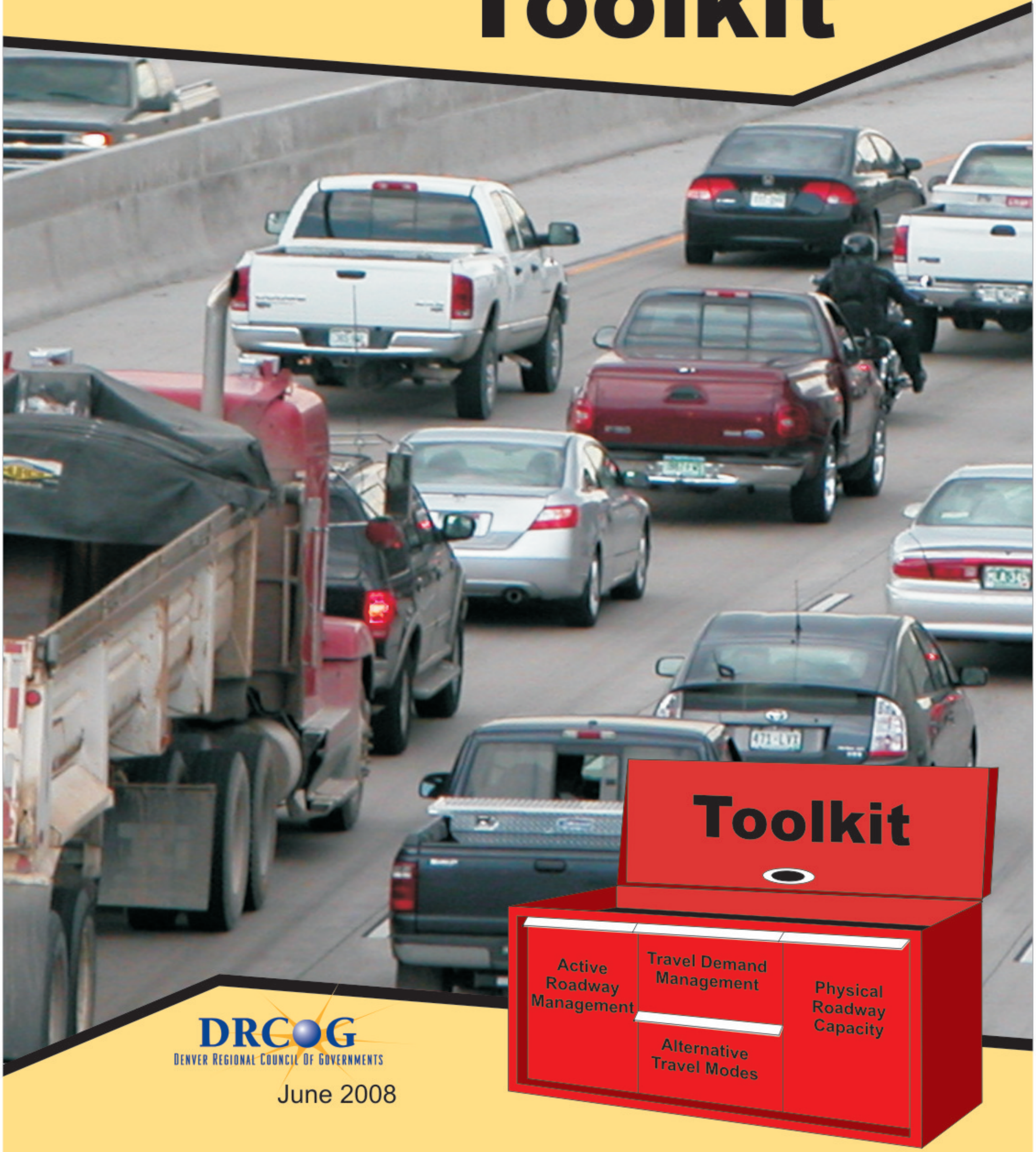
Congestion Mitigation Toolkit



DRCOG
DENVER REGIONAL COUNCIL OF GOVERNMENTS

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Denver Regional Council of Governments

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The Congestion Mitigation Toolkit is a resource for transportation agencies and local jurisdictions to identify strategies to reduce traffic congestion. The Toolkit offers a wide sample of mitigation strategies that address various locations, situations and causes of congestion.

Traffic congestion is common on roadways in the Denver region. Hundreds of miles of regional roadways suffer from severe congestion for several hours every day. The average traveler spends about 50 hours annually delayed in congested conditions. The population and number of motor vehicles in the Denver region are expected to increase by more than 55 percent over the next 30 years. Additional traffic congestion will certainly accompany this growth. The goal of the Denver Regional Council of Governments (DRCOG) Congestion Mitigation Program is to *alleviate* congestion and encourage travelers to *avoid* and *adapt* to congested conditions.

Congestion is generally classified as either recurring or non-recurring. Recurring congestion causes relatively predictable daily delays during weekday rush-hour or peak recreational travel periods. Non-recurring roadway congestion results from incidents or other events that cause traffic delays. Examples include crashes, vehicle breakdowns, construction, weather, sporting and musical events, and roadside visual distractions (crash on other side of the highway, bighorn sheep, etc.).

Three categories of congestion mitigation strategies are typically implemented by state and local roadway agencies to address recurring and non-recurring delay:

❶ **Active roadway management** strategies usually include implementation of intelligent transportation systems (ITS) infrastructure and operational controls. Strategies or projects include signal timing; installation of traffic management technologies such as cameras, vehicle detectors and variable message signs; and development of traffic management centers (TMCs) to allow for real-time traffic monitoring. This category also includes traffic control assistance strategies (e.g. signing) that do not require physical construction to the roadway.

❷ **Travel demand management (TDM) and alternative travel mode** strategies promote and encourage the use of travel alternatives to reduce the demand for single-occupant vehicle trips. Sample projects include transit operational improvements, educational and marketing programs, expansion of transit services, and the provision of bicycle and pedestrian facilities. This document provides a general overview of TDM strategies. A much greater level of detail regarding TDM, efficient land use and development practices, and bicycle and pedestrian facilities can be found in publications on the

DRCOG Web site (www.drcog.org) and in the *Transportation Demand Management Toolkit*, produced October 2002, by the Colorado Department of Transportation (CDOT) (www.dot.state.co.us).

❸ **Physical roadway capacity** projects involve construction within a roadway right-of-way. They typically include adding travel lanes and/or improving roads, intersections or alternative mode features. These types of projects are immediately noticeable to the public. All projects should consider and design for all users, including bicyclists, pedestrians, stranded motorists and transit users (e.g. "complete streets"). Roadway capacity projects generally require lengthy implementation and can often be very costly.

Toolkit strategies

The following pages summarize 34 potential congestion mitigation strategies within the three categories. The list of strategies is a sampling of the most applicable projects for implementation in the region—there are other strategies not listed in this toolkit. Categorization is purely for organizational purposes and does not imply a limited project scope or overall benefit. Strategies in the same or different categories may overlap. Generalized costs, benefits, implementation timeframe and other factors are included for each strategy. It is typically most beneficial for strategies to be implemented in comprehensive packages rather than alone.

In addition to reducing congestion, most strategies will help improve air quality and reduce fuel/energy consumption. The Congestion Toolkit encourages agencies to implement modest, small-scale projects that will reduce traffic delay and increase mobility, perhaps delaying or avoiding higher-cost roadway expansion projects.

