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

Preparing a Benefit-Cost Analysis for the MPDG Program

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
- Required by executive orders, OMB guidance, and by statute for certain programs and Department activities.

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

Economic Analysis Rating

- 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 2.0
  - 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 reasonably likely to exceed costs in order to be considered cost effective

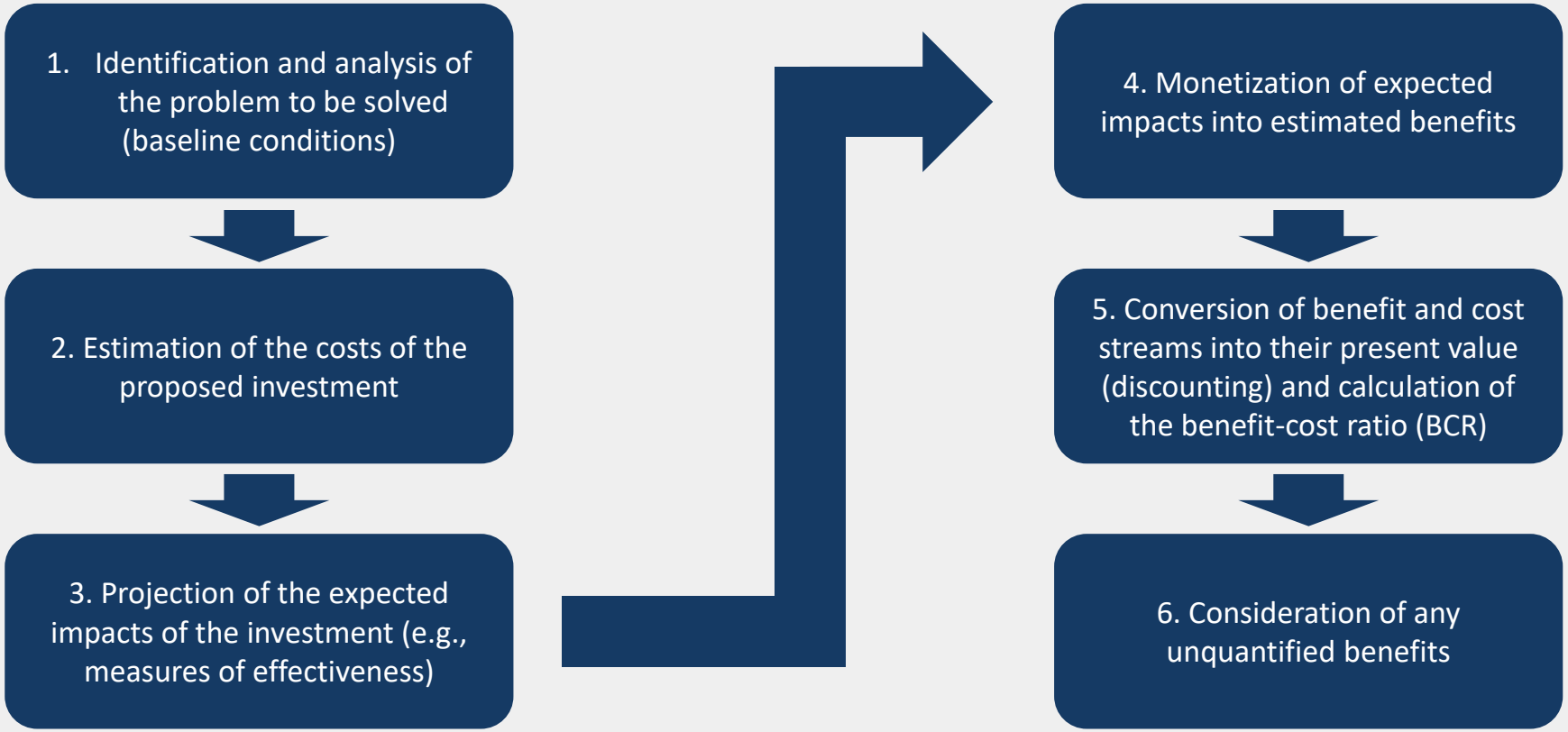
USDOT BCA Review

- 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

What do I need to do a BCA?

