The Role of Transportation Systems

Management & Operations in Supporting Livability and Sustainability

A PRIMER


U.S. Department of Transportation
Federal Highway Administration
Federal Transit Administration

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16. Abstract

This primer describes the role of transportation systems management and operations (M&O) in advancing livability and sustainability. The document highlights the connections between M&O and livability and sustainability objectives and the importance of a balanced, comprehensive approach to M&O in order to support those objectives. The document describes nine key elements for managing and operating transportation systems in ways that support livability and sustainability. The document also provides a vision of how the regional transportation system could look in the future if M&O strategies were comprehensively implemented to advance livability and sustainability goals. Case examples throughout and a section on implementation will help practitioners to get started on implementing M&O to support livability and sustainability in their communities.

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Dear Colleague,

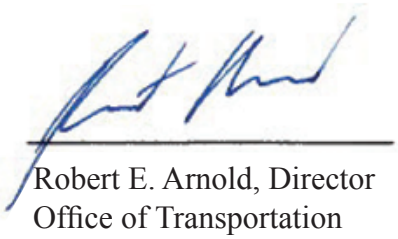
The Federal Highway Administration's (FHWA) Office of Operations and Office of Planning, Environment, and Realty, in partnership with the Federal Transit Administration's (FTA) Office of Planning and Environment, have developed a new product, The Role of Transportation Systems Management & Operations in Supporting Livability and Sustainability: A Primer. This document was developed in collaboration with a broad array of transportation professionals and experts in sustainability. Representatives from State departments of transportation, metropolitan planning organizations, and local governments, as well as non-governmental organizations, transportation industry associations, and other Federal agencies provided insights and guidance through a peer exchange workshop and reviews of the document throughout its development. Input was also solicited from international practitioners in a working session during the Transportation Research Board Annual Meeting in January 2011 to gather input on best practices worldwide.

This primer is part of FHWA's suite of Planning for Operations products. The primer shows that how transportation systems are managed and operated affects the communities they serve in many ways, with implications for mobility and accessibility, safety, community life, economic vitality, and environmental quality. It describes how a comprehensive, balanced approach to management and operations (M&O) can advance livability and sustainability, and identifies key principles or "fundamentals" for managing and operating transportation systems in ways that support livability and sustainability.

Case examples from across the nation and abroad illustrate different ways in which the linkage has been made between M&O and livability and sustainability and provide a guide for implementing these ideas. Examples of operations strategies described include providing real-time travel information to help individuals make better travel choices; ensuring that traffic signals are timed to improve mobility and safety for bicyclists, pedestrians, and transit, while reducing unnecessary delay for drivers; and demand management techniques for travelers and freight, including efforts to encourage shifting trips to off-peak periods to reduce traffic congestion and emissions. The document also provides a vision of how the regional transportation system could look in the future if M&O strategies were comprehensively implemented to advance livability and sustainability goals. It emphasizes that efforts to create more livable, sustainable communities should account for all aspects of transportation — not only planning and project development, but also management and operations.

This primer can be viewed electronically by visiting the U.S. DOT website on Planning for Operations at http://www.plan4operations.dot.gov. We look forward to receiving your feedback, reactions, and experiences in implementing these concepts and utilizing this resource. Please direct any comments, questions, and suggestions to Wayne Berman at wayne.berman@dot.gov or 202-366-4069.

Sincerely yours,



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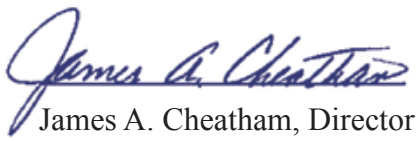

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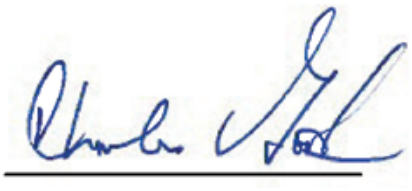

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Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
AVL	Automatic vehicle location
BRT	Bus rapid transit
CDTC	Capital District Transportation Committee
CMP	Congestion management process
DOT	Department of transportation
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	Greenhouse gas
HOT	High-occupancy toll
HOV	High-occupancy vehicle
HUD	U.S. Department of Housing and Urban Development
ICM	Integrated corridor management
ITS	Intelligent transportation systems
M&O	Management and operations (of the transportation system)
MPO	Metropolitan planning organization
NCHRP	National Cooperative Highway Research Program
NITTEC	Niagara International Transportation Technology Coalition
TDM	Travel demand management
TSP	Transit signal priority
U.S. DOT	U.S. Department of Transportation
VICS	Vehicle information and communication system
VMT	Vehicle miles traveled
WSDOT	Washington State Department of Transportation

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Introduction

PURPOSE OF THE PRIMER

Transportation agencies have long been tasked with helping to support community goals of mobility, accessibility, and economic vitality. Recently, there has been a rising interest in having sustainability and livability goals help guide transportation system investments, with considerable focus on the interrelationship between transportation infrastructure, housing, and land use planning.

In addition to planning and designing transportation infrastructure, State, regional, and local governments play a key role in operating transportation systems from maintaining local traffic signals and crosswalks to operating regional transit services and Statewide traveler information programs. However, the role that transportation systems management and operations (M&O) plays in supporting livability and sustainability has not been well defined. As a result, transportation planners, operators, and stakeholders are not fully aware of the role that M&O may play in achieving livability and sustainability goals and how M&O strategies can support these goals in a cost-effective and timely manner. This primer attempts to respond to these gaps. It is designed to increase the understanding of the role of transportation systems M&O in supporting livable and sustainable communities.

The primer is directed at transportation planners and transportation system operators at the State, regional, and local levels. It is also meant to support the broader audience of stakeholders involved in all aspects of transportation and community decision-making, from elected officials and interested citizens to practitioners in related fields such as land use planning, community development, housing, the environment, and public health.

WHAT DO WE MEAN BY LIVABILITY AND SUSTAINABILITY?

Livability and sustainability are two closely related and overlapping societal goals that can be supported, in part, through transportation planning and operations.

Livability in transportation is about using transportation facilities and services to help achieve broader community goals, such as increasing travel choices, improving economic competitiveness, and enhancing unique community characteristics. Livability directly benefits people who live in, work in, or visit an area. Livable transportation systems accommodate a range of transportation modes (walking, bicycling, public transit, and automobiles) by creating balanced multimodal transportation networks that offer multiple transportation choices. Livable transportation systems provide reliable and timely access to jobs, community services, affordable housing, and schools while helping create safe streets and expand business access to markets.

Figure 1 lists six principles of livability established in 2009 by the Partnership for Sustainable Communities, a collaboration among the U.S. Department of Transportation (U.S. DOT), Environmental Protection Agency (EPA), and Department of Housing and Urban Development (HUD).

Specifically, livability in relation to transportation includes:[1]

- Addressing road safety and capacity issues through better planning, design, and construction.
- Integrating health and community design considerations into the transportation planning process to create more livable places where residents and workers have a full range of transportation choices.

[1] U.S. DOT, Federal Highway Administration (FHWA), *The Role of FHWA Programs In Livability: State of the Practice Summary*, March 2011. Available at: http://www.fhwa.dot.gov/livability/state_of_the_practice_summary/.

Partnership for Sustainable Communities

In June 2009, U.S. DOT Secretary Ray LaHood, HUD Secretary Shaun Donovan, and EPA Administrator Lisa P. Jackson announced the new Interagency Partnership for Sustainable Communities. The partnership defined six livability principles that will serve as a basis of interagency coordination designed to help America's neighborhoods become safer, healthier, and more vibrant. The partnership will encourage the incorporation of livability principles into Federal programs while better protecting the environment, promoting equitable development, and helping to address the challenges of climate change.

The Livability Principles

- **Provide more transportation choices.** Develop safe, reliable, and economical transportation choices to decrease household transportation costs, reduce our nation's dependence on foreign oil, improve air quality, reduce greenhouse gas emissions, and promote public health.
- **Promote equitable, affordable housing.** Expand location- and energy-efficient housing choices for people of all ages, incomes, races, and ethnicities to increase mobility and lower the combined cost of housing and transportation.
- **Enhance economic competitiveness.** Improve economic competitiveness through reliable and timely access to employment centers, educational opportunities, services, and other basic needs by workers, as well as expanded business access to markets.
- **Support existing communities.** Target Federal funding toward existing communities—through strategies like transit oriented, mixed-use development, and land recycling—to increase community revitalization and the efficiency of public works investments and safeguard rural landscapes.
- **Coordinate and leverage Federal policies and investment.** Align Federal policies and funding to remove barriers to collaboration, leverage funding, and increase the accountability and effectiveness of all levels of government to plan for future growth, including making smart energy choices such as locally generated renewable energy.
- **Value communities and neighborhoods.** Enhance the unique characteristics of all communities by investing in healthy, safe, and walkable neighborhoods—rural, urban, or suburban.

Source: HUD-DOT-EPA Partnership for Sustainable Communities. Available at *http://www.epa.gov/smartgrowth/partnership/index.html.*

- Using travel demand management (TDM) approaches and M&O strategies to maximize the efficiency of transportation investments.
- Maximizing and expanding new technologies such as intelligent transportation systems (ITS), green infrastructure, and quiet pavement.
- Developing fast, frequent, and dependable public transportation to foster economic development and accessibility to a wide range of housing and employment choices.
- Strategically connecting the modal pieces—bikeways, pedestrian facilities, transit services, and roadways—into a truly intermodal, interconnected system.
- Enhancing the natural environment through improved storm water mitigation, enhanced air quality, and decreased greenhouse gas (GHG) emissions.

Sustainability is frequently defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."[2] Sustainability incorporates the "triple bottom line" concept, which involves maximizing the positive effect of decisions on three factors: equity (also known as social or people), ecology (also known as environment), and economy. The goal of sustainability is "the satisfaction of basic social and economic needs, both present and future and the

[2] The "Brundtland definition" in the World Commission on Environment and Development, *Our Common Future* (New York: Oxford University Press, 1987). Available at: *http://www.un-documents.net/wced-ocf.htm*.

responsible use of natural resources, all while maintaining or improving the well-being of the environment and ecology on which life depends."[3]

In practice, elements of livability and sustainability are closely related, and the transportation solutions that support each area are likely to be similar. Both livability and sustainability address issues of social equity and human health and seek to promote more environmentally friendly travel options and economic activities.

The key differences between livability and sustainability are their timeframes and scope. Sustainability includes a long-term, multigenerational focus that addresses larger environmental goals such as reducing climate impacts, increasing energy efficiency, and reducing natural resource use. Meanwhile, livability initiatives are often focused on near-term planning, funding, and implementation strategies at the community level.

This primer treats livability and sustainability as entwined concepts, seeking to identify ways that M&O can support both sets of goals.

WHAT IS TRANSPORTATION SYSTEMS MANAGEMENT & OPERATIONS?

Transportation systems M&O refers to multimodal transportation strategies to maximize the efficiency, safety, and utility of existing and planned transportation infrastructure. M&O strategies encompass many activities, such as:

- Traffic incident management.
- Traffic signal coordination.
- Transit signal priority (TSP) and bus rapid transit (BRT).
- Freight management.
- Work zone management.
- Special event management.
- Road weather management.
- Congestion pricing.
- Managed lanes.
- Ridesharing and demand management programs.
- Parking management.
- Electronic toll collection and transit smart cards.
- Traveler information systems.

M&O is also connected to planning and infrastructure considerations such as access management, street network layout, and intersection design (e.g., use of roundabouts, right-turn slip lanes and median islands, four-way stops, turning lanes). The emerging integration of operational improvements with urban design and context-sensitive roadway design—through such means as boulevard designs, repurposing of excess road capacity for bicycle lanes, and use of roundabouts—can help improve vehicular operations and multimodal access while improving safety, enhancing aesthetics, and reducing emissions.

M&O strategies involve a range of transportation operators and stakeholders, such as:

- State departments of transportation (DOTs), which are often responsible for operations on freeways and major arterials and for programs such as electronic toll collection, incident management, and traveler information services.
- Local communities, which are often responsible for local road operations, including traffic signals and signage, local transit services, and municipal parking.
- Regional transit operators and commuter rail services that provide travel options.
- Metropolitan planning organizations (MPOs), which often have regional transportation operations committees to coordinate and integrate regional transportation planning and operations. Some MPOs and regional authorities also operate system components, such as signal systems, traveler information systems, TDM programs, transit systems, bridges, and tolling.

[3] U.S. DOT, FHWA, *Sustainable Highways Evaluation Tool*, https://www.sustainablehighways.org/.

WHY IS M&O IMPORTANT TO HELP ACHIEVE LIVABILITY AND SUSTAINABILITY GOALS?

Regardless of whether it is a focus or not, the way in which transportation systems are operated affects how people and communities interact with those systems. Table 1 illustrates how transportation M&O is closely linked to livability and sustainability concerns.

Some conventional applications of M&O strategies have been counted as working against livability and sustainability goals because they facilitate automobile travel speeds that compromise the safety of other modes and improve vehicle traffic movement at the expense of other modes, which potentially encourages more vehicle travel and resulting emissions.

However, M&O strategy applications can increase travel choices and efficiency for all modes—including transit, bicycling, and walking—while reducing emissions and resource use. For instance, a roadway can be operated to optimize only vehicle travel movement, or it can be operated to improve multimodal system performance through:

- Enabling more efficient, reliable transit trips by changing signal timing to prioritize public transit and providing real-time transit information.
- Redesigning existing roads with medians, channelized islands at turning lanes, and/or roundabouts to improve vehicle throughput and multimodal access.
- Adding bicycle lanes that make it easier and safer to ride a bicycle, changing signal timing to make it easier for pedestrians to cross intersections, and installing pedestrian countdown signals to make it safer to cross.
- Developing ridesharing programs and parking management strategies that support moving more people with the same amount of infrastructure.

Both M&O strategies and livability and sustainability goals share an important objective of using resources more efficiently, whether those resources are land, fuel, or funding. M&O strategies do not have to be expensive or complex. Low-cost actions as simple as accounting for different factors when developing traffic signal plans, restriping pavement, or developing bus schedules and routes can increase transportation system efficiency. Many M&O strategies are activities that State and local governments and transportation agencies currently undertake, but which they may not consider to be part of their sustainability or livability efforts.

The key message is that ***M&O strategies can help improve how existing transportation systems interface with the communities they serve***. As a result, considering how transportation is managed and operated can be a vital aspect of supporting livable communities and sustainable planning efforts.

