TECHNICAL BRIEF #3

Benefit Cost Analysis
Transportation Systems Management and Operations

Use of Archived Operations Data in Planning and Benefit Cost Analysis

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.

Effective transportation planning and investment decision making depends on timely, comprehensive, and accurate data. Traditionally data for planning has come from manual collection techniques and approximations from model output. While these sources are still used, transportation planners at the State, metropolitan, and local level are beginning to leverage an increasingly prevalent kind of transportation data—archived operations data. This data is collected and stored to support efforts to monitor and manage the transportation system. The purpose of this brief is to inform practitioners of the availability and potential uses of this data, highlighting the utility of the information in executing benefit-cost analyses (BCA) for transportation systems management and operations (TSM&O) projects and strategies. One tool provided by the Federal Highway Administration (FHWA) to execute BCA is the Tool for Operations Benefit Cost Analysis (TOPS-BC), available from the FHWA website.

Enormous amounts of data on the performance of the transportation system are generated daily from various technologies. For example, there are over 4 billion probe-based road segment speeds generated in the United States each day. Archived operations data can include traffic, transit, freight, bike, pedestrian, construction, and weather information that is usually collected in real time by intelligent transportation system (ITS) infrastructure, such as inductive in-pavement loop detectors, radar detectors, remote traffic microwave sensors (RTMS), Bluetooth, and E-ZPass or other unique ID tag readers. It also includes incident or event information entered into electronic logs by transportation or public safety personnel.

Of the many types of data available, a few are highlighted here:

1. **Travel Time –** A large proportion of TSM&O benefits come from travel time reliability improvements. From a measurement perspective, travel time reliability is quantified from a distribution of travel times for a given facility or trip in a time period.
2. **Incident Data –** Before/after economic evaluations of the safety-related benefits of a TSM&O strategy are supported by incident data: time, location, severity, category, and cost of incident(s).

ARCHIVED OPERATIONS DATA SUPPORT PLANNING NEEDS

Examples include:

1. **Performance-based planning and programming:**
   - i. **Setting outcome-based objectives and tracking performance measures.**
   - ii. **Identifying system performance needs and problems .**
   - iii. **Prioritizing and selecting programs and projects.**
2. **Analytical models:**
   - i. **Model inputs for facilities, traffic and incidents.**
   - ii. **Model calibration and validation.**
   - iii. **Emerging model frameworks.**
3. **Benefit-cost analysis**
   - i. **Analyzing and evaluating scenarios, programs, projects, or strategies.**
   - ii. **Monitoring and evaluating the impacts of implemented programs and projects.**
   - iii. **Informing future projects as to likely benefits and costs.**

FHWA, Desk Reference: "*Use of Archived Operations Data in Planning – A Desk Reference*"

(FHWA-HOP-16-017, estimated April 2016).

3. **Work Zone and Special Event Data** – Roadway construction and special events can be the cause of long-lasting traffic delays. Detailed data can help pinpoint the time and location of work zones and events and provides the analysts with more accurate before/after travel time values.
4. **Freight Data** – The data related to freight terminal activity levels and value of goods moved is useful in evaluating the benefits of intermodal connectivity brought by TSM&O projects.

As stated, this is only a portion of the universe of archived operations data potentially available to the transportation planning community. Other data could include:

- Lane-specific traffic volume, speed, and occupancy data from roadway detectors (e.g., loops, video).
- Travel time data from vehicle probes (e.g., GPS, toll tag readers).
- Weather data, such as duration, extent, predictions.
- Operational status of signals at intersections or ramp meters.
- Location and status of parking facilities (i.e., number of spaces occupied and available, time and duration of parking patterns, current fees).
- Signal timing plans, current or future timing schemes.
- Intelligent traffic system devices such as traffic detectors and traffic signals, and operational strategies such as high-occupancy vehicle restrictions, direction of reversible lanes, and pricing high-occupancy toll lanes by time.

Process and Requirements for BCA

A BCA uses monetized values to compare total benefits with total incremental costs. The results can be presented as a benefit-cost ratio (B/C ratio), with benefits divided by costs. The net benefit is defined as the sum of all benefits minus the sum of all costs and provides an absolute measure of benefits (total dollars) rather than the relative measures provided by the B/C ratio. To perform a BCA, it is necessary to monetize all relevant impacts. In recent years, economists have developed techniques for monetizing non-market impacts, and transportation analysts have been using standardized values for travel time, crash damages, and environmental impacts in evaluating and selecting projects.

As previously mentioned, with TOPS-BC, the FHWA has developed a BCA tool to assist planners in conducting initial BCA of TSM&O projects and strategies. The achievable benefits and the corresponding methodology to monetize these benefits include:

1. **Reduced travel time for drivers and passengers.**[1] The U.S. Department of Transportation recommends valuing travel time savings at 50 percent of the average wage rate for local personal travel.
2. **Reduced vehicle operating costs.** Vehicle operating costs refer to costs that vary with vehicle usage, including fuel, tires, maintenance, repairs, and mileage-dependent depreciation costs.
3. **Increased safety through reduced crashes and incident-induced secondary crashes.** Safety impact analysis requires information on how a project will affect crash frequency and severity. Crashes can impose a variety of costs and thus play a critical role in the evaluation of a project.
4. **Reduced emissions**. The first step in quantifying air pollution impacts is to estimate the changes in vehicle miles, vehicle hours, and vehicle trips for different vehicle classes and to develop a model that quantifies how the project will affect the quantity and mix of air polluting emissions.
5. **Improved travel time reliability:** Travelers plan for additional travel time to account for trip time variability, thereby ensuring on-time arrival. Reducing this buffer time provides additional benefits to travelers.
6. **Lower noise levels:** Researchers have found that traffic noise can impair people's hearing, increase stress, disturb sleep, and contribute to ill health, and also tends to reduce the value of nearby homes.