TOOLKIT: CONGESTION MITIGATION STRATEGIES

❶ Active roadway management

A. Traffic signal timing and coordination
B. Traffic signal equipment modernization
C. Ramp meters
D. Access management
E. Incident management plans (IMP)
F. Courtesy patrol (incident response)
G. Traveler information devices (message signs, Internet)
H. Traffic management center (TMC)
I. Electronic toll collection (ETC)
J. Cordon area congestion fees
K. Roadway signage improvements
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❷ Travel demand management/Alternative travel modes

A. New fixed guideway transit travelways
B. Transit service expansion (more vehicles, extended/new routes)
C. Transit vehicle travel information
D. Transit intersection queue-jump lanes and signal priority
E. Electronic fare collection
F. Parking facility management information signs
G. Telework and flexible work schedules
H. Ridesharing travel services (Carpool, Vanpool, Schoolpool)
I. Alternative travel mode events and assistance
J. Off-street multi-use trails (pedestrian and bicycle)
K. On-street bicycle treatments
L. Efficient land use and development practices

❸ Physical roadway capacity

A. Intersection turn lanes
B. Acceleration/deceleration lanes
C. Hill-climbing lanes
D. Grade-separated railroad crossings
E. HOV bypass lanes at ramp meters
F. Roundabout intersections
G. New grade-separated intersections
H. New (or converted) HOV/HOT lanes
I. New travel lanes (widening)
J. New roadways

1.A. Traffic signal timing and coordination

Description

- Enhancements to timing/coordination plans and equipment to improve traffic flow and decrease the number of vehicle stops

Applicable locations/situations

- Heavily traveled urban corridors with multiple signalized intersections
- Locations with outdated timing plans and signal equipment

Cost: ***Low to moderate***

- Estimated cost for implementing a signal timing plan is about $2,400 per intersection

Timeframe: ***Short-term***

- Implementation of an overall traffic signal timing plan can take six to 12 months, including the following phases: data collection, existing conditions model, cycle analysis, plan development, implementation and fine tuning, and benefits analysis and documentation
- Immediate timing changes can be implemented after a site visit to an intersection.

Benefits

- Fewer vehicle stops and less travel delay
- Reduced air pollution, fuel consumption and travel time
- Increased "capacity" of an intersection to handle vehicles, reduced number of vehicle crashes

Related strategies

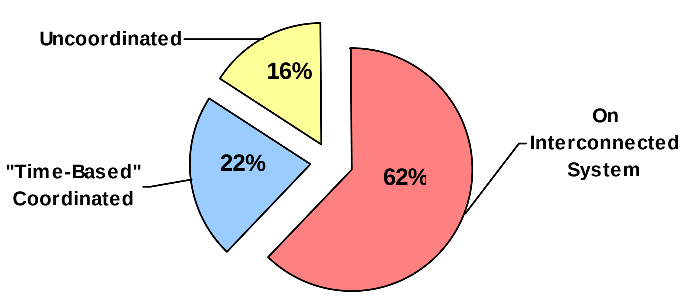
- In some cases existing traffic signals on lower-volume streets may not be warranted. More efficient traffic operations can occur if such signals are removed and stop-signs installed.
- Intersections with low volume late-night traffic could change to flashing operation.

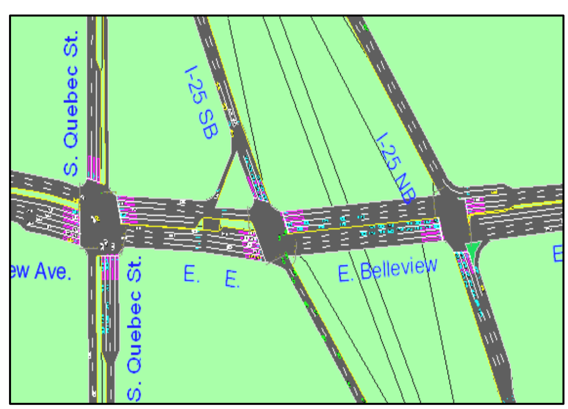
Other factors or considerations

- Emergency preemption of interconnected traffic signals can have extended impacts on signal timing and coordination and cause extensive travel delay during peak travel periods.
- Interjurisdictional cooperation is necessary to ensure optimal use of equipment and a coordinated traffic management approach.

Signalized Intersections in Denver Region (3,540)

Source: 2007 TSSIP Update Summary





1.B. Traffic signal equipment modernization

Description

- Modern technology that provides for real-time traffic and transit management
- Equipment that may permit immediate knowledge of malfunctions
- Responsive control that allows traffic signals to alter timing in response to immediate traffic flow conditions, rather than at predetermined times
- Transit signal priority system that can extend "green-time" a few seconds to allow buses to progress through an intersection

Applicable locations/situations

- Intersections and travel corridors with older, actuated signal equipment
- Streets with high transit volumes and bus stop activity

Cost: ***Low to moderate***

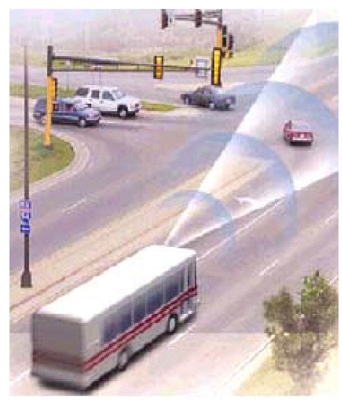
- Costs include initial investment of equipment, software and communication network connections
- The cost varies depending on required transit and signal communications equipment

Timeframe: ***Short- to medium-term***

- Purchase and installation can take place quickly, but may depend upon communications infrastructure already being in place.

Benefits

- Operation and serviceability of new equipment from remote locations
- Immediate traffic signal timing response to traffic flow changes
- Quicker repair of malfunctioning traffic signals
- Reduced travel delays



Related strategies

- New timing coordination plans should be implemented along with modernized equipment.
- In some cases, bus routes or transit stops may be modified to increase ridership in conjunction with the transit signal priority system.
- Appropriate communications infrastructure must be in place for both traffic signal and transit systems.

Other factors or considerations

- Newly signalized intersections (not on an existing interconnected system) may be favored for new technology instead of replacing existing outdated equipment.

1.C. Ramp meters

Description

- Traffic signal device that controls the stream of vehicles entering a freeway
- May include bus or high-occupancy vehicle bypass lanes
- May require ramp widening to avoid extensive vehicle queuing

Applicable locations/situations

- Existing high-volume freeway and expressway facilities
- On-ramps with heavy platoons of vehicles released from arterial/ramp intersections

Cost: ***Low to moderate***

- Equipment and ramp modification expenses are relatively low.
- It is most efficient to install ramp meter equipment in conjunction with a freeway construction or maintenance project.

Timeframe: ***Moderate-term***

- Implementation of ramp metering requires time for planning, engineering and construction phases

Benefits

- Improved speed and travel times on freeway
- Increased traffic volumes and vehicle throughput
- Decreased crash rate on the freeway

Related strategies

- Installation of a vehicle detector at the top of the ramp and active management will help avoid queues extending to the arterial street.

Other factors or considerations

- Limited adjacent rights-of-way may prevent widening of on-ramp or extension of merge area.
- Ramp meters can be controversial due to the perceived inconvenience and negative impacts on some vehicles.
- Vehicle queues backing up the ramp onto surface streets may disrupt intersection operations.

1.D. Access management

Description

- Planning and design practices that identify existing and future land use and arterial access points to maximize traffic safety and mobility
- Strategies include medians, turn lanes, side/rear access points between businesses, shared access, and local land use ordinances to control access

Applicable locations/situations

- Future or existing high-volume arterial corridors with a large number of commercial developments and existing/potential "curb-cuts" or driveways

Cost: ***Low to high***

- Costs and complexity of strategies can vary widely and may depend on whether access controls are implemented before development occurs or as a retrofit.

Timeframe: ***Short- to medium-term***

- Some access management strategies can be implemented quickly if there are cooperating property owners. Major access management plans require a greater amount of time for planning, negotiation and ultimate benefits related to the full anticipated future development. Capital construction efforts (e.g. medians) take a moderate amount of time.