Table 1 How M&O Affects People and Communities

M&O Affects…
…Mobility and Accessibility—How efficiently people and goods can move from place to place and their ability to take advantage of different transportation choices. Example M&O strategies include park-and-ride lots, intermodal centers, TSP, and managed lanes.
…Safety—How safe it is to walk, bicycle, take transit, or drive from place to place. Example strategies include traffic signal timing and the addition and improvement of crosswalks and bicycle lanes.
…Reliability—How much time travelers are stuck in unexpected traffic due to incidents, work zones, special events, or bad weather. Example strategies include traveler information systems, incident response programs, and work zone and special event management.
…Community Life—How pleasant the community environment is in urban areas, suburban neighborhoods, and rural communities. Example strategies include traffic calming, parking management, and pedestrian countdown signals.
…Economic Vitality—How efficiently goods reach markets and how costly it is for the public and shippers to reach destinations. Example strategies include freight management strategies, ridesharing programs, and bus rapid transit.
…Environmental Quality—How much fuel must be used and pollution produced by transportation operations. Example strategies include traveler delay reduction programs, encouragement of non-motorized modes, and support for increased transit ridership and ridesharing.


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Potential Roles of M&O in Supporting Livability and Sustainability

HOW M&O CAN SUPPORT LIVABILITY AND SUSTAINABILITY

M&O strategies can support livability and sustainability in multiple contexts, including:

- **Neighborhood and corridor strategies (applied at a local or regional level),** such as parking management, traffic signal coordination, TSP, arterial management, bicycle sharing, and traffic calming.
- **Regional systems**, such as traveler information systems; congestion pricing and electronic payment/tolls; managed lanes; management of freight, freeways, work zones, traffic incidents, and special events; and emergency response and homeland security.
- **Modal connections**, such as smart cards for transit and parking, real-time transit information, and bicycle/pedestrian operations such as crosswalk signals or bicycle racks on public transit buses.
- **Policy and communications at the state and regional levels**, such as implementation of an intelligent transportation systems (ITS) architecture to ensure that technologies work together effectively and regional transportation plans and long-range state transportation plans that define a vision, goals, and objectives for how a transportation system should operate.

The connections between M&O strategies and livability and sustainability can be broadly grouped into three areas: economic, environmental, and community-related (i.e., related to travel choices and equity). Table 2 highlights these connections and some measures of the benefits.

Transportation systems M&O has wide-ranging impacts on communities and the environment—from how easy it is for a pedestrian to cross the street to how much fuel, productivity, and quality of life is wasted in traffic.

Efforts to create more livable, sustainable communities should account for all aspects of transportation: planning, development, management, and operations.

Table 2 Connections between M&O Strategies and Livability and Sustainability

Category	Specific Connections
The role of M&O in supporting economic sustainability and/or livability issues	• M&O strategies 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.[4] • M&O strategies cost-effectively improve transportation system performance. M&O strategies are able to improve the performance of the transportation system at low- to moderate-cost and often without requiring any expansion of the system's physical capacity.[5] • M&O strategies can enhance economic competitiveness and economic development. Improving multimodal networks can help support commercial districts by making them more attractive for pedestrians and other non-automobile users.[6] M&O strategies that improve transportation system reliability can help support efficient goods movement, which may result in lower costs of goods and may enhance economic competitiveness. • M&O strategies can improve safety. It is estimated that road weather information systems can reduce traveler delay and lower crash rates by seven to 83 percent.[7] Signal coordination can decrease intersection crash rates, reduce rear-end conflicts, and reduce crashes during turning movements at signalized intersections.[8] • Implementation of pricing of lanes or parking (an M&O strategy) can provide a sustainable funding source for transportation. One estimate found first-year revenue generation of $235 to $500 million and longer-term annual revenues of $0.5 to $1 billion from turning a region's freeway shoulders into dynamic priced lanes during the peak periods.[9]
The role of M&O in supporting environmental sustainability and/or livability issues	• M&O strategies can improve air quality and public health by reducing air pollutant emissions. Strategies that reduce vehicle miles traveled (VMT), vehicle trips, and vehicle idling reduce all air pollutants; improving traffic speeds or flow can also reduce some emissions.[10] • M&O strategies can help mitigate climate change by reducing fuel consumption and GHG emissions. Various studies have shown GHG reductions attributable to operations strategies in the range of three to 20 percent.[11] • M&O strategies can support land preservation and reduce sprawl by limiting new infrastructure development. This is an indirect benefit of M&O. M&O contributes to the principle of "fix it first" and can be an alternative to adding additional road capacity.[12]

4 Texas Transportation Institute, *Urban Mobility Report 2009*, July 2009.

5 U.S. DOT, FHWA, *Identifying How Management and Operations Supports Livability and Sustainability Goals*, White Paper, April 2010.

6 American Association of State Highway and Transportation Officials (AASHTO), *The Road to Livability*, April 2010.

7 U.S. DOT, Intelligent Transportation Systems (ITS) Joint Program Office, *Investment Opportunities for Managing Transportation Performance through Technology*, January 2009.

8 Antonucci, Nicholas D., et al. *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan*, National Cooperative Highway Research Program (NCHRP) Report 500, Volume 12, 2004.

9 DeCorla-Souza, Patrick T., "Impacts from Implementing Dynamic Shoulder Travel Lanes with Congestion Pricing," Transportation Research Board Annual Meeting, 2010.

10 U.S. DOT, FHWA, *Multi-Pollutant Emissions Benefits of Transportation Strategies*, November 2006.

11 Neudorff, Louis G., *Moving Cooler— An Operations and ITS Perspective*, ITS America Technical Forum on Sustainability, 2009.

12 Rue, Harrison, *Real Towns: Making your Neighborhood Work* (Sacramento, California: Local Government Commission, 2000).

Category	Specific Connections
The role of M&O in supporting travel choices and social/ equity issues	• M&O strategies can support travel choices by increasing the attractiveness of travel options. Road pricing and high-occupancy toll (HOT) lanes provide more efficient travel options and improve bus operations. M&O strategies reduce transit travel times for buses and street-running rail modes and are a key component of BRT systems; BRT has been shown to increase transit ridership by previous non-riders.[13] Developing parallel bicycle and pedestrian facilities or arterial road diets are other strategies to improve transportation choices, particularly for non-motorized travel.[14] • M&O strategies can increase public awareness of suitable travel options. Through the use of transportation options marketing, TDM, and traveler information programs, travelers can make more informed decisions about their mode choice, travel time, and/or travel routes, leading to smarter, more efficient use of the transportation network.[15] • M&O strategies can provide greater social equity by increasing travel options for disadvantaged populations and communities. Public transit operations strategies can help support mobility and access for those without access to a personal vehicle. M&O strategies that improve multimodal safety are strategies that promote social equity amongst all populations including senior citizens, children, and those with disabilities. • M&O strategies preserve existing communities by maximizing the efficient use of existing infrastructure. ITS and operations investments require minimal new rights of way or construction, thereby preserving existing transportation infrastructure while improving operations.[16]

Many M&O strategies implicitly support livability and sustainability by promoting more efficient use of existing facilities while reducing the need for potentially costly and disruptive capital investments that may be out of character with communities they serve.

M&O strategies can be an important component of regional sustainability efforts. For example, the Sustainable East End Development Strategies planning effort to improve the sustainability and quality of life of Eastern Long Island identified M&O strategies as "low-impact, low-cost, and easily implemented system improvements" that could help the community achieve many of its goals.[17]

[13] U.S. DOT, Federal Transit Administration (FTA), *Bus Rapid Transit and Development: Policies and Practices that Affect Development Around Transit*, December 2009.

[14] U.S. DOT, FHWA and FTA, *Livability In Transportation Guidebook: Planning Approaches that Promote Livability*, 2010.

[15] Governors' Institute on Community Design, *Policies that Work: A Governor's Guide to Growth and Development*, 2009.

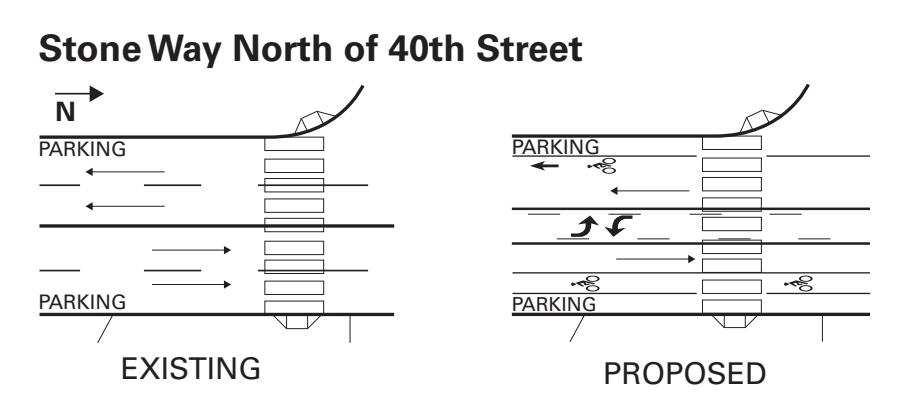
[16] U.S. DOT, ITS Joint Program Office. *Investment Opportunities for Managing Transportation Performance through Technology*, January 2009.

[17] East End Transportation Council, New York Metropolitan Transportation Council, and ARKF, Inc. "Sustainable East End Development Strategies." June 2005.

M&O Supporting Multimodal Options in Seattle

After repaving Stone Way North in the Wallingford area of Seattle, Washington, the Seattle DOT had the option to maintain the roadway's previous cross-section as four general-purpose travel lanes or to adopt a new cross-section and operational strategies for the corridor. Based on a balanced approach to M&O, the city decided to restripe the roadway as a three-lane section with bicycle facilities (a bicycle lane on the uphill side of the street and sharrows on the downhill side), on-street parking, and updated crosswalks.

The restriping allowed the city to complete a project identified in its 2007 Bicycle Master Plan and increase transportation options in the area. A before-and-after study of the corridor showed that peak hour vehicle capacity was maintained despite the reduction in the number of general travel lanes. The study also found a 35 percent increase in bicycle traffic, a 33 percent reduction in collisions with injuries (all modes), and an 80 percent reduction in vehicle-pedestrian collisions.



Source: City of Seattle DOT, *Stone Way N Rechannelization: Before and After Study*, May 2010.

A BALANCED APPROACH TO M&O

Maximizing the livability and sustainability benefits of M&O strategies requires a balanced approach to M&O. Not all M&O strategies support livability and sustainability outcomes equally. For example, traffic signals that prioritize vehicle traffic flow but do not consider the mobility and access needs of pedestrians, bicycles, and transit can actually work against livability and sustainability principles. In contrast, signal timing plans and roundabouts that support livability and sustainability objectives will provide improved mobility in a way that balances vehicular and bus traffic, pedestrians, and bicycle access, in order to support community vitality, safety, and the environment.

A balanced approach to M&O provides a framework that helps practitioners consider tradeoffs, better understand potential impacts on livability and sustainability, and avoid unintended results. Most importantly, this framework encourages practitioners to evaluate transportation system operations from a variety of perspectives and consider how the system can be optimized in multiple ways to achieve different performance measures and goals.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Fundamentals: How to Manage and Operate Transportation Systems to Support Livability and Sustainability

This section highlights nine key elements—"fundamentals"—for managing and operating transportation systems in ways that support livability and sustainability. Many of the activities described in the fundamentals are already part of transportation agency best practices, but may not be applied as part of a more comprehensive, balanced approach to advancing sustainability and livability in transportation operations. M&O strategies are rarely applied in isolation, and approaches from across the fundamentals should be combined to maximize the benefits to communities.

The fundamentals are:

- Operate to serve community priorities.
- Increase opportunities for safe, comfortable walking and bicycling.
- Improve the transit experience.
- Support reliable, efficient movement of people and goods.
- Manage travel demand.
- Provide information to support choices.
- Support placemaking.
- Use balanced performance measures.
- Collaborate and coordinate broadly.

Each of these fundamentals is described below, along with specific examples of their application in different communities across the U.S. and internationally. The individual M&O strategies identified in these sections are examples of good practices but are not fully comprehensive or ranked in any priority order.

OPERATE TO SERVE COMMUNITY PRIORITIES

The choice and implementation of M&O strategies should respond to community priorities, reflecting the community's goals and objectives for the transportation system and its larger context as expressed through the planning process. These goals provide the basis for judging what is considered successful operation of the transportation system. By focusing on community priorities, transportation system operations can help a community achieve its broader goals.

Methods for Incorporating Community Priorities into Operations

- **Incorporate operations considerations into the planning process.**
  Considering operations strategies during the planning process ensures that the strategies sync with long-term plans for the community.
- **Use context-sensitive solutions.**
  This approach focuses on tailoring designs to community needs; operations can be part of this process as well.
- **Conduct public outreach** around proposed operations changes and gather community feedback before and after to guide future changes.

Neighborhood Greenways Program

Portland, Oregon

To meet the city's goals for increasing bicycle mode share, the Portland Bureau of Transportation (PBOT) has developed a network of "neighborhood greenways" (or "bicycle boulevards"). Neighborhood greenways use existing low-traffic, local roads to create high-quality bicycle and pedestrian facilities linking residential areas to schools, parks, and businesses. This program has used relatively low-cost M&O strategies to transform existing streets into a network of multimodal facilities that promote active transportation and neighborhood livability.

Source: G. Raisman, PBOT

Studies to date show that the greenways are well-received by neighborhoods, increase bicycling and walking, and divert minimal amounts of through traffic to nearby local streets.

For more information: *http://www.portlandonline.com/transportation/index.cfm?c=50518*.

Context is an essential consideration in determining how to operate the system. How a roadway operates should depend in part on its character—for instance, a major urban arterial, a small-town main street, a neighborhood street, and a scenic rural road will each have different characteristics, operating speeds, and levels of emphasis on elements such as integration of different modes.

This approach runs in parallel to the idea of context-sensitive design, which calls for transportation facility design to consider how the facility will fit within its total context (physical, aesthetic, historic, etc.). As with that approach, there must be a certain amount of flexibility in the application of traditional roadway operating standards and recognition that systems can still be operated safely while responding to broader community goals.

For example, the Capital District Transportation Committee (CDTC) in the Albany, New York region has established congestion management principles as part of both its metropolitan transportation plan and its congestion management process (CMP). CDTC believes that what the residents of the region want—as articulated in the regional vision and as expressed though resident involvement in corridor- and project-level studies—must help define how congestion management is applied in the region.

A key element of this is the region's decision to implement demand management strategies and operational strategies before capacity expansion when addressing regional congestion. The M&O focus is also influenced by public opinion polling CDTC completed using surveys and public involvement. CDTC found that the public wants more bicycle, pedestrian, and other improvements and that travel time reliability (which can often be addressed through M&O strategies) is the most important congestion issue for travelers in the region.

