HOUSTON'S TRAVEL RATE IMPROVEMENT PROGRAM

"TOOLBOX" OF IMPROVEMENT STRATEGIES

INCREASE SYSTEM EFFICIENCY

Prepared for
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INCREASE SYSTEM EFFICIENCY

The basic transportation system—the roads, transit vehicles and facilities, sidewalks and more—is designed to accommodate a certain amount of use. Some locations, however, present bottlenecks, or constraints, to smooth flow. At other times, high volume congests the entire system.

The strategies listed in this section are aimed at improving peak hour mobility. Improving the operating efficiency of roads, transit and other transport system elements improves the utilization of the capacity that is constructed. The community benefits from reduced congestion and reduced emissions, as well as more efficiently utilizing the infrastructure already in place.

The "tools" included in this category are:

- Flow Signals
- Traffic Signal Improvements
- Incident Management
- Event Management
- Changeable Lane Assignments
- Technology-Based Transit Improvements
- Electronic Toll Collection Systems
- Intersection Improvements
- One-Way Streets

Flow Signals

Implementation
Hurdles: Public
Level: Target Markets
Sector: Public
Locations: Routes

Description

Flow signals (also called ramp meters) are modified traffic signals placed on the entrance ramps of urban freeways. They may operate on a pre-timed cycle or be responsive to conditions on the freeway mainlanes. Flow signals typically release one vehicle per cycle from the ramp. The goal of flow signals are to smooth out the flow of vehicles entering the freeway. Groups of vehicles entering a freeway that is approaching capacity can cause the freeway demand to exceed capacity. Stop and go traffic, reduced volume, and increased accident potential are associated with traffic demand exceeding capacity. If vehicles enter the freeway at a uniform rate, however, the smooth flow of traffic on the freeway can be preserved longer. Ramp meters will not eliminate congestion in most cases, but delaying stop-and-go conditions for 15 to 30 minutes has significant benefits.

Target Market

The flow signals do delay travelers wishing to enter the freeway; however, the emphasis is on preserving smooth flow on the mainlanes. HOV bypass lanes can be used in conjunction with flow signals to retain the travel time savings and delay reduction desired to encourage bus and carpool use, allowing these vehicles to bypass the queues and signals. Flow signals can also have the effect of discouraging short trips on the freeway.

Locational equity considerations (issues related to which ramps have longer wait times) can be accommodated by using a control strategy that presents equal waiting times to close-in and suburban entrance ramps, regardless of freeway conditions in the immediate area. This may result in a less efficient system, but greatly increase the chance of success for the traffic management system.

Benefits and Costs

Flow signal studies have shown that average speeds on the mainlanes increase, travel times decrease, and accident rates decrease. Accident rates have been reduced in the vicinity of flow signals as they provide for improved merging operations. Average volumes on the mainlanes have also increased as higher volumes can be achieved with smooth flow, rather than stop-and-go conditions. The amount of change in travel time is related to the amount of ramp control that is used and how much of the "bottleneck" effect can be addressed by the flow signals.

A summary of studies conducted to assess the impact of flow signals on freeway operations is provided in the table below. Construction and operation costs can be substantial if metering is installed as a stand-alone system, but with Houston's TranStar operation providing communication networks and operations personnel, the cost for new flow signal systems should be much less (1). It is important that the systems be maintained after installation—an element overlooked initially by some other cities. Installation costs are near $35,000 per ramp with annual operating and maintenance costs near 10% of that, with replacement of broken and destroyed signals a significant cost element.

Impact of Flow Signals on Freeway Operations

Location	Change in Spot Speeds	Change in Corridor Travel Time	Change in Accidents	Change in Volume
Portland, OR	+156%	-61%	-43%	NA
Minneapolis, MN	+35%	NA	-27%	+32%
Seattle, WA	NA	-48%	-39%	+62%
Denver, CO	+16%	-37%	-5%	+19%
Long Island, NY	+21%	-20%	NA	NA
Houston, TX	+5% to 10%	-5% to 20%	NA	NA

Source: Reference 2

Implementation Issues

Flow signals are a relatively new technique for Houston, and as such, relatively little data and public reaction is available to assess their future. Tow issues are clear—better public information and more aggressive operating strategies are needed to maximize the system benefits. Implementation thus far has been at a very modest level, given the newness of the idea, but more awareness and knowledge have to be created among travelers and the transportation agencies must be more active in adjusting the green signal rates and monitoring the effect on freeway speeds and queuing.

