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

Preparing a Benefit-Cost Analysis for 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

BCA and MPDG

- All project sponsors should submit a benefit-cost analysis (BCA) as part of their MPDG grant 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
  - Compare assumptions to publicly available data
  - Correct for any technical errors
  - Perform sensitivity analysis on key inputs
  - Consider any unquantified benefits

Economic Analysis

- USDOT considers both the relative magnitude of estimated project benefits and costs and the degree of confidence in the results
- Assign projects to one of five categories
  - 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 Large Projects in INFRA
  - USDOT must determine that the project will be cost effective in order for it to be selected
- Small Projects in INFRA
  - 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 reasonably likely to exceed costs in order to be considered cost effective

What do I need to do a BCA?

- Clear understanding of the problem the project it 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
  - Partners
  - Publicly available data sources

What should my BCA submission include?

- Technical memo/discussion describing the analysis, including any unquantified benefits, and documenting sources of information used (assumptions and inputs)
  - If provided as an appendix, does not count against page limit for application narrative
- An unlocked spreadsheet (e.g., an Excel workbook) showing the calculations used to produce the estimates of benefits and costs

USDOT BCA Guidance

- Covers all USDOT discretionary grant programs
- Updated January 2023
- Available at https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance

What's New?

- Additional background information on BCA
- New and updated monetization values
- Additional guidance and new examples on:
  - Valuing pedestrian and transit infrastructure improvements
  - Valuing the benefits of transit transfer reduction
- Additional guidance on valuation of right-of-way being made available for other purposes

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 travel

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 simply 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 2021 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 2021 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
    - Document any Crash Modification Factor (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
- Can be a function of both changes to travel speed and/or travel distance
- 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_x, NO_x, and $PM_{2.5}$ found in BCA guidance
  - Be careful about the measurement units being applied
  - Check for $PM_{2.5}$ versus PM_{10}
- 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, congestion reduction, pavement damage
  - Values for external congestion, noise, and safety costs included in BCA 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

- Any claimed unquantified benefits should be explained as well as possible
  - Should clearly link specific project outcomes to any claimed unquantified benefits
  - Should quantify magnitudes/timing of impacts wherever possible
  - Should only include impacts that would be counted as benefits, if quantified

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)
  - Dis-benefits should be subtracted from the numerator

Other Types of Economic Analysis

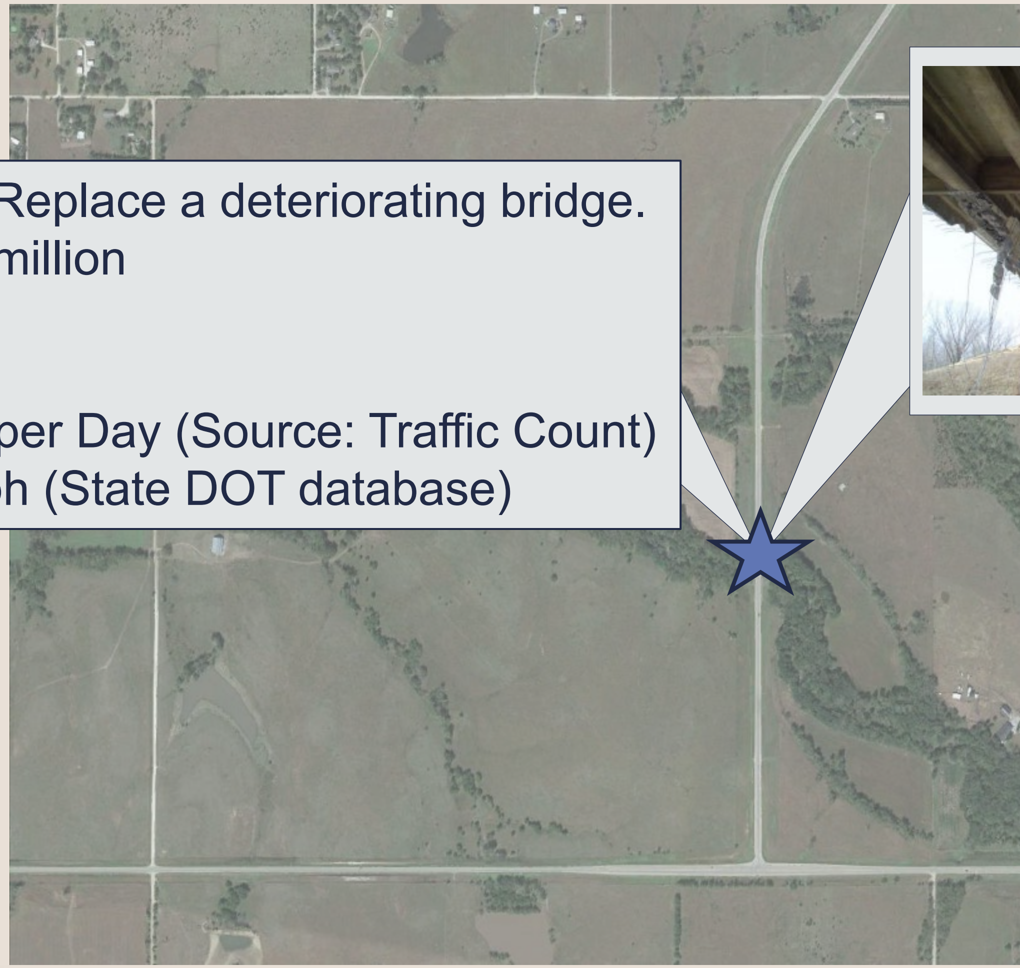
- **Examples**
  - Economic Impact Analysis (e.g., job creation)
  - Financial Impacts (e.g., revenue impacts)
  - Distributional Effects (e.g., equity)
- **Issues**
  - Use different approaches and answer different questions than does BCA
  - Do not represent additional benefits to include in BCA

