CENTRAL MASSACHUSETTS METROPOLITAN PLANNING ORGANIZATION (CMMPO)

Congestion Management Process (CMP) Mitigation Toolbox

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PREFACE

Congestion Management Process (CMP) Mitigation Tool Box Compilation:

Using previously inventoried past CMP-derived suggested improvement options, staff will work to develop a CMP “Tool Box” of standard and customized roadway improvements to address indentified congestion. Staff will also suggest groupings and/or series of improvements, such as Transportation Systems Management (TSM) techniques (signals, signs, and markings) as well as higher cost solutions where deemed necessary.

Introduction: CMP Mitigation Tool Box

Is traffic flow in your town perhaps not as good as it could be? Are travel speeds often **slower** than roads can handle? Do trips often seem to take longer than they should? Are lines of vehicles forming that are just too long, that take too much time to navigate?

When traffic moves slower than it could or should, sometimes the only answer is more space on the road or a costly redesign. But given today's resource realities, and the search for simpler, kinder and more basic solutions to travel frustrations, there are a number of things that you might want to consider looking at first. The concept of more efficiently using existing transportation systems by means other than large-scale construction is known as Transportation Systems Management (TSM).

More reasonable use of the roads not only gets people places faster, saving valuable personal time, but it also avoids adding stress to bodies and minds, and prevents the types of situations that are ripe for "road rage" and other dangerous behaviors. Regular or severe congestion can contribute to a decline in small town character, and can make city streets and town business areas less friendly to local commerce.

Within this guidebook we hope to identify some TSM approaches, appropriate to the region, which you can consider to improve conditions today, with minimal lead time or resource allocation. Additionally, with some basic planning for the future, a number of possible longer-term concepts will be discussed to help fight congestion. If there is value within, your community can start taking planning steps now, using concepts such as access management and intelligent transportation system (ITS) element capabilities, in order to improve the future.

It is our hope that town engineers, highway department heads and other concerned public officials will make use of this library of techniques. First, identify the recurring traffic conditions that test the patience of travelers in your town's various areas. Then, check to see if any of the treatments and methods within can be applied to these situations in a simple systematic approach. It's probably safe to say that any town or locality can find something that can be of immediate benefit.

Regional Background: CMP Recommendations Summary, 1995 to 2012

The following section summarizes recommendations, from the CMRPC planning staff, that came about as a result of Congestion Management Process (CMP) data collection activities. All of these recommendations were included in annual CMP Progress Reports. Most of the communities in the CMRPC region were referenced in this work. Recommendations listed were made between 1995 and 2012. These recommendations are provided as examples of regional congestion solutions that have been suggested in recent years.

Most recommendations pertain to specific intersections or to a section of roadway containing multiple intersections. There are some general suggestions that CMRPC commonly makes for intersections and roadways. These improvement options include:

1. Review signal timing and phasing operations of traffic signals and optimize them as necessary.
2. Maintain/improve pavement markings and signage along the roadway and at intersections.
3. Resurface or repave the roadway as needed.
4. Adjust lane configurations where deemed necessary and feasible.
5. Consider access management techniques.
6. Upgrade traffic signal equipment.
7. Conduct further traffic analyses at some locations in order to acquire more data.

Further, CMPRC has made other suggested recommendation options in the past that were customized for particular roadways or intersections. Beyond the realm of "low cost" solutions, these suggestions represent more mid to longer-term upgrades to a roadway segment or focus intersection. Such options have included:

- Selective/limited widening of a roadway in order to provide for additional travel lanes.
- The realignment of a roadway segment or focus intersection.
- The installation of new signalized traffic control at intersections where warranted.
- Installation of a modern roundabout, replacing an existing signal.

Regional Background: CMP Corridor Profile Recommendations Summary

A Corridor Profile correlates the information generated by various transportation management systems along a particular defined corridor and analyzes performance-based data. A range of suggested improvement options for host community consideration are included within each Corridor Profile document completed by CMRPC staff. Depending on community needs, some listed improvement options can be specific to a certain corridor or can be applied to other locations in the planning region. CMRPC staff typically meets with Corridor Profile host community officials and stakeholders to discuss and incorporate their suggested considerations and improvement ideas into final reports. Some improvements can be accomplished on a short-term basis while others are meant more for the future, perhaps in the 5 to 10 year timeframe. The recommendations listed below were reflected in six Corridor Profile efforts that were completed between 2005 and 2012.

Listed below are a number of short-term improvement options that were included in recent Corridor Profile studies that can be applied at specific intersections or along an entire roadway corridor.

1. Check the signal timing & phasing of signalized intersections.
2. Maintain/improve all signalized traffic control, signage, and pavement markings.
3. Selectively trim any overgrown vegetation that is hindering sight lines to vehicles, signs, or traffic signals.
4. Maintain good pavement surfaces.
5. Maintain bridges, culverts, and other roadside drainage structures and facilities.
6. Consider access management techniques.
7. Incorporate additional signage for safety purposes, such as specific yellow diamond warning signs.
8. Consider enhancing bicycle and pedestrian safety where needed.
9. Reconfigure travel lanes at intersections where appropriate and feasible.
10. Use streetscaping for beautification purposes.

The following suggestions are more for mid and long-term timeframes. These improvement options are expected to be of higher cost and will require lengthier periods to construct or implement. These have been suggested on a community by community basis. These general suggested improvement options may be applied where deemed necessary.

- Realign intersection approaches.
- Consider the use of a modern roundabout as opposed to a traffic signal where appropriate.
- Selectively widen roadways where additional travel lanes are needed.
- Incorporate Intelligent Transportation Systems (ITS) components into the roadway network.
- Install overhead lighting where needed.
- Utilize a “Complete Streets” approach.
- Coordinate operations of adjacent traffic signals where feasible and appropriate.
- Install new traffic signals where warranted or update existing equipment.
- Utilize traffic calming measures along densely settled sections of a roadway, as needed.

We note that a number of the listed suggested improvement options can be utilized to both minimize congestion and to prevent it from spreading. However, other items included in the listings do not necessarily combat congestion, and may in fact increase travel delay. Therefore, not all of the listed topics are included in the following CMP Mitigation Toolbox as potential tools.

Next Steps: Concepts and Tools

We've just listed a number of things that have been proposed in the region recently to improve congestion. But, you have problems now, in your town, in your own ways. What can you do? Where do you start?

1. Transportation Systems Management (TSM)

As mentioned earlier, smaller steps and quicker solutions all fall under the umbrella of Transportation Systems Management – TSM – a set of strategies that largely aim to reduce congestion primarily by improving transportation system capacity and efficiency. TSM strategies may at the same time also address a wide range of other impacts associated with driving such as pedestrian/driver safety, efficiency, travel time, and driver satisfaction. Some TSM strategies are designed to improve system-wide efficiency, while other strategies target particular problem areas where improvements could greatly affect delay, safety, and efficiency.

2. Pavement Markings and Signing

Before anything, make sure that the basics of what has been already installed and accomplished are still working. **Make sure that pavement markings are visible and serve their purpose**. Signs and markings that do not readily appear cause confusion and delay for those taking proper care, and danger for others. Basic sign and marking improvements can restore orderly movement through intersections while reducing crashes by as much as 30%. These features are especially important (and less costly to renew) at locations without traffic signals. Visible markings are surprisingly effective and helpful.

3. Signalized Control

Traffic signal themselves always involve some delay, as some vehicles are held up so that others can pass safely. However, if they are not set up or maintained so as to operate at best efficiency, more delay than is needed will result. Traffic signal optimization - the process of improving the operations, maintenance, timing, and locations of traffic signals to promote smoother traffic flow - should be undertaken on a routine, recurring basis. We've all experienced intersection delay where too much or too little time is assigned to one or more directions, and we all feel the wasted time that results.

All existing signals should undergo a review, with a refinement of existing timing and phasing as is possible and appropriate. **Time assignments for signals often become outdated**. Total delay time at an intersection can be reduced by rebalancing the green time by direction. As an example, new developments such as the addition of homes or stores nearby may increase traffic from one area to another and create a need to adjust the timing of affected traffic signals. (And, some traffic flows may decrease substantially with closures and the like, creating a situation where signals should be removed.)

Other solutions may involve a little more cost or work, such as changing travel lane direction assignments where determined beneficial and feasible. Sometimes intersection approach roadways also need realignment to operate efficiently.

Another signal improvement tactic is the coordination of several signals (i.e., the length of green and red signals and the timing of signal changes) in a corridor to maximize green light time for vehicles traveling at the speed limit. This creates smoother traffic along the corridor. Adjustments of this type are only possible in longer areas of larger towns, and only if the proper wiring and equipment has been or can be installed. In some larger municipalities a central location can be used to oversee and adjust signals remotely.

Traffic signal retiming is one of the most cost effective ways to improve traffic movement and make streets safer. After marking and sign updating, it should be the next step in improving local congestion. Basic fine-tuning can provide significant benefits.

While traffic signals do exhibit and manage delay, and stop-controlled intersections often manage traffic well at less busy locations, as time passes the demand upon a stop-sign location often begin to overwhelm those seeking to get onto the mainline. Stop-controlled locations should be revisited, and if significant traffic increases have resulted in a difficult time for those stopped on the minor road, **a signal may be justified**, resulting in more effective (and safer) traffic flow.

4. Modern Roundabouts

Another possible idea for improving congested locations with frequent vehicle stops, becoming more and more popular in the state, is the use of a modern roundabout. Roundabouts are circular road junctions in which traffic enters a continuous one-way stream around a central island. Such traffic routing can reduce vehicle idle times and improve traffic flow, thereby reducing overall delay and congestion. While not indicated for extremely busy corridors, or in locations that are too close to other traffic restrictions or bottlenecks, **roundabouts do tend to keep traffic moving in a safe manner and provide surprising mobility benefits**.

5. Pavement Preservation

Road roughness results naturally from the gradual deterioration of road surfaces and/or the pavement structure. Not only do rougher roads reduce ride quality, they also reduce driver safety, increase vehicle wear and tear, and increase fuel consumption. Extremely bad conditions can result in vehicles traveling at less than optimal speeds in order to be protective to equipment. The **repair and/or resurfacing of roads in poor condition** can improve systemwide congestion and delay.

6. Vegetation Control

Roadway agencies are encouraged to develop **roadside vegetation management programs**. An integrated roadside vegetation management program consists of eliminating or controlling vegetation through a variety of strategies including mowing, brush cutting (mechanical and hand), use of herbicides, grazing of livestock, cultivating desirable vegetation, and re-vegetation. Employees of local road agencies are responsible for reviewing their roads and rights-of-way, identifying hazards, and making conditions safer. While safety cannot be achieved without a good maintenance program, and it's the main motivation for vegetation clearance, drivers who find themselves in situations where they are unable to see surroundings clearly often slow to otherwise unreasonable speeds in order to be able to detect safety threats. The accumulation of these delays of caution can seriously affect overall mobility in a location or corridor.

These programs keep signs and other vehicles visible to drivers as well as helping pedestrians and bicyclists see motor vehicles. Keep sidewalks and pedestrian paths clear and free from overhanging vegetation; remove trees close to the roadway. Control weeds in accordance with local laws and ordinances to keep sight lines open as well as for pleasant effect.

7. Highway Drainage

Weeds, turf and sod can interfere with **roadside drainage** as well. A high shoulder creates a secondary ditch and damages the pavement. Water on the pavement due to high shoulders creates safety problems, including hydroplaning and isolated icy conditions during the winter, which again slow traffic. Inspect culverts and other underground and roadside drainage structures and facilities, such as swales and retention ponds, as malfunctions can affect the roadway as well. Inspect community-owned bridge structures as additional support.

8. Access Management

Another set of congestion management strategies which approaches things from a slightly different angle is called Access Management. Access Management (AM) is the proactive **management of access points to land parcels** adjacent to all manner of roadways. Access Management provides an important means of maintaining mobility. It calls for effective entries and exits, efficient spacing and design to preserve function, and the overall balanced use of street and road systems. Good AM techniques include:

- **Access Spacing**: increasing the distance between traffic signals and other roadway entries improves the flow of traffic on major arterials or bust town center roads, reducing congestion
- **Driveway Spacing**: fewer driveways spaced further apart allows for more orderly merging of traffic and presents fewer challenges to drivers.

- **Safe Turning Lanes**: dedicated left- and right-turn lanes and roundabouts keep through-traffic flowing.
- **Turn Prohibitions**: disallowing left turns against heavy traffic in locations that can be serviced by nearby U-turns or other local roads keeps traffic flow smooth while preventing dangerous vehicle conflicts.
- **Median Treatments**: two-way left-turn lanes (TWLTL) and raised medians are examples of some of the most effective means to regulate access and reduce crashes.
- **Right-of-Way Management**: As land use changes and grows in density, be mindful of good sight distance, spaced access locations, and other access-related issues.

9. Safe Routes to School

Many weekday congestion problems in certain areas of town and cities are due to the start and end of school days and the need to get large numbers of children to and from school in relatively short periods. A **Safe Routes to School** (SRTS) program can help communities to tailor a combination of engineering, enforcement, education and encouragement strategies to address the specific needs of their schools. This includes the walk or bicycle journey to and from school as well as the drop-off and pick-up process of children at school who are transported by motor vehicle.

Some parents are reluctant to allow their children to walk or bicycle to school due to the traffic congestion and perceived traffic danger during student arrival and dismissal. This often results in more parents driving their children to school which adds to the extra congestion and safety problems at the school, creating an increasing cycle of more traffic problems and less walking. By improving the drop-off and pick-up process, traffic conditions become safer for all, including pedestrians and bicyclists. **Better organized and safer traffic conditions** will ease the concerns of parents, making them more willing to allow their children to walk or bicycle.

10.New Technologies

Above and beyond the things that you can consider now, for immediate or near-term effect, we would like to mention two congestion improvement techniques that may grow to greater importance in the future. You may wish to consider their effects now, pro and con, in your local planning:

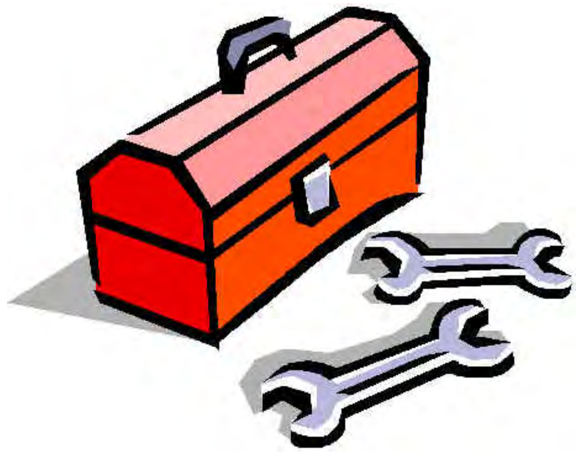
All Electronic Tolling System (AETS)

- MassDOT is planning to convert and replace the I-90 Western Turnpike and I-90 Boston Metropolitan Highway System interchange-based manual cash and electronic toll collection systems with a new system of tolling relying only on All Electronic Tolling (AET). The project will include both roadway tolling infrastructure and toll collection system technology. The institution of this tolling method may benefit flow on I-90 but will change the nature of access point traffic as well. Vehicles may flow onto and off of local highways in greater numbers for a given time period.

Ramp Metering

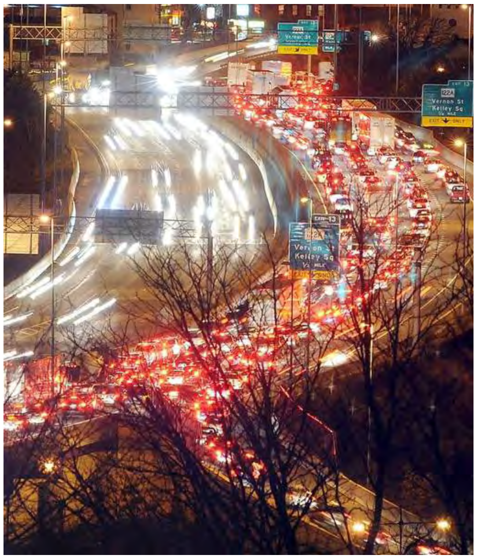
- Interstate Highway Ramp Metering (for example, at I-290 access points) is a possible future way to control the rate of vehicles entering a freeway, creating more space between vehicles so that they do not collide or disrupt existing traffic flow by attempting to enter in large groups. This is achieved through the use of traffic signals at freeway on-ramps to allow only one vehicle to enter the freeway per some short time interval (say, every five seconds). While ramp meters allow freeways to accommodate more vehicles with fewer collisions and greater reliability, they also reduce the number of entering vehicles, encouraging drivers to use parallel streets for short distance trips in order to avoid the ramp wait time, or other local alternative routes to seek quicker freeway access times. In these ways, ramp meters typically reduce congestion on the freeways, but may increase congestion on local roads.

CMP Mitigation Tool Box Resources



A number of suggested methods, techniques, and treatments to reduce roadway congestion have been provided above for host community consideration. In the following pages we present some ways to actually get started using these tactics, with links to important resources that can guide you with further detail on what to do and how much it might cost. Also included in each section are brief excerpts from each of the provided links, encouraging further review by the user.

1. Transportation Systems Management (TSM)



TSM is really a collection of techniques and approaches, many of which we have discussed separately. For some insight on overall approaches, see the various documents linked below. They cover larger and smaller areas of jurisdiction, but all have ideas that can inspire and serve as examples locally.

http://www.fhwa.dot.gov/environment/climate_change/mitigation/resources_and_publications/reference_sourcebook/page06.cfm – FHWA's review of TSM strategies with additional information on their general effects on the level of greenhouse gases.

http://www.nymtc.org/RTP_docs/NYMTC_RTP_Complete.pdf – Chapter 5 discusses the projects and initiatives planned over the next 25 years to improve operations and management of the New York City region's transportation system. It provides a good overview of a systematic approach to TSM.

http://library.oregonmetro.gov/files//executive_summary_june2010_final.pdf – This is a shorter overview of TSM strategies in Oregon with goals, costs and benefits. Plans and techniques such as these can be adapted for local and regional activities in our towns and our state.

http://www.pctpa.net/library/rtp/2035/Chapter%206.7.pdf – One county's approach to TSM.

http://www.nctcog.org/trans/tsm/ – One region's TSM program with plans and phasing.

http://www.dsmic.org/default.asp?PageID=382 – Local and statewide TSM assessments in Minnesota.