Benefits

- Reduction in crashes along a roadway
- Improved roadway capacity; greater vehicle throughput
- Decreased corridor delay

Related strategies

- Access management is enhanced by parking lot/building site designs that incorporate adequate exit/entrance capacity, side or rear access points and walking and transit features.
- Comprehensive local growth management planning should incorporate access management.

Other factors or considerations

- Limiting accessibility to/from developments may bring strong opposition.
- Increased vehicle delays may occur on driveway or side street exits onto the primary road.
- Physical roadway limitations like restricted left turns and minimized points of access may negatively impact adjacent commercial development.

1.E. Incident Management Plans (IMP)

Description

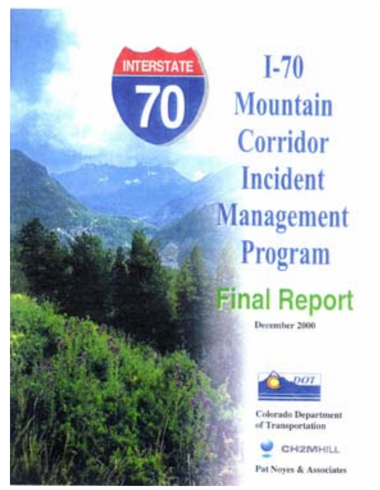
- Operational plans that define roles, rules, procedures, traffic diversion routes, and protocols to be followed by agencies and personnel in the event of an incident (also known as traffic incident management plans–TIMPs)

Applicable locations/situations

- Major travel corridors with multiple emergency, jurisdiction, law enforcement, and transportation responders
- Construction zones, locations with frequent incidents, or highways with limited shoulder width or critical bottleneck points

Cost: ***Low to moderate***

- IMPs are inexpensive unless significant new equipment is required.



Timeframe: ***Short-term***

- An IMP can be completed in four to six months and is immediately ready for implementation.
- Routine updates to IMPs are required.

Benefits

- Reduction in travel delay due to incidents
- Increased roadway safety during and after an incident
- Improved emergency response time and information distribution
- Quicker clearing of crash scenes
- Prompt cleaning of material spills
- Predetermined communication methods and vehicle diversion/detour routes

Related strategies

- Traffic signal timing and coordination plans along predetermined arterial street diversion/detour routes
- Variable message signs and other traveler information devices to alert oncoming traffic
- Training for IMP participating agencies and staff
- Development of a regional IMP, which combines all existing corridor-level IMPs into one document, to provide greater awareness, functionality and efficiency

Other factors or considerations

- Emergency/first responders must participate in the preparation of IMPs. New staff should be educated about IMP protocols.
- Failure to follow IMP protocols could result in additional vehicle delays and possible safety hazards.
- Periodic reviews of IMP use and protocols should be conducted.

1.F. Courtesy patrol (incident response)

Description

- Service provided to stranded freeway (or tollway) travelers to assist with vehicle breakdowns, stalls and crashes

Applicable locations/situations

- Freeways with heavy traffic volumes and/or documented history of incidents
- Corridors with limited shoulder width
- Major construction zones

Cost: ***Low***

- The estimated cost for the existing freeway courtesy patrol program in the Denver metro is $2 million annually, covering approximately 100 miles (additional 55 miles of tollways served by toll authorities).

Timeframe: ***Short-term***

- Development of a courtesy patrol program from conceptual planning to in-the-field assistance can take from one to two years. An even shorter time is required to expand existing service.

Benefits

- Reduced vehicle delay for traffic affected by an incident; subsequent travel time savings
- Fewer secondary crashes
- Greater sense of security for motorists and reduced demand on law enforcement for non-emergencies

Related strategies

- Traveler information devices (stationary or portable) can provide real-time traffic information to motorists upstream of an incident.
- Expanded communication and surveillance capabilities allow regional traffic management centers to detect incidents, coordinate a response and quickly inform the traveling public and media.

Other factors or considerations

- Marketing is necessary to promote courtesy patrol services and benefits.
- Centralized or coordinated dispatch is most efficient.

1.G. Traveler information devices (message signs, Internet)

Description

- Mechanisms to provide information via Internet Web sites, telephone hotlines, television and radio, and variable message signs to allow travelers to make decisions regarding trip departures, route selection and travel mode

Applicable locations/situations

- Heavily traveled freeways or arterials with frequent incidents or travel delays
- Locations before major interchanges and route decision-making points

Cost: ***Moderate***

- Costs depend upon communication networks and assigned technologies
- San Francisco implemented a regionwide traveler information system with an initial investment of $7 million.
- CDOT spends an estimated $3 million statewide annually on traveler information-related equipment and network expansion.

Timeframe: ***Short- to moderate-term***

- Means for distributing roadway condition and traveler information are readily available.
- Other means for distributing traveler information that rely on capital investment, new communication networks and physical rights-of-way can take one to four years to implement.

Benefits

- Improved traveler decisions based upon pre-trip and en-route information.
- Reduced travel times and follow-up congestion at sites of major incidents.

Related strategies

- Commercial traveler information services are now available (some are offered at a fee to subscribers).
- In-vehicle data collection, dissemination and vehicle response are soon expected to be mainstream technologies.

Other factors or considerations

- Roadside (out of vehicle) traveler information systems should take advantage of relationships with new in-vehicle technologies.
- Enhancement of the federally designated 511 hotline services (e.g. via regional Web site) will require participation from many agencies.

511
Traffic and Transit Info

1.H. Traffic management center (TMC)

Description

- Facility serving as a hub for transportation management where information from local networks and other sources is collected and distributed
- Must include operational protocols that define specific responses and actions based on the information at hand (e.g. media notification, sign messages, maintenance crew direction, etc.)

Applicable Locations/Situations

- Jurisdictions that own equipment, collect data and manage traffic
- A strategic, centralized location serviced by major communication lines

Cost: ***Moderate***

- Design and construction of a TMC and purchase of all necessary equipment can range in cost from $500,000 to more than $1,000,000.
- Annual operational budgets (including personnel) must be developed separately.

Timeframe: ***Moderate- to long-term***

- Organizing partner agencies, reaching consensus on key issues and negotiating memoranda of understanding may take a moderate- to long-term commitment.

Benefits

- Increased roadway safety through faster detection and response to incidents or equipment malfunctions
- Fewer travelers impacted by road closures or incidents
- Simultaneous management of ITS applications
- Increased efficiency of operations personnel
- Ability to coordinate/communicate with other TMCs

Source: CDOT

Related strategies

- Most of the active roadway management strategies mentioned in this section of the toolkit are key components of an effective traffic management center.
- Methods for notifying long distance travelers of advisories before their arrival in the region should be implemented.

Other factors or considerations

- A TMC must be fully staffed to effectively monitor and manage critical transportation infrastructure.
- Local traffic management entities must be willing participants with a TMC to ensure its success.

1.1. Electronic toll collection (ETC)

Description

- Equipment that electronically collects tolls from users without requiring vehicles to stop at a toll booth

Applicable Locations / Situations

- Existing staffed toll booths
- Privately owned or public authority roadways/tollways
- HOV/HOT facilities that charge varying rates based on vehicle occupancy and time of day

Cost: ***Moderate***

- Initial investment in electronic toll collection technology can be substantial (overhead transponder readers, surveillance and enforcement equipment).
- The estimated annual maintenance and operational costs for an electronic toll lane are less than $20,000, whereas a staffed toll booth lane can cost nearly $200,000 annually. *(Source: ITE Toolbox)*

Timeframe: ***Short- to medium-term***

- Physical implementation of electronic toll collection equipment can be completed in a short time period for a roadway, unless additional right-of-way is needed.

