MOSAIC
Value and Cost Informed Planning

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Programs Guide

Mosaic - Value and Cost Informed Planning

Oregon Department
of Transportation

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Introduction and Background

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What is the Programs Guide?

The Mosaic Programs Guide is designed to provide information on a variety of beneficial programs that jurisdictions may want to include in the bundles of transportation actions they are considering. The programs are transportation actions that can help meet the goals of the nine Mosaic categories of transportation system performance—access, equity, mobility, quality of life, safety, environmental quality, and economic vitality—but that would not typically be included in a capital improvement plan. The programs are designed to help achieve those goals through an emphasis on vehicular demand and operations rather than capital investments, and to complement actions and investments that emphasize roadway supply and capacity.

What's included in the Programs Guide?

The Programs Guide includes 20 programs in 6 subject areas, including:

- Pricing Programs
- Bicycle and Pedestrian Programs
- Transit Programs
- Travel Demand Management Programs
- Land Use Programs
- Operations/Intelligent Transportation System (ITS) Programs

There is a program description sheet for each program that provides information on what the program is, where it is being used, how it relates to the Mosaic categories of transportation system performance, what is known about the benefits and costs of the program, and what resources for implementation are available. Individual case studies on program effectiveness, frequently from the Pacific Northwest, are also included. The program description sheets aid in identifying and implementing the mix of programs best suited to a community's needs.

How was the Programs Guide developed?

As a starting point for assessing the benefits and costs of implementing programs in Oregon, the Mosaic Programs Guide was developed using the best available research. It was also designed to align with Oregon's Transportation and Land Use Greenhouse Gas (GHG) Reduction Toolkit (Toolkit) so that similar programs and their GHG reduction findings are defined consistently. The programs currently included in the Programs Guide are those that can be implemented at the local (rather than the state) or regional levels. While program effectiveness findings are reported in the literature using various units, findings are presented in terms of the relevant Mosaic specific indicators, wherever possible.

How does the Programs Guide work with Mosaic?

The 20 programs described and included in the Mosaic Programs Guide are widely considered to be beneficial and are frequently implemented by jurisdictions as part of travel demand management efforts. The Mosaic Programs Guide contains a summary of knowledge regarding the costs and benefits of these programs, with particular attention to impacts relating to Mosaic indicators. Users can choose to incorporate these programs into their bundles, as appropriate.

Application of and experiences with the programs vary widely. For 11 of the 20 programs detailed in the Programs Guide, benefit and cost information is built into the Mosaic tool. (Groups 1 and 2, below). The other 9 programs (Groups 3 and 4, below) are considered beneficial, but the benefits and costs are not yet estimated in the actual Mosaic tool.

Group 1: Both Benefit and Cost Values are Included in the Mosaic Tool

The programs in this group are built into the Mosaic tool on the Programs Worksheet. Benefits and costs are automatically calculated by the tool based on user input.

Group 2: Benefit Values are Included in the Mosaic Tool but Costs Must Be Entered Manually

The benefits of programs in this group are built into the Mosaic tool; however, cost information needs to be entered manually based on local estimates.

Group 3: Benefits and Costs are Best Estimated with Local Models

The Mosaic tool does not have these programs built into the tool, but the benefits and costs of the programs in this group may be estimated by local travel models. The resulting data is then uploaded into Mosaic as part of the travel model outputs.

Group 4: Programs are Beneficial but Not Included in the Mosaic Tool (Version 2.0)

A few programs are not capable of measurement within Mosaic at this time, but are included in the Programs Guide. For these, it is expected that cost/benefit information will become more available and more refined over time, enabling estimation of benefits and costs within the Mosaic tool. In the meantime, the Programs Guide includes programs like bike sharing, Safe Routes to School, and real-time transit information systems – even though they cannot yet be measured by Mosaic – because they are believed to help advance outcomes consistent with the Mosaic categories.

The programs included in each group are provided below.

Program Incorporation into Mosaic				
Program Name	**Group 1**	**Group 2**	**Group 3**	**Group 4**
Parking Demand Management and Pricing		X		
Value Pricing			X	

Program Incorporation into Mosaic				
Program Name	**Group 1**	**Group 2**	**Group 3**	**Group 4**
Bike Sharing Program				X
Bike Parking Programs	X			
Safe Routes to School				X
Decrease or Eliminate Transit Fares		X		
Increase Transit Service	X			
Transit Priority Treatments			X	
Real-Time Transit Information Systems				X
Demand Responsive Transit Service				X
Carsharing	X			
Employer-Based TDM programs		X		
Trip Reduction Ordinances/Transportation Management Associations		X		
Individualized Marketing Programs	X			
Education and Outreach Campaigns		X		
Ridesharing	X			
Land Use Strategies		X		
Traffic Management Strategies			X	
High Occupancy Vehicle lanes			X	
Wayfinding and Signage				X

When one or more of the programs are included in a bundle of transportation actions, the information is used to inform the Mosaic output summary tables.

How to use the Programs Guide

Information on how to use the Programs Guide and the corresponding tabs in the Mosaic tool can be found in the Mosaic users guide. Note that users will only need to add those programs that are not already represented in the travel demand model data that is uploaded into the tool.

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Mosaic Program Description Sheets

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Pricing Programs

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Value Pricing

What is it?

Value pricing (also called road pricing or congestion pricing) refers to charging motorists a fee that varies with the level of congestion. Value pricing is different from tolling in that it is used to manage congestion or demand, while tolling is used to generate revenue to repay a bond or debt (though tolls may include a value pricing component). Value pricing reflects the idea that pricing roadways directly benefits motorists through reduced congestion, reduced wear and tear on vehicles, and improved travel time reliability. There are four main types of value pricing strategies:[1]

Which Mosaic Categories does the program support?

ECONOMIC VITALITY
ENVIRONMENTAL STEWARDSHIP
FUNDING/ FINANCE
MOBILITY

- **Variable priced lanes:** This type of pricing involves variable tolls on separated lanes within a highway, such as express toll lanes or high occupancy toll (HOT) lanes. During congested periods, drivers can opt to use the priced lanes for a fee (or for free for HOT lanes if minimum vehicle occupancy requirements are met).
- **Variable tolls on entire roadways:** With this type of pricing, flat toll rates on existing roads or bridges are changed to a variable toll schedule so that the toll is higher during peak travel hours and lower during off-peak hours. This encourages motorists to use the roadway during less congested periods, and allows traffic to flow more freely during peak times.
- **Cordon Pricing:** Cordon pricing involves charging a fee to enter or drive within a congested area, usually a city center.
- **Area-wide Pricing:** Area-wide pricing refers to per-mile charges, which may vary by level of congestion, on all roads within an area.

Electronic payment and pricing applications, particularly variable tolling and congestion pricing, are key elements of the U.S. Department of Transportation (USDOT) Tolling and Pricing Program.

What are the benefits?

- **Economic Vitality:** Reduces traffic congestion, which provides positive economic impacts in the form of improved freight travel time and reliability and increased access to employment centers.
- **Funding/Financing:** Generates operating revenues for local transportation or other infrastructure improvements, which can help create jobs.
- **Mobility:** Encourages spatial and temporal shifts in demand to less congested routes, modes, and travel periods. This helps ensure free-flow travel conditions, reduces congestion, and improves travel time reliability (for transit and/or autos).

[1] Federal Highway Administration. *Congestion Pricing: A Primer*. https://ops.fhwa.dot.gov/publications/congestionpricing/sec2.htm.

- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gas emissions (GHGs) that are harmful to the environment and human health by supporting more fuel-efficient travel speeds and potentially encouraging shifts to more sustainable transportation modes.

Where is it being used?

SR 520 Floating Bridge, WA[2]

Value pricing is becoming more common as public agencies look for more efficient and cost-effective ways of utilizing existing roadway capacity. Examples on the west coast include:[5]

- SR 520 Floating Bridge, King County, WA
- SR 167 HOT Lanes, King County, WA
- I-580/I-680 Express Lanes, Alameda County, CA
- I-15 Express Lanes, San Diego, CA
- I-10 and I-110 Express Lanes, Los Angeles, CA

SR 167 HOT Lanes, WA[3]

How effective is it?

A broad literature review of value pricing programs in the U.S. and around the world conducted by the Federal Highway Administration (FHWA) in 2008 concluded that the introduction of pricing results in vehicle trip reductions ranging from 7% to 30%, depending on the pricing and breadth of the strategy. The highest values represented comprehensive city core area pricing systems (rather than narrow corridors) that were introduced with simultaneous increases in transit service and shared-ride alternatives.[6]

I-680 Express Lanes
Alameda County, CA[4]

Additionally, according to the OSTI Greenhouse Gas Toolkit, congestion pricing could result in a 0.5% to 1.6% reduction in total transportation sector baseline GHG emissions in 2030, and cordon or area pricing could result in a 0.1% to 18.6% reduction in total transportation sector baseline GHG emissions in 2030, depending on the intensity of implementation.[7]

Variable Pricing for Lanes and Roadways

According to a 2012 United States Government Accountability Office (GAO) study, evaluations of 14 value pricing projects in the U.S. have generally resulted in reduced congestion, although other results are mixed. Overall, findings show that HOT lane projects reduce congestion, increase vehicle

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[2] https://www.wsdot.wa.gov/.
[3] https://www.wsdot.wa.gov/Tolling/SR167HotLanes/default.htm.
[4] https://www.alamedactc.org/files/managed/Document/8206/I_680_Southbound_Express_Lane.jpg .
[5] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information is not always available.
[6] Federal Highway Administration. *Examining the Speed-Flow-Delay Paradox in the Washington, DC Region: Potential Impacts of Reduced Traffic on Congestion Delay and Potential for Reductions in Discretionary Travel during Peak Periods: Final Report.* "Chapter 4. Effectiveness of Congestion Pricing Strategies: Literature Review Key Findings." 2008. https://ops.fhwa.dot.gov/publications/fhwahop09017/018_section_4.htm
[7] *Oregon Greenhouse Gas Toolkit Report*. https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

throughput, and generally increase speeds and decrease travel times in both priced HOT lanes and un-priced general purpose lanes. Specific project examples are described below: [8]

- The SR 167 HOT Lanes Pilot Project in Washington improved peak-period, peak-direction vehicle speeds in both the general purpose and HOT lanes for the years 2007 and 2009, even as traffic volumes increased. Specifically, average vehicle speeds increased 21% (from 40.5 to 49.3 miles per hour [mph]) in the general purpose lanes (in conjunction with an 11% increase in traffic volumes) and average vehicle speeds in the HOT lanes increased by 6% (from 57 to 61 mph), in conjunction with a 4% increase in northbound traffic volumes.[9]
- On I-15 in San Diego, drivers in the HOT lanes reportedly saved up to 20 minutes more than drivers in adjacent un-priced lanes during the most congested times. On I-95 in Miami, drivers have reportedly saved about 14 minutes in the HOT lanes and 11 minutes in the adjacent un-priced lanes per trip.[10]
- According to a 2006 evaluation of the I-394 project in Minneapolis, vehicle throughput in the HOT lanes increased by 9% to 13% and by 5% in the adjacent un-priced lanes after the lanes opened. A 2000 evaluation of the SR 91 project in Orange County estimated that vehicle throughput increased 21% on the entire roadway. [11]
- A bridge toll demonstration in Lee County, Florida, included a 50% discount in the hours directly before and after the main peak period (shoulders of the peak) to induce shifts in travel patterns away from the main peak hours. The discount was attributed to a 7% reduction in AM peak hour traffic. In 2001, the Port Authority of New York and New Jersey instituted off-peak savings of 20% for drivers crossing the Hudson River, with early results producing peak-hour volume reductions close to 20%.[12]
- Of seven variable pricing projects that assessed impacts on transit ridership, only one project (I-95 in Miami) was found to result in an increase in transit ridership. Between 2008 and 2010, the average weekday ridership on the I-95 express bus in Miami increased by 57%, from about 1,800 riders in 2008 to more than 2,800 in 2010. About 38% of these riders reported that they used to drive alone.[13]
- Three projects (SR 91 in Orange County, I-394 in Minneapolis, and SR 167 in Seattle) assessed equity impacts on low-income drivers. Results indicated that drivers of all incomes use the HOT lanes, with high-income drivers using them more often than low-income drivers.
- Evaluations of three HOT lane projects (I-15 in San Diego, SR 91 in Orange County, and I-394 in Minneapolis) and one peak-period pricing project—the New Jersey Turnpike—assessed the impacts of pricing on air quality. Minimal air quality improvements were reported on I-15, I-394, and the New Jersey Turnpike, and no effects were found for SR 91.

[8] United States Government Accountability Office. *Traffic Congestion: Road Pricing Can Help Reduce Congestion, But Equity Concerns May Grow.* 2012. https://www.gao.gov/assets/590/587833.pdf.

[9] Washington State Department of Transportation. *SR 167 HOT Lanes Pilot Project Performance Update.* 2010. https://www.wsdot.wa.gov/Tolling/SR167HotLanes/publications.htm.

[10] United States Government Accountability Office. *Traffic Congestion: Road Pricing Can Help Reduce Congestion.* 2012.

[11] United States Government Accountability Office. *Traffic Congestion: Road Pricing Can Help Reduce Congestion*. 2012.

[12] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 14: Traveler Response to Transportation System Changes: Road Value Pricing." 2003. p. 14-5. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c14.pdf

[13] United States Government Accountability Office. *Traffic Congestion: Road Pricing Can Help Reduce Congestion.* 2012.

Cordon and Area Pricing

While no area-wide projects are in place in the U.S, the state of Oregon is currently testing a pricing scheme involving per-mile charges, which may be considered as a replacement for fuel taxes in the future. A value pricing component is also being tested, with higher charges during congested periods on high traffic road segments.[14]

In Norway, several cordon toll programs have been in operation over the last few decades. The first of these "toll rings" was established in 1986 in Bergen (population: 300,000). The idea subsequently spread to Oslo (Norway's capital - population 700,000) in 1990, and to Trondheim (Norway's third largest city - population 140,000) in 1991. The programs charge drivers of autos between $0.80 to $1.75 during workday hours to cross a ring around central areas and have been able to reduce traffic by 5% to 10% through modal shifts away from single-occupancy vehicles (SOV) and temporal shifts away from peak congestion periods.[15]

How much does it cost to implement?

The costs to develop and maintain value pricing and HOT lane schemes depend on the size, scope, and purpose of the program. The costs to convert HOV lanes to HOT lanes as part of congestion projects conducted in three metropolitan areas ranged from $9 to $17 million (M):[16]

- Denver, Colorado (2005): The Downtown Express HOT lanes project cost $9M to implement and included a two-lane barrier-separated reversible facility in the median of a 2-mile section of I-25 and US 36.
- Minneapolis, Minnesota (2005): It cost $13M to implement the conversion of HOV lanes that extended from Highway 101 to I-94 to dynamically-priced HOT lanes. The project included a 3-mile section that had two reversible lanes separated by a barrier from general purpose traffic and an 8-mile section that had one lane in each direction separated from general purpose traffic by double-white stripes.
- Seattle, Washington (2008): In Puget Sound, an HOV to HOT conversion project cost $17M to implement and included 9 miles along SR 167 that extended from 15th Street in Auburn to I-405 in Renton. As of January 2010, the average monthly operating costs for the SR 167 HOT lanes was $97,600 (which included monitoring, maintenance, enforcement, transaction processing, emergency response, a customer service center, TMC operations, and tolling operations). From May through November 2009, the SR 167 lanes generated an average monthly gross revenue of $32,740.[17] Within 12 years, the net annual toll revenue is expected to have recouped the preliminary capital costs of the conversion.[18]

The cost estimate for the cordon pricing program in Oslo, Norway, is shown below: [19]

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[14] Federal Highway Administration. *Congestion Pricing: A Primer*.

[15] *TCRP Report 95.* "Chapter 14: Road Value Pricing." 2003. p. 14-11

[16] Federal Highway Administration. *Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned Desk Reference: 2011 Update.* 2011. p. 135.
https://www.itskr.its.dot.gov/its/benecost.nsf/files/BCLLDepl2011Update/$File/Ben_Cost_Less_Depl_2011%20Update.pdf

[17] Washington State Department of Transportation. SR 167 HOT Lanes Pilot Project Performance Update. 2010.

[18] Federal Highway Administration. *Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned*. 2011. p. 135.

[19] Federal Highway Administration. *Intelligent Transportation Systems Benefits, Costs, Deployment, and Lessons Learned.* 2011. p. 140.

- Oslo, Norway (1990): implementation: $40 M; annual operations and maintenance: $23.3 M.

Implementation resources

The following resources may be helpful for jurisdictions wishing to explore the implementation of value pricing:

- Congestion Pricing, Federal Highway Administration
- Road Pricing Overview, Federal Highway Administration
- Tolling and Pricing Program, Federal Highway Administration:
- Road Pricing TDM Encyclopedia, Victoria Transport Policy Institute:
- Road Pricing Can Help Reduce Congestion But Equity Concerns May Grow, U.S. Government Accountability Office

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Parking Demand Management and Pricing

What is it?

Parking demand management strategies include a number of policies and programs designed to reduce parking demand, preserve parking for certain trip types and users, and promote a shift from single occupant vehicle (SOV) trips to transit, pedestrian, and bicycling trips. Parking demand management includes both parking pricing and supply-side strategies. Parking pricing involves charging a fee for parking, whereas parking supply strategies involve restricting the supply of available parking to achieve a desired outcome. Example programs for each strategy type are described below.

Which Mosaic Categories does the program support?

Pricing Parking

- Introducing or raising parking fees in areas of high parking demand such as a central business district (CBD), employment areas, and retail centers
- Introducing or raising parking fees during times of high parking demand (flat-rate premiums during peak hours or dynamic, performance-based pricing responsive to real-time occupancy levels)
- Designing parking fees to discourage long-term parking and promote parking turnover (to prioritize parking for shopping district customers rather than employees)
- Implementing a downtown employee parking payroll tax
- Unbundling (requiring the separate pricing of residential parking from the rent or sale price of a home or building)

Residential Permit Zone, Salem, OR[1]

Downtown Employee Parking Zone Olympia, WA[2]

Parking Supply

- Parking maximums and area supply management
- Residential parking permit programs
- Parking time limits (2-hour maximum parking)
- Shared parking strategies
- Preferential parking for carpools/vanpools or alternatively fueled vehicles

Both pricing and supply strategies have been used by local jurisdictions to manage parking demand, intensify land uses, and create an incentive for travel by more sustainable transportation modes.

[1] Photo courtesy of CH2M HILL.
[2] http://olympiawa.gov/.

Parking price and availability is of significant importance to travelers making travel decisions and can affect such diverse decisions as mode choice, trip destination choice, and trip frequency.[3]

What are the benefits?

- **Funding/Financing:** Generates operating revenues for local transportation or other infrastructure improvements.
- **Mobility:** Encourages turnover of parking spaces in areas with high parking demand, improving travel time reliability for drivers. Also encourages mode shift to transit (where available), cycling, or walking which can help reduce congestion and vehicle miles traveled (VMT).
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gas emissions (GHGs) that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.

Where is it being used?

Parking pricing is widespread in cities internationally and throughout the United States. Examples on the Pacific coast include: [5]

- Portland, OR
- Eugene, OR
- Olympia, WA
- San Francisco, CA (largest performance parking program in the world)

Metered parking, Downtown Salem, OR[4]

How effective is it?

The following are findings related to the effectiveness of parking demand management strategies:

- For every 1% increase in parking price, parking demand will typically decrease by 0.1% to 0.6% (with 0.3% being the most frequently cited value).[6]
- In general, the user cost of parking has a larger impact on SOV mode share, than the available supply or allowed time limit of parking. A highly-correlated inverse relationship (r = -0.88) exists between increasing on-street meter charges and decreasing SOV use, with similar effects observed for off-street parking monthly rates and daily charges.[7, 8]

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[3] TCRP Report 95. Chapter 18: Traveler Response to Transportation System Changes: Parking Management and Supply. 2003. p. 18-2. http://www.trb.org/Publications/Blurbs/153345.aspx.

[4] Photo courtesy of CH2M HILL.

[5] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information was not always available.

[6] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 13: Traveler Response to Transportation System Changes: Parking Pricing and Fees." 2004. p. 13-4 https://www.trb.org/Publications/Blurbs/155505.aspx

[7] *TCRP Report 95*. "Chapter 18: Parking Management and Supply." 2003. p. 18-30.

[8] Correlation coefficients — indicated by the symbol "*r*" — are measures of the strength of relationship between two variables, and should not be construed as elasticities. They range from 0 to 1 or -1. The closer to 1 or -1, the stronger the relationship, which is inverse if the "*r*" is negative.

