Baltimore Regional Congestion Management Process (CMP): Develop a Process to Evaluate Strategy Effectiveness

1. Introduction and Purpose

The final step in the CMP is to evaluate the effectiveness of implemented CMP strategies (See Figure 1). While assessment of strategies (projects, programs, services, etc.) occurs earlier in the process, at that point, the assessment focuses on identifying viable strategies and analyzing likely benefits to help prioritize and select strategies to address congestion and mobility needs. In this final step, the evaluation focuses on quantifying the impacts of implemented strategies in order to understand their actual effectiveness and/or cost-effectiveness.

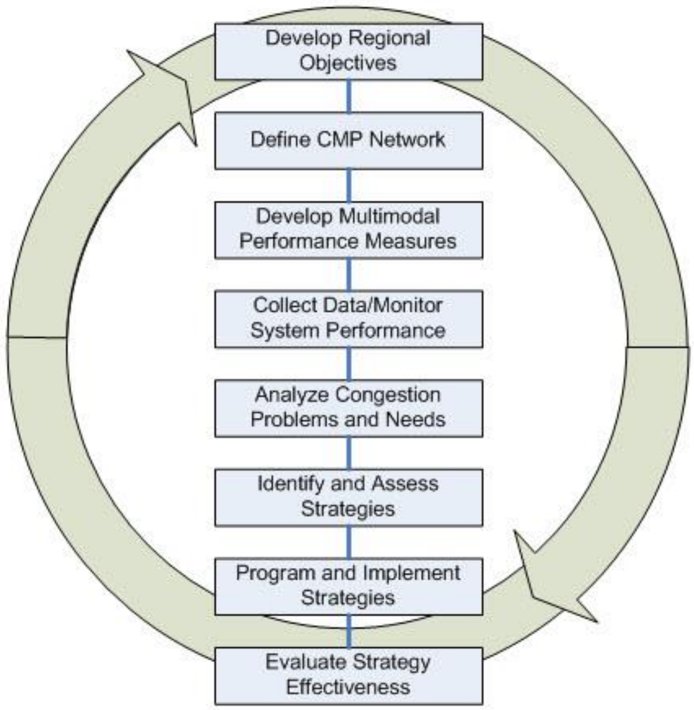

Figure 1. Elements of the CMP (Source: FHWA)

Evaluating post-implementation benefits provides a feedback loop to help ensure that information on the effectiveness of strategies informs future strategy selection and implementation. Strong findings of effectiveness from implemented strategies can encourage their further implementation, while weak effectiveness may suggest using alternative solutions. In addition, findings from post-implementation studies can help to identify the characteristics of a corridor or situation under which certain strategies are most effective. Finally, results can be useful for communicating with the public and decision-makers about the benefits of strategies such as demand management and operational improvements, where projects/programs are often not as readily visible to the public.

2. Organizational Approaches for Conducting Strategy Evaluation

Conducting evaluation studies requires staff resources and/or funding for data collection and analysis (either conducted by the agency directly or through contracting out). As a result, typically the CMP does not include a systematic evaluation of every strategy implemented, but rather typically takes a targeted approach to analyze certain types of strategies of interest or those with particular needs for understanding effectiveness.

In terms of an implementation approach for a regional evaluation process, the FHWA CMP Guidebook describes two alternative approaches to develop a uniform, regional evaluation process for implemented CMP strategies:

- **MPO studies**. The first is a centralized approach where the regional MPO funds studies to measure the effectiveness of congestion strategies or projects. Sometimes these studies are conducted periodically on a sample of projects. For instance, the Boston Region MPO has periodically conducted TIP project impact studies, which analyze a small sample of TIP projects.[1]
- **Project sponsor studies.** The second is a decentralized approach where the regional stakeholder agencies that fund and/or implement the projects are responsible for evaluating their effectiveness, while the MPO provides support to guide the process and compile evaluations to support regional decision making.

