TECHNICAL BRIEF #2

Benefit Cost Analysis Road Weather Management

Conducting Benefit Cost Analysis of Road Weather Management Strategies

This information brief is a continuation of the FHWA Office of Operations Transportation Systems Management and Operations Benefit-Cost Analysis technical briefing series. Earlier briefs were published in 2012 and are available online at: http://www.ops.fhwa.dot.gov/plan4ops/resources/brochures.htm.

Purpose

Transportation agencies have a long history of utilizing benefit-cost analyses (BCA) to evaluate and prioritize investments in major capacity enhancing strategies. The use of BCA has been expanded in many agencies to examine the effectiveness of operational investment types of strategies, such as road weather, management (RWM).

The application of BCA to RWM strategies resulted from increased competition for funding and the accompanying need to provide greater justification for RWM projects through a more systematic assessment process. This process can be used to weigh the relative benefits and costs of projects objectively as well as to provide meaningful analyses that may differ greatly in their scope, intended outcomes, impacts on the transportation system, and costs.

This Technical Brief is the second in a series that explains RWM BCA assessment procedures. It describes what types of cost information is needed and how they can be determined. Additionally, it explains what kinds of benefits State departments of transportation (DOT), local agencies, and analysts are able to evaluate using BCA and BCA modeling tools. More detailed information on the use of BCA in transportation planning procedures can be found on the internet sites provided in this brief.

Benefit-Cost Analysis for Road Weather Management Projects

When conducting a BCA for RWM projects, an analyst applies a discount rate to the estimated benefits and costs identified during each year of the RWM project's life cycle. This yields one or more alternative measures of an RWM project's economic merit. To ensure that the alternatives can be compared objectively, the analyst specifies a multiyear analysis period over which the life-cycle costs and benefits of all alternatives will be measured.

For each alternative, the analyst measures the costs of capital, travel times, crash rates, and other impacts using engineering methods and then compares the results to those of the base case. The differences relative to the base case are quantified by year for each alternative. The analyst assigns dollar values to the different impacts (e.g., fewer hours of delay associated with an alternative relative to the base case are multiplied by a dollar value per hour saved) and discounts them to a present value amount. The analyst can also compare the net present values (NPV) of the alternatives with the NPV of the base case instead of calculating the differences and then discounting them to the present.

Any alternative where the value of discounted benefits exceeds the value of discounted costs is worth pursuing from an economic standpoint (taking into account budgetary constraints). For any given RWM project, however, only one design alternative can usually be selected. Usually, the selected alternative will be the most economically efficient; i.e, the alternative for which the benefits exceed costs by the largest ratio.

Selected General BCA References

Economic Analysis Primer - http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer00.cfm.

Operations Benefit/Cost Analysis Desk Reference – http://ops.fhwa.dot.gov/publications/fhwahop12028/index.htm.

TIGER BCA Resource Guide – http://www.webpages.uidaho.edu/~mlowry/Teaching/EngineeringEconomy/Supplemental/USDOT_Economic_Analysis_Primer.pdf.

Selected RWM BCA References

Road Weather Management BCA Compendium - http://www.ops.fhwa.dot.gov/publications/fhwahop14033/index.htm.

ITS-JPO Benefits and Costs Databases - http://www.itsbenefits.its.dot.gov/ and http://www.itscosts.its.dot.gov/.

Costs and Benefits Included in a Road Weather Management Benefit-Cost Analysis

When analyzing RWM strategies, the impacts of a particular alternative do not always fall neatly into benefit or cost categories. An alternative may reduce agency costs, which is a benefit. Similarly, an alternative may reduce crash rates relative to the base case (another benefit) while a different alternative may increase crash rates (a cost, also called a negative benefit or disbenefit) relative to the base case. Care must be taken to ensure that all costs and benefits of each alternative are fully and accurately accounted for, and likewise that there is no double counting of costs and benefits.