MPDG Info

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

Questions?

Hypothetical BCA Example



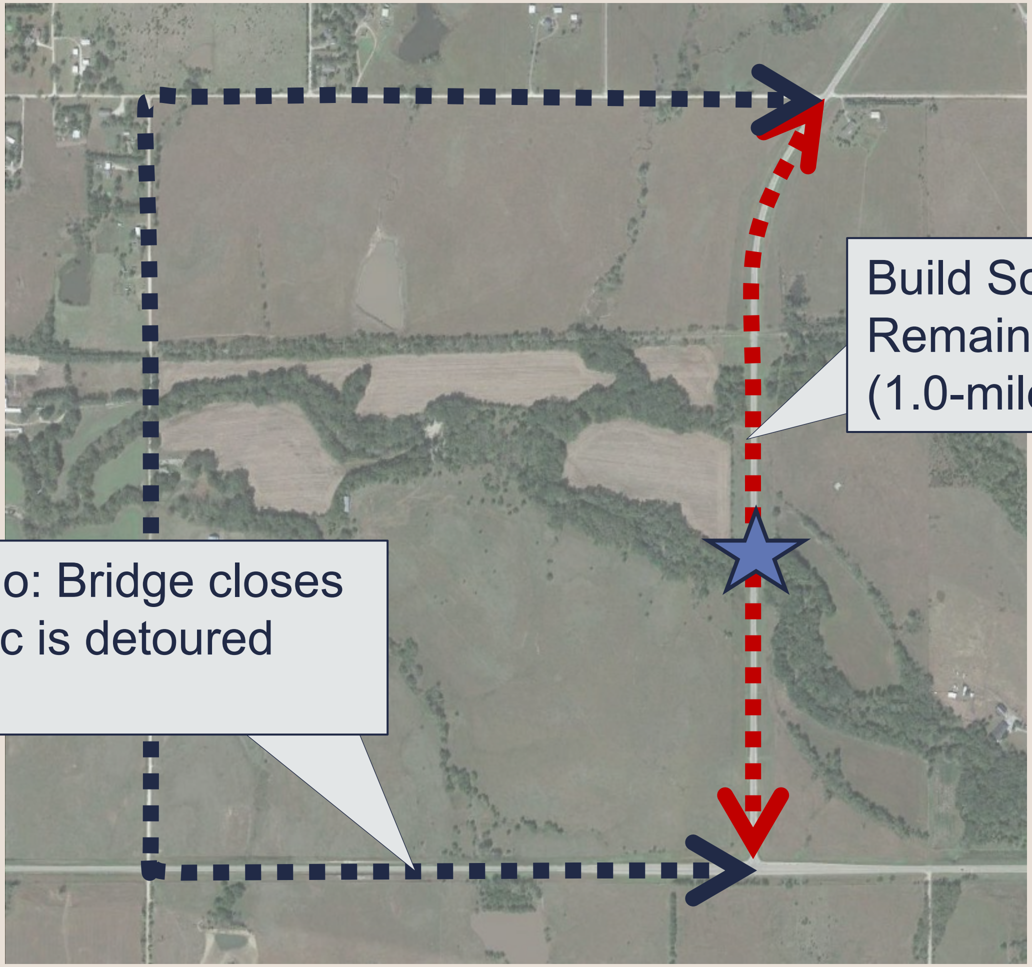
Proposed Project: Replace a deteriorating bridge.
Project Cost: $2.5 million