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

Developing a BCA



Sources of Information for a BCA

- Project planning and engineering documents
- Industry technical references and analytical tools
- DOT BCA Guidance
- Partners
- Publicly available data sources

USDOT BCA Guidance

- Covers all USDOT discretionary grant programs
- Structure of the Guidance
  - Overview of BCA ("how to get started")
  - BCA methodologies
  - Recommended input values
  - Sample calculations
- Available at https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance

What's New for 2024?

- Revised discount rates in accordance with updates to OMB Circular A-94
- Revised values for the social cost of CO_2 emissions
- Other new and updated monetization values:
  - Includes commuter, intercity passenger, and freight rail per-hour operating and social costs
- Simplified measure of emission costs per vehicle mile traveled
- Links to two new documents to aid applicants in their BCA:
  - FHWA Bridge Improvement Program BCA Tool
  - USDOT BCA Spreadsheet Template

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

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 improved and/or replacement facility

Analysis Period

- Should cover both initial development/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 2022 base year for all cost and benefit data
  - Index values for the GDP Deflator included in the BCA guidance
- **Discounting**
  - Use a 3.1% discount rate for all benefits and costs (except CO_2, which should be discounted at 2.0%)
  - Recommend using a 2022 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 or other, lesser 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
- Avoid double-counting benefits
- Negative outcomes should be counted as “disbenefits”
- Any estimated benefits should be clearly tied to the project scope and expected outcomes
- Some common benefit categories estimated in BCAs for transportation projects are presented in the following slides
  - Applicants may also include other benefit categories or approaches in their BCAs

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 Factors (CMFs) 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 value of time for walking, cycling, waiting, standing, transfers, 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 or rail travel time savings, reduced fuel consumption
- Localized, specific data preferred
- Standard per-mile values for light duty vehicles and commercial trucks provided in BCA guidance
  - Should not be converted to per-hour values
- Values for hourly operating costs for commuter, intercity, and freight rail provided in BCA Guidance

Emissions Reduction Benefits

- For infrastructure improvements, emission 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}
- Values for reduced CO_2 emissions should be discounted at **2.0 percent**, while all others should be discounted at **3.1 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.

Work Zone Impacts

- Transportation infrastructure improvements often involve work zones that can have negative impacts on travelers during the construction period
  - Ex: travel times, safety, operating costs
- Applicants should account for any work zone impacts in their analysis
  - If expected to be minimal, the analysis should describe characteristics of the project or delivery method that would mitigate such impacts

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 values benefits to additional users less than those for existing users (see BCA Guidance

Modal Shift

- Projected magnitude
  - Should be based on careful analysis of local conditions and potential for shift 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, noise reduction
  - Values for external congestion, noise, safety, and emission 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
- Total capital costs for the project should be clearly presented in three forms
  - 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

- BCA considers the **increased economic efficiency** resulting from a project, and assesses the net change to overall societal welfare
- This is distinct from other types of economic analysis, such as
  - Economic Impact Analysis (e.g., job creation)
  - Financial Impacts (e.g., revenue impacts)
  - Distributional Effects (e.g., equity)
- These other types of analysis can be used to answer important questions and aid in decision-making; however, they use different approaches and answer fundamentally different questions than does BCA
- Importantly, these analyses do not provide estimates of additive benefits to be considered in BCA

Key Resources for BCA

- **DOT BCA Guidance**
  - https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance
- **DOT BCA Spreadsheet Template**
  - Developed by DOT as an optional template to aid applicants in structuring their BCA and performing certain calculations common to all analyses.
  - Designed as an open-ended template that can handle any project type
  - Available at: https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-spreadsheet-template
- **Bridge Investment Program BCA Tool**
  - Supports estimates of the benefits of bridge preservation or replacement investments using National Bridge Inventory data
  - Applicable to roadway bridge projects for any DOT program where BCA is required
  - Available at: https://www.fhwa.dot.gov/bridge/bip/bca/