Most MPOs use a decentralized approach or conduct a limited set of studies focused on MPO-led programs. An example of an MPO-led study is the Commuter Connections Program evaluation conducted by the National Capital Region Transportation Planning Board (TPB) in Washington, DC to assess the effectiveness of its travel demand management strategies.[2] As another example, the Denver Regional Council of Governments conducts an annual evaluation of projects funded under its Traffic Signal System Improvement Program.[3]

The decentralized approach is most suitable for BMC considering it has many regional stakeholders that fund projects and limited resources and programs directly implemented on its own. BMC can support on-going strategy evaluation within the CMP by helping to provide information on evaluation methods, and examples and results of conducted analyses. BMC can guide regional stakeholders to conduct strategy evaluations, such as by providing information on typical evaluation approaches and issues to consider (including information below in this document as a resource). BMC can be a central resource for regional partners to share studies on the effectiveness of implemented CMP projects, including study inputs and results. BMC could include some of this information on its CMP website. This information can help agencies to better assess when to conduct an assessment, how to structure the analysis, what

[1] See: Boston Region MPO, Work Program: Federal Fiscal Year 2020 TIP Project Impacts: Before-and-After Evaluation, March 2020. Available at: https://www.ctps.org/data/calendar/pdfs/2019/MPO_0305_Work_Program_TIP_Before_and_After_Studies.pdf.

[2] See. Metropolitan Washington Council of Governments, Commuter Connections Transportation Emission Reduction Measure (TERM) Analysis Reports. Available at: https://www.mwcog.org/documents/2017/11/21/commuter-connections-transportation-emission-reduction-measure-term-analysis-report--carsharing-commuter-connections-commuting/

[3] See: Denver Regional Council of Governments, Traffic Operations Program website, Annual Benefits Summary of Projects and Signal Timing Briefs (individual benefits summary reports for each project). Available at: https://drcog.org/programs/transportation-planning/traffic-operations-program.

performance measures to use, how to gather the relevant data, and other aspects of evaluation studies.

These approaches can be institutionalized as part of semi-annual or annual CMP Steering Committee meetings. Specifically, in addition to discussing priority regional needs, the CMP Steering Committee meetings can be used as platforms for the local agencies to share information on evaluation practices and findings with other local stakeholders. Coordination by BMC with state and local agencies that help to illuminate the findings will be valuable to support future strategy choices.

3. Evaluation Methods

Types of Evaluation Study Methodologies

Methodologies for analyzing strategies depend in large part on the specific nature of the strategies being implemented. From an evaluation perspective, CMP strategies generally can be divided into two broad categories: 1) projects, services, or programs that change conditions along a corridor or route, typically by improving existing infrastructure or services in a way that allows a before-and-after study of the change; or 2) new or on-going projects, services or programs where there is a not a clear comparison of before-and-after changes, so comparisons need to be made concerning the impact of the strategy in comparison to what would have been without strategy implementation.

These two types of project evaluation methods are described briefly below, along with examples.

Before-and-After Studies

The impacts of projects, services, or programs that change conditions along existing corridors are services can be evaluated using a before-and-after analysis to measure performance improvement. In this case, the study examines conditions “before” the strategy was implemented, and then conditions “after” the strategy was implemented to assess performance changes, which could include changes in travel speeds, throughput, number of passengers, or vehicle crashes. These changes are then often used to calculate impacts in terms of other measures, such as travel time savings (e.g., hours of delay reduced), air pollutant emissions reductions, and the monetized value of these benefits. Examples of strategies that are well geared toward before and after analyses include:

- Traffic signal timing improvements (e.g., measuring changes in speeds and travel time delays)
- Transit signal priority strategies or conversion of a standard bus corridor to use bus-only lanes or bus rapid transit approach (measuring changes in bus speeds, on-time performance, and ridership)

- Intersection improvements (measuring changes in time stopped at red lights and throughput)
- Transportation operational improvements, such as enhanced incident management (measuring changes in vehicle crash clearance time)
- Roadway capacity improvements (measuring changes in speeds, throughput)
- Traffic calming (measuring changes in vehicle speeds, bicycle activity, crashes)
- Adding on-street bicycle lanes (measuring changes in bicycle activity, crashes)
- A targeted travel demand management initiative, such as an incentive campaign or change in parking fees targeted to a specific corridor (measuring changes in vehicle volumes, non-single occupant vehicle [SOV] use, etc.)

