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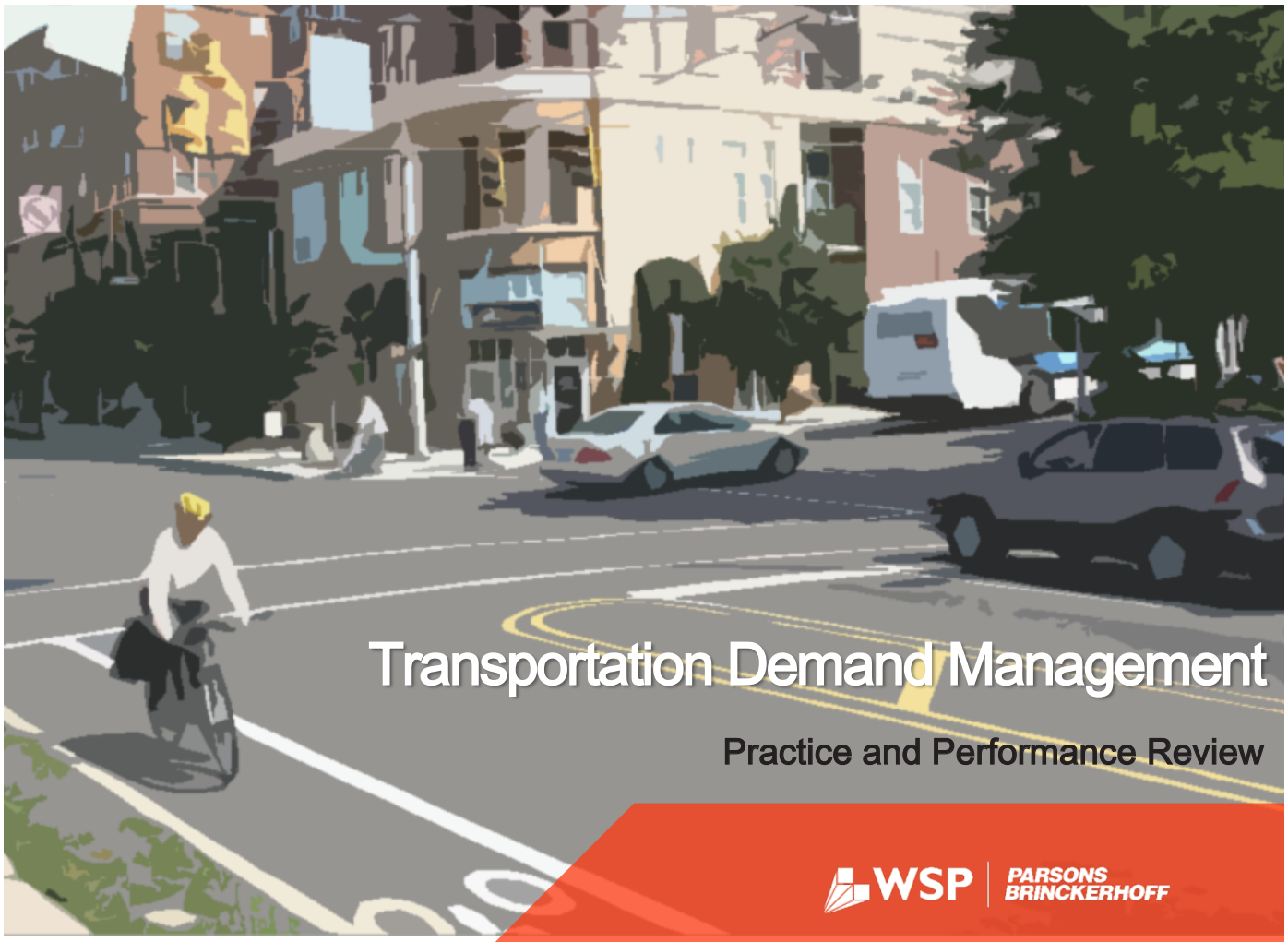
Transportation Demand Management



Transportation Demand Management

Practice and Performance Review

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Prepared for

CRTPO

Revision 2.0 | April 20, 2017

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Development of TDM Strategies

20th century infrastructure development was largely characterized by massive capacity expansion in the 1950's in anticipation of future transportation system demand and subsequent expansion in the following decades to meet that demand. It was a "supply" oriented approach largely supported by the relative lack of fiscal and physical constraints on where, when and how capacity could be deployed. However, 21st century transportation systems, particularly those in major urban areas, face significant physical constraints (in terms of what capacity can be expanded or developed and where) and funding constraints (in terms of available revenue to make those improvements). As such, transportation agencies are increasingly looking towards "demand" oriented strategies that help address transportation related issues, such as congestion and accessibility, without the need for capacity expansion.

What is Transportation Demand Management?

"Transportation demand management (TDM) refers to a set of strategies aimed at reducing the demand for roadway travel, particularly in single occupancy vehicles. These strategies address a wide range of externalities associated with driving, including congestion, poor air quality, less livable communities, reduced public health, dependence on oil, reduced environmental health, and climate change and GHG emissions. Some TDM strategies are designed to reduce total travel demand, while others are designed to reduce peak period demand, which may disproportionately contribute to these externalities."

- U.S. Federal Highway Administration (1)

Specific definitions of Transportation Demand Management (TDM) may vary, but in general the term refers to a broad range of strategies employed to address congestion, mobility and related issues by influencing demand for transportation services, not the supply.[1] Supply-oriented strategies might involve adding lanes or new facilities, thus increasing the supply of available roadway space. TDM strategies, on the other hand, tend to focus on influencing how drivers choose to utilize infrastructure. One of the most common objectives of TDM systems is to induce drivers to utilize modes other than single occupant vehicles during peak periods of the day. TDM objectives may also entail inducing travelers to make trips during less congested times of the day or not to make trips at all.

When TDM strategies were first deployed in the 1970's, they focused on reducing congestion during peak commuting times (such as during the morning and evening rush hour) by increasing the utilization of modes that carried more people such as transit, carpooling, and vanpooling as well as non-motorized modes such as bicycling and walking. Early TDM strategies also encouraged people to shift travel times or not travel at all by promoting flexible work schedules and teleworking respectively. These strategies all worked to reduce the number of vehicles on the road and thus address congestion without

[1] RAND Corporation. *Reference Sourcebook for Reducing Greenhouse Gas Emissions from Transportation Sources*, U.S. Federal Highway Administration, DTHF61-09-F-00117, Washington DC. February 2012.

expanding capacity.[2] However, more recent TDM applications focus on not just reducing the number of vehicles on the road but also managing utilization of roadway infrastructure by those vehicles already on the road, in some cases influencing not only the facilities used but the specific lanes used on those facilities as well.

The wider array of recent TDM strategies reflects the wider range of goals and objectives that can be met through the provision of TDM services. Optimal TDM strategies will depend on the goals and desired results of the overall program. TDM strategies may be deployed to meet any number of transportation-related goals and objectives. These include:

- **Congestion Reduction/ System Reliability / System Efficiency** – Strategies aimed at addressing these transportation goals will be oriented around shifting drivers to higher occupancy modes, shifting when travelers choose to drive, encouraging travelers to not make certain trips, influencing what roads travelers use, and influencing what lanes travelers utilize on certain facilities.
- **Air Pollution / Air Quality** – TDM strategies can impact air quality by reducing congestion and thus time spent by vehicles idling in traffic. Furthermore, by encouraging the use of alternate modes, TDM strategies remove vehicles from the roadway, which in turn reduces mobile source emissions.
- **Economic Development and Land Use** – TDM strategies may be deployed to enhance the accessibility in certain developments and promote economic growth in those areas. Parking initiatives, for example, can increase accessibility to local businesses by discouraging long term parking.
- **Livability and Accessibility** – TDM strategies also provide more transportation options for those without access to a personal vehicle. Strategies that promote transit usage expand modal options for people without cars and encourage others to make use of those modes by providing expedited service relative to a personal automobile.

TDM systems address these goals by providing benefits to the overall transportation system as well as system users. These benefits are shown in the table below:

System Benefits	User Benefits
Greater person throughput	Reliable travel time
Better utilization of available system capacity	Reduced delay
Optimizes transit investments	Reduced out of pocket costs
Preserves options for corridors	More travel choices
Cost recovery from user contributions	Improved economic mobility
Reduction in crashes	

TDM systems may be implemented by a governmental agency, employers, private sector service providers, or through public private partnerships. In fact, a leading practice in recent TDM programs is the integration of multiple programs across multiple employers and institutions in close coordination

[2] Fijalkowski, J, K. McCoy and W. Lyons. *Developing a Regional Approach to Transportation Demand Management and NonMotorized Transportation: Best Practices Case Studies.* Prepared for the US Department of Transportation, Federal Highway Administration, Report FHWA-HEP-13-028, June 2013.

with municipalities and transit authorities. Broadening participation across multiple employers can, with many services, increase cost effectiveness through economies of scale. This integration is further fostered by strong regional leadership and the articulation of performance standards with robust reporting. The establishment of clear and consistent TDM policies and associated performance metrics and reporting requirements can also assist in the identification of future needs and the proactive implementation of new programs to meet those needs. Such programs are generally supported by broad-based public outreach and education campaigns that not only educate on TDM options but actively assist the public in finding alternative mobility services. [3]

TDM Strategy Review

Traditional TDM mechanisms have been utilized to varying degrees for decades. These include such strategies as vanpooling, express transit services, and alternative work schedules, but technology developments are enabling new and innovative approaches to TDM. Smartphones, for example, have the strong potential to enable new TDM and ever evolving TDM programs and services that benefit travelers due to their use of Global Positioning System (GPS)-based location data and internet access capabilities. In addition to enabling new TDM methods, such technologies generate user data that help transportation agencies better monitor overall system performance and modify TDM approaches based on empirical data.