MPDG Info

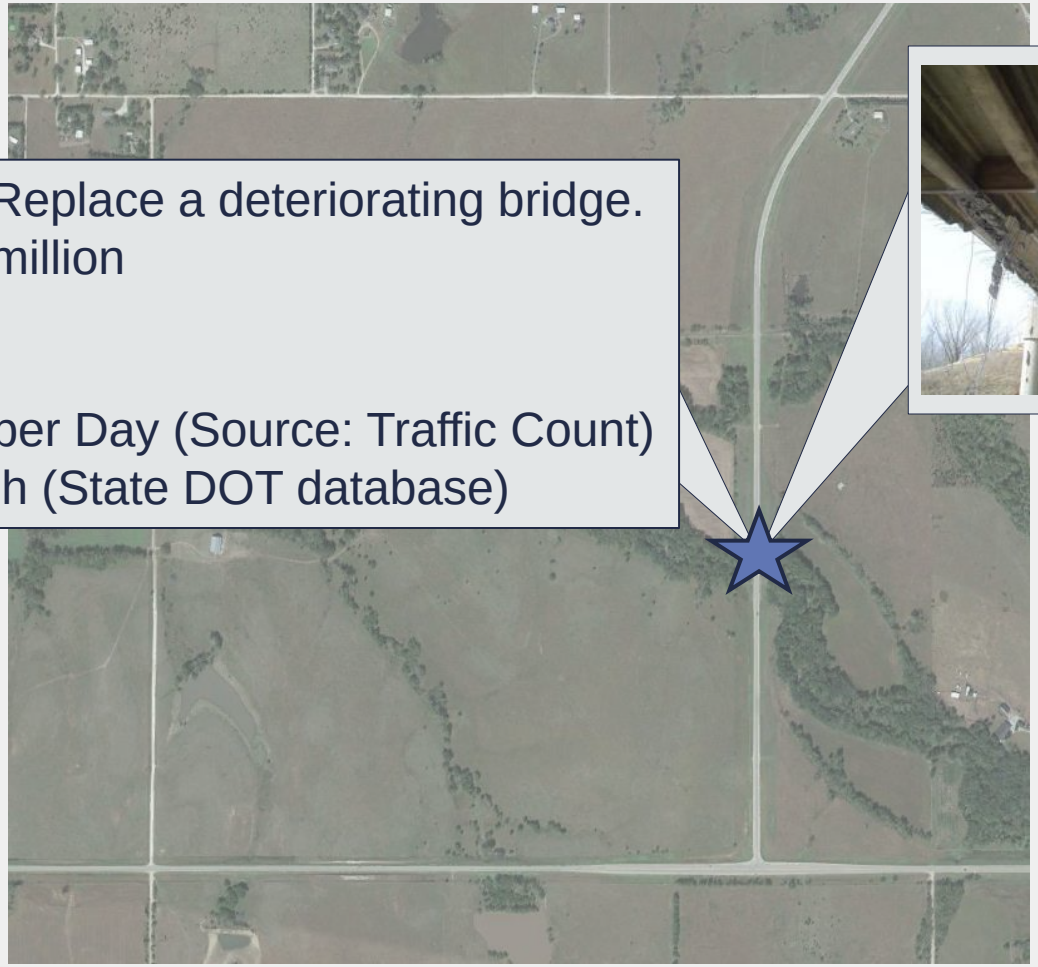
- For additional MPDG information and how to apply: https://www.transportation.gov/grants/mpdg-program
- For technical questions, please email: MPDGrants@dot.gov.

Questions?