2021
AADT: 1,000 Cars per Day (Source: Traffic Count)
Avg. Speed: 45 mph (State DOT database)

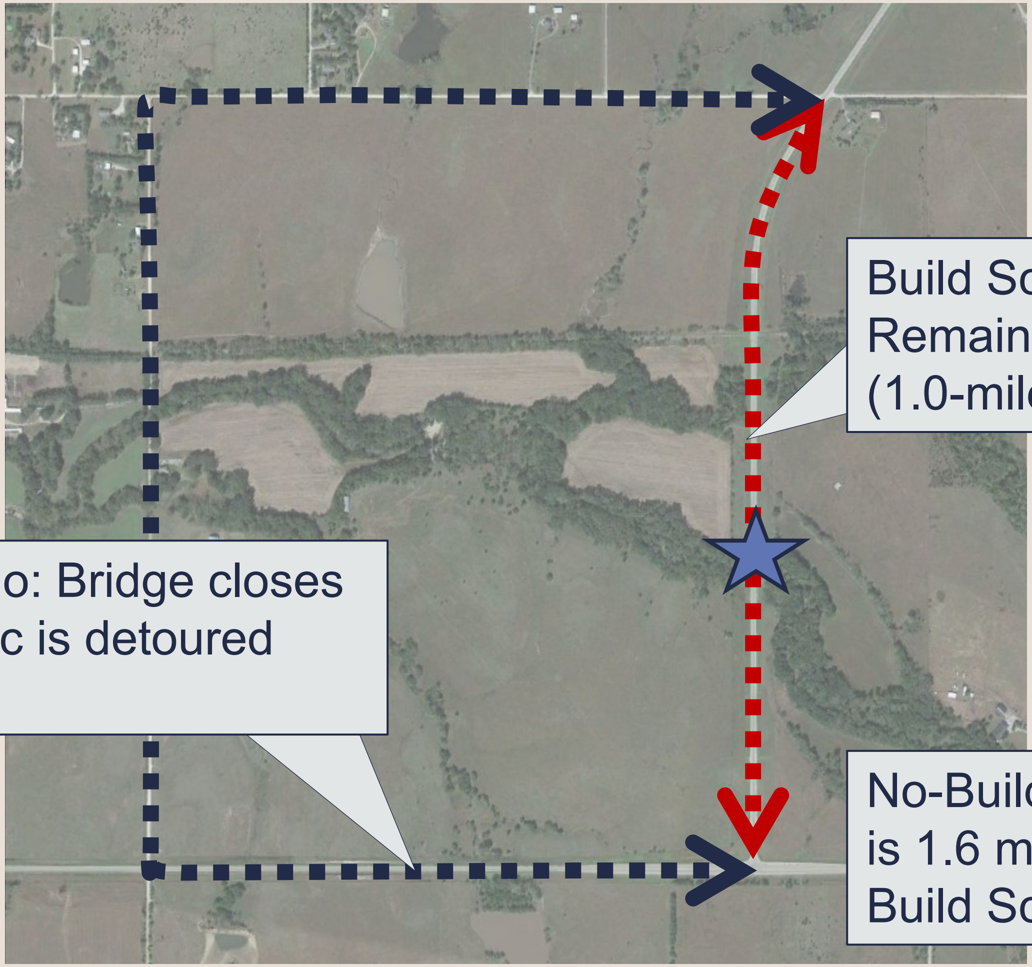
Hypothetical BCA Example

No-Build Scenario: Bridge closes in 2026 and traffic is detoured (2.6-mile route).

Hypothetical BCA Example



Hypothetical BCA Example



Approach

- We want to compare the state of the world with and without the proposed project improvement.
  - No-Build Scenario: Bridge closes in 2026, 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 2026.