In conducting such analysis, it is important to use comparable before and after periods for analysis; for example, using the same month data for different years or using data for a similar time of the day on different days before and after the project is implemented in order to ensure that the results are comparable (not affected by changes in seasonal or day of week effects). It is also important to ensure that the analysis accounts for systemwide effects. For instance, a major roadway capacity improvement may have more than just effects on the expanded roadway; it may wind up shifting traffic patterns so that other parallel or adjoining roadways have changes in speeds and volumes.

A typical approach to such studies is as follows:

Step 1: Identify What to Measure as a Basis for Comparison. First, it is important to identify what will be measured before and after implementation, which will depend on the type of project being implemented. Typical types of data that could be collected include:

- Traffic volumes
- Traffic speeds
- Intersection and approach delay
- Queue lengths
- Transit ridership
- Bicycle and pedestrian counts
- Crashes (or crash rate)

Step 2: Collect "Before" Data. It is next important to identify or collect a set of pre-project data that can be used as a basis for comparison. This step may involve conducting a specific traffic study or may be collected from existing data sources, such as data on transit ridership by route. It will be important to ensure that the "before" data reflect conditions that are comparable to the those that will be made post-project implementation. In designing the study, it may be important to collect data for different times of the day (e.g., AM peak, mid-day, PM peak, evening) as well as days of the week. It may also be important to examine data that goes beyond the project boundaries itself; for instance, for a roadway capacity project, it may be important to examine not only travel conditions on the roadway that will be improved but on nearby/adjoining roadways.

Step 3: Collect Comparable "After" Data. After implementation, data will need to be collected for comparison purposes. It is important to consider near-term and longer-term effects in order to select the appropriate "after" time for analysis. For instance, the addition of bicycle lanes may take some time for bicyclists to learn about the new facilities and begin to increase use of the facility so that benefits might increase over time. Conversely, some strategies' effects might degrade over time.

Additionally, it will be important to consider indirect impacts of a strategy. For instance, a roadway capacity project that is intended to address traffic congestion may wind up encouraging some drivers to shift from parallel roads to the improved roadway, yielding only a small effect on traffic speeds on the improved roadway but more person throughput. The project, therefore, may reduce overall trip times for travelers across the network but show limited effects if only examining speeds on the roadway itself. Studying the before and after conditions across a broader project corridor, therefore, may be necessary.

Step 4: Compare and Evaluate Before-and-After Data. Next, the difference between pre-project and post-project measures will be calculated, as the basis for analyzing project impacts. This information will tell the changes in direct measures, such as speeds and volumes.

Step 5: Analyze Strategy Impacts. Finally, the data on direct measures, such as speeds and volumes, can be used to calculate other measures such as changes in vehicle hours of delay experienced by travelers. In addition to the evaluation of performance in this way, the evaluation may be supplemented with additional information such as stakeholder feedback or data on other types of effects (e.g., changes in public perceptions). In addition, the benefits can be monetized to develop a benefit-cost ratio or return on investment.

It is important to note that for projects where there is a relatively long time period between the "before" and "after" period, changes caused by other factors and not due to the improvement project itself need to be considered. For instance, changes in the economy could result in differences in the overall level of travel demand, which should then be considered and adjusted in the analysis. In some cases, it may not be feasible to conduct before-and-after analysis directly, and it will be necessary to analyze effectiveness in relation to "what would have been" without the project or strategy, using modeling or other approaches described below.