Reference Sourcebook for Reducing Greenhouse Gas Emissions from Transportation Sources

6. Transportation System Management Strategies

Transportation system management (TSM) refers to a set of strategies that largely aim to reduce GHG emissions by reducing congestion, primarily by improving transportation system capacity and efficiency. TSM strategies may also address a wide range of other externalities associated with driving such as pedestrian/driver safety, efficiency, congestion, travel time, and driver satisfaction. Some TSM strategies are designed to reduce total and systemic congestion and improve system-wide efficiency, while other strategies target particularly problematic areas where improvements could greatly affect congestion, safety, efficiency, and GHG emissions.

Transportation System Management Strategies Reviewed in This Report

This review covers the following eight reduction strategies:

- Traffic Signal Optimization
- Ramp Metering
- Incident Management
- Speed Limit Reduction and Enforcement
- Roundabouts
- Capacity Expansion
- Resurfacing Roads
- Alternative Construction Materials

The above strategies seek to reduce congestion and promote efficiency through infrastructure, operational, and technological improvements. Infrastructure strategies seek to reduce GHG emissions by improving the transportation system infrastructure through new or improved construction. The production of pavement materials requires significant amounts of energy and produces significant GHGs. "Green" construction materials are lower-energy alternatives to conventional construction materials and can reduce the life-cycle GHG emissions of transportation construction projects. Resurfacing roads decreases the roughness of road surfaces and allows vehicles to travel more efficiently, which in turn reduces GHGs. Capacity expansion and roundabouts may reduce congestion and allow for more free-flowing traffic with less stoppage and idling time.

Operational strategies focus on minimizing inefficient travel that increases GHG emissions. Proper incident management strategies detect and clear incidents to reduce congestion and promote safer post-accident operations. Speed enforcement and reduction programs seek stricter enforcement of speed regulations as well as lower limits so that travel speeds coincide with speed ranges that promote optimal fuel efficiency.

Technological strategies seek to use automated systems to optimize free-flow of traffic and thus reduce non-VMT production of GHGs. Traffic signal optimization improves the operation, maintenance, timing and location of traffic signals to promote smoother traffic flow and reduce GHG emissions. Ramp metering controls the rate of vehicles entering freeways to reduce congestion around ramps and discourage use of highways/freeways for short trips.

Current FHWA research efforts address the short- and long-term impact of highway operations on travel and GHG emissions. Strategies of particular interest include signal timing, ramp metering, incident management, speed harmonization, and congestion pricing. The travel behavior component of this work will examine key factors affecting travelers' responses to these treatments, such as demand changes from changes in travel time, travel time variability, and travel cost. An important outcome of this research will be to characterize what we know about travel in the months and years following implementation of these strategies. Ultimately, this work will support travel experiments to estimate the network-level travel and GHG impacts of individual and bundled highway measures.

2010 NYMTC
2035 Regional Transportation Plan

A Shared Vision for a Shared Future

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Chapter 5

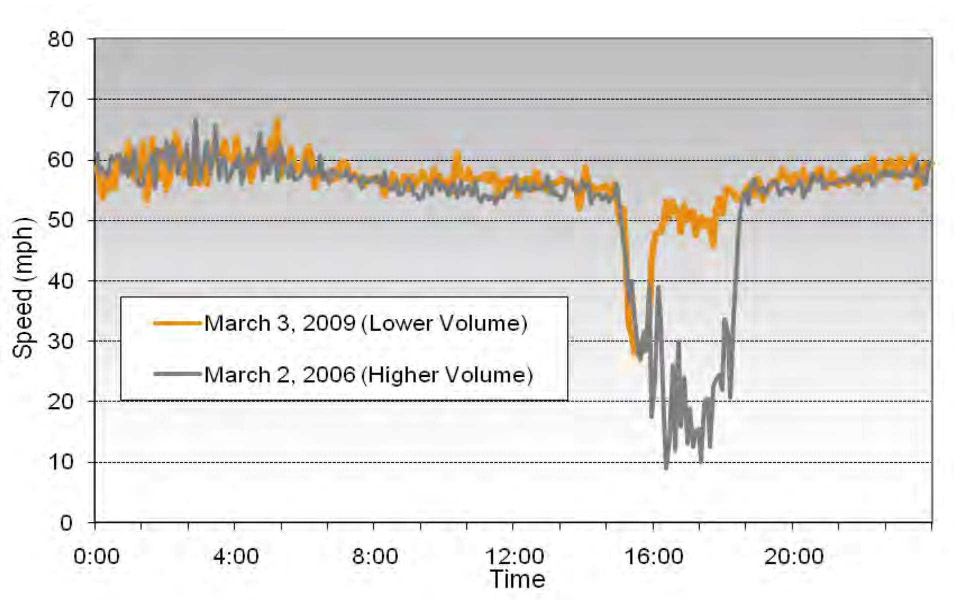
Transportation System Operations and Management

This plan forecasts that the ten-county NYMTC region will add two million more residents by 2035, one million in the five boroughs of New York City alone. The population of the broader tri-state metropolitan area is expected to increase by four million. Population increases, coupled with a growing economy, will translate into higher levels of passenger and freight congestion on an already overburdened transportation system.

NYMTC's members are planning large regional transportation investments to add transportation capacity to serve a vibrant, growing region. At the same time, targeted investments in the system's operation and management can improve the efficiency of existing transportation facilities in ways that relieve vehicular congestion and maximize safety, security and mobility. This chapter introduces projects and initiatives planned over the next 25 years to improve operations and management of the region's transportation system.

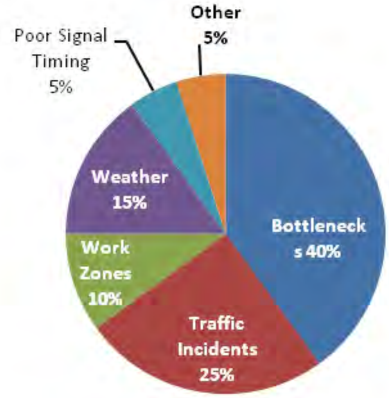
Transportation System Management and Operations (TSMO) strategies provide money saving multimodal solutions that relieve congestion, optimize infrastructure investments, promote travel options and reduce greenhouse gas (GHG) emissions.

Traditionally, improvements to transportation mobility, reliability, safety and accessibility are achieved through capital intensive infrastructure investments. But transportation infrastructure is expensive and cost estimates for the region's 25-year needs runs into the billions of dollars. Transportation system management and operations (TSMO) use past and future transportation investments to their utmost potential through system and demand management solutions that enhance overall system performance. Compared to traditional capital investments such as new roads or additional lanes, TSMO solutions offer high returns on comparatively low cost projects and can delay or remove the need for additional capital intensive infrastructure. This TSMO plan focuses on less intensive traffic operation improvements; delivery of multimodal traveler information; promotions and programs to increase walking, biking, transit use, carpooling, and telecommuting; and ongoing investments to optimize the existing transportation system operations and performance.



A comparison between 2006 and 2009 traffic flow on I-5 northbound near Rosa Parks Boulevard demonstrates that reducing demand reduces congestion. While the reduced demand in 2009 was likely due to the economy, TSMO strategies target system and demand management to achieve improvements in traffic flow.

Both recurring and non-recurring congestion can be addressed using system management and operation solutions.



A range of TSMO projects already completed in the Portland region proves the cost effectiveness of these solutions with a benefit to cost ratio of at least 2:1. For every dollar spent:

- Burnside Road adaptive signal system provides a benefit of $6.50 (after five years)[1]
- Traffic incident detection provides about $6.00 of benefit[2]
- Freeway service patrols range between a benefit of $2.00 to $42.00[2]

TSMO solutions help reduce transportation's contribution to greenhouse gas (GHG) emissions, a driving force in climate change. In Oregon, transportation represents 34 percent of the state's total greenhouse gas emissions.[3] The amount of greenhouse gas produced is directly proportional to the amount of fuel consumed by vehicles. TSMO solutions tackle the problem in two ways: by optimizing traffic flow for fuel economy and by reducing the number of miles driven.

TSMO Vision, Goals and Guiding Principles help to keep Portland a great place to live, work and play.

The Portland region's TSMO plan is part of a broader strategy for achieving regional values and goals, which are presented in two key regional plans – the 2040 Growth Concept and the 2035 Regional Transportation Plan (RTP). The 2040 Growth Concept guides how the region develops. The 2035 RTP implements the growth concept through strategic transportation investments. The 2035 RTP goals are:

Goal #1 Foster Vibrant Communities and Efficient Urban Form – TSMO solutions improve demand and encourage travel behaviors that support efficient urban form.

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[1] DKS Associates. City of Gresham - Burnside Road Adaptive signal timing project (Division to Powell). 2007

[2] US DOT, Intelligent Transportation Systems Joint Program Office. Investment Opportunities for Managing Transportation Performance through Technology. January 16, 2009.

[3] ODOT, Potential Effects of Tolling and Pricing Strategies on Greenhouse Gas Emissions, 2009.

Goal #2 Sustain Economic Competitiveness and Prosperity – TSMO solutions improve system reliability, increase safety and promote transportation choices and traveler information projects to help make the region more accessible and prosperous.

Goal #3 Expand Transportation Choices – TSMO solutions promote the use of travel options and provide multi-modal traveler information.

Goal #4 Emphasize Effective and Efficient Management of the Transportation System – TSMO solutions optimize operations of existing infrastructure, which is more cost effective than building new capital infrastructure and achieves substantial benefits.

Goal #5 Enhance Transportation Safety and Security – TSMO solutions reduce crashes and decrease the severity of crashes. By addressing safety concerns, the cost of incidents and the delays to travelers due to incidents is reduced.

Goal #6 Promote Environmental Stewardship – TSMO solutions manage congestion, provide traveler information and promote travel options resulting in reduced vehicle emissions, energy consumption and reliance on oil.

Goal #7 Enhance Human Health – TSMO solutions support and promote use of active transportation modes, including biking, walking and transit, all of which have demonstrated health benefits.

Goal #8 Ensure Equity – TSMO solutions benefit the entire Portland region and travelers from all geographic, income, and cultural backgrounds.

Goal #9 Fiscal Stewardship – TSMO solutions optimize the operations of existing infrastructure and offer a good return on public investment.

Goal #10 Deliver Accountability – The TSMO plan emphasizes open communication and coordination between partner agencies. Additionally, TSMO solutions deliver accountability through performance monitoring and evaluation requirements.

In compliance with federal guidelines established by the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) and subsequent laws, TSMO strategies must be incorporated in the Regional Transportation Plan (RTP). Previous RTPs emphasize the use of TSMO strategies; the 2035 RTP will be the first to include a comprehensive regional strategy for transportation system and demand management.
The Oregon Transportation Plan (OTP) adopted in September of 2006 also calls for the use of operational solutions as a priority, but does not provide the necessary detail to follow through with TSMO type projects. This TSMO plan fills that role. It identifies and recommends TSMO projects that will benefit the Portland region.

6.7 Transportation Systems Management

This chapter describes Transportation System Management (TSM) techniques, which are generally low-cost and designed to maximize the efficiency of the existing transportation system, reduce travel demand and dependence on single occupant vehicles, improve air quality, and reduce or eliminate the need for new and expensive transportation infrastructure.

TRANSPORTATION SYSTEM MANAGEMENT (TSM)

Finding creative solutions to deal with growth in population, traffic congestion, and achieving federal air quality standards, is an ongoing effort. One element of this effort that remains constant is finding ways to make our existing transportation system as efficient as possible. This is the role of Transportation System Management (TSM).

Transportation Systems Management (TSM) is often used interchangeably with Transportation Control Measures (TCMs) and Travel Demand Management (TDM) to describe a series of techniques designed to maximize the efficiency of the existing transportation system by reducing dependence on single occupant vehicles. The common goals of TSM, TCMs, and TDM are to reduce traffic congestion, improve air quality, and reduce or eliminate the need for new and expensive transportation infrastructure. Techniques are generally low-cost measures to reduce travel demand or improve the utilization of existing transportation facilities.

The differences between the three concepts are subtle. Each contains alternative transportation measures, such as carpooling, transit, bicycling, walking, vanpooling, compressed work weeks, and telecommuting. Transportation Systems Management (TSM) places emphasis on reducing traffic congestion by increasing the person-trip capacity of existing transportation systems. TSM techniques also include restriping roadways for channelization, ramp metering, establishment of freeway auxiliary lanes, and freeway service patrol. Travel Demand Management (TDM) strategies are designed to influence an individual's travel behavior by reducing the demand for single occupant vehicle travel, especially during peak commute periods. TDM strategies include techniques such as preferential parking for carpoolers, teleconferencing and advanced communication technology. Transportation Control Measures (TCMs) are geared towards reducing air pollution through techniques such as alternative fuel vehicles.

Since 1981, the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) have required that Transportation Systems Management (TSM) be part of the regional transportation planning and programming process. Specifically, the Regional Transportation Plan must have a TSM element which describes how the region intends to deal with the movement of people and goods by improving the efficiency and effectiveness of the total transportation system.

SACOG's MTP 2035 identifies a goal to reduce regional trips anticipated in the MTP by 10 percent. Land uses defined by Blueprint principals provide the framework for the future reduction in trips and VMT. TSM and TDM programs are a complementary component toward achieving the 10 percent trip reduction goal. Work-based trips account for about 20 percent of all daily trips in the region. To contribute to the goals set forth in the MTP 2035, TSM and TDM programs will need to expand services to target the other 80 percent of regional trips. This chapter outlines various TSM and TDM strategies currently implemented in Placer County that will contribute toward achieving the regional goal.

According to 2005 Urban Mobility Report prepared by the Texas Transportation Institute, using 2002 data for Sacramento, about 48 percent of daily travel occurs in congested conditions, resulting in 40 hours of delay per traveler per year at a total congestion cost of $739 per traveler per year.

TSM STRATEGIES

Traffic Flow Improvements

Roadway restriping, spot widening, channelization, ramp metering, auxiliary lanes, elimination of on-street parking, and computerized signalization are techniques currently used to improve the flow of traffic without new road construction.

- Roadway restriping seeks to increase the number of lanes by reducing lane width, thus increasing traffic capacity.
- Channelization, which is often done in conjunction with restriping, adds turn lanes to busy roadways to eliminate traffic backups behind cars trying to make turns.
- Auxiliary lanes are often added to ease merging of traffic onto and off of freeways, such as Interstate 80.
- Elimination of on-street parking is done to add lanes, and thus capacity, to heavily traveled roadways. In addition, traffic backups caused by vehicles entering or exiting on-street parking spaces is eliminated.
- Computerized signalization seeks to coordinate signal timing to smooth traffic flow.

Freeway Service Patrol (FSP)

Approximately half of the delay experienced by travelers in the United States is due to causes other than simple high volumes of traffic. Much of this nonrecurring congestion occurs as a result of traffic accidents and stalled vehicles. Quickly identifying and removing vehicle incidents reduces traveler delay by returning traffic capacity to normal levels. Freeway service patrol (FSP) programs are designed to reduce the traffic congestion during peak commute periods on area freeways by removing traffic impediments, such as cars with mechanical problems or that have been involved in accidents, as well as assisting the motoring public.

Transportation Systems Management (TSM)

The Transportation Systems Management (TSM) approach to congestion mitigation seeks to identify improvements to enhance the capacity of existing system of an operational nature. Through better management and operation of existing transportation facilities, these techniques are designed to improve traffic flow, air quality, and movement of vehicles and goods, as well as enhance system accessibility and safety.

Transportation systems management strategies are low-cost but effective in nature, which include, but are not limited to:

- Intersection and signal improvements
- Freeway bottleneck removal programs
- Data collection to monitor system performance
- Special events management strategies

Traffic signal and intersection improvements include such elements as:

- signal timing optimization
- controller/cabinet and signal head upgrades
- vehicle detectors repair/replacement
- communication with a central system
- turning lanes
- grade separations
- pavement striping
- lane assignment changes
- signage and lighting

Freeway and arterial bottleneck removal consists of identifying congested locations and improving such elements as:

- insufficient acceleration/deceleration lanes and ramps
- weaving sections
- sharp horizontal/vertical curves
- narrow lanes and shoulders
- inadequate signage and pavement striping
- other geometric deficiencies

The identification and elimination of traffic bottlenecks can greatly improve traveling conditions and enhance system capacity, reliability, and safety, especially during peak periods. TSM projects can complement the major capacity improvements and infrastructure by providing improved traffic flow on arterials and local streets.

NCTCOG's Current TSM Projects:

1) Thoroughfare Assessment Program (TAP)/Traffic Signal Integration and Monitoring Program. The purpose of this program is to improve traffic flow and enhance the capacity of existing arterial systems by implementing new signal timing and low-cost operational improvements along selected corridors, which include but are not limited to:

- lane assignment changes
- vehicle detector upgrades
- addition of pedestrian push buttons
- signal head upgrades
- controller and cabinet upgrades
- communication with central computer

- addition of GPS clocks
- re-striping

Improved and coordinated traffic flow will result in improvement of the air quality standards in the Dallas- Fort Worth nonattainment area. This project is implemented in three phases as listed below:

TAP Phase 2.0: Phase 2.0 of this Program was completed in July 2009. Signal retiming and low-cost operational improvements at selected locations were implemented on 20 corridors with 482 signalized intersections in the Dallas-Fort Worth Metropolitan Area. Review the TAP Phase 2.0 Executive Summary.

TAP Phase 3.1: This phase of the program began in November 2005, and includes 13 corridors with 258 signalized intersections in the Dallas-Fort Worth Metropolitan Area. Signal retiming and low-cost operational improvements at selected locations will be implemented under this phase of the project by June 30, 2009. Review the TAP Phase 3.1 Executive Summary.

TAP Phase 3.2: Implementation of this phase of the program began in April 2006 and a total of 60 corridors with 1,178 signalized intersections will be improved. This phase of the program will be completed by December 2009. Review the TAP Phase 3.2 Executive Summary prepared by Kimley-Horn and Associates. Review the TAP Phase 3.2 Executive Summary prepared by Teal Engineering Services.

