PART IV

PLANNING

# Chapter 12

# TRANSPORTATION SYSTEM MANAGEMENT

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Well-planned, cost-effective transportation system management (TSM) strategies can improve mobility on existing systems for urban transportation users. This is particularly important considering the high cost of constructing new facility capacity and the current and projected increase in travel. By the year 2000, it is estimated that new development, demographics, family composition, and trip-making trends will result in an increase of nearly 50% in travel within urban areas.1 Because of the burden on the transportation system, maximizing the usefulness and effectiveness of existing facilities and services is essential, even in those situations where new capacity is available.

TSM is the application of construction, operational, and institutional actions to make the most productive and cost-effective use of existing transportation facilities and services. It is through the application of TSM strategies such as operational changes and land-use policies that an urban area is able to maintain mobility and safety in the face of growing demand for travel and limitations on system capacity growth.

The primary purpose of this chapter is to present contemporary operational concepts, applications, and analyses of TSM strategies. The presentation is drawn from references, existing and ongoing research, and current views of national organizations such as the Transportation Research Board, the Institute of Transportation Engineers, and the Association for Commuter Transportation.

## BACKGROUND AND PHILOSOPHY

TSM practices in the 1990s are the byproduct of fundamental traffic engineering actions taken to improve the operation of the highway system beginning in the early 1930s. Decisions such as increasing or decreasing the parking supply, incorporating left turn bays at intersections, or implementing progressively timed traffic signals would later become part of the overall concept of transportation system management.

Urban areas received a great deal of attention between the early 1960s and mid-1970s. In the United States, Congress recognized the importance of metropolitan planning in the 1962 Highway Act, which included the framework for an urban planning process. In the late 1960s, there was a great deal of pressure to establish a federally aided highway public transportation program for larger cities. The 1970 Federal-Aid Highway Act addressed this issue through authorization for a federal-aid urban system and funding allocation for constructing exclusive bus lanes.2

Further recognition and support was given to urban operational planning and improvement needs with the creation of the Urban Area Traffic Operations Improvement Program in the 1968 Highway Act. This program became known as TOPICS (Traffic Operations Program to Improve Capacity and Safety). One of the problems identified by this program was that while earlier extension of the freeway system into urban areas had relieved traffic congestion on many arterials, volumes had increased on other arterials and city streets on which local jurisdictions were unable to finance improvements. In establishing the TOPICS program, Congress also recognized that urban system traffic operational improvements were not receiving the full advantage of modern traffic engineering techniques.3

The concept of transportation system management received formal recognition in the United States as part of the 1975 Joint FHWA-UMTA Urban Planning Regulations. The intent was that TSM include solid practices and applications for the management of supply and demand strategies. As reflected in the appendix to the regulations, TSM includes "operating, regulatory, and service policies so as to achieve maximum efficiency and productivity for the system as a whole."4

In theory, TSM actions are intended to improve the operating efficiency of the existing transportation system (facilities, services, and modes). TSM actions consist of both supply management elements (for example, traffic engineering and signal improvements) and demand management elements (for example, projects to increase the number of high-occupancy vehicles used for commuting). TSM actions must be considered throughout a metropolitan area when addressing system, corridor, individual facility, and site improvements at the planning and project development stages.

The contemporary approach to TSM attempts to bridge the gap between plans, policies, and operational actions used in managing a transportation system. In this regard, two concepts are fundamental to understanding TSM. The first concept is that there will always be a need for *continuously managing and improving* the operation of the transportation system. Because traffic congestion can always be a problem, projects must always be monitored, adjusted, or revised to be effective at providing relief and improvement. The second concept is that TSM plans, policies, and operational actions must *interact and blend* with each other to support the overall long- and short-term mobility goals of a community. The transportation modes, services, policies, and programs must be designed to work together rather then compete. Plans must be developed to provide opportunities for packaging and applying a combination of policies, programs, and operational actions to effectively meet mobility needs. Interaction is critical to the success and effectiveness of this management concept.

## TSM ACTIONS

TSM actions are generally implemented to address problems in two types of environments within a metropolitan area: corridors and activity centers. Corridors include the radial and circumferential travel ways within a region. These travel ways generally include freeways, arterials, and public transit lines. Activity centers are the employment, retail, commercial, educational, special event, and/or recreational areas that generate (or attract) trips (for example, a suburban office park, a shopping center, or a central business district).

TSM actions are usually categorized as supply-side or demand-side actions. *Supply- side actions* are intended to increase existing vehicle capacity on the system. *Demand-side actions* are designed to reduce vehicle demand on the system by increasing vehicle occupancy. Both supply-side and demand-side actions, when applied in a coordinated manner, give transportation professionals powerful tools with which to manage the existing system. Following is a discussion of various TSM actions and whether they have supply-side or demand-side application.

### TRAFFIC ENGINEERING IMPROVEMENTS

Traffic engineering improvements such as channelization, left- or right-turn lanes, one-way streets, reversible traffic lanes, intersection widening, bus turnout bays, and improved signing and pavement markings are the most widely implemented TSM strategies in corridors, activity centers, and surrounding regions. Based on experience in small, medium and large communities, capacity and safety (usually a reduction in vehicle accidents) improvements have been realized as a result of the action. The cost of these improvements varies considerably, but the benefits usually exceed the costs. Traffic engineering improvements improve capacity; thus they are considered to be supply-side actions.

### TRAFFIC CONTROL IMPROVEMENTS

Traffic control systems are designed to reduce travel times, delays, and stops, while also improving average speeds on arterial roadways and freeways. These systems

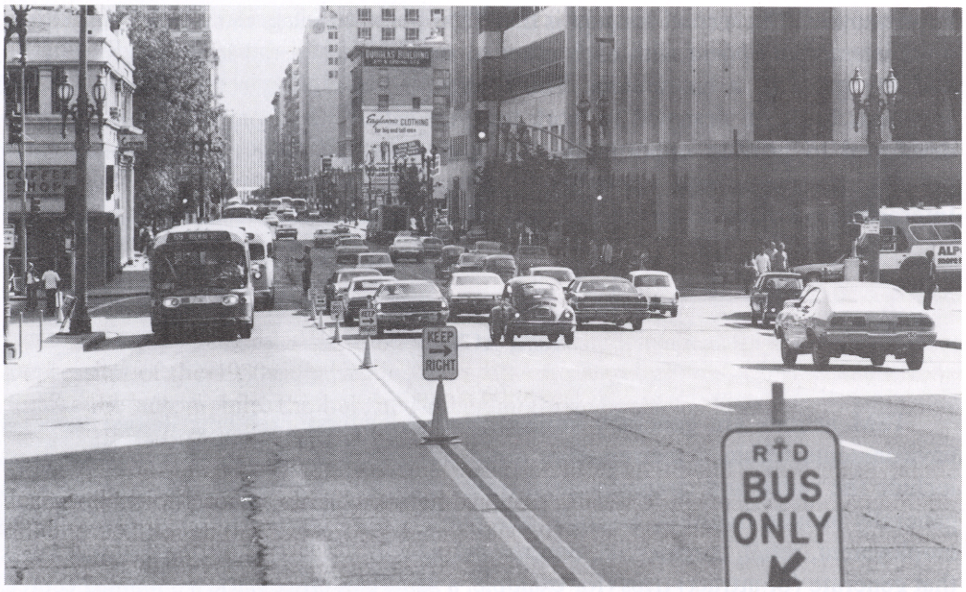


**Figure 12-1** *Contraflow bus lane on CBD street in Los Angeles. (courtesy of Federal Highway Administration)*

include strategies like coordination of traffic signals, continuous optimization of timing plans, use of bus priority signal control systems, and implementation of computer-based traffic control and freeway traffic management. Typical experiences have shown decreases in travel times and vehicle delay on arterials as a result of improved traffic signal systems. Traffic control systems are considered to be supply-side actions due to their impact on capacity.

### Freeway Management Strategies

A comprehensive freeway management system is used to help relieve the traffic delay that accounts for the majority of urban congestion.[5] On a nationwide basis, benefits from these systems indicate an average increase in vehicle speeds combined with an average reduction in delay. These actions improve the vehicle-carrying capacity of the freeway and, therefore, are considered to be supply-side actions. A comprehensive freeway management system includes the following elements and implements those that are needed.

