CHAPTER THREE

DISCUSSION OF
STRATEGIES TO ALLEVIATE CONGESTION

To move toward mitigating the congestion identified in Chapter II, several strategies need to be analyzed to assess their potential for reducing congestion. These strategies can be grouped into two categories, demand management and system management improvements. The following strategies are among those which have most often been studied and implemented throughout the country. A detailed discussion of each follows.

A. System Management & System Efficiency

1. Signal System Improvements/Coordination
2. Capacity Additions
3. Access Management
4. Intelligent Transportation Systems (ITS)
5. Incident Management
6. Reversible Lanes
7. Ramp Metering
8. Improving Intersection/Interchange Geometrics

B. Demand Management & Demand Reduction

1. Commute Alternatives/Rideshare Promotion
2. Carsharing
3. Staggered and Flexible Work Hours
4. Telecommuting
5. Growth Planning
6. Transit Improvements
    a. Transit Mall
    b. Preferential Treatment
    c. Fare Reductions
    d. Express Bus Service
    e. Bus Hubs
    f. Park-and-Ride Lots
    g. New Routes and Frequency Improvements
    h. Fixed Guideway Transit
7. High Occupancy Vehicle (HOV) Lanes
8. Walk/Bicycle
9. Employer Commute/Trip Reduction Ordinances
10. Congestion Pricing
11. Parking Management/Increasing Parking Costs
12. Increase Gas or Auto-Related Taxes/Fees

Each of these strategies will be discussed under a similar format:

1. Definition and introduction.
2. Strategy effectiveness.
3. Necessary data collection.
4. Specific design criteria and local corridors or locations where the strategy appears to meet these criteria.
5. How this strategy interacts with other strategies.
6. Estimate of maximum effectiveness, short term and long term.

See Tables 4 and 5 at the end of this chapter for summaries of the projected effectiveness of each strategy in the Salt Lake Area, conditions under which each strategy is effective, and how the strategies interact. Effectiveness is usually reported in terms of vehicle miles traveled (VMT) or reduced PM peak delay. In the future, the performance measures discussed in Chapter I will be used to evaluate strategy effectiveness. Throughout this chapter, "short term" generally refers to a range of 1 - 10 years and ‘long term’ to 11 - 20 years.

A. System Management & System Efficiency

1. SIGNAL SYSTEM IMPROVEMENTS/COORDINATION

INTRODUCTION

Traffic control systems are designed to reduce travel times, delays, and stops, and improve average speeds on arterial roadways and expressways. Traffic signal improvements generally provide the greatest payoff for reducing congestion on surface streets. There are some basic improvements that can and should be performed to improve traffic flow on arterials:

- Equipment Update
- Timing Plan Improvements
- Interconnected Signals
- Traffic Signal Removal
- Traffic Signal Maintenance

Improvements to traffic signalization is one of the most cost-effective tools to reduce congestion. Appropriately designed and functioning traffic signals provide for orderly traffic movement, interrupt heavy traffic at intervals to allow pedestrians and connecting-street traffic to cross, increase the traffic-handling capacity of an intersection, and reduce the frequency of accidents.

Signal system improvements can occur at isolated intersections and along arterial corridors. Traditional improvement of traffic control signals involves optimizing the phase sequence and timing to accommodate recognized demand volumes. Geometric improvements can accompany the signal operation upgrade to satisfy the existing and future demand volumes. Modernization of the control equipment typically is a part of a signal system upgrade.

Arterial signal coordination involves the optimization of a series of signals along a travel corridor as well as implementing possible intersection geometric improvements. Signals can be coordinated by two methods. The first method involves connecting consecutive signals with wire, either above or below ground. This method of coordination is referred to as "hard-wire" interconnection. Commonly referred to as a Closed Loop System, a hard-wire system is remotely controlled at a site along the corridor or from a central site. The other method involves the installation of a timer unit at each intersection. The timers are set using a common reference time. This method of coordination is referred to as "time-based" coordination. With either of these methods, the times allocated to the phases at a particular intersection may be changed to reflect the current traffic conditions. The times for the signals at the other intersections are then modified to maintain the traffic flow. A hard-wire interconnect system allows on-line changes to be made automatically to all the signals. Time-based systems require the clocks to be adjusted individually to adapt to changes in traffic volumes.

RANGE OF EFFECTIVENESS

Along the Wasatch Front, improved coordinated and real-time signal timing is projected to reduce delay by 6.8 percent.[1]

In Seattle, Washington the King County DOT implemented a 2.1-mile signal priority system. Intersection delay was reduced by an average of 13 percent during the A.M. peak period. In addition, minor traffic movements on side streets, and in left turn lanes off the main street showed intersection delay reductions of 3 percent (.9 second/vehicle). During mid-day peak, intersection delay increased slightly; however, LOS remained the same.[2]

In California, before and after studies were conducted for over 300 signal timing optimization and coordination projects between 1983 and 1993. Reductions reported prior to the project were: 7.4 percent in travel time, 16.5 percent in delay, and 17 percent in stops. It was assessed that performance of 76 of these projects averaged the following reductions: 11.4 percent travel time, 24.9 percent delay, and 27 percent in stops. Major benefits were reported for through traffic for signal spacing up to 0.5 miles and moderate to heavy traffic volumes (v/c ratio greater than 0.6).[3]

Texas implemented a statewide signal synchronization program involving 26 projects. There was a 19.4 percent reduction in delay and an 8.8 percent reduction in the number of stops.[4]

DATA COLLECTION

Data collection to support initial implementation and system upgrades is intensive. Traffic characteristic data such as queue lengths, stop delay, turning movements and link segment volumes would be collected. Data collection to support a closed loop system could be ongoing or occasional. Continuous count stations or intersection approach detection can provide immediate count information to update closed system operation. This is also known as reactive timing. Intermittent spot or hand volume counts can be

[1] Evaluation of High-Level Benefits of the Salt lake City Advanced Traffic Management System, Tabermatics, Inc., March 2000.

[2] *Effectiveness of Signal Priority*, Chada, S.; and Newland, R., ITS Benefits and Unit Costs Database, 2001.

[3] *The Case of Traffic Signal Control Systems*, Skabardonis, Alexander, ITS Benefits and Unit Costs Database, 2001.

[4] *Benefits of the Texas Traffic Light Sychronization Grant Program*, Fambro, D., Texas Transportation Institute, Report No. 0280-1F, Texas A&M University, 1995.

performed to update time and phase operations of time based systems. Individual intersections and corridors would have to be investigated to determine the exact time savings and capacity increase that would result from improved signalization or corridor flow.

DESIGN CRITERIA/LOCAL LOCATIONS

The Traffic Management Committee advises implementation of coordinated signal systems and evaluates the cost. The Committee has developed a set of short-range goals that relate to a plan that can implement a program of signal coordination projects that:

- may be implemented in a short time period (1 to 2 years),
- have a relatively low cost,
- contribute to reduction of motor vehicle emissions,
- improve traffic flow by reducing stops and delays,
- make more efficient use of already existing traffic signal coordination equipment,
- will be compatible with future long range plans.

In the Ogden area, signals are coordinated in much of Ogden City and along SR-126 in south Weber County and North Davis County. By the end of year 2002, UDOT will complete a signal coordination project in Layton (Davis County) that will include up to 27 intersections.
Presently, in the Salt Lake area there are approximately 200 signal timing plans that can be controlled from the TOC. The span of this system includes Bangerter Highway to 3000 East and 9000 South to 1000 North. UDOT plans on updating signal timing plans once every three years.

INTERACTIONS

Signal coordination makes it possible for more vehicles to use a roadway. Therefore, there is a conflict with demand management strategies. However, signal coordination does not increase demand, but accommodates latent demand. Signal coordination also improves traffic flow for those who rideshare or use transit.

MAXIMUM EFFECTIVENESS

Project experience from around the U.S. indicates that:[5]

- Interconnecting previously uncoordinated signals or pretimed signals, and providing newly optimized timing plans and a central master control system can result in a reduction in travel time ranging from 10 to 20 percent.

- Installing advanced computer control has resulted in about a 20 percent reduction in travel time when compared to interconnected pretimed signals operating with old timing plans.

- Installing advanced computer control has resulted in a 10 to 16 percent reduction in travel time when compared to non-interconnected, traffic actuated controls.

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[5] *Urban Traffic Congestion - A Perspective to the Year 2020*, Federal Highway Administration, 1997.

- Optimizing traffic signal timing plans, when compared to previously interconnected signals with various master control forms and varying previous signal timing qualities, has resulted in a 10 to 15 percent reduction in travel time.

A coordinated system has the potential to reduce accident-causing conflicts. However, as multiple phases are introduced to eliminate conflicts, delay is increased with longer cycle lengths. Engineering judgment must be exercised to maximize approach capacity and operations without jeopardizing safety.

A comprehensive signal interconnection effort in Denver, Colorado resulted in a travel time reduction of 7 to 22 percent on arterial corridors.[6]

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[6] *Signal Systems Improvements*, Regional Report, Denver Regional Council of Governments, 1995.

2. CAPACITY ADDITIONS

INTRODUCTION

Widening existing roads and building new roads are two principal ways of adding Single-Occupant Vehicle (SOV) capacity to the street network. Using additional capacity to solve congestion problems has a long history. Throughout the country, engineers and planners have traditionally looked to it as a solution. In the more populated and high growth regions, experience has taught them that while widening or constructing roads may alleviate congestion to some extent or for a short time period, it may be impossible to keep up with demand. In these areas, adding SOV capacity may not prevent congestion from increasing. Furthermore, additional capacity may not even be an option for urbanized areas where housing, commercial, or industrial development is particularly intensive.

RANGE OF EFFECTIVENESS

There are, however, circumstances under which capacity additions are effective and justified. Obviously, where both growth and existing population densities are relatively low, capacity additions might be sufficient to prevent travel speeds from dropping. In other areas, where densities are not so high, but population growth rates are high, additional capacity may be a valid part of a package of strategies to effectively deal with congestion. High growth means more cars and trips, and increasing capacity will provide needed space. Capacity additions are also important because other strategies will not usually be fully effective by themselves. For instance, there will still be increase in demand for travel even with other strategies in place.

Analyses performed by WFRC staff have shown that investment in additional capacity lowers the rate at which peak hour speeds drop. While capacity additions often lower this rate, by themselves they are not sufficient to prevent speeds from dropping, especially in the long term.

DATA COLLECTION

How much decrease occurs in the rate at which speeds drop depends on several factors, such as present capacity, rate of population and employment growth, location and extent of capacity additions, and implementation of other congestion reduction strategies. The modeled data gives some indication of the effectiveness of capacity additions. In order to better evaluate this strategy's effectiveness, volume data would need to be collected over several years on streets affected by the additions. This would permit comparison of v/c ratios before and after capacity additions. Selection of a control area(s) with similar population and employment growth rates where no attempt was made to influence v/c ratios would facilitate a statistical analysis of the effect of additional capacity.

DESIGN CRITERIA/LOCAL LOCATIONS

In order to justify construction of new roads or to widen existing roads and their consequent environmental impacts, a few key conditions must be met:

- Other strategies alone will not reduce congestion sufficiently.

- Current v/c ratio is high.
- Population and/or employment growth rates are high.

Refer to Wasatch Front Regional Council's 2001-2005 Transportation Improvement Program (TIP) and 2030 Long Range Transportation Plan for lists of programmed and planned capacity improvements.

INTERACTIONS

Adding capacity complements transportation system management improvements, such as signal coordination and access control, since these also increase capacity. Because the one permits travel while the other discourages travel, widening or constructing roads either conflicts with or has varying effects upon most demand management strategies. As with other markets, increasing supply, in and of itself, does not increase demand. There must be other factors present for increased demand to accompany increased supply. The number of trips will continue to increase in the Salt Lake Area simply because population and employment are growing, not because capacity is being added.

Of the various locations where capacity may be added, perhaps bottlenecks deserve special attention. Traffic backs up more readily where bottlenecks exist. Therefore, bottlenecks may be important locations for adding capacity, and are discussed below.

Elimination of Bottlenecks

INTRODUCTION

Whenever arriving traffic volume is greater than the capacity of the road segment, a bottleneck occurs. A bottleneck can often be identified by the queue of vehicles that forms upstream from it. Temporary bottlenecks often occur when a lane closes because of an incident. Recurring bottlenecks occur in several common situations, such as downstream of freeway on-ramps, lane drops, and steep road segments. The latter two could be on either arterials or freeways. In all cases, certain minimum traffic volumes would be required for a bottleneck to cause congestion. It is important in considering this strategy to identify the actual bottleneck location and not the entire road segment where vehicles are queued. Hidden bottlenecks, i.e., those that would occur if another bottleneck were not present, must also be identified.

Bottleneck projects typically include using the following types of modifications to existing roadways:

- Lengthening acceleration lanes on entrance ramps.
- Providing supplemental lanes between high volume ramps.
- Entrance ramp controls such as ramp metering or peak-period closure.
- Adding additional through lanes.
- Eliminating ramps that may be too close to other ramps to operate efficiently.
- Traffic signal optimization at intersections.

RANGE OF EFFECTIVENESS

Although the demand and therefore, the effectiveness of eliminating a bottleneck, are hard to predict additional capacity on an arterial street would be approximately 680 cars per hour per additional lane (pchpl), depending on the facility functional class and area type. On a freeway, additional capacity is approximately 2200 pcphpl. Coordinating bottleneck elimination with other capacity additions is important. If capacity is insufficient downstream from the bottleneck, eliminating the bottleneck will not be much use.

DATA COLLECTION

Some bottlenecks can be located through inspection of segments in the vicinity of where queues form. Others must be found through collection of demand flow rates and densities along segments where hidden bottlenecks are suspected.

ITS cameras and detection loops are available to collect information regarding queues. Bottlenecks that are caused by the existence of more lanes at either end of a segment than in the middle are being considered for elimination. Listed below are the specific locations. Note that these locations are not necessarily where the queues exist, but where the number of lanes are insufficient.

1. Interstate-15: Northbound between US-89 off-ramp and Beck Street on-ramp
2. 1300 East: 1300 South- 2100 South
3. Interstate-215 (East): On-ramp from eastbound I-80
4. 9000 South: 700 East - 1300 East
5. 12300 South: State Street - 700 East

DESIGN CRITERIA/LOCAL LOCATIONS

General criteria to be considered when determining whether to eliminate a bottleneck include:

- Length of queue
- Duration of queue
- Existing and future volumes of traffic using road segment

INTERACTIONS

See the "Interactions" section above for capacity additions. The use of other demand strategies discussed in this document to eliminate a bottleneck would not be effective in most instances because they do not reduce peak hour trips sufficiently.

MAXIMUM EFFECTIVENESS

The 2030 LRP adds 441 freeway lane miles and 915 arterial lane miles to the 1996 highway network in the Wasatch Front area. This added capacity is estimated to reduce delay in 2030 on an average weekday from about 700,000 vehicle-hours to approximately 270,000 vehicle-hours. Spread across the system, each additional highway lane mile eliminates roughly 300 vehicle-hours of delay each weekday on average.

Actual delay reduction provided by added capacity will vary by facility type and the degree of congestion allowed to develop prior to implementing the new capacity.

3. ACCESS MANAGEMENT

INTRODUCTION

Access Management is one of the most significant factors in the safe and efficient operation of a highway. Highways are classified according to the function they are expected to serve in the road network. The functional classification of highways is in part based on the concepts of accessibility and mobility. Access control and management refers to implementation and enforcement of guidelines that determine the manner in which users will be provided access to a highway facility.

Comprehensive access management combats congestion, the loss of arterial capacity, and the serious access-related accident experience that is plaguing our nation's roadways. Access management is the careful control of the location, design and operation of all driveways and public street connections to a roadway. This control achieves a significant improvement in traffic safety and operation through access design and spacing because the lack of access control is the largest single cumulative design element reducing roadway safety and capacity. The challenge is to develop effective access policies and standards that find a balance between land development plans and the preservation of the functional integrity of the roadway that serves the development and the region.

What is Access Management[7]?

- Access management deals with the traffic problems caused by unmanaged development before they occur.
- Access management addresses how land is accessed along arterials.

Access management focuses on mitigating traffic problems arising from development and increased traffic volume attempting to utilize these developments.

- Access Management prolongs the functional life of existing highways, by maintaining or increasing capacity, thereby reducing the need for new capital construction to meet increasing system demands.

- Access Management maintains the transportation system travel efficiency necessary for economic prosperity.

- Access Management saves lives; it reduces the frequency of fatal, injury, and property damage accidents.

- Access Management programs establish uniform standards and promote fair and equal application to the development community.

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[7] Utah Division Federal Highway Administration, Traffic Safety Access Management, December 14, 1999.

- Access Management requires cooperation among all agencies that make land use and transportation decisions, thereby achieving improved planning and transportation integration.

- Access Management is a necessary part of traffic congestion management.

RANGE OF EFFECTIVENESS

The state of Colorado concluded that 2-mile signal spacing with right-turns produced a 42 percent fewer total vehicle-hours of travel and 59 percent less vehicle-hours of delay than the 3-mile signal spacing.[8]

The Florida DOT has reported that roadway capacity was increased and preserved when a 4-lane divided highway with 2-mile signalized intersection spacing and extensive median control carried the same volume at the same level of service as a 6-lane divided roadway with 3-mile signal spacing and frequent medial and marginal access.[9]

Access control is most effective on higher functioning streets, such as principal arterial streets. Access control is most effective in areas prior to development, where curb cuts can be controlled and turning movements may be limited as development occurs. Although access control can be a retrofit solution, there are political and social limitations as to the amount of control and the potential impacts of that control on existing properties. Development, new or existing, will generally oppose actions that will limit customers. Access control such as turn restrictions, which might make development patronage less convenient, must demonstrate substantial congestion reduction to be more appealing to fronting development.

DATA COLLECTION

Analysis tools and data generally already exist to determine the benefits of access control. Unfortunately, a significant amount of traffic engineering is required to determine the benefits of corridor level access control. Combining safety and congestion databases to determine arterial streets with high incidents of right angle and rear end collisions might identify additional candidates for access management. Better analysis of trip generation of local developments as it relates to pass-by traffic might add to the technical arguments for access control.

DESIGN CRITERIA/LOCAL LOCATIONS

The following are some of the techniques available to provide access management:[10]

- Medians B wide non-traversable medians provide shelter for vehicles making left turns from or to a street. They also provide refuge for pedestrians attempting to cross the street. Consequently, crash rates on major roadways with non-traversable medians have been found to be substantially lower than undivided roadways or roadways having a continuous two-way left turn lane.

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[8] State of Colorado Access Control Project, Colorado Department of Highways, April 1999.

[9] Ewing, R., Final Report of the Florida Access Control Project, Florida Department of Transportation, July 2000.

[10] *Access Management Location & Design*, NHI Course No. 15225, June 1998.

- Auxiliary Lanes B Left-turn and right-turn bays minimize the conflict between turning vehicle and following through traffic. They also provide space where drivers can wait to complete the turn maneuver. This results in smoother traffic flow, increased capacity and greatly increased safety.

- Signalized Intersection Spacing B Long uniform signalized intersection spacings on major roadways facilitate the use of signal timing plans which can respond to peak and off-peak traffic conditions. Long and uniform spacing improve the progress of traffic flow through the signal system. Capacity is increased and traffic safety is improved.

- Driveway Location and Design B Driveway location and design affects the ability of a driver to safely and easily enter and exit a site. If driveways are too narrow or have an inadequate turning radius, drivers will be unable to maneuver safely on and off the roadway. If the turning radius and width are excessive, the large intersection area is confusing and a hazard for pedestrians, bicycles, and vehicles.

- Driveway Spacing B Driveway spacing standards establish a minimum distance that should be maintained between driveways. Reasonable spacing between driveways is important to the safety and capacity of roadways.

- Corner Clearance B Corner clearance is the distance from an intersection of a public or private road to the nearest access connection. Corner clearance standards preserve good traffic operations at intersections.

- Joint and Cross Access B Joint and cross access requirements consolidate driveways serving more than one property and provide circulation between adjacent parcels. Joint access requirements are used to connect major developments and to improve driveway spacing.

- Reverse Frontage B When land is subdivided for small commercial or residential uses, the lots adjacent to the thoroughfare should not be allowed direct access to the thoroughfare. An alternative is to have an interior street which provides access to the thoroughfare. This eliminates the conflicts between high-speed traffic and traffic entering and exiting at closely spaced driveways. (*See WFRC Technical Memorandum #56 for suggested standards for some of the above techniques*.)

Access control can be implemented on streets prior to commercial development. A more thorough review of municipal land use plans and street plans should be performed to thoroughly identify candidates for controlled access. A preliminary list can be developed based on arterial streets and local knowledge as to the extent of available fronting development. Access control should be pursued aggressively on the following streets as other improvements are implemented. Aggressive controls include driveway restrictions, left turn restrictions; stricter signal warrants which emphasize progression, acceleration and deceleration lane requirements, and related measures.