- The relationship of decreasing on-street parking supply and time limits to decreasing SOV mode share is generally more modest. SOV use increases with the number of on-street parking spaces per 1,000 central business district (CBD) employees (r = 0.23), though the effect is not as strong for off-street parking supply (r = 0.40). Additionally, where the maximum time limit for on-street parking is less restrictive, SOV use is higher (r = 0.20).[9]
- According to the OSTI Greenhouse Gas Toolkit, parking pricing could result in a 0.8% to 1.8% reduction in total transportation sector baseline GHG emissions in 2030, depending on the pricing level. Because the reduction in greenhouse gases would be derived entirely from a decrease in VMT, a 1:1 ratio of percent GHG reduction to percent VMT reduction can be assumed.[10]
- Overall, parking prices are most effective at reducing parking demand when the changes primarily affect commuters or lower-income populations, and when high-quality transit alternatives to SOV use are available in conjunction with supportive land-use patterns.[11] The equity issue that emerges from this finding (i.e., that lower-income populations are more sensitive to price changes) is common to all pricing programs and should be carefully considered prior to implementation. Strategies to reinvest revenues in the communities affected may help to alleviate concerns.
- Parking price increases directed at commuter parking (off-street parking fee surcharges or on-street parking fees for non-residents in residential areas) in the range of $1.00 to $2.00 per day, have been found to reduce long-term parking by approximately 20% to 50%.[12]
- In a study by Donald Shoup, 30% of the drivers of cars in 16 congested downtown traffic areas (1927 to 2001) were found to be cruising for parking, which can cause increased congestion and air pollution. The study recommends setting fair market prices for curbside parking to eliminate cruising.[13]
- A smart parking system outside San Francisco, California, allowed drivers to reserve parking spaces at a BART transit station, either pre-trip or en route, with space availability displayed on roadside dynamic message signs. Surveys showed that the enhancements led to a sizable increase in transit mode share (5.5 more transit commutes per month), a decrease in average commute time (an average of 5% for a 50-minute commute), and a reduction in total vehicle miles traveled per participant of 9.7 miles per month.[14]

[9] *TCRP Report 95.* "Chapter 18: Traveler Response to Transportation System Changes: Parking Management and Supply." 2003. p. 18-30.
[10] While GHG reductions are different than VMT reductions, a 1:1 ratio of percentage of GHG reduction to percentage of VMT reduction is assumed for the programs that derive GHG reductions entirely from reducing VMT (such as parking pricing). This assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. p. B-7.
[11] *TCRP Report 95.* "Chapter 13: Parking Pricing and Fees." 2003. p. 4-5.
[12] *TCRP Report 95.* "Chapter 13: Parking Pricing and Fees." 2003. p. 13-5.
[13] Shoup, D. "Cruising for Parking." *Transport Policy. Volume 13.* 2006. pp. 479 - 486. http://shoup.bol.ucla.edu/Cruising.pdf
[14] Federal Highway Administration. *Intelligent Transportation Systems Benefits, Costs, Deployment and Lessons Learned*. 2011. p. 30. https://www.itskr.its.dot.gov/its/benecost.nsf/files/BCLLDepl2011Update/$File/Ben_Cost_Less_Depl_2011%20Update.pdf.

How much does it cost to implement?

The expenses to operate a parking program include capital or up-front planning and implementation costs, ongoing administrative and operating costs, and enforcement costs, where applicable. Because parking demand is only somewhat decreased in response to price increases, parking fees are generally met with an increase in total revenue, though less than proportionate to the fee change.[15] If parking demand management programs result in travel behavior changes that address broader policy objectives, such as VMT reduction (and correspondingly, traffic congestion or air pollution), the benefits will enhance the cost effectiveness of the program.[16]

More elaborate parking pricing programs may require greater economies of scale to operate without subsidies. In Oakland, California, operating revenue earned in a smart parking system at BART stations was found to be insufficient to recover total system costs unless the scale of the deployment was much larger (greater than 50 spaces per station). Included in the total capital cost of $205,000 to implement the system were two roadside dynamic messaging signs, an integrated web-based reservation system, and interactive voice response support.[17]

Implementation resources

The following resources can assist jurisdictions that wish to implement parking demand management programs:

- Parking Management Comprehensive Implementation Guide – Victoria Transport Policy Institute (2012)
- Parking Pricing Implementation Guidelines - Victoria Transport Policy Institute (2011)
- Contemporary Approaches to Parking Pricing: A Primer – Federal Highway Administration (2012)
- Dynamic Parking Pricing Manual, Florida Department of Transportation (2001)

[15] *TCRP Report 95.* "Chapter 13: Parking Pricing and Fees." 2003. p. 13-5.
[16] *TCRP Report 95.* "Chapter 13: Parking Pricing and Fees." p. 13-36.
[17] Federal Highway Administration. *Intelligent Transportation Systems Benefits, Costs, Deployment and Lessons Learned*. 2011. p. 22. https://www.itskr.its.dot.gov/its/benecost.nsf/files/BCLLDepl2011Update/$File/Ben_Cost_Less_Depl_2011%20Update.pdf

Bicycle and Pedestrian Programs

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Bike Sharing

What is it?

Bike sharing programs typically include a fleet of bicycles strategically placed throughout a city that are available for short-term rental. Programs usually involve distinctive and recognizable bicycles; docking stations; and an information technology (IT) system to facilitate reservations, pick up and drop off, and location tracking. Membership fees and usage fees are typically modest and available in various time increments (e.g., daily, weekly, or annually). Many bike share programs also offer members brief rental periods for free (e.g., 30 minutes), after which they are charged a usage fee based on the length of the rental.

Which General Indicators does the program support?

What are the benefits?

- **Mobility:** Helps increase bicycle mode share and reduce auto traffic.
- **Accessibility:** Increases travel options available to travelers for short and medium distance trips.
- **Quality of Life:** Facilitates the use of active transportation modes and makes it easier to get exercise while also meeting travel needs.
- **Equity:** Increases the travel options available to lower-income residents by providing access to a bicycle without the expense of purchase and repair.

Bicing, Barcelona, Spain[1]

Where is it being used?

There are bike sharing programs in cities throughout the U.S. and around the world. Examples of programs in the U.S. include: [4]

- Nice Ride in Minneapolis, Minnesota
- Capital Bikeshare in Washington, DC
- Hubway in Boston, Massachusetts
- Citi Bike in New York City
- B-cycle, a bikeshare company that has programs in Denver, Colorado; Broward, Florida; Boulder, Colorado; Chicago, Illinois; Des Moines, Iowa; Kailua, Hawaii; Houston, Texas; Kansas City, Missouri; Madison, Wisconsin; Omaha, Nebraska; San Antonio, Texas; and Spartanburg, South Carolina

Capital Bikeshare, Washington, DC[2]

B-cycle Station, San Antonio, TX[3]

[1] Photo courtesy of CH2M HILL
[2] https://ddot.dc.gov/capitalbikeshare
[3] https://www.pedbikeimages.org/pubdetail.cfm?picid=1968/ Greg Griffin, AICP.
[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that was not always available.

How effective is it?

Though still a relatively new phenomenon, bike share programs have been facilitated by the advent of information technology. As such, empirical data on the range of effectiveness of bike share programs are still emerging. These are some of the reported benefits of some recently launched programs:

- Major, comprehensive European programs report increases in cycling ranging from 44% (Lyon, France - first year) to 70% (Paris, France), and even tripling where initial shares were small (Barcelona, Spain - first year).[5]
- In the U.S., users of Minneapolis' Nice Ride Bicycle Share Program reported 23% of their bike share trips would have otherwise been made by car. In Denver, users of the B-cycle bike share program reported that 43% of their trips using bike share replaced car trips.[6]
- Other benefits include reduction in traffic and the creation of jobs. In Paris, it was reported that the Velib bike share program reduced traffic by 5% in the first year. In Montreal, the launch of the Bixi bicycle share program was connected to 400 jobs.[7]
- Public health and environmental benefits are also evident. A study of Barcelona residents using the Bicing bicycle share program found that the increased risk from road traffic incidents and increased exposure to air pollution was offset substantially by the health benefits of increased physical activity (12.28 annual deaths were avoided, on average, when compared with car users). Additionally, as a result of journeys by Bicing, annual carbon dioxide emissions were also reduced by 9,062 metric tons.[8]

How much does it cost to implement?

The costs associated with bike share systems typically involve capital and operating expenditures. Capital expenditures include bikes and stations, IT systems to operate equipment, member access cards (if necessary), purchase of maintenance and distribution vehicles, and installation. Capital costs range from $3,000 to $4,400 per bicycle. Operating costs typically include maintenance, distribution, staff, insurance, office space, storage facilities, website hosting and maintenance, and electricity (if necessary). Average annual operating costs are about $1,600 per bicycle.[9]

Most bike share systems are not financially self sustaining, so it is common for a public agency to implement a bike share system with an operating partner. Funding for public bicycle systems typically comes from a combination of advertisements, user fees, and public government support; and systems often operate as public-private partnerships.[10]

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[5] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 16: Pedestrian and Bicycle Facilities." July 2012. http://www.trb.org/Publications/Blurbs/167122.aspx.

[6] On Bike Share Inc. *Bikeshare Implementation Strategies: A Comparative Guide.* 2012. http://www.onbikeshare.com/PDF/Bike%20Share%20Implementation%20Strategies.pdf.

[7] On Bike Share Inc. *Bikeshare Implementation Strategies*. 2012.

[8] Rojas-Rueda, D., A. de Nazelle, M. Tainio, and M. Nieuwenhuijsen. 2011."The Health Risks and Benefits of Cycling in Urban Environments Compared with Car Use: Health Impact Assessment Study." *British Medical Journal.* Volume 343. https://www.bmj.com/content/2/3946/S125.

[9] DeMaio, P. 2009. "Bike-sharing: History, Impacts, Models of Provision, and Future." Tampa, FL. Center for Urban Transportation Research. *Journal of Public Transportation*. Vol. 12, No.4. https://www.nctr.usf.edu/jpt/pdf/JPT12-4.pdf.

[10] Alta Planning + Design. *Bikesharing/Public Bikes – An Overview of Programs, Vendors, and Technologies.*

Implementation resources

These are some additional resources for jurisdictions considering bike share programs:

- Bike Sharing in the United States: State of the Practice and Guide to Implementation – The Pedestrian and Bicycle Information Center, 2012
- Bikesharing/Public Bikes – An overview of programs, vendors, and technologies – Alta Planning +Design
- Bikeshare Implementation Strategies: A Comparative Guide – On Bike Share Inc., 2012

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Bike Parking

What is it?

The provision of bicycle parking at key destinations (commercial, transit stations, employment centers) can vastly improve the convenience and reliability of bicycling as a travel mode. Bicycle parking includes both short-term and long-term bicycle parking solutions. Some examples include:

- Staple racks (for short-term parking on the sidewalk)
- Bicycle corrals (for short-term parking adjacent to commercial destinations with high demand)
- Bicycle lockers (for long-term parking at transit stations)
- High capacity secure bike locker facilities (at transit stations and/or commercial buildings with high demand)

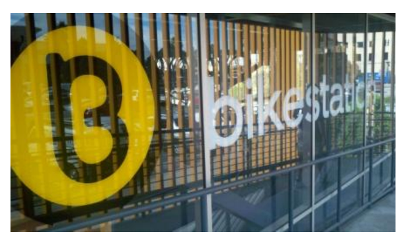
Bicycle parking can also serve as an important first-mile / last-mile solution for accessing transit stations, similar to the role of bikesharing. The provision of bicycle parking at transit stations helps expand the catchment area of transit stations well beyond the range of walking, and comes at a lower cost than providing neighborhood feeder buses and park and ride facilities for cars.[4]

Bicycle parking requirements are also becoming more commonplace in cities across North America as a strategy to increase public bike parking supply. Requirements range from requiring a certain amount of bicycle parking in relation to car parking or requiring a minimum number of spaces per residential unit or square feet of commercial space. Some cities also include requirements or incentives to provide lockers and showers at workplaces.[5] These provisions help reduce barriers to using bicycles for commuting and other utilitarian trip purposes.

Which Mosaic Categories does the program support?


On-Street Bicycle Corral, Portland, OR[1]


Bicycle lockers, LA Metro Station Los Angelels, CA[2]


Bike Station - High Capacity Bike Parking Facility, Long Beach, CA[3]

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[1] Photo courtesy of CH2M HILL.
[2] Photo courtesy of CH2M HILL.
[3] Photo courtesy of CH2M HILL.
[4] Pucher, J., R. Buehler, and M. Seinen. "Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies." *Transportation Research Part A*. 45. 2011. p. 467. http://policy.rutgers.edu/faculty/pucher/TRA960_01April2011.pdf.
[5] Pucher, J., R. Buehler, and M. Seinen. "Bicycling renaissance in North America? " 2011. pp. 466-467.

What are the benefits?

- **Accessibility:** Increases bicycle mode share by enhancing bicycle access to key destinations.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gas emissions (GHGs) that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Quality of Life:** Facilitates the use of active transportation modes, which can increase physical activity and enhance health and quality of life.
- **Economic Vitality:** Increases total local parking capacity, which may translate into enhanced visibility and higher revenues for adjacent businesses.

Where is it being used?

Bike parking facilities and programs are used throughout the U.S. and internationally. Relevant examples in the Pacific Northwest include:[6]

- On-Street Bicycle Corral Parking Program, Portland, OR
- TriMet Bike & Ride, Beaverton and Gresham, OR
- Bike Parking Program, Seattle, WA
- Go By Bike Valet, Oregon Health and Sciences University, Portland, OR
- Bikestation, Hillsboro, OR

How effective is it?

While quantitative empirical data on the general effectiveness of bicycle parking at inducing mode shift and reducing vehicle miles traveled (VMT) is limited, the following findings provide some insight as to the importance of bicycle parking at workplaces, transit stations, and businesses.

Bike Parking at Workplaces

- When four "Bike Central" locations were created in downtown Portland offering showers, changing facilities, and bicycle storage for a modest fee, before and after studies conducted in 1998 and 2001 found that users of the service increased their average frequency of commuting by bicycle from 3.1 to 15.5 days per month, while reducing their rates of driving and transit usage. First year estimates were 14,600 bicycle trips generated and 46,400 VMT, 23 tons of carbon monoxide, and 360 pounds of hydrocarbons reduced.[7]

- A stated preference study in Edmonton, Alberta, in 2007 found that the provision of secure parking at trip destinations was equivalent in benefit to avoiding 26.5 minutes of en route mixed-traffic cycling time.[8] The effect was found to be larger for younger cyclists and less so for older groups.[9]

[6] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that was not always available.
[7] *Transit Cooperative Research Program (TCRP) Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-154.
[8] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-154.
[9] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-153.

- A 2007 study in the UK examined the effects of different degrees of workplace bike parking and facilities provision on bike commute shares. With a base work trip bicycle mode share of 5.8%, the study estimated that bike share would increase to 6.3% with outdoor parking, 6.6% with secure indoor parking, and 7.1% with all of that and the addition of showers.[10]

Bike Parking at Transit Stations

- A national walking and bicycling study estimated that, for the circa 1990 vehicle mix, 150 gallons of gasoline per year are saved for each park-and-ride commuter attracted to bike-and-ride. In the case of commuters previously using an automobile for the entire trip, the corresponding savings is an average of 400 gallons per commuter diverted to bike-and-ride.[11]
- Secured bicycle parking was found to be the most cost-effective solution for reducing hydrocarbon emissions when accessing transit in Chicago because most drive-to-transit trips are relatively short and include higher than average pollutant emissions per mile. The study of bike-and-ride effects on emissions in Chicago found that increasing the capacity in nine Metra stations to 457 bicycles total led to an increase of 222 bicycles parked at the stations within a month, reducing VMT by an estimated 1,739 miles per day.[12]
- A Transit Bike Depot in Colorado was found to reduce combined air emissions (volatile organic compounds [VOC], carbon monoxide [CO], and nitrogen oxides [NOx]) by 8.5 kilograms (kg)/day.[13]
- A stated preference experiment focusing on transit access identified bike lockers as a significant incentive to "bike and ride" instead of driving to transit or all the way. Lockable covered parking was 40% as effective. Relative to bike lanes, lockers were 3 times more important for frequent cyclists, but slightly less important for infrequent cyclists. [14]

Bike Parking at Businesses

The provision of bicycle facilities in commercial districts can be beneficial for local businesses, especially destinations that experience high bicycle mode share. Case studies and examples of effectiveness are provided below.

- Portland's on-street bicycle corral program allows local businesses to request the City to install bicycle parking in the space that one or two automobiles might otherwise occupy, increasing the person capacity of curbside parking by up to 1,200%. Over 85 corrals have been installed throughout the city, and there is presently a long waiting list of businesses that would like one installed.[15]
- In Portland, a study looking at the relationship between consumer habits and mode choice found that for certain establishments (bars, convenience stores, and restaurants), those who arrived by bicycle were on average spending 24% more per month than those arriving by vehicle (and more

[10] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-153.
[11] T*CRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-388.
[12] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-388.
[13] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 388.
[14] *TCRP Report 95. "*Chapter 16: Pedestrian and Bicycle Facilities." 2012. p. 16-28.
[15] https://www.portlandoregon.gov/transportation/article/250076.

overall than customers arriving by all other modes) because, while they were spending less during each trip, they made more trips per month.[16]

How much does it cost to implement?

The costs of bicycle parking can vary depending on the type of facility and the amenities that are provided.

- A simple bicycle staple rack holding two bicycles can cost around $240, including installation (indexed to 2012 dollars), while a bicycle rack (ribbon) holding 10 to 12 bicycles can cost between $400 and $900 (indexed to 2012 dollars).
- Bicycle lockers which provide secure, lockable storage for 1-2 bicycles are provided primarily at transit stations and can cost $1,225 (2012 dollars). [17]
- On-street bicycle corrals which replace 1 to 2 vehicle parking spaces in exchange for 6 to 12 racks that may park 12 to 24 bicycles cost $2,600 to install in Portland, Oregon. This cost includes an encroachment permit, racks, paint, signage, and installation.[18]

Bicycle station costs depend heavily on the amenities offered, including secure bicycle storage, showers, bicycle rental, lockers, and repair equipment.

- A bikestation facility in Washington, DC, with storage for 130 bicycles, lockers, changing rooms, a bike repair shop, and accessory store cost $4 million to build in 2009, while a similar facility in Chicago that featured storage for 300 bicycles cost $3.1 million.[19]
- The bikestation built as part of the Hillsboro, Oregon, Intermodal Transit Facility in 2010 cost $640,000 and includes storage for 80 bicycles, lockers, and shower facilities.[20]
- The TriMet Bike and Ride facilities in Beaverton and Gresham, Oregon, which include bicycle storage and repair equipment, cost $275,000 each to build.[21]

Implementation resources

Jurisdictions and businesses interested in adding bicycle parking should consult with these resources:

- Bicycle Parking Best Practices, 2002, Association of Pedestrian and Bicycle Planners
- Guide for the Development of Bicycle Facilities, 4th Edition, 2012, AASHTO
- Bicycle Parking Guidelines, Washington Bikes
- Bicycle Parking Manual, Cycling Embassy of Denmark

[16] Clifton, K., Morrissey, S.Ritter, and C. Ritter." Exploring the Relationship between Consumer Behavior and Mode Choice." *Transportation Research News.* 2012. p. 29. http://kellyjclifton.com/Research/EconImpactsofBicycling/TRN_280_CliftonMorrissey&Ritter_pp26-32.pdf.

[17] *National Cooperative Highway Research Program (NCHRP) Report 552: Guidelines for Analysis of Investments in Bicycle Facilities*. 2006. p. 17. https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf.

[18] "Fiscal Year 2012-13 Transportation Fee Schedule A." City of Portland. 2012.

[19] http://www.thewashcycle.com/2009/09/cato-institute-calls-bikestation-a-4m-bike-rack.html.

[20] "Project Description for Hillsboro Intermodal Transit Facility." City of Hillsboro.2010.

[21] https://blog.oregonlive.com/commuting/2011/04/sunset_transit_centers_bike_an.html.

Safe Routes to School

What is it?

Safe Routes to School (SRTS) programs are designed to address transportation safety issues in and around school zones and to promote biking and walking to school. SRTS programs help identify and build new bicycling and walking infrastructure to access school facilities and provide education and encouragement to parents and children about walking and bicycling to school. The most common SRTS program elements are: sidewalk improvements (19%), traffic calming (14%), pedestrian/bicycle access projects (14%), and education (13%).[1] SRTS programs can improve safety for individuals walking and biking to school; enhance mobility and air quality near schools; and also increase childhood physical activity levels.

Which Mosaic Categories does the program support?

What are the benefits?

- **Mobility:** Encourages mode shift from driving to walking or bicycling by improving the user experience for active transportation users while helping reduce congestion and vehicle miles traveled (VMT).
- **Accessibility:** Increases travel options available to students, parents, and faculty/staff for short and medium distance trips.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Safety and Security:** Creates a safer and more comfortable environment for all pedestrians and cyclists in the immediate area, whether or not they are trying to access school facilities.
- **Quality of Life:** Facilitates the use of active transportation modes and makes it easier to get exercise while also meeting travel needs.

[1] National Center for Safe Routes to School. *Federal Safe Routes to School Progress Report*. August 2011.

Where is it being used?

SRTS programs are implemented in communities across the country. Examples in the Pacific Northwest include:[5]

- Roosevelt Middle School Kidical Mass, Eugene, OR
- Monmouth-Independence SRTS Program, Independence, OR
- Corvallis-Philomath SRTS Program, Benton County, OR
- Lincoln Elementary School Healthy School Pilot, Mount Vernon, WA
- Longview School Path and Crossing, Moses Lake, WA

Bicycle Safety Education, Eugene, OR[2]

International Walk and Bike to School Day, Portland, OR[3]

Central Oregon Highways Bicycle Program, ODOT[4]

How effective is it?