Link List for All Corridors [pdf]

Map and List of All Locations [Coming Soon]

Performance Measures for all Corridors [Coming Soon]

Contact Information

Natalie Bettger, 817-695-9280 / nbettger@nctcog.org

2) Light-Emitting Diode Traffic Signal Lamps Replacement Program. As of May 2005, 74 percent of the existing incandescent lamps have been replaced with LED lamps, and it is estimated that 90 percent of the existing lamps will be replaced with LED lamps by Spring 2009.

10/4/2013 12/30/2008 BW

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Duluth - Superior Metropolitan Interstate Council
Guiding the Future of Transportation for the Twin Ports Area

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Meeting Information

Current MIC meeting materials

Calendar of upcoming committee meetings

MIC Staff

View a list of MIC staff members, their current projects and contact information.

Transportation Systems Management

January 2012 Update: releases of the Duluth and Superior 2011 TSM Assessments

The 2011 Duluth TSM assessments for the Duluth and Superior areas have been finalized and are available for view at the following links:

2011 TSM Assessment of Duluth Area Intersections

2011 TSM Assessment of Superior Area Intersections

These documents identify a selection of intersections that may be impoved with lower-cost transportation improvements. For each intersection identified, one or more TSM options are provided.

What is TSM?

Transportation Systems Management (TSM) is a strategy aimed at improving the overall performance of the transportation network without resorting to large-scale, expensive capital improvements. TSM integrates techniques from across disciplines to increase safety, efficiency and capacity for all modes in the transportation system.

Examples of TSM actions:

~ Improved or innovative roadway designs
~ Improved signage or signal arrangement
~ Access management
~ Safety and capacity analysis
~ Transit assessments
~ Targeted traffic enforcement
~ Incident response plans
~ Intelligent transportation systems (ITS)

TSM as a planning process at the MIC

The MIC works to strengthen the link between the planning it does and the operations & maintenance performed by area jurisdictions. By including TSM as a planning activity at the MPO level, the MIC aims to bring together all the agencies and jurisdictions needed for the successful implementation of TSM improvements.

Internally, TSM means "evaluation" at the MIC. It is a regularly run, data-driven process for identifying and prioritizing "locations of concern" throughout the system. Results of the analyses are presented to the jurisdictions and relevant agencies, who's input are sought in developing recommended TSM solutions.

For More Information

Contact MIC Planner Robert Herling by phone at (218) 529-7573 or send a message by e-mail.

Previous TSM Assessments (2007)

FINAL: 2007 TSM Assessment of MIC Roadways in Minnesota

FINAL: 2007 TSM Assessment of MIC Roadways in Wisconsin

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We Need Your Input!
You are invited and encouraged to review the draft Grand Avenue/Hwy 23 Corridor Study and submit any comments or questions to MIC Senior Planner Robert Herling by November 29.

Current Planning Initiatives

Duluth-Superior Port Land Use Plan

Northwest Douglas County Freight Movement Study

Grand Ave/State Hwy 23 Corridor Study

Duluth 6th Avenue East Traffic Study

Superior South End Traffic Study

Bike-Ped Advisory Committee (BPAC)

Recent Plans and Studies

Intersection Control Evaluation (ICE) Study for the Duluth Area

Duluth-Superior Cruise Ship Terminal Study

DLH Air Service/Air Cargo Leakage & Expansion Analysis

Duluth Sidewalk Study

Duluth-Superior Metropolitan Bike Map

Central Entrance Corridor Study

Lincoln Park Pedestrian Plan

Transportation Systems Management (TSM)

N Minnesota/NW Wisconsin Freight Plan

UMD-CSS Transportation Study

East 2nd Street Corridor Study (Superior)

DTA Route Analysis for the City of Superior

Downtown Modal Connections Study

Proctor Comprehensive Plan Update 2008

Endion Land Use and Transportation Study

Safe Routes To School Funding Applications

Northwest Superior Traffic Circulation Plan

2. Pavement Markings and Signing

http://safety.fhwa.dot.gov/intersection/resources/fhwasa09020/chap_2.cfm#s21 –This FHWA site, Low Cost Safety Enhancements for Stop-Controlled and Signalized Intersections, lists potential improvements in detail along with their costs and benefits

Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections

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2. Stop-Controlled Intersections

Signing and Pavement Marking Enhancements

Crash Problem

The major crash type at stop-controlled intersections is a right angle crash involving a vehicle entering the intersection from the stop approach and a vehicle on the through approach. In these crashes, most of the vehicles on the stop approach stop or at least slow down to under 10 mph before pulling out. However, many drivers involved in these crashes make poor decisions regarding the available safe gaps between vehicles on the through road. Inattentive or distracted drivers, speeding, and physical limitations of the intersection contribute to future crash potential.

Countermeasures

The set of low-cost countermeasures for stop-controlled intersections is designed to increase drivers' alertness to the presence of the intersection and reduce potential conflicts with other entering vehicles. These countermeasures are primarily intended for deployment at stop-controlled intersections with either single through lanes or multiple undivided through lanes. Countermeasures have been classified as basic or supplemental. Basic countermeasures are those that are usually very low in unit cost and effective in terms of reducing future crash potential and should be considered at all intersections having crashes above a defined crash threshold. Supplemental countermeasures are targeted to intersections with crash levels considerably above the crash threshold or the intersection has specific types of crashes that the countermeasure can address.

Basic Countermeasures

The basic set of countermeasures should be considered as a package of minor improvements consisting of all of the following:

Low-Cost Countermeasures for the Through Approach

- Doubled up (left and right), oversize advance intersection warning signs, with street name sign plaques.

Low-Cost Countermeasures for the Stop Approach

- Doubled up (left and right), oversize advance "Stop Ahead" intersection warning signs.
- Doubled up (left and right), oversize STOP signs.
- Installation of a minimum 6 ft. wide raised splitter island on the stop approach (if no pavement widening is required).
- Properly placed stop bar.
- Removal of any foliage or parking that limits sight distance.
- Double arrow warning sign at stem of T-intersections.

Supplemental Countermeasures—Intersections with Higher Crash Frequencies

In addition to the basic package of countermeasures, additional individual countermeasures can be considered based upon higher frequencies of crashes beyond the crash threshold for basic countermeasures or at intersections that have crash types that the countermeasure can address.

- Installation of a minimum 6 ft. wide raised splitter island on stop approach which requires pavement widening. (See FHWA-HRT-08-063 for further design and performance information.).
- Either a) flashing solar-powered LED beacons on advance intersection warning signs and STOP signs or b) flashing overhead intersection beacons.
- Dynamic warning sign to advise through traffic that a stopped vehicle is present and may enter the intersection.
- Transverse rumble strips across the stop approach lanes in rural areas where noise is not a concern and running STOP signs is a problem. (Use "Stop Ahead" pavement markings if noise is a concern.).
- Dynamic warning sign to advise high-speed approach traffic that a stopped condition is ahead; use this countermeasure when vehicles running the STOP sign is a problem.
- Extension of the through edge line using short skip pattern may assist drivers to stop at an optimum point; this countermeasures is used on intersections with very wide throats in which stopped drivers have difficulty stopping at the

correct location.

- Reflective stripes on sign posts may be used on signs with degraded conspicuity due to sign clutter or competing background features to increase attention to the sign, particularly at night. Supplemental countermeasures should be considered in addition to the basic set of countermeasures and not in lieu of the basic countermeasures on those intersections with higher crash frequencies or those that possess certain physical characteristics that the countermeasure is designed to impact.

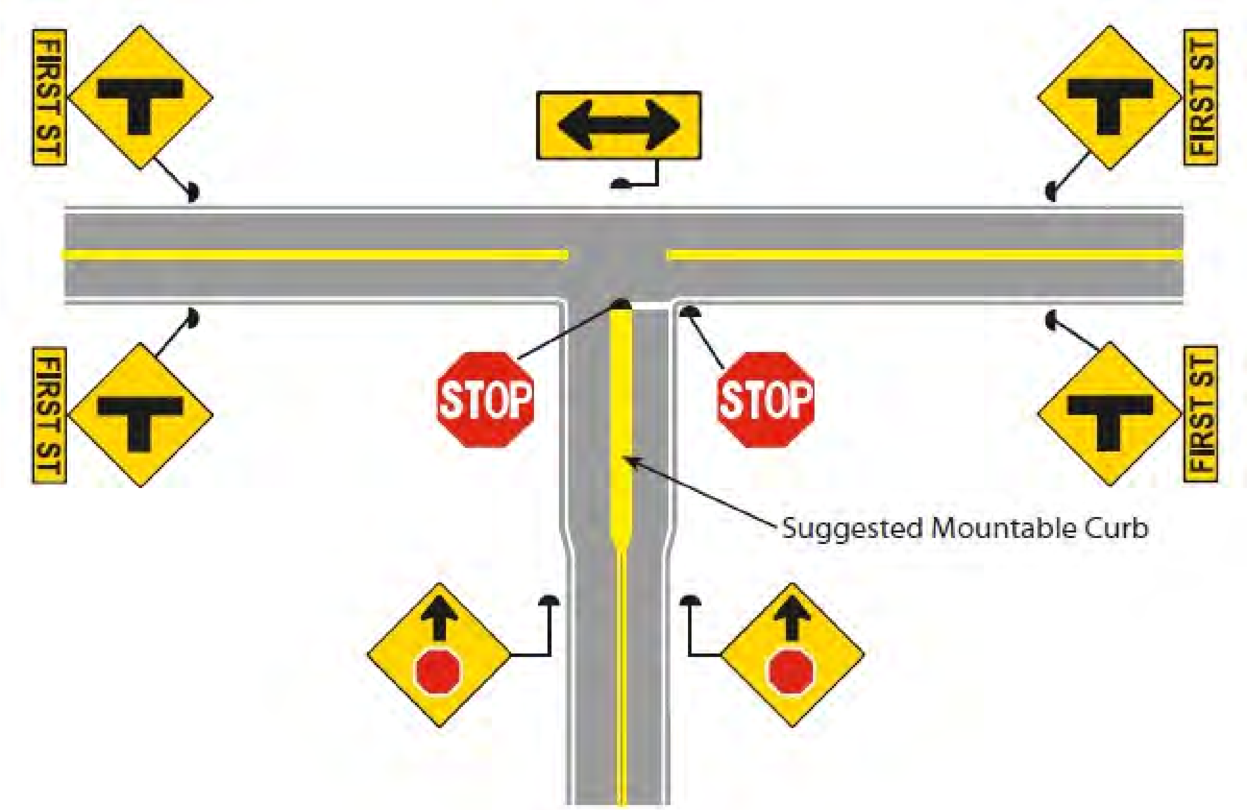

Figure 1: Examples of Basic Low-Cost Countermeasures for Stop-Controlled Intersections – Double Up Oversize Warning Signs, Double STOP Signs, Traffic Island on Stop Approach (if feasible), Street Name Signs, Stop Bars, and Double Warning Arrow at the Stem of T-Intersections

Countermeasure Crash Reduction Factors, Threshold Levels, Additional Implementation Factors, and Estimated Cost Ranges

It is assumed that the existing traffic control devices at intersections under consideration for improvement are MUTCD compliant and usually consist of a single standard size intersection warning sign for each through direction of travel and "Stop Ahead" and STOP signs on the stop approaches. Even with these signs a high frequency of crashes may exist at the intersection. Applying the complete set of sign and markings, defined previously under "Basic Countermeasures," to the intersection is estimated to reduce future crashes by 30 percent (crash reduction factor (CRF) of 40). This estimate was developed by an expert intersection safety panel using past effectiveness research findings in combination with engineering judgment.

Crash reduction factors for supplemental stop-controlled intersection countermeasures have been taken from the *FHWA Toolbox of Countermeasures and Their Potential Effectiveness to Make Intersections Safer* and other FHWA publications. The CRFs, typical crash thresholds for application, additional implementation factors, and estimated cost ranges for each of the countermeasures are provided in Table 1.

Table 1: Crash Reduction Factors, Typical Crash Thresholds, Additional Application Factors, and Estimated Implementation Cost Ranges for Countermeasures at Stop-Controlled Intersections

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factors	Typical Implementation Cost Range per Intersection
Basic set of sign and marking improvements	40%	10 crashes in 5 years	4-5 crashes in	None	$5,000 to $8,000

			5 years		
Installation of a 6 ft. or greater raised divider on stop approach (installed separately as a supplemental counter measure)	15%	20 crashes in 5 years	10 crashes in 5 years	Widening required to install island	$25,000 to $75,000 (pavement widening but no ROW required)
Either a) flashing solar powered LED beacons on advance intersection warning signs and STOP signs or b) flashing overhead intersection beacons	10% (13% for right angle crashes)	15-20 crashes in 5 years	8-10 crashes in 5 years	None	$5,000 to $15,000
Dynamic warning sign which advises through traffic that a stopped vehicle is at the intersection and may enter the intersection	Unknown	20-30 crashes in 5 years	10-20 crashes in 5 years	5 angle crashes in 5 years and inadequate sight distance from the stop approach	$10,000 to $25,000
Transverse rumble strips across the stop approach lanes in rural areas where noise is not a concern and running STOP signs is a problem (“Stop Ahead” pavement marking legend if noise is a concern)	28% (transverse rumble strips) 15% (“Stop Ahead” pavement markings)	5 running STOP sign crashes in 5 years	3 running STOP sign crashes in 5 years	Inadequate stopping sight distance on the stop approach	$3,000 to $10,000
Dynamic warning sign on the stop approach to advise high-speed approach traffic that a stopped condition is ahead	Unknown	8 running STOP sign crashes in 5 years	5 running STOP sign crashes in 5 years	Inadequate stopping sight distance on the stop approach	$10,000 to $25,000
Extension of the through edge line using short skip pattern may assist drivers to stop at the optimum point	Unknown	10 crashes in 5 years	5 crashes in 5 years	Wide throat and observed vehicles stopping too far back from the intersection	Less than $1,000
Reflective stripes on sign posts may increase attention to the sign, particularly at night	Unknown	10 crashes in 5 years	5 crashes in 5 years	Sign visibility or conspicuity significantly degraded particularly at night	Less than $1,000

The entire set of basic signing and marking countermeasures should be the primary improvement considered at stop-controlled intersections with a high frequency of crashes. One exception is stop-controlled intersections on divided multi-lane highways in which J-turn treatments (see next section) are the preferred countermeasure.

Additional supplemental countermeasures beyond the basic sign and marking enhancements should be considered at those intersections which either have much higher levels of crashes beyond the basic sign and marking crash thresholds or have other intersection crash concerns identified in Table 1 that may be addressed by a given countermeasure.

The crash threshold levels in Table 1 may be adjusted to reflect the following: entering traffic volumes (low volume intersections may have a lower threshold); and/or differences in severity rates (e.g., fatalities per 100 crashes) between urban and rural stop-controlled intersections. Refer to the Systematic Approach section of this document for further information on adjusting crash thresholds.

J-Turn Treatments at Stop-Controlled Intersections on Multi-Lane Divided Arterial Highways

Crash Problem

The major crash type at stop-controlled divided arterial highway intersections is a crash involving a vehicle entering the intersection from the stop approach and a vehicle travelling on the through approach, usually on the far side of the intersection from the right. The crash typically occurs after the vehicle from the stop approach has entered the divided median portion of the intersection and is attempting either to cross or turn left onto the far side of the arterial. While sign and marking countermeasures may impact this problem, they are not considered as effective as eliminating the through and left-turn movement from the stop approach and replacing them with a right-turn only J-treatment using a median break downstream.

Countermeasures

The low-cost countermeasure for multi-lane divided arterial intersections is to eliminate left-turn and through movements from the stop approach, forcing all vehicles to turn right. This is accomplished by adding minor channelization to the stop approach and in the median and supplementing the channelization with appropriate signs and markings. Drivers desiring to turn left or proceed through the intersection can make a U-turn a short distance downstream and continue on with their intended movements. Further information on J-turn designs and performance may be obtained from National Cooperative Highway Research Program (NCHRP) Project 15-30. This treatment is also referred to as either Superstreet or a Restricted Crossing U-turn intersection.

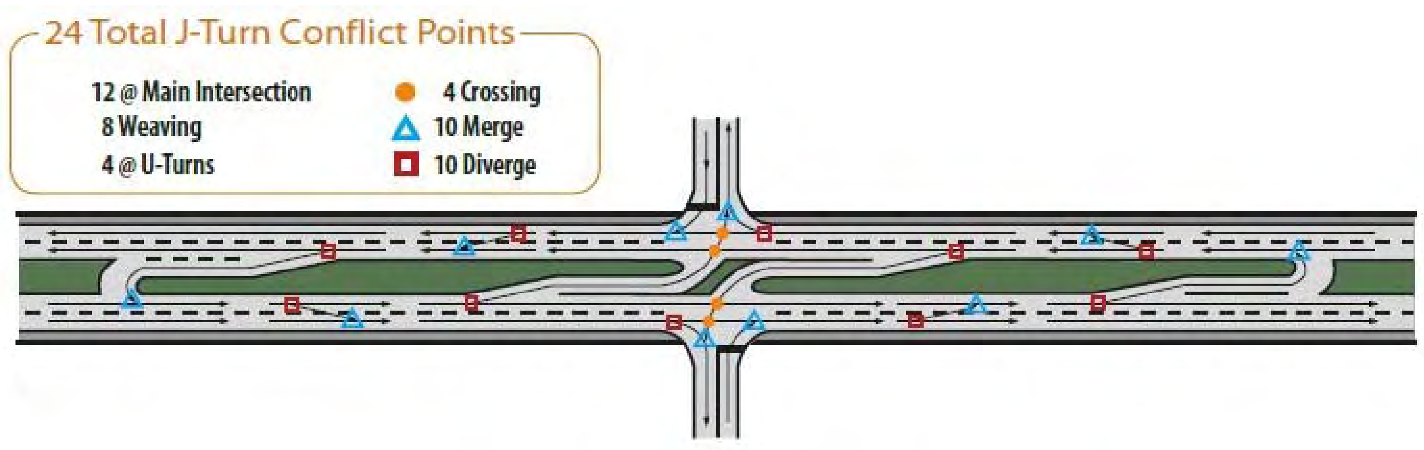

Figure 2: Turn Restrictions at Multi-Lane Highways

Countermeasure Crash Reduction Factors, Threshold Levels, Additional Implementation Factors, and Estimated Cost Ranges

Crash reduction factors for left-turn restrictions from stop approaches to divided highways have been taken from NCHRP Project 15-30, which included an evaluation of J-turn projects in North Carolina. Those evaluations concluded that there was a 100 percent decrease in cross-path crashes, a range of 72 to 84 percent reduction of frontal impact crashes, and an overall intersection reduction of total crashes of 43 to 53 percent.