- Surveillance systems to monitor traffic conditions and collect traffic data.
- Ramp meter signals to smooth traffic flow and improve freeway speeds.
- Control systems to regulate traffic flow to prevent the onset of congestion and restore free flow more quickly when traffic breaks down.

- Incident management programs to reduce the number and duration of incidents.
- Motorist information systems to provide real-time information to drivers on traffic conditions.
- Spot geometric/capacity improvements to reduce or eliminate bottlenecks.
- HOV systems to provide reliable time savings incentives to encourage carpooling, vanpooling, and bus use.

## PRIORITY TREATMENT FOR HIGH-OCCUPANCY VEHICLES

*High-occupancy vehicles* (HOVs) are passenger vehicles that meet or exceed a certain predetermined minimum number of passengers, for example, more than two or three people per automobile. Carpools, vanpools, and buses are HOV vehicles.6 Priority treatment for HOVs is aimed at encouraging multiuser transportation by offering a cost, travel-time, or walking distance savings over non-HOVs. On freeways and arterials, priority treatment is achieved by designating a new or existing lane(s) for the exclusive use of HOVs, usually during peak commuting periods. This strategy is especially important on congested arterials or freeway corridors with limited potential for building additional lanes. HOV programs also help during periods of major bridge or highway reconstruction. While these actions may increase capacity on a facility, they also increase the use of HOVs. Therefore, priority treatments for HOVs can be considered as both supply-side and demand-side actions.

Ramp meter bypass lanes for HOVs, in coordination with ramp meters, are also being used on corridors as part of a freeway traffic management system. (See Fig. 12-2.) These bypass lanes allow HOVs to go around the traffic signal used for ramp metering and enter the freeway with minimal delay from the signal or the vehicle queue.

In activity centers, the opportunities for preferential treatment include providing parking spaces for carpools that offer a cost and/or walking distance savings and providing more green time for buses at signalized intersections. Both concepts have been effective in congested areas at supporting and enhancing ridesharing and transit programs.

During the planning of HOV preferential treatment programs, the following factors must be taken into account:

1. The ability to enforce the preferential treatment in order to minimize violations.
2. The location/placement of preferential treatment so as to promote HOV use.
3. The impacts on non-HOVs.
4. The expenditures/savings to implement HOV programs.
5. The demand for HOV programs.
6. Other actions that might reinforce or enhance the operation of the preferential treatment (for example, an employer-based ridesharing program).

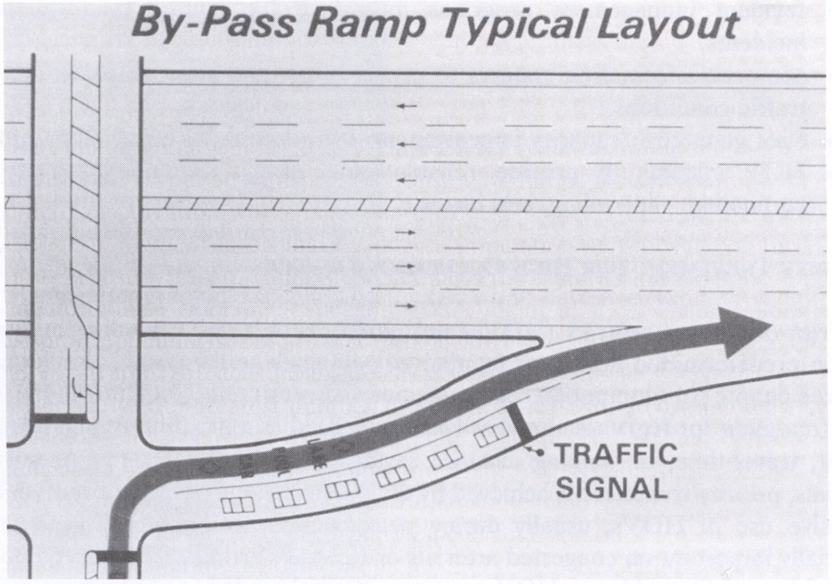


**Figure 12-2** *Typical layout of ramp meter bypass lane. (courtesy of Federal Highway Administration)*

When implemented on a congested freeway or arterial, preferential treatments can increase the people-moving capacity of the facility. HOV lanes (on the mainline, at ramps, or at toll plazas) can also significantly improve the efficiency and economy of public transit and ridesharing operations by providing a time (and a cost) savings to commuters using these services. The travel-time savings may vary depending on the length of time on the HOV lane and the level of congestion on the facility. If implemented and operated in an effective manner, preferential treatments can defer or eliminate the need to construct additional roadway lanes.

## Ridesharing Programs

Ridesharing programs, also referred to as travel demand management (TDM) programs, are institutional and operational actions needed to implement and support the use of HOVs (carpooling, vanpooling, and public transit programs). Ridesharing has been most effective at increasing the use of HOVs when implemented at employment sites where strong management support for the programs exists. Ridesharing programs reduce vehicle trips to the site, thereby relieving congestion at the site entrance or adjacent intersections or both.

To effectively implement ridesharing programs, some or all of the following policies and incentives need to be in place: HOV lanes and ramps, preferential parking for HOVs, employer transportation coordinator(s), flexible work-hour policies, marketing and promotional programs, pricing policies (for example, for parking and transit), revised parking codes and zoning, and matching services. The private sector, as an active participant in the provision of ridesharing services, can benefit through reduced costs for providing employee parking, increased ability to hire and retain employees (especially during periods of company relocation), and a reduction in employee stress levels resulting from an easier commute.


**Figure 12-3** *HOV lane. (courtesy of Federal Highway Administration)*

## Parking Management

Parking management programs are considered to be demand-side actions that strongly influence whether a commuter drives alone or uses an HOV. In a corridor environment park-and-ride lots serve to shift the parking supply from the central business district to the outlying area, reducing congestion and vehicle travel demand through a corridor. These lots support the use of public transit or rideshare programs. The lots can be located at shopping centers or churches or on vacant land that is at or near major freeways.

Parking management programs in activity centers include on-street parking restrictions, residential parking permit programs, on-street parking meters (short- or long-term), on-street parking enforcement or adjudication programs, off-street parking pricing programs (to encourage ridesharing or short-term use ), off-street parking discounts in shopping areas, carpool/vanpool preferential parking (both on- and off-street), and modifications of parking provisions of local zoning codes to encourage carpool and transit use. The amount of parking provided, the location of parking, and the use of the parking spaces all have a direct impact on mode choice. In this regard, parking management actions influence the extent of ridesharing and transit use at an activity center.

## TRANSIT SERVICE IMPROVEMENTS

Transit service improvements in corridors include express bus service, more frequent runs, limited stop bus routes, and transit centers. The *transit centers* provide a point where several routes converge with coordinated "timed" schedules to improve connections with a minimum of waiting time. The centers may also be used to coordinate transfers between different modes of transportation, such as bus, taxi, and rail service.

In congested activity centers, where bus volumes are high, special roadway lanes or streets dedicated for transit vehicles can improve bus travel time and schedule adherence, especially during peak periods. In suburban areas, particularly where active development is taking place, transit service improvements can include special bus lanes, transit centers, bus turnout bays, shelters, reduced transit fare/pass programs, and loop or shuttle service between retail and employment sites. Other types of transit service improvements, especially between activity centers and residential areas, can include minibuses, taxis, or other demand-responsive systems.

Transit service improvements are demand-side actions in that they attempt to relieve congestion by reducing vehicle trips. They can be enhanced further when actions like preferential lanes, signal priority, freeway ramps for buses, and park-and-ride lots are also applied to enhance transit service. With any type of transit improvement, a market research effort is necessary to identify the service needs of specific markets (for example, office parks or educational centers). The development and promotion of new services can be based on the results of the market research effort.

## ORGANIZATIONAL AND INSTITUTIONAL CONCEPTS

Transportation planners and engineers, particularly those working in urbanized areas, recognize that public and private agencies must work together to safely and efficiently operate the transportation system. One agency's role can no longer be considered exclusive of another agency's. Consequently, TSM planning involves pooling the individual resources of various agencies to deal with congestion and mobility issues. Communication, cooperation, and coordination between and within the public and private sectors are essential to effective TSM planning.

## ROLE OF GOVERNMENT AGENCIES

Government agencies at state, local, and regional levels are responsible for facilitating and funding the planning, development, implementation, and operation of TSM actions. Implementation of TSM strategies is often constrained by institutional problems associated with the coordination of many groups in the public sector. The authority for decision making is dispersed among several agencies and often between several levels within each agency. Often the state transportation agency and/or local transportation agencies (city, county, and/or transit operator) share responsibility for the decision making and implementation for TSM.

