U.S. Department of Transportation
Office of the Under Secretary

Preparing a Benefit-Cost Analysis for Multimodal Project Discretionary Grants (MPDG)

Office of the Assistant Secretary for Transportation Policy

Office of the Chief Economist

What is BCA?

Benefit-cost analysis (BCA) is a systematic process for *identifying*, *quantifying*, and *comparing* expected economic benefits and costs of a proposed infrastructure project.

Why do we do BCA?

- Provides a useful benchmark from which to evaluate and compare potential transportation investments
- Adds a degree of rigor to the project evaluation process

What do I need to do a BCA?

- Clear understanding of the problem the project is intended to solve (baseline conditions) and how the project addresses the problem (measures of effectiveness)
- Well-defined project scope and cost estimate
- Monetization factors for key project benefits

What do I need to do a BCA?

- Sources of information may include:
  - Project planning and engineering documents
  - Industry technical references and analytical tools
  - DOT BCA Guidance

BCA and MPDG

- All project sponsors should submit a benefit-cost analysis (BCA) as part of their MPDG application
- Use of the BCA in MPDG
  - Evaluation of the Economic Analysis selection criterion
  - Assessment of project cost-effectiveness

USDOT BCA Review

- USDOT economists will review the applicant's BCA
  - Examine key assumptions
  - Correct for any technical errors
  - Perform sensitivity analysis on key inputs
  - Consider any unquantified benefits

Economic Analysis

- USDOT considers the relative magnitude of estimated project benefits and costs and the degree of uncertainty in the results
- Assign projects one of five ratings
  - High: The project's benefits will exceed its costs, with a benefit-cost ratio of at least 1.5
  - Medium-High: The project's benefits will exceed its costs
  - Medium: The project's benefits are likely to exceed its costs
  - Medium-Low: The project's costs are likely to exceeds its benefits
  - Low: The project's costs will exceed its benefits

Cost Effectiveness Requirements

- **Mega, Rural, and INFRA Large Projects**
  - USDOT must determine that the project will be cost effective in order for it to be selected
- **INFRA Small Projects**
  - USDOT must consider project cost-effectiveness in making selections
- **Cost-effectiveness determinations based on results of the BCA**
  - Projects must be found to have estimated benefits that are at least likely to exceed costs (i.e., rating of Medium or higher) in order to be considered cost effective

USDOT BCA Guidance

- Covers all USDOT discretionary grant programs
- Updated March 2022
- Available at https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance-discretionary-grant-programs-0

What's New?

- New and updated monetization values
- Additional guidance and new examples on:
  - Valuing pedestrian, cycling, and transit infrastructure improvements
  - Valuing the benefits of improved health from active transportation and reduced crowding on transit
- Additional guidance on benefits from reduction in stormwater runoff and wildlife impacts

Transparent & Reproducible Analysis

- BCAs should provide enough information for a reviewer to follow the logic and reproduce the results
  - Spreadsheet or database files showing the calculations
  - Technical memos describing the analysis and documenting sources of information used (assumptions and inputs)
  - Present annual benefit & cost streams by type (not just summary output)

Baselines

- Should measure costs and benefits of a proposed project against a baseline alternative (“base” or “no build”)
- “Do’s”
  - Factor in any projected changes (e.g., increased traffic volumes) that would occur even in the absence of the requested project
  - Factor in ongoing routine maintenance
  - Consider full long-term impacts of no build (e.g. bridge closure/posting)
  - Explain and provide support for the chosen baseline
- “Don’t’s”
  - Assume that the same (or similar) improvement will be implemented later
  - Use unrealistic assumptions about alternative traffic flows

Demand Forecasts

- Most benefit estimates depend on ridership or usage estimates
- Provide supporting info on forecasts
  - Geographic scope, assumptions, data sources, methodology
- Provide forecasts for intermediate years
  - Or at least interpolate—don't apply forecast year impacts to interim years
- Exercise caution about long-term growth assumptions
  - Consider underlying capacity limits of the facility

Analysis Period

- Should cover both initial development and construction and a subsequent operational period
- Generally tied to the expected service life of the improvement or asset
  - I.e., the number of years until you would anticipate having to take the same action again
  - Lesser improvements should have shorter service lives
  - Recommend 20 years maximum for capacity expansion or other operational improvements
- Avoid excessively long analysis periods (over 30 years of operations)
  - Use residual value to cover out-years of remaining service life for long-lived improvements