Bangerter Highway
10400/10600 South, Bangerter Highway to State Street
9000 South, 5600 West to Interstate-15

2000 East, South of Interstate-215
Van Winkle Expressway
700/900 East, Interstate-215 to 12300 South

Less aggressive access control can be considered on other arterial streets. Less aggressive access control includes driveway spacing and corner clearance, better driveway design which emphasizes through street movements, signal restrictions at private driveways, and limited turn restrictions at driveways. Generally, access control on lower functioning streets is designed to mitigate or solve locally specific problems. There are a few streets where aggressive access controls should be implemented where possible, although the need to move traffic should be carefully weighed against the need to access local properties. These streets include:

9000/9400 South, East of Interstate-15
3300/3500 South, 5600 West to Interstate-215 (East)
4500/4700 South, 5600 West to Interstate-215 (East)
Redwood Road, South of Interstate-215
Foothill Boulevard

INTERACTIONS

Access control measures improve the efficiency of the highway system in terms of moving traffic. To this end, access control competes with other trip reduction and mode shift measures and may perpetuate land use sprawl. However, carefully planned access control targeted to the highest functioning streets allows for a more efficient highway system and may minimize congestion. Access control can be complemented with bus turn out design on express bus routes to complement mode shifts.

MAXIMUM EFFECTIVENESS

An effective access management program can:[11]

- Reduce crashes by as much as 50 percent. Fifty percent or more of the traffic crashes on urban arterials are access related.
- Extends life of the highway. Extends the functional life of existing highways by preserving or increasing their capacity, reducing the need for new capital construction to meet increasing system demands.
- Reduces travel time and delay by up to 40 to 60 percent, depending on the type of management technique and other variables. Reduction of time and delay results in fewer stops and fewer deceleration and acceleration cycles.
- Reduces transportation costs.

The key to successful implementation of access control and management is that restrictions are sound, along with effective communications as to where and why they are required. There must also be opportunity for restrictions to be open for reevaluation /amendment as needs change.

It is also important to see this strategy as part of the larger access strategy of the land use plan. Integrated Management Areas and Developed Areas address the need to realize the benefits that come from allowing public motorized access. Protected Areas address society's desire to have no access.

Restricting new access will almost certainly cause a great deal of opposition from some public groups. Many groups feel that restrictions are unfair or unnecessary. Others may feel that this does nothing for those who desire remote settings. This kind of zoning will likely be controversial, no matter the justification. If, however, the reasons are well communicated and the zoning can be made to be truly effective, this opposition can at least be addressed.

Developing Access Management Strategies

Developing access management strategies is important to the effectiveness of any access management program. Metropolitan transportation plans should include an element which focuses on the need for and development of managed access within their areas. Specifically, MPOs should not only be an advocate for access management but also identify the system where access should be managed and establish priorities for management efforts.

Access Management strategies could include:

[11] Access Management Location & Design, NHI Course No. 15255, June 1998.

- MPOs should encourage counties to develop access management plans on the basis of which they will declare certain roadways to be controlled access facilities.
- MPOs should work with DOTs to achieve controls where needed and help ensure that any additional access allowed is in keeping with longer range land use/transportation plans.
- MPOs should encourage all units of government to use the access management tools that are available to them.

4. INTELLIGENT TRANSPORTATION SYSTEM (ITS)

INTRODUCTION

An Intelligent Transportation System (ITS) is an important element of a strategic perspective on how to meet a region's multi-modal transportation needs. ITS is the application of advanced and emerging technologies in information processing, communications, control and electronics to surface transportation needs. Goals of ITS are to provide system efficiency, reduce congestion, minimize environmental impacts, save energy, and improve mobility, safety, and economic productivity. Continued advancement of electronic and software technologies will lead to enhanced assessment and provision of transportation services.

Intelligent Transportation Systems are readily applied to congestion management. Highway ITS technologies assimilate roadway data and transmit information to drivers concerning traffic delays, accidents and alternative route choices through on-board or roadside information systems.

ITS can be divided into several categories. Four of the largest categories
Advanced Vehicle Control Systems (AVCS)

Currently under research are Advanced Vehicle Control Systems (AVCS). This technology provides an in-vehicle collision warning and avoidance system and safety system. These systems will assist drivers in avoiding collisions, enhancing vision, and sensing hazards such as fog, snow, ice and dust.

A national research project demo for AVCS was done in 1997 in San Diego, California. The technology is still being researched and while Utah is involved along with other states in developing a strategic direction for the future of AVCS, there is nothing planned in the near term for the Salt Lake Valley. Much of AVCS deployment will most likely take place in rural areas first.

Advanced Traffic Management Systems (ATMS)

Elements of an ATMS subsystem include all detection and control functionality required for personnel to monitor and control traffic along the roadway. Examples include: surveillance technologies, signal and surface street control, freeway control and information dissemination, railway coordination, tolling management, regional coordination, lane management and parking management.

Advanced Public Transportation Systems (APTS)

These systems include transit vehicle systems, transit information dissemination and roadside systems for transit. Local examples of projects classified under the APTS subsystem include the UTA Radio Communications Upgrade project, the Electronic Payment Technology projects, and the Automated Vehicle Location For Buses project.

Advanced Traveler Information Systems (ATIS)

The Federal Highway (FHWA) projects TRAVTDK, ADVANCE, and FAST-TRAC demonstrate different techniques available to provide traffic and guidance information. These systems are multi-modal trip planning, route guidance, and advisory functions for travelers and drivers of all types. These systems promote the choice of travel mode based on real time information, and reduce overall travel times and delay for travelers.

The Motor Carrier Division of UDOT is currently working on plans for collecting and disseminating roadway information specifically for commercial vehicles. Also, the GIS group at UDOT is developing a way to manage the enormous amount of data collected by the ATMS, such that it will be useful and accessible to those who need it.

RANGE OF EFFECTIVENESS

The use of innovative technologies has proven to provide real solutions to transportation challenges throughout the nation. These Intelligent Transportation Systems (ITS) have reduced travel time, lowered crash rates, and increased transit ridership. Current technologies allow transportation agencies to collect and disseminate real-time information and to improve network efficiencies through the use of adaptive control systems.

On a network experiencing periodic saturation, with congestion causing increases up to a factor of 3 from free flow travel time, drivers with in-vehicle traffic information experience a 4 to 20 percent advantage in travel time.[12]

In APTS, there are a variety of fare collection technologies available, which offer more flexibility and support complexity, including multi-modal integration. Electronic fare payment cards, advance payment systems, tokens, coin-counting mechanisms for turnstiles or bus fare boxes, and flash passes are methods that offer convenience of transit, parking and toll facilities. Reduced cash and token handling results in savings and improved security, while increasing the accuracy and efficiency of accounting and financial reporting. Reduced cash handling requirements alone can lead to a significant savings. New Jersey Transit and the Metropolitan Area Rapid Transit System (MARTA) in Atlanta, Georgia reported $2.7 million and $2 million annual savings. Metropolitan Transit Authority in New York City reported an annual revenue increase of $49 million as a result of increased ridership due to customer convenience. These cost savings translate to the opportunity to provide additional service.[13]

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[12] *Continuing Successes and Operational Test Results*, U.S. Department of Transportation, Federal Highway Administration, Oct 1997, Washington, D.C.

[13] *Electronic Fare Payment Systems- Smart, Convenient, Cost-Effective*, U.S. Department of Transportation, National Associations Working Group For ITS, ITS Sheet 8.

Most existing transportation schemes have limitations for low-income job seekers, people with disabilities, those who do not drive, and seniors. ITS applications support integration that expands transportation options for underserved areas. Many transit agencies are concerned about adopting systems that may be difficult to integrate in the future. As a result, transit operators are discussing the development of a payment system

Benefits and costs associated with ITS, according to the ITS America Ten Year National Program Plan and Research Agenda for ITS (Draft Plan 9/25/01), studies consistently show ITS improvements providing returns of 5:1 to 10:1, compared to conventional investments of 2:1 or 3:1. The Utah benefit/cost ratio for ITS is estimated at 8:1 (low) to 20:1 (high).[14]

According to Minnesota DOT, accidents on Interstate-35 West in Minneapolis before management were 421 per year and are now 308 per year, a 27 percent reduction. Annual accident experience on the same freeway after management is 2.11 collisions per million vehicle miles traveled (VMT) compared to 3.40 collisions per million VMT before management was instituted, a 38 percent reduction.[15]

DATA COLLECTION

Data collection and development of Measures of Effectiveness (MOE) are being accomplished through 1500 roadway traffic sensors deployed as part of the Salt Lake ATMS program, as well as regularly scheduled floating car studies. Data will be used to determine traffic parameters (traffic flow, occupancy, speed, etc.). Evaluations are critical to ensuring progress toward the vision of integrated ITS and achieving ITS deployment goals. Evaluations are also critical to an understanding of the value, effectiveness, and impact of ITS activities and allow for the program's continual refinement.

DESIGN CRITERIA/LOCAL LOCATIONS

Effective transportation management requires a systematic, coordinated, and integrated approach. Projects must be deployed in a manner which:

- Provides near-term solutions to the region’s most critical transportation problems;
- Serves as a foundation for the implementation of additional services (information gathering applications are generally a necessary prerequisite to information dissemination applications); and,
- Makes efficient use of scarce resources (financial, personnel, etc.).

Intelligent Transportation System technology for the Salt Lake Area is a viable alternative for reducing congestion. Travel time delay, property costs, productivity loss, and poor environmental quality are current consequences of congestion in the region. Continuing to utilize ITS technology will have a positive impact.

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[14] Sharon Briggs, ITS Division, Utah Department of Transportation.

[15] *Continuing Successes and Operational Test Results*, U.S. Department of Transportation, Federal Highway Administration, Oct 1997, Washington, D.C.

Under the guidance of the Traffic Management Committee, UDOT, UTA, and local governments have begun or substantially completed deployment of the following projects to effectively manage Salt Lake area traffic on a day-to-day basis.

- Implementation of an Advanced Traffic Management System (ATMS), which currently covers 70 miles of freeways and 250 miles of surface streets. Within the Salt Lake County area, 200 closed circuit television (CCTV) cameras have been deployed to provide full video coverage along freeways and at select intersection sites to monitor congestion and signal coordination; 60 freeway and surface-street variable message signs (VMS) have been deployed for congestion management and traveler information; and over 550 city, county and state traffic signals and 23 ramp meters all linked through 350 miles of fiber-optic cable, have been integrated into a central traffic control system to provide seamless coordination of signal timing between agencies.
- Construction of a 34,000 square foot UDOT Traffic Operations Center (TOC), integrated with two smaller traffic control centers (TCC), operated by Salt Lake City and Salt Lake County.
- Deployment of 15 Road Weather Information System (RWIS) stations.
- Integration of system software and timing plans for freeway traffic management and traffic signal control.
- Integration of the Department of Public Safety's Computer Aided Dispatch (CAD) system and the ATMS, using data flow form the National Architecture. TOC operators provide service 18 hours/day, 7 days/week, with the Utah Highway Patrol dispatch center located in the TOC providing service the remaining hours of the day.
- Development of a website providing real-time traffic information, which includes current traffic advisories, the ability to sign-up for commuter alerts via email, and real-time CCTV camera images, speed flow indications, and VMS messages from currently available cameras, traffic detectors and VMS's.
- Deployment of Incident Management Teams (IMT's) primarily in Salt Lake, Davis, Weber and Utah Counties.
- Expansion of the ATMS to area surrounding the Salt Lake valley.
- Development of a CVISN business plan, which includes sharing data with UDOT Ports of Entry. Utah will join with other regional states in building a CVIEW database. Interfaces will be built from the IFTA (fuel tax), IPR (vehicle registration), and Overweight / Oversize Permitting systems to CVIEW.
- Inter-ties to the University of Utah traffic lab for student training and research; Salt Lake City police and fire dispatch centers; Valley Emergency Communications Center (VECC); Salt Lake County Emergency Operations Center (EOC); State Capitol CEM; and ongoing discussions for integration with the Summit County Sheriff's dispatch center and the Davis County dispatch center.
- Development of the 511 Traveler Advisory Telephone Systems (TAT) provides real-time traveler information, using a voice activated telephone system.
- Real time status updates from statewide personnel of road conditions via touch tone telephone for input into the CommuterLink Website and 511 Traveler Advisory Telephone System.

- Deployment of Highway Advisory Radio (HAR) with expansion into the rural area surrounding the Salt Lake and Ogden areas.

- Automatic Vehicle Location (AVL) will be utilized on highway patrol vehicles during the Olympics as a security measure. This system will be re-deployed after the Olympics for a continued benefit.
- Automatic passenger counters have been installed on 50 UTA buses. This project will assist UTA in establishing functional requirements, recommended procurement strategies and specifications to implement a system-wide, deployment of an automated passenger counting system on a minimum of 10 percent of UTA's bus and light rail fleets.
- A pilot project on 3500 South in spring 2002 will be conducted to support the implementation of a prototype bus traffic signal priority project. This will provide the capability to test the effectiveness of transit signal priority on bus schedule performance and determine impacts on traffic service.
- UDOT will conduct an evaluation study to determine the functionality and usefulness of bus AVL data for traffic management purposes. The evaluation will consider AVL logs for use in traffic planning studies and the use of real-time or post-processed AVL data from buses to assess surface street speeds and travel times.
- Development and installation of variable message signs at bus stop locations at ski resorts in Big and Little Cottonwood Canyons in the Salt Lake Valley will provide status and advisory services to canyon travelers regarding canyon closures, transit status and delays. This project is in coordination with resorts, UDOT, UTA, Salt Lake County, the United States Forest Service, RWIS and EMS.
- A data/GIS management study will be conducted to identify the impacts and issues that will result from UTA's ITS program deployment. The study will develop and recommend specific data management approaches to assist in the optimal storage, integration, use and efficient management.

Other transit ITS projects include bus probe data evaluation, canyon traveler information (on track for late summer 2002), telephone voice response unit, and bus/rail integration and customer information (This project is currently being deployed to provide real-time customer information specifying when the next bus/train will arrive. Electronic signs will hold buses when necessary until train arrives.)

CommuterLink is presently implementing components such as variable message signs, signal coordination, and incident response coordination. The initial system is near completion in Salt Lake County and is expanding into Weber, Davis and Utah Counties.

CommuterLink's Internet site offers real-time traveler information via a map navigator. Some of the highlights include Olympic transportation information, the latest traffic alerts along with the ability to view current roadway conditions with the cameras, poll data, FAQ, links to UDOT, UTA, Salt Lake City, Salt Lake County, weather and IMT. The website has been receiving more than a million hits per month.EMS.

INTERACTIONS

The use of ITS may compete with the purpose of trip reduction programs. However, it can be used to benefit all modes of transport. ITS complements other system management strategies.

MAXIMUM EFFECTIVENESS

Comparison of vehicle speed data collected before and after the activation of a VMS visibility warning system in the Wasatch Front Area indicated that mean vehicle speeds increased after the system was activated. Prior to activation of the signs, the average speed was 54 mph with a standard deviation of 9.5 mph. After the system began operation, average speeds increased to 62 mph with a standard deviation of 7.4 mph. This represents a 15 percent increase in speeds.[16]

Based on a comprehensive analysis the Salt Lake Valley ATMS program has been projected to produce an average delay reduction of 19.5 percent and an average number of stops reduced by 15.2 percent.[17]

5. INCIDENT MANAGEMENT

INTRODUCTION

Traffic incidents (accidents, vehicle breakdowns, and disturbances to traffic flow) are one of the major causes of traffic congestion on urban highway systems. In order to respond quickly to such incidents, many urban areas have implemented regional incident management systems. Incident management systems (IMS) have been shown to be one of the most cost effective highway management strategies adopted in metropolitan areas. These systems consist of actions to address three major stages of an incident:

- detection and verification
- response and clearance
- recovery and information

When an incident occurs, duration time is reduced with the help of an Incident Management System. IMS improves quality of freeway traffic flow and safety at incident scenes. Additionally, IMT reduces time to clear incidents by helping stranded motorists or assisting the Highway Patrol and other agencies.

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[16] Effects of Variable Speed Limit Signs on Driver Behavior During Inclement Weather, Perrin, Joseph, ITE 2000 Annual Meeting, August 2000.

[17] Evaluation of High-Level Benefits of the Salt lake City Advanced Traffic Management System, Tabermatics, Inc., March 2000.

Incident management is a coordinated, preplanned use of people and resources to restore full roadway capacity after an accident. Incident management programs vary widely in cost and sophistication, but all share the common elements of detection, response, clearance, traffic management and motorist information. The effort can involve police, firemen, tow-truck operators, highway maintenance teams, and hazardous material experts to clear highway accidents and breakdowns quickly, and minimize the traffic congestion they cause. Motorists should also be given information and direction concerning the incident and alternative actions. The goal of any incident management plan is to readily identify incidents, effectively divert traffic during the incident clean up, and clear up incidents as quickly as possible. An essential component to effective incident management is a central operations center. Information can be sent directly to the center, analyzed and an appropriate action initiated.

RANGE OF EFFECTIVENESS

Several studies throughout have shown that incident management systems can reduce secondary collisions.[18] However, the reduction in secondary collisions attributable to an incident management program may be difficult to estimate. This is because incident management systems are implemented with coordinated freeway management programs, which also reduce collisions. Studies placed the average increase in collision rate at 300 percent in congested conditions, with variance due to geometric conditions.[19]

In Chicago Illinois an evaluation model developed by the FHWA was used to determine the cumulative delay savings obtained by reducing the duration of incidents. Results of the evaluation include a delay savings of 9.5 million vehicle-hours over a 1-year period when considering the impacts of the full program. This program includes implementation of both freeway service patrols to handle minor incidents and incident management teams to respond to major accidents. A delay savings of 5.6 million vehicle hours resulted from a reduced incident management program, consisting only of incident management teams to handle the major incidents.[20]

In Minnesota, the Highway Helper Program has reduced the duration of vehicle stall times by eight minutes. Studies show good incident detection (camera, loops, and other technology) coupled with good response protocols is extremely effective in combating congestion. Incident Management Programs can reduce delay associated with congestion caused by incidents by 10 to 45 percent. In San Antonio, Texas, the use of the TransGuide System has reduced total accidents by 35 percent and reduced average response time by 20 percent.[21]

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[18] Continuing Successes and Operational Test Results, U.S. Department of Transportation, Federal Highway Administration, Oct 1997, Washington, D.C.

[19] Sullivan, E.C., and Hsu, C.I. Accident Rates Along Congested Freeways: Final Report, Research Report UCB-ITS-RR-88-6, Institute of Transportation Studies, University of California, Berkeley, CA, 1988.

[20] Incident Management: Challenges, Strategies, and Solutions for Advancing Safety and Roadway Efficiency, ATA Foundation for National Incident Management Coalition in Association with Cambridge Systematics, Inc., February 1997.

[21] Managing Our Congested Streets and Highways, FHWA, 2001.

Photogrammetry, the latest software technology in aiding police investigators has been instrumental in completing accident reports. Pictures of vital data from accidents such as skid marks and object location are taken. Actual measurements are determined using the special software. Results in one city showed that photogrammetry reduced overall incident clearance time by 58 percent.[22]

DATA COLLECTION

As illustrated by the above example in Chicago, delay data can be used to monitor the effectiveness of incident management in reducing congestion. Reductions in detection, response, and clearance times also assist evaluation of incident management programs.

DESIGN CRITERIA/LOCAL LOCATIONS

A successful incident management program must address each of the four stages of incident management: detection, response, clearance and recovery. Each stage should be a well-developed, organized effort and expedited with maximum efficiency. The Transportation Research Board has identified the following objectives for effective incident management:

- Incidents must be detected accurately and rapidly.
- The nature of the incidents must be determined quickly.
- All relevant information must be collected and passed on to the appropriate agencies expeditiously.
- Roles and responsibilities of the various agencies involved must be developed, understood and agreed upon.
- An appropriate coordinated response to the incident is necessary.
- Quick removal of both the major and minor accidents needs to be accomplished.
- Traffic management needs to be applied for the duration of the incident.
- Information on traffic conditions and bypass routes needs to be developed and provided to motorists.
- Traffic management plans for "planned" incidents (major events) need to be developed, implemented and operated.

A comprehensive program must provide sufficient geographic coverage to serve all areas that experience daily congestion. Facility specific programs and approaches cannot be expected to meet the objectives of an area wide incident management system.

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[22] *Aggressive Driving on Urban Freeways,* Transportation Researcher, Volume 38, Number 2, 2002.