Table 2: Crash Reduction Factors, Typical Crash Thresholds, Additional Application Factors, and Estimated Implementation Cost Ranges for Countermeasures at J-Turn Stop-Controlled Intersections

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection

J-turn modifications on high-speed divided arterials	100% cross path, 72-84% frontal impact, 43-53% all crashes	4 angle crashes in 5 years*	4 angle crashes in 5 years*	Ability to make U-turn within about ¼ to ½ mile of intersection	$5,000 to $50,000
* If a highway section has a series of stop-controlled intersections with a high collective number of angle crashes, it is preferable to treat the problem on a system basis addressing all of the stop-controlled intersections rather than improving a few intersections that have isolated high numbers of angle crashes.					

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3. Signal Timing

Existing Traffic Signals

http://ops.fhwa.dot.gov/arterial_mgmt/tstmanual.htm – The FHWA Signal Timing Manual will tell you all you need to know, and more, about how to go about optimizing signals. Chapter 2 in particular can guide you with regard to setting a local policy and taking the needed logical steps to make sure that signal timing is not operating in an outdated manner.

http://www.spcregion.org/downloads/ops/Other%20Studies/BenefitsofRetimingTrafficSignals.pdf – A nice basic article outlining needed steps in a compact manner, published in the ITE Journal. This article is highly recommended to get a quick grasp of the possibilities and costs of retiming. Topics include:

- What is signal retiming?
- Why is signal retiming conducted?
- How is signal retiming conducted?
- Who retimes traffic signals?
- What are the constraints of optimizing and operating traffic signals?
- How often should signal retiming be conducted?
- What is the cost of retiming traffic signals?
- What are the benefits of retiming traffic signals?
- Examples of successful retiming projects

New Traffic Signals

http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part4.pdf – Part Four of the Manual for Uniform Traffic Control Design states precisely what is needed in order to show that new signal control may be needed or justified. A certain level of traffic, both on a primary road and its minor intersector, has been shown to be processed better with alternating signals instead of stop sign control. Keep in mind that traffic will likely grow to some extent in future years. Other sections of the materials above will also have discussions regarding signal installation requirements. The MUTCD itself also has valuable guidance with respect to roadway marking and sign design and standards.

Traffic Signal Timing Manual

Arterial Management Home

The ***Traffic Signal Timing Manual*** [HTML, PDF 8.4MB] presents a comprehensive guide and synthesis of current practices related to traffic signal timing for signalized intersections. All the different elements of traffic signal timing, from policy and funding considerations to timing plan development, assessment, and maintenance are covered comprehensively. This manual is the culmination of research into documented practices from across North America. The *Signal Timing Manual* is intended to be a useful reference for a range of practitioners, including traffic engineers, signal technicians, design engineers, teacher, and university students.

Chapter 1 - Introduction. This chapter provides a background on intersection signalization, the need for signal retiming, and the benefits of retiming. It presents the overall structure, scope, and intended use of the manual.

Chapter 2 - Objectives, Policy and Funding Considerations. This chapter provides a summary of signal timing policy and objectives development, along with policy examples, and overview of the signal timing process and its interactions with policy.

Chapter 3 - Operational and Safety Analysis. This chapter provides a summary of the common techniques used to assess the operational and safety performance of signal timing.

Chapter 4 - Traffic Signal Design. This chapter documents the principles of traffic signal design and the relationship to traffic signal timing, including signal control type, signal phasing, detection layout, and how traffic signal design affects isolated and coordinated signal timing operations.

Chapter 5 - Basic Signal Timing Controller Parameters. This chapter presents basic traffic signal timing principles for a single intersection, regardless of coordination. It also describes the procedure to develop safe and efficient intersection operations through signal timing. In addition, it provides guidelines to select values for key signal timing parameters and strategies for their use.

Chapter 6 - Coordination. This chapter presents and defines the concept of coordinating traffic signals, and provides examples from research and practice. It provides an overview of coordination including a summary of objectives, the fundamental concepts, and expectations of coordinated timing.

Chapter 7 - Developing Coordinated Signal Timing Plans. This chapter documents the process used to develop coordinated signal timing plans in a step-by-step fashion. It provides an overview of coordination, including a summary of objectives, the fundamental concepts, and expectations of a coordination plan.

Chapter 8 - Signal Timing Maintenance Operations and Monitoring. This chapter provides a summary of the various steps necessary to maintain effective traffic signal timing plans and corresponding activities.

Chapter 9 - Advanced Signal Timing Topics. This chapter introduces some advanced concepts and applications within signal timing, discussing their effect on signal timing and providing examples when applicable. Topics presented in this chapter include traffic signal preemption, traffic signal priority, transition logic, traffic responsive operation, adaptive traffic signal control, planned special event, incident, and emergency management and weather-related factors influencing signal timing.

The Benefits of Retiming Traffic Signals

SIGNAL RETIMING IS ONE OF THE MOST COST EFFECTIVE WAYS TO IMPROVE TRAFFIC FLOW ALONG A CORRIDOR. TRAFFIC SIGNAL RETIMING CAN SIGNIFICANTLY REDUCE DELAYS AND STOPS EXPERIENCED BY MOTORISTS, WHICH CAN IMPROVE SAFETY AND REDUCE FUEL CONSUMPTION AND EMISSIONS. TYPICALLY, THE BENEFIT TO COST RATIO FOR SIGNAL RETIMING IS ABOUT 40:1.

BY SRINIVASA SUNKARI, P.E.

WHAT IS SIGNAL RETIMING?

Signal retiming is a process that optimizes the operation of signalized intersections through a variety of low-cost improvements, including the development and implementation of new signal timing parameters, phasing sequences, improved control strategies and, occasionally, minor roadway improvements.

The signal timing process often includes the training of engineering and maintenance staff to use existing signal control equipment more efficiently and to support new technologies as they become available for implementation.

Each traffic signal operates under a unique set of timing parameters. These parameters include minimum and maximum green durations, pedestrian indication requirements, gap and extension times, overlaps and phase change intervals (yellow change plus red clearance). A fixed-time signal also must have fixed cycle and split lengths that accurately balance average demand over a period of time.

When signals are operated within a coordinated system, additional parameters are used: cycle (the time needed to serve all phases); offset (the time from a reference point, such as the start of green or yellow of the coordinated phase at one intersection, to the same reference point at the other intersections); and split (the time allowed for each movement or phase—their total is the cycle length).

The offset is used to allow vehicles moving at the proper speed to advance from intersection to intersection without stopping. This process is called progressive movement.

As traffic patterns change over days, weeks and times of year (such as holidays), it is appropriate to modify signal timing parameters. This often includes the development of different timing parameters for morning and evening peak periods, midday off-peak periods, weekends and nights.

Signal retiming is oriented toward optimizing a controller unit's response to the demands of roadway users, including all types of motor vehicles, bicycles and pedestrians. Signal timing strategies include the minimization of stops, delays, fuel consumption and air pollution emissions and the maximization of progressive movement through a system.

Occasionally, the signal retiming process includes the reconfiguration of a signal's operation. This can include a change in the sequence of movements used at an intersection or the addition of signal displays and intervals (phases) to accommodate specific demands or movements, such as left-turn signals. Left-turn movements sometimes are programmed to follow the opposing through movement and accommodate the different arrival times of through movements along a coordinated arterial.

As technology continues to change in the traffic control field, it is important to upgrade existing traffic signal control hardware and accommodate enhanced signal operations. It also is possible to associate minor roadway improvements with the signal retiming effort to improve traffic operations.

For example, the provision of an additional left-turn lane, the extension of a right-turn lane, or the addition of right- and left-turn overlaps to allow for the accommodation of additional vehicle demand often are important.

Finally, training activities should be included as part of the signal retiming effort. Advancements in control technology, signal optimization programs and other traffic engineering tools are important.

WHY IS SIGNAL RETIMING CONDUCTED?

Traffic signal retiming is one of the most cost effective ways to improve traffic movement and make streets safer. Signal retiming is needed as much as patching potholes, removing snow and restriping pavement lines and markings. Following is a summary of the various reasons signal retiming is conducted:

- By coordinating or sequencing signals in relation to each other, platoons, queues, or groups of vehicles can travel through a series of signals with minimal or no stopping.
- The delay time on the approach to an intersection can be reduced by balancing the green time to reduce delay at that intersection.
- With developments such as the addition of new homes or stores, traffic increases and creates a need to adjust the timing of affected traffic signals.
- The diversion of traffic off a freeway or interstate due to an incident (an accident or event) associated with a computerized signal system can be accommodated.
- Motorist frustration caused by excessive delays or stops can be reduced by adjusting timing to reduce stops and delays and provide coordinated flow through groups of signals.
- Emissions and fuel consumption can be reduced by optimizing signal timing and coordinating traffic flow.
- Emergency vehicles, buses and commercial vehicles can save time.
- The number of severe collisions on city streets can be reduced by producing smoother traffic flow and fewer stops.
- The need for costly reconstruction can be postponed or eliminated by providing improved flow using existing resources in a more cost efficient manner.
- Changes in traffic flow for different times of day or days of the week can be accommodated.
- Signal retiming should be conducted during a reconstruction project when a lane closure or traffic detour causes a significant change in demand or capacity.
- Signal retiming is a cost effective method to improve traffic operation. It can produce benefit to cost ratios as high as 40:1.

HOW IS SIGNAL RETIMING CONDUCTED?

Signal retiming determines the timing to be entered in a controller using a series of calculations performed by a traffic engineer. The method for conducting signal retiming can be summarized as follows:

- An inventory of the system is conducted to determine geometric conditions and other pertinent information and to gather field observations of current traffic conditions during peak traffic periods.
- Traffic and pedestrian volume data are collected. Traffic counts include all turning and through movements as well as a classification of vehicles and the number of pedestrians using each crosswalk for each 15-minute interval of the study period. Travel time data also are collected for travel from one end of the system to the other, to identify current operating conditions.
- A collision history and analysis are prepared. Collision records for the past three years are obtained. An analysis is conducted by preparing a collision diagram and causation, collision types and remedy tables to determine if a change in signal operation is likely to provide safer operation.
- Collected data are processed and analyzed using capacity analysis, traffic signal timing optimization and simulation software programs. The model is calibrated using existing timing and the variables are adjusted to determine optimum signal timing.
- Improved coordination offsets through a series or group of signals are determined using signal coordination software programs such as SYNCHRO or PASSER II. The results also may be tested using simulation software programs such as CORSIM.
- The new timing is implemented at the intersection(s).
- The new timing is evaluated in the field during various critical time periods and final adjustments are made. Travel time and delay studies are conducted when the final timing plans are in place. Before-and-after studies are conducted through the groups of signals to determine and document the improvement in traffic flow.
- The process is repeated every three to five years, or more frequently based on changing conditions, to assure the continued optimum flow of traffic.

WHO RETIMES TRAFFIC SIGNALS?

Typically, the ultimate responsibility for signal retiming falls to the agency responsible for the operation of the roadways where signals are located.

On state highways, state departments of transportation (DOT) usually have responsibility for the timing and operation of signal equipment and are tasked with the goal of providing optimal traffic flow. In their timing efforts, the state highway systems usually have priority.

Local counties and municipalities that have responsibility for the operation of signals within their jurisdictions also may time traffic signals. Usually, this is performed within an agency's public works or traffic engineering department, depending on the depth of staff available within the agency.

In today's environment of limited public resources and reduced staffing, many agencies are using the services of consulting engineers to perform signal timing projects. This is particularly applicable to periodic timing applications funded by grants or special funding opportunities.

Political bodies, planning organizations and other advisory committees help drive the signal timing process indirectly by authorizing funding for signal timing studies and related improvements.

In addition, the public is involved as a user and as an affected party. Signal timing complaints and requests often are received from the motoring public with requests to update studies or make signal timing improvements.

WHAT ARE THE CONSTRAINTS OF OPTIMIZING AND OPERATING TRAFFIC SIGNALS?

Many factors limit the extent to which intersection efficiency can be improved with the optimization of signal timing. Although they are interrelated, these factors, or constraints, can be broken into three general categories: institutional, physical and temporal.

Institutional constraints on signal timing optimization pertain to the allocation of resources within an organization or agency and the relationship agencies have across jurisdictional boundaries. Competing budgetary demands within an agency may mean that insufficient resources (in terms of staff time and/or outsourcing

PART 4
HIGHWAY TRAFFIC SIGNALS

CHAPTER 4A. GENERAL

Section 4A.01 Types

Support:

01 The following types and uses of highway traffic signals are discussed in Part 4: traffic control signals; pedestrian signals; hybrid beacons; emergency-vehicle signals; traffic control signals for one-lane, two-way facilities; traffic control signals for freeway entrance ramps; traffic control signals for movable bridges; toll plaza traffic signals; flashing beacons; lane-use control signals; and in-roadway lights.

Section 4A.02 Definitions Relating to Highway Traffic Signals

Support:

01 Definitions and acronyms pertaining to Part 4 are provided in Sections 1A.13 and 1A.14.

CHAPTER 4B. TRAFFIC CONTROL SIGNALS—GENERAL

Section 4B.01 General

Support:

01 Words such as pedestrians and bicyclists are used redundantly in selected Sections of Part 4 to encourage sensitivity to these elements of "traffic."

02 Standards for traffic control signals are important because traffic control signals need to attract the attention of a variety of road users, including those who are older, those with impaired vision, as well as those who are fatigued or distracted, or who are not expecting to encounter a signal at a particular location.

Section 4B.02 Basis of Installation or Removal of Traffic Control Signals

Guidance:

01 *The selection and use of traffic control signals should be based on an engineering study of roadway, traffic, and other conditions.*

Support:

02 A careful analysis of traffic operations, pedestrian and bicyclist needs, and other factors at a large number of signalized and unsignalized locations, coupled with engineering judgment, has provided a series of signal warrants, described in Chapter 4C, that define the minimum conditions under which installing traffic control signals might be justified.

Guidance:

03 *Engineering judgment should be applied in the review of operating traffic control signals to determine whether the type of installation and the timing program meet the current requirements of all forms of traffic.*

04 *If changes in traffic patterns eliminate the need for a traffic control signal, consideration should be given to removing it and replacing it with appropriate alternative traffic control devices, if any are needed.*

05 *If the engineering study indicates that the traffic control signal is no longer justified, and a decision is made to remove the signal, removal should be accomplished using the following steps:*

- *A Determine the appropriate traffic control to be used after removal of the signal.*
- *B. Remove any sight-distance restrictions as necessary.*
- *C. Inform the public of the removal study.*
- *D. Flash or cover the signal heads for a minimum of 90 days, and install the appropriate stop control or other traffic control devices.*
- *E. Remove the signal if the engineering data collected during the removal study period confirms that the signal is no longer needed.*

Option:

06 Because Items C, D, and E in Paragraph 5 are not relevant when a temporary traffic control signal (see Section 4D.32) is removed, a temporary traffic control signal may be removed immediately after Items A and B are completed.

07 Instead of total removal of a traffic control signal, the poles, controller cabinet, and cables may remain in place after removal of the signal heads for continued analysis.

Section 4B.03 Advantages and Disadvantages of Traffic Control Signals

Support:

01 When properly used, traffic control signals are valuable devices for the control of vehicular and pedestrian traffic. They assign the right-of-way to the various traffic movements and thereby profoundly influence traffic flow.

02 Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages:

- A. They provide for the orderly movement of traffic.
- B. They increase the traffic-handling capacity of the intersection if:
  1. Proper physical layouts and control measures are used, and
  2. The signal operational parameters are reviewed and updated (if needed) on a regular basis (as engineering judgment determines that significant traffic flow and/or land use changes have occurred) to maximize the ability of the traffic control signal to satisfy current traffic demands.
- C. They reduce the frequency and severity of certain types of crashes, especially right-angle collisions.
- D. They are coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions.
- E. They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

03 Traffic control signals are often considered a panacea for all traffic problems at intersections. This belief has led to traffic control signals being installed at many locations where they are not needed, adversely affecting the safety and efficiency of vehicular, bicycle, and pedestrian traffic.

04 Traffic control signals, even when justified by traffic and roadway conditions, can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals can result in one or more of the following disadvantages:

A. Excessive delay,
B. Excessive disobedience of the signal indications,
C. Increased use of less adequate routes as road users attempt to avoid the traffic control signals, and
D. Significant increases in the frequency of collisions (especially rear-end collisions).

Section 4B.04 Alternatives to Traffic Control Signals

Guidance:

01 *Since vehicular delay and the frequency of some types of crashes are sometimes greater under traffic signal control than under STOP sign control, consideration should be given to providing alternatives to traffic control signals even if one or more of the signal warrants has been satisfied.*

Option:

02 These alternatives may include, but are not limited to, the following:

A. Installing signs along the major street to warn road users approaching the intersection;
B. Relocating the stop line(s) and making other changes to improve the sight distance at the intersection;
C. Installing measures designed to reduce speeds on the approaches;
D. Installing a flashing beacon at the intersection to supplement STOP sign control;
E. Installing flashing beacons on warning signs in advance of a STOP sign controlled intersection on major- and/or minor-street approaches;
F. Adding one or more lanes on a minor-street approach to reduce the number of vehicles per lane on the approach;
G. Revising the geometrics at the intersection to channelize vehicular movements and reduce the time required for a vehicle to complete a movement, which could also assist pedestrians;
H. Revising the geometrics at the intersection to add pedestrian median refuge islands and/or curb extensions;
I. Installing roadway lighting if a disproportionate number of crashes occur at night;
J. Restricting one or more turning movements, perhaps on a time-of-day basis, if alternate routes are available;
K. If the warrant is satisfied, installing multi-way STOP sign control;
L. Installing a pedestrian hybrid beacon (see Chapter 4F) or In-Roadway Warning Lights (see Chapter 4N) if pedestrian safety is the major concern;
M. Installing a roundabout; and
N. Employing other alternatives, depending on conditions at the intersection.