Inflation and Discounting

- Inflation Adjustments
  - Recommend using a 2020 base year for all cost and benefit data
  - Index values for the GDP Deflator included in the BCA guidance
- Discounting
  - Use a 7% discount rate for all benefits and costs (except CO_2)
  - Recommend using a 2020 base year for discounting

Scope of the Analysis

- Project scope included in estimated costs and benefits must match
  - Don’t claim benefits from an entire project, but only count costs from the grant-funded portion
- Scope should cover a project that has independent utility
  - May need to incorporate costs for related investments necessary to achieve the projected benefits
- Project elements with independent utility should be individually evaluated in the BCA
  - BCA evaluation will cover both independent elements and the submitted project as a whole

Benefits

- Should be presented on an annual basis
  - Don’t assume constant annual benefits without a good reason to do so
- Negative outcomes should be counted as “disbenefits”
  - E.g., work zone impacts
- Avoid double-counting benefits

Safety Benefits

- Typically associated with reducing fatalities, injuries, and property damage
- Projected improvements in safety outcomes should be explained and documented
  - Justify assumptions about expected reductions in crashes, injuries, and/or fatalities (and document any CMF used)
  - Show clear linkage between project and improved outcomes
  - Use facility-specific data history for baseline where possible
- Crash-related injury and fatality data may be available in different forms
  - KABCO injury scales
  - Fatal/Injury crashes vs. fatalities/injuries
  - BCA Guidance provides values covering all of these

Travel Time Savings

- Recommended values found in BCA Guidance
  - See footnotes for discussion of non-vehicle time, long-distance travel, business travel
- Consider vehicle occupancy where appropriate
  - Local/facility-specific values preferred
  - National-level values provided in BCA Guidance
- If valuing travel time reliability:
  - Carefully document methodology and tools used
  - Show how valuation parameters are distinct from general travel time savings

Operating Cost Savings

- Avoid double counting operating savings and other impacts
  - E.g., truck travel time savings, fuel consumption reductions
- Localized, specific data preferred
  - Standard per-mile values for light duty vehicles and commercial trucks provided in DOT BCA Guidance

Emissions Reduction Benefits

- For infrastructure improvements, emissions reductions will typically be a function of reduced fuel consumption
- Recommended year by year unit values for CO_2, SO_2, NO_x, and $PM_{2.5}$ found in BCA guidance
  - Be careful about the measurement units being applied
- Reductions in CO_2 emissions should be discounted at **3 percent**, while all others should be discounted at 7 **percent**

Amenity Benefits

- Pedestrian, cycling, and transit facility/vehicle improvements can improve the quality or comfort of journeys
- Recommended values for different types of improvements found in BCA Guidance
  - Pay attention to whether value is on a “per-trip” or “per-person-mile” basis
- Carefully document baseline amenities, as well as specifically how the proposed project will add any amenity benefit category being claimed

Health Benefits

- Trips diverted to active transportation (walking and cycling) from other modes may yield health benefits to users
- Recommended monetization values, on a per trip basis, are found in BCA Guidance
- Absent local data on existing mode share and estimates age profiles of users, applicants may apply national averages included in the BCA Guidance.

Benefits to Existing and Additional Users

- Primary benefits typically experienced directly by users of the improved facility
- Includes both "existing" users (under baseline) and "additional" users attracted to the facility as a result of the improvement
  - Standard practice in BCA would value benefits to additional users less than those for existing users (see BCA guidance)

Modal Diversion

- **Projected magnitude**
  - Should be based on careful analysis of the market and potential for diversion from other modes that might be attributable to the project
- **Benefits estimates should not be based on comparing user costs of "old" and "new" mode**
  - Would be reflected in benefits to additional users
- **Reductions in external costs would be relevant**
  - E.g., emissions costs, pavement damage
  - Values for noise and congestion costs included in Guidance

Other Benefits

- Agglomeration Economies
- Noise, Stormwater Runoff, and Wildlife Impact Reduction
- Emergency Response
- State of Good Repair
- Resilience
  - Consider expected frequency of events and their consequences
- Property Value Increases
  - Is a measure rather than a benefit—avoid double-counting

Unquantified Benefits

- Should quantify magnitudes/timing of the impacts wherever possible
- Should clearly link specific project outcomes to any claimed unquantified benefits