1. A Successful Return to Ramp Metering, The Houston Experience. John M. Gaynor and Darrell W. Borchardt. Presentation at ITS America's 7th Annual Meeting, 1997.

2. A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility. Institute of Transportation Engineers, Washington D.C., 1997.

Traffic Signal Improvements

Description

Implementation

Hurdles:	None
Level:	Target Markets
Sector:	Public
Locations:	All

Traffic signals can provide for the orderly movement of traffic, increase the capacity of intersections, and reduce the frequency of accidents. Making improvements to traffic signals can be one of the most cost-effective tools to increase mobility on arterials. In many cases, traffic signal equipment can be updated to more modern equipment to allow for greater flexibility of timing plans, including coordination with other nearby signals for progression. In some cases, existing equipment may be adequate, however, due to changing traffic patterns, timing plan improvements may be needed to more efficiently handle current traffic flows.

Target Market

The benefit of studying signal timing and locations is seen when comparing the incurred costs with the amount of delay reduction that can be achieved. In some cases, signals may no longer even be warranted due to changing traffic patterns. In such cases, using stop signs on the minor street may be more beneficial, reducing delay and unwarranted stops. If signal control is warranted only during peak periods, the signal can be timed for flashing operations in the off peak, maintaining the benefit of the signal during peak periods and the benefit of two-way stop control during the off-peak. To determine if traffic signal improvements are warranted, an inventory of existing traffic signals, the approach volumes, and the operating speeds being provided should be undertaken. Studies have shown that travel time and fuel savings from signal retiming programs can produce benefits many times over the costs associated with the program.

Benefits and Costs

Costs associated with signal improvements vary depending on the extent of work performed. Making improvements to existing timing plans or signal removals incur minor expenditures of $300 to $400 per signal. Updating equipment or software can cost between $2,000 and $10,000 per signal. Providing communications between signals to allow for signal coordination can range from $5,000 to $13,000 per signalized intersection (1).

A study of 26 projects in Texas showed an overall benefit/cost ratio of 38:1. A total of $1.7 million was spent among the projects, which resulted in average delay reductions of 19.4 percent, an 8.8 percent reduction in number of stops, and a 13.3 percent reduction in fuel consumption (2). A program to optimize 3,172 signals in California resulted in a benefit/cost ratio of 58:1. The program provided an average delay reduction of 15 percent, 16 percent reduction in stops, 9 percent reduction in fuel consumption, and travel time savings of 7 percent (3). A Virginia signal improvement program resulted in travel time and fuel cost savings of over $7 million annually, with a benefit/cost ratio of 20:1. Providing signal preemption for buses in combination with bus only lanes has improved average transit speeds of up to 20 percent (4).

1. Transportation Control Measure Information Documents, Environmental Protection Agency, Washington D.C., 1991.
2. Fambro, D. et al. Benefits of the Texas Traffic Light Synchronization Grant Program, Research Report 0280-1F, Texas Transportation Institute, Texas A&M University, College Station, TX, 1995.
3. A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility. Institute of Transportation Engineers, Washington D.C., 1997.
4. VASTOP Final Project Report for the Northern Region, Virginia Department of Transportation, August 1991.

Incident Management

Implementation
Hurdles: None
Level: Areawide
Sector: Public
Locations: All

Description

Approximately half of the delay experienced by travelers in the United States is due to causes other than simple high volume of traffic. This nonrecurring congestion occurs as the result of traffic accidents, stalled vehicles, spilled loads, maintenance/construction activities, special events, and weather. The California DOT estimates that for each minute an incident blocks a lane, approximately five minutes are added to the total time the freeway will be congested. The actual capacity reduction of an incident blocking a lane is greater than the physical reduction in capacity due to motorist "rubbernecking"—slowing down to look at the incident—often on both roadway directions. Although a one-lane blockage out of three lanes translates to a 33 percent reduction in physical capacity, studies have shown an incident blocking a single lane out of three lanes results in a capacity reduction of up to 48 percent. Similarly, a two-lane blockage can reduce the capacity of a three-lane section by as much as 79 percent (1).

One method of combating congestion from nonrecurring incidents is to implement an incident management system. Incident management is a coordinated and planned approach for restoring freeway capacity as quickly as possible after an incident has occurred. The major elements of an incident management system are: detection and verification, response, clearance, and motorist notification.