Agency Costs

The assignment of monetary values to the design, construction, and operation of a project is perhaps the easiest valuation concept to understand. These costs are estimated based on past experience, bid prices, design specifications, materials costs, and other information. Care must be taken to make a complete capital cost estimation, including contingencies and administrative expenses such as internal staff planning and overhead. A common error in economic analysis and budgeting is the underestimation of project construction and development costs. Particular care should be used when costing large or complicated projects.

A sample list of agency costs for implementation of automated vehicle location (AVL) for road weather management is shown on Table 1.

Table 1. Agency Costs for Automated Vehicle Location Implementation

Agency Costs of AVL Implementation
Base Station Hardware
Software (Licensing)
Sensors and Software Integration
In-Vehicle Units
Training
Repair and Maintenance
System Integration
Additional Data Channel to Radio System

SOURCE: Federal Highway Administration

Vehicle Operating Costs

The cost to the drivers of operating their vehicles can be affected by a RWM project due to the changes in highway speeds, traffic congestion, pavement surface friction, and other conditions that affect vehicle fuel consumption and wear and tear. Accurate calculations of a RWM project's impacts on vehicle operating costs (VOC) require good information on the relationship of vehicle performance to road weather condition and assumptions about vehicle fleet fuel efficiency and performance. Weather affects or interacts with the following parameters to impact the final value of VOC:

1. Vehicle Type.
2. Vehicle Speed.
3. Speed Changes.
4. Gradient.
5. Curvature.
6. Road Surface Type.

Travel Time, Delay, and Reliability

An hour of travel associated with a business trip or commerce is usually valued at the average traveler's wage plus overhead—representing the cost to the traveler's employer. Personal travel time (either for commuting, household needs or leisure) is usually valued as a percentage of average personal wage or through estimates of what travelers would be willing to pay to reduce travel time. Recently, transportation analysts have added another important performance measure: travel time reliability. Due to uncertainty in travel time, travelers add "buffer time" to their trips to ensure they arrive at their destination on time. Some RWM projects can reduce travel time, some reduce buffer time, and some reduce both. All of these reductions are benefits. Table 2 shows some of the impacts that adverse weather has on traffic parameters that determine travel time, delay, and reliability of the highway or network.

Table 2. Decrease in Traffic Flow Parameters Due to Various Weather Events

Weather Event	Average Speed	Free-Flow Speed	Traffic Volume	Capacity
Light Rain/ Snow	3% - 13%	2% - 13%	5% - 10%	4% - 11%
Heavy Rain	3% - 16%	6% - 17%	14%	10% - 30%
Heavy Snow	5% - 40%	5% - 64%	30% - 44%	12% - 27%

Table 2. Decrease in Traffic Flow Parameters Due to Various Weather Events (Continuation)

Weather Event	Average Speed	Free-Flow Speed	Traffic Volume	Capacity
Low Visibility	10% - 12%	not analyzed	not analyzed	12%

SOURCE: http://www.ops.fhwa.dot.gov/publications/weatherempirical/weatherempirical.pdf.

Safety

The assignment of monetary values to changes in crash rates or severities, or general safety of roads and freeways, can generate controversy because crashes often involve injuries or loss of life. The use of reasonable crash cost values is critical, however, to avoid underinvesting in highway safety. Economists often use the dollar amounts that travelers are willing to pay to reduce their risk of injury or death to estimate monetary values for fatalities and injuries associated with crashes. Medical, property, legal, and other safety-related costs are also calculated and added to these amounts.

Table 3 lists dollar values generally used by transportation planners for calculating safety benefits of transportation projects.[1] The values represent the costs associated with a fatality and various levels of injuries. To determine the safety benefits of a RWM project or strategy, the reduction in fatalities or injury levels is multiplied by the values shown in the table.

Externalities

One of the more challenging areas of BCA is the treatment and valuation of the “externalities” of transportation projects. In economics, an externality is the uncompensated impact of one person’s actions on the well-being of a bystander. In the case of RWM investments, “bystanders” are the non-users of the transportation system. When the impact benefits the non-user, this is called a positive externality. When the impact is adverse, this is called a negative externality.