Capital Costs

- Include all costs of implementing the project
  - E.g., design, ROW acquisition, construction
  - Regardless of funding source
  - Include previously incurred costs
- Three forms of capital costs
  - Nominal dollars (project budget)
  - Real dollars (base year)
  - Discounted Real dollars (use in BCA)

Maintenance Costs

- Net maintenance costs may be positive or negative
  - New facilities would incur ongoing maintenance costs over the life of the project
  - Rehabilitated/reconstructed facilities may result in net savings in maintenance costs between the build/no-build

Residual Value

- For assets with remaining service life at the end of the analysis period, may calculate a "residual value" for the project
  - Recall that service life does not necessarily match the physical life of the asset
- Simple approach: assume linear depreciation
- Be sure to properly apply discounting

Comparing Benefits to Costs

- **Net Present Value (Benefits – Costs)**

- **Benefit-Cost Ratio (Benefits / Costs)**
    - Denominator should only include capital costs (i.e., net maintenance costs and residual value should be in the numerator)

Other Types of Economic Analysis

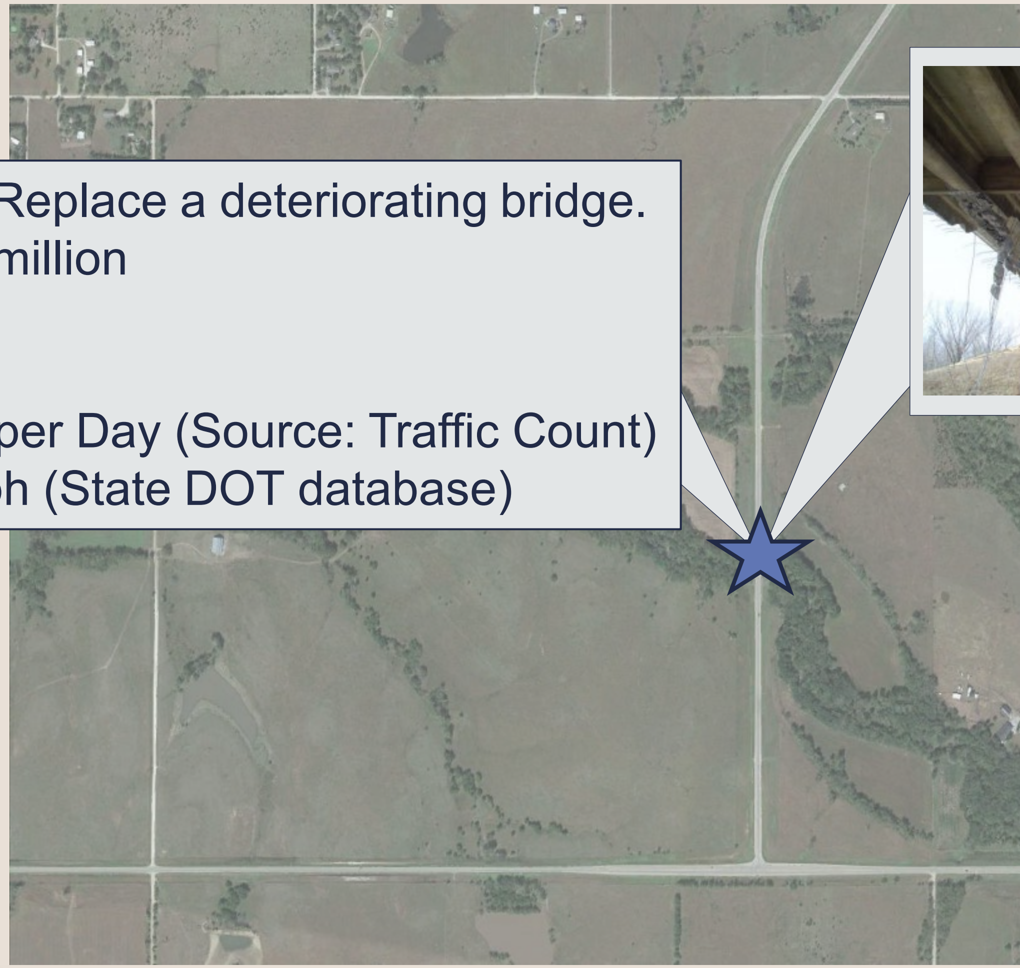
- Examples
  - Economic Impact Analysis
  - Financial Impacts
  - Distributional Effects
- Issues
  - Use different approaches and answer different questions than does BCA
  - Do not represent additional benefits to include in BCA

MPDG Info

- For additional MPDG information and how to apply: https://www.transportation.gov/grants/mpdg-announcement
- For technical questions, please email: MPDGrants@dot.gov.