Roadway operations need to be considered from multiple perspectives: the function a street provides within the overall transportation system, its users, and the communities through which it passes. The City of Pasadena, California, is developing a context-based street classification system to allow planners and operators to more easily identify the appropriate roadway treatments for the context and function of the roadway. This system builds on a long-standing program of residential neighborhood traffic calming through the city's Neighborhood Traffic Management Program. The program relies on outreach into neighborhoods to identify local concerns and to develop consensus on solutions. In recognition that improvements in one neighborhood can push traffic from one neighborhood to another, the program is now being expanded to take a multi-neighborhood approach to traffic management to improve the interfaces between local residential streets and major streets.

Sample Contexts and Priorities

Rural Areas

- For travel between towns, priorities may focus on safe and consistent roadway operations for personal automobiles and trucks, as these modes are often the key to mobility in this context. The focus also may be on balancing roadway safety and efficient freight movement with environmental protection and preserving scenic vistas to attract tourism.
- Within small towns, priorities may be more focused on balancing the needs of through and local traffic, using such strategies as access management, traffic signal coordination, and roundabouts to move vehicles through efficiently while still allowing safe and convenient pedestrian movement and preserving local character. Communities may also be concerned with providing more transportation options to local residents through demand-response transit and intercity bus services.

Urban and Suburban Areas

- In urban centers, priorities will typically incorporate a broader range of modes, often with more focus on supporting transit, pedestrians, and bicycles and facilitating shared modal options like car sharing and bicycle sharing.
- On major arterials and in activity centers, person movement rather than vehicle movement may be the focus, with strategies like TSP and parking management playing key roles.
- Residential neighborhoods and town centers may have a different modal hierarchy, giving precedence to pedestrians and bicyclists over automobiles. The operational priority may be to discourage through traffic to help preserve quiet, safe streets in residential neighborhoods or to encourage more foot traffic in town centers to support local businesses.
- On freeways, particularly where capacity expansions are cost- or space-prohibitive, the focus may be on encouraging higher vehicle occupancies that allow congested roadways to carry more people during peak periods. This can be achieved by linking more typical roadway management strategies with demand management and managed lanes. Managed lanes are a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions, including through the use of roadway pricing (e.g., high-occupancy toll lanes) and/or restricting which vehicles can enter the lanes (e.g., high-occupancy vehicle, express, or truck-only lanes).

INCREASE OPPORTUNITIES FOR SAFE, COMFORTABLE WALKING AND BICYCLING

Walking and bicycling are central to sustainability and livability. These modes are low-cost and broadly available. These modes provide many environmental benefits: they are non-polluting modes, their infrastructure requirements are less intense than other modes, and they can often be supported through existing infrastructure. Walking and bicycling also provide a variety of community benefits: they contribute to the health of individuals, encourage social interaction that strengthens communities, and support the vitality of retail districts and neighborhoods.

Tubular channelizers in Slater, Iowa

Source: Hallmark 2007

Pedestrian Safety Program

Miami-Dade County, Florida

Miami-Dade County has one of the highest rates of pedestrian fatalities per population for large metropolitan regions. To combat this, the county recently implemented a comprehensive pedestrian safety improvement program on eight high-crash corridors. The program focused on immediate implementation of low- and medium-cost treatments, including several M&O strategies; as a result, the total cost of the program was less than $1.1 million. Before-and-after crash data along the target corridors show that pedestrian crashes decreased by over 40 percent after implementation.

Source: University of Florida, Miami-Dade Pedestrian Safety Project: Phase II Final Implementation Report and Executive Summary, August 2008.

While the basic infrastructure to support walking and bicycling—such as sidewalks, bicycle lanes, and shared-use paths—are important, the attractiveness and function of these modes is heavily affected by the management and operation of the transportation system. For example, traffic signal timing determines the amount of time pedestrians have to cross streets and how long they have to wait before crossings. Pedestrian countdown walk

Green Light for Midtown and New Pedestrian Spaces in New York City

Increasing opportunities for walking and bicycling can also involve recognizing situations where these modes are, or should be, the dominant mode. This can be done to attract more pedestrians and bicyclists or address issues with already high volumes of these modes. A high-profile example of this is the 2009 creation of pedestrian areas in Times Square and Herald Square in New York City that was completed under the Green Light for Midtown project.

The project was intended to improve safety, mobility, and livability along the Broadway corridor, which bisects the famous Times Square. The corridor suffered from inadequate pedestrian facilities that often led to people walking in the streets, long crossings and multi-legged intersections, and confusing traffic patterns. To address this, New York City DOT removed vehicular traffic from Broadway in Times Square and Herald Square, in coordination with other traffic changes to signal timing, roadway geometry, crosswalk shortenings, and parking regulation changes. Within the new pedestrian spaces, a variety of streetscape improvements were implemented.

Evaluations of the project found that one year later:

- Vehicular travel speeds in most directions improved by three to 17 percent, including for transit buses.
- Safety was vastly improved for all users, with pedestrian injuries down 35 percent, all traffic injuries down 63 percent, and 80 percent fewer pedestrians walking in the roadway in Times Square.
- Pedestrian volumes were six to eleven percent higher in the two squares.

BEFORE

Source: New York City DOT

AFTER

Source: New York City DOT

Source: New York City DOT, *Green Light for Midtown Evaluation Report*, January 2010.

Rectangular rapid flash beacon on pedestrian sign

Source: FHWA, MUTCD, 2008

signals reduce confusion and help pedestrians make better crossing choices by informing pedestrians of the number of seconds remaining to safely cross the street. Along with infrastructure improvements such as wider sidewalks, pedestrian refuges in medians, and well-designed turning slip lanes (a turn lane offset at an intersection with a pedestrian refuge), pedestrian countdown signals can help make walking safer and more attractive. Similarly, incorporating bicycle detector loops at actuated signals ensures that bicycles will be able to safely cross intersections without undue wait, particularly in the off-peak periods.

Some key M&O-related strategies to promote walking and bicycling are:

- **Traffic Calming**—A combination of M&O and physical measures to encourage lower speeds and reduce traffic volumes, which improve pedestrian and bicyclist safety. Speed limit reductions combined with improved crosswalks, bicycle lanes or shared-lane bicycle markings, on-street parking management, signage, and enforcement can help create visual cues that define areas that demand lower speeds and additional awareness of non-motorist roadway users.

  The Iowa DOT tested various low-cost traffic calming treatments in rural communities to help slow traffic on major roads as they entered the communities. Strategies that showed the greatest effect on traffic speeds were speed feedback signs (signs that measured and displayed the actual approach speeds), colored pavement, on-pavement speed signing, and creation of center medians with tubular channelizers (poles).[18]

- **ITS Technologies**—At signalized intersections, traffic signal timing and pedestrian countdown signals can have an important effect on enabling people to walk or bicycle across streets safely. At non-signalized intersections, rectangular rapid flash

[18] Hallmark, Shauna, et al., "Evaluation of Gateway and Low-Cost Traffic-Calming Treatments for Major Routes in Small Rural Communities," for Iowa DOT and U.S. DOT, November 2007. Available at: http://www.ctre.iaState.edu/reports/traffic-calming-rural.pdf.

beacons attached to pedestrian signs can alert motorists to the presence of a pedestrian crossing or preparing to cross. When the pedestrian activates the system, either by using a push-button or through detection from a sensor, the lights begin to flash, warning the motorist that a pedestrian is in the vicinity of the crosswalk.

- **Complete Streets**—Complete streets are designed and operated to enable safe access and mobility for transportation system users of all ages and abilities, including pedestrians, bicyclists, motorists, and public transportation users. M&O strategies play an important role in helping communities implement complete streets policies once they are adopted and can provide additional options where infrastructure changes are not feasible due to physical or financial constraints. M&O strategies such as traffic signal timing progression that are optimized for transit or bicycle speeds rather than motor vehicle speeds can help to improve multimodal efficiency on complete streets and distinguish them from surrounding auto-oriented streets.
- **Safe Routes to Schools**—Safe Routes to School programs, implemented by school districts and local governments, encourage children to walk and bicycle to school through a combination of education, outreach, and infrastructure improvements. M&O strategies can be used effectively to delineate school zones, alert motorists to the presence of children, and create an environment that promotes multimodal safety and accessibility. Strategies include retroreflective school crossing signs, changeable message signs and speed feedback signs, school zone pavement markings, crossing guards and student patrols, accessible pedestrian signals, and high-visibility crosswalks. FHWA provides funding and resources for Safe Routes to School; some State and local governments provide additional support and funding.
- **Bicycle Sharing**—These programs provide public bicycles at docking stations at various locations throughout an urban area, available on demand to users. Users can pick up a bicycle at a station near their origin and return it at any station in the system. Smartcards or payment kiosks are used to gain access to the bicycles. Several bicycle sharing programs have launched in the United States over the last few years, with one of the most successful in Washington, DC, and neighboring Arlington, Virginia. After a pilot program to demonstrate the model's feasibility, Capital Bikeshare was launched in September 2010 and as of April 2011 had over 110 stations, 1,100 bicycles, 10,700 members, and had logged over 300,000 rides. Several other major U.S. cities have launched bicycle sharing programs, including Chicago, Boston, Minneapolis, Denver, Des Moines, Miami, and San Antonio.

San Antonio B-Cycle

Photo of bicycle share station at La Villita

Source: M. Grant

San Antonio B-Cycle was recently initiated with 140 bicycles at 14 locations located throughout the downtown areas. Individuals can purchase a 24-hour, 7-day, or annual membership. The program was implemented to improve travel choices, save travel costs, reduce motor vehicle travel, and support healthy living as part of implementation of the city's Strategic Transportation Plan and Climate Action Plan. From the program's initiation on March 28, 2011, through May 10, 2011, there were 4,357 bicycle trips through the program.

For more information: *http://sanantonio.bcycle.com*.

IMPROVE THE TRANSIT EXPERIENCE

Improving travel choices by increasing the attractiveness and performance of public transit is a central component of making communities more livable and sustainable, especially in more compact cities and towns where transit can operate cost-effectively. The benefits of transit for communities are numerous. Transit helps reduce vehicle travel and congestion, leading to fewer criteria pollutant and GHG emissions. For individuals, using transit instead of an automobile saves fuel and parking costs and reduces wear and tear on vehicles. When riders can reduce car ownership as a result of transit and other transportation options, household savings can be substantial. Using public transit instead of driving can reduce stress for travelers, improving their overall quality of life. For a community, transit boosts social equity by providing mobility and accessibility

Metro Rapid Limited-Stop Bus System

Los Angeles, California

Los Angeles Metro has a system of rapid bus lines with limited BRT features that improve service compared to regular buses. Metro uses operational strategies to both improve bus travel times (by reducing delay) and make the service more appealing to new riders. These strategies include:

- Transit signal priority at traffic signals.
- Fewer stops and more frequent service.
- Headway-based scheduling so riders do not have to consult schedules.
- NextBus real-time arrival information at each stop.
- Level boarding on low-floor buses.
- A route structure that keeps routes as simple and straight-line as possible to help riders easily understand where buses go.

Results:

- 23-28 percent reduction in transit travel time, with no impact on non-transit vehicle travel time
- 38-42 percent increase in ridership, one-third of whom are new riders
- Passenger subsidy per mile decreased from $0.18 to $0.15 and passengers per revenue mile increased from 51 to 59.7.

For more information: *http://www.metro.net/projects/rapid/.*

Source: H. Rue

to individuals who are unable to drive or have limited access to a vehicle. At a larger scale, by mitigating congestion and increasing vehicle occupancies, transit can help communities avoid costly roadway expansions.

M&O strategies can improve the transit-riding experience and help make transit more competitive with private automobiles. Within the context of M&O, bus transit is often a key focus because it operates in mixed traffic or shared rights of way.

M&O strategies for transit can be broken into several categories.

Roadway operations, which enable transit vehicles to operate more efficiently and reliably within and around general traffic. Strategies include:

- *Transit signal priority (TSP):* Signals can be programmed so that as a bus approaches an intersection, it gets a green light sooner or the light stays green a little longer to reduce the time spent waiting at intersections. TSP can improve on-time performance and decrease overall run time for a route without noticeably disrupting signal operations for general traffic. TSP can be tied to bus schedules so that priority is granted only to buses running behind.
- *Queue jumps:* Queue jumps are right-turn lanes or separate bus-only lanes at intersections that are given a green light before other lanes to allow the bus to get through the intersection before general traffic.
- *Buses on shoulders:* On highways, this strategy permits buses to used paved shoulders as a lane when traffic is slow. This strategy has been in use for nearly two decades in the Minneapolis-St. Paul, Minnesota metropolitan area and a study of routes using the shoulders found ridership on those routes increased by 9.2 percent, even as overall system ridership decreased 6.5 percent.[19]

Transit system operations, which concern transit vehicle operations directly and how they interface with transit users. Strategies in this area focus on streamlining operations to make transit operate more seamlessly for passengers and the system operator. Some widespread techniques for doing this include automatic vehicle location (AVL) systems and related software that track the location of vehicles and help dispatchers and drivers maintain route and schedule adherence. Other strategies include:

[19] U.S. DOT, FTA, Bus-Only Shoulders in the Twin Cities, June 2007. Available at: *http://www.hhh.umn.edu/img/assets/11475/Bus%20Only%20Shoulders%20Report%20FINAL.pdf*.

System-Wide Transit Signal Priority

St. Cloud Metropolitan Transit Commission, St. Cloud, Minnesota

The St. Cloud Metropolitan Transit Commission serves a small metropolitan area in central Minnesota. Following a successful pilot program, the entire traffic signal system in the area served by the agency was equipped with TSP equipment in 2003.

A 2005 evaluation of the found:

- 42 percent reduction in buses that were late by more than 1.5 minutes.
- 32 percent reduction in bus delay time at traffic signals.

With buses better able to stay on schedule, riders can make connections more easily and drivers can give passengers more time to board at stops, which increases customer satisfaction with the system.