In some metropolitan areas, the challenge created by transportation problems has resulted in transportation agencies reexamining their mission and function. For example, many transit agencies have responded to new, nontraditional suburban markets with new types of services. Transit agencies are viewing themselves as "managers of mobility" rather than just operators of traditional bus or rail services. In other metropolitan areas, subregional planning groups have been formed to deal with the transportation problems in their community.7 In still other metropolitan areas, local governments have enacted trip-reduction ordinances that require developers (and employers) to share in the cost and provision of transportation service (for example, traffic signalization, ridesharing, and transit) to their commercial or residential sites.

The metropolitan planning organization (MPO) is one group that can play a key role in the development of TSM within an urban area. Because the MPO is responsible for developing the regional long-range and TSM elements of the transportation plan, it can be the focal point for coordination among agencies on critical issues pertaining to the application of TSM. Often, the MPO is also responsible for collecting the important regional or corridor travel data that are essential when planning, monitoring, and evaluating TSM projects. The MPO can also play a key role in involving the major private sector groups (for example, the chamber of commerce or private developers) in the planning process or when a regional trip-reduction ordinance is being developed.

## TRAFFIC MANAGEMENT TEAMS

One of the most effective means of implementing transportation management strategies is through a traffic management team (TMT). A TMT brings together individuals representing various transportation and support agencies within a specific area. The purpose of the TMT is to improve the overall operation and safety in urban corridors by coordinating the activities of the principal operating agencies in the area (for example, the state highway agency, the local traffic engineering agency, and the transit agency). Subsequently, the TMT is able to provide participating agencies with the following opportunities:

- Direct communications that enhance information exchange among team members and with the public.

° Cooperation and coordination in the daily traffic operation activities of each agency.
• Coordination among agencies on the best means of allocating funds for traffic operations.
° Evaluations of proposed improvements from different points of view (for example, police, fire, emergency rescue, traffic, and transit).
° Meetings with planners and engineers to review and discuss long-range plans.
° Coordination of schedules for construction projects on freeways, arterial s, and bridges.
• Review of construction traffic control plans to assure that all agencies understand how they will be affected.
• Cooperation in determining how to handle traffic during periods of both recurring (daily) and nonrecurring congestion (for example, incidents).
• Cooperation in planning and carrying out traffic management during incidents, special events, and unusual weather conditions (ice storms, snow, hurricanes).
• Joint studies on decreasing the number of incidents in high-accident locations.

TMTs are generally formed to address a tangible problem, need, or circumstance for a given urban area. For example, they can address a specific transportation issue for a freeway corridor such as incident management or traffic management during a freeway reconstruction project. TMTs can also address a wider range of transportation management issues, such as rerouting downtown traffic during street construction, implementing a bus lane on a city street, handling traffic for special events, and correcting traffic and safety problems in a community. A successful team was established for traffic management during the 1984 Los Angeles Olympic Games. TMTs can be used in whatever manner is most appropriate to achieve specific transportation management objectives.

Elements that are common to all successful TMTs include the following: (1) commitment, (2) an understanding of the scope and role of the team, (3) clearly defined objectives, (4) strong representation of participating agencies, (5) a leader, (6) regular meetings, and (7) agreement on the expected duration of the team's existence.8 Successful teams have the common denominator of being able to develop a working partnership among participating agencies and to avoid turf battles that can inhibit progress.

Members of a TMT should be more than just representatives for their respective agencies—they should be action oriented and have the strong support of their superiors. Team members are generally second- or third-level officials (for example, district or city traffic engineers and chief of police of the traffic operations/enforcement unit). The idea is to have members who not only are aware of the daily operations of their respective agencies, but are also able to speak for their agencies and commit them to a course of action agreed upon by the TMT. Regardless of whether the formation of a TMT evolves from existing communications among agencies or is the result of a planned and organized effort, the team's formation should never be forced. The expected duration of a TMT is essentially based on its scope. The agencies that are typically represented on a TMT are listed in Table 12-1.

**TABLE 12-1**
**Agencies Typically Represented on Traffic Management Teams**

°State highway agency (district traffic engineer plus other members as needed)
• City traffic or transportation office(s)
°County traffic or transportation office(s)
°State police or highway patrol
°Police, fire, and rescue department(s)
°County sheriffs office(s)
Regional or metropolitan transit authority
Federal Highway Administration
°Public relations specialists
Other groups where and when needed (e.g., utility companies, public works agencies, private trucking firms, private employers and developers, taxi services)

Source: Adapted from Sheldon G. Strickland and Jonathan D. McDade, "Transportation Management and the 3 C's for Dealing with Urban Congestion," in *Compendium of Technical Papers for the 57th Anual Meeting of the Institute of Transportation Engineers, August 16-20, 1987* (Washington, D.C.: Institute of Transportation Engineers, 1987), pp. 228-32.

In summary, when using TMTs as a means of implementing TSM strategies, it is important to keep a positive atmosphere. By starting out slowly and setting realistic goals, TMTs can be very effective. It is not practical to assume that you can use a "template" in forming a TMT because they are not all alike. They should be formed to meet the local needs. A well-organized TMT can help maintain a high level of cooperation, communication, and coordination among transportation agencies in an urban area.

## INVOLVEMENT OF THE PRIVATE SECTOR

Traditionally, TSM strategies have focused on public initiatives such as traffic signal improvements, roadway widening, preferential treatment for high-occupancy vehicles, and public transit improvements. Nonetheless, traffic congestion caused by private sector development in urban and suburban areas indicates that the provision of transportation services is not a problem to be addressed solely by public agencies. Employers and land developers are particularly instrumental groups because they help to generate traffic and are in a position to influence employee mode choice either directly through various incentives or indirectly through the design of a building or parking facility. Employers also serve as a key channel through which employees receive transportation information and services.

Public agencies can create opportunities for private—public partnerships by requiring that TSM projects complement the private sector development. One of the critical links between public objectives and private sector actions is the local zoning ordinance.9 Most local zoning ordinances contain a set of off-street parking requirements that are intended to control the amount of parking supply created during private land development. Reducing these required parking space amounts when the developer implements TSM actions can reduce vehicle trips and the traffic impacts of the new development. These parking requirements are a potentially valuable tool in enabling the public sector to influence private sector decisions in the area of TSM, with benefits potentially accruing to both the public and private sectors.

The application of a parking code to involve the private sector in the provision of transportation services has proved to be legally and institutionally acceptable in many communities. A number of cities and counties are using the parking codes and other newly developed *trip-reduction* ordinances to establish incentives for developers, landowners, and employers to institute ridesharing and transit programs in exchange for reductions in the amount of parking spaces required—a major incentive for the developer being a reduction in the cost of development. Table 12-2 illustrates typical cost savings based upon increased vehicle occupancy levels.

Locations that have instituted such parking code/zoning changes all share a land-use environment where traffic congestion, pollution, and developmental growth all threaten the balance of public services. Other areas undergoing business declines have shown little interest in revising their parking codes or local ordinances to require developers to implement TSM actions as a condition to building.10

## TRANSPORTATION MANAGEMENT ASSOCIATIONS (TMAs)

In an attempt to channel the private sector's energy to be involved in the provision of transportation services, public—private partnerships have developed through transportation management associations (TMAs). TMAs are made up of several businesses who work together to form a partnership with local governments in order to help solve local transportation problems associated with rapid urban/suburban growth.

TMAs give the business community a voice in local transportation decision making, provide ridesharing and transit services to their employees, and serve as a forum for; public—private consultations on issues of transportation planning, financing, and implementation. TMAs have been active participants with government, including the MPO, in discussions on issues as varied as establishing highway funding priorities, restructuring public transit routes, improving public transit service, minimizing the disruption caused by road reconstruction, and instituting traffic management strategies to mitigate congestion.11 TMAs have been found to be supportive of the goals set forth by the MPO.