Questions?

Hypothetical BCA Example



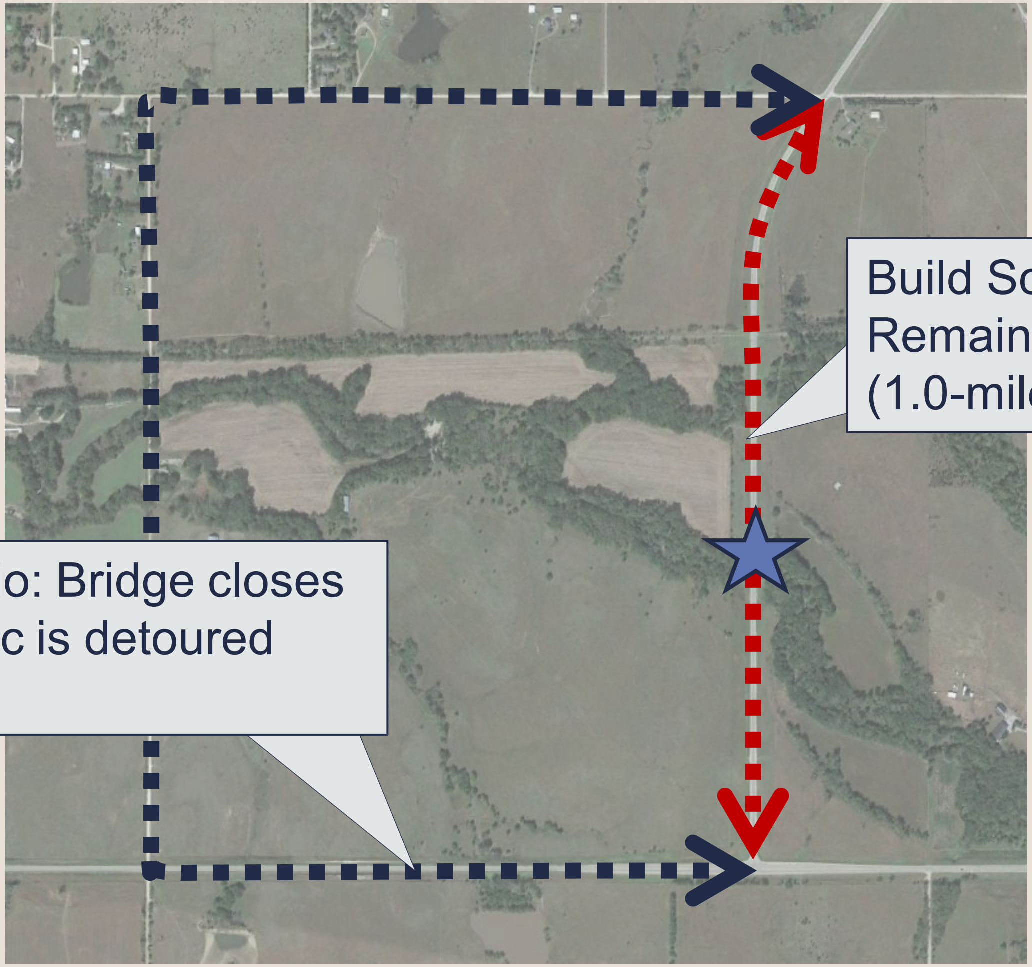
Proposed Project: Replace a deteriorating bridge.
Project Cost: $2.5 million

2020
AADT: 1,000 Cars per Day (Source: Traffic Count)
Avg. Speed: 45 mph (State DOT database)

Hypothetical BCA Example

No-Build Scenario: Bridge closes in 2025 and traffic is detoured (2.6-mile route).