Quantitative data on the effectiveness of SRTS programs are currently limited. Launched in 2005, the U.S. federal SRTS program is not yet at a stage where results can be gauged at a broad-based national level, although baseline data and an evaluation plan have been published.[6,7,8] At the state and local levels, various success stories covering individual programs are available, though these focus primarily on encouragement and rarely report empirical findings. However, a few case studies, as noted in a recently released TCRP report provide outcome data "sufficient to gauge, with caution, basic travel behavior changes."[9]

- A SRTS Program in Marin County that focused on "soft" program elements (outreach, promotion events, and mapping safe routes) plus crosswalk and signage improvements experienced the following 21-month mode shifts for students at the 6-7 school surveyed (results based on 3-day averages in Fall 2000 compared to Spring 2002):[10]
    - Walking to school increased from 14% to 23%
    - Biking to school increased from 7% to 15%
    - Carpooling to school increased from 11% to 21%
    - Single-student-occupancy private vehicles decreased from 62% to 38%

- Among four Corvallis elementary schools participating in the SRTS program, tallies taken between Fall 2008 and Winter 2009 (on 1 day during each season – so results should be used with caution)

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[2] https://www.eugene-or.gov/CivicAlerts.aspx?AID=303&ARC=485.
[3] https://www.portlandoregon.gov/.
[4] https://www.oregon.gov/ODOT/Regions/Pages/Region-4-Central-Oregon.aspx.
[5] In this summary, the best available data on program effectiveness is used. Whenever possible information is provided for the referenced examples; however, that information was not always available.
[6] *Transit Cooperative Research Program Report 95.* "Chapter 16: Traveler Response to Transportation System Changes. Bicycle and Pedestrian Facilities." 2012. p. 16-194. https://www.trb.org/Publications/Blurbs/167122.aspx
[7] National Center for Safe Routes to School. S*afe Routes to School Travel Data: A Look at Baseline Results from Parent Surveys and Student Travel Tallies.* January 2010.
[8] National Center for Safe Routes to School. *Federal Safe Routes to School Program National Evaluation Plan.* August 2011.
[9] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 16: Bicycle and Pedestrian Facilities." p. 16-194.
[10] *TCRP Report 95.* "Chapter 16: Bicycle and Pedestrian Facilities." p. 16-195.

showed that walking increased by 4 percentage points, biking increased by 2 percentage points, and motorized modes (school bus, transit, and family vehicle) showed slight declines.[11]

- Counts taken before and after sidewalk improvements on the approaches to California elementary schools showed a weighted-average five-site 46% increase in schoolchild walking. Similar counts at intersection signalization projects indicated a weighted-average two-site 24% increase. Results for other crossing improvements were inconclusive.[12] Among forms of encouragement programs, multifaceted approaches and "walking school bus" programs achieved walking and bicycling increases within 6% to over 60%, omitting outliers.[13]
- A Boulder, Colorado, SRTS program at the Bear Creek Elementary School included intersection safety improvements and education and encouragement programs. Before any SRTS activities, 25% of students walked or biked to school, which increased to 41% after the SRTS program was funded. After 2 years of the program, 70% were making walking or cycling "a daily habit." Additionally, the city study found a 36% reduction in vehicular traffic (presumably in the school vicinity) after 1 year.[14]
- A safety analysis by the California Department of Transportation estimated that the safety benefit of the Safe Routes to School program was a 49% decrease in childhood bicycle and pedestrian collision rates.[15]

Additionally, a summary of what has been observed about walking and bicycling to school and physical activity levels in elementary and middle school children includes: [16]

- Overall, children who actively commute to school seem to obtain more daily physical activity than those who ride in a car or bus.
- School trip lengths greater than half a mile are more likely to result in significantly higher levels of daily physical activity.
- Children who walk or bicycle to school are more likely to walk or bicycle to other destinations in their neighborhood than children who are driven to school.

[11] *Benton County Health Status Report 2010: Built Environment: Safe Routes to School*. March 2009.

[12] *TCRP Report 95.* "Chapter 16. Bicycle and Pedestrian Facilities." p. 16-32.
[13] *TCRP Report 95.* "Chapter 16. Bicycle and Pedestrian Facilities." p. 16-385.
[14] National Center for Safe Routes to School. *Safe Routes to School Case Studies—From Around the Country.* April 2010.

[15] Orenstein, Marla R., Nicolas Gutierrez, Thomas M. Rice, Jill F. Cooper, and David R. Ragland. *Safe Routes to School Safety and Mobility Analysis.* UC Berkeley Traffic Safety Center. Paper UCB-TSC-RR-2007-1. April 1, 2007. https://escholarship.org/uc/item/5455454c.
[16] National Center for Safe Routes to School. *Safe Routes to School and Health: Understanding the Physical Activity Benefits of Walking and Bicycling to School*. September 2010.

How much does it cost to implement?

SRTS programs vary in cost, depending upon the number of schools and students served and the types of projects and programs being implemented (infrastructure, education and outreach). Across all states, the average SRTS grant as of December 2008 was approximately $154,000.[17] For comparison purposes, this is the average cost required to build about 1.5 miles of sidewalks.[18]

In Oregon, between 2005 and 2012, a total of 123 SRTS grants totaling more than $13 million have been awarded. This equates to an average grant award of $106,000 for all project types (infrastructure, non-infrastructure, and planning/start-up). Specifically, the dollar amount ranges of SRTS grants awarded in Oregon by project type are:[19]

- Infrastructure projects: $116,000 – $500,000
- Non- infrastructure projects: $1,300 – $100,000
- Planning/start-up projects: $1,000 – $3,000

It should be noted that the grant dollar totals described above may be complemented by additional local funding support.

Additionally, SRTS programs have been shown to be highly cost effective. For example, the Auburn School District in Washington state initiated a pilot SRTS program in the late 1990s to address childhood obesity and the high cost of running school buses. The school district was able to reach a milestone of 20% walk mode share and was subsequently able to scale back school bus service, reducing transportation costs by $220,000 annually. This savings equated to 180% each year of the one-time pilot grant award amount of $121,770.[20]

Implementation resources

SRTS programs are a partnership between city and county agencies, schools, community organizations, neighborhoods and schools that share the goal of making walking and biking to school fun, easy, and safe for all students and their families. As of October 2012, SRTS activities are now eligible to compete for funding alongside other programs (including activities formerly eligible under the Transportation Enhancements program and Recreational Trails program) as part of the new Transportation Alternatives program in the MAP-21 transportation bill.

For information on how to implement SRTS program in Oregon, including information on how to complete a SRTS Action Plan and available grant resources, please see the Oregon SRTS Program website. In Oregon, creating an action plan is the first step in the application process for SRTS funding. In addition to funds secured through the federal-aid state SRTS program, SRTS programs may also benefit from local funding. While some communities have implemented complex local government financing tools (such as sales tax funding or bonds) to fund SRTS programs, the easiest and most common way to access local funding is to identify existing pots of money that are currently flowing to transportation, safety, or health issues and tap into them, as appropriate.

[17] Safe Routes to School National Partnership. *Safe Routes to School 2009 Policy Report.* March 2009. https://www.saferoutespartnership.org/sites/default/files/pdf/SRTS-09-FinalPolicy.pdf
[18] Safe Routes to School National Partnership. *Safe Routes to School 2009 Policy Report.* p.7.
[19] National Center for State Routes to School. National Safe Routes to School State Project List. http://apps.saferoutesinfo.org/project_list/.
[20] *TCRP Report 95.* "Chapter 16. Bicycle and Pedestrian Facilities." p. 16-395.

The following list includes additional SRTS program guidance and implementation resources that may be of assistance:

- FHWA Safe Routes to School Program Guidance
- National Centre for Safe Routes to School
- Center for Disease Control - Walking and Bicycling to School Community Presentation
- AASHTO - Safe Routes to School Noteworthy Practices Guide: A Compendium of State SRTS Program Practices
- Sample Oregon SRTS Action Plans
    - Rural Example: Malin K-6, Malin, Oregon
    - Urban Example: Sexton Mountain Elementary, Beaverton, Oregon
- Safe Routes to School National Partnership - Getting Students Active through Safe Routes to School: Policies and Action Steps for Education Policymakers and Professionals

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Public Transportation Programs

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Decrease or Eliminate Transit Fares

What is it?

Transit pricing and fare strategies generally involve reducing or eliminating transit boarding fares to increase ridership. Transit fare reduction programs (e.g., fareless areas, subsidized passes for students or employees) can provide easier access to transit and destinations, encourage mode shift, and reduce vehicle miles traveled (VMT) and associated air and greenhouse gas (GHG) emissions. To the extent that transit programs encourage a shift to transit and more active modes, transit programs can also increase physical activity and quality of life.

Which Mosaic Categories does the program support?

What are the benefits?

- **Mobility:** Alleviates out-of-pocket transportation costs for users and can help reduce congestion and VMT by encouraging a mode shift to transit.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Quality of Life:** Improves transit ridership and associated physical activity for commuters who walk to and from transit stops.
- **Equity:** Makes transit a more viable option for low-income population groups.

SMART, Wilsonville, OR[1]

Where is it being used?

Programs that decrease or eliminate transit fares are used by transit agencies in cities throughout the United States and internationally. Examples of reduced or fareless systems in the Pacific Northwest include: [4]

- South Metro Area Regional Transit, Wilsonville, Oregon*
- Sandy Transit, Sandy, Oregon*
- Corvallis Transit System, Corvallis, Oregon
- Mason Transit, Mason County, Washington*
- Island Transit, Island County, Washington
- TriMet, Portland, Oregon**

** Some services charge fares, primarily on commuter and seasonal routes.*
*** As of Sept 1, 2012, TriMet no longer offers fare-free service areas.*


Island Transit, Island County, WA[2]

Corvallis Transit, Corvallis, OR[3]

[1] https://www.ridesmart.com/.
[2] https://www.islandtransit.org/.
[3] https://www.corvallisoregon.gov/.
[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, this was not always available.

How effective is it?

Transit ridership response to fare changes varies considerably based on individual circumstances (e.g., by type of passenger, type of route, time of day, and/or length of time, etc.). However, aggregate measures from the literature exhibit relative consistency when expressed as averages:[5]

- For every 1% increase (decrease) in bus fares, ridership can be expected to increase (decrease) by a corresponding 0.4% in the 1 to 2 years following a fare change. For every 1% increase (decrease) in rail fares, ridership can be expected to increase (decrease) by a corresponding 0.2% in those same cities. In other words, rail transit ridership is roughly twice as resistant to fare change as bus ridership.
- Rider sensitivity to fare changes appears to decrease with increasing city size.
- Ridership appears to be less sensitive to fare changes in areas where transit is well established and is competitive with auto travel.
- Off-peak transit ridership is generally twice as sensitive to fare changes as peak period ridership.
- One fare-free, off-peak demonstration project in Mercer County, New Jersey, reduced VMT by 30,000 miles per week, or 0.14% of total VMT.[6] This finding is consistent with the GHG reduction effectiveness reported for reduced transit fares in the OSTI Greenhouse Gas Toolkit.[7] The Toolkit reports that a 25% to 50% fare reduction could result in a 0.02% to 0.3% reduction in greenhouse gases in 2030.[8]

A variety of research has also been conducted on the effects of completely eliminating fares, which often produces much higher ridership gains than projected.[9] This is, in part, due to the removal of a psychological barrier for prospective passengers related to farebox apprehension (e.g., confusion over the rate and whether exact change is needed). On average, research shows that most fare-free systems will trigger a 25% to 50% gain in ridership, with new systems expected to have the greatest increase compared to initial ridership projections. Generally, small urban and rural communities are the best suited to the use of fare elimination programs because the farebox recovery rate is quite low. University communities are also well suited to fare elimination programs because the majority of customers are students and staff/faculty who prepay for service (as part of a yearly fee) or are otherwise lower income passengers.

These are some examples of fare elimination programs and the resulting ridership statistics:

- When fares were eliminated in the Corvallis, Oregon, transit system in February 2011, there was a 38% increase in ridership after 8 months. Beaver Bus, the late night transit service co-funded by the

5 *Transit Cooperative Research Program Report (TCRP) Report 95.* "Chapter 12: Traveler Response to Transportation System Changes: Transit Pricing and Fares." 2004. pp 12-6. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf.

6 *TCRP Synthesis 101: Implementation and Outcomes of Fare-Free Transit Systems: A Synthesis of Transit.* 2012. p. 56. https://www.trb.org/Publications/Blurbs/167498.aspx.

7 https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

8 While GHG reductions are different than VMT reductions, a 1:1 ratio of percent GHG reduction to percent VMT reduction is assumed for the programs that derive GHG reductions entirely from reducing VMT (such as decreasing or eliminating transit fares). This assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. p. B-7.

9 Hodge, D. C., J.D. Orrell, and T.R. Strauss. 1994. *Fare-free Policy: Costs, Impacts on Transit Service, and Attainment of Transit System Goals.* Seattle, WA. Washington State Transportation Center. p. 18. Retrieved September 10, 2012, from https://www.wsdot.wa.gov/research/reports/fullreports/277.1.pdf.

City and Oregon State University went fareless in October 2011 and had a ridership increase of 56%.[10] In response to the record ridership, the City increased transit service in September 2012 to help meet demand.[11]

- In 1975, TriMet implemented a free-fare zone within the Portland, Oregon, central business district (CBD). Within 34 months, ridership increased from 900 to 8,200 trips per day (811%) within the "Fareless Square" area.[12] In 1998, TriMet estimated that expanding Fareless Square to the entire system would increase ridership by 25% during peak hours and 60% during the off-peak hours.
- After the implementation of a free-fare zone in the Seattle, Washington CBD, ridership increased from 4,100 to 12,250 trips per day (199%). Of those trips, 25% would have otherwise not been taken, 31% would have been from walking, 19% would have been by the replaced Dime Shuttle, 15% by other buses, and 10% from other modes.[13]

How much does it cost to implement?

In general, decreasing transit fares will nearly always increase ridership, but it will also result in lower fare revenues. Therefore, if fare levels are reduced to increase ridership, success can be reasonably assured, but it will come at the cost of revenue reduction.[14] How much revenue is reduced and the overall financial impact of decreasing or eliminating fares will depend on several factors:

- Factors that may increase costs:
  - Initial cost to transition to decreased or eliminated fares (announcements, printed media, etc.)
  - Reduction in fare revenues received by the transit agency
  - Increased ridership impacts on operations (more service and buses needed)
  - Potential increase in security and maintenance costs
- Factors that may provide cost savings:
  - Reduction in costs associated with fare collection (administration, technology, etc.)
  - Potential increase in eligibility for state and federal funding due to increased ridership

According to surveys, the average cost of fare collection as a percentage of total fare revenue is roughly 6%.[15] The cost of fare collection can include system design and development; procurement and installation of fare collection, dispensing equipment, and related software; purchase or production of fare media; day-to-day administration; marketing; and sales and distribution.[16]

Overall, research on the expected costs and benefits of foregoing fare collection generally shows that eliminating fares may be most beneficial for newly developing or smaller transit systems, where the

[10] https://www.corvallisoregon.gov/.
[11] https://archives.corvallisoregon.gov/public/0/doc/340401/Electronic.aspx.
[12] *TCRP Report 95*. "Chapter 12: Traveler Response to Transportation System Changes: Transit Pricing and Fares." 2004. p. 12-51. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf.
[13] *TCRP Report 95. "*Chapter 12: Traveler Response to Transportation System Changes: Transit Pricing and Fares." 2004. p. 12-51. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf.
[14] *TCRP Report 95*. "Chapter 12: Traveler Response to Transportation System Changes: Transit Pricing and Fares." 2004. p. 12-42. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf.
[15] *TCRP Synthesis 101: Implementation and Outcomes of Fare-Free Transit Systems.* 2012. p. 37. https://www.trb.org/Publications/Blurbs/167498.aspx.
[16] *TCRP Report 32: Multipurpose Transit Payment Media.* 1998. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_32.pdf.

cost of fare collection outweighs fare recovery potential, where excess capacity is ample, and where available subsidies fully cover the costs of operation.

Implementation resources

This TCRP report provides information on implementation resources related to fare policy issues, trends, and technologies:

- TCRP Report 94: Fare Policies, Structures, and Technologies

In addition to federal and state funds for programs that increase transit ridership, these are some examples of funding sources that may help offset lost revenues:

- Partnership opportunities for providing low-priced passes or other special arrangements (such as with local universities, employers, business associations, hotels, social service agencies, or other public, private, and nonprofit entities).
- Local property taxes, advertising revenue, or voter-approved fees. For example, Corvallis, Oregon, voters approved a $2.75 monthly transit fee for local utility customers as a way to offset the loss in fare revenue.[17] The fee has provided a more stable revenue source than fares, allowing the transit agency to increase service hours during difficult economic times.

[17] *TCRP Synthesis 101: Implementation and Outcomes of Fare-Free Transit Systems*. 2012. p. 37. https://www.trb.org/Publications/Blurbs/167498.aspx

Improve Transit Service

What is it?

Transit service can be improved by increasing service hours and frequency and by expanding transit route coverage. Improvements that address routing, coverage, scheduling, and frequency can enhance mobility and accessibility by reducing travel times and increasing the number of destinations that are accessible by transit. To the extent that service improvements encourage a mode shift away from single occupancy vehicles, they can also reduce vehicle miles traveled (VMT) and the associated air and greenhouse gas (GHG) emissions, and increase physical activity and quality of life.

Which Mosaic Categories does the Program Support?

QUALITY OF LIFE
ENVIRONMENTAL STEWARDSHIP
ACCESSIBILITY
MOBILITY

What are the benefits?

- **Mobility:** Reduces travel time for transit users and can help reduce congestion and VMT by encouraging a mode shift to transit.
- **Accessibility:** Improves ease of access and connectivity by enhancing the availability of transit as a viable mode, especially outside of peak hours.
- **Environmental:** Reduces the emission of criteria air pollutants and GHG that are harmful to the environment and human health by encouraging shifts to more sustainable modes.
- **Quality of Life:** Improves transit ridership and physical activity for commuters, who walk to and from transit stops.

Corvallis Transit System
Corvallis, OR[1]


EmX BRT, Eugene, OR[2]


Community Transit, Snohomish County, WA[3]

Where is it being used?

When the economy is healthy and funds allow, transit agencies often increase frequency of service and coverage in response to rises in ridership demand.

Examples of transit agencies in the Pacific Northwest that have increased service are listed below.[4] Note that while these agencies are known to have increased service at some point in the past, the recent economic downturn has required many of them to cut service.

[1] https://www.corvallisoregon.gov/.
[2] Photo courtesy of CH2M HILL
[3] https://www.communitytransit.org/news
[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information is not always available.

- TriMet, Portland, Oregon
- Corvallis Transit System, Corvallis, Oregon
- Community Transit, Snohomish County, Washington
- Whatcom Transportation Authority, Whatcom County, Washington
- C-TRAN, Clark County, Washington

How effective is it?

Transit service changes are often implemented in conjunction with other programs (concurrent modifications in fare structures, station amenity improvements, implementation of parking fees), which makes it difficult to isolate the effectiveness of service changes alone. The following findings provide a mix of national averages and local examples of transit service programs that have improved service hours/frequency and/or routing/coverage.

Transit Service Hours and Frequency

- On average, for every 1% increase (decrease) in transit service frequency, ridership can be expected to increase (decrease) by a corresponding 0.5%.[5] However, for every 1% increase in transit service frequency between residential areas and a central business district, ridership can be expected to increase by 0.9%.[6]
- On routes headed to Portland, Oregon, from Vancouver, Washington, C-TRAN decreased headways during the AM peak period by 8 to 9 minutes and increased service hours from 6:18 PM to 9:33 PM during the PM peak. The result was an average ridership increase of 0.33% for every 1% increase in service.[7]
- The GHG reduction effectiveness reported for improved transit service frequency in the OSTI Greenhouse Gas Toolkit was 0.02% to 0.6% reduction in GHGs in 2030.[8] Because the reduction in GHGs would be derived entirely from a decrease in VMT, a 1:1 ratio regarding the percentage of GHG reduction to the percentage of VMT reduction can be assumed.[9]

While specific quantitative impacts can be hard to isolate, the following underlying patterns relate to some of the circumstances surrounding transit service modifications:[10]

- The level of ridership is typically most sensitive to frequency changes in areas that have infrequent service and on transit lines in middle and upper income service areas.
- Where transit headways are already short and in low income service areas, ridership tends to be less affected by frequency changes and may be more sensitive to fare changes.
- Off-peak riders typically have a higher sensitivity to frequency changes than do peak period riders.

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[5] *Transit Cooperative Research Program (TCRP) Report 95*. "Chapter 9: Traveler Response to Transportation System Changes: Transit Scheduling and Frequency." 2004. p. 9-5. https://www.trb.org/Publications/Blurbs/154748.aspx

[6] *TCRP Report 95*. "Chapter 9: Transit Scheduling and Frequency." 2004. p. 9-16.

[7] *TCRP Report 95.* "Chapter 9: Transit Scheduling and Frequency." 2004. p. 9-9.

[8] *Oregon Greenhouse Gas Toolkit Report*. https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

[9] While GHG reductions are different than VMT reductions, a 1:1 ratio of percent GHG reduction to percent VMT reduction is assumed for the programs that derive GHG reductions entirely from reducing VMT (such as TROs/TMAs). This assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. Page B-7.

[10] *TCRP Report 95*. "Chapter 9: Transit Scheduling and Frequency." 2004. p. 9-4.

- The hours transit service is offered can be just as important as the frequency of service.

Transit Service Routing and Coverage

- The mid-range of ridership response to the expansion of bus transit, by itself or with fare changes, is a 0.6% to 1% increase in ridership for every 1% of increase in transit service.[11]
- In a study estimating the impacts of new and expanded bus service on equivalent VMT there was, on average, a 0.13% annual decline in VMT after a 21% increase in transit service in larger cities; while in smaller cities, there was a 0.03% annual decline in VMT as a result of a 63% increase in transit service.[12]
- In a 1970s transit service demonstration study, a 42% increase in bus service miles in Portland, Oregon, resulted in a 36% increase in ridership (a 0.88% increase in ridership for every 1% increase in service).[13] In a similar study, a 166% increase in bus service miles in Eugene, Oregon, resulted in a 271% increase in ridership (a 1.34% increase in ridership for every 1% increase in service).[14]
- In Portland, Oregon, a major realignment of radial routes into a grid system combined with additional factors resulted in a 0.29% increase in ridership for every 1% increase in service.[15]
- In a 1990s study of transportation control measures (TCM) in California, fixed route transit projects reduced VMT between 21,000 and 4.7 million per year per project, while shuttle transit projects reduced VMT between 10,000 and 835,000 per year per project. Transit projects were also found to reduce the emission of criteria air pollutants. Overall, public transit projects were found to be less effective in reducing VMT and emissions than either demand management or vanpooling TCMs.[16]

How much does it cost to implement?