Target Market

Systems such as closed circuit television (CCTV) cameras, motorist call systems (call boxes and cell telephones), freeway service patrols, and commercial traffic information services are used in incident management programs to reduce the amount of time required to detect and verify incidents. Preplanning by involved agencies can establish procedures to reduce the time to respond and clear incidents (including alternate route planning, incident manuals, fast removal legislation, removal equipment). Finally, motorist notification can be given through dynamic message signs (DMS), highway advisory radio, commercial radio broadcasts, etc., to allow motorists to make informed route choice, mode choice, and departure time decisions. Motorist notification can also reduce incident congestion by causing some motorists to divert to alternate routes.

Cellular telephone call-in programs are an effective tool for detecting incidents. In addition to the typical 911 hotline, many metropolitan areas with incident management programs are implementing cellular telephone hotlines to report incidents. Some of the advantages of relying on cellular telephones as an incident detection tool are: the increasing prevalence of motorists with cell phones, uninvolved motorists can report incidents from the safety of their vehicle while incurring no delay to themselves, and motorists can report conditions that may lead to other incidents such as hazardous debris, animals, signal malfunctions, etc. Some disadvantages include motorist distraction, the possibility for false calls, the frequency of duplicate calls, and the potential that call-in motorists may not be familiar enough with the location of the incident to pinpoint the location. US Wireless, Inc. is testing a system in several areas including Washington, D.C., San Francisco, California and Hampton Roads, Virginia to automatically locate and track cell phone calls that could greatly improve the locational accuracy.

Some of the cities that have implemented cellular call-in hotlines to report incidents include Atlanta, Ft. Lauderdale, Charlotte, Greensboro, Boston, Miami, St. Louis, Riverside, Sacramento, Chicago, Pittsburgh, Columbia, Washington DC, Winston-Salem, and Norfolk. For simplicity, most call in program utilize abbreviated numbers such as *SP (state police), *DOT (department of transportation), *HP (highway patrol), *FHP (Florida Highway Patrol), *95 (Interstate-95), etc. In almost all cases, calls are free to the motorists making the calls. Funding for call-in programs made be made available with state funds, a monthly surcharge added to cellular customers' bills, or paid for as a service of the cellular carrier. A 1993 survey by the Cellular Telephone Industry Association reported that 13 percent of cellular customers had made emergency medical calls for themselves, 29 percent had made emergency medical calls for someone else, 34 percent had made calls for assistance with their disabled vehicle, and 40 percent had made calls for assistance with someone else's disabled vehicle (2).

Another potential strategy to help reduce congestion might be to institute a training program for police officers who are called upon to direct traffic around incidents as well as at special events. The same training could also include training for officers who wish to be employed in an off-duty capacity by retail centers, event promoters, or others.

Benefits and Costs

Freeway service patrols—such as the Houston Motorists Assistance Program (MAP)—have been cited as the single most effective element of an incident management program. Freeway service patrol programs use roving vehicles to patrol congested or high incident sections of freeway. The objectives of freeway service patrols are to locate incidents, minimize incident duration, restore capacity to the facility, and reduce the risks of secondary accidents. At present, there are over 53 service patrols in operation in the United States. Programs vary in size from a single vehicle patrolling a single route to the largest program in Los Angeles, with 150 vehicles covering 41 routes. Budgets range in size from a few thousand dollars a year up to $20 million. The service patrol in San Francisco estimates that response times for incidents serviced by the patrol were reduced by 57 percent since the patrol was implemented. Benefit/cost analyses were performed for 15 of the existing patrols with resulting ratios ranging from 3:1 to 36:1. A 1994 analysis of the Houston Motorist Assistance Program resulted in benefit/cost ratios of between 6:1 and 23:1 (3).

Implementation Issues

Increasing the amount of roadway covered by the Motorists Assistance Program and the time of operation can improve the benefits to Houston travelers. The Harris County Sheriff who staff the vans and the Houston Automobile dealers who provide them are to be congratulated on the service they provide. Ensuring the rapid communication of information between the operators, the TranStar center and the traveling public will maximize the benefits of this program.

1. Goolsby, M. Influence of Incidents on Freeway Quality of Service, Highway Research Record 349, 1971.
2. Gravino, P. Nonbusiness Use Rises for Portable Telephones, Associated Press article appearing in the Washington Times, c. 1993.
3. Fenno, D. and Ogden, M. Freeway Service Patrols: A State of the Practice. Transportation Research Record No. 1634, Transportation Research Board, Washington, D.C., 1998.