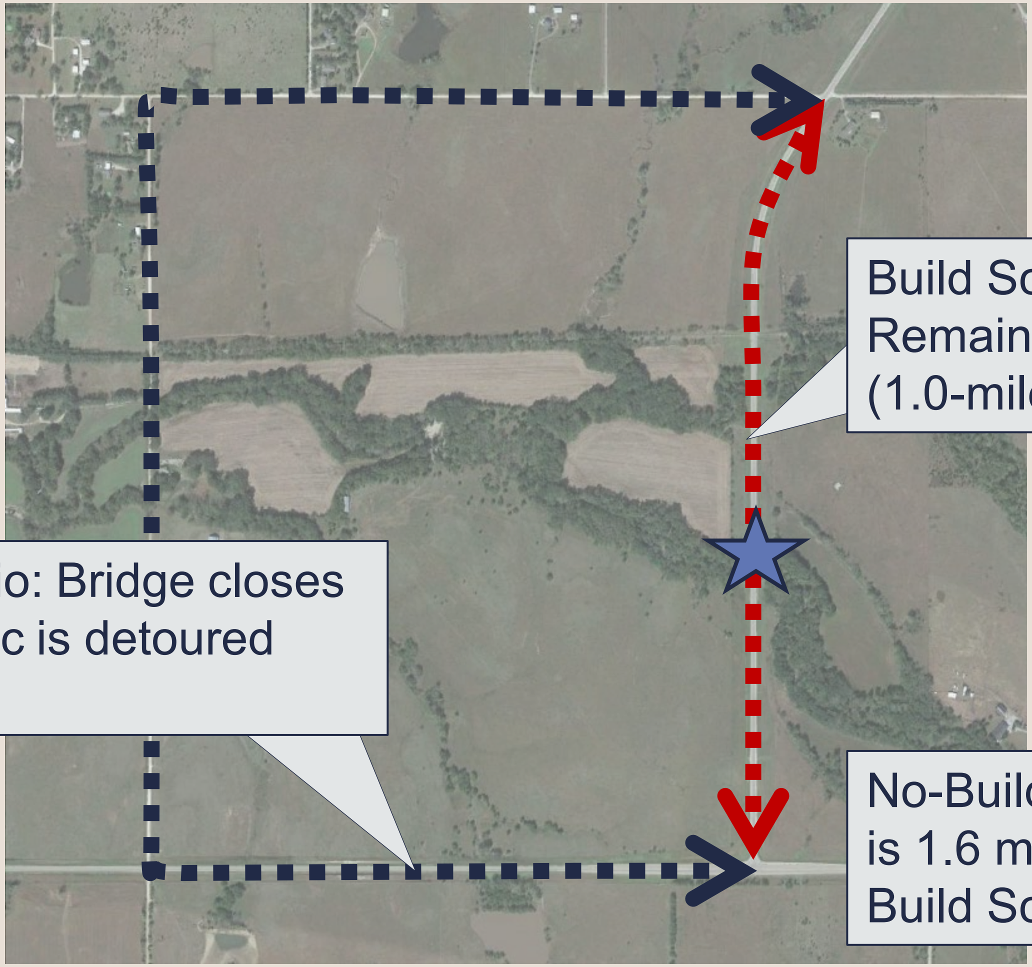
Hypothetical BCA Example



Build Scenario: Bridge Remains open to traffic (1.0-mile route).

No-Build Scenario: Bridge closes in 2025 and traffic is detoured (2.6-mile route).

Hypothetical BCA Example



Build Scenario: Bridge Remains open to traffic (1.0-mile route).

No-Build Scenario: Bridge closes in 2025 and traffic is detoured (2.6-mile route).

No-Build Scenario detour is 1.6 miles longer than Build Scenario route.

Approach

- We want to compare the state of the world with and without the proposed project improvement.
  - No-Build Scenario: Bridge closes in 2025, traffic detours 2.6 miles.
  - Build Scenario: Bridge remains open, existing route is 1.0 miles.
- The expected major benefit categories in this case would be vehicle operating cost savings and travel time savings for mitigating 1.6-miles of additional travel, starting in 2025.

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

$$\text{Annual Vehicle Operating Cost Savings*} = \text{Incremental Detour} \times \text{AADT} \times \text{Vehicle Operating Cost Per Mile} \times \text{Annualization Factor}$$

*Undiscounted.

Vehicle Operating Cost Savings

- **For simplicity, let's assume no heavy trucks and no traffic growth.**

$$\text{Annual Vehicle Operating Cost Savings}^{*} = \text{Incremental Detour} \times \text{AADT} \times \text{Vehicle Operating Cost Per Mile} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Operating Cost Savings}^{*} =$$

*Undiscounted.