If the measurable net benefits of a project are highly positive, the presence of minor unquantified externalities can be tolerated from an economic standpoint even if they are negative. On the other hand, if the net benefits are very low, then the existence of significant unquantified negative externalities may tip the economic balance against the project. Examples of externalities associated with RWM projects and strategies include the use of salt for winter maintenance and its effect on the environment, the reduction of cold starts for engines, and increasing or decreasing emissions.

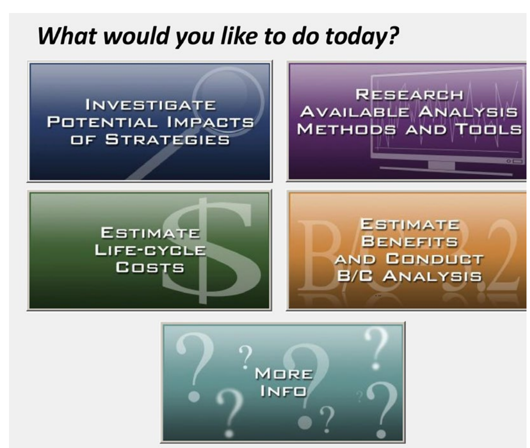
Table 3. Crash Types and Respective Occurring Costs

Crash Type	Cost
Fatal	$9.74M
Critical	$5.78M
Severe	$2.59M
Serious	$1.02M
Moderate	$0.45M
Minor	$0.03M

Source: K. Thomson, “Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses - 2015 Adjustment,” June 17, 2015. Available at: *https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf*.

Tool for Operations Benefit Cost Analysis

Tool for Operations Benefit Cost Analysis (TOPS-BC) provides both an analysis framework and default parameters that enable users to conduct simple sketch-planning-level BCAs for selected RWM strategies. This capability allows users to conduct benefit cost analysis quickly, simply, and with preset input data. TOPS-BC leverages many existing tools to identify best practices and synthesizes their capabilities into a more standardized format for analyzing a broader range of strategies within a single tool. The ability to directly estimate benefits and costs within a single tool is uncommon in other BCA tools. TOPS-BC users are able to assess sketch-planning-level benefits and costs of various RWM strategies using minimal user data input.



SOURCE: FHWA TOPS-BC spreadsheet tool

1 K. Thomson, “Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses - 2015 Adjustment,” June 17, 2015. Available at: *https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf*.

TOPS-BC provides a framework for analysts that can be modified and configured to match the needs of a particular region and its characteristics depending on the location in which a RWM strategy is intended to be implemented. Default data is provided for many impact parameters, performance relationships, and benefit valuations.

The Clear Roads Pooled Fund Benefit-Cost Analysis Toolkit

The Clear Roads Pooled Fund BCA Toolkit was developed to facilitate and streamline BCAs for various winter maintenance and RWM strategies. The original toolkit was developed by Minnesota DOT with input from the Clear Roads Technical Advisory Committee and winter maintenance practitioners. The project consisted of a number of sequential activities, culminating in the development of the web-based toolkit.

The main purpose of this toolkit is to streamline the way BCAs for winter maintenance investments are conducted. It also assists maintenance managers in meeting the demand for maximum benefits accrued versus costs incurred when adopting new RWM practices, equipment, or operations in a more efficient manner and in justifying the expenditures they propose. The toolkit can also be used to examine the costs and benefits of existing practices, equipment, and operations.

SOURCE: http://www.westerntransportationinstitute.org/documents/reports/4W2455_Final_Report.pdf

For more information on The Clear Roads Pooled Fund BCA Toolkit, see: http://www.westerntransportationinstitute.org/documents/reports/4W2455_Final_Report.pdf.

Technical Contacts

If you have any questions regarding Road Weather Management BCA, please contact the following individuals.

Roemer Alfelor
(202) 366-9242
Roemer.Alfelor@dot.gov

Jim Hunt
(717) 221-4422
Jim.Hunt@dot.gov

Ralph Volpe
(404) 562-3637
Ralph.Volpe@dot.gov

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