Source: St. Cloud Metropolitan Transit Commission, *Transit Signal Priority (TSP) Deployment Project Final Report*, **2005.**

- *Improved payment methods:* Faster payment methods speed vehicle boarding and can help buses improve on-time performance, along with simplifying fare collection. These methods include off-board fare collection, which collects fares at the station before passenger boarding, and proof-of-payment systems, which require passengers to have a valid ticket or pass that is subject to random inspection. Many systems now use smart cards, which can have a value loaded in person or via the Internet, and some international transit systems now also have pay-by-phone options. Smart cards in particular offer the opportunity of being able to work with multiple transit providers, simplifying transfers for transit users and expanding their access to more systems. The cards can also be linked to other transit modes, such as car sharing. To address both the cost and delays associated with fare collection, some smaller systems have opted to make their service free, thus alleviating delays during boarding while greatly improving the attractiveness of their services.
- *Improved transit schedule coordination: I*mproved schedule coordination can help improve transfers between different transit services, reducing travel times and making transit a more attractive mode choice. Smooth, timely transfers are particularly important because out-of-vehicle wait times are documented to be perceived as much more onerous than in-vehicle travel times.[20] Approaches to coordination include operating routes with the same headways so they align at certain transfer points, bringing all routes in to dwell at transit hubs for 3-5 minutes before they all depart, or tying feeder bus departures to the arrival of a main bus line or train. Schedule coordination works best where there is good on-time performance of routes.
- *Circulator services:* These specialized transit services generally link popular destinations within downtowns, university campuses, and similar areas. Circulator routes and schedules are meant to be easy to use for new riders, often using loop routes and headway-based schedules that do not require riders to consult a timetable. Many

Charm City Circulator

Baltimore, Maryland

Launched in January 2010, the Charm City Circulator has two routes serving downtown Baltimore and nearby residential neighborhoods. A third route is expected to launch sometime in 2011. The free service is targeted at downtown workers during the day and visitors during evenings and weekends. Buses operate every 10 minutes along linear routes designed to be easily understood. Routes are served by hybrid buses with distinctive designs and all stops are equipped with real-time bus arrival displays. As of June 2011, average daily ridership on the two routes was 7,700, far above initial ridership projections.

For more information: *http://www.charmcitycirculator.com/.*

Source: Signe Renn and Mjach Designs

[20] Dowling, Richard et al. Multimodal Level of Service Analysis for Urban Streets. National Cooperative Highway Research Program (NCHRP) Report 616, 2008. Available at: *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_616.pdf*.

- downtown circulators do not have fares or charge only minimal amounts and accept multiple fare media. Circulator vehicles are generally distinctive, branded separately from other local transit service, and are often provided through collaboration among the local transit agency, the local government, and local businesses or business groups.[21]
- *Real-time information:* By providing accurate, real-time information about the expected arrival of buses and trains, transit systems can help riders know when to leave for a station or bus stop, reducing actual wait time, and minimize uncertainty about arrivals, reducing perceived wait times. Information can be provided via displays in stations, the Internet (accessible to smartphone users as well), and text message systems (for all mobile phones).
- *Access to and from transit stations:* Multimodal access to and from transit stations can be supported through pedestrian and bicycle infrastructure, which in turn may help alleviate the need to add more parking at major stations. Innovative transportation options are also helping to bridge the gap between transit services and riders' origins and destinations, such as bicycle sharing, car sharing, real-time carpooling, and shared fleets of smaller neighborhood vehicles.

M&O strategies should be prioritized for high-frequency, high-capacity transit, which in many communities may be BRT. BRT commonly consists of a range of M&O strategies, with specialized vehicles running on roadways or in dedicated lanes to provide faster, more reliable, and more comfortable service more typical of light rail transit. When BRT vehicles are running in existing roadway lanes mixed with cars, trucks, and local buses, coordinated M&O strategies are especially important. When coordinated with an integrated traffic signal management system and real-time route information, such as Los Angeles' Metro Rapid BRT routes (see box on page 17), buses can deliver faster, more reliable service without affecting other vehicular traffic.

SUPPORT RELIABLE, EFFICIENT MOVEMENT OF PEOPLE AND GOODS

One of the fundamental aims of M&O strategies is to actively support efficient and reliable mobility for people and goods. Being stuck in traffic, particularly in unexpected delays, wastes time and fuel, increases air pollution, creates stress and frustration for drivers, and undermines the timeliness of freight pickups and deliveries. Particularly in congested regions and corridors, M&O strategies applied strategically can help to avoid the need for major capacity expansions that are costly and may not fit within community visions while improving mobility for people and goods and supporting improved safety, air quality, regional economic vitality, and land use efficiency.

To support livability and sustainability, it is important that M&O strategies fit within the context of community goals and focus on the full range of system users. This means emphasizing efficient movement of people and goods rather than just vehicles and giving greater emphasis to modes or techniques that accommodate safe movement for the least cost in terms of economic, environmental, and social costs and the value of different trip purposes. For example, allowing transit buses to operate on the shoulders of roads during peak periods can help maximize the throughput of people on a facility. Inter-regional and interstate freight and recreational movement are often key economic drivers in regions, and these trips can see significant travel time benefits from strategies such as electronic toll collection, incident management, and work zone management.

Reliability refers to the consistency and predictability of travel time for people and goods. It is estimated that more than half of congestion experienced by travelers is caused by non-recurring events, such as weather conditions, work zones, special events, and major incidents and emergencies that are not associated with overall infrastructure capacity.[22] Predictable, consistent travel times are highly

[21] Boyle, Dan, *Practices in the Development and Deployment of Downtown Circulators: A Synthesis of Transit Practice*, Transit Cooperative Research Program (TCRP) Synthesis 87, 2011. Available at: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_87.pdf.

[22] U.S. DOT, FHWA, *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*, 2005. Available at: http://www.ops.fhwa.dot.gov/congestion_report/index.htm.

valued by all users of the transportation system, from freight operators to transit users to commuting motorists. In a 2008 study of the economic impact of traffic incidents on businesses using North Carolina interstates, roughly three quarters of the businesses stated that shipment reliability was highly important because of a just-in-time manufacturing or inventory process.[23] For individual travelers, unexpected congestion on the roads can also be costly as well, such as for workers trying to get to jobs on time, travelers trying to make airplane flights, or for working parents who need pick up their children at daycare on time to avoid late fees.

M&O strategies designed to improve system reliability also can support livability and sustainability by increasing safety, decreasing incidents, and reducing unnecessary delays that increase air pollution and create negative economic impacts on households and businesses. These strategies include the following, which may address all components of the multimodal transportation system:

- **Incident and emergency management** encompasses a wide range of activities performed by professionals from emergency response (police, fire, medical) agencies, emergency management agencies, transportation operators, towing companies, hazardous materials response agencies, coroners, and other organizations to prepare for, respond to, manage, and clear traffic incidents as well as natural and manmade disasters.
- **Travel weather management** involves mitigating the safety and mobility impacts that adverse weather conditions can have on the surface transportation system. Three types of strategies—advisory, control, and treatment—are used to manage and operate the transportation system before, during, and after adverse weather (e.g., fog, snow, flooding, tornadoes, hurricanes) to mitigate the impacts on system users.
- **Work zone management**—Work zones are estimated to cause approximately ten percent of all roadway congestion.[24] In addition, maintenance work on rail systems causes unexpected and often prolonged delays for passengers and freight. Road work also has the potential to deteriorate safe mobility and access for pedestrians and bicyclists. Strategies to manage work zone impacts include traveler information, setting safe speed limits, pedestrian access plans, pre-positioning tow trucks to quickly clear incidents, innovative contracting, ensuring the appropriate geometric design to accommodate larger vehicles, and coordinating work zones on parallel routes.
- **Planned special events management** works to minimize unexpected delay due to sporting events, concerts, festivals, conventions, and other planned events that may have an impact on mobility due to increased travel demand and possibly reduced capacity. By effectively accommodating multiple modes of travel to and from the event, transportation managers can reduce the parking space needed and motorist delay caused by the significant surge in demand for travel and can mitigate the impacts of increased travel demand on communities near the event.[25]

Emphasis on M&O Strategies to Support Livability & Sustainability

Lansing, Michigan

The Tri-County Regional Planning Commission, the MPO for the Lansing, Michigan, metropolitan area, has found through surveys and other public involvement efforts that the public's highest priorities are maintaining mobility, preserving the system, and improving traffic flow through intersections and on major streets, while their lowest priority is system expansion. Given these results, the MPO is opting for a new approach to M&O that applies to all modes in congested corridors and considers a range of strategies, including road diets, traffic calming, ITS, more traditional traffic engineering treatments, and safety strategies. The MPO is also implementing approaches such as moving to continuous flow, lowering speeds, and reducing delays to optimize traffic while supporting livability, sustainability, and GHG reduction on principal arterials.

For more information: *http://www.tri-co.org/.*

[23] Khattak, Asad, Yingling Fan, and Corey Teague. "Economic Impact of Traffic Incidents on Businesses." Transportation Research Record Vol. 2067 (2008): 93-100.

[24] U.S. DOT, FHWA, *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*, 2005. Available at: http://www.ops.fhwa.dot.gov/congestion_report/index.htm.

[25] U.S. DOT, FHWA, *Managing for Planned Special Events Handbook: Executive Summary*, 2007. Available at: http://ops.fhwa.dot.gov/publications/fhwahop07108/index.htm.

In addition to improving reliability, M&O strategies can also promote livable and sustainable communities by contributing to efficient movement of people and goods on an ongoing basis, helping reduce unnecessary delay and minimize fuel consumption and costs. M&O strategies that improve system efficiency can help accommodate travel demand within the existing transportation footprint, reducing the need for roadway widening projects that can have adverse effects on surrounding communities, such as increasing barriers between neighborhoods in developed areas or injuring the beauty of the natural environment in more rural settings. Examples of these strategies include:

- **Freight efficiency improvements** include a variety of strategies focused on improving the efficiency of goods movement. For example, the Kansas City, Missouri, Cross-Town Improvement Project ties together truck and intermodal freight operations with traffic management systems to coordinate short-haul truck traffic movements between distribution centers, intermodal freight facilities, and industrial and commercial manufacturers and receivers. This reduces the number of empty truck movements within the metropolitan area.[26] Freight haulers also benefit from strategies such as weigh-in-motion and electronic toll collection, which improve travel time.
- **Automated toll collection** reduces delays for drivers at toll booths through the use of electronic devices that can collect tolls as drivers pass below sensors. Open-road tolling collects tolls at normal driving speeds and allows drivers to bypass toll booths altogether. Faster toll collection causes less delay for drivers and reduces pollution from idling vehicles. For example, Maryland toll plazas were found to reduce harmful air pollutant emissions by 16 to 63 percent.[27]
- **Adaptive traffic signal control** is designed to reduce waiting time at traffic signals to reduce delays and emissions. Adaptive traffic signal control optimizes signals along arterials corridors in real time based on traffic conditions and system capacity using detection systems and optimization algorithms. A study conducted in 2000 of five cities with adaptive traffic signal control deployments demonstrated decreases in delay by 19 to 44 percent.[28] Adaptive signal control in Toronto, Canada, was shown to reduce vehicle emissions by three to six percent and fuel consumption by four to seven percent.[29] In London, England, TSP was combined with an adaptive signal control system with a resulting seven to 13 percent decrease in bus delay.[30]
- **Reversible lanes, shoulder lanes, ramp metering, and other active traffic management techniques** have been implemented to improve traffic throughput on heavily congested corridors as an alternative to capacity expansion. These improvements allow the system to accommodate peak direction flows without adding capacity that will sit unused for much of the rest of the day. For example, in Honolulu, Hawaii, arterial management is designed to support smooth traffic flow and includes use of contraflow lanes. In Washington, DC, some major arterials use overhead signals and reversible lanes to provide more inbound traffic lanes during morning rush hours and outbound lanes during the afternoon peak. On-street parking and standard lane configurations are used during off-peak periods, enabling good pedestrian and parking access for local businesses and neighborhoods. Multiple strategies may be implemented as part of an integrated corridor management (ICM) approach.[31]

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[26] U.S. DOT, FHWA, *Identifying How Management and Operations Supports Livability and Sustainability Goals*, White Paper, April 2010.

[27] U.S. DOT, ITS Joint Program Office, *Investment Opportunities for Managing Transportation Performance through Technology*, January 2009. Available at: http://www.its.dot.gov/press/pdf/transportation_tech.pdf.

[28] U.S. DOT, FHWA, *What Have We Learned About Intelligent Transportation Systems?*, December 2000. Available at: http://ntl.bts.gov/lib/jpodocs/repts_te/13316.pdf.

[29] Greenough and Kelman, "ITS Technology Meeting Municipal Needs—The Toronto Experience," Paper presented at the 6th World Congress Conference on ITS, Toronto, Canada, November 8-12, 1999. Summarized in the U.S. DOT ITS Joint Program Office, ITS Benefits Database.

[30] Hounsell, Nick, "Intelligent Bus Priority in London: Evaluation and Exploitation in INCOME," Paper presented at the 6th World Congress Conference on ITS, Toronto, Canada, November 8-12, 1999. Summarized in the U.S. DOT ITS Joint Program Office, ITS Benefits Database.

[31] U.S. DOT, ITS Joint Program Office, "Integrated Corridor Management Systems." Available at: www.its.dot.gov/icms/index.htm.

MANAGE TRAVEL DEMAND

Managing and operating the transportation system to improve livability and sustainability means not only reducing unnecessary travel delays but also managing travel demand in ways that support more transportation choices and more efficient use of the transportation system. Transportation demand management (TDM) includes a host of strategies that encourage travelers to use the transportation system in a way that contributes less to congestion, improves air quality, and enhances quality of life. TDM covers many aspects of trip-making, including:

- Whether to make a trip (through options such as telecommuting).
- What mode to use (by encouraging travelers to shift from driving along to ridesharing, transit, or walking and bicycling).
- When to make the trip (by encouraging shifts to off-peak periods).
- What route to choose (by encouraging use of less congested facilities).

TDM addresses travel behavior and habits, seeking to influence travelers' decisionmaking before and during trips. Urban planning and design can complement these M&O strategies by encouraging development that reduces the distance between destinations and facilitates access by all modes.

Managing travel demand brings many benefits to communities and travelers. By introducing choice and flexibility into the transportation system, TDM reduces congestion and improves overall traffic flow. TDM also reduces stresses on transportation infrastructure by reducing both use of existing resources and the need to expand capacity. Reduced congestion and overall VMT from TDM strategies help to reduce air pollution and greenhouse gas emissions. Finally, TDM reduces travel expenses for individuals by reducing gas consumption and reducing the time spent in traffic.

Sample strategies to manage travel demand include:

- **Ridesharing programs** to promote carpooling and vanpooling. This strategy may include a ride-matching program that connects drivers with similar origins, destinations, and schedules. Employers will sometimes sponsor vanpools by subsidizing the vehicle costs. Some locations also provide reserved parking for carpools and vanpools. High-occupancy vehicle (HOV) lanes incentivize ridesharing with faster travel times. HOT lanes offer the same benefits to carpoolers while also allowing non-carpool vehicles to pay to use the lanes.
- **Price signals** such as variably priced toll lanes, parking pricing, or higher transit fares in the peak period for congested transit systems. These strategies encourage travelers to use higher occupancy

TDM in Rural Recreational Situations

Glacier National Park, Montana

TDM has a role to play outside of congested urban areas. In rural communities with large influxes of visitors, TDM can help manage demand to reduce impacts on the natural environment and surrounding communities while improving safety for residents and visitors. Glacier National Park is an example of how providing alternatives can do this.