UDOT's incident management system in the Salt Lake Valley has been in place since 1994. As of April 2002 UDOT expanded the Incident Management Team (IMT) to northern Davis County, Weber County and parts of Morgan County. Current IMT routes include Interstate-15 and US-89 from the Box Elder County line to Farmington, Interstate-84 from Interstate-15 to Taggart's Junction, and SR-39 through Ogden Canyon and on to Huntsville and Trapper's Loop. The team is also able to respond to incidents on other state and city roads if needed.

The Utah Department of Transportation is working with the local jurisdictions to create an area response system for the Wasatch Front freeway system. The goal of the incident management system is to be able to identify incidents as they occur and identify recurring congestion locations for immediate response. This system involves a Traffic Operations Center (TOC), an Advanced Traffic Management System with CCTV cameras, variable message signs, and highway advisory radio, and purchase of several first response vehicles. These vehicles are equipped to respond to most minor road emergencies. Communication and coordination with an operations center and other incident response services are a critical part of this system.

INTERACTIONS

Incident management is compatible with all strategies for managing congestion. ITS is perhaps the most valuable strategy to incident management. All phases of incident management can be expedited through the use of ITS technologies**.**

Another challenge is the general public's lack of awareness of what incident management is and what it can do to help alleviate traffic congestion.

MAXIMUM EFFECTIVENESS

PhotoModeler is the latest technology being utilized locally to map accident scenes. This new system gives highway patrol officers the ability to perform on the scene mapping of accidents in 3-dimensions. With this new technology that the Utah Highway Patrol has recently implemented, investigative time and clearance time has been cut more than 50 percent. For example, field officer investigation times have reduced from 1-2 hours to 15 minutes.

Results in a city in Texas show that using such software has reduced overall incident clearance time by 58 percent and reduced personnel from three officers to one.[23]

6. REVERSIBLE LANES

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[23] *Aggressive Driving on Urban Freeways,* Texas Transportation Researcher, Volume 28, No. 2, 2002.

INTRODUCTION

A reversible lane system allows for one or more lanes to be designated for opposite one-way movement during certain periods of the day. Reversible lanes are an alternative improvement, which utilizes an existing travel corridor for capacity improvement rather than the traditional improvement of widening a facility. The primary function of a reversible lane is to provide increased capacity flow and progression along an identified corridor. Increased traffic flow may be achieved through the use of existing excess capacity. The available capacity is found on an arterial or freeway which exhibits a heavy peak directional flow. Temporary reversal of non-peak direction lane(s) can provide needed peak direction capacity. Care must be taken, however, during the reversal not to degrade operation of the subordinate direction flow or cause deterioration in capacity of the transition points. Enforcement efforts may be necessary to prevent violations of the lane-use regulations.

Reversible lane facilities in the Intermountain West can be found in Denver, Colorado and Phoenix, Arizona. Similar facilities are found in several metropolitan areas throughout the U.S.

RANGE OF EFFECTIVENESS

A reversible lane system is one of the most effective methods of increasing rush period capacity of existing streets and roadways. The system is particularly effective on bridges and in tunnels, where the cost to provide additional capacity would be high.

Dallas, Texas increased the rush-hour capacity of two older thoroughfares by 33 percent for the peak direction. The city's reversible-lane program also decreased congestion, pollution, and travel times.[24]

DATA COLLECTION

The following sections investigate data requirements, advantages and disadvantages, warrants and operational methods for examining reversible lanes as a possible improvement alternative.

Corridor related data might include: roadway geometry, on street and off-street parking, lateral clearance problem locations (bridges, utilities, etc.), existing lane groups and lane transitions at intersections. Existing sign and control devices should be noted for future use or removal. Location of existing rights-of-way, utility placements, utility easements, and structure locations need to be identified to determine improvement constraints.

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[24] *Changing the Course of Urban Traffic*, October 2001, U.S. Department of Transportation.

Operational characteristics of traffic flow within the corridor are assessed by accumulating data elements such as directional daily traffic volume, volume control methods, intersection peak hour turning movements, accident histories, posted speeds and travel time speeds. Travel time speeds should be recorded for the corridor, directionally, during both peak and off-peak periods. In addition, operational characteristics should be accumulated for adjacent parallel facilities to see if they could support the possible excess traffic.

DESIGN CRITERIA/LOCAL LOCATIONS

Implementation of reversible lane operations is typically limited to major urban areas. High directional traffic volumes between suburbs and activity centers are best suited for reversible systems. Below are five factors for consideration to warrant a reversible lane.

1. Existing Condition: Delay/Capacity - Indications of deficient volume to capacity ratios should lead to investigation of measures for increased capacity. Intersection delay, by approach, should also be investigated for the arterials. Conditions on parallel facilities should also be investigated.

2. Speed - Average vehicle speed during peak periods decreases by at least 25 percent below normal period flow. The congestion period occurs at relatively stable and predictable periods. Conduct travel time studies during peak and non-peak periods for the subject roadway and adjacent parallel facilities.

3. Directional Ratio - Reverse flow operation can be generally justified where 65 percent or more of the traffic flows in one direction during peak periods. Examine daily and peak hour flows at intersections in the corridor and at the transition points. Heavy turning volumes at major cross streets should be identified for possible left turn situations.

4. Transition Termini - Adequate capacity, at intersections and for the up/down stream links, of the terminal points is necessary to facilitate both normal and reversed lane traffic conditions. Ensure that capacity and progression during the transition does not degrade operation or cause lingering congestion.

5. Lack of Alternate Improvements - Feasibility investigations of alternate improvements prove negative. Design controls and costs related to estimated construction costs, right-of-way requirements, etc. might preclude a widening alternative.

The 65/35 directional split data is supported in Salt Lake and Ogden areas at the following locations:[25]

Table 1

65/35 Directional Split Criteria Locations

Salt Lake			
	Locations	AM Peak	PM Peak
	I-15 @5900 South	X	
	SR-89 @1087 South State	X	
	SR-186 @Foothill Blvd. South Sunnyside Ave.	X	X
	SR-71 @ East & 1200 South	X	X
	SR-173 @ 5400 South & 900 West	X	
	SR-266 4500 South West of State Street	X	
	I-80 West @ 1100 West	X	
	I-80 East @ 300 East	X	X
	I-15 @ South of 1700 South	X	
	I-15 @ 500/600 South	X	X
	I-215 @ North of 3100 South Overpass	X	X
	SR-71 @ 700 East, South of 4500 South	X	
	SR-68 @ Redwood Road, South of Bluffdale	X	
	I-215 @ 2500 North	X	
Ogden			
	HAFB SR-89	X	
	SR-39 12th Street East of Wall Ave.	X	

Satisfaction of the reversible lane considerations must be logically met and demonstrated by an engineering study in order to justify a reversible lane facility improvement.

Reversible lane systems for the Salt Lake Area are a viable solution to capacity improvement, but only in certain situations. Candidate reversible lane projects for the Salt Lake Area will have to first be identified through corridor consideration of the design criteria listed above. Driver expectancy should also be evaluated to determine its effect on the safety of such a facility.

INTERACTIONS

In the sense that reversible lanes provide additional capacity, they compete with trip reduction ordinances. However, if reversible lanes are used as HOV facilities, they promote rideshare and transit. Reversible lanes work well with access management and other system management efforts.

MAXIMUM EFFECTIVENESS

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[25] *1992/1993 Traffic Volume Report*, Utah Department of Transportation, Urban Transportation Planning Division, May 1994.

Congestion levels in the region are not so intolerable that the public favors implementation of reversible lanes. Unfamiliarity with the technique or safety concerns also creates opposition to reversible lanes. Consequently, implementation of this strategy in the near future will likely be minimal. In the long term, it is reasonable to expect 10 - 20 miles of operational reversible lanes using existing facilities, which could accommodate between 6,000 and 12,000 cars.

Reversible lanes have been utilized as a temporary tool to manage traffic congestion during construction projects in cities such as Tucson, Arizona, Seattle, Washington, Nashville, Tennessee, and Dallas, Texas. More and more cities are testing reversible lanes by opening up HOV lanes during peak-hours of travel. The dilemma with this strategy is that there would be no reward most of the day for car pooling, and the number of violations during restricted hours could increase.

7. RAMP METERING

INTRODUCTION

Ramp control systems regulate the flow of vehicles onto a freeway to maintain operations of the freeway mainline flow at an acceptable level of service. When traffic is heavy, ramp meters allow fewer cars at a time onto the freeway, thereby avoiding further congestion. Ramp metering can be used to discourage drivers from using the freeway for very short trips and to provide incentives for bus riders and carpools by bypassing ramp queues.

Ramp meters use sensors and traffic signals to prevent slowdowns and stop-and-go conditions on the freeway. Ramp control systems can be used on individual on-ramps or on sequences of on-ramps.

Several types of ramp control include: total ramp closures, pre-timed, gap-acceptance, traffic-responsive, and moving-merge systems. The most common type of ramp metering is pre-timed metering. Control indications are used to hold a queue of vehicles on a ramp. At select intervals, only a few vehicles in the queue are released into the freeway traffic flow. The integrity of the freeway flow is maintained. However, the ramp and its approaches may suffer excess delay. High violation rates can be expected unless strict enforcement is provided.

Ramp metering is a cost-effective management technique to move more vehicles safely and at higher speeds than is possible with unregulated access to freeways. Attention should be given to the flow of traffic on the arterials to ensure the effectiveness of ramp metering is not diminished by arterial delays.

RANGE OF EFFECTIVENESS

In estimating ramp metering benefits for the Salt Lake area, projected results showed ramp metering was beneficial only during the a.m. and p.m. peak hours and in the direction of peak travel. Evaluation scenarios included the installation of ramp metering on all freeway entrance ramps along Interstate-15 between Farmington and Bluffdale. The annual benefit was estimated to be a net savings of 410,813 delay hours.

Based on a comprehensive analysis, installation of ramp meters is expected to reduce delay by 48.9 percent. These projections are based on a.m. and p.m. peak hours in the direction of peak travel.[26]

DATA COLLECTION

To determine how much freeway speeds improve along corridors in the planning area when ramp metering occurs, before and after speed data should be collected on the mainline, on ramps, and on arterials connecting to the ramps.

DESIGN CRITERIA/LOCAL LOCATIONS

Several factors should be considered in evaluating the appropriateness of ramp metering for a given location. For example, urban interchanges, where ramp metering is most common, typically interface with arterial and collector facilities. Interference with the ramp approach/intersection control will contribute to degradation of the adjacent surface streets. Ramp metering and adjacent intersection timing plans should be developed with this in consideration.

Ramp metering is not typically considered until widening, lane balance, vertical and horizontal alignment measures, etc., are implemented. In addition, ramp metering is a special use condition not suitable for every ramp location. First, the mainline freeway volume should be saturated whereby the operating level of service is at capacity. Algorithms have been developed to test the sensitivity of merging and freeway volumes. Ramp metering feasibility studies include the upstream and downstream flow of vehicles from a merge area. Several segments of a freeway are investigated for their existing conditions operation. Ramp metering situations with variable timing plans are introduced to determine flow characteristics of the mainline. The optimal design will incorporate a flow for the mainline that will allow a predetermined acceptable speed. Corridor flow optimization for the freeway will determine the ramp timing. Although ramp metering can provide some important improvements to the flow of freeway traffic, it is not always an appropriate solution for a number of reasons.

Currently, there are 23 ramp meters deployed in the Wasatch Front area, all of which are on Interstate-15, with nine located in South Davis County. Most metered ramps include an HOV bypass lane.

INTERACTIONS

As operators experience delay at ramps due to the metering, a shift may occur toward transit and other HOV use. HOV bypass ramp lanes at the metered locations can be an attractive alternative to controlled ramp delay. HOV bypass lanes accommodate HOVs as free flow freeway entry while single occupant vehicles are required to wait and utilize the traffic control. Other trip reduction ordinances are typically not as compatible with ramp metering. System management techniques complement ramp metering.

[26] Evaluation of High-Level Benefits of the Salt Lake City Advanced Traffic Management System, Salt Lake City, Utah, Executive Summary, March 24, 2000.

MAXIMUM EFFECTIVENESS

An evaluation by Partners for Advanced Transit and Highways (PATH) found that ramp metering reduces total vehicle travel time up to 7 percent compared with no metering. The effectiveness of a ramp control algorithm depends on the level of traffic demand. As traffic demand increases, ramp metering tends to be more effective in reducing travel time.[27]

Based on similar systems in other cities, ramp meters are expected to result in a 30 percent reduction in freeway incidents and a 15 percent increase in freeway speeds during peak hours.[28]

In the Minnesota-St. Paul region, ramp metering has increased freeway throughput by 30 percent, from 1,700 vph to 2,200B2,400 vph. Freeway speeds during peak hours have also increased 60 percent from an average of 48 km/h to 77 km/h.[29]

8. Improving Intersection/Interchange Geometrics

INTRODUCTION

The late 1980s saw a renewed interest in safety and geometric design in the United States. The Transportation Research Board (TRB) Committees on Geometric Design and the Operational Effects of Geometric Design launched a five-year series of sessions, beginning in 1988, on the state of the practice of five geometric design topics: sight distance, interchanges, intersections, alignment, and cross sections. An annual meeting was held in Washington, D.C, where interest in geometric design was evidenced by a broad range of research problem statements submitted to and funded under the National Cooperative Highway Research Program (NCHRP).[30]

When improving intersection/interchange geometrics, the preferred strategy involves physical and traffic control improvements to the existing corridors, including the highway main line, interchanges, cross roads and outer roads.

In a joint effort, the city of Fontana, California and Caltrans are in progress of an interchange improvement project that involves Interstate-10 and Sierra Avenue. The interchange improvements includes replacement of the Sierra Avenue freeway overcrossing, widening of the Sierra Avenue railroad overhead structure, reconstruction of all ramps, widening of Sierra Avenue by one lane each direction and new auxiliary lanes on Interstate10. Benefits of this project are to improve safety and provide congestion relief.[31]

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[27] *Evaluation of On-Ram Control Algorithms*, Zhang, Kim, Nie, Jin, Chu, Recker, Partners for Advanced Transit and Highways.

[28] Utah Department of Transportation, CommuterLink, http://www.utahcommuterlink.com.

[29] *Ramp up the Volume*, ITS International, November 1997.

[30] *The Interactive Highway Safety Design Model: Designing for Safety by Analyzing Road Geometrics*, Jerry A. Reagan

[31] *Interstate 10/Sierra Urban Interchange Improvement Project,* www.fontana.org.main/redev/i10factsheet.htm, *October 2001.*

RANGE OF EFFECTIVENESS

Proper implementation of geometric design result in increased traffic flow, improved safety, reduced construction and right-of-way costs.

DATA COLLECTION

When considering such improvement projects, an assessment of current characteristics of the corridors and arterials, and creation of base maps is necessary. The safety and operating efficiency of the existing highway, interchanges and intersections should be evaluated

DESIGN CRITERIA/LOCAL LOCATIONS

There are specific design criteria that are important to roadway design. For instance, mobility, safety, and environmental issues are some of the most critical aspects. In order to achieve balance, tradeoffs among these factors are routinely performed. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) emphasizes the importance of such roadway design. Practices that demonstrate such a design were compiled and documented in a report by the Federal Highway Administration (FHWA) titled *Flexibility in Highway Design.*[32]

This document discusses existing flexibility in design with encouragement to use creative design in addressing site-specific project needs.

Project teams are an important part of the design process, because creative solutions often require a cohesive effort among the planning, designing, and construction engineers. The use of interdisciplinary teams and public involvement are identified as essential components of successful solutions.

Both FHWA and the American Association of State Highway and Transportation Officials (AASHTO) recognize the flexibility that exists in the current design criteria. They also acknowledge the current focus on providing high levels of mobility may conflict with some community interests.

This philosophy was created in the United States as context-sensitive design (CSD) and represents an approach where a balance is sought between safety and mobility needs within the community interests.

Within Salt Lake County in particular, the upgrade of both the geometrics and the controlling hardware for intersections along specific corridors is currently underway, as funding becomes available.

Intersection improvement projects are scheduled for construction in Salt Lake County on 2000 East, 6200 South/4800 West, 4700 South/Interstate-215. In Davis County Antelope Drive/Interstate-15 is scheduled and the 30/31st Street and Wall Avenue project is under construction in Weber County.

[32] *Geometric Design Practices for European Roads*, International Exchange Program, June 2001, U.S. Department of Transportation Federal Highway Administration.

INTERACTIONS

Improving intersection and interchange geometrics works well with the support and development of transit (enhancing bus and rail operations), multi-modal improvements, and with strategies to reduce congestion.

MAXIMUM EFFECTIVENESS

U.S. Corridor Study, Jackson County, Missouri, including 10-miles of highway between Interstate-470 and Highway 7. This project is expected to provide the following benefits:

- increased traffic capacity,
- improved safety and
- efficient use of available right of way

The Alameda corridor project in Los Angeles consolidated 90-miles of railroad track into a single 20-mile rail and highway. This connects the ports of Los Angeles and Long Beach to downtown Los Angeles. This project eliminated more than 200 at-grade intersections, which allows trains to move at higher speeds greatly facilitated the flow of street traffic at intersections.[33]

Transit Alliance, in the Denver, Colorado Metro region proposed an interchange improvement project for Interstate I-70. This project is expected to reduce 41,000 daily vehicle miles of travel and reduce 57,200 daily person-hours of delay[34].

B. Demand Management & Demand Reduction

1. COMMUTE ALTERNATIVES/RIDESHARE PROMOTION

INTRODUCTION

Commute alternatives and ridesharing promotes alternative transportation modes such as, carpooling, vanpooling, riding transit, walking, bicycling and telecommuting. Ridesharing can be used as a transportation management tool to benefit a specific region, corridor, and/or activity center. The mission is to reduce traffic congestion and automobile emissions while optimizing the use of the existing transportation system.

In Utah ridesharing is the second most common travel mode for work trips, with approximately 14 percent of all commuters.

This popularity of ridesharing also holds true for the nation as a whole. Because of this popularity, ridesharing programs are frequently used in metropolitan areas to reduce the number of trips by increasing

[33] *Alameda Corridor Project Under Way in L.A.*, Western Overseas Corporation, September 1997, Newsletter.
[34] *Transit Alliance, May 2001.*

vehicle occupancy rates. Matching services may be undertaken by public agencies and private entities. Promotional efforts may be on an area wide basis or targeted at specific corridors and/or employers.

RANGE OF EFFECTIVENESS

When adopted by large numbers of travelers, rideshare programs have been shown to reduce trips, improve air quality, and reduce highway congestion. (*See Section 9, Employer Commute/Trip Reduction Ordinances*).

DATA COLLECTION

In addition to monitoring the percentage of workers who rideshare, VMT and vehicle occupancy along congested corridors needs to be analyzed regularly to determine how many work trips rideshare is actually eliminating. Employers might also survey employees to learn what incentives would make rideshare a more attractive alternative. Public surveys may also be useful.

DESIGN CRITERIA/LOCAL LOCATIONS

Several conditions help make ridesharing an effective congestion management tool. For example, one survey indicated that work trip distances of greater than 10 or 15 miles provide greater incentive for ridesharing. Unfortunately, this limits the potential market for attracting people to rideshare. Fewer vehicles per household member increases propensity to rideshare. Saving money has been shown to be an incentive to carpool, but an exact correlation between carpooling and household income has not been found. Convenience, travel time, schedule requirements, and unavailability of transit are also factors affecting the desirability of ridesharing.

The transient nature of the above factors means that the effectiveness of rideshare in reducing trips changes over time and by location.

Job-related factors shown to be associated with employee propensity to rideshare include company/agency size, full versus part-time work, and work schedule. The ridesharing mode split is typically higher at companies/agencies with more than 100 employees than at smaller ones. Also, full-time workers at all sites are more likely than part-time workers to rideshare.

Preferential lanes and ramps as well as parking facilities have provided significant incentives to ridesharing (*See HOV Lanes Section 7, Transit Development/Park-and-Ride Lots Section 5*). Experience has indicated that ridesharing to employment centers is more effective when the company management is directly involved with employee matching. Preferential parking programs for rideshare vehicles can also be implemented more effectively.

If the Salt Lake CBD has a 10-mile radius at which rideshare becomes more attractive, areas north of Bountiful, south of the beltway, and west of West Valley will produce the most rideshare trips. Therefore, much of the promotional effort should be directed at corridors connecting these areas with the CBD. Corridors connecting dense residential areas and major employment centers should also be targeted. Development of park-and-ride lots should accompany this promotion *(See Transit Improvements Section 6f.)*. Rideshare promotion at employment centers with 100 or more employees would be beneficial.

Utah Transit Authority's Rideshare Program provides:

- Alternative work hours guidance
- Bicycle commuting/walking and bikes on buses information
- Carpool and Vanpool match lists
- Eco Pass (discounted transit passes)
- Co-op Transit Pass Discount
- Guaranteed ride home
- No-interest van loans
- Telecommuting guidance
- Van leasing
- UTA park-and-ride lots information
- Assistance for an Employee Transportation Coordinator

INTERACTIONS

Ridesharing appears to draw people from both SOV and transit. However, transit improvements such as park-and-ride lots enhance the effectiveness of rideshare programs. Ridesharing appears to conflict with some flextime work schedule programs. Trip reduction programs and ordinances obviously facilitate ridesharing.