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

$$\text{Annual Vehicle Operating Cost Savings*} = \text{Incremental Detour} \times \text{AADT} \times \text{Vehicle Operating Cost Per Mile} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Operating Cost Savings*} = \text{1.6 Miles}$$

No-Build Scenario route: 2.6 miles
Build Scenario route: 1.0 miles

*Undiscounted.

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

Annual Vehicle Operating Cost Savings*	=	Incremental Detour	x	AADT	x	Vehicle Operating Cost Per Mile	x	Annualization Factor
Annual Vehicle Operating Cost Savings*	=	1.6 Miles	x	1,000				

Recent traffic count

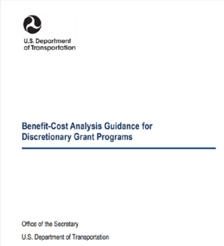
*Undiscounted.

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

Annual Vehicle Operating Cost Savings*	=	Incremental Detour	x	AADT	x	Vehicle Operating Cost Per Mile	x	Annualization Factor
Annual Vehicle Operating Cost Savings*	=	1.6 Miles	x	1,000	x	$0.45		

USDOT BCA Guidance


U.S. Department of Transportation

Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Office of the Secretary
U.S. Department of Transportation

(Appendix A)

*Undiscounted.

U.S. Department of Transportation
Office of the Under Secretary

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

Annual Vehicle Operating Cost Savings*	=	Incremental Detour	x	AADT	x	Vehicle Operating Cost Per Mile	x	Annualization Factor
Annual Vehicle Operating Cost Savings*	=	1.6 Miles	x	1,000	x	$0.45	x	365

We expect this project to have an impact each day (not just weekdays, for example).

*Undiscounted.

Vehicle Operating Cost Savings

- For simplicity, let's assume no heavy trucks and no traffic growth.

Annual Vehicle Operating Cost Savings*	=	Incremental Detour	x	AADT	x	Vehicle Operating Cost Per Mile	x	Annualization Factor
Annual Vehicle Operating Cost Savings*	=	1.6 Miles	x	1,000	x	$0.45	x	365
	=	$262,800 Per Year						

*Undiscounted.

Travel Time Savings

- **For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.**

Annual Vehicle Travel Time Savings* = Marginal Detour Time x AADT x Hourly Value of Time x Vehicle Occupancy x Annualization Factor

*Undiscounted.

Travel Time Savings

- **For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.**

$$\text{Annual Vehicle Travel Time Savings*} = \text{Marginal Detour Time} \times \text{AADT} \times \text{Hourly Value of Time} \times \text{Vehicle Occupancy} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}}$$

No-Build Scenario route: 2.6 miles
Build Scenario route: 1.0 miles

Speed: Observed average speed on both routes

*Undiscounted.

Travel Time Savings

- For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.

$$\text{Annual Vehicle Travel Time Savings*} = \text{Marginal Detour Time} \times \text{AADT} \times \text{Hourly Value of Time} \times \text{Vehicle Occupancy} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Travel Time Savings*} = \frac{\text{1.6 Miles}}{\text{45 mph}} \times 1{,}000 \times$$

Recent traffic count

*Undiscounted.

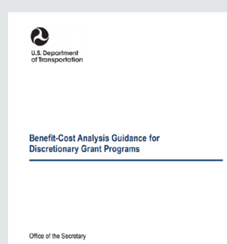
Travel Time Savings

- For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.

$$\text{Annual Vehicle Travel Time Savings*} = \text{Marginal Detour Time} \times \text{AADT} \times \text{Hourly Value of Time} \times \text{Vehicle Occupancy} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6\ \text{Miles}}{45\ \text{mph}} \times 1{,}000 \times \$17.80$$

USDOT BCA Guidance


U.S. Department of Transportation

Benefit-Cost Analysis Guidance for Discretionary Grant Programs

Office of the Secretary
U.S. Department of Transportation

(Appendix A)

*Undiscounted.

U.S. Department of Transportation
Office of the Under Secretary

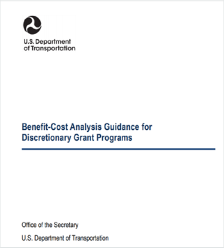
Travel Time Savings

- For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.

$$\text{Annual Vehicle Travel Time Savings*} = \text{Marginal Detour Time} \times \text{AADT} \times \text{Hourly Value of Time} \times \text{Vehicle Occupancy} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$17.80 \times 1.67$$

USDOT BCA Guidance



(Appendix A)

*Undiscounted.