Other Studies of Strategy Effectiveness

While many strategies can be analyzed using before-and-after analyses, some project types are not well geared toward this type of analysis. For instance, when implementing a new service or travel option, such as a new park-and-ride facility, it is difficult to measure the before-and-after effects. Also, it is challenging to measure the before-and-after effects for on-going programs, such as ridesharing program support. As noted above, for some other projects as well, it may not be feasible or appropriate to directly compare conditions before vs. conditions after implementation due to other changes (e.g., in the economy, development, or societal issues) that affect travel patterns of demands. In these cases, the analysis typically involves making comparisons to conditions that would have been present without the strategy being implemented. Such an approach often requires conducting surveys, modeling, sketch planning analyses, or gathering other information to understand how travel behavior changed. Examples of strategies using this type of analysis include:

- New transit services
- New bicycle paths, park-and-ride facilities, or other options
- Most travel demand management programs
- Operational programs, such as traveler information or work zone management programs
- Land use / urban design changes

A typical approach to such studies is as follows:

Step 1: Identify What to Measure. As with before-and-after studies, it is important to first identify what to measure, which may include many of the same types of measures.

Step 2: Collect Data on Use. For many of these types of strategies, the next step is to collect information on the use of a service or facility. For instance, how many riders are using a new transit service? How may bicyclists are using a new path? How many vehicles are using a new park-and-ride? How many people have signed up for a rideshare program? How many people are participating in a vanpool program?

Step 3: Conduct Analysis to Understand What Would have been Without the Strategy. This is the more challenging part of the analysis and may require surveys or other approaches. For instance, for a new transit route or park-and-ride facility, it will be important to not only collect information on ridership/use of the facility but also to understand: How many of the transit riders previously drove? How far did they typically drive? How many transit riders shifted their mode of transit? For a new park-and-ride facility, we want to understand: How many of the park-and-ride facility users previously drove all the way to their destination? How long were those trips? How far are they driving to the park-and-ride? And are they now carpooling or using transit? To collect this information may require a survey of transit or park-and-ride lot users. In other cases, default values could be used from past surveys or information on factors, such as average trip lengths for carpools. The information can then be used to calculate the change in vehicle miles traveled, for instance. In some cases, this analysis could require fairly sophisticated analyses.

Some examples of both of these types of analyses are provided below.

4. Examples of Strategy Effectiveness Evaluations

This section provides examples of strategy effectiveness evaluations across different types of strategies. Table 1 provides a brief description of the seven categories of strategies included in the Congestion Management Process Strategy Guide. For each type of strategy, as available, below are examples of studies that have been conducted within the BMC region, or elsewhere.

Table 1. Types of Strategies in Congestion Management Process Strategy Guide

Strategy and Purpose	Examples
Demand Management Programs and policies to shift away from single-occupancy vehicles (SOV) and reduce the need for peak hour travel	Employer outreach, commuter benefits, parking cash out
Pricing Reduce/shift the SOV demand (discretionary trips or parking) to off-peak periods by controlling pricing	Congestion pricing, demand-responsive parking, VMT fees
Land Use Manage and direct growth to reduce travel distances and alternative mode choices	Zoning, transit-oriented development, high-density development
Transportation Systems Management & Operations (TSMO) Maximize the performance of the existing transportation facilities	Incident management, signal coordination, ramp metering, roadway design improvements
Public Transport Improve access and increase the capacity of existing transit services and facilities.	Route and service optimization, real-time data, signal priority
Bicycle/Pedestrian and Micro-mobility Improve the safety and convenience of non-motorized transportation options	Bike lanes, traffic calming, road diets
Road Capacity Consider infrastructure or operational improvements	Spot and intersection improvements, freight network upgrades, HOV/HOT lanes

Demand Management and Pricing Strategies:

These are two types of strategies that do not include addition/modification to the transportation infrastructure. They address congestion in one of three different ways – reducing the absolute travel demand (i.e., by eliminating trips), reducing the travel demand for SOV (i.e., by shifting to alternatives such as transit, ridesharing, bicycling, or walking), and/or shifting the vehicle travel demand to non-peak periods. Vehicle miles traveled (VMT), SOV mode-share, and travel time savings are some of the primary measures for the evaluation of these strategies. However, the scale and duration of evaluation will vary according to the type of strategy.