Event Management

<u>Description</u>

Special events such as concerts, fairs, sporting events, and rodeos create high traffic demands that can cause traffic congestion in the vicinity of the event, delaying not only event attendees but also the general public traveling through the area. Unlike other types of nonrecurring congestion, congestion due to special events is more predictable and can be planned for in advance. Various transportation and enforcement agencies have developed special event plans or special event centers to mitigate congestion and delay due to special events.

Implementation

Hurdles:	None
Level:	Target Markets
Sector:	Public & Private
Locations:	Sites

<u>Target Market</u>

The first step in planning for event management is to identify major concerns related to the site and surrounding transportation infrastructure. Examples may include limited access to the site, limited capacity of roadways leading to the site, concurrent events within the area of influence, availability of on-site and surrounding area parking, availability of transit services, and potential hot spots such as signalized intersections or vehicle/pedestrian conflict zones.

Special event plans can then be developed to address these concerns. Freeway segments near special event centers often experience a large portion of the event-related congestion. One aspect of a special event plan is to identify and promote the use of alternative entrance and exit routes, which are often underutilized. In many cases, drivers are unaware of the alternate routes or are unaware of the extent of congestion on the primary freeway route. Dynamic message signs, highway advisory radio, temporary signing, and commercial radio can be used to provide alternate route information. For larger events, printed media in the form of brochures or maps may be appropriate.

Temporary capacity improvements can be implemented to address the limited capacity of roadways leading to and from the site. Capacity improvements to the roadway may include the use of reversible lanes, left turn restrictions, restrictions of on-street parking, and lane closures. A lane closure in the outside lane upstream of a freeway entrance ramp allows for improved flow of vehicles exiting the event onto the freeway. Similar lane closures may be made on an arterial to allow for improved flow of event traffic turning onto a multilane arterial.

Temporary capacity improvements may also be made to intersections on entrance and exit routes to the facility. Capacity improvements may include blocking off a street to reduce the number of signal phases, left turn restrictions, and on-site traffic management by traffic officers. Officers may either manually direct traffic at an intersection or provide real-time signal control by manually operating the traffic signal at the controller box. A combination of cones, barrels, and barricades may also be used to enhance traffic control and flow by channeling traffic in the desired direction.

Other elements of special event planning include separation of pedestrian, automobile, and bus traffic to the extent possible, blocking off neighborhood streets to discourage undesired parking, monitoring on-street parking in the vicinity, enforcing illegal parking, and monitoring event traffic flow with CCTV systems.   Traffic management centers conserve as a central point of coordination for agencies involved in the planning and implementation of special event traffic plans.

Benefits and Costs

A strategy to reduce the number of vehicles arriving at a special event is to promote transit use. Bus service to special events can be provided from park and ride lots or designated parking areas such as shopping malls. For events in downtown areas, downtown circulator transit service can be used in conjunction with area parking garages. Transit operations are particularly important for events at facilities such as Houston's Enron Field or the Alamodome in San Antonio where on-site parking is only adequate for a small portion of attendees. Examples of events where transit ridership is high (level of transit use in parenthesis) include Convention Center events in Anaheim (30 percent), Disneyland in Anaheim (50 percent), the Florida Citrus Bowl game in Orlando (35 percent), and large events at the Alamodome in San Antonio (50 percent). In addition to public transportation, many hotels and private companies operate shuttles/tour buses to special events.

One of the goals of event management is the diversion of vehicles from primary routes to alternate underutilized routes. A special event route diversion study conducted at the Texas State Fair in Dallas showed the effectiveness of dynamic messages in diverting freeway traffic to alternate routes. Approximately 56 percent of traffic bound for the State Fair diverted in response to the first dynamic message, while approximately 44 percent of the remaining vehicles bound for the State Fair diverted in response to the second dynamic message (1).

A study on the effectiveness of highway advisory radio (HAR) for encouraging motorist diversion was conducted during the Wurstfest event in New Braunfels. Advance signing was used to inform motorists to tune to the HAR frequency for event information. Approximately 56 percent of vehicles bound for the Wurstfest saw the advanced signing and approximately 67 percent of those drivers diverted to the alternate route, representing 22 percent of all traffic bound for the Wurstfest (2).