The following sections will highlight both traditional and innovative TDM strategies and will highlight how new TDM strategies have been facilitated by technology growth. These strategies may be deployed by private companies for the benefit of their employees or may be deployed and administered by governmental transportation agencies to benefit the general public. As will be seen in subsequent sections of this report, the most effective TDM programs elicit participation from a wide range of public and private partners and use an array of different strategies. The general TDM strategies that will be covered include:

- **Alternate Work Programs**
- **Carpooling and Alternate Mode Incentives**
- **Managed Lanes and Pricing**
- **Traveler Information Systems**
- **Active Traffic Management, Integrated Corridor Management, and Managed Motorways**
- **Parking Management**
- **Other Approaches**

Alternate Work Programs

Alternate work programs are typically provided and administered by employers and address transportation demand by increasing the ability of employees to avoid travelling during period of peak congestion. This reduces demand on the transportation system during periods of the day that traditionally have the highest volume of commuters. Alternate work programs include:

[3] Nelson\Nygard Consulting Associates. State of the Practice: Transportation Demand Management. Prepared for Michigan Sustainable Communities. 2013.

- **Telecommuting** – This involves allowing employees to work at home or some other location, thus completely avoiding the need to travel all the way to the office.
- **Compressed Work Week** – This involves allowing employees to work a longer work day in exchange for fewer work days. The most common arrangements are working an extra hour per day and working a half-day every Friday or a whole Friday every two weeks. This can help manage travel demand in two ways. With the longer work day, departure times in the evening (or morning arrival times) may be shifted until later in the peak period (or earlier in the morning peak) when traffic volumes are reduced. Furthermore, providing a half day off every Friday allows for a departure time prior to the evening rush while a full day off allows for the complete elimination of the commute.
- **Flexible Work Hours** – Employers may also give their employees freedom to select work hours that do not coincide with traditional work hours, meaning that travel during the traditional morning and evening rush hours can be avoided or minimized.

Carpool and Alternate Mode Incentives

These types of programs work to provide incentives for modes of travel that do not involve travelling in a single occupant vehicle (SOV). These alternate modes include everything from bicycling through transit to carpooling and vanpooling. Such incentive programs may take many forms, including:

- **Carpools** – Carpooling is among the oldest of TDM strategies and consists of two or more passengers (including the driver) using a vehicle for a particular trip as opposed to driving in a vehicle as a single occupant. Carpooling is most often encouraged during the typical morning and evening commute. Carpools are generally formed on a voluntary and, occasionally, ad hoc basis. However, employers and agencies can create incentive programs to encourage carpooling. This can take the form of preferential or free parking for carpoolers, monetary incentives, or rewards programs. Transportation agencies may also provide carpooling incentives through discounted access to priced facilities such as priced managed lanes.
- **Vanpools and Shuttle Services**– Vanpools are similar to carpooling but are typically more formalized and consist of larger groups of passengers. Vanpool users share a van or similar vehicle that is leased from a vanpool operating agency or, in some cases, provided directly by their employer. Vanpools often service longer distance commutes where there may be a lack of transit options. The cost of vanpool services varies based on the length of the commute and the number of passengers but average costs are estimated to be $100 per month per person [4]. Shuttle services are similar to vanpools and generally pick up passengers at a specific location, such as a major parking lot or transit center, and deliver them to another specific location, such as an employment center. Shuttle services are most often provided by private employers but may also be provided by transit agencies or non-profit agencies in areas with a lack of transit routes but significant transit demand.

[4] Nelson\Nygard Consulting Associates. 2013. *Transportation Demand Management: State of the Practice*. Prepared for the Michigan Sustainable Communities Initiative.

- **Pass Programs** – Employers may subsidize their employee's use of alternate modes by providing a direct stipend for things like transit passes, vanpooling and shuttle services, or they may offer financial incentives or reward programs for carpooling. In these cases, employees become eligible for the financial incentive or other reward (such as discounts for various goods and services) the more the carpool. Benefits provided under pass programs are generally non-taxable, which can provide a significant incentive for employees to participate.

Case Study
In Centennial, CO a Free Program Provides On-Demand Ridesharing

As ridesharing apps such as Uber and Lyft become more ubiquitous, a number of cities and counties have worked to incorporate these services into their TDM strategies. In suburban Denver, a unique partnership has created a pilot program to provide residents with free first / last mile ridesharing services through Lyft. Funding for the program comes from the city of Centennial and the local Transportation Management Association.

- **Rideshare and Ride Matching** – These applications enable carpooling by matching passengers in need of a vehicle with drivers willing to take on extra passengers. Rideshare and ride matching services have benefited to a large extent from the continued advancement in smartphone technology and the proliferation of that technology among the motoring public. In the past, ride sharing and ride matching were much less formalized, as potential carpool passengers would simply wait in certain locations to be picked up by drivers looking to benefit from carpool oriented services such as high-occupancy vehicle (HOV) lanes. This practice was known as "slugging." Now, users of various smartphone apps can enter their location and a destination and the app will access a database to match up riders and drivers based on that information.
- **Guaranteed Ride Home** – One disadvantage, in the eyes of many commuters, of using carpools and transit is that they are limited in their ability to choose when they leave the office to return home or otherwise make trips from their place of employment. Working late at the office may mean missing the carpool or the last available bus back home. Guaranteed Ride Home programs help to address this concern by guaranteeing free taxi rides or other mobility services for the users of transit, carpools, vanpools or shuttle services.

In some cases incentives for alternate modes may be as simple as developing and dedicating new infrastructure for those modes. This is particularly true with bicycle and pedestrian facilities. Making alternative modes more viable can be a significant inducement to not use an SOV, especially in areas that are very automobile dependent. Bike pedestrian improvements can include bike and pedestrian paths and walkways, bike lanes, lighting, and secure bicycle storage. Additionally, employers can encourage bike and pedestrian use by supplying these facilities in addition to amenities such as employee showers and changing areas. This can be particularly attractive in warmer climates.

Sharing services of all types are anticipated to reduce single occupant vehicle trips as they become more widespread and popular.[5] As noted earlier, smartphone technology has enabled the development and increasing utility of more advanced ride sharing services, most notably in the area of transportation network companies such as Uber and Lyft. These smartphone-based services allow users to arrange a trip in a passenger vehicle, typically one that is operated by another driver (often the owner of the vehicle) who will then make other trips for other customers. Smartphone-based car sharing services, such as Car2Go, allow users to reserve a nearby car for a short period of time. While these services are still passenger vehicle-based, they work within a TDM context by reducing the need to utilize a personal vehicle for all trips. For example, these systems enable the users of transit, HOV and other alternate modes to access a personal vehicle if they must make a trip that cannot be accommodated through their current mode. This increases the flexibility of these modes as users are not totally dependent on them for all trips, making them a more attractive modal option. Bike sharing services, such as the Capitol Bike Share program in Washington DC, provide similar flexibility for short term trips. Users of these services can obtain a bicycle when needed and return it to any number of drop-off locations after it is used.

Managed Lanes and Pricing

The pricing of roadway infrastructure is among the most effective mechanisms for influencing demand as it places a direct cost on the use of transportation infrastructure. The actual structure of the pricing component can be set to achieve any number of goals from congestion reduction to recapturing maintenance and operations costs to environmental goals. Pricing is most effective at when it is structured to match actual travel costs and/or actual demand as closely as possible. This means that pricing systems that vary based on real time traffic conditions are the most effective relative to static or fixed price systems such as traditional toll roads.

Toll roads levy a charge for use but they are not pricing in the strictest sense of the word because the cost to use such facilities is constant. Rates on most toll roads and bridges do not fluctuate based on demand. However, true pricing is a common feature on many managed lanes applications. Managed lanes are typically found in congested corridors and feature a separate lane that is managed either through eligibility requirements, access limitations, or pricing. In terms of access requirements, managed lanes are typically separated, either with special striping or a physical barrier to limit the ability of vehicles to enter and utilize the lane, thus providing a more expedient and reliable trip for the lane's users. Eligibility controls refer to the limiting of access to certain types of vehicles, most often transit vehicles or HOVs. In this regard, managed lanes function as a travel demand mechanism by providing an incentive for drivers to utilize these high occupancy modes and reducing the number of vehicles on the road. Traditional HOV lanes and transit priority lanes are among the oldest of managed lanes applications.

Case Study

I-95 HOT Express Lanes in Miami, Florida

Miami regional partners have implemented express lanes with HOV exemptions as part of a wider effort to address travel demand and congestion in the heavily travelled I-95 Corridor.

[5] Transportation Research Board. 2015. *Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation Services.* Special Report 319, Transportation Research Board, Washington, DC.

