sketch)
 - **Module 4b** (Cal-B/C Corridor)
 - **Module 4c** (Cal-B/C Active Transportation)
 - **Module 4d** (Cal-B/C Park & Ride)
 - **Module 4e** (Cal-B/C Intermodal Freight)
- Start an analysis!
 - **Module 7: How to Start a Cal-B/C Analysis**