Hypothetical BCA Example

Proposed Project: Replace a deteriorating bridge.
Project Cost: $6.3 million

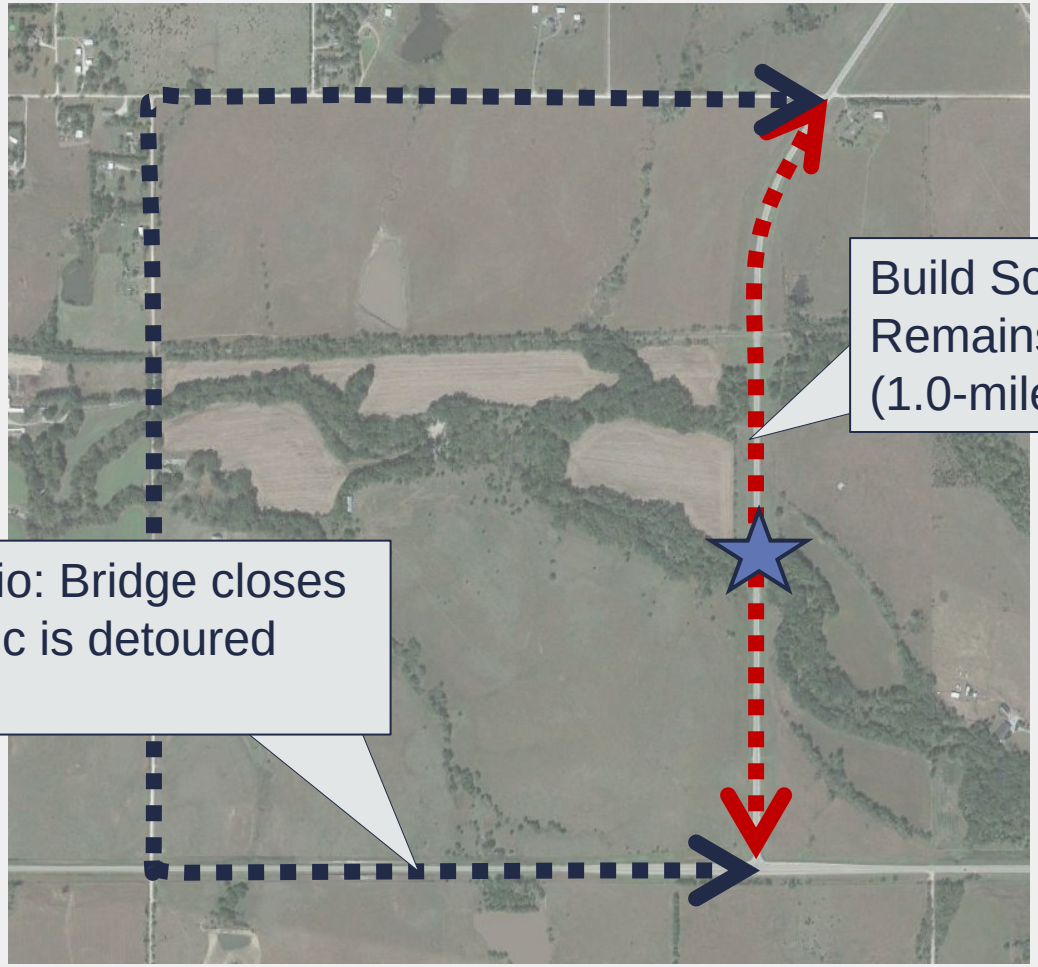
2021
AADT: 1,600 Cars per Day (Source: Traffic Count)
Avg. Speed: 45 mph (State DOT database)