Benefits

- Fewer vehicle stops and less traveler delay at toll stations
- Cost savings due to no (or fewer) toll booth facilities or lanes
- Significant decrease in pollutant emissions from stop-and-go traffic at toll booths/plazas

Related strategies

- New or converted high-occupancy toll (HOT) lanes would also likely use ETC technology.

Other factors or considerations:

- Acquisition of an electronic toll transponder often requires consumers to pay an upfront fee.
- Strict enforcement at toll checkpoints may discourage occasional users who are unfamiliar with electronic toll collection process.

1.J. Cordon area congestion fees

Description

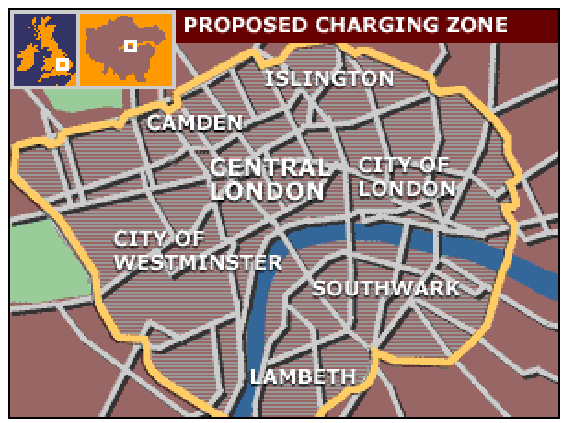
- An established cordon area or zone in which vehicles are charged a fee to enter. Such a fee can be variable (by time of day) or dynamic (based on real-time congestion conditions)
- Should include electronic payment/collection methods using cameras or transponders

Applicable locations/situations

- Highly congested urban centers or concentrated activity areas with well-defined and limited roadways that enter the area
- May be done in conjunction with an "auto restricted zone"

Cost: ***High***

- The cost to implement infrastructure and devices for a large-scale electronic fee collection system can be high (e.g. in Stockholm, Sweden and London, England).



Timeframe: ***Medium- to long-term***

- Extensive time is required for the entire process including political and public discussions, possible ballot measures, construction and implementation.

Benefits

- Reduced pollution and congestion within the cordon area
- Revenues for roadway maintenance and new transit, bicycle and pedestrian facilities
- Overall reduced congestion due to less VMT

Related strategies

- Electronic and variable pricing of toll roads, bridges, or tunnels should be used.
- Expanded transit service and convenient bicycle and pedestrian facilities should be provided to serve people no longer driving into the cordon area.

Other factors or considerations

- Exemption or reimbursement policies for certain vehicles, residents, or businesses may be enacted.
- Parking and congestion issues just outside the cordon area should be monitored.

1.K. Roadway signage improvements

Description

- Adequate or additional signage that facilitates route-finding and the decision-making ability of roadway users
- Signs with clearer/larger lettering that can be read from a greater distance

Applicable locations/situations

- Intersections or off-ramps lacking adequate directional signage or visible route markers
- Major intersecting streets or freeways
- Locations with a high percentage of visiting drivers - “design for the unfamiliar driver”
- Area in which roadway realignment or recent change in access has occurred

Cost: ***Low***

Timeframe: ***Short-term***

- Production of signs and installation can occur shortly after site visits and design of new signing plans. Design should follow the guidance of the Manual on Uniform Traffic Control Devices (MUTCD).

Benefits

- Reduced level of driver uncertainty and fewer erratic driving maneuvers
- Reduced delay for upstream approaching vehicles
- Psychological encouragement to unsure motorists
- Less chance of crashes caused by sudden lane changes, extremely slow-moving vehicles or sudden stops

Related strategies

- Variable message signs and other ITS applications can provide real-time or temporary information to travelers
- Emerging in-vehicle technologies that provide real-time traveler information and route-finding capabilities

Other factors or considerations

- Signs should be installed at visually effective locations.
- Too many signs or sign clutter should be avoided.

1.L. Communications networks and roadway surveillance coverage

Description

- Base infrastructure (fiber, cameras, etc.) required to support all operational activities.
- Communications networks that allow remote roadway surveillance and system control from a TMC and provision of data for immediate management of transportation operations and distribution of information

Applicable locations/situations

- Locations of new roadway construction or major capital improvement projects

Cost: ***Moderate***

- Communication networks are not low-cost or high-profile items, but essential to get the most efficiency and capacity out of the existing transportation system.
- Cost can be reduced when done in conjunction with a larger scale construction project.

Timeframe: ***Medium- to long-term***

- Small-scale items and opportunistic expansion can be done quickly. Larger-scale regional network components require more time for planning and funding.

Benefits

- Increased capability for regional-level coordination of operations and traveler information.

Related strategies

- Supplementing fiber optics communications with wireless technologies may prove beneficial.
- Most active management strategies in this toolkit require the support of roadway surveillance and communications infrastructure.

Other factors or considerations:

- Planning and implementation must account for both existing and potential future technologies.
- Resource sharing and partnering with other users should be pursued.

2.A. New fixed guideway transit travelways

Description

- Exclusive guideways (e.g. light rail, heavy/commuter rail) and street travelways (e.g. 16th Street Mall, bus rapid transit (BRT)) devoted to increasing the person-carrying capacity within a travel corridor (see section 3.F. for information on HOV lanes)

Applicable locations/situations

- Densely developed urban corridors or station areas
- Rights-of-way adjacent to severely congested freeways or arterial streets
- Streets with existing or anticipated high levels of commercial and pedestrian activity

Cost: ***Moderate to high***

- Implementation cost will vary, but cost could be high due to acquisition of rights-of-way, materials and infrastructure.

Timeframe: ***Medium- to long-term***

- Development and implementation of a rail project is a major undertaking that can take 10 or more years from initial planning phases through NEPA studies to an opening day.
- On-street conversion of travel lanes to BRT may not take quite as long.

Benefits

- More consistent and sometimes faster travel times for transit passengers versus driving
- Increased person throughput capacity within a corridor due to people switching from single-occupant motor vehicles to transit
- Stimulation of efficient mixed-use or higher-density development

Related strategies

- Transit-oriented developments (TODs) adjacent to stations stimulate additional use of rail and bus services.
- Parking management, fare collection and other technological transit applications are important elements.
- Transportation demand management services and promotions encourage more transit use.

Other factors or considerations

- Complex project funding arrangements may be required.
- Attractiveness of end-of-line stations may stimulate growth farther from the urban core.
- Fare structure and discount mechanisms are important for inducing motorists to switch to transit.

2.B. Transit service expansion (more vehicles, extended / new routes)

Description

- New bus routes or extension of existing route service
- Run buses more frequently (shorter headways between buses)

Applicable locations/situations

- Areas with growing concentrations of residential, commercial or business activity
- Existing bus routes that are operating near capacity or "crush-load" conditions
- Route locations that offer increased access to major transit stations

Cost: ***Low to moderate***

- Increasing service frequency via shorter headways and more buses redeployed from an existing fleet is low cost. Creating a new bus route requiring new buses is much more costly.

Timeframe: ***Short-term***

- Most minor changes to transit service involve a short-term process that may require public notification; fleet expansion and hiring new personnel would take longer.

Benefits

- Improved convenience and travel reliability for passengers
- Reduced traffic congestion due to trips switched from driving alone to transit

Related strategies

- Transit queue-jump lanes save time.
- Use of automated vehicle location (AVL) technology enables provision of real-time traveler information.
- Developments designed with transit-friendly features and connections to and from transit stops make bus travel more convenient.

Other factors or considerations

- RTD service and ridership standards must be met for existing, modified or new bus routes.
- New or modified service must be marketed to attract additional riders.
- Maintenance of increased vehicle fleet must be accounted for.