MAXIMUM EFFECTIVENESS

From a recent survey of 39 companies/agencies along the Wasatch Front 75 percent drive alone, 12 percent ride the bus, 9 percent rideshare, and 1 to 2 percent walk, bike, vanpool, and telecommute. Telecommuting reduces work trips by 2 percent for companies that the employees work for.[35]

2. CARSHARING

INTRODUCTION

Carsharing is a new revolution in personal transportation for the 21st century. Carsharing is often promoted as an alternative to vehicle ownership by providing the convenience normally associated with owning a vehicle. Carsharing can be beneficial as it requires less parking and discourages unnecessary auto travel.

Carsharing is available in many options: co-operative ownership, non-profit, professional services, station cars, short term rentals, and even private, neighborhood agreements. Carsharing tends to work best for people who drive fewer than 10,000 miles a year, who have one car and occasionally need a second.

Specific benefits derived from carsharing are: user benefits from increased mobility, economic development benefits, equity, option value, user savings and benefits, vehicle choice, and TDM benefits.

Despite the benefits, several barriers must be overcome before carsharing can provide its full potential. One barrier is the need to establish and maintain a pool of users (typically 30 members or more) in individual

[35] *UTA Rideshare 2000 Annual Report.*

neighborhoods. Also, carsharing cannot develop without education and marketing. Potential users need to become familiarized with the concept and understand how it can benefit them.

Presently, there are 22 cities that have carsharing programs available and 9 that are currently planning a program.[36] By reducing per capita vehicle travel carsharing supports TDM objectives. It can help reduce congestion, road and parking facility cost, accidents, pollution, and resource consumption.

Households that share rather than have their own vehicle can reasonably save $500 to $1500 per year. Some households can save on residential parking costs as well as vehicle expenses.

RANGE OF EFFECTIVENESS

Carsharing typically reduces average vehicle use by 40 to 60 percent among drivers who rely on it, making it an important transportation demand management strategy.[37]

DATA COLLECTION

Market research is a continued effort necessary to prove the concept to the firms or members that would provide resources to begin carsharing. Also it is important to determine the public's view on carsharing by collecting survey data.[38]

DESIGN CRITERIA/LOCAL LOCATIONS

Carsharing is most suitable for higher density urban neighborhoods with good walking, cycling, and public transit services. Clustered suburban neighborhoods may also be suitable for carsharing, particularly if they have good transit service, pedestrian-friendly streets and local commercial centers.

Carsharing has not yet been implemented locally.

INTERACTIONS

Carsharing both supports and is supported by most other transportation demand strategies. TDM strategies include measures that increase travel choice and reduce market distortions that encourage excessive automobile travel. Over the long-term they help create a more diverse transportation system and reduce automobile dependency in a community. TDM strategies that integrate with carsharing are:

- *Improve travel choices*. Good public transit, ridesharing, bicycling and walking conditions allow people to reduce their vehicle use and benefit from carsharing.
- *Integrate transportation and land use planning*. Higher density, multi-modal, mixed-use neighborhoods and flexible parking requirements allow residents to reduce their vehicle use.
- *Manage parking for efficiency*.
- *Implement commute trip reduction programs*. Establish TMAs in commercial centers. Encourage employers and employees to cooperate to develop better travel choices and incentives to use alternative modes.

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[36] *If you live in a city, you don't need to own a car. William Clay Ford, Jr., Ford Motor Company Ltd, October 2000.*
[37] *Evaluating Carsharing Benefits*, Todd Litman, Victoria Transport Policy Institute, December 1999.
[38] John Abraham, A Survey of Carsharing Preferences, University of Calgary, 1999.

- *Integrate carsharing with other mobility services*. Carsharing could be packaged with public transit passes, taxi service and rideshare matching, giving users an integrated package of mobility options.

MAXIMUM EFFECTIVENESS

A study by the Swiss Office for Energy Affairs indicate that car owners who switch to car sharing reduce their driving by over 70 percent, without a major perceived loss of mobility.[39]

3. STAGGERED AND FLEXIBLE WORK HOURS

INTRODUCTION

Alternative work schedules lessen the magnitude of peak period automobile travel. Alternative work schedules are designed to discourage traditional Monday through Friday, 8 to 5 schedules and thereby spread the commuter rush over a longer span of time. This allows more optimal traffic flow.

Three programs for alternative work schedules are: *Staggered work schedules* are those in which an individual or a group of workers is assigned to begin work at different times. Spacing arrivals at specified intervals before and after conventional work hours allows workers to travel at times when traffic moves freely and when seats are available on transit. Work hours can be staggered within an organization, or different employers at the same general location. With *flextime*, the employer establishes a band of time, called core time, during which all employees need to be in the office. Flexible time bands are the hours of the workday schedule within which employees may choose their time of arrival and departure. This can range from the employee having complete freedom in setting a work schedule, to cases where the employees are required to establish a schedule in advance and commit to it. The third category, *compressed workweek* (CWW) schedules, allows employees to work four-day workweeks in four 10-hour days, often referred to as a 4/40 program, or work nine hours for four working days, then eight hours on the fifth day. Then work four nine-hour days and take the tenth day off, which is referred to as the 9/80 program. These programs have a double impact on travel to work. One day of commuting is eliminated each week and the early arrivals and late departures built into the 10-hour day means employees travel before and after the rush hour begins.

RANGE OF EFFECTIVENESS

One of the most important potential effects is reducing the volume of peak traffic. Staggered and flexible work hours have a limited appeal because they mainly apply to office environments and show less compatibility with shift and assembly line work, retail sales, continuous coverage operations, or extensive communications and interfacing operations.

Compressed work week schedules have a double impact on travel to work; one day of commuting is eliminated each week and the early arrivals and late departures into the 10-hour day means employees travel before and after the rush hour peaks. Compressed workweeks may reduce vehicle miles of travel, depending on number of commute days and mode of travel. Compressed workweeks appear to reduce not just work trips

[39] *If you live in a city, you don't need to own a* car. William Clay Ford, Jr., Ford Motor Company Ltd, October 2000.

but total trips. The best documented case studies of compressed work weeks have been in the government sector. More private sector implementation should be encouraged, along with evaluation of participation rates, assessments of best markets and evaluations documenting travel impacts.

Some case studies on compressed work weeks suggest VMT reductions of 15 percent. The reason for the VMT reduction is simply the fact that commuters work fewer days per month, and non-work trips do not offset the reductions in work trips.[40] In Denver, Colorado, evaluations of federal employees suggest the strategy had no adverse effects on ridesharing and transit. Denver showed VMT reductions for work and non-work travel among participating employees of 15 percent, with no adverse impacts on ridesharing or transit use. This reduction translated into a 5.6 percent reduction in VMT for Denver federal employees. A study of compressed workweeks suggests it was associated with a decline in solo driving, from 82 percent to 77 percent.

For flextime and staggered work hours, effects on VMT are not as clear. Ability to carpool can be diminished by flexible work hours.

DATA COLLECTION

While flextime strategy appears to reduce travel in peak periods, the effect on mode of travel is mixed. More testing and evaluation aimed at mode choice is encouraged. Consequently, comprehensive evaluations of travel impacts would be useful.

In the Wasatch Front area, surveys need to be conducted to determine successful programs, and firms with similar characteristics need to be identified where these programs may be implemented.

DESIGN CRITERIA/LOCAL LOCATIONS

The use of this strategy needs to be coordinated and expanded in the Salt Lake Area. All three types of staggered and flexible work hours should be promoted in the Salt Lake Area, but especially the compressed workweek because of its VMT reduction potential. Businesses and centers with 100 or more employees should be targeted in particular. After promotion at these locations is accomplished, efforts could be directed to those with less than 100 employees.

Employment sites with 100 or more employees have the greatest reduction potential. Although appeal is not universal, compressed workweeks are generally popular and are compatible with more types of businesses than other alternative work programs. To result in significant congestion reductions, this technique should be included in a voluntary or mandatory Trip Reduction Ordinance (TRO).

INTERACTIONS

Alternative work schedules are often implemented as part of a Commute Trip Reduction program or with telecommute programs. Congestion Pricing can provide an additional incentive for employees to request and use Alternative Work Schedules.

[40] U.S. Dept. of Transportation, Federal Transit Administration, Variable Work Hours, August 1992.

MAXIMUM EFFECTIVENESS

Flextime reduces peak period congestion directly, and can make ridesharing and transit use more feasible. Staggered shifts can reduce peak-period trips, particularly around large employment centers. It is estimated that flextime and telework together can reduce peak-hour vehicle commute trips by 2-5 percent at individual employers. Flextime is a significant factor in Commute Trip Reduction program effectiveness in reducing peak-period traffic.

Compressed workweeks reduce total vehicle travel. One survey of commuters found that it could reduce automobile commutes by 7-10 percent, making it among the most effective commute trip reduction strategies considered. Another analysis estimates that CWW can reduce up to 0.6 percent of VMT and up to 0.5 percent of vehicle trips in a region. Still other research indicates that compressed work schedules may cause modest overall reductions in vehicle travel, in part because participants make additional trips during their non-work days. Compressed workweeks may also encourage some employees to move further from worksites, or to drive rather than rideshare.[41]

4. TELECOMMUTING

INTRODUCTION

Telecommuting is typically thought of as working at home for the purpose of performing work for a business located elsewhere. In recent years, telecommuting centers have emerged where workers may work away from home, with its associated distractions and limitations, and work at "remote office locations" which may be more conveniently located nearer to homes and away from congested areas where "traditional" offices are found. While self-employed workers (either primary or part time) and after-hours workers have often worked from their homes (although perhaps only partially) in the past, the concept of traditional office employees not being present at the office but still working at remote locations is relatively new, and correspondingly uncertain. Self-employed workers and associated self-employed workers who work out of their homes may grow in the future corresponding to national trends of growing small businesses and service businesses. However, traditional workers working at remote locations, either homes or other remote centers, represent the most significant market where telecommuting may ease traffic congestion.

RANGE OF EFFECTIVENESS

Telecommuting is relatively widespread throughout the United States, although at relatively low levels. Approximately 4 percent of the work force along the Wasatch Front usually work at home.[42]

Despite this relatively widespread appeal, it is generally believed that there are factors found at specific locations that make telecommuting more attractive than at other locations. Obviously, areas with long commute distances and greater traffic congestion make the tradeoff for telecommuting more desirable. However, present data and subjective experience from pilot projects suggest that internal management

[41] U.S. Department Of Transportation, Federal Transit Administration, TDM Status Report Variable Work Hours, August 1998.

[42] Census 2000.

practices and specific job situations have a greater bearing on telecommuting than external factors such as traffic congestion.

Telecommuting is appropriate for only certain type of jobs and industries. Recent work suggests that in a work force divided along broad sectors of agriculture, industry, service, and information, it is the information work, which should be of primary interest for telecommuting services. The primary activity of information workers involves the creation, processing, manipulation, or distribution of information. It is generally believed that the vast majority of information workers could telecommute at least on a part time basis. While estimates of the number of information workers, and corresponding potential telecommuters, are as much as 50 percent of the total work force, the actual counting of information workers is difficult to ascertain using current occupational data.

In addition to the types of jobs that may be best suited for telecommuting, experience has found that management practices can also have a profound effect on the ability to work remotely. It is believed that in areas with severe traffic congestion or air quality problems, management practices will be forced (possibly legislated) to be more conducive to telecommuting innovations. National policies toward "information highways" are geared towards businesses, schools, government, hospitals, and similar institutions, and are not expected to have profound impacts on personal communication abilities above what is presently available. Video conferencing and other upcoming technologies will be less expensive and more convenient, at least in the short term, at centralized rather then remote locations.

DATA COLLECTION

To assess the potential of telecommuting, employment and occupational data would be useful. Determining the types of workers presently telecommuting and gaining an understanding of the level of similar job roles which may make use of telecommuting substitutes for travel demand would advance telecommuting analysis and implementation. Occupational data along the lines of "information workers" should be considered. More frequent and possibly targeted household travel surveys would also aid in determining the effectiveness of telecommuting, but may not advance implementation.

DESIGN CRITERIA/LOCAL LOCATIONS

Telecommuting incentives may provide a practical and effective example of public/private partnerships. Management and institutional structures need to be redefined for telecommuting to effectively permeate the labor force. Major government employment offices could take a lead role in redefining these structures. Through this lead, insurance and liability claims, taxes, occupational health and safety concerns, and zoning laws could be overcome through a combination of defining case law and legislation. On the other hand, technology needs (computers, fax machines, high quality printers, video conferencing, etc.), child care services, conference centers, and locational decisions may best be satisfied by competing private providers. These business and societal issues (as opposed to institutional issues) may vary geographically and change rapidly, limiting the effectiveness of prescriptive government solutions.

It is difficult to identify specific corridors or locations where telecommuting benefits will be most predominant. Although it seems reasonable to assume that telecommuting incentives will be greater in corridors and areas of sustained traffic congestion, the social and institutional barriers of telecommuting may not be substantially easier to solve in the areas of greatest demand. From an analysis side, greater emphasis of intra-zonal work trips should be considered. Similarly, work trip travel distributions may change and become shorter toward remote telecommute centers. In the Wasatch Front, social biases such as second income workers or primary child caring workers may display different work trip tendencies than the remainder of the labor force, and may provide solutions for targeting telecommuting centers.

Traditional telecommuting represents true trip reductions in that work trips are allowed to remain home. Telecommuting resulting from telecommuting centers may involve a combination of staggered working hours and trip distance reductions, as well as trip reductions from at-home telecommuters. There is also a concern that telecommuters may increase non-work travel through reduced work trip travel times and more discretionary time to travel during the peak hours. This latent travel demand does not appear to be significant but should be monitored. However, at this time there are no future plans for telecommuting centers along the Wasatch Front.

INTERACTIONS

The nature of present telecommuting and projected telecommuting increases may have negative disruptions on carpools and ridesharing, in terms of disrupting existing car and vanpools. Similarly, telecommuters are not prime candidates for public transit and, to the extent that telecommuting reduces traffic congestion, telecommuting can be considered to compete with transit. Finally, widespread telecommuting may accelerate or magnify the negative impacts of suburban sprawl.

5. GROWTH PLANNING

INTRODUCTION

Growth planning may be defined as the public policy to guide the location, geographic pattern, density, quality and rate of growth of development. By knowing the trip generation characteristics of various land uses, one can theoretically limit the trip generation of a particular area.

A comprehensive growth planning strategy can include not only transportation actions, but also measures to deal with housing, economic development, open space, and community infrastructure.

There is an ultimate savings as a result of growth planning. The ultimate savings contributes to not having to build new highways and add capacity to arterials.

It has been a challenge for many local governments to continue to accommodate automobiles and transit into communities. The goal in using growth strategies is to integrate walking back into communities as one of our primary forms of transportation. A walkable district uses less land than one that is auto-oriented. The objective is to help reduce traffic and congestion as trips made by car are replaced by walking and transit trips.

In January 1997, Envision Utah was formed to help guide the development of the broadly and publicly supported Quality Growth Strategy. Envision Utah is a unique partnership of citizens, business leaders and policymakers, working together to create a strategy that will preserve critical lands and improve our region-wide transportation system.

DATA COLLECTION

Mode split and VMT would be effective in evaluating the effectiveness of growth planning strategies.

INTERACTIONS

Growth planning encourages the use of alternative transportation modes. Through these techniques communities can be planned so transit, biking, and walking are feasible, convenient, and cost effective. One growth strategy will not create this condition nor will growth planning alone. Any growth program must be used in conjunction with transit service improvements and rideshare promotion, for example.

MAXIMUM EFFECTIVENESS

Programs that provide incentives to reduce driving support the other demand management strategies by encouraging drivers to get out of their cars and use other means to reach their destinations. The maximum effectiveness of growth planning strategies depends on how well they are coordinated with transit improvements (*See Section 6, Transit Improvements*) and rideshare promotion.

Mixed-Use Neighborhoods, Pedestrian/Transit-friendly Activity Centers

INTRODUCTION

Mixed-use means locating a variety of different land uses-housing, schools, small shops, offices and neighborhood services-within walking distance of one another. This allows people to perform daily tasks without having to drive.

The concept of mixed-used development has been utilized for many years. However, the rediscovery of this pattern has been seen as a critical point in the recent urban response to traffic congestion. The rising cost of housing, traffic congestion, and the need to restore economic viability of downtown areas all contribute to an increased need for mixed-use development.

Mixed-use is a viable mode of development that can help foster growth. Mixed-use development supports:

- increased densities,
- integrated surrounding development and neighborhoods,
- incorporated public and civic space, and
- walking and biking.

Cities have found that mixed-use development adds quality and stability, resulting in more efficient land use.

RANGE OF EFFECTIVENESS

Studies have shown that mixing land uses alone can reduce vehicle trips in the suburbs by up to 18 to 25 percent. It also provides activity at all times of the day, which makes places safer and more attractive for walking.[43]

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[43] *Citizens For A Better Environment*, http://www.wsn.org/cbe/livablcommunities.html.

DESIGN CRITERIA/LOCAL LOCATIONS

Pedestrian/Transit-friendly Design

People will walk, bicycle and take public transit to many activities, but only if it is pleasant, convenient and safe. Most places today are designed entirely for the automobile and are unpleasant and unsafe to walk. Since many transit riders begin and end their trip as pedestrians, creating an appealing environment is critical for increasing transit use as well as pedestrian travel. Key steps include:

1. Building up to the sidewalk and street-- Most stores are set back from the sidewalk, forcing pedestrians to walk unprotected across large parking lots. Put parking behind businesses to get cars out of the way, providing a more attractive street-front.

2. Providing a comfortable and interesting environment-- Design attractive storefronts with windows and openings on the first floor, and provide amenities such as covered walkways, public plazas, benches, appropriate lighting and nice places to dine.

3. Creating streets for people as well as cars-- All parts of a community should be connected by streets or paths so pedestrians and bicyclists have short, direct routes to their destinations. Narrow, tree-lined streets, smaller intersections, and other "traffic calming" designs should be used in residential areas and activity centers to slow and limit traffic. Noisy high-speed traffic and long distances are the factors that most discourage walking and bicycling.

Jordan Landing, The Gateway Plaza, and Sugar House Commons are developments along the Wasatch Front that are considered pedestrian-friendly districts.

Future plans for redevelopment along 3500 South in West Valley include pedestrian-friendly, mixed-use complexes of offices, open space, retail, and housing. The ultimate goal over time is to make this car-dominated thoroughfare a walkable community.

Several Wasatch Front communities, such as Salt Lake, Layton, and West Valley City are planning for more compact and walkable cities. Plans will capitalize on planned TRAX light-rail lines along with potential bus expansions to create transit-oriented and mixed-use neighborhoods.

Transit-Oriented Developments

INTRODUCTION

Transit-oriented development (TOD) refers to pedestrian-friendly land development activities that are built within easy walking distance of a major transit station. TODs generally include a compact mix of different land uses that are oriented to public walkways, and automobile parking is minimized to promote pedestrian activity. Livable communities are neighborhoods that include a range of housing options, jobs, commercial services, and recreational opportunities all within easy access of transit services. These are communities in which residents, workers, and shoppers can get around without the use of an automobile.

The concept of transit-oriented developments has been utilized by metropolitan areas in an attempt to manage the environmental and social impacts of dispersed growth patterns. TODs will increase pedestrian and transit trip taking while reducing the number and length of auto trips, and they contribute to the livability that is known to be lacking in modern suburban development.

Transit-oriented developments entail creating denser, mixed-use activity nodes connected by high quality pubic transportation. A combination of design features will induce travel mode shifts that result in reduced area-wide traffic congestion. Some of these design features include improving street connectivity, public amenities, and a concentration of residences and jobs in proximity to transit stations and commercial businesses.

Most cities have a comprehensive plan or are in the process of putting a plan together. There are a variety of options available to the counties and their municipalities to plan their growth. To select an appropriate mix of planning tools and to apply them in appropriate times and places is a challenge.

Ballston Station in Arlington, Virginia is a good example of transit-oriented development. The area around the station consists of residential development adjacent to retail and service providers -- a transit village. Denver, Colorado currently has two major models of TODs, the 16th Street Mall and the City Center of Englewood. The 16th Street Mall evolved over a 20-year time span making it the region's densest urban village. Other cities have created TODs in Washington D.C., San Francisco, Portland, Atlanta, San Diego, and St. Louis.