While transit service improvements can increase fare box revenues, this is typically offset by the expense of providing additional service. However, some transit service improvements are more cost-effective than others. For example, increasing off-peak service frequency is typically less expensive on a per hour/mile basis than increasing peak service frequency.[17] Additionally, bus routing and coverage improvements are likely to be less expensive than other improvements designed to increase ridership (express buses, new park and ride facilities, rail projects).[18] However, full development of a new transit route typically takes 1 to 3 years, so a major cost consideration when extending service is sustaining operations during the time that ridership is being established. In general, bus routes that serve multiple transportation needs are the most likely to be successful and cost-effective.[19] See Table 1 for

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[11] *TCRP Report 95.* "Chapter 10: Traveler Response to Transportation System Changes: Bus Routing and Coverage." 2004. p. 10-5. https://www.trb.org/Publications/Blurbs/154974.aspx
[12] *TCRP Report 95*. "Chapter 10. Bus Routing and Coverage." 2004. p. 10-49.
[13] *TCRP Report 95*. "Chapter 10. Bus Routing and Coverage." 2004. p. 10-9.
[14] *TCRP Report 95.* "Chapter 10. Bus Routing and Coverage." 2004. p. 10-9.
[15] *TCRP Report 95.* "Chapter 10. Bus Routing and Coverage." 2004. p. 10-16.
[16] *TCRP Report 95.* "Chapter 10. Bus Routing and Coverage." 2004. p. 10-52.
[17] *TCRP Report 95.* "Chapter 9. Transit Scheduling and Frequency." 2004. p. 9-29.
[18] *TCRP Report 95.* "Chapter 10. Bus Routing and Coverage." 2004. p. 10-53.
[19] *TCRP Report 95.* "Chapter 10. Bus Routing and Coverage." 2004. p. 10-54.

findings from the California TCM study regarding cost-effectiveness of fixed route and shuttle transit service.[20]

Table 1. Cost-effectiveness Ranges of California Fixed Route Transit and Shuttle TCMs

	Cost Per Trip Eliminated	Cost Per VMT Eliminated	Cost Per Pound Eliminated (Criteria Air Pollutants)
Fixed Route Service	$0.22 - $35.00	$0.03 - $2.20	$3.06 - $1,117.00
Shuttle Service	$3.68 - $75.60	$0.05 - $27.70	$6.52 - $610.00

Source: Pansing, Schreffler, and Sillings (1998)[21]

Implementation resources

The following are resources for implementing transit service improvements:

- **Best Practices in Transit Service Planning**: This study, prepared by the Florida Department of Transportation Research Center, provides best practices for transit agencies looking to increase transit service frequency and coverage and includes guidelines from around the country for planning routes to ensure maximum ridership: https://www.nctr.usf.edu/pdf/77720.pdf.
- **Metropolitan-Level Transportation Funding Sources:** This study identifies transportation funding sources potentially available for metropolitan planning organizations that wish to generate new local sources of revenue to finance increased transit service (or expenditures): http://narc.org/uploads/File/Transportation/Library/NCHRP_Metro_Funding.pdf.

[20] *TCRP Report 95.* "Chapter 10: Bus Routing and Coverage." 2004. p. 10-52.
[21] *TCRP Report 95.* "Chapter 10: Bus Routing and Coverage." 2004. p. 10-52.

Transit Priority Treatments

What is it?

Transit priority treatments (e.g. transit signal priority (TSP) and queue jump lanes) allow buses or trains to bypass traffic. These treatments can reduce the transit travel time delay caused by traffic congestion and improve the reliability of transit schedules. Transit priority treatments are a fundamental component for making transit service time-competitive with competing modes. To the extent that they can encourage mode shift, transit priority treatments can also reduce vehicle miles traveled (VMT) and improve environmental quality by reducing greenhouse gas emissions.

TSP facilitates the movement of transit vehicles through traffic-signal-controlled intersections by retrofitting traffic signals with detection systems and installing priority request generators on transit vehicles. Queue jump lanes involve the addition of a travel lane (usually a right-turn lane or bus-only lane) on the approach to signalized intersections, which allows transit vehicles to jump to the front of a queue.

Which Mosaic Categories does the program support?

MOBILITY

ENVIRONMENTAL STEWARDSHIP

FUNDING/ FINANCE

What are the benefits?

- **Mobility:** Reduces in-vehicle transit travel time for users and improves transit schedule reliability. Can also reduce congestion and VMT by making transit more competitive with single occupancy vehicle travel.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by reducing transit vehicle idling and also encouraging mode shift to transit.
- **Funding the System:** May reduce operating costs by reducing fuel consumption from idling.

Where is it being used?

Transit priority treatments are used by transit agencies across North America and the world. Examples in the Pacific Northwest include: [1]

- EmX Bus Rapid Transit, Eugene-Springfield, Oregon
- Swift Bus Rapid Transit, Snohomish County, Washington
- RapidRide Express Bus, King County, Washington
- TriMet, Portland, Oregon

[1] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, this information was not always available.

How effective is it?

Transit Signal Priority


Swift BRT, Snohomish County, WA[2]


EmX BRT, Eugene-Springfield, OR[3]

RapidRide Express Bus, King County, WA[4]

TSP applications are rapidly becoming more popular in the U.S. Typically, transit travel times are reduced by 8% to 12%, depending on the length of corridor, particular traffic conditions, bus operations, and TSP strategy deployed.[5] TSP has also been shown to improve schedule adherence and transit travel time reliability. Increases in general traffic delay associated with TSP have been shown to be negligible, ranging in most cases from 0.3% to 2.5%. These are a few examples of measured benefits:

- In Portland, Oregon, TriMet avoided adding one more bus to a corridor by using TSP, achieving a 10% improvement in travel time and up to a 19% reduction in travel time variability.[6]
- In Tacoma, Washington, TSP with signal optimization reduced transit signal delay approximately 40% in two corridors.[7]
- Los Angeles County Metropolitan Transportation Authority achieve up to a 25% reduction in bus travel times with TSP.[8]
- In Seattle, along the Rainier Avenue corridor, King County Metro bus travel time variability was reduced by 35%.[9]

Transit Queue Jumps

Transit queue jumps have been shown to produce a 5% to 15 % reduction in travel times for buses through intersections. These are some examples of travel time savings associated with queue jumps/bypass lanes: [10]

- In Seattle, along NE 45th Street, a 27-second reduction in bus travel time was achieved during the morning peak, with a 12-second reduction during the afternoon peak, and a 6-second reduction, on average, across an entire day.
- In Denver, on Lincoln Street and 13th Avenue, transit queue jumps/bypass lanes reduced delays at bus intersections by 7 to 10 seconds.

[2] https://www.communitytransit.org/.
[3] Photo courtesy of CH2M HILL.
[4] https://www.transit.dot.gov/.
[5] *Transit Cooperative Research Program (TCRP) Report 118, Bus Rapid Transit Practitioner's Guide*. 2007. p. 4-32. https://www.trb.org/Publications/Blurbs/158960.aspx.
[6] USDOT. *Transit Signal Priority (TSP): A Planning and Implementation Handbook*. May 2005. p. viii. https://www.transit.dot.gov/research-innovation/signal-priority.
[7] USDOT. *TSP: A Planning and Implementation Handbook.* May 2005. p. viii.
[8] USDOT. *TSP: A Planning and Implementation Handbook*. May 2005. p. viii.
[9] *TCRP Report 118.* 2007. p. 4-32.
[10] *TCRP Report 118.* 2007. p. 4-39.

How much does it cost to implement?

Costs associated with TSP are highly dependent on whether the TSP system is localized to a corridor or centralized and integrated with a transit or regional traffic management center. In general, if existing software and controller equipment can be used, costs may be less than $5,000 per intersection, but costs can increase to $20,000 to $30,000 per intersection if equipment needs to be replaced.[11] Costs for transit detection vary significantly based on the ultimate technology chosen. Additional information on the range of capital and operating costs for different TSP detection systems can be found in TCRP Report 118: Bus Rapid Transit Practitioner's Guide, Exhibit 4-38.

The cost of a queue jump or bypass lane depends on whether there is an existing right of way. If roadway lanes or shoulders are available, the costs are primarily for signing and striping modifications ($500 to $2,000) and the provision of a separate signal for the queue jump treatment ($5,000 to $15,000), depending on the type of detection deployed (loop vs. video). Costs for new lane construction, if required, vary based on the extent of roadway reconstruction, utility modification, and right-of-way acquisition required.[12]

By reducing bus travel times and variability, however, transit agencies have realized both capital cost savings (by saving one or more buses during the length of the day to provide service on a route) and operating costs savings (due to more efficient bus operation) from the implementation of transit priority treatments. For example, due to an annual operating cost savings of approximately $3.3 million in Los Angeles, the relative benefit-cost ratio for TSP associated with two bus rapid transit corridors was estimated to be more than 11:1 over 10 years.[13]

Implementation resources

To implement transit priority treatments, agencies should follow a typical transportation project planning, design, and construction process. The following resources may be helpful for jurisdictions wishing to implement transit priority treatments:

- Transit Signal Priority Handbook, United States Department of Transportation
- Bus Rapid Transit Practitioner's Guide, Transit Cooperative Research Program

[11] *TCRP Report 118.* 2007. p. 4-29.
[12] *TCRP Report 118.* 2007. p. 4-39.
[13] *TCRP Report 118.* 2007. p. 4-32.

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Real-time Transit Information Systems

What is it?

Real-time transit information systems provide transit riders with up-to-the-minute information on bus arrivals via the internet, phone, and display boards at key bus stops. The information is based on real-time bus locations using global positioning systems (GPS) rather than a set schedule of arrival and departure times. Access to real-time travel information reduces actual and perceived wait times and increases the reliability of transit, which can encourage a mode shift.

Which Mosaic Categories does the program support?

MOBILITY
ENVIRONMENTAL STEWARDSHIP
FUNDING/ FINANCE
SAFETY & SECURITY

What are the benefits?

- **Mobility:** Reduces actual and perceived out-of-vehicle travel time for transit riders, thereby encouraging a mode shift to transit and reducing congestion and vehicle miles traveled (VMT).
- **Funding the System:** Increases ridership, which boosts operation revenues.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health.
- **Safety and Security:** Allows travelers to reduce time spent waiting at transit stops in conditions that may seem less secure (at night, in unlit areas, etc.).

Where is it being used?

Real-time transit information systems are in use as part of systems across North America and around the world. Examples in the Pacific Northwest include:[1]

- Portland Streetcar, Portland, Oregon
- C-TRAN, Clark County, Washington
- TransLink, Vancouver, British Columbia
- OneBusAway, multiple jurisdictions, Washington

How effective is it?

On average, research has shown that real-time transit information systems are effective in reducing both perceived and actual wait times at transit stops. This is critical—as travelers tend to view out-of-vehicle wait time as twice as costly as on-board travel time.[2] Other research shows that these systems

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[1] In this summary, the best available data on program effectiveness is used. Whenever possible information is provided for the referenced examples; however, this is not always available.

[2] Iseki, H., B.D. Taylor, and M. Miller. 2006. *The Effects of Out-of-vehicle Time on Travel Behavior: Implications for Transit Transfers*. Retrieved from http://www.its.ucla.edu/research/EPIC/Appendix%20A.pdf. Accessed October 2012.

have positive impacts on ridership. A summary of findings from the literature is provided below.

Portland Streetcar, Portland, OR[5]

Impacts on Perceived and Actual Wait Times

- In Seattle, researchers found that the addition of real-time information decreased perceived wait times by 0.7 minutes (13%). A critical finding was that mobile real-time information reduced not only *perceived* wait time, but also *actual* wait time for customers. Real-time information users in the study waited almost 2 minutes less than those using traditional schedule information.[3]

C-TRAN, Vancouver, WA[6]

- In London, shorter wait times were reported by 65% of those surveyed at stops equipped with real-time transit information systems. Average perceived wait times declined from 11.9 minutes before the trial to 8.6 minutes with the real-time transit information system (28%). This is notable because, in actuality, bus frequencies were the same and service reliability actually decreased slightly during the trial. The majority (89%) of survey respondents agreed that real-time information made waiting time more acceptable. Respondents also expressed a slight willingness to pay more in fares for the system. No changes in ridership could be estimated on the basis of the trial.[4]

TriMet, Portland, OR[7]

Impacts on Ridership

- In a study of real-time arrivals in Chicago, average route-level weekday bus ridership increased approximately 2% during the year after the tracking system was implemented when compared with the previous year. Additionally, weekday ridership on Chicago Transit Authority bus routes with real-time information increased by an average of 126 daily rides compared with routes without such information, when controlling for factors such as monthly variations in ridership.[8]
- Another study in Seattle showed that real-time arrival information can make transit a more viable option for all trips, in particular, non-commute trips, which typically occur during off-peak hours when frequencies are lower. Providing real-time information increased the average number of transit trips by at least one additional trip per week for nearly 35% of survey respondents (for non-commute trips) and 15% of survey respondents (for commute trips). It also increased overall satisfaction with public transit for 92% of respondents, 48% of whom reported being "much more

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[3] "Where Is My Bus? Impact of Mobile Real-time Information on the Perceived and Actual Wait Time of Transit Riders." Transportation Research Board 91st Annual Meeting Compendium of Papers DVD. 2012.

[4] *Transit Cooperative Research Program (TCRP) Report 95.* Chapter 11. 2003. p. 11-41.

[5] Photo courtesy of CH2M HILL.

[6] https://www.c-tran.com/c-tran-services/nextride.

[7] http://trimet.org/qrcodes/index.htm.

[8] Tang, L. and P. Thakuriah. *Ridership Effects of Real-time Bus Information System: A Case Study in the City of Chicago* [electronic version]. Transportation Research Part C, 22. June 2012. pp. 146-161.

satisfied" since using real-time systems.[9]

How much does it cost to implement?

The total cost to implement a real-time information system typically includes capital costs (installing automatic vehicle locator (AVL) systems such as GPS in transit vehicles, electronic sign monitors, and prediction model software) and annual operation and maintenance costs (running the system, maintaining equipment, and, potentially, more staff). These are some examples of capital and operating costs:

- In Portland, Oregon, operating and capital costs for TriMet's Transit Tracker system in 2006 included a capital cost of $1,075,000 (for hardware, servers, and software) and annual operating and maintenance costs of $94,000.[10]
- In Salem, Oregon, it was estimated that a real-time transit information system would cost the Salem-Keizer Transit Agency $363,000 in start-up costs and $74,000 in annual operating and maintenance costs
  (2010 dollars).[11]
- A survey of participating domestic and international transit systems revealed the following ranges of capital and operating costs for real-time information systems:[12]
  - *Capital Costs:*
    - AVL system installation: $100 to $7,000 per vehicle (2002 dollars)
    - Additional capital costs: $98,000 (for a small 156-bus system) to $46.5 million (for a large system with 5,700 buses)
  - *Annual Operating and Maintenance (O&M) Costs*:
    - AVL systems: $50 to $1,550 per vehicle
    - Total annual O&M cost: $22,000 to $200,000

In terms of cost effectiveness, a 2006 U.S. Department of Transportation return on investment study of TriMet's Transit Tracker system concluded that the system "most likely achieves positive net social benefits." The study conservatively assumed that the system reduces the costs of out-of-vehicle transit time by 30 to 45 seconds and that uncertainty with the next vehicle's arrival time was reduced by 5%.[13] In London, implementing real-time arrivals on the London Underground system was deemed to provide a first-year return on investment of 83% in social benefits (due to the monetary value of reducing wait time overestimation), as well 16% in financial benefits (due to ridership and revenue increases).[14]

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[9] Ferris, B., K. Watkins, and A. Borning. *OneBusAway: Behavioral and Satisfaction Changes Resulting from Providing Real-time Arrival Information for Public Transit*. 2011. Retrieved from http://docs.trb.org/prp/11-0440.pdf. Accessed October 2012.

[10] Federal Transit Administration and U.S. Department of Transportation. *Real-time Bus Arrival Information Systems: Return-on-investment Study.* 2006. http://fta.dot.gov/documents/Final_Report_-_Real-Time_Systems_ROI_Study.doc.

[11] http://www.salemrivercrossing.org/alternate-modes-study/.

[12] *TCRP Synthesis 48*. *Real-time Bus Arrival Information Systems.* 2003. pp. 22, 43.

[13] Federal Transit Administration and U.S. Department of Transportation. *Real-time Bus Arrival Information Systems.* 2006.

[14] *TCRP Report 95.* "Chapter 11: Traveler Response to Transportation System Changes: Transit Information and Promotion." 2003. p. 41. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf.

Implementation resources

The following resources are available for jurisdictions considering the implementation of real-time information system programs:

- Guidance for Developing and Deploying Real-time Traveler Information Systems for Transit, Federal Transit Administration, 2003
- Developing Traveler Information Systems Using the National ITS Architecture, U.S. Department of Transportation, 1998

Demand Responsive Transit Service

Which Mosaic Categories does the program support?

ACCESSIBILITY EQUITY

What is it?

Demand responsive transit, also known as paratransit, includes services where a transit vehicle does not operate a fixed-route, but picks up and drops off passengers at select locations in response to specific service requests. Demand responsive transit typically serves the general population in low-density and/or rural communities as well as the disabled population. Americans with Disabilities Act (ADA) services are a subgroup of demand responsive transit services designed specifically for persons who, because of a disability, cannot access or ride available fixed-route service.[4]

Services may vary in the level of flexibility that is provided. Some agencies provide fully demand responsive service that involves call-up service door-to-door between any origin and destination in a given area, while others may offer a more defined route with flexible pick up or drop off points upon request that may deviate from the route. Additionally, service may or may not be offered on a fixed schedule.

Demand responsive transit is most commonly operated by private companies under contract with public transit agencies, but can also be operated by community groups, nonprofit organizations, or the public transit agency directly. Paratransit services typically involve the use of small buses or vans that are equipped with wheelchair lifts or ramps. These services can help make the transportation network more accessible for all residents, including those that live in remote locations, the elderly, and the disabled.

Pierce Transit Shuttle
Pierce County, WA[1]

TriMet LIFT Paratransit, Portland, OR[2]

Cherriots CherryLift, Salem-Keizer, OR[3]

What are the benefits?

- **Accessibility:** Increases the travel options available for accessing everyday goods and services.
- **Equity:** Increases accessibility and the travel options available to specific population groups, (elderly, disabled) and in specific geographic areas (rural).

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[1] https://www.piercetransit.org/.
[2] https://trimet.org/.
[3] https://cherriots.org/.
[4] The Americans with Disabilities Act (ADA) requires equal access to public transportation for persons with disabilities.

Where is it being used?

Demand responsive transit is employed in most cities that have public transit service in the United States. These are relevant examples in the Pacific Northwest:[5]

- TriMet LIFT Paratransit, Portland, OR
- Cherriots CherryLift, Salem-Keizer, OR
- Canby Area Transit Dial-A-Ride, Canby, OR
- Spokane Transit Paratransit, Spokane County, WA
- Pierce Transit Shuttle, Pierce County, WA

How effective is it?

Few attempts have been made to monitor and understand demand responsive transit travel behavior and ridership response compared to fixed-route service, due to the wider variation in services offered and the lack of available databases suitable for study. There is also variability in the eligibility requirements for demand responsive transit service and the stringency with which such routes are applied. Total ridership for demand responsive services is most heavily influenced by the size of the target markets and by the service attributes offered.

Because the primary application of demand responsive service is in situations where the density of patrons is low, due either to low-density land use patterns and/or a limited target market segment (ADA), ridership is typically low and the presence or absence of paratransit service has negligible impacts on automobile use, vehicle miles traveled, energy consumption, or emissions.[6] However, demand responsive transit has important equity and accessibility benefits. Information related to the effectiveness of demand responsive transit service is described below.

- A study of ADA and social service paratransit use in Winston-Salem, North Carolina, found that 57% of trips were for medical purposes, 26% were for education purposes, 6% were for shopping, and 5% were for employment, with all remaining trips in the "other" trip purpose category. Senior citizens accounted for 59% of the passengers, while 61% were on disability and 98% were unemployed.

- In Chicago, Illinois, those who were unable to schedule a trip due to service capacity constraints did not make the trip 55% of the time. Of the 45% who found alternate means, at least 36% (and possibly more) used a private vehicle, 21% took a regular taxi, 7% took a fixed-route service, and the rest took other modes.[7]

- Replacing fixed-route service with general demand responsive service generally leads to increases in ridership. In Columbia, Maryland, (population: ~ 100,000), daily ridership increased from 70 to 240 passengers per day (243% increase) after replacing fixed-route transit service with demand responsive service.[8]

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[5] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that was not always available.

[6] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 6: Demand Responsive/ADA." 2004. p. 6-39.

[7] *TCRP Report 95.* "Chapter 6: Demand Responsive/ADA." 2004. pp. 6-38 to 6-39.

[8] *TCRP Report 95.* "Chapter 6: Demand Responsive/ADA." 2004. p. 6-9.

- Of the riders that used general demand-responsive service with route deviation in Prince William County, Virginia, 22% formerly drove alone to work, while 19% formerly drove alone to shop.[9]

How much does it cost to implement?

In general, the cost of implementing demand responsive service depends on the size of vehicles used, hours of operation, character and density of the service area, and ridership levels. The cost of providing federally mandated paratransit service can be 7 to 10 times more expensive per trip than fixed-route passenger trips (often exceeding $20 per trip in 2004 dollars). Often, more than 50% of this cost goes to paying third-party contractors to provide the service. Among 25 public transit agencies in Florida, the cost per hour for paratransit service increased 57% from $23.31 in 2001 to $36.52 in 2005 and increased overall annually from $66,301 in 2001 to $165,524 in 2005. Operating expenses made up 88% of the total expenditures.[10, 11]

To lower costs, some transit agencies in small cities and low density service areas have opted to consolidate transit service offerings into one general flex service instead of providing separate fixed-route service and ADA paratransit service. Flex service typically allows buses to deviate from fixed-routes to serve ADA eligible riders, but requires regular passengers to board or alight at designated stops. Example case studies and their results are described below.