Due to these access and eligibility restrictions, managed lanes have the potential to be underutilized relative to their carrying capacity. Thus, it is increasingly common for agencies to manage such facilities with pricing. HOT lanes are a common managed lanes application where excess capacity is priced for non-HOV use. In these cases, transit and HOV users continue to enjoy free (or discounted) access to the managed lanes while SOVs pay a toll. In order to prevent too many SOVs from using the lanes, operating agencies may utilize a form of congestion pricing for these vehicles where prices fluctuate based on demand. Congestion pricing applications can be variable, in that they fluctuate based on a predetermined schedule, or dynamic in response to actual traffic volumes. These pricing structures incentivize users to either use HOV modes or shift travel to less congested periods of the day if they wish to avoid congestion in the adjacent free lanes without paying a toll.

Traveler Information Systems

Traveler information systems seek to shift travel by simply providing the public with information to aid in trip making decisions. This information may include:

- The range and availability of alternate modes such as transit, car-sharing or bike-sharing services;
- Overall travel time and travel time comparisons for alternate modes relative to SOV,
- Travel cost and travel cost comparisons for alternate modes relative to SOV,

Traveler information systems also aid in decision making once a trip has been initiated. For example, various travel information systems such as dynamic message signs notify drivers of traffic incidents, bottlenecks, slowdowns, lane closures, and other roadway conditions. Providing this information enables travelers to make better informed decisions about their travel and take alternate routes.

New technologies are widening the opportunities to provide traveler information. The growth in popularity of the internet in recent decades resulted in a proliferation of websites that have become increasingly dynamic in terms of the information they can provide. For many years travelers have been able to access website with current information on traffic conditions to inform their travel decisions. However, the limitation on these resources was that the user had to have access to the internet, which often meant travel decisions could only be made prior to leaving on a particular trip. However, the recent explosion in the popularity of smart phones and other web-enabled portable devices means that the public can access this information without having access to a computer. Travel options can be viewed and evaluated after the traveler has departed on a particular trip.

Furthermore, the proliferation of smartphones and the development of new roadside and in-vehicle data systems have resulted in the growth of performance driven web and smartphone based applications. Cities are increasingly developing smartphone applications capable of telling drivers exactly how long and at what cost a trip on an alternate mode will take based on real time data. Many of these applications calculate things such as environmental benefits from taking an alternate mode as an additional inducement to use an alternate mode. Furthermore, states are increasingly utilizing innovative partnerships with the private sector to leverage transportation data resources for use by travelers. The State of Florida has a data sharing agreement with the transportation data provider Waze for the integration of crowd sourced Waze data in the state's various transportation information systems. Waze's data provides context to the state's traditional ITS systems.

Active Traffic Management, Integrated Corridor Management and Managed Motorways

Active traffic management (ATM) is a strategy involving the dynamic management of congestion based on traffic conditions. ATM strategies are focused on optimizing performance along corridors using a variety of tools, including [6]:

- **Dynamic lane use/shoulder control:** This involves the opening roadway shoulders for use by vehicles in response to traffic volumes or closing of mainline travel lanes to traffic in response to traffic incidents. The opening of shoulders creates an additional travel lane to accommodate increased volume. The closing of a mainline lane in response to an accident allows for vehicles to shift lanes well in advance of the incident, reducing the shock to traffic flows from an incident.
- **Dynamic lane reversal / Contraflow lane reversal:** This strategy involves the reversing the direction of traffic flow on a dynamic basis to better control and allocate capacity on congested conditions. Lanes are switched to flow in the direction with the heaviest traffic volumes.
- **Dynamic speed limits/Speed Harmonization:** Involves the changing of speed limits on a dynamic basis based in response to roadway conditions, traffic levels, and/or weather conditions. Speed harmonization uses dynamic speed limits in order to slow traffic down well in advance of bottlenecks and queues, reducing sudden shocks to traffic flow caused by these slowdowns and reducing the chance of an incident.
- **Dynamic Merge Control**: This strategy involves managing vehicular entry into merging areas on a dynamic basis with the use of dynamic message signs or lane control signs. These signs notify drivers that a merging maneuver is imminent, thus encouraging drivers to make the maneuver quicker. The strategy works to reduce shockwaves to traffic flows upstream from the merge point. It requires the monitoring of traffic conditions on mainline lanes and ramps approaching merge areas and the placement of warning signs in a manner that drivers receive sufficient warning to initiate their merging maneuver.
- **Queue warning:** This tool involves using dynamic roadway warning signs to alert drivers that congestion or vehicular queues are ahead. This reduces the chance of rear end collisions when traffic has slowed significantly or stopped on an otherwise fast moving highway. This strategy requires that traffic conditions be monitored continually and that warning signs be strategically placed so as to provide sufficient warning to drivers.
- **Signal Priority:** This strategy involves the management of traffic signals with sensor equipment so as to provide priority to special vehicle classes, most commonly transit vehicles. These vehicles are afforded a shorter wait time, longer green signals, or priority during left turn maneuvers.
- **Adaptive ramp metering:** This involves the dynamic adjustment of traffic signals located near roadway ramp entrances to manage vehicle flow onto major roadways. This requires algorithms,

[6] Federal Highway Administration. "ATDM Program Brief: Active Traffic Management." http://ops.fhwa.dot.gov/publications/fhwahop13003/index.htm, Accessed on 15 September 2016.

as opposed to traditional pre-determined static metering schedules, that take information from any number of sources to determine optimal flow rates onto the metered facility.

- **Dynamic rerouting:** Involves providing drivers with alternative route information in response to traffic or roadway incidents or conditions that impact travel times on dynamic basis, allowing them to bypass congestion.
- **Dynamic junction control:** This tool manages access on mainlines and ramp lanes based on traffic conditions such that priority at roadway junctions is given to facilities with higher traffic volume so as to minimize the impact of merging/diverging movement movements. This can be done through dynamic lane assignment or by opening shoulders. This strategy requires the continual monitoring of traffic volumes on mainline lanes and ramps in the vicinity of the controlled junction.
- **Adaptive traffic signal control:** This strategy involves maximizing vehicle throughput at traffic signals by dynamically adjusting phasing and timing based on prevailing traffic conditions. This requires the continual monitoring of traffic conditions and the queuing of vehicles at intersections as well as traffic flows upstream from the metered intersection.

Examples of ATM systems deployed in the US are found below [7]:

Location	ATM Strategy
Mobile County, AL / Flagstaff, AZ / Portland, ME / Truckee River, NV / Pittsburgh, PA / Knoxville, TN / Cheyenne, WY	Dynamic Speed Limits (weather based)
Los Angeles, CA / Minneapolis, MN / Portland, OR / Houston, TX	Adaptive Ramp Metering
Seattle, WA	Dynamic Lane Use Control, Dynamic Speed Limits, Queue Warning, Adaptive Ramp Metering
Northern Virginia	Dynamic Lane Use Control, Dynamic Speed Limits, Queue Warning, Dynamic Should Use
Los Angeles, CA	Dynamic Junction Control
Chicago, IL	Shoulder Use
St. Louis, MO / Staley's Junction, OR	Dynamic Speed Limits
Manhattan, NY	Adaptive Signal Control

Source: Federal Highway Administration, ATDM Program Brief: Active Traffic Management

Integrated Corridor Management takes the basic ATM framework but applies it across multiple facilities so that operational strategies can be adjusted dynamically in response to system performance and

[7] Federal Highway Administration. "ATDM Program Brief: Active Traffic Management." http://ops.fhwa.dot.gov/publications/fhwahop13003/index.htm, Accessed on 15 September 2016.

incidents on the network. According to FHWA, the key elements of integration with ICM applications fall within three dimensions [8]:

- **Institutional Integration** – This aspect involves the coordination of and collaboration between various agencies, jurisdictions and system stakeholders in support of the ICM program. As part of institutional integration, operational roles and responsibilities are assigned and/or shared in a manner that crosses traditional institutional boundaries.
- **Operational Integration** – This aspect involves the implementation of multi-agency transportation management strategies to promote information sharing and coordinated operations across the various transportation networks, thus aiding in the management of capacity and demand.

Case Study
Integrated Corridor Management (ICM)

One notable example of ICM is found along a 20-mile section of the I-15 corridor from the City of San Diego to the City of Escondido. The system was implemented in 2013 and uses advanced technology to operate and manage freeway, surface streets, and transit networks in a coordinated manner to improve system efficiency and maximize mobility for travelers.

- **Technical Integration** – This aspect allows for the sharing of information, system operations, and control functions to be shared and distributed among the network. This is accomplished through communications links between agencies, system interfaces, and associated standards. Technical integration allows all affected agencies to view, monitor and evaluate the impact of operational decisions, which can only be accomplished with institutional and operational integration.

Managed Motorways concepts uses the tools and strategies of ATM and ICM but in a more holistic and predictive manner. Managed Motorway systems use data collected over the roadway to anticipate where traffic issues are likely to occur and proactively adjust systems such as ramp meters to manage congestion before it can occur. These systems rely on advanced predictive algorithms that must be calibrated based on current traffic.

All three of these advanced TDM approaches require active monitoring roadways and the dynamic management of operational strategies. As such, they make extensive use of various roadside technologies including:

- Dynamic message signs for the conveyance of various information to travelers
- Various roadway-based sensors such as roadway sensors, vehicle detection sensors, microwave sensors, atmospheric sensors, visibility sensors, and pavement condition sensors
- Lane control & dynamic speed limit signals
- Tag readers

[8] FHWA, "Integrated Corridor Management and Traffic Incident Management: A Primer," http://www.ops.fhwa.dot.gov/publications/fhwahop16035/index.htm, Accessed on 16 September 2016.