Section 4B.05 Adequate Roadway Capacity

Support:

01 The delays inherent in the alternating assignment of right-of-way at intersections controlled by traffic control signals can frequently be reduced by widening the major roadway, the minor roadway, or both roadways. Widening the minor roadway often benefits the operations on the major roadway, because it reduces the green time that must be assigned to minor-roadway traffic. In urban areas, the effect of widening can be achieved by eliminating parking on intersection approaches. It is desirable to have at least two lanes for moving traffic on each approach to a signalized location. Additional width on the departure side of the intersection, as well as on the approach side, will sometimes be needed to clear traffic through the intersection effectively.

Guidance:

02 *Adequate roadway capacity should be provided at a signalized location. Before an intersection is widened, the additional green time pedestrians need to cross the widened roadways should be considered to determine if it will exceed the green time saved through improved vehicular flow.*

03 *Other methods of increasing the roadway capacity at signalized locations that do not involve roadway widening, such as revisions to the pavement markings and the careful evaluation of proper lane-use assignments (including varying the lane use by time of day), should be considered where appropriate. Such consideration should include evaluation of any impacts that changes to pavement markings and lane assignments will have on bicycle travel.*

4. Modern Roundabouts

http://www.fhwa.dot.gov/publications/research/safety/00068/00068.pdf – This is FHWA's illustrated introductory guide to roundabouts. One can also order the full guide if roundabout use seems of potential benefit or go to the following link: http://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm

Roundabouts are becoming increasingly popular in the United States. They provide improved safety due to lower speeds and simpler, more obvious flow, and they actually increase the amount of traffic that can be processed under average intersection conditions. Roundabouts save money through the reduction of signal and other maintenance costs and by the less destructive conflicts and crashes that occur compared to crossroads. They are environmentally friendly via their central beauty and lack of overhead signal housing and wiring, as well as in the reduced vehicle delay that generally results. They help to temper "road rage" and impatience by keeping vehicles moving - in an orderly way, and they are very friendly to the older driver who doesn't need to judge high speeds coming from multiple directions. Even pedestrians have an easier time negotiating a crossing as they need only deal with one direction of traffic at a time.

While roundabouts have their drawbacks, primarily in coexisting with tech-oriented signal installations, and are not suitable for all traffic patterns, it's easy to see why they are growing in number. As transportation professionals and the public become increasingly familiar with these types of intersections, it's important to more fully understand all of the advantages and disadvantages, so that we may use them more frequently in good situations while avoiding their less effective placements.

WHAT ARE THEY? No matter what the vehicle, we aren't all travelling in the same direction all the time. Rotaries were early inventions designed to help us avoid crashing into each other while pursuing our single paths; this was accomplished by blending our travel into one direction (in a circle) from which we could all spin off again towards our destinations. In this case, spin is a very appropriate word, as the early idea was to keep things moving fast. This required a wide circle, easy to slide from at high speed and difficult to navigate with the rapid approach of fellow travelers. (Another solution, called "let's take turns", resulted in today's right-angle intersections - which are becoming increasingly unreliable [slow], and untrustworthy [dangerous]). The roundabout was born by taking the flowing concept of the rotary and reducing its size and speeds. The adoption of an approach "yield" rule that let traffic continue to rotate inside the circle, preventing the circle from "locking up", and the addition of horizontal curving of vehicle approach paths, to achieve slower entry and exit speeds, perfected the design.

SAFETY: A review of the many benefits of roundabout design in traffic management begins with its increased overall natural safety. With their slower speeds, fewer potential conflict areas and easier decisionmaking, roundabouts definitely experience fewer crashes, and those that do occur are of lesser severity than those occurring at signalized locations. The design itself has a naturally calming effect, as its engineering features subtlety guide people to be more cautious and considerate. Roundabouts indeed can be seen as a useful additional tool in the fight against aggressive driving and "road rage", as they encourage cooperation between drivers, not competition between vehicles. With no red lights to violate, unexpected danger and rude surprises are minimized. While signaled intersections cause vehicles to stop about half the time, roundabouts keep people moving for the most part, and this sense of progress in travel helps to curb impatience and rash decisionmaking.

Additionally, with the average age of our population growing, it's important to note that the design is elder-friendly, with fewer conflict dangers to evaluate and with slower speeds to fit slower evaluation and reaction times. It's well known that left-turn crashes of all kinds are increasing with the lessened ability of the older driver to estimate speeds; the roundabout has no left turns. Even pedestrians benefit; while it may look like a difficult area to cross, by taking one leg at a time and using the approach dividers as safety islands, pedestrians only have to look one way for each lane or two that is being crossed, allowing for increased eye contact and cooperation with drivers, and resulting in fewer mistakes. Indeed, an increased publicizing of the many safety benefits outlined here would probably go a long way towards wider, more enthusiastic public acceptance of this new traffic management design.

CAPACITY: For moderate traffic flows and intersections that are handing vehicles that approach fairly equally from all directions, roundabouts have been shown to improve efficiency by handing up to 30% more vehicles than signal control would for a similar time period. During heavier vehicle flow periods, everyone naturally gets a turn before too long due to the random nature of destinations and vehicle gaps; and when traffic is light, almost no one has to wait before entering the circle - in contrast to the traffic signal that will be red for each direction some of the time. In effect, we all "take turns" in a more efficient and positive manner.

COST: Maintenance costs for wiring and electricity, and for signal timing, are lower, although the need for fresh striping and general directional painting is greater, and there may be additional cost associated with maintaining the center area landscaping. But, thinking on a larger scale, there's less fuel consumed due to less waiting, and lower costs of all kinds associated with fewer and less violent crashes. As roundabouts manage traffic flow better, fewer lanes are needed in the roadway approaches to the circle, while more right of way may be needed for the circle itself. This characteristic, however, pays big dividends in bridge structure situations, such as those seen at intersections with interstate highways and the like, as a narrower bridge is often feasible, even if more land is used on either side of the bridge. Of course, all these savings also generally result in a lesser impact to the natural environment, which only multiplies their value.

VISUAL APPEAL: You'll never hear the word "beauty" associated with a signalized intersection, but many roundabouts are quite satisfying and appealing in their look. Appropriate landscape treatments – set to scale, not overly distracting or overwhelming – serve to warn drivers to slow down as well as providing a change from the normal feel of transportation infrastructure. There's no need to string unsightly wires, to cut pavement for loop detectors, or to mount cameras to help inform signal operations. Everything is again calmer and gentler, leading naturally to more orderly and cooperative driving habits.

DRAWBACKS: While a beneficial choice for many locations, there are special considerations that sometimes argue against the use of a roundabout , for practical or safety reasons. Here's a list of areas of concern:

- Roundabouts may not process large volumes well, especially if the use by direction in not well balanced
- They may not be workable near bottleneck situations, where occasional delay complicates operations
- They do not work well near rail crossings and drawbridges, where barriers to flow will occur
- It's not possible to use signal preemption to let emergency vehicles pass more easily
- Larger roundabouts with two lanes experience problems with people that are exiting from the inner lane
- Bicycles must use the travel path (as they should); driving around on the outside edge is dangerous
- Ideally, a targeted education effort is needed for public acceptance and proper use
- Results are better with educated, conscientious drivers who understand and respect the "Yield" sign
- More land is needed, and heavy truck use requires provision of "spillage" areas for wide turns
- Sight lines at the approaches need to be kept clear; they, and the center, need to be non-distracting

WHY SHOULD I CARE? Think of it this way: the next time you stop at a red traffic signal and see no one else coming either way… Instead of saying, What a waste of my time! – Think that you could have been entering a roundabout and have been already moving on to your next location. Most people see roundabouts as holding them up, when in fact, most of the time you are able to keep moving! Tools and checklists exist for evaluating the potential use of a roundabout at any given location. Let's give some thought to making it habit – or policy – to purposefully evaluate the potential use of this new infrastructure design whenever we are considering roadway improvements or new intersections.

ROUNDABOUTS:
AN INFORMATIONAL GUIDE

Although roundabouts have been in widespread use in other countries for a number of years, it is only during the past few years that their application in the United States has received increased attention by both the public and transportation professionals. A lack of sufficient information on roundabout operation and design under local U.S. conditions is one of the reasons why these roundabout intersections have seen only sporadic implementation. This national guide bridges this gap by providing a comprehensive source of information on modern roundabouts, from small mini-roundabouts to large freeway interchange roundabouts.

To make the information widely accessible, the guide has been structured and written to address the needs of a wide range of readers, including the general public, policy-makers, transportation planners, operations and safety analysts, and conceptual and detailed designers. Not only does the guide provide general information and planning-level analysis techniques, but it also includes evaluation procedures for assessing operational and safety performance, as well as design guidelines. Input from transportation practitioners and researchers from around the world was used in developing the guide. This book covers the needs of all travel modes and provides design guidance for incorporating these needs into final plans.

The definitive source of information related to the planning, operation, design, and configuration of modern roundabouts in the United States. Comprehensive coverage is provided for all travel modes that need to be considered in roadway design. The information contained in this guide is the culmination of extensive research into best practices from around the world, interpreted in the light of accepted U.S. design standards such as AASHTO's Green Book and the MUTCD.

SAFETY AND OPERATIONAL BENEFITS

Many international studies have found that one of the most significant benefits of a roundabout installation is the improvement in overall safety performance. Specifically, in the United States, it has been found that single-lane roundabouts operate more safely than two-

U.S. Department of Transportation
Federal Highway Administration

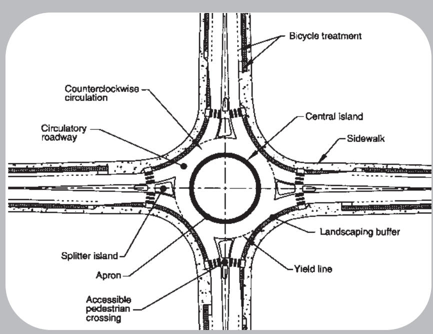
Average annual crash frequencies at 11 U.S. intersections converted to roundabouts.

Type of Roundabout	Percent Change			
	Sites	Total	Injury	PDO
Single-Lane	8	-51%	-73%	-32%
Multi-Lane	3	-29%	-31%	-10%
Total	11	-37%	-51	-29%

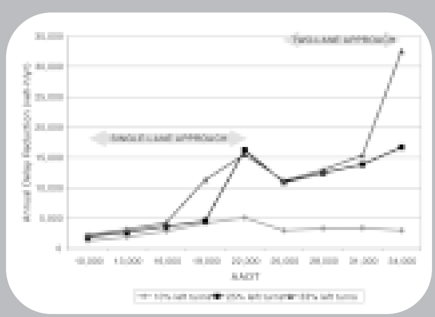
Source: Jacquemart, G. *Synthesis of Highway Practice 264:* Modern Roundabout Practice in the United States. National Cooperative Highway Research Program. Washington, D.C.: National Academy Press, 1998.

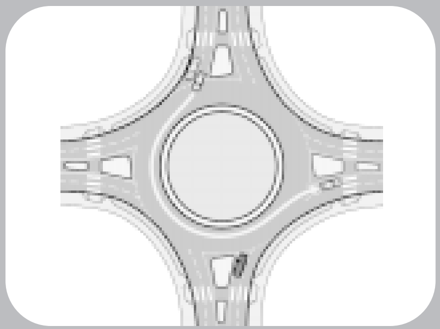
way stop-controlled intersections. The frequency of crashes might not always be lower at roundabouts, but the injury rates are reduced. Pedestrians and bicyclists require specific design treatments to improve their safety.

On a planning level, it can be assumed that roundabouts will provide higher capacity and lower delays than all-way stop control, but less than two-way stop control if the minor movements are not experiencing operational problems. A single-lane roundabout may be assumed to operate within its capacity at any intersection that does not exceed the peak-hour volume warranted for signals. A roundabout that operates within its capacity will generally produce lower delays than a signalized intersection operating with the same traffic volumes and right-of-way limitations.

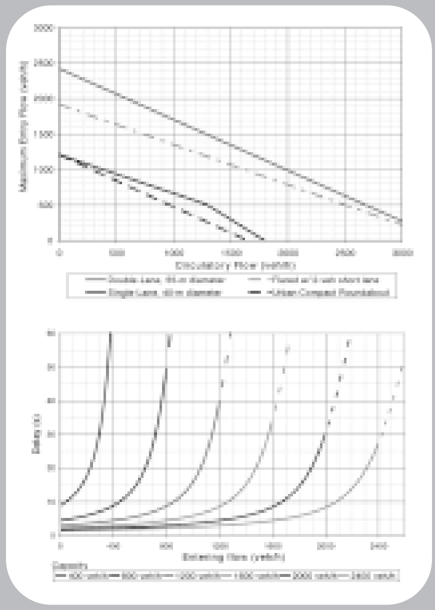


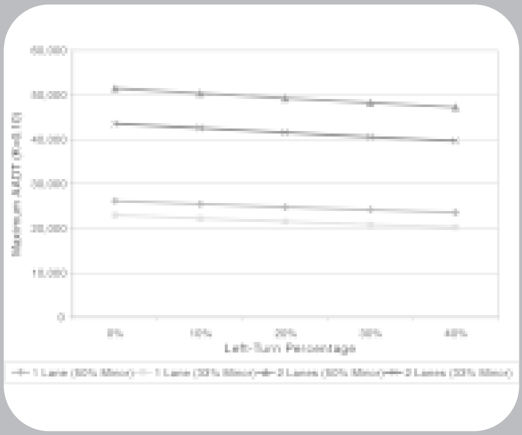
Chapter 1, Introduction.
Defines the key features and dimensions of a roundabout and describes the various types of roundabouts. It clearly highlights the differences between roundabouts and other forms of traffic circles with the generous use of photographs to depict a variety of situations.





Chapter 2, Policy Considerations.
Provides a broad overview of roundabout performance characteristics, including safety, delay, environmental factors, traffic calming, aesthetics, and multimodal considerations, as well as the policy considerations that pertain to their use. Costs associated with roundabouts relative to other intersection forms, legal issues, and education and public involvement techniques are also discussed.



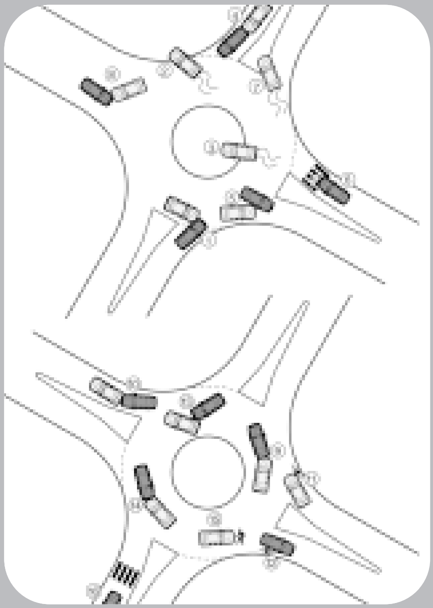


WHEN TO RECOMMEND ROUNDABOUTS: PLANNING ANALYSIS

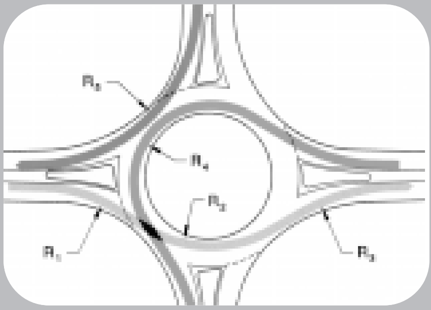
Roundabouts can be considered for a variety of reasons. The roundabout guide describes categories for selection that range from community enhancement and traffic calming, to safety improvements and operational benefits. The maximum daily service volume of a single-lane roundabout varies between 20,000 and 26,000 vehicles per day, depending on the left-turn percentages and the distribution of traffic between the major and minor roads. A double-lane roundabout may service 40,000 to 50,000 vehicles per day.

Chapter 3, Planning.
Presents planning-level guidelines for identifying appropriate intersection control options. This chapter presents daily traffic volume-based procedures for evaluating roundabout feasibility at a given location.

Chapter 4, Operational Analysis.
Details methods for analyzing the operational performance (capacity, delay, and queuing) of each type of roundabout. This chapter describes traffic operations at roundabouts, lists the data required for evaluating roundabouts, shows how to estimate capacity, describes measures of effectiveness, and provides a brief overview of available software tools.



Chapter 5, Safety.
Discusses the improvements in safety performance that roundabouts typically provide at intersections. Roundabout safety related to vehicles, bicycles, and pedestrians is discussed, and international roundabout safety experience is presented for comparison. In addition, crash prediction models are given for evaluating crashes at roundabouts.

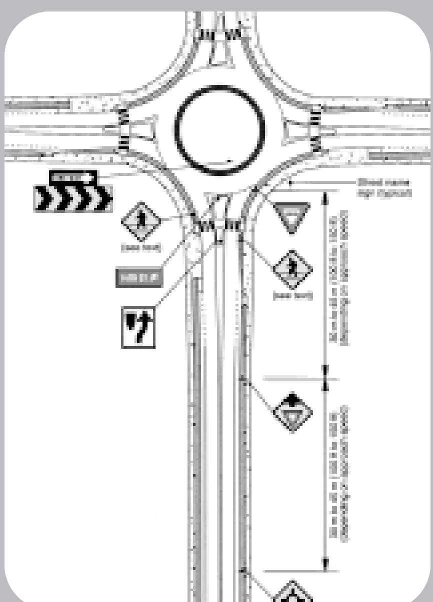


Chapter 6, Geometric Design.
The chapter presents the basic design philosophy of speed reduction and speed consistency to maximize the safety of a roundabout. This chapter presents specific roundabout geometric design principles, and then discusses each design element in detail, along with appropriate parameters to use for each type of roundabout.

ROUNDABOUTS: AN INFORMATIONAL GUIDE

Table of Contents

Additionally, the guide contains over 150 charts, diagrams, plans and photographs which illustrate the various features of roundabouts.