The initiative to form a TMA may be sparked by a variety of motives and circumstances. In some cases, TMAs have been formed, voluntarily, by local employers and property owners who are concerned that traffic congestion or the costs of providing more parking may adversely affect the productivity of their operations and stifle future economic prospects. In other cases, the formation of a TMA has arisen

**TABLE 12-2**

**<u>Sample Cost Savings for Increases in Auto Occupancy</u>**

Auto Parkingb Construction Cost Land CostCommute Commute Constr.&
Maint.Cost
Occupancya Reduction $ savings $ savingsCost Cost $ Savings
(annual)
Increased to: % space surface structured surface structured $ Savings
surface structured
1.2 4 24 24,000 120 ,000 79,000 26,000 12,500
2,600 9,600
1.3 12 72 72,000 360,000 238,000 9,000 34,700
7,900 28,800
1.4 18 108 108,000 540,000 356,000 119,000
54,000 11,900 43,200
1.6 28 168 168,000 840,000 554,000 185,000 85,000 18,500
67,200
1.8 36 216 216,0001, 080,000 713,000 238,000 109,000
23,800 86,400
2.0 42 252 252,0001, 260,000 832,000 277,000 128,000
27,700 100,800
2.5 54 324 324,0001, 620,000 1,090,000 356,000
162,000 35,700129,600

aBase auto occupancy = 1.15 (typical of a non-CBD site with no ridesharing program).
bAssume 200,000-ft2 (18,000-m 2) office building with 800 employees with minimum parking requirement of 600 spaces.
cAssume cost of parking construction per space = $1000 surface, $5000 structured, $10,000 underground.
dAssume land cost = $10/ft2 ($10/0.09 m2).
eAssume vehicle operating costs = $0.15/vehicle-mi ($0.09/vehicle-km) (approximate travel-related cost of vehicle operation, based on AASHTO's *Manual on User Benefit Analysis).* Assumed average trip length = 8 mi (13 km) one way.

Source: Adapted from Steven A. Smith and Stuart J. TenHoor, *Model Parking Code Provisions to Encourage Ridesharing and Transit Use (Including a Review of Experience),* Final Report, prepared by JHK & Associates for the FHWA (Washington, D.C.: Federal Highway Administration, September 1983), p. 7.

out of local ordinances that set traffic reduction or parking space requirements on new development, thus requiring the private sector to provide TSM actions as a condition for going forward with their projects. In either case, TMAs enable their members to consolidate their efforts, pool their resources, and reduce the cost of compliance with local requirements through shared services and joint programs.12 Table 12-3 contains a listing of the typical activities of a TMA.

## PLANNING AND ANALYSIS FACTORS FOR TSM

Systematic planning is an essential ingredient in the development of effective TSM actions. It has four important purposes that, when achieved, can lead to successful actions:

1. *Focuses the program effort.* Planning attempts to answer important questions on what, where, why, when, and how various TSM projects will be undertaken. These questions include who will conduct the programs and for whom the programs will be undertaken. Finally, any TSM plan should attempt to assess the impact that various strategies will have on such issues as travel behavior and mode choice, traffic congestion and vehicle volumes, auto occupancy, delay, parking supply and cost. If these questions are answered in a systematic and explicit manner, the focus of TSM strategies will become clear.

2. *Defines a course of action.* The primary purpose of planning is to define a results-oriented course of action that is based on conditions existing in the marketplace or the system. The planning process recommends a course of action and assures that the selected projects have a reasonable opportunity for success.

3. *Evaluates achievements.* The plan also serves as a guide for monitoring whether TSM activities are being conducted as planned and evaluating whether the desired results are being attained. These results are critical to revising or adjusting TSM actions to meet intended goals and objectives.

4. *Strengthens internal accountability.* A well-conceived plan outlines staff responsibilities in the areas of marketing, implementation, and evaluation. It also gives staff members insight into the relationship of their specific assignments to the overall project and institutional goals.

## DATA COLLECTION EFFORTS

In order to develop effective TSM plans, relevant information is needed. This information (or data) could relate to issues such as costs, performance characteristics of the transportation system, and changes in performance resulting from the

TABLE 12.3
## Typical Activities of a TMA

**Offer a forum for public—private consultation on:**
- **Highway funding priorities.**
- **Minimizing disruptions from road repairs.**
- **Transit service improvements.**
- **Traffic engineering improvements (placement of new signals, changes in traffic flow, etc.).**

**Represent and advocate the needs and interests of TMA members before public agencies, legislative bodies, and the transportation planning process by:**
- **Monitoring traffic conditions and recommending appropriate "quick fix "road improvements.**
- **Conducting employee travel surveys, assessing commuter travel needs (market research), and recommending appropriate changes in transit routing and level of service.**
- **Monitoring development and employment trends and assessing their impact on future road and transit needs.**
- **Advising on alignment and new locations for transportation facilities.**

**Build a local constituency for better transportation and raise funds for local transportation improvements.**

**Promote, coordinate, and provide travel demand management actions to reduce peak-hour demand on transportation facilities and help TMA members comply with local traffic reduction requirements (trip-reduction ordinances, parking codes, conditions of development, permits, proffers, etc.):**
- **Ridesharing (carpooling, vanpooling, public transit).**
- **Variable work hours to spread peak-hour traffic.**
- **Paking management.**
- **Market research, promotion, and evaluation.**
- **Emergency (or guaranteed) ride program.**

**Facilitate commuting and provide internal circulation within the area through:**
- **Daytime circulators.**
- **Subscription van/buses.**
- **Short-term car rentals.**
- **Shuttles to rail stations and fringe parking lots.**
- **Emergency rides for employees who rideshare.**
- **Reverse commute services for employees.**

**Provide specialized membership services to TMA members:**
- **Conduct employee "travel audits" and provide relocation assistance to new employees.**
- **Train in-house transportation coordinators.**
- **Manage shared tenant services, such as day-care centers, security, sanitation, landscaping.**

implementation of different TSM projects. To this end, information is needed to achieve the following:

- To provide data for applying analytical procedures and/or calibrating computer models to estimate the impacts of various strategies.
- To compare the actual results to predicted impacts.
- To compare the results at one site to the results at another.
- To provide data to other areas considering similar projects.
- To monitor the operation and effectiveness of projects for possible revisions or adjustments.

Collecting information/data needs to be considered as standard procedure when planning and implementing any TSM action; however, this effort can utilize significant amounts of resources and is often considered to be time consuming and not cost effective. To make the effort more cost effective, consideration must be given to selecting the measures of effectiveness and identifying data sources as a prelude to actually collecting the information.

**Selecting Measures of Effectiveness**

Measures of effectiveness (MOEs) are used to determine the extent to which a TSM strategy has attained a particular goal or objective. Within the context of TSM, these measures are used as a gauge to evaluate the effectiveness or success of a particular action at meeting its goal. Any action taken by the transportation professionals is intended to satisfy a community goal or objective. The goal may be stated explicitly: "reduce congestion in the core area of the city by minimizing stops and delays." It may also be implied by an elected official's or business leader's pledge to "increase accessibility to a decaying portion of the downtown." Both the explicit and implicit goals are easy enough to state, but may be impossible to measure. Therefore, MOEs are used as yardsticks by which to measure how well goals are being met.13

There are four approaches to developing the measures of effectiveness. One approach has often been viewed as a top-down process. That is, the broad goals are identified, more explicit objectives are stated, and then the measures of effectiveness are used to determine the extent to which the goals and objectives are satisfied.

A second approach is to examine possible actions to be implemented and to attempt to assess what effect the implementation might have under specific conditions. This approach requires the formulation and testing of hypotheses using the planning analysis methods to estimate impacts (as discussed in a later section of this chapter). The measures can then be identified to determine the correctness of the test and estimate the magnitude of the impact.

A third approach is to determine what data are available or easily collected and what measures can be derived from these data. This approach may have the greatest chance of success, given real-world constraints of limited funds and professional staffs.

A fourth and more attractive approach is to use all the approaches in concert. Augmented by tests of sensitivity, relevance, and computational ability, this combined approach allows the planner to proceed with greater assurance of success in measuring goal attainment. Table 12-4 presents a list of 14 of the most frequently used measures of effectiveness. Not all these measures would necesssarily be used ot evaluate a particular TSM project. They should be used selectively.