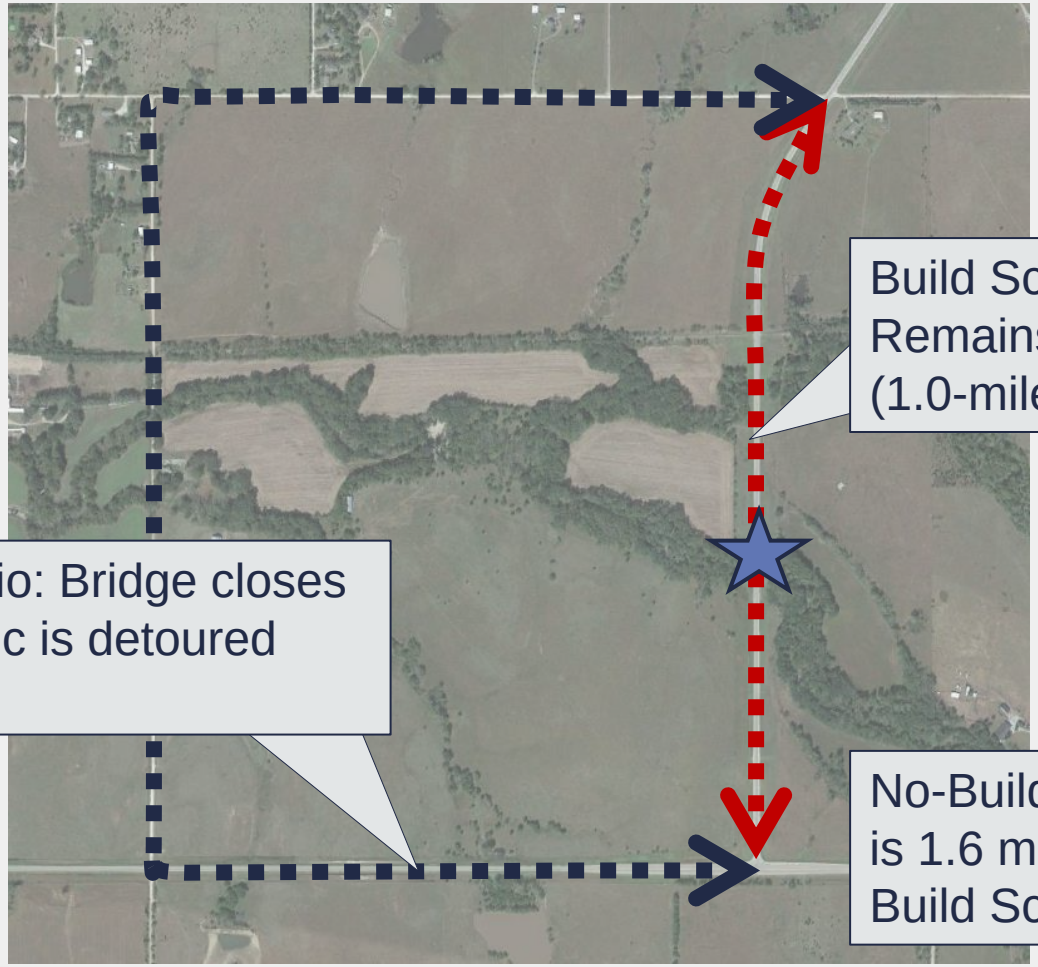
Hypothetical BCA Example

No-Build Scenario: Bridge closes in 2027 and traffic is detoured (2.6-mile route).

Hypothetical BCA Example



Hypothetical BCA Example



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

No-Build Scenario: Bridge closes in 2027 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 2027, 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 2027.

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

*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	1,600	

Recent traffic count

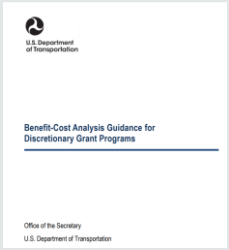
*Undiscounted.

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	1,600	x	$0.52		

USDOT BCA Guidance



(Appendix A)

*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	1,600	x	$0.52	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	1,600	x	$0.52	x	365
	=	$485,888 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.**

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

Annual Vehicle Travel Time Savings* = $\frac{1.6 \text{ Miles}}{45 \text{ mph}}$ x 1,600 x

Recent traffic count

*Undiscounted.

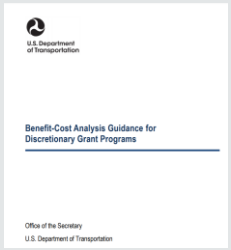
Travel Time Savings

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

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

Annual Vehicle Travel Time Savings* = $\frac{1.6 \text{ Miles}}{45 \text{ mph}}$ x 1,600 x $19.60

USDOT BCA Guidance



(Appendix A)

*Undiscounted.