RANGE OF EFFECTIVENESS

In a study of TODs across the United States, it was concluded that rail tends to stimulate concentrated development in areas such as central business districts where transit is highly accessible and auto traffic is impacted by congestion and costly parking. Another study found that rail alone is not sufficient to generate development.[44]

The city of Portland is recognized nationwide for its innovative transportation and land use ideas. Portland's downtown has accommodated 30,000 new jobs in the last two decades without significant increase in the number of parking spaces or vehicle trips. Assisted in part by the region's excellent light-rail system, there has been a 50 percent increase in public transit trips to downtown, and 43 percent of all work commuting trips in Portland -- many times the national average-- are made on public transit.[45]

Studies in Seattle and San Francisco have shown that denser residential development within an easy walk of a TOD center and transit station will generate walk trips, and that these trips may substitute for vehicle trips.

DATA COLLECTION

Measuring the increase in non-auto trips, calculating the accessibility and mode shifts for levels of transit are effective means of determining benefits of growth management strategies.

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[44] *Measuring the Success of Transit-Oriented Development*, John Niles, Global Telematics, April 1999.

[45]Reducing Dependency on Motor Vehicles, Benfield, F. Kaid, Matthew D. Raimi, and Donald D.T. Chen, Once There Were Greenfields: How Sprawl is Undermining America's Environment, Economy and Social Fabric.

DESIGN CRITERIA/LOCAL LOCATIONS

The vision of more integrated communities that provide both livability and accessibility may be grouped into five basic strategies:

- Compact and balanced communities,
- A greater mix and intensity of land uses,
- An integrated transportation network,
- Pedestrian-friendly development standards, and
- Incentives to reduce driving.

Centers must be within an easy walking distance (1/4-mile) to residents, and one or more other centers must be easily accessible by transit.

An example of a TOD along the Wasatch Front is the Gateway Plaza in downtown Salt Lake City.

INTERACTIONS

Transit-oriented developments benefit from rail or other fixed-guideway transit on a local scale.[46]

MAXIMUM EFFECTIVENESS

In the San Francisco Bay area, a study revealed that 9 percent of residents in the three BART-served counties lived within a half mile of a BART station, and 18 percent of these station-area residents commuted to work by rail transit.

6. TRANSIT IMPROVEMENTS

Transit improvements can cover a broad array of transit-enhancing techniques. These generally take the form of improved marketing, facilities, community transit hubs, technology development, accessibility, schedule adherence, customer convenience, travel time, and rider comfort. This report will discuss some of these techniques in terms of corridors and activity centers. Although many of the techniques discussed could benefit both corridors and activity centers, each technique will not be discussed in both the corridor and activity center sections.

At activity centers, transit service improvements are aimed at providing reliable and convenient bus operations. This is especially true for the older, more congested, downtown areas, where bus volumes are high. They can also be beneficial in suburban areas where active development is taking place.

Activity center transit improvements include the following:

a. Transit mall
b. Preferential treatment
c. Fare reductions

These methods are further encouraged by techniques such as increased parking fees (*See Parking Management, Section 11*), auto-free zones, and improved transit security.

Corridor transit improvements include the following:

d. Express bus service
e. Bus hubs
f. Park-and-ride lots
g. New routes and frequency improvements
h. Fixed guideway transit

TRANSPORTATION IMPACTS

This table summarizes impacts that different types of transit improvements tend to have on the transportation system.

[46] *Measuring Success of Transit-Oriented Development*, Global Telematics, April 1999.

Table 2
Transportation Impacts of Various Transit Improvements

Type of Transit Improvement	Improves Service	Increases Affordability	Increases Transit Use & Reduces Driving
Additional routes, expanded coverage, increased service frequency and hours of operation	X		X
Lower fares, increased public subsidies		X	X
Commute Trip Reduction programs, Commuter Financial Incentives, and other TDM Programs that encourage use of alternative modes		X	X
HOV Priority	X		X
Comfort improvements, such as better seats and bus shelters	X		X
Transit Oriented Development and Smart Growth, that result in land use patterns more suitable for transit transportation	X		X
Pedestrian and Cycling Improvements that improve access around transit stops	X		X
Improved rider information and Marketing programs	X		X
Improved Security	X		X
Services targeting particular travel needs, such as express commuter buses, Special Event service, and various types of Shuttle Services	X		X
Universal Design	X		
Park & Ride facilities	X		X
Bike and Transit Integration (bike racks on buses, bike routes and Bicycle Parking near transit stops)	X		X

6a. Transit Mall

INTRODUCTION

A transit mall may be implemented to enhance the movement of transit vehicles and/or pedestrians relative to auto movement. A transit mall represents a compromise between preferential treatment for transit vehicles (e.g., a bus lane) and a full pedestrian-only mall. It is a street on which transit vehicles are given exclusive or near-exclusive use, sidewalks are widened, and amenities such as benches, displays, and shelters are added for pedestrians and waiting transit patrons. Access to automobiles and trucks is denied or strictly limited, except for cross street traffic.

Bus transit malls, properly designed and implemented, can produce significant advantages for both bus passengers, automotive travelers, pedestrians, and businesses. By separating buses, with their frequent stops, from automotive traffic, the speed of travel can be increased for both. Moreover, bus based strategies can reduce travel time for transit commuters, because service would be more frequent than on light rail (waiting time would be reduced).

RANGE OF EFFECTIVENESS

Portland, Oregon is known as, “the biggest downtown success story in America.”. Thirty years ago Portland’s downtown area was considered a ghost town. Portland has provided an example of how to grow and enhance livability. Portland’s central city plan focused on the most intensive development adjacent to transit-by design transit was put in the center of the action. Since 1971, Tri-Met has expanded service by more than 150 percent and seen nearly a 260 percent increase in ridership.[47]

DATA COLLECTION

Before and after traffic volumes on streets neighboring a mall permit determination of whether traffic simply shifts elsewhere or if an actual reduction in trips occurs. Transit ridership data on routes along the mall also need to be collected to evaluate its effectiveness in attracting transit riders.

DESIGN CRITERIA/LOCAL LOCATIONS

To be considered for conversion to a transit mall, a street segment should have approximately 30 buses using it. Some high transit streets exist in the CBD, such as State Street and North Temple. Other areas with high transit loads may benefit from a limited transit mall strategy, such as South Towne and Valley Fair Malls. Congestion impacts should be analyzed prior to any changes. A transit mall similar to Denver's, where the area is predominantly pedestrian and limited to shuttle buses, may be appropriate to the University of Utah and possibly other area universities.

INTERACTIONS

Since improvements in transit travel times and accessibility occur, trip reduction programs and certain growth management strategies are enhanced by malls. Assuming adequate safety provisions are made, the use of bike and walk modes is facilitated by transit malls.

MAXIMUM EFFECTIVENESS

As a result of Portland's success with transit malls, no new capacity has been added to the downtown area for a quarter of a century.

6b. Preferential Treatment

Exclusive bus lanes

INTRODUCTION

In activity centers, the opportunities for preferential treatment include designing curb bus lanes and timing traffic signals to allow more green time for buses. In essence, this section will cover preferential treatment on non-freeway facilities. *Section 7, HOV Lanes* discusses preferential treatment on freeways. Although the emphasis here is on transit, preferential treatment may also apply to vans and carpools.

Curbside priority bus lanes provide flow lanes for transit and right turning vehicles throughout a congested activity center, arterial, or bottleneck. These are generally intended to increase bus speeds and schedule reliability and thereby encourage ridership and free buses for route expansions. These lanes vary in length and hours of operation; however, most are in effect only during peak periods.

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[47] *At work in the Field of Dreams: Growing smart – an enviable track record of success,* www.tri-met.org/reports/dreamssmart.htm, *July 2002.*

RANGE OF EFFECTIVENESS

In Seattle, Washington their bus priority project implemented in spring of 2000 has reduced signal related stops by 50 percent and reduced bus travel time by 35 percent.

The transit signal priority system deployed on two corridors (Ventura Boulevard and Santa Monica-Beverly Hills Montebello Route) in the City of Los Angeles resulted in reduction of bus journey time of 27 percent.[48]

DATA COLLECTION

In order to determine the effectiveness of preferential treatment in reducing congestion, pilot projects should be initiated in the planning area. VMT data should be collected along the pilot route(s). Ridership and auto/transit mode split should be analyzed before and after beginning treatment to determine the extent of improvement. Information regarding before and after travel times for autos sheds light on overall congestion impacts.

DESIGN CRITERIA/LOCAL LOCATIONS

Factors to consider in applying preferential treatments to activity centers include: 1). ability to enforce against violations; 2). location so as to foster HOV use; 3). impacts on non-HOVs; and 4). other actions that might reinforce or enhance the operation of the preferential treatment.

Provision of preferential lanes, curb or dedicated, could have a significant effect upon peak hour transit ridership with potentially positive effects on traffic congestion in the Salt Lake area. "Quicker" buses can increase ridership by providing prompt service and freeing-up buses for the creation of shorter headways and additional routes. Exclusive transit lanes should be reviewed for viability in Salt Lake where transit use approaches 30 or more buses per hour. Currently, sections of State Street, North Temple, 200 South, and 3500 South might meet this criteria. Provision of a completed network connecting the high use areas is likely to result in the greatest congestion reduction. The links should be formed using other priority treatments as high transit use areas are identified.

INTERACTIONS

Depending on the type of priority treatment used and method of implementation, transit travel time reductions may be derived at the expense of auto traffic or may reduce auto capacity along a given corridor. Preferential treatment for transit obviously is compatible with trip reduction ordinances and programs, as well as some growth management techniques.

MAXIMUM EFFECTIVENESS

Generally, a one percent increase in the speed of bus travel results in a 0.6 to 1.7 percent increase in ridership depending on what current bus speeds are in relationship to auto speeds.

Metro Rapid (MTA) in Los Angeles, California has expanded and implemented a new priority bus service. Bus service runs significantly faster and is more reliable with the new electronic displays and computerized

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[48]*Bus Rapid Transit Shows Promise,* Mass Transit, September 2001.

traffic signal control system, which is used to move special red-painted buses through intersections faster.

Since a demonstration project on two of Los Angeles' most heavily traveled corridors in June 2000, the Metro Rapid service has achieved 25 percent faster travel time and increased bus ridership by 30 percent.[49]

Bus Signal Priority

INTRODUCTION

Priority measures seek to remove the unreliability of bus travel and to reduce travel times by enabling buses to avoid traffic congestion. In providing bus priority, the needs of other road users, e.g. cyclists, pedestrians, general traffic, essential and emergency traffic, travelers with a disability and those accessing frontages must be considered.

Providing priority for buses is one of the most effective ways of achieving transport policy objectives in urban areas.

Advantages of bus priority lanes are:

- Faster, more reliable bus trips
- Less stress and pollution
- A progressive step for public transport

Bus priority is common in several cities around the U.S. and is quite popular throughout United Kingdom and Asia.

RANGE OF EFFECTIVENESS[50]

In Helsinki, Finland the benefits of pilot implementation of public transport signal priorities and real-time passenger information has shown an increase in tramline passengers of 2 percent and an increased number of bus passengers by 1 to 12 percent.

Total travel times decreased by 1 percent (21 seconds) on the tramline, and 58 percent on the bus line.

Experience with a transit priority system implemented on a bus line along an urban arterial in Vancouver, British Columbia has revealed a 29 percent reduction in transit travel time in the a.m. peak and 59 percent during the p.m. peak.

DATA COLLECTION

Data collection needs for signal priority are similar to those for exclusive bus lanes.

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[49] *Real-Time's Rapid Growth*, Transportation Management & Engineering, October/November 2001.

[50] *The Benefits of a Pilot Implementation of Public Transport Signal Priorities and Real-Time Passenger Information*, ITS Benefits and Unit Cost Database, Lehtonen, M.; and Kulmala, R.

INTERACTIONS

Intersections for signal priority are similar to those for exclusive bus lanes

MAXIMUM EFFECTIVENESS

Experience with a transit priority system implemented on a bus line in Vancouver, British Columbia has revealed some positive benefits. The system has reduced the variability of travel time experienced by buses along the route by 29 percent in the a.m. peak and 59 percent during the p.m. peak.[51]

Use of bus signal priority restored service in the Whittier-Wilshire corridor in Los Angeles, California by 22.4 percent in terms of revenue hours and by 16.4 percent in terms of change in peak vehicle pull-out. Operating speeds increased 23 percent from 15 to 19 mph. Ridership showed an increase of 33 percent. With the Ventura corridor, service was increased by 36.5 percent with an increase of ridership by 26 percent.[52]

DESIGN CRITERIA/LOCAL LOCATION

Measures used to reduce travel times and avoid traffic congestion include:

- With-flow and contra-low bus lanes
- Modifications to roundabouts and other traffic management facilities on local roads to allow the safe passage of buses
- Bus only access lanes and through roads
- Priority for buses at traffic signals
- Improved junction designs
- Traveler information
- Appropriate controls on parking and servicing
- Relocation of traffic queues
- Queue jump lanes, which allow buses to overtake long queues of traffic during peak periods
- Bus stop design
- Enhanced interchange

Bus priority projects will improve the metropolitan road network to allow better access for buses, thus making them more reliable and efficient as a mode of transport.

Utah Transit Authority has scheduled a pilot priority project in the year 2002 for the Wasatch Front area for the 3300 South/3500 South corridor.

[51] *Transit Signal Priority: A Comparison to Recent and Future Implementations*, Cima, Bart, ITS Benefits and Unit Cost Database, U.S. Department of Transportation.
[52] *Enhanced Bus Service. The L.A. Experience*, Gregory Scott, Wasatch Front Regional Council.

6c. Fare Reductions

INTRODUCTION

Fare reduction measures include various types of monthly, weekly, or daily passes, free fare in central business districts, "free" ridership days, peak/off peak fare differential to encourage more discretionary trips to be taken on transit during the off-peak, and employer fare subsidy programs. Many U.S. public transit systems and cities have used substantial fare reductions designed to attract new transit riders. Many transit systems have also encouraged employers and employer groups such as business parks to adopt transit fare subsidy programs. Fare reductions fall into two categories: general and activity center.

RANGE OF EFFECTIVENESS

The most conclusive data presented thus far is in Atlanta, Georgia where reduction in fares from 40 cents to 15 cents increased ridership by roughly 28 percent. Experiences in other cities such as San Diego, California and Los Angeles, California where fares were reduced to a flat 25 cents rate produced ridership increases of approximately 22 percent[53]

DATA COLLECTION

For some types of fare reductions, VMT along specific corridors should be collected to determine congestion mitigation effectiveness. For off-peak general fare reductions, area wide VMT growth rates should be monitored. Additionally, if growth in peak and off-peak ridership rates are greater than population and employment growth rates, then the fare reductions are probably having an effect on ridership (assuming effects of other strategies are accounted for).

DESIGN CRITERIA/LOCAL LOCATIONS

Promoting employer-subsidized transit passes might be initiated with employers with 100 or more employees. Pass programs such as Eco Pass and Co-op Transit Pass Discount offer discounted passes for employees. The Summer Youth Pass, a current Utah Transit Authority (UTA) success, has been a continued program annually and expanded to cover targeted corridors and special events. Federal funding should be considered to supplement fare revenues lost due to requested fare decreases as well as employer subsidized transit in-lieu of parking requirements along frequent transit corridors.

Other areas of fare reductions include a fee shuttle servicing the University of Utah/University Hospital district, a deep discount program serving Salt Lake Community College, and a downtown/Capitol connector. Although it is recommended that overall fare revenues (including income from federal, local government, and employer fare subsidies) be maintained at a level that will at least equal 20 percent of operating cost, and allow for continued transit expansion, various "preferred customer" and off-peak fare programs should be considered.

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[53] *Consideration of Possible Types of Actions To Achieve Increases in Transit Ridership and Decreases in Energy Consumption,* Chapter Viii.

INTERACTIONS

Fare reductions compete with rideshare and walk/bike modes in attracting the public. Other trip reduction measures are generally compatible, as are system efficiency improvements.

MAXIMUM EFFECTIVENESS[54]

A large number of cities have indicated an experience of a 1 percent change in transit fare causes a .33 percent change in transit ridership. However, most of this experience used in developing this relationship consisted of small fare changes and would tend to underestimate the effect of large fare reductions, which is discussed below.

<u>No-Fare Transit</u>

A rough analysis presented a 40 to 60 percent increase in transit ridership when eliminating out-of-pocket cost of transit travel. The net effect of no-fare transit and the related service improvements is estimated to be 60 to 80 percent increase in transit ridership.

No fare transit would reduce per passenger operating costs and promote more efficient use of manpower and equipment, because: (1) a greater percentage of riders would be in the off-peak, and (2) riders would board buses faster.

<u>6d. Express Bus Service</u>

INTRODUCTION

Express bus service is defined as a route connecting a residential neighborhood, park-and-ride lot, or transit hub with a high-activity employment center while making at most only a few intermediate stops on the line-haul segment of the trip.

RANGE OF EFFECTIVENESS

Express bus service has the potential to significantly increase transit ridership and decrease auto miles traveled. It also has the potential for meaningful congestion management benefits.

Along the Wasatch Front, express buses are saving 10 to 30 percent on travel times. Typically, 20 to 25 percent of the express bus riders are previous regular route riders. Currently, the typical weekday express bus service experiences 81,971 riders. It is projected that the average weekday ridership will experience a 12 percent increase by 2030.[55]

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[54]*Consideration of Possible Types of Actions To Achieve Increases in Transit Ridership and Decreases in Energy Consumption,* Chapter Viii.

[55] Wasatch Front Regional Council.

DATA COLLECTION

In order to evaluate the effectiveness of express service in mitigating congestion, three data sets are helpful: 1). VMT along the particular corridor where express buses run, 2). ridership on the express buses, 3). auto/transit mode split along the corridor.

DESIGN CRITERIA/LOCAL LOCATIONS

Express bus service appears to attract significant ridership in many communities, provided it can offset the time required to transfer to the bus and can attract sufficient riders to pay for its additional operating costs. To maximize success, express buses should provide a line-haul service of at least 5 - 8 miles, be associated with free or low cost parking, and provide headways of 20 minutes or less for any residential pickup/distribution and 10 minutes or less for any park-and-ride lots served. All of these factors are not always mandatory. Express routes involving travel from concentrated suburban developments to the CBD, those in highly congested corridors with HOV lanes, and those in areas committed to public transit usage have been successful. Elevating CBD or activity center parking charges might also be helpful.

Since employer-dedicated and inter-city express bus services are the most requested and used services provided by UTA, they should be expanded, and if funding is available, UTA should attempt to meet the above design criteria. Improvements to the system, through the use of HOV lanes, transit centers, pricing, etc., would seem to be able to garner even more ridership. Future goals should include a HOV master plan and reductions in required parking for employers that provide express service subsidy.

Currently, the following express bus routes are in-service along the Wasatch Front:

Route Number	Bus Route
51	Tooele Express
72	Ogden/Salt Lake Express
73	SLC- Ogden Highway 89 Express
651	Ogden B UP & L (SLC CBD)
652	Ogden B Unisys
685	Ogden B Brigham City
687	Harrison Boulevard B Thiokol (northwest of Brigham City)
694	Layton Hills Mall B Thiokol
801	SLC/Provo B Orem Express
803	Spanish Fork / SLC Express
804	Lindon/Orem/Pleasant Grove/SLC Express
810	American Fork B University of Utah

INTERACTIONS

Express buses complement growth management, congestion pricing, and trip reduction ordinance strategies. System management tools such as signal coordination and elimination of bottlenecks benefit buses. Telecommuting and rideshare promotion may at times compete with express bus service in reducing VMT.

MAXIMUM EFFECTIVENESS

Express bus popularity comes from its ability to provide convenience somewhat similar to that of a car. In the short term, with limited provision of HOV lanes and parking pricing, express buses are likely to continue at their current rate of popularity. Over time, however, they may decline in popularity because they will be caught in traffic with everyone else entering the CBDs and because employment may become too diffuse to adequately serve with express service. To have a substantial long-term effect, express service should be accompanied by priority treatments and growth management. Until HOV lanes and parking pricing measures are put in place, service improvements such as park and ride lots and increased frequency on express routes would be most appropriate.

6e. Bus Hubs

INTRODUCTION

Bus hubs provide a point where several routes in a corridor converge with coordinated "timed" schedules to permit transfers to other line haul or feeder routes with a minimum of waiting time. These centers can improve the frequency of transit service along corridors while providing a broader area of coverage, especially in less dense suburban areas. These transfer centers can also be used to coordinate transfer between modes such as bus, auto, taxicab, and rail service.

A transit hubs are a base transfer point for local and express service. These are often found in major activity centers which are the focus of travel demand.

Intermodal centers can be defined as an integrated transportation system consisting of two or more modes. Intermodal networks are connected through facilities which allow travelers to transfer from one mode to another during a trip from an origin to a destination. Intermodal networks aim to provide efficient, seamless transport of people and goods from one place to another.