Since 2007, Glacier National Park has run a free shuttle system so visitors can safely travel through the park and avoid traffic and parking problems. In 2003, the park created the Red Bike Program to supply a fleet of bicycles for employees to use for work or recreational trips. The shuttles and bicycle fleet have expanded access, limited vehicular emissions, and reduced traffic by 20 percent.

For more information, contact Susan Law, FHWA at *susan.law@dot.gov*.

Lake Washington Corridor—State Route (SR) 520

Seattle, Washington

U.S. DOT's Urban Partnership Agreement program includes implementation of four "Ts": tolling, technology, transit, and telecommuting/TDM. One recipient of funding is the Puget Sound region, which will focus on the SR 520 corridor that links downtown Seattle to the Eastside area of Lake Washington. The project involves implementation of variable pricing on SR 520 to maintain free-flow traffic in the through lanes, discounted or free access for vehicles with three or more occupants, enhanced bus services, and real-time multimodal traveler information. The project also includes an active traffic management system that will be installed on SR 520 and I-90, which will consist of a series of electronic speed limit, lane status, and dynamic message signs over each lane on the SR 520 and I-90 bridges over Lake Washington.

For more information: *http://www.wsdot.wa.gov/Projects/LkWaMgt/*.

modes (such as with HOT lanes) or to shift their travel to portions of the system with lower demand, whether that be by traveling at a different time, using a different route, or parking in a different location.

- **Other incentives** to encourage travelers to reduce vehicle travel demand. These can include subsidies for ridesharing or transit passes, activity-based promotions and commuter rewards, and preferred parking for rideshare vehicles. Guaranteed ride home programs can also incentivize alternative modes by alleviating concerns about being stranded if a traveler must stay late or leave early from work and cannot participate in his or her regular carpool, vanpool, or transit ride home. The programs generally reimburse participants for taxi fare or rental car on a day that they used one of these options and needed to return home unexpectedly during the day (such as for a sick child).

Commuter Rewards Program

Atlanta, Georgia

Atlanta has a commuter rewards program that since 2002 has offered participants $3 per day (up to $100) for each day they use a commuting alternative within a consecutive 90-day period. According to a 2003 survey, 64 percent of participants continue to use alternative modes 9 to 12 months after the program, even without an incentive. The program has experienced increased interest over the last several years, with more than 8,500 people enrolling in 2008—a threefold increase over 2007.

The Clean Air Campaign in metropolitan Atlanta runs the commuter rewards program as part of a full suite of travel demand management activities. Overall, the TDM program prevents more than 200,000 tons of pollution annually in the region.

Source: Center for Transportation and the Environment, *The Clean Air Campaign Cash for Commuters Program Survey: Technical Report*, 2010.

- **Parking policies** manage the supply and use of parking through strategies such as preferential parking for carpools or car sharing vehicles, and hourly pricing. Parking management can also reduce infrastructure costs by reducing the need to build parking spaces, which are costly to provide and do not in themselves contribute to community vitality. Use of existing parking space can be maximized through the use of shared parking, where users with parking demands that do not overlap share parking lots. For example, church parking lots may be used as park-and-ride lots during the workday, when church parking demands are low. Similarly, sometimes available parking is not immediately visible to motorists and occupancy sensors coupled with communications technologies can alert and direct drivers to such spaces.
- **Car sharing** is a form of short-term car rental that gives members access to vehicles stationed around the community. Vehicles can be reserved by the hour via smartphone, Internet, or call centers. Members get access to vehicles via a smart card and vehicles must generally be returned to the same location they are rented from. Car sharing is an alternative to vehicle ownership in places where people can use alternative modes to get to many or most of their destinations. The programs allow members to reduce the use of their own vehicles, reduce the number of vehicles they own, or eliminate vehicle ownership altogether. This reduces vehicle ownership costs for members while still providing access to a full range of mobility options. For communities, car sharing can help to reduce emissions and congestion. Car sharing programs exist in communities throughout the United States; as of July 2011, there were 26 programs with more than 560,000 members sharing more than 10,000 vehicles.[32]
- **Telecommuting and flexible work schedules** address travel demand by eliminating commute trips or shifting trips to off-peak periods. Less peak period travel reduces congestion, which improves air quality. These programs can also offer important quality of life benefits to participants by reducing the stress of commuting and by allowing workers to balance family and work needs, such as fitting their schedules to school schedules.
- **Freight demand management** involves strategies such as shifting a portion of trucks to off-peak travel times on appropriate facilities. The Chicago Metropolis 2020 Freight Plan included analysis of an alternative where 20 percent of truck traffic was shifted away from morning and evening peak periods and ten percent was shifted from the midday peak period to overnight. This resulting reduction in

[32] Shaheen, Susan and Adam Cohen. Carsharing. Innovative Mobility Research, University of California, Berkeley. Available at: http://www.innovativemobility.org/carsharing/index.shtml.

21st Century Parking Management

SF*park* and ParkPGH

Real-time parking information can help reduce travel delay and emissions (and driver frustration) by reducing the need for drivers to circle around looking for parking. Two recent programs in this area are:

SFpark Begun in 2010, SFpark is a demand-responsive parking pricing and management system. The pilot effort provides real-time parking availability information for on- and off-street parking and also incrementally raises or lowers parking prices based on demand to maintain a minimum level of parking availability. SFpark uses parking meters that accept credit cards and mobile device applications, text messages, and electronic display signs to help improve parking efficiency. For more information, go to: *http://sfpark.org/*.

ParkPGH A project of The Pittsburgh Cultural Trust In Pittsburgh's downtown cultural district, ParkPGH provides real-time information on available parking. An application, website, and call-in phone number all allow travelers to get current information on the number of available spaces in all nearby garages, with data updated each minute through a feed from the gate system at each garage. This makes it easier for the public to access cultural institutions and may reduce travel delay and emissions by avoiding searches for available parking. For more information, go to: *http://parkpgh.org/*.

vehicle hours traveled was estimated to yield an estimated $1.4 billion in direct savings to Chicago metropolitan area businesses.[33] This strategy was estimated to not only significantly reduce delay for commercial vehicles but also provide a boost to the regional economy. (Note: The ability to shift truck traffic to off-peak delivery times, though, is largely dependent on whether freight receivers are available to receive goods shipments at off-peak times.)

- **Active transportation and demand management** is an emerging concept that integrates the concepts of active traffic management and travel demand management. It is a proactive approach to dynamically manage and control the demand for and available capacity of transportation facilities, based on prevailing traffic conditions, using one or a combination of real-time and predictive operational strategies.[34]

PROVIDE INFORMATION TO SUPPORT CHOICES

Managing and operating a multimodal transportation system for improved livability and sustainability involves providing timely and accurate information to system users on transportation conditions. With a greater level of awareness, travelers and freight carriers can make better decisions about when or if to travel, which route to take, and which mode to choose. This contributes to livability through greater predictability of services, more options for avoiding delay, and a higher-quality travel experience. In addition, this information can save lives and reduce injuries by informing the public when road conditions are unsafe and enabling commercial vehicle drivers to locate available parking for critical rest periods. Providing traveler information that helps system users avoid congestion and facilitates taking transit, walking, and bicycling significantly supports environmental sustainability by reducing motor vehicle emissions and infrastructure needs.

Traveler information is vital to managing the surge in travel demand for special events and is used to help attendees plan their travel before the event, en route to the event, and after the event. Traveler information is also crucial in diverting traffic or passengers during an incident, adverse weather, and active work zones.

The Washington State Department of Transportation (WSDOT) provides an extensive website that supplies travelers with real-time traffic flow data, estimated travel times, wait times on popular routes, and traffic camera images updated every 1.5 minutes. WSDOT also operates a 511 telephone service that provides contact information for rail,

[33] Economic Development Research Group, Inc., "Assessing the Economic Impacts of Congestion Reduction Alternatives," in Chicago Metropolis Freight Plan, Chicago Metropolis 2020, 2004. Available at: *http://www.edrgroup.com/library/freight/the-chicago-metropolis-freight-alternatives.html*.

[34] U.S. DOT, FHWA, *Synthesis of Active Traffic Management Experiences in Europe and the United States*, May 2010. Available at: *http://www.ops.fhwa.dot.gov/publications/fhwahop10031/index.htm*.

bus, ferry, and airline operators, as well as construction and traffic incident information. All of this information is managed through a state-of-the-art speech recognition program that allows callers to ask for specific information about travel times or traffic flow on specific highways.[35] The Niagara International Transportation Technology Coalition (NITTEC) provides a similar tool for travelers in its member jurisdictions in the form of a regional transportation information clearinghouse. In this case, partner agencies within NITTEC pool transportation information to provide travelers with comprehensive views of the region and a greater level of customer service than any single agency within NITTEC could provide.[36]

Cross-State Traveler Information, North/West Passage Corridor (Interstates 90 and 94)

Interstates 90 and 94 between Wisconsin and Washington are major corridors for commercial and recreational travel. The extreme winter weather conditions prevalent in the states within this corridor pose significant operational and travel-related challenges. Through the North/West Passage Corridor, the nine States along this corridor are working together to address shared transportation issues related to traffic management, traveler information, and commercial vehicle operations along the corridors. Projects completed thus far include the development of a traveler information website for the entire corridor (*www.i90i94travelinfo.com*) and defining a common set of phases to describe events (incidents, weather) that all States have agreed to use for the corridor. Previously, each State had its own phrases, which made sharing information across states more difficult.

In Singapore, travelers can now access multimodal trip information from on their mobile phones with a public service known as MyTransport.SG offered by the Land Transport Authority. Using location-based service technology to detect the user's location, MyTransport.SG provides real-time bus information, locations for light rail and premium bus service, and a trip planner that shows how to get to a destination via public transportation. For the motorist, it also provides real-time availability at parking lots in a number of areas, live traffic cameras, and up-to-date traffic information including locations of incidents and work zones.[37]

In Japan, motorists can access real-time traveler information in their vehicles using the vehicle information and communication system (VICS). VICS uses roadside infrastructure to detect congestion and then broadcasts traffic information by character multiplex, radio beacons, or optical beacons to vehicles. It can be displayed in the vehicle as text or on a map.[38]

Source: Partners for Advanced Transportation Technology (PATH)

Comparative Travel Times for Car Versus Train

San Mateo County, California

On U.S. 101 in San Mateo County, California, variable message signs display real-time highway travel times to downtown San Francisco alongside transit travel times on the nearby Caltrain commuter train service. Transit information also includes the departure time at nearby park-and-ride stations. This information allows travelers to make modal decisions en route, depending on the conditions. The signs are an integral part of Caltrans' multimodal integrated corridor management approach.

Source: Mortazavi et al., Travel Times on Changeable Message Signs, 2009.

[35] U.S. DOT, FHWA, Livability Initiative Case Studies, July 2010. Available at: *http://www.fhwa.dot.gov/livability/case_studies/*.

[36] U.S. DOT, FHWA, *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration*, August 2007. Available at: *http://ops.fhwa.dot.gov/publications/benefits_guide/index.htm*.

[37] Land Transport Authority, "PublicTransport@SG A Delightful Journey, A Greener Choice," 2009. Available at: *http://www.publictransport.sg/publish/ptp/en.html*.

[38] Greenough and Kelman, "ITS Technology Meeting Municipal Needs—The Toronto Experience," Paper presented at the 6th World Congress Conference on ITS, Toronto, Canada, November 8-12, 1999. Summarized in the U.S. DOT ITS Joint Program Office, ITS Benefits Database.

SUPPORT PLACEMAKING

As both urban and rural jurisdictions increasingly seek development that enhances community vitality, the concept of "placemaking" continues to increase in importance. Placemaking emphasizes the connections between land use and transportation, as well as urban design and operations. Rather than just building roads to provide access and mobility, this approach to transportation planning, design, and operations emphasizes context-sensitive solutions that integrate transportation, building, and landscape design to create a "sense of place."

> *"Placemaking is a multi-faceted approach to the planning, design and management of public spaces. Put simply, it involves looking at, listening to, and asking questions of the people who live, work and play in a particular space, to discover their needs and aspirations. This information is then used to create a common vision for that place. The vision can evolve quickly into an implementation strategy, beginning with small-scale, do-able improvements that can immediately bring benefits to public spaces and the people who use them."*
>
> — Project for Public Spaces

Through coordinated land use, design, and operations strategies, placemaking can help a community tell a story about its history and promote the type of development and transportation facilities that residents prefer for their community. Virtually no group of residents promotes a future community vision consisting of a transportation system allowing only for automobile travel or promoting higher speeds and vehicle volumes on local streets. As a result, placemaking generally supports development that focuses vehicle traffic on appropriate arterials, supports transit where feasible, provides a comfortable walking and bicycling environment to local destinations, and promotes livability and sustainability principles.

M&O strategies can work hand-in-hand with community development by improving roadway network connectivity, access management, reliability, safety, and land use and transportation coordination. As a result, M&O strategies can also play a vital role in developing unique places that support community vitality and reflect the desired character of communities. Successful placemaking often depends on selecting appropriate M&O strategies that complement planning and design efforts and that implement local visions identified through community outreach.

Specific M&O strategies that support placemaking efforts and also have beneficial impacts on mobility, livability, and community design include:

- **Road diets**, or "right-sizing," which combine M&O elements of traffic calming and complete streets to support livability and sustainability, promote transportation choices, and support placemaking. Road diets reduce the number of through travel lanes on a roadway and repurpose that right of way for other uses, such as improved pedestrian and bicycle facilities, on-street parking, and/or landscaping. Although many road diet projects involve nothing more than restriping, they have been found to enhance the surrounding environment, reduce crashes for all modes, promote non-motorized transportation use, and provide cost-effective traffic calming benefits.
- **Network connectivity** enhances livability and sustainability goals by supporting a variety of transportation options for travelers. A well-connected street grid provides direct routes for bicyclists and pedestrians; a variety of routes for vehicles to help reduce congestion and provide alternative routes in case of incidents, construction, or special events; and multiple routes that can be designed to "sort" traffic and provide different travel environments for different modes and trip types. Although changes to network connectivity frequently involve capital investments such as building new roads or paths, M&O strategies can also improve connectivity. For example, converting one-way streets to bidirectional travel can increase connectivity and access while also providing traffic-calming benefits.