All of these systems require that operations be conducted from a centralized Traffic Management Center, which houses the back office components for processing incoming data, computer systems for predictive computations and staff for executing required operational changes in response to conditions.

Parking Management

The availability of free or inexpensive parking is often cited as a key factor in the decision to use a personal automobile as opposed to an alternate mode. The abundance of free and/or low cost parking can lead to an overutilization of those spaces by long term parkers at the expense of short term parkers, which can reduce access to local businesses and residences. It can also lead to the "circling" of cars in dense areas as they look for available spaces, which contributes to localized congestion.

Parking management systems within a TDM context can take several forms:

- **Variable / Dynamic Parking Pricing** – These systems fluctuate the price for parking based on either anticipated or actual demand. Variable parking pricing is set on a schedule, such that rates are highest when demand for parking is expected to be highest. Dynamic parking varies the cost of parking in response to actual demand, such that price for parking increases as the number of available spaces decreases. Both systems work to ensure that parking is always available for those who need it and are willing to pay. Furthermore, by increasing the cost of parking during periods of heaviest demand, these systems incentivize those traveling into dense to utilize alternate modes and avoid the parking charge altogether.

Case Study
SF*park* and Parking Information Systems

SF*park* began as a pilot project in 2010 to evaluate the impact of demand-responsive pricing and real-time parking availability information on traffic congestion in target areas in downtown San Francisco. The program is a partnership effort by San Francisco Municipal Transportation Agency, Metropolitan Transportation Commission and San Francisco County Transportation Authority.

- **Unbundling Parking Costs** – Parking spaces are often leased or sold as part of rental of property sales agreements. This creates an incentive for the new owners / renters to utilize a personal vehicle for the space regardless of their intent to use the vehicle for trips. Local agencies may require that parking spaces be unbundled and sold/leased separately from property sales and rentals, which in turn pushes the new owner / renter to purchase the space for a personal vehicle only if they intend to use it.
- **Parking Taxes** – Taxes may be levied on private providers of parking services. Taxes may be levied to discourage certain types of parking behavior such as parking during peak periods, parking for work/employment, or parking during off-peak periods (such as very early in the day) and reducing available parking. Revenues may be used for the development of alternate modes and related facilities and services that do not require parking a vehicle.

- **Parking Cash-out** – This strategy involves employers not providing free parking for employers but, rather, charging them for parking. However, the employer will also provide a bonus, stipend or pay increase to offset this cost. Employees who wish to utilize an alternate mode for travel into the office are thus able to keep the stipend, thus functioning as a financial incentive to not use a personal vehicle for commuting.
- **Parking Maximums** – Municipalities may choose to limit the number of parking spaces that a new development may offer.
- **Park-and-Ride Lots** – These facilities are generally found on the outskirts or heavily congested areas such as central business districts or along heavily congested roadways and provide access to numerous transit options. They feature sufficient parking which, in turn, provides an incentive for commuters to park and use transit services for the remainder of their trip.

Integrated and Optimized TDM Approaches

TDM systems work best in combination with one another, as opposed to relying on one particular strategy. For example, the combination of congestion pricing, parking management, compact mixed use development, and high capacity transit systems has consistently resulted in reductions of travel demand and the shifting of travel away from SOV to higher occupancy and other alternate modes. [9]

Integrated TDM is the result of years of evolution of the TDM concept. FHWA guidance has noted that there are three primary "philosophies" associated with TDM, and that each one manages a different aspect of demand. These philosophies are [10]:

- Mode and Destination Choice: Refers to influencing whether (and when) to travel, the mode to utilize, and the destination
- Route and Time Choice: Refers to influencing the specific roads that are taken
- Lane choice: Refers to influencing specific lane use on facilities

Evolving transportation technology and long term experience with TDM strategies has allowed for the gradual evolution of integrated TDM approaches over time to incorporate all three of these philosophies. *Figure 1* shows how specific TDM strategies have been implemented over time in support of these three demand management philosophies.

[9] Seattle Urban Mobility Plan, Best Practices: Transportation Demand Management (TDM), January 2008

[10] US Department of Transportation, Federal Highway Administration. "Integrating Demand Management into the Transportation Planning Process: A Desk Reference." FHWA-HOP-12-035, August 2012.

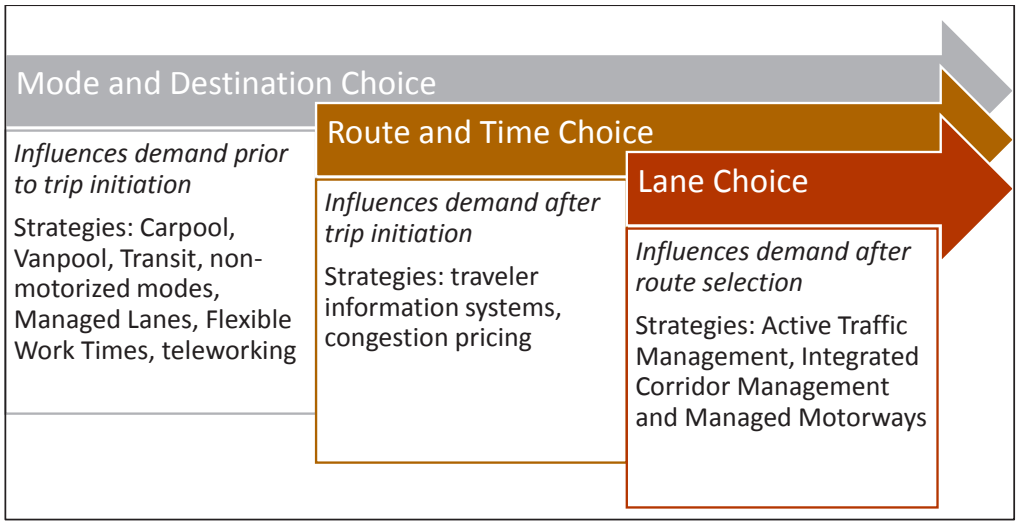


Figure 1: Evolution of the TDM Concept

Integrated TDM programs may be administered by a number of different entities. Individual employers may administer TDM programs within their company that do not necessarily integrate with other municipal or regional programs or programs offered by other employers. The advantage of these systems is that have they have greater flexibility. However, there is also the potential for the employers to lose interest in the program over time and reduce funding, which reduces the benefits of the TDM program [11].

Case Study
Integrated TDM Offerings from Arlington County Commuter Services

Arlington County Commuter Services (ACCS) is a national leader for providing a portfolio of TDM services and programs in areas related to commuter and employer engagement, alternative mobility options, land use policy, and more.

TDM programs may also be administered by public agencies including transit service providers, planning organizations, or city/county governments. The advantage of publicly administered TDM programs is that, due to their stronger focus on addressing public needs, they are more likely to remain dedicated to TDM program funding and program administration in the long term relative to privately managed systems. They are also better positioned to coordinate with other governmental entities and access state and federal TDM funds. However, they often operate with more constraints and may be required to expend extra effort to document program performance to justify the use of public funds [12].

For larger, integrated systems that incorporate numerous employers, transportation agencies, and other service providers, TDM program management is more common through a Transportation Management Organizations (TMO) or Transportation Management Associations (TMA). These organizations often rely

[11] TDM Best Practices, Michigan
[12] TDM, Michigan

on a mix of public and/or private funding and are generally run as a non-profit. As such, they are eligible for a wider array of government funds relative to private or purely public TDM program managers [13]. The pooling of resources and coordination provided by a TMA can help in improving efficiency for all and provides smaller employers with an opportunity to benefit from TDM programs.

The US Department of Transportation Sponsored Urban Partnership Agreement (UPA) and Congestion Reduction Demonstration (CRD) Program are examples of programs aimed at incorporating several different TDM strategies into a comprehensive package of options for managing demand and addressing congestion in urban areas. Some of the strategies utilized in the UPA and CRD programs are pricing, traditional TDM, transit and parking management.

TDM and the Planning Process

The potential for TDM systems to manage travel demand and improve overall travel conditions necessitates its consideration in all phases of the planning process.

Transportation system planning and TDM planning processes are increasingly moving away from project-based decision making and towards outcome-based, measurable decision making. In most jurisdictions, transportation planning is the responsibility of a patchwork of agencies and stakeholders from across the federal, state and local levels. This presents both challenges and opportunities for TDM to be integrated into various transportation and land use planning initiatives.

Case Study

TDM Planning at Denver Regional Council of Governments (DRCOG)

DRCOG has expanded upon its regional TDM vision and goals and created a TDM Strategic Plan that crafts an ambitious rationale for TDM and outlines specific actions, funding sources, and target locations for TDM activities.

FHWA notes that meaningful integration of TDM into the planning process means "consideration of TDM at various steps starting with the highest level of strategy and visioning to more specific goal setting all the way to incorporation into specific plans and conducting performance evaluations." [14] This is particularly true given the multitude of different strategies and the differences in system impacts that different combinations of strategies can bring.