Travel Time Savings

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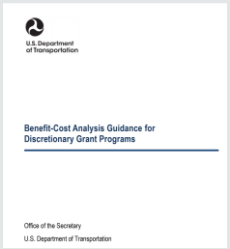
Annual Vehicle Travel Time Savings* = Marginal Detour Time x AADT x Hourly Value of Time x Vehicle Occupancy x Annualization Factor

Annual Vehicle Travel Time Savings* = $\frac{1.6 \text{ Miles}}{45 \text{ mph}}$ x 1,600 x $19.60 x 1.67

USDOT BCA Guidance



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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.**

Annual Vehicle Travel Time Savings*	=	Marginal Detour Time	x	AADT	x	Hourly Value of Time	x	Vehicle Occupancy	x	Annualization Factor	
Annual Vehicle Travel Time Savings*	=	$\frac{1.6 \text{ Miles}}{45 \text{ mph}}$	x	1,600	x	$19.60	x	1.67	x	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.**

Annual Vehicle Travel Time Savings*	=	Marginal Detour Time	x	AADT	x	Hourly Value of Time	x	Vehicle Occupancy	x	Annualization Factor	
Annual Vehicle Travel Time Savings*	=	$\frac{1.6 \text{ Miles}}{45 \text{ mph}}$	x	1,600	x	$19.60	x	1.67	x	365	
	=	$679,662 Per Year									

*Undiscounted.

Hypothetical BCA Example

- Assume construction in 2024, 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	
2024	$6,300,000		$0	$0	
2025	$0		$0	$0	
2026	$0		$0	$0	
2027	$0		$485,888	$679,662	
2028			$485,888	$679,662	
2029			$485,888	$679,662	
2030	$0		$485,888	$679,662	
2031	$0		$485,888	$679,662	
2032	$0		$485,888	$679,662	
2033	$0		$485,888	$679,662	
2034	$0		$485,888	$679,662	

Bridge Closure Year (No-Build Scenario)

Hypothetical BCA Example

- **Next, we discount costs and benefits using a 3.1% 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
2024	$6,300,000	$5,748,633	$0	$0	$0
2025	$0	$0	$0	$0	$0
2026	$0	$0	$0	$0	$0
2027	$0	$0	$485,888	$679,662	$1,000,547
2028	$0	$0	$485,888	$679,662	$970,463
2029	$0	$0	$485,888	$679,662	$941,283
2030	$0	$0	$485,888	$679,662	$912,981
2031	$0	$0	$485,888	$679,662	$885,529
2032	$0	$0	$485,888	$679,662	$858,903
2033	$0	$0	$485,888	$679,662	$833,078
2034	$0	$0	$485,888	$679,662	$808,029

$6,300,000 / (1+0.031)^(2024-2022)

(485,888+679,662) / (1+0.031)^(2027-2022)

(485,888+679,662) / (1+0.031)^(2034-2022)

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
2024	$6,300,000	$5,748,633	$0	$0	$0
2025	$0	$0	$0	$0	$0
2026	$0	$0	$0	$0	$0
2027	$0	$0	$485,888	$679,662	$1,000,547
2028	$0	$0	$485,888	$679,662	$970,463
2029	$0	$0	$485,888	$679,662	$941,283
2030	$0	$0	$485,888	$679,662	$912,981
2031	$0	$0	$485,888	$679,662	$885,529
2032	$0	$0	$485,888	$679,662	$858,903
2033	$0	$0	$485,888	$679,662	$833,078
2034	$0	$0	$485,888	$679,662	$808,029
TOTAL		**$5,748,633**			**$7,210,812**

Results – The NPV and BCR

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

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

$$= \$7{,}210{,}812 - \$5{,}748{,}633$$

$$= \mathbf{\$1{,}462{,}179}$$

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

$$= \frac{\$7{,}210{,}812}{\$5{,}748{,}633}$$

$$= \mathbf{1.3}$$

Questions?