TABLE 12-4
Frequently Used Measures of Effectiveness

°Point -to-point travel time
° Traffic volumes (for an intersection, driveway, or route)
°Vehicle (or person ) delay
° Number of vehicles by odcupancy
° Vehicle-miles of travel (VMT)
° Vehicle-hours of travel (VHT)
° Person-miles if travel (PMT)
°Person-hours of travel (PHT)
°Transit passengers
°Energy consumption
°Air pollution emissions
°Capital costs
°Vehicle requirements

Source: Adapted from Charles M. Abrams and John F. DiRenzo, Measures of Effectiveness for Multimodal Urban Traffic Management, Volume 2: Development and Evaluation of TSM Strategies, Final Report, prepared by JHK & Associates and Peat, Marwick,, Mitchell & Company for the FHWA, Report no. FHWA-RD-79-113 (Washington, D.C.: U.S. Government Printing Office, December 1979), p. 62. Now available as PB 80 198 682.

Selecting an appropriate MOE depends on two important criteria: (1) the level of importance of the measure and (2) the level of effort required to collect the data for that measure.14 The level of importance of a measure of effectiveness indicates its need in the analysis or evaluation. Some measures are absolutely necessary since they uniquely indicate how well a particular objective has been attained. Most may be less important due to the availability of other measures of effectiveness that are easier to use or more descriptive. The level of effort of a measure of effectiveness relates to the ease of field measurement (that is, collection of the data) and /or the ease of modeling. Regardless of the importance of a measure, it cannot be used in an evaluation if the costs (both money and resources) of obtaining the MOE are prohibitively expensive. More specific criteria for developng the measures are contained in Table 12-5.

TABLE 12-5

**Criteria for Developing Measures of Effectiveness**

*Relevancy to objectives*
Each MOE should have a clear and specific relationship to TSM objectives in order to ensure the ability to explain changes in the condition of the transportation system.

*Simple and understandable*
Within the constraints of required precision and accuracy, each MOE should be simple in application and interpretation.

*Quantitative*
MOEs should be specified in numerical terms whenever possible.

*Measurable*
Each MOE should be suitable for application in preimplementation simulation and evaluation (i.e., have well-defined mathematical properties and be easily modeled) and in postimplementation monitoring (i.e., require simple direct field measurement attainable within reasonable time, cost, and personnel budgets).

*Broadly applicable*
MOEs that are applicable to many different types of strategies should be used wherever possible.

*Responsive*
Each MOE should be specified to reflect impacts on the various actor groups, taking into account, as appropriate, geographic area and time period of application and influence.

*Sensitive*
Each MOE should have the capacity to discriminate between relatively small changes in the nature or implementation of a control strategy.

*Not redundant*
Each MOE should avoid measuring an impact that is sufficiently measured by other MOEs.

*Appropriately detailed*
MOEs should be formulated at the proper level of detail for the analysis (e.g., if conceptual-level sketch planning is involved, the appropriate MOE is probably less detailed than one useful for more detailed implementation planning and design).

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Source: Adapted from Charles M. Abrams and John F. DiRenzo, *Measures of Effectiveness for Multimodal Urban Traffic Management, Volume 2: Development and Evaluation of TSM Strategies*, Final Report, prepared by JHK & Associates and Peat, Marwick, Mitchell & Company for the FHWA, Report no. FHWA-RD-79-113 (Washington, D.C.: U.S. Government Printing Office, December 1979), p. 68. Now available as PB 80 198 682.

## Identifying Data Sources

Data used for the analysis of TSM actions (particularly for estimating measures of effectiveness to be used in before-and-after studies) can come from existing records or from new field data collection or both. Potential data sources based on objectives and relevant measures of effectiveness are shown in Table 12-6. The table indicates the source of data (field data collection, surveys and questionnaires, or agency records) for different measures.

**TABLE 12-6**
**Potential Data Sources**

| Objective | MOE | Primary Data Source: Field Counts/ Data Collection | Type of Survey | Agency Records |
|---|---|---|---|---|
| **Maximize capacity** | Critical lane volume | Manual traffic counts | | |
| | Parking supply | Parking inventory | | Municipal |
| | Volume/capacity ratio | Manual traffic counts | | |
| **Maximize productivity** | Operating cost/passenger trip | | | Transit co. |
| | Operating cost/revenue vehicle-mile | | | Transit co. |
| | Operating revenue/operating cost | | | Transit co. |
| | Passengers/revenue vehicle-hour | Transit boarding-alighting counts | On-board | Transit co. |
| **Minimize operating costs** | Operating and maintenance cost | | | DOT/DPW<br>Police<br>Planning<br>Transit co. |
| | Operating deficits | | | Transit co.<br>Municipal |
| | Operating revenue | | | Transit co.<br>Municipal |
| **Minimize auto usage** | Intersection turning movements | Manual traffic counts | | |
| | Number of carpools | | Employee<br>Household | |
| | Number of vehicles by occupancy | Occupancy counts | | |
| | Person-miles of travel (PMT) | Auto-occupancy counts<br>Transit boarding-alighting counts | | |
| | Person trips | Transit boarding-alighting counts<br>Occupancy counts | Household<br>Roadside | Transit co. |
| | Traffic volume | Mechanical counters<br>Manual traffic counts | | |
| | Vehicle-miles of travel (VMT) | VMT counts | | |
| **Maximize transit usage** | Passenger-miles of travel | Transit boarding-alighting counts | Household<br>On-board | |
| | Transit passengers | | Household<br>On-board | Transit co. |
| **Reduce travel time** | Person-hours of travel | Transit boarding-alighting counts<br>Occupancy & VMT counts with floating car technique or license plate survey or moving vehicle methods | | |
| | Point-to-point travel time | Floating car technique, time-lapse photography, moving vehicle method, license plate survey | | |

| Objective | MOE | Primary Data Source: Field Counts/ Data Collection | Type of Survey | Agency Records |
|---|---|---|---|---|
| | Vehicle delay | Manual intersection delay technique, Floating car technique, license plate survey, moving vehicle method | | |
| | Vehicle-hours of travel | VMT counts with floating car technique, license plate survey, moving vehicle method | | |
| | Vehicle stops | Manual intersection delay technique, test car method<br>Time-lapse photography | | |
| **Minimize travel costs** | Parking cost | | Parker<br>Employee | Municipal |
| | Point-to-point out-of-pocket travel costs | | Household<br>Parker<br>Employee | |
| | Point-to-point transit fares | | | Transit co. |
| **Maximize safety** | Accidents | | | Accident |
| | Accident rate | | | Accident<br>Traffic count |
| | Traffic violations | Field observation<br>Time-lapse photography | | |
| **Maximize comfort and convenience** | Parking accumulation | Parking usage study | | |
| | Perceived comfort and convenience | | On-board attitudinal | |
| | Transit load factor | Field observation<br>Transit boarding-alighting counts | | |
| | Trip distance | | Employee<br>Household | |
| | Walk distance from parking location to destination | | Parker<br>Employee | |
| **Maximize reliability** | Perceived reliability of service | | On-board attitudinal | |
| | Schedule adherence | Field observation | | |
| | Variance of average point-to-point travel time | Floating car technique, time-lapse photography, moving vehicle method, license plate survey | | |

Source: Adapted from Charles M. Abrams and John F. DiRenzo, *Measures of Effectiveness for Multimodal Urban Traffic Management, Volume 2: Development and Evaluation of TSM Strategies*, Final Report, prepared by JHK & Associates and Peat, Marwick, Mitchell & Company for the FHWA, Report no. FHWA-RD-79-113 (Washington, D.C.: U.S. Government Printing Office, December 1979), pp. 131-32. Now available as PB 80 198 682.

The data collection effort must be completed within certain budget and time constraints in order to be cost effective. Generally, the sample size and reflected cost estimates of a data collection program result in a desirable study. In some cases, however, projected data needs may exceed the available resources. Possible means of reducing the costs of data collection are contained in Table 12-7.

In most cases, a combination of the methods shown in Table 12-7 is used. As a general guide, it is preferable to sacrifice the coverage of a program (for example, the number of sites) rather than the quality of data at a particular location. Subsequently, when putting together a data collection program, it is important to perform a trade-off analysis. It is also important to perform cost analyses since program costs are affected when data collection procedures are revised. A cost analysis should be repeated until costs are brought within budgetary constraints.15

**TABLE 12 -7**
**Methods to Reduce the Costs of Data Collection**

• Eliminate less important data
• Reduce the number of data collection locations
°°Reduce the time period of data collection
• Scale down experimental control activities
°°Reduce the desired precision of the estimates
- Modify the data collection procedures

Source: Adapted from Charles M. Abrams and John F. DiRenzo, *Measures of Effectiveness for Multimodal Urban Traffic Management, Volume 2: Development and Evaluation of TSM Strategies*, Final Report, prepared by JHK & Associates and Peat, Marwick, Mitchell .£ Company for the FHWA, Report no. FHWA-RD-79-113 (Washington, D.C.: U.S. Government Printing Office, December 1979). Now available as PB 80 198 682.