- The evaluation of a commuter benefits program can be performed at a regional level. For example, the Washington State Commuter Trip Reduction Program conducts analyses of the impacts of the program on vehicle travel. It found, for instance, that it reduced the VMT per employee by 7.4%, while increasing the non-SOV mode share from 34.3% to 39.1% from 2007 to 2016[4].
- The effectiveness of programs to shift the travel time can be measured as a reduction in the ratio of peak-period trips to total trips. For example, the ratio of peak-period trips for participants of California Stanford's Congestion and Parking Relief Incentives experiment were 13-22% lower as compared to Stanford-wide traffic[5].
- The evaluation of pricing schemes can take different forms, based on the type of pricing. For example, in evaluating the effects of a priced managed lane option, Maryland DOT measured the effects of toll lanes on I-95 and MD 200 by measuring traffic volumes (vehicles per day) using the facilities[6], as shown in Figure 2. Implementation of different forms of pricing, such as congestion pricing could be analyzed to explore how many travelers shifted to off-peak periods.

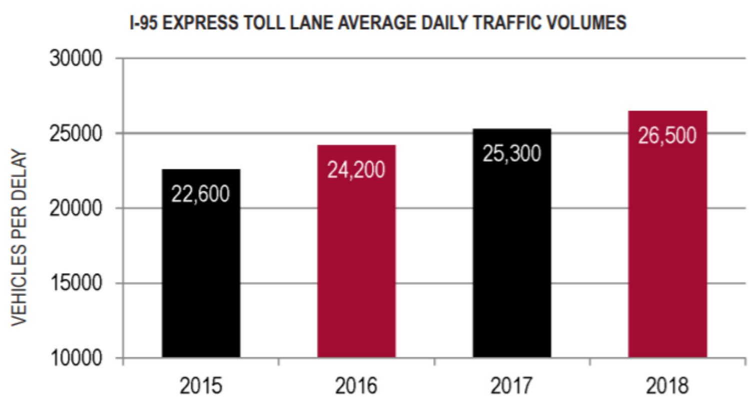

Figure 2. Traffic Volumes on I-95 Express Toll Lanes (Source: MDOT 2019 State Highway Mobility Report)

Land Use Strategies

Land use strategies are often challenging to analyze due to the long timeframe for development changes to occur, which makes before-and-after analysis difficult. Moreover, it is important to consider not just the effects of new development but how land use policies or zoning have affected development. Typically, new development will generate additional traffic, so it is important to not just examine the impacts of new development, but to consider how different development patterns would have generated different levels of traffic. Often, this type of analysis is conducted using modeling, or by making comparisons of travel patterns for different

[4] Washington State Commute Trip Reduction Board – 2017 Report to the Legislature. WS Department of Transportation. https://tdmboard.ning.com/resources
[5] How to Fix Congestion – Pay to Drive Off-Peak. Texas A&M Transportation Institute https://static.tti.tamu.edu/tti.tamu.edu/documents/policy/congestion-mitigation/pay-to-drive-off-peak.pdf
[6] Maryland DOT State Highway Administration (SHA) Mobility Report 2019. https://www.roads.maryland.gov/OPPEN/2019_mobility_report.pdf

types of development patterns, such as transit-oriented development in comparison to more auto-oriented development patterns. For instance, VMT per capita for a new development in a transit-oriented location and with associated urban design can be compared to more typical developments.