The costs are project- or program-specific and can include various cost categories used by transportation departments to implement a project:

- Initial construction of improvements.

[1] The U.S. Department of Transportation recommends valuing travel time savings at 50 percent of the average wage rate for local personal travel. *https://www.transportation.gov/sites/dot.gov/files/docs/USDOT%20VOT%20Guidance%202014.pdf*.

- Installation of technology systems.
- Personnel training.
- Public outreach.
- Ongoing operations, repair and maintenance of infrastructure and systems.

For each year of the life of the project, the benefits and costs will be assigned to the appropriate year in the life of the project. For example, in year 0 (the beginning of a project), no benefits would be realized, but the costs of construction, installation, training and other "up front" costs would be incurred. In subsequent years, benefits would accrue as the improvements in the facilities are realized. Ongoing costs over time would include the service, maintenance, and daily operational costs associated with the improvements.

To account for future inflation and the time value of money, future cost and benefit streams are discounted (divided by a factor to account for inflation and the time value of money) to derive a net present value (NPV) of the streams to calculate the benefit-cost ratio (BCR). Per guidelines provided by the U.S. Office of Management and Budget, a 7 percent discount rate is used in the development of BCRs. TIGER grant applications suggest the analysis be presented at both at both 7 and 3 percent discount rates.

The BCR for a project is the sum of the NPV of benefits for the project divided by the NPV of the project costs. The net benefits for a project as a whole are the difference between the NPV of benefits and the NPV of costs over a specified time period. When a BCR is greater than 1:1 or the net benefits are greater than 0, the benefits outweigh the costs for a project over time. The higher the BCR or net benefits, the more economically attractive a project is. Therefore, BCRs or net benefits can be useful in prioritizing projects.

HOW ARCHIVED OPERATIONS DATA CAN SUPPORT A BENEFIT-COST ANALYSIS

1. Improve existing freeway traffic simulation models (archived data is used for calibration purposes).
2. Calibrate existing and new traffic simulation models using specific software, data, and models such as TOPS-BC; the data helps to evaluate implemented arterial TSM&O strategies and assists in the prediction and quantification of their benefits.
3. Aid in establishing the current impact on traffic caused by external influences (in contrast to simulation scenarios).
4. Contribute to the cost estimation process (for example, estimating incident management response/frequency, parking demand, etc.).

Benefits of Archived Operations Data to Planners

Archived operations data provides numerous benefits to planners. Archived operations data is more accurate than modeled data, serves multiple purposes within a transportation agency, and enables new types of analyses to support better planning and investment decisions. Key benefits of using archived operations data in planning include:

1. **Better project decision making.** The improved accuracy of real-world data over data generated by a model can support better decision making. Because archived data is continuously collected, it overcomes the sampling error inherent in using small samples of data collected manually, providing planners with a better reflection of reality. Visualization of archived operations data produces important insights into the performance characteristics of the transportation system, which leads to better decisions on where to spend transportation dollars.
2. **Expanded analysis supports more comprehensive issue resolution.** The highly detailed nature of archived operations data enables many types of analyses previously unavailable to planners so that the planning process is able to address a wider variety of issues. For example, archived data facilitates the opportunity to include travel time reliability into long-range transportation plans (LRTPs). Travel time reliability could not be adequately measured or modeled without archived data because it requires continuous data collection to see patterns over time.
3. **Improved ability to analyze infrequent or rare events.** Another benefit of using archived operations data over traditional data is that it allows the impacts of relatively infrequent events to be documented and analyzed. Such events may include weather data (e.g.,

a major winter storm, or days when air quality standards are exceeded), incident data (e.g., full closure of a roadway due to a severe incident), special event data (e.g., roadblocks and traffic changes prior to a major sports event). This also enables planners to identify the likely causes of performance problems by correlating multiple data sets over time.

4. **Expanded ability to validate modeled performance**. Archived data allows planners to test the performance of deployed projects and compare the results to the estimates developed in the planning process.

The Use of Archived Data Results in New Transportation Planning Applications

As described in the previous section, a BCA can inform many different phases of the transportation decision-making process. For example, it can assist engineers in developing more cost-effective designs for TSM&O projects that have already been scheduled. In this context, the use of archived data can improve the planning process and enable transportation planning officers to seize the opportunity to apply new methods and applications.

Archived operations data can also be used to identify transportation needs and issues that should be addressed. These generally include safety and air quality improvements and congestion relief strategies. Archived data can be used to map traffic characteristics, resulting in the identification of priority areas for projects or other investments. Moreover, such data can also be used to prioritize and select future project options. Today, substantial opportunities exist for improving transportation management based on archived operations data. Such opportunities were not available before these data were collected.

For more information, FHWA has published several reports providing further insight into executing BCAs for TSM&O projects and strategies, such as the FHWA Operations Benefit/Cost Analysis Desk Reference, the Transportation Systems Management and Operations Benefit-Cost Analysis Compendium, and the Road Weather Management Benefit Cost Analysis Compendium. Such resources assist transportation agencies in correctly applying BCAs to TSM&O projects and strategies. Additionally, transportation management can use procedures described above as guidelines for the use of archived operations data.

Other TSM&O technical briefs take a closer look at the current application of BCA in transportation planning and serve as additional sources of information.

Project Contacts

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