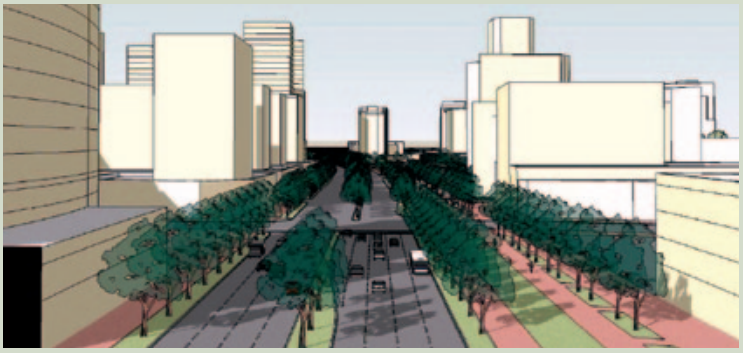
White Flint Sector Plan

Montgomery County, Maryland

White Flint was first proposed as an urban, mixed-use center more than 30 years ago, when Metrorail service was extended to the area. Although the area had ample transit access, White Flint's suburban street layout made direct connections between transit and other destinations difficult. In addition, pedestrian and bicycle conditions were poor and the Rockville Pike acted as a barrier in the community.

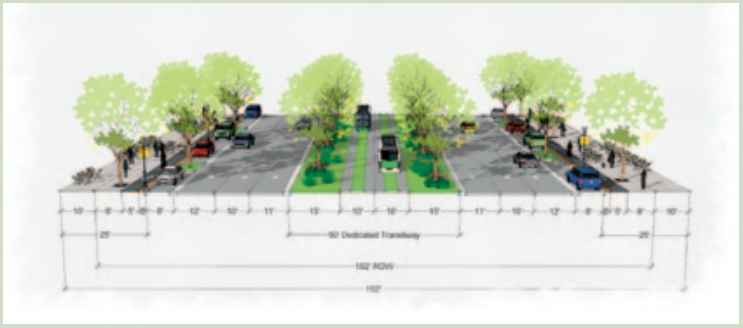
The White Flint Sector Plan aims to transform the area into a vibrant transit-oriented development through a variety of placemaking and management strategies, including:

- Transforming Rockville Pike into a boulevard with street trees and improved crosswalks.
- Developing a transportation network that includes a grid of new public streets and multimodal street hierarchy.
- Improving the pedestrian and bicycling environment.
- Adding bus priority lanes.
- Promoting sustainable development.



Source: Montgomery County Planning Department

Rockville Pike Boulevard and Promenade Cross Section



Source: White Flint Partnership

Alternative Rockville Pike BRT Cross Section

For more information:
http://www.montgomeryplanning.org/community/whiteflint/.

- **Roundabouts**, an alternative to traffic signals that offer multiple safety, operational, and placemaking benefits. From an operations and livability perspective, roundabouts can slow traffic while increasing capacity, reduce queuing and congestion, reduce the frequency and severity of collisions, and minimize potential vehicle-pedestrian conflicts. Roundabouts can also serve in a placemaking role by acting as a gateway treatment and a focal point for businesses or by housing distinctive landscaping or artwork within the center island. Several States and communities consider roundabouts as an equal or better replacement for signals.
- **Truck delivery parking** that supports commercial retail stores and other businesses valued in livable communities. Appropriately designed commercial streets and truck delivery parking areas near businesses enable businesses that rely on truck deliveries to receive necessary goods in a timely manner. Appropriately designed truck delivery parking, particularly curbside parking, also reduces double parking, helping to reduce roadway congestion while improving safety for pedestrians, bicyclists, and motorists.

USE BALANCED PERFORMANCE MEASURES

The performance measures transportation agencies use to evaluate a transportation system and the ways that these metrics are defined and measured significantly impact how the transportation system is managed and operated. Incorporating livability into transportation agencies' performance frameworks necessitates rethinking auto-oriented mobility goals and measures. Effectively evaluating the impact of M&O strategies on livability and sustainability requires new performance measures that are focused on efficient movement of people and goods rather than vehicles and that consider the effects of the transportation network on the full range of livability and sustainability outcomes (e.g., social equity, economic impacts, environmental quality).

For instance, as part of the Federally-required CMP in metropolitan areas larger than 200,000 people, some regions are moving from traditional volume/capacity-based congestion measurement to a broad range of congestion measures that address community concerns, such as multimodal transportation system reliability, access to multimodal travel options, and access to traveler information.[39] These measures help regions consider a broader range of solutions to congestion, including more M&O strategies.

When implementing these performance measures, agencies may need to find new data sources to consistently evaluate some measures. For example, many agencies lack the data to calculate multimodal level-of-service and travel time reliability measures.

Livability performance measures may be context-specific and defined at the community scale. For example, the different needs of urban and rural transportation system users influence how they define livability and the priority they apply to different travel modes and performance metrics. Although specific metrics and methodologies vary by agency, livability and sustainability are generally implemented using the triple bottom line approach of measuring impacts related to economics, environment, and equity. Programs that have successfully integrated M&O, livability, and sustainability in their performance management process appear to share several characteristics, including flexibility or context sensitivity, public involvement in measure selection and development, multidisciplinary or interagency collaboration, and scenario planning or other practical applications of measures. Other key factors to consider when selecting measures include:

- Select measures that directly relate to broader agency and stakeholder goals.
- Measures should be outcome-based.
- Consider data availability and cost.
- Measures should be objective, easily understood, and reproducible.

Table 3 illustrates potential M&O performance measures related to each of the livability principles of the Federal Partnership for Sustainable Communities.

Caltrans Smart Mobility Framework

"Smart Mobility moves people and freight while enhancing California's economic, environmental, and human resources by emphasizing: convenient and safe multimodal travel, speed suitability, accessibility, management of the circulation network, and efficient use of land."

The Caltrans Smart Mobility Framework was developed through a partnership between Caltrans, the California Department of Housing and Community Development, and the Governor's Office of Planning and Research. The framework establishes six Smart Mobility goals that are supported by 17 Smart Mobility Performance Measures. The goal of each measure is to demonstrate the relationship between specific land use and transportation decisions and consequent effects on economic, social, and environmental conditions.

The performance measures evaluated and targets used are tailored to address the needs of seven specific "place types" (e.g., urban, suburban, rural, special use). Certain performance measures, such as collision rates by mode, speed suitability, travel time, and consistency receive high priority for all place and facility types, while the priority of measures such as network performance optimization and speed management, may vary by facility and place type. Use of reasonable professional judgment is recommended when applying Smart Mobility performance measures.

For more information:
http://www.dot.ca.gov/hq/tpp/offices/ocp/smf.html.

[39] U.S. DOT, FHWA, *Congestion Management Process: A Guidebook*, April 2011. Available at: http://www.fhwa.dot.gov/planning/congestion_management_process/cmp_guidebook/chap01.cfm

Table 3 Potential M&O Livability Performance Measures

Livability Principle	M&O Performance Measure
Provide more transportation choices	• Multimodal Level of Service • Transit Accessibility and Coverage • Mode Share • Person Delay (rather than vehicle delay)
Promote equitable, affordable housing	• Jobs/Housing Balance • Location Efficiency • Housing and Transportation Index (combined housing and transportation cost/affordability)
Enhance economic competitiveness	• Travel Time Reliability • Workforce Accessibility • Job Accessibility • Travel Time Index
Support existing communities	• Accessibility to Essential Destinations (e.g., stores, healthcare, schools) • Safety (crashes by mode) • Vehicle Speed Suitability
Coordinate policies and leverage investment	• Consistency with Local Land Use and Transportation Plans • Return on Investment • Cost-Benefit Ratio
Value communities and neighborhoods	• Connectivity Index • Community Character (e.g., resident satisfaction)

COLLABORATE AND COORDINATE BROADLY

Creating livable and sustainable communities requires carefully balancing the needs of multiple segments of a population in the current generation as well as future generations to ensure a healthy, vibrant quality of life for all. To achieve this balance, these diverse perspectives must be heard and incorporated into the decisions regarding the management and operation of the transportation system through full collaboration and coordination of a broad range of stakeholders.

In the Netherlands, more than 300 companies, government agencies, and knowledge institutes joined together in 2005 as part of the Transumo Foundation to lead a transition toward sustainable mobility in the country. Motivated by the inefficiency of the current transportation system and the policies that impede sustainable development, the group began the TRADUVEM project to organize a broadly collaborative transition process that brings together traffic management and transition management professionals as well as other stakeholders to define what sustainable transportation should look like and how to achieve the transition to that vision. TRADUVEM is responding at least in part to a lack of integration between public and private entities, levels of organizational management, regions, and

management and infrastructure planning that has held back widespread innovation in traffic management. The project aims to work toward innovation in traffic management and achievement of the following paradigm shifts:

- "From management of the 'status quo' to management of variation.
- From traffic management to network management.
- From reactive to proactive management.
- From external control to hybrid (external and internal) control.
- From emphasis on throughput to emphasis on sustainability (throughput, safety, environment, livability, etc.)."[40]

In Portland, Oregon, the MPO hosts a Regional Travel Options Subcommittee of 20 agencies and stakeholder organizations that work together to "promote and support travel options to help cut vehicle emissions, decrease congestion and create a healthier community."[41] In 2008, the subcommittee helped develop the Regional Travel Options 2008-2013 Strategic Plan that defines the goals, objectives, and strategies for the Portland region's travel options program. Projects resulting from the plan receive funding through Metro's transportation improvement program. This highly active program creates user-friendly resources for the community to encourage walking, bicycling, and ridesharing.

The management and operation of a regional or statewide transportation system also requires coordination and collaboration among multiple agencies and jurisdictions. A seamless travel experience for the public requires that operating agencies work together to provide comprehensive traveler information, coordinated traffic signals, and efficient management of incidents, special event, or work zones that affect neighboring jurisdictions. High levels of interagency collaboration occur throughout the United States, including the NITTEC, a consortium of 14 agencies in the Niagara region of New York and Ontario that have come together to work toward a common mission to "improve regional and international transportation mobility, promote economic competitiveness, and minimize adverse environmental effects related to the regional transportation system."[42] This ongoing collaborative effort and others are described in the FHWA report *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration*.[43] By coordinating transportation management with regional partners, member organizations can improve the efficiency and reliability of transportation services while using fewer resources.

Coordination and collaboration can also occur at the project level. Coordinating neighborhood traffic management program studies and projects to address whole districts and the impact of the overall system is another opportunity to promote livable and sustainable communities.[44]

User-Friendly Resources to Promote Walking

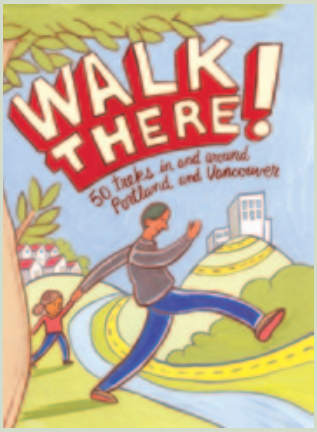


Image: Metro

Published by Portland Metro Regional Government and funded by a health provider, Walk There! is a guidebook with 50 treks in and around Portland and Vancouver.

[40] Immers, Ben, Isabel Wilmink, Paul Potters, *Transitions Towards Sustainable Traffic Management*, 2007. Available at: http://www.transumofootprint.nl/Library/document.aspx?ID=389.

[41] Portland Metro, *Regional Travel Options 2008-2013 Strategic Plan*, 2008. Available at: http://library.oregonmetro.gov/files/rto_strategicplan_6-10-08.pdf.

[42] NITTEC, Niagara International Transportation Technology Coalition homepage, http://www.nittec.org/.

[43] U.S. DOT, FHWA, *The Collaborative Advantage: Realizing the Tangible Benefits of Regional Transportation Operations Collaboration*, August 2007. Available at: http://ops.fhwa.dot.gov/publications/benefits_guide/index.htm.

[44] Dock, Frederick C., "Pasadena's Next Generation of Transportation Management," ITE Technical Conference and Exhibit, 2010.

Putting it All Together

As livability and sustainability principles become engrained with M&O practices, the future of M&O is likely to look quite different than current practice. This section describes a vision for a future where livability and sustainability goals are driving forces behind M&O practices and M&O is fully integrated into community plans and projects. While the examples shown are comprehensive and far-reaching, they also describe an achievable vision. Taken individually, each strategy is based on real-world examples from current practice; in some cases, several elements have been implemented together.

MULTIMODAL CORRIDOR STRATEGY: URBAN/SUBURBAN ROADWAY TRANSITION

The vision for reengineering and revitalizing a typical urban or suburban multimodal corridor incorporates an interconnected system of projects that can be implemented incrementally—project by project—over time as funding is available. A new network of local roads parallel to the main corridor can be built by developers as new development occurs, or as part of redeveloping existing "greyfield" shopping centers. Available public funding can be targeted toward "connecting the dots" of private investment. The strategy can support improved transit using a transit-ready development approach. Using the corridor as a transit target and a magnet to focus a public and private investment along with supportive M&O strategies can multiply the effectiveness of limited dollars and staff time.

Integrated transportation and land use planning, including a focus on effective system operations to support livability and sustainability, can help prioritize other public and private investments (State, local, Federal, and private) in housing, community development, brownfield revitalization, parks, schools, healthcare, and senior centers. An engaging public process can be an ideal opportunity for education and outreach on how M&O strategies can help support and maximize strategic capital investments. For instance, presenting details on a variety of cost-effective M&O strategies, like ride-sharing programs, transportation demand management strategies, pedestrian countdown signals, real-time transit information, and transit system scheduling and reliability improvements, within a corridor planning process can increase awareness and support for redevelopment and transit initiatives. Even if the vision is grand, relatively small incremental actions can start to add up—completing the sidewalk and bicycle networks to connect apartments, schools, and shopping; making every street walkable and bikeable within a ½ mile of every transit stop; or just making the street safe to cross at each bus stop.