2.C. Transit vehicle travel information

Description

- Communications infrastructure, GPS technology, vehicle detection/monitoring devices and signs/media/Internet sites for providing information to the public such as the arrival times of the next vehicles

Applicable locations/situations

- Transit stations and major bus stops.
- Major event and activity venues adjacent to transit stations.

Cost: ***Moderate***

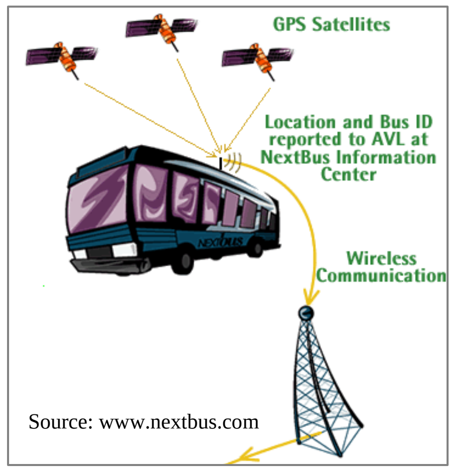
- Costs are dependent upon communication networks, changing technologies and the number of fleet vehicles to be equipped.

Timeframe: ***Medium***

- Time is required for detailed planning, design and funding procurement.

Benefits

- More satisfied customers and increased ridership due to enhanced and reliable information sources
- Improved operations and management of transit service



Source: www.nextbus.com

Related strategies

- Integration of transit information with that provided to motorists (e.g. via Web sites) provides a more comprehensive base of materials for travelers.
- New or expanded transit services can be marketed in conjunction with new information outlets.

Other factors or considerations

- Reliability and accuracy of systems are closely scrutinized by transit agencies.
- This strategy may be more efficient to implement when transit stations are being designed and constructed.

2.D. Transit intersection queue-jump lanes and signal priority

Description

- Additional travel lane at a signalized intersection that allows buses to proceed via their own "green-time" before other vehicles
- Done by restriping within existing road footprint or this may require construction

Applicable locations/situations

- Heavily traveled corridors with multiple traffic signals and frequent transit stops
- A location where a bus needs a "head start" to merge into or cross general-purpose lanes of traffic

Cost: ***Low to moderate***

- Installation and operation cost of queue jump lane and signal equipment is low.
- Constructing a new designated transit lane has a higher cost.

Timeframe: ***Short-term***

- All phases–planning, engineering and implementing–a queue-jump lane can be reasonably completed in less than one year.
- Longer time is needed if new lane must be constructed.

Benefits

- Reduced bus travel delays due to traffic signals and traffic congestion
- Improved operational efficiency of transit service within a corridor
- Increased ridership and reduced congestion due to time savings
- Safer driving conditions for all vehicles due to fewer severe and sudden lane changes by buses

Related strategies

- Queue-jump lanes must be considered when signal coordination plans are being prepared.

Other factors or considerations

- Newly constructed queue-jump lanes are costly if right-of-way must be obtained. Efforts should be made to incorporate the lane into the existing roadway.
- Enforcement at transit queue-jump locations is important to ensure safety and proper operation.
- If the queue-jump lane replaces on-street parking meter spots, cities may receive less parking revenue.

2.E. Electronic fare collection

Description

- Equipment that allows riders to electronically pay a transit fare by using credit, debit and magnetic fare cards

Applicable locations/situations

- Buses in the transit agency vehicle fleet

Cost: ***Moderate to high***

- The cost to purchase and implement electronic fare collection equipment can be high depending on the technology used.
- An initial surge in the maintenance and repair of electronic fare equipment can be expected due to the need for highly trained personnel.

Timeframe: ***Medium-term***

- It is estimated that a full deployment of an electronic fare payment system could take from three to five years

Benefits

- Improved service efficiency, passenger convenience and passenger loading time
- Increased ridership
- Acquisition of more accurate and comprehensive ridership and trip data
- Improved analysis and forecasting of trip ridership patterns and fare structure impacts
- Reduced overall operating cost of fare collection and processing
- Increased revenue through less fare evasion and greater accountability

Related strategies

- Future technology and equipment may allow fare payment media to be used as general-purpose debit cards for other types of purchases.

Other factors or considerations

- Integration with all modes and services of the transit agency should be pursued.
- Prepaid electronic payment options may “mask” the complexity of the fare structure.
- Current fare payment systems may still be needed for passengers not willing to use electronic payment technology.

2.F. Parking facility management information signs

Description

- Signage to notify travelers of the remaining number of unoccupied parking spaces at a public (e.g. *park-n-Ride*) or private parking lot
- Signage that guides travelers to lots with available parking

Applicable locations/situations

- Frequently used *park-n-Ride* lots
- Downtown parking lots

Cost: ***Low to moderate***

- Simple parking management systems can be as inexpensive as $20,000, whereas more sophisticated management programs can cost more than $250,000 to purchase and implement.

Timeframe: ***Short- to medium-term***

- Planning, design and implementation of a parking management system can take from one to three years.

Benefits

- Decreased total travel delay and miles wasted driving around to find a parking spot
- Improves convenience of transit and reduces the frustration of not finding a parking space in a full lot

Related strategies

- Installation of communications infrastructure and monitoring equipment as part of other larger-scale projects is beneficial.
- Variable parking cost mechanisms and different categories of parking spaces at *park-n-Ride* lots (short-term, long-term, preferential spaces for carpools, etc.) may be implemented.

Other factors or considerations

- Frequent verification and validation of methods of determining parking space occupancy must be conducted.
- An abundance of unoccupied parking spaces and the expectation of free parking can decrease the effectiveness of parking signage.

2.G. Telework and flexible work schedules

Description

- Program or adopted policies that allow an employee to work from home
- Employer policies that permit employees to work a compressed work week and take a day off (e.g. work 40 hours in four days or 80 hours in nine days)

Applicable locations/situations

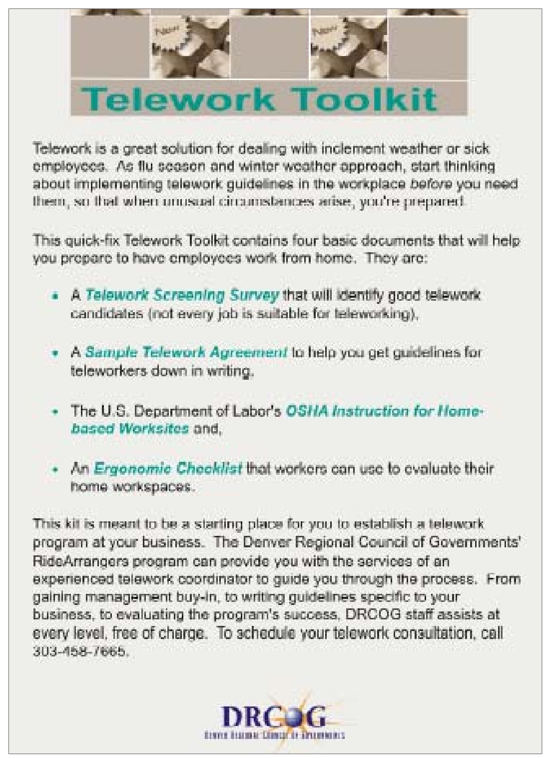
- Workplaces that perform tasks or services that can be completed from remote locations (e.g. via computer or Internet)
- Workplaces with extended daily hours of operation, allowing employees to work nine to 10 hours in a day

Cost: ***Low***

- Very little initial cost is attributed to the employer and the employee.
- RideArrangers will help employers start telework services for free.

Timeframe: ***Short-term***

- With help from a Telework consultant through DRCOG's RideArrangers program, a Telework program can be established and implemented in less than three months.