- In Whatcom County, Washington, annual cost savings of up to $350,000 have been realized from the provision of flex service in rural areas instead of both fixed-route and complementary paratransit service. Route deviations account for 9% of total trips, many for individuals who would be eligible for ADA paratransit.[12]
- In Prince William County, Virginia, operating flex-route service instead of two separate fixed-route and paratransit services mitigated the need to operate an additional 6 vehicles operating 52 daily service hours. The result was an annual savings of $462,000 relative to the actual annual budget of $688,000.[13]
- In order to comply with ADA requirements, the entire Wichita Falls, Texas, system was converted to a fixed-route service that allowed for stops anywhere along a route, as well as route deviation, in response to previously arranged passenger service requests. This saved between $750,000 and $1 million a year.[14]

[9] *TCRP Report 95. "*Chapter 6: Demand Responsive/ADA.*"* 2004. p. 6-37.
[10] Goodwill, J. and H. Carapella. "Creative Ways to Manage Paratransit Costs." *USF Center for Urban Transportation Research.* 2008. pp. 1-88. https://www.nctr.usf.edu/pdf/77606.pdf.
[11] *TCRP Report 95. "*Chapter 6: Demand Responsive/ADA.*"* 2004. p. 6-33.
[12] *TCRP Synthesis 76, Integration of Paratransit and Fixed-Route Transit Services.* 2008. p. 13. https://www.trb.org/Publications/Blurbs/158196.aspx.
[13] *TCRP Report 95. "*Chapter 6: Demand Responsive/ADA.*"* 2004. p. 6-45.
[14] *TCRP Report 95. "*Chapter 6: Demand Responsive/ADA.*"* 2004. p. 6-39.

Implementation resources

The following resources may be helpful to transit agencies looking to implement demand responsive transit service:

- ADA Technical Assistance, Federal Transit Administration
- Topic Guides on ADA Transportation, Federal Transit Administration
- Guidebook to Rural Demand Response Transportation, TCRP Report 136
- Demand-Response Services and the Trip to Work, Community Transportation Association of America
- Resource Guide for Commingling ADA and Non-ADA Paratransit Riders, TCRP Report 143

Transportation Demand Management Programs

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Carsharing

What is it?

Carsharing programs are on-demand automobile rental services that substitute for private vehicle use and ownership. Such programs include commercial car sharing programs and peer-to-peer carsharing programs.

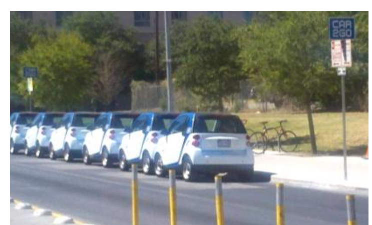
Commercial carsharing, run by private firms, maintain a fleet of vehicles that are deployed regionally (neighborhoods) and are available for short-term rental. Commercial carshare companies typically either offer a fleet of vehicles designed for round-trip rental where vehicles are returned to a designated parking spot or one-way trip rentals where vehicles may be rented and returned anywhere within the company's designated operating area. Typically, the cost of rental includes fuel, insurance, and parking meter fees.

Personal vehicle carsharing, also known as peer-to-peer car sharing, enables private car owners to make their vehicle available on a temporary basis to a private carsharing company for rental. In return, the vehicle owner gets a substantial portion of the rental revenue from the carsharing company. When not rented out, the vehicle owner can continue to use their car as usual. Program users must typically pass an application process before being allowed to use cars.

Carsharing programs can increase accessibility and equity within a city by increasing the transportation choices available and allowing users to easily access cars for occasional trips without the expense of purchasing and maintaining a private vehicle. Car sharing programs have also been shown to lower vehicle miles traveled (VMT) and increase biking, walking, and the use of public transportation.

Which Mosaic Categories does the program support?

Zipcar Parking, California State Univeristy Chico[1]


Car2Go, Austin, TX[2]

U Car Share in Berkeley, CA[3]

What are the benefits?

- **Mobility:** Encourages mode shift to transit, cycling or walking for the majority of trips by allowing individuals to forgo personal vehicle ownership. This helps reduce congestion and VMT.
- **Accessibility:** Increases the types of travel options available and facilitates the use of more sustainable transportation modes by

[1] https://www.csuchico.edu/sustainablefuture/newsletters/issue8/zipcar.shtml.
[2] Photo courtesy of CH2M HILL.
[3] https://commons.wikimedia.org/wiki/File:U_Car_Share_Berkeley_Sign.jpg.

providing a low-cost alternative to personal vehicle ownership.

- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Equity:** Provides lower-income populations with access to the convenience of auto travel for occasional trips without the expense of purchasing and maintaining a private vehicle.
- **Quality of Life:** Increases physical activity and quality of life by enabling users to forgo vehicle ownership and adopt more active modes for the majority of trips where a vehicle is not required.

Where is it being used?

Carsharing systems are becoming increasingly common in medium-large cities across the world and also in university towns. Modern day carsharing began in North America during the mid-1990s; as of July 2009, carsharing as an industry had more than 378,000 members served by more than 9,800 vehicles throughout the continent.[4] Examples of carsharing programs (both commercial and peer-to-peer) operating in the Pacific Northwest include:[5]

- Car2Go, Portland, OR
- Zipcar, Portland and Eugene, OR; Puget Sound, Spokane, and Pullman, WA
- U Car Share, Portland, Monmouth, and McMinnville, OR
- Enterprise CarShare, Corvallis and Eugene, OR
- Getaround, Portland, OR (peer-to-peer)

How effective is it?

Recent studies have shown carsharing programs to be effective in the following areas:

- A survey of members of 10 carsharing programs operating throughout North America during late 2008 showed that the average number of vehicles per household for carsharing members dropped a statistically significant amount, from 0.47 to 0.24, mostly due to one-car households becoming car-free households. Additionally, the average fuel economy of carsharing vehicles used most often by respondents was 10 miles per gallon (mpg) more efficient than the average vehicle shed by respondents. An aggregate analysis suggested that for every carsharing vehicle, 9 to 13 private vehicles are taken off the road (including shed vehicles and postponed purchases).[6]
- A 2007 study of San Francisco's Carma program found that 4 years after the program was introduced, 29% of members had gotten rid of one or more cars. Additionally, before-and-after comparisons revealed declines in travel among members compared to nonmembers. After controlling for the influences of other predictors, City CarShare membership was found to significantly reduce daily VMT. Specifically, all else being equal, City CarShare membership typically

[4] Martin, Elliot, Susan A. Shaheen, and Jeffrey Lidicker. "Carsharing's impact on household vehicle holdings: Results from a North American shared-use vehicle survey." *Transportation Research Record: Journal of the Transportation Research Board*. 2010. pp. 150 to 158. http://tsrc.berkeley.edu/vehicleholdings.

[5] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information is not always available.

[6] Martin, Elliot, Susan A. Shaheen, and Jeffrey Lidicker. "Carsharing's impact on household vehicle holdings." 2010.

reduced travel by 7 vehicle miles per day; residing in dense, transit-friendly San Francisco reduced the figure by another 3 vehicle miles per day; and owning a bicycle cut down on travel by an additional 4 vehicle miles per day. Overall, carshare members' average mode-adjusted daily VMT fell by 67% over the long term (2001 to 2005).[7] This decline was statistically significant and determined to result from a combination of the program members' tendencies to walk, bike, take public transit, and—when they drove—to take shorter trips and have other occupants in the vehicle. Reduced travel was matched by increased accessibility afforded to those who joined the City CarShare program. The authors of the study concluded that rising personal benefits matched by declining social costs (reflected by VMT and fuel consumption) suggested that carsharing was a "win-win" proposition that benefited both program users and non-users.[8]

- Evidence of the effectiveness of carsharing programs in Europe have produced similar results:[9]
  - In 2003, carsharing programs in Edinburgh (regional population: ~ 780,000) and Bristol (regional population: ~ 1,070,000) reduced 2,200 to 2,400 annual vehicle miles per carshare member.
  - A survey of several carsharing programs in the UK (in both urban and rural locations) showed that about 30% to 40% of members gave up a privately owned car when they joined the program or joined as an alternative to purchasing one. The rest (60% to 70%) either did not previously own a car or kept their car after joining the program.
  - In 2004, Carplus in Berlin reported that carshare members increased their walking and cycling by 28% and use of public transit by 35%.
  - In 1998, carshare members in Switzerland who gave up their cars were able to reduce annual car mileage by an average of 72% (from 5,780 miles to 1,620 miles per year).
- According to the OSTI Greenhouse Gas Toolkit, carsharing could result in a 0.05% to 0.2% reduction in total transportation sector baseline greenhouse gas (GHG) emissions in 2030. However, increasing financial support to public, private, and/or nonprofit carsharing organizations could help increase effectiveness up to 1.7%.[10] Because the reduction in greenhouse gases is calculated entirely based on a decrease in VMT, a 1:1 ratio of percent GHG reduction to percent VMT reduction can be assumed.[11]

How much does it cost to implement?

As with any new business, carsharing programs incur startup costs that must be covered before a revenue stream is developed. Startup costs include the need to purchase vehicles, obtain insurance, set up a reservation system, hire staff, market to prospective members, and develop a parking scheme. While costs depend heavily on the size of the carshare program, one carshare operator in the United

[7] Mode-adjusted VMT accounts for occupancy levels of private car trips and nets out transit trips (since no new buses or rail vehicles are added to accommodate these trips).

[8] Cervero, Robert, Aaron Golub, and Brendan Nee. "City CarShare: Longer-Term Travel Demand and Car Ownership Impacts." *Transportation Research Record: Journal of the Transportation Research Board*. 2007. pp. 70 - 80. https://iurd.berkeley.edu/wp/2006-07.pdf

[9] Cairns S., L. Sloman, C. Newson, J. Anable, A. Kirbride, and P. Goodwin. 2004.*Smarter Choices: Changing the Way We Travel.* London Department for Transport. pp. 196 to 208.

[10] *Oregon Greenhouse Gas Toolkit Report*. https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

[11] While GHG reductions are different than VMT reductions, a 1:1 ratio of percentage of GHG reduction to percentage of VMT reduction is assumed for the programs that derive GHG reductions entirely from reductions in VMT (such as car sharing). While carsharing can reduce greenhouse gas through improvements to fuel economy as well, this factor was not included in the GHG reduction estimate for this program. The 1:1 ratio assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. p. B-7.

States estimated that it can cost up to $1 million to open a new market. It then takes time to build the business and break even. All of these steps require risk taking, which a partner organization such as a local agency can help to mitigate. The benefit for the partner is a new mobility option for the partners' constituencies.[12]

As an alternative to commercial car sharing, peer-to-peer car sharing utilizes members' privately owned vehicles, which greatly reduces startup costs. According to one study, the peer-to-peer carsharing model maybe able to reduce the cost of operating a carshare service by 50% or more.[13] This makes peer-to-peer carsharing a potentially strong option for lower density areas where commercial carsharing programs are less economically viable. Currently, peer-to-peer carsharing is being tested in Portland, Oregon, through a federal grant and in partnership with the City of Portland and Oregon Transportation Research and Education Consortium (OTREC).

In terms of cost-effectiveness, carsharing programs in Edinburgh and Bristol in the United Kingdom resulted in a program cost of 5 pence per kilometer (or $0.13 per vehicle mile) reduction. This estimate is derived from the total program costs and total estimated vehicle miles reduced for the programs at the time of analysis.[14]

Implementation resources

Carsharing programs are often the result of partnerships between the public sector and private or non-profit carshare companies. While carshare operators are the most common initiators of program launches in a particular community, there are numerous partnership, business, and operating models available to a community that wishes to implement a carshare program. Some common factors for success include:[15]

- Identifying a champion for car-sharing
- Adopting supportive policies and regulations (e.g., VMT reduction goals, supportive parking policies, etc.)
- Providing financial assistance (e.g., for marketing and/or startup and operating costs, etc.)

The following are additional resources that may aid in the implementation of a carshare program:

- *TCRP Report 108*: *Car-Sharing: Where and How it Succeeds* (2005)
- "Carsharing Parking Policy: A Review of North American Practices and San Francisco Bay Area Case Study" by Susan A. Shaheen, Adam P. Cohen, and Elliot Martin. *Transportation Research Record: Journal of the Transportation Research Board* (2010): 146 – 156.
- *Carsharing – Start Up Issues and New Operational Models* (2004)
- Carsharing.us (a blog) and Carsharing.org (one-stop web resource) by David Brook
- "Peer-to-Peer Car Sharing: Market Analysis and Potential Growth" by Robert C. Hampshire and Craig Gaites. *Transportation Research Record: Journal of the Transportation Research Board* (2011): 119 – 126.

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12 *Transit Cooperative Research Program (TCRP) Report 108. Car-Sharing: Where and How it Succeeds*. 2005. p. 6-7. https://www.trb.org/Publications/Blurbs/156496.aspx

13 Hampshire, Robert C. and Craig Gaites. "Peer-to-Peer Car Sharing: Market Analysis and Potential Growth." *Transportation Research Record: Journal of the Transportation Research Board*. 2011. pp. 119 to 126. https://trrjournalonline.trb.org/doi/abs/10.3141/2217-15.

14 Cairns S, L. Sloman, C. Newson, J. Anable, A. Kirbride, and P. Goodwin. *Smarter Choices: Changing the Way We Travel.* London Department for Transport. 2004. p. 210.

15 *TCRP Report 108: Car-Sharing: Where and How it Succeeds.* 2005. p. 6-19.

Employer Transportation Demand Management (TDM) Programs

What is it?

Employer transportation demand management (TDM) programs are employer-sponsored programs designed to reduce single-occupancy vehicle (SOV) trips to and from the work site. Programs typically include incentives and support for employees to shift travel modes, increase vehicle occupancy rates, and/or reduce the need for travel. A variety of incentives and options may be included in employer TDM programs, such as:

- Transit pass subsidies
- Commuter information services
- Rideshare matching services (carpool/vanpool)
- Parking cash-out programs
- Preferential parking for carpools or vanpools
- Provision of bike lockers, showers, and/or changing facilities
- Reward and recognition programs
- Emergency ride home services
- Flexible/compressed work schedules
- Telecommuting

Employer-based TDM programs may be required by a local trip reduction ordinance (TRO) or supported through a membership in a local transportation management association (TMA). For more information on TROs and TMAs, see the Mosaic TRO/TMA Program Information Sheet. Employer TDM programs can help meet local goals for vehicle miles traveled (VMT) and congestion reduction, environmental stewardship, and quality of life.

Which Mosaic Categories does the program support?

ACCESSIBILITY
ENVIRONMENTAL STEWARDSHIP
MOBILITY
QUALITY OF LIFE

What are the benefits?

- **Mobility:** Encourages a reduction in SOV rates, which can help reduce congestion and VMT.
- **Accessibility:** Increases awareness of and promotes the use of travel options such as transit, carpooling, and non-motorized modes.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Quality of Life:** Promotes the use of active transportation modes which can increase physical activity and enhance health and quality of life.

Where is it being used?

Employer-based TDM programs have been employed at organizations and companies across the United States.
Examples in the Pacific Northwest include: [4]

- Nike, Inc., Beaverton, OR
- West Linn Paper Company, West Linn, OR
- Oregon State University, Corvallis, OR
- Swedish Medical Center, Seattle, WA

Nike, Inc., Beaverton, OR[1]

Swedish Medical Center, Seattle, WA[2]

Oregon State University[3]

How effective is it?

Site-specific Outcomes

The effectiveness of employer TDM programs varies based on the program elements included, the presence of financial incentives, and the transportation options available for accessing the work site. The following are findings based on an 82-program sample of employer TDM programs:[5]

- The average empirically based estimate of site-specific vehicle trip reduction impacts for employer support programs[6] alone is 4% to 5% vehicle trip reduction (VTR). Those TDM programs that provided transportation services[7] were considerably more effective as a group in reducing vehicle trips (22% program VTR).[8] Additionally, the combination of parking fees and employer transportation services produces a particularly strong synergistic effect, with the average of such combinations within the 82-program sample exhibiting an implied 37% VTR. For example, the University of Washington U-PASS program combines parking pricing, transportation services, and modal subsidies, and has obtained a 31% VTR as measured with time-series data over a span of 16 years.[9]

[1] https://ops.fhwa.dot.gov/publications/mitig_traf_cong/images/nike.jpg .
[2] https://ops.fhwa.dot.gov/publications/mitig_traf_cong/swedish_med_case.htm.
[3] http://transportation.oregonstate.edu/.
[4] In this summary, the best available data on program effectiveness is used. Whenever possible information is provided for the referenced examples; however, this is not always available.
[5] *Transit Cooperative Research Program (TCRP)* Report 95. "Chapter 19: Traveler Response to Transportation System Changes – Employer and Institutional TDM Strategies." 2010. https://www.trb.org/Publications/Blurbs/163781.aspx.
[6] Defined as including commuter information services, employee transportation coordinators, rideshare matching, transportation fairs, on-site transit pass sales, and guaranteed ride home.
[7] Defined as including employer assistance with vanpool creation and program management, transit assistance either in the form of running separate shuttles or contracting with the transit operator to intensify service, or allowing use of company vehicles for ridesharing or midday business trips.
[8] *TCRP Report 95.* "Chapter 19: Employer and Institutional TDM Strategies." 2010. p. 19-13.
[9] *TCRP Report 95.* "Chapter 19: Employer and Institutional TDM Strategies." 2010. p. 19-14.

- Employers or institutions located near good transit service had better-performing programs than those not close to good public transit. Out of the 82-program sample of employers, the sites with high transit availability had an average program-level VTR of 26%, compared with 12% where transit availability was low.[10] Additionally, employers that featured transit subsidies in their TDM programs had an average VTR of 21%, versus 14% for those who did not.[11]

System-level Outcomes

While Employer TDM programs are typically focused on reducing site-specific vehicle travel, area-wide impacts may occur as well, though the effects are often dissipated. A limited number of estimates have been made of actual and potential regional and system-level impacts of employer TDM strategies, some of which are described below:

- Theoretical studies have predicted that work trip parking pricing and the elimination of parking subsidies could reduce regional VMT by 1.1% to 2.9%.[12]
- According to the OSTI Greenhouse Gas Toolkit, employer TDM programs could result in up to a 1.7% reduction in total transportation sector baseline greenhouse gas (GHG) emissions in 2030.[13] Because the reduction in greenhouse gases would be derived entirely from a decrease in VMT, a 1:1 ratio of percentage of GHG reduction to percentage of VMT reduction can be assumed.[14]

Additionally, transit agencies often implement programs that reach out to and support employers in reaching their TDM goals. While these are not individual employer TDM programs, they support such programs and can also impact system-level VMT.

- The TriMet Employer Outreach program supports employers of all sizes throughout the Portland region with transportation program assistance, transit pass programs and surveying for Oregon Department of Environmental Quality ECO compliance. In the period from 2009 to 2011, the program reduced vehicle miles traveled (VMT) by an estimated 34,385,606 to 51,578,409 (approximately 0.18% to 0.27% of regional VMT).[15, 16] Additionally, the non-SOV mode split for employers working with the TriMet Employer Outreach program increased from 27.1% in 2009 to 38.5% in 2011.
- The SMART/Wilsonville Employer Outreach Program works with Wilsonville area employers and residents to promote transit and other transportation options. In the period from 2009 to 2011, the program reduced VMT by an estimated 863,918 to 1,295,877 (approximately 0.005% to 0.007% of regional VMT).[17]

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[10] *TCRP Report 95.* "Chapter 19: Employer and Institutional TDM Strategies." 2010. p. 19-12.

[11] *TCRP Report 95.* "Chapter 19: Employer and Institutional TDM Strategies." 2010. p. 19-13.

[12] *TCRP Report 95.* "Chapter 13: Traveler Response to Transportation System Changes – Parking Pricing and Fees." 2010. p. 13-6. https://www.trb.org/Publications/Blurbs/155505.aspx.

[13] https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

[14] While GHG reductions are different than VMT reductions, a 1:1 ratio of percent GHG reduction to percent VMT reduction is assumed for the programs that derive GHG reductions entirely from reducing VMT (such as Employer TDM programs). This assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. p. B-7.

[15] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

[16] Regional VMT for the Portland MSA in 2009 and 2010 estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/. Note that regional VMT data are for 2009 and 2010, while the VMR reported for the RTO rideshare program are for *fiscal years* 2009 to 2011.

[17] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

How much does it cost to implement?

Costs associated with the implementation of employer TDM programs include direct costs associated with administering the program and any costs associated with providing employees with subsidies or financial incentives (transit passes, parking cash-out) services (ridematching), or capital improvements (trip end facilities such as bike lockers and showers). Additionally, cost savings may accrue to employers if revenues are generated (for example, from parking fees) or costs are averted (from reduced employee parking).

Numerous studies in the 1990s investigated the cost-effectiveness of employer TDM approaches for reducing vehicle travel. One survey of 49 employers in 1994 showed an annual direct cost range of $13.92 to $92.94 per employee or $0.62 to $1.35 per daily trip reduced, depending on the extent of programs, services, and incentives offered by the participating employers. However, once annual cost savings were included in the calculation, the employer TDM programs saved an average of $62.30 per employee or $0.78 per daily trip reduced. The study found that the employer TDM programs that incorporated financial incentives and disincentives—particularly the availability and price of parking—were not only the most effective in reducing vehicle trips, but also had the lowest costs.[18]

In the period from 2009 to 2011, the TriMet Employer Outreach Program had a total cost of $871,500 (Metro and local matching funds) and achieved a cost-effectiveness of $.02 - $.03 per vehicle mile reduced.[19]

Implementation resources

The following are resources that may be of assistance in implementing employer TDM programs:

- Commuter Choice Primer: An Employer's Guide to Implementing Effective Commuter Choice Program and the Commuter Choice Decision Support System, FHWA
- Mobility Management Strategies: Commuter Programs, EPA
- Resource List for Commute Options and Tax Benefits, Oregon DEQ
- National TDM and Telework Clearinghouse, National Center for Transit Research at University of Southern Florida
- Best Workplaces for Commuters, National Center for Transit Research at University of Southern Florida
- TDM Encyclopedia: Commute Trip Reduction, VTPI

[18] *TCRP Report 95.* "Chapter 19: Employer and Institutional TDM Strategies." 2010. pp. 19-130, 19-131.

[19] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

Trip Reduction Ordinances (TROs) and Transportation Management Associations (TMAs)

What is it?