Among the various levels at which transportation planning takes place, and thus where TDM should play a critical role, are:

- **Statewide planning** – e.g. system planning, policy direction, statewide TDM programs.

[13] TDM Best Practices, Michigan

[14] US Department of Transportation, Federal Highway Administration. "Integrating Demand Management into the Transportation Planning Process: A Desk Reference." FHWA-HOP-12-035, August 2012.

- **Metropolitan planning** – e.g. long-range regional transportation plans, congestion management process activities.
- **Corridor planning** – e.g. major investment studies, congestion management processes as part of corridor planning.
- **Local planning** – e.g. land use planning activities conducted at the local level.

Regardless of the level at which planning takes place, best practices demonstrate that if plans are made through an objectives-driven, performance-based process, TDM initiatives will always come to the fore.

TDM planning at the MPO level has many advantages, as an MPO's regional transportation responsibilities allow for strategies to be developed with holistic thinking in mind, and deployed where they can have the greatest impact. MPOs are already accustomed to coordinating their activities with multiple jurisdictions, and therefore are uniquely suited to bringing stakeholders together around a common objective. In addition, MPOs are able to allocate funds, such as federal resources, toward specific TDM initiatives.

FHWA identifies three principal planning activities conducted by MPOs which should include TDM strategies and activities:

- Establishing Vision and Goals
- Setting Objectives for TDM
- Defining Performance Metrics

As MPOs become more experienced and proficient in integrating TDM into the planning process, the FHWA describes a process of moving from "Ad-Hoc" TDM planning to more "Defined" TDM initiatives, and ultimately to an "Optimized" state in which managing transportation demand is an embedded philosophy, with TDM strategies that become part of all major initiatives.

Charlotte-Area Regional TDM Strategies

The Charlotte / Gastonia / Concord Metropolitan Statistical Area, which comprises the commute shed for the Charlotte / Mecklenburg area, had a 2010 US Census Population of approximately 2.2 million, and has since grown to 2.5 million in 2016 (estimated), with an additional 60 percent growth between 2010 and the 2040 census. The urbanized area that is currently under the jurisdiction of the regional metropolitan planning organization (MPO) is 930 square miles and includes all of Mecklenburg County and portions of adjacent Union and Iredell Counties with a total of 27 member jurisdictions including cities and towns. In 2013 there were 6,874 total roadway miles in the planning area and, in 2010, daily vehicle miles travelled was 38,566,000.

The INRIX 2016 Traffic Scorecard ranked Charlotte 42nd out of 240 cities in terms of congestion the US. According to the report, Charlotte residents spent about 7 percent of their drive time in congestion with 23.4 hours spent in congestion during peak periods on an annual basis. The Texas A&M Transportation Institute's 2015 Annual Urban Mobility Scorecard noted that Charlotte's travel time index remained constant between 2010 and 2014 at 1.23, meaning that trips during peak periods of the day took 23 percent longer in 2010 as well as in 2014. Charlotte's travel time index placed it 25th in terms of rankings

among US cities in 2010, and that ranking fell to 29th by 2019. Furthermore, over that time the city retained its 46th place ranking in terms of annual delay with total delay in 2014 being approximately 34 million person hours; up from 30 million in 2010. These statistics indicate that congestion is indeed an issue in the Charlotte area, but it has not worsened at the same pace as other US cities.

TDM Program Description

There is no comprehensive, regional TDM program for the region. Various TDM strategies are currently managed by various agencies in the region, most notably by the Charlotte Area Transit System (CATS). However, The CONNECT Our Future Consortium, composed of 83 jurisdictions and organizations in North Carolina and 10 in South Carolina, was recently formed to "create a framework for guiding and investing" in the Charlotte region's growth, an overall objective being to coordinate long range planning and development in the region through a unified vision for future growth. In early 2014, several "Alternative Growth Scenarios" were developed based on the results of community workshops and submitted to the public for feedback. A preferred scenario was selected and recommendations and strategies were developed to help the region achieve its goals. One of the tools that is recommended for achieving the region's preferred development vision is TDM.

The primary agencies involved with TDM service provision in the Charlotte region include the following:

- **Charlotte Area Transit System (CATS)** – CATS is the primary transit provider in the Charlotte region, offering fixed route bus and rail service. CATS is also responsible for managing/administering regional TDM services, albeit limited to the jurisdictional boundaries of CATS.
- **Charlotte Regional Transportation Planning Organization (CRTPO)** - The Charlotte Regional Transportation Planning Organization (CRTPO) is the federally designated Metropolitan Planning Organization (MPO) for the Charlotte Urbanized Area and consists of 27 jurisdictions within Iredell, Mecklenburg and Union counties. As the federally designated MPO for the region, CRTPO is responsible for the development of the region's transportation plans and administration of the CMP.
- **Centralina Council of Governments (CCOG)** – CCOG is a voluntary organization of municipal and county governments serving the Greater Charlotte region including Anson, Cabarrus, Gaston, Lincoln, Iredell, Mecklenburg, Rowan, Stanly, and Union Counties. CCOG serves as a coordinating entity for local governments and administers various state and federal grant programs in the areas of aging, workforce development, economic development and planning. CCOG provides technical assistance services to governmental members in the areas of regional planning, transportation, energy and environment, local government assistance, and business resources. CCOG's Planning Department work collaboratively with regional, state and national partners in the areas of freight mobility planning, bike and pedestrian planning, and transit planning.

Goals and Objectives

As there is no centralized, coordinated TDM program for the region, and as such, there is no one single document from which goals and objectives for a TDM program can be extracted. However, various planning documents from the region's assorted transportation agencies do yield insight as to how TDM strategies are currently utilized and might be expanded in the future to meet regional mobility goals.

The overall mission of CRTPO is "to plan for transportation options that ensure mobility, respect the natural and built environment, and strengthen the economic prosperity of CRTPO's planning area." In support of this mission, the agency's 2040 Metropolitan Transportation Plan is supported by a number of goals and objectives, many of which imply a future role for TDM in the region. The most TDM specific goal found in the MTP is to "encourage walking, bicycling and transit options, integrated with motor vehicle transportation, by providing a transportation system that serves the public with mobility choices." The objective associated with this goal is to "encourage programs and incentives that promote ridesharing (or eliminate barriers to ridesharing)."

A review of the City of Charlotte's Transportation Action Plan (TAP) did not yield any references to TDM strategies as specific approaches for meeting the city's transportation goals and objectives. However, the TAP does include several goals that could be met through various TDM approaches, including:

- "Increase the percent of residents living in Activity Centers and Growth Corridors who walk, bicycle, or take transit to work to 20 percent by 2040, and to 10 percent citywide."
- "Continue to coordinate with regional partners to develop and implement strategies to reduce per capita VMT."
- "Develop plans that include transportation, VMT, economic and air quality impacts, and consider VMT and vehicle trip reduction targets."
- "Assist in the implementation of regional planning initiatives like the Centralina Council of Governments' "Connect Our Future", Regional Growth Framework and Mecklenburg County's Livable Communities Plan that support the TAP."
- "Work with transportation partners to implement the recommendations of the regional Managed Lanes Study and create a regional network of high-occupancy toll (HOT) lanes and/or high-occupancy vehicle (HOV) lanes."

Component Strategies

- **Carpool Ridematching**. CATS provides a carpool ridematching system. Users can sign-up online and receive a computerized list of potential carpool partners. Users can also call a CATS service to receive aid in locating/arranging carpools.
- **Vanpooling**. CATS offers a vanpooling program with a fleet of 7 passenger minivans and 15 passenger vans. Those interested in joining a vanpool can review existing vanpools and sign-up on the CATS vanpool website.
- **Employer Transportation Coordination**. This CATS managed program works with area employers to designate a people within employers/organizations to serve as a liaison and coordinate transit benefit activities between CATS and their fellow employees. Employees of organizations participating in the ETC program receive a 10% discount on transit passes and are eligible for a pre-tax deduction on transit and vanpool passes.
- **HOV Lanes**. HOV lanes, such as on I-77, can be used by vehicles with two or more passengers that includes carpools, vanpools, and transit vehicles. Motorcycles are also allowed to use the lanes. HOV lanes work to achieve TDM goals by providing an incentive to carpool as users of HOV eligible vehicles can benefit from travel times savings relative to driving in potentially congested general purpose lanes.
- **Charlotte Bike Share**. The B-Cycle program was North Carolina's first bike-share system and became operational in 2012. It features 20-stations with 200-bicycle system and accommodated

over 32,000 trips in its first year. The program was launched through a public, private and non-profit partnership with Blue Cross Blue Shield of North Carolina, Carolina Healthcare System and Verizon Wireless.