Telework Toolkit

Telework is a great solution for dealing with inclement weather or sick employees. As flu season and winter weather approach, start thinking about implementing telework guidelines in the workplace *before* you need them, so that when unusual circumstances arise, you're prepared.

This quick-fix Telework Toolkit contains four basic documents that will help you prepare to have employees work from home. They are:

- A ***Telework Screening Survey*** that will identify good telework candidates (not every job is suitable for teleworking),
- A ***Sample Telework Agreement*** to help you get guidelines for teleworkers down in writing,
- The U.S. Department of Labor's ***OSHA Instruction for Home-based Worksites*** and,
- An ***Ergonomic Checklist*** that workers can use to evaluate their home workspaces.

This kit is meant to be a starting place for you to establish a telework program at your business. The Denver Regional Council of Governments' RideArrangers program can provide you with the services of an experienced telework coordinator to guide you through the process. From gaining management buy-in, to writing guidelines specific to your business, to evaluating the program's success, DRCOG staff assists at every level, free of charge. To schedule your telework consultation, call 303-458-7665.

DRCOG

Benefits

- Fewer drivers during morning and afternoon rush hours
- Reduced vehicle miles traveled due to employees working at home or working fewer days at the workplace
- Increased employee productivity, improved employee retention and recruitment, reduced overhead costs and lower demand for physical office and parking space
- Decreased commuting time and expenses for employees

Related strategies

- Telework participants may also be interested in alternative travel mode services on days in which they do commute to the workplace.

Other factors or considerations

- Telework is suitable only for select employees with applicable job responsibilities.
- Employee accountability and consistent communication are necessary to ensure a successful program.
- Employers must establish/install information technology software, hardware and protocols.

2.H. Ridesharing travel services (Carpool, Vanpool, Schoolpool)

Description

- Programs that encourage and facilitate two or more people sharing a ride in a car or van.
- May be operated by a third-party public agency (e.g. DRCOG RideArrangers), private enterprise (e.g. Web-based), individual workplace or business/office park

Applicable locations/situations

- Areas with a high concentration of employees working at one worksite or a group of workplaces
- Schools with a large number of students that are not served by school buses
- Residential areas outside transit service districts or with a high number of long-distance commuters

Cost: ***Low to moderate***

- Ridesharing matching services are relatively inexpensive programs to start and maintain. Vanpool programs cost more because of the vehicle purchases and maintenance.
- RideArrangers will do all the work (except driving) at no cost.

Timeframe: ***Short-term***

- Large- or small-scale programs can be started in a short timeframe.

Benefits

- Fewer single-occupant vehicles on the road and reduced overall traffic congestion
- Lower commuting costs
- Safer and less congestion around schools

Related strategies

- Cross-promotion of complementary transit services can result in greater overall benefits.
- Programs to encourage carpooling to transit stations may have merit.
- Services that provide an emergency ride home to car/vanpoolers (e.g. Guaranteed Ride Home) should be provided.
- Employer-based "trip reduction managers" can operate programs geared toward their employees.

Other factors or considerations

- The personal convenience of a private vehicle is often a deterrent to carpooling.
- Complementary facilities such as high-occupancy vehicle (HOV) lanes that offer carpools a less congested roadway should be cross-marketed.
- Provision of preferential carpool parking spaces offers a further incentive.
- Education of the public of the true costs of commuting and auto ownership is important.

2.I. Alternative travel mode events and assistance

Description

- Variety of events that promote, encourage and educate people about alternative travel modes (e.g. Bike to Work Day, RideSmart Thursdays and employer transportation fairs)
- Programs that provide free or low-cost transit services (e.g. EcoPass) or other incentives

Applicable locations/situations

- Areas with a high concentration of employees working at one worksite or a group of work-places

Cost: ***Low***

- Cost can be relatively low, depending on the level of participation from employers and sponsors.

Timeframe: ***Short-term***

Benefits

- Fewer single-occupant vehicles on the road and less overall traffic congestion
- Lower commuting costs

Related strategies

- Cross-promotion of complementary transit services can result in greater overall benefits.
- Provision of additional transit or vanpool service and construction of bicycling facilities offers further encouragement.
- Complementary facilities such as high-occupancy vehicle (HOV) lanes that offer carpools a less-congested roadway.

Other factors or considerations

- A significant effort may be required to secure sponsorships and media attention to help gain participation in events.
- Education of the public of the true costs of commuting and auto ownership is important.

RideArrangers
a program since 1975
DENVER REGIONAL COUNCIL OF GOVERNMENTS

ridesmart thursdays
transit • vanpool • bike • walk • telework • carpool
Join the Movement!

2.J. Off-street multi-use trails (pedestrian and bicycle)

Description

- Off-street facilities for use by pedestrians, bicyclists and other "non-auto" users. Also popularly known as bike paths, bike trails, shared-use paths, etc.

Applicable locations/situations

- Along drainageways of creeks or rivers, utility easements or parallel to major highways
- Locations that provide access to popular destinations such as transit stations, employment centers, parks, schools and entertainment districts

Cost: ***Low to moderate***

- Cost depends on right-of-way availability and other construction constraints.

Timeframe: ***Medium-term***

- New trail facility sections may take from one to four years to complete. An entire trail system will take much longer.

Benefits

- Fewer single-occupant vehicles on the road and less overall traffic congestion
- Lower commuting costs

Related strategies

- Road construction projects should consider interaction with off-street multi-use trails.
- Access management practices that reduce the number of driveways across trails parallel to roadways reduce the risk for car-bicycle crashes.
- Bicycling promotion events can encourage use of facilities.

Other factors or considerations

- Underpasses or overpasses of major barriers (e.g. highways and railroads) are critical.
- See the DRCOG Pedestrian and Bicycle Element of the 2030 Metro Vision Transportation Plan for more information on design considerations for off-street facilities.

2.K. On-street bicycle treatments

Description

- Designated areas on streets for bicycles–either separated from (bike lanes) or shared with (shoulders, wide curb lane) motor vehicle traffic
- Usually delineated or separated with pavement markings

Applicable locations/situations

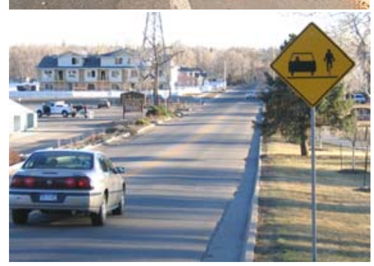
- Along roadways that are part of a comprehensive local or regional bikeway or bicycle route system
- Locations that provide access to popular destinations such as transit stations, employment centers, parks, schools and entertainment districts

Cost: ***Low to moderate***

- Cost depends on whether facility can be marked within the existing roadway footprint or if new construction is required.

Timeframe: ***Short- to medium-term***

- New facilities may take a short time for pavement markings or a few years for construction.



Benefits

- Fewer single-occupant vehicles on the road and less overall traffic congestion
- More comfortable space on roadway for bicyclists
- Lower commuting costs
- Numerous safety benefits to motorists from shoulders

Related strategies

- Road construction projects should consider on-street bicycle treatments.
- Interaction with connecting off-street multi-use trails should be considered.
- Bicycling promotion events can encourage use of facilities.

Other factors or considerations

- Signs and markings for short segments where the pavement narrows (e.g. on an underpass or bridge) should be considered.
- Conflict points at intersections and on approaches to locations with weaving motor vehicle traffic should receive special attention.
- Adjacent on-street parking can impact bicycle lanes.
- See the DRCOG *Pedestrian and Bicycle Element of the 2030 Metro Vision Transportation Plan* for more information on design considerations for on-street facilities.