Implementation Issues

There are no specific issues that hinder the implementation of special event strategies. As noted earlier, unlike other types of nonrecurring congestion, congestion due to special events is more predictable and can be planned for in advance. The critical elements of this planning process to involve insuring that all of the various departments and personnel who have traffic control and management as well as those with parking management responsibilities are involved in the planning. The planning process should include not only public agencies, but appropriate personnel representing those staging the event. In addition, it is critical that parking ingress and egress strategies are coupled with traffic flow strategies. Finally these strategies must include specific plans to separate vehicle and pedestrian traffic, as well as traffic management on neighborhood streets.

1. Weaver, G., Dudek, C., Hatcher, D., and Stockton, W. Approach to Real-Time Diversion of Freeway Traffic for Special Events, Transportation Research Record 644, Transportation Research Board, National Research Council, Washington D.C., 1977.

2. Richards, S., Stockton, W., and Dudek, C. Analysis of Driver Responses to Point Diversion for Special Events, Transportation Research Record 682, Transportation Research Board, National Research Council, Washington D.C., 1978.

Changeable Lane Assignments

Description

Changeable lane assignment systems (CLAS) can more efficiently provide capacity to high volume movements that only occur during a portion of the day. Many facilities experience highly directional demands during peak periods, e.g., heavy flows in one direction in the morning peak period and heavy flows in the opposite direction in the evening peak period. Changeable lane assignment systems temporarily borrow capacity from a low volume movement to provide additional capacity to the higher volume movement to reduce congestion during the peak hours. Common examples of changeable lane assignment systems in Houston include frontage road changeable lane assignment systems and reversible lanes.

Implementation

Hurdles:	None
Level:	Target Markets
Sector:	Public
Locations:	Routes

Target Market

The frontage road system is an essential element in the design and operation of urban freeways in Texas. When frontage road interchanges experience high turning movement demands, permitted double turns are often used to maximize traffic throughput. However, traffic demands can have entirely different characteristics between the morning, mid-day, and evening peak operations, which lead to the need for different lane use controls on a recurring time of day basis. Freeway incidents can often impact frontage roads by creating high frontage road through demand as freeway traffic diverts. Changeable lane assignment systems can address lane imbalances seen on a time of day recurring basis and during freeway incidents.

A frontage road CLAS installation consists of an upstream warning sign, overhead signs near the intersection, and an at-intersection sign. Fiber optic (light bulb) signs are capable of displaying lane assignment configurations that can be adjusted based on volume patterns. The system can operate in a pre-timed manner to accommodate time of day turning demands -- a double turn lane when high turning volumes occur and more through capacity during time periods with higher through demand. When used as an incident management tool, CLAS increases frontage road throughput by displaying the minimum turn configuration (through movement allowed from all lanes).

Benefits and Costs

The results of an analysis of CLAS for time of day operations at three Houston frontage road intersections indicated that the system can provide delay and queue reduction and improved lane balance; however, the travel time benefits were not statistically significant. The results of an analysis indicated that CLAS could provide incident delay reductions for the total freeway/frontage road network when activated in the mid-day and peak direction of flow; the off peak direction of flow caused slight increases in delay (1).

In urban areas, two-way arterials may experience highly directional volumes during different portions of the day. By designating one or more lanes as reversible lanes, they can be operated in the peak direction for part of the day and the normal direction during the remainder of the day. In the case of a three-lane arterial, the center lane may operate as a two-way turn lane during off peak hours and serve the peak direction during peak periods. Reversible lanes increase mobility by temporarily providing additional capacity in the direction of flow during the peak time periods. Under appropriate conditions, this management of capacity potentially relieves the need to increase capacity through the construction of additional lanes. Reversible lanes are typically implemented by one of three methods: suspending lane use signals over the lane (shows a red "X" or a green arrow to indicate the appropriate direction of flow), permanent signs stating the reversible nature of the lane and the hours they are in effect, or physical barriers such as cones and movable barriers.

Implementation Issues

As with many system efficiency measures, the public and governmental agencies must be active partners in identifying potential improvement sites and altering the travel patterns to fit the new operation. Changeable lane assignments and reversible lanes are relatively active methods of adjusting roadway capacity—methods that are technically easy, but which need to be marketed to the public as methods to get the most benefit from the transportation network. The techniques also have to be "marketed" to public sector operators to get them to implement and operate systems that require more active involvement and updating as new techniques are developed and experience is gained.