Performance Metrics

CRTPO is responsible for the regional Congestion Management Process (CMP), a component of the Metropolitan Transportation Plan (MTP), which has the following regional objectives:

- Develop congestion management measures;
- Reduce non-recurring congestion duration;
- Consider the full range of congestion management strategies; and
- Improve the resiliency, redundancy, and reliability of the transportation network

In support of these objectives, CRTPO utilizes the performance measures shown in the table below:

Performance Measure	Definition	Data Source	CMP Objective
% of Roadway Miles at a Travel Time Index (TTI)	A measure of congestion intensity that is calculated as the ratio of travel time during the peak period to the time it takes to make the same trip at free flow speeds	INRIX – GPS based travel time information	Develop congestion management measures
% of Roadway Miles at a Level of Service (LOS)	A qualitative measure that characterizes operational conditions within a traffic stream, and the perception by motorists and passengers.	Travel Demand Model	
Crash Rates	The No. of crashes per 100 million vehicle miles of travel (MVMT) related to the statewide average.	NCDOT	Reduce nonrecurring congestion duration
Were all reasonable techniques and strategies considered?	Determines whether or not capacity-adding SOV projects can be included in the CRTPO MTP, and ultimately in the CRTPO Transportation Improvement Program (TIP).	CMP Strategies for freeways and non-freeways	Consider full range of Congestion management strategies
Extract data from INRIX and use Buffer, or other indices such as % of Roadway Miles at a Planning Time Index (PTI)	PTI represents the total time that should be planned for trips with near-worst case travel. It is a measure of travel reliability, addressing both intensity and variability of congestion. It is calculated as the ratio of the 95th percentile TTI, or specifically, the ratio of the travel time for the worst weekday of the month to free flow travel time.	INRIX – GPS based travel time information	Improve the resiliency, redundancy, and reliability of the transportation network

Planning

TDM strategies do not generally appear as specific strategies in the planning documents for regional transportation agencies. While certain strategies are often referenced as a potential means of addressing transportation challenges, there is generally not a specific recommendation on the implementation of that strategy.

CRTPO's 2040 Metropolitan Transportation Plan (MTP) establishes four broad categories of strategies for mitigating regional congestion. These include:

- Demand Management;
- Alternative Mode Promotion;
- Traffic Operations; and
- Land Use.

The demand management category includes the most overt TDM strategies. Those identified in the MTP as currently being used in the region include HOV lanes, ridematching services, vanpooling, parking cash-out, carpool parking incentives, and telecommuting promotion. The MTP also includes a listing of potential future demand management strategies that include variable priced lanes, congestion pricing, alternative commute subsidy programs, and compressed/flexible workweeks. The Alternative Mode Promotion strategy also include TDM oriented strategies including the currently utilized strategies of park and ride lots and bicycle sharing programs. Despite the inclusion of TDM approaches as a mechanism for managing demand and promoting alternative modes in the regional MTP, there is little detail or direction provided on implementing or expanding these services.

TDM is included as a component of the regional CONNECT Our Future Initiative, meaning that future TDM strategies may be developed as an integrated component of the future regional transportation system. The initiative's website notes that "regional programs make it possible to coordinate trips and provide transportation services and incentives for demand reduction across county lines, an important consideration in a region such as the CONNECT region's, in which 51% of commuters cross a county line for work." This implies that TDM benefits for the Charlotte are most likely to be maximized if programs have a regional, as opposed to city oriented, perspective. The following strategy for implementing a regional TDM plan is provided as part of the CONNECT Our Future initiative:

1. Convene a group of regional leaders (transportation, economic development, environmental, and major employers) to discuss ways to reduce commuting costs, VMT, and air pollution through a regional TDM approach.
2. Upon approval by key policy-makers, proceed with planning for regional TDM program, in collaboration with representatives from each county that wishes to be involved, and including major regional employers who draw workers from multiple counties
3. Convene a group of local government representatives (transportation, economic development, environmental, etc.) and local employers to bring the discussion down to the local level
4. Determine what set of TDM strategies is best suited for local implementation, and how they will integrate with regional efforts. In rural areas, employers may offer teleworking, flexible schedules, or rideshare programs to employees to reduce commuting time and cost. In more developed areas, employers may provide subsidized public transportation passes, incentives or facilities for bicyclers, or discounted parking for employees who carpool.
5. It may be desirable to reach out to one or more large employers (e.g., university, hospital, or factory) to test a pilot project, whether working at the regional or local level. This could be a rideshare program, incentives to take public transportation (see Fare-Free Transit), or the installation of bike storage and facilities for commuters. If a pilot project is used, share and celebrate the results with other large employers.

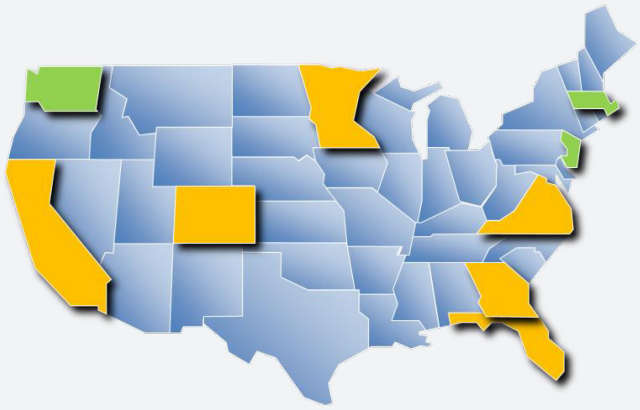
6. Consider backing public sector transportation demand management efforts. This could include supporting multi-use trail projects, promoting existing or proposed subsidies and tax credits for utilizing alternate forms of transportation, or expanding public transportation systems to provide more residents with commuting options.
7. Ensure that employees throughout the region and your community are aware of incentives offered by individual employers and municipal, state, or Federal governments. Create a guide to commuting options and incentives available in print and online for employers and employees.

Performance Measurement of TDM Strategies

The development of TDM strategies emerged out of a recognized need for better surface transportation system performance while reducing the negative externalities associated with unimpeded travel growth. Presently, most metropolitan areas in the United States implement TDM as a mobility service, with limited expectations regarding the performance of the strategies deployed. The usefulness of static marketing and modal promotion over time as conditions change is rarely called into question, let alone respond to variations in demand or economic changes influencing travel demand. Typically, years go by before plans and strategies are changed to suit the current market. Even as more and more jurisdictions embrace TDM strategies as a complement to infrastructure oriented projects, metrics for evaluating the performance of TDM has lagged.

One study of performance measures for TDM identified current and best practices.[15] There are dozens of TDM performance measures in use by various agencies. Some of these measures are standard ones developed by TDM practitioners or researchers and promoted over time. Other measures are local in nature, responding to specific goals and objectives embedded within transportation plans, or are custom-tailored by agencies for specific purposes. This section will discuss some of the key measures in detail, along with relevant illustrations.

National Review of TDM Performance Measures



- Arlington, VA
- Atlanta, GA
- Denver, CO
- Miami, FL
- Minneapolis, MN
- San Francisco, CA
- Washington, DC
- State of Massachusetts
- State of New Jersey
- State of Washington

[15] Thompson, R. and Suter, S. *Development of Standard Performance Measures for Transportation Demand Management Programs*, Transportation Research Record 2319, Transportation Research Board, Washington, DC. 2012.

Figure 2: National TDM Performance Measures Review (15).

The review of TDM performance measures by Thompson and Suter indicate a four stage approach to evaluating performance:

1. **Inputs** involve quantifiable activities often conducted by TDM practitioners.
2. **Outputs** measure the direct results of activities that serve as inputs.
3. **Outcomes** involve a calculation of benefits as yielded from inputs and outputs.
4. **Effectiveness** measures take outcomes, and normalize them by cost, yielding a benefit cost relationship.

Altogether, this four stage approach involves escalating levels of difficulty in calculating the performance of TDM measures over time. These are summarized in turn.

Input Measures

input measures are primarily confined to the actual activities that are often conducted by TDM practitioners. In the context of outreach and marketing, which is the primary level of activity currently applied in the Charlotte area, measures may involve the recording of the absolute number of meetings with employers, events attended, new employers organizations engaged in the program, literature distributed, advertisements and/or radio marketing placed, or Internet-based ad placement.

In terms of best and/or innovative TDM practices as it pertains to input measures, agencies around the United States may identify the same metrics, but the reporting of the absolute number is irrelevant. Instead, outreach and marketing input measures become normalization factors for outputs. As such, the input number becomes the denominator and calculation functions. For example, the number of carpools that are formed at any one ***particular*** event is irrelevant. However, the same number of carpools for formed ***per event*** attended is very much relevant towards effective calculations. Ultimately, these performance measures are described and summarized as placement rates, conversion rates, and cost-effectiveness of marketing and outreach activities.

Output Measures

The common use of output measures in TDM performance assessment involves the measurement of modal use as well as client satisfaction. Common measures of effectiveness currently in use include the number of participants by mode (for example, transit riders, car pullers, vamp rulers, teleworkers, etc.), the number of emergency ride home participants, the utilization of park-and-ride locations, and the conversion rate of new participants in TDM activities. For client satisfaction, these measures may include the number of commuters who recall marketing efforts, satisfaction with the services received, or the number of surveys distributed and/or returned to the TDM agency.

Best practices for TDM measurement, including those endorsed by the referenced article, emphasize the level of participation, and not the absolute number. These measures would include the percentage of employees using alternatives to work separated by mode, the frequency and duration of alternative mobile use, and the percent of the population that oscillate between modes. Furthermore, client satisfaction measures may be linked with marketing and outreach measures to determine an overall effectiveness of TDM program activities. These measures may include placement rates for campaigns and customer interaction, or, the cost per recipient of TDM services.