2.L. Efficient land use and development practices

Description

- Areawide policies and strategies that result in a more transportation-efficient regional development pattern (e.g. urban growth boundary)
- Localized planning, zoning, ordinances and site approval strategies that result in more transportation-efficient developments (e.g. mixed-land-uses, higher density, urban centers, well connected transit, pedestrian and bicycling facilities)

Applicable locations/situations

- New developments on previous vacant or undeveloped sites
- Redevelopment of existing developed sites or retrofits of existing developments
- Locations that could capitalize on proximity to a transit station

Cost: ***Low to moderate***

- Costs can vary widely and are difficult to calculate, as they will be shared by local governments, developers, home buyers, businesses and customers.

Timeframe: ***Short- to long-term***

- Small-scale retrofit practices, rezonings or comprehensive plan amendments can be done in a short to moderate timeframe. Regional-scale policy changes may take a long time to adopt and result in development changes on the ground and integration with transportation systems.

Benefits

- Less motor vehicle use through greater bicycling, walking and transit use
- Related health benefits and economic savings via less infrastructure needs

Related strategies

- Most practices in this section of the toolkit are important components of transit-oriented developments (TODs) that have and will be implemented near major transit hubs.
- Numerous plans and publications produced by DRCOG (www.drcog.org) describe or endorse techniques for more transportation-efficient development.

Other factors or considerations

- Political, economic and social factors will impact the implementation of these practices.

3.A. Intersection turn lanes

Description

- Additional left-turn or right-turn lanes that separate turning vehicles from through-traffic

Applicable locations/situations

- Intersections with a high number of turning vehicles and/or subsequent rear-end crashes
- Intersections with available right-of-way adjacent to the roadway

Cost: ***Low to moderate***

- The cost is relatively low compared to major highway projects, depending on right-of-way needs.

Timeframe: ***Medium-term***

- Agencies must be sure to plan for possible time needed to obtain right-of-way.

Benefits

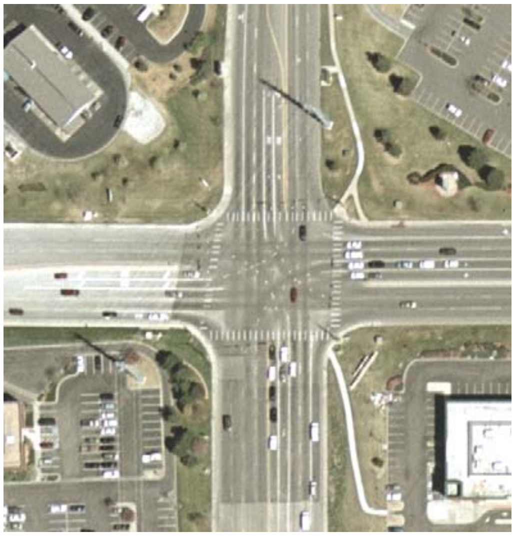
- Greater number of vehicles can pass through the intersection in given amount of time, resulting in a lower level of travel delays and stopped time
- Can reduce the likelihood of rear-end crashes

Related strategies

- Signal timing must be coordinated with neighboring signalized intersections.
- Installation of traffic signal or ITS communication equipment should be done at the time of construction.

Other factors or considerations

- Designs must incorporate accommodations for pedestrians – e.g. signal timing for pedestrian crossing phase, refuge islands and crosswalk markings/treatments.
- Turning radii for trucks should be considered.



3.B. Acceleration / deceleration lanes

Description

- Deceleration lane provided on a freeway just before an exit off-ramp allowing vehicles to reduce speed outside the through-lanes
- Acceleration lane provided as an extension of a freeway on-ramp or an arterial street turn-lane for vehicles to increase speed and merge more smoothly into the through-lane

Applicable locations/situations

- Areas with a high number of merging or weaving vehicles
- Merging points on steep up-grades
- Freeway approaches to off-ramps that require a significant speed reduction

Cost: ***Low to moderate***

- Cost is relatively low if right-of-way or bridge widening is not required.

Timeframe: ***Medium-term***

- Right-of-way is an important factor in the time required for implementation and construction.

Benefits

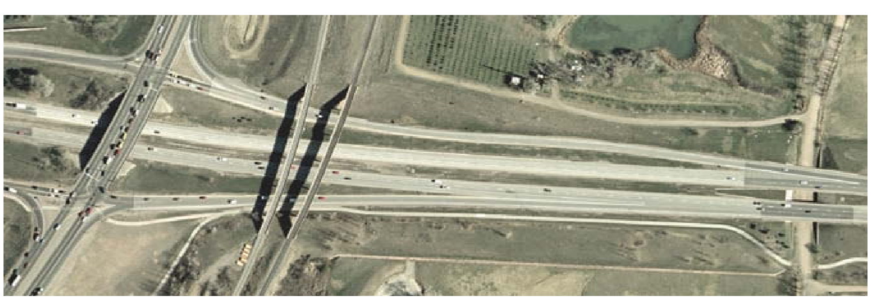
- Slower-moving turning or exiting vehicles are removed from through-lanes resulting in fewer delays for upstream traffic
- Accelerating vehicles are provided more distance to reach the speed of through traffic, resulting in fewer delays caused by merging and weaving vehicles
- In certain situations, can greatly reduce delays (caused by braking) for upstream vehicles during peak traffic flow periods

Related strategies

- Signs to alert drivers to the availability of acceleration or deceleration lanes can greatly increase the proper use of these lanes.

Other factors or considerations

- Some drivers are not familiar or comfortable with the use of acceleration lanes that depart from intersections.



3.C. Hill-climbing lanes

Description
- Additional lanes provided for a short distance to allow slower-moving vehicles (e.g. trucks and recreational vehicles) to move to the right and allow faster-moving vehicles to pass

Applicable locations/situations
- Generally in rural areas with steep or rolling hills. Can be provided on freeways or rural highways
- Locations that experience high peak direction volumes of recreational or weekend traffic
- Urban or suburban freeways with steep climbing up-grades

Cost: ***Low to moderate***
- Cost is relatively low unless right-or-way, major rock-cuts or environmental mitigation is required.

Timeframe: ***Short- to medium-term***
- Shorter segments with no right-of way needs can be done in a short time.

Benefits
- Major travel time savings for vehicles on rural highways, especially those with peak levels of recreational traffic
- Safety benefits due to fewer frustrated drivers making dangerous passing maneuvers

Related strategies
- Providing notification signs several miles before the hill-climbing lane (e.g. “Passing Lane 2 Miles Ahead”) can decrease the frustration of drivers stuck behind a slow-moving vehicle.
- Hill-climbing lanes may sometimes feed into deceleration lanes or emanate from acceleration lanes.

Other factors or considerations
- Intervals or spacing of hill-climbing lanes on long rural segments should be evaluated.
- Impacts of shoulder removal should be considered, if such action is required.

3.D. Grade-separated railroad crossings

Description
- Roadway underpass or overpass of a railroad line

Applicable locations/situations
- Roadways with a high daily volume of traffic
- Locations with either a high frequency of trains crossing the road or long-time durations of multi-car trains blocking the road
- High traffic-generating land uses on either side of the railroad tracks
- Locations with a documented crash rate higher than established thresholds

Cost: ***High***
- Cost is very high to provide either a roadway or railroad bridge or tunnel.

Timeframe: ***Medium- to long-term***
- Implementation requires significant negotiation with railroads and local communities.

Benefits
- Significant reduction in travel delays at high-volume locations
- Likely elimination of car-train crashes
- Decreased noise from train horns/whistles

Related strategies
- Grade-separations should be planned for in conjunction with new roadways that are built.
- The capability to provide real-time information on message signs regarding the location and time of train crossings has been implemented in other cities.

Other factors or considerations
- Long approaches of a gradual grade are required for rail-road bridges that may require right-of-way.