Travel Time Savings

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$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$17.80 \times 1.67 \times 365$$

We expect this project to have an impact each day (not just weekdays, for example).

*Undiscounted.

Travel Time Savings

- **For simplicity, let's assume no heavy trucks, an average speed of 45 mph, and no traffic growth.**

$$\text{Annual Vehicle Travel Time Savings*} = \text{Marginal Detour Time} \times \text{AADT} \times \text{Hourly Value of Time} \times \text{Vehicle Occupancy} \times \text{Annualization Factor}$$

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$17.80 \times 1.67 \times 365$$

$$= \$385{,}777 \text{ Per Year}$$

*Undiscounted.

Hypothetical BCA Example

- Assume construction in 2022, ten years of project operations, and no difference in bridge maintenance costs between the scenarios.

Year	Capital Cost		Vehicle Operating Cost Savings	Vehicle Travel Time Savings	
2022	$2,500,000		$0	$0	
2023	$0		$0	$0	
2024	$0		$0	$0	
2025	$0		$262,800	$385,777	
2026			$262,800	$385,777	
2027			$262,800	$385,777	
2028	$0		$262,800	$385,777	
2029	$0		$262,800	$385,777	
2030	$0		$262,800	$385,777	
2031	$0		$262,800	$385,777	
2032	$0		$262,800	$385,777	

Bridge Closure Year
(No-Build Scenario)

Hypothetical BCA Example

- **Next we discount costs and benefits using a 7% discount rate.**

Discounted Value = Future Year Value / (1+Discount Rate)^(Future Year - Base Discounting Year)

Year	Capital Cost	Discounted Costs	Vehicle Operating Cost Savings	Vehicle Travel Time Savings	Discounted Benefits
2022	$2,500,000	$2,183,597	$0	$0	$0
2023	$0	$0	[illegible]	[illegible]	[illegible]
202[illegible]	[illegible]	$0	$0	$0	[illegible]0
2025	$0	$0	$262,800	$385,777	$462,427
2026	$0	$0	$262,800	$385,777	$432,175
2027	$0	$0	$262,800	$385,777	$403,901
2028	$0	$0	$262,800	$385,777	$377,478
2029	$0	$0	$262,800	$385,777	$352,783
2030	$0	$0	$262,800	$385,777	$329,704
2031	$0	$0	$262,800	$385,777	$308,134
2032	$0	$0	$262,800	$385,777	$287,976

$2,500,000 / (1+0.07)^(2022-2020)

(262,800+385,777) / (1+0.07)^(2025-2020)

(262,800+385,777) / (1+0.07)^(2032-2020)

Hypothetical BCA Example

- **Next we sum the discounted benefits and costs to get total discounted benefits and total discounted costs.**

Year	Capital Cost	Discounted Costs	Vehicle Operating Cost Savings	Vehicle Travel Time Savings	Discounted Benefits
2022	$2,500,000	$2,183,597	$0	$0	$0
2023	$0	$0	$0	$0	$0
2024	$0	$0	$0	$0	$0
2025	$0	$0	$262,800	$385,777	$462,427
2026	$0	$0	$262,800	$385,777	$432,175
2027	$0	$0	$262,800	$385,777	$403,901
2028	$0	$0	$262,800	$385,777	$377,478
2029	$0	$0	$262,800	$385,777	$352,783
2030	$0	$0	$262,800	$385,777	$329,704
2031	$0	$0	$262,800	$385,777	$308,134
2032	$0	$0	$262,800	$385,777	$287,976
TOTAL		**$2,183,597**			**$2,954,578**

Results – The NPV and BCR

- **Lastly, we calculate the project's net present value (NPV) and benefit-cost ratio (BCR).**

Net Present Value (NPV) = Total Discounted Benefits - Total Discounted Costs

= \$2,954,578 - \$2,183,597

= **\$770,981**

Benefit-Cost Ratio (BCR) $= \dfrac{\text{Total Discounted Benefits}}{\text{Total Discounted Costs}}$

$= \dfrac{\$2{,}954{,}578}{\$2{,}183{,}597}$

= **1.4**

Questions?