Outcome Measures

Whereas inputs and outputs pertain to the overall TDM program activities and utilization of alternatives, outcome measures evaluate the benefit upon the overall transportation system. In North Carolina, a common measurement has been the calculation of vehicle miles traveled (VMT) reduction that is a direct outcome from TDM services. This VMT reduction calculation may either be as an absolute number, or as a percentage of overall VMT. Additional outcome related measures utilized by other practitioners around the United States may include: single occupant vehicle trips reduced, percentage of trips taken by mode, absolute number of greenhouse gas emissions or ozone emissions reduced, overall costs to commuters, or improved travel time reliability.

Best practices for TDM activities involve the correlation of TDM investments to overall transportation system metrics. These innovative practices involve the separation of TDM effectiveness by outputs. For example, the TDM agency would establish outcome goals prior to the activity engagement, and then evaluate the effectiveness of meeting those outcome goals from the activity itself. Examples of these types of measures may include: VMT reduction comparisons by geography, sub area, or corridor, VMT reduced by mode, and the reduction in travel time delay for participants by mode.

Effectiveness

Overall, effectiveness measures involve the calculation of cost per input, output, and per outcome for every other performance metric. As such, this category measures efficiency of all efforts and demonstrates the value of TDM services over time. Examples of effectiveness measures include: cost per trip provided, cost per ton of emissions reduced, cost per advertisement viewed, cost per placement, and cost per day of service. Cost-effectiveness measures are essential for identifying the relative value of TDM as compared to other transportation related improvements. From a true calculation of benefits to cost, the appropriate role of TDM services can be aligned with the overall infrastructure investment plans. However, given the difficulty of making these types of calculations, most TDM practitioners do not yield cost-effectiveness performance measurement.

Enhancing Performance Through Cost Effectiveness

The framework for TDM performance measures provides guidance for developing new strategies that enhance the use of multimodal alternatives. To measure the impact of the TDM strategies, it is essential to make comparisons between alternatives and to a baseline – often know as a "build" and "no-build" concept in infrastructure comparison. In this context, the proper phraseology may instead be "encouraged" and "not encouraged", instead of build and non-build.

Comparisons to baseline lend themselves to quantifiable measures of cost-effectiveness that allow for proper role comparison against or in enhancement to infrastructure projects. Also important is establishing as many common measures as possible that can be used for all areas, corridors and strategies within the Charlotte region.

Transportation Policy

The *2040 Metropolitan Transportation Plan* was adopted in 2014 and provides the policy basis for the TDM component of the congestion management process. Within the MTP's CMP component of the plan, four primary objectives to mitigate congestion on the region's roadway system and enhance its performance were identified:

- develop congestion management measures;
- reduce nonrecurring congestion duration;
- consider the full range of congestion management strategies; and
- improve the resiliency, redundancy, and reliability of the transportation network.

In order to achieve the above objectives, the CMP evaluated the following TDM strategies:

- High Occupancy Vehicle lanes;
- ride matching services;
- vanpooling;
- parking cash out or carpool parking incentives;
- alternative commute subsidy programs;
- telecommuting promotion;
- impressed and/or flexible work weeks;
- employer outreach;
- mass marketing;
- cordon pricing;
- improvements for added capacity to regional rail and bus transit systems;
- service coordination for buses and trains;
- access management;
- variable priced lanes;
- congestion pricing can;
- bridge tolling;
- transit signal priority systems;
- addition of bicycle racks of public transit stations;
- bicycles and pedestrian access to transit improvements;
- sidewalk closure program;
- improve pedestrian facilities at intersection;
- creation of new bicycle and pedestrian facilities;
- bike sharing program;
- enhance transit amenities;
- safe routes to school initiatives;
- bicycle and pedestrian education programs;
- bicycle and pedestrian corridor safety studies;
- electronic payment systems;
- park-and-ride lot improvements; and
- use of shoulders for transit vehicles during peak periods.

In this CMP update, CRTPO will revise the new 2045 Metropolitan transportation plan with new TDM strategies yielding low-cost/high-benefit activities with measurable outcomes and cost-effectiveness for congested highway corridors and reassess major expansion projects. Many of the TDM strategies that may be deployed during the 2045 MTP have been discussed and evaluated above. Furthermore, the strategies that were identified in the 2040 CMP are consistent with the types of strategies considered

here. What is different, however, is the focus upon cost-effective performance. In order to assist with this assessment, the following performance strategies are offered.

Initial Performance Measures

Initial performance measures were derived from the 2040 CMP and the evaluation of best practices for TDM strategies. In turn, these performance measures can be detailed into measures of effectiveness. The selection of performance measures acted to:

- Guide overall mobility decisions by giving direction to fully utilize all highway and modal investments.
- Define the most cost-effective techniques and strategies to optimize system performance through demand management.
- Develop a future TDM investment strategy that optimizes the investments already made in the region using multimodal system and demand management strategies.
- Identify TDM strategies to improve system performance and preserve mobility.
- Utilize the most cost effective operational, management and pricing techniques to optimize system performance. Management strategies will be used to their fullest extent to improve mobility and relieve congestion with existing infrastructure and as a complement to new infrastructure.

Inputs

For input measures, the reviewed research guidance indicated that the absolute numbers collected for various outreach and marketing activities should be utilized as normalization factors. Consequently, it will be important for TDM practitioners within the Charlotte region to collect the necessary levels of data inputs in order to create those factors. The data points that will be collected will be dependent upon each of the contributing TDM strategic plans for service providers. Examples of data points include:

- number of active participating employers and commuters
- events conducted
- employers and commuters engaged for the first time
- years of engagement
- extent of marketing distribution
- market penetration with new marketing activities
- number of new incentives provided
- value of incentives and transit passes
- utilization rates

Outputs

Output measures conducted will include similar measures of effectiveness is currently collected. These may include a variety of factors that pertain directly to the utilization of different alternative modes as well as the utilization of TDM services. Inevitably, data collected will be done at either the employment worksite or through regional survey data collection. As such, it is important that surveys and other materials collect sufficient levels of data points in order to reflect utilization and satisfaction factors. The number of participants by mode, participation in other TDM activities (emergency ride home,

incentive program, flexible working arrangement assistance, etc.), utilization, and other components will be normalized by the input factors collected above. This will allow for the calculation of placement rates, utilization rates, cost per marketing distribution, and percentage of employee population utilizing TDM services.

Outcomes

Outcome factors reflect the newest and most important component of TDM performance metrics. As these metrics relate directly to the CMP, it is important that they correlate to the overall CMP performance measures. Suggested factors for which demand management services can also interrelate with infrastructure and technology services include:

Person Throughput

Person throughput is an important measure of mobility and congestion reduction. Person throughput refers to the number of persons utilizing transit and in private vehicles. Increases in the number of persons using a corridor's or area's infrastructure would imply that the operations and management strategies evaluated were effective in serving more persons who are not previously serviced as a result of the TDM strategy. The identified measures of effectiveness for person throughput are:

- Person Miles Traveled (PMT) by mode
- Vehicle Miles Traveled (VMT) by mode

The identified mechanism for assessing person throughput performance will be the calculated outcomes from spot measurement, origin/destination studies, and the regional travel demand model for PMT and VMT. Whereas collection of new data is not anticipated, opportunities to categorize and archive applicable data from corridor, subarea, or municipal studies should be explored and conducted by CRTPO.

Transit Mode Split

A desired outcome of regional TDM strategies is to increase the use of transit relative to the private auto, leading to a mode shift to transit. Mode shift may result from potential users being attracted to transit, or from increased transit use among occasional users. Thus, the central transit evaluation issue is the identification and measurement of mode shift. A mode shift to transit should then facilitate higher transit ridership, reduced levels of traffic congestion, more efficient use of existing road capacity, net reduction in greenhouse gas emissions and fuel consumption. and potentially higher levels of person throughput. The identified measures of effectiveness for transit mode shift are:

- Change in key corridor mode share
- Change in regional mode share

like the calculation for person throughput, these measures will utilize the same data sources for outcome calculation.

Peak Period Vehicle Traffic Volumes

As it pertains to facility performance measure, total vehicular demand for regional highway capacity can be an effective measure for TDM services. Recognizing the regional highway system provides abundant capacity and only suffers a shortage in the peak periods, this measure identifies the success of

alternatives in shifting demand from the peak period and/or shifting to alternative modes of travel. The identified measures of effectiveness for peak period vehicle traffic volumes are:

- Change from baseline in peak hour volumes
- Change in peak period VMT

Travel Time Reliability

Travel time reliability is a key metric for operational and demand management strategies, yet it remains an elusive metric for estimation and quantification. In order to represent travel time reliability, CRTPO will use the travel time index as a means of assessing the collective effectiveness of the strategies at reducing congestion between corridors and/or subareas. The travel time index is the ratio of the average peak period travel time as compared to a free-flow travel time. The free-flow travel time for each road section is the 15th percentile travel time during traditional off-peak times (i.e., weekdays between 9 am and 4 pm, between 7 pm and 10 pm; and weekends between 6 am and 10 pm). For example, a value of 1.20 means that average peak period travel times are 20% longer than free flow travel times. Coupled with a calculation of variability, this provides an approximation of reliability. The identified measures of effectiveness for travel time reliability are:

- Variability of trip travel time by mode
- Change in travel time index (total travel time compared to a free-flow travel time) of travelers by mode

Conclusions

With the largest population in the North Carolina and the most significant congestion issues, the Charlotte metropolitan region could benefit the most from TDM strategies that manage congestion without the need for additional infrastructure investment. Certain strategies are already being utilized, but they are not managed as part of a regionally coordinated and focused initiative. Agencies responsible for regional planning are cognizant of the need to implement TDM as part of a comprehensive and collective vision for regional mobility and have taken steps to integrate TDM in future regional plans. However, these efforts have only recently been initiated, and regional planning appears to focus heavily on infrastructure development and land use. CRTPO might assist the region by providing for the establishment of dedicated staff at relevant regional agencies that can focus on actively pursuing TDM development and implementation in concert with regional planning and infrastructure development initiatives.