## ANALYSIS TECHNIQUES FOR TSM PLANNING

To interpret or analyze the information/data that have been collected, certain planning procedures or techniques are used by engineers and planners. Many techniques are available for analyzing information used in the planning of TSM projects.16 These techniques cover a range of complexity and generally fall into the following categories:

*Specification.* Specification is generally used to set a value or goal on the transportation and activity measures used in an analysis. Although not an estimation technique directly, specification can set a standard from which to measure the performance or impact of a TSM action. Examples are 12 vans placed in service for employees in the next 12 months, 15-min headway on a proposed bus route, and level-of-service C on an improved arterial street.

*Direct measurement.* Direct measurement of the existing environment can provide valuable information for estimating potential services or proposed designs. Even in an

analysis of proposed conditions, values of some measure can be obtained directly through field surveys and maps. Such measures as lane-miles, length of a bus route, adequate turning radii for fire trucks or buses, potential ridership, or employee attitude for a new service can all be assessed using some form of direct measurement.

*Market research. A* form of direct measurement, market research can lead to improved information on attitudes, trends, needs, status and acceptance for a proposed action. Most market research is done through surveys at the workplace, at some point along a trip, through the mail, over the telephone, or through one-on-one interviews. Information from market research can serve as the impetus for TSM programs better suited for transportation users. Examples of market research include transit ridership surveys, employee surveys for a proposed company ridesharing program, and mail-out surveys to identify or monitor travel changes due to a highway reconstruction project.17

*Direct calculation.* Some measures of interest are sums, products, or ratios of other measures. Both travel-related measures (such as cost per person-minutes saved) and financial measures (such as revenue and subsidy requirements) are usually calculated using other estimated values. Summary measures for a study area (such as vehicle miles of travel) are often the sums of values estimated for components such as intersections and street segments.

*Before-and-after studies.* Before-and-after studies are the traditional method used when evaluating TSM actions. Numerous reports and texts have been prepared on undertaking a before-and-after study.

*Analogy.* Performance levels and impacts observed at other sites are often the only simple means of estimating the outcome of a program. Analogy can be used when there is a lack of data or data are difficult to obtain at the proposed location. Analogy is less costly than other programs and leads to a quicker summation of the impact of a TSM action. Data from a single case study or a compilation of several studies may be used with or without modifications to reflect differences between the characteristics of the sites. Examples of the use of analogies include estimating the patronage on a proposed community transit service by using data developed for a similar service, or estimating auto occupancy, mode share, and traffic volumes at an employment site, for a proposed ridesharing program, by using information from a similar program.

*Look-up.* Performance and impact levels of TSM programs can sometimes be synthesized into a graph or table format. The results of research studies employing analytic or simulation models may also be presented in nomographs, graphs, tables, or similar formats from which estimates can be directly extracted. Graphs relating to intersection capacity, critical gap, and conflicting flows are examples.

*Simple equations and formulas.* Estimates are often obtained by applying simple equations, unit rates, or formulas. Examples include trend lines or growth rates used to estimate traffic volume, accident and emission

rates (per vehicle-mile) used to estimate safety and air quality factors, formulas used to allocate transit operating costs among routes based on measures such as vehicle-miles and vehicle-hours, and elasticities used to estimate changes in volume measures.

*Analytical or simulation procedures.* Analytical procedures (manually operated or computerized) may be required to obtain accurate estimates of impacts. Some of the analytical procedures may be simple work sheets; others are best applied with the assistance of a calculator or computer programs. Analytical procedures currently available for estimating the travel impact of different TSM proposals can be grouped into five categories:18

1. Network-based highway and transit planning models—used in travel demand forecasting functions (such as traffic assignment and mode split analyses) that are required to estimate changes in travel patterns within a corridor or network as a result of TSM projects.
2. Quick-response estimation techniques—simplified network-based procedures applicable when data, funds, and resources are limited and results are needed within a short time frame.
3. Highway capacity analysis procedures—used to estimate the capacity of the affected roadway as well as affected modes; also used to estimate operational measures of effectiveness, including level of service and average speed on the affected highways or arterials.
4. Traffic simulation models—used to estimate traffic conditions and to estimate operational or economic measures of effectiveness, particularly when the time-varying nature of traffic flow is important or roadway geometries are complex.
5. Traffic optimization models—used in the impact estimation process to assess, refine, or improve plans for a particular highway or route; also provide estimates of operational and economic measures of effectiveness.

Table 12-8 lists the significant factors that need to be considered when deciding which planning technique to select for the situation.

**TABLE 12-8**
**Considerations in Selecting Planning Techniques**

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• Nature, magnitude, and complexity of the project
° Type of facility (e.g., freeway or arterial)
• Amount of time and level of effort needed
Size of the affected corridor
Volume of traffic that will be impacted
• Size/complexity of the affected corridor or area
• Experience of the professional stafff
Availability of accurate data
Availability of resources (cost, time, labor)

Source: R. A. Krammes and others, *Application of Analysis Tools to Evaluate the Travel Impacts of Highway Reconstruction with Emphasis on Microcomputer Applications*, Final Report, prepared by Texas Transportation Institute, Texas A&M University System, for the FHWA, Report no. FHWA-ED-89-023 (Washington, D.C.: Federal Highway Administration, June 1989 [cover March 1989]), p. 28. Now available as PB 89 187 181.

## TSM AS A COMPONENT IN AIR QUALITY ATTAINMENT

The automobile as presently utilized and powered is a major contributor to air quality degradation. To improve air quality in urban areas, many metropolitan planning organizations/air quality districts have developed transportation control measures (TCMs). TSM activities are universally a major component of such plans.The full TCMs often contain actions beyond transportation system management, such as enhanced vehicle inspection and maintenance requirements, improved vehicle technology and fuels, market-based economic elements, and land-use strategies, as well as alternative transportation services to replace auto trips. TSM actions, however, are usually the dominant strategy.

## TECHNOLOGY APPLICATIONS FOR TSM

There are many reasons for using advanced technologies in TSM applications. New and advanced technology can improve the efficiency and traffic-handling capacity of existing roadways. Technology can address and reduce inherent safety limitations attributable to both human factors and the roadway system. New technology has the potential to improve mobility and commercial productivity by alleviating traffic congestion and roadway incidents. Finally, new and advanced technology can improve the comfort and convenience of the driver and passengers on the system.[19]

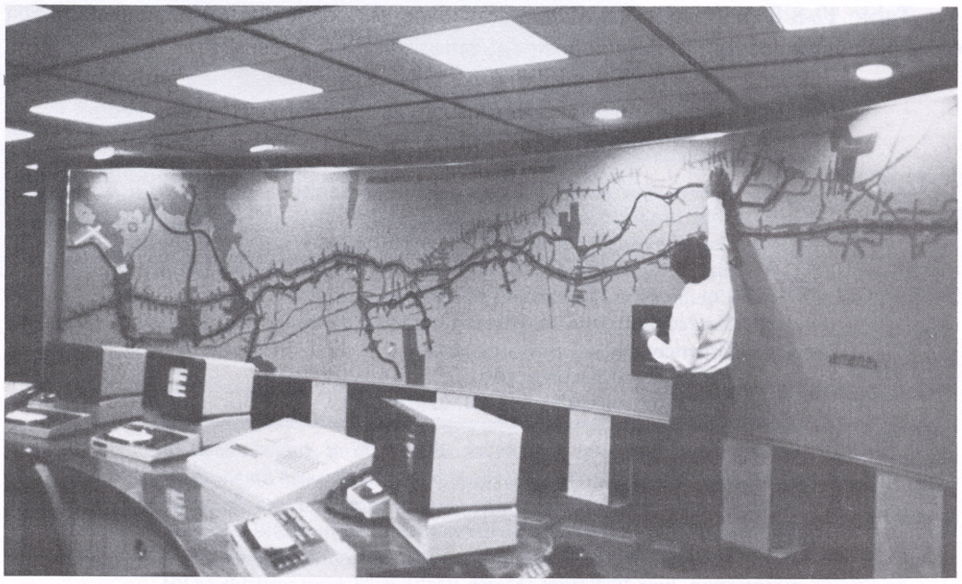

**Figure 12-4** *Freeway management center. (courtesy of Federal Highway Administration)*

The accepted terminology describing the application of new advanced technology to transportation systems management is *intelligent vehicle/highway systems (IVHS).* IVHS technologies can be expected to improve the management of the existing infrastructure, given its operating limitations, primarily by providing significant amounts of real-time information to the motorist and to public and private operating agencies so that travel can be made safely and efficiently.