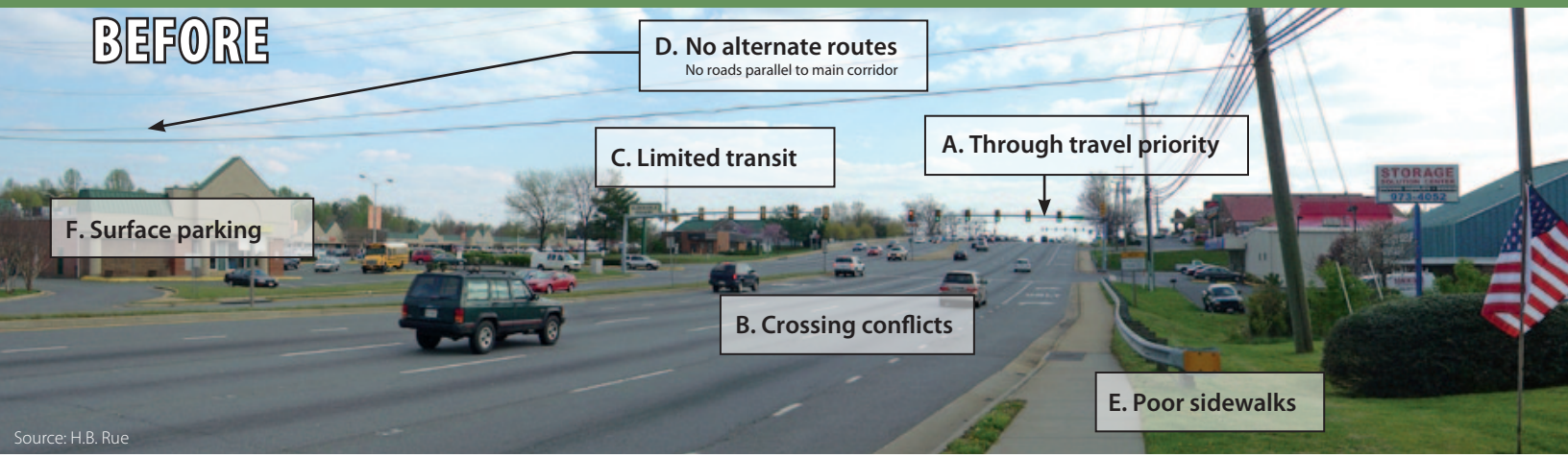
U.S. DOT's Integrated Corridor Management Systems initiative[45] is researching and testing effective M&O strategies for coordinating multimodal transportation operations along congested travel corridors. The graphics on the following pages describe how a similar approach can work on typical urban and suburban non-limited-access arterial corridors:

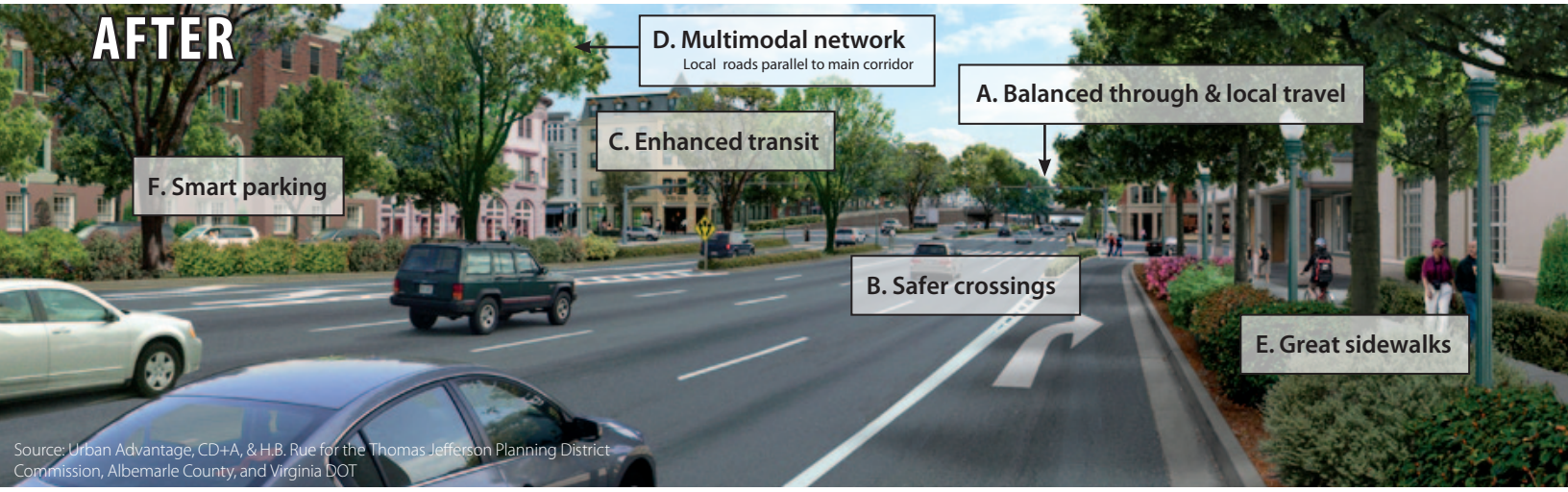
- The **Multimodal Corridor Strategy** before-and-after photo-simulations (see next page) show how a typical corridor can be transformed incrementally over time with public and private capital improvements (in multimodal transportation, housing, mixed-use development, and infrastructure) and a coordinated system of cost-effective M&O investments. The example pictures and captions (see page 34) provide more details on the corridor strategy.
- A **phased M&O implementation strategy** (see page 35) outlines example step-by-step actions.
- The final page in this section outlines how a fully integrated **Regional Transportation Systems Management and Operations Strategy** could coordinate all system elements while supporting regional sustainability and local livability.

[45] U.S. DOT, ITS Joint Program Office, "Integrated Corridor Management Systems." Available at: www.its.dot.gov/icms/index.htm.

Multimodal Corridor Strategy

Suburban Corridor





BEFORE

A. Through travel priority. Typical suburban corridor; signals timed to prioritize through traffic; extended delays for crossing traffic; limited pedestrian crossing time and crosswalks.

B. Crossing conflicts. Mix of four through-travel lanes and two to three turn lanes on each side makes pedestrian crossings hostile and difficult; conflicts with turning and through-travel movements.

C. Limited transit. Limited transit service, no transit stop amenities; no transit signal preference or real-time traveler information.

D. No alternate routes. No nearby parallel roads. All local and through traffic mixes on main corridor, causing over-sized facility and negative impacts on operations and business access.

E. Poor sidewalks. Sidewalks present, but no separation from fast-moving traffic. Limited pedestrian access to businesses. No bicycle lanes or trails on or adjacent to corridor. No shade or lighting for pedestrians.

F. Surface parking. Excessive surface parking for each business inhibits customer access by walking and transit, due to street set-backs and separation between buildings.

Additionally...

No integrated traveler information system for drivers, transit users, and car sharing. Limited detour routes available for incident management and no traveler information system for use in incidents.

AFTER

A. Balanced through & local travel. Tight urban grade separation provides free flow for through traffic and improves cross-traffic. Multimodal bridge supports walk and bicycle crossings and local circulator transit. Adaptive traffic signal control balances through and local traffic, pedestrian, and bicycle travel.

B. Safer crossings. New landscaped pedestrian islands and left turn lanes provide pedestrian refuges and separated crossing movements from turning and through traffic.

C. Enhanced transit. Expanded transit or BRT to serve new development includes transit signal priority, shelters and seating, real time traveler information, and bicycle sharing stations.

D. Multimodal network. New local zoning codes (planned with corridor improvements) encourage transit-ready mixed-use development. New network of parallel roads, built with development, supports walking, biking, and circulator transit. Primary walking and biking routes are on adjacent roads.

E. Great sidewalks. Wide sidewalks set back from traffic provide improved pedestrian operations and business access. Street trees for shade, landscaping for separation, and lighting for security improve pedestrian comfort and safety.

F. Smart parking. New development provides ample shared use structured parking for residential and commercial use. Parking management district provides clear real-time parking availability and variable pricing information (for both on- and off-street) via web, smartphone, and signage. Parking provides car share stations (e.g., ZipCars), secure bicycle parking and lockers, and charging stations.

Additionally...

Integrated transportation system management provides real-time traveler information via web, smartphone, TV/radio/phone, and signs at transit stops and parking. System also tied to incident management, police and rescue systems, providing delay and detour information via new road network.

Multimodal Corridor Strategy

The pictures and captions on this page provide some details about the corridor strategy graphics on previous page. See text labeled with same letter (A through F) in the 'After' column under the corridor graphics.

A

Source: H. Liu, Assoc. Prof. of Civil Engineering, University of Minnesota

Balanced through & local travel. Adaptive traffic signal control balances queuing both for through traffic on the corridor and local traffic on the cross streets. Bicycle detector loops and pedestrian countdown signals improve bicycle and pedestrian travel.

B

Source: Urban Advantage, CD+A, & H.B. Rue for the Thomas Jefferson Planning District Commission, Albemarle County, and Virginia DOT

Safer crossings. Channelized right and left turn lanes with landscaped pedestrian islands can provide pedestrian refuges, while separating crossing movements from turning and through traffic.

C

Source: S. Trainor

Enhanced transit. Stops include comfortable shelters and seating with real time traveler information.

D

Source: City of Charlotte, NC

Multimodal network. A network of new roads parallel to the main corridor can be built around planned transit stations as development occurs, as shown in this concept design for U.S. 29 in Charlotte, NC.

E

Source: H.B. Rue

Great sidewalks. Wide sidewalks set back from traffic, street trees, landscaping, and lighting provide improved pedestrian comfort, security and safety.

F

Source: F. Dock

Smart parking. Active parking management can provide clear real-time parking availability and variable pricing information via signage, web, and smartphone. Priority parking for car sharing and vanpools can support increased use.

MULTIMODAL CORRIDOR PHASED OPERATIONS PLAN

A corridor operations plan, integrated into a regional vision for a livable, sustainable community, can be implemented over time across multiple aspects of transportation planning, safety, land use, and operations. For example:[46]

- **In year two**, a safety project may fix a critical intersection problem, install new signal system technology, and improve intersections to Americans with Disabilities Act (ADA) standards.
- **In year three**, bicycle lanes are added as part of a planned resurfacing project. A new local comprehensive plan, based on the regional vision, is adopted and encourages transit-ready walkable, mixed-use development.
- **In year four**, the new corridor access management overlay zone results in closing several driveways, combining others, and adding sidewalks.
- **In year five**, a change in land use allows addition of channelized turn lanes, pedestrian islands, and connection of sidewalks to serve newly developed apartment complexes. New local zoning codes are adopted, based on the comprehensive plan, allowing more intense redevelopment near transit targets.
- **In year six**, an off-road bicycle connection, built as part of a new development, links to the region's trail system, while new and enhanced transit service is added to serve the corridor.
- **In year seven**, resurfacing and reconstruction resolves pavement deficiencies and adds a new cross-section, replacing an eight-lane undivided facility with six lanes, a landscaped median, and bicycle lanes throughout part of the corridor, with a four-lane divided section where volumes permit.
- **In year eight**, a roundabout resolves an upstream capacity bottleneck and serves as a gateway to the revitalized corridor.
- **In year nine**, new electronic signs are added that direct users to available parking with real-time parking data also available via web and smartphones.
- **In year ten**, an enhancement project permits relandscaping the streetscape in the corridor and completes final bicycle and pedestrian linkages. Also, TSP is implemented as the commercial and residential developments continue. Each development is integrated into the interconnected local road, walking, bicycling, and transit network.
- **In year twelve**, a regional bus rapid transit system is implemented, focused on newly-developed transit targets. The BRT system relies on signal preference technology to maintain schedule, with traveler information provided to customers via next-bus signs at each stop, and via web and smartphone.
- **In year fifteen**, an urban-scaled grade separation at a key roadway crossing is added to improve both local multimodal travel and through traffic flow.

REGIONAL TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS (SEE NEXT PAGE)

The graphic on the next page outlines how the implementation of fully integrated regional transportation systems management and operations can help coordinate multiple transportations systems run by many agencies and operators, to provide seamless service across all travel modes.

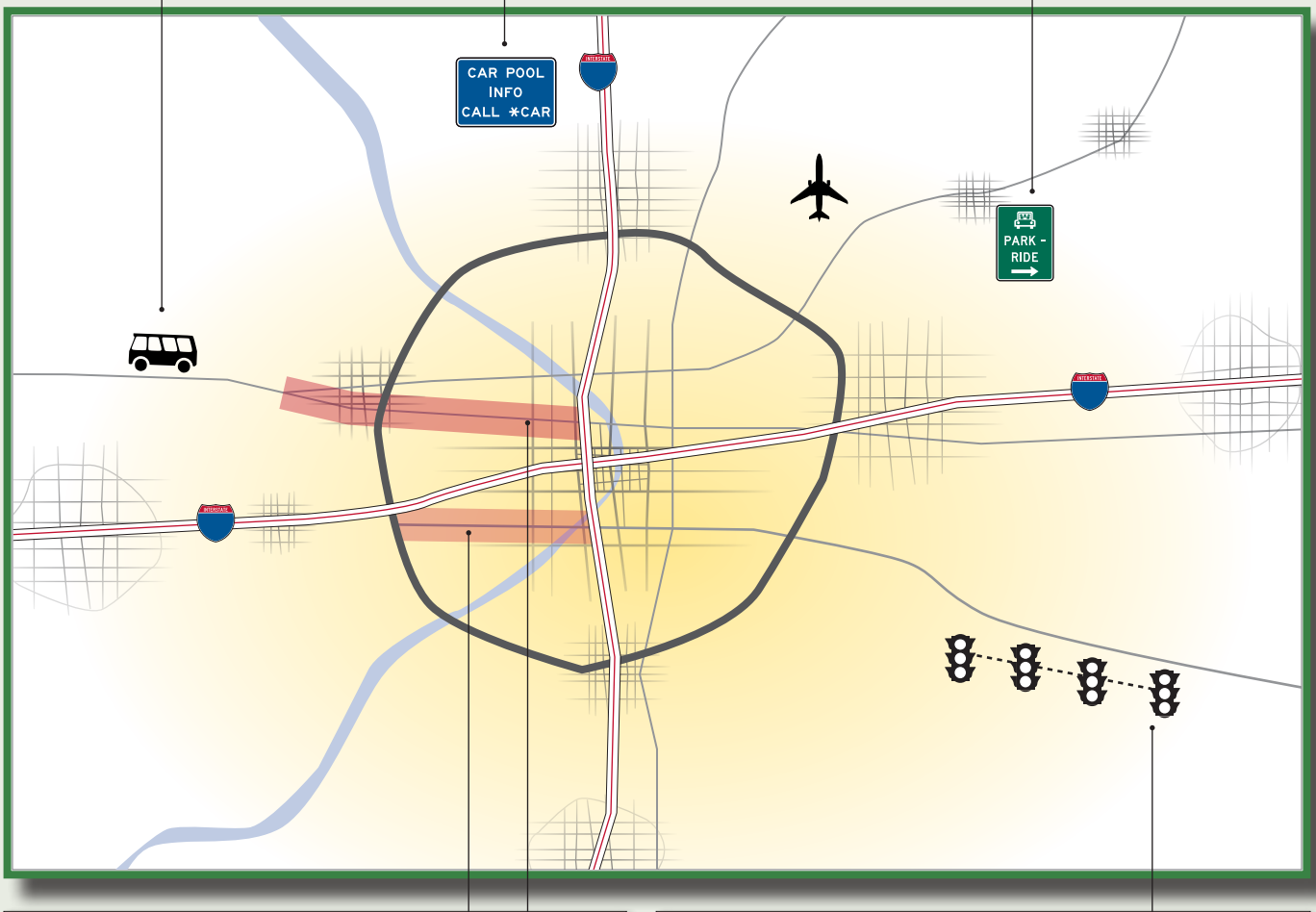
[46] Example phased approach is adapted from Hamilton, Paul, "Implementing A Smart Growth Land Use Pattern To Manage Congestion & Safety By Integrating Regional Transportation Futures Alternatives Analysis With A Regional Concept of Management and Operations (RCMO): A Case Study in Performance Based Planning," presented at Intersection Safety: Achieving Solutions Through Partnerships conference, March 2004.