1. Goolsby, M., Fenno, D., and Voigt, A. Changeable Lane Assignment System (CLAS) on Frontage Roads, Project Summary Report 2910-0, Texas Transportation Institute, Texas A&M University, College Station, TX, 2000.

Technology-Based Transit Improvements

Description

Implementation	
Hurdles:	None
Level:	Area
Sector:	Public
Locations:	All

METRO has identified four advanced transit technologies that can be implemented as a integrated system for managing METRO vehicles. As a group, these four projects are called the Integrated Vehicle Operations Management System (IVOMS). IVOMS includes: automated vehicle location (AVL) system, automatic passenger counters (APC), vehicle tracking system, and bus annunciator system. These new components will work in conjunction with existing technologies such as Electronic Registering Fareboxes, Geographic Information Systems (GIS), Automated Telephone Information System, RCTSS traffic signal priority system, and the Advanced Radio Communications System to allow METRO to fully integrate its systems management.

The AVL system will provide real-time vehicle location for all METRO vehicles. By combining geographic and schedule data with AVL data, real-time calculations will continuously notify the bus operator of schedule deviations to promote on-time vehicle performance. Schedule deviations will be reported to dispatchers, who can then initiate corrective action. The APCs will provide passenger boarding and alighting data that will allow METRO to perform improved ridership and performance evaluations. The vehicle tracking system is a software application tied to the AVL system that will assist operations personnel with bus operations. The Bus Annunciator System will provide audible annunciation of next stop information in compliance with the Americans with Disabilities Act.

Target Market

The projects in IVOMS should benefit riders of all METRO services.

Benefits and Costs

The technologies included in IVOMS are designed to improve several areas of bus service: patron and operator safety; on-time performance; compliance with Americans with Disabilities Act; passenger data collection and reporting; and route and stop analysis. By improving these areas of bus service, METRO will attract more riders as well as provide existing services more cost-efficiently.

Implementation Issues

There are no implementation barriers regarding the technology itself. Education of bus drivers, transit managers, and supervisory personnel will be critical to insure that the system is being used at optimum levels.

Electronic Toll Collection Systems

Implementation
Hurdles: None
Level: Area
Sector: Public & Private
Locations: Business & Routes

<u>*Description*</u>

Many of the negative aspects historically associated with toll roads were related to the standard methods used to collect tolls. Electronic toll collection technologies have made the construction and expansion of toll roads more attractive in recent years. The Harris County Toll Road Authority's program is similar to most—motorists establish prepaid accounts and are debited for each toll via an automatic vehicle identification system consisting of tollbooth-mounted antennas, a computer system, and vehicle-mounted transponders. Since tolls can be collected electronically at normal speed, motorists are not delayed and many fewer tollbooth lanes are required, reducing required right-of-way, infrastructure, and operating and maintenance costs.

<u>*Target Market*</u>

Electronic toll collection also makes variable toll pricing feasible as a traffic demand management tool. A prime example is the toll schedule being used on California's SR-91 Express Lanes. There is a different toll schedule for each day of the week and each direction of travel. Tolls on weekdays are varied an average of 10 times during each day in increments as small as one hour. Tolls range from a low of 75 cents to a high of $3.75. Such a complex system is much easier to deploy with automated toll systems.

<u>*Benefits and Costs*</u>

The capacity of a manually operated tollbooth is approximately 350 vehicles per hour, while the capacity of an automatic coin machine booth is approximately 500 vehicles per hour (<u>1</u>). To maintain the capacity of the basic section of a toll facility, five to six traditional tollbooths are required for each basic lane. In addition to the costly expense for the right-of-way required for such large toll plazas, manual and automatic coin machine tollbooths cost approximately $60,000 per lane (<u>2</u>). These traditional collection methods also incurred high operating and maintenance costs of approximately $45,000 per lane per year for automatic coin machine tollbooths and $140,000 per lane per year for manual tollbooths (<u>2</u>). Other negative aspects included increased accident potential due to speed differentials and weaving maneuvers upstream/downstream of the toll plaza and increased vehicular emissions due to idling and acceleration.