South Davis existing transit service includes Flextrans, Paratransit, and bus service. Bus service is being improved with high frequency bus routes and expanded bus service. There are 8 park-n-ride lots in the South Davis area and others are being proposed to accommodate future commuter rail riders.

RANGE OF EFFECTIVENESS

Timing is very important in the use of these hubs. Research has suggested that transfers are considered to be one of the most negative aspects of transit passengers' perceptions of transit service. Coordinating schedules and interlining bus routes at transit centers is essential to maintain the full benefits of transit hubs.

DATA COLLECTION

Monitoring transit ridership and conducting on-board surveys would be useful in monitoring and determining the effectiveness of these hubs.

DESIGN CRITERIA/LOCAL LOCATIONS

The usefulness of transit hubs in a given area appears to depend on that area's population, employment density and off peak times. In medium, low, or mixed density areas such as exist in the vast majority of the service area, transit hubs/feeder bus systems have the potential to greatly increase service while maintaining transit efficiency. However, direct transit should be considered in large high-density residential areas and no service or extremely limited service should be considered in very low-density areas at peak times.

Local bus hubs are located in Salt Lake CBD, University of Utah, Valley Fair Mall, 10000 South TRAX, the Ogden Intermodal Center, and Layton Hills Mall.

Transit hubs are scheduled in phase I of the long range plan for Davis County in Layton at the Layton Commuter Rail Station, and in Bountiful near 500 South and I-15. The Roy commuter rail station in Weber County. In Salt Lake County will they will be located at North Temple at the light rail train (LRT) station near Redwood Road, University of Utah at the LRT station, Union Park Area, West Jordan near SLCC Jordan campus, Sandy/South Jordan near the Sandy Civic Center

Intermodal centers also scheduled for phase I and II in Salt Lake County will be located at the Gateway, near 600 West 200 South, Mid-Valley at the LRT commuter rail station, and in West Valley City at the Valley Fair Mall. In Weber County at 24^{th} Street and Wall Avenue in Ogden.

INTERACTIONS

The interaction of transfer centers can be used in conjunction with other strategies such as parking management, congestion pricing, and development strategies to encourage higher occupancy vehicle use.

MAXIMUM EFFECTIVENESS

On a route-by- route basis, the VMT reduction effects of bus transfer centers are similar to that of limited stop and express routes, but transfer centers allow these service levels to be provided to multiple routes at minimum cost.

<u>6f. Park-and-Ride Lots</u>

INTRODUCTION

The primary purpose of park-and-ride facilities is to provide a common location for individuals to transfer from a low to high occupancy travel mode. In the context of freeway corridor management, such facilities become an important component of efforts to encourage HOV use.

For the purpose of this report, park-and-ride lots with more than one transit end point to include an express bus are considered to be transfer centers, and those without a transit connection are discussed in *Section 1, Commute Alternatives/Rideshare Promotion.* The remaining lot types are the "kiss-and-ride" lots and the full park-and-ride lots. Kiss-and-ride lots have transit service and short-term parking (up to 15 minutes). These serve as central points for dropping off and picking up passengers. Full park-and-ride lots accommodate long-term parking and transit service.

Benefits of the park-and-ride facilities relative to user cost and travel time savings, more effective congestion management, lower demand for parking spaces in congested areas, reduced energy consumption and vehicular emissions, enhanced mobility, and improved efficiency of the transit system.

RANGE OF EFFECTIVENESS

The most successful lots provide some form of direct access to high-speed transit services. The range of effectiveness of park-and-ride lots varies greatly, depending mostly on suitability of the location and frequencies/destinations of the associated transit service.

A survey conducted in the Wasatch Front area revealed which factors were of importance in making park-and-ride lots appealing. Proximity to residence and available parking spaces were of the most concern to individuals.

DATA COLLECTION

Maintaining usage counts and conducting surveys to determine motivation for usage are both helpful.

DESIGN CRITERIA/LOCAL LOCATIONS

The most important considerations in locating park-and-ride facilities include: traffic reduction, compatibility with surrounding land uses, transit efficiency, design features, and types of usage. To be successful, a park-and-ride sites needs to be consistent with origin and destination travel patterns, be located along a major transportation corridor to intercept home-to-work trips destined for major activity centers at a point where there is sufficient transit demand, and be located prior to where road congestion begins. Park-and-ride lots are especially helpful in providing service for people who live in low-density areas who may not be served by regular routes.

As of year-end 2000, there are eight park-and-ride lots in Utah County, six in Weber County, five in Davis County, and twenty-one in Salt Lake County. Eleven park-n-ride lots have been added between 1300 South and 10000 South to accommodate TRAX riders.

A park-n-ride lot is scheduled for construction at US 89/200 North in Ogden. Additional lots are anticipated as part of the Long Range Plan.

MAXIMUM EFFECTIVENESS

The VMT reduction effects of park-and-ride lots in the Salt Lake Area are included with rideshare promotion HOV, express bus, and fixed guideway transit strategies.

6g. New Routes and Frequency Improvements

INTRODUCTION

The geographic expansion of transit route systems and increases in service frequency represent a class of transit service improvements that offers wide opportunity for application and reasonable likelihood of positive impact on ridership. Routing and scheduling improvements are those that bring transit service closer to the potential patrons, provide it more frequently, or extend the amount of time that it is available.

RANGE OF EFFECTIVENESS

The Jacksonville Transportation Authority (JTA) reported a 4.26 percent increase in bus ridership. The bus ridership is partly attributed to two new routes and frequency improvements on six other routes that were implemented with an October fare increase.[56]

The city of Minneapolis drastically improved their transit service by implementing some key improvement elements in St. Louis Park, Hopkins, and Minnetonka. There was a 30 percent increase in service hours from simplifying route structures, creating new intra-community and suburb to suburb connections, providing more direct and quick service between numerous community locations, and adding passenger shelters at key transfer locations.[57]

DATA COLLECTION

To evaluate the effectiveness of new routes and frequency improvements in reducing congestion, ridership, mode split, and VMT along the affected corridors should be analyzed.

DESIGN CRITERIA/LOCAL LOCATIONS

Utah Transit Authority (UTA), where possible, uses some basic guidelines in planning new routes. These include the following:

- Provide service to 80 percent of the urbanized service area population; day routes accessible within 1/4 mile (2 blocks), night routes accessible within ½ mile (4 blocks). Routes should be closer where terrain inhibits walking.

- Service major employment, minority housing, colleges, shopping centers, major medical facilities, senior centers, and civic activities.

Once the planning guidelines have been used to help identify a possible service expansion area, the following guidelines can be used to further evaluate the proposal:

- Ridership demand for new peak hour express or worker service. Should be an 80 percent or higher load factor on a 45-passenger bus.

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[56] *JTA Reports Increase in Bus Riders*, The Business Journal of Jacksonville, 1998.
[57] *Three Cities Transit Restructuring Plan*, www.metrocouncil.org.

- Minimum ridership demand for local service. Should be comparable to adjacent homogenous routes, (e.g. passengers per mile, trip, hour).

- Recovery time to revenue time. Should be a maximum of 20 percent. The recovery time should also be a minimum of 5 minutes at the end of the line.

- Farebox recovery. Should be at or in excess of 20 percent of operating expenditures excluding purchased transportation.

- Passengers per revenue mile and revenue hour. Should be equal to or better than that of other similar service in the area.

- Annual transit rides per capita. Should be at 16 rides or higher.

Like bus service area expansion, increased bus frequency is an ongoing UTA priority. UTA's planning criteria for existing route frequency increases include the following:

- Existing headways do not meet the planning policy headways. Policy headways are 60 minutes for base service, 30/60 minutes (depending on demand) for peak hour service, and 60 minutes for night service.

- Overloading or excessive customer standing is required. This is where the average occupant load per trip is 61 on a 48-passenger bus; or where 15 or more people on a local bus or 5 or more people on an express bus are required to stand for more than five miles.

- Average route speeds drop below policy speeds. Policy speeds, including stops, are 15 mph for urban bus travel, 25 mph for suburban travel, or 35 mph for express travel.

Once the planning guidelines have been used to help identify a possible service expansion area, the same guidelines as used for the new routes can be used to further evaluate the increased frequency proposal.

INTERACTIONS

New routes and frequency improvements complement growth management, congestion pricing, and trip reduction ordinance strategies. System management tools such as signal coordination benefit buses. Telecommuting competes with buses in reducing VMT.

MAXIMUM EFFECTIVENESS

Based on travel model estimates, transit will serve 2 percent of all trips in the year 2030. For regular daily commuting transit will have a greater impact serving 7 percent of commuting trips (33 percent of college trips and 5 percent of work trips). Local bus service would account for about 35 percent of these transit trips.

6h. Fixed Guideway Transit

INTRODUCTION

There are five major types of transit services in this category: heavy rail, light rail, commuter rail, fully automated rail, and transit ways. The focus of this discussion will be on light rail. Transit ways are discussed in *Section 7, HOV Lanes* and *Section 6b Preferential Treatment*" of this chapter.

Light rail transit is a medium capacity (ranging from 2,000 to 20,000 passengers per hour) rail service that can operate either on reserved rights-of-way or in mixed traffic on urban arterial streets. Because light rail more easily fits into urban corridors, it is less expensive to construct than heavy rail. However, it cannot carry as many passengers because of its size limitations.[58]

RANGE OF EFFECTIVENESS

In general, transit operating in an exclusive right-of-way (ROW) is less affected by traffic congestion, accidents and other factors, and as such, runs on a more reliable schedule. Evidence suggests that fixed rail systems attract more riders than buses under comparable conditions. It is projected that by year 2030, ridership will reach about 125,000 given current plans.

DATA COLLECTION

Data collection needs for evaluating the effectiveness of fixed guide ways are similar to those for new routes and frequency improvements.

DESIGN CRITERIA/LOCAL LOCATIONS

When designing light rail and transit stations, there are some common design criteria that are utilized. A 28 foot wide space is necessary for in between stations and in road running, without in road running a 35 foot space is used, and a 44 foot space is used with a center platform.

Currently, the Medical Center LRT Project is under construction. This project will extend from Rice-Eccles Stadium to the University of Utah Health Sciences Complex. Environmental work on commuter rail service from the Ogden area to Salt Lake City is beginning.

INTERACTIONS

Interaction of this strategy with other strategies is similar to the interaction of express bus service.

MAXIMUM EFFECTIVENESS

Based on travel model estimates, transit will save 2 percent of all trips in the year 2030. For regular daily commuting transit has a greater impact serving 7 percent of commuting trips (33 percent of college trips and 5 percent of work trips). Light rail and commuter rail will account for about 63 percent of these transit trips.

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[58] United States Environmental Protection Agency, Improved Public Transit, Dec. 98.

TRAX

INTRODUCTION

TRAX is a light rail short for Transit Express. Light Rail is electrically powered and runs on tracks, either on railroad right-of-way or tracks in city streets. Some people describe it as an updated version of the trolley cars, which were used in most major cities from the turn of the century to the 1950s. However, today's light rail vehicles (LRVs) are faster, quieter, safer, more comfortable and can carry up to 420 passengers (including sitting and standing passengers on a three-car train). The TRAX north/south line is a 15-mile line that runs from 10000 South in Sandy to the Delta Center in downtown Salt Lake City. A 2.5 mile line from downtown to the University of Utah was completed December 2001.

RANGE OF EFFECTIVENESS

The availability of parking on campus has increased from 400 vacant spaces to 2000 vacant spaces, with completion of the University line.[59]

Currently, there are 59 U.S. light rail projects in the planning phase, another 38 in design, and 20 under construction.

DATA COLLECTION

Surveys, parking data, ridership data and traffic volumes will provide information on light rails effectiveness in reducing VMT.

DESIGN CRITERIA/LOCAL LOCATIONS

Light rail plans in the U.S. attract the most supporters when linked to airports, downtown areas, schools and other major activity centers.

A light rail extension from downtown Salt Lake City to the University of Utah has been added to complement the successful north-south TRAX line, which has been operating since December 4, 1999. The University line opened on December 15, 2001. Currently, there are 16 TRAX stations on the North/South line. The locations of these stations are: Delta Center, Temple Square, City Center, Gallivan Plaza (transfer point), Courthouse, 1300 South-Ballpark, 2100 South, 3300 South, 3900 South, 4500 South, 5300 South, 6400 South, 7200 South, 780-0 South, 9000 South, and 10000 South. All include park-n-ride lots with the exception of the Delta Center, Temple Square, City Center, Gallivan Plaza (transfer point), and the Courthouse. The University line is divided into reaches. These reaches are from Main Street to 400 East, 400 East to 800 East, 800 East to 1100 East, 1100 East to Rice Eccles Stadium. There are 4 TRAX stations located at 200 East, 600 East, 900 East and the Stadium.

TRAX is wheelchair accessible. Bikes are allowed on TRAX vehicles during all hours of operation. Bicycle racks are located at each TRAX station. Downtown stations have bicycle racks located in close proximity to the station.

[59] *People Ride Bus and TRAX to the U Parking Crunch Eases*, University of Utah News and Public Relations, April 2002.

Thirty-four UTA bus routes have been re-oriented to serve the North/South TRAX line. These new routes began running on December 6, 2000 when TRAX officially began passenger service.

INTERACTIONS

TRAX is well-suited to accompany transit users riding bus service. It is easily accessible to bikers.

MAXIMUM EFFECTIVENESS[60]

One of the most successful light rail systems in the U.S. is the most recent to open. Dallas Area Rapid Transit (DART) is one of the most busily expanding lines in the country. Ridership is exceeding expectation. The 20-mile starter system is carrying 40,000 daily riders, which is a long way from the initial projection of 15,000. Dallas, Texas opened a 32 km line in 1996 and recorded patronage levels well in excess of predictions.

In San Diego, California the initial 25 km light rail line built in 1981 has become 77 km by 1997.

The light rail system in Portland, Oregon was an immediate success with 40 percent more passengers carried than predicted. Currently, a 29 km extension is now under construction.

Other major cities are experiencing light rail success in Baltimore, Los Angeles, Sacramento, and Denver.

Outside the U.S. other counties are experiencing successful light rail systems as well. One of the first cities in Europe to reintroduce trams reported an increase of 39 percent in ridership. As well in Europe, Strasbourg opened their system in 1994 and its success has reduced private car flow into the city by 17 percent. Paris is reported to be operating at 16 percent above predictions, and in Grenoble, their ridership increased by 50 percent.

7. High Occupancy Vehicle (HOV) Lanes

INTRODUCTION

High occupancy vehicles lanes (HOV lanes) have typically been reserved for one or more of the following: carpools, vanpools, buses, motorcycles and alternative fuel vehicles. Single-occupant vehicles buying into HOV lanes is being implemented and evaluated in several corridors.

HOV lanes can be a successful alternative transportation mode in areas with heavy traffic congestion. The first major HOV facility in the United States was implemented in 1969 on the Shirley Highway (I-395) in Northern Virginia**.** HOV facilities have proven to be flexible, cost effective alternatives for increasing the capacity of congested urban transportation systems. These lanes may be used to improve the mobility of a corridor by: increasing the people-moving capacity of the facility; providing a reliable travel-time savings to HOV users; and providing an incentive for people to share rides.

Travel time advantages serve as incentives for commuters to choose to ride a bus, vanpool, or carpool rather than drive themselves. Opportunities to expand high-speed facilities are limited. If appropriate corridors

[60] Fact Sheet Number 56 Light Rail Successes Despite Spurious Type Opposition, www.lrta.org/facts56.html.

are selected and operating properly, HOV lanes help assure that capacity will be available in the future to serve growth in personal travel.

High occupancy vehicle lanes are designed and operated in a variety of different configurations. Projects range from temporary restriping of shoulders to delineate HOV lanes to constructing exclusive roads or lanes reserved for HOV only. Traditionally, HOV facilities are implemented on freeways or expressways. However, HOV lanes may extend onto principal arterials that interface with higher speed facilities and have logical origin and destination points.

There are essentially five different types of HOV lanes used on freeways:

Concurrent Flow

This consists of a freeway lane in the peak direction of flow (normally inside lane) that is physically separated from the other freeway lanes but is designated for use by HOVs at least for a portion of the day.

Reversible Lanes

Some U.S. cities utilize reversible HOV lanes. These barrier-separated, single-lane facilities allow the traffic direction to be reversed based on peak flow. Lane signals and gates usually control these lanes. *(See Section 6 in TSM).*

Contra flow Lanes

Contra flow HOV lanes are found where low traffic demand in the off-peak direction will allow a lane to be "borrowed" for a HOV lane during peak hours. The contra flow lane is separated from oncoming traffic by movable concrete barriers on interstates.

The Lincoln Tunnel contra flow bus lane is an example of a well-utilized HOV lane. One of the few facilities in the country where buses are the main users of the facility, the contra flow lanes carries nearly half of all bus riders entering Manhattan CBD. The 2.5-mile facility, which opened in 1970, decreased bus commute times leading to increased ridership.[61]

Queue-Jumping Lanes

Queue-jumping lanes are highway lanes or intersections that high occupancy vehicles can enter directly, while other vehicles must wait in line to enter during a specific time of the day. Examples include HOV lanes at ramp meters, toll plazas and locations where intense gridlock, or isolated bottlenecks, usually occur.

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[61]*Simulated Travel Impacts of HOV Lane Conversion Alternatives, Center for Transport Studies, Department of Civil & Environmental Engineering, July 2000.*

HOT Lanes

HOT lanes allow single-occupancy vehicles to pay a toll to use the HOV lanes. A number of communities have installed electronic tolling systems on some of their HOV lanes as a way of "selling" unused capacity in a HOV lane (*See Section 9, Congestion Pricing*).

RANGE OF EFFECTIVENESS

Cities that have implemented HOV lanes into their transportation system have generally faired quite well. For example, the Bay Bridge between San Francisco and Oakland is one of the oldest and most successful uses of HOV lanes. The configurations of the bridge lanes have changed over time; the current bridge approach contains 22 lanes. Three lanes are dedicated to HOV use, saving carpoolers an average of 10 minutes during peak hours, and a $1 toll is collected in the other lanes. A recent traffic study reported that the average auto occupancy rate was 1.83 persons per vehicle, an increase of 38 percent over the average rate of 1.33 persons per vehicle prior to the introduction of HOV lanes. During the peak morning commute hour, carpool lanes carry 57 percent of commuters crossing the bridge in only one-quarter of the vehicles.

The design of HOV lanes in the Twin Cities Metropolitan Area consists of mixed-flow lanes, concurrent flow lanes and barrier-separated, reversible HOV lanes. The lanes are supported by a variety of elements, including two major transit stations, seven park-and-ride lots, ramp meters, HOV bypass lanes at selected ramps and three directly accessible parking garages in downtown Minneapolis, which offer discounted rates to carpoolers. HOV lanes on I-394 save two-person carpoolers an average of five to seven minutes per one-way travel. Approximately 48 percent of eastbound commuters use the Express Lane during peak hours.

Houston has 105 miles of HOV lanes, moving 96 to 228 percent more people per lane than general-purpose lanes. Nearly 5 percent of the city's workforce travels in reversible HOV lanes, which can be used by buses, carpools, vanpools and motorcycles. At peak congestion times, the minimum vehicle occupancy increases to three people. Houston also uses HOT lanes that for a fee allow carpools with two people per vehicle to use some designated HOV lanes during peak periods.[62]

Caltrans reports that Route 99 HOV Lanes carry 3,760 people per hour, compared to adjacent mixed-flow lanes, which carry 1,740 per hour. The benefit to carpoolers along Route 99 is around an average of 12-minute time-savings.[63]

The world's first automated toll road –a 16-k stretch of SR-91 in Orange County, CA which opened in December 1995 saves more than 20 minutes each way during peak hours. The four privately built and operated lanes, two in each direction, allow free travel to HOVs with three or more occupants, and variable pricing to other vehicles depending on time of day and day of the week.[64]

[62]*Georgia Department of Transportation, April 2001.*

[63]*Sacramento Metro Chamber, January 2002.*

[64]*Pricing Catches On*, Research & Technology Transporter, June 1997.

DATA COLLECTION

Data collection is needed to determine the potential effectiveness of the operation of HOV facilities. Obviously, data on the split among 1 person, 2 person, and 3+ person vehicles helps. Estimates of travel time, vehicle occupancy, park-and-ride usage and knowledge of trip length on the facility are also valuable.

DESIGN CRITERIA/LOCAL LOCATIONS

Within the Inter-Regional Corridor Alternatives Analysis, HOV lanes were discussed and recommended in the Locally Preferred Alternative.[65] HOV lanes on Interstate-15 are recommended from 10600 South in Sandy to University Parkway in Provo, located in Utah County. The HOV lanes (one in each direction) would extend from the current Interstate-15 HOV lanes and have similar physical and operating characteristics. These lanes would be in addition to two new general-purpose lanes along the same segment. The HOV facility would be buffer-separated from general traffic lanes and have an occupancy requirement of two or more persons per vehicle during the peak period. Buses, motorcycles and emergency response vehicles could also use the restricted lanes.