The information provided by IVHS technologies has three important implications for improved management of the existing system. First, the information can make the operations of the system more efficient by effectively using the available facilities, services, modes, and routes. Second, the efficient operation of the system, because of IVHS technologies, may preclude the urgency or need for major system expansion. Third, efficient operations can also lead to an extension of the life of a particular facility, thereby postponing the need for replacement.

Improved management of the existing infrastructure is tied to the efficiencies gained through the use of information provided by IVHS technologies. The real-time information made possible by implementing IVHS technologies can include the following:

1. Location of reconstruction and maintenance activities.
2. Location of underused or overused facilities and services.
3. Identification and location of good operations.
4. Identification of restricted or out-of-service facilities.
5. Identification of alternate routes (detours), modes, services, and conditions.
6. Identification of ridesharing and transit opportunities.
7. Monitoring and routing of heavy and hazardous shipments.

There are four IVHS components that stem from advances in electronics, communications, and information processing. IVHS technologies will be discussed briefly, along with their near- or long-term impact on the improved management of the existing infrastructure.

## ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

ATMS provide the real-time means for transportation operators to effectively monitor traffic conditions, quickly adjust traffic operations, and effectively respond to accidents. They include traffic detectors, computerized signals, adjustable speed limit signs, and changeable roadside information signs and lights. ATMS can reduce traffic congestion and delays and permit shorter response times for traffic incidents. There are many examples of this type of technology:

• Computerized traffic control systems, in place at about 20% of the signalized intersection locations.
° Adaptive and interactive signal control, now in the developmental stages.
° Incident detection and response systems, being developed in a number of urban areas.

- Automatic vehicle identification systems being used to provide smooth access to restricted highways or for quicker toll collection or automatic payment.
- Identification systems to monitor hazardous cargoes or track stolen cars.

## Advanced Traveler Information Systems (ATIS)

ATIS provide drivers with in-vehicle information on congestion, navigation and location, traffic conditions, and alternative routes. ATIS could also be designed to provide travelers with trip information at the home or in the office on bus schedules, congestion, and so on. These systems are the link to travelers, providing them with the necessary information on opportunities for trip making. Additional information could be provided to include local accidents, construction areas, weather and road conditions, alternate routes, and ridesharing and transit services. In consort with other IVHS technologies, information could be provided on potentially dangerous driver, vehicle, road, or environmental conditions. Specific types of ATIS technologies include:

- On-board replication of maps and signs.
- Pretrip electronic route planning.
- Traffic information broadcasting systems.
- Safety warning systems.
- On-board navigation systems.
- Electronic route guidance systems.

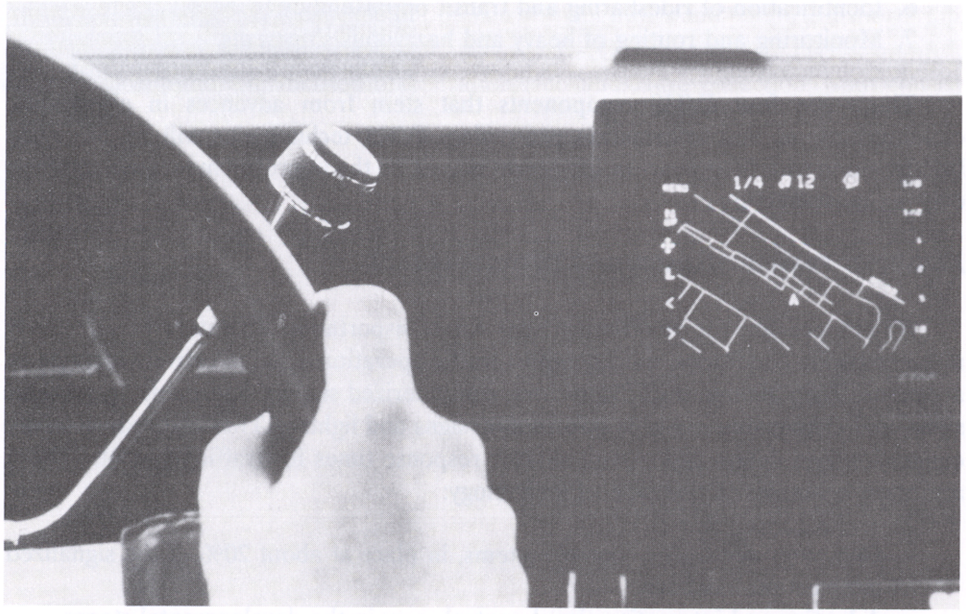

**Figure 12-5** *In-vehicle electronic map. (courtesy of Federal Highway Administration)*

## COMMERCIAL VEHICLE OPERATIONS (CVO)

CVO include technologies and fleet-control operations intended to enhance the efficiency of operating trucks and fleets of vehicles. Such systems also improve the efficiency of regulatory compliance, vehicle inspection, and fleet monitoring operations. Several of these types of systems are being used and many more are being planned. It appears that the effect of this technology on infrastructure management is near term.

## ADVANCED VEHICLE CONTROL SYSTEMS (AVCS)

AVCS are those technologies designed to help the driver perform certain vehicle control functions. Using data collected by on-board sensors, AVCS provide information to vehicle operators that allows them to make decisions quickly and accurately or that allows action to be taken independent of the operator. A number of AVCS technologies are available or under development. Some of these include:

- Antilock braking systems.
- Speed control warning systems.
  - Adaptive speed control.
- Driver assist systems.
- Radar braking.
  - Automatic headway control.
- Automatic lateral control.
  - Proximity warning.
- Smart cruise control.
- Automatic speed control.
- Automatic highway systems.

# CASE STUDIES

The following case studies provide illustration and insight into the application of the key concepts presented in this chapter.

## INTEGRATED TRAFFIC CONTROL—THE SMART CORRIDOR—LOS ANGELES, CALIFORNIA

The "Smart Corridor" (see Fig. 12-6) consists of 12.3 mi (19.7 km) of the Santa Monica Freeway and five parallel arterials. Traffic data and management strategies will be coordinated among the California Department of Transportation, the California Highway Patrol, the city of Los Angeles Police Department, and the Los Angeles County Transportation Commission. This coordination will be accomplished by linking together the five existing traffic control centers operated by these agencies and developing a common data base of information that they all can share. Through this mechanism, traffic management strategies such as ramp metering policies, parking enforcement, signal timing, and detours around major congestion or incidents will be coordinated.

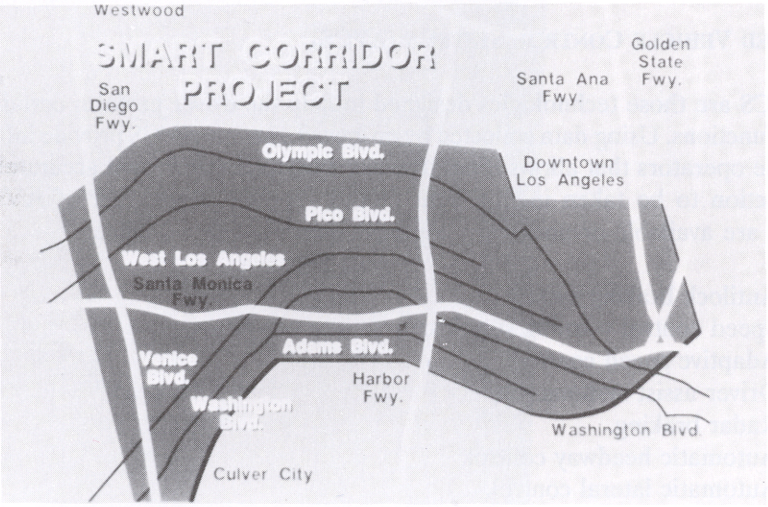


**Figure 12-6** *Smart Corridor map. (courtesy of Federal Highway Administration)*

The project also involves consideration and potential application of advanced traffic management strategies. Strategies considered include coordination of ramp meter signals with traffic signals, use of changeable message signs on arterials and at parking garage exits to advise motorists of the best routes, application of expert systems theory to the problems of incident detection and response, freeway-to-freeway connector metering, and a critical examination of various innovative mechanisms for communicating motorist information, such as areawide highway advisory radio, computer bulletin boards, telephone dial-in systems, commercial television, and videotext.