Chapter 7, Traffic Design and Landscaping. Discusses a number of traffic design aspects that should be considered once the basic geometric design has been established. These details include signs, pavement markings, illumination, and landscaping. Chapter 7 also discusses issues regarding work-zone traffic control at roundabouts.

Chapter 8, System Considerations. Identifies specific issues and treatments that may arise within a systems context. The chapter discusses signal control at roundabouts and the issue of rail crossings through or near a roundabout. Roundabouts in series with other roundabouts are also discussed, including those at freeway interchanges and those in signalized arterial networks. Finally, Chapter 8 presents simulation models as supplementary operational tools capable of evaluating roundabout performance within an overall roadway system.

Roundabout or Traffic Circle?

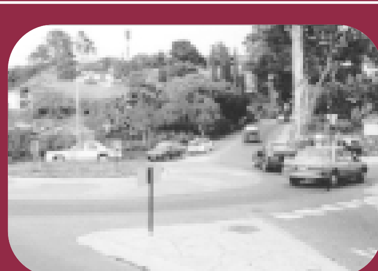
Since the distinctions between modern roundabouts and other kinds of circular intersections may not always be obvious, the negative aspects of older rotaries or traffic circles may be mistaken by the public with a roundabout. Therefore, the ability to carefully distinguish roundabouts from traffic circles is important in terms of public understanding.

Traffic Control

Yield control is used on all entries. The circulatory roadway has no control.

Some traffic circles use stop control, or no control, on one or more entries.

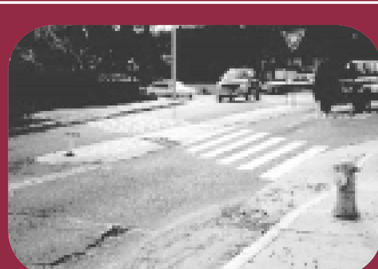
Priority to Circulating Vehicles



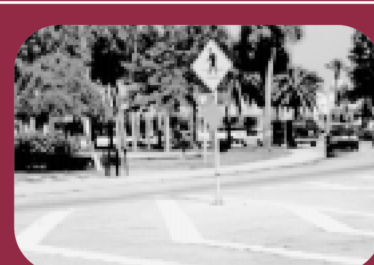
Circulating vehicles have the right of way.

Some traffic circles require circulating traffic to yield to entering traffic.

Pedestrian Access



Pedestrian access is allowed only across the legs of the roundabout, behind the yield line.



Some traffic circles allow pedestrian access to the central island.

Direction of Circulation

All vehicles circulate counter-clockwise and pass to the right of the central island.

Some neighborhood traffic circles allow left-turning vehicles to pass to the left of the central island.

The important difference between roundabouts and other forms of traffic circles is the reduction of absolute and relative speeds between users.

Roundabouts require conformance to common practices to ensure safe, optimal operation. A scattered approach to design can lead to inconsistencies at a national level that are consequential in terms of driver expectation and safety.

Contributors to the book include:

- Kittelson & Associates, Inc.
- Ruhr-University Bochum (Germany)
- University of Idaho
- Hurst-Rosche Engineers
- Buckhurst Fish & Jacquemart
- Queensland University of Technology (Australia)
- University of Florida
- Pennsylvania State University
- Eppell Olsen & Partners (Australia)

In addition the document benefited from extensive review by representatives of French and British practices as well as AASHTO, MUTCD, and representatives of the Americans With Disabilities Act.

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Roundabouts: An Informational Guide (FHWA-RD-00-067) will be available on the internet at the Turner-Fairbank Highway Research Center website: http://www.tfhrc.gov.

Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA
22101

A report may be obtained from the FHWA Report Center. Fax requests to (301) 577-1421 or e-mail requests to report.center@fhwa.dot.gov. Requests for the report will be logged and copies mailed when the document is published. The Report Center may be reached by phone at (301) 577-0818.

FHWA-RD-00-068

5. Pavement Preservation

http://www.fhwa.dot.gov/infrastructure/asstmgmt/pmprimer.pdf – Most localities have their own established procedures for keeping road condition up-to-date, but this short FHWA paper will provide a review of the basics.

Pavement Management Primer

What Is Pavement Management?

Pavements represent the largest capital investment in any modern highway system. Maintaining and operating pavements on a large highway system typically involves complex decisions about how and when to resurface or apply other treatments to keep the highway performing and operating costs at a reasonable level. Traditional methods, used since Roman times, left these decisions up to a road supervisor who would select treatments based on his extensive knowledge and experience. This system is still widely practiced and works well in low traffic areas or where repair/restoration funds are not limited. In most cases, however, this is not the situation. First, rarely are there enough funds to complete all identified road repairs, and second, high traffic levels severely restrict when roads can be closed for maintenance.

Pavement management brings more science into this process. A pavement management system consists of three major components:

1. a system to regularly collect highway condition data
2. a computer database to sort and store the collected data
3. an analysis program to evaluate repair or preservation strategies and suggest cost-effective projects to maintain highway conditions

In most agencies, these components are then combined with planning needs and political considerations to develop annual highway repair/preservation programs.

Data collection ranges from simple "windshield surveys" to the use of elaborate testing vehicles that measure smoothness, skid resistance, faulting, and cracking in the road surface. Some agencies own and operate their own vehicles; others contract out the data collection. To make fair comparisons between potential projects, the highways are divided into segments that are more or less equal in length. The data from each segment is stored as one record in the database. The length of a typical segment ranges from 0.1 mile to 1 mile.

The database and analysis are usually set up using commercially available software. The size of the database will vary depending on the number of highways and the length of segment used for analysis. Most pavement management software vendors provide customized input screens, analysis packages, and reports as needed by the agency.

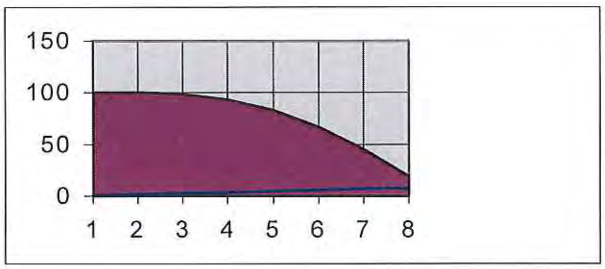
The analysis part of a pavement management system attempts to predict how long a pavement segment will last with a certain kind of repair under the given traffic loads, climate, and other factors. This analysis is based primarily on the collective experience of highway experts (road supervisors) and on the historical costs incurred for repairs or reconstruction. More sophisticated analysis packages also predict annual repair costs, overall system performance, and expected pavement conditions on related routes within planning corridors. Overall, the intent of the analysis is to identify the most cost-effective ways to maintain a highway system in satisfactory condition. Many systems provide a kind of learning process to the analysis program based on the actual performance trends of the highway system. After a few cycles of data collection, these systems can predict the local conditions with remarkable accuracy.

The most common uses of the pavement management information are by planning departments in highway agencies for scheduling repair and reconstruction projects. In addition, pavement management information is used by road supervisors departments for evaluating repair methods and by engineering groups for evaluating pavement designs.

Does It Work?

Several firms began to experiment with pavement management on computer systems during the 1970's and made some interesting discoveries:

1. **Pavement Deterioration**—Pavements tend to deteriorate very slowly during the first few years after placement and very rapidly when they are aged. Even though pavement designs and materials varied widely, the deterioration of pavements followed a standard curve. This curve, pavement condition vs. age, is shown in the following figure.



2. **Costly Maintenance Practices**—Typically, State and local governments invest more funds for maintaining highways than for any other public purpose. While much of this is due to the high cost of repairs and heavy usage of the highways, there is strong evidence that some of the high operating costs originate from inappropriate or poorly timed maintenance decisions.

3. **Preserve vs. Reconstruct**—Successive years of collecting pavement condition data showed that it was far more economical to preserve roads than to delay repairs and reconstruct roads. The studies further showed that as traffic levels increase the costs of delaying repair work increased greatly. This suggested that the traditional practice of repairing the worst roads first is, in fact, a very expensive way to operate a highway system.

4. **Data Collection Problems**—Data collection by observation was very difficult and was often not objective. Data collection on large highway systems usually required several observers to collect data and led to inconsistencies in the data. This finding led to the development of vehicles that mechanically measure smoothness and other road conditions.

5. **Using Computers**—Early mainframe computers took as much as a week to analyze pavement data and cast some early shadows on the value of the process. With the incredible computing power available on today's desktop computers, these analyses

can be run in a matter of seconds. This allows decision-makers to consider numerous "what-if" alternatives.

Most government agencies have had difficulties introducing pavement management into their decision-making process. Significant misunderstandings still exist about the capabilities of the systems and whether strategically planning highway maintenance is appropriate. Reports are often misinterpreted and not used effectively. Development of pavement management systems can be costly and usually takes several years to produce tangible results.

Today, most of the larger highway systems have incorporated pavement management systems into their operating plans. These agencies report that the systems are worthwhile, but that several cycles of data collection are needed to produce significant cost savings in operations and maintenance.

Conclusion

More than ever before citizens are demanding accountability from their local governments. In State highway agencies, critical decisions are made every day that affect the overall performance and operating costs of their highways. In this environment, poor decisions can be very costly. Information from a pavement management system provides an effective way to get better performance with less cost by providing valuable information to the appropriate decision-makers.

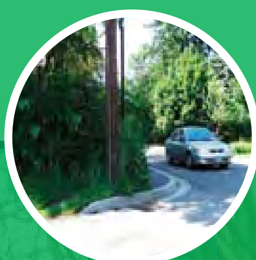
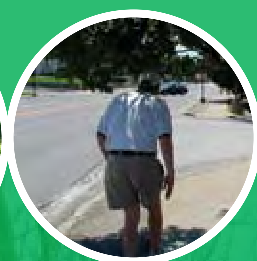
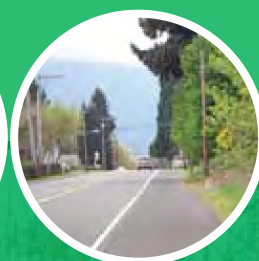
It is unlikely that traffic levels will decrease in the future or that pavements will get so good that they never need repair. Similarly, it is unlikely that major increases in funding for transportation will occur in the near future. The need for efficient management is greater today than ever before, and for highway pavements, the tool for efficiency is a good pavement management system.

6. Vegetation Control

http://safety.fhwa.dot.gov/local_rural/training/fhwasa07018/vegetationfv1108.pdf – The purpose of this guide is to help local road agency maintenance workers identify locations where vegetation control is needed to improve traffic and pedestrian safety, to provide guidance for maintenance crews, and to make them aware of safe ways to mow, cut brush and otherwise control roadside vegetation.

VEGETATION CONTROL FOR SAFETY

A Guide for Local Highway and Street Maintenance Personnel

Revised August 2008

U.S.Department of Transportation
Federal Highway Administration

I. INTRODUCTION

Scope and Objectives

Safety is a main concern of highway and street agencies. In fact, roadway safety cannot be achieved without a good maintenance program. Employees of local road agencies are responsible for reviewing their roads and rights-of-way, identifying hazards, and making conditions safer.

One potential hazard is vegetation. Trees close to the road can present a fixed object hazard. Grass, weeds, brush and tree limbs can obscure or limit a driver's view of traffic control devices, approaching vehicles, wildlife and livestock, and pedestrians and bicycles. Controlling vegetation helps reduce crashes and injuries.

The purpose of this guide is to help local road agency maintenance workers identify locations where vegetation control is needed to improve traffic and pedestrian safety, to provide guidance for maintenance crews, and to make them aware of safe ways to mow, cut brush and otherwise control roadside vegetation. This document is not intended to be a design guide; if further clarification is needed, maintenance personnel should consult an engineer.

Goals of Vegetation Control

The main goals of vegetation control include:

- Keeping signs visible to drivers.
- Keeping road users (vehicles, bicycles and pedestrians) visible to drivers.
- Improving visibility of livestock and wildlife near the road.
- Helping pedestrians and bicyclists see motor vehicles.
- Keeping sidewalks and pedestrian paths clear and free from overhanging vegetation.
- Removing trees close to the roadway which could result in a severe crash if hit.
- Improving winter road maintenance in snow and ice areas.

- Helping drainage systems function as designed.
- Preserving pavements through daylighting and root system control.
- Controlling noxious weeds in accordance with local laws and ordinances.

This publication describes conditions commonly found on local highways and streets and how road workers can identify potential hazards caused by vegetation. Detailed information is presented about sight distances, worker safety, and setting up temporary traffic control.

Roadside Vegetation Management

Roadway agencies are encouraged to develop roadside vegetation management programs to define the best maintenance practices for each location. An integrated roadside vegetation management program consists of eliminating or controlling vegetation through a variety of strategies including mowing, brush cutting (mechanical and hand), use of herbicides, grazing of livestock, cultivating desirable vegetation, and re-vegetation.

Be sure you know your state's laws and regulations dealing with vegetation control, including any record-keeping and reporting requirements. Consult with your local weed control specialist to determine the type of vegetation and the best way to control it. If noxious weeds are present, mowing, for example, will spread the seeds and spread the infestation so you have more work to do next year. Use of herbicides may not be permitted by local ordinance or a plant on the Threatened and Endangered Species list may be present. Different species require different treatments.

One useful way to look at how and why vegetation control is needed for safety is to think in terms of Roadside Management Zones. The figure on the next page shows the zones and the objectives of each zone, as developed by the Washington State Department of Transportation.

7. Highway Drainage

http://www.fao.org/docrep/006/t0099e/t0099e07.htm – Conduct routine maintenance for culverts and other underground and roadside drainage structures and facilities, such as swales and retention ponds. Be mindful of the ongoing needs of community-owned bridge structures.

CHAPTER 7

ROAD MAINTENANCE

7.1. Introduction

Road maintenance is essential in order to (1) preserve the road in its originally constructed condition, (2) protect adjacent resources and user safety, and (3) provide efficient, convenient travel along the route. Unfortunately, maintenance is often neglected or improperly performed resulting in rapid deterioration of the road and eventual failure from both climatic and vehicle use impacts. It follows that it is impossible to build and use a road that requires no maintenance.

In order to plan for road maintenance needs, it is important to keep a complete set of "as built" plans and records of all maintenance operations and observations. The as built plan should contain the following:

1. Complete job index
2. Complete history of project from planning stage to construction
3. Photographic records
4. Exact location and observations of any unstable conditions in relation to the road location
5. Exact location of culverts and other drainage features
6. Wet areas that may have required additional excavation and replacement with more suitable ballast backfield materials
7. All major changes made to the original plan

Probably the most valuable tool for any maintenance program is the knowledge and experience gained by individuals performing the maintenance. Every effort should be made to retain competent, knowledgeable, and experienced individuals in these positions not only from the standpoint of instituting and executing a good maintenance program, but for future road planning needs as well.

In deciding on an appropriate level of maintenance for a particular road or road segment, consideration must be given to the amount and type of vehicle use and physiographic and climatic variables which may impact drainage structures. A useful guide to the types and frequency of maintenance activities appropriate for a given road is shown in Table 43.

7.2 Drainage System Maintenance

Drainage structures must be kept free of debris and obstructions. On newly constructed roads, or in upstream areas where heavy earth moving is taking place (e.g., urban development, logging, mining, etc.), cleaning may have to be more frequent.

Grass growing in ditches, unless it is dense enough to cause a major impediment to flow, should not be removed during cleaning. Likewise, shoulder and cut banks must not be undercut.

Table 44. Typical road maintenance activities appropriate for a given road use level.

Management Decision for Road	Types of Activities That Could Be Expected

Always open	- Regularly scheduled running surface reshaping or repair - Regularly scheduled ditch and culvert cleaning, repair - Yearly brush, tree, snag safety check, removal - Yearly stream trash removal around channel crossings - Yearly reseeding and/or fertilizing of cut and fill slopes - Yearly fence, cattle guard check - Snow thaw road check and repair - Storm damage and pollution control structure check and repair - Seasonal check of signs and notices
Closed-usable	- Periodic dust control near inhabited or work areas - Pre and post rainy season channel crossing and ditch maintenance - Storm damage and pollution control structure check and repair - Yearly brush, tree, snag safety check, removal - Yearly reseeding and/or fertilizing of cut and fill slopes - Periodic check of closure controls and signs - Yearly fence, cattle guard check
Closed-not usable	- Pre and post rainy season channel crossing and ditch maintenance - Yearly stream trash removal around channel crossings - Yearly inspection and maintenance of drainage structures - Road outsloped and/or water barred; channel crossings usually removed - Periodic check of closure controls and signs
Reactivate-unusable	- Reconstruct channel crossing structures (culverts, etc.) - Reinstall ditches and cross drains, if needed - Clear debris, slides, trees; remove hazard trees and brush - Regrade and finish road surface - Sign and post as needed - Check, repair, or install fence as needed - Reconstruct road to higher standard if necessary

The objective in "pulling a ditch" is to grade the ditch so as to clean it of debris that could divert flow from the ditch on to the road surface. Hand clearing with a shovel is effective when the work load is light or the presence of structures (e.g. cross drains or culvert inlets) make it impractical to use heavy equipment. With a grader, the following procedure is followed:

1. Flag all culverts and cross drains

2. Remove snags, rocks, and other hazards before grading begins

8. Access Management

http://ops.fhwa.dot.gov/access_mgmt/how_is_am_acheived.htm - is a short listing of how access management is achieved. Since the development of access management techniques often is a long –term process involving many governmental and other entities, a full review of all the needed steps is generally beyond the scope of a short paper or document.

http://ops.fhwa.dot.gov/access_mgmt/docs/benefits_am_trifold.htm - is a good FHWA resource which again lists many of the tactics and techniques that are being employed throughout the country.

http://www.cmrpc.org/access_management - is a webpage dedicated to access management by CMRPC. For examples, there are access management plans for the towns of Boylston, Holden, and Westborough.