INTERACTIONS

In addition to designating a priority lane for HOV use, successful HOV projects have included complementary improvements. Physical improvements such as park-and-ride lots and HOV bypass ramps are generally incorporated into HOV facility designs. Other supportive improvements include carpool and vanpool programs, parking policies, employer/public relations, and marketing. A combination of several of these strategies usually produces a successful and accepted HOV project. ITS technology, including ramp metering and automated vehicle applications, could also be integrated beneficially with HOV designs.

MAXIMUM EFFECTIVENESS

The following conditions are necessary to make HOV an attractive alternative:

- General support should exist from the agencies involved and the public.
- Intense recurring congestion must exist on the freeway general-purpose main lanes. The travel patterns on the freeway should be conducive to being serviced by rideshare (bus, vanpool, carpool)
- The HOV lane design should allow for safe, efficient, and enforceable operation.

There has been debate on the usefulness of HOV lanes. Not all HOV lanes have been as effective as the Shirley Highway and California State Route 91.

The Dallas-area HOV lanes studied operate on I-30, I-35 east, and I-635. Since opening, each of the lanes has seen a significant increase in carpooling-ranging from a 79 percent increase to a 296 percent increase.[66]

[66] *Dallas HOV Lanes Get the Job Done*, Texas Transportation Researcher, Volume 38, Number 2, 2002.

8. Walk / Bicycle

INTRODUCTION

The Utah Department of Transportation (UDOT) and the Office of Program Development have implemented a statewide pedestrian and bicycle plan that has been adopted since February 2001.

This plan was prepared in compliance with the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the Twenty-First Century (TEA-21) in 1998.

The goals and objectives of the plan are to: (1). construct and maintain pedestrian facilities, and (2). provide for the safety of non-motorized and motorized State transportation system users. *(For more information see the Statewide Pedestrian and Bicycle Plan.)*

Increasingly, transportation officials are recognizing the increased use of bicycles and walking as viable transportation modes. While recreational cycling/walking still predominates in the USA, the number of people using bicycles/walking for commuting and other travel has been increasing since the early 1970s.

There is an interesting statistic with regard to bicycles, as an example of their increased popularity. From 1971 through 1985, more bicycles were sold than cars. A relatively small percentage of commuters has always either walked or biked to work. According to the 2000 Census current percentages are as follows:

	County		
	Salt Lake	Davis	Weber
	(Percent)		
Walk	2	1.4	1.6
Bike	1.2	0.8	1.1

Generally, land use patterns, weather, and topography influence the degree to which biking and walking are used as modes of transportation. For example, relatively small, densely populated college towns have the highest percentage of cyclists and pedestrians as a transportation mode (i.e. Boulder Colorado, Eugene Oregon, Iowa City Iowa, Ann Arbor Michigan, and Champaign Illinois). Areas of this size, density and socio-economic makeup can have more than 20 percent of the commute trips by biking or walking.

Bicycling and walking have been successful in some large metropolitan areas as well. Seattle and Portland are recognized for their programs. Other established, generally older urban areas have long had a tradition of walking or biking. New York City, for example, is generally an area of dense, mixed land uses (i.e. commercial/office/residential). Since many residents live in or near the CBD, owning a car is often not necessary, and hence many walk to work or shopping.

RANGE OF EFFECTIVENESS

The trip lengths of bicyclists and pedestrians are, for the most part, relatively short. The 1990 Census (Personal Transportation Survey) indicates that about 28 percent of all trips are less than one mile in length, which is considered a comfortable walking distance. About 40 percent of all bike/pedestrian trips are less than 2 miles in length, and almost 63 percent of all of these trips are within 5 miles. In most cases, a 5-mile distance can be considered well within the ability of the average person on a bicycle.

Safety is and should be a concern whenever bike/pedestrian facilities are proposed. The feeling of the lack of safety is one of the most frequently cited reasons people of all ages do not walk or ride their bicycles. Safety concerns range from personal security to fear of motor traffic. Many times bicyclists have accidents when they violate traffic rules. For example, a recent study found that bicycling against traffic increases accident risk by 360 percent, and bicycling on the sidewalk increases accident risk by 180 percent. Safety concerns are greatest in areas where the streets are the most congested.

A 1993 Federal Highway Administration study shows that cities with higher levels of bicycle commuting have on average 70 percent more bikeways per roadway mile and six times more bike lanes per roadway mile. Communities across the country are realizing that something as simple as a 4-foot wide bicycle lane is enough to transform potential cyclists into actual riders. A 1996 study on the impact of bicycle lanes in Santa Barbara found that streets where bike lanes were added saw the number of bicyclists increase by 47 percent compared to just one percent on streets without bike lanes.

AASHTO's *Guide for the Development of Bicycle Facilities, 1999;* US DOT's *Manual on Uniform Traffic Control Devices*; FHWA's *Improving Conditions for Bicycling and Walking;* FHWA's *Conflicts on Multitple-Use Trails: Synthesis of the Literature and State of the Practice*; and Weber State University's *Bicycle and Pedestrian Planning Guide for Utah* are excellent references not just for planning and design aspects, but for safety issues as well.

DATA COLLECTION

Planning for bicycles and walking begins with observing and gathering data on the existing conditions of travel, such as problems, deficiencies, safety concerns, and needs. Census data, home interview surveys, bicycle/pedestrian/vehicle counts, rights-of-way, non-motorized vehicle facilities, bus and truck traffic, and speeds of traffic should be considered.

Bicycle and pedestrian counts can be used to identify locations of frequent use. However, these counts are not always indicative of the existing or future demand. Many potential walkers or bicyclists will not make trips with this mode, and are forced into cars simply because available streets are unsafe and/or unattractive. This is particularly true when there are relatively long stretches of roads that have no sidewalks to walk on, or shoulders to ride bikes on. Therefore, traffic generators along a prospective route should be evaluated as to the potential bicycle and pedestrian traffic they would generate, given better conditions for bicycling and walking.

DESIGN CRITERIA/LOCAL LOCATIONS

To be effective congestion management tools, biking and walking should be carefully planned. With bicycling and walking, there are both distance and safety thresholds as far as a willingness to travel is concerned. With regard to distances for bicycling, national surveys estimate an average-maximum benefit of 4 to 6 miles. For walking, the distance threshold is about one mile.

According to AASHTO, bicycle traffic usually is generated where residential areas are close to accessible destinations. Areas near bicycle traffic generators should be reviewed, and existing and potential bicycle users identified. Examples of bicycle traffic generators include major employment centers, schools, parks, shopping centers, neighborhoods, recreational facilities, colleges and military bases. Convenient access and bicycle parking should be provided at transit stations, ferries and other intermodal transfer points.

In the Salt Lake/Ogden area, there are numerous activity centers that are good candidates for generating bicycle and walking traffic, such as the University of Utah, the Salt Lake City CBD, Hill Air Force Base, Weber State University, Salt Lake Community College, the Salt Lake County Government Center, State Office Building, UDOT Calvin L. Rampton Complex, and other major employers. The University of Utah and Downtown Salt Lake City have a very active bike/pedestrian community. Salt Lake City has a full-time alternative modes coordinator whose function is to further and encourage the use of bicycles and walking as a mode choice, particularly in the downtown area and the University of Utah. In addition, UDOT's Bicycle and Pedestrian Coordinator has been active with the University and other biking communities. As far as congestion management strategies are concerned, the development and implementation of bicycle and/or pedestrian facilities should be given priority at the generators mentioned previously.

AASHTO recently updated their "Guide for the Development of Bicycle Facilities" in 1999. This manual is very helpful for both planning and design issues. The Design guidelines from this manual should be used as much as possible. The MUTCD also is useful for proper signing and marking of bicycle and pedestrian projects.

Salt Lake City, Salt Lake County, Sandy, Ogden, and other communities along the Wasatch Front have developed a number of bicycle lanes, and routes on existing streets. In addition, several bicycle lanes and paths have been provided or planned in the Salt Lake and Ogden Urbanized Areas, including shared pathways along the Jordan River Parkway and the Bonneville Shoreline Trail.

INTERACTIONS

Biking and walking are the most energy efficient transportation modes. Bicycling reduces traffic congestion. Bicycle trips can replace many short automobile trips.[67]

However, there are a limited number of commuters who will switch due to the obstacles, such as traffic, weather, hills, etc. According to many surveys, those commuters likely to switch are those who currently use transit, and also are recreational or infrequent utilitarian cyclists or walkers. This means that even though more commuters may switch to walking or cycling, they are not necessarily leaving their single-occupant vehicle to do so.

Multi-mode bicycling and walking have the potential for some congestion relief. For example, transit combined with walking or biking can reduce trips, and have an impact on the mode split (more transit as a result of the passengers' increased flexibility). UTA allows bicycles on most of its bus and TRAX routes. This strategy has proven effective in creating more bike trips and increasing transit ridership, which reduces auto trips. Several park-and-ride lots are planned throughout the area. These facilities help reduce single-

[67] United States Department of Transportation, 1990.

occupant trips. Bicycle storage facilities should be incorporated into the design of these new lots. Once again, that will increase the options for the current and potential non-traditional commuter. The more flexibility a mode has, the greater its attractiveness.

MAXIMUM EFFECTIVENESS

Overall, in the Salt Lake/Ogden area, increasing the use of bicycles and walking as a congestion mitigation strategy has a relatively small effect. However, there are certain areas where it can have a fairly significant effect, such as universities, community colleges, downtown, and large employment centers.

In the short term, this strategy is probably not as effective as it could be because of existing land use patterns, parking availability and the relative lack of bicycle and pedestrian facilities and amenities.

In the long term, there is considerably more potential for congestion mitigation effectiveness. It is anticipated that many more bicycle and pedestrian projects now being planned by the communities along the Wasatch Front will be in place, and that future land uses may become more conducive to bicycle and pedestrian use. With these developments, more biking and walking facilities will be incorporated into the various designs of future transportation projects. The anticipated future increase in urban densities and more mixed-use developments in certain areas of the Salt Lake/Ogden region will improve the effect of biking and walking. In addition, the gradual improvement in the bicycle and pedestrian "friendliness" of the area, bike racks on transit, bike storage facilities at transit stations and park-and-ride lots, and the like, will help to make it possible to reach the potential usage of bicycles and walking.

9. EMPLOYER COMMUTE / TRIP REDUCTION ORDINANCES

INTRODUCTION

TDM is an effective way for local governments to reduce traffic congestion and improve roadway levels of service. However, the effectiveness of public TDM programs depends upon private sector participation. Prior to the 1980's, local governments relied on voluntary participation of the private sector in TDM initiatives. But voluntary cooperation was difficult to achieve in all but those areas where traffic congestion had already reached extreme levels. Increased demand for new roadways and declining revenue sources often left local governments unable to finance the needed roadway improvements in the 1980's. As a result, more emphasis was placed on managing transportation demand. A regulatory alternative that emerged is the trip reduction ordinance (TRO).

A TRO is a regulatory tool for mandating participation in TDM. Generally a TRO requires certain organizations, such as major employers or developers, to plan and carry out measures aimed at reducing the number of single occupant vehicle trips generated to and from a given location. In 1984, the first two TROs appeared in California. The initial success of these two initiatives brought TROs into the national spotlight. Today, over 50 TROs are in effect across the country.

Trip reduction ordinances were created as a way to alleviate traffic congestion in a small geographic area. Some county and regional bodies have enacted area wide TROs. New federal legislation has given rise to regional and even statewide mandates for adoption of TROs.

RANGE OF EFFECTIVENESS

Washington State implemented a TRO in 1991 and revised it in 1997. This program reduced peak- period trips by 25 percent in 1999 and a 35 percent reduction is expected by year 2005.for employers with more than 100 employees.[68]

The TRO program implemented at Kaiser Permanente, one of the largest health care providers in northern California, resulted in nearly one-third of the work force using transportation alternatives an average of three days per week, which eliminates 48 million miles of vehicle travel per year.[69]

The City of Kent, King County Metro, and the Washington State Department of Transportation created a collaborative partnership among major employers. In 1999, the TRO program removed 18,500 vehicles every morning from the state of Washington's roadways.[70]

There are successful mobility management plans implemented by well known companies in other countries:[71]

- In Belgium, only 30 percent of Ford Motor Company employees drive to work alone.
- Twenty-seven percent of the employees of Novartis in Switzerland journey to work by cycle.
- Pioneer Pacific Station Tower in Vancouver, British Columbia has created an extremely effective program. Fifty percent of their employees use transportation alternatives.

DATA COLLECTION

Participation rates for TDM programs, surveys, monitoring transit ridership, VMT, and auto/transit mode split are useful tools when determining if these programs and TROs are having an impact. Also, employers and developers must collect information on employees' commute behavior in order to measure the success of the TDM program.

DESIGN CRITERIA/LOCAL LOCATIONS

Large employers (employees of 100 or more) have typically been the target for implementing TRO programs. However, studies have shown that this has been poorly targeted. This approach affects a relatively small percentage of the commuter fleet. Based on experience in Los Angeles, studies show that work trips to major employment sites (of 100 or more employees) only account for about 40 percent of total work-related travel. Work-related travel, in turn, only represents approximately 26 percent of all trips and 32 percent of vehicle miles traveled on an average annual basis.[72]

In 1995 Davis and Salt Lake Counties, implemented an Employee-based TRO program which has recently been revised to extend to 2007.[73]

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[68] Washington State TRO Law, www.wsdot.wa.gov/pubtran/ctr.

[69] Kaiser Permanente, www.epa.gov/oms/transp/comchoic/waytogo.htm.

[70] Commute Trip Reduction, www.ci.kent.wa.us/PublicWorks/SpecialPrograms/ctr.htm.

[71] *Mobility Management Measures in Companies*, 2002, www.mobilitymanagement.be/english/fame.htm.

[72] Kenneth P. Green, Looking Beyond ECO: Alternatives To Employer-Based Trip Reduction, March 1995.

[73] Rule R307-320, www.rules.utah.gov/publicat/code/r307/r307-320.htm.

There are 73 companies along the Wasatch Front that participate in the 7 rideshare programs available. As a result, the solo occupant driving rate has decreased from 81 percent to 55 percent between 1994 and 2000 at these companies.[74]

Barriers

There are barriers associated with implementing TRO programs. These barriers include: lack of support, resistance by employers and employees, and contradictory employment practices (such as inflexible work schedules).

There are some guidelines which may be helpful in order to implement an effective TRO program.

- Make TRO programs diverse and flexible to meet employees' varying needs. Design programs to support a variety of choices and incentives.
- Provide positive incentives, including improvements to alternative modes (rideshare, transit, cycling, walking), financial incentives, and support services such as Guaranteed Ride Home programs.
- Involve employees in program planning and marketing.
- Encourage the concentration of employment into large commercial centers with quality public transit service, and appropriate amenities such as shops and services within convenient walking distance.
- Implement Parking Management (*See Parking Management/Increasing Parking Costs, Section 11*).
- Form Transportation Management Associations (TMA) so employers can coordinate their TRO programs.

INTERACTIONS

TRO programs support and are supported by most other TDM strategies, particularly parking management, parking pricing, ridesharing, pubic transit improvements, nonmotorized travel, and smart growth.

MAXIMUM EFFECTIVENESS

Along the Wasatch Front, TROs have reduced 3 million VMT per year from employer TDM programs.[75]

University of Illinois at Champaign-Urbana serves over 100,000 students, facility, and staff. In 1988, the rising number of solo commuters contributed to a serious parking shortage. However, instead of building additional parking lots, the university looked to TDM strategies which have increased transit ridership by nearly 150 percent since the program's inception. As an incentive to use commute alternatives, students and faculty are required to pay a transportation fee which entitles them to unlimited access to local transit, and local planners have raised the annual campus parking fee from $78 to $200.[76]

[74] UTA Rideshare, 2000 Annual Report.
[75] Utah Transit Authority CM/AQ Submittal.
[76] Robert Patton, Senior Planner, University of Illinois.

10. CONGESTION PRICING

INTRODUCTION

Congestion pricing is a method used to charge a premium to motorists that desire to drive during peak travel periods or on congested facilities   In a theoretical sense, this pricing technique is promoted by economists as a practical means of allocating limited resources, i.e. highway capacity during the peak travel periods.

Congestion pricing and other forms of road pricing are controversial yet potentially effective means of improving traffic flow and reducing congestion-related pollution. Such strategies use pricing (e.g. during peak driving periods) to create incentives to change travel behavior. Many researchers strongly endorse road/congestion pricing as a potentially effective strategy to reduce SOV travel while funding alternative transportation modes. Some believe that ITS technologies such as electronic toll collection can facilitate such a strategy.

The Federal Highways Administration utilized a value pricing pilot program to learn the potential of different value pricing approaches for reducing congestion. Two important findings resulted; which conclude that drivers do alter their behavior in response to value pricing and highway users are receptive to value pricing if it can be shown to provide them with improved transportation services.[77]

An excellent example of successful congestion pricing is the four new lanes in the median of California State Route 91. This is the first commercial test of congestion pricing in the United States. Ninety-One Express Lanes is the world's first automated toll road; the first implementation of congestion pricing on a U.S. toll facility; and the first toll road to be privately financed in the U.S. in more than 50 years. Upon completion of construction the developer and builder, the California Private Transportation Company, transferred the project's ownership to Caltrans and now leases the facility back from the agency.[78]

HOT Lanes

High Occupancy Toll (HOT) lanes are HOV lanes that also allow lower occupancy vehicle users if they pay a toll. This allows excess HOV lane capacity to be used while maintaining an incentive for mode shifting. HOT lanes are often proposed as a compromise between HOV lanes and road tolling as a solution to traffic congestion.

Interest in HOT lanes has grown since the opening of the State Route 91 Value-Priced Express Lanes in Orange County in December 1995. These lanes have significantly reduced congestion. In San Diego, the reversible HOV lanes on Interstate-15 were converted to HOT lanes in early 1998. Reaction to these lanes has been favorable.

HOT lanes have now become widely accepted in the industry, thanks to the success of these projects. According to a recent report by the Reason Public Policy Institute, consumer demand is growing, and HOT lanes are "on the drawing board, in process, or operational in some 20 locations in 9 states."[79]

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[77] *The Price of Congestion*, Transportation Management + Engineering, August/September 2002.

[78] *High-Occupancy Vehicle/Toll Lanes: How Do They Operate and Where Do They Make Sense?* Intellimotion, Volume VIII, No. 2, 1999.

[79] *ITE Journal,* High-Occupancy/Toll (HOT) Lanes and Value Pricing, June 1998.

A variation on HOT lanes is used on the Katy Freeway in Houston, Texas. HOT lanes on Highway 1 in Santa Cruz, California, have been approved and additional HOT lanes have been studied in Sonoma County and Southern California.

"FAIR" Lanes

Fast and Intertwined Regular (FAIR) Lanes are a form of congestion pricing in which revenues from electronic tolled lanes are credited to motorists using adjacent lanes (DeCorla-Souza, 2000). This is intended to overcome political objections to congestion pricing by insuring that all road users directly benefit: people who choose to pay for use of tolled lanes benefit from reduced congestion, and those who use other lanes benefit from financial credits.

The concept involves separating freeway lanes using plastic pylons and striping into two sections: Fast lanes and Regular lanes. The FAIR lanes will operate for the entire length of the bottleneck segment of the freeway, so that there will be no congestion back up into the Fast lanes at the point where Fast and Regular lanes merge downstream. The Fast lanes would be electronically tolled express lanes, where tolls are set in real time to limit traffic to the free-flowing maximum.

Types of Congestion Pricing

- Parking surcharges in congested areas.
- Point pricing at a specific location.
- Cordon pricing in which charges are affixed to any vehicle crossing a boundary.
- Zone pricing in which vehicles in a particular zone are charged a fee.
- Prices based on distance traveled in congested areas.
- Congestion-specific pricing which is a combination of distance traveled and time spent in travel.

RANGE OF EFFECTIVENESS

In Houston, Texas high-speed electronic toll lanes collect about 40 percent of the 270,000 daily tolls. Value pricing has also been successfully carried out in California and Florida.

A case study revealed on Interstate-15 HOT lanes in San Diego, carpools increased by 30 percent after the HOV lanes were converted to HOT lanes. [80]

In 1998, the 60-mile Washington D.C. Beltway had over 19 miles with more than 200,000 ADT, with its highest segment carrying 262,400 ADT. Performance impacts of FAIR lanes show an increase in the number of vehicles during the PM peak period from 23,200 vehicles to 27,600 vehicles in each direction. The delay is cut in half and average speed over all lanes for a four hour period increase from 25.5 mph to 38.3 mph.[81]

Implementation Challenges

[80] *ITS Decision*, Congestion Pricing, June 6, 2000.