Trip reduction ordinances (TROs) are regulations that typically require employers of a certain size to reduce the single occupancy vehicle (SOV) commute rate of their employees. TROs can be implemented locally or at the state level. In Oregon, the Employee Commute Options (ECO) Rule requires employers in the Portland area with 100 employees or more to provide incentives to employees that have the potential to reduce commute trips to the work site by 10% from an established baseline.[1]

A transportation management association (TMA) is a non-profit organization of several employers that partner with public agencies and combine resources to design commute option programs and promote efficient use of transportation and parking resources. TMAs are appropriate for any geographic area where there are multiple employers or businesses clustered together that may benefit from cooperative transportation management. Regional and local governments, business associations, and individual businesses can all help establish TMAs.[3] While the existence of a TRO is often a driver for the formation of a TMA, it is not a prerequisite. TROs and TMAs can help meet transportation demand management (TDM) goals for mode split, traffic congestion, accessibility, and environmental quality.

Which Mosaic Categories does the program support?

Westside Transportation Alliance, Washington County, OR[2]

What are the benefits?

- **Mobility:** Encourages a reduction in SOV rates, which can help reduce congestion and vehicle miles traveled (VMT).
- **Accessibility:** Increases awareness of and promotes the use of travel options such as transit, carpooling, and non-motorized modes.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.

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[1] Oregon Department of Environmental Quality. "ECO Frequently Asked Questions. "https://www.oregon.gov/deq/aq/programs/Pages/ECO.aspx.
[2] https://www.wta-tma.org/.
[3] *Victoria Transportation Policy Institute (VTPI) TDM Encyclopedia.* Transportation Management Associations. https://www.vtpi.org/tdm/tdm44.htm.

- **Quality of Life:** Promotes the use of active transportation modes which can increase physical activity and enhance health and quality of life.

Where is it being used?

Examples of TROs and TMAs in the Pacific Northwest include the following.[4]

TROs

- Employee Commute Options (ECO) Rule, Portland, OR
- Commute Trip Reduction (CTR) Law, state of Washington

TMAs

- Lloyd District Transportation Management Association, Portland, OR
- Westside Transportation Alliance, Washington County, OR
- Gresham Regional Center TMA, Gresham, OR
- Greater Redmond Transportation Management Association, Redmond, WA

How effective is it?

The following are findings related to the effectiveness of TROs and TMAs at encouraging mode shift and reducing VMT:

TROs

- A before and after survey of the large employers affected by TROs in Los Angeles, California; Sacramento, California; and Portland, Oregon, showed a 5.4% to 7.6% average decrease in employee drive alone commute mode share. In Los Angeles and Sacramento, the changes were primarily achieved through a shift to carpool and vanpool, whereas in Portland, the reductions were primarily the result of shifts to transit.[5]

- A 1993 study estimated that a 25% increase in average vehicle ridership (AVR) for employers affected by TROs would produce a 2% to 3% decrease in regional vehicle trips and about a 3% to 4% decrease in regional VMT.[6]

- A 2003 evaluation of the effects of Washington's Commute Trip Reduction (CTR) program on an 8.6-mile section of I-5 in Seattle estimated that the average vehicle trip reduction (VTR) at 189 involved employers was between 11% and 14%. Traffic simulation was then used to project that absent the CTR program, peak-period I-5 ramp volumes would increase by about 4%, peak-period traffic congestion would be up from 23% to 44%, and corridor peak-period vehicular emissions would rise on the order of 11%.

TMAs

- From 2009 to 2011, three Portland area TMAs experienced the following results:[7,8]

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[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information was not always available.

[5] *Transit Cooperative Research Program (TCRP) Report 95 Chapter 19.* "Traveler Response to Transportation System Changes: Employer and Institutional TDM Strategies." 2010. p. 19-90. https://www.trb.org/Publications/Blurbs/163781.aspx

[6] *TCRP Report 95 Chapter 19.* "Traveler Response to Transportation System Changes: Employer and Institutional TDM Strategies." 2010. p. 19-91.

- The Lloyd TMA reduced vehicle miles traveled (VMT) by an estimated 3,075,416 to 4,613,123 (approximately 0.016% to 0.024% of regional VMT).
- The Washington Transportation Alliance TMA reduced VMT by an estimated 4,280,155 to 6,420,232 (approximately 0.02% to 0.03% of regional VMT).
- The Gresham TMA reduced VMT by an estimated 600,822 to 901,232 (approximately 0.003% to 0.005% of regional VMT).

Some of the factors affecting TMA success included the number of TMA staff, local funding support, and the TMA's geographic location (availability of free parking, availability of bike and transit infrastructure).[9]

- Additionally, according to the OSTI Greenhouse Gas Toolkit, TROs/TMAs could result in up to a 1.7% reduction in total transportation sector baseline GHG emissions in 2030.[10] Because the reduction in greenhouse gases would be derived entirely from a decrease in VMT, a 1:1 ratio of percentage of GHG reduction to percentage of VMT reduction can be assumed.[11]

How much does it cost to implement?

TROs

Costs associated with a TRO are primarily related to the expenses involved in monitoring and enforcing the ordinance, and—when support is offered to affected employers—grants. One example is Washington state's CTR program, which had an investment of $2.7 million in 2005. This was combined with additional investment by local jurisdiction partners and participating employers (estimated to be in the $30 to $40 million range). For employers and agencies competing for CTR funds, WSDOT sets an upper limit of $460 annual cost per average daily trip reduced (or less than $2.00/day). In terms of cost-effectiveness, the CTR program was estimated to save at least $24 million annually in reduced Puget Sound travel delay cost (based on 2003 data) and $13.7 million in fuel costs for workers at the affected CTR sites. [12]

TMAs

Costs associated with TMAs are generally divided into three basic categories: operations (staff salaries and overhead), marketing and promotions (information materials, promotional events, newsletters), and member services (guaranteed ride home vouchers, transit pass discounts, transportation studies). Funding for TMAs can include both private and public sources and typically include membership dues, fees for services, public grants, and private and in-kind contributions.[13] According to a study completed

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[7] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

[8] Regional VMT for the Portland MSA in 2009 and 2010 estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/. Note that regional VMT data are for 2009 and 2010, while the VMR reported for the RTO rideshare program are for *fiscal years* 2009 to 2011.

[9] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

[10] https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

[11] While GHG reductions are different than VMT reductions, a 1:1 ratio of percent GHG reduction to percent VMT reduction is assumed for the programs that derive GHG reductions entirely from reducing VMT (such as TROs/TMAs). This assumption is consistent with assumptions in the OSTI GHG Toolkit source document, *Moving Cooler.* Appendix B. p. B-7.

[12] *TCRP Report 95 Chapter 19.* "Traveler Response to Transportation System Changes: Employer and Institutional TDM Strategies." 2010. p. 19-132.

[13] National Center for Transit Research. 2001. *TMA Handbook: A Guide to Successful Transportation Management Associations*. University of South Florida. pp. 5-3 to 5-5. https://trid.trb.org/view/708166

in 1992, TMAs typically average $8 to $16 annually (converted to 2012 dollars) per covered employee in the TMA's district.[14]

In terms of cost-effectiveness, from 2009 to 2011, three Portland area TMAs experienced the following results:

Portland-area TMAs

TMAs	Total Expenditures (FY 09/10 & 10/11)	Vehicle Miles Reduced (low estimate)a	Vehicle Miles Reduced (high estimate)a	Cost Effectiveness ($ per VMR)b
Lloyd TMA	$131,660	3,075,416	4,613,123	$.03 - $.04
WTA TMA	$162,355	4,280,155	6,420,232	$.03 - $.04
Gresham TMA	$149,121	600,822	901,232	$.17 - $.25

Source: Portland Metro RTO 2012 Program Evaluation. https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf
Table Notes:
a. The VMR shows a "high" and a "low" estimate, assuming that only between 40% and 60% of VMR reduced can be attributed to the program.
b. Cost-effectiveness estimated by Mosaic Program Guide authors is based on total expenditures (including Metro and local matching funds). The $ per VMR reported is based on the total costs and vehicle miles reduced reported over the 2-year study period.

The cost of reducing 1 VMT through a program such as a TMA is a mere fraction of the benefits to society. For example, benefits in the form of reduced out-of-pocket user costs accrue to commuters that are able to reduce their driving. Specifically, the average cost per mile for gas alone is $.11 to $.19, and around $.51 to $.70 per mile for the total combined costs of vehicle ownership.[15] This shows that when the total costs and benefits to society are considered, such a program may be considered highly cost-effective.

Implementation resources

These are additional resources that may help to implement a TMA program:

- TMA Handbook: A Guide to Successful Transportation Management Associations, 2001
- VTPI TDM Encyclopedia: Transportation Management Associations
- National Directory of Transportation Management Associations, August 2012

[14] Ferguson, Erik, Catherine Ross, and Michael Meyer. 1992. "Transportation Management Associations: Organization, Implementation, and Evaluation." *Transportation Research Record Journal of the Transportation Research Board.* Issue: 1346. pp. 36-43. https://pubsindex.trb.org/view.aspx?id=371422

[15] AAA. 2012. *Your Driving Costs: How Much are You Really Paying to Drive?* https://newsroom.aaa.com/wp-content/uploads/2012/04/YourDrivingCosts2012.pdf.

Individualized Marketing Programs

What is it?

Individualized marketing programs are education and outreach efforts that encourage voluntary travel behavior change (VTBC). These programs differ from traditional mass marketing campaigns in that they are tailored to the travel needs of individuals instead of the general public. Typically, customized information on travel options and alternatives are provided to individuals based on their unique interests and home and/or work location.

Which Mosaic Categories does the program support?

What are the benefits?

- **Mobility:** Helps reduce congestion and vehicle miles traveled by encouraging a shift to transit, rideshare, and non-motorized travel modes.
- **Environmental:** Helps reduce the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Quality of Life:** Helps increase awareness of the active transportation mode options available and helps remove barriers to adoption and use.


TravelSmart, Perth, Australia[1]

Where is it being used?

Individualized marketing programs are used in cities throughout the U.S. and around the world, including: [2]

- Whatcom SmartTrips, Bellingham, Washington
- SmartTrips in Portland, Oregon
- TravelSmart in Perth, Australia
- Influencing Travel Behavior Program, United Kingdom

How effective is it?

From 2009 to 2011, the Portland Smart Trips Green Line program reduced vehicle miles traveled (VMT) by an estimated 15,713,667 to 23,570,500 (approximately 0.08% to 0.12% of regional VMT).[3] The Portland Smart Trips NNW program reduced VMT by an estimated 6,605,922 to 9,908,882

[1] https://www.transport.wa.gov.au/activetransport/active-transport.asp.

[2] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that was not always available.

[3] Regional VMT for the Portland MSA in 2009 and 2010, estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/. Note that regional VMT data are for 2009 and 2010, while the VMR reported for the RTO rideshare program are for *fiscal years* 2009 to 2011.

(approximately 0.03% to 0.05% of regional VMT).[4] On average, the Portland SmartTrips program serves approximately 20,000 households in a program year.[5] Additionally, SmartTrips and TravelSmart projects have been shown to reduce drive-alone car trips by area residents within the SmartTrips service area 9% to 13%, with a corresponding increase in walking, bicycling, and transit mode shares.[6,7]

The Federal Transit Administration's (FTA) Individualized Marketing Demonstration Program, 2003 to 2006, produced average mode share results from four cities across the U.S.: Bellingham, Washington; Cleveland, Ohio; Durham, North Carolina; and Sacramento, California (see Table 1).

Table 1: FTA Individualized Marketing Demonstration Program Results

Travel Mode	"Before" Mode Share	"After" Mode Share	% Change	Absolute Shifts (% Points)
Walk	8%	9%	+20%	+1%
Bike	2%	3%	+25%	+1%
Public Transit	2%	2%	+25%	<+1%
Auto Driver	69%	66%	-5%	-3%
Auto Passenger	19%	20%	+6%	+1%

Source: Brög and Barta (2007) as reported in *TCRP Report 95,* "Chapter 16: Pedestrian and Bicycle Facilities," Table 16-57.

Additional findings from other sources include:

- Quantification of individualized marketing effects on physical activity shows a typical increase of 11 to 13 hours per year per person.[8]
- Travel mode shifts attributable to individualized marketing have been shown to hold for up to 4 years, compared with a few months to 1 year for conventional promotions.
- Launching individualized marketing programs and improving transit facilities at the same time has been shown to more than double the increase in transit use. In a study of nine cities, the average increase in transit trips per person in neighborhoods near recent transit expansions was 23%. This increased to 48% in areas where individualized marketing programs were implemented in conjunction with transit improvements.[9]

How much does it cost to implement?

On average, a typical Portland SmartTrips 20,000-household program costs about $570,000.[10] Information on the costs, benefits, and estimated cost-effectiveness of two SmartTrips programs in the

[4] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.
[5] https://www.portlandoregon.gov/transportation/43801.
[6] http://www.pedbikeinfo.org/.
[7] Regional VMT for the Portland MSA in 2009 and 2010 estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/. Note that regional VMT data are for 2009 and 2010, while the VMR reported for the RTO individualized marketing programs are for *fiscal years* 2009 to 2011.
[8] *Transit Cooperative Research Program (TCRP) Report 95*. "Chapter 16: Pedestrian and Bicycle Facilities." 2009. p. 16-372.
[9] Brög et al. as reported in *TCRP Report 95*. "Chapter 16: Pedestrian and Bicycle Facilities." 2009. p. 16-220.
[10] https://www.portlandoregon.gov/transportation/43801.

Portland area from 2009 to 2011 are provided in Table 2 below. These programs involved a total of 58,684 households and 146,112 residents.

Table 2: Portland SmartTrips Programs

Portland SmartTrips Program	Total Expenditures (FY 09/10 & 10/11)	Vehicle Miles Reduced (low estimate)$_a$	Vehicle Miles Reduced (high estimate)$_a$	Cost-effectiveness ($ per VMR)$_b$
Green Line	$751,539	15,713,700	23,570,500	$.03 - $.05
North /Northwest	$507,405	6,605,900	9,908,900	$.05 - $.08

Source: Portland Metro RTO 2012 Program Evaluation. https://library.oregonmetro.gov/files//appendix_d_rto_evaluation_2012.pdf
Table Notes:
a. The VMR shows a "high" and a "low" estimate, assuming that only between 40% and 60% of VMR reduced can be attributed to the program.
b. Cost-effectiveness estimated by Mosaic Program Guide authors is based on total expenditures (including Metro and local matching funds). The $ per VMR reported is based on the total costs and vehicle miles reduced reported over the 2-year study period. Cost-effectiveness may even be greater if the finding that individualized marketing programs typically produce results that last up to 4 years is taken into consideration.

There is a growing body of international evidence that individualized marketing programs produce positive benefit/cost ratios:[11]

- **Linz, Australia:** Based only on cost recovery from increased transit revenues, the first year rate of return ranged from 1.1 to 1.6 (more than 100% of program costs were recovered in the first year).
- **South Perth, Australia:** Benefit-cost estimates were 44:1 for 10 years and 77:1 for 25 years. The analysis examined a broad range of benefits, including transit net fare revenue gain, avoided road construction costs, avoided traffic control costs, and public health savings from reduced air pollution and improved health and fitness.
- **Influencing Travel Behavior Program, United Kingdom:** The average benefit-cost ratio of early individualized marketing pilot projects was estimated to be 31:1. The study noted that individualized marketing cost-effectiveness appears to improve as the scale of implementation is increased.

Implementation resources

Individualized marketing programs are frequently run by city transportation departments and may receive additional funding through grants and/or regional/state funds. The SmartTrips programs in Oregon was originally brought to the U.S. in 2002 by the Portland Office of Transportation and adapted from individualized marketing programs, TravelSmart in Australia and in Europe. The following case study provides more information on the history of SmartTrips and includes ideas and resources for implementation:

- Portland Smart Trips Case Study, Pedestrian and Bicycle Information Center

[11] Parker et al. As reported in *TCRP Report 95*. Chapter 16. 2007. p. 16-396.

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Education and Outreach Campaigns

What is it?

Travel option education and outreach programs are designed to increase awareness of and promote existing non-single-occupancy-vehicle (SOV) transportation facilities and services. These programs are typically designed as mass-marketing/outreach campaigns and aim to encourage mode shift to transit, non-motorized, and/or rideshare options; improve health; and reduce vehicle miles traveled (VMT). Examples of education and outreach program elements include:

- Distribution of informational materials (transit schedules, bike and walking maps, “how to” information) in multiple languages
- Event-based outreach (at farmers markets, community events, corporate and school outreach)
- Newsprint adds/stories and radio commercials
- Websites with travel option information, trip logs, etc.
- Commute challenges (Bike Commute Challenge, Try it Week)
- Sponsored bike rides and car free events (Sunday Parkways, Kidical Mass, Ciclovía)

What are the benefits?

- **Mobility:** Encourages a reduction in SOV rates, which can help reduce congestion and VMT.
- **Accessibility:** Increases awareness of and promotes the use of travel options such as transit, carpooling, and non-motorized modes.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases that are harmful to the environment and human health by encouraging shifts to more sustainable transportation modes.
- **Quality of Life:** Promotes the use of active transportation modes, which can increase physical activity and enhance health and quality of life.

Which Mosaic Categories does the program support?

Drive Less. Save More. outreach booth[1]

BTA’s Bike Commute Challenge[2]

Commute Options, Bend, OR[3]

1 https://www.oregonmetro.gov/news.
2 https://www.portlandoregon.gov/transportation/article/410100.
3 http://www.commuteoptions.org/.

Where is it being used?

Educational and outreach campaigns have been conducted in jurisdictions across North America. Examples in Oregon include: [4]

- Drive Less Save More, Oregon Department of Transportation
- Bike More Challenge, Bicycle Transportation Alliance
- Way to Go Program, Rogue Valley Transit District
- Commuter Challenge, Bend
- Business Commute Challenge, Eugene
- Kidical Mass, Multiple Oregon Jurisdictions

How effective is it?

The effectiveness of education and outreach campaigns vary based on the number of people reached and the types of promotional materials and events included. The outcomes of different types of education and outreach efforts, including mass marketing campaigns, commute challenge events, and transit information and promotional activities are described below:

- Oregon's mass-marketing education and outreach program, the Drive Less Save More Campaign, seeks to raise public awareness about the benefits of driving less and the travel options available to help reduce SOV trips. Initially launched in the Portland metro area in 2006, the program transitioned to a statewide focus in 2010. An independent program evaluation conducted in 2009 produced the following results:[5]
    - More than 222,000 people (nearly 19% of Portland's population) reduced their car trips as a result of the campaign.
    - From 2006 to 2009, conservative estimates show that the campaign reduced 21.8 million vehicle miles in the Portland metro area (about 0.06% of regional VMT[6]), which equates to 10,700 tons of greenhouse gases saved and more than $8 million of savings in auto operating costs for the public.
- The effectiveness of several commute challenge events in jurisdictions throughout Oregon are described below:
    - The Bicycle Transportation Alliance (BTA) holds an annual statewide Bike Commute Challenge in September to promote bicycle usage and reduce SOV use and traffic congestion. From 2009 to 2011, a total of 1,020,898 bike miles were logged. In 2010, the amount of miles ridden by new and previous "drive alone" bike commuters was 847,265 miles (approximately 0.01% of regional VMT for the Portland metro area). Additionally, in 2009, a post-program ODOT survey showed a 0.5% increase in transit use, carpooling, and biking following the annual September challenge.[7]

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[4] In this summary, the best available data on program effectiveness is used. Whenever possible information is provided for the referenced examples; however, this is not always available.

[5] http://drivelesssavemore.com/pages/about-us

[6] Regional VMT for the Portland MSA from 2006 to 2009, estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/

[7] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

- Point2Point Solutions provides outreach, education, and marketing on travel options within the Central Lane Metropolitan Planning Organization (CLMPO), including an annual week-long Business Commute Challenge. In 2011, 2,329 participants from 107 businesses reduced their driving by 92,958 miles (approximately 0.01% of regional VMT[8]) and saved 34 tons of carbon dioxide (CO_2).[9]
- The Commute Options program in Bend, Oregon, sponsors an annual Commute Options Week to promote alternatives to driving alone. In 2007, the event reduced VMT by an estimated 45,885 vehicle miles and saved approximately 20 tons of CO_2.[10]

- Research shows that traveler response to transit information and promotional programs depends on the quality of the transit service, type of promotion, and external circumstances. In general, transit ridership gains primarily represent more frequent riding by pre-existing users. Isolated cases show short-term ridership gains (10% to 12%) from the distribution of promotional information. Additionally, special day/week events with incentives have produced 4% to 35% short-term ridership gains. Overall, the research shows that increases in ridership from transit information and promotional programs are most likely to occur as the result of individualized efforts that target specific populations based on market research findings.[11]

How much does it cost to implement?

The costs of education and outreach programs vary depending on the targeted population and the types of education and outreach events programmed. Examples of program costs and cost-effectiveness findings are described below:

- From 2009 to 2011, the BTA Bike Commute Challenge Program costs were $82,625 (Metro and local matching funds) and the program achieved a cost-effectiveness of $0.10 per vehicle mile reduced.[12]
- Costs for car-free events depend on route length, the number of intersections blocked or rerouted, the number of police or road management personnel, and the amount of outreach conducted. Through the use of volunteer staff in Bogota, Colombia, costs for Car Free Day events are kept to $23,810, or $395 per mile of route.
- One study in 2003 found that marketing programs typically provide financial paybacks in 1 year or less (plus additional benefits to society), indicating a strong return on investment.[13]
- The cost effectiveness of different transit information and promotion programs cluster around a highly cost-effective 3:1 benefit/cost ratio. (However, less favorable benefit/cost ratios may simply have not made their way into available research). Nevertheless, efforts that don't entail too many

[8] Regional VMT for the Eugene-Springfield area for 2011, estimated on the basis of freeway and arterial VMT data in the *2011 Urban Mobility Report,* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/

[9] Point2Point Solutions. *2011 Annual Report.*

[10] Commute Options for Central Oregon. 2008. *The Year in Review - 2007 Commute Options Annual Report.* http://www.commuteoptions.org/.