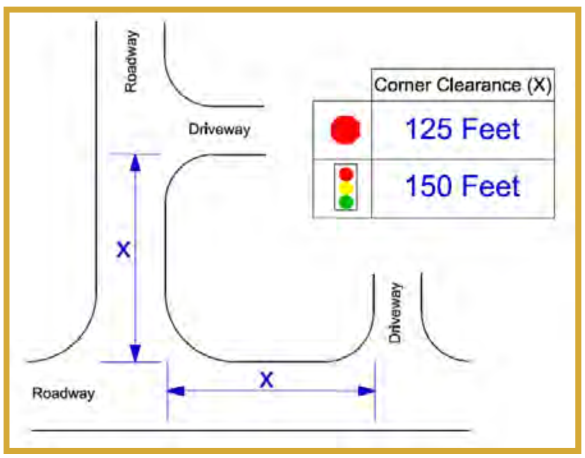
The Federal Highway Administration defines access management as "the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding system in terms of safety, capacity, and speed." In practical terms, it means managing the number of driveways that a vehicle may encounter without hampering reasonable access to a property and removing slower, turning vehicles from the arterial as efficiently as possible. Access Management focuses on both short term and long term improvements.

Driveways are points of access from public streets to private property and are not intersections. Safety studies have confirmed that crash rates increase as the spacing of access points decreases. This is especially true for commercial entrances and exits. Vehicles entering or exiting the road at driveway locations generally operate at slower speeds than the prevailing traffic, which increases crash potential and slows roadway travel. Managing driveway spacing often enhances operations and safety for the entire corridor.

Access Management Best Practices

Lot Frontage and Setback Requirements

- **Increase minimum lot size for corner lots to improve corner clearance**
  Corner clearance is the distance from an intersection of a road to the nearest access connection. Ensuring an adequate lot size with appropriate corner clearance will protect the development potential and market value of corner properties while helping ensure that these properties do not create access problems on surrounding roadways.



- **Increase minimum lot frontage and setback requirement**
  Establishing higher lot frontage and dimensional requirements on arterial roadways allows for greater spacing between driveways. When establishing setback requirements, consider roadway improvement needs and ensure the setback is sufficient to avoid structural encroachment within the pathway of planned future improvement.

Minimum Lot Frontage	
Posted Speed (MPH)	**Lot Width (Feet)**
≤ 30	225
35	275
40	330
45	385
≥50	450

Driveway Guidelines

The following are design standards and guidelines that the town could use while reviewing site plans.

<u>Driveway design elements (width & radii) based on driveway classifications:</u>

Driveway Classification	Expected Trips
Low Volume	1-20 trips/day 1-5 trips/hour
Medium Volume	21-600 trips/day 6-60 trips/hour
High Volume	601-4,000 trips/day 61-400 trips/hour
Major Volume	>4,000 trips/day >400 trips/hour

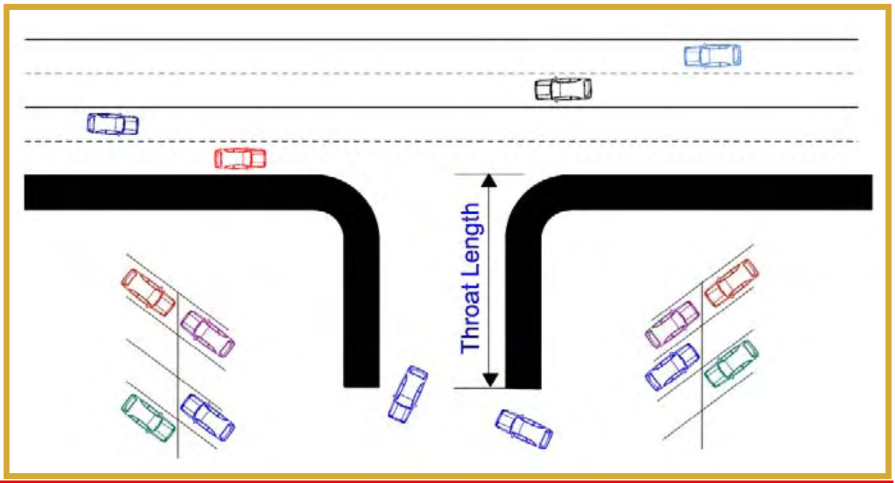
<u>Driveway Design Elements:</u>

Driveway Class	Driveway Width (feet)	Minimum Radius Returns (feet)
Low Volume	10 – 24	15
Medium Volume	24 – 36*	30 (40 Recommended)
High Volume	36**	**
Major Volume	**	**

* A 36 ft. driveway is usually marked with two exit lanes of 11 ft. width, with the balance of 14 ft. used for a single, wide entry lane. A larger width will be required for a divided driveway design.

**Driveway widths and lane requirements are determined by a traffic study.

Throat Lengths



Land Use	Driveway Throat Length
Major entrance to a development with 4 or more total lanes in the driveway	≥300 ft, based on traffic engineering study
Regional Shopping Center (>150,000 sq. ft.)	250 ft.
Community Shopping Center (100,000-150,000 sq. ft.)	150 ft.
Small Strip Shopping Center	50 ft.
Commercial Developments (convenience stores, Gas Stations)	30 ft.

Driveway Spacing:

Posted Speed Limit (mph)	Minimum Driveway Spacing (ft) on roadways with AADT ≥ 2000	Minimum Driveway Spacing (ft) on roadways with AADT ≤ 2000
30	160	75
35	220	125
40	275	175
45	325	225
≥ 50	400	275

How is Access Management Achieved?

Access Management

Access management is achieved through the application of these planning, regulatory, and design strategies.

- Policies, directives, and guidelines issued by state and local agencies having permit authority on development and roadway infrastructure improvements.
- Regulations, codes, and guidelines that are enforceable.
- Acquisition of access rights by states and local jurisdictions that serve to protect transportation interests and enable sufficient infrastructure is built.
- Land development regulations by state and local jurisdictions that address property access and related issues.
- Development review and impact assessments by state and local jurisdictions.
- Good geometric design of transportation facilities
- Understanding of access implications by businesses and property owners.

Some property owners and some local planners or permit agencies do not always consider the full effects of introducing driveways or minor streets. Further, local entities often perceive economic damage when some access management techniques are proposed, i.e., closing median breaks, relocating driveways, or limiting the number of access points. Continuous education, case studies and examples are needed to show that carefully planned development can coexist with good access management. It is important to show that well-planned access helps maintain property values while fulfilling the FHWA role of promoting safe and efficient transportation for the general public. Public and business community involvement is essential. Effective interaction is crucial to the success of the implementation of the project.

A second challenge to implementing Access Management is its low tech/low cost nature. It is often overlooked in favor of costlier solutions. An effective new activity herein would be to market AM strategies to national and local business associations, thereby educating them that good practice can coexist with healthy businesses, and increasing their acceptance and demand for such applications.

Benefits of Access Management Brochure

Access Management > Resources

Purpose of the Brochure

This brochure serves as a guide to the major benefits of several access management techniques in use across the United States. The purpose of this brochure is to provide a comprehensive and succinct examination of the benefits of access management and address major concerns that are often raised about access management.

The benefits usually identified with access management include improved movement of through traffic, reduced crashes, and fewer vehicle conflicts. Most major concerns about access management relate to potential reductions in revenue to local businesses that depend on pass-by traffic.

This brochure does not describe the precise strategies that transportation departments should follow to implement an access management program, but rather provides an introduction to the key concepts. The brochure may also be a useful tool to distribute at public meetings for both general access management plans and specific applications of access management techniques.

This brochure describes the relevant benefits and issues with three key sets of access management techniques:

1. Access spacing, including spacing between signalized intersections and distance between driveways;
2. Turning lanes, including dedicated left- and right-turn lanes, as well as indirect left turns and U-turns, and roundabouts; and
3. Median treatments, including two-way left-turn lanes and raised medians.

What is Access Management?

Access management is a set of techniques that state and local governments can use to control access to highways, major arterials, and other roadways. Access management includes several techniques that are designed to increase the capacity of these roads, manage congestion, and reduce crashes.

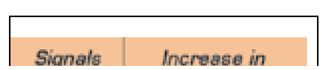
- Increasing spacing between signals and interchanges;
- Driveway location, spacing, and design;
- Use of exclusive turning lanes;
- Median treatments, including two-way left turn lanes (TWLTL) that allow turn movements in multiple directions from a center lane and raised medians that prevent movements across a roadway;
- Use of service and frontage roads; and
- Land use policies that limit right-of-way access to highways.

State, regional, and local governments across the United States use access management policies to preserve the functionality of their roadway systems. This is often done by designating an appropriate level of access control for each of a variety of facilities. Local residential roads are allowed full access, while major highways and freeways allow very little. In between are a series of road types that require standards to help ensure the free flow of traffic and minimize crashes, while still allowing access to major businesses and other land uses along a road.

Access Spacing

Signal Spacing

Increasing the distance between traffic signals improves the flow of traffic on major arterials, reduces congestion, and improves air quality for heavily traveled corridors. The



Signals	Increase in

9. Safe Routes to School

http://guide.saferoutesinfo.org/dropoff_pickup/student_drop-off_and_pick-up_tools.cfm – Numerous tools can be used to improve the safety and efficiency of the school drop-off procedure. This site list and discusses many of the possibilities. Schooltime congestion is a major factor in many towns, and options to do things a little differently should be considered for potentially large benefits.

Student Drop-off and Pick-up Tools

When assessing the drop-off and pick-up process, activity on school grounds (on site) as well as activity in the area surrounding the school (off site) must be considered. These images depict an on-site drop-off and pick-up process that is orderly – motor vehicles are approaching single file and releasing students directly to the sidewalk in the designated drop-off zone.

But, off site, on a street near the same school, the process is chaotic. Notice the backed-up street, delaying commercial vehicles, school busses and parents wishing to drop off children. Such situations are often accompanied by unsafe driving behavior as everyone rushes to beat the morning bell or get to work on time. Developing safe routes to schools requires an orderly process for dropping off and picking up children both on and off the school campus.

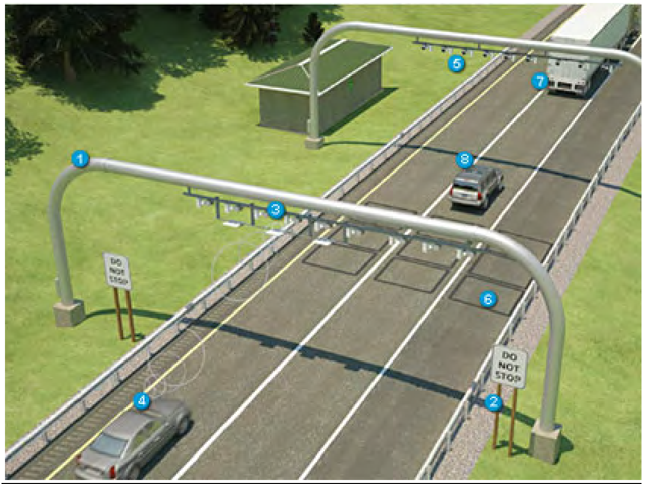
Numerous tools can be used to improve the safety and efficiency of the drop-off and pick-up process at schools including:

- Encouraging walking, bicycling and carpooling
- Curb striping and other pavement markings
- Signage
- Separating motor vehicles from pedestrians and bicyclists
- Adding a drop-off and pick-up lane
- Assistants to help students exit and enter motor vehicles
- Adding an off-site queuing lane
- Temporary street closure and one-way street
- Temporary use of school grounds as drop-off and pick-up zone
- Education, including maps and frequent reminders using school announcements and newsletters
- Monitoring and enforcement of drop-off and pick-up policies

This guide was developed by the Pedestrian and Bicycle Information Center (PBIC) in collaboration with SRTS experts from around the country and support from the National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration (FHWA), Centers for Disease Control and Prevention (CDC) and Institute of Transportation Engineers (ITE).

10. New Technologies

All Electronic Tolling System (AETS)



http://www.env.state.ma.us/mepa/mepadocs/2013/072413em/nps/enf/15080.pdf - is a copy of the Environmental Notification Form (ENF) from MassDOT in regards to the proposed All Electronic Tolling (AET) conversion project for the Massachusetts Turnpike (I-90).

http://trmi.com/index.php - gives an example of the AETS from TRMI, a developer of this type of toll collection system.

Massachusetts Department of Transportation
Highway Division

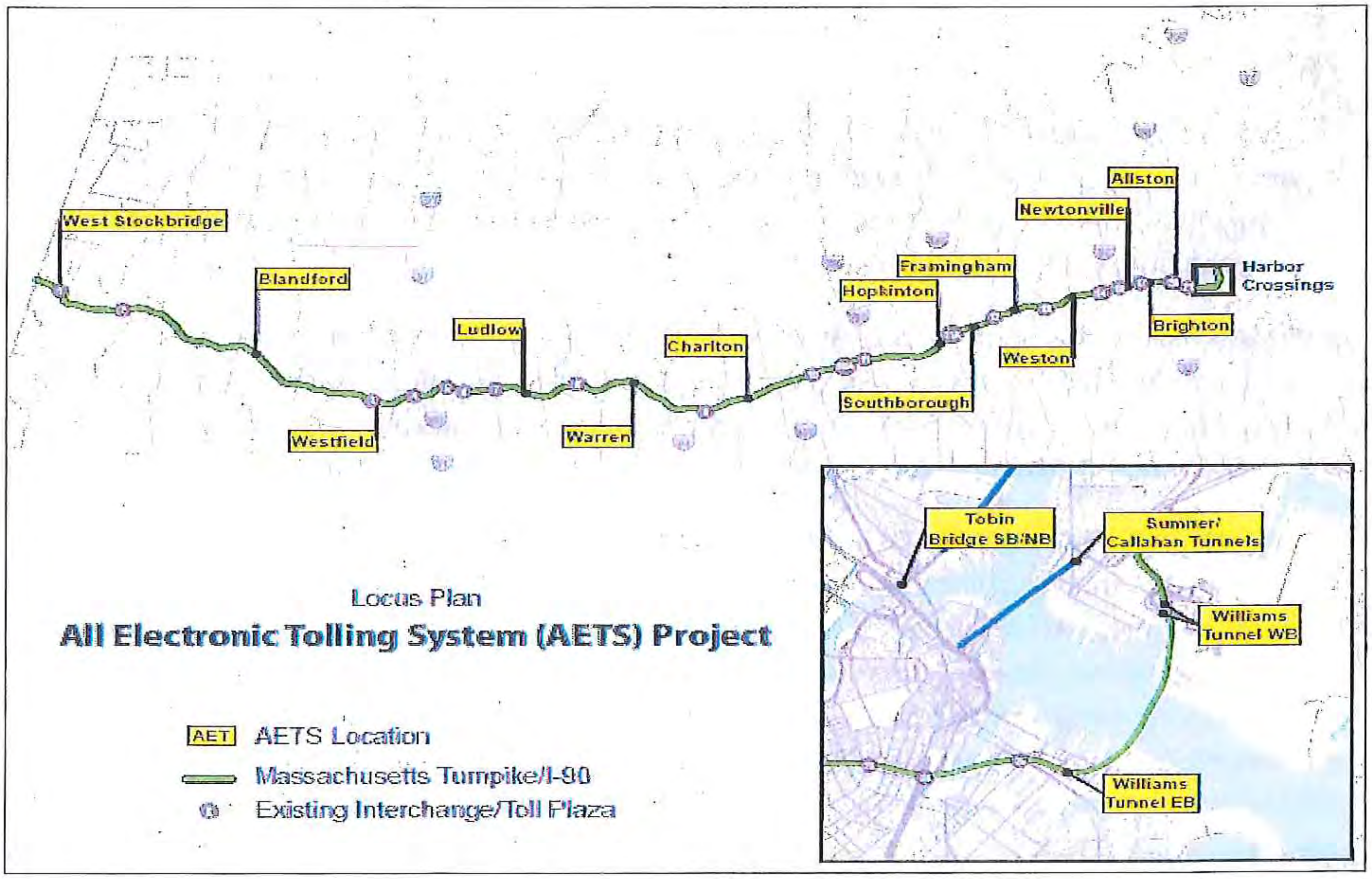
All Electronic Tolling System Implementation

Public Information Meeting

Project Summary

MassDOT proposes to convert and replace the I-90 Western Turnpike, I-90 Boston Extension and Boston Harbor Crossing cash and electronic toll collection systems with a new system of tolling relying only on All Electronic Tolling (AET). The project will include both roadway tolling infrastructure and toll collection system technology.

<u>The project area is illustrated in the figure below.</u>



The AETS Toll Concept

The entry-exit ticket-based toll concept on the Western Turnpike will be eliminated and replaced with automated toll collection technology at ten toll zone gantries. The existing barrier toll plazas on the MHS will, likewise, be replaced by toll zone gantries. Figure 1 illustrates the typical roadside components of an AETS gantry. Toll rates at all toll zones will be based on payment type (E-ZPass or Pay-By-Plate) and vehicle class. Figure 2 illustrates the existing interchanges and toll plazas and the preferred AETS locations for the Massachusetts Turnpike and Harbor Crossings.

The MHS Boston Extension currently collects tolls in two locations, in Weston and in Allston-Brighton-Cambridge utilizing five plazas. These will be replaced with a series of mainline AETS toll zones between Weston and the Williams Tunnel to capture vehicular movements within this segment of the Turnpike corridor.

The MHS Williams Tunnel currently collects tolls in two nearby westbound (inbound) plazas by Logan Airport. These structures will be retained, but cash collection booths and equipment will be removed. Also, this tunnel will be converted from one-way to two-way tolling, with the addition of an AETS toll zone for east-bound traffic. Rates will be modified to reflect the change in tolls being collected in both directions.

The MHS Sumner Tunnel currently collects tolls at a single southbound plaza in East Boston. This facility will be removed and replaced with AETS toll zones for both southbound traffic (Sumner) as well as northbound traffic through the Callahan Tunnel.