Transportation Systems Management & Operations (TSMO) Strategies

TSMO strategies are often implemented on already existing transportation infrastructure. Their effectiveness therefore is often measured by comparing the relevant performance measure values before and after the project. Vehicle throughput, travel time savings and crash counts are common measures for TSMO strategy evaluations. The traffic performance data can be accessed from the RITIS PDA Suite and the crash count data can be accessed from the Maryland Statewide Vehicle Crashes database. Examples of these analyses include:

- Maryland DOT evaluated the effectiveness of signal operation efforts by measuring the delay savings in vehicle-hours. The vehicle-hours can be further converted into fuel savings. Maryland DOT also evaluated the effectiveness of its Coordinated Highway Action Response Team (CHART) systems that respond to incidents quicker. The evaluation calculated the reduction in motorist delay based on the average duration of an incident in relation to estimated time without CHART (2019 Mobility Report).
- Virginia DOT measured the effectiveness of the I-66 Active Traffic Management System was measured by comparing the annual averages of 5 performance measures: Average travel time, Planning Time Index, Buffer Index, total delay, and crash counts[7].
- The effectiveness of installing an adaptive traffic control system in Albany, NY was measured by performing a before and after analysis of corridor system delay and side street delay[8]. Average speeds and queue lengths were used as additional measures of effectiveness.
- Figure 3 shows the effectiveness of ramp metering in different US cities measured as part of an FHWA case study[9].

Figure 3. Regional Benefits of Ramp Metering (Source: FHWA)

[7] Evaluation of the Impact of the I-66 Active Traffic Management System: Phase II. Virginia Transportation Research Council, 2018. http://www.virginiadot.org/vtrc/main/online_reports/pdf/19-R7.pdf
[8] Adaptive Traffic Signal Control System (ACS Lite) for Wolf Road, Albany, New York – Final Report. 2014. http://www.utrc2.org/sites/default/files/pubs/Final-Adaptive-Traffic-Signal-Wolf-Road.pdf
[9] Ramp Metering: A Proven, Cost-Effective Operational Strategy—A Primer. FHWA. https://ops.fhwa.dot.gov/publications/fhwahop14020/sec1.htm

Public Transportation Strategies

Transit ridership is a key performance measure used for evaluating the effectiveness of new transit projects. This data can be converted to the number of car trips avoided and VMT reduced to measure congestion mitigation. Since improving access is a key objective for both CMP as well as the transit strategies, measuring the number of jobs accessible by a 45-minute transit trip due to the new transit project can be another useful measure. To measure the effectiveness of strategies that deal with altering existing transit services, including operational strategies, before-and-after data for transit ridership, bus speeds, on-time performance, and job accessibility can be compared. Some examples of transit strategy evaluation conducted by the MDOT Maryland Transit Administration (MTA) are as below:

- MDOT MTA conducted a before-and-after study to evaluate the mobility and safety impacts of nine dedicated bus lane projects[10]. The improvement in three measures - peak period average travel time for buses, peak period average travel time for general traffic, weekday bus crash rates (per 1000 bus stops) was used for this evaluation. The analysis was done using data from February-June in the year before and the year after the dedicated bus lanes were implemented.
- MDOT MTA evaluated the efficiency of adding Transit Signal Priority (TSP) along Liberty Heights Avenue (CityLink Lime) and Belair Road / Gay Street (CityLink Brown) by conducting a before and after study of travel time[11]. The results of the study will be available from MTA when the study is finalized.

Bicycle/Pedestrian and Micro-Mobility Strategies

New bicycle/pedestrian projects are generally evaluated by measuring the volume of non-motorized users on the relevant project corridor. Road diet projects like reconfiguration of roadways are multi-modal in the sense that vehicle lanes are cut down and bicycle/pedestrian lanes are added. The evaluation of such projects needs to study the change in patterns for both modes. Example of similar project evaluations are as below:

- The New York City DOT uses 12-hour bicycle counts to measure the effectiveness of newly added bike lanes[12]. The safety impacts of bike lanes are measured as the improvement in bicycle and pedestrian crash counts and vehicle speeding[13].

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[10] Dedicated Bus Lanes Before and After Study 2019. Baltimore Link and Maryland DOT MTA. https://www.mta.maryland.gov/infrastructure-improvements

[11] Draft BaltimoreLink Transit Signal Priority Phase 2 – Belair Rd & Liberty Heights Ave Memo. For Maryland MTA by Sabra & Associates.