Regional Transportation Systems Management and Operations Strategy

Many agencies, one coordinated transportation system, providing seamless service across all modes.

Regional carpool, vanpool, and on-demand rural transit integrated with web-based information and scheduling systems, and linked to scheduled urban transit service. Shared and on-demand rides are easy to schedule and track via smartphones and web. Rural on-demand and scheduled transit service uses automatic vehicle locators so riders can know exact arrival time (via web or auto-dialed phone call) to be ready for pick up.

Park-and-ride lots in rural communities are planned with development to support future scheduled commuter buses, with access by walking and biking from nearby neighborhoods.



Corridor operations and redevelopment applied to key redeveloped urban and suburban corridors (see Corridor Strategy on pages 34 – 35). Smaller-scaled elements of the corridor M&O strategy applied to corridors through small towns and small cities.

Signals and systems management, freeway management, incident management, congestion, construction delay, and transit operations are all managed or coordinated from a single regional operations center, linked to each agency and local and State police/ emergency operations.

Additionally:

- **Integrated transportation finance and billing systems** allow all operators' systems to use a single-payer card for vehicle fuel and maintenance, bicycle maintenance, pay-as-you-drive insurance, tolls, transit, parking, car share and bicycle sharing, rental, taxi, etc. Tax-deductible and employer subsidies are automatically credited to cards. Graphs on monthly bills show comparisons of cost per mode against prior month and year. Summary data allows regional system operators to track usage and plan system improvements.
- **Regional ITS architecture and data management system** integrated across State DOT highway operators, local and regional signal synchronization, corridor management, local and regional transit systems, vehicle locators and real-time route information, ride-share and vanpool information, congestion and incident delay information, and car sharing and bicycle sharing systems. Data collection programs support sustainable performance measures.

GETTING STARTED

The way a transportation system is operated makes a difference to community livability and sustainability, so it is vital to incorporate M&O strategies into livability-focused vision development, planning, programming, and implementation efforts. However, it can be difficult to know where to start and how to balance the needs of system users with broader community goals.

Comprehensively incorporating livability and sustainability strategies into systems M&O can appear overwhelming to the typical roadway or transit system operator; they are not typically included in the up-front planning that establishes a broad community or regional vision and goals. Fortunately, there are many smaller steps that practitioners, policymakers, and others can take to start this process.

- **System Operators**—Look into opportunities to incorporate livability and sustainability considerations into your current work. For example, a roadway operator could reach out to transit operators as part of a signal retiming program to find out how new signal timing could benefit bus operations. Roadway and transit operators can also approach local and regional planners to discuss how to integrate M&O approaches into the planning process. This can start with a request to be notified of any major upcoming planning efforts, especially those at the corridor or regional level.
- **Planners**—Reach out to operators to see how their current efforts and resources could help achieve longer-term goals. Incorporate M&O as a strategy in plans and discuss M&O benefits with the public, particularly as a short-term means to address multimodal system needs while larger projects move forward. Consider how M&O strategies could help meet community goals that may be identified through a corridor, regional, State, or neighborhood planning process.
- **Decisionmakers**—M&O strategies are often less expensive than capital improvements, and they can help ensure that system investments reach their full potential. Work with a wide range of partners to see how coordinated improvements in one area, such as transportation system management and operations, can have a positive impact on other areas, such as economic development or housing affordability and access. New partners may bring access to new funding streams and synergistic projects that can leverage multiple funding sources for implementation.

Some of the key themes that can help practitioners and policymakers move forward include:

- **Create partnerships.** Livability and sustainability solutions require input from a wider range of agencies and interests than may traditionally be involved in M&O or transportation planning. Reaching out to local planners, economic development groups, housing agencies, resource agencies, police and emergency management, businesses, land-owners, and other community groups is the first step in developing effective, integrated solutions.
- **Engage with the community and stakeholders.** Although using "systems management and operations" as the meeting topic is unlikely to draw widespread participation, M&O strategies can easily be incorporated into discussion of a comprehensive vision, integrated multimodal plan, and coordinated implementation. Framing M&O strategies as a cost-effective, phased implementation of a broader long-term vision can help generate support from the public and policymakers.

- **Take a multimodal perspective.** Maximizing the efficiency of existing system investments is a key M&O strategy. This can often be accomplished by "completing and connecting" the multimodal network with relatively smaller incremental investments in pedestrian, bicycle, and transit access improvements, as well as local roadway connections.
- **Balance priorities.** Recognizing the range of users and how their demands on the system vary—by mode, time of day, purpose, season, incidents and events, etc.—can help operators plan and manage the system to balance competing priorities.
- **Recognize and emphasize the broader benefits of M&O.** This primer has highlighted the range of benefits that M&O can bring to communities and the transportation system. For operators, emphasizing these benefits can help planners, decision-makers, and the public understand the role of M&O in creating better communities.
- **Pick a project; pick a place.** Working together on a single project in a specific place—an intersection improvement, neighborhood plan, regional vision, or corridor plan—can be the best way to start incorporating M&O strategies into overall livability and sustainability efforts.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Glossary

Accessibility. The ease of reaching valued destinations, such as jobs, shops, schools, entertainment, and recreation.[47]

Active Transportation. Any self-propelled, human-powered mode of transportation.[48]

Brownfield revitalization. With certain legal exclusions and additions, the term "brownfield site" means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.[49] Brownfield cleanup and redevelopment activities improve communities as dilapidated and often dangerous buildings are demolished or renovated and contaminated soil is removed and replaced. Such improvements create a sense of possibility and renewal in the community.[50]

Bus Rapid Transit (BRT) Systems. BRT is an innovative, high capacity, lower cost public transit solution that can significantly improve urban mobility. This permanent, integrated system uses buses or specialized vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet transit demand. BRT systems can easily be customized to community needs and incorporate state-of-the-art, low-cost technologies that result in more passengers and less congestion.[51]

Complete Streets. Streets designed and operated to enable safe access and mobility for transportation system users of all ages and abilities, including pedestrians, bicyclists, motorists, and public transportation users.

Congestion Management Process (CMP). A CMP is a systematic and regionally-accepted approach for managing congestion that provides accurate, up-to-date information on transportation system performance and assesses alternative strategies for congestion management that meet state and local needs. The CMP is intended to move these congestion management strategies into the funding and implementation stages.[52]

Congestion Pricing. Sometimes called "value pricing," congestion pricing is a way of harnessing the power of the market to reduce traffic congestion. Congestion pricing works by shifting purely discretionary rush hour highway travel to other transportation modes or to off-peak periods. By removing even a fraction of the vehicles from a congested roadway, pricing enables the system to flow more efficiently, allowing more vehicles to move through the same physical space.[53]

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Connectivity Index. A Connectivity Index can be used to quantify how well a roadway network connects destinations. Indices can be measured separately for motorized and nonmotorized travel, taking into account nonmotorized shortcuts, such as paths that connect cul-de-sacs, and barriers such highways and roads that lack sidewalks.[54]

Context Sensitive Roadway Design. This form of design promotes a collaborative, multidisciplinary process that involves all stakeholders in planning and designing transportation facilities that meet the needs of users and stakeholders. Context sensitive roadway designs are compatible with their setting and preserve scenic, aesthetic, historic and environmental resources; respect design objectives for safety, efficiency, multimodal mobility, capacity and maintenance; and integrate community objectives and values relating to compatibility, livability, sense of place, urban design, cost and environmental impacts.[55]

Green Infrastructure. Green infrastructure is strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.[56] One common use in transportation of green infrastructure is as an approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure water management approaches and technologies infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore natural hydrologies.[57]

Greenhouse Gas (GHG) Emissions. Gases that trap heat in the atmosphere are often called greenhouse gases.[58] Many chemical compounds found in the Earth's atmosphere act as "greenhouse gases," including some that occur in nature (water vapor, carbon dioxide, methane, and nitrous oxide) and others are exclusively human-made (like gases used in refrigerants).[59]

High Occupancy Toll (HOT) lanes. HOT lanes are limited-access, normally barrier separated highway lanes that provide free or reduced cost access to qualifying HOVs, and also provide access to other paying vehicles not meeting passenger occupancy requirements.[60]

Intelligent Transportation Systems (ITS). The application of advanced technologies to improve the efficiency and safety of transportation systems.[61]

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[60] U.S. DOT, FHWA, *A Guide for HOT Lane Development*, March 2003. Available at: http://ntl.bts.gov/lib/jpodocs/repts_te/13668_files/images/13668.pdf.

[61] U.S. DOT, FHWA, *Planning Glossary*. Available at: http://www.fhwa.dot.gov/planning/glossary/index.cfm.

Intermodal. The ability to connect, and the connections between, modes of transportation.[62]

Livability. Using the quality, location, and type of transportation facilities and services available to help achieve broader community goals. Livability in transportation helps to achieve those goals by leveraging financial resources and using the transportation planning process to advance supportive projects, policies, or decisions. Livability directly benefits people who live in, work in, or visit an area - whether in an urban, suburban, or rural context.

Managed Lanes. Transportation facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions. Examples of managed lane projects include HOV lanes, HOT lanes, value priced lanes, or exclusive or special use lanes.[63]

Management and Operations (M&O). See transportation systems management and operations.

Metropolitan planning organization (MPO). A metropolitan planning organization (MPO) is defined in Federal Transportation Legislation (23 USC 134(b) and 49 USC 5303(c)) as the designated local decision-making body that is responsible for carrying out the metropolitan transportation planning process. An MPO must be designated for each urban area with a population of more than 50,000 people (i.e., for each Urbanized Area (UZA) defined in the most recent decennial Census).[64]

Mode Share. The percentage share that a particular type of transportation mode (i.e., car, bus, rail, plane, etc.) has in relation to other modes.[65]

Parking Management. Parking management includes a variety of strategies that encourage more efficient use of existing parking facilities, improve the quality of service provided to parking facility users and improve parking facility design.[66]

Placemaking. Placemaking is a multi-faceted approach to the planning, design and management of public spaces. Put simply, it involves looking at, listening to, and asking questions of the people who live, work and play in a particular space, to discover their needs and aspirations. This information is then used to create a common vision for that place. The vision can evolve quickly into an implementation strategy.[67]

Quiet Pavements. Innovative pavement technologies that result in substantial reductions in tire/pavement noise.[68]

Reliability. Refers to the degree of certainty and predictability in travel times on the transportation system. Reliable transportation systems offer some assurance of attaining a given destination within a reasonable range of an expected time. An unreliable transportation system is subject to unexpected delays, increasing costs for system users.[69]

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[62] U.S. DOT, FHWA, *Planning Glossary*. Available at: http://www.fhwa.dot.gov/planning/glossary/index.cfm.

[63] U.S. DOT, FHWA, *Managed Lanes: A Primer*, August 2008. Available at: http://www.ops.fhwa.dot.gov/publications/managelanes_primer/index.htm.

[64] U.S. DOT, FHWA, *Census Issues: Frequently Asked Questions*, March 2003. Available at: http://www.fhwa.dot.gov/planning/census_issues/metropolitan_planning/faqa2cdt.cfm#q29.

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[66] Victoria Transport Policy Institute, *The TDM Encyclopedia*, June 2011. Available at: http://www.vtpi.org/tdm/tdm28.htm.

[67] Project on Public Spaces, "What is Placemaking?" http://www.pps.org/articles/what_is_placemaking/.

[68] U.S. DOT, FHWA, *Quiet Pavement Systems in Europe*, FHWA International Technology Exchange Program, April 2005. http://international.fhwa.dot.gov/quiet_pav/index.cfm.

[69] U.S. DOT, FHWA, *Planning Glossary*. Available at: http://www.fhwa.dot.gov/planning/glossary/index.cfm.

Road Diets. Entails removing travel lanes from a roadway and utilizing the space for other uses and travel modes.[70]

Road pricing. Road pricing refers to a fee related to the use of a roadway facility. Road pricing may impose a price on a vehicle's use of the road based on time of day, location, type of vehicle, number of occupants, or other factors.[71]

Sprawl. Urban form that connotatively depicts the movement of people from the central city to the suburbs. Concerns associated with sprawl include loss of farmland and open space due to low-density land development, increased public service costs, and environmental degradation as well as other concerns associated with transportation.[72]

Sustainability. Meeting the needs of the present without compromising the ability of future generations to meet their own needs.[73] Sustainability incorporates the 'triple bottom line' concept, which includes giving consideration to three primary principles: equity (also known as social or people), ecology (also known as environment), and economy (also known as the bottom line or cost component). The goal of sustainability is "the satisfaction of basic social and economic needs, both present and future and, the responsible use of natural resources, all while maintaining or improving the well-being of the environment and ecology on which life depends.[74]

Traffic Calming. The combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users.[75]

Transportation systems management and operations (M&O). An integrated program to optimize the performance of existing infrastructure through the implementation of systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system.[76]

Travel Time Index. The travel time index is a measure of average conditions that tells one how much longer, on average, travel times are during congestion compared to during light traffic.[77]

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[70] Institute of Transportation *Engineers, Road Diet Handbook*, 2004. Available at: *http://www.oregonite.org/2007D6/paper_review/D4_201_Rosales_paper.pdf*.

[71] U.S. DOT, FHWA, *Road Pricing Defined*. Available at: *http://www.fhwa.dot.gov/ipd/revenue/road_pricing/defined/index.htm*.

[72] U.S. DOT, FHWA, *Planning Glossary*. Available at: *http://www.fhwa.dot.gov/planning/glossary/index.cfm*.

[73] World Commission on Environment and Development, "Towards Sustainable Development," in *Our Common Future*, 1987. Available at: *http://www.un-documents.net/ocf-02.htm*.

[74] U.S. DOT, FHWA, "What is Sustainability?" in *Sustainable Highways Evaluation Tool*, August 2006. Available at: *https://www.sustainablehighways.org/296/what-is-sustainability.html*.

[75] Lockwood, Ian, "ITE Traffic Calming Definition," *ITE Journal*, July 1997, pg. 22.

[76] Transportation Research Board, *Glossary of Regional Transportation Systems Management and Operations Terms*, Transportation Research Circular, E-C133, April 2009. Available at: *http://onlinepubs.trb.org/onlinepubs/circulars/ec133.pdf*.

[77] U.S. DOT, FHWA, *Travel Time Reliability: Making it there on Time, All the Time*, January 2006. Available at: *http://ops.fhwa.dot.gov/publications/tt_reliability/brochure/ttr_brochure.pdf*.

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