Cost data averaged from five toll facilities in five states showed electronic toll collection systems provide cost savings of over $40,000 per lane for equipment costs, and $40,000 per lane in annual operating and maintenance costs compared with automatic coin machines, and $135,000 per lane in annual operating and maintenance costs compared with manual tollbooths (<u>2</u>). Express lanes, which allow payment only by electronic toll collection, provide 2.6 times the capacity of an automatic coin machine tollbooth lane and 3.7 times the capacity of a manual tollbooth lane (<u>3</u>). Electronic toll collection is estimated to provide emission savings of up 83 percent for hydrocarbons, 75 percent for carbon monoxide, and 50 percent for nitrous oxide (<u>4</u>).

Implementation Issues

Electronic toll collection systems can also be used for a variety of parking or other transportation pricing programs. The non-stop and automated nature of the technology can provide a relatively easy way to track parking use, and to reward those who use parking spaces only a few times per month. Discounted transit passes or close-in parking can be the reward for carpoolers or frequent transit riders. Car use would not be prohibited, making the program more adaptable for those who periodically need their vehicle. Toll systems could be programmed to accept lower toll payment for those users participating in a need-based social service program. Food stamp recipients, for example, could pay half of the toll as a way to allow them easier access to jobs in the suburbs where transit is not as accessible. The automated nature of the technology makes the program design more flexible and the options much greater.

1. Lawrence, Y. AVI – A Management View, AVI Technology for Toll Collection: An International Symposium, International Bridge, Tunnel, and Turnpike Association, 1990.

2. Cost-Effectiveness Analysis of AVI/ETTM for Florida's Turnpike System, Center for Urban Transportation Research, University of South Florida-Tampa, 1992.

3. Analysis of Automatic Vehicle Identification Technology and Its Potential Application on the Florida Turnpike: Technical Memorandum 2, Center for Urban Transportation Research, University of Florida-Tampa, 1990.

4. Public Technology, Inc. Traveling with Success, How Local Governments Use Intelligent Transportation Systems, Washington D.C., 1995.

Intersection Improvements

Description

Implementation

Hurdles: None
Level: Area
Sector: Public
Locations: Routes

Intersections are locations where vehicle conflicts exist. Intersection designs should provide operational quality and safety for all types of vehicles and for pedestrians. The street capacity is not usually controlled by the general segments but by the intersection capacity. Improvements such as providing traffic control devices (e.g., yield and stop signs or traffic signals) can provide significant capacity and safety improvements. Providing the appropriate traffic control for the existing volumes will maximize these benefits.

Roadways should ideally intersect at 90 degrees, but desirably no less than 75 degrees. Intersections with less than 90-degree intersections have larger crossing distances for the minor street movement and increase crossing vehicle exposure time. The capacity of an intersection decreases approximately 1 percent for each one degree of intersection angle less than 90 degrees (1). Intersections where the angle of intersection of the two roadways is 60 degrees or less may require reconstruction or positive traffic control such as signalization to improve operations and safety. A number of options exist for redesigning the minor road alignment where small angles of intersection exist. Intersections with more than four "legs" experience significant operational problems and should be avoided.

Locating intersections on horizontal and vertical curves is also undesirable due to limitations of stopping sight distance, driver expectancy, and driver inability to judge the increase or decrease in stopping distance required by steeper grades. Ideally, intersections should be located on level, straight road sections. Corner radius design (sharpness of the turn) is based on providing turning paths for the type of vehicles expected to use the intersection. Inadequate design can lead to operational problems. Corner radii designed for smaller vehicles can create problems for oversized vehicles using the intersection, while designs for larger vehicles create larger intersections that are more difficult to mark, signalize, and increase pedestrian crossing distances.

Target Market

As traffic demands change over time, changes of intersection traffic control devices may be warranted to improve intersection operations. As demand reaches certain thresholds, the conversion of a stop-controlled intersection to a signal controlled intersection can provide increases in capacity and safety. Likewise, if traffic patterns change significantly, intersections operating under signal control might be better served with stop-control. In areas where vehicle flow is the dominant concern, traffic control devices should be designed to favor the heavier and faster flow movement to reduce accident potential and delay. In other areas where walking, cycling, or access to property or businesses is more important, traffic can be controlled to a lower speed.