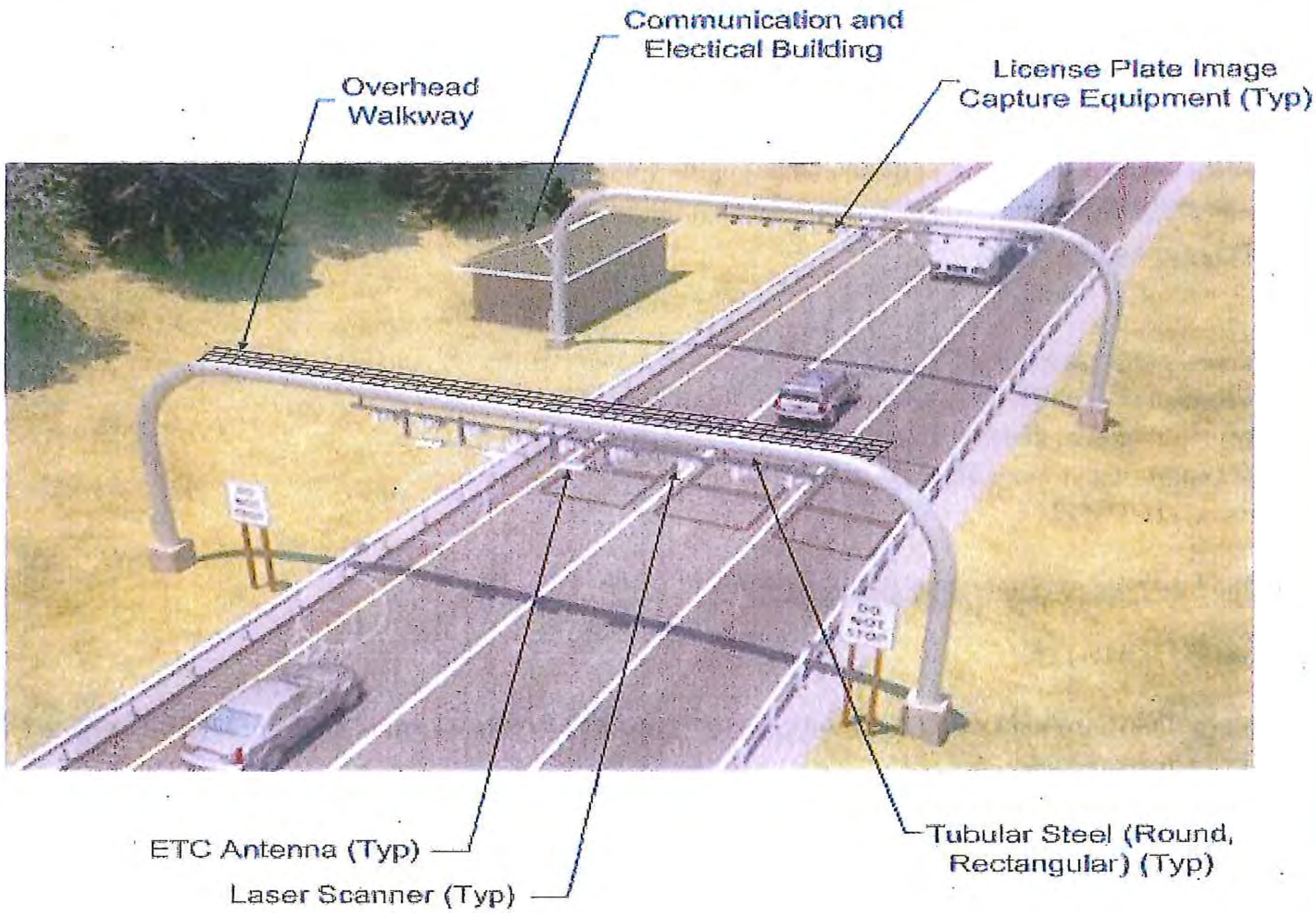
The Tobin Bridge currently collects tolls in the southbound plaza on the bridge. This facility will be replaced initially with an AETS toll zone for southbound traffic in a Pilot Program (more below). A northbound AETS toll zone will subsequently be implemented around the same time as the Western Turnpike and MHS AETS implementation.

For E-ZPass drivers, the system works essentially the same as today – except there are no toll plazas to navigate or E-ZPass Lanes to find. Tolls from the AETS toll zones will be posted directly to their E-ZPass accounts and will appear on E-ZPass statements. Drivers will always save the most money by paying tolls with an E-ZPass account in good standing.

Drivers without E-ZPass – Pay-By-Plate customers - will see tolls on invoices; tolls will be accumulated for a configurable period of time and then mailed to vehicle owners for payment. For this added convenience, customers will pay a higher toll rate to cover the additional costs of license plate image processing and billing. Pay-By-Plate customers will always be encouraged and have the option to convert to E-ZPass at any time, to save more time and money. If invoices are ignored they will become toll violations with increasingly serious consequences. This includes MassDOT taking advantage of multi-state enforcement reciprocity agreements to collect past due tolls from non-residents.

The combination of gantry footings, building/pad for the modular enclosures containing the communications and electrical equipment, and short access drive serving each enclosure will total less than 20,000 square feet of new impervious surface for the combined 18 gantry locations (or "toll zones"). No wetland impacts are expected to be associated with the gantry construction (cumulative wetland buffer zone impacts are anticipated to be less than 4,000 square feet). Emergency generators at each modular enclosure will be fueled by natural gas, propane, or diesel fuel.

A typical gantry and related appurtenances is illustrated below.



Public Comments and the MEPA Process

An informational Environmental Notification Form (ENF) was filed with the Massachusetts Environmental Policy Act (MEPA) Office at the Executive Office of Environmental and Energy Affairs on July 15, 2013. Notice of the environmental review was published in the Environmental Monitor and several newspapers statewide on or before July 24, 2013. Comments on the project are due by August 27, 2013 and must be submitted in writing, via email or fax (see below for information on how to comment). After the public comment period closes, the Secretary of Environmental and Energy Affairs will issue a certificate on the ENF on September 6, 2013, stating whether or not additional MEPA review is required.

The public information meeting held August 15, 2013, served as the formal MEPA Consultation Session where agency staff and the general public had the opportunity to ask questions about the project. To comment formally on the project and the ENF, comments must be submitted in writing, via fax **or** email to:

Secretary Richard Sullivan
Executive Office of Energy and Environmental Affairs
Attn: Purvi Patel, EEA No. 15080
100 Cambridge Street, Suite 900
Boston, MA 02114

Email: purvi.patel@massmail.state.ma.us

Fax: (617) 626-1181

For more information about the project, a copy of the ENF can be downloaded from MEPA's website at the following address:

http://www.env.state.ma.us/mepa/mepadocs/2013/072413em/nps/enf/15080.pdf

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- Airport AVI
- Toll Equipment
- Automated Access
- Project Profiles

- Project Profiles
- Open Road Tolling
- Software Demos

Electronic Tolling and Automated Access Systems for Roadways, Airports, Parks, Bridges and Walkways

TRMI custom-designs integrated software, hardware and network solutions for Electronic Toll Collection (ETC) including All Electronic Tolling (AET), Open Road Tolling (ORT), cashless tolling, violation enforcement systems, automated access systems, automatic vehicle identification (AVI) and provides full support for legacy, mixed-mode, cash-inclusive systems.

With in-house capabilities in electronic, mechanical, software, network and database engineering and development, we build a wide array of niche and enterprise solutions for cashless tolling, video tolling and other forms of automated access systems.

Open Design Opens Your Future
Our open-design approach to software engineering is intentionally designed to open up a flexible future as you expand and enhance your systems.

We value the long-term relationships we build with our customers, and we continually improve our designs, tools, and methods to meet our customers' needs and to keep pace with changing technologies. Our systems utilize proven designs that are highly functional, yet easy to understand and maintain. TRMI can help you and your systems grow forward.

Project Profiles

Features wide-area network communications using low-cost broadband connections… which resulted in customer savings of $97,000 per year in operating costs.

New Hampshire DOT

TRMI designed and developed a 102-lane E-ZPass electronic toll collection system installed at 10 toll plazas for the New Hampshire Departmernt of Transportation.

Open Road Tolling

TRMI's systems accurately and reliably process millions of toll transactions every day.

We designed ORT 2.0™ for greater accuracy...

Building on the best practices from first-generation designs, TRMI has engineered a second generation of Open Road Tolling (ORT) with accuracy and reliability that can make your move to All Electronic Tolling (AET) more practical and more viable.

Software Demos

Ramp Metering

http://www.ops.fhwa.dot.gov/bn/resources/rampmetering.pdf - is a brief PowerPoint presentation by FHWA regarding the types of ramp metering, where ramp metering is used, and some of the challenges and benefits.

http://ops.fhwa.dot.gov/publications/ramp_mgmt_handbook/faqs/ramp_faqs.htm - is a Ramp Management & Control Handbook. Within this link are frequently asked questions in regards to ramp metering. For additional information, look at the bottom of the page for another link to the FHWA Freeway Management Program website.

Ramp Metering

The application of control devices to regulate the number of vehicles entering or leaving the freeway, in order to achieve operational objectives.

Types of Ramp Metering

- Stand-alone (i.e., "time of day") 1960-70
  - *Often manually operated (switch on, switch off) or simple "traffic cop" management*
  - *An isolated, pre-timed location. Not much capability to adjust to traffic demand.*
  - *Problems: no way to clear congested queues; not responsive to upstream demand*
- Local Control 1970-80
  - *Fixed segments of 'upstream+ramp+downstream' sections of highway using detectors to verify success*
  - *Problems: not responsive to downstream bottlenecks that would back up*

- Coordinated 1980-1990
  - *Improvements on local control; use of TMC's; greater sophistication*
  - *First use of algorithms (beyond just "timing patterns")*
- Responsive (i.e., "adaptive") 2000's
  - *At the most-congested MPO's; can understand multiple and dynamic bottlenecks.*
  - *Uses real-time data in 30-sec or 5-min intervals to readjust the algorithms*
- Predictive Future?
  - *In theory, would use upstream changes in traffic density to predict conditions and "forewarn" the meters how to operate*

U.S. Department of Transportation Federal Highway Administration

FHWA Home | Feedback

January 2006

FHWA-HOP-06-083

Ramp Management & Control Handbook

Questions and Answers

Frequently Asked Questions

1. What is Ramp Management?

Ramp management is the "application of control devices, such as traffic signals, signing, and gates to regulate the number of vehicles entering or leaving the freeway, in order to achieve operational objectives". Most ramp management strategies are employed to balance freeway demand and capacity, maintain optimum freeway operation by reducing incidents that produce traffic delays, improve safety on the adjacent freeway or surface street, or give special treatment to a specific class of vehicles.

2. Why is Ramp Management Important?

Managing and controlling traffic on ramps is important because freeway entrance and exit ramps are the only facilities motorists may use to legally make connections to and from limited access facilities and as such represent the only locations where traffic entering and exiting a limited access facility can be controlled. Often, ramps are too closely spaced, do not offer adequate acceleration distances for posted speeds, or are simply overwhelmed by the increasing number of motorists that use them on a daily basis. When conditions like these exist, impacts may develop that affect the efficient and safe operation of traffic on ramps and the facilities to which they are connected (i.e., freeways and arterials). Ramp management offsets problems like these to obtain desired benefits or to satisfy pre-determined goals and objectives.

Ramp management also serves as an effective medium through which different agencies can collaborate to address needs more effectively. Since ramps often join facilities that are operated by different agencies, ramp management can break down barriers that exist between agencies, allowing agencies to work together more effectively to address issues.

3. What are the Benefits of Ramp Management?

Ramp management strategies may be used to improve safety and mobility by improving the flow of vehicles that enter and exit a freeway facility. Other in direct benefits of ramp management include environmental improvements such as reduced fuel consumption and vehicle emissions, as well as improved public perception and use of the transportation system, and the individuals responsible for it.

4. How do Ramp Management Strategies Improve Safety?

The manner in which safety is improved depends on the type of ramp management strategy selected. Ramp metering improves safety by breaking up platoons of vehicles entering the freeway, thereby allowing more orderly and safe interactions between merging vehicles and freeway mainline vehicles. Ramp closure improves safety by preventing vehicles from using ramps, where nearby events or activities pose a safety threat to vehicles. Other strategies improve safety by alerting motorists of conditions that motorists do not expect, while others reduce conflicts between through traffic and vehicles that intend to use the ramp.

5. How do Ramp Management Strategies Improve Mobility?

Ramp management strategies aim to improve conditions on the adjacent freeway and surface streets, resulting in benefits to mobility. By managing how vehicles use ramps, practitioners can set limits based on downstream capacity to maintain a pre-determined operational objective. For instance, ramp metering is often used to balance capacity and demand. Even in an uncongested state, a platoon of vehicles merging onto a freeway can cause enough turbulence (stop-and-go conditions as freeway vehicles slow down or quickly change lanes to accommodate the merging vehicles) to cause localized congestion around the ramp merge area. Metering can minimize these impacts by releasing vehicles in a controlled manner depending on the freeway mainline’s ability to accept traffic. Operational characteristics that may be improved through the application of ramp management strategies include; speed, travel time, and delay.

6. How do Ramp Management Strategies Improve the Environment?

Ramp management strategies improve the environment by improving traffic flow on ramps

Freeway Management Program

The Freeway Management Program supports and promotes the use of integrated and coordinated freeway systems and proactive freeway management to improve the safety efficiency and reliability of travel on the nation's freeway facilities.

Read more about the Freeway Management Program.

Focus Areas

- Freeway Operations and Traffic Management
- Managed Lanes and HOV Facilities

Program Resources

- Publications
- Training and Outreach
- Related Programs and Links

You will need the Adobe Acrobat Reader to view the PDFs on this page.

FHWA

Role of Transportation Management Centers in Emergency Operations Guidebook
The purpose of this Guidebook (HTML, PDF 3.1MB) is to increase communication, collaboration, and cooperation among Transportation Management Centers (TMC) and emergency response agencies so they can effectively respond to a variety of situations ranging from a localized traffic incident to major regional events such as hurricane evacuations.

Read More News

Concluding Remarks

Ongoing Effort

- We hope that this document will be of help to you as you assess the cause of delay in your town or locality and make plans to remedy them. Analysis of problems and improvement plans with measurable results are the keystones of current Federal transportation planning, and these concepts are just as valid in the smallest areas. Once you've taken steps and measures to defeat unnecessary congestion, revisit the area of your activity and look again. Note the improvements that can be seen and use the knowledge you have gained on approaches and cost to further plan for delay reduction in other locations. Problems that are beyond the scope of local resources may be addressed through federal funding sources where the same types of analyses will be applied. Increased amounts of information on existing problem areas as well as how older problems were remedied all feed ion the Performance Measurement approach to transportation planning.

Environmental Benefits

- Remember that the delay you save today also helps keep our air cleaner through the lowering of engine idle time, as idling results in wasteful and unhealthy fuel use. The reduction of greenhouse gases, and major byproduct of carbon-based fuels used in transportation today, is a major goal in the state of Massachusetts. Federal Congestion Management and Air Quality (CMAQ) funding can also help address problem areas that are especially plagued with idling or unnecessary delay.

Long Range Vision

- CMRPC and the Central Massachusetts Metropolitan Planning Organization will soon be undertaking an update to the area's Regional Transportation Plan. Healthy air and congestion reduction are sure to be continued goals of the Plan, in which we hope to incorporate a regionwide, systematic review of signal timing and phasing. The goal is to encourage and implement the upgrade of inefficient and failing systems in order to address delay at some of its roots. Look for this update and see if your locality can be guided by or tap into this regional approach.

Other Valued References & Resources

More complex, larger-scope projects may require assistance in both funding and design concept and execution. The following is a list to resources that might help to address situations of this type.

Massachusetts Highway Department Project Development and Design Guidebook

The purpose of this Project Development & Design Guide (Guidebook) is to provide designers and decision-makers with a framework for incorporating context sensitive design and multi-modal elements into transportation improvement projects. The emphasis is to ensure that investments in transportation infrastructure encourage projects that are sensitive to the local context while meeting the important needs of the people they serve. The Complete Street concept often accomplishes these objectives.

A Complete Street accommodates all users and is safe, comfortable and convenient for travel via automobile, foot, bicycle and transit. A complete street may include sidewalks, bike lanes, median islands, accessible pedestrian signs, curb extensions, and frequent and safe crossing opportunities. Benefits from Complete Streets include reducing congestion and costs, safety improvements, and improving modal connectivity.

A third and major guiding principle of the Guidebook is to present a clear project development process that can be easily understood by project proponents and constituents and simply and consistently administered throughout the Commonwealth. With that in mind, a Project Development chapter is presented that is designed to broaden the users' understanding of project development, from idea through construction. The chapter describes how projects progress through planning, design, environmental review, and right-of-way steps; how projects move from the design phase into the construction phase; and a suggested process for assessing projects after completion. This material is extremely helpful in assessing project ideas that may be too large for a town to undertake on its own.

The entire manual can be found online, available by segment, at:

http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/ProjectDevelopmentDesignGuide.aspx.

This page also includes links to other valuable resources, including MassDOT's Project Need Form, a document that assembles preliminary data and other descriptive information that it used to assess conditions and determine whether the design of a larger project would be worthwhile to pursue.

Intelligent Transportation Systems

Intelligent transport systems (ITS) are advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

Looking towards the future, local communities should consider how they can make use of these developing system efficiencies. Examples include:

- Coordinated, progressive traffic signal systems.
- Adaptive traffic signal systems, more sensitive to traffic flow.
- Provision of Opticom capability or similar, where necessary.
- Variable Message Signs (VMS) providing driver information, such as anticipated travel times, for in-trip decision making.

Read more about ITS at the USDOT website, Research and Innovative Technology Administration (RITA) - Intelligent Transportation Systems (ITS). See CMRPC's page at http://www.cmrpc.org/intelligent_transportation_systems.

Asset Management Systems

Asset management aims to preserve assets and minimize their whole-life cost. While operating in a financially sustainable manner, they can provide a framework for improving the long-term performance of transportation systems.

The systems noted below can help provide valuable information about localized areas that may need congestion improvement measures. Incorporating known structure condition and coordination with known or desirable future improvement planning can assist in the best use of resources in project design.

- MassDOT Bridge Management System (BMS)
  See http://www.eot.state.ma.us/acceleratedbridges/pr_inspect.htm
  See http://www.mhd.state.ma.us/default.asp?pgid=content/bridge_operations&sid=about

- CMRPC & MassDOT Pavement Management System (PMS)
  See http://www.cmrpc.org/pavement_management

- CMRPC & MassDOT Safety Management System (SMS)
  See http://www.cmrpc.org/transportation_safety_planning

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