[12] Protected Bike Lanes in NYC. New York City DOT, 2014. https://www1.nyc.gov/html/dot/downloads/pdf/2014-11-bicycle-path-data-analysis.pdf

[13]Measuring the Street: New Metrics for 21st Century Streets. New York City DOT. https://www1.nyc.gov/html/dot/downloads/pdf/2012-10-measuring-the-street.pdf

- Seattle DOT evaluated the mobility impacts of road reconfiguration projects by doing a before and after analysis[14]. The analysis was done using 1 month of data each from before and after the project was implemented. The efficiency was evaluated using the following measures – traffic volume, vehicle speed (average speed, 85th percentile speed, percentage of speeders), peak hour travel time, collisions, and 5-hour bicycle counts. Vehicle speed is a critical measure since it has a direct impact on the bicycle level of stress (LTS).

Road Capacity Strategies

Vehicle throughput, speeds, and peak hour travel time savings are typically key measures for evaluating the effectiveness of capacity changes on roadway corridors. Queue lengths are more relevant for intersection improvements. With data available going back to October 2008, the RITIS PDA Suite serves as a useful data source for conducting before-and-after studies for projects on existing corridors. Studying the performance of parallel/surrounding roadways can support the evaluation of regional effectiveness. Examples of efficiency evaluation for capacity improvement strategies are as below.

- The Maryland DOT 2019 Mobility Report evaluates the performance benefits of several projects implemented in the previous years.
    - The opening year benefits of twelve new projects that range from interchange construction to providing turn lanes at intersections. The benefits were quantified in terms of the monetary value of congestion reduction, fuel savings, and safety savings.
    - The effectiveness of six roadway improvement projects was measured by conducting a before-and-after analysis of the Travel Time Index (TTI) along the improved corridor. The analysis was performed using INRIX Data from 2011 (before) and 2018 (after).
    - The benefits of two HOV lanes were evaluated by comparing the person throughput per lane per hour and travel times for the HOV lane and non-HOV lanes for different times of the day, with travel time savings shown in Figure 5.

[14] Evaluations (Before and After Reports). Seattle Department of Transportation. https://www.seattle.gov/transportation/document-library/reports-and-studies

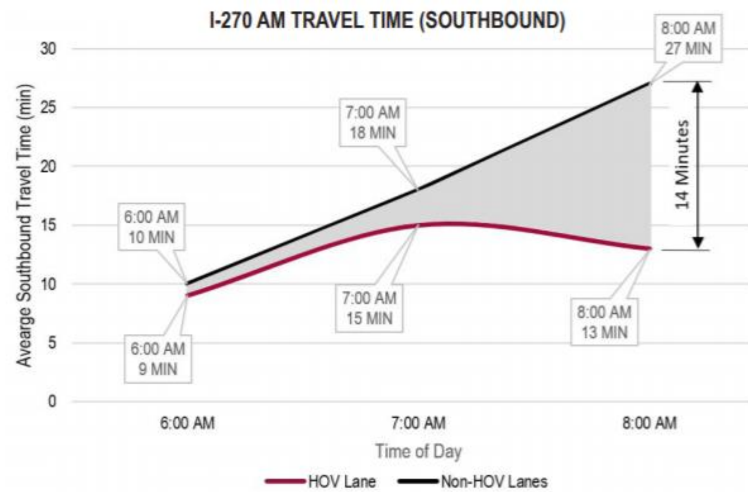

Figure 4. Travel time savings on HOV Lanes (Source: MDOT 2019 State Highway Mobility Report)

- Houston METRO's HOV lanes (113 miles in 2006) handled almost 118,000 person trips each weekday, by serving about 36,400 multi-occupant vehicle trips. Their efficiency was evaluated as the difference in average travel times between HOV lanes and adjacent lanes, which ranged from 12–22 minutes per trip[15].

[15] High-Occupancy Vehicle Lanes, US DOT. https://www.transportation.gov/mission/health/High-Occupancy-Vehicle-Lanes