Case Studies in TDM

The following case studies, some of which are referenced throughout the report, are examples of successful TDM strategies implemented in jurisdictions across the country. An analysis of these case studies demonstrates the following key findings:

- Long-term partnerships among a range of local and regional stakeholders, including the private sector, are critical for the success of any TDM project.
- Engagement with transit and highway users must be strategic, robust, creative, and context-specific.
- Integrating land use planning into TDM strategies increases the chances of success.
- Data collection is essential for evaluating the effectiveness of TDM projects.
- Effective performance measures are needed to monitor projects and refine strategies over time.

MPO–Initiated, Integrated TDM Initiative and Plans

Arlington County Commuter Services (ACCS) – Arlington, VA

As the county with the highest proportion of non-residents commuting into it for work in the United States, Arlington, Virginia is known for having significant traffic congestion and transportation challenges. However, the county has benefited tremendously from the vision and programming overseen by ACCS, the dedicated TDM agency for the county. ACCS guides a portfolio of TDM programs and services including:

- Employer and residential services: The organization uses a business-to-business model that targets employers and residential property managers to extend transit benefits to employees and residents in the county.
- Commuter transit fare sales: A dedicated website allows customers to buy transit tickets and passes online, as well as manage employer-provided transit benefits cards.
- Bike Share: A national model in successful bike share systems, Capital Bikeshare began as an initiative of ACCS, providing critical last and first mile connections for residents and commuters.
- Site-Plan Enforcement: ACCS is involved with an innovative land-use tool that permits developers to side-step from particular zoning requirements (e.g. related to density restrictions) in exchange for agreeing to certain conditions that mitigate the congestion impacts of a development.

Denver Regional Council of Governments (DRCOG) – Denver, CO

To take TDM from the vision and goals stage to planning and implementation, DRCOG has produced a regional TDM Strategic Plan to guide TDM strategies and investments and specifically define an administrative structure to oversee TDM programs. The guide begins by offering a broad and ambitious rationale for TDM, focusing on the benefits to commuters in the form of increased choices, and to communities in the form of reduced congestion, infrastructure costs, and health and environmental improvements. The plan also identifies potential funding sources for programs and establishes evaluation criteria for various TDM programs.

In addition to the TDM Strategic Plan, DRCOG produces stand-alone plans for bicycle and pedestrian mobility which outline the goals and strategies in those areas related to reducing SOV travel in the region. The TDM plan is seen as unique for the locational emphasis that it places on various TDM efforts.

Washington State DOT *Moving Washington* Program

The Washington State Department of Transportation (WSDOT) is considered a national model for its comprehensive TDM program. Supported by state legislation that requires county and local governments in congested areas to develop plans for employers to reduce SOV trips, a philosophy has been ingrained that considers TDM activities as an essential part of transportation planning and policy.

WSDOT's *Moving Washington* policy framework guides decision making according to three principles:

- Operate efficiently
- Manage demand
- Add capacity strategically

Strategies for addressing congested corridors are evaluated against each of the three principles above, and efforts are made to build consensus around priority projects and corridors together with local communities, federal agencies, transit agencies and community groups. Because of WSDOT's long experience with TDM, the organization is able to offer technical assistance which includes 18 years of trip reduction performance data to local agencies and companies to help them develop locally-tailored TDM programs.

WSDOT also provides capital assistance for the state's transit agencies that operate vanpool programs, as well as regional mobility grants that fund a variety of transportation investments in communities across the state.

Stand-Alone TDM Strategies

Dry Creek First and Last Mile Pilot Program – Centennial, CO

Commuters in a section of Centennial, CO, a suburb to the south of Denver, now have the option to request a free ride on the Lyft app to get to and from the nearby light rail station as part of an innovative new pilot program. As in many parts of the country, long distances from transit stations can make it difficult to persuade drivers to change their commuting habits, even if an area is fortunate to have a developed regional rail network. Reliable bus connections to and from transit stations are also difficult to create in low-density suburban areas, so communities are often left to subsidize expensive paratransit options that shuttle passengers from origin to destination in small vans. These programs are often expensive to provide, despite the relatively small number of people served. In Centennial, the local paratransit service ("Call-n-Ride") cost $2.60 each way for the passenger but more than $20 each way per trip in operator subsidy.

The new pilot project, which was the result of a partnership between the City of Centennial and the Denver South Transportation Management Association, is expected to be able to serve three times as many passengers as Call-n-Ride did, for the same cost.

I-95 Express Lanes – Miami, FL

Highlights:

- Introduction of new HOT lanes to reduce chronic congestion
- Incentives provided to carpool users, transit buses, and registered vanpools to use HOT lanes toll-free.

- Partnership with regional body—South Florida Commuter Services—to perform employer outreach and education around mobility options.
- After implementation of the facility in 2008 (as well as after expansion in 2010) speeds on the HOT and general purpose lanes increased significantly.

The I-95 corridor provides a crucial link between downtown Miami and communities and employment centers to the north. Previous highway management strategies included the installation of an HOV lane in each direction, however the lanes became heavily congested, along with the adjacent mainline corridor. Transit service along the corridor was also minimal, leaving commuters with little choice but to face increasingly congested highway segments on I-95.

Faced with these challenges, state, local, and federal stakeholders developed a plan for the corridor that began with priced managed lanes and evolved into a more holistic TDM strategy for the entire region. Tolled express lanes were added to the roadway through re-striping, with exceptions made for HOV 3+ rather than HOV 2+. In one of the most successful implementations of managed lanes in the U.S., speeds on the HOT lanes and general purpose lanes increased substantially after the facility was opened.

Beyond the implementation of the express lanes, regional stakeholders engaged South Florida Commuter Services to conduct employer outreach and education with the goal of registering carpool users who would benefit from the new facility. The organization maintained a database of carpool users and provided regular reports to inform additional outreach and education efforts.

SF*park* & Parking Information Systems

The availability and price of parking can be difficult for TDM planners to influence, yet both play a critical role in commuters' decision making regarding process. Too much free parking can stymie the efforts of TDM planners to reduce SOV trips, yet in congested downtown environments, limited on-street parking (often priced inexpensively) exacerbates congestion by creating an incentive for drivers to "circle the block" looking for available spots.

In San Francisco, a pilot project called SF*park* began in 2010 to test the impact that demand-responsive pricing and real-time parking availability information had on traffic congestion and parking space utilization in specific areas of the downtown core. By adjusting the price of both on-street parking meters and off-street parking garages up or down, the goal is that a minimum number of parking spaces would be available on every block, even in high demand areas. At low-demand times of day, prices would fall to encourage utilization of on-street parking spots. Real-time information on parking availability and rates was also part of the program so that drivers could be steered to areas with available parking.

Several evaluations of SF*park* have shown that the program has been effective at reducing "cruising" for parking in the areas of the city where the program was implemented. The program was also effective at reducing parking occupancy, thereby freeing more spaces in high-demand areas. Although the program, which was supported by the Department of Transportation's Urban Partnership Program, was technically challenging to implement, the data that the city received on parking patterns and trends was invaluable in crafting a new parking policy city-wide. The city has replaced all legacy parking meters with smart meters which will allow them to easily expand the SF*park* program to other areas.

Integrated Corridor Management (ICM) – I-15, San Diego, CA

One notable example of ICM is found along a 20 mile section of the I-15 corridor from the City of San Diego to the City of Escondido. The system was implemented in 2013 and uses advanced technology to operate and manage freeway, surface streets, and transit networks in a coordinated manner to improve system efficiency and maximize mobility for travelers. The I-15 ICM system utilizes predictive algorithms and real-time modeling tools to forecast traffic across the managed networks. These algorithms recommend strategies to manage anticipated congestion, such as coordinating freeway ramp meters and arterial traffic signals, and provides routing information for travelers to detour around major incidents.

The system has a very strong focus on providing traveler information to aid in routing and decision making. For example, a coordinated detour messaging system was recently activated which relies on 40 alternate route signs installed on various surface streets near the corridor. In the event of a major incident, overhead changeable message signs on the freeway, which are operated by Caltrans, direct motorists away off the freeway while the arterial-based routing signs guide motorists along surface streets and then back to the freeway past the incident. Furthermore, a free 511 San Diego mobile phone application provides travelers with services such as predicted travel times, maps with current traffic conditions, incident and construction notifications, bus routes (with fares and arrival times), and information on dynamic toll rates for the I-15 Express Lanes. The I-15 ICM system represents a partnership between SANDAG, USDOT, Caltrans, the San Diego Metropolitan Transit System, North San Diego County Transit District, and the cities of San Diego, Escondido, and Poway [16].

[16] San Diego Association of Governments. I-15 Integrated Corridor Management. http://www.sandag.org/index.asp?projectid=429&fuseaction=projects.detail, accessed on 15 September 2016.