[11] *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 11: Traveler Response to Transportation System Changes – Transit Information and Promotion." 2003. p. 11-5. https://www.trb.org/Publications/Blurbs/153344.aspx.

[12] Portland Metro. *RTO 2012 Program Evaluation.* https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

[13] Ker, Ian. 2003. *Travel Demand Management: Public Transport Business Case*. AARB Transport Research. RC5051. TravelSmart Program.

transit agency "give-aways" should at least break even, if not actually produce net revenue gains from increased ridership.[14]

Implementation resources

Funding for education and outreach programs can come from a variety of state and local funding sources, including state grant programs and monies from partner agencies and the private sector. ODOT's Drive Less Save More Campaign receives funding from federal Surface Transportation Program funds, earned media and in-kind contributions, and private and public sector contributions, and provides funding and technical campaign assistance to local jurisdictions throughout Oregon.[15]

The following resources may assist Oregon jurisdictions with the implementation of a travel options education and outreach program:

- Drive Less. Save More. Portal, Oregon Department of Transportation (includes tips, articles, photos, graphics and videos available for use to propel communications and public outreach efforts)
- TDM Encyclopedia: TDM Marketing, VTPI
- May is National Bike Month - Getting Started Guide, League of American Bicyclists
- Car Free Days, Pedestrian and Bicycling Information Center
- Fostering Sustainable Behavior - Community Based Social Marketing, Doug McKenzie-Mohr, Ph.D.

[14] *TCRP Report 95.* "Chapter 11: Transit Information and Promotion." 2003. p. 11-7.
[15] ODOT. Flex Fund Program Description: Drive Less Save More.

Ridesharing

Which Mosaic Categories does the program support?

What is it?

Ridesharing programs facilitate sharing motor vehicles to increase the number of passengers per vehicle, thereby reducing per person user costs and vehicle miles traveled (VMT). Rideshare programs typically include programs that use databases to match riders with carpools or vanpools. Carpooling involves the use of participants' own vehicles, whereas vanpooling involves the use of rented vans. The use of advanced "smart" technology to identify ride matches in real time—real-time ridesharing—is becoming more commonplace. Casual carpooling is another form of ridesharing that occurs under unique conditions, for example, on congested routes where there are incentives for high occupancy vehicles. Employer-based ridesharing programs are also common (see Mosaic program information sheet "Employer TDM" for more information).

What are the benefits?

- **Mobility:** Reduces VMT, which can ease congestion and also reduce per person user costs because the price of fuel, parking fees, and/or rental fees can be divided among multiple riders.
- **Accessibility:** Increases travel options by making ridesharing a more convenient and practical mode of travel.
- **Environmental:** Reduces VMT, which reduces air emissions and greenhouse gases.

Drive less. Connect.[1]

SchoolPool Program, San Diego[2]

Valley Vanpool, Oregon[3]

Where is it being used?

There are ridesharing programs in cities throughout the U.S. and around the world. Examples of programs on the west coast include:[4]

- Drive Less. Connect.- Oregon Department of Transportation
- Valley Vanpool – Multiple Locations, Oregon
- 511 RideMatch Service - San Francisco, CA
- iCommute – San Diego, CA
- King County Metro Rideshare Operations – King County, WA
- Examples of dynamic, real-time ridesharing programs and applications include SideCar, Lyft, Zimride, and Ridejoy.

[1] https://www.oregonmetro.gov/tools-partners
[2] http://www.sandag.org/
[3] https://www.ltd.org/
[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that was not always available.

How effective is it?

The effectiveness of ridesharing programs can be measured on the basis of such factors as mode shift, reduction in VMT, and the amount of time that people continue to rideshare.

The following are the results of ridesharing programs that measured effectiveness:

- Between 2009 and 2011, Portland Metro's Carpool Match Employer Outreach program reduced VMT by an estimated 13,044,000 to 19,565,000 (approximately 0.07% to 0.1% of regional VMT).[5, 6] During the same time period, the Metro Vanpool program reduced VMT by 3,804,307 (0.02% of regional VMT). This number is the result of coordinating an average of 19 vanpools and 147 riders per month.[7]
- In a 2012 study of Let's Carpool, a New Zealand-based ride matching program, the percentage of customers who reported carpooling as their main commute mode increased 15% after enrolling in the program, while the percentage of customers who reported driving alone decreased 7%.[8]
- In 2003, two carpooling programs in the United Kingdom resulted in an average annual VMT reduction of 2,836 miles per program participant.[9]
- According to a 2005 Transit Cooperative Research Program report on vanpools, the typical vanpool rider's trip is 10 to 12 minutes longer compared with driving alone, but the tradeoff is reduced travel cost and stress. One-way vanpool trips were, on average, 24 to 54 miles long (signaling that vanpooling may be more important to reducing VMT than its low mode share might initially indicate). The report also found that slightly more than half of new vanpoolers had formerly commuted by auto.[10]
- A 2002 assessment of the RIDES for Bay Area Commuters Program found that the average amount of time a customer used a new mode was 1.6 to 1.9 years; and 8% to 14% of all customers continued to use the new mode until they were no longer making the trip to work. People who traveled in vanpools used the new mode for the longest period of time (more than 3 years).[11]

How much does it cost to implement?

From 2009 to 2011, Portland Metro's regional vanpool program cost $365,485 and achieved a cost effectiveness ratio of $.10 per vehicle mile reduced (VMR). Similarly, the Carpool Match Employer Outreach Program cost $363,937 and achieved a cost effectiveness ratio of $.02 to $.03 per VMR (both

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[5] In June 2011, CarpoolMatchNW.org transitioned to http://www.drivelessconnect.com/.

[6] Regional VMT for the Portland MSA in 2009 and 2010. Estimated based on freeway and arterial VMT data in the *2011 Urban Mobility Report* published by the Texas Transportation Institute. https://mobility.tamu.edu/ums/archive/. Note that regional VMT data are for 2009 and 2010, while the VMR reported for the RTO rideshare program are for *fiscal years* 2009 to 2011.

[7] Portland Metro *RTO 2012 Program Evaluation*. https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.

[8] Abrahams, W. and M. Keall. *Effectiveness of a web-based intervention to encourage carpooling to work: A case study of Wellington, New Zealand*. *Transport Policy.* Volume 2. 2012. https://www.sciencedirect.com/science/article/pii/S0967070X12000066.

[9] Cairns, S., L. Sloman, C. Newson, J. Anable, A. Kirbride, and P. Goodwin. 2004. *Smarter Choices: Changing the Way We Travel.* London Department for Transport. p. 245, Table 9.5.

[10] *Transit Cooperative Research Program Report 95.* "Chapter 5: Vanpools and Buspools." 2005. https://www.trb.org/Publications/Blurbs/156124.aspx.

[11] Smith, V. and S. Beroldo. *Tracking the Duration of New Commute Modes Following Service from A Ridesharing Agency: Longitudinal Study*. Transportation Research Record No. 1781. 2002.

findings are based on total program costs, including Metro and local matching funds).[12] See Table 1 for a comparison of programs.

Table 1: Rideshare Programs

Rideshare Program	Total Expenditures (FY 09/10 & 10/11)	Vehicle Miles Reduced (low estimate)[a]	Vehicle Miles Reduced (high estimate)[a]	Cost Effectiveness ($ per VMR)[b]
Carpool Match NW	$363,937	13,043,506	19,565,260	$.02 - $.03
Metro Vanpool	$365,485	3,804,307	3,804,307	$.10

Source: Portland Metro RTO 2012 Program Evaluation https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.
a. The VMR shows a "high" and a "low" estimate, assuming that only 40% to 60% of VMR reduced can be attributed to the program. VMR by vanpools was estimated from vanpool rider data, including the distance of vanpool trips.
b. Cost effectiveness estimated by Mosaic Program Guide authors is based on total expenditures (including Metro and local matching funds). The $ per VMR reported is based on the total costs and vehicle miles reduced reported over the 2-year study period.

In the UK, the cost effectiveness of the two carpooling programs assessed was estimated to be $.02 and $.10 per VMR. This estimate was derived from the total program costs in 2012 dollars ($53,000 and $141,000) and total estimated VMR (510,000 and 6,126,000) for each program at the time of their assessment in 2003.[13, 14]

In addition to VMR, the cost effectiveness of ridesharing programs has been assessed to consider other benefits such as reduced transit expenditures and environmental and safety benefits. For example, a recent study estimated that $30 million a year could be saved through casual carpooling during the morning commute on the Bay Bridge to San Francisco. This figure was based on the reduced costs of fewer bus purchases and paid bus drivers, as well as the value of time saved, lower emissions, and fewer accidents.[15]

Implementation resources

For more information on ridesharing programs, including incentives and benefits, technologies, federal funding sources, and a comprehensive list of local, statewide, national, and international rideshare programs and providers, the following resource is recommended:

- Ridesharing Options Analysis and Practitioners' Toolkit, December 2010, Federal Highway Administration

[12] Portland Metro RTO *2012 Program Evaluation*. https://library.oregonmetro.gov/files/appendix_d_rto_evaluation_2012.pdf.
[13] Cairns, S., L. Sloman, C. Newson, J. Anable, A. Kirbride, and P. Goodwin. *Smarter Choices: Changing the Way We Travel*. London Department for Transport. 2004. P. 245.
[14] Note: Cost effectiveness estimated by Mosaic program guide authors is based on the report data; kilometers and GBPs were converted to miles and 2012 dollars, accordingly.
[15] Minett, P. and J. Pearce. 2011. *Estimating the Energy Consumption Impact of Casual Carpooling. Energies.* 4(1): pp. 126-139. https://www.mdpi.com/1996-1073/4/1/126.

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Land Use Programs

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Land Use Strategies

What is it?

Land use strategies refer to policies that promote compact, mixed-use development and the efficient use of land. Such policies improve bike, pedestrian, and transit access and can reduce trip lengths and vehicle miles traveled. Examples include:

- **Zoning and land use code changes** that result in increased densities; mixed use development; smaller lots; improved bike, pedestrian, and transit access; and the removal of parking minimums.
- **Infill development and adaptive reuse** programs that support redevelopment and smart growth goals (e.g., tax abatement, developer subsidies, transfer of development rights)
- **Urban growth boundary** (UGB) policies and programs that set minimum densities and limit expansion of the UGB.
- **Transit-oriented development** (TOD) programs that promote residential and commercial centers, corridors, and main streets that are designed to encourage transit use and non-motorized travel options.
- **Siting policies** that require schools, employment centers, and other key destinations to be placed in areas with high quality transit, bicycle, and pedestrian access.

Which Mosaic Categories does the program support?

ACCESSIBILITY
ENVIRONMENTAL STEWARDSHIP
MOBILITY
QUALITY OF LIFE
LAND USE

What are the benefits?

- **Mobility:** Reduces congestion and vehicle miles traveled (VMT) by shortening trip distances between key origins and destinations and making sustainable transportation modes more accessible and convenient.
- **Accessibility**: Enhances the number of key destinations accessible in an area by bike, transit, or foot.
- **Environmental Stewardship:** Reduces energy consumption and greenhouse gas emissions per capita by encouraging shifts to smaller lots and more sustainable transportation modes. Also preserves open space and protects biodiversity by preventing urban sprawl and habitat fragmentation.
- **Land Use:** Enhances land values and promotes neighborhood and downtown revitalization.
- **Quality of Life**: Promotes the use of active transportation modes and enhancement of the pedestrian environment.

Where is it being used?

Land use strategies are used in jurisdictions throughout the nation. Examples in Oregon include:[4]

- Transit-Oriented Development Program, Metro, Portland, OR
- UGB Expansion Analysis, City of Eugene, OR
- Parking Standards Code Amendment, City of Medford, OR
- Adaptive Reuse-Rehab Grant Program, Oregon City, OR
- Infill Design Project, City of Portland, OR

Transit Oriented Development Portland, OR[1]

How effective is it?

Research findings suggest that in places where development is compact, land uses are compatible and intermingled, and good transit access and pedestrian interconnections are present, there are average shorter trip lengths, higher transit and non-motorized mode shares, and lower household vehicle trip generation and VMT.[5] These effects are further enhanced by location proximity to the urban core. However, travel behavior shifts will be gradual.

Urban Growth Boundary, Eugene, OR[2]

Land Use Changes

A careful review of several reports on the relationship between VMT and land use changes (including changes to characteristics such as density, diversity of land uses, urban design, and regional accessibility), resulted in the following conclusions. (For each characteristic, the relationship is isolated from other overlapping characteristics, such that the results are additive in nature.)[6]

Medium-Density Residential Infill Development, Portland, OR[3]

- For every 1% increase in local density, VMT can be expected to decrease by a corresponding 0.05%.
- For every 1% increase in local diversity (land use mix), VMT can be expected to decrease by a corresponding 0.05%.
- For every 1% increase in local urban design,[7] VMT can be expected to decrease by a corresponding 0.03%.

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1 https://www.oregonmetro.gov/.
2 https://www.eugene-or.gov/documentcenter/view/17775.
3 https://www.portlandoregon.gov/bps/article/223705.
4 In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information is not always available.
5 *Transit Cooperative Research Program (TCRP) Report 95.* "Chapter 15: Traveler Response to Transportation System Changes – Land Use and Site Design." 2003. p. 15-8. https://www.trb.org/Publications/Blurbs/153167.aspx
6 *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. pp. 15-114 to 15-117.
7 Local urban design refers to building orientation, landscaping, pedestrian amenities, and other micro features of the urban environment. In the EPA's Smart Growth Index (SGI) model "density" is represented by residents plus employees divided by land area; "diversity" is represented by a jobs-population balance measure; "design" is represented by a combination of sidewalk completeness,

- For every 1% increase in regional accessibility, VMT can be expected to decrease by a corresponding 0.2%.

Because the results for each land use change characteristic may be added, assuming a *concurrent and equal* 1% increase in local density, diversity, and design (holding aside regional accessibility) the cumulative effect is equivalent to a combined decrease in VMT of about 0.13%. The key indication of this finding is that the location of new compact, mixed use development is important (i.e., regional accessibility plays a factor) and "that dense, mixed-use developments in the middle of nowhere may offer only modest regional travel benefits."[8] If, however, a *concurrent and equal* 1% increase in regional accessibility is also assumed, the cumulative effect becomes equivalent to a combined decrease in VMT of 0.33%.[9]

This finding is within the range of other often cited findings regarding the relationship between VMT and density. That is, a doubling of density is often reported to be associated with 15% to 30% less VMT per household.[10] However, these findings use density as a proxy for all other characteristics historically associated with density (e.g., regional location, urban transportation alternatives, and built environment characteristics) and do not necessarily isolate the affects of density alone. Thus, this range of effectiveness would likely only be seen for centrally located and well designed infill development projects.[11]

One advantage of using the isolated effectiveness findings for each land use characteristic is that appropriate policy responses are more easily identified. Note, however, that the results do not consider the importance of enhanced transit service feasibility, which must be calculated separately.[12]

Transit-oriented Development

Traveler response to TOD is influenced by a broad variety of factors, including land use and site design, automobile ownership, relative transit and highway accessibility, parking supply, parking pricing, transit support, and preferences of residents. Additionally, higher densities, greater diversity of land uses, and better design are associated with more transit use and walking and fewer automobile trips per resident and worker. Numerical examples of actual transit ridership gains that can be clearly attributed to TOD implementation are few because of multiple confounding factors. However, the following research results present some good approximations:[13]

- Transit mode shares along the Washington Metro system were found to decrease 7% for every 1,000 feet of distance from a station in the case of housing and by 12% in the case of offices.
- A 2003 California TOD travel characteristics study found that TOD office workers within 1/2 mile of rail transit stations had transit commute shares averaging 19% compared to 5% region-wide. For

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route directness, and street network density; and "regional accessibility" is represented by an accessibility index that is derived with a gravity model.

[8] Ewing, Reid and Robert Cervero. 2001. *Travel and the Built Environment: A Synthesis, Transportation Research Record 1780. Paper No. 01-3515. https://trid.trb.org/view.aspx?id=717403*.

[9] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. pp. 15 to 115.

[10] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-12.

[11] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-114.

[12] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-115.

[13] *TCRP Report 95.* "Chapter 17: Traveler Response to Transportation System Changes – Transit Oriented Development." 2007. pp. 17-6 to 17-9. https://www.trb.org/Publications/Blurbs/159049.aspx

residents, the statewide average transit share for TODs within 1/2 mile of the station was 27% compared to 7% for residences between 1/2 mile and 3 miles of the station.

- Taken together with shifts in other modes, the apparent effect of TOD development on auto use of TOD residents ranged from an indiscernibly small reduction on average across surveyed California residential sites to an 18% drop in auto use found in an 8-site Portland survey.

Environmental Effects

According to the OSTI Greenhouse Gas Toolkit, combined land use and transportation strategies could result in a 0.2% to 2.1% reduction in total transportation sector baseline greenhouse gas (GHG) emissions in 2030. Additionally, aggressive/maximum deployment could result in a 2.7% to 4.4% reduction in 2050.[14] While the majority of transportation sector GHG emission reductions from combined land use and transportation strategies would be derived from VMT reduction, an exact 1:1 ratio cannot be assumed for this program due to carbon dioxide (CO_2) impacts related to cold starts and lower vehicle operating speeds within compact areas. For this reason, a conservative ratio of GHG reduction equal to nine tenths VMT reduction is recommended.[15]

How much does it cost to implement?

Public costs associated with supporting compact, mixed use development are typically lower than those for supporting decentralized development due to the reduction in required public infrastructure (e.g., roads and utilities) and public services (e.g., public schools, fire, police, libraries, community centers).[16] One study conducted in New Jersey estimated a public capital expenditure savings of 10% over 20 years for a compact statewide land use development scenario compared to a lower density scenario, based on the same assumed growth in population, households, and jobs. Specifically, the study estimated that the compact land use scenario resulted in a 24% reduction in road investments, an 8% reduction in utility costs, and a 3% reduction in school costs. The study also found that land consumption would decrease by 60% (including environmentally sensitive and agricultural lands) and that median housing costs would decrease by 6%.[17]

Another study based on four decades of literature on fiscal impacts of alternative land development forms concluded that estimated total public capital costs per dwelling unit could be reduced 49% to 63% by choosing a central location, using a mix of housing types, and by allowing contiguous development when compared to low density locations.[18, 19]

Implementation resources

The following resources may assist local jurisdictions with the implementation of combined land use and transportation strategies:

[14] *Oregon Greenhouse Gas Toolkit Report.* https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.
[15] Ewing, Reid and Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen. 2008. *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute.
[16] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-120.
[17] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-120.
[18] *TCRP Report 95.* "Chapter 15: Land Use and Site Design." 2003. p. 15-121.
[19] Note: percentages calculated by Mosaic program guide authors are based on original report findings reported in 1987 dollars.

- Tool Kit for Integrating Land Use and Transportation Decision-Making, FHWA
- Smart Growth Implementation Toolkit, Smart Growth America
- TOD-ucation 100 and 200 Report Series, Center for Transit Oriented Development and FTA
- The Infill Design Toolkit, City of Portland
- Planning for Schools and Livable Communities: The Oregon School Siting Handbook, state of Oregon
- Smart Growth: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs, EPA

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Operations/ITS Programs

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Traffic Management Strategies

What is it?

Traffic management strategies involve operational approaches to improve traffic flows on freeways and arterials in locations with high levels of congestion. System efficiency strategies are designed to improve the operations of the existing transportation system, make better use of existing capacity, and encourage more fuel-efficient travel speeds. Example strategies include:

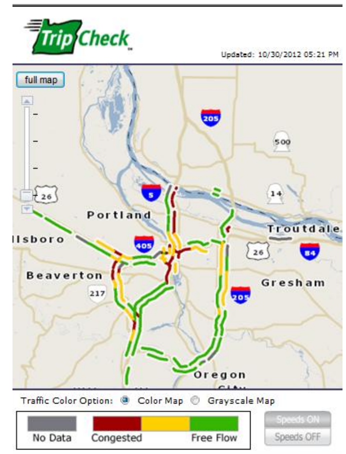
Which Mosaic Categories does the program support?

ECONOMIC VITALITY
ENVIRONMENTAL STEWARDSHIP
MOBILITY
SAFETY & SECURITY

- **Freeway Management/Arterial Management:** The use of techniques such as ramp metering and traffic signal coordination to reduce congestion and improve traffic flow.
- **Integrated Corridor Management:** The strategic use of all possible capacity in a transportation system to help provide optimal traffic flow throughout a network.
- **Transportation Management Center (TMC):** A facility that collects real-time traffic data and provides coordinated transportation management on roadways. TMCs are integral to a variety of management and operations strategies.
- **Road Weather Management:** Real-time monitoring of roadway conditions (including traffic cameras) during inclement weather to provide advance warning to motorists or provide restrictions on travel (such as requiring chains or snow tires on mountain passes). This strategy also includes mobilizing snow plows during threats of extreme weather to ensure prompt snow removal.
- **Traveler Information Systems:** These systems can provide information about travel conditions on roadways (accidents, weather, congestion, and delay) and travel options to allow travelers to make efficient decisions about route and mode choice. This helps reduce travel time and optimizes the use of the transportation network.
- **Active Traffic Management:** The use of automatic systems and human intervention to manage traffic flow, reduce accidents, and reduce congestion using managed lanes or smart lanes. Sensor loops are placed in roadways to monitor roadway activity and observe real-time traffic, while computer systems, linked with variable message signs, are used to re-set speed limits on the system in advance of accidents and bottleneck locations.

What are the benefits?

- **Mobility:** Improves travel time and travel time reliability; reduces congestion and delay.
- **Economic Vitality:** Provides positive economic impacts in the form of improved freight travel time and reliability while also improving access to industrial and employment centers.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gases (GHGs) that are harmful to the environment and human health by encouraging more fuel-efficient travel speeds.
- **Safety and Security:** Reduces crash rates through smoothed traffic flow and road weather management and provides a more resilient transportation network through optimization of the system capacity.