3.E. HOV bypass lanes at ramp meters

Description

- An additional on-ramp lane to be used by buses or vehicles with two or more people adjacent to a meter-controlled lane

Applicable locations/situations

- Metered on-ramps with significant queuing of vehicles in peak hours
- Locations with a high number of buses that would avoid delays at the ramp meters

Cost: ***Low to moderate***

- Cost depends on amount of right-of-way needed and the scale of construction impediments.

Timeframe: ***Short- to medium-term***

- Shorter segments with no right-of-way needs can be done in a short time.

Benefits

- Offers a reduction in travel delays and more consistent travel times for buses to help keep them on schedule
- Encourages carpooling and vanpooling if the driver and passengers can pass by stopped vehicles

Related strategies

- HOV lanes on freeways can be coordinated with bypass lanes.
- Carpool/vanpool/TDM services can be promoted with educational campaigns for bypass lanes.

Other factors or considerations

- The need for breakdown space or shoulders should be considered.
- Adequate width and length of the ramp beyond the “stop bar” must be provided for merging.

3.F. Roundabout intersections

Description

- An intersection modification that does not use traffic signal or stop sign controls
- Provides continuous movement via entrance and exit lanes to/from a typically circular distribution roadway

Applicable locations/situations

- Certain congested intersections with many turning vehicles
- Atypical locations with more multiple (>4) roadway approaches

Cost: ***Moderate***

- Cost affected by the amount of right-of-way needed.

Timeframe: ***Medium-term***

- Completion time for a replacement roundabout is related to the amount of planning and public outreach time needed and the right-of-way acquisition process

Benefits

- Greater capacity than traditional 3- or 4-way intersections in many situations
- Fewer crashes over time
- Lower air pollutant emissions due to fewer stopped vehicles

Related strategies

- Access management for the approach roadways and adjacent properties should be done.

Other factors or considerations

- Detailed evaluations to determine benefits and appropriateness of a roundabout at the specific location must be conducted and presented to the public.
- Appropriate treatments and facilities for bicyclists and pedestrians need to be considered.
- Accommodation of large vehicles (e.g. fire trucks, buses and semi-trucks) important.
- Campaigns to educate the public on how to use a new roundabout are essential.

Source: Mapquest.com

3.G. New grade-separated intersections

Description

- An overpass or underpass for one roadway to avoid intersecting with a cross street

Applicable locations/situations

- Very high-volume and congested intersections
- Locations with limited right-of-way or physical constraints to expanding the width of the intersection approaches

Cost: ***High***

- Cost depends on the amount of right-of-way needed and the scale of construction impediments.

Timeframe: ***Medium- to long-term***

- Completion of a grade-separated intersection can take from five to 15 years, including planning, engineering, environmental analysis and construction phases.

Benefits

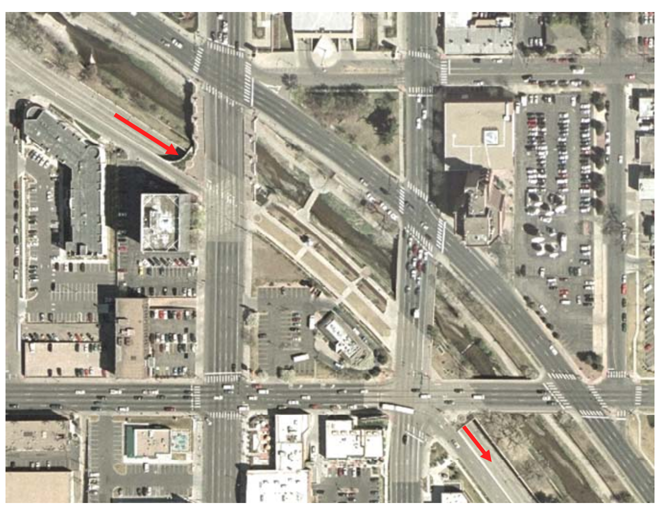
- Increased capacity and fewer stops
- No stops for through-traffic
- Fewer turning movement conflicts

Related strategies

- Transit enhancements (e.g. queue-jump lane) may be considered.

Other factors or considerations

- Appropriate accommodations for bicyclists and pedestrians must be implemented.
- Signing and pavement markings are especially important for roadway users unfamiliar with these types of designs.



3.H. New (or converted) HOV / HOT lanes

Description

- A new lane, or conversion of existing lane, that serves buses, high-occupancy vehicles (HOV), and other approved users such as motorcycles, toll paying vehicles (HOT), low-emission vehicles or hybrid engine vehicles
- Congestion-based (dynamic) or time-based (variable) pricing typically used for HOT lanes

Applicable locations/situations

- Highly congested corridors with extensive bus service

Cost: ***Moderate to high***

- Construction of a new set of lanes is much more costly than converting existing traffic lanes.

Timeframe: ***Medium- to long-term***

- Time is required for planning, design, rule setting, construction and if needed, environmental studies and legislation.

Benefits

- Offers a reduction in travel delays and more consistent travel times for buses to help keep the vehicles on schedule
- Encourages carpooling and vanpooling if HOV lane driver and passengers can pass by stopped or delayed vehicles

Related strategies

- Enhanced bus service, bus rapid transit and carpool/vanpool/TDM services will increase the number of persons using the facility.
- Electronic toll collection methods are commonly used.

Other factors or considerations

- A good level of service (free-flowing traffic) for buses and HOVs must be maintained.
- Several unique design and operational aspects must be evaluated – e.g. time of day operations/reversing of lanes, traffic operations at start and end points and the types of vehicles permitted.
- Legislation may be required before implementation.
- Emergency vehicle access and egress must be planned for.
- Enforcement technologies, methods and personnel are critical to a successful facility.

3.I. New travel lanes (widening)

Description

- New travel lanes added along an existing roadway

Applicable locations/situations

- Severely congested roads with a clear capacity or safety deficiency
- Location with limited appropriate alternative routes

Cost: ***High***

- Cost depends on amount of right-of-way needed and the scale of construction impediments.

Timeframe: ***Medium- to long-term***

- Completion of a capacity expansion project can take from five to 20 years, including planning, engineering, environmental analysis and construction phases.

Benefits

- Increased capacity and reduced congestion and travel delays for existing level of traffic
- Less traffic on parallel side streets and arterials as vehicles divert to the widened road

Related strategies

- Active roadway management strategies in this toolkit and newer technology to monitor/control traffic conditions should be implemented during construction.
- TDM strategies could provide significant benefits during construction and they could carry over following project completion.
- Preservation of right-of-way and building set-back requirements should be established many years before construction.

Other factors or considerations

- Appropriate bicycle, transit and pedestrian facilities must be considered.
- Construction will impact property owners, businesses and residents on the roadway itself or on parallel streets.
- New lanes could possibly move the bottleneck point downstream if project is not of sufficient length.

3.J. New roadways

Description

- A new roadway along separate right-of-way to serve newer developed or developing areas

Applicable locations/situations

- Location that serves areas experiencing new development or anticipating development soon
- Location that would divert traffic from an existing severely congested corridor

Cost: ***High***

- Cost depends on amount of right-of-way needed and the scale of construction impediments.

Timeframe: ***Medium- to long-term***

- Completion of a new roadway project can take from five to 25 years, including planning, engineering, environmental analysis and construction phases.

Benefits

- Increased capacity to serve developing areas
- Reduced traffic and congestion on parallel streets due to vehicles diverted to the new road

Related strategies

- Active roadway management strategies in this toolkit and newer technology to monitor/control traffic conditions should be implemented during construction.
- Transit service can be provided to reduce the demand for vehicle travel on the new road.
- Land use practices that manage the amount of new development in the area to a level that the roadway system can adequately handle should be enacted.

Other factors or considerations

- Appropriate bicycle, transit and pedestrian facilities must be considered.
- Preservation of right-of-way many years before construction will reduce cost and impacts.

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