Finally, the project will incorporate consideration of improving the policy elements of traffic management. This will include an examination of freeway service patrol ideas, establishing incident management teams for both freeways and arterials, applying enforcement, and selecting accident investigation sites. A 7-month conceptual design study for the Smart Corridor was completed in 1989. Following completion of this effort, it will take 3.5 years and $30 million to complete the design and install the system. The project is not expected to be operational until late 1992.

## FREEWAY MANAGEMENT—THE FLOW PROGRAM—SEATTLE, WASHINGTON[20]

In the Seattle area, the Washington State Department of Transportation (WSDOT), working closely with the city, and the transit operator (Metro) implemented a comprehensive package of freeway management actions along Interstate 5 North (north from Seattle). Freeway management strategies incorporated into the "Flow Program" have enabled the WSDOT to maintain a viable freeway operation without the expensive construction of new facilities. The program includes the use of HOV lanes, a ramp metering system with HOV bypass lanes, express bus service with designated freeway transit stops (known as "freeway flyer stops"), a corridor ridesharing program with park-and-ride lots, and a civilian-assisted fast-lane enforcement plan. The Flow Program, in conjunction with programs like reduced carpool parking fees, variable work hours, transit service improvements, and vanpool incentive actions, provides a realistic package of actions to maintain future mobility through the I-5 corridor.

The WSDOT had three primary objectives for implementing the Flow Program: (1) improve I-5 freeway operating efficiency in order to save time and money, (2) reduce merging and congestion related accidents, and (3) maximize the people-moving capability of the freeway through on-ramp metering and HOV lanes.

In the Seattle area, coordination and cooperation between state and local agencies have made the Flow Program a success. The early involvement and subsequent support of the media and the public also played a key role in the success of the effort.

## PUBLIC—PRIVATE AGREEMENTS AND TMOs—MONTGOMERY COUNTY, MARYLAND[21,22]

Montgomery County is located immediately northwest of Washington, D.C., with a population of 700,000 and an employment base of over 250,000. Since 1973 the county has had an Adequate Public Facilities Ordinance (APFO) that requires local officials to examine the adequacy of transportation facilities and services before approving new land developments. Over time, the requirements have become progressively stronger and more effective, with increasing emphasis on public—private sector solutions. The ordinance has been the stimulus for a number of far-reaching traffic congestion alleviation requirements in the county.

The county's APFO requires that public facilities be adequate to handle new demands before development can take place. The ordinance technically covers all public facilities, but it is transportation that has grown to be the most significant issue with respect to new development. If a proposed development will produce unacceptable levels-of-service conditions on the nearby roads, then public or private sector solutions must be found to either reduce trips or increase the capacity of roads.

The APFO spells out two approaches to determining the adequacy of public facilities to meet the demands of new development: (1) a local area review test and (2) a policy area review test. The local area review is basically an intersection analysis on the roads in an area surrounding the development site. For large sites (for example, 1000 dwelling units or 1 million $ft^2$ of commercial space), this area could cover 1 mi or more. This review requires that traffic on the roads in the surrounding area operate at no worse than level-of-service E. If the required conditions for traffic flow are not met, the developer must work with the county to implement acceptable TSM actions.

The policy area review follows the local area review and is intended to identify the downstream and upstream impacts of the additional development within one of the 19 general subareas of the county. Each subarea has predetermined levels of acceptable traffic congestion. The subareas with good levels of transit service have higher levels of acceptable traffic congestion than subareas with low levels of transit service. Based on these levels, a determination is made as to whether sufficient transportation capacity exists within the policy subarea to allow additional development to take place.

To provide transportation improvements to existing developments, Montgomery County has also embarked on an effort to establish *transportation management organizations* (TMOs) in certain subareas of the county with high-density existing development. The organizations are voluntary, nonprofit, membership associations that include both the private and public sectors. The organizations have the following primary purposes:

1. To serve as a forum for private and public sector responses to transportation problems.
2. To identify and implement actions to reduce traffic congestion, air pollution, and energy consumption.
3. To facilitate orderly growth.
4. To ensure adequate access and internal mobility.
5. To coordinate "demand management" programs that include promoting transit and ridesharing services, spreading employee arrival and departure hours, and implementing parking management and other programs to encourage the use of high-occupancy vehicles for commuting.
6. To organize, manage, and promote bus or van programs.
7. To develop and coordinate common parking policies and other incentives and disincentives aimed at reducing the use of single-occupant cars.
8. To help members meet trip-reduction obligations.
9. To conduct a cooperative planning program to meet future needs.

## SUMMARY

Transportation system management actions are tools for the transportation professional to meet the management and operational challenges of relieving congestion, maintaining mobility, and improving the efficiency of transportation facilities, services, and modes. TSM actions must interact and blend with other construction and land-use actions to meet the long- and short-term goals of the community. The key ingredients to achieving success with TSM actions are the following:

° Have institutions and organizations that recognize the need for a variety of TSM actions.

° Undertake thoughtful planning to make TSM actions an integral part of the transportation plans and programs.

• Coordinate among the public and private providers of transportation.

° Have a willingness to apply TSM actions in an innovative manner.

° Have an ability to market and inform the public on the TSM action(s).

This chapter presented the contemporary approach to the planning and application of TSM actions. It has also presented the philosophy that TSM has evolved from a planning concept to include the actual operation and management of transportation. The chapter emphasized the need for coordination among institutions and between the public and private sectors to make TSM actions effective. The traffic management teams, metropolitan planning associations, and transportation management associations discussed in the chapter are creative approaches that can be used to achieve coordination.

Simplified and complex approaches to analyzing the effectiveness of TSM actions were also presented in this chapter as essential ingredients to a thoughtful TSM planning process. Traditional and innovative TSM actions were included to demonstrate*the* variety of actions to better manage traffic and improve mobility. Advanced technologies (known as intelligent vehicle/highway systems or IVHS) were also addressed to illustrate their potential application to improving mobility. Finally, case studies were presented to illustrate the concepts presented.

It is important to bridge the gap between TSM as a systems concept developed by states and metropolitan planning organizations and the application of operational actions implemented by states and local operation agencies. Effective TSM is critical to metropolitan areas and should recognize and build upon the strength of urban planning and traffic operational disciplines.

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Some citations are no longer available from their original source. These citations are often available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. We have verified the order numbers for many of these citations, and they are found at the end of the citation. Prices are available through NTIS at the address above.

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## EXERCISES

12-1 Identify five existing transportation system management actions in your community. Why would you consider each of these actions to be TSM? What do you think is the goal of these actions? How would you assess the effectiveness of these TSM actions at achieving the goal you have identified? Who is responsible for planning, implementing, and operating each of the TSM actions that you have listed?

12-2 Discuss how the Federal-Aid Highway program, between 1960 and 1975, recognized the importance of a program to improve traffic operations in urban areas. How did this lead to the formal establishment of TSM in 1975? How has the federal role in urban transportation evolved from 1975 to today?

12-3 Compare and contrast the TSM planning requirements for a corridor to that of an activity center. Account for the types of actions, institutional and organizational factors, data needs, and analysis considerations.

12-4 Using examples, discuss the differences in the application of supply-side TSM actions and demand-side TSM actions.

12-5 Select one or more TSM actions and develop a plan for implementing the project in a congested corridor. What type of supply-side and demand-side actions would be considered? Include in the plan recommendations for organizational and institutional arrangements that would need to be established, data collection factors, measures of effectiveness, and analysis techniques that could be used. Justify your recommendations.

12-6 Develop a plan as in Exercise 12-5 to relieve congestion at a major suburban employment center.

12-7 What factors need to be considered when evaluating the effectiveness of a TSM action? What role do MOEs play? How can the cost of data collection be minimized?

12-8 What are the important impacts provided by IVHS technologies on transportation system management? What are the issues that need to be addressed when applying IVHS? What organizational arrangements would be needed?

12-9 What are the potential roles and responsibilities of the private sector in TSM? What types of TSM projects would be enhanced by the private sector? How can the public sector involve the private sector in TSM?

12-10 Discuss the critical barriers that you feel need to be overcome in order to implement effective TSM actions.