Benefits and Costs

Raised areas that guide traffic flow at intersections can reduce the number and severity of conflicts at intersections. Traffic islands not only increase the safety of vehicle-vehicle conflicts but also serve as pedestrian refuge locations at large intersections. At intersections with moderate to high turning volumes, slow or stopped vehicles waiting to make turning movements can greatly reduce the capacity of the through movement. The addition of turning lanes separates these movements by providing storage for turning vehicles and reducing conflicts between the through and turning vehicles. The addition of right turn bays and double left turn bays to all intersection approaches of two major arterials in Dallas increased intersection capacity by approximately 30 to 40 percent. The addition of right turn bays on all approaches at the intersection of two major arterials (single left turn bays already present) resulted in total intersection capacity gains of approximately 10 to 15 percent (1). At some intersections, especially on local streets, improving speeds and capacity may not be the goals of intersection improvements. The implementation of traffic circles may be used to increase bicycle and pedestrian safety through reduced vehicular speeds.

Providing standard lane widths of 12 feet improves the capacity of intersections relative to lesser dimensions. Studies have shown that intersections with 11-foot lanes have total intersection delays of approximately 16 percent higher than comparable intersections with 12-foot lanes (2). Additional discussion of these and other intersection design considerations are included in a later section on arterial access management.

Implementation Issues

There are a number of potential implementation issues associated with intersection improvements. First, most all improvements cost money, including signalization, intersection geometry, traffic islands, turning bays, and lane-width increases. Second, intersections require sufficient long-range planning that facilitates future expansion when traffic volumes warrant. Both are functions of the public-sector.

1. Stover, V. and Koepke, F. Transportation and Land Development, Institute of Transportation Engineers, Washington D.C., 1988.

2. Traffic Engineering Handbook, Institute of Transportation Engineers, Washington D.C., 1992.

One-Way Streets

Description

Implementation

Hurdles:	Public
Level:	Target Markets
Sector:	Public
Locations:	Businesses

In new developments such as shopping centers, sports arenas, parks, etc., one-way streets may be included in the original street and traffic plans. In other cases, existing two-way streets may be converted to one-way streets. Streets in major activity centers such as central business districts are often converted to one-way streets and traffic signal timing improvements implemented to serve high volumes through closely spaced intersections more efficiently. One-way streets may be operated as reversible lanes serving the predominate direction of flow in the morning and evening peak periods or adjusting to serve special events.

Target Market

One-way streets can provide numerous benefits including: allowing lane width adjustments to increase capacity of existing lanes or adding lanes which may be general purpose or special use lanes, redistributing traffic to relieve congestion on nearby streets, providing multiple turn lanes, allowing for improved signal timing with respect to progression and reduced phasing, and reducing pedestrian-vehicle conflicts. One-way streets can also preserve frontage assets such as sidewalks, trees, and other vegetation that might otherwise be lost due to widening of the two-way street to increase capacity. Negative impacts of one-way streets may include higher speeds, which may reduce pedestrian safety, and the potential for adverse impacts on businesses.

Benefits and Costs

The capacity of a street lane may be increased by as much as 50 percent when converting from two-way to one-way (1). There are no delays in turning movements due to oncoming vehicles and the pavement is used more efficiently. The additional space and traffic capacity may also permit full time or part time parking that would otherwise be infeasible with two-way operation. The conversion of a two-way street to a one-way street greatly reduces the number of conflict points at intersections. Studies have shown that the conversion can result in accident and travel time reductions of 10 to 50 percent, depending on the problem severity and design quality in the "before" case (1). Conversion of Fifth Avenue in New York to one-way operations resulted in decreased travel time of 37 percent and reduction in number of stops by 60 percent, even though volumes increased by 19 percent. Accident rates on Madison Avenue and Fifth Avenue in New York declined 44 and 32 percent, respectively after conversion to one-way operations. Included in those figures are reductions of accidents involving pedestrians of 41 and 29 percent, respectively (1). Basic costs associated with converting two-way streets to one-way streets range from $500 to $2000 per block; they can be much more depending on the types of improvements other than traffic-related (2).

Implementation Issues

Some one-way street programs have been criticized as being bad for businesses located along the street. Loss of parking or faster traffic past businesses sometimes has the effect of making an area less pedestrian or shopper-friendly. The way to make a one-way street conversion successful appears to be to design the program to accomplish local business and traffic goals. Areas with few merchants may benefit from smoother, faster traffic flow, while shopping areas may benefit more from a program oriented toward parking and pedestrian accommodations.

1. Traffic Engineering Handbook, Institute of Transportation Engineers, Washington D.C., 1992.
2. Transportation Control Measure Information Documents, Environmental Protection Agency, Washington D.C., 1991