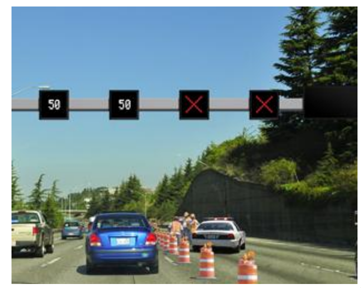


TripCheck, ODOT[1]

Where is it being used?

Traffic management strategies are employed throughout the U.S. Relevant west coast examples include:[4]

- TripCheck, Oregon Department of Transportation
- Active Transportation Management Signs, Washington Department of Transportation
- Quickmap, California Department of Transportation



Active Traffic Management, WSDOT[2]

How effective is it?

This section describes what is known related to the effectiveness of traffic management strategies. However, the reader should note that impacts in specific locations will be highly contextual and accurate evaluation will likely require more detailed analysis using various traffic modeling tools, in addition to transportation demand models.

Variable Message Signs with Integrated Transit Information, Caltrans[3]

Traffic management and operations strategies can save travelers time and money by reducing congestion. By one measure, operational improvements nationwide resulted in a savings of 308 million annual hours of delay, with a value of $6.5 billion, in 2007.[5] Findings related to the effectiveness of traffic management and operation strategies are below:

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[1] https://www.tripcheck.com/Pages/Road-Conditions?curRegion=0&mainNav=RoadConditions.

[2] https://www.wsdot.wa.gov/.

[3] https://www.fhwa.dot.gov/publications/publicroads/08sep/images/sly7.jpg .

[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information was not always available.

[5] Federal Highway Administration (FHWA). *The Role of Transportation Systems Management & Operations in Supporting Livability and Sustainability.* "Chapter 2: Potential Roles of M&O in Supporting Livability and Sustainability. The Role of Transportation Systems Management & Operations in supporting Livability and Sustainability." 2012. https://ops.fhwa.dot.gov/publications/fhwahop12004/c2.htm#fn4

- According to the OSTI Greenhouse Gas Toolkit, traffic management strategies could result in a 0.07% to 1.3% reduction in total transportation sector baseline GHG emissions in 2030.[6]
- A traffic management system in Espanola, New Mexico, developed in June 2006 integrated the operations of eight signalized intersections through connections to a traffic operations center. The project resulted in a 27.5% reduction in total crashes compared with previous years, and a reduction in vehicle delay of 87.5%.[7]
- The installation of an advanced traffic management system in Fort Collins, Colorado, reduced travel times up to 36%, while in Virginia, coordinated signal systems resulted in a 30% reduction in corridor travel times versus isolated systems.[8,9]
- A variable speed limit system installed in St. Louis, Missouri, reduced the crash rate by 4.5% to 8% as a result of a reduction in speed differentials during stop-and-go congestion.[10]

Additionally, providing pre-trip traveler information via the internet, wireless-enabled devices, television, radio, and other services allows users to make more informed decisions for trip departure, route choice, and mode of travel, which can lead to mode shift and vehicle miles traveled (VMT) reduction. Example applications are below: [11]

- In the San Francisco Bay Area, variable message signs provide integrated transit information to allow motorists to compare the travel time between remaining on a highway versus taking a train from a nearby transit station. This led to a modal shift to transit of 4% for travelers.
- In Japan, a personalized travel planning system provided commuters with geographic positioning system- (GPS) equipped cell phones and internet access to help them analyze their daily travel behavior and choose more environmentally friendly routes and modes. Survey data show shifts in users' travel behavior (primarily mode selection) reduced carbon dioxide emissions 20% during their daily commutes.

How much does it cost to implement?

Costs for transportation management and operations strategies vary depending on the type of strategy employed and the extent of implementation. Examples of capital and operating costs for various strategy applications are provided below:

Traffic Management Centers (TMCs): The cost of TMCs can vary greatly due to the size of the facility, the number of agencies present, and the number of functions performed by the facility. Capital costs range from $1.8 million to $11 million per facility, while operations and maintenance costs range from $50,000 up to $1.8 million per year.[12]

[6] *Oregon Greenhouse Gas Toolkit Report.* https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.
[7] FHWA. *NM 68, Riverside Drive City of Espanola, New Mexico ITS Project Final Evaluation Report.* 2008.
[8] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference*. 2011. p. 25. https://www.itskr.its.dot.gov/its/benecost.nsf/files/BCLLDepl2011Update/$File/Ben_Cost_Less_Depl_2011%20Update.pdf.
[9] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 26.
[10] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 43.
[11] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 147.
[12] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 102.

Freeway/Arterial Management: Optimizing signal timing is considered a low cost, effective approach for reducing congestion. Based on data from numerous studies, average costs per signal update are around $3,000. The cost of the traffic management system in Espanola, New Mexico, (which included video detection equipment, a fiber optic communication system, a wireless communication system, and traffic management system hardware and software) was $862,279 for full deployment.[13] In Allegheny County, Pennsylvania, an optimized traffic signal timing project resulted in a benefit-cost ratio of 57:1 along a corridor.[14]

Traveler Information Systems: The cost to implement a traveler information system depends on the strategies used. For example, the average costs to design, implement, and operate a 511 system for the first year can range from $1.8 million for a metropolitan system to $2.5 million for a statewide system. This is much higher than the cost of using an internet website to disseminate traveler information, which can range from $12,000 for a rural transit traveler information site to more than $250,000 for a site that integrates TMC data and includes multimodal data for a regional or metropolitan area.[15]

In Vancouver, Washington, a traveler information system was implemented at a cost of $511,300. The system consisted of three variable message signs, two highway advisory radio stations, and one road weather information system. Road weather information was also made available on the Washington State Department of Transportation website.[16]

Integrated Corridor Management: Integrated corridor management (ICM) strategies on I-15 in San Diego, California, were estimated to have a benefit-cost ratio of 9.7:1 over a 10-year lifecycle. Improvements in arterial and overall system performance were forecast to result in a reduction in travel delay, vehicle-hours of travel, fuel consumption, and vehicular emissions.[17]

Road Weather Management: Studies of road weather management systems have resulted in positive benefit-cost ratios. In Michigan, an analysis before deployment of the system estimated benefit-cost ratios ranging from 2.8 to 7 due to reduced travel times, reduced crash rates, and lower operating costs. Moreover, the use of weather information in Iowa, Nevada, and Michigan has reduced winter maintenance costs by $272,000 to $814,000, resulting in benefit-cost ratios of 1.8 to 36.7.[18]

Implementation resources

The following resources may be helpful for jurisdictions wishing to implement traffic management strategies:

- Freeway Operations and Traffic Management, Federal Highway Administration
- Traffic Incident Management, Federal Highway Administration
- Traffic Signal System Management, Federal Highway Administration
- Corridor Traffic Management, Federal Highway Administration
- Operations and Management: Managing Existing Road Systems for Efficiency and Economy, Victoria Transport Policy Institute

[13] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 113.
[14] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 26.
[15] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 145.
[16] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 38.
[17] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference.* 2011. p. 38.
[18] FHWA. *Intelligent Transportation Systems: Benefits, Costs, Deployment and Lessons Learned Desk Reference*. 2011. p. 67.

High Occupancy Vehicle (HOV) Lanes

Which Mosaic Categories does the program support?

What is it?

High occupancy vehicle (HOV) lanes are travel lanes designated solely for non-single occupancy vehicle (SOV) automobiles (such as 2 or more people/vehicle) and transit vehicles. Free-flow highway lanes can be designated HOV lanes during certain hours of the day (peak periods) or designated HOV lanes for all hours of the day. HOV lanes encourage shift from SOV to carpooling by providing more reliable and shorter travel times during congested conditions. HOV lanes are included on freeways as well as arterial streets and may include exceptions for motorcycles and single-occupant hybrid or electric vehicles. Several indicators of success for HOV facilities include a regional population over 1.5 million, HOV access to major employment centers with over 100,000 jobs, a central business district, and geographic barriers that constrict travel patterns while concentrating development.[1]

SR 16 HOV Lane, WSDOT[2]

What are the benefits?

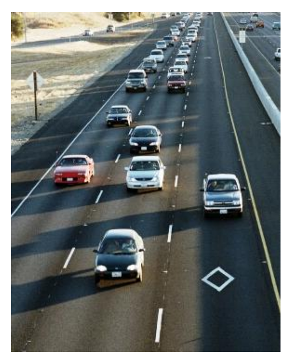
- **Mobility:** Encourages carpool travel by providing shorter and more reliable travel times for high occupancy vehicles during peak congestion periods. Reduces SOV use and vehicle miles traveled (VMT) by making ridesharing more accessible and convenient.
- **Environmental Stewardship:** Reduces the emission of criteria air pollutants and GHGs that are harmful to the environment and human health by encouraging reductions in SOV use.


Bus in HOV lane, WSDOT[3]

Where is it being used?

HOV lanes have been used throughout North America as well as internationally. Relevant examples on the west coast include: [5]

- I-5 HOV Lane, Portland, OR
- Washington State HOV Network, Puget Sound Region, WA
- HOV Lanes, California


HOV Lane, Caltrans[4]

[1] *Transit Cooperative Research Program Report 95.* "Chapter 2: Traveler Response to Transportation System Changes: HOV Facilities." 2004. pp. 2-7, 2-8. https://www.trb.org/Publications/Blurbs/158237.aspx
[2] https://www.wsdot.wa.gov/Tolling/TNBTolling/default.htm.
[3] https://www.wsdot.wa.gov/HOV/.
[4] http://www.dot.ca.gov/trafficops/tm/hov.html.
[5] In this summary, the best available data on program effectiveness is used. Whenever possible information is provided for the referenced examples; however, that information is not always available.

How effective is it?

This section describes what is known related to the effectiveness of HOV lanes. However, the reader should note that impacts in specific locations will require more detailed analysis using travel demand models.

Time savings from using an HOV lane vary from day to day and may be much higher during peak congestion periods than during the hours immediately before and after the peak (shoulders of the peak). An average of the travel time savings gathered from about 30 HOV examples nationwide ranges from 2 to 39 minutes for commuters traveling the full length of the HOV facility compared to the general purpose lanes. Based on the full length of the HOV facility being studied, the largest time savings (6 to 20 minutes per mile) are generally seen from short HOV lanes that function as queue bypasses at toll stations and other bottlenecks, such as bridges or tunnels. Longer HOV facilities along freeways save up to about 1.6 minutes per mile, while HOV lanes on arterial streets typically save about 0.5 minutes per mile.[6]

According to travel demand model research and travel surveys, new HOV facilities induce increased mode split for transit and carpooling. This results in lower SOV use, as roughly 25% to 50% of bus riders, carpoolers, and vanpoolers (higher for carpoolers and vanpoolers) on HOV facilities in various U.S. cities indicated that they previously drove alone. Shifts in carpool, vanpool, and bus route choice accounted for 15% to 35% of HOV lane carpool users.[7]

Although traffic volumes and vehicle miles of travel (VMT) may drop slightly when an HOV lane is opened and stay lower than they might otherwise, HOV facilities do not appear to counter long-term growth trends in travel demand. A more realistic expectation is that HOV lanes help reduce growth in VMT and increase potential person-carrying capacity by inducing higher vehicle occupancies.[8] The long-term increase in average vehicle occupancy (AVO) for a freeway where an HOV lane is opened is 6% to 20% (with an average of 8% to 9%). The existence of parallel highways can dampen the effect of HOV facilities on AVO increases by 33% to 50%. In a summary of 22 historical HOV projects, it was found that there was an average 9% gain in AVO in the AM peak hour. The change, over periods of time that varied from 1 to 20 years, ranged from a 2% decline in AVO to a 36% gain. The I-5 reversible express lanes in Seattle had an AVO increase of 36% over a 10-year span after opening in 1982.[9]

In several examples, HOV lane productivity is higher than the general purpose lane productivity overall. The regional averages for HOV facilities in Los Angeles, Houston, and Minneapolis are about 25% to 40% of all freeway person movement in the AM peak hour and direction, which is greater than the corresponding average proportions of freeway lanes allocated to HOV facilities.[10] However, of studied facilities, there are wide differences in use; some had steady growth for 6 to 8 years, others had a slowing of growth after 3 or 4 years, and one had almost no growth in use immediately after opening. In areas where parallel transit or highway improvements have been introduced, HOV lanes typically have little or no growth in use after a short time as other travel options are available within a corridor.

[6] *TCRP Report 95.* "Chapter 2: HOV Facilities." 2004. p. 2-57.
[7] *TCRP Report 95.* "Chapter 2: HOV Facilities." 2004. p. 2-7.
[8] *TCRP Report 95.* "Chapter 2: HOV Facilities." 2004. p. 2-7.
[9] *TCRP Report 95*. "Chapter 2: HOV Facilities." 2004. p. 2-7.
[10] *TCRP Report 95.* "Chapter 2: HOV Facilities." 2004. p. 2-7.

In terms of environmental benefits, according to the OSTI Greenhouse Gas Toolkit, HOV Lanes could result in up to a 1.7% reduction in total transportation sector baseline greenhouse gas (GHG) emissions in 2030. Additional findings suggest that the conversion of all existing and new HOV lanes to 24-hour operation could result in up to a 0.02% reduction in total transportation sector baseline GHG emissions in 2030 and converting off-peak direction general purpose lanes to reversible HOV lanes on congested freeways could result in a range of 0.07% to 0.18% reduction in total transportation sector baseline GHG emissions in 2030.[11]

How much does it cost to implement?

The costs of constructing and operating an HOV lane will vary depending on the type and length of facility, the extent of signage required, and the extent of study needed to anticipate traffic impacts, appropriate access/egress locations, etc. However, HOV lanes are generally found to be cost-effective investments. Two example studies are described below:

- An evaluation of the economic feasibility for 14 HOV facilities in Los Angeles County concluded that, in general, the carpool lanes were a good investment for the California Department of Transportation. The benefit-cost (B-C) analysis found that the B-C ratios ranged from 0.9 to 36.2 (1.0 is the break-even point), while the average was 10.0 and median was 7.4. The economic rates of return ranged from 5% to 172% with an average of 42% and median of 27%. This analysis did not include benefits to bus operations and emission reduction or mode shifts to HOV, which are also likely to have occurred.[12]
- A benefit-cost analysis of five Dallas and two Houston HOV facilities was conducted using an economic analysis tool developed under NCHRP Project 7-12. The analysis found benefit-cost ratios ranging from 6 to 48 with an average benefit-cost ratio of over 17. Constructing an HOV lane instead of an additional general purpose lane in each direction on each of the freeways was found to be 12% to 180% more effective when benefit-cost ratios were compared. The added benefit averaged across the seven facilities was 73%, which included accident rates.[13]

Implementation resources

The following resources may be helpful for jurisdictions implementing HOV lanes:

- Federal-Aid Highway Program Guidance on HOV Lanes, Federal Highway Administration
- Transportation Control Measures: HOV Lanes, Environmental Protection Agency
- HOV Priority: Strategies to Improve Transit and Ridesharing Speed and Convenience, Victoria Transport Policy Institute

[11] *Oregon Greenhouse Gas Toolkit Report.* https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.
[12] *TCRP Report 95.* "Chapter 2: HOV Facilities." 2004. p. 2-94.
[13] *TCRP Report 95*. "Chapter 2: HOV Facilities." 2004. p. 2-95.

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Wayfinding and Signage

What is it?

Which Mosaic Categories does the program support?

ACCESSIBILITY

ENVIRONMENTAL STEWARDSHIP

MOBILITY

QUALITY OF LIFE

Wayfinding is the process used to orient and navigate oneself through the built environment using spatial and environmental cues such as signage. Wayfinding can be described as orientation with respect to nearby places and the target destination, route decision choice to reach that destination efficiently, route monitoring that includes reassurance elements, and destination recognition to determine when the desired location has been reached.

The Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices for Streets and Highways (*MUTCD) provides federal and state standards for wayfinding signage (design, size, lettering, and location) that are intended only to direct motorists on highways. As the MUTCD does not apply to wayfinding on local streets, many cities have installed local wayfinding signage that is designed to be unique and foster community identity. Wayfinding in urban settings can serve as a tool for marketing a city, creating a cohesive identity and advertising lesser-known attractions.

In addition to being well-designed, wayfinding signage should highlight important destinations and be functional for users of all modes of transportation. Signs should be contextual, based on the application and the primary audience. For example, pedestrian signage that is designed to be seen at close distance can have smaller type and a more elaborate font than roadway signage, which should be large and clear enough to be readable from moving vehicles. Signage can also incorporate real-time displays to help provide efficient direction (e.g., available parking at nearby garages).

For transit, wayfinding involves providing information to transit riders before a trip, during a trip, and at stations regarding how to reach a destination. Transit wayfinding can range from simple bus maps and schedules to state-of-the-art trip planners and real-time arrival systems.

What are the benefits?

- **Mobility:** Reduces vehicle miles traveled (VMT) by enabling efficient route choice.
- **Accessibility:** Improves ease of connections by providing efficient route direction and monitoring for all modes.
- **Environmental:** Reduces the emission of criteria air pollutants and greenhouse gas emissions (GHGs) that are harmful to the environment and human health by reducing VMT.
- **Quality of Life:** Enhances journey ambiance by providing distinct, cohesive signage that can enhance community character and identity.

Where is it being used?

Wayfinding and signage are keystones of successful urban districts across the world. Relevant examples in the Pacific Northwest include:[4]

- Pedestrian Wayfinding Signage System, Portland, OR
- Wayfinding Sign Project, Forest Grove, OR
- West Seattle Trails Wayfinding Kiosk, Seattle, WA

Downtown Portland Pedestrian Wayfinding Signage System[1]

Parking Wayfinding, Seattle, WA[2]

Bicycle Wayfinding Sign, Salem, OR[3]

How effective is it?

Truly effective wayfinding systems are a hallmark of great cities and can make a positive impact on community interaction while greatly enhancing the urban landscape and encouraging travel and exploration in unfamiliar areas. Wayfinding is also an important tool for economic development for cities by helping to attract businesses, residents, and tourists. Making the parking and walking experience pleasant and attractive increases the appeal of the location and can increase repeat visits to primary and secondary destinations by as much as 30%. These benefits more than make up for the low cost of installing these systems.[5]

When determining route choice, developing a high-quality pedestrian environment with proper wayfinding can significantly alter a person's walking experience and increase the utility of walking along a certain path.[6] While signage is often seen as a secondary feature of developing pedestrian-friendly places, there is value added in terms of human scale, complexity, coherence, and sense of place.

One case study found that providing high quality navigation tools to employees resulted in a 17% shift in primary commute mode from automobile to walking, cycling, or transit. While this likely represents the higher end of travel impacts (because it was applied when the worksite location was moving), the finding speaks to the potential of wayfinding programs to have larger impacts when implemented as part of

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[1] https://www.portlandoregon.gov/shared/cfm/image.cfm?id=150334.
[2] https://www.seattle.gov/transportation/projects-and-programs/programs/parking-program/parking-regulations/parking-signs.
[3] Photo courtesy of CH2M HILL.
[4] In this summary, the best available data on program effectiveness is used. Whenever possible, information is provided for the referenced examples; however, that information was not always available.
[5] Flores, M. and M. Young. "Wayfinding: The Value of Knowing How to Get There." *Landscape-Land Use Planning Newsletter.* Fall 2011. https://thefield.asla.org/2011/11/15/wayfinding-the-value-of-knowing-how-to-get-there/.
[6] Guo, Z. "Does the Pedestrian Environment Affect the Utility of Walking? A Case of Path Choice in Downtown Boston." *Transportation Research Part D: Transport and Environment.* 14. 2009. pp. 343 to 352.

comprehensive Transportation Demand Management (TDM) programs that include a variety of improved travel services, incentives, and marketing activities.[7]

Signage can have safety benefits as well. Studies have shown that placing advance street name signs reduced the likelihood of sideswipe crashes by 10% at study intersections in Massachusetts, Wisconsin, and Arizona. The signs were most effective at three-legged intersections in high volume areas or where there were a large expected number of crashes. The low cost of installing more signs would achieve a 2:1 benefit-cost ratio if crashes were reduced by 0.01 per intersection-year.[8]

In Williamsburg, Virginia, the Historic Triangle Wayfinding Sign System was evaluated to determine its effectiveness in providing motorists with guidance and directional information. The signs were found to have no effect on the number of crashes and to provide several benefits, including improved navigation and guidance for motorists to access tourist destinations.[9]

How much does it cost to implement?

Program cost information was not readily available; however, wayfinding systems are expected to involve mostly modest investments in program development, installation, management, and ongoing maintenance. The program must evolve as nearby destinations change and new investments are made in a local area.

Implementation resources

Resources that may help jurisdictions implement wayfinding and signage systems are below:

- Manual on Uniform Traffic Control Designs, Federal Highway Administration
- Principles of Urban Wayfinding Systems, Institute of Traffic Engineers Journal
- Wayfinding Design Guidelines, Cooperative Research Centre for Construction Innovation
- Guidelines for Transit Facility Signing and Graphics, *TCRP Report 12*
- You Are Here: A Guide to Developing Pedestrian Wayfinding, Victoria Department of Transport
- Traveler Information Systems and Wayfinding Technologies in Transit Systems, US DOT
- Multimodal Navigation Tools, VTPI

[7] Victoria Transport Policy Institute (VTPI). *Online TDM Encyclopedia*. Multi-Modal Navigation Tool. https://www.vtpi.org/tdm/tdm113.htm.

[8] Federal Highway Administration. *Safety Evaluation of Advance Street Name Signs.* 2009. https://www.fhwa.dot.gov/publications/research/safety/09029/rptwcov_HRT-09-029_lo.pdf.

[9] Virginia Transportation Research Council. *Evaluation of the Historic Triangle Wayfinding Sign System.* 2009. http://www.virginiadot.org/vtrc/main/online_reports/pdf/09-r12.pdf.

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