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.**

Annual Vehicle Operating Cost Savings*	=	Incremental Detour	x	AADT	x	Vehicle Operating Cost Per Mile	x	Annualization Factor

Annual Vehicle Operating Cost Savings* =

*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

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

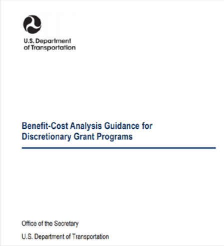
*Undiscounted.

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	$0.46		

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.

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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	$0.46	x	365

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

*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	$0.46	x	365
	=	$268,640 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.

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

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

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.**

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

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

Recent traffic count

*Undiscounted.

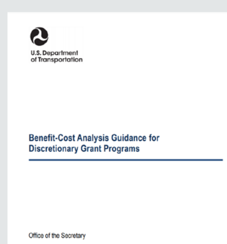
Travel Time Savings

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

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

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$18.80$$

USDOT BCA Guidance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Benefit-Cost Analysis Guidance for Discretionary Grant Programs

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(Appendix A)

*Undiscounted.

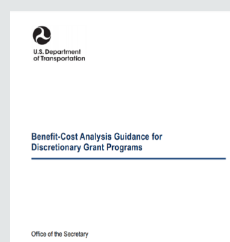
Travel Time Savings

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

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

$$\text{Annual Vehicle Travel Time Savings}^{*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$18.80 \times 1.67$$

USDOT BCA Guidance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Benefit-Cost Analysis Guidance for Discretionary Grant Programs

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*Undiscounted.

Travel Time Savings

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

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

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$18.80 \times 1.67 \times 365$$

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.

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

$$\text{Annual Vehicle Travel Time Savings*} = \frac{1.6 \text{ Miles}}{45 \text{ mph}} \times 1{,}000 \times \$18.80 \times 1.67 \times 365$$

$$= \$407{,}450 \text{ Per Year}$$

*Undiscounted.

Hypothetical BCA Example

- **Assume construction in 2023, 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	
2023	$2,500,000		$0	$0	
2024	$0		$0	$0	
2025	$0		$0	$0	
2026	$0		$268,640	$407,450	
2027			$268,640	$407,450	
2028			$268,640	$407,450	
2029	$0		$268,640	$407,450	
2030	$0		$268,640	$407,450	
2031	$0		$268,640	$407,450	
2032	$0		$268,640	$407,450	
2033	$0		$268,640	$407,450	

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
2023	$2,500,000	$2,183,597	$0	$0	$0
2024	$0	$0	[illegible]	[illegible]	[illegible]
202[illegible]	[illegible]	$0	$0	$0	[illegible]0
2026	$0	$0	$268,640	$407,450	$482,043
2027	$0	$0	$268,640	$407,450	$450,508
2028	$0	$0	$268,640	$407,450	$421,035
2029	$0	$0	$268,640	$407,450	$393,491
2030	$0	$0	$268,640	$407,450	$367,748
2031	$0	$0	$268,640	$407,450	$343,690
2032	$0	$0	$268,640	$407,450	$321,206
2033	$0	$0	$268,640	$407,450	$300,192

$2,500,000 / (1+0.07)^(2023-2021)

(268,640+407,450) / (1+0.07)^(2026-2021)

(268,640+407,450) / (1+0.07)^(2033-2021)

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
2023	$2,500,000	$2,183,597	$0	$0	$0
2024	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0
2026	$0	$0	$268,640	$407,450	$482,043
2027	$0	$0	$268,640	$407,450	$450,508
2028	$0	$0	$268,640	$407,450	$421,035
2029	$0	$0	$268,640	$407,450	$393,491
2030	$0	$0	$268,640	$407,450	$367,748
2031	$0	$0	$268,640	$407,450	$343,690
2032	$0	$0	$268,640	$407,450	$321,206
2033	$0	$0	$268,640	$407,450	$300,192
TOTAL		**$2,183,597**			**$3,079,913**

Results – The NPV and BCR

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

$$\text{Net Present Value (NPV)} = \text{Total Discounted Benefits} - \text{Total Discounted Costs}$$

$$= \$3{,}079{,}913 - \$2{,}183{,}597$$

$$= \mathbf{\$896{,}316}$$

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

$$= \frac{\$3{,}079{,}913}{\$2{,}183{,}597}$$

$$= \mathbf{1.4}$$

Questions?