[81]*ITS Quarterly*, Spring 2000 issue, Volume VIII, No. 2.

Most technological components for congestion pricing (electronic toll collection systems) have been tested and demonstrated throughout the world and are ready for widespread deployment.

The main challenge to the implementation of congestion pricing is opposition from groups who consider themselves worse off once pricing is established. Users generally accept congestion pricing on a single lane that was not previously available if other lanes are free, as with HOT lanes. Where all previously free lanes are tolled, there is often opposition because the toll is perceived as double taxation and because of hardship on less affluent people. One of the big lessons learned from many of the congestion pricing projects is that marketing, public education and involvement with the project, and transparency in terms of toll revenue redistribution are essential to gain wide support for the project.

DESIGN CRITERIA/LOCAL LOCATIONS

Generally, toll facilities are successful if there are physical constraints to overcome so that there are a limited number of entry or access points. Tunnels and bridges have been financed by tolls in other parts of the country. Long stretches of high speed (expressways and freeways) road with limited or out of the way alternatives have also been funded with tolls in various parts of the country. In Utah (including the Salt Lake Area), there are long stretches of highway with limited travel options which may be candidates for tolls, but they are generally remote and do not experience peak delays. To the extent that toll roads may be feasible financing options and that those roads may experience peak delays, marginal cost pricing may be considered in the local area.

Presently, there is one toll road in effect in the South Ogden area, Adams Avenue Toll Road. At this time, daily usage for this toll road is about 900 vehicles per day. This particular road is mostly used for work trips. Fees are $1 for the toll road. Available payment methods are cash and credit card. Placements of bar codes on the side of vehicles are also offered. In the future there are plans to implement a transponder for use on the dash or sun visor of the vehicle.

INTERACTIONS

Congestion pricing can have a number of travel impacts depending upon the variability and steepness of prices, the price elasticity of drivers, the level of availability of travel alternatives, schedule flexibility (Economists measure price sensitivity using elasticities, which is defined as the percentage change in consumption caused by a percentage change in price -"prices" in this case represent perceived user costs, which can include money, time, and discomfort- So for example, a price elasticity of -0.1 for urban highways would indicate that a 10 percent increase in tolls would reduce vehicle use by 1 percent).

Potential travel impacts are:

- A change in the time of travel: shift of peak to off-peak traffic with a consequent reduction of peak period traffic and a potential reduction of total traffic
- A shift in mode: from automobile to alternative travel modes (transit, carpooling, cycling etc.)
- A shift in routes: to untolled roads or less tolled roads.
- Linked trips: more combination of activities on a single trip
- A change in destination: for non-work trips, shorter trips would potentially be made; for work trips there could actually be changes in work or residential location
- Land use: in the long run, particularly if there were congestion pricing on a regional level, land use patterns would be affected. It's still unclear in what ways land use could be affected. Some argue that it would discourage sprawl; others believe it would increase decentralization.

Marginal cost pricing can be designed to complement most congestion management options. The problems appear to be more political. Marginal cost pricing will raise the cost of travel to commuters, although arguably to reflect the true cost of pollution and congestion imposed on others. If the additional revenue collected were used to promote alternative modes such as transit and ridesharing, marginal cost pricing would complement these measures. However, experience in other areas has been that politicians view the marginal cost charges as revenue, which should be used to build more roads and ease the congestion, which they are "taxing." Therefore, while marginal cost pricing can be viewed as a revenue stream, which is neither necessarily competing against nor complementing other measures, it can have positive effects toward true trip reduction of discretionary trips by its very nature.

MAXIMUM EFFECTIVENESS

The Utah Department of Transportation has proceeded with a "pay as you go" financing philosophy. Marginal cost pricing has been suggested to accompany other financing options such as toll roads or parking surcharges. It is doubtful that the UDOT will look toward marginal cost pricing as a means of revenue financing in the near future. Although this point does not preclude marginal cost pricing, since this pricing can stand on its own economic merits, experience in other areas has shown that the political attraction of marginal cost pricing is typically the ability to gain additional revenue. Therefore, marginal cost pricing is not presently anticipated to be implemented in the near term. In the longer term, there may be a few individual streets where marginal pricing controls can be looked at in the form of increased tolls or parking charges at certain high demand periods, but it is again doubtful that these controls will be accompanied with real single occupant vehicle reduction (or peak reduction) incentives other than the direct additional cost of travel.

In terms of congestion reduction, the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area estimates that raising the Bay Bridge toll from $1 to $3 (excluding low-income drivers) during the morning rush hour would reduce traffic by 7 percent (Marshall, 1994).

11. PARKING MANAGEMENT/INCREASE PARKING COSTS

INTRODUCTION

Parking management is an essential tool for managing transportation demands. Parking management is a set of strategies used to balance the supply and demand for parking. To be an effective part of a regional congestion relief or mobility enhancement strategy, parking management should be implemented at an area-wide level. The development and management of parking supply involves many public and private sector groups. Government agencies set parking requirements in codes, some localities build and manage parking facilities, almost all communities regulate on-street parking, and often local governments regulate parking rates. Private commercial parking lot operators provide a substantial amount of parking space in most urban areas. Developers provide parking as part of development projects, and retailers often provide large amounts of parking for easy automobile access.

An area-wide parking management strategy relies on two key components: pricing and supply management.

Pricing

Most employees who receive free parking do not think of it as a perk. The challenge with this option is to alter employee thinking so that parking is viewed as a benefit, not a guarantee. Parking Management encourages employees to use shared commute methods by making single-occupancy vehicle (SOV) travel less convenient and/or more expensive. Most effectively employed in the suburbs, where parking is viewed as plentiful and inexpensive, this approach treats parking as a privilege.

Proven methods of parking management include:

- Charging a fee for parking if it is currently free.
- Establishing a "cash out" program whereby all employees are given a transportation subsidy. Those employees who choose to drive must pay a fee for parking equal to that of the subsidy; those who use transit, vanpools or carpools can keep the subsidy to help pay those costs.
- Offering prime, preferential spaces to those who carpool and vanpool regularly.
- Renting spaces for use by other businesses, or for park-and-ride.

These programs can also be beneficial to employers by eliminating the need for additional lot construction and reducing maintenance costs. With a cash out system, employees who currently drive do not suffer negative consequences, and those who do not drive now receive a subsidy for their efforts.

Parking Plan

A well conceived parking plan should include:

- An assessment of current conditions
- An analysis of current demand
- Recommended changes and systems required to increase the effectiveness of the current parking supply
- A parking development strategy that includes recommendations on the supply and pricing of parking in the community.

- Recommended revisions to parking regulations that reinforce flexibility and encourage such things as shared parking, fee in lieu of required parking development, allowances for off-site or satellite parking, incentives for development of ridesharing, and incentives or parking credits for development near transit stations.

Strategies[82]

Parking management includes various strategies that result in more efficient use of parking resources. Parking management can help address a wide range of transportation problems. For a list of these strategies refer to, *Parking Management, Strategies for More Efficient Use of Parking Resources*, Online TDM Encyclopedia, Victoria Transport Policy Institute, www.vtpi.org/tdm/tdm28.

RANGE OF EFFECTIVENESS[83]

Parking requirements can be reduced at sites that implement TDM programs. For example, parking requirements can usually be reduced 10 to 30 percent at sites with Commute Trip Reduction programs or Location Efficient Development without problem.

Cashing out parking means that commuters who are offered subsidized parking are also offered the cash equivalent if they use alternative travel modes. This tends to reduce automobile commuting by 15 to 25 percent, and is fairer since it gives non-drivers benefits comparable to those offered motorists.

DATA COLLECTION

Surveys of employers and other parking providers can be conducted to assess parking cost and availability. Questions can be directed to employees to determine the effect of parking cost and availability on mode choice.

DESIGN CRITERIA/LOCAL LOCATIONS

Parking management needs to be implemented at an area-wide level in order to be an effective part of a regional congestion relief or mobility enhancement strategy. An area-wide parking management can have a dramatic impact on travel behavior. An area-wide program would be an important incentive in encouraging travelers to use alternative modes of transportation. Such a strategy relies on two key components: pricing and supply management.

Parking requirements and management practices tend to vary depending on land use and geographic conditions. Parking demand in an area increases with population and employment density, and facility costs tend to increase with land values. As a result, parking congestion problems (i.e., inadequate parking supply in a particular area) tend to be greatest in busy commercial and high density residential areas.

Parking Management often involves making the most convenient parking spaces available to priority uses. Parking facilities must be located near destinations. Exactly how near depends on the type of land use and the type of user.

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[83] Parking Management, Strategies for More Efficient Use of Parking Resources, Online TDM Encyclopedia, Victoria Transport Policy Institute

Currently, parking management is minimally deployed in the region, primarily by local universities and the Salt Lake City International Airport. These systems utilize advanced signage and lot detection to warn drivers when lots are at full capacity and direct them to other parking areas. Some cities have begun to use parking management as a tool to encourage alternative modes. For example, Salt Lake City set maximums on parking spaces instead of minimums.

INTERACTIONS

Parking management programs work tools work well with TDM strategies like commute alternatives, transit and rideshare services and park-n-ride lots.

MAXIMUM EFFECTIVENESS

There are several documented cases of dramatic declines in solo driving and trip making resulting from employers imposing parking pricing, or removing employee parking subsidies, whether alone or in combination with alternative mode programs. Examples span suburban, urban and downtown areas.

In suburban settings, both public and private employers have reduced solo driving through a combination of pricing strategies and alternative mode programs such as carpool and transit encouragements. Cases summarized in the literature illustrate the possible range of reduction in solo driving

- 12 percent reduction in the case of the Nuclear Regulatory Commission compared to before pricing (though the 42 percent solo share is about 40 percent below solo shares of other employers in the area)
- 17 percent less for Bellevue City Hall compared to before pricing
- 25 percent less for CH2MHill compared to before pricing
- 25 percent decline in the case of Twentieth Century Corporation
- 40 percent lesser proportion of solo drivers at Pacific Northwest Bell compared to other employers in the area.

In an urban but not downtown setting, Commuter Computer outside the Los Angeles central business district dropped the drive alone share from 42 percent to 8 percent by eliminating free parking. Clearly, increased parking rates decidedly influence trip making and parking behavior.[84]

An Above-Average Example of a Car Parking Cash Out Program

CH2M Hill is a Bellevue, Washington engineering firm with 430 employees. The table shows mode choice for employees who chose not to drive to work.[85]

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[84] *Park Pricing, U.S. Department Of Transportation Federal Transit Administration.*

[85] *Modern Transit Society, September 1998.*

Table 3

Effective Changes in Mode Choice

Mode	Before (%)	After (%)
Drive Alone	89	54
Car Pool	9	12
Bus	1	17
Walk/Bike	1	17
Total	100	100

12. Increase Gas or Auto-Related Taxes/Fees

INTRODUCTION

Fuel taxes are an effective means of generating revenue for transportation improvements. Fuel tax as a revenue generator has been the basis for most of the highway infrastructure finance in the United States over the past 40 years.

WFRC's Long Range Plan assumes that gasoline and special fuel taxes available for highway funding will increase by five cents per gallon approximately every six years. This assumption is based on historical trends. In addition to the gas tax, the legislature has also programmed over $100 million statewide in state general funds for highway projects.

Other State revenues were assumed to increase at moderate rates. User fees and permit revenues were assumed to grow at rates consistent with historical trends, yielding a total of $441.7 million in 2015.

Alternative Fuels

Taxation of alternative fuels can complicate the revenue-raising efforts of all levels of government. Alternative fuels are not taxed in Utah, but a tax credit is given to those who convert their vehicles to run on alternate fuels.

Auto-Based Taxes/Fees

Municipalities have several sources of locally generated automobile-based revenues. These revenues are registration fees, licenses and permits, traffic fines, meter and parking fees, traffic and parking fines, tolls, and county/state grants.

New technologies on vehicle identification and monitoring provide for some different approaches in assessing vehicle utilization. Three such taxes that have been proposed include a tax on vehicle miles traveled (VMT tax), an emissions-indexed VMT tax, and congestion taxes *(See Employer Commute/Trip Reduction Ordinances, Section 9).*

A vehicle miles traveled (VMT) fee is a road use fee based on miles driven. A VMT fee could be based on odometer readings or by using more sophisticated technology to track mileage.

An emissions-based VMT fee would be charged at a rate determined by a vehicle's level of pollutant emissions. Emission fees provide incentives for reducing VMT as well as improving the emissions of the vehicle. Revenues generated would be used to subsidize low-income household transportation or support transit or ridesharing programs.

RANGE OF EFFECTIVENESS

Fuel taxes are an effective means of generating revenue for transportation improvements. Users of the highway system contribute in the order of 57 billion dollars towards possible investment in road improvements covering approximately 84 percent of the transportation expenditures of all levels of government in the United States.[86]

Currently, the state of Utah imposes a 24.5 cent per gallon of gasoline local/state tax and the federal tax is 18.4 cents per gallon. Seventy-five percent of the state tax is allocated to the Utah State Transportation Fund and the other 25 percent goes to the cities and counties. In comparison to other states, Utah ranks 44th among the highest, with Georgia being the lowest taxed state at 7.5 cents per gallon and New York the highest at 31.75 cents per gallon.[87]

Although fuel taxes have traditionally been the major source of highway revenues; there are several concerns with the stability of this funding source over the next 20 years. Revenues from fuel taxes will fail to keep pace with inflation. Indexing fuel taxes to the price of fuel can provide a roller coaster effect, with the revenues increasing or decreasing depending on fuel price.

Fuel taxes will likely remain the major source of transportation revenue in the foreseeable future. For this reason officials should consider looking at a variety of funding sources so that a transportation program is not dependent on one source of funds.

In debates on raising the gas tax, opponents claim that a gas tax increase will have a serious economic impact on a region's or state's economy. This impact is described in terms of jobs lost and reduced economic competitiveness. Therefore, impacts of raising fuel taxes must be carefully considered before undertaking such action.

DESIGN CRITERIA/LOCAL LOCATIONS

Legislation and/or a referendum are usually required to implement a gas tax. Because of this, the politics surrounding a proposed gas tax can be quite volatile. Experience from successful efforts in the U.S. suggests that the following steps are necessary to increase a gas tax:

- Clearly define in understandable terms the needs that will be addressed by increased funding.
- Develop a comprehensive package of transportation improvements so that voters can see what they will get for increased taxes.
- Create a consensus among transportation agencies that an increase is necessary.
- Have advanced negotiations with key actors in the policy process (e.g., governor, legislative leadership, business community, transportation, organizations, environmental groups, etc.).
- Provide opportunities for public input and build support among public groups.

[86] Bureau of Transportation Statistics, 2000.
[87] *The Utah Taxpayer,* Volume 25, Number 4, April 2000.

- Establish a credible focal point of overall leadership.

INTERACTIONS

Auto-related taxes and fees are compatible with Congestion Pricing *(See Section 9)* as strategies for revenue sources to obtain transportation financing.

MAXIMUM EFFECTIVENESS

In most cases, auto-related expenditures exceed revenues. This is due to most states and communities in the US, gas taxes, registration fees, parking fines and fees, and other automobile-generated revenues are set and distributed to local governments at levels that are barely adequate to cover the costs of construction and paving projects. Some of these funds collected are being diverted to supporting alternatives to make cities less auto dependent.[88]

For the Salt Lake/Ogden area, nearly 10 billion in revenues from gas taxes and highway user fees are projected to be available over the next 30 years after maintenance and operating costs.[89]

SUMMARY

With a realization that future provisions of additional highway capacity will likely never exceed demand, many non-traditional measures may help reduce demand or increase supply. All of these strategies can be expected to have related air quality benefits, which have not been quantified. Tables 4 and 5 describe the locations and conditions where these strategies are effective.

Table 4
WHERE EFFECTIVE - SYSTEM MANAGEMENT STRATEGIES

DESCRIPTION	WHERE EFFECTIVE
1. Signal System Improvements / Coordination	All Arterials Where Signals Are Spaced >= 3 Per Mile, Signalized Intersections
2. Capacity Additions	Arterial Segments, Especially At Bottlenecks
3. Access Management	Arterials, Arterial Intersections
4. Intelligent Transportation Systems (ITS)	Freeways, Other Arterials
5. Incident Management	Freeways, Principal Arterials
6. Reversible Lanes	Freeways = 60/40 Directional Split, Right of Way Limitation, and Low Left Turn Demand (arterials only)
7. Ramp Metering	Freeways with adequate ramp and cross street capacity
8. Improving Intersection / Interchange Geometrics	Intersections, Interchanges

[88] *Cities for Climate Protection,* International Council for Local Initiatives (ICLEI), 1999.
[89] Wasatch Front Urban Area Long Range Plan Transportation Plan 2002-2030 Financial Plan.

Table 5
WHERE EFFECTIVE - DEMAND MANAGEMENT STRATEGIES

DESCRIPTION	WHERE EFFECTIVE
1. Commute Alternatives/Rideshare Promotion	Regional, Major Employment Centers
2. Car Sharing	Regional, Major Employment Centers
3. Staggered and Flexible Work Hours	Regional, Major Employment Centers
4. Telecommuting	Regional, Suburban (White Collar) Growth Centers
5. Growth Planning / Land Use Planning	Regional High Growth Areas
6. Transit Improvements	
6a. Transit Mall	Street Segments With High Numbers of Buses
6b. Preferential Treatment	Corridors With High Numbers of Buses
6c. Fare Reductions	Regional, Activity Centers, Encouraged Growth Areas
6d. Express Bus Service	Principal Arterials Connecting High Density Residential Development With Major Employment Centers
6e. Bus Hubs	Connecting Corridors With Several Buses, Suburban Malls
6f. Park-and-Ride Lots	Principal Arterials Connecting Residential Development to Major Activity Centers
6g. New Routes and Frequency Improvements	Regional
6h. Fixed Guideways	Corridors Connecting High Density Residential Development with Major Employment Centers
7. HOV Lanes	Principal Arterials with 3+ Lanes in the Direction Considered, Restricted Left Turns, and Average Trip Length Greater Than 10 Miles
8. Walk / Bicycle	Minor Arterials and Collectors Leading to CBD, or Colleges or major employment centers
9. Employer Commute / Trip Reduction Ordinances	Regional, Major Employment Centers
10. Congestion Pricing	Facilities With Limited Number of Access Points
11. Parking Management / Increase Parking Costs	Major Employment Centers, Activity Centers
12. Increase Gas or Auto-Related Taxes / Fees	Regional

Glossary of Acronyms and Abbreviations

ATMS	Advanced Traffic Management Systems
ATIS	Advanced Traveler Information Systems
APTS	Advanced Public Transportation Systems
AASHTO	American Association of State Highway and Transportation Officials
AVI	Automated Vehicle Identification
AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CBD	Central Business District
CCTV	Closed Circuit Television
CVISN	Commercial Vehicle Information System Network
CMP	Congestion Mitigation Prioritization
CMS	Congestion Management System
CM/AQ	Congestion Mitigation/Air Quality
CVIEW	Commercial Vehicle Information Exchange Window
DAQ	Department of Air Quality
DOT	Department of Transportation
DRAM	Residential Allocation Model
EMPAL	Employment Allocation Model
EOC	Emergency Operations Center
EIS	Environmental Impact Statement
FAQ	Fact, Answer, Question
FHWA	Federal Highway Administration
FAIR	Fast and Intertwined Regular
HAR	Highway Advisory Radio
HOT	High Occupancy Toll
HOV	High Occupancy Vehicles
IMS	Incident Management System
ITS	Intelligence Transportation System
IMT	Incident Management Teams
IVHS	Intelligent Vehicle Highway System
IFTA	International Fuel Tax Agreement
ISTEA	Inter-Modal Surface Transportation Efficiency Act
LOS	Level of Service
LRV	Light Rail Vehicles
LRP	Long Range Plan
MOE	Measures of Effectiveness
MUTCD	Manual on Uniform Traffic Control Devices
MPO	Metropolitan Planning
NHI	National Highway Institute
RWIS	Road Weather Information System
RMS	Ramp Metering Station
ROW	Right-of-Way
SR	State Route

SOV	Single Occupancy Vehicles
SLCC	Salt Lake Community College
TAT	Traveler Advisory Telephone Systems
TEA-21	Transportation Equity Act for the 21st Century
TMS	Traffic Monitoring Station
TOC	Traffic Operating Center
TAC	Technical Advisory Committee
TRO	Trip Reduction Ordinance
TDM	Transportation Demand Management
TOD	Transit-Oriented Developments
TMA	Transportation Management Association
UTA	Utah Transit Authority
UDOT	Utah Department of Transportation
TIP	Transportation Improvement Projects
VMT	Vehicle Miles Traveled
VECC	Valley Emergency Communications Center
VMS	Variable Message Signs
V/C	Volume/Capacity
WFRC	Wasatch Front Regional Council